B Systematic Section

Oxytrichidea EHRENBERG, 1838

- 1838 Oxytrichina EHRENBERG, Infusionsthierchen, p 362 (in part) – Name-bearing type: *Oxytricha* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS, 1824.
- 1841 Keronidae DUJARDIN, Zoophytes, p 410 (in part; published as Keroniens).
- 1852 Oxytrichina E. – PERTY, Zur Kenntniss kleinster Lebensformen, p 153 (in part).
- 1858 Oxytrichina – CLAPARÈDE & LACHMANN, Mém. Inst. natn. génev., 5: 135 (in part).
- 1859 Oxytrichina, EHRBG. – STEIN, Infusionsthierchen I, p 140 (in part).
- 1875 Keronina – FROMENTEL, Microzoaires, p 159 (in part).
- 1882 Oxytrichidae, EHR. – KENT, Manual infusoria II, p 759 (in part).
- 1889 Pleurotrichina BÜTSCHLI, Protozoa, p 1746.
- 1926 Pleurotrichidae, BÜTSCHLI – CALKINS, Biology of the protozoa, p 394.
- 1932 Oxytrichidae EHRENBERG, 1838 – KAHL, Tierwelt Dtl., 25: 537 (in part).
- 1936 Pleurotrichinae BÜTSCHLI, 1889 – BHATIA, Protozoa: Ciliophora, p 371.
- 1960 Oxytrichidae EHRENBERG, 1838 – CORLISS, Ciliated protozoa, p 169 (in part).
- 1972 Oxytrichidae EHRENBERG, 1838 – BORROR, J. Protozool., 19: 13.
- 1974 Oxytrichidae – STILLER, Fauna Hung., 115: 102.
- 1979 Oxytrichoidea JANKOWSKI, Trudy zool. Inst., Lenigr., 86: 77.
- 1979 Oxytrichidae EHRENBERG, 1838 – CORLISS, Ciliated protozoa, p 311 (in part).
- 1983 Oxytrichidae – CURDS, GATES & ROBERTS, British and other freshwater ciliated protozoa, p 428.
- 1985 Gonostomidae CULBERSON, Diss. Abstr. int., 46: 2589.
- 1985 Oxytrichidae – SMALL & LYNN, Illustrated guide to the protozoa, p 458.
- 1987 Oxytrichidae EHRENBERG, 1838 – TUFFRAU, Annls Sci. nat., 8: 116 (in part).
- 1994 Oxytrichidae EHRENBERG 1838 – TUFFRAU & FLEURY, Traite de Zoologie, 2: 141 (in part).
- 1997 Oxytrichidae EHRENBERG, 1838 – BERGER & FOISSNER, Arch. Protistenk., 148: 145.
- 1997 Oxytrichidae EHRENBERG, 1838 – EIGNER, J. Euk. Microbiol., 44: 559 (in part).
- 1997 Parakahliellidae EIGNER, J. Euk. Microbiol., 44: 563 (in part).

Characterisation: Hypotrichous ciliates with usually 18 frontal-ventral-transverse cirri clustered to six distinct groups and/or at least one fragmenting (splitting) dorsal kinety (primarily kinety 3; fragmentation sometimes secondarily lost). In the 18-cirri oxytrichids the frontal-ventral-transverse cirri originate from usually six longitudinal primordia segregating 1, 3, 3, 3, 4, 4 cirri.

Remarks: Previously we categorised this monophylum as family (BERGER & FOISSNER 1997), as also indicated by the defined ending -idae. Here I ignore the category as such because it is of no scientific value (for details, see AX 1995, p 18; SUDHAUS & REHFELD 1992, p 12; WESTHEIDE & RIEGER 1996, p VII); however, to avoid inflation, I have retained the name.

The list of synonyms includes most classifications of “oxytrichids” proposed since the establishment of this group by EHRENBERG. “In part” means that genera are included which are not considered in the present book. KAHL’s (1932) classification and some later proposals are shown in detail in Tables 7–13. It would be too tedious to compare every

previous classification with my proposal because, with few exceptions (for example, BORROR 1972a), most were created without detailed discussion of the characters used, especially those published after KAHL (1932). However, some general statements can be made: (i) The typical 18-cirri oxytrichids (for example, *Oxytricha*, *Tachysoma*, *Urosoma*, *Stylonychia*, *Steinia*, *Histriculus*) are almost always included in the Oxytrichidae. (ii) There are some deviating taxa (for example, *Ancystropodium*, *Gonostomum*, *Gastrostyla*, *Onychodromus*, *Laurentiella*) which are classified in various families. (iii) *Kerona* was never considered an oxytrichid, except by those authors who included all non-euplotid hypotrichs in this group (CORLISS 1960, KAHL 1932). Conversely, SMALL & LYNN (1985) assigned oxytrichid taxa to at least four families (Oxytrichidae, Gonostomatidae, Amphiseliidae, Trachelostylidae; the latter three were new!) without, however, detailed explanation. Furthermore, they made some curious nomenclatural mistakes. For instance, they transferred the type of *Gonostomum* STERKI, 1878, *G. affine*, to *Trachelostyla* KAHL, 1932; however, simultaneously they considered *Gonostomum* as valid. In general, I discuss deviating classifications in the corresponding group section.

The characterization proposed above unifies about 170 valid species, many of which have 18 frontal-ventral-transverse cirri clustered to six distinct groups (Fig. 6a). This pattern evolved, without doubt, only once, and taxa showing this pattern constitute the main part of the Oxytrichidae of most previous classifications (see Tables 7–13). Molecular biological and morphogenetic data and cladistic analyses suggest that some taxa with a deviating ventral infraciliature (*Laurentiella*, *Onychodromus*, *Pattersoniella*) – and thus previously classified as Oxytrichidae sensu lato or in other families – very likely evolved from 18-cirri oxytrichids (BERGER & FOISSNER 1997, SCHLEGEL et al. 1991). *Paraurostyla*, *Gastrostyla*, *Ancystropodium*, and *Territricha* are further taxa which are often considered to be in close relationship with the oxytrichids, although they also have a slightly to distinctly increased number of frontal-ventral-transverse cirri. Unfortunately, it is unknown if they are sister groups of the 18-cirri oxytrichids, or if they evolved from 18-cirri oxytrichids in that the number of cirri increased secondarily. However, all three groups (18-cirri oxytrichids, *Laurentiella* ..., *Paraurostyla* ...) have one curious character in common, namely fragmentation of at least one dorsal kinety. Kinety 3 shows simple fragmentation in the basic pattern (Fig. 24a), and I argue that it is almost impossible that this (“unimportant”) feature evolved independently several times in exactly the same way. Thus, I consider it as the most important autapomorphy of the Oxytrichidae, having occurred either earlier or concomitantly with the 18 frontal-ventral-transverse cirral pattern. The very unusual dorsal ciliature of the ectocommensal *Kerona pediculus* originates by multiple fragmentation of 3 dorsal kineties (Fig. 208v–y). I assume that this is a modified pattern, like that of *Onychodromus quadricornutus* (Fig. 195s, t), strongly suggesting an inclusion of *Kerona* in the Oxytrichidae.

For a detailed overall characterization of the Oxytrichidae, see the general section of this book.

How to recognise an oxytrichid ciliate in practice

Before using the “Key to all genera of the Oxytrichidae” (see below), you have to know whether the hypotrich in question belongs to this group at all. If one or more of the following points apply, the answer is “yes”:

- The species has 18 frontal-ventral-transverse cirri arranged essentially as shown in Figure 6a. In some species the number of transverse and pretransverse ventral cirri is slightly to distinctly decreased or these cirri are even lacking (Fig. 19d). For some similar soil species, see also my revision on *Lamtostyla* (BERGER & FOISSNER 1988a), which is now classified in the Amphiseliidae (PETZ & FOISSNER 1996).
- It is a non-euplotid hypotrich with a rigid body (except *Psilotricha*). Do not restrict mobility or squeeze the cell when checking the flexibility!
- The dorsal infraciliature is slightly to distinctly irregular due to fragmentation (for example, Fig. 219i). Unfortunately, this character needs silver impregnation or very detailed live observation with Normarski differential interference contrast optics!
- The ventral infraciliature shows one of the following patterns: Figure 29f (*Gonostomum*), Figure 29j (*Onychodromopsis*), Figure 30b (*Coniculostomum*), Figure 30i (*Onychodromus*), Figure 30j (*Laurentiella*), Figure 30k (*Pattersoniella*), Figure 30l (*Gastrostyla*), Figure 30m (*Kerona*), Figure 30n (*Paraurostyla*), Figure 30o (*Territricha*), Figure 198a, e (*Ancystropodium*), Figure 198.1f (*Apoamphisiella*), Figure 218h (*Parentocirrus*), Figure 219.1 (*Pseudouroleptus*).
- It lives on hydras or bryozoans. *Kerona pediculus* is the only known hypotrich living on these metazoans (Fig. 30m, 208).

Key to all genera of the Oxytrichidae

Many characters (size, shape, flexibility, cortical granules, colour of cytoplasm, arrangement of cirri, length of dorsal cilia, nuclear apparatus, shape of undulating membranes) can be recognised by careful examination of live specimens with bright field illumination and interference contrast optics. Admittedly, this requires patience and experience. Thus, the following key, based mainly on characters recognisable after protargol impregnation, a well-known and widely used technique for identifying ciliates (see chapter 6 in the general section), can also be used for unstained material. Live observation is indispensable for species identification! The following key includes **all genera** considered in the present book. A similar key for all 18-cirri oxytrichid genera is given by BERGER & FOISSNER (1997). Species which do not have the most common type of nuclear apparatus (namely 2 macronuclear nodules and 2 or more micronuclei) are listed in Table 1. Eighteen-cirri oxytrichids with distinct cortical granules and/or distinctly coloured cytoplasm belong to the Oxytrichinae (Table 2). If you have problems assigning a species to a group, see the somewhat heterogeneous *Oxytricha*. It includes species with a deviating oral apparatus (e. g., *O. siseris*, *O. longissima*) or an increased number of caudal cirri (e. g., *O. faurei*).

Note: For designation of characters used in the following key, see mainly Figures 6a, b, 29a–m, 30a–o.

- 1 Ectocommensal on hydras or bryozoans; body kidney- or bean-shaped; 6 distinctly curved frontoventral rows (Fig. 30m, 208a, l) *Kerona pediculus* (p 826)
- Not ectocommensal; body not kidney- or bean-shaped; frontoventral rows more or less straight (for example, Fig. 29j, 30j, n) or lacking, that is, only 2 (for example, Fig. 6a, 29a) or more marginal (for example, Fig. 29b, 30g) rows present 2
- 2 Dorsal processes (horns) present (Fig. 30i, 193a, l, r, 195a) . *Onychodromus* (p 722)
- Dorsal processes lacking 2a
- 2a Anterior end narrowed, that is, set off plug-like from rest of cell ("cephalised"); few (usually 2) cirri right of posterior end of right marginal row (Fig. 246e, arrow); marine or brackish water (Fig. 82a, b, 246a–j; 207a–f) *Hemigastrostyla* (p 933)
- No such curious character combination 3
- 3 Two or more right, and one or more left rows of marginal cirri, and/or one or more frontoventral rows (for example, Fig. 29b, j, l, 30b, g, j, l, n, 218h) 4
- One right and one left row of marginal cirri, and no distinct frontoventral row(s), but several (usually 18 [for example, Fig. 6a], some species with less [for example, Fig. 29e], two with more [Fig. 30k, o]) frontal-ventral-transverse cirri clustered to distinct groups 14
- 4 Typical 18 frontal-ventral-transverse cirri pattern present (for example, Fig. 29b, 30g) 5
- Typical 18 frontal-ventral-transverse cirri lacking (for example, Fig. 30j, n, 218h) . 8
- 5 Body tailed (Fig. 29l) *Parurosoma dubium* (p 492)
- Body not tailed 6
- 6 Macronucleus moniliform (Fig. 1a, 30b) *Coniculostomum* (p 606)
- Macronucleus consists of two nodules 7
- 7 Body very flexible; cortical granules present; caudal cirri present (sometimes difficult to distinguish from marginal cirri, which usually insert more ventrally than caudal cirri (for example, Fig. 29b, 91c) *Allotricha* (p 261)
- Body rigid; cortical granules lacking; caudal cirri absent (Fig. 30g, 189f) *Pleurotricha* (p 698)
- 8 (4) Body tapered posteriorly (Fig. 219.1) or with club-shaped process (Fig. 198) 8a
- Body not distinctly tapered and/or without club-shaped process 9
- 8a Body with club-shaped process (Fig. 198) *Ancystropodium maupasi* (p 778)
- Body tapered posteriorly (Fig. 219.1) *Pseudouroleptus caudatus* (p 889)
- 9 Oral apparatus (undulating membranes and adoral zone of membranelles) in *Gonostomum* pattern (Fig. 19c, h, 124a–c) *Gonostomum gonostomoida* (p 392)
- Oral apparatus not in *Gonostomum* pattern 10
- 10 Body almost triangular, rigid (Fig. 30j) *Laurentiella strenua* (p 753)
- Body more or less elliptical, flexible (for example, Fig. 29j, 30l, n, 218h) 11

- 11 One more or less continuous frontoventral row, that is, 3 cirral rows including marginal rows (for example, Fig. 30l, 202h) *Gastrostyla* (p 789)
- More than 1 frontoventral row, that is, 4 or more cirral rows including marginal rows (for example, Fig. 30n) 12
- 12 Two frontoventral rows, that is, 4 (Fig. 215a–c, 218h) to 5 (Fig. 29j) cirral rows including marginal rows 13
- Usually 3–7 frontoventral rows, that is, 5–9 (or more) cirral rows including marginal rows (Fig. 30n, 212r) *Paraurostyla* (p 841)
- 13 Single pretransverse ventral cirri present (Fig. 29j) *Onychodromopsis* (p 475)
- Single pretransverse ventral cirri lacking (Fig. 215c, 218h) 31
- 14 (3) Transverse cirri more than 5 in number (Fig. 30k, o) 15
- Transverse cirri 5 or less in number (for example, Fig. 29a, e, f) 16

Fig. 29a–g Ventral infraciliature (protargol impregnation) of representatives of genera assigned to the Oxytrichinae. For designation of structures, see Figure 6a; sources and sizes, see species descriptions. **a)** *Oxytricha granulifera*. Arrowhead marks postoral ventral cirrus V/3 which is close behind the buccal vertex in *Oxytricha*. **b)** *Allotricha antarctica*. Arrow marks second (= inner) right marginal cirral row. **c)** *Cyrtohymena muscorum*. Note strongly curved paroral (arrow). **d)** *Notohymena rubescens*. Note anteriorly hooked paroral (tiny arrow). **e)** *Urosomoida agilis*. Note reduced number of pretransverse ventral and transverse cirri (arrowhead). **f)** *Gonostomum affine*. Note special oral apparatus. **g)** *Urosoma caudata*. Note linear arrangement of frontoventral cirri (arrowhead). Figures on p 107.

Fig. 29h–m Ventral infraciliature (protargol impregnation unless otherwise indicated) of representatives of genera assigned to the Oxytrichinae. For designation of structures, see Figure 6a; sources and sizes, see species descriptions. **h)** *Tachysoma pelliellum*. *Tachysoma* lacks caudal cirri. **i)** *Australocirrus oscitans*. Note huge oral apparatus (body flexible). **j)** *Onychodromopsis flexilis*. Note increased number of cirral rows and special arrangement of frontal-ventral-transverse cirri. Arrow marks pretransverse ventral cirri. **k)** *Rubrioxytricha haematoplasma*. *Rubrioxytricha* has a reddish or brownish cytoplasm. **l)** *Parurosoma dubium* (mercuric chloride fixation). Note increased number of marginal rows. **m)** *Pseudostrombidium planctonicum* (cilia of cirri also shown). Euplanktonic; note increased number of caudal cirri (arrowheads). Figures on p 108.

Fig. 30a–f Ventral infraciliature (protargol impregnation) of representatives of genera assigned to the Stylonychinae. For designation of structures, see Figure 6a; sources and sizes, see species descriptions. **a)** *Stylonychia mytilus* complex. Note straight and parallel arrangement of undulating membranes. **b)** *Coniculostomum monilata*. Has almost the same ciliature as *Stylonychia* (compare black cirri of a and b), except for the parental right marginal rows (white cirri). **c)** *Steinia sphagnicola*. Note fragmented endoral (arrowhead) and conspicuous pit (tiny arrow). **d)** *Histriculus histrio*. Marginal rows closed posteriorly (at least in this species; arrowhead) and lacks caudal cirri. **e)** *Sterkiella histriomuscorum*. Arrowhead marks postoral ventral cirrus V/3, which is distinctly set off in *Sterkiella*. **f)** *Parastylonychia plouneouri*. Marine; lacks caudal cirri. Figures on p 109.

Fig. 30g–j Ventral infraciliature (protargol impregnation) of representatives of genera assigned to the Stylonychinae. For designation of structures, see Figure 6a; sources and sizes, see species descriptions. **g)** *Pleurotricha lanceolata*. Note increased number of marginal rows (arrow). **h)** *Rigidocortex octonucleatus*. Has about 8 macronuclear nodules. **i)** *Onychodromus grandis*. *Onychodromus* has dorsal horns. **j)** *Laurentiella strenua*. Note triangular shape. Figures on p 110.

29a

b

c

d

e

f

g

Fig. 29h-m Legend on p 106.

Fig. 30a-f Legend on p 106.

Fig. 30g-j Legend on p 106.

Fig. 30k-o Ventral infraciliature (after protargol impregnation) of representatives of genera assigned to the Stylonychinae (k) or of uncertain position within the Oxytrichidae (l-o). k) *Pattersoniella vittiphila*. Note increased number of frontal-ventral-transverse cirri. l) *Gastrostyla steinii*. Note irregular frontoventral row. Arrow marks prominent postoral ventral cirrus. m) *Kerona pediculus*. Note bean-shaped outline and the highly increased number of frontoventral cirri within the 6 frontal-ventral-transverse cirri streaks (1-6). Dorsal side almost completely ciliated. Lives on hydras and bryozoans. n) *Paraurostyla weissei* complex. Note frontoventral rows (arrows). o) *Territricha stramenticola*. Note slightly increased number of postoral ventral and transverse cirri.

- 15 Two macronuclear nodules; 3 frontal cirri (Fig. 30o); common in litter of European beech forests *Territricha stramenticola* (p 884)
- 13–19 macronuclear nodules; 5–8 frontal cirri (Fig. 30k, 197g); in soil of Southern hemisphere *Pattersoniella vitiphila* (p 766)
- 16 (14) Undulating membranes in *Steinia* pattern (Fig. 19j, 20f, 30c) .. *Steinia* (p 624)
- Undulating membranes not as above 17
- 17 Undulating membranes in *Cyrtohymena* pattern (Fig. 19g, 20e) *Cyrtohymena* (p 279)
- Undulating membranes not as above 18
- 18 Undulating membranes in *Notohymena* pattern (Fig. 19f, 20b) *Notohymena* (p 324)
- Undulating membranes not as above 19
- 19 Undulating membranes and adoral zone of membranelles in *Gonostomum* pattern (Fig. 19c, h, 20c) 20
- Undulating membranes and adoral zone not as above 21
- 20 Adoral zone of membranelles <30 % of body length; 4 dorsal kineties (Fig. 29g, 128o; often rather slender and tailed) *Urosoma* (p 396)
- Adoral zone of membranelles 40–50 % of body length; 3 dorsal kineties (Fig. 29f, 117g; very common in soil) *Gonostomum* (p 367)
- 21 (19) Undulating membranes in *Stylonychia* pattern (for example, Fig. 19i, 20d, 30a, b, f) 22
- Undulating membranes in *Oxytricha* pattern (for example, Fig. 6a, 19e, 20a, 29a, 30e) 23
- 22 Caudal cirri present (often prominent, sometimes, however, difficult to distinguish from marginal cirri, which usually insert more ventrally than caudal cirri; Fig. 30a, 148a, 161a) *Stylonychia* (p 501)
- Caudal cirri absent (Fig. 30f; marine) *Parastylonychia plouneouri* (p 697)
- 23 (21) Caudal cirri present (sometimes difficult to distinguish from marginal cirri, which usually insert more ventrally than caudal cirri; Fig. 6b) 25
- Caudal cirri absent 24
- 24 Marginal rows distinctly separate posteriorly; body supple (for example, Fig. 29h, 135p) *Tachysoma* (p 431)
- Marginal rows confluent posteriorly; body rigid (Fig. 30d) *Histriculus* (p 645)
- 25 (23) Number of pretransverse ventral and transverse cirri usually <6 (if 6 pretransverse ventral cirri and transverse cirri present, see also *Oxytricha*; Fig. 19d, 29e) ... *Urosomoida* (p 345)
- Two pretransverse ventral and 5 (sometimes only 4) transverse cirri (for example, Fig. 29a, 30e; if only 4 dorsal kineties and 1 or 2 caudal cirri present, see also *Urosomoida*) 26
- 26 Caudal cirri 10–20 in number, form rather dense corona at narrowly rounded posterior end of organism (caudal cirri sometimes difficult to distinguish from marginal cirri, which usually insert more ventrally than caudal cirri, Fig. 29m; usually planktonic) *Pseudostrombidium planctonicum* (p 494)

- Caudal cirri 1–3 in number 27
- 27 Macronuclear nodules 7–13, usually about 8 in number (Fig. 30h, 192a–l; body rigid) *Rigidocortex octonucleatus* (p 718)
 Macronuclear nodules 2 (very common), 3 (only *Sterkiella thompsoni*), or 4 (common) in number 28
- 28 Body flexible and oral apparatus very prominent (Fig. 29i, 142a–e)
 Australocirrus oscitans (p 470)
- No such character combination 29
- 29 Cytoplasm colourless, that is, not distinctly reddish or brownish; usually 3 caudal cirri 30
- Cytoplasm usually distinctly, rarely only slightly homogeneously orange to reddish or brown; only 1 or 2 caudal cirri (Fig. 29k, 144c) *Rubrioxysticha* (p 479)
- 30 Adoral zone of membranelles ≤ 35 % of body length; postoral ventral cirri form narrow group close behind buccal vertex; ratio of body width to length < 40 %, usually about 30 %; body supple (for example, Fig. 29a; if only 4 transverse cirri and 4 dorsal kineties present, see also *Urosomoida*); species identification usually very difficult *Oxytricha* (p 115)
- Adoral zone of membranelles ≥ 40 % of body length; postoral ventral cirri do not form narrow group close behind buccal vertex, that is, cirrus V/3 distinctly set off from the other two postoral cirri; ratio of body width to length ≥ 40 %; body rigid or slightly flexible (for example, Fig. 30e, 181a–g; often misidentified as *Oxytricha* or *Stylo-nychia*) *Sterkiella* (p 668)
- 31 (13) 2 macronuclear nodules (for example, Fig. 215c) *Apoamphisiella* (p 781)
- Usually 8 (range 7–12) macronuclear nodules (Fig. 218h, i)
 Parentocirrus hortualis (p 879)

Oxytrichinae EHRENBERG, 1838

1838 Oxytrichina EHRENBERG, Infusionsthierchen, p 362 (in part) – Name-bearing type: *Oxytricha* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS, 1824.

1997 Oxytrichinae JANKOWSKI, 1979 – BERGER & FOISSNER, Arch. Protistenk., 148: 145.

C h a r a c t e r i s a t i o n: Oxytrichidae with flexible (supple) body. Cortical granules present, secondarily lost several times. Adoral zone of membranelles usually ≤ 40 % of body length. Primarily 18 frontal-ventral-transverse cirri clustered to six distinct groups, number of cirri of some groups (especially transverse and pre- and postoral ventral cirri) slightly to distinctly decreased. Postoral ventral cirrus V/3 participates in primordia formation. Dorsal morphogenesis primarily in *Oxytricha* pattern (Fig. 24a), secondarily fragmentation of kine 3 and dorsomarginal kineties absent.

R e m a r k s: Recently I categorised this monophylum as subfamily, as also indicated by the defined ending -inae (BERGER & FOISSNER 1997). Here I ignore the category as such, but, to avoid inflation, retain the name. Furthermore, in BERGER & FOISSNER (1997) I credited this taxon to JANKOWSKI (1979, p 77) because he published this category as follows: Subfamily 1. Oxytrichinae EHRENBURG, 1838, s. str., subfam. n. Now I prefer to credit it to EHRENBURG (1838), as obviously already proposed by JANKOWSKI (1979) himself.

Phylogenetic analysis strongly suggests that the 18-cirri oxytrichids branch into two roughly equal sized groups, namely the Oxytrichinae with a plesiomorphic flexible body, and the Stylonychinae with a rigid body as an evolutionary novelty. In the cladogram proposed (Fig. 25a, b), the Oxytrichinae are defined by a distinctive ontogenetic autapomorphy, namely the participation of the posterior-most postoral ventral cirrus (V/3) in primordia formation (for detailed explanation of this character, see character 19 in the phylogeny chapter of the general section). In the Oxytrichinae this cirrus is usually arranged very close to the remaining postoral cirri, whereas it is distinctly displaced posteriorly in the sister group, Stylonychinae. The other features mentioned in the characterisation of the Oxytrichinae are either plesiomorphies (for example, flexible body, cortical granules present) or conspicuous autapomorphies of members of this group, for instance, number of pretransverse ventral and transverse cirri decreased in *Urosomoida*, loss of fragmentation of dorsal kinety 3 in *Urosomoida* and in the *Urosoma-Gonostomum* group, and loss of dorsomarginal kineties in *Gonostomum*.

Some of the sister group relationships proposed in the cladogram are well-defined (for example, *Gonostomum-Urosoma*, *Oxytricha-Allotricha*), others are rather weak due to several parallelisms (Fig. 25a, b). In addition, some taxa (*Australocirrus*, *Onychodromopsis*, *Rubrioxytricha*, *Parurosoma*, *Pseudostrombidium*), also having the typical (or somewhat modified) 18 frontal-ventral-transverse cirral pattern and a supple body, could not be considered in the phylogenetic analysis because detailed morphogenetic data are lacking. Thus, the proposed cladograms are rather incomplete and will change more or less significantly as further taxa are analysed. Furthermore, most of the important morphogenetic characters used for the analysis are substantiated for the type species only. As a consequence of this uncertainty I did not name clades within the Oxytrichinae.

Still, some genera are not defined by a unique character (autapomorphy) but by a specific combination of plesiomorphies, that is, their monophyly is questionable. Thus, and because I did not name and characterise the sister groups within the Oxytrichinae, the characterisation of a genus includes all features necessary to separate it from the other genera of the Oxytrichinae.

Key to genera

For identification of taxa, see general key on page 104. Species with the 18 frontal-ventral-transverse cirral pattern and cortical granules belong to the Oxytrichinae (Table 2).

***Oxytricha* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS, 1824**

- 1824 *Oxytricha* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS, Encyclopédie méthodique, p 593 (see nomenclature and taxonomy) – Type (subsequent designation by FOISSNER 1989, p 235; see nomenclature): *Oxytricha granulifera* FOISSNER & ADAM, 1983.
- 1826 *Oxitricha* BORY DE SAINT-VINCENT, Essai d'une classification, p 55 (see nomenclature and taxonomy).
- 1830 *Oxytricha pellationella* BORY. – EHRENBURG, Abh. preuss. Akad. Wiss., year 1830: 43 (see nomenclature).
- 1838 *Oxytricha* – EHRENBURG, Infusionsthierchen, p 363 (see nomenclature and taxonomy).
- 1859 *Oxytricha* EHRBG. – STEIN, Organismus der Infusionsthier I, p 182 (in part).
- 1866 *Actinotricha* COHN, Z. wiss. Zool., 16: 283 (synonym) – Type (by original designation and monotypy): *Actinotricha saltans* COHN, 1866.
- 1875 *Oxytricha* – FROMENTEL, Études microzoaires, p 160 (in part; see nomenclature and taxonomy).
- 1882 *Oxytricha*, EHRENBURG – KENT, Manual infusoria, p 786 (in part).
- 1882 *Opisthotricha* KENT, Manual infusoria II, p 785 – Type (original designation): *Oxytricha parallela* ENGELMANN, 1862.
- 1889 *Oxytricha* (*Oxitricha* p. p. BORY 1824) EHRB. 1830 emend. STERKI 1878 – BÜTSCHLI, Protozoa, p 1749 (in part).
- 1932 *Oxytricha* (BARY, 1824) EHRENBURG, 1838, emend. WRZESNIEWSKI, 1877 – KAHL, Tierwelt Dtl., 25: 599 (in part; incorrect spelling of BORY).
- 1932 *Oxytricha* WRZESNIEWSKI, 1877 – KAHL, Tierwelt Dtl., 25: 601 (in part).
- 1932 *Opisthotricha* KENT, 1881 – KAHL, Tierwelt Dtl., 25: 608 (in part).
- 1972 *Oxytricha* EHRENBURG, 1830 – BORROR, J. Protozool., 19: 13 (in part; see nomenclature and taxonomy).
- 1974 *Oxytricha* EHRENBURG emend. WRZESNIEWSKI – STILLER, Fauna Hung., 115: 128.
- 1989 *Oxytricha* – FOISSNER, Sber. öst. Akad. Wiss., 196: 235 (fixation of type species; see nomenclature).
- 1997 *Oxytricha* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS, 1824 – BERGER & FOISSNER, Arch. Protistenk., 148: 146.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Frontoventral cirri in V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral cirri and 5, rarely 4 transverse cirri. One right and 1 left row of marginal cirri. Usually 5 or 6, rarely 4 dorsal kineties. Caudal cirri present. Primordia V and VI of proter originate from cirrus V/4 and V/3 respectively. Dorsal morphogenesis in *Oxytricha* or *Urosomoida* pattern.

Nomenclature: The nomenclature of *Oxytricha* is very complicated. BORY DE SAINT-VINCENT established this genus as "*Oxitricha*"; however, the spelling *Oxytricha*, which was used for the first time by EHRENBURG (1830, p 43, 54), prevailed. In spite of this, BORY DE SAINT-VINCENT should be accepted as the author of *Oxytricha* (CORLISS 1979).

BORY DE SAINT-VINCENT assigned the following species to "*Oxitricha*": *O. lepus* (basionym: *Trichoda lepus* MÜLLER, 1773, p 89; species indeterminata); *O. pulex* (basionym: *Trichoda pulex* MÜLLER, 1773, p 80; 1786, p 225, Tab. XXXI, fig. 26; species indeterminata?); *O. pullicina* (basionym: *Trichoda pulex* MÜLLER, 1773, p 80; 1786, p 225, Tab. XXXI, fig. 25); *O. pelionella* (basionym: *Trichoda pellationella* MÜLLER, 1773, p 80; now

Tachysoma pellationum); *O. gallina* (basionym: *Trichoda gallina* MÜLLER, 1786, p 209; now *Uroleptus gallina* (MÜLLER, 1786) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991); *O. pullaster* (basionym: *Trichoda pullaster* MÜLLER, 1773, p 81; now *Holosticha pullaster* (MÜLLER, 1773) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991); *O. transfuga* (basionym: *Trichoda transfuga* MÜLLER, 1776, p 281; now *Uronychia transfuga* (MÜLLER, 1776) STEIN, 1859c); *O. bulla* (basionym: *Trichoda bulla* MÜLLER, 1786, p 222; species indeterminata); *O. gibbosa* (basionym: *Trichoda gibba* MÜLLER, 1786, p 179; species indeterminata?); *O. volutator* (basionym: *Himantopus volutator* MÜLLER, 1786, p 251; species indeterminata); *O. joblotii* (species indeterminata); *O. felis* (basionym: *Trichoda felis* MÜLLER, 1786, p 213; species indeterminata); *O. variabilis* (species indeterminata); *O. ambigua* (basionym: *Trichoda ambigua* MÜLLER, 1786, p 200; now *Spirostomum ambiguum* (MÜLLER, 1786) EHRENBERG, 1835).

EHRENBERG (1830) used the name *Oxytricha* in combination with the species names *O. pellationella* (now type of *Tachysoma*), *O. piscis* (now *Uroleptus piscis*), *O. pullaster* (now *Holosticha pullaster*), and *O. lepus* (indeterminable).

Neither BORY DE SAINT-VINCENT nor EHRENBERG (1830, 1838) fixed a type species. This was done for the first time by FROMENTEL (1875) with *Oxytricha crassa* CLAPARÈDE & LACHMANN, 1858, a species not originally included in "*Oxitricha*" (see above and below). Unfortunately, KAHL (1932) ignored this decision, and transferred *O. crassa* to the subgenus "*Holosticha (Trichotaxis)*". KAHL (1932) himself did not fix a type species in *Oxytricha*. Forty years later, BORROR (1972a) synonymised *Steinia* with *Oxytricha*, fixing *Oxytricha platystoma* EHRENBERG, 1831, as type of *Oxytricha*; however, this species was subsequently designated as the type of the resurrected *Steinia* (FOISSNER 1989, p 235). This caused an almost indissoluble type problem since none of the originally included species is now considered to be an *Oxytricha* and many of them are indeterminable. Thus, FOISSNER (1989) proposed *Oxytricha granulifera* FOISSNER & ADAM, 1983, as type, because this species represents what is generally considered as a "typical" *Oxytricha*, especially in the sense of KAHL (1932), who provided the last authoritative characterisation of this voluminous taxon. Furthermore, *Oxytricha granulifera* is described in great detail both by live observations and after protargol impregnation, it is well characterised morphogenetically, and the holo- and paratype slides are deposited in a museum. Thus, I agree with FOISSNER (1989) to "fix" *O. granulifera* finally as the type of *Oxytricha*, although this is not in agreement with Article 67 (g) of the ICZN (1985). Accordingly, a species cannot be fixed as type species if it was not originally included; however, following the code strictly would mean numerous changes of names, which is hardly in the interest of the nomenclatural stability.

KAHL (1932) divided *Oxytricha* into 7 subgenera, namely *Oxytricha (Oxytricha)*, *O. (Opisthotricha)*, *O. (Stylonychia)*, *O. (Histrio)*, *O. (Tachysoma)*, *O. (Steinia)*, and *O. (Urosoma)*, so producing some primary and secondary homonyms. The most interesting example is the primary homonymy of *O. (Opisthotricha) muscorum*, *O. (Stylonychia) muscorum*, *O. (Histrio) muscorum*, and *O. (Steinia) muscorum*, which I corrected just re-

cently (FOISSNER et al. 1991; see also *Sterkiella histriomuscorum* and *Cyrtohymena muscorum*).

Some incorrect subsequent spellings: *Ocytricha* sp. (GEBHARDT 1933, p 154); *Onytricha* (MAUPAS 1888, p 276); *Opistotricha* (GRACIA & IGUAL 1987b, p 3; SUDZUKI 1964a, p 249, 1964c, p 168; SUDZUKI & SHIMOIZUMI 1967, p 216); *Opistotricha similis* (HORVÁTH 1950, p 156); *Opistrottricha similis* (HORVÁTH 1950, p 155); *Opithotricha muscorum* KAHL (WANG 1977, p 145); *Oxitrica* sp. (GRACIA et al. 1987b); *Oxitricha* spec. (VOSS 1978, p 42); *Oxitrycha* sp. (SALVADÓ & GRACIA 1993, p 893); *Oxythricha* (BAMFORTH 1967, p 15; HENEERY & GORDEN 1989, p 1019); *Oxyticha* (BURGES 1958, p 43); *Oxytrichia* (LACKEY 1926a, b, p 37, 45; LACKEY 1927, p 519; LACKEY 1942, p 196); *Oxytrichum* (GIPSON & KALINSKY 1982, p 134); *Oxytrocha* sp. (CAIRNS & YONGUE 1973b, p 202).

T a x o n o m y: The characterisation of *Oxytricha* is according to BERGER & FOISSNER (1997). For explanation of patterns mentioned, see chapters 1 and 2 in the general section. *Oxytricha* is the most voluminous taxon within the oxytrichids, comprising about 50 valid species and 60 species indeterminata; most of the latter have been described by DUMAS (1929, 1930). Only about a quarter of the valid species is characterised in detail both by live observations and after protargol impregnation. All other valid taxa are described usually only after more or less exact live observation or inadequate staining methods, and the differences to other oxytrichids are often rather vague. However, the available data leave at least a small chance of recognising them; thus, I do not classify them as species indeterminata. More detailed investigations of these species will presumably reveal that some belong to other taxa, that is, the "valid" *Oxytricha* species mentioned in this book very likely do not form a monophylum. However, the available data are too scant for a more detailed classification. Furthermore, the sparse and often rather doubtful observations made the construction of a useful key almost impossible. Identification of *Oxytricha* species is thus a very difficult task. One of the most problematic species is *Oxytricha hymenostoma*, which looks like a *Sterkiella* or *Stylonychia*. However, STOKES (1887b) described the body as soft and flexible, so preventing a synonymisation with the rather similar and very common *Sterkiella histriomuscorum* or a *Stylonychia*.

Opisthotricha KENT was established to include *Oxytricha* species with elongated caudal cirri. However, at the present stage of knowledge this character can be used for species distinction only. Synonymy was already proposed by BORROR (1972a).

Oxytricha and *Allotricha* are very likely sister groups, as indicated by the almost identical ventral and dorsal infraciliature and – more convincingly – by distinctive morphogenetic peculiarities (see Fig. 23c). However, the autapomorphy of this *Oxytricha*-*Allotricha* group has to be substantiated by the investigation of further species. *Allotricha*, a resurrected taxon described by STERKI (1878), has at least two right marginal rows, and can thus be easily distinguished from *Oxytricha*.

Species are arranged according to biotopes, namely freshwater, soil, and saline waters. Some of them (for example, *Oxytricha setigera*) occur in two types of biotopes. Species are arranged alphabetically within these biotope groups.

Key to species

The identification of *Oxytricha* species is very difficult and in several cases very likely impossible, especially in practical applications (for example, water pollution assessment), when often only few specimens are available. Furthermore, the differences to other groups are often very difficult to ascertain, especially in life; thus, see also *Urosomoida* if the number of transverse cirri and pretransverse ventral cirri is decreased and only 4 dorsal kineties are present, *Rubrioxxytricha* if the cytoplasm is homogeneously reddish or brownish, *Urosoma* if frontoventral cirri form a line, as in Figure 19a, and only 4 dorsal kineties present, *Sterkiella histriomuscorum* if the body is not very flexible, cortical granules are lacking, and the posterior postoral ventral cirrus V/3 is distinctly set off. Detailed live observation using oil immersion is absolutely necessary for identification. Important characters for identification are, among other things, the biotope, the size, the length of dorsal cilia, the nuclear apparatus, and the cortical granules. **Note that characters and data mentioned in the keys and tables are usually not repeated in the text!**

- 1 Two macronuclear nodules 2
- More than 2 macronuclear nodules 1a
- 1a 8 macronuclear nodules; cortical granules present (Fig. 73c, d, f, h) *O. ottowi* (p 218)
- 4–6, usually 4 macronuclear nodules; cortical granules lacking (Fig. 68a, f) *O. islandica* (p 207)
- 2 Dorsal cilia $>6\ \mu\text{m}$ 3
- Dorsal cilia $\leq 6\ \mu\text{m}$ 11
- 3 Only 1 micronucleus between macronuclear nodules (Fig. 1c) 6
- Each macronuclear nodule with 1 or more micronuclei (if only 1 micronucleus is present, it is usually not located between the 2 macronuclear nodules; for example, Fig. 2) 3a
- 3a Freshwater or soil 4
- Marine 50
- 4 Length in life about 200 μm ; 4 distinct caudal cirri (Fig. 52a, b) *O. parallela* (p 171)
- Length in life about 60–120 μm ; 3 or less caudal cirri 5
- 5 Undulating membranes nearly straight, arranged side by side (Fig. 77) *O. pseudosimilis* (p 222)
- Undulating membranes distinctly bent, arranged consecutively (Fig. 58c, g) *O. siseris* (p 187)
- 6 (3) Length in life about 40–60 μm , rarely up to 80 μm 7
- Length in life usually more than 80 μm or 6 dorsal kineties (Fig. 244d–g) 8a
- 7 Buccal cirrus at posterior end of undulating membranes; 4 dorsal kineties (Fig. 55g, h, i, p, r) *O. setigera* (p 175)

- Buccal cirrus at anterior end of undulating membranes; 5 dorsal kineties (Fig. 33a–e; see also the very similar *O. opisthomuscorum*, lead 10–) *O. balladyna* (p 126)
- 8a** (6) Length in life 155–280 μm ; cortical granules present (Fig. 40a–d) *O. granulosa* (p 148)
- Length in life about 80–150 μm ; cortical granules lacking **8b**
- 8b** In life about 4.6 times as long as broad (Fig. 59) *O. sphagni* (p 190)
- In life about 2.5–3.5 times as long as broad (Fig. 35, 37a, 73a) **9**
- 9** Outline spindle-shaped; about 2.5 times as long as broad (Fig. 37a, b) *O. euglenivora* (p 136)
- Outline others; about 3–3.5 times as long as broad **10**
- 10** Transverse cirri fringed, distally distinctly bent to the left (Fig. 35) *O. crassistilata* (p 135)
- Transverse cirri not fringed, distally not bent (Fig. 73a, b; see also the very similar *O. balladyna*, lead 7–) *O. opisthomuscorum* (p 217, 925)
- 11** (2) Length in life more than 200 μm **12**
- Length in life less than 200 μm **13**
- 12** Marginal cirri become distinctly longer toward rear (Fig. 36; very uncertain species) .
..... *O. elongata* (p 136)
- Marginal cirri of about same length (Fig. 47) *O. longissima* (p 164)
- 13** (11) Symbiotic algae present (Fig. 34a, b) *O. chlorelligera* (p 129)
- Symbiotic algae absent **13a**
- 13a** Outline very slender; only 3 very prominent adoral membranelles (Fig. 90; very rare [uncertain?], marine species) *O. tricornis* (p 241)
- Outline less slender than shown in Figure 90; normal adoral zone of membranelles **14**
- 14** Single micronucleus between macronuclear nodules (Fig. 1c) **15**
- Two or more micronuclei (if only 1 micronucleus present, then usually not between macronuclear nodules) **22**
- 15** Length in life about 150–200 μm (Fig. 46a, b) *O. longicirrata* (p 163)
- Length in life less than 150 μm **16**
- 16** Length in life about 35–70 μm **17**
- Length in life about 80–120 μm **19**
- 17** 4 transverse cirri (Fig. 53a, b) *O. pseudofurcata* (p 173)
- 5 transverse cirri **18**
- 18** Right marginal row terminates in front of right transverse cirrus; pretransverse ventral cirri distinctly displaced anteriorly; saline lakes (Fig. 83a–g) ... *O. geleii* (p 232)
- Right marginal row terminates behind transverse cirri at posterior end of cell; pretransverse ventral cirri not distinctly displaced anteriorly; soil (Fig. 76) *O. pseudofusiformis* (p 222)
- 19** (16) Caudal cirri conspicuously elongated (for example, Fig. 84a, b) **20**
- Caudal cirri not distinctly elongated (for example, Fig. 54a–c) **21**
- 20** Saline waters (Fig. 84a, b) *O. halophila* (p 232)

- Freshwater 49
- 21 (19) All marginal cirri long and fine; transverse cirri long and prominent; dorsal cilia about 6 μm long (Fig. 54a–c) *O. saprobia* (p 174)
- Posterior-most left and right marginal cirrus slightly elongated and enlarged; transverse cirri not conspicuously enlarged; dorsal cilia about 2 μm long (Fig. 32) *O. alfredi* (p 125)
- 22 (14) Cortical granules present and/or cytoplasm rusty or reddish by granules (Note that *O. enigmatica* also has cortical granules, Fig. 82a, b, 246c) 23
- Cortical granules absent and cytoplasm more or less colourless 31
- 23 Cytoplasm rusty or reddish by granules 24
- Cytoplasm without distinctly coloured granules (cortical granules present!) 25
- 24 Cell about 2.7–3.3 times as long as broad; transverse cirri displaced anteriad, protruding only slightly beyond posterior end of cell (Fig. 31b, c) *O. aeruginosa* (p 122; see also *Rubrioxytiricha*)
- Cell only about 1.6 times as long as broad; transverse cirri obviously arranged rather closely to posterior end of cell (Fig. 222o–t) *O. truncata*, a species indeterminata? (p 254)
- 25 (23) Body cylindrical, about 8.5 times as long as broad (Fig. 39a, g) *O. faurei* (p 146)
- Body not cylindrical, about 2–3.5 times as long as broad 25a
- 25a Marine (Fig. 186d) *O. durhamiensis* (p 228)
- Freshwater or soil 26
- 26 Body about 2 times as long as broad, outline pyriform; freshwater (Fig. 61a–e) *O. tenella* (p 191)
- Body about 2.5–3.5 times as long as broad, outline more or less elliptical; soil (for example, Fig. 71a–d) 27
- 27 Cortical granules colourless or only slightly yellowish 28
- Cortical granules orange-yellow or shiny red 30
- 28 Cortical granules rod-shaped, about $2\text{--}3 \times 0.5\text{--}1 \mu\text{m}$ sized, arranged in short longitudinal rows; 6 dorsal kineties (Fig. 71a–d, g) *O. longigranulosa* (p 213)
- Cortical granules spherical, $0.5\text{--}1 \mu\text{m}$ across, arranged in long longitudinal rows or in irregular patches; 5 or 4 dorsal kineties (Fig. 65a, b, g, 116b) 28a
- 28a Cortical granules in longitudinal rows; 5 dorsal kineties (Fig. 65b) 29
- Cortical granules in irregular patches; 4 dorsal kineties (Fig. 111b) *Urosomoida granulifera* (p 352)
- 29 Transverse cirri constantly 5 ($n = 15$) in number; right marginal row begins at level of right frontal cirrus, terminates behind transverse cirri; anterior pretransverse ventral cirrus distinctly separated from posterior one (Fig. 65f) *O. granulifera* (p 197)
- Transverse cirri usually 4, rarely only 3 (mean = 3.9; $n = 15$) in number; right marginal row begins at about level of middle frontoventral cirri and terminates slightly above level of transverse cirri; both pretransverse ventral cirri are located at

- about same level, immediately right of left transverse cirrus (Fig. 78a)
 O. quadricirrata (p 223)
- 30 (27) Cortical granules orange-yellow; about 23–27 adoral membranelles (Fig. 63a–e)
 O. auripunctata (p 194)
- Cortical granules shiny red; about 36–42 adoral membranelles (Fig. 79a–e)
 O. rubripuncta (p 224)
- 31 (22) Soil 32
- Freshwater or saline water 38
- 32 Length in life about 150–200 μm (Fig. 64) *O. bimembranata* (p 196)
- Length in life usually <150 μm 33
- 33 4 or 5 transverse cirri; usually not very flexible (Fig. 183, 184)
 Sterkiella histriomuscorum (p 683)
- Usually 5, rarely 6 transverse cirri 35
- 34 (43) Usually 4 transverse cirri (that is, 6 cirri inclusively pretransverse ventral cirri;
 Fig. 44a–d) *O. longa* (p 158)
- 5 transverse cirri (that is, 7 cirri inclusively pretransverse ventral cirri; Fig. 57a–d) ..
 O. similis (p 183)
- 35 (33) Body in life about 4–6 times as long as broad (Fig. 74) *O. procera* (p 220)
- Body in life about 2.2–3.7 times as long as broad 36
- 36 Body in life about 2.8–3.7 times as long as broad; transverse cirri project distinctly
 beyond posterior end of cell (Fig. 69a–l) *O. lanceolata* (p 209)
- Body in life usually less than 2.8 times as long as broad; transverse cirri project only
 slightly beyond posterior end of cell (Fig. 72a, b, 75) 37
- 37 Body margins straight or slightly convex, sides usually nearly parallel, posterior end
 broadly rounded (Fig. 72a–d, 116a–e) 37a
- Body margins strongly convex, outline broadly elliptical, posterior end often nar-
 rowly rounded or slightly pointed (Fig. 75) *O. proximata* (p 221)
- 37a 5 dorsal kineties (Fig. 72d) *O. nauplia* (p 215)
- 4 dorsal kineties (Fig. 116e) *Urosomoida antarctica* (p 365)
- 38 (31) Saline water 39
- Freshwater 41
- 39 2 cirri right of transverse cirri and posterior end of right marginal row; body slightly
 twisted (Fig. 82a, b, arrow; has tiny cortical granules, Fig. 246c) *O. enigmatica* (p 229)
- No such cirri; body not twisted 40
- 40 Length in life about 80–120 μm , about 3.5 times as long as broad, outline more or
 less parallel-sided (Fig. 85b) *O. oxymarina* (p 233)
- Length in life about 65 μm , about 2 times as long as broad, outline broad elliptical
 (Fig. 80) *O. alfredkahli* (p 227)
- 41 (38) Length in life about 130–180 μm , outline distinctly ovoid (Fig. 38d, e, i)
 O. fallax (p 137)
- Length in life about 70–120 μm , outline not distinctly ovoid 42

- 42 Caudal cirri distinctly longer than marginal cirri (for example, Fig. 44a) 43
- Caudal cirri not distinctly longer than marginal cirri (for example, Fig. 48) 45
- 43 Only 2 rather long caudal cirri, which point somewhat to the right (Fig. 57a) 34
- 3 caudal cirri 44
- 44 Body in life about 2 times as long as broad (Fig. 50a, b; see also *Sterkiella histriomuscorum*) *O. monspessulana* (p 168)
- Body in life about 4.0–5.5 times as long as broad (Fig. 49a–c) *O. minor* (p 166)
- 45 (42) 1 supernumerary cirrus immediately behind right frontal cirrus (Fig. 60)
..... *Oxytricha* sp. (p 190)
- No such cirrus immediately behind right frontal cirrus 46
- 46 3 postoral ventral cirri, arranged rather close to proximal end of adoral zone of membranelles (Fig. 51a) 47
- Posterior postoral ventral cirrus distinctly displaced posteriad (Fig. 42d, arrow), or usually more than 3 postoral ventral cirri (Fig. 62) 48
- 47 Transverse cirri usually more than 5 in number (Fig. 51a, b) ... *O. multiseta* (p 169)
- Transverse cirri 5 in number (Fig. 48) *O. matritensis* (p 165)
- 48 (46) 5 dorsal kineties; ventral infraciliature rather variable (Fig. 62)
..... *O. variabilis* (p 193)
- 6 dorsal kineties; ventral infraciliature not conspicuously variable (Fig. 41a–g, 42a–h) *O. hymenostoma* (p 150)
- 49 (20) Body in life about 2 times as long as broad, outline distinctly ovoid; transverse cirri conspicuously displaced anteriad, do not protrude beyond posterior end of cell (Fig. 43a) *O. kahlovata* (p 157)
- Body in life about 3.3 times as long as broad, outline long-elliptical; transverse cirri protrude distinctly beyond posterior end of cell (Fig. 84c) *O. parahalophila* (p 170)
- 50 (3a) Anterior end cephalised; 180–240 µm long (Fig. 81) *O. discifera* (p 227)
- Anterior end not cephalised; 50–100 µm long (Fig. 86a, 87a, 88a) *O. saltans* (p 236)

***Oxytricha aeruginosa* WRZESNIEWSKIEGO, 1866 (Fig. 31a–e)**

- 1866 *Oxytricha aeruginosa* WRZESNIEWSKIEGO, Wykaz Szkoty Głownej Warszawskiej, No. 5: 18 (latin diagnosis, no illustration).
- 1867 *Oxytricha aeruginosa* WRZESNIEWSKIEGO, Przyczynek do historyi naturalnej wymoczków, p 51 (Fig. 31b–e; in Polish).
- 1867 *Oxytricha aeruginosa* WRZESNIEWSKIEGO, Rocznik ces. król. Towarzystwa Naukowego Krakowskiego, 12: 279 (Fig. 31b–e; in Polish).
- 1870 *Oxytricha aeruginosa* WRZESNIEWSKI, Z. wiss. Zool., 20: 471 (in German).
- 1882 *Oxytricha aeruginosa*, WRZ. – KENT, Manual Infusoria II, p 787.
- 1932 *Oxytricha aeruginosa* WRZESNIEWSKI, 1870 – KAHL, Tierwelt Dtl., 25: 602.
- 1972 *Oxytricha aeruginosa* WRZESNIEWSKI, 1869 – BORROR, J. Protozool., 19: 13.

Nomenclature and taxonomy: *Oxytricha aeruginosa* WRZESNIEWSKI in MAUCH (1976, p 435) is an incorrect subsequent spelling. *Oxytricha aeruginosa* was pub-

Fig. 31a-e *Oxytricha aeruginosa* (a, from CHORIK 1968; b-e, after WRZESNIEWSKIEGO 1867a. a-e, from life). a-e) Ventral views, a = 150 μ m, b, c = 160 μ m. In (b) 1 fronto-ventral cirrus is arranged very close to the right frontal cirrus, which is very likely a misobservation, in (c) only 3 frontoventral cirri are present. d) Lateral view, 155 μ m. e) Resting cyst, 80 μ m; p 122. Fig. 31f *Oxytricha sordida*, a supposed synonym of *O. aeruginosa* (after WRZESNIEWSKI 1861). Ventral view from life, about 110 μ m; p 125.

lished four times as species nova! The text and the illustrations by WRZESNIEWSKIEGO (1867a, b) are identical. Following KAHL (1932), later always incorrectly dated with 1870, the year the German version was published. The correct name in KAHL (1932) is *Oxytricha* (*Oxytricha*) *aeruginosa* because KAHL divided *Oxytricha* into subgenera. The redescrptions by AGAMALIEV (1974; Fig. 221a, b) and PÄTSCH (1974; Fig. 220m) are insufficient because no rusty granules are mentioned. A further population is described by CHORIK (1968, p 133) from small water bodies in Moldova (Fig. 31a); the reliability of this Russian redescription was not checked. The figure in LOKOT (1987) is probably copied from KAHL (1932).

Several more or less reddish *Oxytricha* species have been described, but none of these has been synonymised with the poorly known *O. aeruginosa*. *Oxytricha rubripuncta* is edaphic and has red granules in the cortex. Another edaphic species, *O. auripunctata*, has orange-yellow cortical granules, usually only 4 transverse cirri, and is somewhat smaller (80–130 μ m) than *O. aeruginosa*. The freshwater species, *Rubrioxytricha haematoplasma* and *R. ferruginea*, have a homogeneously reddish and rusty coloured cytoplasm and cortical granules. *Cyrtohymena muscorum* also has red granules in the cy-

toplasm; however, it lives mainly in terrestrial habitats and the undulating membranes are in *Cyrtohymena* pattern (Fig. 94a–d, g, h). Detailed redescription necessary.

Morphology and biology: In life about $120\text{--}165 \times 45\text{--}60\ \mu\text{m}$. Usually long, sometimes broadly elliptical, both ends rounded. Anterior portion narrowed and slightly bent to left. Two macronuclear nodules. Number of micronuclei unknown, but probably 2 or more. Contractile vacuole distinctly in front mid-body. Cytoplasm more or less intensely coloured by russet and black granules ("Körnchen"). WRZESNIEWSKI (1870) observed that these granules are more numerous in well-fed specimens than in starved specimens; thus, he supposed that they originate from digested food, for example diatoms. Movement rapid.

Adoral zone of membranelles about 1/3 of body length, distinctly overlapping right margin. Buccal area medium-sized, undulating membranes distinctly curved. 3–4 (probably usually 4) frontoventral cirri. Posterior postoral ventral cirrus located about in mid-body. Five transverse cirri. Caudal cirri of about same length as marginal cirri. Cyst spherical, approximately $80\ \mu\text{m}$ across, with a somewhat irregular, about $9\ \mu\text{m}$ thick (mucous?) layer (Fig. 31e).

Occurrence and ecology: Rare, uncertain species; recorded from the benthos of fresh, brackish, and marine waters; however, identifications never substantiated by detailed data! Locus classicus is Warsaw, Poland, where WRZESNIEWSKIEGO (1866) discovered *Oxytricha aeruginosa* in a spring in the garden of the University. CHORIK (1968; uncertain!) found it in small water bodies in Moldova (Fig. 31a).

Records not substantiated by illustrations: running waters in Nordwürttemberg, brooks near Bonn, and Elbe Estuary, Germany (BUCK 1961, JUTRCZENKI 1982, RIEDEL-LORJÉ 1981); among detritus and in the surface film of ditches regularly contaminated with pesticide sprays, and in unsprayed ditches in the Elbe flood plain, Germany (CASPERS & HECKMAN 1982); Turiec River in Slovakia (TIRJAKOVÁ 1993); Russia (LOKOT 1987); Reelfoot Lake and Conestoga drainage basin, Pennsylvania, USA (BEVEL 1938, CAIRNS 1965a); occasionally among algae in ponds along Pine Lake, Michigan, USA (KOFOLD 1896).

Several records from marine biotopes, for example, in the sub-littoral of the Bay of Biscay (FERNANDEZ-LEBORANS & NOVILLO 1993), in low-salinity lagoons (maximum salinity = 0.34 ‰) of Caspian Sea, Divichinskiy Estuary (USSR), and Baltic Sea (AGAMALIEV 1969, 1973, 1986; identifications questionable, see taxonomy; AGAMALIYEV 1974, AGAMALIYEV & ALIYEV 1983, PATTERSON et al. 1989, PETRAN 1977, SICH 1990).

Biomass of 10^6 individuals about 50 mg (NESTERENKO & KOVALCHUK 1991). MIHAILOWITSCH (1989) found *O. aeruginosa* ($n = 17$) in saline inland waters in Germany at $4.6\text{--}14.3\ ^\circ\text{C}$, pH 7.1–7.6, $39\text{--}156\ \text{mg l}^{-1}\ \text{CO}_2\ \text{free}$, $3.5\text{--}17.6\ \text{mg l}^{-1}\ \text{O}_2$, $0.15\text{--}7.3\ \text{mg l}^{-1}\ \text{NH}_4^+\text{-N}$, $0.02\text{--}0.2\ \text{mg l}^{-1}\ \text{NO}_2^-\text{-N}$, $1.1\text{--}13.4\ \text{mg l}^{-1}\ \text{NO}_3^-\text{-N}$, $108\text{--}12\ 763\ \text{mg l}^{-1}\ \text{Cl}^-$, 90 to $3590\ \text{mS m}^{-1}$ specific conductivity. JENNINGS & MOORE (1902b) and WAGNER (1908) observed spontaneous aggregations of *O. aeruginosa* on slides or even in small open dishes.

According to SLÁDEČEK et al. (1981), WEGL (1983), and FOISSNER (1988a), *Oxytricha aeruginosa* indicates strict betamesosaprobity ($s = b$; $b = 10$, $I = 5$, $SI = 2.0$). However, it is poorly known and thus it can not be excluded that *O. aeruginosa* was confused with other (common) reddish oxytrichids, like *Rubrioxytricha haematoplasma*. Thus, we excluded it from the list of water quality indicators (FOISSNER et al. 1991).

Supposed synonym: *Oxytricha sordida* WRZESNIEWSKI, 1861, Annls Sci. nat., Zoologie, 16: 332 (Fig. 31f). Remarks: WRZESNIEWSKI (1861) mentioned that the cytoplasm is sometimes russet, indicating that it is *Oxytricha aeruginosa*, which he described a few years later. The only significant difference is the position of the transverse cirri, namely at the tip of the cell in *O. sordida* (uncertain), and distinctly anteriorly displaced in *O. aeruginosa*. STEIN (1862) assumed that *O. sordida* is identical with *Tachysoma pellicionellum*. The name *O. sordida* was mentioned for the last time (?) by KENT (1882, p 788), who, obviously erroneously stated that *O. sordida*, *O. aeruginosa*, and *Urosoma macrostyla* had been described by WRZESNIEWSKI (1870) in his account on the Infusoria of Warsaw. WRZESNIEWSKI (1861) discovered *O. sordida* in a pond near Warsaw, Poland.

Oxytricha alfredi nom. nov. (Fig. 32)

1932 *Oxytricha minor* KAHL, Tierwelt Dtl., 25: 602.

Nomenclature and taxonomy: The correct name in the original description is *Oxytricha* (*Oxytricha*) *minor*, which is a junior secondary homonym of *O. minor* (MACKELL, 1887) KAHL, 1932 (see below). Thus, the species by KAHL (1932) needs a new name: *Oxytricha alfredi* nom. nov. This species is almost certainly not identical with *Cyrtohymena gracilis* (cortical granules present, rather long caudal cirri; Fig. 96f), as suggested by BORROR (1972a). *Oxytricha minor* sensu MOTE (1954; Fig. 184l) is probably *Sterkiella histriomuscorum*, and the CHORIK (1968; Fig. 231h) population is insufficiently redescribed. *Oxytricha minor* sensu LOKOT (1987) is a redrawing from KAHL's (1932) *O. euglenivora*. Poorly known species, thus detailed redescription necessary.

Morphology: In life about 80 μm long and 2.8 times as long as broad; according to DINGFELDER (1962; without illustration) 85–115 μm long. Elliptical. Contractile vacuole slightly in front of mid-body. Adoral zone of membranelles about 35 % of body length. Frontal cirri slightly enlarged. Transverse cirri protrude somewhat beyond posterior end of cell. KAHL (1932) drew 2 slightly elongated cirri at posterior end of cell; it is unknown if these are the posterior-most marginal cirri, or caudal cirri. Dorsal cilia 2–4 μm long.

Fig. 32 *Oxytricha alfredi* (from KAHL 1932). Ventral view from life, 80 μm .

Occurrence and ecology: Not very common, in polluted lotic and lentic water bodies. KAHL (1932) did not mention the type location. He found "*Oxytricha minor*" in the sapropel, probably somewhere in Germany. Records from freshwater habitats not substantiated by illustrations: Bulgarian running water (RUSSEV et al. 1976); side arm of Danube River, rivers, and water reservoir in Czechoslovakia (MATIS 1961, 1977, MATIS & TIRJAKOVÁ 1994a); Turiec River in Slovakia (TIRJAKOVÁ 1993); at pH 6.4–7.2 in rain puddles near Erlangen, Germany, during spring (DINGFELDER 1962); ≤ 40 ind. cm^{-2} in mesosaprobic running waters in Northern Italy (MADONI 1980, 1983, 1984, MADONI & GHETTI 1977); slightly and heavily polluted waters in Barcelona, Spain (MARGALEF LÓPEZ 1945); Latvian river (LIEPA 1973); pelagial of water reservoirs of Kiev and Kremenchug and cooling plant in Moldova (CHORIK & VIKOL 1973, NEBRAT 1975, 1980); Utah, USA (SHAWHAN et al. 1947); Conestoga drainage basin in Pennsylvania, USA (CAIRNS 1965a); south-eastern Louisiana, USA (BAMFORTH 1963). Records from terrestrial habitats also not substantiated by illustrations (BAMFORTH 1967, 1968, 1969, 1973, 1976, 1980a, 1984, BAMFORTH & BENNETT 1985, LOUSIER & BAMFORTH 1990, MARTIN & SHARP 1983).

Feeds on bacteria and algae. Biomass of 10^6 individuals about 17 mg. MATIS (1975) found *O. alfredi* in road pools and in a drainage canal near Bratislava, Slovakia, at 1–31 °C, pH 5.8–6.9, and 0.7–12.5 mg l^{-1} O_2 . PATRICK et al. (1967) recorded it once from the Savannah River, USA, at 5–<10 mg l^{-1} Cl^- , 5–10 mg l^{-1} CO_2 , >5–7 mg l^{-1} O_2 , 0.1–0.4 mg l^{-1} Fe^{2+} , 3–<10 mg l^{-1} Ca^{2+} , 0.03–0.05 mg l^{-1} $\text{NH}_3\text{-N}$, <0.007 mg l^{-1} $\text{NO}_2\text{-N}$, 0.07–0.2 mg l^{-1} $\text{NO}_3\text{-N}$, 0.05–0.1 mg l^{-1} PO_4^{3-} , 10–<30 mg l^{-1} SO_4^{2-} , 23–28 °C, 0.5 to 1.0 mg l^{-1} BOD_5 . REINNARTH (1979) found *O. alfredi* in the mud-water interface of a eutrophic pond in Germany at +1 to –2 cm depth, pH 7.1–7.3, –113 to +210 mV redox potential, 0.07–2.5 mg l^{-1} $\text{NH}_4^+\text{-N}$, and 1.5–5.0 mg l^{-1} $\text{NO}_3\text{-N}$. MATIS & STRAKOVÁ-STRIEŠKOVÁ (1991) found it in a brook and in two thermal lakes in Czechoslovakia at 17–42 °C and pH 5.0–7.5. MAUCH (1976) mentioned one reference where *O. alfredi* was found in sewage-polluted water.

Oxytricha balladyna SONG & WILBERT, 1989 (Fig. 33a–f, Table 15)

1932 *Balladyna similis* KAHL, Tierwelt Dtl., 25: 592 (Fig. 33f).

1972 *Holosticha similis* (KAHL, 1932) – BORROR, J. Protozool., 19: 11.

1989 *Oxytricha balladyna* (KAHL, 1932) – SONG & WILBERT, Lauterbornia, Heft 3: 166 (Fig. 33a–e).

1991 *Oxytricha balladyna* SONG & WILBERT, 1989 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 299.

Fig. 33a–f *Oxytricha balladyna* (a–e, from SONG & WILBERT 1989; f, from KAHL 1932. a, c, f, from life; b, d, → e, protargol impregnation). a, f) Ventral views, a = 40 μm , f = 60 μm . b) Ventral infraciliature, 44 μm . Arrow marks anterior postoral ventral cirrus. c) Lateral view. d, e) Dorsal infraciliature, d = 40 μm , e = 45 μm . According to SONG & WILBERT (1989), dorsal kineties 4 and 5 are only a single kinety which is interrupted in mid-body. BC = buccal cirrus, CC = caudal cirri, FVC = posterior frontoventral cirrus, Mi = micronucleus, RMR = right marginal row, 1–5 = dorsal kineties 1–5.

Nomenclature and taxonomy: BORROR (1972a) transferred it to *Holosticha* WRZEŚNIEWSKI, 1877. Since he classified *H. similis* STOKES, 1886, in *Keronopsis*, *Holosticha similis* (KAHL, 1932) was not a junior secondary homonym in his revision. STILLER (1974a, p 132) proposed, under the headline "*Balladinella* gen. n.", that *Balladyna fusiformis* KAHL, 1932 and *B. similis* had to be separated from the other *Balladyna* species because the transverse cirri are longitudinally arranged and the peristomial lip is anteriorly curved. According to CORLISS (1979), the second original spelling in STILLER (1974a, p 130), namely "*Balladynella* n. n.", is the correct one. However, since the establishment of the genus is not accompanied by the fixation of a type species, *Balladynella* (or *Balladinella*) is invalid (ICZN 1985, Article 13 b) and both names must be considered as nomina nuda. Since no redescription of *Balladyna fusiformis* is available I do not establish a new genus. To avoid a secondary homonymy with *Oxytricha similis* ENGELMANN, 1862, SONG & WILBERT (1989) introduced the replacement name "*balladyna*". Thus they themselves – and not KAHL (1932) – are the authors of the present species (if it is classified in *Oxytricha*). Possibly a synonym of *O. opisthomuscorum* (p 217, 925).

The outline, the long caudal cirri, and the size of the population of SONG & WILBERT (1989) agree well with the original description. In contrast, the number of frontoventral cirri and the arrangement of the transverse cirri differs significantly. Thus, I am not sure if these two populations are conspecific. However, it cannot be excluded that the deviations are due to the small size, which makes live observations very difficult. *Oxytricha balladyna* sensu SONG & WILBERT (1989) is easily confused with the very similar *O. setigera* (cp. Fig. 33a with Fig. 47a, 48a). Thus, an identification should always be confirmed by very careful live observations (1000 $\times$, differential interference contrast) or on protargol-impregnated material; they differ significantly in the position of the buccal cirrus and the number of dorsal kineties. Further investigation recommended.

Morphology and biology: About 60–80 μm long in life according to KAHL (1932); 40–60 $\times$ 20–25 μm according to SONG & WILBERT (1989). Long oval, posterior end rounded; according to SONG & WILBERT (1989) narrowly rounded or slightly tapered. The remaining description is based on the data by SONG & WILBERT (1989). For the KAHL (1932) population, see Figure 33f. Invariably ($n = 24$) only 1 micronucleus (not shown in Fig. 33f) between the 2 macronuclear nodules, reminiscent of *Balladyna fusiformis*. Contractile vacuole about in mid-body, during diastole with inconspicuous collecting canals. Cytoplasm bright and colourless, cortical granules absent. Rapid, somewhat jumping movement.

Adoral zone of membranelles about 36 % of body length. Undulating membranes short, intersecting, and only inconspicuously curved. Anterior portion of peristomial lip conspicuously curved according to original description (Fig. 33f). Invariably 18 ($n = 14$) frontal, ventral, and transverse cirri. All frontoventral cirri arranged right of adoral zone of membranelles, posterior one at about level of buccal vertex (Fig. 33b). Frontal and transverse cirri slightly enlarged. Transverse cirri arranged in an almost longitudinally orientated hook (however, see KAHL's illustration), protrude distinctly beyond posterior

end of cell. Marginal rows begin slightly behind level of buccal vertex, distinctly separate posteriorly. Dorsal cilia spreading, in life about 10 μm long. According to SONG & WILBERT (1989) invariably 4 ($n = 20$) dorsal kineties, the fourth being interrupted in mid-body. In my opinion, however, 5 kineties are present, the fourth being the posterior portion of kinety 3, and the fifth is very likely a dorsomarginal kinety (compare with *O. tenella*). Invariably 3 ($n = 14$) prominent, in life about 20 μm long caudal cirri at end of kineties 1, 2, and (probably) 4 (Fig. 33b, d, e).

Occurrence and ecology: Infrequent, probably confined to freshwater. KAHL (1932) did not mention the type location; he found it in the sapropel, probably somewhere (near Hamburg?) in Germany. SONG & WILBERT (1989) isolated *Oxytricha balladyna* from the Poppelsdorfer Weiher, a eutrophic pond near Bonn, Germany. Records not substantiated by illustrations: Czechoslovakia (MATIS & TIRJAKOVÁ 1994a, TIRJAKOVÁ 1992b, 1993); Latvian rivers (LIEPA 1973, 1978); sporadically in an alphamesosaprobic and a polysaprobic area of a mountain brook in Yugoslavia (PRIMC 1984); freshwater habitats in south-eastern Louisiana, USA (BAMFORTH 1963). Biomass of 10^6 individuals about 6 mg (population of SONG & WILBERT 1989).

Oxytricha chlorelligera KAHL, 1932 (Fig. 34a, b)

1932 *Oxytricha chlorelligera* KAHL, Tierwelt Dtl., 25: 601 (Fig. 34a).

1968 *Oxytricha chlorelligera* KAHL, 1932 – CHORIK, Free-living ciliates, p 133 (Fig. 34b).

1991 *Oxytricha chlorelligera* KAHL, 1932 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 277.

Nomenclature and taxonomy: The correct name in the original description is *Oxytricha* (*Oxytricha*) *chlorelligera* because KAHL (1932) divided *Oxytricha* into several subgenera. Incorrect subsequent spelling: *Oxytricha chlorigella* (HORVÁTH 1939a, p 545; HORVÁTH 1942, p 4). The HORVÁTH (1939b; Fig. 221i) population is insufficiently redescribed in that he did not mention the symbiotic algae, the most important character of this species. The illustration in DRAGESCO & DRAGESCO-KERNÉIS (1986, p 473, Planche 140H) is a redrawing from KAHL (1932). Detailed redescription necessary.

Fig. 34a, b *Oxytricha chlorelligera* (a, from KAHL 1932; b, from CHORIK 1968). Ventral views from life, a = 115 μm , b = 130 μm . The globules are symbiotic green algae.

Morphology and biology: In life about 115 μm long and 3–3.5 times as long as broad. Anterior end slightly bent to the left. Macronuclear nodules only slightly separate; micronuclei not observed, according to KAHL (1932) probably only one present. Contractile vacuole about in mid-body. Rapid movement. Adoral zone of membranelles 1/3 of body length. 18 frontal-ventral-transverse cirri. Frontal cirri distinctly enlarged. Five transverse cirri, only the right two protrude slightly beyond posterior end of cell. Probably 3 inconspicuous caudal cirri. Dorsal cilia 2–4 μm long.

Occurrence and ecology: Very probably confined to freshwater. KAHL (1932) did not mention the type location; he found *Oxytricha chlorelligera* among *Utricularia*, very likely somewhere (near Hamburg?) in Germany. CHORIK (1968) observed it in small water bodies in Moldova.

Records not substantiated by illustrations: pond in Czechoslovakia (HASSDENTEUFELOVÁ-MORAVCOVÁ 1955); bank of Danube River in Czechoslovakia (TIRJAKOVÁ 1992a); pond in botanical garden of Kiel University, and small, stagnant water bodies in the Kotton forest near Bonn, Germany (AX & AX 1960, BICK 1957, 1958); Lake Balaton, Kalános brook, and Danube River, Hungary (GELLÉRT & TAMÁS 1959b, MATIS & TIRJAKOVÁ 1995, VÖRÖSVÁRY 1950); water reservoirs in the Ukraine (KRAVCHENKO 1969); low-salinity lagoons of Caspian Sea (AGAMALIEV 1973, 1986, AGAMALIYEV & ALIYEV 1983); reservoirs and Araks River in Azerbaijan (ALEKPEROV 1988, 1990, ALIEV 1982a); Lake Dzhandar, Azerbaijan? (ALIEV 1988); cooling plant in Moldova (CHORIK & VIKOL 1973); oligotrophic lakes and rivers in Latvia (LIEPA 1973, 1990, LIYEPA 1984a, VEYLANDE & LIYEPA 1985); Russia (LOKOT 1987; with illustration, however, probably a redrawing); stagnant water bodies of the Tibetan Plateau (WANG 1977); China (NING et al. 1993, YANG 1989); pond, pools, and lentic areas along stream margins in the USA (LACKEY 1938a); ponds in Cameroon (DRAGESCO & DRAGESCO-KERNÉIS 1986, NJINE 1977, NJINE & DEVAUX 1977).

Feeds on bacteria, flagellates, and diatoms (VÖRÖSVÁRY 1950). Biomass of 10^6 individuals about 35 mg (FOISSNER et al. 1991). BICK (1957) found *O. chlorelligera* in a deciduous forest pond only during winter, when the pond was not shaded and therefore enough light was available for assimilation of the symbiotic algae; he provided the following autecological data: pH 6.4–7.0, 0.2–2 mg l^{-1} O_2 , 0–0.7 mg l^{-1} NO_3^- -N, 0–2.3 mg l^{-1} NH_4^+ -N, 0–1.1 mg l^{-1} H_2S . HEMPSTEAD & JAHN (1940) recorded it from small, shallow pools of Silver Lake Bog (Iowa, USA) at 14.2 mg l^{-1} H_2S ! PATRICK et al. (1967) found *Oxytricha chlorelligera* in the Savannah River, USA, at 20–23 °C, 1–3 mg l^{-1} Cl^- , 7 to 9 mg l^{-1} O_2 , 1–<5 mg l^{-1} BOB₅, 3–<10 mg l^{-1} Ca^{2+} , 0.07–0.2 mg l^{-1} NO_3^- -N, 0.001 to <0.007 mg l^{-1} NO_2^- -N, 0.017–0.033 mg l^{-1} PO_4^{3-} -P, 1–>10 mg l^{-1} SO_4^{2-} . Tolerates a maximum salinity of 0.2 % (AX & AX 1960).

According to SLÁDEČEK et al. (1981), WEGE (1983), FOISSNER (1988a), and FOISSNER et al. (1991), *Oxytricha chlorelligera* is confined to alphamesosaprobic areas: a; a = 10, I = 5, SI = 3.0. However, this has to be verified by further autecological and saprobiological data on reliably determined populations.

Table 15 Morphometric data of *Oxytricha auripunctata* (aur, from BLATTERER & FOISSNER 1988), *O. balladyna* (bal, from SONG & WILBERT 1989), *Oxytricha* sp., *O. enigmatica*, *O. faurei* (dsp, eni, fau, from DRAGESCO & DRAGESCO-KERNÉIS 1986), *O. geleii* (gel, from WILBERT 1986b), *O. granulifera* (gra, from FOISSNER & ADAM 1983b), *O. islandica* (isl, from BERGER & FOISSNER 1989a), *O. lanceolata* (la1, from BERGER & FOISSNER 1987a; la2, from BERGER & FOISSNER 1989; la3, from FOISSNER 1996b), *O. longa* (lg1, from GELEI & SZABADOS 1950, sublimate fixation; lg2, lg3, population 3, respectively 4 from GANNER et al. 1987b), *O. longigranulosa* (lo1, from BERGER & FOISSNER 1989a; lo2, from BLATTERER & FOISSNER 1988), *O. nauplia* (nau, from BERGER & FOISSNER 1987a), *O. ottowi* (ott, from FOISSNER 1996c), *O. pseudofusiformis* (psf, from DRAGESCO & DRAGESCO-KERNÉIS 1986), *O. pseudosimilis* (pss, from HEMBERGER 1985), *O. quadricirrata* (qua, from BLATTERER & FOISSNER 1988), *O. rubripuncta* (ru1, from BERGER & FOISSNER 1987a; ru2, from SHIN 1994), *O. saltans* (sal, from SONG et al. 1991), *O. setigera* (se1 = population from the Glockner area, se2 = population from the Tullnerfeld, both from FOISSNER 1982; se3, from GSCHWIND 1991), *O. siseris* (sis, from FOISSNER 1982), *O. tenella* (ten, from SONG & WILBERT 1989). All data are based on protargol-impregnated material unless otherwise indicated. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	aur	96.0	9.8	10.2	83	116	14
	bal	40.4	2.9	7.2	35	44	14
	dsp	95.0	-	-	84	105	6
	eni	109.0	-	-	75	128	11
	fau	143.0	-	-	92	172	16
	gel	51.1	5.7	11.1	42	63	12
	gra	80.6	8.9	11.1	70	103	25
	isl	93.8	12.1	13.0	72	115	10
	la1	87.9	7.3	8.3	75	100	12
	la2	94.5	12.2	12.9	70	108	10
	la3	93.5	7.1	7.6	87	110	11
	lg1	140.0	-	-	-	-	1
	lg2	58.9	7.1	12.0	47	75	25
	lg3	60.6	9.6	15.8	39	76	25
	lo1	87.6	8.5	9.6	72	98	13
	lo2	75.7	6.3	8.3	65	83	10
	nau	63.3	8.1	12.7	56	80	10
	ott	92.2	8.4	9.1	78	103	14
	psf	41.0	-	-	35	46	6
	pss	-	-	-	95	120	?
	qua	64.9	6.7	10.3	57	79	15
	ru1	140.1	11.8	8.5	112	160	15
	ru2	134.9	19.9	14.7	100	170	12
	sal	76.1	6.1	8.1	64	86	16
	se1	37.2	3.9	10.5	30	43	10
	se2	47.4	4.5	9.4	40	54	10
	se3	36.9	2.9	8.0	30	42	21
	sis	76.2	6.2	8.2	64	86	11
	ten	50.9	4.7	9.1	46	60	9
Body, width	aur	24.2	2.5	10.5	21	29	14
	bal	19.8	2.3	11.7	17	24	14
	dsp	33.0	-	-	23	36	6

Table 15 Continued

Character	Species	mean	SD	CV	Min	Max	n
Body, width	eni	41.0	-	-	32	56	11
	fau	42.5	-	-	34	52	14
	gel	23.1	2.8	12.2	17	26	12
	gra	33.6	4.6	13.8	28	43	25
	isl	30.7	3.6	11.8	25	35	10
	la1	30.8	3.5	11.4	27	39	12
	la2	34.2	3.4	10.0	29	42	10
	la3	34.9	4.8	13.8	28	46	11
	lg1	44.0	-	-	-	-	1
	lg2	19.4	5.0	25.9	13	30	25
	lg3	16.4	2.4	14.6	10	21	25
	lo1	31.9	3.1	9.8	27	38	13
	lo2	27.5	2.8	10.3	21	32	10
	nau	26.1	2.6	9.8	21	29	10
	ott	32.8	5.4	16.3	23	40	14
	psf	17.0	-	-	16	19	6
	pss	-	-	-	40	50	?
	qua	24.5	3.6	14.7	19	32	15
	ru1	45.1	4.6	10.1	34	52	15
	ru2	47.5	8.7	18.3	33	62	12
	sal	35.1	9.8	28.1	27	45	16
	se1	13.6	1.4	10.5	12	16	10
	se2	14.8	1.5	9.9	13	17	10
	se3	15.1	1.1	7.4	14	17	21
	sis	21.4	2.8	13.1	18	27	11
	ten	26.3	3.9	14.9	21	31	9
Adoral zone of membranelles, length	aur	26.7	1.8	6.6	22	29	14
	bal	14.6	0.9	6.3	13	17	8
	gel	16.8	1.4	8.1	15	19	12
	gra	26.5	1.9	7.2	24	32	25
	isl	29.1	2.7	9.2	22	31	10
	la1	27.5	1.1	3.9	25	29	12
	la2	30.1	3.5	11.6	24	34	10
	la3	29.4	1.4	4.6	27	32	11
	lo1	28.1	1.3	4.7	25	30	13
	lo2	26.7	2.2	8.1	23	30	10
	nau	21.1	1.5	6.9	18	22	10
	ott	31.3	3.6	11.4	24	35	14
	qua	24.3	1.3	5.5	22	27	15
	ru1	43.7	3.5	8.1	35	49	15
	ru2	40.9	3.1	7.6	33	44	12
	sal	18.4	2.1	11.2	14	21	16
	se1	11.8	0.6	5.1	11	13	10
	se2	13.0	1.0	7.7	11	14	10
	se3	12.3	1.1	8.8	11	14	20
	sis	26.4	2.1	8.1	24	31	11
	ten	18.8	1.6	8.4	16	21	8

Table 15 Continued

Character	Species	mean	SD	CV	Min	Max	n
Adoral membranelles, number	aur	24.4	1.2	4.9	23	27	13
	bal	16.2	0.6	3.8	15	19	7
	dsp	38.0	-	-	30	43	6
	eni	49.0	-	-	45	53	11
	fau	46.0	-	-	30	50	18
	gel	19.9	0.9	4.5	18	21	13
	gra	31.2	1.3	4.1	29	32	25
	isl	26.7	2.3	8.5	21	29	10
	la1	26.5	1.5	5.5	23	28	12
	la2	27.6	0.8	3.1	26	29	10
	la3	27.9	1.4	5.2	26	30	11
	lg1	-	-	-	21	22	?
	lg2	19.9	1.1	5.8	18	22	25
	lg3	16.7	0.9	5.5	15	18	24
	lo1	26.5	1.1	4.0	24	28	13
	lo2	22.0	1.3	6.1	20	24	10
	nau	24.5	1.7	6.7	22	27	10
	ott	25.5	2.7	10.4	21	29	14
	psf	15.0	-	-	12	18	6
	pss	21.0	-	-	-	-	?
	qua	19.7	0.6	3.0	19	21	15
	ru1	39.2	1.9	4.9	36	42	15
	ru2	28.1	1.4	4.9	26	30	12
	sal	15.1	1.7	11.2	13	18	14
	se1	14.7	1.3	9.1	13	18	10
	se2	14.9	0.8	5.6	14	16	10
	se3	15.2	0.5	3.4	14	16	18
	sis	25.2	2.5	9.8	22	30	11
	ten	26.0	1.8	7.0	23	28	7
Right marginal row, number of cirri	aur	18.4	1.7	9.2	15	21	14
	bal	6.3	0.9	14.9	6	8	12
	dsp	31.0	-	-	26	41	6
	eni	27.0	-	-	20	32	11
	fau	37.0	-	-	24	45	14
	gel	21.9	2.1	9.6	18	25	15
	gra	32.1	2.5	7.7	29	41	25
	isl	25.6	2.2	8.5	21	28	10
	la1	28.4	2.0	7.1	25	32	12
	la2	28.5	1.9	6.7	26	32	10
	la3	28.6	2.2	7.6	25	33	11
	lg1	-	-	-	20	22	?
	lg2	20.4	1.8	8.9	16	23	25
	lg3	16.4	1.8	10.7	14	20	25
	lo1	25.9	1.6	6.1	23	28	13
	lo2	19.1	1.5	8.0	17	22	10
	nau	21.5	1.8	8.6	19	24	10
	ott	24.6	1.8	7.4	22	27	14
	psf	9.0	-	-	7	11	6

Table 15 Continued

Character	Species	mean	SD	CV	Min	Max	n
Right marginal row, number of cirri	pss	15.0	-	-	14	17	?
	qua	15.1	1.0	6.9	14	17	15
	ru1	28.6	2.4	8.5	24	32	15
	ru2	22.8	1.6	7.1	20	26	10
	sal	5.6	0.8	14.6	5	7	16
	se1	4.3	0.6	14.9	3	5	10
	se2	4.6	0.8	17.4	3	6	10
	se3	7.7	0.4	5.8	7	8	27
	sis	11.5	1.2	10.0	10	14	11
	ten	25.6	1.5	5.9	23	27	7
Left marginal row, number of cirri	aur	17.7	2.1	12.0	15	22	14
	bal	8.3	0.8	9.9	7	9	12
	dsp	23.0	-	-	17	31	6
	eni	24.0	-	-	20	27	9
	fau	41.0	-	-	31	47	13
	gel	20.5	1.8	8.8	18	24	15
	gra ¹	34.0	2.6	7.6	30	43	25
	isl	26.2	2.9	11.2	22	32	10
	la1	31.4	2.6	8.4	27	35	12
	la2	31.7	3.6	11.3	25	36	10
	la3	30.0	2.6	8.8	25	34	11
	lg1	-	-	-	19	21	?
	lg2	19.7	1.8	9.1	17	23	25
	lg3	15.8	1.7	10.6	13	20	25
	lo1	22.9	1.4	6.2	21	25	13
	lo2	19.1	1.7	8.7	17	22	10
	nau	20.8	1.7	8.1	18	23	10
	ott	22.5	2.2	10.0	19	26	14
	psf	8.0	-	-	7	9	6
	pss	15.0	-	-	14	15	?
	qua	15.9	1.6	9.8	13	18	15
	ru1	29.4	1.7	5.7	26	32	15
	ru2	22.9	1.8	7.8	20	26	10
	sal	9.2	0.7	7.1	8	10	16
	se1	6.5	0.7	10.3	6	8	10
	se2	6.4	0.5	7.6	6	7	10
	se3	7.5	0.6	7.8	6	8	25
	sis	14.2	1.2	8.4	12	17	11
	ten	22.3	1.9	8.5	19	25	7
Transverse cirri, number (pretransverse ventral cirri included)	lg1	6.0	-	-	-	-	1
	lg2	6.0	0.4	6.8	5	7	25
	lg3	5.7	0.6	11.0	4	6	25

¹ Caudal cirri included.

Oxytricha crassistilata KAHL, 1932 (Fig. 35)

1932 *Opisthotricha crassistilata* KAHL, Tierwelt Dtl., 25: 609.

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; thus, the correct name in the original description is *Oxytricha (Opisthotricha) crassistilata*. Incorrect subsequent spellings: *Oxytricha crasistillata* (KAHL) BORR. (TIRJAKOVÁ & MATIS 1987a, b, p 9, 22); *Oxytricha crasistylata* KAHL (MATIS 1975, p 586); *Opisthotricha crassistylata* (STILLER 1974b, p 145, 146). BORROR (1972a) synonymised *Oxytricha crassistilata*, *O. opisthomuscorum*, and *O. euglenivora*, because they all have a single micronucleus, long dorsal cilia and caudal cirri, and enlarged transverse cirri. I consider them three valid species because there are reliable differences in the habitat, the body shape, and the shape of the transverse cirri; however, detailed redescriptions are needed. *Oxytricha crassistilata* sensu ALEKPEROV (1993) from Russian soil has two micronuclei, which does not match the original description (Fig. 241a, b). *Oxytricha crassistilata* resembles *Tachysoma pellionellum*, which, however, lacks caudal cirri.

Morphology: In life 90–150 µm long, about 3.5 times as long as broad. Irregularly elliptical; left margin convex, right one straight or convex in well feed specimens. Contractile vacuole slightly above mid-body. Well feed specimens with dark granules. Adoral zone of membranelles about 35 % of body length, membranelles prominent. Buccal area conspicuously small, anterior portion obviously covered by a conspicuous cytoplasmic lip. All 18 frontal, ventral, and transverse cirri prominent; especially transverse cirri strongly enlarged, protrude distinctly beyond posterior end of cell. Marginal cirri “long”. Dorsal cilia 8–10 µm long. Three conspicuously elongated, soft caudal cirri.

Occurrence and ecology: Probably confined to freshwater. KAHL (1932) did not mention the type location; he found *O. crassistilata* among decaying blades of grass and *Glyceria*, probably somewhere (near Hamburg?) in Germany. Records not substantiated by illustrations: at 5–28 °C, pH 5.8–6.3, and 6.2–12.4 mg l⁻¹ O₂ in road pools near Bratislava and in submerged and wet mosses in Slovensky raj, Czechoslovakia (MATIS 1975, TIRJAKOVÁ & MATIS 1987a); rare in Maritza River, Bulgaria (DETCEVA 1981); Ukraine (KOVALCHUK 1997); China (NING et al. 1993).

Feeds on flagellates. Biomass of 10⁶ individuals about 36 mg. DETCEVA (1983c) found *O. crassistilata* with low frequency (0.3 %) in an alphamesosaprobic section of the Maritza River, Bulgaria, under

Fig. 35 *Oxytricha crassistilata* (from KAHL 1932). Ventral view from life, 120 µm. Note the single micronucleus between the macronuclear nodules, the prominent transverse cirri, and the elongated caudal cirri and dorsal cilia.

following conditions: pH 7.4, 4.6 mg l⁻¹ O₂, 53 % O₂ saturation, 51 mg l⁻¹ Ca²⁺, 52 mg l⁻¹ Mg²⁺, 224 mg l⁻¹ HCO₃⁻, 34 mg l⁻¹ SO₄²⁻, 14 mg l⁻¹ Cl⁻, 19.2 °dH, 0.6 mg l⁻¹ NH₄⁺-N, 0.05 mg l⁻¹ NO₂⁻-N.

Oxytricha elongata (SMITH, 1897) KAHL, 1932 (Fig. 36)

1897 *Opisthotricha elongata* SMITH, Trans. Am. microsc. Soc., 19: 65 (Fig. 36).

1932 *Opisthotricha elongata* SMITH, 1897 – KAHL, Tierwelt Dtl., 25: 609.

Fig. 36 *Oxytricha elongata* (after SMITH 1897a). Ventral view from life, 250–320 µm. Arrangement of cirri obviously incorrectly observed; however, because of large size considered as valid species.

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha* (*Opisthotricha*) *elongata*. In the rather similar *Oxytricha longissima* all marginal cirri are of about the same length, whereas they are distinctly elongated posteriorly in *O. elongata*. BORROR (1972a) synonymised *O. elongata* with *O. similis*, which is, however, distinctly smaller (80–100 µm) and has only 2 caudal cirri. Doubtful species; detailed redescription necessary.

Morphology: In life 250–320 µm long (incorrect measurement?), about 3 times as long as broad. Body margins slightly converging posteriorly, both ends broadly rounded. Contractile vacuole about in mid-body. Rapid movement. Adoral zone of membranelles about 1/3 of body length. Arrangement of frontal and ventral cirri insufficiently observed, probably typically oxytrichid. Five transverse cirri, do not protrude beyond posterior end of cell. Marginal cirri very much longer posteriorly than anteriorly; number very likely distinctly underestimated in Figure 36 because 11 right marginal cirri seem very few for an about 300 µm long species. Three caudal cirri of about same length as posterior marginal cirri. Dorsal cilia likely short.

Occurrence: Locus classicus is a pond in Louisiana, USA (SMITH 1897a). KAHL (1932) found similar, but somewhat smaller (about 200 µm) specimens in the sapropel (in Germany?). Not found since.

Oxytricha euglenivora KAHL, 1932 (Fig. 37a, b)

1932 *Opisthotricha euglenivora* KAHL, Tierwelt Dtl., 25: 609 (Fig. 37a).

1968 *Oxytricha* (*Opisthotricha*) *euglenivora* KAHL, 1932 – CHORIK, Free-living ciliates, p 135 (Fig. 37b).

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha*

(*Opisthotricha*) *euglenivora*. BORROR (1972a) synonymised it with *O. crassistilata* (Fig. 35) and *O. opisthomuscorum* (Fig. 73a, b). However, I follow KAHL (1932) and consider them to be three valid species, although the differences are admittedly not very prominent (see key). Detailed redescription necessary.

M o r p h o l o g y: In life about 80–90 μm long and 2–2.5 times as long as broad. Well-fed specimens spindle-shaped or ovoid. Slightly contractile. Contractile vacuole distinctly in front of mid-body. Adoral zone of membranelles about 1/3 of body length. All 18 frontal-ventral-transverse cirri and marginal cirri distinctly enlarged. Transverse cirri rather steeply arranged, protrude distinctly beyond posterior end of cell. Three conspicuously elongated caudal cirri. Dorsal cilia about 10 μm , posteriorly even up to 15 μm long.

Fig. 37a, b *Oxytricha euglenivora* (a, from KAHL 1932; b, from CHORIK 1968). Ventral views from life, a = 80 μm , b = 90 μm . Note single micronucleus; p 136.

O c c u r r e n c e a n d e c o l o g y: According to KAHL (1932) common and sometimes abundant on old leaves with algae (“oligosapropel”); with reference to the low number of records, however, obviously very rare. KAHL (1932) did not mention the type location, but he probably found *Oxytricha euglenivora* somewhere (near Hamburg?) in Germany. CHORIK (1968) observed it in small water bodies in Moldova. LOKOT (1987; erroneously designated as *O. minor* KAHL) found it in freshwater bodies of the Lake Baikal area, Russia. Records not substantiated by illustrations: fishponds in Tomky, Czechoslovakia (MATIS 1973); small, meso- to eutrophic lake in Germany (MÜCKE 1979); in plankton of Goloseevo pond in Kiev, Ukraine (KOVALCHUK & SVINTSOVA 1994); Pantanal flood plain, Brazil (HARDON & HECKMAN 1996, HECKMAN 1998). Feeds on algae, especially on euglenoid flagellates (species name!). Biomass of 10^6 individuals about 30 mg.

Oxytricha fallax STEIN, 1859 (Fig. 38a–j, m–r, Table 17)

- 1859 *Oxytricha fallax* STEIN, Organismus der Infusionsthiere I, p 189 (Fig. 38d–g).
- 1882 *Oxytricha fallax*. STEIN – KOWALEWSKIEGO, Pam. fizyogr., 2: 413 (Fig. 38c).
- 1882 *Oxytricha fallax*, STEIN – KENT, Manual infusoria II, p 787.
- 1930 *Oxytricha fallax* STEIN – WANG, Contr. biol. Lab. Sci. Soc. China, 6: 13 (Fig. 38b).
- 1932 *Oxytricha fallax* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 602.

Fig. 38a–c *Oxytricha fallax* (a, from CURDS 1969; b, from WANG 1930; c, after KOWALEWSKIEGO 1882). Ventral views from life, a = 155 μm , b = 140 μm , c = size not indicated; p 137.

- 1937 *Oxytricha fallax* STEIN – SOKOLOFF & ANCONA, An. Inst. Biol. Univ. Mx., 8: 174 (Fig. 38o).
 1961 *Oxytricha fallax* STEIN, 1859 – REUTER, Acta zool. fenn., 99: 19 (Fig. 38h).
 1962 *Oxytricha fallax* STEIN – LIEBMANN, Handbuch der Frischwasser- und Abwasserbiologie I, p 359 (Fig. 38i).
 1968 *Oxytricha fallax* STEIN, 1859 – CHORIK, Free-living ciliates, p 133 (Fig. 38m).
 1969 *Oxytricha fallax* STEIN, 1859 – CURDS, Wat. Pollut. Res., No. 12: 67 (Fig. 38a).
 1972 *Oxytricha fallax* STEIN – BICK, Ciliated protozoa, p 180 (Fig. 38j).
 1982 *Oxytricha fallax* STEIN, 1859 – HEMBERGER, Dissertation, p 142 (Fig. 38n).
 1991 *Oxytricha fallax* STEIN, 1859 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes fr Wasserwirtschaft, 1/91: 279.
 1993 *Oxytricha hymenostoma* STOKES, 1887 – SHIN & KIM, Korean J. Zool., 36: 223 (Fig. 38p–r).
 1994 *Oxytricha hymenostoma* STOKES, 1887 – SHIN, Dissertation, p 137 (Fig. 38p–r; mixed up the figures of *Rubrioxytricha haematoplasma* and *O. hymenostoma*).

Nomenclature and taxonomy: The correct name in KAHL (1932) is *Oxytricha* (*Oxytricha*) *fallax* because he divided *Oxytricha* into subgenera. Incorrect subsequent spellings: *Oxitricha fallax* (BATTISH 1992, p 57; Bauer 1983, p 38); *Oxytricha fallax* STEIN (CAIRNS & RUTHVEN 1972, p 420; STOUT 1984, p 123); *O. falax* (BAKOWSKA & JERKA-DZIADOSZ 1978, p 297).

BORROR (1972a) synonymised several species with *O. fallax*, for example *O. hymenostoma* (70–110 μm long) and *O. bimembranata* (probably confined to edaphic habitats). This is not justified because only an about 150–200 μm large freshwater *Oxytricha* with an oval outline may be identified with *O. fallax*. Thus, the populations of FOISSNER (1979a), GRIMES (1972 and his later works), and REYNOLDS (1932) are probably not conspecific with *O. fallax*. The same is true for *O. fallax* sensu HASHIMOTO (1961, 1962,

Fig. 38d–j *Oxytricha fallax* (d–g, after STEIN 1859b; h, after REUTER 1961; i, from LIEBMANN 1962; j, after BICK 1972a. d–i, from life; j, from life?). **d)** Ventral view of a specimen with typical body shape, 148–173 μm . **e)** Ventral view of a slightly contracted specimen. **f)** Ventral view of a specimen creeping between detritus. **g)** Cyst, size not indicated. **h–j)** Ventral views, h = size not indicated, i = 155 μm , j = 150 μm ; p 137.

Fig. 38k Insufficient redescription of *Oxytricha fallax* (after QUENNERSTEDT 1865). Ventral view from life, size not indicated; p 137.

Fig. 38l *Oxytricha hymenostoma* (after REYNOLDS 1932). Ventral view, haematoxylin staining, 75–100 μm ; p 150.

Fig. 38m-o *Oxytricha fallax* (m, from CHORIK 1968; n, from HEMBERGER 1982; o, from SOKOLOFF & ANCONA 1937. m, o, from life; n, protargol impregnation). m, o) Ventral views, m = 160 μ m, o = size not indicated. n) Ventral infraciliature, 195 μ m; p 137.

1963, 1964), who identified his population according to the descriptions by BISHOP (1943; classified as indeterminable), HORVÁTH (1933; no illustration), and LUND (1935; synonymised with *O. hymenostoma*); I classify the FOISSNER, GRIMES, REYNOLDS, and HASHIMOTO populations as *O. hymenostoma*. I found a specimen matching the original description in every respect in a betamesosaprobic brook near the town of Salzburg. Thanks to its large size I was able to undertake several counts and measurements and the results agreed very well with the data by HEMBERGER (1982). *Oxytricha fallax* sensu SCHMALL (1976; p 38) is very likely a misidentified *Histriculus histrio* because “the marginal rows are closed and caudal cirri are lacking” (Fig. 177q).

The *Oxytricha hymenostoma* STOKES of SHIN & KIM (1993b; see also SHIN 1994) is distinctly larger (120–190 $\times$ 50–85 μ m) than the type population described by STOKES (1887b; about 100 μ m). Thus, the Korean population is preliminary classified as *O. fallax* and briefly described.

The populations by BARKER (1949; Fig. 232i), BATTISH (1992; his Fig. 54), BISHOP (1943; Fig. 221f), CELA (1972; Fig. 232n), CHARDEZ (1967; Fig. 223p), CONN (1905; Fig. 221c), FORMISANO (1957; Fig. 234b), GREGORY (1923; Fig. 240n), HEBERER (1928; Fig. 229h), KOFFMAN (1926; Fig. 231d), LUNDIN & WEST (1963; Fig. 220k), QUENNERSTEDT (1865; Fig. 38k), SMITH (1978; Fig. 221e; see also BLOCK 1984), and WEST & LUNDIN

(1963; Fig. 220k) are insufficiently redescribed. An identification as *O. fallax* should be based mainly on the original description (Fig. 38d–f) until an authoritative redescription is available.

Morphology and biology: In life 130–180 μm long and about 2.5 times as long as broad; according to HEMBERGER (1982) up to $200 \times 110 \mu\text{m}$. Long oval, posterior end broadly, anterior often narrowly rounded (Fig. 38d). Rather contractile and very flexible (Fig. 38f). Macronuclear nodules about $30\text{--}35 \times 15\text{--}20 \mu\text{m}$, fine granulated. Usually 2 micronuclei, difficult to discern in life. The amiconucleate race reported by WOODRUFF (1921) is probably an *Oxytricha hymenostoma*. Contractile vacuole slightly in front of mid-body. Cortical granules lacking. Cytoplasm colourless; sometimes packed with about 25 μm sized food vacuoles causing dark appearance at low magnification. Swims 2.3 body-lengths per rotation (BULLINGTON 1925, JENNINGS 1899b, LUDWIG 1929). WOODRUFF (1907) reported on great variation of some characters (size, shape, number of micronuclei...) during life cycle.

Adoral zone of membranelles about 40–45 % of body length, about 50 membranelles. Basis of membranelles about 12–14 μm broad. 18 frontal-ventral-transverse cirri arranged as shown in Figure 38d–f. Frontal and transverse cirri and buccal cirrus enlarged. Frontal cirri in life about 25 μm long; transverse cirri in life about 40 μm , according to HEMBERGER only 25 μm long, protrude slightly (left) to distinctly (right) beyond posterior end of cell (Fig. 38d, e). About 25 left and 28–30 right marginal cirri. Dorsal cilia about 2–3 μm , according to HEMBERGER (1982) 4–5 μm long. Caudal cirri inconspicuous in life because only slightly longer (25 μm) than marginal cirri (20 μm).

Population of SHIN & KIM (1993b) and SHIN (1994; described as *O. hymenostoma*; Fig. 38p–r): In life $120\text{--}190 \times 50\text{--}85 \mu\text{m}$; soft and flexible; subelliptical or oval; both ends rounded; left anterior margin concave; 2 macronuclear nodules, after protargol impregnation $18\text{--}20 \times 10\text{--}11 \mu\text{m}$; usually 2, rarely 3, micronuclei, in life(?) about 4 μm across; contractile vacuole near mid-body; no cortical granules; adoral zone of membranelles about 41 % ($36\text{--}56 \mu\text{m}$) of body length, 26–31 (mean = 28) membranelles; buccal cavity deep; undulating membranes 22–38 μm long; almost invariably 18 frontal-ventral-transverse cirri (sometimes only 4 postoral and pretransverse ventral cirri); arrangement of postoral ventral cirri somewhat unusual (Fig. 38r); 14–20 (mean = 17.6) left and 20–23 (mean = 20) right marginal cirri; 6 (rarely 5) dorsal kineties, kinety 3 (in median) with about 15 basal body pairs; cilia 5 μm long; invariably 3 caudal cirri.

Cyst with smooth wall (Fig. 38g; STEIN 1859b). BRAND (1923) also figured a cyst, however, the identification is not substantiated by an illustration of an excysted specimen. REES (1878) described infections of the macronucleus by parasitic algae. SCHNEIDER (1930) observed the formation of a cell envelope (= Hülle) after the addition of iodine-ink (not substantiated by an illustration).

Morphogenesis commences with the proliferation of an oral primordium at the left transverse cirrus (HEMBERGER 1982). TCHANG & HUANG (1983) provided a rather schematic illustration of a middle morphogenetic stage showing 6 frontal-ventral-transverse

Fig. 38p-r *Oxytricha fallax* (from SHIN 1994. p, from life; q, r, protargol impregnation). p) Ventral view, 116 μm . q, r) Dorsal and ventral infraciliature, 120 μm ; p 137.

cirri streaks with 1, 3, 3, 3, 4, and 4 cirri respectively (see also DILLER 1965a). TCHANG & PANG (1979a, b), WOODRUFF (1913), and ZHANG et al. (1983) studied the nucleocytoplasmic relationship and the phenomenon of macronuclear regulation in dorsiconjugants. A specimens regenerates within 5–6 min after being deeply cut in the middle region (ISHIKAWA 1912).

Although little is known about the morphology, a considerable number of biochemical, genetic, and other investigations exist. However, I doubt that the identification was correct in all cases. For instance, the experiments by SCHLEGEL (1985) and SCHLEGEL & STEINBRÜCK (1986) revealed that their *O. fallax* differs significantly from the type species, *O. granulifera*, whereas it agrees rather well with some other, probably *Stylonychia* species. In spite of this uncertainty, some of these works are cited: ADL & BERGER (1995, 1996), CARTINHO (1984), CARTINHO & HERRICK (1984), DAWSON (1984), DAWSON & HERRICK (1982, 1984a, b), DAWSON et al. (1984), DILLER (1962, 1965a), DOAK et al. (1994, 1997), GATES (1986), GRESLIN et al. (1988), HERRICK et al. (1985, 1987a, b), HUNTER et al. (1989), JAHN (1966), KAINE (1982), KAINE & SPEAR (1980, 1982, see also KRAUT et al. 1986), KRAMER (1988), MAUPAS (1889), MURTI (1976), PLUTA & SPEAR (1981), PLUTA et al. (1982, 1984), PREER & PREER (1979), RAE & SPEAR (1978), RAIKOV (1989), SEEGLER et al. (1996, 1997), SPEAR (1980), STEINBRÜCK (1990), SWAGER et al. (1990), SWANTON et al. (1982), TCHANG et al. (1981), VERNI & ROSATI (1980), WADA &

SPEAR (1980), WILLIAMS & HERRICK (1991), WILLIAMS et al. (1993), WITHERSPOON et al. (1997).

Occurrence and ecology: According to the faunistic data rather common in freshwater; however, see taxonomy for uncertainty in species identification. Obviously prefers eutrophic stagnant and slightly to heavily organically polluted running waters, where *O. fallax* lives mainly in the aufwuchs, detritus, and in layers of filiform bacteria. According to own experience much more seldom than, for example, *Tachysoma pelionellum* or species of the *Stylonychia mytilus* complex.

Locus classicus is a brook in the "Procopthal" near Prague, Czechoslovakia, where STEIN (1859b) discovered *Oxytricha fallax* together with *Gonostomum affine* between decaying leaves of trees. Records substantiated by illustrations: trout-rearing basins in Germany (HEMBERGER 1982); Poland (KOWALEWSKIEGO 1882); small water bodies in Moldova (CHORIK 1968); in great numbers in Lake Ho Hu in Nanking, China, during February (WANG 1930); mesosaprobic water bodies in Mexico (SOKOLOFF & ANCONA 1937). SHIN & KIM (1993b) and SHIN (1994) found *O. fallax* in the Han River in Seoul, Korea, in early June and late August.

Records from freshwater habitats not substantiated by illustrations: *Sphaerotilus* community in a river near Vienna, Austria (STRUHAL 1969; further records from Austria see FOISSNER & FOISSNER 1988 and PETZ et al. 1988); fish farm in Belgium (CHARDEZ 1989); various, often polysaprobic water bodies in Belgium (BERVOETS 1940); rivers and limnocrone in Bulgaria (DETCHIEVA 1979b, 1981, 1991, 1993, DETSCHEWA 1972, RUSEV et al. 1988, RUSSEV et al. 1984); brook heavily polluted by brewery sewage in Czechoslovakia (VAŠIČEK 1964); littoral of a side arm of Danube River and periodical pools with pH 5.8–6.0 in Czechoslovakia (MATIS 1961, 1975; further records from Czechoslovakia: ŠRÁMEK-HUŠEK 1953, MATIS & TIRJAKOVÁ 1994a); cooling system of a conventional power station supplied with water from the beta- to alphamesosaprobic Rhine River in Germany (BERNERTH 1982); plankton of Rhine River, Germany (CZERNIN-CHUDENITZ 1958); polysaprobic area in the Weiße Elster River, Germany, downstream of a sewage treatment plant (BEER 1958); upper layer of mud in Isebekkanal, Hamburg, Germany (CASPERS & SCHULZ 1962); floating, foul-smelling *Oscillatoria* mats in a side arm of Mosel River, Germany (LAUTERBORN 1901); betamesosaprobic area of Elbe River and polluted Hamburg Harbour, Germany (GRIMM 1968, HECKMAN et al. 1990); alphamesosaprobic Oker River in Braunschweig, Germany (REICHENBACH-KLINKE 1959); throughout the year with high abundance (30 ind. ml⁻¹) in road pools with putrefying plants in Bavaria (DINGFELDER 1962); highly polluted Salzach River at the village of Laufen, Bavaria (BAUER 1983); meso- to eutrophic lakes and pools near Münster, Germany (MÜCKE 1979); scattered in a polluted lake near Berlin, Germany, in February (MARSSON 1901); Westphalian caves and mines in the Erzgebirge, Germany (GRIEPENBURG 1934, 1935, WETZEL 1929); well of a garden on Heligoland, Germany (LAUTERBORN 1894); oligo- to betamesosaprobic area and pelagial of a branch of Danube River in Hungary (BERECZKY 1969, 1991, NOSEK & BERECZKY 1981); polluted Zagyva River, Hungary (HAMAR 1971);

6–8 ind. ml⁻¹ sediment and in detritus-drifts in Lake Balaton, Hungary (GELLÉRT 1961, GELLÉRT & TAMÁS 1958, 1959b); eutrophic soda lake (STILLER 1942) and together with *Dexiostoma campylum*, *Trithigmostoma cucullulus*, and *Paramecium caudatum* in a ditch near Szeged, Hungary (HORVÁTH & KUHN 1941); stalactite cave in north-east Hungary (BAJOMI 1969; further records from Hungary: BEREZKY 1977b, HORVÁTH 1933, KREPUSKA 1917, 1930); 48 ind. cm⁻² in a slightly polluted area of Parme River, Northern Italy (MADONI 1980, 1983, 1984, MADONI & GHETTI 1977); littoral area of Lake Como, Italy (CATTANEO 1888; further records from Italy: CANELLA 1954, GRISPINI 1938); the Netherlands (VERSCHAFFELT 1930); with 33 % frequency in the *Sphaerotilus natans* community of Łyna River, Poland (HUL 1986); heavily polluted river in Poland (GRABACKA 1988); abundant in putrefying water in Warsaw, Poland (WRZESNIEWSKIEGO 1866); polluted Lobregat River and other freshwater habitats near Barcelona, Spain (GRACIA & IGUAL 1987a, GRACIA et al. 1987a, 1989, MARGALEF LÓPEZ 1945); Danube River, Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); Lake Geneva, Switzerland (ANDRÉ 1912, 1916, MERMOD 1914); ponds near Basle, Switzerland (RIGGENBACH 1922); Save River, Yugoslavia (PRIMC 1981); reservoirs in the USSR (ALEKPEROV 1984b, c, BELOVA 1988, KRAVCHENKO 1969); Lake Baikal (GAJEVSKAJA 1927, GAJEVSKAJA 1933, ROSSOLIMO 1923; further records from the USSR: AGAMALIEV 1973, CHORIK & VIKOL 1973, DADAY 1903, 1904, LIEPA 1973, 1983, ZHARIKOV & ROTAR 1992); sediment of Changjiang River, China (GU et al. 1988; further records from China: NING et al. 1993, SHEN 1981, SHEN & GONG 1989, YANG 1989); Tibetan Plateau (WANG 1977); pond in Japan (YOSHINO 1993, uncertain); Costa Rica (RUIZ 1961); Conestoga drainage basin, Pennsylvania, USA (CAIRNS 1965a); Douglas Lake and Black River, Michigan, USA, at pH 6.5–7.0 and 20–24 °C (CAIRNS & YONGUE 1966); New Jersey, USA (DILLER 1965a); among algae in Creel Bay, North Dakota, USA (EDMONDSON 1920); tree holes in Ohio, USA (LACKEY 1940); on polyurethane foam in a shallow, eutrophic pond with hard and well-buffered water in Spokane County, Washington, USA (PRATT et al. 1986); common in decaying *Ceratophyllum* from bottom of Put-in Bay Harbour, Lake Erie, USA (JENNINGS 1899a); pond and river in Virginia, USA (HENEERY & CAIRNS 1980, YONGUE & CAIRNS 1979; further records from North America: BOVEE 1960, McCASHLAND 1956, McCORMICK & CAIRNS 1990, McCORMICK et al. 1991, WANG 1928, YONGUE & CAIRNS 1971); tributary of Amazon River, Colombia (BOVEE 1957); moss infusion from Venezuela (SCORZA & NUÑEZ MONTIEL 1954); freshwater habitats in Tahiti (EDMONDSON 1910); Algeria (DADAY 1910); Coast Lake in Victoria Land, Antarctica (THOMPSON 1972).

REUTER (1961, 1963a) found *O. fallax* in rock pools with up to 20.5 % NaCl(!); however, he did not mention at which specific salinity it occurred. ZINN (1954) observed it in a *Typha*-pond in Massachusetts at a salinity of about 1 %. BUTSCHINSKY (1897) and ZACHARIAS (1888) found *O. fallax* in saline lakes in the USSR and in Germany. KUMSARE et al. (1974), LACKEY (1936, 1938a), LACKEY & LACKEY (1970), and MERESCHKOWSKY (1877) recorded it from marine habitats. DIAZ PÉREZ & MONTOTO LIMA (1989) found *O. fallax* in the polluted Almendares River estuary (average salinity 1–1.5 ‰) at the north coast of Havana City, Cuba. However, most of these records are not substantiated by il-

lustrations. Thus, the tolerance to high salinity has to be verified on reliably determined populations.

Oxytricha fallax occurred also in activated sludge, trickling filters, and rotating biological contactors (BAHR 1954, BANINA 1983, 1990, BARKER 1943, CURDS 1969, 1975, KLIMOWICZ 1970, 1972, KUTIKOWA 1984, LIEBMANN 1962, LUNA-PABELLO et al. 1996, MA-MAEVA 1983, SCHERB 1968b, STAMM 1979, 1984, WACHS 1968, 1984), and according to LACKEY (1938a) also in Imhoff tanks. LACKEY (1938a) counted up to 500 ind. ml⁻¹ in trickling filters, LIEBMANN (1936) up to 400 ind. ml⁻¹ in putrid waste water. KLIMOWICZ (1973) found up to 284 ind. ml⁻¹ at a sludge loading of about 0.06 kg BOD₅ kg⁻¹ dry mass d⁻¹. *Oxytricha fallax* usually occurred during the maturation (second to fifth week) of the sludge (CURDS 1965a, 1966b, HAMM 1964). KRISHNAMOORTHY & SARKAR (1981) found it in Indian secondary stabilisation ponds with a BOD (BOD₅?) range of 50–80 mg l⁻¹, and LUGO et al. (1991) found high numbers in a stabilisation pond in Mexico. SMITH (1982) recorded *O. fallax* from guano of penguins on the sub-Antarctic island of South Georgia; the identification is, however, not substantiated by morphological data.

Records from terrestrial habitats are certainly misidentifications (BHATTACHARYA et al. 1977, BUITKAMP 1977a, 1979, CAIRNS & RUTHVEN 1972, KOFFMAN 1934, SMITH 1972, 1973a, b, 1974a, 1975, 1985, STELLA 1948, STOUT 1961, 1963, 1968, 1970, 1978, 1984, TAKAHASHI & SUHAMA 1991, VARGA 1936); however, the rather similar (synonymous?) *O. bimembranata* was discovered in soil. SMITH (1981) recorded *O. fallax* from turf peat mosses (pH 4.9, water content about 56 % dry weight) from the Crozet Islands.

Feeds on bacteria (*Bacillus subtilis*, *Pseudomonas fluorescens*), diatoms, filamentous growths, flagellates (*Chilomonas*, *Peranema trichophorum*), ciliates (*Uronema nigricans*, *Dexiostoma campylum*), and detritus (CURTIS & CURDS 1971, FAURÉ-FREMIET 1961a, FOISSNER & SCHIFFMANN 1974, JOHNSON 1933, 1937, TAMÁS & GELLÉRT 1958). Large food vacuoles can contain more than 40 specimens of *Uronema nigricans*. *Oxytricha fallax* may be grown on 0.1 % lettuce medium (GIESE 1959).

WOODRUFF (1905a, b; see also WOODRUFF & BAITSELL 1911) maintained a culture of *O. fallax* for over 860 generations and a shortest generation time of about 7 h was observed. According to BAITSELL (1914), the division rate is usually below 2 divisions per day (Russian readers, see also ZAIKE 1970). Biomass of 10⁶ individuals about 155 mg (FOISSNER et al. 1991; calculated from average size), according to REUTER (1963b) 91 mg.

Some autecological data are summarised in Table 17. Further data: 13–24 mg l⁻¹ COD (MADONI & GHETTI 1981a); betamesosaprobity and alphamesosaprobity, 38 to 72 mg l⁻¹ Ca²⁺, 7.3–26 mg l⁻¹ Mg²⁺, 116–348 mg l⁻¹ HCO₃⁻, 16–104 mg l⁻¹ SO₄³⁻, 10 to 38 mg l⁻¹ Cl⁻, 0–0.08 mg l⁻¹ Fe²⁺ (DETCHÉVA 1983c); 7.0–46.5 °C, pH 5.0–7.3 (MATIS & STRAKOVÁ-STRIEŠKOVÁ 1991). PATRICK et al. (1967) found *Oxytricha fallax* twice in clean areas of the Savannah River, USA, at >6–8 mg l⁻¹ O₂, 0.5–1 mg l⁻¹ BOD₅, 0.005 to 0.04 mg l⁻¹ NH₃-N, 0.01–0.03 mg l⁻¹ PO₄³⁻-P. PRIMC (1983) observed *O. fallax* only at temperatures of 10–15 °C. This agrees with the results by BIERLE (1970) who found optimal growth at 14 °C; however, he observed a thermoresistance of up to 35.7 °C. ISSEL (1901, 1906, see also BRUES 1928, p 160) recorded it from Italian thermal waters at

32–45 °C (identification doubtful because specimens only 69–86 µm long); MATIS (1971) found 27 °C as broadest range between maximum and minimum temperature of occurrence.

Hydrogen-sulphide intolerant (WETZEL 1928b). Lethal doses ($LD_{50\ 48h}$) of lead acetate and lead nitrate was 200 mg l⁻¹ and 200–250 mg l⁻¹, respectively; 300 mg l⁻¹ and 500 mg l⁻¹ killed *O. fallax* instantly, and 20–100 mg l⁻¹ lead acetate and 40–80 mg l⁻¹ lead nitrate, respectively, slowed down the growth pattern (KHAN & NASREEN 1981, NASREEN & KHAN 1979). Lead accumulation was evident as deposition of black granules in the body (FERNANDEZ-LEBBORANS et al. 1985). 50 mg l⁻¹ of three anionic detergents killed most of the specimens in 24 h, and 400 mg l⁻¹ in 1 h, respectively (MORENO-BARON & LOPEZ-OCHOTERENA 1976). LAIRD (1958) found *O. fallax* in infusions with 2 µg ml⁻¹ DDT. 0.25 µg ml⁻¹ desiccated venom (pH of solution 7.3, medium = 0.025 % beef extract) of the *Crotalus atrox* rattlesnake had an immediate effect on locomotion; after 24 h animals were alive, but feeble; all were dead after 48 h (PHILPOTT 1930). STATKEWITSCH (1904) studied the effect of electrical current on *O. fallax*.

Oxytricha fallax inhabits polluted waters (MARSSON 1903) and is classified as alpha-mesosaprobic indicator of water quality: a; b = 1, a = 8, p = 1, I = 4, SI = 3.0 (FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). The chemical data, however, indicate that the betamesosaprobic valence should be slightly increased (Table 17). According to LIEBMANN (1962), *Oxytricha fallax* avoids water that is contaminated with liquid manure. The autecological data and the saprobic classification should be checked on reliably determined populations.

Oxytricha faurei TUCOLESCO, 1962 (Fig. 39a–j, Table 15)

1962 *Oxytricha faurei* TUCOLESCO, Annls Spéleol., 17: 105 (Fig. 39g–j).

1986 *Oxytricha faurei* (TUCOLESCO, 1962)? – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 465 (Fig. 39a–f).

Nomenclature and taxonomy: TUCOLESCO (1962a) established this species as “*O. faurei*” under the headlines “Genre *Oxytricha*” and “Sous-genre *Opisthotricha*”; the correct name in the original description is thus *Oxytricha (Opisthotricha) faurei* and the author’s name is not be put in parentheses as suggested by DRAGESCO & DRAGESCO-KERNÉIS (1986). These authors neither mentioned nor drew cortical granules. In addition, their population differs from the original description in some other characters (ratio of body length to body width, shape and relative length of buccal area, shape of posterior end of left marginal row). Thus, the conspecificity of these two populations is doubtful. Conversely, the descriptions agree well in that several elongated, fine caudal “cirri” are present. Detailed redescription needed; possibly this worm-like species belongs to another taxon.

Fig. 39a-f *Oxytricha faurei* (from DRAGESCO & DRAGESCO-KERNÉIS 1986. a-f, protargol impregnation). **a)** Ventral infraciliature, 170 µm. This African population differs in some respects from the type population (Fig. 39g-j) so that the conspecificity is uncertain. **b, c)** Ventral infraciliature of anterior and posterior part of cell. **d)** Ventral infraciliature of posterior portion of a specimen with 6 transverse cirri. **e, f)** Arrangement of fine caudal "cirri" in dorsal view. Bar divisions = 10 µm; p 146.

Morphology and biology: In life about 160–180 µm long and 8.5 times as long as broad, protargol-impregnated specimens of DRAGESCO & DRAGESCO-KERNÉIS (1986) only about 3.4 times as long as broad. Margins parallel, posterior end more or less rounded, anterior distinctly indented at right margin (Fig. 39g). Cross-section round (Fig. 39i). Macronuclear nodules after protargol impregnation 13–25 µm long (mean = 17 µm; n = 24). 2–3 small spherical micronuclei. Contractile vacuole slightly in front mid-body.

Fig. 39g-j *Oxytricha faurei* (after TUCOLESCO 1962. g-j, from life). g) Ventral view, 160–180 μm . The cortical granules are drawn only in the anterior portion (arrow). h) Posterior end of cell in ventral view. i) Cross-section. j) Arrangement of cortical granules in lateral view (left) and as seen from above (right); p 146.

Cortical granules rod-shaped, rather regularly arranged in longitudinal rows. Granules probably colourless because TUCOLESCO (1962a) did not mention any colour (Fig. 39g, h, j); granulation not mentioned by DRAGESCO & DRAGESCO-KERNÉIS (1986).

Adoral zone of membranelles only about 18 % of body length in type population (Fig. 39g), about 33 % in African population (Fig. 39a). Buccal area very small. Five transverse cirri, protrude only slightly, if at all, beyond posterior end of cell. Marginal rows widely separate in type population (Fig. 39g, h); left marginal row distinctly overlapping on right margin in African population (Fig. 39a, c). Dorsal cilia shortish than long. 5–6 fine, distinctly elongated caudal cirri (Fig. 39g, h).

Occurrence and ecology: Very rare species. Locus classicus is a water body in the Jalomcioara Cave, Romania. TUCOLESCO (1962a) also found *O. faurei* in a small brook outside the cave. DRAGESCO & DRAGESCO-KERNÉIS (1986) collected it in freshwater habitats near Cotonou, Benin. Feeds on diatoms (DRAGESCO & DRAGESCO-KERNÉIS 1986). Biomass of 10^6 individuals of type population about 50 mg.

Oxytricha granulosa SCHMITZ, 1986 (Fig. 40a–d)

1986 *Oxytricha granulosa* SCHMITZ, Dissertation, p 91 (type slides are deposited in the Institut für landwirtschaftliche Zoologie und Bienenkunde at the University of Bonn, Germany).

Nomenclature and taxonomy: This species is described in a thesis, which is generally not considered a valid publication (ICZN 1985, Article 9). Conversely, *O. granulosa* is included in the Zoological Record. Investigation of other populations recommended.

Morphology and biology: In life (?) 155–280 $\times$ 45–60 μm (mean = 195 $\times$ 50 μm). Long elliptical, anterior end broadly rounded, posterior portion tapering. Smooth and flexible, slightly contractile. Two ellipsoidal, 18–25 μm sized macronuclear nodules

Fig. 40a–d *Oxytricha granulosa* (from SCHMITZ 1986. a, b, from life; c, d, protargol impregnation). a) Ventral view, 160 μm . b) Ventral view (?) showing rows of cortical granules. c, d) Dorsal and ventral infraciliature, 160 μm . Explanation of original labels: AMZ = adoral zone of membranelles, Cc = caudal cirri, cV = contractile vacuole, DK = dorsal kineties, Ek = inclusion, endM = endoral, Frc = right frontal cirrus, GR = cortical granules, Ma = macronuclear nodule, Marg L = left marginal cirral row, Marg R = right marginal cirral row, Mi = micronucleus, parM = paroral, Trvc = transverse cirri; p 148.

left of median; only one small (2–3 μm) globular micronucleus between macronuclear nodules. Contractile vacuole, according to description, in front of mid-body, according to Figure 40a, however, slightly behind mid-body, during diastole with short collecting canals. Pellicle colourless. Cortical granules yellow-green, spherical, about 0.7 μm across, arranged in 14–18 longitudinal rows per side (Fig. 40b). Cytoplasm colourless, with many compact food vacuoles containing algae and yellowish, irregularly shaped inclusions rendering cells brownish at low magnification. Rapid movement.

Adoral zone of membranelles $1/4$ – $1/3$ of body length, consists of 44–50 adoral membranelles; distal end distinctly overlapping on right margin. Paroral and endoral in *Oxytricha* pattern, composed of basal body pairs each (Fig. 40a, d). Three slightly enlarged frontal cirri, 1 buccal cirrus, 4 frontoventral cirri, 3–4 postoral ventral cirri (2 adjoin buccal vertex, 1 or 2 slightly to distinctly separated posteriorly), 1–2 pretransverse ventral cirri, 5–6 about 18 μm long transverse cirri, which do not protrude beyond posterior end of cell; number of frontal-ventral-transverse cirri obviously slightly variably (Fig. 40d). 31–48 (mean = 40) left and 33–48 (mean = 41) right marginal cirri, in life about 15 μm long, each composed of 2×6 basal bodies; marginal rows not distinctly separated posteriorly. Dorsal cilia 6–8 μm long, arranged in 4–5 dorsal kineties of body length (Fig. 40c), rightmost kinety often terminating near mid-body (dorsomarginal row!). 2–4 inconspicuous, about 15 μm long caudal cirri, composed of 2×2 basal bodies.

Occurrence and ecology: Rare. Locus classicus is the Rhine River (Oberer Niederrhein) in Germany, where SCHMITZ (1986) discovered *O. granulosa* in the aufwuchs at less than 10 °C during spring and autumn. Feeds on green algae and diatoms.

Oxytricha hymenostoma STOKES, 1887 (Fig. 38l, 41a–g, 42a–i, Table 3)

- 1887 *Oxytricha hymenostoma* STOKES, Ann. Mag. nat. Hist., 20: 111 (Fig. 41a).
 1888 *Oxytricha hymenostoma*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 290 (Fig. 41a).
 1891 *Oxytricha ludibunda* STOKES, Jl R. microsc. Soc., year 1891: 702 (Fig. 41e).
 1932 *Oxytricha hymenostoma* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 603.
 1932 *Oxytricha ludibunda* STOKES, 1891 – KAHL, Tierwelt Dtl., 25: 603.
 1932 *Oxytricha fallax* – REYNOLDS, J. exp. Zool., 62: 330 (Fig. 38l; misidentification).
 1935 *Oxytricha* – LUND, J. Morph., 58: 258, 275 (Fig. 42g).
 1950 *Oxytricha elliptica* GELEI & SZABADOS, Annls biol. Univ. szeged., 1: 265, 285 (Fig. 41f, g).
 1966 *Oxytricha minor* DRAGESCO, Arch. Protistenk., 109: 197 (Fig. 42i).
 1970 *Oxytricha elliptica* GELEI & SZABADOS, 1950 – DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun (Numéro hors-série): 122 (Fig. 42h).
 1970 *Oxytricha lundii* DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun (Numéro hors-série): 123 (for the *Oxytricha* of LUND 1935).
 1970 *Oxytricha minima* DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun (Numéro hors-série): 123 (see nomenclature).
 1972 *Opistotricha macrostoma* DRAGESCO, Annls Fac. Sci. féd. Cameroun, 9: 119 (Fig. 41b–d; incorrect subsequent spelling of *Opisthotricha*).
 1972 *Oxytricha fallax* STEIN – GRIMES, J. Protozool., 19: 428 (Fig. 42d; misidentification).
 1974 *Oxytricha dragescoi* STILLER, Annls hist.-nat. Mus. natn. hung., 66: 133 (see nomenclature).
 1979 *Oxytricha fallax* STEIN (1859) – FOISSNER, Int. Rev. ges. Hydrobiol. Hydrogr., 64: 131 (Fig. 42a–c; misidentification).
 1981 *Oxytricha fallax* – HAMMERSMITH & GRIMES, J. Embryol. exp. Morph., 63: 19 (Fig. 42e, f; misidentification).
 1986 *Oxytricha hymenostomata* STOKES, 1887 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 461 (Fig. 41b; incorrect subsequent spelling).
 1988 *Oxytricha ludibunda* STOKES, 1891 – FOISSNER, Hydrobiologia, 166: 22.

Fig. 41a–c *Oxytricha hymenostoma* (a, after STOKES 1887b; b, after DRAGESCO 1972a from DRAGESCO & DRAGESCO-KERNÉIS 1986; c, from DRAGESCO 1972a. a, from life; b, c, protargol impregnation). a) Ventral view, 100 μ m. The body shape, the undulating membranes, the length of the adoral zone of membranelles, the posteriorly displaced posterior postoral ventral cirrus are reminiscent of *Stylonychia* spp. or *Sterkiella histriomuscorum*. However, according to STOKES the body is soft and flexible, strongly indicating that *O. hymenostoma* is an Oxytrichinae. b, c) Ventral and dorsal infracapitulum, b = 70 μ m, c = 75 μ m; p 150.

1991 *Oxytricha hymenostoma* STOKES, 1887 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsber. Bayer. Landesamtes für Wasserwirtschaft, 1/91: 289.

Nomenclature and taxonomy: *Oxytricha minor* DRAGESCO, 1966a, is a junior secondary homonym of *O. minor* (MASKELL, 1887b) KAHL, 1932 and a primary homonym of *O. minor* KAHL, 1932 (now *O. alfredi*). This was already recognised by DRAGESCO (1970), who introduced the replacement name *O. minima* for his species. STILLER (1974a) was obviously unaware this because she proposed another substitute name, namely *O. dragescoi*. Incorrect subsequent spellings: *Oxytricha hymatostoma* STOKES (SHIN & KIM 1993b, p 224); *Oxytricha hymenostomata* (CAIRNS 1965a, p 12; FOISSNER 1988a, p 22; GROLIÈRE 1975, p 491; HORVÁTH 1950, p 159; LEPSI 1965, p 975); *Oxytricha lundibunda* (THOMPSON 1972, p 287).

I agree with HEMBERGER (1982) that the two species of STOKES should be synonymised because the original descriptions do not show significant differences. BORROR

Fig. 41d–g *Oxytricha hymenostoma* (d, from DRAGESCO 1972a; e, after STOKES 1891; f, g, from GELEI and SZABADOS 1950. d, protargol impregnation; e, from life; f, g, opalblue staining after BRESSLAU). d, f, g) Ventral and dorsal infraciliature, d = 70 μ m, f, g = 100 μ m. e) Ventral view, 105 μ m; p 150.

(1972a) assumed identity with *O. fallax*, which is, however, distinctly larger and has an oval outline. *Oxytricha elliptica*, *O. lundi*, and *Opisthotricha macrostoma* were already synonymised with the present species by DRAGESCO & DRAGESCO-KERNÉIS (1986). The populations by REYNOLDS (1932), GRIMES (1972), FOISSNER (1979a), and HAMMERSMITH & GRIMES (1981) are too small to be reliably identified with *O. fallax*. In addition, they do not show the characteristic oval body shape. Conversely, *O. hymenostoma* sensu SHIN & KIM (1993b; Fig. 39p–r) is classified as *O. fallax* because of its large size (120–190 $\times$ 50–85 μ m). HASHIMOTO (1961, 1962, 1963, 1964) identified his “*O. fallax*” according to the descriptions by BISHOP (1943; classified as unidentifiable taxon), HORVÁTH (1933; no figure), and LUND (1935; classified as *O. hymenostoma*), indicating that he did not work with a true *O. fallax*. Thus, I preliminarily classify his population as *O. hymenostoma*.

The preceding paragraph shows how complicated the taxonomy of *O. hymenostoma* is and, unfortunately, I am not able to provide a satisfactory solution. The original description and several redescriptions listed above are reminiscent of *Sterkiella histriomuscorum* (for example, Fig. 41f, 42a, d, e) or of a small *Stylonychia* (Fig. 41a, b, d, e, 42g–i) in many characters: shape, arrangement of postoral ventral cirri, pattern of undulating membranes, length of adoral zone of membranelles. However, according to STOKES

Fig. 42a–c *Oxytricha hymenostoma* (from FOISSNER 1979a. a–c, composite after live observation and protargol- and Chatton-Lwoff silver-impregnated specimens). a) Ventral infraciliature, 110 μm . b) Lateral view, 125 μm . c) Dorsal infraciliature, 120 μm . The silverline system is shown only in the left posterior portion; p 150.

(1887b), the body is soft and flexible; synonymisation is hence not justified. None of the redescrptions considers both the live aspect and the infraciliature with a detailed morphometric characterisation, thus none can be deemed authoritative. Detailed redescription necessary.

The population by ESPOSITO et al. (1978) is only schematically illustrated, so that the identification cannot be verified (Fig. 221j). The populations by CONN (1905; Fig. 221d), CURDS (1969; Fig. 221g), and NAIDU (1965; Fig. 224m) are insufficiently redescrbed.

Morphology and biology: Classification in *Oxytricha* uncertain, see taxonomy. In life 70–110 μm long, 2.5 times as long as broad. Elliptical to nearly parallel-sided. Both ends rounded. Usually 2 micronuclei, however, amiconucleate races are reported (DAWSON 1919, 1920). Contractile vacuole about in mid-body, pulsates about every 14–15 s (GELEI 1935). Rapid movement.

Fig. 42d-f *Oxytricha hymenostoma* (d, from GRIMES 1972b; e, f, after HAMMERSMITH & GRIMES 1981. d, protargol impregnation; e, f, redrawn from scanning electron micrographs). d) Ventral infraciliature, about 80 μ m. Arrow marks posterior postoral ventral cirrus. e, f) Ventral and dorsal infraciliature, e = 55 μ m, f = 60 μ m. Possibly *Sterkiella histriomuscorum*; p 150.

Adoral zone of membranelles about 40–45 % of body length (that is, Stylonychinae-like!), 22–35 membranelles. Frontal and transverse cirri distinctly enlarged. Buccal cirrus somewhat behind anterior end of undulating membranes. Third postoral ventral cirrus distinctly displaced posteriad (Fig. 42d, arrow). According to STOKES (1887b, 1891), transverse cirri protrude slightly beyond posterior end of cell; according to the redescrptions all transverse cirri protrude. Caudal cirri inconspicuous, arranged at ends of kineties 1, 2, and 4 (Fig. 41c, g, 42c, f).

Resting cysts in live about 18–20 μ m across. Wall smooth, about 2–3 μ m thick (GRIMES 1973d). Ultrastructure and morphogenesis of *O. hymenostoma* are described by HASHIMOTO (1961), GRIMES (1972), and GRIMES & ADLER (1976). The formation of the oral primordium commences very close to the left transverse cirrus, and dorsal infraciliature originates according to the *Oxytricha* pattern. Conjugation was studied by HAMMERSMITH (1976a).

Further literature, mainly concerning experiments on regeneration, doublet formation, biochemistry, and genetics: BANCHETTI et al. (1978b, 1980a, b, 1982a), CETERA et al.

Fig. 42g-i *Oxytricha hymenostoma* (g, after LUND 1935; h, from DRAGESCO 1970; i, from DRAGESCO 1966a. g, Haidenhain's hematoxylin stain; h, i, protargol impregnation). Ventral infraciliature, g = 75 μ m, h = 65 μ m, i = about 80 μ m; p 150.

Fig. 42j *Keronopsis longicirrata* (from GELEI & SZABADOS 1950. Bresslau stain). Ventral infraciliature, 100 μ m (nuclear apparatus not known). A supposed synonym of *Oxytricha longicirrata*, p 163.

(1978), ESPOSITO et al. (1976a, 1978), GRIMES (1973a–c, e, 1974, 1976, 1982a), GRIMES & GAVIN (1987), GRIMES & HAMMERSMITH (1980), HAMMERSMITH (1976b, 1978), NOBILI et al. (1981), REYNOLDS (1932; see also FAURÉ-FREMIET 1967), RICCI et al. (1978, 1980a).

Occurrence and ecology: In the aufwuchs and detritus of freshwater habitats. Locus classicus is a hay-infusion from the USA; STOKES (1887b) did not state the specific locality where he discovered *Oxytricha hymenostoma*, however, he lived and worked in Trenton, New Jersey, USA, and I assume that the type locality is near there. Locus classicus of the synonym *O. ludibunda* is a pond with decaying *Sphagnum* in the USA (STOKES 1891). Locus classicus of the synonym *O. minor* is a hay-infusion(?) from Thonon, France (DRAGESCO 1966a) and the locus classicus of the synonym *O. elliptica* is a rain pool in Szeged, Hungary (GELEI & SZABADOS 1950). Locus classicus of the synonym "*Opistotricha macrostoma*" is a plant infusion in Uganda (DRAGESCO 1972a). Further records substantiated by illustrations: eutrophic alpine ponds in Austria (FOISSNER 1979a); freshwater canals near Pisa, Italy (ESPOSITO et al. 1978); river near Antelias, Lebanon (LUND 1935); Japan (HASHIMOTO 1961); freshwater aquarium in the Osborn Zoological Laboratory in New Haven, USA (REYNOLDS 1932); Jordan River, a small stream located on the campus of Indiana University of Bloomington, USA (GRIMES 1972b, HAMMERSMITH & GRIMES 1981); Cameroon (DRAGESCO 1970).

Records from freshwater habitats not substantiated by illustrations: slime of polluted waters in England (CURTIS & CURDS 1971); Italy (GRISPINI 1938); Turiec River in Slovakia (TIRJAKOVÁ 1993); water reservoirs in the USSR (KRAVCHENKO 1969); China (NING et al. 1993, SHEN & GONG 1989); Tibetan Plateau (WANG 1977); debris from a pond near New Haven, Connecticut, USA (DAWSON 1919); infrequent in soft waters and frequent in hard waters of south-eastern Louisiana, USA (BAMFORTH 1963); at about 24 °C in the Tahquamenon River, Douglas Lake Region, Michigan, USA (CAIRNS & YONGUE 1966); various water bodies in Conestoga Basin, Pennsylvania, USA (CAIRNS 1965a); river with medium-hard water in Eastern United States (PATRICK 1961); Peru (SARMIENTO & GUERRA 1960); mosses from Venezuela (SCORZA & NUÑEZ MONTIEL 1954); Coast Lake, Victoria Land, Antarctica (THOMPSON 1972).

HORVÁTH (1950) found *O. hymenostoma* in the sandy soil of the flood plain of the Tisza River at Szeged, Hungary. The records from Indian soil (BHATTACHARYA et al. 1977), Mississippi deltaic soils, USA (BAMFORTH 1969), and soil from paddy fields in Japan (TAKAHASHI & SUHAMA 1991) are not substantiated by illustrations.

According to literature common in biological sewage-treatment plants, such as activated sludge, percolating filters, and rotating biological contactors (BANINA 1983, CURDS 1975, KLIMOWICZ 1973, KUTIKOWA 1984, MADONI & GHETTI 1981b, MADONI et al. 1979, REID 1969). CURDS (1966b) observed *O. hymenostoma* mainly during maturation of activated sludge. KLIMOWICZ (1972) counted 2735 ind. ml⁻¹ in a Polish aeration tank under following conditions: mean sludge loading = 0.04 kg BOD₅ kg⁻¹ dry mass d⁻¹, mean concentration of activated sludge = 3.75 g l⁻¹, time of sewage aeration = 24 h, destruction of organic matter = 90 % BOD₅, mean oxygen content in aeration tank = 3.4 mg l⁻¹, 5 to

16 °C, mean pH of affluent sewage = 6.9; abundances were higher at low sludge loading than at high loading (KLIMOWICZ 1970).

Feeds on bacteria, autotrophic flagellates (*Chlamydomonas* sp.), algae, diatoms, filamentous growths, flagellates, ciliates (CURTIS & CURDS 1971, FOISSNER 1979a); also cannibalistic (DAWSON 1919). Average generation time over a four month period (presumably at room temperature) about 11 h, shortest generation time 5 h (DAWSON 1919). HASHIMOTO (1961) estimated 6.8 h at 25–27 °C in a wheat infusion and with *Chilomonas paramecium* as food. GRIMES (1972b) maintained the organisms in phosphate-buffered baked lettuce medium inoculated with *Enterobacter aerogenes*. Biomass of 10⁶ medium-sized individuals about 30 mg (FOISSNER et al. 1991).

PATRICK et al. (1967) found *Oxytricha hymenostoma* in the Savannah River, USA, under following conditions: >4–20 °C, 7–<11 mg l⁻¹ O₂, 0.5–1.0 mg l⁻¹ BOD₅, 0.009 to 0.08 mg l⁻¹ NH₃-N, <0.007 mg l⁻¹ NO₂-N, >0.05–0.2 mg l⁻¹ NO₃-N, >0.01–0.05 mg l⁻¹ PO₄³⁻-P. FOISSNER et al. (1982) provided following autecological data for populations from small, lentic, dystrophic alpine water bodies from Austria (56 analyses): 0.2 × 10⁶ to 20 × 10⁶ bacteria ml⁻¹ (direct counting), 0.2–23 °C, pH 4.7–6.2, 3.0–12.9 mg l⁻¹ O₂ (37–191 % saturation), 9–100 mg l⁻¹ KMnO₄-consumption, 0.0–6.2 mg l⁻¹ NH₄⁺-N, 0–3 mg l⁻¹ NO₂-N, 0–0.5 mg l⁻¹ NO₃-N, 0–0.57 mg l⁻¹ PO₄³⁻-P, 0–1.2 mg l⁻¹ Fe³⁺, up to 0.8 mg l⁻¹ H₂S.

Oxytricha hymenostoma is classified as polysaprobic indicator of water quality: p; a = 2, p = 8, I = 4, SI = 3.8 (SLÁDEČEK et al. 1981, WEGE 1983, FOISSNER et al. 1991). This distribution agrees with the fact that it occurs in sewage treatment plants mainly during the maturation phase. However, I have some doubt that all other sample sites mentioned above were alphamesosaprobic or polysaprobic. Thus, the saprobic classification has to be confirmed on reliably determined populations.

Oxytricha kahlovata nom. nov. (Fig. 43a–c)

1932 *Opisthotricha ovata* KAHL, Tierwelt Dtl., 25: 609 (Fig. 43a).

1971 *Opisthotricha ovata* KAHL – CHARDEZ, Revue verviét. Hist. nat., 28: 38 (Fig. 43c; incorrect subsequent spelling).

1974 *Oxytricha ovata* (KAHL) – PÄTSCH, Arb. Inst. landw. Zool. Bienenk., 1: 61 (Fig. 43b).

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha* (*Opisthotricha*) *ovata*. However, this is a junior primary homonym of *Oxytricha ovata* DUMAS, 1929. BORROR (1972a) synonymised *O. kahlovata* with *Cyrtohymena sapropelica*, which also has distinctly anteriorly displaced transverse cirri and a single micronucleus (Fig. 96h). However, they differ in body-shape and shape of undulating membranes. The arrangement of the frontal and ventral cirri is doubtful in *Oxytricha ovata* sensu PÄTSCH (1974), so that the following description is based mainly on KAHL's data. The re-description by BIERNACKA (1967; Fig. 226e) is insufficient.

Fig. 43a–c *Oxytricha kahlovata* (a, from KAHL 1932; b, from PÄTSCH 1974; c, from CHARDEZ 1971. a, c, from life; b, protargol impregnation). a, c) Ventral views, a = 110 μm , c = 105 μm . b) Ventral infraciliature, 70 μm ; p 157.

M o r p h o l o g y: In live about 100 to 120 μm long. Anterior end narrow, posterior very broadly rounded, that is, outline oval. KAHL (1932) did not observe a micronucleus, but he supposed one, which is confirmed by the redescription by PÄTSCH (1974; Fig. 43b). Contractile vacuole distinctly in front of mid-body. Cytoplasm often darkly granulated. Adoral zone of membranelles about 1/3 of body length. Frontal cirri distinctly, transverse cirri probably not enlarged. Dorsal cilia in life about 6 μm long. Three elongated caudal cirri.

Occurrence and ecology: KAHL (1932) discovered *O. kahlovata* among decaying blades of grass in a freshwater habitat, probably somewhere in Germany. Possible polysaprobic. Further records: freshwater in Belgium (CHARDEZ 1971); scattered in some brooks near Bonn, Germany (PÄTSCH 1974); Latvian rivers (LIEPA 1978). AGAMALIEV (1975) recorded it from the western coast of the Caspian Sea (see also AGAMALIYEV 1976b). ROSA (1962; Tafel III, 16) found *O. kahlovata* in Czech forests. Feeds on bacteria and flagellates. Biomass of 10^6 individuals about 70 mg. DETCHEVA (1979c)

found it once in the Strouma River, Bulgaria, at 20 °C, pH 7.7, 10 mg l⁻¹ O₂ (97 % saturation), 2.4 mg l⁻¹ BOD₅, 51 mg l⁻¹ Ca²⁺, 16 mg l⁻¹ Mg²⁺, 98 mg l⁻¹ SO₄²⁻, 11 mg l⁻¹ Cl⁻, 0.08 mg l⁻¹ NH₄⁺-N, 1.3 mg l⁻¹ NO₃⁻-N, 0.11 mg l⁻¹ NO₂⁻-N, 0.11 mg l⁻¹ Fe²⁺.

***Oxytricha longa* GELEI & SZABADOS, 1950 (Fig. 44a–q, 45a, b, Tables 3, 4, 15)**

- 1933 *Oxytricha pelionella* O. F. MÜLLER – HORVÁTH, Arch. Protistenk., 80: 295 (Fig. 45a, b; misidentification; incorrect subsequent spelling of *pellionella*).
- 1950 *Oxytricha longa* GELEI & SZABADOS, Annls biol. Univ. szeged., 1: 266, 286 (Fig. 44a).
- 1984 *Oxytricha longa* GELEI & SZABADOS – NIESSEN, Diplomarbeit, p 71 (Fig. 44o–q).
- 1987 *Urosomoida agiliformis* FOISSNER, 1982 – GANNER, FOISSNER & ADAM, Annls Sci. nat., 8: 199, in part: populations P3 and P4; not populations P1 and P2 (Fig. 44b–n; authoritative redescription).

Fig. 44a–d *Oxytricha longa* (a, from GELEI & SZABADOS 1950; b–d, population 3 from GANNER et al. 1987b. a, sublimate fixation; b, from life; c, d, protargol impregnation). a, b) Ventral views, a = 140 µm, b = 60 µm. Arrows in (b) mark 2 caudal cirri. d) Ventral and dorsal infraciliature, 60 µm. *Oxytricha longa* should not be confused with *Urosomoida agilisformis*, which has only 1–4 transverse cirri inclusively pretransverse ventral cirri. 1–4 = dorsal kineties 1–4; p 158.

T a x o n o m y: I am rather certain that the populations P3 and P4 by GANNER et al. (1987a, b) are conspecific with the population described by GELEI & SZABADOS (1950), especially since they have the same number of dorsal kineties. I don't know why GANNER et al. (1987b, Table II) assumed that *Oxytricha longa* has 5 kineties, although in the original description (p 286) it says: "so dass wir in den meisten Präparaten nur 4 Borstenreihen (= dorsal kineties) antreffen". The most important character for separation from *U. agilisformis* is the sum of the transverse cirri and pretransverse ventral cirri (see key and Table 15). Furthermore, morphogenesis of *Oxytricha longa* proceeds as in *Oxytricha granulifera*, that is, primordia V and VI of the proter do not originate de novo as in *Urosomoida* spp., but from cirrus IV/3 and V/4 respectively (Table 4).

Oxytricha longa is also rather similar to *O. similis*, especially concerning the 2 caudal cirri which point towards the right side. However, according to the authoritative redescription by KAHL (1932), *O. similis* has 5 transverse cirri (Fig. 57a–d). SONG & WILBERT (1989, p 162) provided no figure but included a morphometric characterisation of *Oxytri-*

Fig. 44e-h *Oxytricha longa* (population 3 from GANNER et al. 1987b. e-h, protargol impregnation). e) Ventral infraciliature of anterior half of cell, 30 μm . f-h) Ventral infraciliature of early morphogenetic stages, f = 60 μm , g, h = 55 μm . Arrow in (f) denotes first proliferation of basal bodies for oral primordium of opisthe; p 158.

cha longa. Their population usually has 3 (mean = 2.86; $n = 7$) caudal cirri, like the NIESSEN (1984, Fig. 44q) population, indicating that further species exist.

Morphology and biology: In life 60–100 $\times$ 25–40 μm . Elliptical. Macronuclear nodules about 12 $\times$ 5 μm after protargol impregnation. Usually 2 (rarely 3), after protargol impregnation, 1.5–3.0 $\times$ 1.4–2.3 μm sized micronuclei. Posterior portion of narrow buccal area covered by a very hyaline pellicular projection (Fig. 44a, b). Buccal cirrus at anterior end of undulating membranes. Membranes slightly curved, but not intersecting. Dorsal kinety 2 anteriorly and kinety 3 posteriorly slightly shortened. Kinety 4 terminates somewhat in front mid-body. Caudal cirri on kineties 1 and 2, distinctly longer than marginal cirri (Fig. 44a, b, d, m, see taxonomy).

Morphogenesis commences with proliferation of basal bodies close to the postoral ventral cirrus IV/2 (Fig. 44f; GANNER 1991, GANNER et al. 1987b). Immediately afterwards, a second field of basal bodies develops apokinetaly in front of the left trans-

Fig. 44i-n *Oxytricha longa* (population 3 from GANNER et al. 1987b. i-n, morphogenetic stages after protargol impregnation). i-k) Ventral infraciliature of middle stages, i = 65 μm , j, k = 60 μm . Arrows in (i) mark dispersal of buccal and anterior postoral ventral cirrus. Arrows in (j) denote development of marginal primordia. Arrows in (k) mark origin of dorsal kinety 4 (dorsomarginal row) in proter and opisthe. l-n) Ventral and dorsal infraciliature of late stages, l, m = 60 μm , n = 70 μm . Dotted lines in (l) connect cirri which originate from same streak. Arrow in (m) marks parental dorsal kinety 4. New cirri black, parental white; p 158. →

Fig. 440-q *Oxytricha longa* (from NIESSEN 1984. o, from life; p, q, protargol impregnation). o) Ventral view, 80 µm. p, q) Ventral and dorsal infraciliature, 80 µm. This population from Australian saline soils deviates in some characters (invariably 3 caudal cirri, arrangement of frontoventral and postoral ventral cirri, 5 transverse cirri) from the populations of GELEI & SZABADOS (1950) and GANNER et al. (1987b), indicating that it is possibly another species; p 158.

verse cirrus (Fig. 44g). The formation of the frontal-ventral-transverse streaks of the proter proceeds simultaneously with those of the opisthe (Fig. 44h-j). The streaks V and VI of the opisthe extend towards the frontal field and generate the streaks V and VI of the proter (Fig. 44i). The streaks I-VI generate the following numbers of cirri both in the proter and in the opisthe: 1, 2, 3, 3, 4, and 4. This holds for the large number of specimens with 4 transverse cirri. About 8 % of the specimens investigated by GANNER et al. (1987b) had 5 transverse cirri. In specimens with only 3 transverse cirri (8 % of specimens) cirrus III/1 is lacking. Morphogenesis of dorsal ciliature is in *Urosomoida* pattern, that is, fragmentation of dorsal kinety 3 does not occur.

Occurrence and ecology: In the aufwuchs and detritus of freshwater habitats and in soil. Locus classicus is the Ski István Square in Szeged, Hungary, where GELEI &

SZABADOS (1950) discovered *O. longa* in a slightly polluted, well-oxygenated rain puddle. High abundances occurred 10 days after sampling, indicating that it is resistant to pollution. This is supported by the sample site of population 4 by GANNER et al. (1987b), namely the bank of the Salzach River in Salzburg, Austria, which was polysaprobic by wastes of pulp and paper industry, but well-oxygenated; population P3 was isolated from a meadow soil in Israel. HORVÁTH (1933) found *Oxytricha longa* in a pond in Szeged, Hungary.

Further records: brooks and rivers in Upper Austria (BLATTERER 1994, own observations); rarely in a eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany (SONG & WILBERT 1989); salt polluted running waters in Germany (MIHAILOWITSCH 1989); La Jarosa Reservoir, Spain (FERNANDEZ-LEBORANS et al. 1990); alkaline saline soils from arid regions in South Australia (NIESSEN 1984, POMP & WILBERT 1988).

Feeds on bacteria, small flagellates, and ciliates. Can be cultured in table water (Eau de Volvic, France) with some squashed wheat grains to support bacterial growth (GANNER et al. 1987b). Grew well also in plant infusion and in broth (HORVÁTH 1933). Biomass of 10^6 individuals about 30 mg.

Fig. 45a, b *Oxytricha longa* (after HORVÁTH 1933. a, toluidinblue staining; b, from life?). Ventral and right lateral view, 110 μ m; p 158.

Oxytricha longicirrata KAHL, 1932 (Fig. 46a, b)¹

1932 *Urosoma longicirrata* KAHL, Tierwelt Dtl., 25: 607.

Nomenclature and taxonomy: KAHL (1932) classified *Urosoma* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Urosoma) longicirrata*. The overall morphology and the nuclear apparatus is reminiscent of that of *Ancystropodium maupasi* (Fig. 198a–g). However, this species has a very long retractable tail-like process which was not observed in *Oxytricha longicirrata*. Furthermore, *Ancystropodium* has a ventral infraciliature which agrees with that of *Gastrostyla*. The large buccal area and the position of cirrus III/2 (distinctly behind level of cirrus VI/4) do not justify the classification in *Urosoma*. *Oxytricha longicirrata* differs from *Urosoma emarginata* (Fig. 127a–y), which has also a notch on the right posterior margin, not only in the arrangement of the frontoventral cirri, but also in that it has only one micronucleus, conspicuously long cirri, and a short tail-like process. *Pseudostrom-*

¹ *Keronopsis longicirrata* GELEI & SZABADOS, 1950, Annls biol. Univ. szeged., 1: 271, 289 (Fig. 42j), a somewhat superficially described species from a rain puddle in Szeged, Hungary, is possibly a junior synonym, as indicated by body shape and long cirri (names!). 32 membranelles, 5 transverse cirri. Feeds on flagellates.

Fig. 46a, b *Oxytricha longicirrata* (from KAHL 1932). Left lateral and ventral view from life, 180 μ m. Note single micronucleus (large black dot in b); p 163.

bidium planctonicum is pelagic and has two micronuclei and numerous caudal cirri (Fig. 147a–j). Detailed redescription necessary.

Morphology and biology: In life about 150–200 μ m long. Broadest (about 1/3 of body length) near anterior end. Only slightly or not flattened. Posterior end with a short, conspicuous tail-like process pointing in a right-dorsal direction (but not as long and not as retractable as in *Ancystropodium maupasi*). Macronuclear nodules almost adjoining, spherical to slightly ellipsoidal. Contractile vacuole about at level of cytostome. Slow rotating movement. Adoral zone of membranelles about 38 % of body length. Frontal lip collar-shaped. Frontal, ventral, and transverse cirri distinctly enlarged. All cirri conspicuously long, marginal cirri posteriorly longer than anteriorly. Likely typical *Oxytricha* cirral pattern. Transverse cirri distinctly displaced anteriorly, that is, do not (?) protrude beyond posterior end of cell. Probably three

inconspicuous caudal cirri. Dorsal cilia in life about 5 μ m long.

Occurrence and ecology: Very rare species. Locus classicus is a pond near Hamburg, Germany, where KAHL (1932) discovered *O. longicirrata* in the flocculent sapropelic detritus. The mud was 10–15 cm deep and consisted largely of decaying plants, such as *Lemna* and *Stratiotes* (KAHL 1927a). KAHL (1932) always found it there with low abundance and mainly during the winter. The records from a Polish pond filled with sugar factory wastes and from Latvian rivers are not substantiated by illustrations (GRABACKA 1973, LIEPA 1978). MATIS & TIRJAKOVÁ (1994a) found it in running waters in Slovakia. Feeds on rhodobacteria. Biomass of 10^6 individuals about 175 mg.

Oxytricha longissima DRAGESCO & NJINE, 1971 (Fig. 47)

1971 *Oxytricha longissima* DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 134 (Fig. 47).

1986 *Oxytricha longissima* DRAGESCO & NJINÉ, 1971 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 469.

Taxonomy: Perhaps identical with the poorly known *Oxytricha elongata* (Fig. 36). In life it can be confused with *Urosoma gigantea* (Fig. 134c–g), but after protargol impregnation can be unequivocally separated by the number of dorsal kineties and the position of the transverse cirri. Some morphometric data in the original description of *Oxytricha longissima* are obviously wrong. Most of them are corrected in DRAGESCO & DRAGESCO-KERNÉIS (1986). Detailed reinvestigation necessary.

Fig. 47 *Oxytricha longissima* (after DRAGESCO & NJINE 1971 from DRAGESCO & DRAGESCO-KERNÉIS 1986). Ventral infracilia-ture of a specimen with 4 postoral ventral cirri, protargol impregnation, 220 μ m; p 164.

Morphology and biology: In life about 250 μ m long, after protargol impregnation 210–235 $\times$ 96–120 μ m. Macronuclear nodules after protargol impregnation 18–34 μ m long (mean = 26 μ m); each nodule with 1 spherical micronucleus, after protargol impregnation 5.5–7.5 μ m across.

Adoral zone of membranelles about 1/3 of body length. According to the DRAGESCO & DRAGESCO-KERNÉIS (1986) text, *Oxytricha longissima* has only 35–38 (mean = 37) adoral membranelles, according to Figure 47, however, about 46 membranelles are present; the higher value is more likely for such a large hypotrich. Undulating membranes almost in *Stylonychia* pattern, indicating that classification in *Oxytricha* is incorrect. Frontal, ventral, and transverse cirri distinctly to slightly larger than marginal cirri. 3–4 postoral ventral cirri. Five distinctly anteriorly displaced transverse cirri, do not reach posterior end of cell. 40–54 (mean = 46) right and 37–42 (mean = 40) left marginal cirri. Dorsal cilia 2–4 μ m long, arranged in 5 kineties. Caudal cirri inconspicuous.

Occurrence and ecology: Locus classicus is a stagnant water in a track near Dovala, Cameroon (DRAGESCO & NJINE 1971). NJINÉ (1977a) found *Oxytricha longissima* with a frequency of 7.1 % and at 23–27 °C. Not found since. Biomass of 10⁶ individuals about 570 mg.

Oxytricha matritensis RAMIREZ-MONTESINOS & PEREZ-SILVA, 1966 (Fig. 48)

1965 *Oxytricha matritensis* ALONSO, Int. Congr. Protozool., 2: 230 (nomen nudum).

1966 *Oxytricha matritensis* RAMIREZ-MONTESINOS & PEREZ-SILVA, Microbiologia esp., 19: 194 (Fig. 48).

Nomenclature and taxonomy: The name published by ALONSO (1965) is not accompanied by a description sufficient for differentiation from other taxa, so that it must be considered as nomen nudum. RAMIREZ-MONTESINOS & PEREZ-SILVA (1966) did not

Fig. 48 *Oxytricha matritensis* (from RAMIREZ-MONTESINOS & PEREZ-SILVA 1966. Stained with crystal violet and iodine-glycerine after PEREZ-SILVA & RAMIREZ-MONTESINOS 1964). Ventral infraciliature, length about 110 μm ; p 165.

observe caudal cirri, indicating that this species possibly belongs to *Tachysoma*. However, since it cannot be excluded that they overlooked them due to the inadequate stain method, I preliminarily avoid changing the generic classification. A synonymisation with *Oxytricha aeruginosa* as suggested by BORROR (1972a) is not justified because no coloured cytoplasm is described for *O. matritensis*. BORROR (1972a) also suggested identity with *O. multiseta*, which has, however, more than 5 transverse cirri. Poorly known, doubtful species which needs detailed reinvestigation.

M o r p h o l o g y a n d b i o l o g y: In life about 100 to 120 μm long, 3 times as long as broad. Elliptical. Macronuclear nodules about $19 \times 7 \mu\text{m}$. Usually 2 micronuclei, about 3 μm across. Adoral zone of membranelles about 1/3 of body length. Ventral infraciliature presumably without specialities. Dorsal cilia 2–4 μm long. Caudal cirri possibly absent (see taxonomy). Cyst spherical, about 24–26 μm in diameter. ALONSO (1965) and ALONSO & PÉREZ-SILVA (1966a) studied the polytene chromosomes.

O c c u r r e n c e: Locus classicus is Madrid, Spain, where RAMIREZ-MONTESINOS & PEREZ-SILVA (1966) discovered *Oxytricha matritensis* in a moss habitat at a spring in the playground of the “Centro de Investigaciones Biológicas”, presumably a freshwater habitat. Not found since. Biomass of 10^6 individuals about 37 mg.

Oxytricha minor (MASKELL, 1887) KAHL, 1932 (Fig. 49a–c)

1887 *Opisthotricha parallela*, ENGELM, var. *minor* MASKELL, Trans. Proc. N. Z. Inst., 20: 17 (Fig. 49a).

1932 *Opisthotricha parallela* var. *minor* MASKELL, 1888 – KAHL, Tierwelt Dtl., 25: 609 (Fig. 49b).

1975 *Opisthotricha parallela* (ENGELMANN, 1862) – GROLIÈRE, Protistologica, 11: 493 (Fig. 49c; authoritative redescription).

N o m e n c l a t u r e a n d t a x o n o m y: According to Article 45 (g) of the ICZN (1985) the rank of MASKELL’s (1887b) taxon “var. *minor*” is subspecific since it was published before 1961. Thus, the change in rank from subspecies to species level does not affect the authorship (Article 50 (c)). The generic change was already undertaken by KAHL (1932) when he classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha* (*Opisthotricha*) *parallela* var. *minor*. However, *Oxytricha minor* (MASKELL, 1887) KAHL, 1932 is the senior secondary homonym of *Oxytricha minor*

Fig. 49a–c *Oxytricha minor* (a, after MASKELL 1887b; b, from KAHL 1932; c, from GROLIÈRE 1975. a, b, from life; c, protargol impregnation). a) Ventral surface in dorsal view, 70 μm . b) Ventral view, 100 μm . c) Ventral infraciliature, 60 μm ; p 166.

KAHL, 1932; the KAHL (1932) species thus requires a substitute name (see *Oxytricha alfredi*).

The original description is rather superficial, so that each identification must be somewhat arbitrary. The population described by GROLIÈRE (1975) is much more similar to the KAHL (1932) population than to *O. parallela*, which is about 200 μm long and has 4 distinct caudal cirri. The conspecificity of KAHL's and GROLIÈRE's population is mainly indicated by the elongated body which is slightly but distinctly bent to the left in mid-body (compare with Fig. 49b, c). Redescription needed, especially live observation and morphometric characterisation.

Morphology and biology: In life about 100 μm long, after protargol impregnation 50–70 $\times$ 10–12 μm (mean = 58 $\times$ 10.5 μm). Elongated with parallel margins, both ends rounded. Very flexible. Macronuclear nodules after protargol impregnation 8–10 μm long, each nodule with 1 micronucleus. Contractile vacuole in front of mid-body. Cytoplasm colourless, very transparent.

Adoral zone of membranelles about 1/3 of body length, 20–25 membranelles. Undulating membranes rather straight. Arrangement of frontal-ventral-transverse cirri as in many other *Oxytricha* species; according to GROLIÈRE (1975) only 3 frontoventral cirri and sometimes only 1 pretransverse ventral cirrus. Five transverse cirri, protrude distinctly beyond posterior end of cell. 25–30 right and 18–21 left marginal cirri. Dorsal cilia short, arranged in 3 kineties (uncommon, possibly a short row was overlooked?). Three caudal cirri, distinctly longer than marginal cirri (Fig. 49b, c).

Occurrence and ecology: Very likely confined to freshwater. Locus classicus is a freshwater habitat in the Wellington District, New Zealand (MASKELL 1887b). KAHL (1932) provided no information about the sample site. GROLIÈRE (1975) found *Oxytricha minor* in temporary pools near Besse-en-Chandesse, France. Feeds on bacteria. Biomass of 10⁶ individuals about 4 mg.

Oxytricha monspessulana (CHATTON & SÉGUÉLA, 1940) BORROR, 1972 (Fig. 50a, b)

1939 *Opisthotricha monspessulana* CHATTON & SEGUELA, C. r. hebd. Séanc. Acad. Sci., Paris, 208: 869 (nomen nudum).

1940 *Opisthotricha monspessulana* CHATTON & SÉGUÉLA, Bull. biol. Fr. Belg., 74: 365, 417 (Fig. 50a, b).

1972 *Oxytricha monspessulana* CHATTON & SÉGUÉLA, 1940 – BORROR, J. Protozool., 19: 14.

Nomenclature and taxonomy: The name published by CHATTON & SEGUELA (1939) is not accompanied by a description sufficient for differentiation from other taxa, so that it must be considered a nomen nudum. Although BORROR (1972a) did not use the phrase “nov. comb.”, as he did in other cases, I consider him as combining author. Some characters, for instance, the long adoral zone of membranelles and the arrangement of the postoral ventral cirri, are reminiscent of *Sterkiella histriomuscorum*, with which it is possibly synonymous. The population described by GROLIÈRE (1969) is obviously not conspecific with *Oxytricha monspessulana* because it has 4 macronuclear nodules and an inflexible body. GROLIÈRE’s population and that studied by FERNANDEZ-LEBORANS (1985) are classified as *Sterkiella cavicola* (Fig. 181j–l).

Morphology and biology: In life 90–120 × 55–65 µm. Flexible, which is the only reason why I do not synonymise it with *Sterkiella histriomuscorum*. Macronuclear nodules ellipsoidal, each with 1 spherical micronucleus. Contractile vacuole slightly in front of mid-body.

Adoral zone of membranelles almost half of body-length (indicating that this species is a Stylonychinae, see taxonomy), about 40 membranelles. Frontal,

Fig. 50a, b *Oxytricha monspessulana* (after CHATTON & SÉGUÉLA 1940. a, from life; b, wet silver impregnation). a) Ventral view, 90–120 µm. Possibly a *Sterkiella*. b) Ventral infraciliature of an very early morphogenetic stage, size not indicated. Only a small part of the silverline system is shown (arrow). OP = oral primordium.

ventral, and transverse cirri distinctly larger than marginal cirri. Five transverse cirri, protrude slightly (left) to distinctly (right) beyond posterior end of cell. Dorsal cilia 1–2 μm long, arranged in 6 kineties. Three rather long and flexible caudal cirri.

Occurrence and ecology: Locus classicus is Montpellier, France, where CHATTON & SÉGUÉLA (1940) discovered *O. monspessulana* in a basin with algae (*Spirogyra* sp., Characeae) and decaying leaves in the “Jardin des Plantes”, a botanical garden. The record by GROLIÈRE & NJINÉ (1973) is obviously identical to that of GROLIÈRE (1969), classified as *Sterkiella cavicola*. *Oxytricha monspessulana* feeds on bacteria. Biomass of 10^6 individuals about 90 mg.

Oxytricha multiseta

DRAGESCO, 1966 (Fig. 51a, b)

1961 *Opisthotricha similis* ENGELMANN, 1862 – REUTER, Acta zool. fenn., 99: 19 (Fig. 51b; misidentification?).

1966 *Oxytricha multiseta* DRAGESCO, Protistologica, 2: 87 (Fig. 51a).

Taxonomy: The population by REUTER (1961) has 3 caudal cirri, so that the identification as *O. similis* (2 caudal cirri) is not justified. The body-shape and the ventral infraciliature of his population are reminiscent of that of *Oxytricha multiseta*. However, REUTER (1961) described 2 pretransverse ventral and 5 transverse cirri, whereas *O. multiseta* obviously has 8 to 9 pretransverse ventral and transverse cirri. Thus, an identification as *O. multiseta* should be primarily based on the original description (Fig. 51a). BORROR (1972a) synonymised *O. multiseta* with *O. aeruginosa* – which has, however, a reddish, granulated cytoplasm – and the poorly known *O. matritensis* (Fig.

Fig. 51a, b *Oxytricha multiseta* (a, from DRAGESCO 1966b; b, after REUTER 1961. a, protargol impregnation; b, from life). a) Ventral infraciliature, 110 μm . b) Ventral view, size not indicated.

48). *Oxytricha multiset*a and *O. matritensis* differ only in the number of transverse cirri, which, however, has to be confirmed by detailed redescrptions. The increased number of transverse cirri in *O. multiset*a is reminiscent of *O. variabilis* (Fig. 62), and the overall morphology agrees with that of *O. longa* (4 transverse cirri) and *Urosomoida agilisformis*. However, *Urosomoida* species usually have a lower number of pretransverse ventral and transverse cirri.

Morphology and biology: According to DRAGESCO (1966b) in life (?) about 120 μ m long, population by REUTER (1961) in life 80–90 μ m long and 3.6 times as long as broad. Long elliptical, distinctly converging posteriorly, both ends rounded. Adoral zone of membranelles about 30 % of body length, 26–29 membranelles. All postoral ventral cirri arranged very close to cytostome. Distance between posterior postoral ventral cirrus and pretransverse ventral cirri rather large. According to original description 6–7 transverse cirri; Figure 51a shows a specimen with 6 transverse cirri and 2 pretransverse ventral cirri. About 33 right and 29 left marginal cirri. Dorsal cilia short, caudal cirri inconspicuous; distinguishable from marginal cirri in live specimens according to REUTER (1961; Fig. 51b).

Occurrence and ecology: Locus classicus is a small pool in Haute-Savoie, France (DRAGESCO 1966b). Not found since. REUTER (1961) found his population in a small rock pool (0.06 % NaCl) on Långskär Island, Finland. Biomass of 10^6 individuals about 30 mg.

***Oxytricha parahalophila* (WANG & NIE, 1935) comb. nov. (Fig. 84c)**

1935 *Opisthotricha parahalophila* WANG & NIE, Sinensia, 6: 503 (incorrect original spelling).

1935 *Opisthotricha parahalophila* WANG & NIE, Sinensia, 6: 504, 505.

Nomenclature and taxonomy: In accordance with Article 32b (i) of the ICZN (1985) I chose the species name “*parahalophila*” as the correct original spelling. “*Opisthotricha parahalophila*” in WANG & NIE (1935, p 440) is an incorrect subsequent spelling of *Opisthotricha*.

Almost all characters, excluding the freshwater habitat, of *Oxytricha parahalophila* agree very well with that of *O. halophila* KAHL, 1932; especially *O. halophila* from saline inland waters (Fig. 84h) is rather similar. But because of the different biotops (freshwater against marine) I preliminarily consider both *O. parahalophila* and *O. halophila* as individual species; however, their validity has to be checked by detailed redescrptions.

Morphology and biology: In life 70–115 $\times$ 30 μ m. Both ends rounded, widest at or slightly in front of mid-body. Macronuclear nodules ellipsoidal, not widely separated. Single spherical micronucleus between macronuclear nodules, not, however, shown in Figure 84c! Contractile vacuole slightly in front of mid-body. Cortical granules absent.

Cytoplasm colourless, granulated, usually transparent, slightly opaque in well-fed specimens. Adoral zone of membranelles about 1/3 of body length. Frontal, ventral, and transverse cirri slightly enlarged. Transverse cirri long and slender. Dorsal cilia "long and fine", according to the illustration, however, only about 4 μm . Three long and straight, but rather thin caudal cirri, usually directed slightly to the right.

Occurrence and ecology: Locus classicus is a pond in Siao-Ying, China, where WANG & NIE (1935) discovered *Oxytricha parahalophila* in an old standing culture among submerged mosses. Not found since. Feeds on bacteria and diatoms. Biomass of 10^6 individuals about 20 mg.

Oxytricha parallela ENGELMANN, 1862 (Fig. 52a–c)

1862 *Oxytricha parallela* ENGELMANN, Z. wiss. Zool., 11: 388 (Fig. 52a, b).

1882 *Opisthotricha parallela*, ENG. sp. – KENT, Manual infusoria II, p 785.

1931 *Opisthotricha parallela* KENT – TAI, Sci. Rep. natn. Tsing Hua Univ., 1: 51 (Fig. 52c).

1932 *Opisthotricha (Oxytricha) parallela* ENGELMANN, 1862 – KAHL, Tierwelt Dtl., 25: 609.

Nomenclature and taxonomy: This species was unequivocally established in *Oxytricha*, and not in *Opisthotricha* as erroneously assumed by BORROR (1972a). KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Opisthotricha) parallela*. Incorrect subsequent spellings: *Opisthotricha parallelis* ENGELMANN (for example, WEBB 1956, p 153), *Opistotricha parallela* ENGELMANN (MÜCKE 1979, p 274). The

Fig. 52a–c *Oxytricha parallela* (a, b, after ENGELMANN 1862; c, from TAI 1931. a–c, from life). a) Dorsal view, 125 μm . Note the 4 elongated caudal cirri (arrows) and the long dorsal cilia. b, c) Ventral views, b = 160 μm , c = 74 μm .

Fig. 52d *Opisthotricha parallelis* (from KAHL 1928). Insufficient redescription, 100 μm . Note two buccal cirri; p 172.

specimen measured by TAI (1931; Fig. 52c) was only 74 μm long. However, since the other characters (4 caudal cirri, long dorsal cilia) agree rather well with the original description, I accept the identification. The population described by KAHL (1928; Fig. 52d) is distinctly smaller and clearly has 2 buccal cirri; it is preliminarily classified as insufficient redescription, as in *Opisthotricha parallela* sensu SCHUSTER (1899; Fig. 240i). The small population of GROLIÈRE (1975) is fixed as the authoritative redescription of *O. minor* (MASKELL, 1887) KAHL, 1932 (Fig. 49c). Detailed redescription of *O. parallela* needed.

Morphology and biology: According to the text by ENGELMANN (1862), in life about 200 μm long, according to the illustrations, only 120–160 μm , TAI (1931) population, even only 74 μm (see taxonomy); about 4 times as long as broad. Body margins nearly parallel, both ends rounded. Contractile vacuoles about in mid-body; TAI (1931) described 2 vacuoles (misobservation?). Rapid movement.

Adoral zone of membranelles only about 1/4 of body length. Frontal and transverse cirri distinctly enlarged. According to Figure 52b, only 3 frontoventral cirri present. Five transverse cirri, protrude distinctly beyond posterior end of cell. Dorsal cilia “long”, probably about 10 μm . Four prominent, widely spread caudal cirri.

Occurrence and ecology: Locus classicus is a freshwater habitat near Leipzig, Germany (ENGELMANN 1862). TAI (1931) found *Oxytricha parallela* in a pond on west campus of Tsing Hua University, China.

Records not substantiated by illustrations: Lansersee, a small lake in Tyrol, Austria (DALLA TORRE 1891); rare in Maritza River, Bulgaria (DETCHIEVA 1981); Moldavia River in Prague, Czechoslovakia (KALMUS 1928, ŠRÁMEK-HUŠEK 1953); freshwater habitats near Perth, England (CRAIGIE 1921); ponds and infusion of willow twigs, Estonia (JACOBSON 1928); mouth of Schussen River, Germany (WETZEL 1928a); brook near Bonn, Germany (JUTRCZENKI 1982); small, eutrophic lake in Germany (MÜCKE 1979); polluted Tisza River in Hungary (JÓSA 1974, STILLER 1942); stagnant water in Italy (CUNEO 1891); Latvian rivers (LIEPA 1978, 1990); stagnant water with *Lemna minor* in Warsaw, Poland (WRZESNIEWSKIEGO 1866); cooling plant in Moldova (CHORIK & VIKOL 1973); inland salt waters of the USSR (BOUTCHINSKY 1895); soil in Japan (TAKAHASHI & SUHAMA 1991); St. John's Bayou, a fairly large body of brackish water in Louisiana, USA (BORROR 1962, PATTERSON et al. 1989, SMITH 1904).

DETCHIEVA (1983c) found *O. parallela* in the Maritza River, Bulgaria, under following conditions: alphamesosaprobity, 0.3 % frequency, pH 7.4, 23 °C, 6.1 mg l⁻¹ O₂ (72 % saturation), 89 mg l⁻¹ Ca²⁺, 8.8 mg l⁻¹ Mg²⁺, 235 mg l⁻¹ HCO₃⁻, 59 mg l⁻¹ SO₄²⁻, 20 mg l⁻¹ Cl⁻, 19 °dH, 0.8 mg l⁻¹ NH₄⁺-N, 0.085 mg l⁻¹ NO₂⁻-N, 0.05 mg l⁻¹ Fe²⁺. WEBB (1956) recorded it throughout the year from brackish water at Parkgate, Cheshire, near the Dee River estuary, Wales, at a salinity of up to 1.7 %. BARNES et al. (1976) found it in the sediment of a sheltered and organically rich site on Scolt Head Island, Norfolk, England.

Feeds on bacteria, diatoms, and detritus (WEBB 1956). Biomass of 10^6 individuals about 67 mg (when 160 μm long).

***Oxytricha pseudofurcata* nov. spec. (Fig. 53a, b)**

1954 *Tachysoma furcata* KAHL – GELEI, Acta biol. hung., 5: 335 (misidentification).

Taxonomy: The determination of GELEI (1954b) is certainly wrong because *Tachysoma bicirratum* (the replacement name for *Tachysoma furcata*) has long dorsal cilia, whereas they are short in *Oxytricha pseudofurcata*. Furthermore, the latter species has 2 caudal cirri and not 2 elongated marginal cirri as in *Tachysoma bicirratum*. The rather similar *Oxytricha setigera* has long dorsal cilia. Detailed redescription necessary.

Diagnosis: In life about $66 \times 25 \mu\text{m}$; 1 micronucleus between the 2 macronuclear nodules; about 18 adoral membranelles; 4 transverse cirri; usually 4, rarely 5 dorsal kineties with 2–4 μm long dorsal cilia; 2 elongated caudal cirri.

Type locality: Hypertrophic ponds on a pasture in the Börzsöny mountains, Hungary.

Morphology and biology: Elliptical, both ends rounded. Macronuclear nodules arranged very closely. Contractile vacuole about in mid-body, during diastole with longitudinal collecting canals. Anterior and posterior portion of cell packed with greyish cytoplasmic crystals. Rapid movement. Adoral zone of membranelles about 37 % of body length. Buccal area rather wider than narrow. Frontal, ventral, and transverse cirri slightly enlarged; arrangement of these cirri obviously genus specific. Transverse cirri protrude far beyond posterior end of cell. Right marginal row terminates adjacent to right transverse cirrus, usually consists of 13 (sometimes up to 17) cirri, left marginal row usually with 12 (sometimes up to 16) cirri. Probably 3 dorsal kineties of about body length and 1 distinctly shortened kinety. Caudal cirri rather long, especially the right one.

Fig. 53a, b *Oxytricha pseudofurcata* (from GELEI 1954b. a, sublimate fixation; b, opal-blue stain after BRESSLAU). Ventral and dorsal infraciliature, a = 55 μm , b = 50 μm .

Occurrence and ecology: Probably confined to freshwater habitats. GELEI (1954b) found this population in 4 hypertrophic, ephemeral ponds in Hungary, described in detail by GELEI (1954a). According to GELEI et al. (1954), *Oxytricha pseudofurcata* was highly abundant in pond III during summer when the water temperature was about 34 °C! Feeds on bacteria, hyphae, and autotrophic flagellates. Biomass of 10⁶ individuals about 10 mg.

***Oxytricha saprobia* KAHL, 1932 (Fig. 54a–c)**

1932 *Oxytricha saprobia* KAHL, Tierwelt Dtl., 25: 603 (Fig. 54a).

1972 *Oxytricha saprobia* KAHL – BICK, Ciliated protozoa, p 21 (Fig. 54b).

1977 *Oxytricha saprobia* KAHL 1935 – BEREZKY, Annls Univ. Scient. bpest. Rolando Eötvös, 18–19: 169 (Fig. 54c).

1991 *Oxytricha saprobia* KAHL, 1932 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 292.

Nomenclature and taxonomy: Incorrect subsequent spelling: *Oxytricha saprobica* KAHL, 1932 (FOISSNER & FOISSNER 1988, p 90). The illustration in BICK (1972a, Fig. 54c) looks like a redrawing from KAHL (1932, Fig. 54a). *Oxytricha saprobia* sensu VUXANOVICI (1963; Fig. 220l) is insufficiently described. Detailed redescription necessary.

Morphology and biology: In life about 100 µm long and 2.7 times as long as broad. Asymmetrical, margins distinctly converging posteriorly, right one nearly straight,

left convex. Contractile vacuole slightly in front of mid-body. Adoral zone of membranelles about 37 % of body length. Distal adoral membranelles conspicuously long. Fronto-ventral cirri distinctly en-

Fig. 54a–c *Oxytricha saprobia* (a, from KAHL 1932; b, from BICK 1972a [possibly a redrawing from KAHL 1932]; c, from BEREZKY 1977a. a, b, from life; c, method not indicated). Ventral views, a, b = 100 µm, c = size not indicated. Note single micronucleus (arrow).

larged. Transverse cirri prominent, protrude slightly (left) to distinctly (right) beyond posterior end of cell.

Occurrence and ecology: Common in freshwater habitats, sometimes abundant according to KAHL (1932) who found *O. saprobia* between decaying blades of grass, probably somewhere (near Hamburg?) in Germany. TIRJAKOVÁ (1993) recorded it from the Turiec River in Slovakia and BEREČKY (1977a) counted 15–25 ind. l⁻¹ in the spring and autumn plankton of the Danube River, Hungary, under the following conditions: 10–12 °C, pH 7.7–8.0, 7.5–10.2 mg l⁻¹ O₂, 5.1–7.9 mg l⁻¹ O₂-consumption, 0.35–1.2 mg l⁻¹ NH₄⁺, 0.03–0.44 mg l⁻¹ NO₂⁻.

Records from freshwater habitats not substantiated by illustrations: moderately to heavily polluted running waters in Austria (AUGUSTIN et al. 1987, BLATTERER 1994, FOISSNER & FOISSNER 1988); beta- to alphamesosaprobic Main River and Agger River, Germany (BERNERTH 1982, NUSCH 1970); mesosaprobic Danube River, Hungary (BEREČKY 1979, BEREČKY et al. 1983, NOSEK & BEREČKY 1981); China (NING et al. 1993, YANG 1989); south-eastern Louisiana, USA (BAMFORTH 1963). VARGA (1953b) recorded it from fermented farmyard manure. According to PRIMC (1983), *O. saprobia* prefers low water temperatures (about 5 °C). Terrestrial records not substantiated by illustrations (BAMFORTH 1969, LUZZATTI 1938).

Feeds on bacteria and flagellates. Biomass of 10⁶ individuals about 34 mg (FOISSNER et al. 1991). *Oxytricha saprobia* is classified as alphameso- to polysaprobic indicator: a–p; a = 6, p = 4, I = 3, SI = 3.4 (FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). However, *O. saprobia* is little known and confusion with other, more common species (for example, *O. setigera*, see below) cannot be excluded. This classification thus has to be verified on reliably determined populations.

***Oxytricha setigera* STOKES, 1891 (Fig. 55a–s, 56a–n, Tables 3, 15, 16)**

- 1891 *Oxytricha setigera* STOKES, Jl R. microsc. Soc., year 1891: 701 (Fig. 55a).
- 1932 *Oxytricha setigera* STOKES, 1891 – KAHL, Tierwelt Dtl., 25: 604.
- 1932 *Steinia balladynula* KAHL, Tierwelt Dtl., 25: 614 (Fig. 55b).
- 1950 *Oxytricha plana* GELEI & SZABADOS, Annls biol. Univ. szeged., 1: 268, 287 (Fig. 55l, m).
- 1950 *Tachysoma fusiformis* GELEI & SZABADOS, Annls biol. Univ. szeged., 1: 272, 290 (Fig. 55n).
- 1963 *Oxytricha setigera* STOKES – WEST & LUNDIN, Pap. Mich. Acad. Sci., 48: 108 (Fig. 55j).
- 1977 *Oxytricha setigera* STOKES – BUITKAMP, Acta Protozool., 16: 272 (Fig. 55k).
- 1977 *Oxytricha setigera* STOKES 1891 – BEREČKY, Annls Univ. Scient. bpest. Rolando Eötvös, 18–19: 169 (Fig. 56n).
- 1978 *Oxytricha setigera* – SMITH, Br. Antarct. Surv. Sci. Rep., No. 95: 75 (Fig. 55c).
- 1982 *Oxytricha setigera* STOKES, 1891 – FOISSNER, Arch. Protistenk., 126: 83 (Fig. 55d–i; authoritative redescription).
- 1986 *Oxytricha buitkampi* DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 472.
- 1989 *Cyrtohymena balladynula* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.
- 1989 *Oxytricha setigera* STOKES, 1891 – SONG & WILBERT, Lauterbornia, Heft 3: 164 (Fig. 55o–s).

- 1991 *Oxytricha setigera* STOKES, 1891 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 294.
 1991 *Oxytricha setigera* STOKES, 1891 – GSCHWIND, Diplomarbeit, p 59 (Fig. 56a–m).

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name of *S. balladynula* in the original description is thus *Oxytricha (Steinia) balladynula*. Incorrect subsequent spellings: *Oxytricha setifera* (STOUT 1978, p 17); *O. (Steinia) balladynulla* (DRAGESCO & DRAGESCO-KERNÉIS 1986, p 473); *Steinia balladina* KAHL, 1930 (CHARDEZ 1987, p 13).

There are some differences between the original description and the redescription by FOISSNER (1982), namely in the body shape, the nuclear apparatus, and the number of marginal cirri. Nevertheless, I agree with FOISSNER (1982) that his redescription should be considered as authoritative. It is conceivable that STOKES (1891) made some misobservations because of the very small size of *O. setigera*. *Oxytricha balladynula* is very likely synonymous with *O. setigera* because the size, the long dorsal cilia, the low number of

Fig. 55k–n *Oxytricha setigera* (k, from BUTKAMP 1977b; l–n, from GELEI & SZABADOS 1950. k, protargol impregnation; l, m, opalblue stain after BRESSLAU; n, sublimate fixation). Ventral and dorsal infraciliature, k = 40 μ m, l, n = 55 μ m, m = 35 μ m; p 175.

- ← **Fig. 55a–j** *Oxytricha setigera* (a, after STOKES 1891; b, from KAHL 1932; c, from SMITH 1978; d–i, from FOISSNER 1982; j, from WEST & LUNDIN 1963. a–f, j, from life; g–i, protargol impregnation). a–d, j) Ventral views, a, c, d, j = 50 μ m, b = 60 μ m. Should not be confused with *Oxytricha balladyna* (p 126). e, f) Dorsal and lateral view, e = 70 μ m, f = 55 μ m. g, h) Ventral and dorsal infraciliature, g = 45 μ m, h = 40 μ m. i) Ventral infraciliature of anterior half of cell, 25 μ m; p 175.

marginal cirri, and the nuclear apparatus agree rather well with the authoritative redescription; the rectangular outline agrees better with the original description (compare with Fig. 55a, b, d). KAHL (1932) classified *O. balladynula* in the subgenus *Steinia* because the peristomial lip is distinctly curved anteriorly (Fig. 55b, d, o), and FOISSNER (1989) transferred it to *Cyrtohymena*. Furthermore, *Oxytricha plana* and *Tachysoma fusiformis* have to be synonymised with the present species because there is no character which allows a reliable separation from *Oxytricha setigera*. *Oxytricha buitkampii* was established by DRAGESCO & DRAGESCO-KERNÉIS (1986) for the population by BUITKAMP (1977b; Fig. 55k; see also FOISSNER 1987d). *Oxytricha setigera* sensu SONG & WILBERT (1989) agrees more or less completely with the redescription by FOISSNER (1982). The populations by WEST & LUNDIN (1963) and SMITH (1978) are rather superficially described, however, the small sizes and the long dorsal cilia indicate that they in fact observed something like *O. setigera*.

In life *O. setigera* can be easily confused with the very similar *O. balladyna* (compare Fig. 55a with Fig. 33a). Thus, an identification should always be confirmed by detailed live observations or protargol impregnation, where the significant difference, namely the position of the buccal cirrus, is recognisable.

Morphology and biology: In life $40\text{--}60 \times 16\text{--}21\text{ }\mu\text{m}$. Long-oval; according to FOISSNER (1982) and SONG & WILBERT (1989) posteriorly often somewhat tapered, after STOKES (1891) and KAHL (1932) body margins nearly parallel. Flattened about 1.5–2 to 1, according to GSCHWIND (1991) loaf-shaped in lateral view (Fig. 56b). Very flexible, slightly contractile, especially anterior portion of cell. Macronuclear nodules in life about $10 \times 5\text{ }\mu\text{m}$, after protargol impregnation $8\text{--}12 \times 4\text{--}7\text{ }\mu\text{m}$ (mean = $9.1 \times 5.3\text{ }\mu\text{m}$; $n = 10$). Micronucleus in life about $3\text{ }\mu\text{m}$ across. Contractile vacuole about in mid-body, during diastole with very inconspicuous collecting canals. Cortical granules absent, cytoplasm colourless. Rapid movement, sometimes slightly jumping.

Adoral zone of membranelles 25–33 % of body length. Bases of largest membranelles in life about $6\text{ }\mu\text{m}$ wide. Buccal area deep, in life anteriorly curved like a hook. Undulating membranes distinctly curved, crossing, that is, in typical *Oxytricha* pattern. Frontal and transverse cirri slightly enlarged. Posterior frontoventral cirri arranged behind level of cytostome (Fig. 55g, p, arrow). 8–10, usually 9 frontoventral and postoral and pretransverse ventral cirri. Invariably 5 ($n = 10$), in life about $20\text{ }\mu\text{m}$ long transverse cirri which protrude far beyond posterior end of cell. Marginal rows begin somewhat behind level of buccal vertex, distinctly separate posteriorly. Marginal cirri in life about $15\text{ }\mu\text{m}$ long. Dorsal cilia in life $10\text{--}15\text{ }\mu\text{m}$ long, slightly curved, almost perpendicularly spread in resting animals. Constantly 4 ($n = 10$) dorsal kineties, kinty 1 distinctly short-

Fig. 55o–s *Oxytricha setigera* (from SONG & WILBERT 1989. o, q, from life; p, r, s, protargol impregnation). o, → q) Ventral and lateral view, o, q = $45\text{ }\mu\text{m}$. p, r, s) Ventral and dorsal infraciliature, $45\text{ }\mu\text{m}$. Arrow in (p) marks posterior frontoventral cirrus. AZM = adoral zone of membranelles, BC = buccal cirrus, CC = caudal cirri, CV = contractile vacuole, FC = right frontal cirrus, PVC = posterior postoral ventral cirrus; p 175.

550

Fig. 56a–e *Oxytricha setigera* (originals kindly supplied by W. FOISSNER [from GSCHWIND 1991]. a, b, from life; c–e, protargol impregnation). a) Ventral view, 47 μm . b) Lateral view. Note loaf-shaped outline and fine dorsal cilia. c, d) Ventral infraciliature of various specimens, c, d = 35 μm . Note position of buccal cirrus at posterior end of undulating membranes. e) Dorsal infraciliature, 35 μm ; p 175.

Fig. 56f-m *Oxytricha setigera* (originals kindly supplied by W. FOISSNER [from GSCHWIND 1991]. f-m, morphogenetic stages after protargol impregnation; parental cirri white, new cirri black). f-i) Ventral and dorsal infraciliature of two middle stages, f, g, = 48 μ m, h, i = 51 μ m. j, k) Ventral and dorsal infraciliature of a late stage, 48 μ m. l, m) Ventral and dorsal infraciliature of a very late stage, 47 μ m. 1-6 = frontal-ventral-transverse streaks; p 175.

Fig. 56n *Oxytricha setigera* (from BEREČKY 1977a). Ventral view from life, size not indicated; p 175.

ened anteriorly, kineties 2 and 3 about of body length, kinety 4 terminates about in mid-body (dorsomarginal row), sometimes consists of 2 basal body pairs only (Fig. 55s). 3–4 (mean = 3.5 and 3.9 in 2 populations; $n = 10$ each) fine, in life about 18 μm long caudal cirri.

Morphogenesis of cell division is described by GSCHWIND (1991; Fig. 56f–m). It commences with the proliferation of basal bodies between the left transverse cirrus and the left pretransverse ventral cirrus. This and later stages are reminiscent of the type species, *O. granulifera*. Dorsal morphogenesis is in *Urosomoida* pattern. Some comments on morphogenesis, but no figures, are given by TARTAR (1941).

Occurrence and ecology: Widely distributed throughout the year in lentic and lotic freshwater habitats and in soil, often abundant. Locus classicus is a pond near Trenton in New Jersey, USA (STOKES 1891). Records largely substantiated by illustrations: Austria (AUGUSTIN et al. 1987, FOISSNER 1987b, FOISSNER & FOISSNER 1988); beta- to alphamesosaprobic brook in Bavaria (GSCHWIND 1991); Poppelsdorfer Weiher, a eutrophic pond in Bonn, Germany (SONG & WILBERT 1989); mesosaprobic Danube River (35 ind. l^{-1}) and rain puddle in Szeged, Hungary (BERECZKY 1977a, b, BERECZKY et al. 1983, GELEI & SZABADOS 1950); freshwater habitats in Michigan, USA (LUNDIN & WEST 1963, WEST & LUNDIN 1963); soil of a “savane brûlée”, Plateau du Grand Nord, Ivory Coast and soil of a deciduous forest near Bonn, Germany (BUIKAMP 1977a, b, 1979); various terrestrial habitats in Australia (BLATTERER & FOISSNER 1988); soil from South Georgia, South Shetland, South Orkney, Signy, and Deception Islands, Antarctica (SMITH 1972, 1973a, 1974a, 1978, 1985).

Records from terrestrial and freshwater habitats not substantiated by illustrations: mesosaprobic running waters in Upper Austria (AOÖLR 1994b, BLATTERER 1994, FOISSNER & MOOG 1992, own observations); soil in Belgium (CHARDEZ 1967); Bulgarian rivers (DETCHIEVA 1979b, 1981, RUSSEV et al. 1976); forest and agricultural soils and freshwater in Czechoslovakia (MATIS & TIRJAKOVÁ 1994a, ROSA 1957a, b, 1962, TIRJAKOVÁ 1988, 1992b, 1993); soil of a beech wood in Denmark (STOUT 1968); soil from East Greenland (STOUT 1970); sediment of Loch Leven, England (BRYANT & LAYBOURN 1974); clean and beta- to alphamesosaprobic brooks and rivers in Bavaria (FOISSNER 1997a, FOISSNER et al. 1992a, b); aufwuchs of a mesotrophic Eifel Maar lake, Germany (PACKROFF 1992, PACKROFF & WILBERT 1991); unpolluted foothill stream (Breitenbach) near the village of Schlitz, Germany (PACKROFF & ZWICK 1996); beech-forest and limed spruce forest in Germany (LEHLE 1989, 1993, 1994); Italy (GRISPINI 1938); Latvian river (LIEPA 1973); La Jara Reservoir, Spain (FERNANDEZ-LEBORANS et al. 1990); Danube River, Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); soil influenced by herbicide, USSR (GEL’CER & GEPTNER 1976); stream in India (RANGANATHAN & SHREEDHARAN 1986); leaf-litter in a pond near

Tokyo and soil in Japan (HATANO & WATANABE 1981, TAKAHASHI & SUHAMA 1991); lakes, rivers, eutrophic ponds, upper soil horizon of a Delta hardwood bottomland forest, soil of a cedar glade, and Mississippi deltaic soils, USA (BAMFORTH 1967, 1969, 1995, BOVEE 1960, CAIRNS 1965a, CAIRNS & YONGUE 1966, MARTIN & SHARP 1983, MCCASHLAND 1956, PATRICK 1961, PRATT et al. 1986); New River in Virginia, USA, at 13–19 °C, pH 7.0–7.3, and 7–8 mg l⁻¹ O₂ (YONGUE & CAIRNS 1979); limnetic habitats on the campus of the University of Costa Rica (RUIZ 1961); soil in Peru, Brazil, Costa Rica, and Australia (FOISSNER 1995b, 1997b); beech wood soils, inundated soil under grassland, and burnt sites in New Zealand (STOUT 1961, 1963, 1984); bryophyte peat and angiosperm soil from the sub-Antarctic island of South Georgia (SMITH 1982).

Some autecological data of freshwater populations are listed in Table 16. BUTKAMP (1979) found *O. setigera* mainly in soil samples incubated at 30 °C and 35 °C. Detailed autecological data of various terrestrial populations are given in FOISSNER & PEER (1985) and FOISSNER et al. (1985).

Feeds on bacteria and heterotrophic flagellates. STOUT (1956) cultured *Oxytricha setigera* in peat extract. Biomass of 10⁶ individuals after FOISSNER (1987a) about 8 mg, after NESTERENKO & KOVALCHUK (1991) about 12 mg.

Oxytricha setigera is classified as alpha- and betamesosaprobic indicator of water quality: a–b; b = 4, a = 6, I = 3, SI = 2.6 (FOISSNER 1988a, FOISSNER et al. 1991, MORAVCOVÁ 1977, SLÁDEČEK et al. 1981, WEGL 1983). This largely agrees with the available autecological and faunistic data. However, since it can not be excluded that it was sometimes mixed up with the rather similar *O. balladyna*, further autecological investigations on reliably determined populations are needed.

Oxytricha similis ENGELMANN, 1862 (Fig. 57a–d, Tables 16, 17)

- 1861 *Oxytricha pellionella* (EHR. STEIN) – WRZESNIOWSKI, Annls Sci. nat., 16: 333 (Fig. 57d; misidentification).
- 1862 *Oxytricha similis* ENGELMANN, Z. Wiss. Zool., 11: 388 (no figure).
- 1882 *Opisthotricha similis*, ENG. sp. – KENT, Manual infusoria II, p 785.
- 1932 *Opisthotricha (Oxytricha) similis* ENGELMANN, 1862 – KAHL, Tierwelt Dtl., 25: 611 (Fig. 57a; authoritative redescription).
- 1935 *Opisthotricha similis* (ENGELMANN) KAHL 1932 – WANG & NIE, Sinensia, 6: 502 (Fig. 57b).
- 1972 *Opisthotricha similis* ENGELMANN – BICK, Ciliated protozoa, p 21 (Fig. 57c).
- 1991 *Oxytricha similis* ENGELMANN, 1862 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 300.

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Opisthotricha) similis*, which is a secondary homonym of *O. (Histrio) similis* in KAHL (1932, p 615). *Oxytricha similis* is a slender, medium-sized species with 2, more or less prominent caudal and 5 transverse cirri. The 2 caudal cirri are arranged rather symmetrical in the population of WANG & NIE (1935), whereas both point slightly to the right in the other popula-

Fig. 57a–d *Oxytricha similis* (a, from KAHL 1932; b, after WANG & NIE 1935; c, after BICK 1972a; d, after WRZESNIEWSKI 1861. a, b, d, from life; c, from life?). Ventral views, a = 90 μ m, b = 65 μ m, c = 105 μ m, d = 80 μ m; p 183.

tions, suggesting that they are not conspecific. The population by REUTER (1961) has 3 caudal cirri and is classified as *O. multiseta* (Fig. 51b). The populations by CURDS (1969; Fig. 221h) and PÄTSCH (1974; Fig. 230h) are insufficiently re-described. *Oxytricha similis* should not be confused

with *Tachysoma pellionellum*, which has long dorsal cilia and a single micronucleus between the macronuclear nodules and lacks caudal cirri. The rather similar *Oxytricha longa* and *Urosomoida agiliformis* have fewer transverse cirri. Identification should be confirmed on protargol-impregnated material. Detailed redescription necessary.

Morphology and biology: In life about 80–100 μ m long, 3.8 times as long as broad (KAHL 1932); according to WANG & NIE (1935) in life 60–90 $\times$ 22–27 μ m. Long elliptical, according to ENGELMANN (1862) margins almost parallel. Contractile vacuole slightly in front of mid-body.

Adoral zone of membranelles about 27 % of body-length. Arrangement of frontal, ventral, and transverse cirri obviously genus-specific. Five transverse cirri, protrude distinctly beyond posterior end of cell. Dorsal cilia 2–4 μ m long. Some biochemical data, for example, DNA content of micronucleus, are given by STEINBRÜCK et al. (1981; see also KRAUT et al. 1986) and SCHLEGEL & STEINBRÜCK (1986); however, the identifications are not substantiated by illustrations.

Occurrence and ecology: In the aufwuchs and detritus of mesosaprobic water bodies; not as common as, for instance, *Tachysoma pellionellum*. Locus classicus is a freshwater habitat near Leipzig, Germany (ENGELMANN 1862). WRZESNIEWSKI (1861) found "*O. pellionella*" in a pond in Mokotow near Warsaw, Poland. KAHL (1932) observed *Oxytricha similis* repeatedly in mesosaprobic detritus, and WANG & NIE (1935) collected it from a pond near Tsing-Liang-Shan in Nanking, China.

Table 16 Autecological data of *Oxytricha setigera* (columns 1–5) and *O. similis* (columns 6, 7; see also column 7 of Table 17). References: column 1, from PATRICK et al. (1967; 9 analyses from Savannah River, USA); column 2, from CAIRNS & YONGUE (1973a; 2 areas of Cape Fear River in near Fayetteville, North Carolina, USA); column 3, from DETCHEVA (1983c; rarely in Maritza River, Bulgaria); column 4, from BEREZKY (1977a; high abundance in the summer plankton of Danube River in Hungary); column 5, from FOISSNER et al. (1991; various running waters in Austria, $n = 12-14$, $n_{\text{COD}} = 6$, $n_{\text{NO}_2\text{-N}} = 9$); column 6, from MADONI & GHETTI (1981a; few records from Torrente Stirone, Northern Italy); column 7, from DETCHEVA (1983c; 1 record from Maritza River, Bulgaria)

Parameter ¹	Reference						
	1	2	3	4	5	6	7
Saprobity	-	-	a	-	-	-	a
Frequency (%)	-	-	0.6	-	-	-	0.3
Temperature (°C)	14.5–29	23–27	22.8	22	3.3–10.7	18.5–19	25
pH	6.5–7.0	6.6–7.3	6.6–7.4	7.9	7.0–8.7	7.8–8.5	7.6
O ₂ (mg l ⁻¹)	6.3–10.7	6.6–9.5	3.5–6.2	8.9	7.8–13.1	7.3–8.6	4.6
O ₂ (% saturation)	-	-	41–73	-	74–113	-	57
BOD ₅ (mg l ⁻¹)	0.5–<3	1–6	11–12	7.1	0.7–>7.8	-	7.2
Total hardness (°dH)	-	-	-	-	3.0–12.8	-	-
CO ₂ (mg l ⁻¹)	>1–10	-	-	-	-	-	-
HCO ₃ ⁻ (mg l ⁻¹)	-	-	213–284	-	-	-	277
KMnO ₄ -consumption	-	-	-	-	2.4–25	-	-
COD (mg l ⁻¹)	-	-	-	-	7–15	44–56	-
NH ₄ ⁺ -N (mg l ⁻¹)	0.001–0.17	0.005–0.7	0.04	0.23	0.008–0.95	0.55–1.8	0.04
NO ₂ ⁻ -N (mg l ⁻¹)	-	-	-	0.07	<0.001–0.01	0.11–2.2	-
NO ₃ ⁻ -N (mg l ⁻¹)	0.07–<0.5	0.25–0.84	0.4–1.1	0.61	0.5–6.6	0.7–1.2	0.18
PO ₄ ³⁻ -P (mg l ⁻¹)	0.012–0.1	0.05–0.28	-	-	0.008–0.66	0.35–1.0	-
Cl ⁻ (mg l ⁻¹)	1–<10	12.5–34	17–28	-	0.9–90	88.5–1094	24.5
Fe ²⁺ (mg l ⁻¹)	0.1–0.6	-	0.07–1.5	-	-	-	0.04
Mg ²⁺ (mg l ⁻¹)	<3–3	1.7–5	21	-	-	-	22
Ca ²⁺ (mg l ⁻¹)	-	4–10	60–69	-	-	-	70
SO ₄ ²⁻ (mg l ⁻¹)	2–11	5.7–18	75–167	-	-	-	131

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

Records from freshwater habitats not substantiated by illustrations: mesosaprobic brooks and rivers in Upper Austria (AOÖLR 1992, 1993a–c, 1994a, 1995a–c, BLATTERER 1994); rare in Maritza River, Bulgaria (DETCHEVA 1981); moss samples with varying water content and running waters in Czechoslovakia (MATIS & TIRJAKOVÁ 1994a, TIRJAKOVÁ & MATIS 1987a); underground water in Czechoslovakia (MORAVCOVÁ 1986); slime of polluted waters in England (CURTIS & CURDS 1971); sewage fishponds in Bavaria, Germany (KAUFMANN 1958); Illach River, Germany (FOISSNER 1997a); freshwater basins with organic material from the vicinity of Bonn, Germany (BICK 1967a); alphamesosaprobic river near Krefeld, Germany (HEUSS 1976); very abundant in sandy detritus in Hamburg Harbour, Germany (BARTSCH & HARTWIG 1984); aufwuchs and detritus drifts in Lake Balaton, Hungary (GELLÉRT & TAMÁS 1958, TAMÁS & GELLÉRT 1958); rock pool with

Table 17 Autecological data of *Oxytricha fallax* (columns 1–5), *Gastrostyla muscorum* (column 6), and *Oxytricha similis* (column 7; see also columns 6, 7 of Table 16). References: column 1, from LACKEY (1938a; various limnetic and marine habitats in the USA, $n = 14$); column 2, from CAIRNS & YONGUE (1973a; Cape Fear River near Fayetteville, North Carolina. The values are from “Station 2, year 1970”; no detailed information on sample size); columns 3 and 7, from BICK & KUNZE (1971; summary of literature data); column 4, from MADONI & GHETTI (1981a; Torrente Stirone in Northern Italy. The values are from “Station 8, J.F.”); column 5, from DETCHEVA (1972a, 1975a–c, 1976b, 1977, 1979a, c, 1983a; many analyses from Bulgarian running waters. The data of DETCHEVA 1971, 1975a are identical); column 6, from DETCHEVA (1971, 1975a; 1 analysis from a Bulgarian running water. The data of these two references are identical). Some further data of these references are given in the text

Parameter ¹	Reference						
	1	2	3	4	5	6	7
Frequency (%)	7.3	-	-	-	1.1–5.8	0.9	-
Temperature (°C)	-	25–27	2–56	1.8–7	7–24	12	-
pH	4.6–7.5	6.6–6.7	6.8–7.5	7.6–7.9	6.8–8.3	7.2	8.9–9.8
O ₂ (mg l ⁻¹)	-	6.9–11.4	3–5	11.5–12.7	0.8–10.7	2.3	0–6.3
O ₂ (% saturation)	-	-	-	-	9–97	21	-
BOD ₅ (mg l ⁻¹)	-	3.5–10.3	-	-	2–27	58	-
NH ₄ ⁺ -N (mg l ⁻¹)	-	0.03–0.1	0.23–0.4	-	0.03–1.15	-	0–12.4
NO ₂ ⁻ -N (mg l ⁻¹)	-	-	-	0.02–0.04	0–0.34	0.11	-
NO ₃ ⁻ -N (mg l ⁻¹)	-	0.25–0.4	-	1.6–3.2	0–11	4.27	-
PO ₄ ³⁻ -P (mg l ⁻¹)	-	0.06–0.07	-	0.17–0.2	-	-	-

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

0.34 % salinity near the Biological Station Espeyrend, Norway (REUTER 1963a); Warsaw, Poland (WRZESNIEWSKIEGO 1966); 54 specimens per 25 ml sediment in a eutrophic reservoir near Barcelona, Spain (SALVADÓ CABRÉ 1993, SALVADO & GRACIA 1991; further records from Spain: FERNANDEZ-LEBORANS et al. 1990, FRANCO et al. 1995, GRACIA & IGUAL 1987b, GRACIA et al. 1989, MARGALEF LÓPEZ 1945); Turiec River in Slovakia (TIRJAKOVÁ 1993); Danube River, Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); low salinity lagoons of the Caspian Sea (AGAMALIEV 1973, 1986); lakes in Azerbaijan (ALIEV 1982b); China (SHEN 1980, SHEN & JIANG 1979, SHEN et al. 1995, WANG et al. 1992, YANG 1989); lakes and ponds in the USA (CAIRNS et al. 1973, HENEGBRY & CAIRNS 1980, YONGUE & CAIRNS 1971); Des Plaines River wetlands and New River, USA (HENEGBRY & GORDEN 1989, YONGUE & CAIRNS 1979).

Terrestrial records not substantiated by illustrations (possibly confused with *Urosomoida agilisformis* or *Oxytricha longa*): soils in Szeged, Hungary (HORVÁTH 1950); dry mosses in Bratislava, Czechoslovakia (TIRJAKOVÁ & MATIS 1987b).

Feeds on bacteria, diatoms, filamentous growths, and small colourless flagellates (BICK 1968a, BICK & KUNZE 1971, CURTIS & CURDS 1971). Biomass of 10⁶ individuals about 14 mg (FOISSNER et al. 1991). Some autecological data are shown in Tables 16, 17. *Oxytricha similis* is abundant at alkaline conditions and at high bacterial abundances, es-

pecially in spring and autumn; tolerates 3.7 % salinity (inland natron lake water; BICK 1964).

MATIS (1975) found *O. similis* in road pools in Bratislava, Czechoslovakia, at 1 to 11.5 °C, pH 5.5–6.4, and 5.8–8.4 mg l⁻¹ O₂ and MATIS & STRAKOVÁ-STRIEŠKOVÁ (1991) recorded it from a brook and 2 thermal lakes in Czechoslovakia at 20–38 °C and pH 5–7.3. LEGNER (1975) counted up to 39 ind. ml⁻¹ twelve days after the addition of 0.2 g l⁻¹ glucose and 0.3 g l⁻¹ peptone. Eurythermic (1–38 °C) with an optimum at 10 °C (BICK & BERTRAM 1973, MATIS 1975, MATIS & STRAKOVÁ-STRIEŠKOVÁ 1991, PRIMC 1983).

Oxytricha similis also occurs in percolating filters and activated sludge plants, but is not recorded from Imhoff tanks (BANINA 1983, CURDS 1975, CURDS & COCKBURN 1970a, KUTIKOWA 1984). According to CURDS & COCKBURN (1970b), it is characteristic for activated-sludge plants having effluents of high quality with a BOD₅ <20 mg l⁻¹.

Oxytricha similis indicates beta- and alphamesosaprobic conditions: b-a; b = 5, a = 5, I = 3, SI = 2.5 (FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). This classification largely agrees with the faunistic records and the ecological data. However, the autecology and saprobiology of this species has to be confirmed on reliably determined populations.

Oxytricha siseris VUXANOVICI, 1963 (Fig. 58a–h, Table 15)

1963 *Oxytricha siseris* VUXANOVICI, Studii Cerc. Biol., 15: 215 (Fig. 58a).

1974 *Tachysoma siseris* (VUXANOVICI, 1963) – STILLER, Annls hist.-nat. Mus. natn. hung., 66: 133.

1982 *Oxytricha siseris* VUXANOVICI, 1963 – FOISSNER, Arch. Protistenk., 126: 85 (Fig. 58b–h; authoritative re-description; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: The original description is somewhat superficial. Thus, the redescription by FOISSNER (1982), which largely agrees with the original description, should be considered as authoritative. *Oxytricha siseris* differs from *O. setigera*, among others, in the number of micronuclei and in the shape and arrangement of the undulating membranes, which is not in the typical *Oxytricha* pattern. Cannot be synonymised with *Tachysoma pellionellum* as suggested by BORROR (1972a).

Morphology and biology: In life 80–120 × 35 µm; after VUXANOVICI (1963) only 60–80 µm long in life. Slenderly oval, margins often converging posteriorly, thus posterior end usually narrowly rounded. Macronuclear nodules 11–13 × 5–9 µm (mean = 11.7 × 7.0 µm; n = 11) after protargol impregnation, arranged slightly left of median, always distinctly separated. Each macronuclear nodule with a single, after protargol impregnation about 2.3–2.7 µm (n = 11) sized, globular micronucleus. Contractile vacuole only slightly in front of mid-body, during diastole with 2 long collecting canals. Cortical granules absent. Cytoplasm colourless, posteriorly often with many cytoplasmic crystals.

Fig. 58a-e *Oxytricha siseris* (a, from VUXANOVICI 1963; b-e, from FOISSNER 1982. a-c, from life; d, e, protargol impregnation). a, c) Ventral views, a = 60 μ m, c = 85 μ m. b) Lateral view, 85 μ m. d, e) Ventral and dorsal infraciliature, d, e = 75 μ m; p 187.

Rapid, jerky movement, also swims very fast by rotation about main body axis, rarely gliding.

Adoral zone of membranelles about 1/3 of body length, middle portion slightly displaced to left margin (Fig. 58d, h). Buccal area very small, distinctly excavated, anteriorly hooked. Peristomial lip motile, with peculiar short appendages which do not impregnate with protargol (Fig. 58h). Paroral moderately long, slightly bent, consists of 2 rows of basal bodies, arranged in middle portion of buccal area, distinctly in front of endoral. Endoral almost straight to distinctly curved, probably consists of 2 rows of basal bodies too. Frontal and ventral cirri only slightly, transverse cirri distinctly larger than marginal cirri. According to VUXANOVICI (1963) and FOISSNER (1982), only 3 frontoventral cirri present (Fig. 58a, d); in my opinion, however, the anterior-most cirrus on the postoral area corresponds to the posterior-most frontoventral cirrus of other *Oxytricha* species. Postoral ventral cirri somewhat displaced posteriorly (Fig. 58g, arrowheads). 1 or 2 pretransverse ventral cirri (Fig. 58d, g). Figure 58g is identical to Figure 58d except that the anterior pretransverse ventral cirrus located to the left at about the level of the posterior-most

Fig. 58f-h *Oxytricha siseris* (f, h, from FOISSNER 1982; g, from FOISSNER 1982 slightly modified. f, from life; g, h, protargol impregnation). f) Dorsal view, 90 μ m. g) Ventral infraciliature as in Figure 58d. The arrow-heads mark the 3 postoral ventral cirri; further details, see text. h) Ventral infraciliature of anterior half of cell, bar = 20 μ m. e = endoral, PL = peristomial lip, p = paroral; p 187.

postoral ventral cirrus is shown (reconstructed after unpublished microphotographs kindly supplied by W. FOISSNER). Usually 5, rarely 6, in life about 40 μ m long transverse cirri which protrude far beyond posterior end of cell. Both marginal rows begin at about level of buccal vertex. Marginal cirri in life about 30 μ m long; distance widens posteriorly. Dorsal cilia in life 13 μ m (anterior half) to 20 μ m (posterior half) long, motile. Usually 5, rarely 6 dorsal kineties. Kinty 1 distinctly shortened anteriorly, consists of 18–30 basal body pairs. Constantly 3 ($n = 11$), in life up to 40 μ m long, prominent motile caudal cirri on dorsal kineties 1, 2, and 3 (Fig. 58e); however, morphogenesis will possibly show that they originate from kineties 1, 2, and 4, as in many other species.

Occurrence and ecology: Rare, in freshwater and terrestrial habitats. Locus classicus is a small basin in the botanical garden of Budapest, Romania (VUXANOVICI 1963). FOISSNER (1982) found *Oxytricha siseris* in the alluvial soil of two xerothermic, uncultivated grassland sites and in two wheat fields in the Tullner Feld, Lower Austria; for detailed descriptions of these sites and autecological data, see FOISSNER & PEER (1985,

Fig. 59 *Oxytricha sphagni* (from KAHL 1932). Ventral view from life, 100–120 μm . Note single micronucleus.

“Profile 1, 3, 4, and 6”). FERNANDEZ-LEBORANS & ANTONIO-GARCIA (1988) and FERNANDEZ-LEBORANS et al. (1987) provided some data on the effects of the heavy metals lead, zinc, mercury, and cadmium. They obtained their samples from the Manzanares River, La Pedriza, Spain. TIRJAKOVÁ (1988) found *O. siseris* in 4 of 145 soil samples from different fields in Czechoslovakia. Soil in Brazil (FOISSNER 1997b). Probably feeds on bacteria. Biomass of 10^6 cells about 30 mg (FOISSNER 1987a).

Oxytricha sphagni KAHL, 1932 (Fig. 59)

1932 *Opisthotricha sphagni* KAHL, Tierwelt Dtl., 25: 608.

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; thus the correct name in the original description is *Oxytricha (Opisthotricha) sphagni*, which is a junior secondary homonym of *Oxytricha (Histrio) sphagni* in KAHL (1932). Detailed redescription necessary.

Morphology and biology: In life about 100–120 μm long. Long-elliptical. Contractile vacuole slightly in front mid-body. Adoral zone of membranelles about 27 % of body length. Frontal and transverse cirri only slightly enlarged, transverse cirri distinctly protruding beyond posterior end of cell. Marginal cirri displaced inwards. Dorsal cilia in life about 15 μm long, where not spread but trailing behind. Three distinctly elongated caudal cirri.

Occurrence: Obviously very rare. KAHL (1932) discovered *O. sphagni* in *Sphagnum*, probably somewhere (near Hamburg?) in Germany. Records not substantiated by illustrations: Tibetan Plateau (WANG 1977); Yuelushan Area, China (YANG 1989). Biomass of 10^6 individuals about 17 mg.

Oxytricha sp. (Fig. 60, Table 15)

1986 *Oxytricha* sp. – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 468.

Nomenclature and taxonomy: Very probably this form is not a true *Oxytricha* because the ventral infraciliature differs significantly from the typical *Oxytricha* pattern. The somewhat increased number of transverse cirri is reminiscent of *O. multiseta* and *O. variabilis*, from which it differs, however, in the arrangement of the ventral cirri. Redescription (live observation, morphometric characterisation, dorsal infraciliature) necessary.

Fig. 60 *Oxytricha* sp. (from DRAGESCO & DRAGESCO-KERNÉIS 1986). Ventral infraciliature, protargol impregnation, 105 μ m; p 190.

Morphology and biology: After protargol impregnation about $95 \times 32 \mu\text{m}$. Both ends rounded. Macronuclear nodules after protargol impregnation $14\text{--}19 \mu\text{m}$ (mean = $15 \mu\text{m}$; $n = 12$) long, micronuclei not observed. Adoral zone of membranelles about 36 % of body length. Buccal area large. Buccal cirrus at about level where undulating membranes cross. Arrangement of frontal-ventral-transverse cirri rather unusual. 6 transverse cirri; 2 small pretransverse ventral cirri at about level of anterior-most transverse cirrus. Four not conspicuously elongated caudal cirri in gap between ends of marginal rows. Dorsal infraciliature not described, dorsal cilia probably short.

Occurrence: Freshwater in Benin (Africa).

***Oxytricha tenella* SONG & WILBERT, 1989**
(Fig. 61a–e, Table 15)

1989 *Oxytricha tenella* SONG & WILBERT, *Lauterbornia*, 3: 166 (the slide of holotype specimens is deposited in the College of Fisheries, Ocean University of Qingdao, China).

Nomenclature and taxonomy: *Oxytricha tennella* in SONG & WILBERT (1989, p 219) is an incorrect original spelling. The body shape is reminiscent of *O. fallax*, which is, however, at least twice as long and has no cortical granules. The terrestrial species *O. proximata* is $70\text{--}140 \mu\text{m}$ long and also lacks cortical granules. The terrestrial *O. granulifera* is somewhat longer ($80\text{--}130 \mu\text{m}$) and has differently arranged frontoventral cirri.

Morphology and biology: In life $50\text{--}70 \times 30\text{--}40 \mu\text{m}$. Posterior end broadly, anterior distinctly more narrowly rounded (Fig. 61b, c). Macronuclear nodules in life about $10 \times 15 \mu\text{m}$, after protargol impregnation $9\text{--}15 \times 7\text{--}11 \mu\text{m}$ (mean = $10.9 \times 8.2 \mu\text{m}$; $n = 14$ and 10 , respectively), nodules very closely arranged (Fig. 61a, e). 2–3 (mean = 2.2; $n = 13$) micronuclei. Contractile vacuole in about mid-body or slightly in front; during diastole with short, inconspicuous collecting canals. Cortical granules irregularly arranged (apparently in several layers); colour, shape, and size of granules not mentioned. Cytoplasm slightly yellowish, often dark greyish due to inclusions. Moderately rapid movement.

Fig. 61a-e *Oxytricha tenella* (from SONG & WILBERT 1989. a-c, from life; d, e, protargol impregnation). a-c) Lateral, ventral, and dorsal view, a = 65 μ m, b = 70 μ m, c = 75 μ m. Cortical granules are only shown in (c). d) Ventral infraciliature, 55 μ m. Arrow marks posterior frontoventral cirrus. e) Dorsal infraciliature, 55 μ m.

Adoral zone of membranelles about 37 % of body length. Undulating membranes almost straight, crossing at about middle portion. Buccal cirrus at anterior end of undulating membranes. Constantly ($n = 9$) 18 frontal, ventral, and transverse cirri. Frontal and transverse cirri enlarged, all other cirri rather fine and short (8–12 μm). Posterior fronto-ventral cirrus (Fig. 61d, arrow) distinctly separate from the other 3 cirri. Transverse cirri protrude only slightly beyond posterior end of cell. Marginal rows nearly uninterrupted posteriorly (Fig. 61d). Dorsal cilia in life 2–4 μm long, according to SONG & WILBERT (1989) constantly ($n = 8$) arranged in 4 rows, each of body length, kinety 4 often irregularly interrupted; however, in my opinion, kinety 4 in Figure 61e in fact consists of 2 kineties, namely an anterior dorsomarginal row and a posterior fragment of kinety 3. Invariably 3 ($n = 9$), in life only 5–7 μm long caudal cirri, probably at end of kineties 1, 2, and 4.

Occurrence and ecology: Locus classicus is Bonn, Germany, where SONG & WILBERT (1989) discovered *Oxytricha tenella* in a brook (Melbbach) about 50 m above the Poppelsdorfer Weiher, a eutrophic pond. Feeds on small algae and flagellates. Biomass of 10^6 individuals about 20 mg. Not found since.

Oxytricha variabilis GROLIÈRE, 1975 (Fig. 62)

1975 *Oxytricha variabilis* GROLIÈRE, Protistologica, 11: 490.

Nomenclature and taxonomy: BORY DE SAINT-VINCENT in LAMOUROUX et al. (1824, p 597) used the almost homonymous binomen *Oxitricha variabilis*, which is obviously only an unjustified replacement name for *Trichoda praeceps* MÜLLER, 1786 (see species indeterminata and EHRENBERG 1834, p 1203). Because the original spellings of BORY'S and GROLIÈRE'S name deviate in one letter of the genus name I do not replace GROLIÈRE'S name. *Oxytricha variabilis* is described only after protargol impregnation; thus live observations (for example, cortical granules lacking or present?) and morphometric characterisation necessary.

Morphology and biology: After protargol impregnation $88\text{--}115 \times 27\text{--}40 \mu\text{m}$ (mean = $100 \times 32 \mu\text{m}$; $n = ?$). Body margins nearly parallel, both ends broadly rounded. Macronuclear nodules ovoid or spherical, about 15–17 μm long, usually each nodule with 2 micronuclei.

Adoral zone of membranelles about 40 % of body length, 28–32 membranelles. According to microphotographs by GROLIÈRE (1975), endoral distinctly shorter than paroral.

← According to SONG & WILBERT (1989), dorsal kinety 4 is interrupted (arrowhead and arrow) in mid- body. In my opinion, arrow marks anterior end of kinety 4 and arrowhead denotes posterior end of kinety 5. Kinety 5 is probably a dorsomarginal kinety. CC = caudal cirri, X = gap between posterior end of marginal rows, 4 = dorsal kinety 4; p 191.

Fig. 62 *Oxytricha variabilis* (from GROLIÈRE 1975). Ventral infraciliature, protargol impregnation, 100 μm . Arrowhead marks frontoventral cirrus III/2. Note supernumerary ventral cirri; p 193.

Buccal cirrus at anterior end of undulating membranes. Frontal cirri only slightly enlarged. Number of ventral and transverse cirri rather variable. Cirrus III/2 (Fig. 62e, arrowhead) arranged on left, between migratory cirri, similarly to in the type species *O. granulifera*. Up to 5 postoral ventral cirri. 4–6 transverse cirri, do not protrude on left, protrude slightly beyond posterior end of cell on right. 5 dorsal kineties, dorsal cilia 2–4 μm long. Caudal cirri apparently inconspicuous.

Occurrence and ecology: Locus classicus is a pond in the forest between Randan and St-Yorre, France. A detailed description of this site is given by GROLIÈRE & NJINE (1973). Feeds on bacteria. Biomass of 10^6 individuals about 27 mg. FERNANDEZ-LEBORANS et al. (1987) provided some data on the effects of the heavy metals lead, zinc, mercury, and cadmium; they obtained their samples from the Manzanares River,

La Pedriza, Spain. STRÜDER-KYPKE (1996) recorded *Oxytricha variabilis* from the aufwuchs of dystrophic lakes in Germany.

Oxytricha auripunctata BLATTERER & FOISSNER, 1988 (Fig. 63a–e, Table 15)

1988 *Oxytricha auripunctata* BLATTERER & FOISSNER, *Stapfia*, 17: 61 (1 slide of holotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: The decreased number and the small size of the transverse cirri and the arrangement of the frontoventral cirri is reminiscent of *Urosomoida*. BLATTERER & FOISSNER (1988) could not count the number of dorsal kineties exactly, but they supposed that it has 5. Since all *Urosomoida* species invariably have 4 kineties, I agree with the original classification. *Oxytricha auripunctata* differs from other soil species with cortical granules (*O. granulifera*, *O. rubripuncta*, *O. longigranulosa*) in morphometric characters and the shape and colour of the cortical granules. *Oxytricha auripunctata* should not be confused with the terrestrial *Urosomoida dorsiincisura*, which also has yellowish cortical granules, but 4–6 macronuclear nodules.

Morphology and biology: In life 80–130 $\times$ 25–35 μm . Elliptical, both ends moderately narrowly rounded, right margin usually straight, left distinctly convex. Two

Fig. 63a-e *Oxytricha auripunctata* (from BLATTERER & FOISSNER 1988. a-d, from life; e, protargol impregnation). a) Ventral view, 90 μm . b) Part of pellicle with irregular rows of cortical granules. c, d) Lateral and dorsal view. e) Ventral infraciliature, 90 μm . Arrow marks right frontal cirrus; p 194.

macronuclear nodules, after protargol impregnation $12-16 \times 3.8-6.3 \mu\text{m}$ (mean = $14.5 \times 4.9 \mu\text{m}$; $n = 14$). 1-5 (mean = 2.3 ; $n = 14$) spherical micronuclei, after protargol impregnation $1.4-2.1 \mu\text{m}$ (mean = $1.5 \mu\text{m}$; $n = 14$) across. Contractile vacuole about in mid-body, during diastole with 2 collecting canals. Cortical granules about $0.5 \mu\text{m}$ across, orange-yellow, stain with protargol, arranged around cirri and in rather disorganised rows on ventral surface (Fig. 63b). Cytoplasm filled with $2-4 \mu\text{m}$ sized, greasy globules and many $3-7 \mu\text{m}$ sized, yellowish crystals; these inclusions and the cortical granules give *O. auripunctata* an orange-yellow colour at low magnifications. Slow movement.

Adoral zone of membranelles about 28 % of body length. Frontal cirri slightly enlarged, bases of all other cirri of about same size. Frontal, ventral, and marginal cirri in life about $12 \mu\text{m}$ long; 3-4 (mean = 3.8 ; $n = 20$), in life about $18 \mu\text{m}$ long transverse cirri, protrude distinctly beyond posterior end of cell. Postoral ventral cirri arranged about in a line in median of cell. In 1 of 20 specimens a surplus cirrus between postoral and pre-transverse ventral cirri. Marginal rows distinctly separate posteriorly, right one slightly

shortened anteriorly. Distance between left marginal cirri becomes wider toward rear (Fig. 63e). Dorsal cilia in life about 2 μm long, probably arranged in 5 kineties (difficult to discern because cortical granules stain with protargol!). Usually 3, sometimes (4 of 20 specimens) 4–5 caudal cirri dorsally arranged in gap between marginal rows.

Occurrence and ecology: Likely confined to terrestrial habitats. Locus classicus is Tailem Bend near Adelaide, Australia, where BLATTERER & FOISSNER (1988) discovered *O. auripunctata* in mosses of a natural pine forest, and also found it in litter and roots under mosses of the same site. Also recorded from Costa Rica (FOISSNER 1997b). Feeds on fungi, heterotrophic flagellates, and ciliates. Biomass of 10^6 cells 25 mg.

Oxytricha bimembranata SHIBUYA, 1929 (Fig. 64)

1929 *Oxytricha bimembranata* SHIBUYA, Proc. imp. Acad. Japan, 5: 155.

1930 *Oxytricha bimembranata* SHIBUYA – SHIBUYA, J. imp. agric. Exp. Stn Nishigahara, 1: 200 (Fig. 64).

1932 *Oxytricha bimembranata* SHIBUYA, 1929 – KAHL, Tierwelt Dtl., 25: 602.

Taxonomy: The drawings of SHIBUYA (1929, 1930) are more or less identical. I do not agree with BORROR (1972a) that this terrestrial species is synonymous with the freshwater species *O. fallax* although it has about the same size and a similar body shape.

Identity with *O. proximata* SHIBUYA, 1930 cannot be excluded (Fig. 75h). The MATIS & DANIŠKOVÁ (1972) population is classified as *Sterkiella histriomuscorum*. Detailed redescription necessary.

Morphology and biology: In life 150–200 μm long, almost three times as long as broad. Elongate-elliptical, margins slightly converging anteriorly and rather oblique on anterior left and posterior right borders. Contractile vacuole at level of buccal vertex. Cortical granules absent. Adoral zone of membranelles about 1/3 of body length. Frontal and transverse cirri only slightly enlarged. Pretransverse ventral cirri displaced somewhat anteriad. Five transverse cirri, the left 4 protrude slightly beyond posterior end of cell. Marginal rows distinctly separate posteriorly. Caudal cirri and dorsal cilia not mentioned, probably inconspicuous and, respectively, short.

Occurrence: Probably confined to terrestrial habitats. Locus classicus is Tokyo, Japan, where SHIBUYA (1929) discov-

Fig. 64 *Oxytricha bimembranata* (from SHIBUYA 1930). Ventral view from life, 150–200 μm .

ered *O. bimembranata* in the soil of the experimental farm at Nishigahara. NIKOLJUK & GELTZER (1972; the illustration is from KAHL 1932) found it in soils of the USSR. BAMFORTH (1963; without description and illustration!), however, recorded it from freshwater in south-eastern Louisiana, USA. Biomass of 10^6 individuals about 150 mg.

Oxytricha granulifera FOISSNER & ADAM, 1983 (Fig. 21a, 65a–z, 66a–g, 67a–g, Tables 3, 4, 15, 18)

1983 *Oxytricha granulifera* FOISSNER & ADAM, Zool. Scr., 12: 1 (Fig. 65a–z, 66a–g; 1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1989 *Oxytricha granulifera* FOISSNER and ADAM, 1983 – FOISSNER, Sber. öst. Akad. Wiss., 196: 235.

Nomenclature and taxonomy: FOISSNER (1989) proposed *O. granulifera* as the type species of *Oxytricha* (for details, see the relevant chapter in the genus section). The subspecies, *O. granulifera quadricirrata* BLATTERER & FOISSNER, 1988, is classified as separate species (Fig. 78a, b).

Morphology and biology: In life $80\text{--}130 \times 35\text{--}50\text{ }\mu\text{m}$. Outline rather constant, broad to slender oval, posterior end usually broadly rounded, very rarely slightly tapered, anterior portion usually distinctly narrowed. Right margin slightly convex to slightly concave, left always distinctly convex (Fig. 65a, b). Macronuclear nodules in life about $22 \times 9\text{ }\mu\text{m}$, after protargol impregnation $10\text{--}20 \times 7\text{--}9\text{ }\mu\text{m}$ (mean = $14.4 \times 7.7\text{ }\mu\text{m}$; $n = 25$). Distance between macronuclear nodules after protargol impregnation $7\text{--}17\text{ }\mu\text{m}$ (mean = $10.7\text{ }\mu\text{m}$; $n = 25$). Constantly 2 ($n = 25$), in life about $5 \times 4\text{ }\mu\text{m}$ sized micronuclei. Contractile vacuole about in mid-body, during diastole with 2 short collecting canals. Cytopyge on right posterior margin. Pellicle and cytoplasm colourless. Cortical granules colourless to slightly yellowish, absent only along dorsal kineties and marginal rows (Fig. 65b, 67a, b, f). Granules stain slightly red with methyl green-pyronin, are not ejected, and render specimens a weak yellow-brown shade. Cells, especially in posterior portion, packed with yellowish, $2\text{--}4\text{ }\mu\text{m}$ sized crystals. Moderately rapid movement, often stands almost still, attaches closely to soil particles.

Adoral zone of membranelles about $1/3$ of body length. Bases of largest membranelles in life about $7\text{ }\mu\text{m}$ broad. Buccal cavity moderately deep. Frontal, ventral, and transverse cirri only very slightly larger than marginal cirri. Frontoventral cirrus III/2 located on left, between migratory cirri VI/3 and VI/4 (Fig. 65f). Cirrus IV/3 displaced distinctly posteriad. Anterior pretransverse ventral cirrus (cirrus V/2) arranged more anteriorly than in *O. quadricirrata* (compare Fig. 65f with Fig. 78a). Transverse cirri in life about $22\text{ }\mu\text{m}$ long, protrude distinctly beyond posterior end of cell. Number of frontal, frontoventral, postoral ventral, and pretransverse ventral cirri constantly 3, 4, 3, and 2, respectively ($n = 25$). Marginal cirri in life about $12\text{ }\mu\text{m}$ long, bases posteriorly distinctly smaller than anteriorly. Caudal cirri in life about $15\text{ }\mu\text{m}$ long, difficult to distinguish from

Fig. 65a-g *Oxytricha granulifera* (from FOISSNER & ADAM 1983b. a-d, from life; e, wet silver impregnation; f, g, protargol impregnation). a) Ventral, dorsal, and lateral view, a, c = 110 μ m, b = 130 μ m. The colourless, 0.5-1.0 μ m sized, spherical cortical granules are arranged in longitudinal rows. d) Cyst, 32 μ m. e) Part of silverline system of ventral surface, bar = 18 μ m. f, g) Ventral and dorsal infraciliature, f, g = 85 μ m. Arrows in (f) mark pretransverse ventral cirri, arrowhead denotes frontoventral cirrus III/2. CW = cyst wall, G = granules on cyst wall, Ma = macronucleus, S = mucous layer; p 197.

Fig. 65h–m *Oxytricha granulifera* (from FOISSNER & ADAM 1983b. h–m, ventral [h, j, l] and dorsal [i, k, m] infraciliature of morphogenetic stages after protargol impregnation). h, i) Very early stage, 90 μ m. j–m) Early stages, j, k = 85 μ m, l, m = 80 μ m. OP = oral primordium; p 197.

Fig. 65n-s *Oxytricha granulifera* (from FOISSNER & ADAM 1983b. Ventral [n, p, r] and dorsal [o, q, s] infra-ciliature of morphogenetic stages after protargol impregnation). n, o) Early stages, 90 μ m. p-r) Middle stages. AM = new adoral membranelles, PO = primordium of cirri and undulating membranes of opisthe; p 197.

Fig. 65t-w *Oxytricha granulifera* (from FOSSNER & ADAM 1983b. t-w, ventral [t, v] and dorsal [u, w] infraciliature of morphogenetic stages after protargol impregnation). t, u) Middle stage, 85 μm. v, w) Late stage, 70 μm. 1-6 = primordia of the frontal-ventral-transverse cirri of proter and opisthe respectively; p 197.

Fig. 65x-z, 66a-c *Oxytricha granulifera* (from FOISSNER & ADAM 1983b. x-z, a-c, ventral [x, a] and dorsal [y, z, b, c] infraciliature of morphogenetic stages after protargol impregnation). x-z) Late stages, x, y = 85 μ m, z = 75 μ m. a-c) Very late stages, a, b = 85 μ m, c = 100 μ m. Parental cirri white, new cirri black; p 197.

Fig. 66d–g *Oxytricha granulifera* (from FOISSNER & ADAM 1983. d–g, ventral [d, f] and dorsal [e, g] infracilia-
ture of morphogenetic stages after protargol impregnation). d, e) Very late stage, 110 µm. f, g) Opisthe, 55 µm.
Parental cirri white, new cirri black; p 197.

cirri of left marginal row; usually 1 cirrus each on dorsal kineties 1, 2, and 4. Dorsal cilia in life about 3 µm long. Invariably 5 ($n = 25$) dorsal kineties (Fig. 65g, 67g). Kinity 1 anteriorly distinctly and kinity 3 posteriorly slightly shortened. Kinity 4 begins somewhat behind mid-body. Kinity 5 (= dorsomarginal row) terminates slightly in front of mid-body.

Fig. 67a–c *Oxytricha granulifera* (original SEM micrographs, kindly supplied by W. FOISSNER). **a)** Ventral view. The small, bright dots are extruded cortical granules. **b)** Cortical granules. **c)** Ventral view of a very early morphogenetic stage showing longitudinal oral primordium (arrow; cp. Fig. 65j); p 197.

Cysts in life about 32 μm across, colourless to slightly yellow-brown. Cyst wall smooth, thin, and rather densely covered with 1.4–2.8 μm sized, slightly orange coloured granules embedded in a mucous layer surrounding the cyst (Fig. 65d); presumably, these granules originate by fusion of the cortical granules of the non-encysted specimens. Cytoplasm densely granulated, with some about 5 μm sized, shining inclusions. Macronucleus irregularly spherical.

Morphogenesis of cell division is described minutely by FOISSNER & ADAM (1983b). For details, see Figures 65h–z, 66a–g, 67c, and Tables 3, 4. The anlagen formation proceeds identically to in *Allotricha antarctica* (Table 4), strongly indicating a close relationship of *Oxytricha* and *Allotricha* (Fig. 25a, b).

Some biochemical and genetic data on *O. granulifera* are provided by GREENWOOD et al. (1991a, b), PALMEDO & AMMERMAN (1997a, b), SCHLEGEL (1985, 1991), and SCHLEGEL & STEINBRÜCK (1986; see also SCHLEGEL et al. 1996). The small subunit rRNA sequence is 1758 bases long, the G + C content is 46 % (LEIPE et al. 1994, SCHLEGEL et al. 1991).

Occurrence and ecology: Common; very likely confined to terrestrial habitats. Locus classicus is the soil of a deciduous forest (*Fagus sylvatica*, *Quercus robur*, *Galium odoratum*, *Convallaria majalis*), about 1 km north of the village of Baumgarten in Lower Austria (FOISSNER & ADAM 1983b). A detailed description of this site and autecological data are given by FOISSNER et al. (1985, "Profil 7"). They found *O. granulifera* also in the soil of wheat fields, xerothermic uncultivated grassland, and humid lowland sites. Detailed autecological data of an alpine population are given in FOISSNER & PEER (1985). Further records: soil of a paddy field in Japan (W. FOISSNER, pers. comm.); bark of *Acacia* trees in Costa Rica (FOISSNER 1994c, 1997b); Peru (FOISSNER 1997b); various soil samples from Australia (BLATTERER & FOISSNER 1988); soil from Marion Island, South Atlantic Ocean (FOISSNER 1996).

Feeds on bacteria, fungi, and heterotrophic flagellates. Can be cultured in lettuce medium diluted 1:1 with table water (Eau de Volvic, France) and with some wheat grains to

Table 18 Metal accumulation and distribution in cadmium-treated cells of *Oxytricha granulifera*, *Stylonychia lemnae*, and *S. notophora* ($\mu\text{g g}^{-1}$ dry weight; from PICCINI et al. 1992). *Stylonychia notophora* was obtained from G.R. SAPRA; this population is classified as *S. pustulata* in this book)

Species				Cd		Zn		
	Treatment μM of Cd		Total homogenate	Supernatant (% total metal)	Pellet (% total metal)	Total homogenate	Supernatant (% total metal)	Pellet (% total metal)
<i>O. granulifera</i>	-	day 1	-	-	-	1400	6	94
		day 3	-	-	-	1700	3	97
<i>O. granulifera</i>	50	day 1	2900	40	60	2500	7	93
		day 3	5500	10	90	3000	20	80
<i>S. lemnae</i>	2.5	day 1	185	25	75	2765	30	70
		day 2	635	6	94	2625	10	90
<i>S. notophora</i>	15	day 1	1780	12	88	1790	5	95

support bacterial growth. Biomass of 10^6 individuals about 72 mg (FOISSNER 1987a). *Oxytricha granulifera* is much more sensitive to copper than to cadmium (IRATO et al. 1993). 50 μM cadmium (as $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) did not damage the cells, whereas 20 μM copper killed them in one day and 10 μM in three days. One-day exposure to cadmium induced an accumulation of $3000 \mu\text{g Cd g}^{-1}$ of dry weight, 30 % of which was present in the cytosol (IRATO et al. 1991, Table 18). Detoxification mechanisms, see IRATO et al. (1995), PICCINNI (1992), and PICCINNI et al. (1992).

Oxytricha islandica BERGER & FOISSNER, 1989 (Fig. 68a–f, Table 15)

1989 *Oxytricha islandica* BERGER & FOISSNER, Bull. Br. Mus. nat. Hist., 55: 37 (1 slide of holotype specimens, reference number 1988:2:1:15, and 1 slide of paratype specimens, reference number 1988:2:1:16, are deposited in the British Museum of Natural History in London).

Taxonomy: The 4 dorsal kineties are reminiscent of *Urosomoida*. Indeed, at superficial live observation it can be easily confused with *U. dorsiincisura*, which has the same size and nuclear apparatus. However, this species has cortical granules and only 2–3 transverse cirri (including the pretransverse ventral cirri). In *O. islandica* the frontoventral cirri are arranged as in the type species of *Oxytricha*, *O. granulifera*, and 2 pretransverse ventral and 5 transverse cirri are invariably present. Confusion with other quadrinucleate oxytrichids, for example, *Cyrtohymena quadrinucleata* or *Sterkiella cavicola*, is unlikely.

Morphology and biology: In life $100\text{--}140 \times 35\text{--}45 \mu\text{m}$. Long elliptical, right margin sometimes straight, both ends rounded. Slightly contractile. Macronuclear nodules in life about $13 \times 10 \mu\text{m}$, after protargol impregnation $9\text{--}17 \times 7\text{--}8 \mu\text{m}$ (mean = $13.1 \times 7.4 \mu\text{m}$; $n = 10$), arranged in line almost in median of cell (Fig. 68a, f). 1 or 2 (mean = 1.8; $n = 10$) micronuclei, in life about $4 \mu\text{m}$ across. Contractile vacuole somewhat in front of mid-body, during diastole without distinct collecting canals. Cortical granules lacking. Cytoplasm colourless, posterior portion packed with cytoplasmic crystals and food vacuoles. Rapid movement.

Adoral zone of membranelles about 31 % of body length. Bases of largest membranelles in life about $7 \mu\text{m}$ wide. Buccal area flat, undulating membranes nearly straight. Typical *Oxytricha* cirral pattern with constantly ($n = 10$) 3 frontal cirri, 1 buccal cirrus, 4 frontoventral cirri, 3 postoral ventral cirri, 2 pretransverse ventral cirri, and 5 transverse cirri. Frontal and marginal cirri in life about $15 \mu\text{m}$, transverse cirri about $22 \mu\text{m}$ long. Usually 4 (as in *Urosomoida*!), sometimes (1 of 10 specimens) 5 dorsal kineties. Kineties

← Fig. 67d–g *Oxytricha granulifera* (original SEM micrographs, kindly supplied by W. FOISSNER). d, g) Ventral and dorsal view of anterior cell portion showing frontoventral cirrus III/2 (arrow) and dorsal bristles. e) Left lateral view. f) Detail showing some marginal cirri, and ejected cortical granules arranged in short, longitudinal rows; p 197.

Fig. 68a-f *Oxytricha islandica* (from BERGER & FOISSNER 1989a. a-d, from life; e, f, protargol impregnation). a, b) Ventral and lateral view, a = 120 μ m, b = 110 μ m. c, d) Shape variants in ventral view, c, d = 130 μ m. e, f) Ventral and dorsal infraciliature, e, f = 102 μ m; p 207.

1–3 distinctly bent, kinety 1 slightly shortened anteriorly, kinety 4 terminates roughly in mid-body. Dorsal cilia in life about 3 µm long. Caudal cirri on dorsal kineties 1–3.

Occurrence and ecology: Very probably confined to terrestrial habitats. *Locus classicus* is the soil of a pasture with *Deschampsia caespitosa* and moss (pH 5.8), about 100 m from the shore on the Vatnsney peninsula, “Hritserkur”, Iceland (BERGER & FOISSNER 1989a). FOISSNER et al. (1990) found *O. islandica* in the soil of a meadow in Aigen in Styria, Austria. Feeds on cysts of amoebas. Biomass of 10⁶ individuals about 50 mg.

Oxytricha lanceolata SHIBUYA, 1930 (Fig. 69a–l, 70a–c, Tables 3, 15)

1930 *Oxytricha lanceolata* SHIBUYA, J. imp. agric. Exp. Stn Nishigahara, 1: 210, 214 (Fig. 69a).

1935 *Oxytricha lanceolata* SHIBUYA, 1930 – KAHL, Tierwelt Dtl., 30: 841.

1987 *Oxytricha lanceolata* SHIBUYA, 1930 – BERGER & FOISSNER, Zool. Jb., 114: 219 (Fig. 69g–l; authoritative redescription; 1 slide of neotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1989 *Oxytricha lanceolata* SHIBUYA, 1930 – BERGER & FOISSNER, Bull. Br. Mus. nat. Hist., 55: 39 (Fig. 69b–f; 1 slide of protargol-impregnated specimens, reference number: 1988.2:1:17, is deposited in the British Museum of Natural History in London).

1996 *Oxytricha lanceolata* SHIBUYA, 1930 – FOISSNER, Acta Protozool., 35: 116 (Fig. 70a–c).

Nomenclature and taxonomy: KAHL (1932, 1935) divided *Oxytricha* into subgenera; the correct name in his revision is thus *Oxytricha (Oxytricha) lanceolata*. The habitat and the morphology of the populations described by BERGER & FOISSNER (1987a, 1989a) correspond very well with the original description, which is, however, based on living observations only. The Antarctic population described by FOISSNER (1996b) agrees very well with the Eurasian populations (BERGER & FOISSNER 1989a, SHIBUYA 1930); only the frontoventral cirrus III/2 and pretransverse cirrus V/2 are somewhat differently arranged. Both cirri are displaced slightly posteriad in the Antarctic population (cp. Fig. 69c, j, l with 70c). Very likely, *Oxytricha lanceolata* is confined to terrestrial habitats. Hence it may not be synonymised with the coloured freshwater species, *O. aeruginosa*, as suggested by BORROR (1972a).

Morphology and biology: In life about 90–110 × 30–50 µm. Outline long elliptical or lanceolate, equally rounded at both ends. Anterior portion sometimes slightly narrowed (Fig. 69b, f, h). Distinct dorsal furrow anteriorly. Macronuclear nodules in life 21 × 10 µm, after protargol impregnation 13–21 × 7–10 µm (mean = 15.3 × 7.8 µm; n = 12). 1–3, usually 2, in life about 3 µm sized spherical micronuclei. Contractile vacuole slightly in front of mid-body, during diastole with 2 inconspicuous collecting canals. Cytoplasm colourless, opaque by small (<1 µm), greasy granules (no cortical granules!); posterior portion of cell packed with 3–8 µm sized, colourless globules and 2–7 µm sized crystals. Very rapid movement, sliding hastily to and fro.

Fig. 69a-f *Oxytricha lanceolata* (a, from SHIBUYA 1930; b-f, from BERGER & FOISSNER 1989a. a, b, e, f, from life; c, d, protargol impregnation). a, b) Ventral views, a = 90–100 μm , b = 110 μm . c, d) Ventral and dorsal infraciliature, c, d = 105 μm . e, f) Lateral and dorsal view, e, f = 130 μm ; p 209.

Adoral zone of membranelles about 30 % of body length, cilia of distal membranelles about 13 μm long. Undulating membranes almost straight. Frontal cirri slightly enlarged, in life about 16 μm long. Usually 4, rarely 3 (Fig. 69j) or 5 frontoventral cirri. All postoral ventral cirri immediately behind buccal vertex. Usually 5, rarely (1 of 12 specimens) 6 enlarged transverse cirri, slightly cup-shaped, in life about 28 μm long. Marginal cirri 13–15 μm long; left row J-shaped, terminates at posterior end of cell, right one terminates at level of posterior transverse cirrus. Dorsal cilia in life 3–4 μm long. Constantly ($n = 12$) 4 dorsal kineties, kinety 1 slightly shortened anteriorly, kinety 4 terminates in mid-body. Usually 1 caudal cirrus each on dorsal kineties 1–3, sometimes 2 on each of these kineties; caudal cirri not conspicuously elongated but rather motile.

Antarctic population (Fig. 70a–c) in life 80–120 μm long; invariably ($n = 11$) 2 micronuclei; 4–7 (mean = 4.6; $n = 11$) frontoventral cirri; usually 2, rarely 3 (mean = 2.1; $n = 11$) pretransverse ventral cirri; usually 5, rarely 6 (mean = 5.2; $n = 11$) transverse cirri; usually 4, rarely 5 (mean = 4.1; $n = 11$) dorsal kineties.

Stomatogenesis begins with the formation of a long and narrow oral primordium which extends from left transverse cirrus to posterior postoral ventral cirrus (Fig. 69l).

Fig. 69g-l *Oxytricha lanceolata* (from BERGER & FOISSNER 1987a, g-i, from life; j-l, protargol impregnation). g-i) Ventral, dorsal, and right lateral view, g = 100 μ m, h, i = 110 μ m. j, k) Ventral and dorsal infraciliature of a specimen with only 3 frontoventral cirri and only 2 caudal cirri, j, k = 90 μ m. l) Ventral infraciliature of a very early morphogenetic stage, 85 μ m. Arrowheads mark 3 caudal cirri; p 209.

Fig. 70a–c *Oxytricha lanceolata* (from FOISSNER 1996b. a, from life; b, c, protargol impregnation). a) Ventral view, 97 μ m. b, c) Ventral and dorsal infraciliature, 107 μ m. Arrow and arrowhead in (b) marks frontoventral cirrus III/2 and pretransverse ventral cirrus V/2, respectively, which are slightly displaced posteriad as compared to the Eurasian populations (cp. with Fig. 69c, j, l). Arrow in (c) marks a short, fifth dorsal kinety found in few specimens; p 209.

Occurrence and ecology: Common in terrestrial habitats. Locus classicus is the soil from a field at Miyako-mura near Chiba, Japan (SHIBUYA 1930). BERGER & FOISSNER (1987a) found *O. lanceolata* in the upper soil layer (0–5 cm) of a conventionally farmed pasture near the village of Seekirchen, Austria. Autecological data of this population are given by FOISSNER et al. (1987a, Versuchsfläche F). BERGER & FOISSNER (1989a) found it in a reddish soil of a heath with grass, about 1800 m above sea-level on the Pico de Arieiro, Madeira, Portugal. FOISSNER (1996b) found *O. lanceolata* in a bulked sample

(wet *Bryum* moss from edge of meltstream; algae from meltstream; *Bryum* moss from dry area near stream) from Garwood Valley, South Victoria Land. Further records: upper soil layer of a flood plain dominated by *Alnetum incanae* (pH 7.2) near the Rotmoos in the Fuscher Tal, Austria (FOISSNER 1987b); soil from the islands Corsica, France, and Bornholm, Denmark (W. FOISSNER, pers. comm.); soils in Belgium (CHARDEZ 1967, CHARDEZ & KRIZELJ 1970); subtropical soils in China (SHEN et al. 1992); Brazil and Tasmania (FOISSNER 1997b); soil from Gough and Marion island, South Atlantic Ocean (FOISSNER 1996c).

Feeds on bacteria, fungi, globular green algae, and heterotrophic flagellates. Biomass of 10^6 individuals about 70 mg (FOISSNER 1987a).

Oxytricha longigranulosa BERGER & FOISSNER, 1989 (Fig. 71a–h, Tables 3, 15)

1988 *Oxytricha longigranulosa* BERGER & FOISSNER, 1989 – BLATTERER & FOISSNER, *Stapfia*, 17: 65 (1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1989 *Oxytricha longigranulosa* BERGER & FOISSNER, *Bull. Br. Mus. nat. Hist.*, 55: 39 (Fig. 71a–c, e–h; 1 slide of holotype specimens, reference number 1988:2:1:18, and 1 slide of paratype specimens, reference number 1988:2:1:19, are deposited in the British Museum of Natural History in London).

Morphology and biology: The BLATTERER & FOISSNER (1988) population is somewhat smaller than the type population; however, the important characters agree rather well (Table 15). In life about $135 \times 55 \mu\text{m}$, sometimes only $80 \times 35 \mu\text{m}$. Elliptical, right margin straight, left one distinctly vaulted at level of contractile vacuole. Both ends rounded. Macronuclear nodules in life $18\text{--}21 \times 10\text{--}11 \mu\text{m}$, after protargol impregnation $12\text{--}17 \times 7\text{--}9 \mu\text{m}$ (mean = $14.8 \times 7.6 \mu\text{m}$; $n = 13$), according to BLATTERER & FOISSNER (1988) $9\text{--}11 \times 5\text{--}7 \mu\text{m}$ ($n = 10$, protargol impregnation). 1–2, according to BLATTERER & FOISSNER (1988) 2–6, after protargol impregnation $2\text{--}3 \mu\text{m}$ sized, almost spherical micronuclei; if only one micronucleus is present, it is not located between the 2 macronuclear nodules as, for example, in *Oxytricha setigera*. Contractile vacuole in front of mid-body, during diastole without collecting canals (possible rather inconspicuous). Cortical granules colourless, anterior with an inconspicuous knob, stain red with methyl green-pyronin, but are not ejected (Fig. 71b–d). Cytoplasm colourless, with many about $5 \mu\text{m}$ sized greasily shining globules and many food vacuoles. Gliding movement, sometimes nearly jumping.

Adoral zone of membranelles about 1/3 of body length. Bases of largest membranelles in life about $7 \mu\text{m}$ broad. Buccal area flat, undulating membranes almost straight. Bases of all cirri of nearly same size. Typical *Oxytricha* cirral pattern (Fig. 71f). Type material constantly with 5 ($n = 13$) transverse cirri, population of BLATTERER & FOISSNER (1988) sometimes (3 of 10 specimens) with only 3 transverse cirri. Marginal and transverse cirri in life $12\text{--}15 \mu\text{m}$ and $18\text{--}22 \mu\text{m}$ long, respectively. Constantly 6 dorsal kineties. Kineties 1 and 2 of about body length, kinety 3 with a bend to the right at poste-

rior end and kinety 4 distinctly bent to the left anteriorly so that the connection (before fragmentation) of these 2 kineties is still recognisable (Fig. 71g, dotted line). Kinety 5 half of body length, kinety 6 consists of about 4 basal body pairs only. Dorsal cilia in life 3–4 μm long. Caudal cirri on kineties 1, 2, and 4.

Stomatogenesis commences with the proliferation of basal bodies near the transverse cirri and near the postoral ventral cirri (Fig. 71h). Dorsal morphogenesis very likely in *Oxytricha* pattern (with 2 dorsomarginal kineties).

Occurrence and ecology: Rather certainly confined to terrestrial habitats. Locus classicus is a brown soil of a deciduous forest with fragments of leaves and roots (pH 3.5) from Mt Kura-Take, Amakusa Kumamoto Prefecture, Japan (BERGER & FOISSNER 1989a). BLATTERER & FOISSNER (1988) found *O. longigranulosa* in barks overgrown with lichens and mosses from a secondary pine forest (Scots Pine, *Pinus silvestris*) on the area of a tropical forest between Cairns and Innisfail, Australia. FOISSNER (1997b and pers. comm.) found it in soil samples from Kenya, Panama, and Brazil, FOISSNER (1996c) in soil from Marion Island (South Atlantic Ocean). BONKOWSKI (1996) observed it in leaf litter of a beech forest in Germany, indicating that *Oxytricha longigranulosa* is a cosmopolitan. Feeds on bacteria, fungal spores, heterotrophic flagellates, naked amoebas, and ciliates. Biomass of 10^6 individuals about 100 mg (type material).

Oxytricha nauplia BERGER & FOISSNER, 1987 (Fig. 72a–d, Table 15)

1987 *Oxytricha nauplia* BERGER & FOISSNER, Zool. Jb. Syst., 114: 219 (1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: Differs from other small to medium sized *Oxytricha* species mainly in the body shape, the ventral cirral pattern, the number and arrangement of the dorsal kineties, and the habitat. Identification, however, has to be proved on protargol-impregnated specimens.

Morphology and biology: In life 80–100 $\times$ 40 μm . Elliptical to almost parallel sided, anterior portion converging. Macronuclear nodules in life about 21 $\times$ 10 μm , after protargol impregnation 10–14 $\times$ 6–9 μm (mean = 11.1 $\times$ 7.8 μm ; n = 10). Distance between macronuclear nodules after protargol impregnation 3–9 μm (mean = 5.4 μm ; n =

← Fig. 71a–h *Oxytricha longigranulosa* (a–c, e–h, from BERGER & FOISSNER 1989a; d, original, kindly supplied by W. FOISSNER. a–c, e, from life; d, methyl green-pyronin staining; f–h, protargol impregnation). a) Ventral view, 130 μm . b) Colourless, rod-shaped extrusomes (about 2.0 $\times$ 0.5 μm) in lateral view. c, d) Dorsal and ventral view. Extrusomes (cortical granules) arranged in short rows. Arrow in (d) marks an extrusome in lateral view, c = 150 μm . e) Lateral view. f, g) Ventral and dorsal infraciliature, f, g = 100 μm . Dotted line in (g) connects posterior end of dorsal kinety 3 and anterior end of dorsal kinety 4. h) Ventral infraciliature of an early morphogenetic stage, 100 μm ; p 213.

Fig. 72a–d *Oxytricha nauplia* (from BERGER & FOISSNER 1987a. a, b, from life; c, d, protargol impregnation). a, b) Ventral and dorsal view, a = 110 μm , b = 125 μm . c, d) Ventral and dorsal infraciliature, c, d = 70 μm ; p 215.

10). 2–3 in life 2–3 μm sized spherical micronuclei. Contractile vacuole about in mid-body. Cortical granules lacking. Cytoplasm colourless, packed with 2–5 μm sized crystals, shining globules, and food vacuoles. Rapid movement.

Adoral zone of membranelles about 1/3 of body length, bases of largest membranelles in life about 7 μm broad. Buccal area flat and very narrow. Bases of frontal cirri only slightly enlarged. Right frontal cirrus between distal end of adoral zone of membranelles and anterior end of right marginal row. Invariably 4 frontoventral cirri which are, however, not arranged in typical *Oxytricha* pattern (Fig. 72c). Constantly 5 transverse cirri displaced somewhat anteriad so that they protrude only slightly beyond posterior end of cell; bases only slightly enlarged, arranged in an almost longitudinally orientated hook. All cirri in life about 20 μm long. Dorsal cilia in life 2 μm long, constantly arranged in 5 rows ($n = 10$). Kineties 1–4 unshortened, kinty 5 terminates at about level of buccal vertex (Fig. 72d). Usually 3, rarely 4 very motile caudal cirri.

Occurrence and ecology: Probably confined to terrestrial habitats. Locus classicus is the upper soil layer (0–5 cm) of a salt soil with rushes, about 50 m from the

sea in the Nauplia Bay, Peloponnesus, Greece (BERGER & FOISSNER 1987a). Also recorded from Costa Rica (FOISSNER 1997b). Feeds on fungal spores and flagellates, like *Anisomonema* sp. and *Euglena viridis*. Biomass of 10^6 cells about 26 mg (FOISSNER 1987a).

***Oxytricha opisthomuscorum* FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (Fig. 73a, b, 244a–j, Table 52, Addendum 1 on p 925)**

1932 *Opisthotricha muscorum* KAHL, Tierwelt Dtl., 25: 608 (Fig. 73a).

1980 *Oxytricha muscorum* (KAHL, 1930–35) – FOISSNER, Ber. Nat.-Med. Ver. Salzburg, 5: 110 (Fig. 73b).

1991 *Oxytricha opisthomuscorum* FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 311.

1997 *Oxytricha opisthomuscorum* FOISSNER and others, 1991 – PETZ & FOISSNER, Polar Record, 33: 318 (Fig. 244a–j; description see p 925).

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Opisthotricha) muscorum*, which is a primary homonym of 3 other *Oxytricha muscorum* described by KAHL (1932; for details, see *Cyrtohymena muscorum*). The nomenclatural rectification was done by FOISSNER et al. (1991). Both KAHL (1932) and FOISSNER (1980a) described this species after live specimens; this explains some minor differences in the cirral pattern. The FOISSNER (1980a) population is reminiscent of *O. setigera*, which is, however, smaller and which has fewer marginal cirri. FERNANDEZ-LEBORANS (1985, p 376) described the fine structure of the undulating membranes of “*Oxytricha muscorum*”. The micrograph (his Fig. 13), however, shows an increased number of cirri on the frontal area so that the identification is doubtful; according to this paper the anterior portion of the paroral is composed of 6 rows with 46–48 basal bodies, whereas the posterior portion consists of 2 adjoining and parallel rows of 20–22 basal bodies each. Detailed redescribed by PETZ & FOISSNER (1997a, see p 925).

Morphology and biology:
After KAHL (1932) in life 80–100 μm ,

Fig. 73a, b *Oxytricha opisthomuscorum* (a, from KAHL 1932; b, from FOISSNER 1980a). Ventral views from life, a = 90 μm , b = 75 μm . Note single micronucleus between macronuclear nodules.

after FOISSNER (1980a) in life 65–80 μm long. About 3 times as long as broad. According to KAHL (1932), right margin rather more straight than convex, left anteriorly slanted. Rather contractile (FOISSNER 1980a). Macronuclear nodules arranged in median or even slightly right of it. Contractile vacuole about in mid-body. Hasty, jerky movement.

Adoral zone of membranelles about 38 % of body length. Peristomial lip anteriorly distinctly bent to the left, which is reminiscent of *Cyrtohymena* species. Arrangement of frontoventral cirri not as in many other *Oxytricha* species, especially posterior-most cirrus distinctly displaced posteriad (Fig. 73a and 244c, large arrow). Five transverse cirri which protrude rather far beyond posterior end of cell. Dorsal cilia stiff, after KAHL (1932) in life 10–15 μm , according to FOISSNER (1980a) 9–12 μm long, spread in resting animals, during swimming, however, trailed behind like fringes. Three long (about 1/3 of body length, according to KAHL 1932) and soft caudal cirri, energetically motile.

Occurrence and ecology: Locus classicus are mosses on walls and rocks near Hamburg, Germany (KAHL 1932). FOISSNER (1980a, c) found *O. opisthomuscorum* on irrigated rocks and in pasture pools in the Glockner area, Austrian Alps. Records not substantiated by illustrations: in road pools near Bratislava, Czechoslovakia, during autumn at 10–21 $^{\circ}\text{C}$, pH 5.5–6.6, and 7.3–12.5 $\text{mg l}^{-1} \text{O}_2$ (MATIS 1975); submerged, wet, moist, and dry mosses in the area of Slovensky raj, Czechoslovakia (TIRIAKOVÁ & MATIS 1987a); in two thermal lakes in Czechoslovakia at 7.0–40.5 $^{\circ}\text{C}$ and pH 5.0–7.4 (MATIS & STRAKOVÁ-STRIEŠKOVÁ 1991); Turiec River in Slovakia (TIRIAKOVÁ 1993); frequent in mosses and clear water from a spring in Italy (STELLA 1947); freshwater habitats in the Tibetan Plateau (WANG 1977); soil near Manaus, Brazil (FOISSNER 1997b); various soil samples (damp soil; wet mosses) from South Victoria Land and grass sward from *Deschampsia antarctica* patch (pH 4.4) of a sheltered north-facing slope on Signy Island, Antarctica (FOISSNER 1996b). Feeds on bacteria, green algae, and flagellates. Biomass of 10^6 individuals about 20 mg (population by KAHL 1932).

Oxytricha ottowi FOISSNER, 1996 (Fig. 73c–h, Table 15)

1996 *Oxytricha ottowi* FOISSNER, Biol. Fertil. Soils, 23: 289 (two type slides have been deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Morphology and biology: In life about $85\text{--}110 \times 25\text{--}35 \mu\text{m}$. Outline roughly elliptical, both ends broadly rounded, dorsoventrally flattened up to 2:1. Very flexible. Invariably ($n = 19$) 8 globular to ellipsoidal macronuclear nodules slightly left of median, after protargol impregnation $6\text{--}9 \times 4\text{--}7 \mu\text{m}$ (mean = $7.9 \times 6.0 \mu\text{m}$; $n = 14$). 0–5 (mean = 3.2; $n = 19$) globular micronuclei, after protargol impregnation 2–3 μm across. Contractile vacuole slightly in front of mid-body, without conspicuous collecting canals. Cortical granules elongate, about $2.0 \times 0.5 \mu\text{m}$, colourless, stain deep-blue with methyl green-pyronin and light-brown with protargol, arranged in many loose rows (Fig. 73d, f).

Fig. 73c-h *Oxytricha ottowi* (from FOISSNER 1996c. c-f, from life; g, h, protargol impregnation). c) Lateral optical section showing that cortical granules (arrowhead) are rod-shaped. g, h) Ventral and dorsal infraciliature and nuclear apertures. e) Cytoplasmic crystals. f) Arrowhead marks posterior end of dorsal kinety 5. The main species character is the macronucleus which invariably consists of eight nodules; p 218.

Cytoplasm colourless, with few to many 3–4 μm sized crystals, some 2–4 μm sized fat globules, and food vacuoles (Fig. 73c, e). Movement moderately rapid, without peculiarities.

Adoral zone of membranelles about 34 % of body length. Buccal cavity comparatively large and deep, right third covered by hyaline lip. Paroral and endoral curved and tightly spaced, that is, in parallel and/or intersecting optically only in anterior third, both composed of dikinetids arranged in zigzag. Pharyngeal fibres conspicuous. Frontal and marginal cirri about 15 μm , transverse cirri about 20 μm long. Frontal-ventral-transverse cirri (except pretransverse ventral cirri) slightly enlarged as compared to marginal cirri. Invariably ($n = 14$) 3 frontal cirri, 4 frontoventral cirri, and 1 buccal cirrus; usually 3, rarely 4, postoral ventral cirri; usually 2, rarely only 1, pretransverse ventral cirri; usually 5, rarely 4, transverse cirri. Marginal rows widely open at posterior end, gap occupied by caudal cirri right of cell median. Dorsal cilia about 3 μm long, invariably ($n = 14$) arranged in 6 dorsal kineties. Constantly ($n = 14$) 3 caudal cirri on kineties 1, 2, and 4 (Fig. 73h), caudal cirri not conspicuously elongated.

Occurrence and ecology: Locus classicus is the Transvaal Bay, Gough Island, South Atlantic Ocean, where FOISSNER (1996c) discovered it in fern bush (*Histiopoteris incisa*) peat litter, mixed with some soil and moss (pH 4.4; 30 m above sea level). Feeds on bacteria, heterotrophic flagellates, and coccal cyanobacteria.

Oxytricha procera KAHL, 1932 (Fig. 74)

1932 *Opisthotricha procera* KAHL, Tierwelt Dtl., 25: 608.

Nomenclature and taxonomy: KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha* (*Opisthotricha*) *procera*. I do not agree with BORROR (1972a) that this species is identical with the limnetic *O. similis* which has only 2 caudal cirri. However, the validity of *O. procera* has to be confirmed by a detailed redescription. *Opisthotricha procera* sensu NAIDU (1965; Fig. 224k) is insufficiently redescribed.

Morphology and biology: In life about 100–120 μm long. Outline slightly spindle-shaped. Contractile vacuole distinctly in front of mid-body where the body is broadest. Cytoplasm packed with dark granules, especially in posterior portion. Adoral zone of membranelles about 28 % of body length. Number and arrangement of frontal, ventral, and transverse cirri probably genus-specific. Transverse cirri protrude dis-

Fig. 74 *Oxytricha procera* (from KAHL 1932). Ventral view from life, 110 μm .

tinctly beyond posterior end of cell. Dorsal cilia in life 3–4 μm long. Three clearly discernible caudal cirri.

Occurrence and ecology: KAHL (1932) discovered this little-known species in terrestrial mosses from Wisconsin and California, USA. Records not substantiated by illustrations: Canale Naviglio navigabile in Parma, Italy (MADONI & GHETTI 1977); soft water Escambia River in Florida, USA (PATRICK 1961). Biomass of 10^6 individuals about 20 mg.

Oxytricha proximata SHIBUYA, 1930 (Fig. 75)

1930 *Oxytricha proximata* SHIBUYA, J. imp. agric. Exp. Stn Nishigahara, 1: 209, 213 (Fig. 75).

1935 *Oxytricha proximata* SHIBUYA, 1930 – KAHL, Tierwelt Dtl., 30: 841.

Taxonomy: BORROR (1972a) synonymised this terrestrial species with the limnetic *O. fallax* probably because of the broad body shape. It differs from the limnetic *Oxytricha tenella*, which has a similar body shape and size, by the lack of cortical granules. Identity with *O. bimembranata* cannot be excluded (Fig. 64a). Detailed redescription necessary.

Morphology and biology: In life 70–140 μm long, about 2.2 times as long as broad. Elongate ovate or elongate elliptical, posterior end obtusely pointed. Number of micronuclei not mentioned in original description, but very probably more than one because the two macronuclear nodules are widely separated, which would be rather unusual for a species with a single, central micronucleus. Contractile vacuole distinctly in front of mid-body.

Adoral zone of membranelles about 40 % of body length. Frontal and transverse cirri slightly enlarged. Five transverse cirri, protrude somewhat beyond posterior end of cell; the figure, however, gives the impression that only 4 transverse cirri are present (KAHL 1932). Dorsal cilia 2–4 μm long. Caudal cirri inconspicuous because marginal rows appear as being uninterrupted posteriorly.

Occurrence and ecology: Rare species, probably confined to terrestrial habitats. Locus classicus is Nishigahara near Tokyo, Japan, where SHIBUYA (1930) discovered *Oxytricha proximata* in the soil from a field. Records not substantiated by illustrations: soil in Belgium (CHARDEZ 1967); moss on a rock near the village of

Fig. 75 *Oxytricha proximata* (from SHIBUYA 1930). Ventral view from life, 70–140 μm . TC = right transverse cirrus.

Boldogkövőáralja, Hungary, and 20–30 ind. ml⁻¹ in soil of a Hungarian deciduous forest (GELLÉRT 1956, 1957). Feeds on detritus (GELLÉRT 1956). Biomass of 10⁶ individuals about 60 mg.

Fig. 76 *Oxytricha pseudofusiformis* (from DRAGESCO & DRAGESCO-KERNÉIS 1986). Ventral infraciliature, protargol impregnation, about 65 μ m.

***Oxytricha pseudofusiformis* DRAGESCO & DRAGESCO-KERNÉIS, 1986 (Fig. 76)**

1986 *Oxytricha pseudofusiformis* DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 469.

T a x o n o m y: This rather small species is somewhat superficially described, detailed redescription thus necessary. Generic classification uncertain.

M o r p h o l o g y: After protargol impregnation 35–46 $\times$ 16–19 μ m. Elliptical, both ends rounded. Macronuclear nodules after protargol impregnation 5–6 μ m long; central micronucleus only 1.5 μ m across. Adoral zone of membranelles about 30 % of body length. Undulating membranes obviously difficult to discern. 5–7 cirri on frontal area, that is, 1–3 of the typical 8 cirri (3 frontal, 4 frontoventral, 1 buccal) are absent. 4–5 postoral and pretransverse ventral cirri. Constantly 5, about 13 μ m long transverse cirri, which protrude only slightly beyond posterior end of cell. Marginal cirri about 8 μ m long. 3–4 inconspicuous caudal cirri. Dorsal cilia presumably rather short because neither drawn nor mentioned by DRAGESCO & DRAGESCO-KERNÉIS (1986).

O c c u r r e n c e a n d e c o l o g y: Locus classicus is the soil of a savannah in Pendjari, Bénin. Not found since. Biomass of 10⁶ individuals about 4 mg.

***Oxytricha pseudosimilis* HEMBERGER, 1985 (Fig. 77, Tables 3, 15)**

1985 *Oxytricha pseudosimilis* HEMBERGER, Arch. Protistenk., 130: 405 (the holotype slide is deposited in the Institut für landwirtschaftliche Zoologie und Bienenkunde at the University of Bonn, Germany).

T a x o n o m y: Differs from *Oxytricha similis* in the habitat (terrestrial against limnetic), in the number of caudal cirri (3 against 2), and in the length of the dorsal cilia (8–10 μ m against 2–4 μ m). The overall morphology is somewhat reminiscent of *Tachysoma pel-lionellum* sensu ROUX (1901), who also drew 2 micronuclei (Fig. 136s); however, the

Roux population obviously has no caudal cirri, so that a conspecificity can be excluded. The arrangement of the frontoventral cirri and the shape of the undulating membranes and adoral zone of membranelles of *O. pseudosimilis* does not agree very well with the typical *Oxytricha* patterns; the oral apparatus is almost of the *Gonostomum* type. Redescription, especially live observation, drawing of the dorsal infraciliature, and morphometric characterisation needed.

Morphology and biology: After protargol impregnation $95\text{--}120 \times 40\text{--}50\text{ }\mu\text{m}$. Body margins more or less parallel, both ends broadly rounded. Rather fragile. Two micronuclei. Contractile vacuole about in mid-body. Cytoplasm blackish. Adoral zone of membranelles $1/4\text{--}1/3$ of body length, middle portion laterally positioned and undulating membranes rather short and do not intersect (both characters almost as in *Gonostomum*). Frontal and ventral cirri slightly, transverse cirri distinctly enlarged compared with marginal cirri. 3 about $15\text{--}18\text{ }\mu\text{m}$ long caudal cirri. Three dorsal kineties of body length, and usually 1, sometimes 2 kineties of half body length. Dorsal cilia $8\text{--}10\text{ }\mu\text{m}$ long. Morphogenesis commences with proliferation of basal bodies adjacent to left transverse cirrus. Dorsal morphogenesis in *Urosomoida* pattern (further details, see HEMBERGER 1982, p 158–161).

Occurrence and ecology: Locus classicus is a woodland soil near Puerto Maldonado, Peru. Not found since. Biomass of 10^6 cells 180 mg (FOISSNER 1987a).

Oxytricha quadricirrata BLATTERER & FOISSNER, 1988 (Fig. 78a, b, Table 15)

1988 *Oxytricha granulifera quadricirrata* BLATTERER & FOISSNER, Stapfia, 17: 63 (1 slide of holotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: BLATTERER & FOISSNER (1988) established *O. quadricirrata* as subspecies of *O. granulifera* because the live aspect and the infraciliature are very similar. However, there are some minor differences in the infraciliature which indicate a separation at the species level: (i) in *O. granulifera* the right marginal row begins more anteriorly and terminates more posteriorly than in *O. quadricirrata*; (ii) in *O. granulifera* the left pretransverse ventral cirrus is located more anteriorly than in *O. quadricirrata*; (iii) *Oxytricha granulifera* has constantly 5 ($n = 25$, FOISSNER & ADAM 1983b) transverse cirri, whereas *O. quadricirrata* usually has 4 (mean = 3.9, $n = 15$). Ac-

Fig. 77 *Oxytricha pseudosimilis* (from HEMBERGER 1985). Ventral infraciliature, protargol impregnation, $110\text{ }\mu\text{m}$; p 222.

Fig. 78a, b *Oxytricha quadricirrata* (from BLATTERER & FOISSNER 1988. a, b, protargol impregnation). Ventral and dorsal infraciliature, 60 μ m. Arrowhead marks a single basal body pair left of kinety 5. 1–5 = dorsal kineties 1–5; p 223.

according to Article 50 c (i) of the ICZN (1985) a change in rank of a taxon in the species group does not affect the authorship of the name.

M o r p h o l o g y: In life 70–100 $\times$ 20–30 μ m. Live aspect – including cortical granules – as in *O. granulifera* (see p 197). A single basal body pair left of dorsal kinety 5, possible a further character which allows a separation from *O. granulifera* (Fig. 78b, arrowhead).

O c c u r r e n c e: Locus classicus is the upper soil layer (0–5 cm, pH 6.3) with

roots and litter of a sand-hill in the 99-miles desert north of Lake Alexandrina, near Adelaide, Australia. Soil in Brazil (FOISSNER 1997b). Biomass of 10^6 cells about 13 mg.

Oxytricha rubripuncta BERGER & FOISSNER, 1987 (Fig. 79a–h, Tables 3, 15)

1987 *Oxytricha rubripuncta* BERGER & FOISSNER, Zool. Jb. Syst., 114: 222 (Fig. 79a–c; 1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1994 *Oxytricha rubripuncta* BERGER & FOISSNER, 1987 – SHIN, Dissertation, p 141 (Fig. 79f–h).

Nomenclature and taxonomy: “*Oxytricha rubripuncta*” in BLATTERER & FOISSNER (1988, p 72) is an incorrect subsequent spelling. According to the arrangement of the frontoventral cirri and the slightly reduced number of transverse cirri this species could also be classified in *Urosomoida*. However, since more than 4 dorsal kineties are present, the generic classification of BERGER & FOISSNER (1987a) is accepted. *Oxytricha rubripuncta* should not be confused with *O. auripunctata*, which has orange-yellow cortical granules. The freshwater species *O. aeruginosa* has a rusty granulated cytoplasm and transverse cirri which do not protrude beyond the posterior end of the cell. In life *O. rubripuncta* could be confused with *Urosomoida agilis*, which sometimes also has a reddish granulation, but after protargol impregnation these two species can be easily separated by the different number and arrangement of dorsal kineties and transverse cirri. *No-*

Fig. 79a–e *Oxytricha rubripuncta* (from BERGER & FOISSNER 1987a. a–c, from life; d, e, protargol impregnation). a) Ventral view, 150 μm . b) Dorsal view, 155 μm . The red cortical granules are arranged around the bases of the cirri and dorsal cilia. c) Cytoplasmic crystals. d, e) Ventral and dorsal infraciliature, d, e = 135 μm ; p 224.

tohymena rubescens and *Cyrttohymena muscorum*, which are also reddish granulated, have a different oral apparatus.

Morphology and biology: In life about $150 \times 45 \mu\text{m}$, according to SHEN (1994) $120\text{--}160 \times 40\text{--}60 \mu\text{m}$. Margins slightly converging posteriorly. Somewhat contractile. Macronuclear nodules in life about $21 \times 13 \mu\text{m}$ ($13\text{--}22 \times 5\text{--}11 \mu\text{m}$, according to SHIN 1994), after protargol impregnation $15\text{--}25 \times 6\text{--}8 \mu\text{m}$ (mean = $20.1 \times 7.2 \mu\text{m}$; $n = 15$). 2–4, usually 2, in life about $3 \mu\text{m}$ sized micronuclei. Contractile vacuole about in mid-body, during diastole with collecting canals. Cortical granules about $1 \mu\text{m}$ across, arranged around bases of cirri and dorsal cilia (Fig. 79b), so that specimens appear reddish even at low magnification. Cytoplasm colourless.

Adoral zone of membranelles about 30 % of body length. The SHIN (1994) population has a distinctly lower number of adoral membranelles and marginal cirri as compared

Fig. 79f–h *Oxytricha rubripuncta* (from SHIN 1994. f, from life; g, h, protargol impregnation). f) Ventral view, 128 μm . g, h) Ventral and dorsal infraciliature, 145 μm ; p 224.

to the type material (Table 15). Buccal area flat. Pharyngeal fibres prominent in life. Frontal cirri about 15 μm long in life, bases distinctly enlarged. Rarely 1 frontal cirrus and 1 frontoventral cirrus lacking. Frontoventral cirri arranged as in *Urosomoida* and not, as erroneously stated in the original description, as in many *Oxytricha* species. Usually 3, rarely up to 5 postoral ventral cirri. Usually 4 ($n = 15$), sometimes 3 or 5, only slightly enlarged transverse cirri, situated very close to posterior end of cell and almost between posterior end of marginal rows. Marginal cirri in life 10–12 μm long. Invariably 6 ($n = 15$) dorsal kineties (Fig. 79e, h). Dorsal cilia about 3 μm long. Usually 3, very rarely 4 caudal cirri on kineties 1, 2, and 4. The formation of the oral primordium commences adjacent to the postoral ventral cirri.

Occurrence and ecology: Locus classicus is the upper soil layer (0–5 cm) of an uncultivated grassland dominated by *Poa* sp. in the Golan Hills, Israel (BERGER &

FOISSNER 1987a). SHIN (1994) found it in moss-covered soils at Kwanak Campus, Seoul, Korea. Feeds on bacteria, diatoms (*Hantzschia* sp.), autotrophic flagellates (*Chlamydomonas* sp.), testate amoebas (*Trinema lineare*), and ciliates (*Sathrophilus* sp.). Biomass of 10^6 individuals about 200 mg (FOISSNER 1987a).

***Oxytricha alfredkahli* FOISSNER, 1987 (Fig. 80)**

1932 *Oxytricha ovalis* KAHL, Tierwelt Dtl., 25: 603 (Fig. 80).

1987 *Oxytricha alfredkahli* FOISSNER, Arch. Protistenk., 133: 223.

Nomenclature and taxonomy: KAHL (1932) classified *Oxytricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Oxytricha) ovalis*, which is, however, a junior primary homonym of *O. ovalis* SCHMARDT, 1854, and *O. ovalis* FROMENTEL, 1876 (now *O. fromenteli* FOISSNER, 1987d). *Oxytricha alfredkahli* is the replacement name for *O. ovalis* KAHL, 1932. Very little known and perhaps invalid species from saline waters. Detailed redescription necessary.

Morphology: In life about 65 μ m long. Elliptical to oval. Adoral zone of membranelles about 40 % of body length. Sometimes 1 or 2 supernumerary cirri on frontal area. Transverse cirri long, protrude distinctly beyond posterior end of cell. Dorsal cilia 2–4 μ m long.

Occurrence and ecology: Locus classicus is saline water (2.0–2.5 % salt content) in Oldesloe near Hamburg, Germany, where it is rather common (KAHL 1932). All other records not substantiated by illustrations: Parma River near Langhirano, Italy (MADONI & GHETTI 1977; further record from Italy: GRISPINI 1938); at 0.6–0.8 % salinity in the Danzig Bay, Poland (BIERNACKA 1962); reservoirs in Azerbaijan (ALEKPEROV 1982b, 1983); Gulf of Riga, Latvia (BOIKOVA 1984a, b); eutrophic lake in China during summer (GONG 1986); bottom of freshwater ponds from Al-Hassa Oasis, Saudi Arabia (AL-RASHEID 1996b); Gulf of Mexico (BORROR 1962). The terrestrial record by LUZZATTI (1938) is unreliable. Biomass of 10^6 individuals about 13 mg.

***Oxytricha discifera* KAHL, 1932 (Fig. 81)**

1932 *Oxytricha discifera* KAHL, Tierwelt Dtl., 25: 604 (Fig. 81).

1933 *Oxytricha discifera* KAHL 1932 – KAHL, Tierwelt N.- u. Ostsee, 23: 113 (Fig. 81).

1992 *Oxytricha discifera* KAHL, 1930-5 – CAREY, Marine interstitial ciliates, p 192.

Nomenclature and taxonomy: KAHL (1932) divided *Oxytricha* into several subgenera; the correct name in the original description is thus *Oxytricha (Oxytricha) dis-*

Fig. 80 *Oxytricha alfredkahli* (from KAHL 1932). Ventral view from life, 65 μm ; p 227.

Fig. 81 *Oxytricha discifera* (from KAHL 1932). Ventral view from life, 200 μm ; p 227.

cifera. Because of the cephalisation and some uncertain observations (see next paragraph) the generic classification is uncertain. Detailed redescription needed.

M o r p h o l o g y: In life 180–240 μm long (240 to 250 μm according to AL-RASHEID 1996a), about 4–5 times as long as broad, that is, slender elliptical; anterior portion (1/8 of body length) cephalised, posterior end broadly rounded; undersized specimens with inconspicuous cephalisation. Rather fragile. Two macronuclear nodules, each with a micronucleus. Contractile vacuole absent or omitted (KAHL 1932). Probably 18 frontal-ventral-

transverse cirri, however, only 5 transverse cirri unequivocally recognised (KAHL 1932); transverse cirri V/I and VI/I rather strong, protrude distinctly beyond posterior end of cell. Dorsal cilia long, about 8 μm . Caudal cirri possibly lacking, that is, classification in *Oxytricha* uncertain.

Occurrence and ecology: Marine sediments, not very common but sporadically rather abundant (HARTWIG 1974, KAHL 1932, PATTERSON et al. 1989). Locus classicus is the Kiel Bay (Baltic), where KAHL (1932) discovered *O. discifera* in the sediment. Almost katharobic (KAHL 1932). Records not substantiated by illustrations: Venice, Adriatic Sea (KIESSELBACH 1936); North Sea (KÜSTERS 1974); mesopsammon of Black Sea (KOVALEVA 1966, KOVALEVA & GOLEMANSKY 1979); Barents Sea (AZOVSKY 1996, KOVALEVA 1967); mesopsammon of the Ussuri Gulf, Japan Sea (RAIKOV 1963); White Sea (BURKOVSKY 1968, 1970a, b, 1978, 1984, 1987, BURKOVSKY et al. 1980, 1994, RAIKOV 1962; further record from the USSR: BURKOVSKII & AZOVSKII 1985); in 0.1–0.4 mm sized sand of western Caspian Sea (AGAMALIEV 1970, 1983, AGAMALIYEV 1974); in 26–75 % of sediment samples of Loch Eil, Scotland, a marine habitat enriched with pulp mill effluent (WYATT & PEARSON 1982); Kandalakshsky Bay, White Sea (AZOVSKY et al. 1996); marine interstitial of Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-RASHEID 1996a); sediment of eutrophic Mullet Bay, St. George's Harbour, Bermuda (HARTWIG 1980). Grazes on detritus and bacteria (WYATT & PEARSON 1982).

Oxytricha durhamiensis nov. spec. (Fig. 186d)

1972 *Oxytricha halophila* (KAHL, 1932) – BORROR, Acta Protozool., 10: 66 (misidentification).

Taxonomy: This population differs from *O. halophila* in that it has cortical granules and two micronuclei. Thus, identification with KAHL's (1932) species as supposed by BORROR (1972b) is not justified. Reinvestigation recommended. *Oxytricha durhamiensis* differs from the other marine *Oxytricha* species by the cortical granulation.

Diagnosis: In life 60–100 × 33–45 µm sized, marine *Oxytricha*(?) with about 0.5 µm sized spherical cortical granules. 5 or 6 dorsal kineties.

Type location: Tidal marsh ditches and pools near Adam's Point, Durham, New Hampshire, USA.

Morphology and biology: Outline elliptical; flattened about 2:1 dorso-ventrally. Cell obviously not rigid because it can bend laterally, indicating that classification in *Oxytricha* is correct. Two macronuclear nodules, each with one micronucleus. Contractile vacuole present. Cortical granules in linear oblique groups of 2–5 granules parallel to dorsal kineties; granulation rows similarly on ventral side, between most massive frontal cirri each row of granules approximately 10 in number; colour of cortical granules not mentioned. Posterior portion of cell with irregular oblong granules about 4 × 2 µm. Free-swimming individuals move in a slow, narrow counter-clockwise helix; most specimens creep rapidly and irregularly forward, showing a strong tendency to veer to the right.

Adoral zone of membranelles ("buccal cavity") 26–33 µm long, about 25–30 adoral membranelles, each with 3 (likely 4, as in other hypotrichs) closely set rows of cilia. Cilia on mediad edge of each membranelle form a narrow field and beat independently of membranelle. Paroral probably composed of basal body pairs; paroral and endoral separated by sharp ridge. 18 frontal-ventral-transverse cirri. Frontal cirri distinctly enlarged. Transverse cirri protrude distinctly beyond posterior end of cell. 24 right marginal cirri, 8 µm apart in single row, marginal cirri about 20 µm long. Dorsal cilia 4–5 µm long and 4 µm apart. 3–4 caudal cirri ("terminal marginal cirri bristle-like"), about 16 µm long; may beat when animal is manoeuvring in a small place.

Occurrence and ecology: The population became abundant on or near the surface scum of cultures derived from a collection made on 18 December, 1968 from Adam's Point tidal marsh. Food vacuoles contained chloroplasts and diatoms (BORROR 1972b).

***Oxytricha enigmatica* DRAGESCO & DRAGESCO-KERNÉIS, 1986 (Fig. 82a, b, 246a–j, Tables 15, 53, Addendum 5)**

1986 *Oxytricha enigmatica* DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 463.

1997 *Hemigastrostyla enigmatica* (DRAGESCO & DRAGESCO-KERNÉIS, 1986) – SONG & WILBERT, Arch. Protistenk., 148: 421 (Fig. 246a–j; detailed redescription and new combination, see Addendum 5).

Fig. 82a, b *Oxytricha enigmatica* (from DRAGESCO and DRAGESCO-KERNÉIS 1986. a, b, protargol impregnation). a) Ventral infraciliature, 120 μm . b) Ventral infraciliature of posterior part of cell. Arrow marks 2 additional cirri to right of transverse cirri; p 229.

Taxonomy: I am rather certain that this species is not an *Oxytricha*. The straight undulating membranes are reminiscent of *Stylonychia*, and the longitudinal arrangement of the frontoventral cirri is similar to in *Urosoma*. However, since *O. enigmatica* obviously has a flexible body and, furthermore, some characters are still unknown, the originally proposed classification is preliminarily maintained. The slightly twisted body and the right marginal row which terminates immediately in front of the right transverse cirrus, is reminiscent of *O. geleii*. However, in this somewhat smaller species, the pretransverse ventral cirri are conspicuously displaced anteriorly and no cirri are present right of the transverse cirri (compare Fig. 82b with Fig. 83b). Both species occur in saline waters! Redescribed and transferred to *Hemigastrostyla* by SONG & WILBERT (1997a; see Addendum 5).

Morphology and biology: After protargol impregnation $75\text{--}128 \times 32\text{--}56 \mu\text{m}$. Macronuclear nodules after protargol impregnation $11\text{--}19 \mu\text{m}$ (mean = $15 \mu\text{m}$; $n = 15$) long. Number of micronuclei unknown. Adoral zone of membranelles about 45 % of body length, wide overlapping on right margin. Undulating membranes rather straight, arranged side by side as in *Stylonychia* pattern. Arrangement of frontal, ventral, and transverse cirri somewhat deviating from typical *Oxytricha* pattern (Fig. 82a). Five (!) frontoventral cirri and 4–5 postoral and pretransverse ventral cirri. Five enlarged transverse cirri protrude slightly beyond posterior end of cell. Right marginal row terminates in front of right transverse cirrus. Two curious cirri right of posterior end of right marginal row (Fig. 82b, arrow). 5–7 fine caudal cirri. Number of dorsal kineties not known. According to the text and Figure 82b the dorsal cilia are long, in Figure 82a, however, they look rather short.

Fig. 83a–g *Oxytricha gelei* (from WILBERT 1986b. a, from life and after protargol impregnation; b–g, protargol impregnation). a) Ventral view, 70 μm . b, c) Ventral and dorsal infraciliature, b, c = 45 μm . Arrows mark anterior and posterior postoral ventral cirrus; immediately behind are the two pretransverse ventral cirri. d) Ventral infraciliature of a very early morphogenetic stage, 55 μm . e) Ventral infraciliature of a middle morphogenetic stage, 65 μm . f, g) Ventral and dorsal infraciliature of late morphogenetic stages, f, g = 70 μm ; p 232.

Occurrence and ecology: Perhaps restricted to saline waters (PATTERSON et al. 1989). Locus classicus are saline pools near the shore of Lake Nokoué, Bénin (DRAGESCO & DRAGESCO-KERNÉIS 1986). Feeds on diatoms and dinoflagellates. Biomass of 10^6 individuals (after protargol impregnation) about 50 mg.

***Oxytricha geleii* (WILBERT, 1986) comb. nov. (Fig. 83a–g, Tables 3, 15)**

1986 *Holosticha geleii* WILBERT, Symposia Biologica Hungarica, 33: 251.

Taxonomy: Although the arrangement of the ventral cirri is reminiscent of *Holosticha*, a detailed inspection of Figure 83b and the morphogenesis indicate that it is more probably an oxytrichid. The unusual appearance of the infraciliature is mainly caused by the conspicuously anteriorly displaced pretransverse ventral cirri. The slight torsion, the right marginal row which terminates immediately in front of the right transverse cirrus, and the saline habitat indicate a close relationship to *Oxytricha enigmatica*. The undulating membranes do not intersect and the number of dorsal kineties is rather low, hence the classification in *Oxytricha* cannot be definite.

Morphology and biology: In life 40–60 µm long, about 2.3 times as long as broad. Body slightly twisted. Flexibility of body not known. Macronuclear nodules after protargol impregnation 5–10 µm long (mean = 7.4 µm; n = 11). Contractile vacuole slightly in front of mid-body. Adoral zone of membranelles about 1/3 of body length. Undulating membranes slightly bent, but not intersecting (similar to in *O. enigmatica*). Pretransverse ventral cirri arranged immediately behind postoral ventral cirri, giving the impression of a mid-ventral row (Fig. 83b). Usually 9, sometimes only 7 frontoventral and postoral and pretransverse ventral cirri. 4–6, usually 5 transverse cirri. Invariably 3 dorsal kineties of body length, each with a caudal cirrus (Fig. 83c). Dorsal cilia 2–4 µm long.

Some morphogenetic stages are shown in Figures 83d–g. The formation of only 6 longitudinally arranged streaks (Fig. 83e) producing 18 frontal-ventral-transverse cirri (Fig. 83b) is typical for the Oxytrichidae. The morphogenesis of the dorsal infraciliature proceeds in *Gonostomum* pattern.

Occurrence and ecology: Probably restricted to saline habitats. Locus classicus of this somewhat unusual species is the Little Manitou Lake (salinity 9.6 %) in Saskatchewan, Canada. Feeds on diatoms. Biomass of 10⁶ individuals about 6 mg.

***Oxytricha halophila* KAHL, 1932 (Fig. 84a, b)**

1932 *Opisthotricha halophila* KAHL, Tierwelt Dtl., 25: 611 (Fig. 84a, b).

1933 *Opisthotricha halophila* KAHL 1932 – KAHL, Tierwelt N.-u. Ostsee., Lieferung 23 (Teil II. c): 114.

Nomenclature and taxonomy: Incorrect subsequent spellings: *Opisthotricha halophyla* (TUCULESCU 1965, p 201); *Oxytricha (Opisthotricha) halophila* (TUCULESCU 1965, p 160). KAHL (1932) classified *Opisthotricha* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Opisthotricha) halophila*. *Oxytricha halophila* is possibly the senior synonym of the limnetic *O. parahalophila* (Fig. 84c).

Oxytricha halophila sensu AGAMALIEV (1978, 1983) is rather certainly not identical to the population described by KAHL (1932) because 2–3 micronuclei are reported; it is classified as insufficient redescription (Fig. 233l, m). The same is true for *O. halophila* sensu CZAPIK & JORDAN (1976a) because the single micronucleus is not described (Fig. 232m). *Oxytricha halophila* sensu BORROR (1972b) differs significantly from the type population in that it has two micronuclei and cortical granules, strongly indicating that is a different species (see *O. durhamiensis*; Fig. 186d).

Morphology and biology: In life about 110 μm long, 4 times as long as broad. Long elliptical (Fig. 84a). Contractile vacuole at about level of buccal vertex. Adoral zone of membranelles 1/4 of body length. About 1/3 of length of transverse cirri protrudes beyond posterior end of cell. Marginal cirri inserted very close to body margin. Three fine, setiform caudal cirri, conspicuously elongated. Dorsal cilia 2–4 μm long. KAHL (1932) mentioned another very similar population (Fig. 84h) under this species name with an oblique right anterior end and transverse cirri protruding somewhat further beyond the posterior end.

Occurrence and ecology: Probably confined to saline waters (PATTERSON et al. 1989). Locus classicus is the detritus in a marine ditch of the Sylt Island, Germany (KAHL 1932). The second population described by KAHL (1932, Fig. 84h) occurred in saline inland waters of Oldesloe, near Hamburg, Germany. Records not substantiated by illustrations: Bay of Danzig, Poland (BIERNACKA 1962); west coast of Caspian Sea (AGAMALIEV 1971); saline lake near Black Sea, Romania (TUCOLESCO 1962b); Barents Sea (AZOVSKY 1996). Biomass of 10^6 individuals about 23 mg.

Oxytricha oxymarina nom. nov. (Fig. 85a–e)

1932 *Oxytricha marina* KAHL, Tierwelt Dtl., 25: 603 (Fig. 85b).

1933 *Oxytricha marina* KAHL 1932 – KAHL, Tierwelt N.- u. Ostsee, Lieferung 23 (Teil II.3): 113.

1972 *Oxytricha marina* KAHL? – DRAGESCO, Annls Fac. Sci. Univ. fd. Cameroun, 11: 88 (Fig. 85a).

1974 *Oxytricha marina* KAHL, 1932 – JONES, Univ. South Alabama Monogr., 1: 41 (Fig. 85e).

Fig. 84a, b *Oxytricha halophila* (from KAHL 1932). Ventral views from life, a = 110 μm , b = ? μm . Arrow marks single micronucleus; p 232.

Fig. 84c *Oxytricha parahalophila* (from WANG & NIE 1935). Ventral view, 80 μm ; p 170.

Fig. 85a-d *Oxytricha oxymarina* (a, from DRAGESCO 1972b; b, from KAHL 1932; c, d, from AGAMALIEV 1978. a, protargol impregnation; b, from life; c, d, wet silver impregnation). a, c) Ventral infraciliature, a = 90 μ m, c = 85 μ m. b) Ventral view, 110 μ m. d) Dorsal infraciliature, very likely not correct, 85 μ m; p 233.

1978 *Oxytricha marina* KAHL, 1932 – AGAMALIEV, Acta Protozool., 17: 437 (Fig. 85c, d).

1983 *Oxytricha marina* KAHL, 1932 – AGAMALIEV, Ciliates of Caspian Sea, p 108 (Fig. 85c, d).

1986 *Oxytricha marina* KAHL, 1932 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 472.

Nomenclature and taxonomy: KAHL (1932) divided *Oxytricha* into several subgenera (Table 7); thus, *Oxytricha (Oxytricha) marina* KAHL, 1932, is a primary homonym of *Oxytricha (Steinia) marina* KAHL, 1932 (Tierwelt Dtl., 25: 614). Since I found no literature where either of these two species was given a new name as demanded by the ICZN (1985), I hereby rename the first species: *Oxytricha oxymarina* nom. nov., for *Oxytricha (Oxytricha) marina*. The other species is now considered to be a *Cyrtohymena*, *C. marina* (KAHL, 1932) FOISSNER, 1989.

The descriptions listed above do not agree very well in all characters, so that an identification should be based mainly on the original description. *Oxytricha marina* sensu

BIERNACKA (1967; Fig. 226d) and sensu GANAPATI & RAO (1958; Fig. 228a) are insufficient redescrptions. Detailed reinvestigation needed.

Morphology and biology: In life 80–120 μm long. Body margins parallel or slightly converging anteriorly. Both ends broadly rounded. Slightly contractile. Macronuclear nodules, according to DRAGESCO (1972b), after protargol impregnation 14–18 μm ; according to JONES (1974), in life only 10–12 μm long. 2–3 about 3 μm sized spherical micronuclei. Contractile vacuole distinctly in front of mid-body. Cytoplasm colourless, posterior cell portion usually with dark granules (Fig. 85b).

Adoral zone of membranelles about 1/3 of body length, after DRAGESCO (1972b) 30–32, after AGAMALIEV (1978) 30–35 membranelles. Buccal area obviously very small. According to KAHL (1932) and DRAGESCO (1972b) transverse cirri protrude distinctly beyond posterior end of cell, after JONES (1974) they do not. Number of marginal cirri: 33–39 right and 31–33 left (DRAGESCO 1972b), 24–26 right and 18–20 left (AGAMALIEV 1978). Dorsal infraciliature shown in Figure 85d rather certainly incorrect. Dorsal cilia short, caudal cirri obviously inconspicuous.

Occurrence and ecology: Common in brackish and marine habitats and in inland salt waters. Locus classicus is a marine ditch on Sylt Island, Germany (KAHL 1932). DRAGESCO (1972b) found *O. oxymarina* in a saline pond at Lake Tchad, Tchad. JONES (1974) observed it in Mobile Bay (Alabama, USA), AGAMALIEV (1978) in the Caspian Sea.

Records from marine habitats not substantiated by illustrations (see also PATTERSON et al. 1989): Bay of Naples, Adriatic (NOBILI 1957); Kiel Bay and supra-littoral zone of the Bay of Eckernförder, Baltic Sea (BOCK 1952, HARTWIG 1974); Danzig Bay and a harbour in Poland (BIERNACKA 1962, 1968); Gulf of Riga, Baltic Sea (BOIKOVA 1984b); Caspian Sea (AGAMALIEV 1971, 1983, 1990); saline lake in Romania near Black Sea (TUCOLESCO 1962b); Barents Sea (AZOVSKY 1996); Logy Bay in Newfoundland, Canada, Atlantic Ocean (LACKEY & LACKEY 1970); marine interstitial of Saudi Arabian Gulf Islands of Al-Batinah, Abu Ali, and Tarut (AL-RASHEID 1996a, 1997); Bay of Bengal, Indian Ocean (RAO & GANAPATI 1968).

Feeds on diatoms, small flagellates, and small ciliates. Biomass of 10^6 individuals about 20 mg (population of KAHL 1932).

Fig. 85e *Oxytricha oxymarina* (from JONES 1974). Ventral view from life, 110 μm ; p 233.

***Oxytricha saltans* (COHN, 1866) REES, 1881 (Fig. 86a–k, 87a–l, 88a–g, 89e, 245a–e, Table 15, Addendum 4)**

- 1866 *Actinotricha saltans* COHN, Z. wiss. Zool., 16: 283 (Fig. 87a–c).
 1867 *Actinotricha saltans* COHN – QUENNERSTEDT, Acta Univ. lund., 4: 40 (Fig. 87f).
 1881 *Oxytricha saltans* – REES, Zur Kenntniss der Bewimperung der hypotrichen Infusorien, p 16.
 1882 *Actinotricha saltans*, COHN – KENT, Manual infusoria II, p 790.
 1883 *Actinotricha saltans* (COHN) – MAUPAS, Archs Zool. exp. gén., 1: 544 (Fig. 87i, j).
 1884 *Oxytricha saltans*, COHN sp. – REES, Tijdschr. ned. dierk. Vereen., I: 646, 647 (Fig. 87e, g).
 1884 *Oxytricha saltans* COHN sp. – ENTZ, Mitt. zool. Stn Neapel, 5: 367 (Fig. 88a–g).
 1886 *Actinotricha hyalina* PEREYASLAWZEWA, Zap. novoross. Obshch. Estest., 10: 88 (Fig. 89e).
 1926 *Actinotricha saltans* COHN – LEPSI, Infusorien des Süßwassers und Meeres, p 86 (Fig. 87h).
 1932 *Actinotricha saltans* COHN, 1866 – KAHL, Tierwelt Dtl., 25: 604 (Fig. 87d).
 1933 *Tachysoma (Actinotricha) saltans* COHN 1866 – KAHL, Tierwelt N.- u. Ostsee, 23: 113.
 1934 *Actinotricha saltans* COHN 1866 – WANG, Rep. mar. biol. Ass. China, 3: 63 (Fig. 87l).
 1965 *Actinotricha saltans* COHN – LEPSI, Protozoologie, p 975 (Fig. 87k; poor drawing).
 1972 *Tachysoma saltans* (COHN, 1866) – BORROR, J. Protozool., 19: 15.
 1991 *Oxytricha saltans* (COHN, 1866) KAHL, 1932 – SONG, SHIN & KIM, Korean J. syst. Zool., 7: 235 (Fig. 86a–k; authoritative redescription).
 1997 *Oxytricha saltans* (COHN, 1866) – SONG & WILBERT, Arch. Protistenk., 148: 420 (Fig. 245a–e).

Nomenclature and taxonomy: *Actinotricha hyalin* in PEREYASLAWZEWA (1886, p 97) is an incorrect original spelling. KAHL (1932) classified *Actinotricha* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Actinotricha) saltans* (COHN, 1866). See Addendum 4 for an important nomenclatural note. The combining author is REES (1881), who correctly included *Actinotricha* in *Oxytricha*. Caudal cirri are present, proving that the classification in *Tachysoma*, as suggested by BORROR (1972a), is not justified. Synonymy of *Actinotricha saltans* and *Actinotricha hyalina* was already suggested by KAHL (1932). The description is mainly based on the authoritative redescription by SONG et al. (1991). The ALZAMORA (1929; Fig. 89a) and LEPSI (1927; Fig. 89b, c) populations are insufficiently redescribed, although the distinctly shortened right marginal row in Figures 89b, c indicates that LEPSI's identification was correct. The identification by DRAGESCO (1963; Fig. 89d) is rather uncertain and was thus not included in the list of synonyms (see insufficient redescriptions).

Morphology and biology: In life 50–80 × 15–25 µm (SONG et al. 1991), 60 µm (COHN 1866; erroneously “0,6 Mm” [= 600 µm] are given), 80–100 µm (MAUPAS 1883), 50–82 µm (REES 1884), 50–100 × 30–40 µm (ENTZ 1884), 50–100 × 35 µm

Fig. 86a–f *Oxytricha saltans* (from SONG et al. 1991. a–d, from life; e, f, protargol impregnation). **a)** Ventral view, 80 µm. **b)** Lateral view. Nuclear apparatus after Feulgen staining. **c, d)** Well (with ingested ciliates) and poorly fed (with greasily shining globules) specimens, c = 78 µm, d = 70 µm. **e, f)** Ventral and dorsal infraciliature, 75 µm. Long arrow in (e) marks anterior-most postoral ventral cirrus, short arrow denotes anterior end of right marginal cirral row. Anterior arrowhead marks buccal cirrus, posterior one denotes caudal cirri; p 236.

Fig. 86g–k *Oxytricha saltans* (from SONG et al. 1991. g–k, protargol impregnation). g–j) Schematic illustrations of variability of dorsal infraciliature. k) Detail of ventral ciliature showing fibres anchoring cirri in the cell. Explanation of original labels: AL = anterior longitudinal fibre, C = cirrus, LMC = left marginal cirral row, PF = peripheral fibre, PL = posterior longitudinal fibre, RMC = right marginal cirral row, VC = postoral ventral cirrus; p 236.

(WANG 1934); according to COHN (1866), about twice as long as broad. Ovoid to elongate-lanceolate, usually elliptical and anterior portion slightly converging. Flexible but not distinctly contractile. Macronuclear nodules distinctly separate, after protargol impregnation $11\text{--}21 \times 8\text{--}13 \mu\text{m}$ (mean = $16 \times 10 \mu\text{m}$; $n = 16$). 2–3 spherical micronuclei. Contractile vacuole lacking (COHN 1866, SONG et al. 1991); according to the detailed re-description by ENTZ (1884), contractile vacuole in mid-body but period between systoles usually rather long, so that cells have no conspicuous vacuole for much of the time. Cortical granules lacking. Cytoplasm colourless, posterior cell portion often packed with $1\text{--}5 \mu\text{m}$ sized, greasily shining globules (Fig. 86d); in anterior and posterior end often one conspicuous shining globule each (like the “Fettkörnchen” in *Tachysoma pellionellum*). Movement characteristic, that is, often immobile for several minutes with radiating distal adoral membranelles, then jumping suddenly; also evenly creeping among algae (COHN 1866). Notes on movement, see BULLINGTON (1925).

Adoral zone of membranelles about 25 % of body length, that is, buccal cavity rather short and narrow. Distal (about 5) membranelles about $20 \mu\text{m}$ long, spine-shaped and

Fig. 87a-l *Oxytricha saltans* (a-c, from COHN 1866; d, after ENTZ and REES from KAHL 1932; e, g, from REES 1884; f, after QUENNERSTEDT 1867; h, from LEPSI 1926b; i, j, from MAUPAS 1883; k, from LEPSI 1965; l, from WANG 1934. a-l, from life). a, d, e, g-i, k, l) Ventral views, a = 60 μ m, d = 70 μ m, e, g = 50-82 μ m, h = 100 μ m, i = 90 μ m, k = size not indicated, l = 95 μ m. b, c) Small specimens. f) Ventral ciliature seen from dorsal, 83 μ m. j) Left lateral view, 90 μ m; p 236.

thus radiating (thus the name *Actinotricha*!). Undulating membranes rather short, parallel, that is, not in the typical *Oxytricha* pattern. Proximal 2-3 membranelles covered by lip and usually separate from anterior (main) portion (for example, Fig. 86a, e, 87a, f, i, l, 88a). All cirri, except transverse cirri, rather fine. Arrangement of cirri rather invariable (Fig. 86e). Constantly ($n = 26$) 3 frontal cirri, only 3 frontoventral cirri, 1 buccal cirrus

Fig. 88a–g *Oxytricha saltans* (from ENTZ 1884. From life). **a–d**) Dorsal (showing mainly ventral side), ventral, and lateral view, 50–100 μ m. **e**) Dorsal view of a late morphogenetic stage. **f, g**) Prominent broom-shaped transverse cirrus and radiating adoral membranelles; p 236. **Fig. 89a–d** Insufficient redescrptions of *Oxytricha saltans* (**a**, from ALZAMORA 1929; **b, c**, from LEPSI 1927; **d**, from DRAGESCO 1963. **a–c**, from life; **d**, protargol impregnation). **a**) Ventral side seen from dorsal, 60 μ m. **b, c**) Ventral views, 100 μ m. Shortened right marginal cirral row indicates that the LEPSI identification is correct. **d**) Ventral infraciliature, 35–75 μ m; p 236.

(near buccal vertex), 3 postoral ventral cirri (about in mid-body), 2 pretransverse ventral cirri. Invariably ($n = 26$) 5 very strong, broom-shaped transverse cirri (Fig. 88f) which protrude distinctly beyond posterior end of cell; COHN (1866) counted 6–8 transverse cirri which is likely a misobservation. Right marginal cirral row begins in mid-body. Usually 5, rarely 6 (mean = 5.3; $n = 11$) dorsal kineties (including dorsomarginal row[s]), cilia 9–13 μm long (Fig. 86a, f–j). Constantly ($n = 7$) 3 fine caudal cirri which consist of 2 basal body pairs only (Fig. 86e, f).

Occurrence and ecology: Common in marine biotopes. Locus classicus is Heligoland, Germany, North Sea (COHN 1866). Locus classicus of the synonym, *Actinotricha hyalina*, is the Black Sea (PEREYASLAWZEWA 1886). SONG et al. (1991) collected *O. saltans* from shrimp culture ponds (containing a lot of organic matter) around the Gulf of Jiaozhou, Qingdao, China, where it occurred from May to July. SONG & WANG (1993) found it in marine cultivations along the Bohai Bay and in the Yellow Sea, China. Records largely substantiated by illustrations: Kattegat (Sweden), Baltic (QUENNERSTEDT 1867, 1869); Bay of Naples and coast of Algiers, Mediterranean (ENTZ 1884, MAUPAS 1883, REES 1881); the Netherlands, North Sea (REES 1884); highly abundant from a standing culture of sea-water from Bay of Amoy, China, in late July (WANG 1934). Records not substantiated by illustrations: North Sea (KÜSTERS 1974); sediment of Kiel Bay, Baltic (BOCK 1952, HARTWIG 1974); Genoa and Venice, Mediterranean and Adriatic (GRUBER 1884, KIESSELBACH 1936); saline lake sometimes supplied with sea water near Sebastopol, Ukraine (DAGAJEVA 1930); Black Sea (JELIASKOWA-PASPALLEWA 1933, LEPSI 1965); harbour of Ostend (Belgium), Atlantic Ocean (PERSOONE 1968); coast of the Netherlands, Atlantic Ocean (REES 1881); Caspian Sea (AGAMALIEV 1971, 1983); rock pools in New Hampshire, Atlantic Ocean (MARTINEZ 1980); Rio de Janeiro Bay, Atlantic Ocean (FARIA et al. 1922); Barents Sea (KOVALJEVA 1967). Feeds on bacteria and small flagellates and ciliates (SONG et al. 1991, Fig. 86c). SONG et al. (1991) found *O. saltans* at 19–21 °C, pH 7.9–8.0, about 100 % oxygen saturation, and 3.0–3.2 % salinity. Temperature optimum for growth 34 °C, lethal (LD_{50}) temperature 37 °C (MARTINEZ 1980).

Fig. 89e *Actinotricha saltans* (from PEREYASLAWZEWA 1886). Ventral view from life, size not indicated; p 236.

Oxytricha tricornis MILNE, 1886 (Fig. 90)

1932 *Oxytricha tricornis* MILNE, 1886 – KAHL, Tierwelt Dtl., 25: 603.

Nomenclature and taxonomy: KAHL (1932) divided *Oxytricha* into several subgenera; the correct name in his revision is thus *O. (Oxytricha) tricornis*. Little known species (very likely because of small size) urgently in need of detailed redescription. Classification in *Oxytricha* uncertain. BORROR (1972a) synonymised it with *Gonostomum strenuum*, which is, however, broader and lives in freshwater.

Fig. 90 *Oxytricha tricornis* (from MILNE 1886). Ventral view from life, about 70 μ m. Note slender outline and three conspicuous adoral membranelles; p 242.

MADRAZO-GARIBAY & LOPEZ-UCHOTERENA (1973) recorded and figured a “*Stylonichia tricornis* (TAGLIANI, 1922)” from freshwater in Mexico (Fig. 240j). This is not a “new combination” of the MILNE species, but of TAGLIANI’s (1922) *Dipleurostyla tristyla*, which is very likely a fragment of a (oxytrichid?) hypotrich. Furthermore, Figure 240j is only a redrawing of TAGLIANI’s illustration.

Morphology: In life about 70 μ m long and five times as long as broad, that is, very slender, widest in mid-body, tapering gradually toward ends. Flexible and highly contractile. Two macronuclear nodules. Three very conspicuous adoral membranelles, one fourth to one third of body length (other, small adoral membranelles possibly overlooked). Eight or ten scattered “ventral cirri” and 6 long transverse cirri. Two rows of marginal cirri. Dorsal cilia likely short (“minute”).

Occurrence: Locus classicus is very likely the Irish Sea near Glasgow, England (MILNE 1886). AGAMALIEV (1971, 1973a) recorded *Oxytricha tricornis* from the Caspian Sea.

***Oxytricha* species at present classified in taxa not revised in this book**

Opisthotricha elongata GRANDORI & GRANDORI, 1934, Boll. Lab. Zool. agr. Bachic. R. Ist. sup. agr. Milano, 5: 290, Tavola XIII, fig. 278. Remarks: GRANDORI & GRANDORI (1934) classified *Opisthotricha* as subgenus of *Oxytricha* so that the correct name is *Oxytricha (Opisthotricha) elongata*, and it is thus not a primary homonym of *Opisthotricha elongata* SMITH, 1897. According to the shape of the adoral zone of membranelles, GRANDORI & GRANDORI’s (1934) species very likely belongs to the *Trachelostyla/Trachelochaeta* group. *Opisthotricha elongata* on page 338 is an incorrect subsequent spelling of *Opisthotricha*. In life about 120 μ m long. Soil in Italy. Detailed redescription necessary.

Oxytricha alba FROMENTEL, 1876, Études microzoaires, p 268, Planche XIII, fig. 16. Remarks: Junior synonym of *Holosticha pullaster* (MÜLLER, 1773) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (for details, see FOISSNER et al. 1991, p 240).

Oxytricha auricularis CLAPARÈDE & LACHMANN, 1858, Mém. Inst. natn. génev., 5: 148, Planche V, fig. 5, 6. Remarks: According to CAREY & TATCHELL (1983) the junior synonym of *Epiclintes felis* (MÜLLER, 1786) CAREY & TATCHELL, 1983.

Oxytricha capitata PEREYASLAWZEWA, 1886, Zap. novoross. Obshch. Estest., 10: 91, fig. 15. Remarks: KAHL (1932) transferred it to *Amphisiella* GOURRET & ROESER, 1888.

Oxytricha crassa CLAPARÈDE & LACHMANN, 1858, Mém. Inst. natn. génev., 5: 147, Planche VI, fig. 7. Remarks: FROMENTEL (1875) fixed it as type species of *Oxytricha*, which was, however, neglected by later authors. KAHL (1932, p 588) transferred it (as "*Trichotaxis (Oxytricha) crassa*") to the subgenus "*Holosticha Trichotaxis*" ("*Holosticha (Trichotaxis) crassa*"; incorrect spelling of *Trichototaxis*).

Oxytricha flava COHN, 1866, Z. wiss. Zool., 16: 288, Tafel XV, Fig. 27–29. Remarks: Now *Pseudokeronopsis flava* (COHN, 1866) WIRNSBERGER, LARSEN & UHLIG, 1987.

Oxytricha flava var. *carnea* COHN, 1866, Z. wiss. Zool., 16: 288. Remarks: Now *Pseudokeronopsis carnea* (COHN, 1866) WIRNSBERGER, LARSEN & UHLIG, 1987.

Oxytricha fusca PERTY, 1852, Zur Kenntniss kleinster Lebensformen, p 154, Tafel VI, Fig. 19A, B. Remarks: Junior synonym of *Urostyla grandis* EHRENBERG, 1830.

Oxytricha gibba CLAPARÈDE & LACHMANN, 1858, Mém. Inst. natn. génev., 5: 144, Planche V, fig. 8. Remarks: According to CLAPARÈDE & LACHMANN (1858) possible identical with *Oxytricha gibba* (MÜLLER, 1786) sensu EHRENBERG (1938), after KAHL (1932, p 547) an *Uroleptus*.

Oxytricha kessleri WRZEŚNIEWSKI, 1877, Z. wiss. Zool., 29: 275, Tafel XIX, Fig. 12–15. Remarks: Now *Holosticha kessleri* (WRZESNIEWSKI, 1877) WRZESNIEWSKI, 1877 (see FOISSNER et al. 1991, p 228).

Oxytricha longi-caudata WRIGHT, 1862, Q. Jl microsc. Sci., 2: 220, Planche IX, Fig. 7, 8. Remarks: Junior synonym of *Psammomitra retractilis* (CLAPARÈDE & LACHMANN, 1858) BORROR, 1972, a species recently transferred to *Uroleptus* (SONG & WARREN 1996).

Oxytricha micans ENGELMANN, 1862, Z. wiss. Zool., 1: 387. Remarks: Junior synonym of *Holosticha pullaster* (MÜLLER, 1773) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (see FOISSNER et al. 1991, p 240).

Oxytricha oculata MERESCHKOWSKY, 1877, Trudy imp. S-peterb. Obshch. Estest., 8: 232, Tafel I, fig. 9, 10. Remarks: Uncertain species! According to KAHL (1932, p 582) a *Holosticha*.

Oxytricha pernix WRZESNIEWSKI, 1877, Z. wiss. Zool., 29: 273, Tafel XIX, Fig. 10, 11. Remarks: Now *Pseudokeronopsis pernix* (WRZESNIEWSKI, 1877) BORROR & WICKLOW, 1983.

Oxytricha retractilis CLAPARÈDE & LACHMANN, 1858, Mém. Inst. natn. génev., 5: 148, Planche V, fig. 3, 4. Remarks: Now *Uroleptus retractilis* (CLAPARÈDE & LACHMANN, 1858) SONG & WARREN, 1996. Previously classified in *Psammomitra* (BORROR 1972).

Oxytricha rubra EHRENBERG, 1835, Abh. preuss. Akad. Wiss., year 1835: 164 and Mittheilungen der Gesellschaft naturforschender Freunde zu Berlin, year 1835: 5. Remarks: Now *Pseudokeronopsis rubra* (EHRENBERG, 1835) BORROR & WICKLOW, 1983.

Oxytricha scutellum COHN, 1866, Z. wiss. Zool., 16: 287, Tafel XV, Fig. 43–46. Remarks: According to KAHL (1932, p 579) a *Holosticha*.

Oxytricha tubicola GRUBER, 1880, Z. wiss. Zool., 33: 450, Tafel XXVI, Fig. 11, 12. Remarks: Now *Stichotricha tubicola* (GRUBER, 1880) BORROR, 1972.

Oxytricha urostyla CLAPARÈDE & LACHMANN, 1858, Mém. Inst. natn. génev., 5: 141, Planche V, fig. 2. Remarks: Now *Pseudourostyla urostyla* (CLAPARÈDE & LACHMANN, 1858) BORROR, 1972. According to FOISSNER et al. (1991, p 260) a supposed synonym of *Paraurostyla weissei* (STEIN, 1859) BORROR, 1972 (see also Fig. 227l, m).

Oxytricha velox QUENNERSTEDT, 1869, Acta Univ. lund., 6: 20, Fig. 20, 21. Remarks: KAHL (1932, p 589) transferred it to "*Trichotaxis*" (incorrect spelling of *Trichototaxis*).

Oxytricha viridis PEREYASLAWZEWA, 1886, Zap. novoross. Obshch. Estest., 10: 91, Fig. 16. Remarks: A junior primary homonym of *O. viridis* FROMENTEL, 1876, a species indeterminata. According to BORROR & WICKLOW (1983), *O. viridis* PEREYASLAWZEWA is synonymous with *Pseudokeronopsis rubra*; thus, I do not replace its name.

Oxytricha wrzesniewskii MERESCHKOWSKY, 1877, Trudy imp. S-peterb. obshch. Estest., 8: 231, Tafel II, fig. 6. Remarks: According to KAHL (1932, p 583) a *Holosticha*.

Species indeterminata

DUMAS (1929, 1930, 1937), a French amateur protistologist, described about 550 new species, mainly ciliates from various biotopes of the French Massif Central. Probably most of the about 80 hypotrichous species (mainly assigned to *Kerona*, *Oxytricha*, and *Stylonychia*) are species indeterminata. A list of all DUMAS' names is provided by FOISSNER (1995a).

New species of *Oxytricha* – SESHACHAR & KASTURI BAI, 1963, Arch. Protistenk., 106: 456 (Fig. 222c, d). Remarks: In life 200–450 × 100–150 µm. Anterior end narrow rounded, posterior pointed. 3 (!) about 10 × 7 µm sized macronuclear nodules, sometimes with a thin, threadlike connection. 7–14 micronuclei. Contractile vacuole large, situated at posterior end (?). Adoral zone of membranelles about 1/2 of body length. Marginal rows converging posteriorly. 5 transverse cirri, 3 of them are elongated and protrude beyond posterior end of cell. Isolated from a freshwater fish tank in Bangalore, India. The animals were cultured in 0.01 % Knops solution, Erd-Schreiber, and hay infusion and were fed with Quaker oats, lettuce infusion, and Horlick's malted milk. SESHACHAR & KASTURI BAI (1963) did not mention a species name. The position of the contractile vacuole in the posterior portion is rather unreliable. *Sterkiella thompsoni* (Fig. 182f–k) also has 3 macronuclear nodules; however, this species is much smaller (90–139 µm long) and possibly endemic to Antarctica.

Opisthotricha sordis LEPSI, 1965, Protozoologie, p 22 (Fig. 224h). Remarks: In life (?) 130 µm long. Polysaprobic. *Oxytricha sordis* in LEPSI (1965, p 975) is very likely only another combination of the same species.

Opistotricha terricola GELLÉRT, 1957, Annls Inst. biol. Tihany, 24: 21 (Fig. 222b). Remarks: Incorrect subsequent spelling of *Opisthotricha*. "*O. tericola*" in LEPSI (1965, p 975) is also an incorrect subsequent spelling. About 80 µm long. 2 spherical macronuclear nodules, 2 micronuclei. About 20 adoral membranelles, adoral zone of membranelles 25 % of body length. 3 frontal, 1 buccal, and only 2 frontoventral cirri. Postoral ventral cirri lacking, 2 pretransverse ventral cirri, 4 transverse cirri, only 1 long caudal cirrus. Feeds on bacteria. Soil of a deciduous forest in Hungary. The arrangement of the cirri is rather unusual; somewhat reminiscent of *Urosoma similis*.

Oxitricha joblotii BORY DE SAINT-VINCENT in LAMOUROUX et al., 1824, Encyclopedie methodique, p 596. Remarks: According to EHRENBURG (1838, p 367) possible synonymous with *Stylonychia pustulata* or *Tachysoma pellationellum*.

Oxitricha núm. 1 – IZQUIERDO, Protozoos, p 191 (Fig. 229g). Remarks: Incorrect subsequent spelling of *Oxytricha*. In life 130 µm long. Freshwater in Chile.

Oxitricha núm. 2 – IZQUIERDO, Protozoos, p 192 (Fig. 229f). Remarks: Incorrect subsequent spelling of *Oxytricha*. In life 140 µm long. Freshwater in Chile.

Oxitricha núm. 3 – IZQUIERDO, Protozoos, p 191 (Fig. 229e). Remarks: Incorrect subsequent spelling of *Oxytricha*. In life 92 µm long. Freshwater in Chile.

Oxytricha pullicina BORY DE SAINT-VINCENT in LAMOUROUX et al., 1824, Encyclopedie methodique, p 595. Remarks: Established for a broad form of *Trichoda pulex* MÜLLER, 1773.

Oxytricha variabilis BORY DE SAINT-VINCENT in LAMOUROUX et al., 1824, Encyclopedie methodique, p 597. Remarks: Possible only a (unjustified?) replacement name for *Trichoda praeceps* MÜLLER, 1786. See also *Oxytricha variabilis* GROLIERE, 1975.

Oxytricha acuminata DUMAS, 1930, Microzoaires, p 57 (Fig. 239t). Remarks: *Oxytricha acuminata* DUMAS is a junior primary homonym of *O. acuminata* STOKES, 1887. Because it is a species indeterminata, I do not replace the name. In the legend to the figure (Planche XXVIII, fig. 24) designated as "*Oxytricha fastigiata (labiata)*". Infusion of terrestrial moss, France.

Oxytricha acuminata MAHAJAN, 1977, Rec. Surv. India, 72: 223 (Fig. 234d). Remarks: *Oxytricha acuminata* MAHAJAN is the junior primary homonym of *O. acuminata* STOKES, 1887, *O. acuminata* DUMAS, 1930, and *O. acuminata* VUXANOVICI, 1963 (see previous and next entry). Because it is a species indeterminata, I do not replace the name. Although I did not check the type slides (Z. S. I. Reg. No. Pt 694-701), I am rather sure that this taxon is indeterminable. 100–115 × 50–60 µm. Nine frontoventral, 5 ventral, and 5 transverse cirri; marginal rows interrupted posteriorly. Freshwater in Fatch Sagar, Udaipur, India.

Oxytricha acuminata VUXANOVICI, 1963, Studii Cerc. Biol., 15: 215 (Fig. 223k). Remarks: *Oxytricha acuminata* VUXANOVICI, 1963, is the junior primary homonym of *O. acuminata* STOKES, 1887 (now in *Urosoma*) and *O. acuminata* DUMAS, 1930. Because it is a species indeterminata, I do not replace the name. A special feature of this form is a conspicuous single cirrus just behind the contractile vacuole, which is displaced posteriorly. Stagnant waters in Romania.

Oxytricha ambigua DUJARDIN, 1841, Zoophytes, p 419, Planche XI, fig. 15. Remarks: A nominal species and not a redescription of *Trichoda ambigua* MÜLLER, 1786 (now *Spirostomum ambiguum*) because, unlike in other redescriptions by DUJARDIN, no synonyms are listed in a footnote.

Oxytricha anca DUMAS, 1930, Microzoaires, Planche XXIX, fig. 3 (Fig. 239o). Remarks: Without description. France.

Oxytricha arcuata DUMAS, 1930, Microzoaires, p 54 (Fig. 239d, e). Remarks: Bog in France.

Oxytricha barbula DUMAS, 1930, Microzoaires, p 55 (Fig. 239k). Remarks: Ditch with grass in France.

Oxytricha becciformis DUMAS, 1929, Microzoaires, p 72 (Fig. 236l). Remarks: In the legend to the figure (Planche XXVII, fig. 15) designated as *Oxytricha labiata*. Balaine, France.

Oxytricha bilobata FROMENTEL, 1876, Études microzoaires, p 264, Planche XII, fig. 6. Remarks: Very likely a fragment of a hypotrichous ciliate. Never(?) mentioned in the literature since.

Oxytricha cornipes DUMAS, 1929, Microzoaires, p 70 (Fig. 236d). Remarks: Rather surely a small fragment of a hypotrich. Balaine, France.

Oxytricha cornuta DUMAS, 1929, Microzoaires, p 73 (Fig. 236n). Remarks: *Oxytricha cornuata* in the legend to the figures (Planche XXVII, fig. 18) is an incorrect original spelling. Balaine, France.

Oxytricha curta DUMAS, 1929, Microzoaires, p 72 (Fig. 236k). Remarks: Pond with cress, Balaine, France.

Oxytricha cypris DUMAS, 1929, Microzoaires, p 74 (Fig. 243t). Remarks: Certainly a fragment. France.

Oxytricha decumana PERTY, 1852, Mitt. naturf. Ges. Bern, 1852: 64. Remarks: No illustration available. I assume that PERTY (1852a) was published before PERTY (1852b), where *O. decumana* is described on page 154. Freshwater, Switzerland.

Oxytricha deformis FROMENTEL, 1876, Études microzoaires, p 267, Planche XIII, fig. 8. Remarks: FROMENTEL (1876) selected an appropriate species name: very likely a deformed specimen.

Oxytricha dubia O. F. M. – KOVALEVA & GOLEMANSKY, 1979, Acta Protozool., 18: 275. Remarks: Mentioned in a list of psammobiotic ciliates of the Black Sea. I could not find the basionym.

Oxytricha dujardiniana DIESING, 1866, Sber. Akad. Wiss. Wien, 53: 95. Remarks: Established for *O. gibba* sensu DUJARDIN (1841, p 418, Planche XI, fig. 12), which is, however, rather certainly a species indeterminata.

Oxytricha ehrenbergiana DIESING, 1866, Sber. Akad. Wiss. Wien, 53: 95. Remarks: It is very difficult to find out for which population this species was established. From the list of synonyms in DIESING (1850, p 157) and DIESING (1866b), I conclude that the limnetic

Oxytricha gibba sensu EHRENBURG (1838, Infusionsthierchen, p 365, Tafel XLI, II) was meant. However, this form is rather superficially described, so that an identification will never be possible.

Oxytricha ephippioïdes DUMAS, 1929, Microzoaires, p 74 (Fig. 243r). Remarks: Certainly a fragment. France.

Oxytricha exociformis DUMAS, 1930, Microzoaires, p 56 (Fig. 239l). Remarks: Possibly an *Uroleptus*-like species because ventral rows are present. Marshy ditch in France.

Oxytricha fimbriata DUMAS, 1930, Microzoaires, Planche XIV, fig. 7 (Fig. 239b, c). Remarks: In the text (p 53) designated as "*Oxytricha fimbriata*, DE FROMENTEL". This author, however, redescribed *Trichoda fimbriata* MÜLLER, 1786, which is the anterior portion of *Stylonychia mytilus* (EHRENBURG 1838, p 371).

Oxytricha formosa ALEKPEROV, 1984, Zool. Zh., 63: 1461 (Fig. 223m, n). Remarks: Infaciliature unreliable; very likely some cirri were not recognised with the wet silver impregnation method. Freshwater from Azerbaijan.

Oxytricha fromenteli FOISSNER, 1987, Arch. Protistenk., 133: 223. Remarks: *Oxytricha fromenteli* is the replacement name for *O. ovalis* FROMENTEL, 1876, Études microzoaires, p 264, Planche XII, fig. 2, which is a junior primary homonym of *O. ovalis* SCHMARDT, 1854. *Oxytricha fromenteli* is presumably a *Steinia* or *Cyrtohymena* species because the buccal area is very large. *Oxytricha ovalis*, DE FROMENTEL sensu DUMAS (1929, p 70) is a redrawing from the original description (Fig. 236c).

Oxytricha furcatus SMITH, 1897, Am. mon. microsc. J., 18: 147 (Fig. 220e). Remarks: "*Oxytricha furcatus*" in the legend to the figure of the original description is an incorrect original spelling. KAHL (1932, p 602) – who considered it as a valid species – made a justified emendation: *Oxytricha furcata*. Thus, his own species *Oxytricha (Tachysoma) furcata* KAHL, 1932, is a junior primary homonym which has to be replaced. The very prominent adoral zone of membranelles and the obviously straight undulating membranes would require a classification in *Stylonychia*. On the other hand, the very soft and flexible body is typical for members of *Oxytricha*. In life 127–170 µm long, elliptical, both ends rounded. Two ellipsoidal macronuclear nodules. Contractile vacuole about in mid-body. Arrangement of frontal and ventral cirri as in species of the *Stylonychia mytilus* complex, but all cirri, except the frontal cirri, furcated. Five transverse cirri, fimbriated at their ends, only the left transverse cirrus does not protrude beyond posterior end of cell. Marginal rows "continuous, but heavier and longer posteriorly", indicating that caudal cirri present. SMITH (1897b) found this, in my opinion, doubtful form in an old infusion of rose fission petals (USA). PATRICK (1961) and PATRICK et al. (1967) recorded it from rivers in the USA and DINGFELDER (1962; Fig. 224c) from a puddle in Bavaria.

Oxytricha galeata DUMAS, 1929, Microzoaires, p 75 (Fig. 243s). Remarks: Certainly a fragment. France.

Oxytricha gyrinioïdes DUMAS, 1929, Microzoaires, p 74 (Fig. 243q). Remarks: France.

Oxytricha hengshanensis LIU et al., 1992 in SHEN, LIU, SONG & GU, 1992, Subtropical soil animals of China, p 155 (Fig. 240l, m). Remarks: I have some doubt that the ventral infraciliature is correctly drawn. A micrograph of a protargol-impregnated, slightly damaged specimen, kindly supplied by SHEN YUNFEN, shows that it is possibly a *Cyrtohymena* species because the undulating membranes are distinctly bent. The anteriorly displaced "postoral ventral cirri" are perhaps an artefact. In spite of these uncertainties, a short description (based on a translation by Mr WU DONGLI): in life (?) 124–153 × 53–76 µm. Body ovoid, both ends rounded, flexible. Two macronuclear nodules. Contractile vacuole about in mid-body. Cytoplasm colourless, cortical granules lacking. Many food vacuoles with algae and amoebas. Rapid movement. Adoral zone of membranelles 1/3 of body length, 23 adoral membranelles. 3 enlarged frontal cirri, 1 buccal cirrus, 3 longitudinally arranged cirri, 1 cirrus behind right frontal cirrus and at level of anterior end of right marginal row. 3 "postoral" ventral cirri longitudinally arranged right of the proximal portion of adoral zone of membranelles (Fig. 240l, arrow). 2 pretransverse ventral cirri and 5 almost horizontally arranged transverse cirri. Left marginal row longer than right one (possibly including caudal cirri). 3 dorsal kineties. Locus classicus is a subtropical soil on the Hengshan Mountain, Hunan, China.

Oxytricha immemorata ALEKPEROV, 1984, Zool. Zh., 63: 1460 (Fig. 224a, b). Remarks: Infraciliature unreliable; possibly some cirri were not recognised with the wet silver impregnation method. Freshwater from Azerbaijan.

Oxytricha incrassata DUJARDIN, 1841, Zoophytes, p 418, Planche XI, fig. 14. Remarks: Probably indeterminable.

Oxytricha labiata DUMAS, 1930, Microzoaires, p 55 (Fig. 239j). Remarks: A junior primary homonym of the next species; because it is a species indeterminata, I do not replace the name. Bog in France.

Oxytricha labiata FROMENTEL, 1876, Études microzoaires, p 264, Planche XII, fig. 1. Remarks: Likely a deformed specimen. A senior primary homonym of *O. labiata* DUMAS.

Oxytricha lacerata DUMAS, 1929, Microzoaires, p 71 (Fig. 236g). Remarks: Freshwater in France.

Oxytricha lacrimula DUMAS, 1929, Microzoaires, p 71 (Fig. 236f). Remarks: Freshwater in France.

Oxytricha lata STERKI, 1878, Z. wiss. Zool., 31: 44, 55 (Fig. 224d). Remarks: STERKI (1878) mentioned and drew only the fan-shaped adoral zone of membranelles.

Oxytricha lingua DUJARDIN, 1841, Zoophytes, p 418, Planche XI, fig. 11. Remarks: In life about 125 µm long. Presumably cortical granules present. Stagnant freshwater in Paris, France. Very likely not an *Oxytricha*, perhaps a *Holosticha* or *Urostyla*.

Oxytricha longipes DUMAS, 1930, Microzoaires, p 55 (Fig. 239i). Remarks: Roadside ditch on a meadow in France.

Oxytricha luteolucens DUMAS, 1937, Microzoaires, p 20 (Fig. 239q). Remarks: Only 1 macronuclear nodule. France.

Oxytricha merula FROMENTEL, 1876, Études microzoaires, p 269, Planche XX, fig. 8. Remarks: It is uncertain if the specimen observed is a hypotrichous ciliate at all.

Oxytricha monstrosa VUXANOVICI, 1963, Studii Cerc. Biol., 15: 214 (Fig. 223l). Remarks: In life 75–85 µm long. Body rigid, not contractile, hence very likely no *Oxytricha*; the overall view is reminiscent of a *Histiculus*. Frontal cirri about 13 µm long. 9 left and 11 right marginal cirri. Stagnant freshwater in Bucharest, Romania. STILLER (1974a, p 133) transferred this superficially described form to *Tachysoma* (*T. monstrosa*) because the marginal rows are widely separated posteriorly and no caudal cirri are drawn.

Oxytricha nova KLOBUTCHER, SWANTON, DONINI & PRESCOTT, 1981, Proc. natn. Acad. Sci. U.S.A., 78: 3015 (Fig. 235A, B). Remarks: This name is a nomen nudum (ICZN 1985, Article 13) because the publication is accompanied neither by a description or a definition that states characters that are purported to differentiate the taxon, nor by a bibliographic reference to such a published statement. Only very few morphological data of this organism are known (2 macronuclear nodules, 4 micronuclei, Fig. 235A). The scanning electron micrographs available (Fig. 235B, Figure 1 in AMMERMAN 1985, Figure 1b in STEINBRÜCK 1986 and SCHLEGEL & STEINBRÜCK 1986) do not allow an identification to species or genus level. The straight to slightly curved paroral and the long adoral zone of membranelles (almost 50 % of body length) indicate that *O. nova* belongs to the Stylonychiinae (and not to the Oxytrichinae), a classification supported by biochemical investigations (SCHLEGEL 1985, SCHLEGEL & STEINBRÜCK 1986, SCHLEGEL et al. 1991). The biochemical data also indicate that *O. nova* is closely related to the "*Oxytricha bifaria*" of the Italian protozoologists, a form which I (preliminary) classify as *Stylonychia pustulata*. Recently, we recognised that *O. nova* is a species of the *Sterkiella histriomuscorum* group (FOISSNER & BERGER 1999; see this paper for further details). *Oxytricha nova* is the subject of many molecular-biological studies: ALLEN & OLINS (1984), BAROIN TOURANCHEAU et al. (1995), BERCHTOLD et al. (1995), BERNHARD et al. (1995), BOSWELL et al. (1982, 1983), BUTLER et al. (1984), DELGADO et al. (1988, 1991), DUBOIS & PRESCOTT

(1995), ELWOOD et al. (1985), FANG & CECHE (1993b, 1995), FANG et al. (1993), GAJADHAR et al. (1991), GOTTSCHLING & CECHE (1984), GOTTSCHLING & ZAKIAN (1986), GRAY et al. (1991), GREENWOOD et al. (1991a, b), GRESLIN et al. (1988, 1989), GUNDERSON et al. (1995), HARPER & JAHN (1989), HERRICK (1992), HICKE et al. (1990, 1995), HOFFMAN & PRESCOTT (1966, 1997a, b), JAHN (1988), JAHN et al. (1988), KLOBUTCHER (1987), KLOBUTCHER & JAHN (1991), KLOBUTCHER & PRESCOTT (1986), KLOBUTCHER et al. (1984, 1986, 1988), KRAUT et al. (1986), KRISHNAN et al. (1990), LAPORTE & THOMAS (1997, 1998), LEE & KUGRENS (1992), LINGNER et al. (1994), LIPPS et al. (1982), MARTIN & GRIMES (1987), MELEK et al. (1994), MITCHAM et al. (1992, 1994), OKA & THOMAS (1987), OLINS et al. (1993), PRESCOTT (1984, 1992a, b, 1993, 1994), PRESCOTT & DUBOIS (1996), PRESCOTT & GRESLIN (1992), PRESCOTT et al. (1982), PRICE & CECHE (1987, 1989), RAGAN et al. (1996), RAGHURAMAN & CECHE (1989, 1990), RAGHURAMAN et al. (1989), RAIKOV (1989), RIBAS-APARICIO et al. (1987), SAPRA et al. (1985), SCHLEGEL (1991), SHIPPEN et al. (1994), SOGIN et al. (1986), STEINBRÜCK (1990), SWAGER et al. (1990), SWANTON et al. (1980a, b, 1982), WILLIAMSON et al. (1989), WILLIS et al. (1993), ZAHLER & PRESCOTT (1988, 1989), ZAHLER et al. (1991). Complete small subunit rRNA sequence 1771 nucleotides long; G * C content 45 % (LEIPE et al. 1994). LAUGHLIN et al. (1983) described a method for the large-scale cultivation of *Oxytricha nova*. Before 1978, PRESCOTT and co-workers studied a rather similar organism which was originally referred to as *Stylonychia mytilus* prior to being identified as *Oxytricha* sp. in LAUTH et al. (1976; further details on the confusing “nomenclature” of the organisms used by the American workers, see KLOBUTCHER & PRESCOTT 1986, p 113).

Oxytricha oblonga DUMAS, 1929, Microzoaires, p 72 (Fig. 236j). Remarks: *Oxytricha oblonga* in the legend to Planche XXVII is an incorrect original spelling. Posterior end with 4 cirri. Balaine, France.

Oxytricha oblongatus – SHARMA, SOBTI & KATHURIA, 1986, Res. Bull. Panjab Univ. Sci., 37: 119. Remarks: I do not know the original description of this “species”. Possibly it is a numen nudum. In life 80–100 µm × 40–50 µm. 2 macronuclear nodules. India.

Oxytricha obtusa DUMAS, 1930, Microzoaires, p 53 (Fig. 239a). Remarks: Ventral surface covered with small cirri; thus surely not an *Oxytricha*. France.

Oxytricha oltenica LEPSI, 1965, Protozoologie, p 972, 975 (Fig. 224e). Remarks: Perhaps a *Stylonychia*? Romania?

Oxytricha ovata DUMAS, 1929, Microzoaires, Planche XXVII, fig. 6 (Fig. 236p) and DUMAS (1930; as “*Oxytricha ovata*”) Planche XII, fig. 6 not fig. 11 (Fig. 236q). Remarks: A senior primary homonym of *Oxytricha* (*Opisthotricha*) *ovata* KAHL, 1932. Without description. Only 1 macronuclear nodule. France.

Oxytricha ovalis SCHMARD, 1854, Denkschr. Akad. Wiss., Wien, 7: 17, 25 (Fig. 222h). Remarks: In life 87–104 µm long. Ovoid. Ephemeral pond near Luxor, Egypt. I agree with FOISSNER (1987d) that this species is so insufficiently described that an identification is impossible.

Oxytricha (?) *parvula* VUXANOVICI, 1963, Studii Cerc. Biol., 15: 214 (Fig. 223i, j). Remarks: About 40 µm long, oval. Adoral zone of membranelles 1/2 of body length. Stagnant freshwater in Bucharest, Romania.

Oxytricha pisciunculiformis DUMAS, 1929, Microzoaires, p 75 (Fig. 243u). Remarks: Likely an *Uroleptus*. France.

Oxytricha pistilloïdes DUMAS, 1929, Microzoaires, p 71 (Fig. 236h). Remarks: Very poorly described. Balaine, France.

Oxytricha pleuronectes DUMAS, 1929, Microzoaires, p 73 (Fig. 236o). Remarks: Possibly a fragment of a hypotrich. France.

Oxytricha plicata EICHWALD, 1852, Bull. Soc. impér. nat. Moscou, 25: 518, Tafel VI, fig. 14. Remarks: Indeterminable, perhaps a euplotid. Baltic Sea.

Oxytricha praeceps DUMAS, 1930, Microzoaires, p 54 (Fig. 239f, n, u). Remarks: The body shape is reminiscent of that of *Holosticha pullaster*, which has, however, the contractile vacuole distinctly behind mid-body. Bog and river in France. In DUMAS (1937, p 20) again designated as new species. “*Oxytricha maeceps*” in the legend to the figure (Planche V, fig. 2) is an incorrect subsequent spelling.

Oxytricha proboscis DUMAS, 1930, Microzoaires, p 56 (Fig. 239r, s). Remarks: In wet mosses (*Hypnum*) in France.

Oxytricha protensa PERTY, 1852, Mitt. naturf. Ges Bern, 1852: 64. Remarks: PERTY (1852a) mentioned only the name. An insufficient description is given by PERTY (1852b, Kenntnis kleinster Lebensformen, p 153, Tafel VI, Fig. 20A–E). Very likely not an *Oxytricha* because of the conspicuously elongated body. Freshwater in Switzerland.

Oxytricha quadrinucleata CULBERSON, 1986, Diss. Abstr. Int., 46B: 2589. Remarks: Very likely, CULBERSON (1986) is the author of this nomen nudum, that is, the name is published without description (possibly available in his dissertation).

Oxytricha quercineti LEPSI, 1948, Notat. biol., Buc., 6: 154. Remarks: LEPSI (1948a) provided a long description but no illustration of this soil species. In life 100 × 40 µm. Body shape similar to that of *Tachysoma pellionellum*, elliptical, left margin not concave. Very flexible. Frontal cirri enlarged. 2–3 frontoventral and 3 postoral ventral cirri. Caudal cirri

lacking. Marginal rows not interrupted posteriorly. 5 transverse cirri, distinctly protruding beyond posterior end. Dorsal cilia short. Adoral zone of membranelles narrow, 30–35 μm long. Peristomial lip anteriorly not conspicuously bent. Undulating membranes short. 2 macronuclear nodules. Cytoplasm rather colourless, without symbiotic algae. Feeds on bacteria. Lively movement. Polysaprobic. Litter of an oak forest near Harbovát, Romania. I do not believe that this species can be identified. However, it is not impossible that this particular biotope contains some characteristic species.

Oxytricha radians DUJARDIN, 1841, Zoophytes, p 420, Planche XI, fig. 16. Remarks: In life 50 μm long. Possibly an oligotrichid or a euplotid ciliate.

Oxytricha rostrata DUMAS, 1930, Microzoaires, p 56 (Fig. 239m). Remarks: In the legend to the figure (Planche XXVI, fig. 20) designated as *O. cultriformis*. Bog and ditch with plants in France.

Oxytricha saltans VUXANOVICI, 1963, Studii Cerc. Biol., 15: 214 (Fig. 232o). Remarks: STILLER (1974a, p 133) transferred it to *Tachysoma* (*T. saltans*) because the marginal rows are widely separated posteriorly. BORROR (1972a) synonymised it with *Actinotricha saltans* COHN, 1866, which he also transferred to *Tachysoma*. *Oxytricha saltans* VUXANOVICI is somewhat reminiscent of *Tachysoma humicola*, which is, however, restricted to terrestrial habitats. In life 40–55 μm long, not contractile but flexible. Adoral zone of membranelles 1/3 of body length, consists of 9 or 10 membranelles. 5 transverse cirri, in life 20 μm long, protrude distinctly beyond posterior end of cell. 8–9 left and right marginal cirri, respectively, in life 10 μm long. Lake “Floreasca” in Bucharest, Romania. VUXANOVICI (1963) found it also in a freshwater habitat in the botanical garden of Bucharest.

Oxytricha stratiformis DUMAS, 1930, Microzoaires, p 54 (Fig. 239h). Remarks: Roadside ditch on a meadow in France.

Oxytricha striata SCHMARDA, 1854, Denkschr. Akad. Wiss., Wien, 7: 17, 24 (Fig. 222i). Remarks: In life 208 μm long, both ends rounded. Ephemeral stagnant freshwater near Luxor, Egypt. Reminiscent of *Tachysoma pellionellum*, which is, however, distinctly smaller.

Oxytricha subcylindrica DUMAS, 1929, Microzoaires, p 71 (Fig. 236i). Remarks: Anterior end with 6–8 enlarged cirri, posterior end with 5 cirri. Balaine, France.

Oxytricha tetranucleata NÉMETH in GELEI, 1950, Acta biol. hung., 1: 80 (Fig. 240g). Remarks: The reference “NÉMETH 1950” in GELEI is given without source; possibly this is an unpublished paper. Only the figure is available. Generic classification uncertain. Hungary. The same is true for the second NÉMETH species described in GELEI (1950), namely,

Holosticha oxytrichoidea (= *Holostischa oxytrichoidea* in the legend; Fig. 222a), which is probably an oxytrichid because it has only 18 frontal, ventral, and transverse cirri.

Oxytricha trifallax GRESLIN, PRESCOTT, OKA, LOUKIN & CHAPPELL, 1989, Proc. natn. Acad. Sci. U. S. A., 86: 6264 and *Oxytricha trifallax* HUNTER, WILLIAMS, CARTINHOOR & HERRICK, 1989, Genes & Development, 3: 2110. Remarks: I am not sure if these are the "original descriptions"; both do not contain morphological data, thus a nomen nudum (ICZN 1985). The author's got it from R HAMMERSMITH, Ball State University. Further literature: DOAK et al. (1997), DUBOIS & PRESCOTT (1995), HOFFMAN & PRESCOTT (1997a, b), KLOBUTCHER & HERRICK (1997), LINGNER et al. (1994), PRESCOTT & DUBOIS (1996), SEEGMILLER & HERRICK (1998), SEEGMILLER et al. (1997), WILLIAMS et al. (1993), WITHERSPOON et al. (1997). SEEGMILLER et al. (1996) collected wild *O. trifallax* cells from diverse limnetic sites in Indiana, USA. Recently we found that *O. trifallax* belongs to the *Sterkiella histriomuscorum* group (details see FOISSNER & BERGER 1999).

Oxytricha truncata VUXANOVICI, 1963, Studii Cerc. Biol., 15: 212 (Fig. 222o–t). Remarks: According to Article 45 (g) of the ICZN (1985) the forms *Oxytricha truncata* f. *piriforme* VUXANOVICI, 1963 (p 213; Fig. 222s, t) and *Oxytricha truncata* f. *dilatata* VUXANOVICI, 1963 (p 213; Fig. 222q, r) are of infrasubspecific rank. BORROR (1972a) synonymised this rather superficially described species with *O. fallax* because the body shape and the size are very similar. I do not accept this synonymisation because VUXANOVICI (1963) mentioned a granulation and a brown-reddish colour, perhaps similar to in *O. aeruginosa*. However, in this species the body is not as broad and the transverse cirri do not protrude beyond the posterior end of the cell. In life 100–150 µm, "forma *piriforme*" 100–120 µm, "forma *dilatata*" 80–100 µm long; only about 1.6 times as long as broad. Oval or distinctly pyriform (Fig. 222o–q, s). Two macronuclear nodules. Micronuclei not mentioned. Contractile vacuole about in mid-body. Cells packed with granules and small globules giving them a rusty colour, "forma *piriforme*" appears reddish. Adoral zone of membranelles 40–45 % of body length. Arrangement and number of frontal and ventral cirri certainly not exactly observed. 5 transverse cirri. Dorsal cilia 2–4 µm long. Locus classicus is the Lacul Fundeni, a pond in Bucharest, Romania, where VUXANOVICI (1963) discovered it between decaying plant material. Not found since.

Oxytricha viridis FROMENTEL, 1876, Études microzoaires, p 266, Planche XIII, fig. 5. Remarks: LONGHI (1895) found *O. viridis* FROMENTEL in a lake in Italy.

EHRENBERG (1831, p 119; 1838, p 366) transferred *Trichoda cicada* MÜLLER, 1786 (now *Aspidisca cicada*) to *Oxytricha*.

Insufficient redescrptions

Actinotricha saltans COHN – ALZAMORA, Notas Resúm. Inst. esp. Oceanogr., 2: 13 (Fig. 89a). Remarks: Poor drawing. Bay of Palma de Mallorca, Mediterranean.

Actinotricha saltans COHN – DRAGESCO, 1963, Cah. Biol. mar., 4: 265 (Fig. 89d). Remarks: Some characters (length of right marginal cirral row, number of transverse cirri) of this redescription, which is obviously exclusively based on silver impregnated material, do not agree very well with the authoritative redescription. Saprobic sediment in/near Roscoff, France, Atlantic Ocean.

Actinotricha saltans COHN – LEPSI, 1927, Studii Cerc. Acad. RPR, 12: 124 (Fig. 89b, c). Remarks: Poor drawing, although the distinctly shortened right marginal cirral row and the radiating distal adoral membranelles indicate that the LEPSI identification is correct. In life $102 \times 34 \mu\text{m}$. Black Sea? LEPSI (1926a; without illustration) population in life $162 \times 54 \mu\text{m}$, that is, too large; Black Sea.

Opisthotricha parallela ENGELMANN – SCHUSTER, 1899, Sci. Gossip, 5: 203 (Fig. 240i). Remarks: Freshwater in England.

Opisthotricha parallelis ENG. – KAHL, 1928, Arch. Hydrobiol., 19: 211 (Fig. 52d). Remarks: KAHL (1928b) gives only an illustration and no description of this form. It has 2 buccal cirri, indicating that it is not *O. parallela*. In life about $100 \mu\text{m}$ long and three times as long as broad. Both ends rounded. Contractile vacuole slightly in front of mid-body. Adoral zone of membranelles about $1/3$ of body length. Frontal cirri distinctly enlarged. Two (!) buccal cirri near anterior end of undulating membranes. 5 transverse cirri, protrude slightly beyond posterior end of cell. Caudal cirri obviously present, however, number not discernible. Dorsal cilia short ($2\text{--}4 \mu\text{m}$). KAHL (1928a, b) found this ciliate in the Oldesloer Salzstellen in a small trench (salinity 0.29 ‰, containing numerous Rhodobacteriaceae) near Alt-Fresenburg near Hamburg, Germany.

Opisthotricha procera KAHL – NAIDU, 1965, Hydrobiologia, 25: 560 (Fig. 224k). Remarks: Arrangement of ventral cirri unreliable. Among algae in an old well in Nakash, Cuddapah, India.

Opisthotricha similis ENGELMANN, 1862 – CURDS, 1969, Wat. Poll. Res., No. 12: 68 (Fig. 221h). Remarks: The drawing is rather schematic and does not agree with the authoritative redescription by KAHL (1932; Fig. 57a).

Opisthotricha ovata KAHL 1930 – BIERNACKA, 1967, Wiss. Z. Ernst Moritz Arndt-Univ. Greifswald, 16: 244 (Fig. 226e). Remarks: Incorrect subsequent spelling of *Opistho-*

tricha. In life 100–120 µm long, 3 caudal cirri. Feeds on flagellates. Polysaprobic; among decaying algae in polluted littoral areas of the Hiddensee Island, Baltic Sea.

Oxitricha fallax – BATTISH, 1992, Freshwater zooplankton of India, p 57, Fig. 54. Remarks: Incorrect spelling of *Oxytricha*. Very superficially illustrated. Planktonic in India.

Oxytricha – DUMAS, 1929, Microzoaires, Planche XXXVI, fig. 38 (Fig. 236m). Remarks: Without description. France.

Oxytricha – MAUPAS, 1888, Archs Zool. exp. gén., 6: 222, 276 (Fig. 230a, b). Remarks: In life 100–190 µm long, very flexible but only slightly contractile. Arrangement of cirri, see Figure 230a. Freshwater. Cyst spherical, wall with more or less regularly arranged thickenings (Fig. 230b). Although this population is well described, I could not identify it with any species. The overall morphology is reminiscent of *O. fallax*, whereas the conspicuous cyst indicates that it is perhaps a species of its own.

Oxytricha aeruginosa WRZESNIEWSKI – PÄTSCH, 1974, Arb. Inst. landw. Zool. Bienenk., 1: 58 (Fig. 220m). Remarks: 100–200 × 40–70 µm. Slender. 2 macronuclear nodules, 2 micronuclei. Contractile vacuole at about level of buccal vertex. Marginal rows confluent posteriorly, marginal cirri about 10 µm long. Transverse cirri do not protrude beyond posterior end of cell. Adoral zone of membranelles 1/3 of body length, undulating membranes slightly bent. 4–6 dorsal kineties of body length. Morphogenesis commences with the proliferation of the oral primordium very close to the left transverse cirrus. Freshwater near Bonn, Germany. PÄTSCH (1974) described no red granulation of the cytoplasm; thus, the identification with *O. aeruginosa* is unjustified. Perhaps identical with *Histriculus histrio* because the ventral infraciliature is rather similar and no caudal cirri are described. However, since no information is available on the flexibility of the cell, I avoid synonymisation with *H. histrio*.

Oxytricha aeruginosa WRZESNIEWSKI, 1870 – AGAMALIEV, 1974, Acta Protozool., 13: 71 and AGAMALIEV, 1983, Ciliates of Caspian Sea, p 108 (Fig. 221a, b). Remarks: About 120–150 µm long; 30–35 adoral membranelles; 40 right and 38 left marginal cirri; marginal rows widely open posteriorly; only 3 dorsal kineties and probably no caudal cirri. Solid surface overgrowth of the eastern coast of the Caspian Sea. The identification is very doubtfully, since no red colouring is mentioned. Furthermore, AGAMALIEV (1974) described only 3 dorsal kineties. Very likely he overlooked some kineties in the wet silver impregnated material because he (AGAMALIEV 1983, p 108ff) described 3 kineties also in *O. marina*, *Opisthotricha halophila*, and *Stylonychia mytilus* which is, of course, a misobservation.

Oxytricha chlorigella KAHL – HORVÁTH, 1939, Allatt. Közl., 36: 83 (Fig. 221i). Remarks: Incorrect subsequent spelling of *Oxytricha chlorelligera*. HORVÁTH (1939b) did not men-

tion the symbiotic algae, which are characteristic for the species. Furthermore, there are some differences in the arrangement of the postoral ventral and transverse cirri. Reminiscent of *O. hymenostoma*.

Oxytricha crassistilata KAHL, 1932 – ALEKPEROV, 1993, Zoosystematica Rossica, 2: 26 (Fig. 241a, b). Remarks: In life 25–30 μm long. Cytoplasm transparent. 2 bean-shaped macronuclear nodules, each with 1 micronucleus. 25–30 adoral membranelles. 10 ventral cirri (buccal, frontoventral, postoral ventral, pretransverse ventral), 5 transverse cirri, 12 right and 10 left marginal cirri. 4 dorsal kineties of body length, 1 shortened kinety, 3 caudal cirri. Soils of St. Petersburg and its suburbs, Russia. Does not match the original description in many characters (size, nuclear apparatus...).

Oxytricha fallax – BARKER, 1949, J. Proc. Inst. Sew. Purif., year 1949: 11 (Fig. 232i). Remarks: Only 86 μm long! Sewage treatment plant.

Oxytricha fallax – BISHOP, 1943, J. Morph., 72: 443 (Fig. 221f). Remarks: I do not believe that BISHOP (1943) worked with *O. fallax* because the outline does not show the typical pyriform shape.

Oxytricha fallax – GREGORY, 1923, J. Morph., 37: 555 (Fig. 240n). Remarks: Neither size (80–130 μm) nor body shape allow an unequivocally identification with *O. fallax*. Furthermore, the arrangement of the ventral cirri is insufficiently observed.

Oxytricha fallax STEIN – HEBERER, 1928, Treubia, 10: 27 (Fig. 229h). Remarks: HEBERER wrote that his form is probably identical with *O. fallax*. He observed two cells bursting and the release of many spheres of different size; he interpreted this process as multiple division without encystment and designated the spheres as anisogametes. Freshwater in West-Lombok, Indonesia.

Oxytricha fallax – QUENNERSTEDT, 1865, Acta Univ. lund., 2: 59 (Fig. 38k). Remarks: Sweden.

Oxytricha fallax – SMITH, 1978, Br. Antarct. Surv. Sci. Rep., No. 95: 75 (Fig. 221e). Remarks: Soil of various Antarctic islands. *Oxytricha fallax* is not reliably recorded from terrestrial habitats (FOISSNER 1987a). Perhaps *Sterkiella histriomuscorum*.

Oxytricha fallax, St. – KOFFMAN, 1926, Acta zool., Stockh., 7: 310 (Fig. 231d). Remarks: Garden soil near Stockholm, Sweden. *Oxytrich fallax* rather certainly does not inhabit terrestrial habitats (FOISSNER 1987a).

Oxytricha fallax STEIN – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 221c). Remarks: Number and arrangement of cirri rather doubtful. Furthermore, the body

shape does not match the characteristic *fallax* type. Freshwater habitats in Connecticut, USA.

Oxytricha fallax STEIN – WEST & LUNDIN, 1963, Pap. Mich. Acad. Sci., 48: 108 (Fig. 220k). Remarks: See also LUNDIN & WEST (1963) and WEST (1953). Freshwater habitats of the Upper Peninsula, Michigan, USA.

Oxytricha fallax STEIN – CHARDEZ, 1967, Revue Écol. Biol. Sol, 4: 294 (Fig. 223p). Remarks: Possibly identical with *O. proximata* (a species also mentioned in his faunal list!), which is originally described from terrestrial habitats and has a similar body shape and size as *O. fallax*. Soil in Belgium.

Oxytricha fallax STEIN – FORMISANO, 1957, Annali Fac. Sci. agr. Univ. Napoli, 22: 26 (Fig. 234b). Remarks: Rhizosphere of cultivated plants in the Campania soils, Italy.

Oxytricha fallax STEIN, 1859 – CELA, 1972, Physis, 31: 576 (Fig. 232n). Remarks: In life 97–160 × 36–68 µm (mean = 129 × 52 µm; n = 5). In the Yalca Lagoon, Argentina, on *Azolla filiculoides*.

Oxytricha furcata SMITH 1897 – DINGFELDER, 1962, Arch. Protistenk., 105: 621 (Fig. 224c). Remarks: In life 91–116 µm long. Elliptical. About 30 right and 20 left marginal cirri; marginal rows converging posteriorly. About 35 adoral membranelles. 4 transverse cirri, protrude distinctly beyond posterior end of cell. Arrangement of ventral cirri unreliable; especially the longitudinal row behind the buccal vertex is probably a misobservation. Infusion of mud from a puddle, Bavaria, Germany.

Oxytricha halophila KAHL, 1932 – AGAMALIEV, 1978, Acta Protozool., 17: 439 and AGAMALIEV, 1983, Ciliates of Caspian Sea, p 110 as *Opisthotricha halophila* KAHL, 1932 (Fig. 233l, m). Remarks: In life 160–180 × 40–50 µm. Two macronuclear nodules, 2 or 3 micronuclei. Contractile vacuole about at level of buccal vertex. Live specimens yellowish-white. Adoral zone of membranelles 1/3 of body length, about 34–38 adoral membranelles. Distal end of adoral zone conspicuously overlapping to right side of cell. About 28–35 cirri in each marginal row, rows distinctly separate posteriorly. Three dorsal kineties of body length (misobservation). Caudal cirri? Fine sand, algae detritus, and periphyton of the Caspian Sea (see also AGAMALIEV 1971). The identification is certainly incorrect because *Oxytricha halophila* sensu KAHL (1932) has only a single micronucleus and prominent caudal cirri (Fig. 84a, b).

Oxytricha halophila KAHL, 1932 – CZAPIK & JORDAN, 1976, Acta Protozool., 15: 441, 442 (Fig. 232m). Remarks: The characteristic single micronucleus is not described; thus, the identification cannot be accepted. Brackish water in the Gdansk Bay (Baltic Sea) at a salinity of 0.3–0.7 ‰.

Oxytricha henegui F.-F., 1924 – MATIS, 1977, Acta Fac. Rerum nat. Univ. comen. Bratisl., 22: 25. Remarks: Possibly erroneously written for *Opisthonecta hennegui* FAURÉ-FREMIET, 1924, a peritrichous ciliate (see FOISSNER et al. 1992c).

Oxytricha hymenostoma STOKES – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 221d). Remarks: Freshwater habitats in Connecticut, USA.

Oxytricha ludibunda STOKES, 1891 – CURDS, 1969, Wat. Poll. Res., No. 12: 67 (Fig. 221g). Remarks: The drawing is rather schematic and does not allow unequivocal identification. CURDS (1969) assumed that the posteriorly displaced macronuclear nodules can be used to separate this species from congeners like *O. fallax*.

Oxytricha ludibunda STOKES – NAIDU, 1965, Hydrobiologia, 25: 559 (Fig. 224m). Remarks: In life 90–103 × 42–46 µm. Numerous in dirty water in Cuddapah, South India.

Oxytricha marina KAHL 1930 – BIERNACKA, 1967, Wiss. Z. Ernst Moritz Arndt-Univ. Greifswald, 16: 244 (Fig. 226d). Remarks: In life about 120 µm long, flexible, rapid movement. Feeds on diatoms. Polluted areas of the littoral of the Hiddensee Island, Baltic Sea.

Oxytricha marina KAHL, 1932 – GANAPATI & RAO, 1958, Andhra Univ. Mem. Oceanogr., 2: 86 (Fig. 228a). Remarks: In life 150–170 µm long. Caudal cirri lacking, indicating that they observed a *Tachysoma*. Sea near Visakhapatnam, India.

Oxytricha minor KAHL, 1932 – CHORIK, 1968, Free-living ciliates, p 133 (Fig. 231h). Remarks: CHORIK (1968) did not draw the single micronucleus and the somewhat elongated marginal cirri at the posterior end of the rows. Small water bodies in Moldova.

Oxytricha parvistyla STEIN – EDMONDSON, 1920, Trans. Am. microsc. Soc., 39: 185. Remarks: STEIN (1859b) did not describe an *O. parvistyla*. I assume that it should read *O. platystoma*. EDMONDSON (1920) also recorded *Tachysoma parvistyla* STOKES; thus, a confusion with this species must be excluded. Devil's Lake Complex, North Dakota, USA.

Oxytricha pustulata EHRBG. – JAWOROWSKI, 1893, Spraw. Kom. fizyogr., 28: 41. Remarks: JAWOROWSKI (1893) mentioned this binomen in a faunal list of Krakow, Poland. Probably he meant *Stylonychia pustulata*, which he, however, also listed.

Oxytricha saprobia (KAHL, 1935) – VUXANOVICI, 1963, Studii Cerc. Biol., 15: 215 (Fig. 220l). Remarks: This population has a distinctly longer adoral zone of membranelles (46 % of body length) than the population described by KAHL (1932; about 37 %). Moreover, KAHL (1932) drew prominent transverse cirri and a single micronucleus between the macronuclear nodules, which is not the case in Figure 220l. Romania.

Oxytricha sardida ENTZ – BULLINGTON, 1925, Arch. Protistenk., 50: 271. Remarks: 120–140 × 40 µm. I do not know this species. Perhaps an incorrect spelling of *O. sordida*, which is, however, from WRZESNIEWSKIEGO (1866).

Oxytricha similis ENGELMANN – PÄTSCH, 1974, Arb. Inst. landw. Zool. Bienenk., 1: 61 (Fig. 230h). Remarks: In life 100–150 × 40–50 µm. Flexible. Adoral zone of membranelles 30–40 µm long. Only 3 frontoventral cirri, 3 caudal cirri, 5 dorsal kineties. Brook near Bonn, Germany. Very likely not identical with *O. similis*, which has only 2 caudal cirri.

Oxytricha sp. – CHAUDHURI, 1929, Annls Protist., 2: 54, 57 (Fig. 242a, b). Remarks: Soil in India.

Oxytricha sp. – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 224i, j). Remarks: CONN (1905) found two *Oxytricha* sp. in freshwater habitats of Connecticut, USA. Both forms have an unreliable arrangement of ventral cirri.

Oxytricha sp. – CZAPIK, 1959, Acta Hydrobiol., 1: 191 (Fig. 228i). Remarks: Perhaps a *Stylonychia*. Benthic area of fishponds in Poland.

Oxytricha sp. – GRANDORI & GRANDORI, Boll. Lab. Zool. agr. Bachic. R. Ist. sup. agr. Milano, 5: 289, Tavola XIII, fig. 269. Remarks: Soil in Italy.

Oxytricha sp. – JACOBSON, 1931, Arch. Protistenk., 75: 76 (Fig. 226i). Remarks: An identification is impossible because no morphological details (for example, flexibility) are described.

Oxytricha sp. – MOTE, 1954, Proc. Iowa Acad. Sci., 61: 588 (Fig. 222e). Remarks: The supernumerary cirri are reminiscent of *Gastrostyla*. Soil of a virgin prairie in Iowa, USA.

Oxytricha sp. – NIKOLJUK & GELTZER, 1972, Pochvennye prostejsie SSSR, p 128, Plate XII, Fig. 228. Remarks: Perhaps *Gonostomum* sp. Soil from the USSR.

Allotricha STERKI, 1878

- 1878 *Allotricha* STERKI, Z. wiss. Zool., 31: 37, 48, 57 – Type (by monotypy): *Allotricha mollis* STERKI, 1878.
 1882 *Allotricha*, STERKI – KENT, Manual Infusoria II, p 782.
 1889 *Pleurotricha* (*Allotricha*) STERKI 1878 – BÜTSCHLI, Protozoa, p 1747.
 1979 *Allotricha* STERKI, 1878 – CORLISS, Ciliated protozoa, p 312.
 1987 *Allotricha* STERKI, 1878 – TUFFRAU, Annls Sci. nat. (Zool.), 8: 116.
 1994 *Allotricha* STERKI, 1878 – TUFFRAU & FLEURY, Traite de Zoologie, 2: 144.
 1996 *Onychodromopsis* STOKES, 1887 – PETZ & FOISSNER, Acta Protozool., 35: 264.
 1997 *Onychodromopsis* STOKES, 1887 – BERGER & FOISSNER, Arch. Protistenk., 148: 146.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern or rather straight and arranged almost side by side. Frontoventral cirri in V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral and 5 transverse cirri. Two or more right and 1 or more left rows of marginal cirri. Caudal cirri present. Primordia V and VI of the proter originate from cirrus V/4 and V/3 respectively. No parental marginal rows retained after division. Dorsal morphogenesis in *Oxytricha* pattern.

Taxonomy: The characterisation is that of *Onychodromopsis* in BERGER & FOISSNER (1997), where we followed the PETZ & FOISSNER (1996) definition of *Onychodromopsis*. For a detailed description of patterns, see chapter 2 in the general section.

Allotricha was established for a metabolic (that is flexible) hypotrich with typical *Oxytricha* cirral pattern but more than 2 (marginal) cirral rows (see below). Thus, BÜTSCHLI (1889) classified *Allotricha* as subgenus of *Pleurotricha*, whereas KAHL (1932, p 593) mentioned the type species (as *A. mollis*) in *Pleurotricha*. BORROR (1972a, p 15) synonymised *Allotricha mollis* with *Pleurotricha lanceolata*, which has, however, a rigid body. CORLISS (1979), TUFFRAU (1987), and TUFFRAU & FLEURY (1994) classified *Allotricha* in uncertain position in the Sporadotrichina and Oxytrichidae, respectively. Very recently, PETZ & FOISSNER (1996) considered *A. mollis* as genus and species indeterminata because the original description lacks details and a figure.

STERKI (1878) made rather exact observations (including morphogenetic ones) and wrote on p 48 “Der einfacheren Bezeichnung wegen benenne ich die 8 charakteristischen Stirnwimpern, die bei *Stylonychia*, *Oxytricha*, *Histrio*, *Pleurotricha* und *Allotricha* offenbar vollkommen homolog sind, mit Zahlen und zwar...”. Furthermore, he gave a diagnosis on p 59: “*Allotricha* n. gen. Die Stirn-, Bauch- und Afterwimpern der Oxytrichen, ausserdem rechts zwei Reihen borstenförmiger Wimpern (ähnlich den Pleurotrichen). Körper metabolisch. Peristom, Consistenz, Aussehen, Färbung und Bewegungsweise der Urostylen. Ist also in keinem der bisherigen Genera unterzubringen. *A. mollis*. Sehr viel beobachtet; häufig”. Unfortunately, STERKI (1878) did not figure the type species. Nevertheless, I reactivate *Allotricha* because the diagnosis exactly matches the descriptions of *Pleurotricha variabilis* REUTER, *Onychodromopsis flexilis* sensu PETZ & FOISSNER (1996), and my nomen nudum species *Parurosoma granulifera* in FOISSNER et al. (1991, p 262).

The “Reihen borstenförmiger Wimpern” mentioned in the original description are certainly not misobserved dorsal kineties because STERKI (1878, p 48) was the first to describe these inconspicuous structures minutely. Further details, see *Allotricha mollis*.

Key to species

- 1 Length in life usually less than 150 µm; transverse cirri conspicuously displaced anteriorly, protrude only slightly beyond posterior end of cell, hook-shaped arrangement (Fig. 92a, h); cirrus III/2 arranged left of posterior migratory cirrus (cirrus VI/3; Fig. 92h, j, arrow); prefers (exclusively in?) terrestrial habitats *A. antarctica* (p 268)
- Length in life usually more than 150 µm; transverse cirri arranged more or less terminally, protrude distinctly beyond posterior end of cell, arranged in oblique row (Fig. 91a, c); cirrus III/2 arranged left between level of cirri IV/3 and VI/3 (Fig. 91c, arrow); prefers (exclusively in?) freshwater 2
- 2 Cortical granules (0.5–1.0 µm) present (Fig. 91b) *A. mollis* (p 262)
- Cortical granules absent (Fig. 91s)
 Pleurotricha variabilis, a supposed synonym of *A. mollis* (p 268)

Allotricha mollis STERKI, 1878 (Fig. 91a–g, t, Tables 3, 19)

1878 *Allotricha mollis* STERKI, Z. wiss. Zool., 31: 48, 58 (no illustration).

1932 *Allotricha mollis* STERKI – KAHL, Tierwelt Dtl., 25: 593 (mentioned at *Pleurotricha*; no own observations).

1982 *Pleurotricha tihanyiensis* (GELLERT & TAMAS, 1958) – HEMBERGER, Dissertation, p 223 (Fig. 91g; unpublished thesis; see taxonomy).

1986 *Pleurotricha tihanyiensis* (GEL. & TAM). HEM. – SCHMITZ, Dissertation, p 94, Abb. 40.

1988 *Pleurotricha* spec. – KRAMER, Diplomarbeit, p 29 (Fig. 91f; unpublished thesis).

1991 *Parurosoma granulifera* BERGER – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 261, 262 (nomen nudum species; Fig. 91c).

Taxonomy: STERKI (1878) provided a short definition of *A. mollis* but unfortunately no illustration. It was transferred to *Pleurotricha* (KAHL 1932), synonymised with *P. lanceolata* (BORROR 1972a), or classified as species indeterminata (PETZ & FOISSNER 1996). Conversely, I consider the characterisation (see relevant chapter in genus section) as sufficient and assume that STERKI observed the same species that I previously called (in FOISSNER et al. 1991) *Parurosoma granulifera* because (i) STERKI (1878, p 48, 58) described a ventral cirral pattern (only including frontal-ventral-transverse cirri) identical to in other 18-cirri oxytrichids; my “*P. granulifera*” has a typical *Oxytricha* cirral pattern (Fig. 91c, f). (ii) STERKI mentioned 2 right cirral rows (similar to in pleurotrichs); “*P. granulifera*” usually has 2 right marginal rows (Fig. 91c, f). (iii) The body of *Allotricha* is metabolic (STERKI 1878), that is, flexible as in “*P. granulifera*”; thus, synonymisation with the rigid *Pleurotricha lanceolata*, as suggested by BORROR (1972a), is unjustified.

(iv) Peristome, consistence, appearance, colouring, and movement is as in urostylids (STERKI 1878); all of which matches "*Parurosoma granulifera*", which was mentioned in FOISSNER et al. (1991) in the chapter similar species of *Paraurostyla weissei*, which was considered as typical urostylid in STERKI's time!

The HEMBERGER (1982; Fig. 91g) population has distinctly larger frontal-ventral-transverse cirri than "*Parurosoma granulifera*" (Fig. 91c) or *Pleurotricha* spec. sensu KRAMER (1988; Fig. 91f). Furthermore, in the HEMBERGER population the right transverse cirrus (VI/1) is somewhat displaced anteriorly, indicating that it is possibly a different species. Unfortunately, neither HEMBERGER (1982) nor KRAMER (1988) mentioned whether cortical granules are present or not. *Pleurotricha variabilis* REUTER is classified as supposed synonym of *A. mollis* (see below for details).

In life, *Allotricha mollis* can be easily confused with the equally sized *Paraurostyla weissei*, also having cortical granules, 2 macronuclear nodules, and additional cirral rows; however, *P. weissei* has more transverse cirri and cirral rows and a different arrangement and number of frontal and ventral cirri.

Most data in the following chapter are own observations (Fig. 91a–e; slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria). Data from KRAMER (1988) are indicated, and data from HEMBERGER (1982) are mentioned separately because they presumably relate to a different species.

Morphology and biology: In life about $160\text{--}220 \times 60\text{--}80\ \mu\text{m}$ (original data), according to SCHMITZ (1986) $180\text{--}290 \times 75\text{--}110\ \mu\text{m}$. Flattened about 2–2.5:1 dorso-ventrally. Long elliptical, usually both ends rounded, posterior one sometimes inconspicuously tapered. Very flexible. Two macronuclear nodules in life about $30 \times 15\ \mu\text{m}$, nucleoli globular, about $1.5\ \mu\text{m}$ across. Usually 2 (sometimes 3), $4\ \mu\text{m}$ sized, ellipsoidal or spherical micronuclei (however, see Table 19). Contractile vacuole somewhat in front of mid-body, during diastole with long canals (Fig. 91a–c). Cortical granules yellowish, in older cultures almost yellow-red, about $1\ \mu\text{m}$ across, usually arranged in loose groups and short rows, especially around cirri and dorsal cilia (Fig. 91b). Pellicle and cytoplasm colourless. Posterior cell portion packed with cytoplasmic crystals and $2\text{--}4\ \mu\text{m}$ sized globules. Movement moderately fast gliding.

Adoral zone of membranelles about 35 % of body length, bases of largest membranelles in life $12\text{--}14\ \mu\text{m}$ broad. Buccal area broad and deep, almost as in *Cyrtohymena*. Undulating membranes distinctly curved and intersecting, that is, more or less in *Oxytricha* pattern (Fig. 91c, f, t). Frontal cirri enlarged, in life about $20\ \mu\text{m}$ long. Frontoventral and ventral cirri slightly enlarged, rather invariably arranged as in Figure 91c. Transverse cirri arranged in an oblique row, slightly enlarged, in life $25\text{--}30\ \mu\text{m}$ long, protrude distinctly beyond posterior end of cell (Fig. 91a, c, f, t). Usually 2 right marginal rows of body length, a third row is distinctly shorter and confined to mid-body (Fig. 91e), sometimes a fourth right marginal row with 7–19 cirri (SCHMITZ 1986). Invariably 1 left marginal row. Marginal cirri in life $15\text{--}20\ \mu\text{m}$ long. Six dorsal kineties, including 2 dorso-marginal rows. Kineties 4–6 shortened anteriorly, kineties 3 and 6 distinctly shortened

Fig. 91h-s *Pleurotricha variabilis*, a supposed synonym of *Allotricha mollis* (after REUTER 1961. h-s, from life). h-r) Ventral views of 11 specimens from 4 different clones (h-j, culture 1; k, culture 2; l-o, culture 3; p-r, culture 4). s) Ventral view of a typical specimen, 200–220 μ m. Arrow marks frontoventral cirrus III/2; p 268.

posteriorly. Dorsal cilia in life about 3 μ m, according to SCHMITZ (1986) 6–8 μ m long, as in the HEMBERGER population. Caudal cirri about 15 μ m long, at posterior end of kineties 1, 2, and 4. Very likely usually more than 3 caudal cirri (Fig. 91d), the KRAMER (1988) and SCHMITZ (1986) populations with 3–6 cirri (4.4 on average; n = 9).

← **Fig. 91a-g** *Allotricha mollis* (a-c, originals; f, from KRAMER 1988; g, from HEMBERGER 1982. a, b, from life; c-g, protargol impregnation). a, b) Ventral views, c = 180 μ m, d = 200 μ m. The yellowish cortical granules are shown in the right posterior quarter of (b). c, f, g) Ventral infraciliature, c = 190 μ m, f = 150 μ m, g = 270 μ m. Arrow in (c) marks frontoventral cirrus III/2, arrow in (g) denotes right transverse cirrus which is displaced anteriorly in the HEMBERGER population, indicating that it is probably another species. d) Dorsal infraciliature, 215 μ m. Arrows mark posterior end of kinety 3 and anterior end of kinety 4. This specimen has 2 caudal cirri each on kineties 1 and 2 and 1 cirrus on kinety 4. Very likely this is the typical pattern in this species. e) Middle stage of morphogenesis in ventral view, 170 μ m. The cirri of a frontal-ventral-transverse primordium are connected by a broken line. Parental cirri white, new cirri black. Arrow marks new dorsomarginal kineties of opisthe; p 262.

Fig. 91t *Allotricha mollis* (original scanning electron micrograph kindly supplied by W. FOISSNER). Ventral view, 125 μ m. The arrows mark the 3 postoral ventral cirri which are slightly larger than the cirri of the innermost (third) right marginal row. The transverse cirri are arranged in an oblique row as in the neotype material (cf. Fig. 91c) and not hook-shaped as in the HEMBERGER population (Fig. 91g). Note curved paroral; p 262.

Cyst spherical, in life 80 μ m in diameter on average (75 to 90 μ m; $n = 14$). Cyst wall about 3–5 μ m thick, moderately wrinkled but without spines, which is a further difference to *A. antarctica*.

Formation of the frontal-ventral-transverse cirri streaks typically oxytrichid (Fig. 91e). All new right marginal rows are formed from streaks occurring in the outer parental right marginal row; no parental right marginal cirri are retained after division.

The HEMBERGER (1982; Fig. 91g) population in life (?) about $270 \times 90 \mu$ m, ratio of length to width about 3:1. Elliptical, both ends broadly rounded. Two macronuclear nodules, 2–4 micronuclei (Fig. 91g). Adoral zone of membranelles about 1/3 of body length, about 50 adoral membranelles. Typical *Oxytricha* cirral pattern, frontal-ventral-transverse cirri distinctly enlarged, transverse cirri arranged in hook shape. Three right marginal rows with 31–37 (outer), 29–35 (middle), and 20–22 (inner) cirri. 37–40 left

Table 19 Morphometric data of *Allotricha antarctica* (ant, from PETZ & FOISSNER 1996) and *A. mollis* (mo1, original data; mo2, from KRAMER 1988; mo3, from SCHMITZ 1986). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	ant	139.6	16.2	11.6	105	194	31
	mo1	206.2	19.5	9.5	158	231	12
	mo2	167.7	-	-	105	205	58
Body, width	ant	63.1	9.2	14.6	43	83	31
	mo1	64.4	8.5	13.2	52	76	12
	mo2	47.8	-	-	30	72	38
Anterior macronuclear nodule, length	ant	28.2	4.8	17.0	22	38	31
	mo1	34.3	6.7	19.5	23	44	10
Anterior macronuclear nodule, width	ant	15.1	1.4	9.5	12	18	31
	mo1	19.5	3.9	21.0	11	24	10
Posterior macronuclear nodule, length	ant	26.8	4.5	16.7	22	39	31
	mo1	32.9	7.7	23.5	23	45	10
Posterior macronuclear nodule, width	ant	16.6	2.0	11.9	13	22	31
	mo1	18.6	3.5	18.8	10	23	10
Macronuclear nodules, distance between	ant	15.5	5.1	33.1	4	27	31
	mo1	28.0	7.4	26.7	18	40	10
Micronuclei, number	ant	2.3	0.6	25.3	1	4	31
	mo1	2.4	0.5	21.8	2	3	8
	mo2	11.8	-	-	6	17	25
Micronucleus, diameter ¹	ant	4.4	0.4	9.5	4	5	31
	mo1	3.0	0.5	16.7	2	4	9
Adoral membranelles, number	ant	33.0	1.7	5.0	30	37	31
	mo1	56.4	3.4	5.9	50	61	11
	mo2	49.0	-	-	38	57	31
	mo3	-	-	-	48	64	?
Adoral zone of membranelles, length	ant	54.0	3.3	6.2	47	61	31
	mo1 ¹	71.2	8.1	11.3	60	82	12
	mo2	68.7	-	-	60	75	20
Right marginal row 1, number of cirri	ant	28.8	2.2	7.6	24	33	31
	mo1	34.0	3.5	10.4	28	40	11
	mo2	29.9	-	-	24	36	27
	mo3	-	-	-	30	48	?
Right marginal row 2, number of cirri	ant	17.1	3.5	20.3	10	25	31
	mo1	33.1	3.5	10.6	26	38	11
	mo2	21.6	-	-	10	31	27
	mo3	-	-	-	22	44	?
Right marginal row 3, number of cirri	mo1	10.9	5.3	48.5	3	21	9
	mo2	8.9	-	-	4	20	15
	mo3	-	-	-	14	26	?
Left marginal row, number of cirri	ant	25.6	2.6	10.1	20	31	31
	mo1	36.8	3.1	8.4	33	42	12
	mo2	29.1	-	-	24	38	27
	mo3	-	-	-	36	47	?

¹ The micronuclei of both species are almost spherical.

marginal cirri. At least 4 dorsal kineties, cilia about 6–7 μm long. Six caudal cirri, difficult to recognise.

Occurrence and ecology: Probably common in freshwater and thus presumably sometimes confused with *Paraurostyloa weissei*. Locus classicus not mentioned by STERKI (1878), but possibly Schleithem in Canton Schaffhausen, Switzerland, where he lived and worked. According to STERKI, *A. mollis* is a frequent and abundant species. I found it in the aufwuchs of an oligosaprobic brook in Aigen, a suburb of Salzburg, Austria (Fig. 91a–e), and in a xenosaprobic alpine brook in Kaprun, Austria. W. FOISSNER (pers. comm.) sampled *A. mollis* in a mesosaprobic river in Bavaria immediately after flooding (Fig. 91t). These records indicate that *A. mollis* prefers clean or only slightly polluted running waters. HEMBERGER (1982) gives no locality. SCHMITZ (1986) found it in the aufwuchs of lentic areas in the mesosaprobic Rhine River, Germany. The KRAMER (1988) population is from Ithaca, USA. Feeds on green algae, diatoms, and ciliates. Biomass of 10^6 individuals about 180 mg.

Supposed synonym: *Pleurotricha variabilis* REUTER, 1961, Acta zool. fenn., 99: 17 (Fig. 91h–s). Remarks: REUTER (1961) did not mention cortical granules. I presume that he overlooked them; however, further populations have to be checked because it cannot be excluded that a species without cortical granules exists. PETZ & FOISSNER (1996) transferred it to *Onychodromopsis* (*O. variabilis*) and considered it as synonym of *O. flexilis* in the legend to the figures. In life 200–220 μm long. Elliptical, broadest at about level of contractile vacuole. Two macronuclear nodules. Adoral zone of membranelles about 1/3 of body length. Occasionally 1 or 2 additional ventral cirri at level of posterior macronuclear nodule (Fig. 91i–l). Transverse cirri protrude slightly beyond posterior end of cell. Often a surplus, more or less long cirral row between or left of the 2 right marginal rows (Fig. 91h, n–r). Locus classicus is a pool with melted snow on grass about 60 m from the seashore near Helsingfors, Finland. Not found since.

Allotricha antarctica nov. spec. (Fig. 92a–y, 93a, b, Tables 3, 4, 19)

- 1972 *Pleurotricha* sp. – THOMPSON, Antarctic Res. Ser., 20: 285 (Fig. 92j; a slide of wet silver impregnated specimens is deposited in the U. S. National Museum, Washington, D. C.; see THOMPSON 1972, p 287).
 1978 *Pleurotricha lanceolata* – SMITH, Scient. Rep. Falkld Isl. Depend. Surv., No. 95: 78 (Fig. 92k; misidentification).
 1996 *Onychodromopsis flexilis* STOKES, 1887 – PETZ & FOISSNER, Acta Protozool., 35: 264 (Fig. 92a–i, l–y, 93a, b; authoritative description; type slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: PETZ & FOISSNER (1996, 1997) identified this species with the type of *Onychodromopsis* STOKES, 1887, which has, however, a different cirral pattern (Fig. 143a–d). *Allotricha antarctica* differs from *A. mollis* in body size and correlated charac-

Fig. 92a–g *Allotricha antarctica* (from PETZ & FOISSNER 1996. a–g, from life). **a)** Ventral view of a typical specimen, 125 μm . **b)** Broad specimen. **c)** Lateral view. **d)** Cortical granulation consisting of small and large granules. **e)** Cytoplasmic crystals. **f)** Optical section of resting cyst, 45 μm . **g)** Detail of cyst wall; p 268.

ters (for example, number of membranelles), position and arrangement of transverse cirri, position of frontoventral cirrus III/2, shape and arrangement of undulating membranes (cp. Fig. 91c with 92h), and geographic distribution so that synonymy can be excluded. The following chapter is based mainly on the very detailed description by PETZ & FOISSNER (1996); data from THOMPSON (1972) and SMITH (1978) are indicated.

D i a g n o s i s: Field populations in life about $90\text{--}125 \times 40\text{--}70 \mu\text{m}$, cultured stocks $100\text{--}200 \times 40\text{--}80 \mu\text{m}$. Cortical granules colourless. On average 33 adoral membranelles.

Fig. 92h, i *Allotricha antarctica* (from PETZ & FOISSNER 1996. h, i, protargol impregnation). Ventral and dorsal infraciliature of same specimen, 155 μ m. Arrow in (h) marks frontoventral cirrus III/2 which is differently arranged to in *A. mollis* (Fig. 91c, f). Arrowhead marks surplus dorsal kinety seen only in this specimen, arrow in (i) denotes interkinetal dorsal dikinetid. Explanation of original labels: Cc = caudal cirri, 1, 4, 5, 6 = dorsal kineties; p 268.

Undulating membranes almost straight and arranged side by side. Frontoventral cirrus III/2 immediately left of migratory cirrus VI/3. Transverse cirri arranged in hook shape, distinctly displaced anteriad. 2–3 right and 1 or 2 left marginal cirral rows.

Type location: Terrestrial moss from the coast of Core Bay, Prince Edward Island, Prince Edward Islands, Subantarctic.

Morphology and biology: Field populations in life on average $113 \times 55 \mu\text{m}$ ($n = 30$), specimens of cultured stocks on average 24 % larger than in raw culture. THOMPSON (1972) population, after wet silver impregnation, $100\text{--}125 \times 40\text{--}55 \mu\text{m}$ (mean = $111 \times 48 \mu\text{m}$; $n = 25$). Body very flexible, broadly elliptical and dorso-ventrally flattened up to 2:1. Macronuclear nodules ellipsoidal, nucleoli globular to ellipsoidal, $1\text{--}4 \mu\text{m}$ across after protargol impregnation. Micronuclei almost globular, usually one in variable position in indentation of each macronuclear nodule. Contractile vacuole in mid-body, with 2 collecting canals. Cortical granules $0.8\text{--}1.0 \mu\text{m}$ across, arranged in rather narrowly spaced longitudinal rows underneath entire cell surface as in *Oxytricha granulifera*, rather compact, stain blue but are not extruded when methyl green-pyronin is added, impregnate faintly to intensely with protargol depending on method and bleaching time. A second type of granules, in great numbers between larger granules, stains red with methyl green-pyronin (Fig. 92d); when the stain is added, many of them are extruded and adhere to cirri and adoral membranelles. Cytoplasm colourless, in field populations with many about $1\text{--}4 \mu\text{m}$ sized lipid droplets and $3\text{--}5 \mu\text{m}$ long, colourless crystals mainly in posterior portion (Fig. 92e). Food vacuoles $15\text{--}20 \mu\text{m}$ across. Glides moderately fast.

Adoral zone of membranelles about 40 % of body length (PETZ & FOISSNER 1996, THOMPSON 1972), distal portion ventrally covered by frontal scutum, cilia gradually shortened from distal to proximal end of zone, widest bases about $10 \mu\text{m}$ in life. 35 adoral membranelles on average (THOMPSON 1972). Buccal cavity occupying about one third of cell width, anteriorly slightly curved and merging into frontal scutum, posteriorly gradually deepened and covered by buccal lip. Buccal lip hyaline, bent upright to and continuous with frontal cell surface, commences at level of buccal cirrus, gradually widened posteriorly to form wedge-shaped structure obliquely merging into posterior buccal vertex; longitudinally bipartite by deep cleft containing proximal 2/3 of paroral, right sheet narrower than left. Paroral after protargol impregnation $25\text{--}32 \mu\text{m}$ long (mean = $28 \mu\text{m}$, $n = 31$), anteriorly slightly curved, cilia about $8 \mu\text{m}$ long. Endoral after protargol impregnation $25\text{--}35 \mu\text{m}$ long (mean = $29 \mu\text{m}$, $n = 31$), straight, inserts on right wall of buccal cavity, not recognisable in scanning electron micrographs because underneath buccal lip. Paroral and endoral usually side by side in silvered specimens, posterior portions rarely slightly intersecting in surface view of cell, both very likely composed of dikinetids (Fig. 92h). Pharyngeal fibres $30\text{--}55 \mu\text{m}$ long in protargol slides, originate from adoral membranelles and undulating membranes. All cirri of field populations in life about $13 \mu\text{m}$ long, insert in shallow cortical pits. Cirral composition as shown in Figure 92h, only slightly variable, that is, one basal body row $\pm$ may occur in most frontal-ventral-transverse cirri; first cirrus of inner left marginal row usually composed of three kineties. Constantly ($n = 31$) 3 frontal cirri, 1 buccal cirrus, 4 frontoventral, 5 postoral and pre-transverse ventral cirri, and 5 transverse cirri. Arrangement of frontal-ventral-transverse cirri invariably as shown in Figure 92h, that is, almost identical to in *Oxytricha granulifera*! Transverse cirri only slightly protruding beyond posterior end of cell. Marginal rows open at posterior end, gap occupied by caudal cirri. Usually 2 left (81 %, $n = 31$) and 2 right (86 %, $n = 80$) marginal rows; left outer row, however, frequently consisting on av-

Fig. 92j-n *Allotricha antarctica* (j, from THOMPSON 1972; k, from SMITH 1978; l-n, from PETZ & FOISSNER 1996. j, wet silver impregnation; k, NOLAND's stain fixation; l-n, protargol impregnation). j, k) Ventral infraciliature of non-dividing specimens, j = 100–125 μ m, k = 140 μ m. Arrow in (j) marks frontoventral cirrus III/2, located left of cirrus VI/3; this is an important difference to *A. mollis* (cf. Fig. 91c). The drawing by SMITH (1978) is somewhat superficial, however, it very likely shows the same species. l) Very early divider with oral primordium close to the transverse cirri. m) Early divider showing basal body patch close to postoral ventral cirrus V/3. Arrowhead denotes outer left marginal row. n) Anlage 2 (arrow) extending anteriorly from oral primordium. Explanation of original labels: Azm = adoral zone of membranelles, Cc = caudal cirri, Em = endoral, Fc = right frontal cirrus, iL = inner left marginal row, Ir = inner right marginal row, oL = outer left

erage of 5 cirri only, in 19 % of specimens even lacking, one cell with short third row (Fig. 92a, h). Rarely a very short third right marginal row is present, namely 1–7 cirri left of inner row (6 %) or 2–3 cirri between inner and outer row (8 %); very likely, these are remnants from last generation and/or young postdividers with parental cirri still in resorption (Fig. 92y, Table 19). Dorsal cilia 3–5 μm long, insert in shallow cortical pits. Kineties 1–3 almost as long as body, kinety 4 curved and commencing behind mid-body, kinety 5 extends from anterior to mid-body, kinety 6 in anterior third of cell, consists of 4–5 bristles only; frequently, some irregularly arranged cilia between kineties 3 and 4, very likely remnants from last generation. Rarely 7 kineties. According to THOMPSON (1972) likely 5 dorsal kineties (presumably he overlooked the short dorsomarginal row!). Three (4–5 in six of 34 specimens) caudal cirri on dorsal kineties 1, 2, and 4, inconspicuous because not elongated and composed of only 4, rarely 6 cilia (Fig. 92h).

Resting cysts globular to slightly ellipsoidal (Fig. 92f), in life about 40 μm (34–48 μm ; $n = 31$) in diameter. Cyst wall colourless, about 2 μm thick, compact; surface studded with about 2 μm long, hyaline spines and sometimes separated by narrow, transparent layer from compact part of wall (Fig. 92g). Cyst contents (cell) usually conspicuously lobed, does not occupy entire cyst volume (Fig. 92f); however, when cyst is slightly pressed, its contents expand, completely filling interior. Cortex distinctly striated. Cytoplasm contains many 1–3 μm sized, colourless globules. Macronuclear nodules and micronuclei do not fuse (Fig. 92f).

M o r p h o g e n e s i s (Fig. 92l–y, 93a, b): This part of life cycle is described in great detail by PETZ & FOISSNER (1996; see this paper for a detailed documentation with micrographs).

Oral primordium and cirral streaks (Fig. 92l–y): Stomatogenesis commences with the apokinetal (?) proliferation of basal bodies close to the left transverse cirri (Fig. 92l). The anarchic field then elongates anteriorly in a narrow streak. Simultaneously, a small field of basal bodies appears adjacent to postoral ventral cirrus V/3, which disintegrates slightly later; both the basal body field and the dissolved cirrus produce the opisthe's anlage 6 (Fig. 92m). Very likely, this anlage does not contribute to the oral primordium because it is slightly but distinctly separate from the oral anlage in 81 % of the cases observed ($n = 16$) and cirrus V/3 is inactive during physiological regeneration. Slightly before or after disintegration of cirrus V/3, some basal bodies separate from the anterior end of the oral primordium, migrate antieriad and become the opisthe's anlage 2, seemingly touching the parental undulating membranes (Fig. 92n, o). However, scanning electron micrographs reveal that this streak is on the cell surface and does not contact the parental membranes, which are still intact and within the buccal cavity and the longitudinal cleft of the buccal lip; very likely, this streak does not contact the proter's anlage 2 (dissolved buccal cirrus) either, although sometimes being rather close to it.

← marginal row, Op = oral primordium, Or = outer right marginal row, Pf = frontoventral cirrus VI/4, Pm = paroral, Tc = transverse cirri, Vc = pretransverse ventral cirrus VI/2; p 268.

Fig. 920-s *Allotricha antarctica* (from PETZ & FOISSNER 1996. Morphogenetic stages after protargol impregnation). o-q) Early dividers showing development of the opisthe anlagen 2-6. r, s) Early dividers. Arrows mark disaggregating cirrus IV/3 (r) and III/2 (s). Arrowhead denotes dedifferentiating buccal cirrus. Explanation of original labels: Em = endoral, Pm = paroral, 2-6 = frontal-ventral-transverse cirri primordia; p 268.

Fig. 92t, u *Allotricha antarctica* (from PETZ & FOISSNER 1996. t, u, protargol impregnation). Middle dividers showing separation of cirral streaks 5 and 6 and marginal anlagen formation (arrowheads). 1–6 = frontal-ventral-transverse cirri primordia; p 268.

Almost simultaneously with the dedifferentiation of cirrus V/3, the middle postoral ventral cirrus V/4 disaggregates, forming opisthe's anlage 5; in 28 % of cases ($n = 18$) it even dissolves immediately before cirrus V/3. Membranelles begin to differentiate in the oral anlage from right to left in a posteriad direction (Fig. 92o). Subsequently, the anterior postoral ventral cirrus IV/2 breaks up into files of basal bodies aligning to anlage 4 of the opisthe (Fig. 92p). Simultaneously, the opisthe's anlage 3 develops near, and possibly from, the posterior ends of anlagen 5 and 6 or from remnants of the oral primordium (Fig. 92q). At this stage, the opisthe's cirral streaks often appear to be connected with the oral primordium (Fig. 92r), which has, however, usually commenced to form adoral membranelles (Fig. 92p, q, s).

Posterior frontoventral cirrus IV/3 disintegrates next and produces anlage 4 of the proter (Fig. 92r). Then, frontoventral cirrus III/2 and buccal cirrus II/2 disaggregate almost simultaneously, forming proter's anlagen 3 and 2, respectively (Fig. 92s). Slightly later, the opisthe's primordia 5 and 6 separate in midregion. The anterior portions move

Fig. 93a, b *Allotricha antarctica* (from PETZ & FOISSNER 1996; a, b, protargol impregnation). Morphogenesis of dorsal infraciliature proceeds in *Oxytricha* pattern, that is, dorsal kinety 3 fragments (arrows) and 2 dorso-marginal kineties (kineties 5, 6) originate near right marginal row anlagen (see Fig. 92w); p 268.

forward, as indicated by the decreased distance to frontoventral cirrus VI/3, becoming proter's anlagen 5 and 6 (Fig. 92s–u). The origin of the opisthe's anlage 1 (undulating membranes) could not be clarified. It develops rather late from anarchic basal bodies located between the oral primordium and the posterior ends of the cirral streaks. Finally, all primordia of the opisthe distinctly separate from those of the proter due to cell elongation and/or anlagen movement (Fig. 92t, u). In the broadened middle dividers, 6 cirral streaks each are recognisable in proter and opisthe (Fig. 92v–x). Cirri differentiate from anterior to posterior in the classic oxytrichid pattern (Fig. 92w, x).

← **Fig. 92v–y** *Allotricha antarctica* (from PETZ & FOISSNER 1996. v–y, protargol impregnation). v) Middle divider showing marginal anlagen formation. Arrows mark anlage for inner right marginal row. w, x) Late dividers showing migration of cirri, development of dorsomarginal kineties (= dorsal kineties 5, 6; arrowheads), and origin of outer left marginal row (large arrows). y) Postdivider (opisthe; 90 µm) still having some parental cirri. Parental cirri white, new cirri black; p 268.

Concomitant with cirral streak separation, distinct changes occur in the daughter's oral structures. The opisthe's oral primordium invaginates, while the parental adoral zone and buccal cavity evaginate. The evagination is accompanied by a dedifferentiation of the parental paroral, which proliferates basal bodies at least at its anterior end (Fig. 92u, v). This anlage forms the leftmost frontal cirrus. The endoral, which is always separate from the paroral anlage, is very likely also partially or completely reorganised as indicated by its slightly loosened kinetids; a special primordium is, however, not formed. When the buccal cavity evaginates, the undulating membranes become more narrowly spaced and optically intersect in their posterior third. When the buccal field invaginates in early postdividers, the membranes move apart and thus do not intersect any longer (Fig. 92w–y). While the buccal cavity is restored, the pharyngeal fibres are resorbed and rebuilt.

Marginal anlagen (Fig. 92t–y): Differentiation commences in middle dividers. The second (47 % of cases), third (35 %) or, rarely, first (18 %) cirrus of the outer right row and, slightly later, invariably the first cirrus of the inner left row commence anlagen formation in the proter; the primordia for the opisthe originate from parental cirri at about mid-body (Fig. 92t, u). A few cirri each disintegrate into files of basal bodies which align longitudinally to form a row. These primordia subsequently become double-rowed and elongate by basal body proliferation and incorporation of additional cirri at their posterior ends (Fig. 92u, v). The inner right and outer left marginal row are morphogenetically inactive, but originate from primordia formed at the anterior ends of the remaining parental outer right and inner left marginal rows respectively (Fig. 92v). The primordia in the left marginal row are distinctly smaller than those in the right row and thus produce fewer cirri. The parental inner right marginal row is completely resorbed only after cytokinesis. Therefore, specimens having three right marginal kineties are very likely postdividers (Fig. 92y).

Dorsal morphogenesis is in *Oxytricha* pattern. Usually 1, rarely 2, caudal cirri each differentiate at the posterior ends of kineties 1, 2, and 4 (Fig. 93a, b). Nuclear division proceeds as usual, that is, the macronuclear nodules first fuse and then split twice, the last macronuclear division being completed in the postdividers. Physiological regeneration (reorganisation) largely resembles the development of the proter. For details, see PETZ & FOISSNER (1996).

Occurrence and ecology: Common in terrestrial habitats of the Antarctic region. PETZ & FOISSNER (1996) found their populations at 2 sites of the Prince Edwards Islands (lat 46°35'S, long 37°56'E; Subantarctic), namely in a slightly saline and acidic (pH 6.1) grass sward on rock at the seaward limit of vegetation on Marion Island and in a slightly saline and acidic (pH 6.3) moss sample collected between *Poa* and *Callitricha* vegetation near a penguin rookery on Prince Edward Island (collected by Dr J. COOPER, University of Cape Town). At these sites, *A. antarctica* occurred together with *Acineria uncinata*, *Colpoda aspera*, *C. cucullus*, *C. inflata*, *C. steinii*, *Cyrtolophosis mucicola*, *Haplocaulus terrenus*, *Leptopharynx costatus*, *Nivaliella plana*, *Platyophrya vorax*, and *Pseudoplatyophrya nana*. SMITH (1978) observed *Allotricha antarctica* in moss peat,

grass soil, and *Aceana* soil in South Georgia, the South Orkney Islands, the Elephant Island, and many other sites of the Antarctic region (SMITH 1972, 1973a, 1974a, 1981, 1982, 1984). Conversely, THOMPSON (1972) found his population in a rock tidal pool with freshwater dilution on one of the Joubin Islands, near the Antarctic peninsula. FOISSNER (1996c) recorded *A. antarctica* from soil of Marion Island, South Atlantic Ocean.

Feeds on bacteria (up to 45 µm long), starch, flagellates (*Polytoma* sp.), and ciliates like *Colpoda steinii* and *Cyclidium glaucoma* (PETZ & FOISSNER 1996). Biomass of 10⁶ individuals about 80 mg (PETZ & FOISSNER 1996).

Cyrtohymena FOISSNER, 1989

1989 *Cyrtohymena* FOISSNER, Sber. öst. Akad. Wiss., 196: 238 – Type (original designation): *Oxytricha* (*Steinia*) *muscorum* KAHL, 1932.

1997 *Cyrtohymena* FOISSNER, 1989 – BERGER & FOISSNER, Arch. Protistenk., 148: 145.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Cyrtohymena* pattern. Frontoventral cirri form V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse and 5 (rarely 4) transverse cirri. One right and 1 left row of marginal cirri. Usually 6 dorsal kineties. Caudal cirri present. Primordia V and VI of proter originate de novo. Dorsal morphogenesis in *Oxytricha* pattern.

Additional characters: Outline long elliptical, rarely distinctly converging posteriorly. Usually 2:1, rarely more flattened. Body rather flexible, some species, however, almost rigid (see taxonomy). Two or 4 (*C. quadrinucleata*) macronuclear nodules. One, two, or more micronuclei. Contractile vacuole in or near mid-body; collecting canals usually present. About half of species with cortical granules; *Cyrtohymena muscorum* additionally with reddish granules in cytoplasm. Pellicle and cytoplasm colourless (not homogeneously coloured), an important difference to *Rubrioxytricha*. Movement usually rapid, sometimes slowly gliding. Buccal cavity broad and very deep, thus bright at low magnification. Frontal cirri slightly to distinctly enlarged as compared with frontoventral cirri, often arranged in a steeply rising row (from right to left). Presumable all species with 6 dorsal kineties, inclusively 2 dorsomarginal rows (see, however, the very large *Cyrtohymena australis*). Three inconspicuous to distinctly elongated caudal cirri on dorsal kineties 1, 2, and 4. Dorsal cilia 3–5 µm long.

Taxonomy: The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of the patterns mentioned in the characterisation, see chapter 2 in the general section. *Cyrtohymena* contains the bulk of the species originally described in *Steinia*. BORROR (1972a) and HEMBERGER (1982) synonymised *Steinia* with *Oxytricha*, considering the differences in the oral apparatus as insufficient to distinguish genera. This simplification was not accepted by GROLIÈRE (1975), and FOISSNER (1982), who re-

established *Steinia* (now *Cyrtohymena*) because of the apomorphic pattern of undulating membranes (Fig. 19g, 20e, 21c). Somewhat later, FOISSNER (1989) described *Steinia sphagnicola*, a species very closely related to the type of *Steinia*, *S. platystoma*. Both species have a fragmented sinusoidal endoral which does not intersect with the curved paroral (Fig. 20f). Thus, the other *Steinia* species were assigned to a new taxon, *Cyrtohymena* (FOISSNER 1989).

Cyrtohymena is well defined and usually easily identified by the sole autapomorphy, namely the distinctive arrangement of paroral and endoral and the broad, deep and thus very transparent buccal cavity (Fig. 98l). However, some species (*C. inquieta*, *C. quadrinucleata*, *C. tetracirrata*) deviate from the majority in that the body is rather inflexible, the relative length of the adoral zone is 40–50 % of body length, and the postoral ventral cirrus V/3 is distinctly displaced posteriad and thus possibly not involved in primordia formation. All three character states indicate that these three species belong to the Stylo-nychinae, that is, *Cyrtohymena* is possibly not monophyletic and the distinctive pattern of undulating membranes evolved twice. However, detailed morphogenetic and molecular biological data are needed to prove this hypothesis.

Cyrtohymena should not be confused with *Steinia*, which has another pattern of undulating membranes, a peculiar pit in the buccal cavity, and a very rigid body (Fig. 22b). Possibly some of the little known *Cyrtohymena* species (*C. gracilis*, *C. sapropelica*, *C. aestuarii*, *C. granulata*, *C. torrenticola*) are synonyms of other species or belong to closely related taxa, such as *Notohymena*.

Very likely, *Cyrtohymena* has a world-wide distribution; however, there is some evidence that certain species do not occur in Australia. BLATTERER & FOISSNER (1988), for instance, studied 21 soil and moss samples from this continent, but did not find *C. muscorum*, which is rather common in European terrestrial habitats. *Cyrtohymena* comprises terrestrial, freshwater, and marine species.

Key to species

Species identification in *Cyrtohymena* unconditionally needs live observation because several species have cortical granules, that is, identification after only protargol impregnation is insufficient.

1	2 macronuclear nodules	2
-	4 macronuclear nodules (Fig. 103a, b)	<i>C. quadrinucleata</i> (p 320)
2	1 micronucleus, usually arranged between the 2 macronuclear nodules (for example, Fig. 96f, h, 101i)	3
-	2 or more micronuclei	5
3	Cortical granules brownish, arranged in longitudinal rows (Fig. 96f)	
		<i>C. gracilis</i> (p 305)
-	Cortical granules absent	4

- 4 Transverse cirri conspicuously displaced anteriad, do not protrude beyond posterior end of cell; in life about 100 μm long; sapropelic form (Fig. 96h) *C. sapropelica* (p 306)
- Transverse cirri protrude distinctly beyond posterior end of cell; in life about 150 to 180 μm long; terrestrial habitats, especially mosses (Fig. 101h, i) *Cyrtohymena* sp. (p 307)
- 5 (2) Cortical granules present 6
- Cortical granules absent 8
- 6 Cortical granules pink to ruby-red, granules occur also in cytoplasm (Fig. 94a, b, d, g, h) *C. muscorum* (p 281)
- Cortical granules not pink to ruby-red, do not occur in cytoplasm 7
- 7 Marine habitats *C. marina* (p 323)
- Freshwater or terrestrial habitats 13
- 8 (5) 4 transverse cirri 9
- 5 transverse cirri 10
- 9 Terrestrial (Fig. 102a, c, f, h) *C. tetracirrata* (p 317)
- Freshwater or brackish water (Fig. 101e, f) *C. aestuarii* (p 308)
- 10 (8) Especially central portion of cell with dark (sometimes greenish) granules (no cortical granules; Fig. 96g) *C. granulata* (p 306)
- Cell without conspicuous dark granules 11
- 11 Outline rather slender, posterior end of cell narrowly rounded (Fig. 96i) *C. torrenticola* (p 307)
- Outline otherwise 12
- 12 Length in life less than 150 μm (Fig. 101a–c) *C. inquieta* (p 313)
- Length in life about 150–250 μm (Fig. 99a–m) *C. candens* (p 308)
- 13 (7) Length in life 250–400 μm (Fig. 97a) *C. australis* (p 296)
- Length in life 90–170 μm 14
- 14 Transverse cirri displaced markedly anteriad (Fig. 98a, f) .. *C. primicirrata* (p 300)
- Transverse cirri displaced not markedly anteriad (Fig. 96a) *C. citrina* (p 293)

***Cyrtohymena muscorum* (KAHL, 1932) FOISSNER, 1989 (Fig. 94a–z, 95a–s, Tables 3, 4, 20)**

- 1932 *Steinia muscorum* KAHL, Tierwelt Dtl., 25: 613 (Fig. 94a).
 1956 *Steinia dubia* GELLÉRT, Acta biol. hung., 6: 349 (Fig. 94n; new synonym).
 1963 *Steinia inquieta* (STOKES, 1887) – REUTER, Sarsia, 10: 7 (Fig. 94m; misidentification).
 1970 *Steinia muscorum*, KAHL, 1932 – DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun (Numero hors-serie): 118 (Fig. 94k).
 1972 *Oxytricha muscorum* KAHL, 1932 – BORROR, J. Protozool., 19: 14.
 1972 *Tachysoma dubia* (GELLÉRT, 1956) – BORROR, J. Protozool., 19: 15.
 1977 *Oxytricha rubra* BUTTKAMP, Decheniana, 130: 122 (Fig. 94l).

- 1982 *Steinia muscorum* KAHL, 1932 – FOISSNER, Arch. Protistenk., 126: 105 (Fig. 94b–f; authoritative redescription; neotype slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
- 1986 *Steinia muscorum* KAHL, 1932 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 482.
- 1987 *Oxytricha germanica* FOISSNER, Arch. Protistenk., 133: 224.
- 1989 *Steinia muscorum* KAHL, 1932 – BERGER & FOISSNER, Bull. Br. Mus. nat. Hist. (Zool.), 55: 41 (Fig. 94g–j; a protargol-impregnated slide [1988:2:1:23] is deposited in the British Museum [Natural History] in London).
- 1989 *Cyrtohymena muscorum* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.
- 1991 *Cyrtohymena muscorum* (KAHL, 1932) FOISSNER, 1989 – VOSS, Arch. Protistenk., 140: 67 (Fig. 94o–z, 95a–s).
- 1996 *Cyrtohymena muscorum* – BONKOWSKI, Berichte des Forschungszentrums Waldökosysteme, 134: 80, Abb. 6.2.2a.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Steinia) muscorum*. Since the presence of a subgeneric name does not affect homonymy between species group names (ICZN 1985, Article 57 d), this name is a primary homonym of 3 other *muscorum* species described by KAHL (1932) in other subgenera (*Opisthotricha*, *Histrio*, *Stylonychia*) of *Oxytricha*. Hence, 3 of these 4 species required replacement names (FOISSNER et al. 1991). “*Steinia muscorum*” was fixed as type of *Cyrtohymena* (FOISSNER 1989); thus, we did not replace its species name. The synonym *Oxytricha rubra* BUITKAMP, 1977a is preoccupied by *Oxytricha rubra* EHRENBURG, 1835 (Abh. preuss. Akad. Wiss., year 1835: 164). EHRENBURG’S species is the well-known marine *Pseudokeronopsis rubra*, whereas the BUITKAMP (1977a) species was renamed as *Oxytricha germanica* and concomitantly synonymised with *Cyrtohymena muscorum* (FOISSNER 1987d).

Steinia dubia, also having a pale pink cytoplasm and a semicircularly curved paroral, is very likely a further synonym of *Cyrtohymena muscorum*. In *Steinia dubia* the posterior-most marginal cirri are longer than the other marginal cirri and the marginal rows are not confluent posteriorly (Fig. 94n), which is, according to GELLÉRT (1956), typical for *Tachysoma*; very likely for the reason BORROR (1972a) transferred it to *Tachysoma*, which is, however, unreasonable because the type species of *Tachysoma*, *T. pel-lionellum*, has a rather different arrangement of undulating membranes. I assume that GELLÉRT (1956) overlooked the caudal cirri.

REUTER (1963a) stated that his *Steinia inquieta* is not identical with *Cyrtohymena muscorum*. However, the habitat, the brownish cortical granules (which are irregularly distributed in the cytoplasm), and the habitus do not support his statement.

DRAGESCO (1970) mentioned neither cortical granules nor any colour of the cytoplasm, very likely because he did not make live observations. In spite of this uncertainty I accept his identification, because all other data agree rather well with the original description. However, DRAGESCO (1970) provided differing sizes, namely 96–116 µm in the text and about 260 µm for Figure 94k.

Fig. 94a-f *Cyrtohymena muscorum* (a, from KAHL 1932; b-f, from FOISSNER 1982. b, e, alpine population from Hochmais [neotype material]; d, f, population from mosses in Morzg, Salzburg city. a-d, from life; e, f, protargol impregnation). a-d) Ventral, lateral, and dorsal view, a = 200 µm, b = 150 µm, d = 185 µm. e, f) Ventral and dorsal infraciliature, e = 120 µm, f = 105 µm. CC = caudal cirri, K = large vacuole with crystals, sG = ruby to pale red, about 0.5–1.5 µm sized cortical granules occurring also in the cytoplasm; p 281.

Morphology and biology: In life 130–200 × 30–60 µm (BERGER & FOISSNER 1989a, FOISSNER 1982), after KAHL (1932) up to 250 µm, according to REUTER (1963a) 130 µm long. Length of synonyms 140–150 µm (GELLÉRT 1956) and, respectively, 180–200 µm (BUTKAMP 1977a). Elliptical, both ends more or less broadly rounded. Body rather flexible. Macronuclear nodules *in vivo* about 20 × 12 µm, after protargol impregnation 14–25 × 6–14 µm, with many small nucleoli. Usually 2, rarely up to 5, in life about 6 × 4 µm sized micronuclei. Contractile vacuole with long collecting canals, anterior one often with a small dilatation. Pellicle colourless, close underneath and in cytoplasm few to very many 0.5 µm (sometimes up to 1.5 µm) sized, ruby to pale red granules so that cells are slightly to distinctly reddish; granules usually irregularly arranged, mainly around dorsal bristle rows and cirri, sometimes forming short rows (Fig. 94a, d, h). After death granules loose colour very rapidly. Cells usually packed with 2–5 µm sized, yellowish, spindle- or drumstick-shaped crystals. Movement moderately rapid.

Adoral zone of membranelles about 35 % of body length. Bases of largest membranelles in life about 8 µm wide. Undulating membranes consist of 2 rows of basal bodies. Buccal area partially covered by a hyaline cytoplasmic fold (Fig. 94g). Frontal cirri strongly enlarged. Rather invariably 2 pretransverse ventral cirri, according to FOISSNER

Fig. 94g-j *Cyrtohymena muscorum* (from BERGER & FOISSNER 1989a. g, h, from life; i, j, protargol impregnation). g, h) Ventral and lateral view, 160 μm . i, j) Ventral and dorsal infraciliature, 145 μm . Note that all postoral ventral cirri are arranged rather closely to buccal vertex; p 281.

(1982), however, rarely up to 6 such cirri present. Transverse cirri in life 20–30 μm long, protrude distinctly beyond posterior end of cell. Left marginal row J-shaped (Fig. 94e, i), after BUITKAMP (1977a), however, terminates about at level of posterior-most transverse cirrus. Marginal cirri in life 20 μm , dorsal cilia 3 μm , after BUITKAMP (1977a) 5 μm long. Dorsal kineties 3 and 5 slightly shortened posteriorly, kinety 4 begins and kinety 6 terminates somewhat in front of mid-body. Very rarely a seventh kinety with 2–4 basal body pairs; DRAGESCO (1970) counted only 5 kineties (very likely he overlooked the short kinety 6). Caudal cirri in life 15–25 μm long.

Cyst spherical, 40–55 μm across, according to REUTER (1963a) only about 35 μm . Outer membrane about 0.7 μm thick, smooth, without a mucous layer. Going inwards, 3

Fig. 94k–n *Cyrtohymena muscorum* (k, from DRAGESCO 1970; l, from BUITKAMP 1977a; m, after REUTER → 1963a; n, from GELLÉRT 1956. k, l, protargol impregnation; m, from life; n, sublimate fixation and opalblue staining). k, l, n) Ventral infraciliature and nuclear apparatus, k = 260 μm , l = 185 μm , n = 135 μm . m) Ventral view, size not indicated; p 281.

94k

m

n

Fig. 94o–t *Cyrtohymena muscorum* (from Voss 1991b. o, from life; p–t, protargol impregnation). o–q) Ventral view and ventral and dorsal infraciliature of non-dividing specimens, o = 135 μ m, p, q = 160 μ m. r–t) Ventral infraciliature of very early and early morphogenetic stages, r = 160 μ m, s = 165 μ m, t = 185 μ m. AZM = adoral zone of membranelles, BC = buccal cirrus, CC = caudal cirri, e = endoral, FC = frontal cirri, FVC = frontoventral cirri, LMR = left marginal row, Ma = macronuclear nodule, Mi = micronucleus, OP = oral primordium, p = paroral, PRVC = anterior pretransverse ventral cirrus, PVC = postoral ventral cirri, RMR = right marginal row, TC = transverse cirri, 1–6 = dorsal kineties 1–6; p 281.

Fig. 94u–z *Cyrtohymena muscorum* (from Voss 1991b. u–z, ventral infraciliature of morphogenetic stages after protargol impregnation). u–z) Early and middle stages, u = 175 μ m, v, x = 145 μ m, w = 150 μ m, y = 140 μ m, z = 125 μ m. Some parental cirri are modified to primordia, namely the postoral ventral cirri (v, arrows), the posterior frontoventral cirri (w, arrows), and the buccal cirrus (x, arrow). AO = anlage of frontal cirri of opisthe, aM = new adoral membranelles; p 281.

Fig. 95a-g *Cyrtohymena muscorum* (from Voss 1991b; a-g, ventral and dorsal infraciliature of morphogenetic stages after protargol impregnation). a-g) Middle stages, a, b = 135 μ m, c, g = 130 μ m, d-f = 120 μ m. Arrows in (a) mark anterior-most cirri of marginal rows which are modified to primordia; arrowhead denotes anlage of undulating membranes of opisthe. The anlagen 5 and 6 of the proter originate de novo, the autapomorphy of the *Cyrtohymena*-*Notohymena*-*Urosomoida* clade. Parental cirri white, new cirri black. DP = dorsal primordia, 1-6 = frontal-ventral-transverse cirri streaks I-VI; p 281.

Fig. 95h–m *Cyrtohymena muscorum* (from Voss 1991b. h–m, ventral and dorsal infraciliature and nuclear apparatus of morphogenetic stages after protargol impregnation). h–m) Late stages showing migration of new cirri, formation of marginal rows, and early stages of dorsal morphogenesis which is in *Oxytricha* pattern. Bars = 50 μm. Arrows mark anlagen of dorsomarginal kineties. Note that the undulating membranes are not curved and arranged side by side at this stage of division. Parental structures white, new black; p 281.

Fig. 95n-s *Cyrtohymena muscorum* (from Voss 1991b. n-s, ventral and dorsal infraciliature of morphogenetic stages after protargol impregnation). n-p) Very late stages, bar = 50 μ m. q-s) Postdividers, bar = 50 μ m. Note, that the genus-specific shape of the undulating membranes is only attained just after cell fission. Parental cirri white, new cirri black; p 281.

zones are discernible: (i) a colourless, vitreous, 2 μ m thick, shining layer, which remains after squeezing the cyst, (ii) a dense layer of red granules, and (iii) the centrally arranged, colourless cytoplasm with the nuclear apparatus (FOISSNER 1982).

Table 20 Morphometric data of *Cyrtohymena australis* (from FOISSNER 1995b. au1, population from Peru; au2, population from Costa Rica), *C. citrina* (cit, from BERGER & FOISSNER 1987a), *C. muscorum* (mu1, from BUITKAMP 1977a; mu2, from FOISSNER 1982; mu3, from BERGER & FOISSNER 1989a; mu4, from VOSS 1991b), *C. primicirrata* (pri, from FOISSNER 1984), *C. quadrinucleata* (qu1, from DRAGESCO & NJINÉ 1971; qu2, from FOISSNER 1984), *C. tetracirrata* (tet, from BERGER & FOISSNER 1987a). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated; if only one value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	au1	285.3	38.7	13.6	245	370	15
	au2	179.1	22.6	12.6	145	230	15
	cit	99.0	11.3	11.3	75	112	11
	mu1	-	-	-	180	200	?
	mu2	120.0	13.4	11.2	100	146	13
	mu3	129.4	14.7	11.3	105	155	22
	mu4	175.8	40.2	22.8	117	246	25
	pri	84.7	10.0	11.9	74	102	9
	qu1	107.0	-	-	100	120	?
	qu2	86.6	6.3	7.2	77	100	10
	tet	89.3	8.1	9.0	77	105	8
Body, width	au1	97.3	10.3	10.6	80	120	15
	au2	67.6	10.7	15.9	50	83	15
	cit	33.5	4.8	14.2	27	41	11
	mu2	46.0	5.1	11.0	37	56	13
	mu3	47.7	5.3	11.2	36	56	22
	mu4	49.1	7.8	15.9	33	66	25
	pri	36.0	2.8	8.3	29	38	9
	qu1	47.0	-	-	40	57	?
	qu2	40.8	4.3	10.5	34	49	10
	tet	46.1	8.5	18.4	34	59	8
Adoral membranelles, number	au1	57.3	4.8	8.4	50	64	15
	au2	48.1	5.5	11.4	43	58	15
	cit	33.6	2.0	6.0	31	37	11
	mu1	-	-	-	37	41	?
	mu2	41.1	3.5	8.6	33	47	13
	mu3	34.8	3.9	11.1	24	40	22
	mu4	34.7	2.9	8.3	30	45	25
	pri	30.2	3.2	10.7	27	36	9
	qu1	36.0	-	-	35	38	?
	qu2	40.0	3.4	8.4	35	47	10
	tet	33.4	2.7	8.0	28	36	8
Right marginal row, number of cirri	au1	36.1	3.6	10.1	29	41	15
	au2	33.8	3.9	11.7	27	40	15
	cit	21.1	2.2	10.3	18	25	11
	mu1	23	-	-	-	-	1
	mu2	25.0	1.8	7.2	22	28	13
	mu3	23.0	1.7	7.5	20	25	22
	mu4	20.1	1.9	9.5	18	24	25

Table 20 Continued

Character	Species	mean	SD	CV	Min	Max	n
Right marginal row, number of cirri	pri	20.3	2.0	9.8	17	24	9
	qu1	22.0	-	-	12	23	?
	qu2	20.3	0.9	4.7	18	21	10
	tet	17.0	3.1	18.3	14	24	8
Left marginal row, number of cirri	au1	38.1	3.7	9.7	31	42	15
	au2	35.8	4.2	11.8	31	45	15
	cit	21.5	2.1	9.6	17	24	11
	mu1	22.0	-	-	-	-	1
	mu2	27.4	2.3	8.5	24	31	13
	mu3	24.7	2.6	10.5	20	29	22
	mu4	25.0	1.5	6.2	22	28	25
	pri	15.6	1.5	9.7	13	18	9
	qu1	19.0	-	-	17	20	?
	qu2	18.3	2.2	12.1	15	22	10
	tet	16.4	2.7	16.3	13	21	8
Dorsal kineties, number	cit	5.8	0.4	6.9	5	6	11
	mu1	6.0	-	-	-	-	?
	mu2	6.0	0	0	6	6	13
	mu3	6.1	0.3	4.8	6	7	22
	mu4	6.0	0	0	6	6	25
	pri	6.0	0	0	6	6	10
	qu2	6.0	0	0	6	6	8
	tet	6.0	0	0	6	6	8

Morphogenesis of *Cyrtohymena muscorum* is described in great detail by Voss (1991b; Fig. 94r–z, 95a–s; Table 4). It proceeds rather similarly to in other oxytrichids. In the middle stages the paroral and endoral are arranged in parallel. They cross in late stages, and the *Cyrtohymena*-specific figure is attained only after cell fission (Fig. 95p–s). The de novo formation of primordia V and VI of the proter is possibly an autapomorphy of the *Urosomoida-Cyrtohymena-Notohymena* group (Fig. 25a, Table 4).

Occurrence and ecology: Common and sometimes rather abundant in terrestrial mosses and soil; very likely confined to terrestrial habitats. Locus classicus, that is, sample site of type population, not fixed. KAHL (1932) discovered *Cyrtohymena muscorum* in mosses of Germany and California, USA. According to Article 75 (f) of the Iczn (1985), the place of the origin of the neotype becomes the type locality of the nominal species. FOISSNER (1982), who provided the neotype, found *C. muscorum* in the soil of an alpine pasture at Hochmais beside the Glockner Road, Salzburg, Austria. A detailed description of this site (new locus classicus), dominated mainly by *Rumex* sp. and *Urtica* sp., is given in FOISSNER (1981; site SO 3).

Further records substantiated by illustrations: Austria (FOISSNER & FOISSNER 1988); litter of a beech forest near Bergheim, Salzburg, Austria (BERGER & FOISSNER 1989a); soil

of a mixed woodland in Melbtal near Bonn, Germany (BUIKAMP 1977a, 1979; locus classicus of the synonym *Oxytricha rubra*); terrestrial moss in Ruhpolding, Germany (VOSS 1991b); leaf litter of a beech forest in Germany (BONKOWSKI 1996); humus underneath mosses near the village of Boldogkövaralja, Hungary (GELLÉRT 1956; locus classicus of the synonym *Steinia dubia*); rain-wet mosses near Espegrend, Blomsterdalen, Norway (REUTER 1963a, b); infusion of dry mosses from the park of the University of Yaounde, Cameroon (DRAGESCO 1970).

Records not substantiated by illustrations: garden soil in Upper Austria (PETZ et al. 1988); agricultural soil and dry mosses in Czechoslovakia (TIRJAKOVÁ 1988, TIRJAKOVÁ & MATIS 1987a); dry mosses, leaf litter, inundated meadows, agricultural soil, and soil infusions in Germany (DINGFELDER 1962, LEHLE 1989, WENZEL 1953); soil from Japan (TAKAHASHI & SUHAMA 1991); soil and mosses from the Antarctica (SUDZUKI 1979). Possibly, *Cyrtohymena muscorum* is not represented in the Australian fauna because BLATTERER & FOISSNER (1989) did not record it from any of their 21 samples from various terrestrial habitats.

TIRJAKOVÁ (1992b) and TIRJAKOVÁ & MATIS (1987a) recorded *C. muscorum* from freshwater in Czechoslovakia, BUCK (1961) from various, usually heavily polluted running waters in Nordwürttemberg, Germany, and WANG (1977) from lentic water bodies of the Tibetan Plateau. Probably, they observed *Rubrioxxytricha* species, which are also reddish but confined to freshwater habitats.

Feeds on fungal spores, diatoms, heterotrophic flagellates, testaceans (*Schoenbornia* sp.), and ciliates (*Odontochlamys* sp., *Opercularia* sp., *Gonostomum* sp.). Voss (1991b) cultured *C. muscorum* in mineral water (Vittel); every second or third day a few drops of a suspension of yeast cells and *Chlorogonium elongatum* were added. Biomass of 10⁶ large specimens about 225 mg (FOISSNER 1987a); REUTER (1963b) calculated an average biomass of only 55 mg.

Cyrtohymena citrina (BERGER & FOISSNER, 1987) FOISSNER, 1989 (Fig. 96a–e, Table 20)

1932 *Steinia (Histrio) inquieta* (STOKES, 1887) – KAHL, Tierwelt Dtl., 25: 613 (Fig. 96c; misidentification).

1985 *Steinia citrina* FOISSNER – FOISSNER, PEER & ADAM, Mitt. öst. bodenk. Ges., 30: 109 (nomen nudum).

1987 *Steinia citrina* BERGER & FOISSNER, Zool. Jb. Syst., 114: 225 (Fig. 96a–d; one slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1989 *Cyrtohymena citrina* (BERGER & FOISSNER, 1987) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: FOISSNER et al. (1985) published the name without indication; thus, it was a nomen nudum until BERGER & FOISSNER (1987a) provided the original description. The combination *Cyrtohymena citrina* was already used by BLATTERER & FOISSNER (1988, p 70), but FOISSNER (1989) must be credited with the authorship because he established *Cyrtohymena*. KAHL (1932) classified *Steinia* as subge-

Fig. 96a–d *Cyrtohymena citrina* (from BERGER & FOISSNER 1987a. a, b, from life; c, d, protargol impregnation). a, b) Ventral and lateral view, a = 130 μ m, b = 125 μ m. The yellow to orange-yellow cortical granules are shown in (b) only. c, d) Ventral and dorsal infraciliature, c, d = 100 μ m. Note that all postoral ventral cirri are arranged close to the buccal vertex; p 293.

nus of *Oxytricha*; the correct name in his revision is thus *O. (Steinia) inquieta*. KAHL (1932) erroneously identified his granule-bearing population with *C. inquieta*, which has, however, no cortical granules according to the original description (STOKES 1887b).

Cyrtohymena citrina should not be confused with *C. primicirrata* (transverse cirri distinctly displaced anteriad) and *C. australis* (significantly larger, namely 250–400 μ m). Possibly these three yellowishly granulated species form a clade within *Cyrtohymena*.

Morphology and biology: In life 120–150 μ m, after KAHL (1932) 100 to 170 μ m long. Slender, sometimes somewhat S-shaped, left margin slightly convex, right nearly straight; according to KAHL (1932) margins distinctly converging posteriorly (Fig. 96e). Both ends more or less broadly rounded. Body flexible and moderately contractile. Macronuclear nodules in life 25 $\times$ 14 μ m, after protargol impregnation 11–21 times 7–10 μ m. 1–4, usually 2, in life about 7 $\times$ 5 μ m sized micronuclei. Contractile vacuole

Fig. 96e–j Ventral view of some *Cyrtohymena* species (from life). e) *Cyrtohymena citrina* (from KAHL 1932), 150 μm . Differs from the type population in that the postoral ventral cirrus V/3 is displaced somewhat posteriad; p 293. f) *Cyrtohymena gracilis* (from KAHL 1932), 100 μm . Note the single micronucleus between the two macronuclear nodules; p 305. g) *Cyrtohymena granulata* (from KAHL 1932), 100 μm ; p 306. h) *Cyrtohymena sapropelica* (from KAHL 1932), 100 μm . Note the single micronucleus between the two macronuclear nodules and the distinctly anteriorly displaced transverse cirri; p 306. i) *Cyrtohymena torrenticola* (from ŠRÁMEK-HUŠEK 1957), 120 μm ; p 307. j) *Cyrtohymena marina* (from KAHL 1932), 130 μm ; p 323.

with inconspicuous collecting canals. Cells yellow at low magnification due to yellow to orange-yellow cortical granules, about 0.5–1.5 μm across, mainly arranged around cirri and dorsal cilia (Fig. 96b); according to KAHL (1932) granules brownish (possibly due to weak illumination).

Adoral zone of membranelles about 35 % of body length. Undulating membranes consist of 2 or 3 rows of basal bodies. Frontal cirri in life about 20 μm long, bases slightly enlarged. All three postoral ventral cirri arranged close to buccal vertex (Fig. 96a, c), according to KAHL (1932) posterior one (cirrus V/3) displaced somewhat posteriad (Fig. 96e). Distance between posterior transverse cirrus and end of cell 3–6 μm (mean = 3.5 μm ; $n = 11$), thus transverse cirri protrude distinctly beyond posterior end of cell. Left marginal row J-shaped, nearly overlapping to right body margin. Right row almost straight, terminates at level of pretransverse ventral cirri. Dorsal kinety 1 anteriorly almost unshortened, kinety 4 begins at mid-body. Invariably 3 caudal cirri.

Occurrence and ecology: Not very common in terrestrial and freshwater habitats. Locus classicus is the litter and upper soil layer of a very shallow soil of a goat pasture between Nauplion and Tripolis, Peloponnesus, Greece (BERGER & FOISSNER 1987a). FOISSNER et al. (1985) found *C. citrina* in soils in the Tullnerfeld, Lower Austria. KAHL (1932) isolated his population from katharobic waters with *Utricularia* and *Hottonia*. I found *C. citrina* in the detritus of an aquarium (24 °C; together with *Stylonychia pustulata*, *Holosticha monilata*, *Euplotes patella*, *Vorticella campanula*, *Mesodinium pullex*, *Chilodonella acuta*, *Frontonia leucas*, *Urocentrum turbo*), and between leaves in the clean Illach River, Bavaria, Germany, in October (see FOISSNER 1997a). FOISSNER (1995b, 1997b, and pers. comm.) found *C. citrina* in soil from Japan, the Dominican Republic, Costa Rica, and Peru.

Feeds on diatoms (*Pinnularia* sp.), flagellates (*Anisonema* sp.), fungi, and ciliates (*Cyclidium* sp., *Vorticella* sp., *Pseudocohnilembus* sp.). Biomass of 10⁶ individuals about 54 mg (FOISSNER 1987a).

***Cyrtohymena australis* FOISSNER, 1995 (Fig. 97a–m, Table 20)**

1995 *Cyrtohymena australis* FOISSNER, Arch. Protistenk., 145: 70.

Taxonomy: This species, *Cyrtohymena citrina*, and *C. primicirrata* very likely form a clade of their own within *Cyrtohymena*, having yellowish cortical granules as apomorphy. Autapomorphies of *C. australis* are the enormous size and the increased number of dorsal kineties.

Morphology and biology: In life 250–400 × 60–100 µm. Lanceolate, right margin usually slightly concave, left approximately convex, widest in buccal area, gradually narrowed and broadly rounded at both ends. Dorso-ventrally flattened up to 2:1. Very flexible. Macronuclear nodules ellipsoid, in life about 45 × 20 µm, in middle third of cell left of median, with many tiny nucleoli. 2–8 micronuclei (4–5 on average; n = 15), almost spherical, often distant from macronuclear nodules, after protargol impregnation 4–6 × 2.7–3.5 µm (n = 15). Contractile vacuole slightly in front of mid-body at left margin, with 2 long collecting canals extending anteriorly and posteriorly. Cells yellow at low magnification due to brilliant citrine colour of cortical granules. Granules globular, 0.4–1.0 µm across, arranged mainly around cirral bases and dorsal bristles but also in loose rows between cirri and bristles (Fig. 97g, h, m), do not impregnate with protargol. Cytoplasm colourless, with some fat globules, 2–4 µm across, and many small and large food vacuoles. Moves rapidly to and fro.

Fig. 97a–i *Cyrtohymena australis* (from FOISSNER 1995b. a, b, g, h, from life; c–f, i, protargol impregnation). → a, b) Ventral and right lateral view, 305 µm. c–f) Details of oral structures. The anterior portion of the paroral consists of short kineties and has fan-shaped fibres attached (c). The adoral membranelles are of different size

and their fine structure varies depending on the location within the membranelar zone. g) Surface view showing arrangement of cortical granules (circles) on ventral side. h) Dorsal view of broad specimen showing pattern produced by cortical granules. i) Ventral infraciliature. Arrowheads mark distal and proximal end of endoral. Small arrows denote the rather inconspicuous pretransverse ventral cirri. Long arrow marks distal end of adoral zone of membranelles, which is very near to right frontal cirrus (III/3). AZM = adoral zone of membranelles, Ma = macronuclear nodule, Mi = micronucleus; p 296.

Fig. 97j, k *Cyrtohymena australis* (from FOISSNER 1995b. j, k, protargol impregnation). Ventral and dorsal infraciliature, 260 μ m. This specimen has only 1 pretransverse ventral cirrus. Note the increased number of dorsal kineties and the sometimes increased number of basal bodies per bristle unit. Arrow marks caudal cirri; p 296.

Adoral zone of membranelles about 34 % of body length, bases of largest membranelles in life about 20 μ m wide. Buccal cavity large and deep. Paroral almost semicircular with 2 fan-like bundles of fibres at anterior end, in large specimens composed of oblique rows having 4–6 cilia each in anterior and dikinetids in posterior half. Endoral hook-like, extends diagonally across buccal cavity and crosses (optically) paroral in pos-

Fig. 97l, m *Cyrtohymena australis* (from FOISSNER 1995b. l, protargol impregnation; m, from life). **l)** Ventral infraciliature of anterior third. **m)** Dorsal side of posterior third showing arrangement of cortical granules within (arrows) and between (arrowhead) dorsal kineties. AZM = adoral zone of membranelles, e = endoral, Ma = macronuclear nodule, Mi = micronucleus, p = paroral, PVC = postoral ventral cirri; p 296.

terior third, very likely composed of dikinetids. Pharyngeal fibres inconspicuous. Frontal cirri 20–25 μm long, slightly (cirrus III/3) to distinctly (cirrus I/1) enlarged (Fig. 97j). Usually 3, rarely only 2 postoral ventral cirri; posterior postoral ventral cirrus (V/3) arranged rather close to other posterals (Fig. 97i, j). Usually 2, rarely only 1 pretransverse ventral cirrus. Transverse cirri (very rarely up to 7) in life 30 μm long, displaced slightly anteriorly. Marginal cirri in life 20–25 μm long, rows distinctly separated posteriorly, gap occupied by caudal cirri right of cell median. Marginal, transverse, and caudal cirri form conspicuous fringe at posterior end. Dorsal cilia in life about 5 μm long, arranged in 5–7 rows almost as long as body and few shortened rows at margins of anterior body half. Bristle complexes composed of 2–6 basal bodies, only 1 or 2 of which are, however, ciliated (Fig. 97k).

Morphogenesis commences with the proliferation of basal bodies at the postoral ventral cirri and the uppermost 2 transverse cirri (Costa Rica population; FOISSNER 1995b).

Occurrence and ecology: Probably widespread in soils of South America. Locus classicus is soil from the Amazon rain forest near the town of Iquitos, Peru (FOISSNER 1995b, 1997b). FOISSNER (1995b) found two other populations of *C. australis*, one in Costa Rica (a tropical dry forest in Santa Rosa National Park, about 5 km east of the ranch house "La Casona", near a small path to the Pacific Ocean) and another at Curaçao, a small island at the north coast of Venezuela, where it occurred in a rather saline sample collected in a garden in the town of Salina.

Feeds on fungal spores, testate amoebae (*Trinema lineare*, *Euglypha* spp.), ciliates (*Leptopharynx costatus*, *Drepanomonas pauciciliata*), and cysts of *Polytoma* sp. Biomass of 10^6 individuals about 350 mg.

***Cyrtohymena primicirrata* (BERGER & FOISSNER, 1987) FOISSNER, 1989**
(Fig. 20e, 98a–o, Table 20)

- 1970 *Steinia platystoma* EHRBG-STEIN, 1859 – DRAGESCO, Anns Fac. Sci. Univ. féd. Cameroun, (Numéro hors-série): 119 (Fig. 98h–j; misidentification).
 1984 *Steinia inquieta* (STOKES, 1887) – FOISSNER, Stapfia, 12: 115 (Fig. 98a–g; misidentification; 1 slide of protargol-impregnated material is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
 1987 *Steinia primicirrata* BERGER & FOISSNER, Zool. Jb. Syst., 114: 227, 228 (pro *Steinia inquieta* sensu FOISSNER 1984).
 1987 *Steinia ultricirrata* BERGER & FOISSNER, 1987 – FOISSNER, Progr. Protistol., 2: 127 (nomen nudum; see FOISSNER & FOISSNER 1988, p 91).
 1989 *Cyrtohymena primicirrata* (BERGER & FOISSNER, 1987) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Taxonomy: FOISSNER (1984) identified his population with cortical granules as *Steinia inquieta* (STOKES), considering the redescription of KAHL (1932) as decisive. However, STOKES (1887b) mentioned neither a cortical granulation nor a colouring of the cytoplasm in the original description of this species. Thus, BERGER & FOISSNER (1987a) established *S. primicirrata* for *S. inquieta* sensu FOISSNER (1984). The infraciliature, especially the distinctly anteriorly displaced transverse cirri of *Steinia platystoma* sensu DRAGESCO (1970) agrees very well with the illustration by FOISSNER (1984; cp. Fig. 98f and 98i); although DRAGESCO (1970) did not mention a cortical granulation (very likely because he made no live observations), I consider the DRAGESCO and FOISSNER populations as conspecific.

Fig. 98a–g *Cyrtohymena primicirrata* (from FOISSNER 1984. a–e, from life; f, g, protargol impregnation). **a, c, e** Ventral, dorsal, and lateral view, a = 120 µm, c = 115 µm, e = 155 µm. The yellow, 0.5–0.8 µm sized cortical granules are shown in (c) only. **b** Cytoplasmic crystals. **d** Pellicle with cortical granules. **f, g** Ventral and dorsal infraciliature, 85 µm; p 300.

Fig. 98h-j *Cyrtohymena primicirrata* (from DRAGESCO 1970. h-j, protargol impregnation). h-j) Ventral and dorsal infraciliature, h, j = 75 μ m, i = 70 μ m; p 300.

Fig. 98k, l *Cyrtohymena primicirrata* (original scanning electron micrographs, kindly supplied by W. FOISSNER). **k)** Ventral view, 95 μm . Arrow marks a cilium of dorsal kinety 1. **l)** Buccal area with prominent paroral; endoral is arranged in deep buccal cavity (arrow). Arrowheads mark special cilia at right margin of adoral membranelles, originally designated “paroral” cilia by STERKI (1878; see general section for details). BC = buccal cirrus, p = paroral; p 300.

The granule-bearing *Steinia inquieta* sensu KAHL (1932) is classified as *C. citrina* (Fig. 96e). According to FOISSNER (1984), the pellicle of *S. primicirrata* is only slightly flexible, which is atypical for a member of the Oxytrichinae. Thus, this character has to be checked and morphogenetic data are needed to clarify the position of this species.

Morphology and biology: In life about $90\text{--}130 \times 35\text{--}50 \mu\text{m}$, $66\text{--}105 \mu\text{m}$ after fixation (DRAGESCO 1970). Elliptical; slightly converging posteriorly, broadest at level of buccal vertex, right margin convex, left usually slightly concave, both ends broadly rounded. Macronuclear nodules in life about $20 \times 12 \mu\text{m}$, after protargol impregnation

Fig. 98m-o *Cyrtohymena primicirrata* (originals kindly supplied by W. FOISSNER. m, n, protargol impregnation; o, scanning electron micrograph). m, n) Ventral and dorsal infraciliature. Note the supernumerary frontoventral cirrus (arrowhead) and the somewhat unusual arrangement of the postoral ventral cirri (cp. with Fig. 98f). Arrow marks posterior end of dorsal kinety 6. o) Pellicle of ventral surface. The small pores are very likely caused by ejected extrusomes (cortical granules). 1-5 = dorsal kineties 1-5; p 300.

10–15 × 7–9 μm. Usually 2 (rarely 3), after protargol impregnation 2.6–3.3 μm sized, spherical micronuclei. Contractile vacuole with short collecting canals. Pellicle only slightly flexible (check; see taxonomy). Cortical granules shiny yellow, so that specimens appear distinctly yellowish even at low magnification; granules about 0.5–0.8 μm across, usually arranged in groups of 3–10 along cirri, adoral membranelles, and especially around dorsal cilia (Fig. 98c, d). Cytoplasm colourless, in posterior half of cell usually many 1–7 μm sized yellowish cytoplasmic crystals.

Adoral zone of membranelles about 38 % of body length. Bases of largest membranelles in life about 8 μm broad. Pharyngeal fibres easily recognisable in life. Paroral consists of 3 or 4 rows of basal bodies, terminates distally distinctly in front of endoral, which consists of 2 or 3 rows of basal bodies. From paroral many fibres run dorsally (Fig. 98f). Frontal and transverse cirri moderately enlarged, in life about 20 μm and 30 μm

long respectively. Five (very rarely 6) conspicuously anteriorly displaced transverse cirri, that is, distance between posterior-most transverse cirrus and end of cell after protargol impregnation 9–14 μm (mean = 11 μm ; $n = 9$). Dorsal kinety 5 only slightly shortened posteriorly, kinety 6 about 1/3 of body length. Invariably 3, in life about 20 μm long very motile caudal cirri insert dorsally exactly in gap between marginal rows.

Occurrence and ecology: Rare in terrestrial and freshwater habitats. Locus classicus is the upper soil layer (0–2 cm) of a flood plain, dominated by *Phalaris australis* and *Phragmites australis* in Vogelsang near the village of Grafenwörth, Lower Austria (BERGER & FOISSNER 1987a). A detailed description of this site is given by FOISSNER et al. (1985; Profil 5). DRAGESCO (1970) found his population in freshwater habitats in Yaounde, Cameroon. Recently, W. FOISSNER (pers. comm.) isolated *C. primicirrata* from a pond in a forest near a lake (Grabensee) in Salzburg, Austria (Fig. 98k–o). However, according to FOISSNER (1987a) *C. primicirrata* prefers terrestrial habitats. Feeds on diatoms, fungal spores, testate amoebae (*Trinema lineare*), and ciliates. Biomass of 10^6 individuals about 77 mg (FOISSNER 1987a).

Cyrtohymena gracilis (KAHL, 1932) FOISSNER, 1989 (Fig. 96f)

1932 *Steinia gracilis* KAHL, Tierwelt Dtl., 25: 614 (Fig. 96f).

1989 *Cyrtohymena gracilis* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Steinia) gracilis*. Differs from other species with granulation by the single micronucleus and the conspicuous long caudal cirri. Little-known species, thus detailed redescription required. Possibly a synonym of *C. muscorum*.

Morphology and biology: In life about $100 \times 33 \mu\text{m}$. Slender oval; some (degenerative?) specimens with nearly parallel margins. Body flexible and slightly contractile. Cortical granules brownish, arranged in conspicuous longitudinal rows. Cytoplasm often dark by oblong crystals. Moves rapidly to and fro, swims slightly bent, under rotation about longer axis of cell. Eighteen frontal, ventral, and transverse cirri. All cirri very long. Transverse cirri conspicuously enlarged, about 50 % of their length protrude beyond posterior end of cell. Three caudal cirri 1/4–1/3 of body length.

Occurrence: Very rare in terrestrial and limnetic habitats. KAHL (1932) mentioned no type location; he wrote “together with *Steinia candens*, but usually more abundant”; however, under *S. candens* he mentioned three locations, namely (i) Hamburg, Germany, (ii) alpine mosses, and (iii) mosses from America. Records not substantiated by illustrations: freshwater in Czechoslovakia (TIRJAKOVÁ 1992b); small, eutrophic lake (Heiligens Meer) in Germany (MÜCKE 1979); mosses from a spring in Italy (STELLA 1947).

***Cyrtohymena granulata* (KAHL, 1932) FOISSNER, 1989 (Fig. 96g)**

1932 *Steinia granulata* KAHL, Tierwelt Dtl., 25: 614 (Fig. 96g).

1989 *Cyrtohymena granulata* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in the original description is thus *O. (Steinia) granulata*. Little-known species, detailed redescription necessary.

Morphology and biology: In life about $100 \times 25 \mu\text{m}$. Margins usually almost in parallel, left often slightly convex. Moderately contractile. Each macronuclear nodule with a single micronucleus. Cortical granules lacking. Cytoplasm always with dark (often they appear greenish) globules, either near mid-body or in the periphery and at posterior end of cell. Full set (18) of frontal, ventral, and transverse cirri; latter protrude distinctly beyond posterior end of cell. Three caudal cirri, hardly longer than marginal cirri.

Occurrence: Locus classicus of this rather seldom species is Wisconsin, USA, where KAHL (1932) found *C. granulata* very abundantly and persistently in a terrestrial (?) moss carpet. MADONI & GHETTI (1977; not substantiated by an illustration or description) counted 40 ind. cm^{-2} in a heavily polluted running water in Parma, Italy, together with *Paramecium*, *Colpidium*, and *Glaucoma*. Further record: soil of paddy fields in Japan (TAKAHASHI & SUHAMA 1991).

***Cyrtohymena sapropelica* (KAHL, 1932) FOISSNER, 1989 (Fig. 96h)**

1932 *Steinia sapropelica* KAHL, Tierwelt Dtl., 25: 613 (Fig. 96h).

1989 *Cyrtohymena sapropelica* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Steinia) sapropelica*. Little-known species, detailed redescription necessary.

Morphology and biology: In life about $100 \mu\text{m}$ long. Outline somewhat variable, usually slender oval and right anteriorly slanted; left body margin slightly convex. Body moderately contractile. Without conspicuously coloured extrusomes (KAHL 1932), that is, cortical granules very likely absent. Adoral zone of membranelles short with a high peristomial lip and high undulating membranes. Eighteen or 17 (?) frontal, ventral, and transverse cirri; latter distinctly displaced anteriad so that they do not protrude beyond posterior end of cell. Three distinctly elongated caudal cirri.

O c c u r r e n c e a n d e c o l o g y: Very rare, limnetic. KAHL (1932) discovered *C. sapropelica* in the sapropel (see also MAUCH 1976); unfortunately, KAHL fixed no type location. CHORIK & VIKOL (1973) recorded it from a cooling plant in Moldova. Feeds on ciliates (KAHL 1932).

***Cyrtohymena torrenticola* (ŠRÁMEK-HUŠEK, 1957) FOISSNER, 1989**
(Fig. 96i)

1957 *Steinia torrenticola* ŠRÁMEK-HUŠEK, Věst. čsl. zool. Spol., 21: 4, 21 (Fig. 96i).

1989 *Cyrtohymena torrenticola* (ŠRÁMEK-HUŠEK, 1957) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

T a x o n o m y: Little-known species, thus detailed redescription necessary. The slender outline is reminiscent of *Urosoma*, which has, however, a different oral apparatus.

M o r p h o l o g y a n d b i o l o g y: In life about $120 \times 22 \mu\text{m}$. Anterior half of cell with more or less parallel margins and broadly rounded, posterior half continuously converging and very narrowly rounded. Macronuclear nodules in life about $21 \mu\text{m}$ long, arranged slightly right of median. No cortical granules mentioned. Adoral zone of membranelles about 35 % of body length. Three postoral ventral cirri, according to the figure, the anterior-most is located in front of cytostome (misobservation?). Five transverse cirri arranged rather close to posterior end of cell. According to ŠRÁMEK-HUŠEK (1957) three short but conspicuous caudal cirri (obviously not shown in the figure).

O c c u r r e n c e: Locus classicus is Cerný potok at Staré Vody, an oligo- or betameso-saprobic brook of a river system ("Kleine March") in Czechoslovakia (ŠRÁMEK-HUŠEK 1957). Not found since.

***Cyrtohymena* sp. (Fig. 101h, i)**

1932 *Steinia candens* KAHL, Tierwelt Dtl., 25: 613, in part: Fig. 116_{18, 21}; not Fig. 120₅, 121₂.

T a x o n o m y: KAHL (1932) provided four illustrations of *C. candens*. In two of them the body margins are more or less parallel and at least two micronuclei are present; they are classified as *C. candens*. The remaining two forms are anteriorly slightly to distinctly narrowed and clearly have only one micronucleus between the two macronuclear nodules (Fig. 101h, i). Because of the latter difference, especially, I separate the populations with one micronucleus from *C. candens*. Detailed description necessary.

M o r p h o l o g y a n d b i o l o g y: In life about $150\text{--}180 \mu\text{m}$ long. Anterior portion slightly narrowed and sometimes inconspicuously curved to the left. Ratio of length to

width about 2.8:1. Body very likely flexible. Macronuclear nodules left of median with one micronucleus in between. Cortical granules lacking, cytoplasm colourless.

Adoral zone of membranelles about 40 % of body length. Transverse cirri protrude distinctly beyond posterior end of cell. Dorsal cilia in life about 4 μm long. Three distinctly elongated caudal cirri.

Occurrence: KAHL (1932) found *Cyrtohymena* sp. in terrestrial mosses from the Alps and from North America.

***Cyrtohymena aestuarii* (MARGALEF LÓPEZ, 1945) comb. nov. (Fig. 101e, f)**

1901 *Oxytricha platystoma* EHRBG. – ROUX, Mém. Inst. natn. génev., 19: 102 (Fig. 101e; misidentification).

1945 *Oxytricha* (*Steinia*) *candens* KAHL var. *aestuarii* MARGALEF LÓPEZ, Boln R. Soc. esp. Hist. nat., 43: 377 (Fig. 101f).

Nomenclature and taxonomy: As the name for the variety was published before 1961, the change in rank does not affect the authorship (ICZN 1985; Articles 45 g (ii), 50 c (i)). Both populations have only 4 transverse cirri, suggesting identity with *C. tetracirrata*. However, this species is very likely confined to terrestrial habitats (FOISSNER 1987a, own observations), whereas the ROUX (1901) and MARGALEF LOPEZ (1945) populations were from fresh and brackish water respectively; I thus avoid a synonymisation. Detailed redescription necessary.

Morphology and biology: After MARGALEF LÓPEZ (1945) in life about 200 μm long, according to ROUX (1901) only 90–110 $\times$ 28–33 μm . Body margins more or less in parallel, both ends broadly rounded. Slightly flexible. Cortical granules not mentioned. Cytoplasm colourless, with many spherical inclusions. Adoral zone of membranelles about 40 % of body length. Buccal area large. Arrangement and number of cirri in frontal area obviously incorrectly observed by MARGALEF LÓPEZ (1945; Fig. 101f). Transverse cirri protrude distinctly beyond posterior end of cell. About 17 right and 13–14 left marginal cirri, which is rather low for such a large species (misobservation?).

Occurrence and ecology: Locus classicus is a saline pond in the estuary of the Llobregat River in Barcelona, Spain (MARGALEF LÓPEZ 1945). ROUX (1901) found his population in a clean, stagnant water body near Geneva, Switzerland. Probably feeds on protozoa.

***Cyrtohymena candens* (KAHL, 1932) FOISSNER, 1989 (Fig. 99a–m, Table 20)**

1932 *Steinia candens* KAHL, Tierwelt Dtl., 25: 613, in part: Fig. 120s, 121z; not Fig. 116_{18, 21} (Fig. 99g, h).

1966 *Steinia simplex* DRAGESCO, Protistologica, 2: 88 (Fig. 99f; new synonym).

Fig. 99a-e *Cyrtohymena candens* (from FOISSNER 1982. a-c, from life; d, e, protargol impregnation). a-c) Ventral, dorsal, and lateral view showing, among other things, contractile vacuole with collecting canals (b), a, b = 135 μ m. d, e) Ventral and dorsal infraciliature, d = 115 μ m, e = 120 μ m. CC = caudal cirri; p 308.

- 1975 *Steinia candens* KAHL, 1932 – GROLIÈRE, Protistologica, 11: 495 (Fig. 99i).
 1977 *Oxytricha platystoma* EHRB. – BUTTKAMP, Acta Protozool., 16: 272 (Fig. 99j; misidentification).
 1982 *Steinia candens* KAHL, 1932 – FOISSNER, Arch. Protistenk., 126: 105 (Fig. 99a-e; authoritative re-description; 1 slide of protargol-impregnated material is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
 1986 *Steinia candens* KAHL, 1932 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 481, in part: Fig. 142F,G,J; not Fig. 142H,I.
 1987 *Steinia candens* KAHL, 1932 – BERGER & FOISSNER, Zool. Jb. Syst., 114: 227, 228.
 1989 *Cyrtohymena candens* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.
 1989 *Cyrtohymena simplex* (DRAGESCO, 1966) – FOISSNER, Sber. öst. Akad. Wiss. 196: 239.
 1994 *Cyrtohymena candens* – FOISSNER, Katalog des Oberösterreichischen Landesmuseums Linz, 71: 192 (colour-micrograph of a protargol-impregnated specimen).

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Steinia) candens*. “*Oxytricha caudens* KAHL” in CAIRNS (1966a, p 61), NING et al. (1993, p 2), and YANG (1989, p 157) is an incorrect subsequent spelling.

Synonymy with *C. inquieta* cannot be excluded; see relevant chapter in *C. inquieta* for discussion of this problem. *Steinia simplex* is obviously somewhat superficially described (Fig. 99f). In my opinion, DRAGESCO (1966b) erroneously interpreted a pretrans-

Fig. 99f–j *Cyrtohymena candens* (f, from DRAGESCO 1966b; g, h, from KAHL 1932; i, from GROLIÈRE 1975; j, after BUITKAMP 1977b. f, i, j, protargol impregnation; g, h, from life). f, i, j) Ventral infraciliature, f = 215 μ m, i = 210 μ m, j = 150 μ m. Arrowheads in (j) mark caudal cirri. Ciliary pattern (for example, lack of postoral ventral cirri) in (f) unreliable. g, h) Ventral views, g = 180 μ m, h = 150 μ m; p 308.

verse ventral cirrus as sixth transverse cirrus, and furthermore he very likely overlooked the anterior two postoral ventral cirri.

The undulating membranes of *Steinia platystoma* sensu BUITKAMP (1977b) show the typical *Cyrtohymena* pattern; since BUITKAMP did not mention a cortical granulation and because of the size (200–250 μ m), I synonymise it with *C. candens* (Fig. 99j). The re-descriptions of CHARDEZ (1971, 1981; Fig. 223d, 234l) are insufficient. KAHL (1932) provided four illustrations of the present species; two of these are anteriorly convergent and have only one micronucleus, indicating that they are a different species (see *Cyrtohymena* sp.; Fig. 101h, i).

Fig. 99k *Cyrtohymena candens* (original scanning electron micrograph, kindly supplied by W. FOISSNER). Buccal area with prominent, semicircularly curved paroral running proximally between two distinct folds (arrowheads). BC = buccal cirrus, e = endoral, FC = frontal cirri, p = paroral; p 308.

Fig. 99i, m *Cyrtohymena candens* (original scanning electron micrographs, kindly supplied by W. FOISSNER). Ventral and dorsal side. Arrow in (m) marks excretion pore of contractile vacuole. b = dorsal kineties, p = curved paroral; p 308.

Morphology and biology: In life $150\text{--}250 \times 60\text{--}80 \mu\text{m}$; $150\text{--}200 \times 60\text{--}80 \mu\text{m}$ (KAHL 1932), $185\text{--}260 \times 55$ to $65 \mu\text{m}$ (Bouin fixed specimens; GROLIÈRE 1975), about $150 \mu\text{m}$ long (FOISSNER 1982), $200\text{--}250 \mu\text{m}$ long (in life?; BUITKAMP 1977b). Length of synonym, *S. simplex* in life (?) $240 \mu\text{m}$ on average (DRAGESCO 1966b). Broad elliptical, margins sometimes nearly in parallel, left margin often straight, right convex. Both ends broadly rounded. According to KAHL (1932) slightly contractile, according to FOISSNER (1982) very flexible. Macronuclear nodules after protargol impregnation $35 \mu\text{m}$ long (GROLIÈRE 1975). 2–5 spherical micronuclei. Contractile vacuole with long collecting canals, excretion pore slit-like (Fig. 99m, arrow). Cortical granules lacking, cytoplasm colourless, according to KAHL (1932) shiny due to many cytoplasmic crystals. Movements usually hasty, stays close to soil particles.

Adoral zone of membranelles between 35 % (Fig. 99d) and 55 % (Fig. 99i) of body length; the latter value is very high and rather atypical for a member of the Oxytrichinae. About 45 adoral membranelles (BUITKAMP 1977b). Buccal area very wide and deep. According to BUITKAMP (1977b) frontal cirri consist of 10×12 cilia. About 16–23 left and 17–28 right marginal cirri. After FOISSNER (1982) and according to scanning electron micrographs (W. FOISSNER, pers. comm.) 6 dorsal kineties, according to GROLIÈRE (1975)

and BUITKAMP (1977b) only 5 (Fig. 99e); possibly they overlooked the rather short kinety 6. Three distinctly elongated caudal cirri.

Resting cyst spherical, with 3–5 μm long spines, about 40 μm across. Cyst wall distinctly yellowish (W. FOISSNER, pers. comm.). ALONSO (1975) and ALONSO & PÉREZ-SILVA (1966a, b, 1967, 1969) studied the polytene chromosomes in the macronuclear anlage.

Occurrence and ecology: Common in soil and in benthic freshwater habitats. Locus classicus is Volksdorf, Hamburg, Germany, where KAHL (1932) discovered *C. candens* in mosses from a shaded wall. Records substantiated by illustrations: soil of alpine pastures in the Glockner area, Austria (FOISSNER 1982, FOISSNER & FOISSNER 1988); puddles at the shore of Lake Geneva (= locus classicus of the synonym, *Steinia simplex*) and pond in France (DRAGESCO 1966b, GROLIÈRE 1975); soil of the savannah of Lamto, Ivory Coast (BUIKAMP 1977b); bark of a tree near Ross Highway, about 50 km east of Alice Springs, Australia (BLATTERER & FOISSNER 1988; Fig. 99k–m are also from an Australian population); soil in Tasmania (FOISSNER 1997b).

Records not substantiated by illustrations: Belgium (CHARDEZ 1987); rivers in Bulgaria (DETCHIEVA 1981, 1991); agricultural soil, submerged and terrestrial mosses, and freshwater from Czechoslovakia (TIRJAKOVÁ 1988, 1992b, TIRJAKOVÁ & MATIS 1987a, b); soil of a beech wood in Denmark (STOUT 1968); in Staufen and in a pond in Germany (ALONSO & PÉREZ-SILVA 1966a, MÜCKE 1979); beta- to alphamesosaprobic running waters in Italy (MADONI 1980, MADONI & GHETTI 1981a, STELLA & CAMPEA 1948); Segovia and Lobregat River, Spain (ALONSO & PÉREZ-SILVA 1966a, b, GRACIA et al. 1989); freshwater habitats in the Tibetan Plateau (WANG 1977); China (NING et al. 1993, YANG 1989); soil in Costa Rica (FOISSNER 1995b); Rio Bella, Peru (CAIRNS 1966a); saline soils south-east of Adelaide, Australia (POMP & WILBERT 1988).

Feeds on heterotrophic flagellates, amoebas, and ciliates (FOISSNER 1982, GROLIÈRE 1975). Biomass of 10^6 individuals about 150 mg (FOISSNER 1987a). DETCHIEVA (1983a) found *C. candens* in oligosaprobic areas of the Maritza River, Bulgaria, under following conditions: 0.3 % frequency, 17.4 °C, pH 7.4, 8.2 mg l⁻¹ O₂ (87 % saturation), 49 mg l⁻¹ Ca²⁺, 6.3 mg l⁻¹ Mg²⁺, 192 mg l⁻¹ HCO₃⁻, 10 mg l⁻¹ SO₄²⁻, 12.5 mg l⁻¹ Cl⁻, 0.05 mg l⁻¹ NH₄⁺, 0.4 mg l⁻¹ NO₃⁻, 0.12 mg l⁻¹ NO₂⁻, 0.02 mg l⁻¹ Fe²⁺. For autecological data of terrestrial populations, see FOISSNER (1981, 1985a), FOISSNER & PEER (1985), and FOISSNER et al. (1985).

Cyrtohymena inquieta (STOKES, 1887) FOISSNER, 1989 (Fig. 100a, b, 101a–c)

1859 *Oxytricha platystoma*. EHRBG. – STEIN, Organismus der Infusionsthierie I, p 190, in part: Tafel XII, Fig. 16, 18; not Fig. 17, 19, 20 (Fig. 100a, b).

1887 *Histrio inquietus* STOKES, Ann. Mag. nat. Hist., 20: 113 (Fig. 101a).

1888 *Histrio inquietus* STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 296.

1972 *Oxytricha inquieta* (STOKES, 1887) KAHL, 1932 – BORROR, J. Protozool., 19: 13.

- 1974 *Oxytricha candens* (KAHL) – PÄTSCH, Arb. Inst. landw. Zool. Bienenkd., 1: 62 (Fig. 101c; very likely a misidentification).
 1975 *Steinia macrostoma* GROLIÈRE, Protistologica, 11: 495 (Fig. 101b; new synonym).
 1987 *Steinia inquieta* (STOKES, 1887) – BERGER & FOISSNER, Zool. Jb. Syst., 114: 227, 228.
 1989 *Cyrtohymena inquieta* (STOKES, 1887) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.
 1989 *Cyrtohymena macrostoma* (GROLIÈRE, 1975) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: “*Stienia macrostoma*” in GROLIÈRE (1975, p 481) is an incorrect subsequent spelling of *Steinia*. KAHL (1932) provided *C. inquieta* with brownish cortical granules, which is unjustified because STOKES (1887b) mentioned neither cortical granules nor a colouring of the cytoplasm. Thus, *C. inquieta* sensu KAHL (1932) is classified as *C. citrina* (Fig. 96e). Accordingly, *C. inquieta* is a species without cortical granulation which differs from *C. candens* only in body size (BERGER & FOISSNER 1987a); *Cyrtohymena inquieta* is less than 150 µm long, *C. candens* becomes 150 to 250 µm long. This separation is of course somewhat arbitrarily and synonymy cannot be excluded. However, there is further a character indicating the validity of these two species, namely the absence of one postoral or pretransverse ventral cirrus in *C. inquieta* (Fig. 101a). This is confirmed by protargol impregnation of *Steinia macrostoma*, which is thus considered as new synonym of *C. inquieta* (Fig. 101b).

Neither STOKES (1887b) nor GROLIÈRE (1975) wrote anything about the flexibility of the cell. STOKES (1887b) assigned it to *Histrio*, indicating that *C. inquieta* has a rigid body like *Histriculus* or *Steinia*. This would correlate with other apomorphies of the Stylonychinae, namely the long adoral zone of membranelles (about 50 % of body length) and the lack of cortical granules. The micrograph of a protargol-impregnated specimen in GROLIÈRE (1975; his Fig. 26) shows a distinctly curved paroral (unfortunately no distinct endoral), indicating that the oral apparatus is *Cyrtohymena*- and not *Steinia*-like; thus, it is not transferred to *Steinia*. Detailed reinvestigation needed.

Oxytricha platystoma sensu GU & ZHANG (1992) is very likely identical with *C. inquietea*. STEIN (1859b) obviously confused *Steinia platystoma* (Fig. 172i, j) and a *Cyrtohymena* species which is preliminarily classified as *C. inquieta* (Fig. 100a, b).

Steinia candens var. *depressa* GELLÉRT and *S. ovalis* REUTER are preliminarily treated as supposed synonyms of *C. inquieta* because they are less than 150 µm long (Fig. 101d, g). It is impossible to separate them reliably from *C. inquieta* or *C. candens* with the data available. Detailed investigations of populations from the type locations are needed to elucidate the taxonomic status of these little-known species.

Steinia inquieta sensu REUTER (1963a) from rain-wet mosses is preliminarily classified as *C. muscorum* because it has dark brown granules (Fig. 94m). The DINGFELDER (1962; Fig. 223c) and VUXANOVICI (1961; Fig. 234f–h) redescrptions of *C. inquieta* are insufficient.

Morphology and biology: In life about 95 µm (STOKES 1887b), after protargol impregnation about 90 µm long (PÄTSCH 1974), according to GROLIÈRE (1975) 95–140 × 30–50 µm (mean = 110 × 43 µm) after protargol impregnation. Body margins

distinctly converging posteriorly, anterior end broadly rounded. Macronuclear nodules after protargol impregnation about 14 μm long, arranged slightly left of median. At least two, after protargol impregnation about 4 μm sized spherical micronuclei. Cortical granules lacking!

Adoral zone of membranelles about 50 % of body length (see taxonomy), consists of 45–50 membranelles. Buccal area very large. Frontal and transverse cirri distinctly enlarged. Both STOKES (1887b) and GROLIÈRE (1975) draw only 4 postoral and pretransverse ventral cirri, possibly a typical character of *C. inquieta* (Fig. 101a, b); however, the STEIN (1859b; Fig. 100a, b) and PÄTSCH (1974; Fig. 101c) illustrations do not confirm this peculiarity, indicating that these populations are not conspecific. About 20 right and 14–16 left marginal cirri. According to GROLIÈRE (1975) only 5 dorsal kineties and no caudal cirri; probably he overlooked the usually rather short outer dorsomarginal row and misinterpreted the caudal cirri as marginal cirri.

Fig. 100a, b *Cyrtohymena inquieta* (after STEIN 1859b). Ventral and dorsal view of ventral ciliature from life, sizes not indicated; p 313.

Occurrence and ecology: Very likely confined to freshwater habitats. Locus classicus is a pond with *Lemna* in North America, probably near Trenton, New Jersey, where STOKES lived. GROLIÈRE (1975, 1977, 1978) discovered the synonym, *Steinia macrostoma*, in a pond in France. PÄTSCH (1974) found it in small running waters near Bonn, Germany. Records not substantiated by illustrations: terrestrial mosses from Belgium (CHARDEZ 1983, 1987); once in the Bulgarian Strouma River (DETCHEVA 1979c; incorrectly spelled as *Steinia inquieta*); freshwater habitat in the Tibetan plateau (WANG 1977); Brush Lake, Ohio, USA (RIDDLE 1905); Pantanal flood plains, Brazil (HARDIOM & HECKMAN 1996). Feeds on bacteria, flagellates, and ciliates (GROLIÈRE 1975).

Supposed synonyms: *Steinia candens* var. *depressa* GELLÉRT, 1942, Acta Scientiarum Mathematicarum et Naturalium, 8: 28 (Fig. 101d). Remarks: GELLÉRT (1942) found this 100–120 μm sized population without cortical granules in the algae layer of

Fig. 101a–c *Cyrtohymena inquieta* (a, after STOKES 1887b; b, from GROLIÈRE 1975; c, from PATSCH 1974. a, from life; b, c, protargol impregnation). a) Ventral view, 70 μ m. Note the lack of one postoral ventral or pre-transverse ventral cirrus, which is confirmed by protargol impregnation (Fig. 101b). Possibly, this species belongs to *Steinia*, as indicated by the long adoral zone of membranelles and the rigid body (see text). b, c) Ventral infraciliature, b = 115 μ m, c = 90 μ m; p 313. d) *Cyrtohymena candens* var. *depressa*, a supposed synonym of *C. inquieta* (from GELLÉRT 1942). Ventral infraciliature after sublimate fixation and opalblue staining after

tree bark in Hungary. Buccal cavity less broad than in *C. inquieta* and *C. candens*. Synonymy with *C. inquieta* uncertain because full set (3) of postoral ventral cirri present. FOISSNER (1989, p 239) transferred it to *Cyrtohymena*: *C. candens* var. *depressa* (GELLÉRT, 1942) FOISSNER, 1989.

Steinia ovalis REUTER, 1961, Acta zool. fenn., 99: 19 (Fig. 101g). Remarks: FOISSNER (1989, p 239) transferred it to *Cyrtohymena*, *C. ovalis* (REUTER, 1961). This species is reminiscent of *C. inquieta* and *C. candens*; because it is less than 150 µm long, I assign it to the *C. inquieta* group, which has, however, only 2 postoral ventral cirri. In life about 130–140 µm long; slender oval; adoral zone of membranelles about 1/3 of body length; peristomial lip anteriorly rectangularly curved; only the three posterior-most transverse cirri protrude beyond posterior end of cell; probably 3 slightly enlarged caudal cirri. Locus classicus is the groundwater from the northern sandy beach of the Langskär Island in Finland. REUTER (1961) found it 0.1–0.2 m (?) from the sea, indicating that *S. ovalis* is a marine interstitial form. Not found since.

Cyrtohymena tetracirrata (GELLÉRT, 1942) FOISSNER, 1989 (Fig. 102a–k, Table 20)

1942 *Steinia tetracirrata* GELLÉRT, Acta Scientiarum Mathematicarum et Naturalium, 8: 25 (Fig. 102a, b).

1972 *Oxytricha tetracirrata* GELLÉRT, 1942 – BORROR, J. Protozool., 19: 14.

1987 *Steinia tetracirrata* GELLÉRT, 1942 – BERGER & FOISSNER, Zool. Jb. Syst., 114: 225 (Fig. 102c, e, h, i; authoritative redescription; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1989 *Cyrtohymena tetracirrata* (GELLÉRT, 1942) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Taxonomy: Very likely *C. tetracirrata* is confined to terrestrial habitats. *Oxytricha candens* var. *aestuarii* MARGALEF LÓPEZ, 1945 and *O. platystoma* sensu ROUX (1901) also have only 4 transverse cirri (Fig. 101e, f). However, they were collected from brackish and, respectively, freshwater habitats, which is the main reason I do not synonymise them with *C. tetracirrata*. The non-terrestrial populations are preliminarily classified as *C. aestuarii* MARGALEF LÓPEZ, 1945.

Cyrtohymena tetracirrata has an almost rigid body, a long adoral zone (40 % of body length), and cirrus V/3 is distinctly displaced posteriad indicating that it is not involved in primordia formation. These character states suggest that it is (like *C. quadrinucleata* and *C. inquieta*) not an Oxytrichinae, but a Stylonychinae; however, morphogenetic and molecular biological data are needed to verify this hypothesis.

← BRESSLAU, 100 µm; p 315. e, f *Cyrtohymena aestuarii* (e, after ROUX 1901; f, after MARGALEF LÓPEZ 1945). Ventral views in life, e = 95 µm, f = 210 µm; p 308. g *Cyrtohymena ovalis*, a supposed synonym of *C. inquieta* (after REUTER 1961). Ventral view in life, about 130 µm; p 317. h, i *Cyrtohymena* sp. (from KAHL 1932). Ventral views in life, h = 180 µm, i = 150 µm. Note single micronucleus between macronuclear nodules; p 307.

Fig. 102j, k *Cyrtohymena tetracirrata* (originals, kindly supplied by W. FOISSNER). j) Ventral infraciliature after protargol impregnation. k) Cyst in life, bright field; p 317.

Morphology and biology: In life about $150\text{--}170 \times 60\text{--}70\ \mu\text{m}$, according to GELLÉRT (1942, 1956) only $90\text{--}110\ \mu\text{m}$ long. Body margins more or less parallel, right one sometimes slightly convex; some specimens posteriorly slightly broader than anteriorly; both ends broadly rounded. Body almost inflexible and fragile, according to GELLÉRT (1942) flexible. Macronuclear nodules in life about $20\text{--}30 \times 14\text{--}16\ \mu\text{m}$, after protargol impregnation $14\text{--}18 \times 10\text{--}11\ \mu\text{m}$ (mean = $17 \times 10\ \mu\text{m}$; $n = 8$), arranged about in median of cell (Fig. 102a, f, i). Distance between macronuclear nodules after protargol impregnation $7\text{--}18\ \mu\text{m}$ (mean = $13\ \mu\text{m}$). Nucleoli large, easily recognisable even in life. 2–3, in life about $5\ \mu\text{m}$ sized, spherical micronuclei. Contractile vacuole with distinct collecting canals. Cortical granules lacking. Cytoplasm colourless, many about $12\text{--}17\ \mu\text{m}$ sized food vacuoles, some with crystalline content.

Adoral zone of membranelles about 40 % of body length. Bases of largest membranelles in life about $11\text{--}13\ \mu\text{m}$ broad. Undulating membranes consist of 3–4 rows of basal bodies. Frontal cirri distinctly enlarged, in life about $25\text{--}30\ \mu\text{m}$ long. Arrangement of frontoventral cirri usually as in Figures 102a, f, sometimes cirrus VI/3 slightly displaced posteriad (Fig. 102h, arrow). Invariably 4, in life about $30\ \mu\text{m}$ long, slightly to distinctly enlarged transverse cirri (Fig. 102a, f, h, j). Marginal cirri in life about $20\text{--}25\ \mu\text{m}$ long, left row terminates in median of cell, right one ends slightly subterminally. Dorsal

← Fig. 102a–i *Cyrtohymena tetracirrata* (a, b, after GELLÉRT 1942; c, e, h, i, from BERGER & FOISSNER 1987a; d, f, g, originals. a, b, sublimate fixation and opalblue staining; c–e, g, from life; f, h, i, protargol impregnation). a, b, f, h, i) Ventral and dorsal infraciliature, a, b, h, i = $80\ \mu\text{m}$, f = $105\ \mu\text{m}$. Arrowheads in (f) mark the 3 caudal cirri, arrow in (f, h) denotes frontoventral cirrus VI/3, which is in a somewhat unusual position in (h). c–e) Ventral, dorsal, and right lateral view, c = $160\ \mu\text{m}$, d, e = $150\ \mu\text{m}$. g) Part of the cyst wall; height of protuberances = $2.5\text{--}4\ \mu\text{m}$; p 317.

kinety 4 somewhat shortened anteriorly, kinety 5 about half of body length, kinety 6 consists of about 6 basal body pairs (Fig. 102i). Usually 3, rarely 4, in life about 30 μm long caudal cirri on dorsal kineties 1, 2, and 4; arranged dorsally in gap between marginal rows (Fig. 102f, i).

Resting cyst spherical, with many 2.5–4.0 μm high protuberances (Fig. 102g, k). Diameter without tubercles 42–56 μm . Cyst wall 1–2 μm thick, distinctly yellowish. Cytoplasm slightly yellowish.

Occurrence and ecology: Probably confined to terrestrial habitats. *Locus classicus* is a tree bark grown with algae (*Pleurococcus vulgaris*) in Hungary (GELLÉRT 1942). Unfortunately, the paper is written in Hungarian so that I could not find the sample site; possibly it is near Tihany, where GELLÉRT lived and worked. GELLÉRT (1956) found *C. tetracirrata* in mosses and tree barks near the village of Boldogkővaralja, Hungary, and BERGER & FOISSNER (1987a) in a salt soil with rush, about 50 m from the sea in Nauplia Bay, Greece. I found it in compost heaps near the village of Garsten (Upper Austria) and Salzburg (Fig. 102d, f) and in terrestrial mosses from a gorge (Glasenbachklamm) in Salzburg, Austria.

Feeds on bacteria, flagellates (*Anisonema* sp.), and ciliates. Can be cultured in Eau de Volvic (France) with yeast as food. Biomass of 10^6 individuals about 150 mg (FOISSNER 1987a).

***Cyrtohymena quadrinucleata* (DRAGESCO & NJINE, 1971) FOISSNER, 1989**
(Fig. 21c, 103a–f, Table 20)

1971 *Steinia quadrinucleata* DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 129 (Fig. 103a).

1984 *Steinia quadrinucleata* DRAGESCO & NJINE, 1971 – FOISSNER, Stapfia, 12: 118 (Fig. 103b–f; authoritative redescription; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1986 *Steinia quadrinucleata* DRAGESCO et NJINE, 1971 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 482.

1989 *Cyrtohymena quadrinucleata* (DRAGESCO & NJINE, 1971) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: *Steinia quadrinucleatus* in NJINE (1977, p 232) is an incorrect subsequent spelling. DRAGESCO & NJINE (1971) and DRAGESCO & DRAGESCO-KERNÉIS (1986) mentioned a third undulating membrane, which is a misobservation and/or a misinterpretation of the protargol preparations. Some character states (body almost rigid, adoral zone of membranelles more than 40 % of body length) indicate that *Cyrtohymena quadrinucleata* (and *C. tetracirrata* and *C. inquieta*) does not belong to the Oxytrichinae, but to the Stylonychinae. Furthermore, the posterior-most postoral ventral cirrus (V/3) is possibly not involved in primordia formation (according to an unpublished scanning electron micrograph of a population from Namibia, kindly supplied

Fig. 103a–d *Cyrtohymena quadrinucleata* (a, from DRAGESCO & NJINE 1971; b–d, from FOISSNER 1984. a, protargol impregnation; b–d, from life). a) Ventral infraciliature, 105 µm. b–d) Ventral, dorsal (with contractile vacuole), and lateral view, b = 140 µm; p 320.

by W. FOISSNER), another, certainly plesiomorphic character of the Stylonychinae (Fig. 25a, b); however, detailed morphogenetic and molecular biological data are needed for final classification.

Morphology and biology: In life about 140×55 µm (FOISSNER 1984). Orthogonal, anteriad often slightly converging; both ends broadly rounded. Pellicle only slightly flexible (FOISSNER 1984; see taxonomy). Macronuclear nodules in life $15\text{--}20 \times 10$ µm, after protargol impregnation $9\text{--}16 \times 7\text{--}10$ µm ($n = 10$), sometimes arranged in 2 indistinct pairs left of median (Fig. 103b). 2–4 in life about 3 µm sized, spherical micronuclei. Contractile vacuole without conspicuous collecting canals. Pellicle and cytoplasm colourless. Cortical granules lacking. Posterior half of cell usually with

Fig. 103e, f *Cyrtohymena quadrinucleata* (from FOISSNER 1984. e, f, protargol impregnation). Ventral and dorsal infraciliature, 80 μ m; p 320.

numerous 0.5–5.0 μ m sized, yellowish crystals, so that specimens appear dark at low magnification and bright field illumination. Moves rapidly to and fro.

Adoral zone of membranelles about 47 % of body length (see taxonomy). Bases of largest membranelles in life about 11 μ m broad. Pharyngeal fibres easily recognisable in life. Paroral consists of 3 or 4 rows of basal bodies, with many dorsally running fibres (Fig. 103e); endoral composed of 2 or 3 rows. Frontal cirri distinctly enlarged, in life about 20 μ m long. Transverse cirri slightly enlarged, in life about 28 μ m long, distinctly protruding beyond posterior end of cell, somewhat fringed distally. Marginal cirri in life 15 μ m long, rows not confluent posteriorly. Dorsal kineties 3 and 4 slightly shortened an-

teriorly. Three, in life about 25 μm long, enlarged caudal cirri; arranged dorsally, almost exactly above gap of marginal cirri (Fig. 103f).

Occurrence and ecology: Not very common in terrestrial and freshwater habitats. Locus classicus is a leaf-littered pond near Yaounde, Cameroon (DRAGESCO & NJINE 1971; see also NJINÉ 1977). FOISSNER (1984) found *C. quadrinucleata* in the upper soil layer of a conventionally farmed field in the town of Salzburg, Austria. W. FOISSNER (pers. comm.) found it also in soils from Namibia and Antarctica. Further record: soil of rain forest in Brazil (FOISSNER 1997b). Biomass of 10^6 specimens about 81 mg (FOISSNER 1987a). Feeds on ciliates.

Cyrtohymena marina (KAHL, 1932) FOISSNER, 1989 (Fig. 96j)

1932 *Steinia marina* KAHL, Tierwelt Dtl., 25: 614 (Fig. 96j).

1989 *Cyrtohymena marina* (KAHL, 1932) – FOISSNER, Sber. öst. Akad. Wiss., 196: 239.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Steinia) marina*, which is a primary homonym of *Oxytricha (Oxytricha) marina* KAHL, 1932; the latter received a replacement name. Little-known species; detailed redescription thus necessary.

Morphology: Length in life 100–150 μm . Long elliptical, that is, 4–5 times as long as broad. Flexible and soft, slightly contractile. Cortical granules sparse and delicate, arranged in short rows (colour? probably inconspicuous). Adoral zone of membranelles about 1/4 of body length.

Occurrence and ecology: Very rare in marine habitats. Locus classicus is the North Sea near Sylt, Germany, where KAHL (1932) discovered *C. marina* in a mesosaprobic culture with *Oscillatoria*. Records not substantiated by illustrations: brackish water (1–18 ‰ salinity, 22–27 °C) of Black Sea in Bulgaria (DETCHIEVA 1980, 1981, 1983d). REINNARTH (1979) found a rather similar species (*Steinia* cf. *marina*) in the mud-water interface of freshwater habitats near Bonn, Germany; very likely confused with another species.

Insufficient redescriptions

Steinia candens KAHL 1930 – CHARDEZ, 1981, Revue verviét. Hist. nat., 38: 53 (Fig. 223d). Remarks: Neither the number and the arrangement of the cirri nor the morphology of the oral apparatus indicate that the identification is correct. Freshwater in Belgium.

Steinia caudens KAHL – CHARDEZ, 1971, Revue verviét. Hist. nat., 28: 38 (Fig. 234l). Remarks: Incorrect subsequent spelling. The illustration does not show the typical *Cyrtohymena*-like buccal area. Freshwater in Belgium.

Steinia inquieta (STOKES, 1887) – VUXANOVICI, 1961, Studii Cerc. Biol., 13: 439 (Fig. 234f–h). Remarks: Cytoplasm with yellowish, 0.5–1.0 µm sized granules; cortical granules dark. The identification cannot be accepted because *Cyrtohymena inquieta* has no cortical granules. Lake in Bucharest, Romania.

Steinia inquieta (STOKES 1887) KAHL, 1932 – DINGFELDER, 1962, Arch. Protistenk., 105: 620 (Fig. 223c). Remarks: In life about 150 µm long. DINGFELDER (1962) identified his population according to KAHL (1932), however, he did not mention if his population has a cortical granulation or not. During warm season in road pools in Bavaria, Germany.

***Notohymena* BLATTERER & FOISSNER, 1988**

1988 *Notohymena* BLATTERER & FOISSNER, Stapfia, 17: 70 – Type (original designation): *Notohymena rubescens* BLATTERER & FOISSNER, 1988.

1997 *Notohymena* BLATTERER & FOISSNER, 1988 – BERGER & FOISSNER, Arch. Protistenk., 148: 146.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Notohymena* pattern. Frontoventral cirri in V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral and 5 or 4 transverse cirri. One right and 1 left row of marginal cirri. Six dorsal kineties. Caudal cirri present. Primordia V and VI of proter originate de novo. Dorsal morphogenesis in *Oxytricha* pattern.

A d d i t i o n a l c h a r a c t e r s: Long elliptical, both ends usually moderately broad rounded. 2–3:1 flattened dorsoventrally. Very flexible and slightly contractile. Two ellipsoidal macronuclear nodules arranged slightly left of median. Contractile vacuole somewhat in front of mid-body, during diastole with two, usually short collecting canals. Cortical granules present (*N. rubescens*, *N. antarctica*, *N. australis*); *Notohymena selvatica* was described without live observation, this character is thus not mentioned in the original description. Pellicle and cytoplasm colourless, cytoplasm usually with many 1–3 µm sized globules and cytoplasmic crystals. Usually rapid movement. Buccal area deep, thus appears bright at low magnification. Frontal cirri slightly to distinctly enlarged. Arrangement of frontoventral cirri as in Figure 104f. Left marginal row usually terminates at posterior end at mid-line, right one at about level of posterior transverse cirri. Transverse cirri protrude distinctly beyond posterior end of cell, arranged in a rather oblique row. Usually 6 dorsal kineties, including 2 dorsomarginal rows.

T a x o n o m y: The characterisation is according to BERGER & FOISSNER (1997); for detailed description of patterns mentioned, see chapter 2 in the general section. The cladistically significant character of *Notohymena*, namely the hook-shaped distal end of the paroral, is recognisable only after protargol impregnation (Fig. 104h).

The morphogenesis of the type species, *N. rubescens*, shows a conspicuous feature, namely the new formation of anlagen V and VI of the proter (Fig. 104t, u; Voss 1991a), which is considered as the autapomorphy of the *Urosomoida-Cyrtohymena-Notohymena* group (Fig. 25a, Table 4).

Key to species

Species identification in *Notohymena* unconditionally requires live observation because almost all (see taxonomy) species have cortical granules, that is, identification based only on protargol impregnation is insufficient.

- 1 Length in life about 170–190 µm; 4 transverse cirri (Fig. 109) . *N. selvatica* (p 344)
- Length in life 80–140 µm; usually 5 transverse cirri 2
- 2 Cortical granules ruby-coloured (Fig. 104e, g) *N. rubescens* (p 325)
- Cortical granules yellow or yellow-green to orange-green 3
- 3 6–11 caudal cirri (Fig. 107a, e, 108a, e) *N. australis* (p 340)
- 3 caudal cirri (Fig. 106a, e) *N. antarctica* (p 334)

Notohymena rubescens BLATTERER & FOISSNER, 1988 (Fig. 20b, 22c, 104a–z, 105a–n, Tables 3, 4, 21)

1988 *Notohymena rubescens* BLATTERER & FOISSNER, Stapfia, 17: 71 (Fig. 104a–h; the slide of holotype-specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1991 *Notohymena rubescens* BLATTERER & FOISSNER, 1988 – Voss, Arch. Protistenk., 140: 219 (Fig. 104i–z, 105a–n).

T a x o n o m y: Differs from *Notohymena antarctica* mainly in the colour of the cortical granules; live observation is thus indispensable for distinction. In life, *N. rubescens* should not be confused with the terricolous species *Oxytricha rubripuncta* (Fig. 79a–e) and *Cyrtohymena muscorum* (Fig. 94a–n), which also have red granules. However, in *Oxytricha rubripuncta* the undulating membranes are only slightly curved and in *Cyrtohymena muscorum* – which has the typical *Cyrtohymena* pattern of undulating membranes – the granules occur both close underneath the pellicle and in the cytoplasm. Furthermore, both species are usually larger than *Notohymena rubescens*. The reddish and brownish coloured *Rubrioxxytricha* species are confined to freshwater.

Fig. 104a–f *Notohymena rubescens* (from BLATTERER & FOISSNER 1988. a, d, e, from life; b, c, f, protargol impregnation). a) Ventral view, 100 μm . b, c) Ventral and dorsal infraciliature, b, c = 90 μm . d, e) Lateral and dorsal view, d = 110 μm , e = 105 μm . f) Ventral infraciliature of anterior half of cell, bar division = 10 μm . Arrow marks genus-specific hook at anterior end of paroral. cG = ruby-coloured cortical granules; p 325.

Fig. 104g, h *Notohymena rubescens* (from BLATTERER & FOISSNER 1988. g, from life; h, protargol impregnation). g) Dorsal surface with the ruby-coloured cortical granules. h) Ventral infraciliature. Arrow marks hook at anterior end of paroral, the autapomorphy of *Notohymena*; p 325.

M o r p h o l o g y a n d b i o l o g y: The Voss (1991a) population from Germany agrees very well with the type population from Australia. In life $90\text{--}100 \times 30\text{--}35 \mu\text{m}$. Left margin convex, right straight to slightly convex. Macronuclear nodules of type population after protargol impregnation $9\text{--}15 \times 6\text{--}9 \mu\text{m}$ (mean = $11.8 \times 7.3 \mu\text{m}$; $n = 10$), according to Voss (1991a) $8\text{--}20 \times 7\text{--}11 \mu\text{m}$ (mean = $14.3 \times 9.5 \mu\text{m}$; $n = 25$), with many spherical nucleoli. Distance between macronuclear nodules after protargol impregnation $4\text{--}15 \mu\text{m}$ (mean = $10.5 \mu\text{m}$; $n = 25$). 1–4, usually 2, after protargol impregnation $3 \mu\text{m}$ sized, spherical micronuclei. Cortical granules $1.0\text{--}1.4 \mu\text{m}$ across, ruby-coloured; specimens thus appear conspicuously reddish at low magnification and bright field illumination; granules arranged in small groups around cirri and dorsal cilia, on ventral side arranged in short rows (Fig. 104e, g, i).

Adoral zone of membranelles about 34 % of body length, bases of largest membranelles in life approximately $7 \mu\text{m}$ wide. Anterior portion of peristomial lip hooked (Fig. 104a, i, arrow). Undulating membranes probably composed of 2 rows of basal bodies each. Number of frontal (3), buccal (1), frontoventral (4), postoral ventral (3), pre-transverse ventral (2), transverse (5), and caudal cirri (3) invariable at sample sizes of 10

Fig. 104i–k *Notohymena rubescens* (from Voss 1991a. i, bright field with oblique illumination; j, phase contrast; k, protargol impregnation). i) Ventral view. Arrow marks hooked anterior end of peristomial lip (that is not the hooked end of the paroral!). The general appearance of the oral apparatus is reminiscent of *Cyrtohymena*. j) Cyst. k) Ventral infraciliature of anterior half of a morphogenetic stage. Arrow marks reorganizing undulating membranes of proter. Ma = anterior macronuclear nodule, sG = cortical granules; p 325.

Fig. 104l–o *Notohymena rubescens* (from Voss 1991a. l–o, protargol impregnation). Ventral infraciliature → and nuclear apparatus of very early and early morphogenetic stages, bar = 30 µm. The formation of the oral primordium commences near the left transverse cirrus (l). Next, it extends anteriorly up to the postoral ventral cirri. See text for details. OP = oral primordium; p 325.

Fig. 104p, q *Notohymena rubescens* (from Voss 1991a. p, q, protargol impregnation). Ventral infraciliature of early morphogenetic stages, bar = 30 μ m. Arrows mark parental cirri (V/3 in p; V/4 in q) which are modified to primordia. See text for details; p 325.

(BLATTERER & FOISSNER 1988) and 25 (VOSS 1991a). Frontal, ventral, and marginal cirri in life about 14 μ m, transverse cirri about 20 μ m long. Bases of frontal and transverse cirri distinctly enlarged. Dorsal cilia in life about 3 μ m long. Dorsal kineties 1, 4, and 6 anteriorly slightly, kineties 5 and 6 posteriorly distinctly shortened (Fig. 104c, w).

Cyst spherical, mean diameter in life 33 μ m (SD = 2.2 μ m, CV = 6.7 %, Min = 28 μ m, Max = 36 μ m, n = 25). Cytoplasm heavily granulated. Cyst wall covered with a 2 μ m thick, mucous layer. Ectocyst smooth (Fig. 104j).

M o r p h o g e n e s i s of cell division is described in great detail by Voss (1991a; Fig. 104k–z, 105a–n). It commences with the proliferation of basal bodies close to the left transverse cirrus to form the oral primordium (Fig. 104l–p). Three frontal-ventral-transverse streaks of the opisthe separate from the oral primordium and 3 from the post-oral ventral cirri (Fig. 104q–v). In the proter, anlage I originates from the parental undulating membranes, anlage II from the buccal cirrus, anlagen III and IV from left (III/2) and right (IV/3) posterior frontoventral cirri, and primordia V and VI originate de novo (Fig. 104r–v, x, z, 105a, Table 4). The genus-specific hook at the anterior end of the paroral is formed by addition of basal bodies, whereby the undulating membranes are ar-

Fig. 104r, s *Notohymena rubescens* (from Voss 1991a. r, s, protargol impregnation). Ventral infraciliature of middle morphogenetic stages, bar = 30 μ m. Arrows mark parental cirri (buccal cirrus and IV/3 in r; III/2 in s) which are modified to primordia. See text for details; p 325.

ranged side by side (Fig. 104k, x, z, 105a, b, e, f). They cross (optically) in late stages and their characteristic arrangement is attained just after cell fission, similarly to in *Cyrtohymena muscorum*. Dorsal morphogenesis is in the plesiomorphic *Oxytricha* pattern (Fig. 104w, y, 105c, d, g, i, l).

Occurrence and ecology: Probably restricted to terrestrial habitats; not very common. Locus classicus is a tropical forest between Cairns and Innisfail, Eastern Australia, where BLATTERER & FOISSNER (1988) discovered *Notohymena rubescens* in barks (grown with lichens and mosses) from a secondary pine forest (Scots Pine, *Pinus silvestris*); they screened 21 soil samples from Australia, but *N. rubescens* occurred only once. Voss (1991a) found his population in an air-dried moss and soil sample from the park of

Fig. 104t–w *Notohymena rubescens* (from Voss 1991a. t–w, protargol impregnation). t–v) Ventral infracilia- →
ture of middle morphogenetic stages, bar = 30 μ m. Arrows mark de novo formation of streaks V and VI in pro-
ter (t, u) and modification of anterior-most right marginal cirrus to right marginal primordium of proter (v). w)
Dorsal infraciliature of a middle morphogenetic stage, bar = 30 μ m. 2–6 = frontal-ventral-transverse cirri pri-
mordia II–VI; p 325. Figures on p 332.

104t

u

v

w

Fig. 104x–z, 105a *Notohymena rubescens* (from Voss 1991a. Protargol impregnation). Ventral and dorsal ciliature of middle and late morphogenetic stages, bar 30 μ m. See text for details. 1–6 = primordia I–VI; p 325.

Fig. 105b, c *Notohymena rubescens* (from Voss 1991a. b, c, protargol impregnation). Ventral and dorsal infraciliature of a late morphogenetic stage, bar = 30 μ m. Parental structures white, new black; p 325.

the “Ketteler Hof” at the village of Haltern, Germany, as well as in terrestrial mosses from St. Jean sur Mayenne, France.

Feeds on fungal spores, heterotrophic flagellates, and naked amoebas. Voss (1991a) cultured *N. rubescens* in mineral water (Vittel), adding a few drops of a dense suspension of yeast cells and *Chlorella* sp. every second or third day. Biomass of 10^6 individuals about 100 mg.

Notohymena antarctica FOISSNER, 1996 (Fig. 106a–e, Table 21)

1996 *Notohymena antarctica* FOISSNER, Acta Protozool., 35: 109.

Taxonomy: *Notohymena antarctica* is very similar to *N. australis* as concerns size, shape, and cortical granules. However, it has fewer adoral membranelles and marginal cirri and, more importantly, only 3 caudal cirri. The unusually high number, namely 6–8, of caudal cirri in *N. australis* is confirmed in both the type material and a German population.

Fig. 105d–f *Notohymena rubescens* (from Voss 1991a. d–f, protargol impregnation). **d, e**) Dorsal and ventral infraciliature of late morphogenetic stages, bar = 30 μ m. Parental structures, new black. **f**) Basal body pairs are added to form genus-specific, broadened anterior end of paroral. CC = new caudal cirri, DP = primordia of dorsomarginal kineties; p 325.

M o r p h o l o g y: In life 80–110 $\times$ 30–40 μ m. Prolate ellipsoidal, right side straight or slightly concave, left rather distinctly convex, both ends broadly rounded, flattened up to 3:1. Flexible like, for example, *Oxytricha granulifera*. Macronuclear nodules ellipsoidal, after protargol impregnation 11–18 $\times$ 7–8 μ m (mean = 12.9 $\times$ 7.9 μ m; n = 11), rather close (mean = 7 μ m) together in middle third of cell to left of mid-line. Usually 1 globular (3–4 $\times$ 2.3–3 μ m, after protargol impregnation) micronucleus attached to each macronuclear nodule; rarely 3 micronuclei. Contractile vacuole in mid-body at left margin, with two inconspicuous collecting canals. Cytopyge in posterior end between transverse cirri and left marginal cirral row; faecal balls contain yellowish globules like those found in the cytoplasm. Pellicle colourless, flexible; cortical granules arranged in groups around cirral bases and dorsal bristles (Fig. 106c), yellow to yellow-green, give cell yellowish colour at low magnification and bright field illumination, do not stain with protargol. Cytoplasm colourless, contains some 1–4 μ m sized, yellowish fat globules and rather many

Fig. 105g-j *Notohymena rubescens* (from Voss 1991a. g-j, protargol impregnation). Dorsal and ventral infraciliature of very late morphogenetic stages, bar = 30 μ m. Arrows in (g) mark fragmentation of dorsal kineties 3. Parental structures white, new black. DP = primordia of dorsomarginal kineties; p 325.

Fig. 105k–n *Notohymena rubescens* (from Voss 1991a. Protargol impregnation). Ventral and dorsal infraciliature of very late morphogenetic stages and postdividers, bar = 30 μ m. Note that the genus-specific hook at the anterior end of the paroral is formed just in the postdivider. Parental structures white, new black; p 325.

Fig. 106a–e *Notohymena antarctica* (from FOISSNER 1996b. a–c, from life; d, e, protargol impregnation). a) Ventral view, 95 μ m. b) Cytoplasmic crystals. c) Yellow cortical granules around dorsal cilia. d, e) Ventral and dorsal infraciliature, 85 μ m. Arrow marks hook of paroral, arrowhead denotes right frontal cirrus (III/3); p 334.

1–3 μ m long crystals, mainly in posterior half (Fig. 106a, b). Scrabbles rather quickly amongst soil particles.

Adoral zone of membranelles 37 % of body length. Buccal field rather large and deep, anterior portion semicircularly curved, similarly to in *Cyrtohymena*. Paroral and endoral conspicuously curved, intersect optically in mid-portion, paroral distinctly longer than endoral, its distal end hooked (autapomorphy of *Notohymena*!), both very likely composed of basal body pairs. Arrangement of frontal-ventral-transverse cirri as in Figure 106d. Constantly 3 frontal cirri, 1 buccal cirrus, 4 frontoventral cirri, 3 postoral and 2

Table 21 Morphometric data of *Notohymena antarctica* (ant, from FOISSNER 1996b), *N. australis* (au1, from FOISSNER & O'DONOGHUE 1990; au2, from GSCHWIND 1991), *N. rubescens* (ru1, from BLATTERER & FOISSNER 1988; ru2, from VOSS 1991a), and *N. selvatika* (sel, from HEMBERGER 1985). All data are based on protargol impregnated specimens. All measurements in micrometres. ? = sample size not indicated. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	ant	85.5	5.8	6.7	70	91	11
	au1	81.0	8.9	11.5	66	95	12
	au2	133.4	13.8	10.3	108	160	22
	ru1	84.1	3.3	4.0	77	88	10
	ru2	104.1	15.5	14.9	81	136	25
	sel	-	-	-	170	190	?
Body, width	ant	30.4	2.1	7.0	28	34	11
	au1	31.4	4.5	14.4	22	29	12
	au2	58.1	9.3	12.7	42	72	21
	ru1	33.7	2.9	8.5	30	38	10
	ru2	36.4	6.0	16.5	26	51	25
	sel	-	-	-	60	70	?
Adoral zone of membranelles, length	ant	32.4	2.2	6.8	28	35	11
	au1	31.1	2.7	8.8	27	35	12
	au2	49.3	6.6	13.3	38	60	22
	ru1	29.2	2.0	7.0	26	32	10
	ru2	32.2	4.4	13.7	26	44	25
	sel ¹	49.0	-	-	-	-	1
Adoral membranelles, number	ant	30.2	1.9	6.4	27	33	11
	au1	39.0	3.6	9.3	30	44	12
	au2	39.0	1.9	4.9	35	43	19
	ru1	26.6	1.3	4.8	24	28	10
	ru2	30.4	2.1	6.9	26	34	25
	sel	-	-	-	25	30	?
Right marginal row, number of cirri	ant	16.8	1.2	6.9	15	19	11
	au1	29.5	3.9	13.3	24	38	12
	au2	36.0	2.3	6.5	31	40	19
	ru1	18.3	1.3	7.3	16	20	10
	ru2	17.9	1.2	6.7	15	20	25
	sel	-	-	-	18	21	?
Left marginal row, number of cirri	ant	17.9	1.3	7.3	15	24	15
	au1	28.2	2.5	8.8	24	32	12
	au2	36.3	2.9	8.1	31	44	20
	ru1	17.0	1.3	7.8	15	19	10
	ru2	19.6	1.2	6.1	17	22	25
	sel	-	-	-	17	21	?
Dorsal kinetics, number	ant	6.0	0	0	6	6	11
	au1	6.3	0.5	7.3	6	7	12
	au2	6.3	0.6	9.0	6	8	19
	ru1	6.0	0	0	6	6	10
	ru2	6.0	0	0	6	6	25
	sel	6.0	-	-	-	-	?

¹ From Figure 109.

pretransverse ventral cirri, and 5, slightly enlarged transverse cirri ($n = 11$). Frontal and transverse cirri about 20 μm , marginal cirri about 15 μm long. Gap between posterior end of marginal rows indistinct because left row extends to mid-line of cell and is indistinctly separated from caudal cirri. Dorsal cilia in life about 3 μm long. Dorsal kineties 1 and 4 slightly shortened anteriorly, kineties 2 and 3 as long as body, kinety 5 terminates behind mid-body, kinety 6 consists of about 5 basal body pairs only and ends in front of mid-body. Invariably ($n = 11$) 3 caudal cirri, about 20 μm long.

Occurrence and ecology: Terrestrial. Locus classicus is a sheltered north-facing slope on Signy Island, South Orkney Islands, Antarctica (lat 60°40'S, long 45°40'W), where FOISSNER (1996b) discovered *Notohymena antarctica* in a grass sward from *Deschampsia antarctica* patch (pH 4.4). Feeds on ciliates, heterotrophic flagellates, and, possibly, on bacteria.

Notohymena australis (FOISSNER & O'DONOGHUE, 1990) comb. nov. (Fig. 107a–g, 108a–e, Table 21)

- 1988 *Notohymena australis* (FOISSNER & O'DONOGHUE im Druck) nov. comb. – BLATTERER & FOISSNER, *Staphia*, 17: 70 (Fig. 107f, g; see nomenclature).
 1990 *Oxytricha australis* FOISSNER & O'DONOGHUE, *Invertebr. Taxon*, 3: 689 (Fig. 107a–e; the slide of holotype specimens is deposited in the South Australian Museum).
 1991 *Notohymena australis* (FOISSNER & O'DONOGHUE im Druck) BLATTERER & FOISSNER 1988 – GSCHWIND, *Diplomarbeit*, p 68 (Fig. 108a–e).

Nomenclature and taxonomy: BLATTERER & FOISSNER (1988) made the new combination before the original description, which was in press for several years, was available. This obviously invalid nomenclatural act is corrected here.

At superficial live observation, *N. australis* is easily confused with *Holosticha multistilata* because the colour of the cortical granulation is very similar (FOISSNER & O'DONOGHUE 1990). In terms of the increased number of caudal cirri *N. australis* is reminiscent of the euplanktonic *Pseudostrombidium planctonicum*, which has, however, different undulating membranes and a tapered body (Fig. 147a–j). *Notohymena australis* is also easily confused with *Cyrtohymena citrina*, which is very similar in all characters except the undulating membranes, which are in *Cyrtohymena* pattern.

Morphology: In life 80–140 $\times$ 30–45 μm (FOISSNER & O'DONOGHUE 1990), after GSCHWIND (1991) 120–150 $\times$ 50 μm . Body margins sometimes slightly converging posteriorly (Fig. 107b). Macronuclear nodules in life about 14 $\times$ 10 μm , after protargol impregnation 8–17 $\times$ 7–11 μm (mean = 11.7 $\times$ 8.4 μm ; $n = 12$), located close together to far apart in middle third of cell. 1–4, usually 3, in life about 3.0 $\times$ 2.5 μm sized micronuclei, in life of refractive bright appearance. Cortical granules mainly along cirral rows and dor-

Fig. 107a-e *Notohymena australis* (from FOISSNER & O'DONOGHUE 1990. a-c, from life; d, e, protargol impregnation). a) Ventral view, 110 μ m. b) Lateral view showing cortical granules and contractile vacuole, 100 μ m. c) Lateral view, 100 μ m. d, e) Ventral and dorsal infraciliature, 80 μ m. This specimen has two supernumerary postoral ventral cirri and only one pretransverse ventral cirrus! Genus-specific hook of the paroral is shown in Fig. 107f, g. CC = caudal cirri, 1, 4, 6 = dorsal kineties; p 340.

Fig. 107f, g *Notohymena australis* (from BLATTERER & FOISSNER 1988). Ventral infraciliature of anterior half of cells of type population, bar = 10 μ m. Only (g) shows genus-specific hook of paroral clearly (arrowhead); p 340

sal kineties, arranged in small groups; cells appear greenish at low magnification; granules do not impregnate with protargol.

Adoral zone of membranelles about 38 % of body length, bases of largest membranelles in life about 7 μ m wide. Number of postoral and pretransverse ventral and transverse cirri rather variable, therefore difficult to describe any individual as "typical". Number of postoral ventral cirri: mean = 4.3, median = 4.0, SD = 1.6, CV = 36 %, Min = 3, Max = 7, n = 12; pretransverse ventral cirri: mean = 1.7, median = 2.0, SD = 0.2, CV = 35.5 %, Min = 1, Max = 3, n = 12; transverse cirri: mean = 5.2, median = 5.0, SD = 0.6, CV = 11.8, Min = 4, Max = 6, n = 12. Marginal cirri in life about 10 μ m, frontal and transverse cirri about 18 μ m, dorsal cilia about 2 μ m long. Dorsal kineties 1–3 almost unshortened (sometimes a fourth unshortened kinty occurs). Kinty 4 begins and kinty 5 terminates slightly behind mid-body; kinty 6 consists of 2–5 basal body pairs only. 6–11 (mean = 7.5, median = 8, SD = 0.6, CV = 8.6 %, Min = 6, Max = 8, n = 12, FOISSNER and O'DONOGHUE 1990; mean = 9.1, median = 9, SD = 1.0, CV = 11.5 %, Min = 8, Max = 11, n = 19, GSCHWIND 1991) caudal cirri arranged as in Figures 107e, 108e, located dorsally

Fig. 108a–e *Notohymena australis* (from GSCHWIND 1991. a, c, from life; b, d, e, protargol impregnation). a, c → Ventral and dorsal view (a = 140 μ m, c = 120 μ m) showing, among other things, cortical granules and defecation. b, d, e) Ventral and dorsal infraciliature, d, e, = 120 μ m, bar = 30 μ m. Arrows mark broadened (hook-shaped) anterior end of paroral, the sole autapomorphy of *Notohymena*; p 340.

above gap between marginal rows, appearing in life as conspicuous seam (Fig. 107a, 108a).

Occurrence and ecology: Locus classicus is a small pond in metropolitan Perth, Western Australia. Recently, W. FOISSNER (pers. comm.) found *Notohymena australis* in an alphamesosaprobic area of the Amper River, Bavaria (GSCHWIND 1991). In cultures *N. australis* feeds on bacteria, rice starch, and ciliates (*Dexiostoma campylum*, *Glaucoma scintillans*).

***Notohymena selvatica* (HEMBERGER, 1985) BLATTERER & FOISSNER, 1988**
(Fig. 109, Table 21)

1985 *Oxytricha selvatica* HEMBERGER, Arch. Protistenk., 130: 406 (Fig. 109; 1 slide of type specimens is deposited in the Institut für landwirtschaftliche Zoologie und Bienenkunde of the University of Bonn, Germany).

1988 *Notohymena selvatica* (HEMBERGER, 1985) – BLATTERER & FOISSNER, Stapfia, 17: 70.

Taxonomy: HEMBERGER (1985) mentioned some resemblance to “*Oxytricha muscorum* KAHL” (I assume that he meant *Cyrtohymena muscorum*; note that KAHL described 4

different *O. muscorum*!) and “*Oxytricha rubra* BUITKAMP”, which I consider as a synonym of *C. muscorum*. *Cyrtohymena muscorum* has a cortical granulation; thus, it is unclear if this resemblance refers only to the general appearance of the oral apparatus, or if *Notohymena selvatica* also has reddish cortical granules. Reinvestigation required.

Morphology: In life (?) 170–190 times 60–70 μm . Slightly tapered posteriorly. 2–3 micronuclei. Cortical granules not mentioned, possibly present (see taxonomy). Adoral zone of membranelles about 27 % of body length. Postoral ventral cirri arranged in line. Pre-transverse ventral cirri very close to distinctly enlarged, about 20 μm long transverse cirri; rather invariably 4 transverse cirri. Marginal cirri 14–18 μm , dorsal cilia 6 μm long. Four

Fig. 109 *Notohymena selvatica* (after HEMBERGER 1985). Ventral infraciliature and nuclear apparatus after protargol impregnation, 180 μm .

dorsal kinetics of body length (very likely kinetics 1–4) and 2 shortened kinetics (dorso-marginal rows). Caudal cirri 30 µm long.

O c c u r r e n c e: Locus classicus is a soil from a woodland in Peru; not found since. Biomass of 10⁶ individuals about 560 mg (FOISSNER 1987a).

***Urosomoida* HEMBERGER in FOISSNER, 1982**

1982 *Urosomoida* HEMBERGER, 1981 – FOISSNER, Arch. Protistenk., 126: 115 – Type (original designation; see also nomenclature): *Uroleptus agilis* ENGELMANN, 1862.

1985 *Urosomoida* HEMBERGER, Arch. Protistenk., 130: 415 (see nomenclature).

1997 *Urosomoida* HEMBERGER in FOISSNER, 1982 – BERGER & FOISSNER, Arch. Protistenk., 148: 148.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Frontoventral cirri in V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. One (or 2) pretransverse ventral cirrus and less than 4 transverse cirri. One right and 1 left row of marginal cirri. Four dorsal kinetics. Caudal cirri present. Primordia V and VI of proter originate de novo. Dorsal morphogenesis in *Urosomoida* pattern.

A d d i t i o n a l c h a r a c t e r s: Outline usually long elliptical or posteriorly converging, sometimes slightly S-shaped. Flattened about 2:1. Very flexible. Two or 4 macronuclear nodules. Contractile vacuole about in mid-body (*Urosomoida agilis*, *U. perthensis*) or slightly ahead of it (*U. agiliiformis*, *U. dorsiincisura*, *U. minima*?); during diastole usually with short and inconspicuous collecting canals. Pellicle and cytoplasm colourless. Cytoplasm with 5–10 µm sized food vacuoles, usually many cytoplasmic crystals, and up to 4 µm sized, yellowish shining globules. Some species with cortical granules. Movement slow or moderately rapid.

Adoral zone of membranelles 1/4–1/3 of body length. Bases of all cirri of about same size. Marginal cirri in life 10 µm (*U. minima*, *U. agilis*) to 15 µm (other species), transverse cirri 15–20 µm, and caudal cirri 10 µm (*U. minima*) and 15–25 µm (other species) long. Transverse cirri protrude distinctly beyond posterior end of cell. Dorsal kinety 1 slightly to distinctly shortened anteriorly (not known for *U. minima*). Dorsal cilia 3 to 4 µm, in *U. minima* 4–6 µm long. Common in freshwater and terrestrial habitats.

N o m e n c l a t u r e a n d t a x o n o m y: The nomenclature of this genus is rather complicated. FOISSNER (1982), who described two new *Urosomoida* species, assigned it to HEMBERGER, referring to his unpublished thesis (HEMBERGER 1982, p 262). The nomenclaturally valid paper describing the new taxa of this thesis, was only published three years later (HEMBERGER 1985). Thus, *Urosomoida* HEMBERGER, 1985 would contain two species which were already described in 1982, namely *U. agiliiformis* FOISSNER, 1982 and *U. dorsiincisura* FOISSNER, 1982. This is of course impossible! According to Article 50a

of the ICZN (1985), "HEMBERGER in FOISSNER, 1982" is the author of *Urosomoida* because FOISSNER (1982) published the diagnosis proposed by HEMBERGER (1982) verbatim. Furthermore, FOISSNER (1982) fixed *Uroleptus agilis* as type species, as proposed by HEMBERGER (1982). *Urosomoides* in CORLISS (1994, p 15) and SMALL & LYNN (1985, p 460, 461) and *Urosomoidea* spp. in FUNKE (1986, p 72) are incorrect subsequent spellings.

The characterisation is according to BERGER & FOISSNER (1997); for a description of the patterns mentioned therein, see chapter 2 in the general section. The flexible body, the involvement of postoral ventral cirrus V/3 in primordia formation, the short adoral zone of membranelles, and the cortical granules in some species assign *Urosomoida* unambiguously to the Oxytrichinae (Fig. 25a). Together with *Notohymena* and *Cyrtohymena*, it shares the character that primordia V and VI of the proter are formed de novo (Table 4, Fig. 113k). The autapomorphies of *Urosomoida* are (i) the usually distinct reduction of the number of pretransverse ventral cirri and transverse cirri (convergence to some *Urosoma* species) and (ii) lack of fragmentation of dorsal kinety 3 (convergence to *Urosoma* and some *Oxytricha* species).

Urosoma differs from *Urosomoida* in the arrangement of the frontoventral cirri (longitudinal row against V-shaped pattern) and in the shape of the undulating membranes and the adoral zone of membranelles (*Gonostomum* pattern against *Oxytricha* pattern). *Oxytricha* differs from *Urosomoida* in that it usually has a full set (7, sometimes 6) of pretransverse ventral and transverse cirri and more (usually 5 or 6) dorsal kineties. However, some transitions exist between these taxa so that an unequivocal classification is not always possible (for example, *Urosomoida antarctica*, *U. granulifera*, *Oxytricha islandica*, *O. auripunctata*, *O. longa*); morphogenetic data are needed for a more accurate classification of these species.

Concerning the ventral ciliature, most *Urosomoida* species differ almost exclusively in the number of pretransverse ventral and transverse cirri (Table 22). The infraciliature of *U. minima* deviates in some points (for example, only 3 dorsal kineties) from the rather uniform organisation, indicating that the classification of this species is uncertain.

Key to species

Species identification unconditionally requires live observation because some species have cortical granules. The differences between *Urosomoida* and *Oxytricha* are sometimes indistinct, thus refer also to the *Oxytricha* key if identification is unsuccessful.

- 1 Usually 4, rarely up to 6 macronuclear nodules (Fig. 115a, c) *U. dorsiincisura* (p 362)
- 2 macronuclear nodules 2
- 2 Invariably only 1 micronucleus between macronuclear nodules (Fig. 114a, e) *U. perthensis* (p 362)

- Usually with at least 1 micronucleus near each of the two macronuclear nodules (for example, Fig. 110e, g) 3
- 3 Cortical granules present (Fig. 110h) 6
- Cortical granules absent 4
- 4 3 dorsal kineties *U. minima* (p 366)
- 4 dorsal kineties (for example, Fig. 110d, 112c) 5
- 5 1–4, usually 3 transverse cirri, including pretransverse ventral cirri (Fig. 112a, b) ...
..... *U. agilisformis* (p 356)
- Usually 4 or 5 transverse cirri and 2 pretransverse ventral cirri (Fig. 44a, c, 116d) 8
- 6 (3) Body distinctly tapered posteriorly; usually 3 pretransverse ventral and transverse cirri (Fig. 110a–j) *U. agilis* (p 347)
- Body long elliptical; 5 or 6 pretransverse ventral and transverse cirri (Fig. 63a, e, 111a, e) 7
- 7 Cortical granules colourless, irregularly arranged in a few groups; 2 caudal cirri (Fig. 111b) *U. granulifera* (p 352)
- Cortical granules orange-yellow; usually 3, sometimes 4–5 caudal cirri (Fig. 63) ...
..... *Oxytricha auripunctata* (p 194)
- 8 (5) Body broadly elliptical; 2 postoral ventral cirri (Fig. 116a, b, d)
..... *U. antarctica* (p 365)
- Body long elliptical; 3 postoral ventral cirri (Fig. 44a, c) .. *Oxytricha longa* (p 158)

***Urosomoida agilis* (ENGELMANN, 1862) HEMBERGER in FOISSNER, 1982**
(Fig. 110a–q, Tables 3, 4, 22)

- 1862 *Uroleptus agilis* ENGELMANN, Z. wiss. Zool., 11: 386 (Fig. 110a).
 1882 *Uroleptus agilis* ENG. – KENT, Manual infusoria II, p 781.
 1932 *Uroleptus agilis* ENGELMANN, 1862 – KAHL, Tierwelt Dtl., 25: 550.
 1972 *Oxytricha agilis* (ENGELMANN, 1862) – BORROR, J. Protozool., 19: 13.
 1975 *Oxytricha agilis* ENGELMANN – BUTKAMP, Acta Protozool., 14: 68 (Fig. 110j–q).
 1982 *Urosomoida agilis* (ENGELMANN, 1862) – FOISSNER, Arch. Protistenk., 126: 115 (Fig. 110e–i; authoritative redescription; neotype slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
 1985 *Urosomoida agilis* (ENGELMANN) – HEMBERGER, Arch. Protistenk., 130: 415.
 1986 *Oxytricha agilis* (ENGELMANN, 1862) BORROR, 1972 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 465.
 1987 *Urosomoida agilis* (ENGELMANN, 1862) HEMBERGER, 1985 – BERGER & FOISSNER, Zool. Jb., 114: 235 (Fig. 110b, c; one slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: For the complicated nomenclature, see relevant chapter of genus section. *Uroleptus agilis* in ENGELMANN (1862, p 387, footnote 1) is an incorrect spelling of *Uroleptus*. *Urosomoida agilis* is very similar to some *Urosoma* species as concerns the tapered posterior end. However, the V-shaped arrangement of the

Fig. 110a–d *Urosomoida agilis* (a, from ENGELMANN 1862; b, c, from BERGER & FOISSNER 1987a; d, original from a terrestrial population from the Schlossalm area in Salzburg. a, b, from life; c, d, protargol impregnation). a, b) Ventral views, a = 195 μm , b = 120 μm . c, d) Ventral and dorsal infracapitulum, c, d = 90 μm . Arrow marks pretransverse ventral and transverse cirri. 1–4 = dorsal kineties 1–4; p 347.

frontoventral cirri and the oral apparatus of the *Oxytricha* type allow an unambiguous separation. *Uroleptus agilis* sensu EDMONDSON (1906; Fig. 234e), sensu SMITH (1914; Fig. 233i), and sensu TAI (1931) are *Uroleptus* species because mid-ventral cirri are present.

Morphology and biology: In life 80–160 $\times$ 30–35 μm (BERGER & FOISSNER 1987a, FOISSNER 1982), after ENGELMANN (1862) 75–240 μm (rather high variability!), after BUITKAMP (1975) 130 μm long; the BULLINGTON (1925, without illustration) population is 214–238 $\times$ 71 μm , indicating misidentification. Usually spindle-shaped, anteriorly broad, posteriorly very narrowly rounded or even distinctly pointed. Slightly contractile. Macronuclear nodules in life 10–14 $\times$ 7 μm . Usually 2, sometimes up to 5, in life about 4 $\times$ 2 μm sized micronuclei. Anterior collecting canal of contractile vacuole with a vesicle. Cortical granules about 0.5 μm sized, colourless to yellowish, rarely reddish, arranged mainly around bases of cirri and basal body pairs of dorsal cilia (Fig. 110h). Posterior portion of cell often densely filled with up to 5 μm sized, yellowish, cytoplasmic crystals, so that cells appear dark at low magnification and bright field illumination. Cy-

Fig. 110e–i *Urosomoida agilis* (from FOISSNER 1982. e, h, i, from life; f, g, protargol impregnation). e, h, i) Ventral, dorsal, and left lateral view, e = 135 μm , h, i = 120 μm . Figure 110h shows the cortical granules and the contractile vacuole with collecting canals. f, g) Ventral and dorsal infraciliature, 95 μm . sG = colourless, rarely yellowish or reddish cortical granules; p 347.

topyge, through which vacuoles with about 3–4 μm sized crystals may be discharged, near posterior end of cell (Fig. 110b).

Bases of largest membranelles in life about 5–7 μm wide, cilia of distal membranelles about 15 μm long. Buccal cirrus somewhat behind anterior end of undulating membranes. Distance between marginal cirri distinctly wider posteriorly than anteriorly. Transverse cirri rather inconspicuous. Cyst about 50 μm across, with smooth surface (ENGELMANN 1862).

M o r p h o g e n e s i s commences with the proliferation of basal bodies between the postoral ventral cirri and the left marginal row (Fig. 110k). The primordia V and VI of the proter are formed de novo, as in *U. agiliformis*. This is obviously the sole synapomorphy of the *Urosomoida*-*Notohymena*-*Cyrtohymena*-group (Fig. 25a). See legend to Figure 110j–q and Table 4 for further details.

Fig. 110j–o *Urosomoida agilis* (from BUTKAMP 1975. j–o, ventral infraciliature and nuclear apparatus of morphogenetic stages after protargol impregnation). j) Non-dividing specimen, 120 μ m. k) Very early stage. Oral primordium originates between postoral ventral cirri and left marginal row. l) Early stage. The buccal cirrus, 2 frontoventral cirri (III/2 and IV/3), and the postoral ventral cirri are modified to primordia. m, n) Middle stages. Primordia V and VI (arrowheads) of proter originate de novo. Both in the proter and in the opisthe 6 frontal-ventral-transverse cirri streaks are recognisable. New marginal rows are formed. o) Late stage showing formation of new dorsal kineties 4 (dorsomarginal rows, arrowheads). OP = oral primordium; p 347.

Fig. 110p, q *Urosomoida agilis* (from BUTKAMP 1975. p, q, protargol impregnation). Ventral infraciliature and nuclear apparatus of very late morphogenetic stages. Parental structures, new black; p 347.

Fig. 110r *Urosomoida minima* (from HEMBERGER 1985. r, protargol impregnation). Ventral infraciliature and nuclear apparatus, 80 μ m; p 366.

Occurrence and ecology: Common in terrestrial habitats and in freshwater. Locus classicus is a saline lake near Eisleben, Germany (ENGELMANN 1862); however, salinity of this lake is low (KAHL 1932). Terrestrial records, largely substantiated by illustrations: Austria (FOISSNER & FOISSNER 1988, FOISSNER et al. 1990); pasture and mixed woodland near Bonn, Germany (BUTKAMP 1975, 1977a, 1979); Pisang-Peak, Himalayas (FOISSNER 1986a); savannah of Lamto, Ivory Coast (BUTKAMP 1977b); rain forest in Brazil (FOISSNER 1997b).

Records from freshwater habitats not substantiated by illustrations: Belgium (CHARDEZ 1987); drinking-water of Brünn, Czechoslovakia (ŠRÁMEK-HUŠEK 1953); saline lakes near Halle, Germany (ZACHARIAS 1888); beta- to alphamesosaprobic running waters in Germany and Italy (FOISSNER et al. 1992b, MADONI 1980, MADONI & GHETTI 1980, 1981a); bog in Switzerland (MERMOD 1914); Iowa, USA (SHAWHAN et al. 1947); ooze of a lake of the Devil's Lake complex in North Dakota, USA (EDMONDSON 1920, HAMMER 1986); Tahiti (EDMONDSON 1910).

Records from terrestrial habitats not substantiated by illustrations: with a constancy of 15–22 % in various agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988); soil infusions and ridges near Erlangen, Germany (DINGFELDER 1962); Italy (LUZZATTI 1938); alka-

line soils (salt content 12–45 g l⁻¹) from arid regions in southern Australia (POMP & WILBERT 1988); Antarctica (SUDZUKI 1979).

Feeds on bacteria, diatoms, amoebas, testaceans (*Trinema lineare*); inorganic soil particles were also ingested. BUITKAMP (1975) used diluted soil extract as culture medium, adding a grain of polished rice to support bacterial growth. According to FOISSNER (1985a) and FOISSNER et al. (1985), *Urosomoida agilis* is an indicator of mull-like moder. Biomass of 10⁶ specimens about 30 mg (FOISSNER 1987a). MATIS (1975) found it in road pools near Bratislava, Czechoslovakia, at 16.0–28.5 °C, pH 5.8–6.4, and 7.6–10.8 mg l⁻¹ O₂.

***Urosomoida granulifera* FOISSNER, 1996 (Fig. 111a–f, Table 22)**

1996 *Urosomoida granulifera* FOISSNER, Acta Protozool., 35: 115 (type slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: FOISSNER (1996b) did not explain why he classified this species in *Urosomoida* and not in *Oxytricha*; very likely because the ventral and dorsal infraciliature is more or less identical with that of “*Urosomoida agilisformis*” sensu GANNER et al. (1987a, b). However, the GANNER population is obviously very closely related to the type species of *Oxytricha*, *O. granulifera*, as indicated by morphogenetic details (primordium V of the proter originates from postoral ventral cirrus V/4, and primordium VI from posterior postoral ventral cirrus V/3). Furthermore, in *Urosomoida granulifera* the number of pre-transverse ventral and transverse cirri is not distinctly decreased as in “typical” *Urosomoida* species (*U. agilis*, *U. agilisformis*), and 4 dorsal kineties are also known from some “*Oxytricha*” species. Consequently, morphogenetic data are needed to clarify the systematic position of *U. granulifera*.

Morphology and biology: In life about 70–100 × 20–30 µm. Shape highly variable, slenderly to broadly elliptical or parallel-sided, sometimes slightly fusiform, both ends narrowly to broadly rounded. Dorsoventrally flattened up to 2:1. Usually 2, very rarely 3 distinctly ellipsoidal macronuclear nodules in middle third of cell to left of median, after protargol impregnation 12–20 × 5–7 µm (mean = 15.6 × 5.7 µm; n = 12). Micronuclei ellipsoidal, after protargol impregnation 3.0 × 2.4 µm on average, number highly variable (2–8; mean = 3.1; n = 12), however, most specimens have two. Contractile vacuole in mid-body, with 2 inconspicuous collecting canals extending anteriorly and posteriorly. Cortex colourless. Cortical granules inconspicuous because colourless, minute (about 1 µm across) and sparse, form small, irregularly arranged patches composed of up to 30 granules. Cytoplasm colourless, contains many small, yellowish crystals. Movement moderately rapid, scrabbling amongst soil particles.

Adoral zone of membranelles about 34 % of body length, bases of largest membranelles in life about 7 µm wide. Buccal cavity narrow and flat, right half and posterior

Fig. 111a-f *Urosomoida granulifera* (from FOISSNER 1996b. a-d, from life; e, f, protargol impregnation). a, c, d) Ventral and lateral view, 80 μ m. Short canals are formed during diastole of contractile vacuole (c). b) Dorsal view showing spherical, colourless cortical granules arranged in irregular groups. e, f) Ventral and dorsal infraciliature, 100 μ m. Arrowheads mark right transverse cirrus and anterior end of dorsal kinety 1; p 352.

Table 22 Morphometric data of *Urosomoida agilis* (af1, from FOISSNER 1982; af2, from FOISSNER & ADAM 1983a), *U. agilis* (ag1, from BUITKAMP 1975; ag2, from FOISSNER 1982; ag3, from BERGER & FOISSNER 1987a), *U. antarctica* (ant, from FOISSNER 1996b), *U. dorsiincisura* (dor, from FOISSNER 1982), *U. granulifera* (gra, from FOISSNER 1996b), *U. minima* (min, from HEMBERGER 1985), and *U. perthensis* (per, from FOISSNER & O'DONOGHUE 1990). All data after protargol impregnation. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	af1	70.4	4.0	5.6	64	77	12
	af2	69.5	7.2	10.4	55	87	25
	ag1	130.0	-	-	-	-	1
	ag2	94.0	15.3	16.3	79	124	8
	ag3	86.1	5.3	6.2	78	96	15
	ant	61.6	5.4	8.9	52	70	13
	dor	81.3	8.5	10.4	70	98	10
	gra	73.9	9.2	12.4	59	90	12
	min	-	-	-	75	90	?
	per	42.6	4.4	10.2	38	51	10
Body, width	af1	20.6	2.2	10.8	17	24	12
	af2	21.7	3.2	14.9	16	28	25
	ag1	42.0	-	-	-	-	1
	ag2	17.9	2.1	11.7	14	21	8
	ag3	25.3	4.2	16.7	17	32	15
	ant	27.3	3.3	12.1	22	33	13
	dor	24.0	2.0	8.3	20	27	10
	gra	21.5	3.1	14.6	17	29	12
	min	15.0	-	-	-	-	?
	per	18.8	2.1	11.2	15	22	10
Adoral membranelles, number	af1	21.7	0.8	3.9	20	23	12
	af2	22.2	1.3	6.0	20	26	25
	ag1	25.0	-	-	-	-	?
	ag2	27.9	1.5	5.5	25	30	8
	ag3	25.7	1.9	7.6	23	30	15
	ant	19.5	0.8	4.0	18	21	13
	dor	31.6	2.2	7.0	28	36	10
	gra	23.7	1.9	7.9	21	27	12
	min	-	-	-	14	15	?
	per	16.6	1.0	5.8	15	18	10
Right marginal row, number of cirri	af1	20.1	1.0	4.7	19	22	12
	af2	24.1	2.3	9.7	20	29	25
	ag1	-	-	-	20	22	?
	ag2	22.4	2.0	8.9	19	25	8
	ag3	22.7	2.5	10.8	17	27	15
	ant	17.0	1.2	7.2	14	19	13
	dor	34.1	1.9	5.6	32	39	10
	gra	24.1	3.7	15.2	16	30	12
	min	-	-	-	11	13	?
	per	19.5	1.9	9.7	17	22	10

Table 22 Continued

Character	Species	mean	SD	CV	Min	Max	n
Left marginal row, number of cirri	af1	19.6	1.6	8.2	16	22	12
	af2	21.6	2.0	9.2	18	25	25
	ag1	-	-	-	24	26	?
	ag2	22.4	2.2	10.0	19	26	8
	ag3	23.7	3.5	14.9	20	31	15
	ant	19.9	2.1	10.3	17	24	13
	dor	29.7	2.4	8.1	26	34	10
	gra	23.3	3.2	13.7	17	29	12
	min	-	-	-	12	16	?
	per	16.4	2.1	12.6	14	21	10
Postoral ventral cirri, number	af1	3.2	0.6	18.6	3	5	12
	af2	3.0	0.4	15.0	2	5	25
	ag1	3.0	-	-	-	-	?
	ag2	2.6	0.7	26.5	1	3	8
	ag3	3.1	0.3	8.8	3	4	15
	dor	3.0	0	0	3	3	10
	gra	2.9	-	-	2	3	12
	min	3.0	-	-	-	-	?
	per	3.1	0.3	10.2	3	4	10
Transverse cirri, number (including pretransverse ventral cirri)	af1	3.1	0.3	9.7	3	4	12
	af2	2.9	0.6	20.8	1	4	25
	ag1	3.0	-	-	-	-	?
	ag2	3.0	0	0	3	3	8
	ag3	3.0	0	0	3	3	15
	ant ¹	5.1	-	-	5	6	13
	dor	2.8	0.4	14.3	2	3	10
	gra ¹	3.9	-	-	3	4	12
	min	5.0	-	-	-	-	?
	per	5.0	0	0	5	5	10
Caudal cirri, number	af1	2.2	0.4	17.2	2	3	12
	af2	2.1	0.5	24.8	1	4	25
	ag1	3.0	-	-	-	-	?
	ag2	3.0	0	0	3	3	8
	ag3	3.0	0	0	3	3	15
	ant	2.0	0	0	2	2	13
	dor	2.2	0.4	17.2	2	3	10
	gra	2.0	0	0	2	2	12
	min	3.0	-	-	-	-	?
	per	3.0	0	0	3	3	10

¹ Pretransverse cirri (invariably 2) not included!

third of adoral zone covered by hyaline lip. Paroral and endoral almost straight, extend side by side diverging posteriorly (that is, without distinct *Oxytricha* pattern). Pharyngeal fibres inconspicuous. Frontal, transverse, and caudal cirri in life about 18 μm long, other cirri about 12 μm long. Marginal rows open at posterior end, gap occupied by posterior-

Fig. 112a–e *Urosomoida agiliformis* (from FOISSNER 1982. a, d, e, from life; b, c, protargol impregnation). a, d, e) Ventral, dorsal, and lateral view, a = 110 μ m, d, e = 85 μ m. b, c) Ventral and dorsal infraciliature, 75 μ m. Arrow in (b) marks frontoventral cirrus III/2, arrowheads in (c) denote caudal cirri.

most transverse cirrus and caudal cirri. Ventral and dorsal infraciliature (Fig. 111e, f) as in *Oxytricha longa*. Dorsal cilia in life about 4 μ m long.

Occurrence and ecology: Locus classicus is the Livingstone Island, South Shetland Islands, Antarctica, where FOISSNER (1996b) discovered *Urosomoida granulifera* in *Drepanocladus uncinatus* moss. Possibly feeds on bacteria.

Urosomoida agiliformis FOISSNER, 1982 (Fig. 112a–e, 113a–v, Tables 3, 4, 22)

- 1982 *Urosomoida agiliformis* FOISSNER, Arch. Protistenk., 126: 117 (Fig. 112a–e; 1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Austria).
- 1983 *Urosomoida agiliformis* FOISSNER, 1982 – FOISSNER & ADAM, Zool. Anz., 211: 161 (Fig. 113a–v).
- 1987 *Urosomoida agiliformis* FOISSNER, 1982 – GANNER, FOISSNER & ADAM, Ann. Sci. nat., Zool., 8: 200, in part: populations P1 (= population of FOISSNER 1982) and P2 (= population of FOISSNER & ADAM 1983a); not populations P3 and P4 (see taxonomy).
- 1996 *Urosomoida agiliformis* FOISSNER, 1982 – WANG & SONG, J. Ocean Univ. Qingda, 26: 179, Fig. 1A–J (reinvestigation of morphogenesis).

Fig. 113a-f *Urosomoida agilis*-*formis* (from FOISSNER & ADAM 1983a. a-f, protargol impregnation). a, b) Ventral and dorsal infraciliature of a non-dividing specimen, 65 μ m. c-f) Ventral and dorsal infraciliature of very early morphogenetic stages, c, d = 80 μ m, e, f = 85 μ m. The macronuclear nodules are conspicuously enlarged and of irregular shape (f). OP = oral primordium, 1-4 = dorsal kineties 1-4; p 356.

Nomenclature and taxonomy: *Urosomoides agiliformis* in SMALL & LYNN (1985, p 461) is an incorrect subsequent spelling of *Urosomoida*. Two features strongly suggest that the GANNER et al. (1987a, b) populations P3 and P4 are not conspecific with *U. agiliformis*; firstly, the number of pretransverse ventral and transverse cirri is significantly higher (means = 6.0 and 5.7 respectively) in P3 and P4 than in the populations P1 and P2 described by FOISSNER (1982) and FOISSNER & ADAM (1983a) (means = 3.0 and 2.9 respectively); secondly, the primordia V and VI of the proter do not originate de novo, but they are derived from the postoral ventral cirri V/4 and V/3 respectively, identically to in the type species of *Oxytricha*, *O. granulifera* (Table 4). The latter character is, at the present stage of knowledge, the only autapomorphy of the *Oxytricha-Allotricha* group (Fig. 25a). Thus, P3 and P4 of GANNER et al. (1987b) are classified in *Oxytricha* (see *O. longa*).

Morphology: In life about $80\text{--}100 \times 20\text{--}30\ \mu\text{m}$. Margins almost in parallel, both ends rounded. Macronuclear nodules after protargol impregnation $9\text{--}18 \times 4\text{--}7\ \mu\text{m}$ (mean = $15 \times 5\ \mu\text{m}$; $n = 12$), usually ellipsoidal, rarely broadly spindle-shaped, conspicuously voluminous and often connected by a thin thread (Fig. 112c). Cytoplasm often with many, $3\text{--}6\ \mu\text{m}$ sized, yellowish crystals surrounded by tiny granules. Buccal cirrus at anterior end of undulating membranes. Dorsal kineties 1 and 2 distinctly shortened anteriorly, kinty 4 terminates slightly ahead of mid-body. Distance between basal body pairs of kineties posteriorly distinctly wider than anteriorly.

Morphogenesis of cell division commences with the proliferation of basal bodies at three sites, namely twice left of the postoral ventral cirri and once left of the transverse cirri (Fig. 113c). For details, see Figures 113a–v and Table 4. According to FOISSNER & ADAM (1983a), 1, 2, 2, 3, 3, and 3 cirri originate from the frontal-ventral-transverse cirri streaks I–VI; however, BERGER et al. (1985a) assumed that streak VI produces 4 cirri, resulting in the following pattern: 1, 2, 2, 2, 3, 4.

Occurrence and ecology: Common in terrestrial habitats and in the ooze and aufwuchs of freshwater. Locus classicus is the soil of a beech forest near the village of Baumgarten, Lower Austria (for details see FOISSNER et al. 1985, Profil 7). FOISSNER &

← **Fig. 113g–m** *Urosomoida agiliformis* (from FOISSNER & ADAM 1983a. g–m, protargol impregnation). g–j) Ventral and dorsal infraciliature of early morphogenetic stages, g–j = $84\ \mu\text{m}$. k, l) Ventral and dorsal infraciliature of a middle morphogenetic stage, $80\ \mu\text{m}$. This specimen has 5 dorsal kineties. Arrow marks new (de novo) anlage of primordia V and VI of proter. m) Ventral infraciliature of a middle stage, $80\ \mu\text{m}$. AD = primordia of dorsal kineties, AO = primordium of cirri and undulating membranes of opisthe, ARMR = primordia of right marginal rows, PVC = postoral ventral cirrus, 1–6 = frontal-ventral-transverse cirri primordia I–VI; p 356.

Fig. 113n–r *Urosomoida agiliformis* (from FOISSNER & ADAM 1983a. n–r, protargol impregnation). n) Dorsal → infraciliature of a middle morphogenetic stage (same as Fig. 113m), $80\ \mu\text{m}$. o–r) Ventral and dorsal infraciliature of late morphogenetic stages, o, p = $70\ \mu\text{m}$, q, r = $75\ \mu\text{m}$. Parental structures white, new black. AD₄ = primordium of dorsal kinty 4 (dorsomarginal row), CC = caudal cirri; p 356. Figures on p 360.

Fig. 113s-v *Urosomoida agiliiformis* (from FOISSNER & ADAM 1983a. s-v, protargol impregnation). s, t) Ventral and dorsal infraciliature of a very late morphogenetic stage, 75 µm. Above the arrowhead in (t) the micronucleus did not impregnate. u, v) Ventral and dorsal infraciliature of an opisthe, 40 µm. Parental structures white, new black; p 356.

ADAM (1983a) found *U. agiliformis* in the soil of an alpine pasture near the village of Heiligenblut, Austria. Further records: soils from alpine pastures in the Gasteiner and Fuschner valleys in Salzburg, and in a meadow in Aigen in Styria, Austria (FOISSNER 1985a, 1987b, FOISSNER & PEER 1985, FOISSNER et al. 1990); beta- to alphamesosaprobic brooks and rivers in Austria and Germany (BLATTERER 1994, FOISSNER & MOOG 1992, FOISSNER et al. 1992a, b); limed and fertilized spruce forest soils near Ulm, Germany (LEHLE 1989, 1994); leaf litter of beech forests in Germany (BONKOWSKI 1996); forest humus in France (PALKA 1991); soil from the Pisang-Peak, Himalayas (FOISSNER 1986a); sand from the Coral Pink Sand Dunes near the Zion National Park, Utah, USA (FOISSNER 1994b); soil from Qingdao, China (WANG & SONG 1996); soils from South America, Australia, and Tasmania (FOISSNER 1997b). Feeds on bacteria and ciliates. Biomass of 10^6 individuals about 30 mg (FOISSNER 1987a).

***Urosomoida perthensis* FOISSNER & O'DONOGHUE, 1990 (Fig. 114a–e, Table 22)**

1990 *Urosomoida perthensis* FOISSNER & O'DONOGHUE, Invertebr. Taxon, 3: 692 (1 slide of holotype specimen is deposited in the South Australian Museum).

M o r p h o l o g y: In life $50\text{--}70 \times 20\text{--}30\text{ }\mu\text{m}$. Long elliptical, not contractile. Macronuclear nodules spherical to slightly ellipsoid, after protargol impregnation $7\text{--}8 \times 5\text{--}6\text{ }\mu\text{m}$ (mean = $7.3 \times 5.7\text{ }\mu\text{m}$; $n = 10$). Micronucleus after protargol impregnation approximately $2.7 \times 2.4\text{ }\mu\text{m}$ ($n = 10$). Contractile vacuole lacks collecting canals. Cortical granules absent, endoplasm colourless, but heavily granulated.

Bases of largest membranelles in life about $4\text{ }\mu\text{m}$ wide. Buccal cavity narrow but deep, right anterior margin raggedly curved to adoral zone of membranelles. Undulating membranes lying almost over each other. Cirri about $15\text{ }\mu\text{m}$ long and thick in relation to body size. Bases of pretransverse ventral cirri distinctly smaller than those of all other cirri. Marginal rows distinctly separated posteriorly. Dorsal kinety 1 distinctly, kinety 2 slightly shortened anteriorly; kinety 1 in middle part with a conspicuous gap due to lack of about 2 basal body pairs; kinety 4 terminates about at first third of cell. Prominent caudal cirri at posterior end of kineties 1–3.

O c c u r r e n c e a n d e c o l o g y: Locus classicus is a small pond in the town of Perth, West Australia. W. FOISSNER (pers. comm.) found *Urosomoida perthensis* also in soil from South Africa. In cultures, it feeds on rice starch and bacteria.

***Urosomoida dorsiincisura* FOISSNER, 1982 (Fig. 115a–e, Table 22)**

1982 *Urosomoida dorsiincisura* FOISSNER, Arch. Protistenk., 126: 119 (1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Fig. 114a-e *Urosomoida perthensis* (from FOISSNER & O'DONOGHUE 1990. a-c, from life; d, e, protargol impregnation). a-c) Ventral, dorsal, and lateral view, a = 55 μ m, b, c = 50 μ m. Note the single micronucleus (black dot) between the two macronuclear nodules. d, e) Ventral and dorsal infracapitulum, 40 μ m; p 362.

Fig. 115a–e *Urosomoida dorsiincisura* (from FOISSNER 1982. a, d, e, from life; b, c, protargol impregnation). a, e) Ventral and left lateral view, a = 145 μ m, e = 140 μ m. b, c) Ventral and dorsal infraciliature, 80 μ m. Arrow in (b) marks frontoventral cirrus III/2, arrowhead in (c) denotes posterior end of dorsomarginal kinety. d) Dorsal view showing contractile vacuole with inconspicuous collecting canals and 0.5 μ m sized, yellowish, reticularly arranged cortical granules, 140 μ m. DF = dorsal furrow; p 362.

Taxonomy: Differs from the equally sized and also quadrinucleate *Oxytricha islandica* (Fig. 68a–f) by the lower number of transverse cirri, by the somewhat higher number of adoral membranelles, the presence of cortical granules (Fig. 115d), and the more posteriorly located frontoventral cirrus III/2 (Fig. 115b, arrow). *Oxytricha auri-punctata* has a similar cortical granulation, but only 2 macronuclear nodules.

Morphology: In life about 100–150 $\times$ 25–40 μ m. Margins nearly parallel, both ends broadly rounded. Dorsal surface with a distinct furrow in left anterior part of cell (Fig. 115d). Macronuclear nodules ellipsoidal to bean-shaped, after protargol impregnation 8–11 $\times$ 4–7 μ m, rather invariably arranged in two distinctly separated groups, each group usually with 1 micronucleus. Pellicle conspicuously crenellated at bases of cirri. Cortical granules about 0.5 μ m sized, yellowish, usually reticular arranged (Fig. 115d).

Bases of largest membranelles in life about 7 μ m wide. Buccal cavity moderately deep. Caudal cirri vigorously motile, arranged dorsally slightly right of median. Dorsal kinety 4 terminates about in mid-body (Fig. 115c, arrowhead).

O c c u r r e n c e a n d e c o l o g y: Probably confined to terrestrial habitats. Locus classicus is an intensively cultivated field near Zwentendorf, Lower Austria (Profil 3 in FOISSNER et al. 1985). FOISSNER & PEER (1985) found *U. dorsiincisura* in the marginal area of a graded ski-trail in the Gasteiner Valley, Salzburg, Austria. TIRJAKOVÁ (1988) recorded it from agricultural soils in Czechoslovakia and W. FOISSNER (pers. comm.) in soil from South Africa.

Feeds on bacteria, amoebas, and ciliates. Biomass of 10^6 specimens about 38 mg (FOISSNER 1987a).

Urosomoida antarctica FOISSNER, 1996 (Fig. 116a–e, Table 22)

1996 *Urosomoida antarctica* FOISSNER, Acta Protozool., 35: 115 (type slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

T a x o n o m y: As stated by FOISSNER (1996b), the classification of this species is uncertain and requires morphogenetic data. The almost full set of 17 frontal-ventral-transverse cirri (1 postoral is lacking!) is reminiscent of *Oxytricha*, whereas the simple dorsal infraciliature (obviously the *Urosomoida* pattern) indicates that it might belong to *Urosomoida*.

M o r p h o l o g y a n d b i o l o g y: In life about $60\text{--}75 \times 25\text{--}35 \mu\text{m}$. Broadly elliptical, posteriad usually slightly broadened, both ends broadly rounded. Dorsoventrally flattened up to 2:1. Macronuclear nodules distinctly ellipsoidal, in middle third of cell left of median, after protargol impregnation $11\text{--}17 \times 6\text{--}10 \mu\text{m}$ (mean = $13.5 \times 7.6 \mu\text{m}$; $n = 13$). Micronuclei slightly ellipsoidal, after protargol impregnation $2.8 \times 2.4 \mu\text{m}$ on average, number rather variable (1–3), if only one present, usually attached to anterior macronuclear nodule. Contractile vacuole without distinct collecting canals. Cortical granules lacking. Cytoplasm contains many $2\text{--}3 \mu\text{m}$ sized, colourless fat globules, some small vacuoles with yellowish, crystalline content, and many $4\text{--}6 \mu\text{m}$ sized food vacuoles. Moves slowly.

Adoral zone of membranelles about 32 % of body length, bases of largest membranelles in life about $6 \mu\text{m}$ wide. Buccal cavity narrow and flat. Paroral and endoral membrane almost straight, slightly intersecting optically. Pharyngeal fibres inconspicuous. All cirri strikingly thin; frontal, transverse, and caudal cirri in life about $18 \mu\text{m}$, all other cirri $12 \mu\text{m}$ long. Ventral and dorsal infraciliature, see Figure 116d, e. Invariably only 2 postoral ventral cirri. Right marginal row terminates at about level of pretransverse ventral cirri, left one J-shaped, leaving a broad gap which is occupied by caudal cirri.

O c c u r r e n c e a n d e c o l o g y: Locus classicus is Garwood Valley, South Victoria Land, Antarctica, where FOISSNER (1996b) discovered *U. antarctica* in three small samples which were bulked: “salt” soil from near Garwood glacier; dry soil from “flood

Fig. 116a–e *Urosomoida antarctica* (from FOISSNER 1996b. a–c, from life; d, e, protargol impregnation). a–c) Ventral views and right lateral view, 70 µm. d, e) Ventral and dorsal infraciliature, 63 µm. Note that *U. antarctica* has only two postoral ventral cirri and two caudal cirri; p 365.

plain” of melt-stream; rock flour from glacial outflow stream. No other ciliates recorded in this sample! Feeds on bacteria and, possibly, also on heterotrophic flagellates and small naked amoebae.

***Urosomoida minima* HEMBERGER, 1985 (Fig. 110r, Tables 3, 22)**

1985 *Urosomoida minima* HEMBERGER, Arch. Protistenk., 130: 416 (type slides are deposited in the Institut für landwirtschaftliche Zoologie und Bienenkunde der Universität Bonn, Germany).

T a x o n o m y: The classification in *Urosomoida* is uncertain because there are supernumerary frontoventral cirri, less than 4 dorsal kineties, and the oral apparatus is not exactly in the *Oxytricha* pattern. Redescription necessary.

M o r p h o l o g y: After protargol impregnation 75–90 µm long. Long elliptical, posterior end slightly tapered. Three distal membranelles separated from proximal portion of adoral zone of membranelles by a distinct gap. Buccal area very small. Undulating membranes nearly straight and clearly not intersecting. Both right and left marginal row begin

at about level of cytostome and terminate distinctly ahead of posterior cell end. Oral primordium originates left of postoral ventral cirri.

O c c u r r e n c e a n d e c o l o g y: Locus classicus is an infusion of soil from a garden near Bonn, Germany. HEMBERGER (1982, 1985) found *U. minima* also in the soil of a woodland from near Bonn. Not found since. Biomass of 10^6 individuals about 12 mg (FOISSNER 1987a).

Insufficient redescrptions

Ciliate sp. – MOTE, 1954, Proc. Iowa Acad. Sci., 61: 588, Plate VIII, Fig. 30a (Fig. 225u). Remarks: MOTE (1954) found this hypotrich in a prairie soil in Iowa, USA. In terms of the body shape and the (insufficiently described) ciliature it could be a *Urosomoida*.

Uroleptus agilis EHR. – SMITH, 1914, Kans. Univ. Sci. Bull., 9: 164 (Fig. 233i). Remarks: “*Urp leptus agilis* ENG.” in the legend to the figure is an incorrect subsequent spelling. Obviously a *Uroleptus* because a mid-ventral row is present. In life 83–250 μ m long. Limnetic habitat in Kansas, USA.

Uroleptus agilis EHRBG. – TAI, 1931, Sci. Rep. natn. Tsing Hua Univ., 1: 50, Pl. XIV, Fig. 6. Remarks: A *Uroleptus* because a mid-ventral row is present. In life about 160 μ m long. Stream on east campus of Tsing Hua University, China.

Uroleptus agilis (?) ENG. – EDMONDSON, 1906, Proc. Davenport Acad. Sci., 11: 98 (Fig. 234e). Remarks: A *Uroleptus* because a mid-ventral row is present. Freshwater in Iowa, USA.

Gonostomum STERKI, 1878

1878 *Gonostomum* STERKI, Z. wiss. Zool., 31: 57 – Type (original designation): *Oxytricha affinis* STEIN, 1859.

1882 *Plagiotricha* KENT, Manual infusoria II, p 771 – Type (original designation): *Oxytricha strenua* ENGELMANN, 1862.

1932 *Gonostomum* STERKI, 1878 – KAHL, Tierwelt Dtl., 25: 597.

1982 *Gonostomum* STERKI, 1878 – FOISSNER, Arch. Protistenk., 126: 74.

1984 *Gonostomum* STERKI, 1878 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 8.

1997 *Gonostomum* STERKI, 1878 – BERGER & FOISSNER, Arch. Protistenk., 148: 145.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles and undulating membranes in *Gonostomum* pattern. Frontoventral cirri roughly in V-shaped pattern. Postoral ventral cirri right of adoral zone. Usually fewer than 4 transverse cirri. One right and 1 left row

of marginal cirri. Three dorsal kineties. Caudal cirri present. Primary primordia. Dorsal morphogenesis in *Gonostomum* pattern.

Additional characters: Body flattened about 2:1, flexible. Contractile vacuole about in mid-body, slightly to distinctly displaced inwards. Cortical granules present, however, difficult to discern; cytoplasm colourless. Adoral zone of membranelles 40 to 50 % of body length, distally not overlapping on right margin. Buccal area flat and narrow. Left frontal cirrus displaced posteriorly, sometimes slightly larger than middle and right one. Buccal cirrus at level of rather short paroral. Three, *Gonostomum affine* rarely with 4 dorsal kineties, each with one mobile caudal cirrus; kinty 1 slightly shortened anteriorly; dorsal cilia in life about 3 µm long, except in *G. gonostomoida*, where they are 5 µm, posteriorly even up to 9 µm long. Feed mainly on bacteria. Common in terrestrial habitats, rarely in freshwater.

Nomenclature and taxonomy: STERKI (1878) established *Gonostomum* unambiguously for *Oxytricha affinis*, whereas KENT (1882) designated *O. strenua* clearly as type species of *Plagiotricha*. Obviously erroneously, JANKOWSKI (1979) was of contrary opinion. *Plagiotricha* KENT, 1882 is a homonym of *Plagiotricha* BORY DE SAINT-VINCENT in LAMOUROUX et al. (1824). I do not know the original description of "*Gonostomum mereschowskii*" mentioned in LEPSI (1929b, p 297); very likely it is a nomen nudum, that is, a new species without description.

Plagiotricha KENT was established for *Oxytricha strenua* because of the oblique arrangement of the ventral cirri. KENT (1882) also included *Gonostomum affine*, that is, KENT himself synonymised *Plagiotricha* and *Gonostomum*, considering the latter name as unsuitable.

The characterisation of *Gonostomum* is according to BERGER & FOISSNER (1997); see chapter 2 in the general section for a description of the patterns mentioned. The taxonomy is somewhat complicated because of the rather high variability in the number and the arrangement of the frontal-ventral-transverse cirri, especially in the types species. Previously, *Gonostomum* was rather differently classified. For example, CORLISS (1979) included it in the Holostichidae, however, was uncertain and thought that it could belong to the Oxytrichidae, a classification proposed by STILLER (1974b) and TUFFRAU (1987). SMALL & LYNN (1985) established the Gonostomatidae comprising *Gonostomum*, *Trachelochaeta*, and *Wallackia*. Unfortunately, they made a curious nomenclatural mistake in that they transferred the type of *Gonostomum*, *G. affine*, to *Trachelostyla*. According to HEMBERGER (1982) and SONG (1990), morphogenesis of *G. affine* and *G. strenuum* proceeds typically oxytrichid, that is, 6 frontal-ventral-transverse cirri primordia occur (Fig. 120a-j, 122f-u). Furthermore, morphogenesis proved that *G. affine* has "postoral" ventral cirri; however, during interphase they are not located in the postoral area, but right of the adoral zone of membranelles (Fig. 117r).

Gonostomum develops long cirral streaks during early morphogenesis. Later, these so-called primary primordia divide transversely to form secondary primordia, the usual

oxytrichid cirral anlagen in proter and opisthe. This type of primordia formation occurs also in *Urosoma emarginata* (Fig. 127m–p) and *Tachysoma pelliellum* (Fig. 135j–m). *Urosoma* even has the same type of oral apparatus (*Gonostomum* pattern), suggesting a rather close relationship of these two taxa (BERGER & FOISSNER 1997, FOISSNER 1983a).

Gonostomum franzi FOISSNER, 1982 was transferred to *Kahliella* CORLISS, 1960 because of deviating morphogenetic data: *K. franzi* (FOISSNER, 1982) BERGER & FOISSNER, 1988b; recently, EIGNER (1995) classified this species in *Orthoamphisiella* EIGNER & FOISSNER, 1991 (*O. franzi*). The oral apparatus of *Kahliella* CORLISS, 1960, *Wallackia* FOISSNER, 1976 and *Cladotricha* GAJEVSKAIA, 1925 looks like that of *Gonostomum*, indicating parallelism or a close relationship of these taxa (BERGER & FOISSNER 1987a, BLATTERER & FOISSNER 1988, EIGNER 1995).

FOISSNER (1982) and I agree with the comprehensive list of synonyms for the type species proposed by BUITKAMP (1977a), and *Gonostomum parvum* LEPSI, 1947 is a species indeterminata (Fig. 228h). Thus, *Gonostomum* comprises only four species at the present stage of knowledge.

So far it was generally assumed that the short undulating membrane is the endoral, which consists of only few loosely arranged basal bodies (FOISSNER 1982). However, scanning electron micrographs reveal that this is the paroral (Fig. 21d, e, 119b), which is arranged on the ventral surface and not in the buccal cavity like the endoral.

Key to species

- 1 2 macronuclear nodules (for example, Fig. 117a) 2
- 10–17, usually 14 or 15 macronuclear nodules (Fig. 123a–f) ... *G. kuehnelti* (p 391)
- 2 Left of right marginal row 1 (rarely 2) frontoventral row(s); dorsal cilia 5–9 µm long (Fig. 124a, b) *G. gonostomoida* (p 392)
- Continuous frontoventral row lacking; dorsal cilia about 3 µm long (for example, Fig. 117d, 122d) 3
- 3 4–6 migratory cirri (Fig. 122d; very important, invariably difference to *G. affine*); number of “postoral” ventral cirri distinctly increased, forming an oblique row with 6–8 cirri at level of proximal portion of adoral zone of membranelles; left marginal row terminates behind transverse cirri (Fig. 122a, d) . *G. strenuum* (p 384)
- Usually 2 migratory cirri (Fig. 117r); usually 3 “postoral” ventral cirri, arranged rather irregularly ahead of level of buccal vertex; left marginal row terminates at level of transverse cirri (Fig. 117a, d, f, h, o, r, 119e) *G. affine* (p 369)

Gonostomum affine (STEIN, 1859) STERKI, 1878 (Fig. 20c, 21d, e, 117a–z, 118a–t, 119a–f, 120a–j, Tables 3, 23, 27)

1859 *Oxytricha affinis* STEIN, Organismus der Infusionsthier I, p 186 (Fig. 117j–l).

1865 *Oxytricha affinis* – QUENNERSTEDT, Acta Univ. lund., 2: 59 (Fig. 118l).

- 1878 *Gonostomum affine* – STERKI, Z. wiss. Zool., 31: 54, 57, Tafel IV, Fig. 2.
- 1882 *Plagiotricha (Gonostomum) affinis*, STEIN sp. – KENT, Manual infusoria II, p 772.
- 1888 *Stichochaeta affinis* (STEIN) – GOURRET & ROESER, Archs Biol., 8: 187.
- 1897 *Gonostomum affine* (STEIN) – ŠVEC, Bull. int. Acad. tchéque Sci., 4: 34, 46 (Fig. 118m).
- 1911 *Gonostomum affine* (STEIN) – GOODEY, Proc. R. Soc., 84: 169 (Fig. 118o).
- 1926 *Gonostomum affine*, St. – KOFFMAN, Acta zool., 7: 312 (Fig. 118t).
- 1929 *Gonostomum andoi* SHIBUYA, Proc. imp. Acad. Japan, 5: 156 (Fig. 117m).
- 1930 *Gonostomum andoi* SHIBUYA – SHIBUYA, J. imp. agric. Exp. Stn Nishigahara, 1: 200 (Fig. 117m).
- 1932 *Gonostomum (Oxytricha) affine* (STEIN, 1859) – KAHL, Tierwelt Dtl., 25: 598 (Fig. 117v–z).
- 1934 *Gonostomum affine* STEIN – GRANDORI & GRANDORI, Boll. Lab. Zool. agr. Bachic. R. Ist. sup. agr. Milano, 5: 287, Tavola XIII, fig. 270b.
- 1942 *Gonostomum algicola* GELLÉRT, Acta Sci. math.-nat. Univ. Kolozsvár, 8: 23 (Fig. 118j, k; new synonym; according to W. FOISSNER [pers. comm.], a distinct species).
- 1952 *Gonostomum affine* STEIN 1859 – ŠRÁMEK-HUŠEK, Čslká Biol., 1: 183 (Fig. 117s).
- 1952 *Gonostomum affine* STEIN 1859 – ŠRÁMEK-HUŠEK, Chekh. Biol., 1: 373, 376 (Fig. 117s).
- 1953 *Gonostomum affine* – JÍROVEC, WENIG, FOTT, BARTOŠ, WEISER & ŠRÁMEK-HUŠEK, Protozoologie, p 514 (Fig. 117s).
- 1953 *Gonostomum affine* (STEIN 1859) – WENZEL, Arch. Protistenk., 99: 109 (Fig. 118c–e).
- 1956 *Gonostomum spirotrichoides* GELLÉRT, Acta biol. hung., 6: 347 (Fig. 118f).
- 1956 *Gonostomum bryonicolum* GELLÉRT, Acta biol. hung., 6: 348 (Fig. 118g).
- 1956 *Gonostomum ciliophorum* GELLÉRT, Acta biol. hung., 6: 348 (Fig. 118h).
- 1957 *Gonostomum geleii* GELLÉRT, Annls Inst. biol. Tihany, 24: 19 (Fig. 118b).
- 1957 *Urosoma macrostoma* GELLÉRT, Annls Inst. biol. Tihany, 24: 21 (Fig. 118a; new synonym).
- 1963 *Gonostomum strenuum* (ENGELMANN) – LUNDIN & WEST, Free-living protozoa, p 67 (Fig. 117u; misidentification).
- 1967 *Gonostomum affine* (STEINE) KAHL – CHARDEZ, Revue Écol. Biol. Sol, 4: 294 (Fig. 118s; incorrect spelling of STEIN)
- 1972 *Gastrostyla affine* (STEIN, 1859) – BORROR, J. Protozool., 19: 14.
- 1972 *Trachelostyla bryonicolum* (GELLÉRT, 1956) – BORROR, J. Protozool., 19: 15.
- 1972 *Trachelostyla ciliophorum* (GELLÉRT, 1956) – BORROR, J. Protozool., 19: 15.
- 1972 *Trachelostyla spirotrichoides* (GELLÉRT, 1956) – BORROR, J. Protozool., 19: 15.
- 1972 *Trachelostyla geleii* (GELLÉRT, 1957) – BORROR, J. Protozool., 19: 15.
- 1972 *Trachelostyla macrostoma* (GELLÉRT, 1957) – BORROR, J. Protozool., 19: 15.
- 1973 *Gonostomum affine* STEIN, 1859 – LEPINIS, GELTZER, TSCHIBISOVA & GEPTNER, Key to soil protozoa, p 154 (Fig. 118i).
- 1974 *Gonostomum algicolum* GELLÉRT – STILLER, Fauna Hung., 115: 93.
- 1974 *Trachelostyla canadensis* BUITKAMP & WILBERT, Acta Protozool., 13: 208 (Fig. 117p).
- 1977 *Trachelostyla affine* (STEIN) – BUITKAMP, Decheniana, 130: 123, 125 (Fig. 117o, q).
- 1978 *Gonostomum affine* – SMITH, Br. Antarct. Surv. Sci. Rep., No. 95: 75 (Fig. 118p).
- 1981 *Gonostomum affine* STEIN 1859 – CHARDEZ, Revue verviét. Hist. nat., 38: 53 (Fig. 117t).
- 1982 *Gonostomum affine* (STEIN, 1859) STERKI, 1878 – FOISSNER, Arch. Protistenk., 126: 77 (Fig. 117a–i; authoritative redescription; 1 slide of neotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
- 1984 *Gonostomum affine* (STEIN, 1859) STERKI, 1878 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 9.
- 1984 *Gonostomum algicola* GELLÉRT, 1942 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 12.
- 1984 *Gonostomum bryonicolum* GELLÉRT, 1956 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 15.
- 1984 *Gonostomum ciliophorum* GELLÉRT, 1956 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 16.
- 1984 *Gonostomum spirotrichoides* GELLÉRT, 1956 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 13.
- 1985 *Gonostomum affine* – FLEURY, IFTODE, DEROUX & FRYD-VERSAVEL, Protistologica, 21: 509 (Fig. 119a).
- 1985 *Gonostomum affine* STEIN, 1859 – LÜFTENEGGER, FOISSNER & ADAM, Oecologia, 66: 574 (Fig. 117n).
- 1985 *Trachelostyla affine* – SMALL & LYNN, Illustrated guide to the protozoa, p 461.

Fig. 117a-i *Gonostomum affine* (from FOISSNER 1982. a-c, from life; d, f-i, protargol impregnation; e, wet silver impregnation). a-c) Ventral, dorsal, and lateral view, a-c = 100 µm. d, f, h, i) Ventral infraciliature of specimens from various populations, d, f = 65 µm, h = 70 µm, i = 50 µm. e, g) Silverline system and dorsal infraciliature, e, g = 65 µm. CC = caudal cirri, FB = defecation ball, TC = transverse cirri; p 369.

- 1986 *Gonostomum affine* (STEIN, 1859) STERKI, 1878 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 453.
- 1988 *Gonostomum affine* – BERGER & FOISSNER, Arch. Protistenk., 136: 67, 74 (Fig. 117r).
- 1995 *Gonostomum affine* (STEIN, 1859) – SHIN & KIM, Korean J. Zool., 38: 161 (Fig. 119d–f).
- 1997 *Gonostomum affine* – BERGER & FOISSNER, Arch. Protistenk., 148: 132, 133 (Fig. 20c, 21d, e).

Nomenclature and taxonomy: *Gonostomum affinis* in CUTLER (1920, p 136) and *Oxytricha affinis* in GRANDORI & GRANDORI (1934, p 287) are incorrect subsequent spellings. *Gonostomum affine* shows a high intra- and inter-population variability in body size and ventral infraciliature (FOISSNER 1982), strongly suggesting that this very common soil ciliate is a sibling species complex. At the present state of knowledge, however, I agree with the comprehensive list of synonyms proposed by BUITKAMP (1977a), and consider *G. algicola* and *Urosoma macrostoma* as further synonyms. MAEDA & CAREY (1984) recognised most of these species using, for example, the number of transverse cirri for species distinction. The redescrptions by DELHEZ & CHARDEZ (1970; Fig. 228d) and ROSA (1957a; Fig. 233b) are insufficient.

Some populations of *Gonostomum affine* show the typical number of 4 frontoventral cirri and 3 “postoral” ventral cirri (Fig. 117o, r, 119e, 120a). Conversely, *G. strenuum* has a distinctly higher number of cirri (Fig. 121, 122d). However, there transitions exist between these two patterns (for example, Fig. 117f, m, 118o and *G. affine* sensu NIESSEN 1984); thus, synonymy of *G. affine* and *G. strenuum* cannot be excluded.

Morphology and biology: Size rather variable: in life 85–116 μm long and 3.5–4 times as long as broad (STEIN 1859b), 50–80 μm (ŠRÁMEK-HUŠEK 1952a, b), 63–125 μm (mean = 83 μm , $n = 26$; WENZEL 1953), up to 160 μm long (DINGFELDER 1962). Outline long elliptical or spindle-shaped, broadest usually at level of buccal vertex. Anterior end usually narrow, posterior broadly to narrowly rounded. Invariably 2 spherical or ellipsoidal macronuclear nodules slightly left of median, usually distinctly separate from each other; nodules after protargol impregnation $8\text{--}23 \times 4\text{--}11 \mu\text{m}$ (mean = $13 \times 6 \mu\text{m}$). 1–4, usually 2 spherical or ellipsoidal, after protargol impregnation about 1.3–4.0 μm sized micronuclei. Contractile vacuole during diastole usually with an anterior collecting canal (Fig. 117b), systole after 6–21 s (GELLÉRT 1956). Cortical granules (mucocysts?) colourless, spherical, $<1 \mu\text{m}$, loosely arranged in indistinct longitudinal rows and granules, therefore difficult to discern (Fig. 119c; FOISSNER 1986b). Cytoplasm colourless, with cytoplasmic crystals, greasily shining, 1–3 μm sized globules, and about 5–10 μm sized food vacuoles. Rapid movement, with jerky, relatively long interruptions; swimming in lively rotation about longer body axis.

← Fig. 117j–q *Gonostomum affine* (j–l, after STEIN 1859b; m, after SHIBUYA 1929; n, from LÖFTENEGGER et al. 1985; o, q, from BUITKAMP 1977a; p, from BUITKAMP & WILBERT 1974. j–n, from life; o–q, protargol impregnation). j, k, m, n) Ventral views, j, k = 85–116 μm , m = 100 μm , n = 110 μm . l, q) Ventral view and ventral infraciliature of postconjugational specimens, q = 140 μm . Arrowhead in (q) marks left, slightly enlarged frontal cirrus. o, p) Ventral infraciliature, o = 105 μm , p = 60 μm . Arrowheads in (o) mark left, slightly enlarged frontal cirrus and caudal cirri. Arrows denote “postoral” ventral cirri; p 369.

Fig. 117r-z, 118a, b *Gonostomum affine* (r, from BERGER & FOISSNER 1988b; s, from ŠRÁMEK-HUŠEK 1952a, b; t, after CHARDEZ 1981; u, from LUNDIN & WEST 1963; v-z, from KAHL 1932; a, b, from GELLÉRT 1957. r, protargol impregnation; s-z (t?), from life; a, b, sublimate-glycerine-alcohol fixation and opalblue staining after BRESSLAU). r) Ventral infraciliature, 60 μ m. The cirri originating from the primordia I-VI are connected by broken lines. The posterior cirrus of primordium IV (IV/2) and the two cirri of primordium V (V/3, V/4) are the "postoral" ventral cirri which are arranged right of the proximal portion of the adoral zone of membranelles. Arrows mark the 2 migratory (= frontoterminal) cirri. s-z, a, b) Ventral views showing variability of ciliature causing a rather high number of synonyms (names, see list of synonyms), s, u, x-z = size not indicated, t = 105 μ m, v = 120 μ m, w = 100 μ m, a = 75 μ m, b = 50 μ m; p 369.

Endoral after protargol impregnation 7–11 μm , paroral 12–16 μm long (SHIN & KIM 1995). Frontal, ventral, and transverse cirri slightly enlarged, according to BUITKAMP (1977a) left frontal cirrus larger than middle and right one (Fig. 117o, q). Number and arrangement of frontoventral and transverse cirri rather variable, cirri on frontal area sometimes form a short, slightly oblique row (for example, Fig. 117i–m). Figure 117r shows a specimen where the oxytrichid lineage, that is, the typical number and arrangement of frontoventral and postoral ventral cirri, is well recognisable. The posterior cirrus of streak IV and the two cirri of streak V form the “postoral ventral cirri”, identical to, for instance, in *Oxytricha* or *Tachysoma*, where these 3 cirri are, however, arranged just behind the buccal vertex. All cirri about 12 μm long. Dorsal cilia 3 μm , according to BUITKAMP (1977a) 3–7 μm long; GELLÉRT (1956) described “long cilia” for *Gonostomum bryonicolum* and *G. spirotrichoides*. Very rarely 4 dorsal kineties.

Cyst spherical, about 33 μm across, with a smooth, thin wall (Fig. 118n; CHAUDHURI 1929, SANDON 1927); according to an unpublished scanning electron micrograph (kindly supplied by W. FOISSNER), however, with small warts.

M o r p h o g e n e s i s of cell division is described by HEMBERGER (1982; Fig. 120a–j) and NIESSEN (1984). It proceeds rather similarly to in *G. strenuum*. The formation of primary primordia is considered as synapomorphy of the *Gonostomum-Urosoma-Tachysoma pelliellum* group. Conjugating stages and postconjugates usually slender (Fig. 117l, q; CHAUDHURI 1929).

O c c u r r e n c e a n d e c o l o g y: Very likely the most widely distributed and most common, and often also the most abundant hypotrich in almost all terrestrial habitats (soil, litter, mosses, lichens) all over the world (for example, FOISSNER 1997b). Locus classicus is the “St. Procop-Tal” near Prague, Czechoslovakia, where STEIN (1859b) discovered *Gonostomum affine* in marshy water with decaying leaves of trees. Indicates terrestrial influence in limnetic habitats, for example, after inundation (FOISSNER et al. 1995).

Records largely substantiated by illustrations: soils from Austria (AESCHT & FOISSNER 1992, 1993, FOISSNER 1987b, FOISSNER & FOISSNER 1988, FOISSNER et al. 1990, LÜFTENEGGER et al. 1988, PETZ et al. 1988) and Belgium (CHARDEZ 1967, 1981); forest mosses and pond in Czechoslovakia (ŠRÁMEK-HUŠEK 1952a,b, ŠVEC 1897); agricultural soils in England (GOODEY 1911); dunghill in France (FLEURY et al. 1985); upper soil layer (0–5 cm) of a pasture and a mixed forest near Bonn, Germany (BUIKAMP 1977a); mosses, coniferous and deciduous litters, lichens, rotten wood, and moist layer of algae on a window of a greenhouse (pH 4.8–5.2) in Germany (KAHL 1932, WENZEL 1953); soils in Hungary (GELLÉRT 1942, 1956, 1957); Italy (GRANDORI & GRANDORI 1934); terrestrial and limnetic habitats in Sweden (KOFFMAN 1926, QUENNERSTEDT 1865, 1869); USSR (LEPINIS et al. 1973); subtropical soil in China (SHEN et al. 1992); soil from the experimental farm in Nishigahara near Tokyo, Japan (SHIBUYA 1929, 1930); terrestrial (?) habitats in Ullung Island, Korea (SHIN & KIM 1995); prairie soil from Canada (BICK & BUIKAMP 1976, BUIKAMP & WILBERT 1974); limnetic habitats from the Upper Peninsula of Michigan, USA

Fig. 118n–t *Gonostomum affine* (n, after SANDON 1927; o, after GOODEY 1911; p, from SMITH 1978; q, original kindly supplied by W. FOISSNER; r, from LÜFTENEGGER et al. 1985; s, from CHARDEZ 1967; t, after KOFFMAN 1926. n–q, s, t, from life). n) Resting cyst, according to text 33 µm, according to legend of figure only 17 µm across. o–q, s, t) Ventral views, o, s = 95 µm, p = 85 µm, t = 80 µm. r) Growth curve at 10 °C and 21 °C; p 369.

(LUNDIN & WEST 1963); mosses from USA (KAHL 1932); soils and moss peat of Sub-antarctic and maritime Antarctic islands (SMITH 1978, 1981, 1982).

Records from freshwater habitats not substantiated by illustrations: Belgium (CHARDEZ 1984); running waters in Bulgaria (DETCHEVA 1979b, 1981, DETCHEVA 1972, RUSSEV et al. 1976, 1984); submerged and wet mosses and other sites in Czechoslovakia (TIRJAK-

Fig. 118c–m *Gonostomum affine* (c–e, from WENZEL 1953; f–h, from GELLÉRT 1956; i, from LEPINIS et al. 1973; j, k, after GELLÉRT 1942; l, after QUENNERSTEDT 1865; m, after ŠVEC 1897. c–e, i, l, m, from life; f, sublimate fixation and nigrosin staining; g, h, j, k, sublimate fixation and opalblue staining after BRESSLAU). c–m) Ventral views and dorsal view (k) of various synonyms, c, d = 95 µm, e = 75 µm, f = 100 µm, g, h = 70 µm, i = 75–115 µm, j, k = 60–100 µm, l = size not indicated, m = 130 µm; p 369.

Fig. 119a–c *Gonostomum affine* (a, from FLEURY et al. 1985; b, c, originals kindly supplied by W. FOISSNER. a, protargol impregnation; b, scanning electron micrograph; c, from life). **a)** Ventral infraciliature, bar = 20 μ m. Arrow marks short paroral which consists of loosely arranged basal bodies. **b)** Cell from a soil from Mittenwald (Germany) in ventral view. Small arrow denotes posterior-most “postoral” ventral cirrus, large one paroral, which consists of few, loosely arranged cilia. **c)** Dorsal view of a specimen from a Japanese population. The <1 μ m sized, colourless spherical cortical granules (mucocysts?) are arranged in indistinct rows and are rather difficult to discern; p 369.

OVÁ 1992b, TIRJAKOVÁ & MATIS 1987a); Denmark (NIELSEN 1960); in May about 20 ind. ml⁻¹ in the littoral of a pond near Randan and in mineral waters in France (GROLIERE 1977, GROLIERE & NJINE 1973, CHAOUTE et al. 1990); ephemeral water bodies in Germany at pH 6.2–7.2 (DINGFELDER 1962); oligo- and mesosaprobic brook and rivers in Bavaria, Germany (FOISSNER 1997a, FOISSNER et al. 1992a, b); Schussen River in Germany (WETZEL 1928a); caves in Germany (GRIEPENBURG 1934, 1935) and Italy (BOSCOLO 1968, STELLA & SALVADORI 1953; see also GITTLESON & HOOVER 1969); pelagial of a side-branch of the Danube River in Hungary with 0.9 % dominance in late September (BERECZKY 1991); thermal waters in Hungary (DADAY 1891); abundant in polluted water in Poland (WRZESNIEWSKIEGO 1866); Romania (LEPSI 1932); Switzerland (MERMOD 1914, MES-

Fig. 119d-f *Gonostomum affine* (from SHIN & KIM 1995. d, from life; e, f, protargol impregnation). **d)** Ventral view, 82 µm. **e, f)** Ventral and dorsal infraciliature, 82 µm. Note that in *Gonostomum* the postoral ventral cirri (arrowheads) are arranged not behind but beside the adoral zone of membranelles; p 369.

SIKOMMER 1954); Tibetan Plateau (WANG 1977); Turkestan (DADAY 1903, 1904); littoral of Lake Baikal (GAJEVSKAJA 1927, GAJEWSKAJA 1933); China (HAN & HAO 1995, as *G. affxifine*); at 24–27 °C and pH 6–7 in Michigan waters, USA (CAIRNS & YONGUE 1966); Brush Lake, Ohio, USA (RIDDLE 1905); Amazon River (CAIRNS 1966a); Madagascar (SONDHEIM 1929).

Records from terrestrial habitats not substantiated by illustrations: Belgium (CHARDEZ 1983a); Bulgaria (DECHEVA 1966, 1968, 1970, 1973, DETCHEVA 1972b); Czechoslovakia (TIRJAKOVÁ 1988, TIRJAKOVÁ & MATIS 1987a, b); Denmark (BRUNBERG NIELSEN 1968, STOUT 1968); England (CUTLER 1920, STOUT 1963); soil lichens from the sea shore at Banyuls-sur-Mer, France (FOISSNER 1986c); forest humus in France (PALKA 1991, 1993); beech forest, limed spruce forests, polluted soils, and other sites in Germany (FUNKE 1986, LEHLE 1989, 1993, 1994, LEHLE et al. 1992, NIEBUHR 1989, VARGA 1935b); Greenland (DIXON 1939); Scoresby Land, East Greenland (STOUT 1970); Hungary (HORVÁTH 1950); Italy (COPPA 1921, LUZZATTI 1938, STELLA 1948); Romania (RADU & TOMESCU

1972, TOMESCU 1978, 1987); Yugoslavia (VARGA 1962); India (BHATIA 1936, SANDON 1927); USSR (DIXON 1937, MIRZA-ZADE & IBADOV 1988, MORDKOVICH 1986, MUSAIEV & IBADOV 1979, YAKIMOFF & ZÉRÉN 1924); Himalayan region up to 4500 m above sea level (FOISSNER 1986a); soil from paddy fields in Japan (HINO & MOMIKI 1931, TAKAHASHI & SUHAMA 1991); bark of *Acacia* trees and soil in Costa Rica (FOISSNER 1994c, 1995b); sand from the Coral Pink Sand Dunes near the Zion National Park, Utah, USA (FOISSNER 1994b; further records from the USA: BAMFORTH 1967, 1968, 1969, BOVEE 1979, MARTIN & SHARP 1983, SANDON 1928); savannah near Lamto, Ivory Coast (BUTIKAMP 1977a, 1979); Australia (BLATTERER & FOISSNER 1988, POMP & WILBERT 1988); New Zealand (STOUT 1958, 1960, 1961, 1978, 1984); some islands in the southern Atlantic Ocean (SANDON & CUTLER 1924); Antarctica (SMITH 1973a, 1974a, 1975, 1984, 1985).

BOUTCHINSKY (1895) and BUTSCHINSKY (1897) found *Gonostomum affine* in inland salt waters of the USSR, WILBERT (1995) in saline lakes in Australia, and FERNÁNDEZ-LEBORANS & NOVILLO (1993) in the sub-littoral of the Bay of Biscay. FERNÁNDEZ-LEBORANS & NOVILLO (1994) found the synonym *G. algicola* in the sea at Castro Urdiales, Spain. WENINGER (1970) recorded *G. affine* from percolating filters in Austria, and RICHARDS & CUTLER (1933) from filters for the purification of waste waters from beet sugar factories. BUCHAR (1958) found *G. affine* in the foam of cicadas.

Feeds mainly on bacteria (BUTIKAMP 1977a, DINGFELDER 1962, FOISSNER 1987a), but also on algae, fungi, heterotrophic flagellates, and detritus (GELLÉRT 1956, HORVÁTH 1950). Generation time about 13.4 h at 10 °C and 10.6 h at about 21 °C when cultured polyaxenically in lettuce medium with crushed wheat grains to support bacterial growth (LÜFTENEGGER et al. 1985); at 5 °C and 30 °C culturing was impossible. Highest individual densities (3800 ind. ml⁻¹) were obtained at 21 °C (Fig. 118r). BUTIKAMP (1979), however, recorded *Gonostomum affine* from 5 °C to 40 °C. STOUT (1956) cultured *G. affine* in peat or yeast extract. Biomass of 10⁶ individuals about 39 mg (FOISSNER 1987a), 23 mg (MUSAIEV & IBADOV 1980), 20–45 mg (BUTIKAMP 1979), about 19 mg (NESTERENKO & KOVALCHUK 1991). Some autecological data of limnetic populations from various running waters in Bulgaria are summarised in Table 27. Autecological data of terrestrial populations are given in FOISSNER (1981), FOISSNER & PEER (1985), and FOISSNER et al. (1985). The latter authors found *G. affine* at pH 3.1 in an alpine pseudogley of a wooded area. REINNARTH (1979) observed it in the mud-water interface of a eutrophic pond in Germany at following conditions: -0.5 to -2 cm sediment depth, pH 7.1–7.6, -149 to +4 mV redox potential, 0.73–1.33 mg l⁻¹ NH₄⁺-N, and 0.09–0.99 mg l⁻¹ NO₃⁻-N. Does not tolerate hydrogen sulphide (WETZEL 1928b). Effect of heavy metals, see FERNÁNDEZ-LEBORANS et al. (1987).

← Fig. 120a–j *Gonostomum affine* (from HEMBERGER 1982. a–j, protargol impregnation). a–i) Ventral infraciliature and nuclear apparatus of early, middle, and late morphogenetic stages, a = 110 µm. *Gonostomum* develops long cirral streaks during early morphogenesis (e); later, these so-called primary primordia divide transversely to form secondary primordia (f). j) Dorsal infraciliature of a late morphogenetic stage. Arrows mark new caudal cirri of opisthe. OP = oral primordium; p 369.

Table 23 Morphometric data of *Gonostomum affine* (af1, from BUITKAMP & WILBERT 1974; af2, from BUITKAMP 1977a; af3, 6 populations from the Glockner area from FOISSNER 1982; af4, 5 populations from the Tullnerfeld from FOISSNER 1982; af5, population from saline Australian soils; af6, from SHIN & KIM 1995), *G. gonostomoida* (gon, from HEMBERGER 1985), *G. kuehnelti* (kue, from FOISSNER 1986b), and *G. strenuum* (str, from SONG 1990). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	af1 ¹	59.0	-	-	-	-	1
	af2 ¹	105.0	-	-	-	-	1
	af3	69.3	16.0	23.0	43	112	26
	af4	65.2	10.0	15.3	43	84	26
	af5	131.2	13.5	-	100	150	15
	af6	83.1	6.9	8.3	73	97	8
	kue	60.2	6.6	10.9	50	71	15
	str	103.8	7.9	7.6	88	119	11
Body, width	af1 ¹	22.2	-	-	-	-	1
	af2 ¹	37.5	-	-	-	-	1
	af3	23.7	6.6	27.6	16	46	26
	af4	23.5	5.7	24.4	16	45	26
	af5	55.2	6.3	-	43	68	15
	af6	31.9	8.9	27.8	24	52	8
	kue	23.7	2.7	11.6	20	28	15
	str	37.0	5.0	13.4	28	44	11
Adoral zone of membranelles, length	af1 ¹	31.0	-	-	-	-	1
	af2 ¹	48.0	-	-	-	-	1
	af3	33.4	10.7	31.9	21	59	26
	af4	31.5	5.8	18.3	21	44	26
	af5	61.4	5.7	-	50	70	15
	af6	40.2	5.6	13.8	33	49	8
	kue	28.0	1.5	5.4	25	32	15
	str	54.5	7.2	13.2	41	69	11
Adoral membranelles, number	af1 ¹	22.0	-	-	-	-	1
	af2	-	-	-	21	25	?
	af3	27.9	5.9	21.0	22	40	26
	af4	28.5	3.2	11.3	23	38	26
	af5	28.2	1	-	26	30	15
	af6	25.1	2.5	10.1	22	29	8
	gon	33.0	-	-	-	-	?
	kue	26.0	1.2	4.6	24	28	15
Macronuclear nodules, number	str	29.5	2.2	7.3	26	33	11
	kue	14.2	2.1	14.9	10	17	15
Right marginal row, number of cirri	af1	-	-	-	21	23	?
	af2	17.0	-	-	15	31	?
	af3	20.4	3.6	17.7	14	28	26
	af4	18.9	2.0	10.8	15	24	26
	af5	28.7	1.9	-	26	31	15
	af6	16.4	2.1	12.6	14	20	8
	gon	23.0	-	-	18	27	?

Table 23 Continued

Character	Species	mean	SD	CV	Min	Max	n
Right marginal row, number of cirri	kue	21.3	1.9	9.0	18	25	15
	str	25.8	2.0	7.6	23	29	13
Left marginal row, number of cirri	af1	-	-	-	13	14	?
	af2	14.0	-	-	11	20	?
	af3	14.5	2.9	19.9	8	21	26
	af4	13.6	2.1	15.8	9	18	26
	af5	15.2	2.1	-	11	19	15
	af6	10.1	1.7	17.1	8	14	8
	gon	14.0	-	-	12	15	?
	kue	16.3	1.0	6.3	15	18	15
	str	17.7	5.2	29.6	17	21	13
	af1	6.0	-	-	5	6	?
Ventral cirri on frontal area, number (frontal and buccal cirri not included)	af2	7.0	-	-	6	13	?
	af3	8.1	1.4	17.6	7	14	26
	af4	8.8	2.9	32.9	6	15	26
	af5	-	-	-	9	13	15
	af6	7.0	0	0	7	7	8
	kue	7.0	0	0	7	7	15
	af1	2.0	-	-	-	-	?
Transverse cirri, number (pre- transverse ventral cirri included)	af2	-	-	-	0	6	?
	af3	3.5	1.9	55.6	0	7	26
	af4	4.6	1.0	21.4	3	6	26
	af5	1.0	0	0	1	1	15
	af6	4.1	0.35	8.6	4	5	8
	gon	-	-	-	2	3	?
	kue	4.0	0	0	4	4	15
	str	5.8	0.8	13.1	4	7	17
Caudal cirri, number	af1	3.0	-	-	-	-	?
	af2	3.0	0	0	3	3	?
	af3	2.9	0.5	16.2	1	4	26
	af4	3.1	0.4	12.5	2	4	26
	af5	3.0	0	0	3	3	15
	af6	3.0	0	0	3	3	5
	gon	3.0	-	-	-	-	?
	kue	3.0	0	0	3	3	15
	str	3.0	0	0	3	3	17
	af2 ¹	13.0	-	-	-	-	1
Paroral, number of basal bodies	af3	13.5	3.7	27.7	8	23	26
	af4	11.1	1.9	17.2	8	14	26
	af6	10.6	1.9	18.1	8	14	8
	gon ¹	11.0	-	-	-	-	1
	kue			about 10			?
	str ¹	17.0	-	-	-	-	1

¹ From corresponding figures.

Gonostomum strenuum (ENGELMANN, 1862) STERKI, 1878 (Fig. 121, 122a–u, Tables 3, 23)

- 1862 *Oxytricha strenua* ENGELMANN, Z. wiss. Zool., 11: 387 (Fig. 121).
 1878 *Oxytricha strenua* ENGELMANN – STERKI, Z. wiss. Zool., 31: 57 (see taxonomy).
 1882 *Plagiotricha strenua*, ENG. sp. – KENT, Manual infusoria II, p 772.
 1888 *Stichochaeta strenua* (ENGELMANN) – GOURRET & ROESER, Archs Biol., 8: 187.
 1932 *Gonostomum (Oxytricha) strenuum* (ENGELMANN, 1862) – KAHL, Tierwelt Dtl., 25: 597.
 1972 *Gonostomum strenuum* (ENGELMANN, 1862) STERKI, 1878 – BORROR, J. Protozool., 19: 14.
 1984 *Gonostomum strenua* (ENGELMANN, 1862) STERKI, 1878 – MAEDA & CAREY, Bull. Br. Mus. nat. Hist., 47: 11.
 1990 *Gonostomum strenua* (ENGELMANN, 1862) – SONG, J. Protozool., 37: 249 (Fig. 122a–u).
 1997 *Gonostomum strenua* ENGELMANN, 1862 – OLMO & TÉLLEZ, Arch. Protistenk., 148: 191, Fig. 1–16, Table 1 (morphometric characterisation and morphogenesis).

Nomenclature and taxonomy: Although STERKI (1878) did not use the binomen *Gonostomum strenuum*, he is generally accepted as combining author (BORROR 1972a, MAEDA & CAREY 1984) because he wrote about *Gonostomum* “...eine sehr einheitliche wohlungrenzte Gruppe, zu der offenbar auch *O. strenua* ENGELMANN zu ziehen ist”. Incorrect subsequent spellings: *Gonostomum stenum* (ENGELMANN) (MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA 1982, p 292); *Gonostomum sternuum* (McCASHLAND 1956, p 38); *Gonostomum strenum* (ENGELMANN) (CAIRNS & YONGUE 1973a, p 32).

There is no doubt that *Gonostomum strenuum* and *G. affine* are difficult to separate (especially in life), indicating that they are synonymous. For instance, it could be possible that *G. andoi* (Fig. 117m) and *G. affine* sensu GOODEY (1911; Fig. 118o), which are (preliminary) classified as synonyms of *G. affine*, are conspecific with *G. strenuum* because they have a rather long frontoventral row terminating behind the level of the buccal vertex. This row, the higher number of migratory cirri in *Gonostomum strenuum*, and the different sites where the left marginal row terminates support the recognition of both species.

Gonostomum strenuum sensu LUNDIN & WEST (1963; Fig. 117u) is classified as *G. affine* because it has a very low number of cirri. The KOFFMAN (1926; Fig. 232p) and MADRAZO-GARIBAY & LOPEZ-UCHOTERENA (1973; Fig. 241e) populations are insufficiently redescribed.

Morphology and biology: In life 90–120 × 25–50 µm (SONG 1990), 80–130 × 20–55 µm (OLMO & TÉLLEZ 1997), after ENGELMANN (1862) up to 150 µm long. Outline rather similar to in *G. affine*, anterior end somewhat pointed, posterior rounded. Macronuclear nodules after protargol impregnation 13–20 × 6–13 µm (mean = 17.1 × 9.1 µm; n = 16), conspicuously separate, lying slightly left of median (Fig. 117a, e). 2–3 (mean = 2.1; n = 17), after protargol impregnation 1.9–2.8 µm (mean = 2.3 µm; n = 16) long micronuclei.

Fig. 121 *Gonostomum strenuum*
 (from ENGELMANN 1862). Ventral view from life, 135 µm.

Fig. 122a–c *Gonostomum strenuum* (from SONG 1990. a–c, from life). **a, b**) Ventral views, 110 µm. The cortical granules (mucocysts?) and the contractile vacuole are shown only in (b). **c**) Cortical granules (mucocysts?) in lateral view, bar = 3 µm. CV = contractile vacuole, sG = cortical granules; p 384.

Cortical granules (mucocysts?) small, colourless and thus difficult to discern, after ejection spindle-shaped, about 1.0–1.5 µm long, do not impregnate with protargol (Fig. 119c).

Frontal cirri slightly enlarged, in life about 20 µm long. Arrangement and number of frontal-ventral-transverse cirri rather invariable. Number of cirri in streak III (without right frontal cirrus; Fig. 122d) 2–3 (mean = 2.1; n = 17); streak IV 3–4 (mean = 3.3; n = 17); streak V (without pretransverse ventral cirri and transverse cirri) 6–8 (mean = 7.2; n = 17); streak VI (only migratory cirri) 4–6 (mean = 4.4; n = 17). Usually only 2 transverse cirri in the narrow sense; remaining cirri near them must be designated as pretransverse ventral

Fig. 122d-f *Gonostomum strenuum* (from Song 1990. Protargol impregnation). d, e) Ventral and dorsal infraciliature of a non-dividing cell, 100 μ m. Cirri originating from same primordium connected by a broken line. f) Very early morphogenetic stage. Arrow marks oral primordium. BC = buccal cirrus, e = endoral, FC = left frontal cirrus, FTC = 4-6 migratory cirri, p = paroral, PRVC = pretransverse ventral cirri, 1-6 = frontal-ventral-transverse cirri primordia 1-VI, 1-3 = dorsal kineties; p 384.

Fig. 122g-j *Gonostomum srenuum* (from Song 1990. g-j, morphogenetic stages after protargol impregnation). g, h) Ventral infraciliature of early stages, g = 115 μm , h = 110 μm . i, j) Ventral and dorsal infraciliature of a middle stage, 125 μm . Note that primary primordia are formed! Arrow in (i) marks primordium I of proter, arrows in (j) denote sites where proliferation in dorsal kineties commences; p 384.

Fig. 122k-n *Gonostomum strenuum* (from Song 1990. k-n, morphogenetic stages after protargol impregnation). k, l) Ventral and dorsal infracapitulum of a middle stage, 130 μ m. Arrows mark primordia of marginal rows. m, n) Ventral and dorsal infracapitulum of a late stage, 140 μ m. l-vi = frontal-ventral-transverse cirri primordia l-vi; p 384.

Fig. 122o–q *Gonostomum strenuum* (from SONG 1990. o–q, morphogenetic stages after protargol impregnation). o, p) Ventral and dorsal infraciliature of a late stage, 115 μm . q) Ventral infraciliature of a very late stage, 160 μm . I–VI = frontal-ventral-transverse cirri primordia I–VI, 1, 2 = dorsal kineties 1 and 2; p 384.

cirri. Occasionally one or two cirri in front of these cirri. Right marginal row terminates at level of transverse cirri, left row usually behind right transverse cirrus, thus posterior-most left marginal cirri difficult to discern from the about 20 μm long caudal cirri. Cyst spherical, with smooth wall, in life about 40 μm across (OLMO & TÉLLEZ 1997).

M o r p h o g e n e s i s of cell division is described in great detail by SONG (1990; Fig. 122d–u). As in the type species, primary primordia are formed (Fig. 122i, k). The number of cirri originating from the frontal-ventral-transverse streaks I–VI are as follows (see Fig. 122d, o, q, s, u): 1, 2, 2–3 (4?), 3–4, 8–11, and 7–10. Morphogenesis of dorsal infraciliature is in *Gonostomum* pattern, that is, no fragmentation of kine 3 and no dorsomarginal row. Further details, see Figures 122f–u and OLMO & TÉLLEZ (1997).

O c c u r r e n c e a n d e c o l o g y: According to literature rare in limnetic and terrestrial habitats; however, it cannot be excluded that *G. strenuum* was sometimes confused with the rather common *G. affine*. The locus classicus is near Leipzig, Germany,

Fig. 122r-u *Gonostomum sirenum* (from SONG 1990. Protargol impregnation). r-t) Dorsal and ventral infraciliature of very late morphogenetic stages, r-t = 155-160 μ m. u) Postdivider, 75 μ m. Cirri originating from the same streak are connected by a broken line. CC = caudal cirri, p = paroral, p. 384.

where ENGELMANN (1862) discovered *G. strenuum* in a ditch with *Lemna* sp. SONG (1990) isolated it from the upper soil layer in the Baguan hills (about 50 m above sea-level) in Qingdao, China. OLMO & TÉLLEZ (1997) found it in moss samples from emergent stones at the bank of the Guadarrama River, Spain (1188 m above sea-level). Records not substantiated by illustrations: mud of Loch Leven, England (BRYANT & LAYBOURN 1974); Indonesia (VAN OYE 1922); Cape Fear River near Fayetteville, North Carolina, USA (CAIRNS & YONGUE 1973a); pond on Mount Desert Island, USA (McCASHLAND 1956); agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988); Gulf of Mexico (BOVEE in BORROR 1962).

Feeds on bacteria and green algae and can be cultured in Eau de Volvic with some crushed wheat grains (SONG 1990). CAIRNS & YONGUE (1973a) found *G. strenuum* at following conditions: 23–26 °C, pH 6.2–7.1, 5.8–8.5 mg l⁻¹ O₂, 0.9–3.8 mg l⁻¹ BOD₅, 18 to 24 mg l⁻¹ Cl⁻, 0.44–0.59 mg l⁻¹ NH₄⁺-N, 0.08–0.67 mg l⁻¹ NO₃⁻-N, 0.08–0.14 mg l⁻¹ PO₄³⁻-P, 0.16–0.21 mg l⁻¹ Fe²⁺. Does not tolerate hydrogen sulphide (WETZEL 1928b).

Gonostomum kuehnelti FOISSNER, 1987 (Fig. 123a–f, Table 23)

1987 *Gonostomum kuehnelti* FOISSNER, Sber. öst. Akad. Wiss., 195: 263 (1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: Differs from *G. affine* unequivocally in the number of macronuclear nodules and the almost invariable number and arrangement of frontal, ventral, and transverse cirri; however, using only the infraciliature, a clear separation is not always possible because some populations of *G. affine* possess an almost identical cirral pattern (cp. Fig. 123e with Fig. 117r). *Gonostomum kuehnelti* is similar to *Kahliella franzi* (FOISSNER, 1982) BERGER & FOISSNER, 1988b as concerns body shape and number of macronuclear nodules. However, *K. franzi* is larger, has no cortical granules, and has more ventral cirri, which are arranged in distinct rows.

Morphology and biology: In life 60–90 × 25–35 µm. Outline slender to broad oval, posteriorly more rounded than anteriorly. Macronuclear nodules spherical or ellipsoidal, lying slightly left of median. Micronuclei do not impregnate with protargol during interphase, in morphogenetic stages about 7 micronuclei were observed. Contractile vacuole with two collecting canals. Cortical granules (mucocysts?) rod-shaped, 1.0–1.5 µm long, loosely arranged, colourless, stain red with methyl green-pyronin, usually they were ejected under the cover slip, hence they can be easily overlooked. Cytoplasm strongly opaque by many about 10 µm sized food vacuoles and 1–3 µm sized, shining inclusions. Movement slowly gliding or rotating.

Adoral zone of membranelles displaced slightly more inwards than in *Gonostomum affine*, proximal portion covered by a broad protoplasmic lip. Arrangement and number of frontal, ventral, and transverse cirri almost invariable (Fig. 123e). Left frontal cirrus

Fig. 123a–f *Gonostomum kuehnelti* (from FOISSNER 1987f. a–d, from life; e, f, protargol impregnation). a, b) Ventral and lateral view, 90 µm. c) Pellicle with 1.0–1.5 µm long cortical granules (black rods). d) Dorsal view showing cortical granules and contractile vacuole during diastole. e, f) Ventral and dorsal infraciliature, 65 µm. Large arrows in (e) mark migratory cirri VI/3 and VI/4, small arrows denote “postoral” ventral cirri. Arrow in (f) marks caudal cirri. sG = cortical granules; p 391.

often slightly enlarged. Marginal rows open posteriorly, right row always terminates more anteriorly than left one, which ends in median of cell. All cirri about 20 µm long.

Occurrence and ecology: In terrestrial habitats often associated with the very common *G. affine*; thus, nuclear apparatus should be checked. Locus classicus is Seekirchen, Salzburg, Austria, where FOISSNER (1987f) discovered *G. kuehnelti* in the upper soil layer of an organically farmed field; for detailed description of this site see FOISSNER (1987f) and FOISSNER et al. (1987a; “Versuchsfläche G”). Further records: leaf litter of a beech forest in Germany (BONKOWSKI 1996); soil sample from Kenya (FOISSNER 1987f). Feeds on bacteria and heterotrophic flagellates. Biomass of 10^6 individuals about 30 mg (FOISSNER 1987a).

Gonostomum gonostomoida (HEMBERGER, 1985) comb. nov. (Fig. 124a–f, Table 23)

- 1985 *Trachelochaeta gonostomoida* HEMBERGER, Arch. Protistenk., 130: 400 (1 slide of type specimens is deposited in the Institut für landwirtschaftliche Zoologie of the University of Bonn, Germany; Fig. 124a).

T a x o n o m y: The shape of the adoral zone of membranelles, the short undulating membranes, and the dorsal infraciliature requires classification in *Gonostomum*. The main difference to the other *Gonostomum* species is the additional cirral row left of the right marginal row. Morphogenetic stages reveal that this row and its primordium is homologous to primordium VI of *Gonostomum* or other typical oxytrichids. This is mainly indicated by the two anterior-most cirri of this row, which are not involved in primordia formation during morphogenesis, identically to the migratory cirri (VI/3 and VI/4) of the other oxytrichids (Fig. 124e). The origin and variability of the transverse cirri is somewhat unclear. HEMBERGER (1982) wrote that during morphogenesis one or two cirri are differentiated at the posterior end of the frontoventral row (Fig. 124f). However, the specimens shown in Figures 124a, d have three enlarged cirri, suggesting that probably at least one, but possibly even two parental transverse cirri are retained after division. This hypothesis, however, would require a rather variable number of 1–3 transverse cirri within a population because no parental transverse cirri are present in the proter. Such a variability is not described by HEMBERGER (1982), indicating a possibly different mode of morphogenesis. Redescription necessary.

M o r p h o l o g y a n d b i o l o g y: In life (?) 110–200 × 30–50 µm (that is, distinctly larger than the rather similar *G. affine*!). Lanceolate. Macronuclear nodules ellipsoidal. Two micronuclei. Adoral zone of membranelles about 40 % of body length. Bases of the frontal-ventral-transverse cirri, except that of frontoventral row, slightly enlarged. All cirri about 25 µm long. Usually 9, sometimes 10 or 11 enlarged cirri in frontal area; HEMBERGER (1985) wrote, obviously erroneously, that usually 10 cirri are present. Frontoventral row with 17 or 18 cirri, rarely specimens with 2 rows occur (Fig. 124c). Transverse cirri slightly enlarged. Dorsal cilia 5 µm, posteriorly about 9 µm long.

O c c u r r e n c e a n d e c o l o g y: As yet found only at the very extraordinary type location: an infusion of excrement of the common land snail, *Deroceras reticulatum* (MÜLLER) collected near Bonn, Germany (HEMBERGER 1982, 1985, KERNEY et al. 1983). Biomass of 10⁶ individuals about 204 mg (FOISSNER 1987a).

Species indeterminata

Gonostomum parvum LEPSI, 1947, Bull. Sect. scient. Acad. roum., 29: 670 (Fig. 228h). Remarks: Possibly identical with *G. affine*. In life 60–80 µm long, cytoplasm colourless. Two macronuclear nodules. Transverse cirri lacking. Ponds in Romania. GELLÉRT (1957) recorded it from the soil of a woodland in Hungary.

Fig. 124a-f *Gonostomum gonostomoida* (a, c-f, from HEMBERGER 1982, 1985. a-f, protargol impregnation). **a)** Ventral infraciliature and nuclear apparatus, 175 μ m. **b)** Same as (a), however, cirri originating from same primordium are connected by a broken line. The cirri between the two arrowheads are lacking in the very similar, but smaller *Gonostomum affine* (cp. with Fig. 117r). Arrows mark "postoral" ventral cirri. **c)** Specimen with two ventral rows. **d-f)** Ventral infraciliature of middle and late morphogenetic stages. Old structures white, new black. CC = caudal cirri, p = paroral; p 392.

Insufficient redescrptions

Gonostomum affine STEIN – ROSA, 1957, Přírodov. Sb. ostrav. Kraje, 18: 45 (Fig. 233b). Remarks: Soil of a woodland in Czechoslovakia.

Gonostomum affine (STEIN) KAHL – DELHEZ & CHARDEZ, 1970, Annls Spéleol., 25: 135 (Fig. 228d). Remarks: Especially the very long caudal cirri indicate a misidentification. Limnetic in a Belgian cave.

Gonostomum sp. – CHAUDHURI, 1929, Annls Protist., 2: 54, 57 (Fig. 231b, c). Remarks: Soils in India.

Gonostomum sp. – MOTE, 1954, Proc. Iowa Acad. Sci., 61: 578, 588 (Fig. 225o). Remarks: Neither the shape of the adoral zone of membranelles nor the arrangement of the frontal, ventral, and transverse cirri indicate that it is a *Gonostomum*. Soil of virgin prairie in Iowa, USA.

Gonostomum sp. – WALKER & HOFFMAN, 1985, Cytobios, 44: 153. Remarks: WALKER & HOFFMAN (1985) examined the encystment of an unidentified species of *Gonostomum* by transmission electron microscopy. Unfortunately they gave no drawing or description of the infraciliature. They found that the cyst of *Gonostomum* sp. is clearly of the kinetosome-resorbing (KR) type and stated that the results of their investigation further reinforces the SMALL & LYNN (1985) classification. Accordingly, *Gonostomum* is a stichotrichine and its encystment varies slightly but significantly from that described for several sporadotrichine hypotrichs. This classification is not in accordance with the results obtained by the morphogenetic studies on *G. affine* and *G. strenuum*, which indicate a close relationship to typical oxytrichids such as *Urosoma* and *Tachysoma* (HEMBERGER 1982, SONG 1990).

Gonostomun strenuum (ENGELMANN, 1862) STERKI, 1878 – MADRAZO-GARIBAY & LÓPEZ-OCHOTERENA, 1973, Revta Soc. mex. Hist. nat., 34: 66 (Fig. 241e). Remarks: Incorrect subsequent spellings of genus and species name. The low number of cirri in the anterior half indicates that it is not a *Gonostomum* of the *strenuum* type. Found in the San Anton waterfall in Morelos State, Mexico.

Gonyostomum semen (EHRBG.) – SCHMIDT, 1916, Verh. naturh. Ver. preuss. Rheinl., 72: 93. Remarks: Very likely erroneously, SCHMIDT (1916) mentioned this phytomastigophorean taxon in the Oxytrichidae of his faunal list from the Rhineland and Westphalia, Germany.

Oxytricha (*Plagiotricha*, KENT.) *strenua* ENGELM. – KOFFMAN, 1926, Acta zool., 7: 312 (Fig. 232p). Remarks: Soil near Stockholm, Sweden.

Urosoma KOWALEWSKIEGO, 1882

- 1882 *Urosoma* KOWALEWSKIEGO, Pam. fizyogr., 2: 406 – Type (by monotypy): *Urosoma cienkowskii* KOWALEWSKIEGO, 1882 (= junior synonym of *Oxytricha caudata* EHRENBURG, 1833).
- 1883 *Urosoma* KOWALEWSKI, Biol. Zbl., 3: 240 (German translation of Polish original description by August WRZESNIOWSKI; without illustrations).
- 1889 *Urosoma* KOWALEWSKY 1882 – BÜTSCHLI, Protozoa, p 1748.
- 1932 *Urosoma* KOWALEWSKI, 1882 – KAHL, Tierwelt Dtl., 25: 606 (see nomenclature).
- 1982 *Urosoma* KOWALEWSKI, 1882 – FOISSNER, Arch. Protistenk., 126: 109.
- 1986 *Urosoma* KOWALEWSKI, 1882 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 457.
- 1987 *Urosoma* – FOISSNER, Jber. Haus Nat. Salzburg, 10: 64.
- 1997 *Urosoma* KOWALEWSKIEGO, 1882 – BERGER & FOISSNER, Arch. Protistenk., 148: 148.

Characterisation: Adoral zone of membranelles and undulating membranes in *Gonostomum* pattern. Frontoventral cirri arranged in a row with anterior cirrus (III/2) usually slightly displaced to left. Postoral ventral cirri in dense cluster behind buccal vertex or absent. Usually 2 pretransverse ventral and 5 transverse cirri. One right and 1 left row of marginal cirri. Four dorsal kineties. Caudal cirri present. Primary primordia. Dorsal morphogenesis in *Urosomoida* pattern.

Additional characters: Body flexible, but not distinctly contractile, flattened about 2:1. Anterior end rounded. Two, 4 (*U. acuminata*), or about 8 (*U. octonucleata*, *U. polynucleata*) macronuclear nodules slightly left of median. Contractile vacuole slightly to distinctly in front of mid-body. Pellicle and cytoplasm colourless. Close underneath pellicle in most species (*U. acuminata*, *U. caudata*, *U. emarginata*, *U. gigantea*, *U. karini*, *U. octonucleata*, *U. polynucleata*) numerous, about 2–3 µm sized, ellipsoidal, colourless structures, very likely mitochondria. Some species with tiny cortical granules. Adoral zone of membranelles 18 % (*U. polynucleata*) to 30 % (*U. salmastra*) of body length and usually clearly arranged on left body margin, similarly to in *Gonostomum* (Fig. 125i, 127g, 128f). Buccal area flat and small. Frontal cirri not to slightly enlarged. Cirrus III/2 slightly enlarged in some species (*U. acuminata*, *U. karini*, *U. polynucleata*, *U. similis*). Buccal cirrus often near anterior end of anterior undulating membrane. Number of right marginal cirri usually slightly higher than number of left marginal cirri. Distance between marginal cirri posteriorly often wider than anteriorly. Dorsal cilia 3–4 µm long. Very likely all species with one caudal cirrus each on dorsal kineties 1, 2, and 3. Common, but usually not very abundant in freshwater and soil.

Nomenclature and taxonomy: KAHL (1932) classified *Urosoma* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Urosoma)*. Incorrect spellings: *Urosomas* (?; EDDY 1925, p 85); *Urozoma cienkowskii* KOWALEWSKI, 1882 (DETCHÉVA 1992, p 109; RUSSEV et al. 1984).

The characterisation is according to BERGER & FOISSNER (1997); see chapter 2 in the general section for detailed description of patterns mentioned. KOWALEWSKIEGO (1882)

and KAHL (1932) separated *Urosoma* from other oxytrichids mainly by the tapered or tail-like posterior end of the cell. BORROR (1972a) included it in *Oxytricha*, whereas STILLER (1974b), CORLISS (1979), CURDS et al. (1983), and TUFFRAU (1987) considered *Urosoma* as valid. However, only FOISSNER (1982, 1983a, 1987b), DRAGESCO & DRAGESCO-KERNÉIS (1986), and BERGER & FOISSNER (1987a, 1989a) described some species in detail. Most species now assigned to *Urosoma* are in fact rather slender and posteriorly more or less distinctly narrowed. However, the only autapomorphy of *Urosoma* is the peculiar arrangement of cirrus III/2, namely in front of the level of cirrus VI/4, that is, the fronto-ventral cirri form a row, and not a V-shaped pattern as in most other oxytrichids (Fig. 19a, 125i; BERGER & FOISSNER 1997). Such a row also occurs in some species originally assigned to *Perisincirra* (*P. similis*; Fig. 131d, f) and *Hemisincirra* (*H. polynucleata*; Fig. 130f, h). This character and the agreements in the oral apparatus and dorsal infraciliature strongly suggest that these species belong to *Urosoma*, although the frontal-ventral-transverse cirri behind the adoral zone are partially or completely reduced. Very likely, *Perisincirra similis* and *Hemisincirra polynucleata* form a distinct clade in *Urosoma*.

Urosoma has several synapomorphies with *Gonostomum*, supporting the sister group relationship proposed by FOISSNER (1983a; Fig. 25a). WIRNSBERGER et al. (1986) ignored the primary primordia (Fig. 127m; character 16 in Fig. 25a) and the distinctive oral apparatus (Fig. 19h; characters 1, 3 in Fig. 25a), but used the decreased number of pretransverse ventral and transverse cirri as autapomorphies. Thus, WIRNSBERGER et al. (1986) arrived at *Gonostomum* and *Urosomoida* as sister groups.

According to JANKOWSKI (1979, p 68), *Tricholeptus* FROMENTEL, 1875 (p 177) is possible a synonym of *Urosoma*. However, since the type species, *Tricholeptus aculeatus*, is insufficiently described (FROMENTEL 1876, p 294; Planche XX, Fig. 7) and since this taxon was never accepted by later authors (for example, KAHL 1932) it is considered as nomen oblitum (CORLISS 1979, p 208).

Key to species

1	2 macronuclear nodules	4
-	More than 2 macronuclear nodules (Fig. 128b, 129a, 130a)	2
2	Usually 4 macronuclear nodules (Fig. 128a-o)	<i>U. acuminata</i> (p 414)
-	Usually 8 (6-9) macronuclear nodules	3
3	3 postoral ventral cirri; transverse cirri subterminal (Fig. 129a-f)	<i>U. octonucleata</i> (p 417)
-	Only 1 postoral ventral cirrus; transverse cirri terminal and inconspicuous (Fig. 130a-i)	<i>U. polynucleata</i> (p 419)
4	(1) Posterior end rounded, tapering, or tail-like	5
-	Right margin posteriorly distinctly emarginated (Fig. 127a-c)	<i>U. emarginata</i> (p 409)
5	Posterior end rounded (for example, Fig. 132a)	6

- Posterior end tapering or tail-like (for example, Fig. 125g, 126a, c, 131a) 8
- 6 Length in life 170–230 μm (Fig. 134a–w) *U. gigantea* (p 425)
- Length in life 50–160 μm 7
- 7 Cortical granules lacking; undulating membranes arranged one after another, endoral much shorter than paroral (Fig. 133a–c) *U. salmastra* (p 424)
- Cortical granules present; undulating membranes overlapping, of about equal length (Fig. 132a–e) *U. karini* (p 422)
- 8 (5) Posterior body part tail-like (Fig. 125a–q) *U. caudata* (p 398)
- Posterior body part tapering (for example, Fig. 126c, 131a) 9
- 9 3 postoral ventral cirri; 5 subterminally arranged, distinctly enlarged transverse cirri (Fig. 126a, c–e) *U. macrostyla* (p 404)
- Postoral ventral cirri absent; 2–3 inconspicuous, terminal transverse cirri (Fig. 131a–g) *U. similis* (p 419)

***Urosoma caudata* (EHRENBERG, 1833) comb. nov. (Fig. 125a–u, Tables 24, 41)**

- 1833 *Oxytricha caudata* EHRENBERG, Abh. preuss. Akad. Wiss., year 1833: 278, 279.
- 1838 *Oxytricha caudata* – EHRENBERG, Infusionsthierchen, p 365, in part: Tafel XL, Fig. XI₁₋₃; not Tafel XL, Fig. XI₄₋₆ (Fig. 125a–c).
- 1882 *Urosoma cienkowskii* KOWALEWSKIEGO, Pam. fizyogr., 2: 406 (Fig. 125r; new synonym).
- 1883 *Urosoma cienkowskii* KOWALEWSKI, Biol. Zbl., 3: 240 (German translation of the Polish original description by August WRZESNIEWSKI).
- 1887 *Oxytricha caudata* STOKES, Ann. Mag. nat. Hist., 20: 112 (Fig. 125f; new synonym; homonym).
- 1888 *Oxytricha caudata*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 291 (Fig. 125f).
- 1930 *Oxytricha caudata* STOKES – WANG, Contr. biol. Lab. Sci. Soc. China, 6: 14 (Fig. 125d).
- 1932 *Urosoma (Oxytricha) caudata* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 607.
- 1932 *Urosoma cienkowskii* KOWALEWSKI, 1882 – KAHL, Tierwelt Dtl., 25: 607 (Fig. 125e).
- 1935 *Urosoma cinekowski* KOWALEWSKI 1882 – WANG & NIE, Sinensia, Shanghai, 6: 500 (Fig. 125s; incorrect subsequent spelling).
- 1956 *Urosoma cienkowskyi* KOWALEWSKI – GRAAF & MEIJER, Micro-organismen, p 111, 112 (Fig. 125t; incorrect subsequent spelling).
- 1963 *Urosoma caudata* (STOKES) – LUNDIN & WEST, Free-living protozoa, p 67 (Fig. 125p).
- 1967 *Urosoma caudata* (STOKES) 1887 – BIERNACKA, Wiss. Z. Ernst Moritz Arndt-Univ. Greifswald, 16: 247 (Fig. 125u).
- 1972 *Urosoma cienkowskii* KOWALEWSKI – BICK, Ciliated protozoa, p 19 (Fig. 125q).
- 1972 *Trichotaxis caudata* (EHRENBERG, 1838) – BORROR, J. Protozool., 19: 11 (incorrect subsequent spelling of *Trichototaxis*).

Fig. 125a–k *Urosoma caudata* (a–c, after EHRENBERG 1838; d, from WANG 1930; e, from KAHL 1932; f, from → STOKES 1887b; g–k, from FOISSNER 1982. a–h, k, from life; i, j, protargol impregnation). a–c) Various views, 170–210 μm . d–g) Ventral views, d = 240 μm , e = 250 μm , f = 220 μm , g = 225 μm . h) Mitochondria(?) close beneath the pellicle. i, j) Ventral and dorsal infraciliature of same specimen, 105 μm . Arrow marks frontoventral cirri, which are arranged in a row and not in a V-shaped pattern as in most other oxytrichids. k) Two specimens creeping on a soil particle.

Fig. 125l–q *Urosoma caudata* (l–o, from FOISSNER 1984; p, from LUNDIN & WEST 1963; q, from BICK 1972a. l, m, p, q, from life; n, o, protargol impregnation). l, p, q) Ventral views, l = 200 μ m, p = size not indicated, q = 270 μ m. m) Dorsal view of a very slender, worm-like specimen, 200 μ m. n, o) Ventral and dorsal infraciliature of same specimen, 195 μ m. Arrow marks inconspicuous caudal cirri at tip of tail; p 398.

1982 *Urosoma cienkowskii* KOWALEWSKI, 1882 – FOISSNER, Arch. Protistenk., 126: 112 (Fig. 125g–k; authoritative redescription; slides of neotype material are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1984 *Urosoma cienkowskii* KOWALEWSKI, 1882 – FOISSNER, Stapfia, 12: 121 (Fig. 125l–o; 1 slide of protargol impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: KAHL (1932) classified *Urosoma* as subgenus of *Oxytricha*; the correct names in his revision are thus *Oxytricha (Urosoma) caudata* STOKES and *Oxytricha (Urosoma) cienkowskii*. Incorrect subsequent spellings: *Uro-*

soma caudatum STOKES (WEBB 1961; p 140); *Urosoma cienckowski* KOW. (COPPA 1921, p 188); *Urosoma cienkowsky* KOWALEWSKI, 1882 (LUZZATTI 1938, p 102).

EHRENBERG (1838) emphasised that *Oxytricha caudata* is very similar to *O. rubra* (now *Pseudokeronopsis rubra*), except that *O. caudata* is more pointed posteriorly, and in that he observed cirri not in the median of the cell (that is, he observed no mid-ventral cirri!), but near the oral apparatus and also 5 cirri near the posterior end. This strongly indicates that EHRENBERG observed an oxytrichid and not an urostylid as suggested by KENT (1882) and BÜTSCHLI (1889). Thus, I classify *O. caudata* EHRENBERG as senior synonym of *Urosoma cienkowskii* KOWALEWSKIEGO and *Oxytricha caudata* STOKES. The latter is a junior primary homonym, which, however, need not be replaced because of synonymy (Article 60a of ICZN 1985).

KAHL (1932) separated *U. caudata* (STOKES) and *U. cienkowskii* by the body shape and the number of postoral and pretransverse ventral cirri: *U. caudata* anteriorly broad and 5 cirri (Fig. 125f), *U. cienkowskii* parallel sided and 8 cirri (Fig. 125r). WANG & NIE (1935) confirmed the increased number of cirri between buccal vertex and transverse cirri in *U. cienkowskii* (Fig. 125s), a phenomenon which can also be observed in other oxytrichid species. Thus, I preliminarily agree with FOISSNER (1982), who considered these differences to be a mainly intraspecific variability. However, there is no doubt that *U. cienkowskii* has to be separated from *U. caudata* if the increased number of cirri is substantiated by protargol impregnation and morphometric analysis.

Without foundation, BORROR (1972a) transferred *Oxytricha caudata* EHRENBERG to *Trichototaxis* and synonymised *Oxytricha caudata* STOKES with *Urosoma acuminata*, which has, however, 4 macronuclear nodules. Some illustrations of the present species are rather poor; in spite of this, the identifications can be accepted (for example, Fig. 125p). The redescrptions by CONN (1905; Fig. 225i), DUJARDIN (1841), DUMAS (1929, 1930, Fig. 236a, b, r, 239g), and FROMENTEL (1876) are insufficient. "*Oxytricha caudata* EHR." sensu CLAPARÈDE & LACHMANN (1859, Planche V, Fig. 7) is an *Uroleptus* because mid-ventral cirri are present.

Morphology and biology: In life 150–300 × 20–50 µm; 170–210 µm (EHRENBERG 1838), 240 µm (KOWALEWSKIEGO 1882), 210–255 µm (STOKES 1887b), 150 to 300 µm (KAHL 1932), 250–300 × 40–50 µm (WANG & NIE 1935), 180–270 times 20–35 µm (FOISSNER 1982; terrestrial population), 150–250 µm (FOISSNER 1984; freshwater population); ratio of length to width usually 7:1, that is, slender-elongate, anterior end rounded, posterior end tail-like; some populations almost vermiform (Fig. 125m). Macronuclear nodules in life about 14–17 × 6–10 µm, after protargol impregnation 8–14 times 4–7 µm (n = 17; FOISSNER 1982, 1984). 2–4, in life about 4 µm, after protargol impregnation 2.5–4.0 × 2–3 µm sized micronuclei. Contractile vacuole with short and inconspicuous collecting canals. Mitochondria give cells a slightly brownish shimmer at low magnification (Fig. 125h; FOISSNER 1982). Around bases of cirri and dorsal cilia small (about 0.5 µm), colourless cortical granules (Fig. 125h). Cytoplasm of anterior cell part sometimes with reddish crystals (FOISSNER 1982), according to KOWALEWSKIEGO (1882) whole

Fig. 125r-u *Urosoma caudata* (r, after KOWALEWSKIEGO 1882; s, after WANG & NIE 1935; t, from GRAAF & MEIJER 1956; u, from BIERNACKA 1967. r-u, from life). r-u) Ventral views, r = 240 μ m, s = 285 μ m, t = size not indicated, u = >200 μ m; p 398.

cytoplasm appears reddish. According to KAHL (1932; sapropelic populations), WANG & NIE (1935), and RECK (1987) symbiotic algae present (confused with ingested algae? other species?). Moves moderately rapidly, jerks hastily to and fro.

Adoral zone of membranelles 15–20 % of body length. Usually 3 postoral ventral cirri and 1 pretransverse ventral cirrus (Fig. 125i, n); according to KOWALEWSKIEGO (1882) and WANG & NIE (1935), however, 6 (5 plus 1) postoral and 2 pretransverse ventral cirri (Fig. 125r, s; see taxonomy). Transverse cirri about 25 μ m long, at anterior end of tail-like process. Left marginal row terminates about 20 μ m in front of tip of tail; cirri in life 10–15 μ m long. Dorsal kinety 1 distinctly shortened anteriorly. Distance between basal body pairs widens posteriad. Caudal cirri difficult to discern even after protargol impregnation; very likely three rather fine, about 15 μ m long cirri. Morphogenesis of *Urosoma caudata* commences with formation of an oral primordium left of and beside postoral

ventral cirri (FOISSNER 1984), identically to in *Urosoma emarginata* and *Urosoma polynucleata*.

Occurrence and ecology: Common, but usually with low abundance in detritus and aufwuchs (rarely in the pelagial) of moderately to distinctly polluted lentic and lotic waters; also common in terrestrial habitats. Recorded from Eurasia, South America, and Africa. After KAHL (1932) one of the most common oxytrichids in saprobic habitats;

according to my experience, however, much more seldom than, for example, *Tachysoma pelliellum*, *Stylonychia pustulata*, or *Oxytricha* spp.

Locus classicus is a freshwater habitat near Berlin, Germany (EHRENBURG 1833, 1838). Locus classicus of the synonym, *Urosoma cienkowskii*, is the Weichsel River near Warsaw, Poland (KOWALEWSKIEGO 1882, KOWALEWSKI 1883). Locus classicus of the synonym, *Oxytricha caudata* STOKES, is a *Lemna* pond in the USA, probably near Trenton, New Jersey, where STOKES lived and worked. Further records substantiated by illustrations: arable land and bottom-land in the Tullnerfeld, Lower Austria (FOISSNER 1982; see FOISSNER et al. 1985 for detailed description of sites); very abundant in cyanobacteria slimes (*Spirolina jenneri*) in a hypertrophic pond in Salzburg, Austria (FOISSNER 1984); the Netherlands (GRAAF 1956, 1957, GRAAF & MEIJER 1956, GROOT & GRAAF 1960); in great abundance together with species of the *Stylonychia mytilus*-complex in standing water collected more than a month previously from Lake Ho Hu in Nanking, China (WANG 1930, WANG & NIE 1935).

Records from freshwater habitats not substantiated by illustrations: brook in Upper Austria (BLATTERER 1994); Maritza River, Bulgaria (DETCHIEVA 1981); submerged and wet mosses and Turiek River in Czechoslovakia (SCHMARD 1846, TIRJAKOVÁ 1993, TIRJAKOVÁ & MATIS 1987a); sediment of Esthwaite, one of the most eutrophic lakes in the English Lake District (FINLAY 1982, WEBB 1961); pronounced summer maximum in a eutrophic water body in England (FINLAY et al. 1979); peat-bogs in France (GROLIERE 1977, ORMANCY 1852); betamesosaprobic rivers in Germany (BUCK 1959, 1961, MAUCH 1976); mesotrophic lake in Germany (MÜCKE 1979); about 20 ind. cm⁻² in the pseudoperiphyton of a eutrophic pond in Bonn, Germany (WILBERT 1969); eutrophic lake in Germany with a maximum of 2937 ind. l⁻¹ in the autumn plankton (RECK 1987; with symbiotic algae, other species?); sediment of Hamburg Harbour, Germany (BARTSCH & HARTWIG 1984); together with alphamesosaprobic species in the sediment of sewage oxidation ponds of Munich, Germany (KAUFMANN 1958); detritus drifts in Lake Balaton, Hungary (GELLÉRT & TAMAS 1958); 4 ind. cm⁻² in an alphamesosaprobic section of the Po River, Italy (MADONI 1979); well in Italy (GRISPINI 1938; further records from Italy: CANELLA 1954, COPPA 1921); sediment of Latvian rivers (LIEPA 1986, 1990, VEYLANDE & LIYEPA 1985); Spain (FINLAY et al. 1993, MARGALEF LÓPEZ 1945); in bogs near Berne (Switzerland) from April to December (PERTY 1852b); eutrophic ponds in Yugoslavia (SCHMARD 1847); rivers, reservoirs, and other habitats in USSR (ALIEV 1982a, KRAVCHENKO 1969, MOVCHAN & PROTASOV 1986, WEISSE 1848a, b, c); Lake Dong Hu in Wuhan, China (SHEN 1980); Tibetan Plateau (WANG 1977); slightly polluted third order stream in a mid-Atlantic State, USA (NIEDERLEHNER et al. 1990); Colorado, USA (BEARDSLEY 1902, HAMILTON 1943); in bogs with up to 14.2 mg l⁻¹ H₂S in Iowa, USA (HEMPSTEAD & JAHN 1940, SHAWHAN et al. 1947); at 15–17 °C in a slow-moving stream in Kentucky, USA, the bed littered with leaves, rocks, and fallen tree limbs (GITTLESON & FERGUSON 1971); Louisiana, USA (BAMFORTH 1963); Massachusetts, USA (COLE 1853); at 20 °C and pH 6.0–6.5 in a bog and in a river in Michigan, USA (CAIRNS & YONGUE 1966); Cape Fear River in North Carolina, USA (CAIRNS & YONGUE 1973a); among

algae-covered poplar roots and once in black sediment of Mirror Lake in Ohio, USA (STEHLE 1920); Conestoga drainage basin in Pennsylvania, USA (CAIRNS 1965a); Savannah River, USA (PATRICK et al. 1967); Mexico (LÓPEZ-POCHTERENA & ROURE-CANE 1970, MADRAZO-GARIBAY & LÓPEZ-POCHTERENO 1973, PEREZ REYES & SALAS GOMEZ 1961); Peru (ESCOMEL 1929, only 70 μm long; SARMIENTO & GUERRA 1960); irrigation ditches with diatoms and cyanobacteria in Egypt (SCHMARD 1854).

Records from terrestrial habitats not substantiated by illustrations: sub-alpine grassland in Austria (FOISSNER et al. 1990); Czechoslovakia (ROSA 1957a); Italy (LUZZATTI 1938); Abaco Island, Bahamas (CAIRNS & RUTHVEN 1972); cedar glade in Tennessee (MARTIN & SHARP 1983); soil near Lake Baringo, Kenya (W. FOISSNER, pers. comm.).

Records from saline habitats: littoral detritus of the Hiddensee Island and saline reservoir near the Baltic (BIERNACKA 1967, Fig. 125u; CZAPIK 1962); saline lake in Romania (TUCOLESCU 1962b); low salinity lagoons (about 1 ‰) in the Caspian Sea (AGAMALIYEV 1974); sea water (EICHWALD 1849; uncertain).

Feeds on bacteria, cyanobacteria (*Oscillatoria*), diatoms, ciliates, heterotrophic flagellates, hyphae and/or spores of fungi and yeast (FINLAY et al. 1993, FOISSNER 1987a, WANG 1930, WANG & NIE 1935). Biomass of 10^6 individuals according to FOISSNER (1987a) 34 mg, according to NESTERENKO & KOVALCHUK (1991; incorrectly spelled as “*Urozoma cienkowiekii* KOWAL.”) 180 mg (other species?). Autecological data, see Table 41. RUTHVEN (1972; station 6) and CAIRNS & DICKSON (1972) found *U. caudata* at following heavy metal concentrations: 0.046 mg l⁻¹ Cu, 0.067 mg l⁻¹ Zn, 0.036 mg l⁻¹ Cr, 0.017 mg l⁻¹ Pb.

Urosoma macrostyla (WRZESNIEWSKIEGO, 1866) comb. nov. (Fig. 126a–g, Table 24)

- 1866 *Oxytricha macrostyla* WRZESNIEWSKIEGO, Wykaz Szkoty Głownej Warszawskiej, No. 5: 17 (Latin diagnosis, without illustration).
- 1867 *Oxytricha macrostyla* WRZESNIEWSKIEGO, Przyczynek do historyi naturalnej wymoczków, p 56 (Fig. 126a, b).
- 1867 *Oxytricha macrostyla* WRZESNIEWSKIEGO, Rocznik ces. król. Towarzystwa Naukowego Krakowskiego, 12: 284 (Fig. 126a, b).
- 1870 *Oxytricha macrostyla* WRZESNIEWSKI, Z. wiss. Zool., 20: 474.
- 1932 *Urosoma (Oxytricha) macrostyla* WRZESNIEWSKI, 1870 – KAHL, Tierwelt Dtl., 25: 607, in part: Fig. 113₂₄; not Fig. 113_{22, 23}.
- 1972 *Urosoma acuta* DRAGESCO, Anns Fac. Sci. Univ. féd. Cameroun, 11: 86 (Fig. 126f, g; new synonym).
- 1986 *Urosoma acuta* DRAGESCO, 1972 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 457.
- 1986 *Urosoma ambigua* DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 459 (Fig. 126c–e; new synonym).

Nomenclature and taxonomy: Incorrect subsequent spelling: *Urosoma macrostyla* (HORVÁTH 1950, p 149). KAHL (1932) classified *Urosoma* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Urosoma) macrostyla*, that is,

Table 24 Morphometric data of *Urosoma acuminata* (ac1, from FOISSNER 1982; ac2, from BERGER & FOISSNER 1987a), *U. caudata* (ca1, from FOISSNER 1982; ca2, from FOISSNER 1984), *U. emarginata* (em1, from FOISSNER 1982; em2, from FOISSNER 1983a), *U. gigantea* (gig, from BERGER & FOISSNER 1987a), *U. karini* (kar, from FOISSNER 1987b), *U. macrostyla* (mac, from DRAGESCO & DRAGESCO-KERNÉIS 1986), *U. octonucleata* (oct, from BERGER & FOISSNER 1989), *U. polynucleata* (pol, from FOISSNER 1984), *U. salmastra* (sal, from DRAGESCO & DRAGESCO-KERNÉIS 1986), and *U. similis* (sim, from FOISSNER 1982). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the column mean, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	ac1	113.2	20.4	18.0	80	152	11
	ac2	154.5	14.2	9.2	125	180	13
	ca1	111.3	16.1	14.5	80	132	6
	ca2	167.1	19.2	11.5	136	190	11
	em1	87.0	6.8	7.8	73	95	10
	em2	109.4	13.7	12.5	83	140	25
	gig	157.7	12.3	7.8	140	182	25
	kar	119.2	18.1	15.2	92	154	10
	mac	150.0	-	-	130	168	5
	oct	141.2	13.5	9.6	105	155	11
	pol	143.3	19.8	13.8	112	182	15
	sal	73.0	-	-	48	101	29
	sim	113.3	15.6	13.8	83	140	17
Body, width	ac1	29.4	3.4	11.5	23	36	11
	ac2	43.8	3.3	7.5	38	49	13
	ca1	21.3	4.8	22.5	15	29	6
	ca2	20.6	1.4	6.9	17	22	11
	em1	21.5	1.7	8.1	20	25	10
	em2	26.8	1.9	6.9	22	31	25
	gig	47.2	3.7	7.8	42	58	25
	kar	36.1	4.6	12.7	29	42	10
	mac	33.0	-	-	24	39	5
	oct	25.8	1.9	7.5	22	28	11
	pol	21.4	2.1	9.6	18	25	15
	sal	21.0	-	-	15	30	27
	sim	17.1	1.7	9.9	14	20	17
Adoral membranelles, number	ac1	23.6	1.1	4.9	22	26	11
	ac2	36.0	1.4	3.9	34	38	13
	ca1	26.5	1.0	3.6	25	28	6
	ca2	23.6	1.4	5.8	21	25	11
	em1	25.0	0.9	3.6	24	27	10
	em2	31.9	1.6	5.1	26	34	25
	gig	46.8	2.7	5.7	42	58	25
	kar	22.0	1.0	4.5	21	24	10
	mac	43.0	-	-	38	45	5
	oct	25.1	0.7	2.8	24	26	11
	pol	21.5	1.4	6.6	19	24	15
	sal	23.0	-	-	21	26	17
	sim	21.6	0.7	3.1	20	23	17

Table 24 Continued

Character	Species	mean	SD	CV	Min	Max	n
Macronuclear nodules, number ¹	ac1	4.0	0	0	4	4	11
	ac2	3.9	0.4	9.7	2	4	34
	oct	7.6	0.8	10.9	6	8	11
	pol	7.7	0.7	9.1	6	9	15
Right marginal row, number of cirri	ac1	35.3	3.0	8.6	29	40	11
	ac2	43.2	2.4	5.4	37	46	13
	ca1	45.2	6.0	13.4	36	53	6
	ca2	54.6	7.3	13.3	3.8	64	11
	em1	33.3	1.3	4.0	32	36	10
	em2	37.9	2.9	7.6	31	43	25
	gig	42.9	2.2	5.1	38	46	25
	kar	29.2	2.3	8.0	26	33	10
	mac	50.0	-	-	40	59	5
	oct	37.3	1.8	4.8	35	40	11
	pol	33.0	2.0	6.2	30	38	15
	sal	26.0	-	-	22	30	24
	sim	33.6	2.8	8.4	27	37	17
	sim	33.6	2.8	8.4	27	37	17
Left marginal row, number of cirri	ac1	32.4	3.2	9.9	28	38	11
	ac2	40.4	1.4	3.4	38	43	13
	ca1	41.2	4.9	11.8	33	48	6
	ca2	51.3	7.4	14.4	38	60	11
	em1	29.9	1.3	4.3	28	32	10
	em2	36.3	3.2	8.9	27	40	25
	gig	34.6	2.2	6.3	30	38	25
	kar	30.4	3.4	11.3	26	36	10
	mar	50.0	-	-	45	55	5
	oct	31.1	1.7	5.5	28	34	11
	pol	26.9	1.8	6.7	24	30	15
	sal	21.0	-	-	16	25	20
	sim	27.6	2.1	7.8	24	32	17
	sim	27.6	2.1	7.8	24	32	17
Pretransverse ventral cirri, number	ac1	0.5	0.5	109.5	0	1	11
	ac2	1.9	0.3	14.4	1	2	13
	ca1	0.7	0.5	70.7	0	1	6
	ca2	0.9	0.3	33.1	0	1	11
	em1	1.9	0.5	28.3	1	3	10
	em2	2.0	0	0	2	2	25
	gig	1.9	0.3	14.4	1	2	25
	kar	1.1	0.3	28.7	1	2	10
	mac	2.0	-	-	-	-	?
	pol	0	0	0	0	0	15
	sal	1.0	-	-	-	-	?
	sim			probably absent			
	sim			probably absent			
	sim			probably absent			
Transverse cirri, number	ac1	4.0	0	0	4	4	11
	ac2	4.9	0.3	5.6	4	5	13
	ca1	4.3	0.5	11.0	4	5	6
	ca2	4.9	0.3	6.1	4	5	11
	em1	4.1	0.3	7.3	4	5	10
	em2	4.9	0.3	5.6	4	5	25

Table 24 Continued

Character	Species	mean	SD	CV	Min	Max	n
Transverse cirri, number	gig	5.0	0	0	5	5	25
	kar	5.0	0	0	5	5	10
	mac	5.0	-	-	-	-	?
	oct ²	3.5	0.5	15.1	3	4	11
	pol	2.0	0	0	2	2	15
	sal	4.0	-	-	3	5	?
	sim	2.1	0.2	11.4	2	3	17

¹ All other species have two macronuclear nodules.

² Pretransverse ventral cirri included.

Oxytricha macrostyla was never formally transferred to *Urosoma*, which hereby undertaken.

KAHL (1932) and FOISSNER (1982) synonymised *Opisthotricha emarginata* STOKES with *Urosoma macrostyla*, assuming that WRZEŚNIEWSKI (1870) had overlooked the conspicuous notch at the right posterior margin described in *O. emarginata*. BORROR (1972a) synonymised both species with *Urosomoida agilis*, which has, however, cortical granules, fewer pretransverse ventral and transverse cirri, and a different arrangement of frontoventral cirri. I consider both *Urosoma macrostyla* and *U. emarginata* as valid species. By contrast, *U. ambigua* is obviously a junior synonym of *U. macrostyla*, which is indicated especially by the distinctly enlarged and anteriorly displaced transverse cirri (cp. Fig. 126a with 126c, e). *Urosoma acuta* is rather superficially described and only after protargol impregnation; the body shape and size, the subterminal transverse cirri, and many morphometric data agree rather well with *U. ambigua* and/or *U. macrostyla*. I have some doubt that the arrangement and the number of frontoventral and postoral ventral cirri is correctly illustrated (Fig. 126g). Redescription of *U. macrostyla* necessary.

Morphology and biology: In life about $120 \times 30 \mu\text{m}$ (WRZEŚNIEWSKI 1870), according to DRAGESCO & DRAGESCO-KERNÉIS (1986) $130\text{--}170 \times 25\text{--}40 \mu\text{m}$ (mean = $150 \times 33 \mu\text{m}$; n = 5). Elongate, anterior broad, posterior narrowly rounded (Fig. 126a, c, g). Not distinctly contractile. Macronuclear nodules after protargol impregnation $13 \times 16 \mu\text{m}$. 1–3 globular micronuclei. Contractile vacuole slightly behind buccal vertex. Cortical granules lacking (not mentioned by WRZEŚNIEWSKI 1870 and DRAGESCO & DRAGESCO-KERNÉIS 1986).

Adoral zone of membranelles about 27 % of body length. Transverse cirri do not protrude beyond posterior end of cell, distinctly enlarged (species name! Fig. 126a, c, e, g). Marginal rows terminate very close to posterior tip (Fig. 126a, d). Four dorsal kineties (DRAGESCO & DRAGESCO-KERNÉIS 1986). According to WRZEŚNIEWSKI (1870), 4–7 distinctly elongated, rather fine cirri at posterior end (caudal cirri?).

Fig. 126a–g *Urosoma macrostyla* (a, b, after WRZESNIEWSKIEGO 1867a; c–e, from DRAGESCO & DRAGESCO-KERNÉIS 1986; f, g, from DRAGESCO 1972b. a, b, f, from life; c–e, g, protargol impregnation). a, c, g) Ventral views, a = 120 μ m, c = 165 μ m, g = 145 μ m. Note the distinctly enlarged transverse cirri. b) Lateral view of anterior end. d) Ventral infraciliature, 145 μ m. e) Ventral infraciliature of anterior (above) and posterior (below) portion of cell, bar = 10 μ m. Note prominent transverse cirri. f) Outline in ventral view; p 404.

The following data are from the synonym *U. acuta* (Fig. 126f, g): after protargol impregnation 120–170 μ m long. Posteriorly tapered. 43–53 adoral membranelles. Six cirri on frontal area, 5 postoral ventral cirri, 6 transverse cirri (probably 5 transverse cirri and 1 pretransverse ventral cirrus), 42–63 right and 39–62 left marginal cirri.

Occurrence and ecology: Not very common in freshwater habitats; records from soil not substantiated by illustrations. Locus classicus is a small water body with *Sphagnum* and *Lemna trisulca* in Grójec near Warsaw (Poland), where WRZESNIEWSKIEGO (1866) discovered *Urosoma macrostyla* very abundantly in the surface film (“Kahm-

haut”) of a several day old sample together with numerous other species (WRZEŚNIEWSKI 1870). Locus classicus of the synonym *Urosoma acuta* is Lake Chad (Chad), where DRAGESCO (1972) found it very abundantly. Locus classicus of the second synonym, *U. ambigua*, is a saline pool near Cotonou, Benin (DRAGESCO & DRAGESCO-KERNÉIS 1986).

Records not substantiated by illustrations: wells in Czechoslovakia and Italy (VEJDovsky 1882; GRISPINI 1938, determination uncertain because 290 µm long); agricultural soils and freshwater in Czechoslovakia (TIRIAKOVÁ 1988, 1992b; possible *U. emarginata*); caves in France (MONIEZ 1889); soil infusion with pH 7 in Germany (DINGFELDER 1962); sandy soil near Tisza River, Hungary (HORVÁTH 1950); benthal of a freshwater lagoon of the Caspian Sea (AGAMALIEV 1973, 1986); periphyton of Lake Dong Hu in China (SHEN 1980); soil in Costa Rica and Brazil (FOISSNER 1995b, 1997b). Feeds on bacteria and algae (HORVÁTH 1950).

Urosoma emarginata (STOKES, 1885) comb. nov. (Fig. 127a–y, Tables 3, 24)

1885 *Opisthotricha emarginata* STOKES, Ann. Mag. nat. Hist., 15: 445 (Fig. 127a).

1888 *Opisthotricha emarginata*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 289 (Fig. 127a).

1932 *Urosoma (Oxytricha) macrostyla* WRZEŚNIEWSKI, 1870 – KAHL, Tierwelt Dtl., 25: 607, in part: Fig. 113_{22, 23}, not Fig. 113₂₄ (Fig. 127b; see taxonomy).

1982 *Urosoma macrostyla* (WRZEŚNIEWSKI, 1870) – FOISSNER, Arch. Protistenk., 126: 114 (Fig. 127c–h; see taxonomy; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1983 *Urosoma macrostyla* (WRZEŚNIEWSKI, 1870) – FOISSNER, Arch. Protistenk., 127: 413 (Fig. 127i–y; see taxonomy).

T a x o n o m y: KAHL (1932) and FOISSNER (1982) synonymised *Urosoma emarginata* (STOKES) with *U. macrostyla* (WRZEŚNIEWSKIEGO), assuming that WRZEŚNIEWSKIEGO (1866) had overlooked the conspicuous notch at the right posterior margin. I consider both species as valid. Furthermore, *U. macrostyla* has rather prominent, distinctly anteriorly displaced transverse cirri. BORROR (1972a) synonymised both species with *Urosomoida agilis* (ENGELMANN), which has, however, cortical granules, fewer pretransverse ventral and transverse cirri, and a different arrangement of frontoventral cirri (Fig. 110c).

M o r p h o l o g y a n d b i o l o g y: In life 125–145 µm long (STOKES 1885b), according to FOISSNER (1982) 150–190 × 40–60 µm. Elongate, anterior end rounded, posterior end narrowly rounded or even pointed, right posterior margin conspicuously emarginated; not distinctly contractile. Usually 2 (rather seldom 4), after protargol impregnation 8–24 × 5–7 µm sized macronuclear nodules. 2–4, in life about 9 × 3 µm, refractile micronuclei. Contractile vacuole with long collecting canals, anterior one often with a small vesicle at level of cytostome. Cortical granules absent. Posterior third of cell usually packed with 1–2 µm sized, colourless globules; cells thus appear dark at low magnification and bright field illumination. Food vacuoles about 7 µm across. Movement rapid and erratic.

Adoral zone of membranelles about 24 % of body length. Right frontal cirrus often slightly thicker than other frontal cirri. Transverse cirri do not protrude beyond posterior end of cell and are not distinctly larger than marginal cirri. Marginal cirri in life about 13 μm long, right row terminates at level of transverse cirri, left at tip of posterior end. Dorsal kinety 1 anteriorly, kinety 4 posteriorly distinctly shortened.

Resting cysts smooth, colourless, in life about 45 μm across, surrounded by an about 20 μm thick mucous layer.

Morphogenesis is described in great detail by FOISSNER (1983a; Fig. 127i–y). It commences left of the postoral ventral cirri (Fig. 127j), identically to in *U. polymucleata* and *U. caudata*. Streaks II–VI of proter and opisthe originate by division of five long primary primordia (Fig. 127m, o, p). According to FOISSNER (1983a), 1, 2, 3, 3 (4), and 5 (4) cirri originate from the primordia I–VI. However, if streak II produced only 2 cirri, *U. emarginata* could have only four transverse cirri. Thus, BERGER et al. (1985a) changed it to the common pattern, namely 1, 3, 3, 3, 4, and 4.

Occurrence and ecology: Not very common in freshwater and terrestrial habitats. Locus classicus is central New Jersey, USA, where STOKES (1885b) discovered *Urosoma emarginata* in lentic water with aquatic plants. KAHL (1932) found it “not sel-

← **Fig. 127a–l** *Urosoma emarginata* (a, from STOKES 1885b; b, from KAHL 1932; c–h, from FOISSNER 1982; i–l, from FOISSNER 1983a. a–f, from life; g–l, protargol impregnation). a–c) Ventral views, a = 130–145 μm , b = 140 μm , c = 165 μm . Note conspicuous notch at posterior end of right margin. d) Layer of cortical structures (mitochondria?) in surface (above) and lateral view (below). e, f) Dorsal and left lateral view showing contractile vacuole with collecting canals and defecation (arrowhead), e = 185 μm , f = 175 μm . g–i) Ventral and dorsal infraciliature, g, h = 90 μm , i = 125 μm . j) Ventral infraciliature and nuclear apparatus of a very early morphogenetic stage, 125 μm . k, l) Ventral infraciliature of early morphogenetic stages, k, l = 110 μm . Arrows in l) mark 4 streaks in frontal area, including the modified anterior-most postoral ventral cirrus. OP = oral primordium; p 409.

Fig. 127m–t *Urosoma emarginata* (from FOISSNER 1983a. m–t, protargol impregnation). m–q) Ventral and → dorsal infraciliature of middle morphogenetic stages, m, n = 125 μm , o = 115 μm , p, q = 130 μm . The posterior-most frontoventral cirrus (IV/3) and the two posterior postoral ventral cirri (V/3 and V/5) are modified to primordia. Five long primary primordia are recognisable (m, n). The primary primordia are divided and the buccal cirrus and the undulating membranes are modified to primordia (o). Some cirri of the right marginal row are also modified to primordia (p, q). r–t) Ventral and dorsal infraciliature of late morphogenetic stages, r = 130 μm , t = 115 μm . Differentiation of new frontal-ventral-transverse cirri. Parental structures white, new black. AD = anlage of dorsal kineties; p 409. Figures on p 412.

Fig. 127u–y *Urosoma emarginata* (from FOISSNER 1983a. u–y, protargol impregnation). u–w) Ventral and → dorsal infraciliature of late morphogenetic stages, u = 130 μm , v, w = 100 μm . Cirri originating from one streak are connected by a broken line; supernumerary cirri will be resorbed later. The dorsomarginal rows (= dorsal kineties 4) originate from parental marginal cirri (u). New caudal cirri are formed at posterior end of new dorsal kineties 1–3 (w). x, y) Ventral and dorsal infraciliature of a very late morphogenetic stage, 180 μm . The new cirri migrate to their final positions. Parental dorsal kinety 4 is still recognisable (y). Parental structures white, new black. AD₄ = anlage of new dorsal kinety 4; p 409. Figures on p 413.

AD₄

AD₄

127u

dom", mainly among *Lemna*, probably somewhere in Germany. FOISSNER (1982, 1983a) isolated *U. emarginata* from various soils (water meadow, field) in the Tullnerfeld, Lower Austria (Profile 2, 5, 6 in FOISSNER et al. 1985). I found few specimens in a leaf littered pond near the village of Bad Ischl, Austria, and in a six day old, saprobic sample from a eutrophic pond in Salzburg city, Austria.

FOISSNER (1983a) cultured *U. emarginata* in salad medium diluted 1:1 with table water (Volvic, France) and with some squeezed wheat grains to support bacterial growth; high abundances occurred after 5–10 days. Biomass of 10^6 individuals 41 mg (FOISSNER 1987a).

Urosoma acuminata (STOKES, 1887) BÜTSCHLI, 1889 (Fig. 128a–o, Table 24)

1887 *Oxytricha acuminata* STOKES, Ann. Mag. nat. Hist., 20: 111 (Fig. 128a).

1888 *Oxytricha acuminata*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 290 (Fig. 128a).

1889 *Oxytricha acuminata* STOKES – BÜTSCHLI, Protozoa, p 1748, 1749 (see nomenclature).

1932 *Urosoma (Oxytricha) acuminata* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 606.

1982 *Urosoma acuminata* (STOKES, 1887) – FOISSNER, Arch. Protistenk., 126: 109 (Fig. 128b–g; authoritative redescription; 1 slide of neotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1987 *Urosoma acuminata* (STOKES, 1887) KAHL, 1932 – BERGER & FOISSNER, Zool. Jb. Syst., 114: 231 (Fig. 128h–o; 1 slide of protargol impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: Already BÜTSCHLI (1889) proposed a classification in *Urosoma*; thus, he and not KAHL is the combining author. Furthermore, KAHL (1932) classified *Urosoma* only as subgenus of *Oxytricha*, so that the correct name in his revision is *Oxytricha (Urosoma) acuminata*. The morphometric characterisations by FOISSNER (1982) and BERGER & FOISSNER (1987a) showed that *U. acuminata* rather constantly has four macronuclear nodules. Therefore, synonymy with the binuclear *U. caudata*, as proposed by BORROR (1972a), can be excluded.

Morphology and biology: In life $110\text{--}220 \times 20\text{--}35 \mu\text{m}$: $110\text{--}170 \mu\text{m}$ (STOKES 1887b), $160\text{--}220 \times 23\text{--}35 \mu\text{m}$ (FOISSNER 1982), after BERGER & FOISSNER (1987a) up to $50 \mu\text{m}$ broad; maximum width usually at level of buccal vertex. Slightly contractile. Posterior end tapered or tailed, often curved to the right, not, however, emarginated as in *Urosoma emarginata*! Macronuclear nodules in life about $16 \times 9 \mu\text{m}$, after protargol impregnation $7\text{--}21 \times 4\text{--}10 \mu\text{m}$. 2–8, in life $4 \times 3 \mu\text{m}$ sized micronuclei. Contractile vacuole with collecting canals; anterior one sometimes with a small vesicle at level of cytostome. After protargol impregnation many argentophilic globules especially around bases of cirri (BERGER & FOISSNER 1987a). Endoplasm colourless, often opaque by many, about $1 \mu\text{m}$ sized ellipsoidal structures (bacteria?). Movement moderately rapid, often stands still for short time and adheres close to substrate particles.

Fig. 128a-g *Urosoma acuminata* (a, from STOKES 1887b; b-g, from FOISSNER 1982. a-e, from life; f, g, protargol impregnation). a, b) Ventral views, a = 170 μ m, b = 200 μ m. c, d) Dorsal and lateral view showing contractile vacuole with collecting canals (c), c, d = 175 μ m. e) Pellicle with mitochondria(?). f, g) Ventral and dorsal infraciliature of same specimen, 145 μ m. P = ingested fungal spore; p 414.

Adoral zone of membranelles about 20–26 % of body length. Usually 3, rarely only 2 postoral ventral cirri. Transverse cirri about 15 μ m long, distinctly subterminal. Marginal and caudal cirri 10–15 μ m long. Dorsal kinety 1 anteriorly, kinety 4 anteriorly and posteriorly slightly shortened.

Cyst spherical, in life 40–50 μ m (43 μ m on average; n = 17) across (BERGER & FOISSNER 1987a). Cyst formation takes a long time in cultures. Initially, the outer layer is smooth and about 2 μ m thick. Cyst densely filled with 1–3 μ m sized, clod-like inclusions. Sometimes contractile vacuole recognisable and movement of cytoplasm can be clearly seen. A second type of cysts occurred rather frequently in older cultures. It had an about 3 μ m thick, rough wall and a rather clear zone which sometimes contained fast moving particles, probably some sort of parasite. There were many transitions between these two types (Fig. 128l, m).

Occurrence and ecology: Not very common in the aufwuchs of freshwater and in terrestrial habitats. Eurasia and Africa. Locus classicus is a pond with algae in

Fig. 128h-o *Urosoma acuminata* (from BERGER & FOISSNER 1987a. h-m, from life; n, o, protargol impregnation). h-j) Ventral, dorsal, and lateral view, h = 205 μ m, i = 200 μ m, j = 180 μ m. k) Cross-section about in mid-body, bar = 30 μ m. l, m) Resting cysts, 43 μ m in diameter on average. n, o) Ventral and dorsal infracapitulum of same specimen, 165 μ m. p 414.

USA, probably near Trenton, New Jersey, where STOKES lived and worked. FOISSNER (1982) found *U. acuminata* in the soil of a flood plain in the Tullnerfeld, Lower Austria (see FOISSNER et al. 1985, "Profil 2", for detailed description of site). BERGER & FOISSNER (1987a) isolated it from the upper soil layer (1–5 cm) of an uncultivated grassland (dominated by *Poa* sp.; about 1500 m above sea-level) in the Golan Hills, Israel.

Records not substantiated by illustrations: brook in Upper Austria (BLATTERER 1994); soil from the Fuscher Valley, Austria (FOISSNER 1987b); conventionally farmed, sub-alpine grassland in Styria, Austria (FOISSNER et al. 1990); sediment of unpolluted foothill stream (Breitenbach) near the village of Schlitz, Germany (PACKROFF & ZWICK 1996); aufwuchs of the littoral from Lake Balaton, Hungary (TAMÁS & GELLÉRT 1959); well in Italy (GRISPINI 1938); Turiec River in Slovakia (TIRJAKOVÁ 1993); Donor water reservoir, USSR (ALEKPEROV 1989); soil from paddy field in Japan (TAKAHASHI & SUHAMA 1991); freshwater habitats in south-eastern Louisiana and Conestoga drainage basin in Pennsylvania, USA (BAMFORTH 1963, CAIRNS 1965a); soil near Lake Baringo, Kenya (W. FOISSNER, pers. comm.).

Feeds on autotrophic flagellates, diatoms (*Hantzschia* sp.), and fungal spores (BERGER & FOISSNER 1987a, FOISSNER 1982). Biomass of 10^6 individuals 73 mg (FOISSNER 1987a). PATRICK et al. (1967) found *U. acuminata* with low abundance in the Savannah River, USA, at 12–17 °C, $9\text{--}11\text{ mg l}^{-1}\text{ O}_2$, $0.5\text{--}1\text{ mg l}^{-1}\text{ BOD}_5$, $5\text{--}10\text{ mg l}^{-1}\text{ CO}_2\text{ free}$, $0.009\text{--}0.03\text{ mg l}^{-1}\text{ NH}_3\text{-N}$, $0.001\text{ mg l}^{-1}\text{ NO}_2\text{-N}$, $0.07\text{--}0.2\text{ mg l}^{-1}\text{ NO}_3\text{-N}$, $1\text{--}3\text{ mg l}^{-1}\text{ Cl}^-$.

***Urosoma octonucleata* BERGER & FOISSNER, 1989 (Fig. 129a–f, Table 24)**

1989 *Urosoma octonucleata* BERGER & FOISSNER, Bull. Br. Mus. nat. Hist. (Zool.), 55: 41 (reference numbers of types slides deposited in British Museum: 1988.2:1:26 holotype, and 1988.2:1:27 paratype).

Taxonomy: In life, *U. octonucleata* can be easily confused with *U. polynucleata* because the body shape and the nuclear apparatus are very similar. Furthermore, the infraciliature of the frontal area and the dorsal surface and many morphometric characters are almost identical. However, they can be separated by the number of postoral ventral cirri (3 in *U. octonucleata* against 1 in *U. polynucleata*) and the number and position of the transverse cirri including the pretransverse ventral cirri (three to four distinctly subterminal in *U. octonucleata* against two terminal in *U. polynucleata*).

Morphology and biology: In life $140\text{--}180 \times 24\text{--}40\text{ }\mu\text{m}$. Vermiform, posterior end tapered and usually curved to the right. Macronuclear nodules in life about $7 \times 5\text{ }\mu\text{m}$, arranged in a line slightly left of median. 2–3 (usually 2) in life about $4\text{ }\mu\text{m}$ sized, spherical micronuclei. Contractile vacuole distinctly in front of mid-body, during diastole with two collecting canals. Cortical granules lacking. Cytoplasm with numerous $1\text{ }\mu\text{m}$ sized, colourless granules and some about $7\text{ }\mu\text{m}$ sized food vacuoles; posterior portion with many cytoplasmic crystals.

Fig. 129a-f *Urosoma octonucleata* (from BERGER & FOISSNER 1989a. a-d, from life; e, f, protargol impregnation). a-c) Ventral, lateral, and dorsal view, a = 170 μ m, b, c = 160 μ m. d) Colourless, about 2 μ m sized structures (mitochondria?) close beneath the pellicle. e, f) Ventral and dorsal infraciliature, 155 μ m; p 417.

Adoral zone of membranelles about 23 % of body length; distal 4 membranelles slightly separated from proximal, nearly perpendicularly arranged portion of adoral zone. Bases of largest membranelles in life about 5 μ m wide. Frontal cirri in life about 15 μ m, marginal cirri about 10 μ m long. Postoral ventral cirri arranged in a line. Usually 2 slightly enlarged transverse cirri. Dorsal kinety 1 anteriorly, kinety 4 posteriorly shortened.

Occurrence and ecology: Locus classicus is a slightly reddish-brown soil grown with *Opuntia ficusindica* and tufts of grass (0-5 cm, pH 4.8, 150 m above sea-

level) in Garajan Kap, Madeira, Portugal. Feeds on bacteria. Biomass of 10^6 individuals about 60 mg.

Urosoma polynucleata (FOISSNER, 1984) comb. nov. (Fig. 130a–i, Tables 3, 24)

1984 *Hemisincirra polynucleata* FOISSNER, Stapfia, 12: 119 (1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: The arrangement of the frontoventral cirri and undulating membranes, the dorsal infraciliature, and the mitochondria (?) close beneath the pellicle indicate that this species belongs to *Urosoma*. Should not be confused with *U. octonucleata* (more postoral ventral and transverse cirri, Fig. 129a–f) and *U. similis* (2 macronuclear nodules, Fig. 131a–g).

Morphology and biology: In life $140\text{--}200 \times 20\text{--}30\text{ }\mu\text{m}$. Vermiform, anterior three quarters parallel sided, posterior quarter tapered and usually somewhat curved to the left, sometimes slightly twisted. Macronuclear nodules in life $8 \times 4\text{ }\mu\text{m}$. Two (rarely up to 4), in life about $4 \times 3\text{ }\mu\text{m}$ sized micronuclei, usually one each near anterior and posterior macronuclear nodules (Fig. 130a, f). Contractile vacuole with two long collecting canals. Close beneath pellicle many tiny granules (mucocysts?) and ellipsoidal structures (mitochondria?; Fig. 130c). Movement slow.

Adoral zone of membranelles about 18 % of body length. Invariably only 1 postoral ventral cirrus (cirrus IV/2?). Transverse cirri at tip of tail (or lacking and possibly confused with caudal cirri?). All cirri rather fine, $10\text{--}13\text{ }\mu\text{m}$ long. Dorsal kinety 1 anteriorly, kinety 4 posteriorly shortened (Fig. 130g). Morphogenesis commences with the formation of a small oral primordium just behind the buccal vertex (Fig. 130h).

Occurrence and ecology: Locus classicus of this autochthonous soil species is the upper soil layer of a xerothermic site ("Heisslände Althann") in the Tullnerfeld, Lower Austria ("Profil 1" in FOISSNER et al. 1985). Biomass of 10^6 individuals about 30 mg (FOISSNER 1987a).

Urosoma similis (FOISSNER, 1982) comb. nov. (Fig. 131a–g, Table 24)

1982 *Perisincirra similis* FOISSNER, Arch. Protistenk., 126: 94 (Fig. 131a–g; 1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1984 *Hemisincirra similis* (FOISSNER, 1982) – FOISSNER, Stapfia, 12: 119.

Taxonomy: The arrangement of the frontoventral cirri, the oral apparatus in *Gonostomum* pattern, and the possession of caudal cirri and 4 dorsal kineties indicate a classi-

Fig. 131a-g *Urosoma similis* (from FOISSNER 1982. a-c, from life; d-g, protargol impregnation). a-c) Ventral, dorsal, and lateral view, a = 165 μ m, b, c = 185 μ m. d, e) Ventral and dorsal infraciliature of same specimen, 120 μ m. f, g) Ventral infraciliature of anterior and posterior portion of cell, bar = 20 μ m. This specimen has only three frontoventral cirri. CC = caudal cirri, e = endoral (possibly the paroral), p = paroral, TC = transverse cirri, III/2 = frontoventral cirrus III/2; p 419.

fication in *Urosoma*. In contrast, the type species of *Hemisincirra* HEMBERGER, 1985 (basionym: *Uroleptus kahli* BUTTKAMP, 1977) has no caudal cirri and only 3 dorsal kineties.

Morphology and biology: In life 120–180 $\times$ 18–28 μ m. Lanceolate, often slightly sigmoid, anteriorly often truncated, margins continuously converging posteriorly. Macronuclear nodules in life 17 $\times$ 7 μ m, with many small and large nucleoli. Rather invariably two, in life about 4 μ m sized ellipsoidal or spindle-shaped micronuclei. Contractile vacuole slightly in front of mid-body, without distinct collecting canals; however,

← **Fig. 130a-i** *Urosoma polynucleata* (from FOISSNER 1984. a-e, from life; f-i, protargol impregnation). a, b) Ventral and dorsal view, 155 μ m. c) About 2 μ m sized structures (mitochondria?) close beneath the pellicle. d) Cross-section in mid-body. e) Right lateral view, 155 μ m. f, g) Ventral and dorsal infraciliature, 145 μ m. h) Ventral infraciliature of a very early morphogenetic stage, 140 μ m. i) Ventral infraciliature of anterior portion of cell. CC = caudal cirri, OP = oral primordium, RMR = posterior-most cirrus of right marginal row, just behind two transverse cirri; p 419.

sometimes a small additional vacuole in front of it; immediately before systole the two vacuoles fuse. Cortical granules and typical subpellicular "mitochondria" lacking. Cytoplasm packed with many colourless, about 0.5 μm sized granules and tiny yellowish crystals. Food vacuoles 4–8 μm across. Movement rapid.

Adoral zone of membranelles about 20 % of body length. Adoral zone and undulating membranes in *Gonostomum* pattern. Frontal cirri in life about 15 μm long, right cirrus slightly enlarged, left arranged very close to adoral zone of membranelles. Some specimens with less than 4 frontoventral cirri (Fig. 131f). Transverse cirri in life about 18 μm long, protrude distinctly beyond posterior end of cell. Distance between basal body pairs in dorsal kineties 1 and 2 posteriorly about 2 times as large as anteriorly. Three caudal cirri, one each on dorsal kineties 1–3.

Occurrence and ecology: Autochthonous soil species (FOISSNER 1987a). *Locus classicus* is the village of Zwentendorf, Lower Austria, where FOISSNER (1982) discovered *U. similis* in the upper soil layer of an intensively farmed field. Records not substantiated by illustrations: rarely in organically and conventionally farmed sub-alpine grassland in Styria, Austria (FOISSNER et al. 1990); agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988); soil in Costa Rica (FOISSNER 1995b). Feeds on bacteria. Biomass of 10^6 individuals about 32 mg (FOISSNER 1987a).

Urosoma karini FOISSNER, 1987 (Fig. 132a–e, Table 24)

1987 *Urosoma karini* FOISSNER, Jber. Haus Nat. Salzburg, 10: 62 (1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: *Urosoma karini* is very similar, possibly even synonymous with *U. salmastra* from Africa (Fig. 133a–c). Concerning the infraciliature there are only minor but possibly significant differences in the arrangement of the undulating membranes and the number of marginal cirri. However, live observation (cortical granules present or not?) on the African species should be awaited.

Morphology and biology: In life 100–160 $\times$ 25–35 μm . Long elliptical, sometimes almost parallel sided, posterior end rounded; not contractile. Two (rarely 3), after protargol impregnation 18–31 $\times$ 7–11 μm sized macronuclear nodules. 1–3 (usually 2), after protargol impregnation 6 $\times$ 4 μm sized micronuclei. Contractile vacuole without distinct collecting canals. Cortical granules tiny, colourless, arranged in rows, well distinguishable from ellipsoid mitochondria (Fig. 132b). Posterior cell part with many crystals, which appear dark at low magnification and bright field illumination. Slow movement.

Adoral zone of membranelles about 20 % of body length. Row of frontoventral cirri slightly curved. Postoral ventral cirri distinctly behind level of buccal vertex, form an irregular row with frontoventral cirri; some specimens with 2–3 supernumerary postoral

Fig. 132a–e *Urosoma karini* (from FOISSNER 1987b. a–c, from life; d, e, protargol impregnation). a) Ventral view, 135 μm . b) Pellicle with mitochondria and colourless cortical granules. c) Right lateral view, 135 μm . d, e) Ventral and dorsal infraciliature of same specimen, 155 μm . G = cortical granules, M = mitochondria; p 422.

ventral cirri. Transverse cirri fine, about 20 μm long, protrude distinctly beyond posterior end of cell. Rather invariably 6 pretransverse ventral and transverse cirri (very likely 2 pretransverse ventral cirri and 4 transverse cirri; see, however, Table 24). Marginal cirri in life about 12 μm long. Dorsal kinety 1 (and 3?) anteriorly slightly shortened, kinety 4 about 1/3 of body length.

Cyst spherical, about 32–40 μm in diameter ($n = 14$), colourless to slightly yellowish, covered by a very inconspicuous mucous layer. Surface of cyst with many fibrils, similar to in *Engelmanniella* (data kindly supplied by W. FOISSNER, from a terrestrial population from St. Vincent, an island in the Caribbean Sea).

Fig. 133a-c *Urosoma salmastra* (from DRAGESCO & DRAGESCO-KERNÉIS 1986. a-c, protargol impregnation). a, b) Ventral infracapitulum, a = 75 μ m, b = 65 μ m. c) Dorsal infracapitulum, 70 μ m.

Occurrence and ecology: Locus classicus is the upper soil layer of an alpine pasture (pH 7.5, 1,270 m above sea-level) in the Fuschler Valley in Salzburg, Austria. According to FOISSNER (1987a), *U. karini* is an autochthonous soil species. W. FOISSNER (pers. comm.) found it in a soil sample from St. Vincent, an island in the Caribbean Sea. Feeds on heterotrophic flagellates and bacteria.

***Urosoma salmastra* (DRAGESCO & DRAGESCO-KERNÉIS, 1986) comb. nov.**
(Fig. 133a-c, Table 24)

1986 *Oxytricha salmastra* DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 467.

Taxonomy: The anteriorly displaced frontoventral cirrus III/2, the arrangement of the undulating membranes, and the dorsal infracapitulum indicate a classification in *Urosoma*. Possibly the senior synonym of *U. karini* (see there). Reinvestigation (especially live observation) necessary to check whether cortical granules are present or not.

Morphology: After protargol impregnation 50–100 $\times$ 15–23 μ m. Long elliptical, posteriorly rounded. Macronuclear nodules about 12 μ m long. Two about 2 μ m sized micronuclei. Cortical granules not mentioned. Adoral zone of membranelles about 30 % of body length. Endoral very short, arranged in front of paroral (if correct, an important dif-

ference to *U. karini*). Some specimens with 7 or 9 frontoventral cirri. Dorsal kinety 4 about 1/3 of body length.

O c c u r r e n c e: Locus classicus is a salt marsh at the lagoon of Cotonou, Benin (DRAGESCO & DRAGESCO-KERNÉIS, 1986). CHAOUITE et al. (1990) found *U. salmastra* in mineral and thermo-mineral waters in France.

Incertae sedis

Urosoma gigantea (HORVÁTH, 1933) comb. nov. (Fig. 134a–w, Tables 3, 24)

1933 *Oxytricha gigantea* HORVÁTH, Arch. Protistenk., 80: 298 (Fig. 134a, b).

1935 *Urosoma* (für *Oxytricha*) *gigantea* J. HORVATH, 1933 – KAHL, Tierwelt Dtl., 30: 841.

1987 *Urosoma gigantea* (HORVÁTH, 1933) KAHL, 1935 – BERGER & FOISSNER, Zool. Jb. Syst., 114: 233 (Fig. 134c–g; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1988 *Oxytricha gigantea* HORVÁTH, 1933 – BERGER & FOISSNER, Arch. Protistenk., 136: 66 (Fig. 134h–w).

Nomenclature and taxonomy: KAHL (1932, 1935) classified *Urosoma* as subgenus of *Oxytricha*, so that the correct name in KAHL (1935) is *Oxytricha (Urosoma) gigantea*. Consequently, KAHL (1932) cannot be the combining author as erroneously assumed by BERGER & FOISSNER (1987a). Thus, I formally transfer it to *Urosoma*, although its systematic position is uncertain (see list of synonyms). The *Gonostomum*-like oral apparatus, the distinct mitochondria close beneath the pellicle, and the reduced number (4) of dorsal kineties (despite the large size) indicate a classification in *Urosoma*. By contrast, the arrangement of the frontoventral cirri, the lack of primary primordia, and the long adoral zone of membranelles (37 %) do not match the characterisation of *Urosoma*. The type population and the BERGER & FOISSNER (1987a, 1988b, c) population agree very well in body shape and size, ventral infraciliature, arrangement of the undulating membranes, possession of short rows of cortical granules, and habitat; thus, I have no doubt that the identification is correct, although HORVÁTH (1933) counted 5 dorsal kineties.

Morphology and biology: In life 170–230 × 65–90 µm, according to HORVÁTH (1933) 200–230 µm, according to BERGER & FOISSNER (1987a; n = 3) 170–210 µm long. Long ovoid, usually distinctly narrowed posteriorly, sometimes body margins almost in parallel; both ends rounded. Macronuclear nodules in life brightly shining, about 32 × 14 µm, after protargol impregnation 18–28 × 7–11 µm (mean = 21 × 9 µm; n = 25); nucleoli large. 2–7 (usually 3), in life about 3 µm sized globular micronuclei. Cortical granules spherical, less than 1 µm across, colourless, arranged in short rows (Fig. 134f). Cytoplasm greyish, packed with cytoplasmic crystals, especially in posterior part of cell. Movement moderately rapid.

Fig. 134a–g *Urosoma gigantea* (a, b, after HORVÁTH 1933; c–g, from BERGER & FOISSNER 1987a. a, opalblue staining after BRESSLAU; b, after live and stained material; c–g, from life). a–e) Ventral, lateral, and dorsal views, a, b = 265 µm, c = 220 µm, d, e = 175 µm. f) Pellicle with ellipsoid structures (mitochondria?) and tiny (<1 µm), colourless cortical granules. g) Resting cyst, diameter 3 = 145 µm. M = mitochondria?, sG = cortical granules, 1, 2, 3 = diameters of cyst (see text); p 425.

Adoral zone of membranelles about 37 % of body length. Bases of largest membranelles in life about 8 µm wide. Buccal area largely covered by an arched hyaline plasma lip. Paroral after protargol impregnation 20–27 µm (mean = 24 µm; n = 25), endoral 17–25 µm (mean = 20 µm; n = 25) long. Frontal cirri in life about 25 µm long. Arrangement of frontal, ventral, and transverse cirri rather invariable (Fig. 134a, h). Transverse cirri in life about 30 µm long, distinctly protruding beyond posterior end of cell. Marginal cirri in life about 21 µm long; right marginal row begins at level of right frontal

Fig. 134h–m *Urosoma gigantea* (from BERGER & FOISSNER 1988b. h–m, protargol impregnation). h, i) Ventral and dorsal infraciliature of a non-dividing specimen, 160 µm. The cirri of a primordium are connected by a broken line. j, k) Ventral infraciliature of very early morphogenetic stages, j = 180 µm, k = 170 µm. l, m) Ven-

tral infraciliature of early morphogenetic stages, l = 180 μ m, m = 165 μ m. Arrowhead marks frontoventral cirrus III/2. I-VI = frontal-ventral-transverse cirri primordia I-VI, 1-4 = cirri within a primordium and dorsal kineties 1-4; p 425.

Fig. 134t–w *Urosoma gigantea* (from BERGER & FOISSNER 1988b. t–w, protargol impregnation). **t, u**) Dorsal and ventral infraciliature of very late morphogenetic stages, t = 180 μ m, u = 210 μ m. **v, w**) Ventral and dorsal infraciliature of an opisthe, 110 μ m. Parental structures white, new black; p 425.

cirrus, terminates slightly subterminally, left row J-shaped. Dorsal kinety 1 slightly shortened anteriorly, kinety 4 terminates in mid-body (Fig. 134i).

In cultures *U. gigantea* encysted after conjugation. Cysts yellowish, consist of (i) an outer hyaline mucous layer with adhering bacteria, (ii) an inner, relatively firm mucous layer with 2 μ m sized ellipsoid yellow inclusions, (iii) an about 3.5 μ m thick cyst wall,

← **Fig. 134n–s** *Urosoma gigantea* (from BERGER & FOISSNER 1988b. n–s, protargol impregnation). **n–p**) Ventral and dorsal infraciliature of middle morphogenetic stages, n = 195 μ m, o, p = 185 μ m. **q–s**) Ventral infraciliature of late morphogenetic stages, q = 165 μ m, r = 180 μ m, s = 170 μ m. Arrow in (s) marks a supernumerary cirrus within primordium VI. Parental structures white, new black. P = primordium of new dorsal kinety 4; p 425.

and (iv) the cytoplasm with 4–8 μm sized globules. Diameters of cysts (see Fig. 134g; $n = 14$): 1 = 52–70 μm (mean = 65 μm), 2 = 76–105 μm (mean = 90 μm), and 3 = 111–150 μm (mean = 132 μm).

M o r p h o g e n e s i s of cell division commences apokinetally with the proliferation of basal bodies in the area between the postoral ventral cirri and transverse cirri (Fig. 134j). A large oral primordium is formed, its narrowed anterior portion elongates to the level of the buccal vertex and splits in the middle region to form streaks I and II. The postoral ventral cirri V/3 and V/4 are modified to primordia (Fig. 134k, l). Next, the postoral ventral cirrus IV/2 is disorganised. Five streaks of the opisthe are recognisable at this stage (Fig. 134m). Simultaneously the buccal cirrus (II/2) and the cirrus III/2 organise primordia for the proter. Three other primordia are present at the level of the cytostome. At least the middle and right primordium are derived from a streak of the opisthe. Six frontal-ventral-transverse primordia are discernible in the next stage in both the proter and the opisthe. Cirrus IV/3 has been reabsorbed (Fig. 134n). Some loosely arranged basal bodies are present between the right streak (primordium VI) of the proter and primordium IV of the opisthe. Morphogenesis continues with elongation of the frontal-ventral-transverse streaks and the formation of marginal primordia in the anterior and middle portion of the right marginal row (Fig. 134o). The proliferation of new basal body pairs occurs at two levels in dorsal kineties 1, 2, and 3 (Fig. 134p). The parental undulating membranes commence with reorganisation when the undulating membranes of the opisthe are formed. The anterior cirri are already segregated from the frontal-ventral-transverse streaks. Both the right and left marginal primordia are elongated (Fig. 134q). The primordia of dorsal kinety 4 originate at the anterior end of the right marginal primordia at about the time the macronuclear nodules fuse (Fig. 134r). Morphogenesis then continues very similarly to, for instance, in *Oxytricha granulifera*. Unfortunately, we could not find the exact origin of all primordia in either the proter or the opisthe (BERGER & FOISSNER 1988b). Thus, the data of *Urosoma gigantea* are not used in Table 4.

O c c u r r e n c e a n d e c o l o g y: Locus classicus is a periodically occurring, sodium hydroxide rich pond north of Szeged (Hungary). HORVÁTH (1933) found *U. gigantea* also in infusions of dry soil from this pond. BERGER & FOISSNER (1987a) isolated it from a very similar habitat, namely from soil of a saline grassland with halophytes near a lake (Neusiedlersee) in eastern Austria. Feeds on bacteria, fungi, heterotrophic flagellates, and ciliates like *Vorticella* sp. Biomass of 10^6 individuals 270 mg (FOISSNER 1987a).

Insufficient redescriptions

Oxytricha caudata – DUJARDIN, 1841, Zoophytes, p 420, Planche XIII, Fig. 6.

Oxytricha caudata, EHR. – DUMAS, 1929, Microzoaires, p 70 (Fig. 236a, b) and DUMAS, 1930, Microzoaires, p 53 (Fig. 236r, 239g). Remarks: Very likely an *Uroleptus* because 4–5 cirral rows are present. Pond in France.

Oxytricha caudata – FROMENTEL, 1876, Microzoaires, p 266, Planche XIII, Fig. 4. Remarks: Freshwater in France.

Urosoma cienkowski KOW. – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 59 (Fig. 225i). Remarks: Freshwater in Connecticut, USA.

Urosoma sp. – LEPSI, 1927, Studii Cerc. Acad. RPR, 12: 126 (Fig. 226j). Remarks: Perhaps *U. caudata*. In life $146 \times 56 \mu\text{m}$. Between *Oscillatoria*. Poly- or mesosaprobic. Romania.

Urosoma sp. – LEPSI, 1965, Protozoologie, p 35 (Fig. 225h). Remarks: Macronuclear nodules arranged biserially. Romania?

Tachysoma STOKES, 1887

1887 *Tachysoma* STOKES, Ann. Mag. nat. Hist., 20: 108 – Type (not fixed by STOKES 1887b; subsequent designation by BORROR 1972a, p 15): *Trichoda pellionella* MÜLLER, 1773.

1888 *Tachysoma*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 293.

1932 *Tachysoma* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 604 (see nomenclature).

1972 *Tachysoma* STOKES, 1887 – BORROR, J. Protozool., 19: 15.

1974 *Tachysoma* STOKES – STILLER, Fauna Hung., 115: 138.

1997 *Tachysoma* STOKES, 1887 – BERGER & FOISSNER, Arch. Protistenk., 148: 148.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Frontoventral cirri in V-shaped pattern or arranged almost in a row. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral and (4 to) 5 transverse cirri. One right and 1 left row of marginal cirri. Four to 6 dorsal kineties. Caudal cirri absent. Frontal-ventral-transverse cirri originate from primary primordia or separate anlagen. Dorsal morphogenesis in *Tachysoma*, *Oxytricha*, or *Urosomoida* pattern.

Additional characters: Dorso-ventrally flattened about 2:1. Very flexible. Two macronuclear nodules slightly left of median. Contractile vacuole about in mid-body or slightly in front of it. Pellicle and cytoplasm colourless. Buccal area small to moderately broad. Transverse cirri protrude distinctly beyond posterior end of cell. Marginal rows distinctly separated posteriorly.

Nomenclature and taxonomy: KENT (1882, p 783) proposed the name *Mesotricha* for *Stylonychia echinata*, a generally accepted junior synonym of *T. pellionellum*, to separate it from other oxytrichids because of the long dorsal cilia. However, this character is inappropriate for the distinction of supra-specific taxa. Furthermore, *Mesotricha* is a nomen oblitum, because neither KAHL (1932), CORLISS (1979), JANKOWSKI (1979), nor anyone else mentioned it. KAHL (1932) classified *Tachysoma* as subgenus of

Oxytricha; the correct name in his revision is thus *Oxytricha (Tachysoma)*. Some incorrect subsequent spellings of *Tachysoma*: *Tachiosoma pellionella* (BICZÓK 1979, p 127; HAMAR 1971, p 120); *Tachyosoma pellionella* (SCHÖNBORN 1984, p 22); *Taxyosoma (Oxytricha) pellionella* KAHL (LEPINIS et al. 1973, p 169).

The characterisation is according to BERGER & FOISSNER (1997). See chapter 2 in the general section for a detailed description of patterns mentioned. Cladistic analysis revealed that *Tachysoma* is closely related to *Gonostomum* and *Urosoma* because of primary primordia formation (Fig. 25a). However, in *Tachysoma* this type of primordia formation occurs only in the type species, *T. pellionellum*, and not in *T. terricola*, the second species so far morphogenetically analysed (HEMBERGER 1982). Different strategies not only in the ventral but also in the dorsal morphogenesis suggest that *Tachysoma* is an artificial assemblage of flexible oxytrichids unified by the loss of caudal cirri, a character which very likely evolved independently in several oxytrichids, namely *Tachysoma*, *Histriculus*, *Pleurotricha*, and *Parastylonychia*.

Tachysoma hyalina BERGER, FOISSNER & ADAM, 1984, *T. perisincirra* HEMBERGER, 1985 (both without postoral ventral cirri), and *T. longa* HEMBERGER, 1985 (postoral ventral cirri left of frontoventral cirri) were transferred to *Lamtostyla* BUITKAMP, 1977b by BERGER & FOISSNER (1987a, 1988a). *Tachysoma raptans* HEMBERGER, 1985 (Arch. Protistenk., 130: 414) differs from *Lamtostyla longa* and *L. granuliferum* FOISSNER, 1997b only in some morphometric characters (number of adoral membranelles and marginal cirri); FOISSNER (1997b) thus transferred it to *Lamtostyla*: *L. raptans*. However, detailed data on ventral and dorsal morphogenesis (and likely molecularbiological characteristics) are needed for final classification of these species. Their ventral infraciliature is reminiscent of *Gonostomum*, especially as concerns the “postoral” ventral cirri, which are arranged right (and not behind!) of the proximal portion of the adoral zone of membranelles.

Tachysoma spec. in WILBERT & KAHAN (1981, p 91) has several frontoventral cirri arranged in zigzag, indicating that it is a holostichid hypotrich. The marine *T. parvulum* CORLISS & SNYDER, 1986 is superficially described; according to PETZ et al. (1995, p 170) it is also a holostichid, and they thus transferred it to *Notocephalus*, *N. parvulus* (CORLISS & SNYDER, 1986) PETZ, SONG & WILBERT, 1995.

Tachysoma should not be confused with *Oxytricha* and *Urosomoida*, which, however, have inconspicuous caudal cirri (use differential interference contrast optics or protargol impregnation). Five species (*T. pellionellum*, *T. granuliferum*, *T. humicola*, *T. dragescoi*, *T. ovata*) are described in detail, that is, both by live observation and after protargol impregnation.

Key to species

- 1 Limnetic or terrestrial 2
- Marine 8
- 2 Length in life about 200 µm (Fig. 138a) *T. chilensis* (p 451)

- Length in life less than 150 μm 3
- 3 Dorsal cilia about 10–15 μm long 4
- Dorsal cilia 2–5 μm long 6
- 4 Each macronuclear nodule with an adjacent micronucleus; terrestrial (Fig. 139i) ...
..... *T. terricola* (p 458)
- Only one micronucleus between the two macronuclear nodules; freshwater (for ex-
ample, Fig. 135g) 5
- 5 Posterior-most left and right marginal cirrus distinctly enlarged and elongated (rare
species; Fig. 139h) *T. bicirratum* (p 457)
- All marginal cirri of about same length (very common species; Fig. 136a).
..... *T. pellionellum* (p 433)
- 6 (3) Cortical granules yellowish to orange-yellow (Fig. 140c)
..... *T. granuliferum* (p 459)
- Cortical granules absent 7
- 7 Length in life about 40–60 μm ; terrestrial (Fig. 138b–e, 139a–f)
..... *T. humicola* (p 452; identification of subspecies, see couplet 10)
- Length in life about 130–140 μm ; freshwater (Fig. 139g) *T. balatonica* (p 456)
- 8 (1) Length in life 150–260 μm *T. rigescens* (p 461)
- Length in life about 35–50 μm 9
- 9 Single micronucleus between macronuclear nodules; 5 transverse cirri (Fig. 141j, p,
q) *T. ovata* (p 464)
- Two very small micronuclei, that is, both macronuclear nodule with each one micro-
nucleus; 4 transverse cirri (Fig. 141d, e, f) *T. dragescoi* (p 463)
- 10 Posterior-most dorsal cilia 2–3 μm long (Fig. 139a, e) *T. humicola humicola* (p 456)
- Posterior-most dorsal cilia about 10 μm long (Fig. 138b, c, e)
..... *T. humicola longisetum* (p 456)

***Tachysoma pellionellum* (MÜLLER, 1773) BORROR, 1972 (Fig. 135a–s,
136a–x, 137, Tables 3, 25–28)**

- 1773 *Trichoda pellionella* MÜLLER, Vermium Terrestrium et Fluviatilium, p 80.
- 1786 *Trichoda pellionella* – MÜLLER, Animalcula Infusoria, p 222 (Fig. 135a’).
- 1824 *Oxitricha pelionella* – BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONG-
CHAMPS, Encyclopédie methodique, p 595 (incorrect subsequent spelling of *pellionella*).
- 1824 *Oxitricha joblotii* BORY DE SAINT-VINCENT in LAMOUROUX, BORY DE SAINT-VINCENT & DESLONGCHAMPS,
Encyclopédie methodique, p 596 (according to EHRENBURG 1838, a synonym).
- 1826 *Oxitricha pelionella* – BORY DE SAINT-VINCENT, Essai d’une classification, p 56 (incorrect subsequent
spelling of *pellionella*).
- 1831 *Oxytricha pellionella* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1831: 118.
- 1833 *Oxytricha pellionella* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1833: 174, 325, Tafel III, Fig. VI
(on p 325 it is designated as “Das häutige Hecheltierchen”).
- 1838 *Oxytricha pellionella* – EHRENBURG, Infusionsthierchen, p 364 (Fig. 135a).
- 1850 *Oxytricha pellionella* BORY – DIESING, Systema Helminthum I, p 157.

Fig. 135a-g *Tachysoma pellionellum* (a, after EHRENBERG 1838; a', from MÜLLER 1786; b-d, from STEIN 1859b; e, from PÄTSCH 1974; f, g, originals of a population from the Füscher-Ache, a small, oligosaprobic to betamesosaprobic alpine river in Salzburg, Austria. a-d, from life; e-g, protargol impregnation). a-c) Ventral views, sizes not indicated. d) Dorsal view. The two micronuclei are probably a misobservation because the general appearance indicates unambiguously that the identification is correct. e, f) Ventral infraciliature, e = 70 µm, f = 50 µm. g) Dorsal infraciliature, 60 µm. Arrow marks the single micronucleus between the two macronuclear nodules. FC = right frontal cirrus (III/3), FVC = anterior-most frontoventral cirrus (VI/4), 1-6 = dorsal kineties 1-6; p 433.

- 1858 *Stylonychia echinata* CLAPARÈDE & LACHMANN, Mém. Inst. natn. génev., 5: 165 (Fig. 136r).
 1859 *Pleurotricha echinata* - STEIN, Organismus der Infusionsthiere I, p 171.
 1859 *Oxytricha pellionella*. EHRBG. - STEIN, Organismus der Infusionsthiere I, p 185 (Fig. 135b-d).
 1878 *Oxytricha pelionella* - STERKI, Z. wiss. Zool., 31: 55, 56 (Fig. 136o, q; incorrect subsequent spelling).
 1882 *Oxytricha pellionella*, MÜLL. sp. - KENT, Manual infusoria II, p 786.
 1887 *Tachysoma agile* STOKES, Ann. Mag. nat. Hist., 20: 108 (Fig. 136k).
 1887 *Tachysoma mirabile* STOKES, Ann. Mag. nat. Hist., 20: 109 (Fig. 136l).
 1888 *Tachysoma agilis*, STOKES - STOKES, J. Trenton nat. Hist. Soc., 1: 294.
 1888 *Tachysoma mirabilis*, STOKES - STOKES, J. Trenton nat. Hist. Soc., 1: 295.
 1901 *Oxytricha pellionella* (O.-F. MÜLL.) - ROUX, Mém. Inst. natn. génev., 19: 101 (Fig. 136s).
 1908 *Oxytricha pellionella* O. F. MÜLL. - BÜRGER, An. Univ. Chile, 122: 187 (Fig. 135q).
 1932 *Tachysoma (Oxytricha) pellionella* (MÜLLER - STEIN, 1859) - KAHL, Tierwelt Dtl., 25: 606 (Fig. 136i).
 1932 *Tachysoma echinata* (CLAP. u. L.) - KAHL, Tierwelt Dtl., 25: 617.
 1932 *Tachysoma mirabilis* STOKES, 1887 - KAHL, Tierwelt Dtl., 25: 606.
 1933 *Oxytricha pellionella* O. F. M. - GAJEWSKAJA, Zoologica, 32: 147 (Fig. 136t).
 1935 *Oxytricha pellionella* (MÜLLER) KAHL, 1932 - WANG & NIE, Sinensia, 6: 497 (Fig. 136m).

- 1953 *Tachysoma pellionella* – JIROVEK, WENIG, FOTT, BARTOŠ, WEISER & ŠRÁMEK-HUŠEK, *Protozoologie*, p 512, 514 (Fig. 136p).
- 1963 *Tachysoma pellionella* – SLÁDEČEK, *Sb. vys. Šk. chem.-technol. Praze*, 7: 590 (Fig. 136p).
- 1968 *Oxytricha (Tachysoma) pellionella* (O. F. MÜLLER) STEIN, 1859 – CHORIK, *Free-living ciliates*, p 135 (Fig. 136u).
- 1969 *Tachysoma pellionella* (MÜLLER-STEIN, 1859) – CURDS, *Wat. Poll. Res.*, No. 12: 68 (Fig. 136n).
- 1972 *Tachysoma pellionella* (MÜLLER, 1786) KAHL, 1932 – BORROR, *J. Protozool.*, 19: 15.
- 1972 *Tachysoma pellionella* (O. F. MÜLLER) – BICK, *Ciliated protozoa*, p 182 (Fig. 136h).
- 1974 *Tachysoma pellionella* (O. F. MÜLLER) – PATSCH, *Arb. Inst. landw. Zool. Bienenk.*, 1: 65 (Fig. 135e).
- 1975 *Tachysoma pellionella* (MÜLLER-STEIN, 1859) KAHL, 1932 – GROLIÈRE, *Protistologica*, 11: 491 (Fig. 136f, g).
- 1977 *Oxytricha (Tachysoma) pellionella* (O. F. M.) STEIN 1859 – BEREZKY, *Annls Univ. Scient. bpest. Rolando Eötvös*, 18–19: 169 (Fig. 135r).
- 1979 *Oxytricha pelionella* MÜLL.-STEIN, 1859 – MAMAEVA, *Infusoria of the Volga basin*, p 71 (Fig. 135s; incorrect subsequent spelling).
- 1981 *Tachysoma pellionella* (MÜLLER, 1786) – FOISSNER & DIDIER, *Annls Stn limnol. Besse*, 15: 259 (Fig. 136a–c).
- 1981 *Tachysoma pellionella* (MÜLLER) STEIN 1859 – CHARDEZ, *Revue verviét. Hist. nat.*, 38: 53 (Fig. 136j).
- 1982 *Tachysoma pellionella* (MÜLLER, 1786) KAHL, 1932 – HEMBERGER, *Dissertation*, p 243 (Fig. 135h–o).
- 1988 *Tachysoma pellionellum* (O. F. MÜLLER, 1773) – FOISSNER, *Hydrobiologia*, 166: 30, 43 (emendation).
- 1991 *Tachysoma pellionellum* (MUELLER, 1773) BORROR, 1972 – FOISSNER, BLATTERER, BERGER & KOHMANN, *Informationsberichte Bayer. Landesamtes für Wasserwirtschaft*, 1/91: 304.
- 1993 *Tachysoma pellionellum* (MÜLLER, 1773) – SHIN & KIM, *Korean J. Zool.*, 36: 228 (Fig. 136v–x).
- 1997 *Tachysoma pellionellum* (MÜLLER, 1773) BORROR, 1972 – BERGER, FOISSNER & KOHMANN, *Bestimmung und Ökologie der Mikrosaprobien*, p 167 (Fig. 135p).

Nomenclature and taxonomy: KAHL (1932) classified *Tachysoma* as subgenus of *Oxytricha*; the correct names in his revision are thus *Oxytricha (Tachysoma) pellionella*, *O. (Tachysoma) echinata*, and *O. (Tachysoma) mirabilis*. This implies that KAHL (1932) is not the combining author as generally, but erroneously, assumed (for example, BORROR 1972a, JANKOWSKI 1979). In my opinion, BORROR (1972a) is the combining author in that he fixed it as the type species.

Incorrect subsequent spellings: *Histrio pelionella* (LACKEY 1936, p 269); *Oxytricha (Tachysoma) pelionella* (LIEPA 1973, p 34); *Oxytricha pelionella* (for example, BALDENS-PERGER 1927, p 243; CIENKOWSKY 1855, p 305; GITTLESON & HOOVER 1969, p 750; MAMAEVA 1979c, p 233; MYLNIKOVA 1993, p 193; SCHIEDERMAYR 1887, p 13; ZOLOTAREV 1987, p 114); *Oxytricha pellionela* (NIKOLYUK 1965, p 46); *Oxytricha pellionnella* O. F. M. (ILOWAIISKY 1926b, p 97; ROUX 1900, p 464); *Oxytricha perionella* MÜLL (SHIBUYA 1927, p 385); *Oxytrichia pelionella* (LACKEY 1936, p 269); *Oxytrichia pellionella* (BALDENS-PERGER 1927, p 295); *Tachysoma pelionella* (HORVÁTH 1950, p 159; TIRJAKOVÁ 1992b, p 294); *Tachysoma pelionellum* (LARSEN 1992, p 301; TIRJAKOVÁ 1991, p 868); *Tachysoma petlionella* (ALEKPEROV 1986, p 57).

Tachysoma pellionellum is one of the most common oxytrichid hypotrichs in freshwater, which should, however, not be confused with the also very common and thus often associated holostichid, *Holosticha pullaster* (MÜLLER, 1773) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (contractile vacuole distinctly behind mid-body; midventral

Fig. 135h–o *Tachysoma pelliellum* (from HEMBERGER 1982. h–o, protargol impregnation). Morphogenesis in ventral view, h = 90 μ m. The most important event is the formation of so-called primary primordia (l). Arrows in (o) mark primordia of dorsal kinety 6. See also text. OP = oral primordium; p 433.

row, that is, many more cirri on the ventral surface; more transverse cirri; short dorsal cilia).

BERECZKY (1977a; Fig. 135r) illustrated rather short dorsal cilia, so that the identification is questionable. The HORVÁTH (1933; Fig. 45a, b) population is classified as *Oxytricha longa* and that of WRZESNIEWSKI (1861; Fig. 57d) as *Oxytricha similis*. The redescrptions of the following authors are insufficient: ALADRO-LUBEL et al. (1990; Fig. 241d), BALDENSBERGER (1927), BELTRAN (1928; Fig. 228c), BIERNACKA (1959; Fig. 225t), BROD-

Fig. 135p-s *Tachysoma pellionellum* (p, from BERGER et al. 1997; q, from BÜRGER 1908; r, from BEREZKY 1977a; s, from MAMAIEVA 1979b. p-s, from life). p) Ventral view of a freely motile (not squeezed) specimen from a pond (Leopoldskroner Weiher) in the city of Salzburg, Austria; note the curved outline, documenting that *T. pellionellum* is very flexible. Arrow marks right transverse cirrus. q-s) Ventral views, q = 75 μm , r = 90 μm , s = 70 μm . Arrows in (q) mark the "Fettkorn" in anterior and posterior portion of cell, respectively. CV = contractile vacuole in mid-body, Ma = anterior macronuclear nodule; p 433.

SKY & YANKOWSKAYA (1929; Fig. 226f), BUISÁN (1944; Fig. 233d), CONN (1905; Fig. 225f, l), DUJARDIN (1841), EDMONDSON (1906; Fig. 234i), FELLERS & ALLISON (1920; Fig. 225r), FERNANDEZ-LEBORANS & CASTRO DE ZALDUMBIDE (1985), KOFFMAN (1926), LEPINIS et al. 1973 (Fig. 225j), LEPSI (1957; Fig. 225e), QUENNERSTEDT (1865; Fig. 225n), ROSA (1957a, b; Fig. 233a, c), SMITH (1978; Fig. 225m), SMITH (1914; Fig. 233g), SAMANO & SOKOLOFF (1931; Fig. 225g), SOKOLOFF & ANCONA (1937; Fig. 234j), TCHANG et al. (1984; Fig. 232j, k), WANG (1925; Fig. 242d). The illustration in MADONI (1981) is identical with that by BICK (1972a).

Morphology and biology: In life 55–100 $\times$ 15–30 μm , usually about 65–85 μm long. Long elliptical or even with parallel margins. Both ends rounded. Anteriorly somewhat more flattened than posteriorly (Fig. 135b–d, 135p, 136a–c). Slightly contractile. Macronuclear nodules ellipsoidal, in life about 10–12 $\times$ 5–7 μm , after protargol impregnation 8–12 $\times$ 4–7 μm , with many small and large nucleoli. Invariably 1, in life about 3–4 μm , after protargol impregnation 2.2–2.7 $\times$ 1.8–2.6 μm sized, globular micronucleus between the two closely spaced macronuclear nodules; micronucleus in life conspicuously shining, thus it can sometimes be seen already at middle magnification. STEIN (1859b) and ROUX (1901) draw two micronuclei, which must, however, be interpreted as

Fig. 136a–e *Tachysoma pellationum* (from FOISSNER & DIDIER 1981. a–c, from life; d, e, protargol impregnation). a–c) Ventral, dorsal, and lateral view, a = 70 μm , b, c = 85 μm . d, e) Ventral and dorsal infraciliature, d = 50 μm , e = 40 μm . The specimen in (d) has 3 pretransverse ventral cirri; p 433.

misobservation. Especially the illustrations by STEIN (1859b) unambiguously show *T. pellationum* (Fig. 135b–d). Contractile vacuole without collecting canals, situated at body margin so that pellicle sometimes arched. Cortical granules absent (see also SCHNEIDER 1930). Cytoplasm with some small granules and 2–5 μm sized, yellowish shining spherical inclusions. Usually a very conspicuous, about 5 μm sized, greasily shining globule that looks like a ring with a thick (about 1 μm) wall (in German, “Fettkorn”), in both ends of the cell (Fig. 135b–d, q, 136i, m); these globules often surrounded by numerous small granules which appear dark at bright field illumination; thus, middle portion of cell usually looks bright! Moves hastily to and fro, body distinctly curved (Fig. 135p); forward motion in numerous short, jerky movements.

Adoral zone of membranelles in life $1/4$ – $1/3$ of body length. Buccal area flat and rather narrow. According to FOISSNER & DIDIER (1981) both undulating membranes consist of two rows of basal bodies each; according to FERNANDEZ-LEBORANS (1983, 1985) the paroral is made up of one row only. Frontal cirri slightly, transverse cirri strongly enlarged, bases of remaining cirri consist of 2 rows of basal bodies only. Base of buccal cirrus rather small. Anterior-most frontoventral cirrus (VI/4) somewhat separated from the three other frontoventral cirri, which are invariably arranged as shown in Figures 135f,

Fig. 136f–j *Tachysoma pellionellum* (f, g, from GROLIÈRE 1975; h, from BICK 1972a; i, from KAHL 1932; j, after CHARDEZ 1981. f, g, protargol impregnation; h–j, from life). f, g) Ventral and dorsal infraciliature, 65 μm . h–j) Ventral views, h = 70 μm , i = 80 μm , j = 62 μm . Only drawing (i) shows the typical “Fettkörper”, conspicuous ring-like structures in anterior and posterior portion of cell; p 433.

136d, w. Postoral ventral cirri arranged nearly in line, base of anterior-most cirrus orientated longitudinally. Usually 2, sometimes 3 (mean = 2.4; $n = 12$) pretransverse ventral cirri. Transverse cirri very prominent, in life about 15–20 μm long, posteriorly often fringed and curved to the left (Fig. 135b–d, i, t). Marginal rows with roughly same number of cirri. Right one begins at about level of posterior-most frontoventral cirrus (Fig. 135f, 136d); marginal cirri in life 8–10 μm long. Dorsal cilia anteriorly 8–10 μm , posteriorly up to 15 μm long, always spread and thus easily recognisable even at low magnification (100 $\times$; use differential interference contrast optics). Dorsal kineties 1 and 2 as long as body, kineties 3 and 4 slightly shortened anteriorly, kinety 6 terminates in about mid-body (Fig. 135g, 136e); arrangement of kineties especially in anterior and posterior portion of cell difficult to discern.

Fig. 136k–u *Tachysoma pellionellum* (k, l, after STOKES 1887b; m, from WANG & NIE 1935; n, from CURDS 1969; o, after STERKI 1878; p, after JIROVEC et al. 1953 from SLÁDEČEK 1963; q, after STERKI 1878; r, after CLAPARÈDE & LACHMANN 1858; s, after ROUX 1901; t, after GAJEWSKAJA 1933; u, from CHORIK 1968. k–u, from life). k–n, p–u) Ventral views, k = 106 μ m, l = 55 μ m, m = 75 μ m, n = 62 μ m, p–r = size not indicated, s = 100 μ m, t = 90 μ m, u = 85 μ m. o) Left lateral view; p 433.

Fig. 136v-x *Tachysoma pellionellum* (from SHIN & KIM 1993b. v, from life?; w, x, protargol impregnation). v) Ventral view, 85 μm . w, x) Ventral and dorsal infraciliature, 90 μm . Note the prominent transverse cirri and the single micronucleus between the two macronuclear nodules; p 433.

AUERBACH (1854) and PROWAZEK (1899a) described a cyst about 23 μm in diameter. Cysts subjected to very low oxygen tensions were found to excyst (STOUT 1954a). However, *Tachysoma pellionellum* was never reliably recorded from terrestrial habitats, strongly indicating that it does not make cysts. Accordingly, these old observations have to be verified on reliably determined populations.

Tachysoma pellionellum has $1.2 \times 0.6 \mu\text{m}$ sized mitochondria with several cords, each consisting of four tubules (WILBERT & HELLER 1971).

Morphogenesis of cell division is described by FERNANDEZ-LEBORANS & CASTRO DE ZALDUMBIDE (1983) and, in more detail, by HEMBERGER (1982, Fig. 135h-o). It commences with the proliferation of basal bodies near the left transverse cirrus (Fig. 135h). The oral primordium moves anteriorly into the area of the postoral ventral cirri (Fig. 135i). These cirri are involved in primordia formation and a narrow streak originates from the oral primordium in the direction of the buccal vertex. This streak divides into 3 long primordia, which are arranged in parallel to 2 further streaks right of them. Thus, in the middle stage of morphogenesis 5 long, so-called primary primordia are present (Fig. 135j, k). Posteriorly they are connected by an oblique, loosely arranged group

Table 25 Morphometric data of *Tachysoma dragescoi* (dra, from SONG & WILBERT 1997), *T. granuliferum* (gra, from BERGER & FOISSNER 1987a), *T. humicola humicola* (hum, from FOISSNER 1984), *T. humicola longisetum* (lon, from FOISSNER 1998), *T. ovata* (ova, from SONG & WILBERT 1997), *T. pellionellum* (pe1, from FOISSNER & DIDIER 1981; pe2, from SHIN & KIM 1993b), and *T. terricola* (ter, from HEMBERGER 1985). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	dra	35.8	3.8	10.6	30	42	16
	gra	62.6	7.0	11.2	55	76	11
	hum	42.5	4.3	10.0	38	50	11
	lon	44.0	3.9	8.8	37	50	13
	ova	38.3	3.8	9.9	32	45	16
	pe1	52.4	5.1	9.7	45	63	12
	pe2	87.5	6.9	7.9	79	100	8
	ter	90.0	-	-	70	100	?
Body, width	dra	21.1	2.8	13.3	16	26	16
	gra	23.6	2.3	9.8	21	27	11
	hum	21.0	2.6	12.4	18	27	11
	lon	21.2	2.4	11.2	18	27	13
	ova	28.6	3.0	10.5	24	34	16
	pe1	17.1	2.2	8.8	15	19	12
	pe2	38.9	3.4	8.8	35	45	7
	ter	30.0	-	-	28	40	?
Macronuclear nodule, length	dra	-	-	-	5	6	5
	gra	12.4	1.6	13.2	10	14	11
	hum	7.8	1.8	22.9	6	10	11
	lon	7.2	1.3	18.8	6	10	13
	ova	6.9	0.9	13.4	6	9	16
	pe1	9.2	1.5	16.4	8	12	12
	pe2	13.1	1.8	13.5	11	15	7
	ter	-	-	-	-	-	-
Macronuclear nodule, width	gra	5.4	1.0	19.1	4	7	11
	hum	5.7	0.4	6.3	6	6	11
	lon	5.4	0.7	14.3	4	7	13
	pe1	5.3	0.9	17.6	4	7	12
	pe2	5.9	0.7	11.8	5	7	7
	ter	-	-	-	-	-	-
Adoral zone of membranelles, length	dra	13.4	1.1	8.1	12	15	16
	gra	21.7	1.4	6.2	20	24	11
	hum	14.0	0.9	6.4	13	16	11
	lon	14.6	0.7	5.3	13	15	13
	ova	15.6	1.5	9.6	13	18	16
	pe1	19.5	2.1	11.0	17	25	12
	pe2	26.8	3.6	13.4	20	32	8
	ter	-	-	-	-	-	-
Adoral membranelles, number	dra	13.7	1.0	6.9	12	15	16
	gra	22.7	1.4	6.0	21	25	11
	hum	14.8	0.6	4.1	14	16	11
	lon	15.0	0	0	15	15	13
	ova	15.6	1.0	6.2	14	17	10
	ter	-	-	-	-	-	-

Table 25 Continued

Character	Species	mean	SD	CV	Min	Max	n
Adoral membranelles, number	pe1	20.5	1.0	5.1	18	22	12
	pe2	20.6	1.1	5.1	19	22	8
	ter	16.0	-	-	-	-	?
Left marginal row, number of cirri	dra	7.6	0.7	9.6	7	9	16
	gra	14.7	0.8	5.3	13	16	11
	hum	7.2	0.4	5.6	7	8	11
	lon	7.1	-	-	7	8	13
	ova	15.1	0.8	5.1	14	16	16
	pe1	13.7	1.8	23.6	9	16	12
	pe2	16.0	0.5	3.3	15	17	8
	ter	-	-	-	12	14	?
	dra	6.3	1.0	16.1	5	8	16
Right marginal row, number of cirri	gra	16.3	1.1	6.8	15	18	11
	hum	6.5	0.7	10.7	6	8	11
	lon	6.0	0	0	6	6	13
	ova	15.4	1.3	8.5	13	17	16
	pe1	14.0	1.1	7.7	12	16	12
	pe2	15.5	0.9	6.0	14	17	8
	ter	-	-	-	11	14	?
	dra	3.0	0	0	3	3	16
	gra	4.0	0	0	4	4	11
Dorsal kineties, number	hum	4.0	0	0	4	4	11
	lon	4.0	0	0	4	4	13
	ova	3.0	0	0	3	3	16
	pe1	6.0	0	0	6	6	12
	pe2	6.0	0.5	8.3	5	7	9
	ter	4.0	-	-	-	-	?
	dra	3.0	0	0	3	3	16

of basal bodies which form the primordium of the undulating membranes of the opisthe (Fig. 135l). In the next stage, these primary primordia divide at about the level of the buccal vertex, similarly to in *Urosoma emarginata* (Fig. 127o). Now, 6 secondary primordia (including the primordium of the undulating membranes and the left frontal cirrus) are present in both the proter and the opisthe. Dorsal morphogenesis is not figured by HEMBERGER (1982). However, he mentioned that an anterior and posterior primordium occurred in dorsal kineties 1–3. Unlike in other typical oxytrichids, not only the primordia of dorsal kinty 3 divided, but also those of dorsal kinty 2 (Fig. 24d). Thus, the parental dorsal kineties 1–3 form the new dorsal kineties 1–5 of the proter and opisthe. Kinty 6 is a dorsomarginal row (Fig. 135o, arrows).

Occurrence and ecology: One of the most common hypotrichs in the aufwuchs and detritus of freshwater habitats such as running waters, lakes, ponds, peat-bogs, springs, and infusions; sometimes abundant (EHRENBERG 1838, FINLAY et al. 1993, KAHL 1932, STEIN 1859b, own observations). Very likely oligo-euryhaline (up to 4 ‰ salinity)

with freshwater-optimum (ALBRECHT 1983, 1984). According to WILBERT (1969) and NUSCH (1970) more abundant during spring and autumn than in the remaining seasons. However, SCHÖNBORN (1982, 1984) found highest abundances (110 ind. cm⁻²) in February and observed a correlation with high population densities of diatoms; BICK (1972a) found *T. pellationellum* frequently also in layers of naviculid diatoms, and HEUSS (1976) observed maximal abundances during spring and summer. These deviating observations indicate that no season is preferred (KALMUS 1928). Often associated with the likewise very common *Holosticha pullaster* with which it may be confused at superficial observation (see taxonomy). Cosmopolitan.

Locus classicus is Denmark, where MÜLLER (1773) discovered *T. pellationellum* in a plant infusion. Records largely substantiated by illustrations: very common in lotic and lentic waters in Austria (own observations); submerged *Sphagnum* (pH 4) in Belgium (CHARDEZ 1981); Sava River, Croatia (PRIMC-HABDIJA et al. 1996); Czechoslovakia (JÍROVEC et al. 1953); peat-pit in France (GROLIÈRE 1975); pond-like section of moderately organically polluted brook with filamentous algae near Besse-en-Chandesse, France (FOISSNER & DIDIER 1981); about 20 ind. cm⁻² in the aufwuchs of mesosaprobic brooks in Germany (PÄTSCH 1974); common in infusions and stagnant waters in Berlin, Germany (EHRENBERG 1838); peat-pit and ponds near Berlin, Germany (locus classicus of the synonym *Stylonychia echinata*; CLAPARÈDE & LACHMANN 1858); plankton of the mesosaprobic Danube River in Hungary (BERECZKY 1977a, b, 1979, NOSEK & BERECZKY 1981); littoral and profundal of Lake Geneva, and common in lentic waters in Switzerland (ANDRÉ 1914, 1916, FOREL 1904, ROUX 1900, 1901); Volga River (MAMAEVA 1979a-c); at 3–19 °C among algae (*Tetraspora*, *Draparnaldia*) in the littoral of Lake Baikal (GAJEVSKAJA 1927, GAJEVSKAJA 1933, ROSSOLIMO 1923); USSR (CHORIK 1968); pond in China (WANG & NIE 1935); Han River in Seoul, Korea (SHIN & KIM 1993a, b); freshwater near Trenton?, New Jersey, USA (locus classicus of the synonyms *T. agile* and *T. mirabile*; STOKES 1887b); Chile (BÜRGER 1908).

Records from freshwater habitats of Europe and Asia not documented by illustrations: small stagnant and running waters in the Austrian Alps (FOISSNER 1979a, 1980c, FOISSNER & ADAM 1979); Enns River, Austria (MEISRIEMLER & RIEDL 1985); beta- to alphamesosaprobic brook in Salzburg, Austria (HASLAUER & PICHLER 1979); mesosaprobic Traun River and Danube River, Austria (FOISSNER & MOOG 1992, KALTENBACH 1960, SCHIEDERMAYR 1887); very abundant in ponds in western Austria (DALLA TORRE 1891); pelagial of groundwater ponds in Styria, Austria (KRAINER 1988); hypertrophic pond at Salzburg University, Austria (BLATTERER 1989); betamesosaprobic rivers in Upper Austria (for example, AOÖLR 1994b, own observations); drinking water of the town of Linz, Upper Austria (SCHIEDERMAYR 1882; further records from Austria: FOISSNER & FOISSNER 1988, HELD 1937, SCHMARD 1846, STORCH 1869); abundant in the aufwuchs of oligosaprobic to betamesosaprobic running waters in Belgium (AELTERMAN 1952; further records from Belgium: BERVOETS 1940, CHARDEZ 1987, GILLARD 1950); running waters in Bulgaria (DETCHIEVA 1979b, 1981, 1986, 1991, 1993, DETCHEVA 1972, RUSSEV et al. 1984); springs in Prague, Czechoslovakia (VEJDOVSKÝ 1882); in the plankton of a fast

flowing (0.9 m s^{-1}) river in Czechoslovakia (PROWAZEK 1899a); abundant in the Moldavia River, Czechoslovakia, throughout the year (KALMUS 1928); in 5 betamesosaprobic and 2 alphamesosaprobic sites in waters of Czechoslovakia (ŠRÁMEK-HUŠEK 1956b, 1957); saprobic brook and ponds in Czechoslovakia (BUCHAR 1957, MATIS 1973, ŠVEC 1897); submerged and wet mosses in Czechoslovakia (TIRJAKOVÁ 1991, TIRJAKOVÁ & MATIS 1987a); spring water with suspended organic matter in Bratislava, Czechoslovakia (COHN 1875; further records from Czechoslovakia: HANUŠKA 1962, HASSDENTEUFLOVÁ-MORAVCOVÁ 1955, SLÁDEČEK & SLÁDEČKOVÁ 1974, ŠRÁMEK-HUŠEK 1953, TIRJAKOVÁ 1992b, 1993); Denmark (NIELSEN 1960); sand and mud flats from rivers near Plymouth, England? (LACKEY & LACKEY 1963); near Perth, England (CRAIGIE 1921); slow sand filters at the Metropolitan Water Board, London, England (LLOYD 1973; see also CURDS 1979); rivers, ponds, ditches, and bogs in Estonia (JACOBSON 1928); near Lyon, France (ORMANCY 1852); alphamesosaprobic to polysaprobic section of a French river (GROLIÈRE et al. 1990; further record from France: MONIEZ 1889); backwash sludge from oxidators and filters of waterworks in Germany (FOISSNER 1996a, GIERIG 1993); oligosaprobic to betamesosaprobic and betamesosaprobic to alphamesosaprobic areas of brooks near Bonn, Germany (JUTRCZENKI 1982); abundant in the aufwuchs of oligosaprobic, oligosaprobic to betamesosaprobic, and alphamesosaprobic reservoirs in Germany (NUSCH 1970); highly polluted Salzach River at the village of Laufen, Germany (BAUER 1983); benthos of mesosaprobic brooks and rivers in Germany (BAUER 1987, FOISSNER et al. 1992a, b, SCHÖNBORN 1981, 1982, 1996, ZIEMANN 1985); highly abundant, especially during winter, in the aufwuchs of the betamesosaprobic Elbe River and in the aufwuchs of Hamburg harbour, a highly stressed habitat in the freshwater section of the Elbe Estuary, Germany (BARTSCH & HARTWIG 1984, GRIMM 1968, HECKMAN et al. 1990, TENT 1981); caves in Germany (GITTLESON & HOOVER 1969, GRIEPENBURG 1934, 1935); cooling system of a conventional power station at the beta- to alphamesosaprobic Main River, Germany (BERNERTH 1982); clean brooks in Bavaria, Germany (FOISSNER 1997a); Schussen River, Germany (WETZEL 1928a); very abundant in the aufwuchs of a eutrophic lake and pond in Germany throughout the year (MÜCKE 1979, SONG & WILBERT 1989, WILBERT 1969); aufwuchs of oligotrophic, mesotrophic, and eu- to polytrophic Eifelmaas lakes, Germany (PACKROFF 1992, PACKROFF & WILBERT 1991); pond with leaf litter in Germany (BICK 1958); in the sludge of the influent of a wastewater fishpond in Munich, Germany (KAUFMANN 1958; further records from Germany: BAIER 1934, GREISER 1974, HENDERSON 1905, HEUSS et al. 1972, PACKROFF & ZWICK 1996, SCHMIDT 1916); Greece (STEPHANIDES 1948); radioactive (200–450 cps) spring in Greenland (LARSEN 1992); Lake Balaton, Hungary (ENTZ 1897, FRANCÉ 1897); pond with iron bacteria in a cave in Hungary (DUDICH 1932; further records from Hungary: BEREZKY 1995, BICZÓK 1955a, HAMAR 1971, STILLER 1942); Lake Como, Italy (CATTANEO 1882); alpine lakes (1267 m and 1920 m above sea level) in Italy (MONTI 1904, 1905); well and spring in Italy (GRISPINI 1938, STELLA 1947); up to 24 ind. cm^{-2} in mesosaprobic brooks in Italy (MADONI 1980, 1983, 1984, MADONI & GHETTI 1977, 1981a; further records from Italy: CALLONI 1890, CUNEO 1891, ENRIQUES 1913); Latvian rivers (LIEPA 1990); various habi-

tats in the Netherlands (VERSCHAFFELT 1930); sporadically with low abundance in the *Sphaerotilus* community of a Polish river (HUL 1986); pond near Warsaw, Poland, together with *Stylonychia pustulata*, *Cyclidium glaucoma*, and species of the *Paramecium aurelia* complex (WRZESNIEWSKIEGO 1866; further record from Poland: JAWOROWSKI 1893); Danube River in Romania (SPANDL 1926b); Henares River, Spain (FERNANDEZ-LEBORANS & NOVILLO 1996, FERNANDEZ-LEBORANS et al. 1985, FINLAY et al. 1993, MARGALEF LÓPEZ 1945); Danube River in Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); bogs near Berne, Switzerland (SAKOWSKY-CAMPIONI 1906); alpine lakes in Switzerland (MESSIKOMMER 1954, ZSCHOKKE 1900); profundal (35 m) of Lake Neuchatel, Switzerland (MONARD 1920; further records from Switzerland: ANDRÉ 1912, 1915, 1926, BOURQUIN-LINDT 1919, CDANN 1907, MERMOD 1914, MESSIKOMMER 1948, PERTY 1852b); aufwuchs from alphamesosaprobic Save River, Yugoslavia (PRIMC 1981, 1984); in the epiphyton of more than 75 % of collected samples from karstic running waters, Yugoslavia (PRIMC-HABDIJA & HABDIJA 1991); 30 ind. cm⁻² in the littoral of Lake Kinneret, Israel (MADONI 1990); stagnant water in India (BHATIA 1936); Lake Dzhandar, Azerbaijan? (ALIEV 1988); Araks River (ALIEV 1982a), Oka River (NEISWESTNOWA-SHADINA 1935, SASSUCHIN 1930, SASSUCHIN et al. 1927), and Volga River in the USSR (ZYKOFF 1903); plankton of reservoirs in the USSR (ALEKPEROV 1980, MYLNIKOVA 1992; further records from the USSR: ALEKPEROV 1984c, BELOVA 1988, DADAY E. 1904, DADAY J. 1903, EHRENBURG 1830, EICHWALD 1844, 1849, GORIDCHENKO 1984, LIEPA 1973, 1983, MERESCHKOWSKY 1877, MINKÉWITSCH 1898, MOVCHAN & PROTASOV 1986, MYLNIKOVA 1981, 1993, OLEKSIV 1985, SHADIN et al. 1931, VEYLANDE & LIYEPA 1985, WEISSE 1845, 1848a, ZHARIKOV 1982, 1992, ZOLOTAREV 1987); sediment of a Chinese river (GU et al. 1988; further records from China: MA 1994, as *T. pellinnella*; MA & DANG 1994, NING et al. 1993, SHEN & GONG 1989); Japan (EDMONDSON & KINGMAN 1913); Mongolia (DADAY 1906); stagnant waters in Tibetan plateau (WANG 1977).

America: Ice Lake (about 3700 m above sea level) and habitats near Greeley, Colorado (EDMONDSON 1912; further records from Colorado: BEARDSLEY 1902, COCKERELL 1907, HAMILTON 1943); Iowa (SHAWHAN et al. 1947); south-eastern Louisiana (BAMFORTH 1963); Ocqueoc River, Michigan (CAIRNS & YONGUE 1966); epilimnion of Douglas Lake, Michigan (YONGUE & CAIRNS 1976); North Carolina (BEVEL 1938); Devil's Lake complex, North Dakota (EDMONDSON 1920); among algae on submerged rock in clear water in Mirror Lake, Ohio (STEHLE 1920); Oklahoma (GABEL 1927); Conestoga drainage basin and pond of University of Pennsylvania (CAIRNS 1965a, WANG 1928); Mountain Lake region, Virginia (BOVEE 1960); abundant in clear flowing water with abundant plant life, USA? (HAUSMAN 1917); Fourth Lake, Canada (FANTHAM & PORTER 1948); in the moss *Catharinea undulata* from the bank of a brook near Montreal, Canada (FANTHAM & PORTER 1946); Mexico (LÓPEZ-POCHOTERENA & ROURE-CANE 1970); Argentina (BUSTOS 1933, SECKT 1924); Brazil (CUNHA 1913, PINTO 1925); Venezuela (SCORZA & NUÑEZ MONTIEL 1954).

Africa: pond in the bank of the Nile River, Egypt, together with two *Euglena* species (SCHMARD 1854).

Records from marine and brackish habitats and inland salt waters are not substantiated by illustrations (for example, ANDRUSSOWA 1886, BORROR 1962, BOUTCHINSKY 1895, BUTSCHINSKY 1897, CAREY 1992, DAGAJEVA 1930, FOWELL 1944, GALLIFORD & WILLIAMS 1948, LACKEY 1936, PARONA 1883, PATTERSON et al. 1989, REES 1884, SCHMARD 1846, 1847, SMITH 1904, VERSCHAFFELT 1930, WILBERT 1995, ZACHARIAS 1888). FINLEY (1930) noted that under experimental conditions a maximum of 1.4 % salt is tolerated. HAMMER (1986) found an upper limit of 7 % salinity. ALBRECHT (1986) and MIHAILOWITSCH (1989) recorded *Tachysoma pellationellum* from salt polluted running waters in Germany with 36–12 763 mg l⁻¹ Cl⁻ and 51–3590 mS m⁻¹ specific conductivity. KAHL (1928a, b) did not find it in saline freshwater habitats (Oldesloer Salzwasserstellen) in areas with either low or with high salt content.

Tachysoma pellationellum was never reliably recorded from terrestrial habitats (FOISSNER 1987a) indicating that it cannot make cysts; the numerous terrestrial records from all over the world are thus very likely misidentifications. Probably it was confused with *Oxytricha setigera*, which is common in terrestrial habitats and also has long dorsal cilia and a single micronucleus (for example, BAMFORTH 1967, 1968, 1969, 1976, BICZÓK 1955b, 1956, 1979, BRUNETTI & CARLETTI 1932, CHARDEZ 1967, CHAUDHURI 1929, CUNNINGHAM & LÖHNIS 1914, DECHEVA 1968, 1970, 1973, DETCHEVA 1972b, DIXON 1939, EHRENBERG 1849, 1869, FANTHAM & PATERSON 1926, GEL'GER & GEPTNER 1976, GELLÉRT 1957, GRANDORI & GRANDORI 1934, HEINIS 1937, HORVÁTH 1950, HINO & MOMIKI 1931, LOUISIER & BAMFORTH 1990, MARTIN & SHARP 1983, NIKOLJUK & GELTZER 1972, NIKOLYUK 1956, 1965, ROSA 1962, ROSA & LHOTSKY 1971, SANDON 1927, SHEN et al. 1992, SHIBUYA 1927, SMITH 1972, 1973a, 1974a–c, 1975, 1982, 1984, 1985, STOUT 1955, 1958, 1960, 1961, 1963, 1968, 1970, 1984, TIRJAKOVÁ & MATIS 1987a, VARGA 1935a, b, 1936, 1953a, 1958, 1960). SMITH (1981) recorded *Tachysoma pellationellum* from a moss peat (pH 4.1, water content about 400 % dry mass) on South Georgia, South Atlantic.

Tachysoma pellationellum is occasionally found in activated sludge (BANINA 1983, 1990, CURDS 1966b, 1969, 1975, CURDS & COCKBURN 1970a, ETTL 1996, HAMBURG-EISENBERG 1933, KUTIKOWA 1984, MADONI 1988a, MADONI & GHETTI 1981b, MARCO et al. 1991, SIMAKOV 1986), percolating filters (BEGER 1935, CURDS 1975, CURDS & COCKBURN 1970a, RICHARDS & CUTLER 1933) and the film of rotating biological contactors (MADONI & GHETTI 1981b, MADONI et al. 1979). In activated sludge plants an effluent-BOD₅ range of 11 to 20 mg l⁻¹ is indicated (CURDS & COCKBURN 1970b). SCHERB (1968a) counted up to 600 ind. ml⁻¹ activated sludge and stated that *Tachysoma pellationellum* occurs more frequently in plants treating dairy wastes than in plants treating municipal wastes. STOUT (1954b) found it in an oxidation pond of an experimental meat digestion plant in New Zealand; the record from the anaerobic digester of the same plant, however, appears doubtful. SMITH (1982) recorded *Tachysoma pellationellum* from the guano of a king penguin colony from the sub-Antarctic island of South Georgia; the identification is, however, not substantiated by morphological data!

Feeds on bacteria, cyanobacteria, diatoms, autotrophic flagellates, green algae, filamentous growth, detritus (BICK 1980, CURTIS & CURDS 1971, FINLAY et al. 1993, FOISSNER

Table 26 Autecological data of *Tachysoma pellionellum*. References: column 1, from BICK & KUNZE (1971; summary of literature data); column 2, from BERECKY (1977a; Danube River in Hungary, sample size not indicated); column 3, from DETCHEVA (1972a, 1975a–c, 1976b, 1978, 1979a, c, 1982b, 1983a, b, c; many analyses from Bulgarian running waters); column 4, from MADONI & GHETTI (1981a; Stirone River in Northern Italy, sample size not indicated); column 5, from FOISSNER et al. (1982a; 31 analyses from stagnate alpine water bodies in Austria); columns 6, 7, from FOISSNER et al. (1991; 6 = total range from various running waters in Austria, n = 18–35; 7 = only high abundances considered, n = 3)

Parameter ¹	Reference						
	1	2	3	4	5	6	7
Saprobity	-	-	o-a	-	b, a	o-b/b-a	b/b-a
Frequency (%)	-	-	2.7–10.7	5	-	26	2.2
Temperature (°C)	0–43	7–12.5	7–26	1.8–25	5–20	0.1–11	3–5
pH	6.4–9.1	7.7–8.1	6.3–8.2	7.6–8.4	4.8–5.8	7.0–8.6	7.1–8.2
O ₂ (mg l ⁻¹)	0–22.5	9.2–12.8	3.4–14.5	8.1–12.7	2.8–11.3	7.3–14.2	12–13
O ₂ (% saturation)	-	-	40–100	-	33–131	62–117	98–103
BOD ₅ (mg l ⁻¹)	10.9–24.5	2–12.8 ⁵	1.0–22	-	-	0.8–4.7	1.7–2.3
Total hardness (°dH)	-	-	-	-	1–7	3.2–13.7	9.4
KMnO ₄ -consumption	-	-	0.6–69	13–24 ⁴	12–54	2.5–24	11–19
NH ₄ ⁺ -N (mg l ⁻¹)	0–3.9	0.52–0.75	0.008–155	-	0–0.8	<0.01–1.5	0.01–0.05
NO ₂ -N (mg l ⁻¹)	-	0.003–0.055	0–0.6	0.02–0.04	0	0–0.02	0–0.02
NO ₃ -N (mg l ⁻¹)	-	0.47–1.65	0–9	0.6–3.2	0–0.2	0.2–3	0.4–1.2
PO ₄ ³⁻ -P (mg l ⁻¹)	-	-	-	0.16–0.38	0–0.26	0–0.25	0.02–0.05
Bacteria ml ⁻¹ (× 10 ⁶)	-	-	-	-	0.03–10 ²	<0.0045 ³	<0.004 ³

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

² Direct counting.

³ Plate method, 22 °C, 48 h.

⁴ COD.

⁵ BERECKZY (1977a) designated it as “O₂ (Verbrauch)”. Probably she meant the BOD₅.

1980c, FOISSNER & DIDIER 1981, MADONI 1981, NOLAND 1925, RIGGENBACH 1922). One specimen consumes 48–84 diatoms d⁻¹ and about 7200 bacteria d⁻¹, corresponding to a food volume of 48 900–63 100 µm³ ind.⁻¹ d⁻¹ (SCHÖNBORN 1981, 1982). *Tachysoma pellionellum* itself is only sometimes consumed by the oligochaete *Chaetogaster diastrophus* (SCHÖNBORN 1984). Generation time and production data of *Tachysoma pellionellum* under natural conditions in running waters are summarised in Table 28. SCHÖNBORN (1981, 1982, 1992) estimated 50–82 generations per year in running waters in Germany. Biomass of 10⁶ individuals 12–15 mg (FOISSNER et al. 1991) to 34 mg (SCHÖNBORN 1981, 1982).

Some autecological data are shown in Tables 26, 27 and Figure 137. Further autecological data: scattered in a betamesosaprobic brook in Czechoslovakia at 8.5 °C, pH 7.6, 9.8 mg l⁻¹ O₂, 80 % O₂ saturation, 5.5 mg l⁻¹ BOD₅ (VAŠIČEK 1964); 7–20 °C, pH 6.6–6.9, 1.2–2.6 mg l⁻¹ O₂ (MATIS 1975); 7–46.5 °C, pH 5.5–7.8 (MATIS & STRAKOVÁ-STRIEŠKOVÁ 1991); 0.3–7.2 mg l⁻¹ DOC (STÖSSEL 1979); 71–1097 µS cm⁻¹ (20 °C; n =

Table 27 Autecological data of *Tachysoma pellionellum* (columns 1–3), *Gonostomum affine* (column 4), and *Pleurotricha lanceolata* (column 5). References: columns 1, 2, from SCHMERENBECK (1975; experimental running waters; 1 = total range, 2 = optimal range); column 3, from MIHAILOWITSCH (1989; 68–76 analyses from salt polluted ditches in Germany); column 4, from DETCHEVA (1972a, 1975, 1983c; Bulgarian running waters, sample sizes not indicated); column 5, from PATRICK et al. (1967; 4 records from the Savannah River, USA)

Parameter ¹	Reference				
	1	2	3	4	5
Saprobity	2.3–3.7	2.3–3.0	-	o/a	-
Frequency (%)	-	-	-	0.87–2.1	-
Temperature (°C)	-	-	1.2–20.5	19.8–21	>8–20
pH	4.9–8.5	6.7–8.3	6.7–8	7.5–7.8	-
O ₂ (mg l ⁻¹)	1.2–9.5	6.5–9.5	1.2–17.6	5.6–9	7.0–<11
O ₂ (% saturation)	-	-	-	62–92	-
BOD ₅ (mg l ⁻¹)	0.4–41	0.4–2.6	-	1–15	0.5–<3
KMnO ₄ -consumption	-	-	-	7.2–38	-
NH ₄ ⁺ -N (mg l ⁻¹)	0–27	0–5.4	0.04–7.3	0.08–1	<0.009 ³
NO ₂ ⁻ -N (mg l ⁻¹)	0–67	0–3	0.01–0.8	0.94–2	<0.007
NO ₃ ⁻ -N (mg l ⁻¹)	10–99	-	0.38–13.4	0.11–3.3	>0.05–0.2
PO ₄ ³⁻ -P (mg l ⁻¹)	-	-	-	-	>0.003–0.017
Bacteria ml ⁻¹ (× 10 ⁶)	1.2–204 ²	1.2–90 ²	-	-	-

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

² Direct counting.

³ NH₃-N.

32), 0.9–91 mg l⁻¹ Cl⁻ (n = 16), 5–45 mg l⁻¹ SO₄²⁻ (n = 16), <0.01–0.25 mg l⁻¹ P_{total} (n = 32), 5–19 mg l⁻¹ COD (n = 12), <10–13 000 endotypical Coli per 100 ml (44 °C; n = 26; FOISSNER et al. 1991); pH 7.4, 8.2 mg l⁻¹ O₂ (80 % saturation), 45–57 mg l⁻¹ BOD₅, 5.5 mg l⁻¹ NH₃, 92 mg l⁻¹ nitrate and nitrite (JUSTYN 1960). STOUT (1956) found a survival time of 113 h at low oxygen levels (identification uncertain because “*Chlorella*” are present). REINNARTH (1979) recorded *T. pellionellum* in the sediment from -0.5 to -4 cm at a redox potential of +153 to -229 mV, pH 6.8–7.7, 3.2–15.0 mg l⁻¹ NH₄⁺-N, 0.9–2.5 mg l⁻¹ NO₃⁻-N. SCHMERENBECK (1975) found, under experimental conditions, that *T. pellionellum* is highly abundant at flowing velocities of 0.3–0.6 m s⁻¹, above all when mineralisation is completed; dominant in the aufwuchs community especially at high current velocities and high abundances of diatoms. Eurythermic (Tables 26, 27; BICK & BERTRAM 1973, ISSEL 1901, NISBET 1984, PRIMC 1983), however, according to WANG (1928) and MÜNCH (1970) low temperatures (up to 15 °C) were preferred. *Tachysoma pellionellum* survived a direct transfer from 6 to 43 °C and from 43 to 25 °C (SCHARF 1961). Lowest pH = 4.0 (BICK & DREWS 1973). BICK (1957) and HEUSS (1976) found it in polluted water bodies with up to 1.6 mg l⁻¹ hydrogen sulphide; however, the specimens were only 2.7 times as long as broad (usually about 3.5:1), indicating that these conditions are not favourable. Accord-

Table 28 Annual values of the abundance, the generation time, and the production of some populations of hypotrichous ciliates from two running waters in Germany (from SCHÖNBORN 1981, 1982). Species: column 1 = *Euplotes affinis*, column 2 = *E. charon*, column 3 = *E. patella*, column 4 = *Stylonychia mytilus* complex, column 5 = *Tachysoma pellionellum*, column 6 = *Uroleptus piscis*

Parameter	Species					
	1	2	3	4	5	6
Mean abundance	0.3	-	1.1	1.2	9.9	0.2
(ind. cm ⁻²) ¹	2.4	0.08	-	0.1	13.9	-
Mean abundance	134	-	1058	1648	31 811	419
(ind. m ⁻²) ¹	24 800	800	-	1700	139 000	-
Mean generation time (h) ¹	84.0	-	97.5	118.5	95.4	72.0
	88.0	72.0	-	258.0	106.2	-
Minimum generation	24	-	24	24	24	24
time (h) ¹	72	72	-	120	48	-
Maximum generation	120	-	120	360	240	120
time (h) ¹	88	72	-	258	106	-
Annual production	80	-	274	126	132	23
(ind. cm ⁻² y ⁻¹) ¹	386	23	-	10	3700	-
Annual production	9909	-	81 521	476 500	8 200 000	136 400
(ind. m ⁻² y ⁻¹) ¹	3 800 000	200 000	-	99 000	37 000 000	-
Mean biomass	0.0	-	0.52	0.71	1.06	0.19
(mg m ⁻²) ¹	0.79	0.06	-	0.70	4.84	-
Annual production	0.3	-	40.9	191.0	278	66.3
(mg m ⁻² y ⁻¹) ¹	121.6	17.7	-	39.8	1321	-
P/B ratio (a) ¹	75	-	79	269	262	348
	153	295	-	57	273	-
Food consumption	1	-	32	842	736	123
(mg m ⁻² y ⁻¹)	377	34	-	1021	10 302	-

¹ Upper line: Ammerbach, a brook near the village of Jena, Germany. Mean width = 163 cm, mean depth = 7.5 cm; current velocity at mean water = 0.55 m s⁻¹; mean water (MQ) = 34 l s⁻¹, annual mean of water temperature = +8.5 °C (minimum temperature about 4 °C, maximum temperature about 14 °C), O₂-saturation = 80–90 %, saprobic index according to ciliate community = 2.6. Lower line: Saale River near the village of Rothenstein, Germany. Width about 55 m, mean depth = 0.75 m, current velocity at MQ = 0.70 m s⁻¹, MQ about 29 m³ s⁻¹, minimum water temperature about 0 °C, maximum water temperature about 17 °C, O₂ = 8–10 mg l⁻¹, BOD₅ <6 mg l⁻¹, saprobic index = 2.5.

ing to WETZEL (1928b) H₂S is not tolerated. BICZÓK (1955a) studied the effect of root extracts of various plants on *T. pellionellum*. For the effect of carbonic acid, see NIKITINSKY & MUDREZOWA-WYSS (1930).

The saprobic classification of *T. pellionellum* is very diverse; it varies from beta-mesosaprobic (CURDS 1966b, FOISSNER 1979b, ŠRÁMEK-HUŠEK 1958) over alphameso-saprobic (for example, KOLKWITZ 1950, KOLKWITZ & MARSSON 1902, 1909, MARSSON 1903, MAUCH 1976) to alphamesosaprobic to polysaprobic (HEUSS & FRIEDRICH 1978, SLÁDEČEK 1969, SLÁDEČEK et al. 1981). The latter authors proposed the following saprobic valencies: a–p; o = 1, b = 2, a = 3, p = 4, I = 1, SI = 3.0. This classification, especially

Fig. 137 *Tachysoma pellionellum* (from HEUSS 1976). Distribution expressed as percentage of n records in the spectra of some physical and chemical factors. 1 = temperature, 2 = pH, 3 = specific conductivity, 4 = O_2 , 5 = O_2 saturation, 6 = BOD_5 , 7 = $KMnO_4$ -consumption, 8 = Cl^- , 9 = PO_4^{3-} , 10 = NH_4^+ .

the strong emphasis of the polysaprobity, does not match the autecological data (Tables 26, 27, Fig. 137) and most of the numerous records. However, there is no doubt that *T. pellionellum* has a rather wide saprobic range, which is indicated by records such as those by CURTIS (1969) and CURTIS & CURDS (1971), who found it rather frequently in the slime of sewage fungus, and KÜHN (1940), who recorded it from springs. HEUSS (1976) found it predominantly at BOD_5 values of $<9 \text{ mg l}^{-1}$ (Fig. 137). I found *T. pellionellum* mainly in running waters with saprobic indices from 1.7–2.6 (mean = 2.2; $n = 34$), and 2.2–2.5 ($n = 3$) if only records with high abundances are considered.

Thus, FOISSNER et al. (1991) suggested the following distribution: b-a; o = 1, b = 4, a = 4, p = 1, I = 1, SI = 2.5. This agrees largely with the classification by FRIEDRICH (1990; see also DIN 1990 and BERGER et al. 1997): b = 3, b-a = 12, a = 3, I = 8, SI = 2.1. The distributions proposed by BICK (1972a; b = 5, a = 5, i = 3) and MORAVCOVÁ (1977; b = 3, a = 7, I = 4, SI = 2.6) seem to stenosaprobic.

Tachysoma chilensis (BÜRGER, 1905) comb. nov. (Fig. 138a)

Fig. 138a *Tachysoma chilensis* (after BÜRGER 1905). Ventral view from life, 200 μ m; p 451.

Nomenclature and taxonomy: The rank of the name *chilensis* is sub-specific because it was published before 1961 (Article 45 g, ICZN 1985). Since a change in rank of the species group does not affect the authorship of the name of the taxon, BÜRGER (1905) is the author of this species (Article 50 c[i]). BÜRGER (1905) expressly mentioned that this large and flexible form has no caudal cirri; I thus transfer it to *Tachysoma*. Although some characters are not described (number of micronuclei, probably two or more because the macronuclear nodules are widely separated; dorsal cilia, probably short since BÜRGER did not draw them) it should be possible to identify this rather large species. Detailed redescription necessary.

Morphology: In life about $200 \times 64 \mu$ m. Left body margin convex, right concave, both ends rounded. Contractile. Cytoplasm anteriorly and posteriorly densely filled with small, greasily shining granules, right part with greasy globules. Adoral zone of membranelles about 35 % of body length. Dorsal cilia very likely short (see taxonomy).

Occurrence: Locus classicus is an irrigation canal in Santiago, Chile. Also recorded by CARBONELL (1935; as *Oxytricha chilensis* BÜRGER) in the River plate, Argentina.

***Tachysoma humicola* GELLÉRT, 1957 (Fig. 138b–e, 139a–f, Table 25)**

1957 *Tachysoma humicola* GELLÉRT, Annls Inst. biol. Tihany, 24: 20 (Fig. 139f).

1984 *Tachysoma humicola* GELLÉRT, 1957 – FOISSNER, Stapfia, 12: 121 (Fig. 139a–e; authoritative redescription; slides of neotype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1998 *Tachysoma humicola longisetum* FOISSNER, Europ. J. Protistol., 34: 226 (slides of type specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: The synonymisation of this terrestrial form with *T. bicirratum* as suggested by BORROR (1972a) is unjustified because *T. bicirratum* lives in the sapropel of freshwater and the posterior-most marginal cirri are enlarged and elongated. The rather superficially described limnetic *Oxytricha saltans* VUXANOVICI is somewhat reminiscent of the present species (Fig. 232o).

FOISSNER (1998) described the subspecies *Tachysoma humicola longisetum*, which differs from *T. humicola humicola* almost exclusively in that the posterior-most dorsal cilia are distinctly elongated (cp Fig. 138c, e with Fig. 139e). Thus, the following description matches both taxa unless otherwise indicated.

Fig. 138b–e *Tachysoma humicola longisetum* (from FOISSNER 1998. b, c, in life; d, e, protargol impregnation). b) Ventral view, about 40 μm . c) Dorsal view. Large arrow marks elongated, posterior-most dorsal cilia; small arrows denote an inconspicuous but rather invariably (see Fig. 138e) discontinuity in dorsal kinyt 3. d, e) Ventral and dorsal infraciliature and nuclear apparatus, 44 μm . Arrowhead in (d) denotes posterior-most cirrus of right marginal row. Note single micronucleus and prominent transverse cirri; p 452.

Fig. 139a–f *Tachysoma humicola humicola* (a–e, from FOISSNER 1984; f, after GELLÉRT 1957. a–c, from life; d, e, protargol impregnation; f, sublimate fixation and opalblue staining after BRESSLAU). a) Ventral view, 52 μm . b) Dorsal view of a backward moving specimen. c) Right lateral view. d–f) Ventral and dorsal infraciliature, d, e = 40 μm , f = 60 μm . Arrow in (d) marks right frontal cirrus, arrowhead points at posterior-most cirrus of right marginal row; p 452. **g** *Tachysoma balatonica* (after GELLÉRT & TAMÁS 1958). Ventral infraciliature, opalblue staining after BRESSLAU, 150 μm ; p 456. **h** *Tachysoma bicirratum* (from KAHL 1932). Ventral view from life, 60–90 μm ; p 457. **i** *Tachysoma terricola* (from HEMBERGER 1985). Ventral infraciliature and nuclear apparatus after protargol impregnation, 90 μm ; p 458.

Morphology and biology: Subspecies *T. humicola humicola* in life about $45\text{--}60 \times 15\text{--}20\text{ }\mu\text{m}$ (FOISSNER 1984), according to GELLÉRT (1957) $50\text{--}60\text{ }\mu\text{m}$ long, subspecies *longiseatum* in life about $40 \times 20\text{ }\mu\text{m}$ (FOISSNER 1998). Body margins in life usually parallel, after protargol impregnation, however, always broadly oval, that is, both ends broadly rounded. Rather flexible, but not conspicuously contractile. Macronuclear nodules usually slightly obliquely arranged about in mid-body, in life about $7\text{ }\mu\text{m}$ across, with many nuclei of various size. Usually 1, rarely 2 spherical micronuclei between macronuclear nodules, after protargol impregnation $1.6\text{--}2.8\text{ }\mu\text{m}$ across. Contractile vacuole during diastole with 2 collecting canals. Cortical granules absent. In posterior half of cell usually many "saturn-shaped", yellowish, $1.5\text{--}4.0\text{ }\mu\text{m}$ sized crystals. Movement characteristic: crawls a short distance then suddenly jerks back, whereby it is conspicuously curved (Fig. 139b).

Adoral zone of membranelles about 1/3 of body length. Bases of largest membranelles in life only $3\text{ }\mu\text{m}$ broad. Buccal area flat. Paroral only slightly curved, endoral short, straight, arranged beside paroral. Frontal and frontoventral cirri not enlarged. Invariably 5 thick, in life about $15\text{ }\mu\text{m}$ long transverse cirri; GELLÉRT (1957) drew only 4 transverse cirri; possibly he took the right transverse cirrus as right marginal cirrus. Remaining cirri about $8\text{ }\mu\text{m}$ long. Left transverse cirrus in life conspicuously spread to left, transverse cirrus VI/1 in life often slightly thicker than other transverse cirri. Two pre-transverse ventral cirri, right cirrus (VI/2) almost in gap between right transverse cirrus and posterior-most cirrus of right marginal row (Fig. 138d, 139d, arrowhead), which begins just at level of cytostome. Left marginal row terminates almost at posterior end. Dorsal kineties 1 and 4 slightly shortened anteriorly, kinety 4 only 1/3 of body length. Dorsal cilia in life $2\text{--}3\text{ }\mu\text{m}$ long, posterior-most cilia of subspecies *humicola* also $2\text{--}3\text{ }\mu\text{m}$ long, posterior-most cilia of subspecies *longisetum* about $10\text{ }\mu\text{m}$ long.

Occurrence and ecology: Widely distributed, but rather more rare than common in terrestrial habitats. Locus classicus (of *T. humicola* and *T. humicola humicola*) is the litter of a deciduous forest in Hungary (GELLÉRT 1957). FOISSNER (1984, 1987b) found *Tachysoma humicola* in the upper soil layer of a salt-steppe in the so-called "Hölle" in Seewinkel, Burgenland, Austria, and in the soil of a flood plain in the Fuschertal valley, Salzburg, Austria. Further records: spruce forest in Upper Austria (AESCHT & FOISSNER 1993); bark of *Acacia* trees and soil in Costa Rica (FOISSNER 1994c, 1995b); soil from flood plain primary (?) rain forest near Manaus, Brazil (FOISSNER 1997b); soil of the bush in the Brisbane Water National Park near Sydney and in the litter and root layer and under moss of a pine forest near Adelaide, Australia (BLATTERER & FOISSNER 1988). Locus classicus of *T. humicola longisetum* is the upper soil layer from the Shetani volcano in the Tsavo National Park, Kenya(?).

Feeds on bacteria, testate amoebas (*Trinema lineare*), and detritus (FOISSNER 1984, GELLÉRT 1957). Biomass of 10^6 individuals about 9 mg (FOISSNER 1987a).

***Tachysoma humicola humicola* GELLÉRT, 1957 (Fig. 139a–f, Table 25)**

1957 *Tachysoma humicola* GELLÉRT, Annls Inst. biol. Tihany, 24: 20 (Fig. 139f).

1984 *Tachysoma humicola* GELLÉRT, 1957 – FOISSNER, Stapfia, 12: 121 (Fig. 139a–e; authoritative redescription; slides of neotype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

R e m a r k s: Taxonomy, morphology, and ecology, see *T. humicola*. Differs from the second subspecies, *T. humicola longisetum* (see below), almost exclusively in that the posterior-most dorsal cilia are not elongated (Fig. 139e).

***Tachysoma humicola longisetum* FOISSNER, 1998 (Fig. 138b–e, Table 25)**

1998 *Tachysoma humicola longisetum* FOISSNER, Europ. J. Protistol., 34: 226 (Fig. 138b–e; slides of type specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

R e m a r k s: Taxonomy, morphology, and ecology, see *T. humicola*. Differs from the second subspecies, *T. humicola humicola* (see above), almost exclusively in that the posterior-most dorsal cilia are distinctly longer (about 10 µm) than the other cilia (2–3 µm; Fig. 138c, e). Detailed description of this subspecies, see FOISSNER (1998).

***Tachysoma balatonica* GELLÉRT & TAMÁS, 1958 (Fig. 139g)**

1958 *Tachysoma balatonica* GELLÉRT & TAMÁS, Annls Inst. biol. Tihany, 25: 229, 240.

T a x o n o m y: I have some doubt that this is a *Tachysoma* because the adoral zone is about 50 % of body length and the posterior postoral ventral cirrus is displaced distinctly posteriad, indicating that it belongs to the Stylonychinae (for example, *Histiculus*). The posterior-most marginal cirri are enlarged and elongated similarly to in *T. bicirratum*; however, this species is smaller, has only one micronucleus, and probably long dorsal cilia (Fig. 139h). Detailed redescription necessary; possibly better classified as species indeterminata.

M o r p h o l o g y: In life 130–140 µm long. Elliptical. Flexibility not mentioned (see also taxonomy). Each macronuclear nodule with a single micronucleus. Adoral zone of membranelles about 50 % of body length. About 41 adoral membranelles, 13 distal membranelles high, proximal membranelles low. Frontal, ventral, and transverse cirri distinctly enlarged. GELLÉRT & TAMÁS (1958) drew only 2 frontoventral cirri, which would be very unusual; presumable they omitted 2 cirri. Two pretransverse ventral and 5 fringed transverse cirri. Posterior-most cirrus of each marginal row conspicuously enlarged and

elongated. Dorsal cilia very likely short and inconspicuous because not mentioned by GELLÉRT & TAMÁS (1958).

Occurrence and ecology: Locus classicus is the eastern shore of Lake Balaton, Hungary, where GELLÉRT & TAMÁS (1958) discovered it in detritus drifts. GELLÉRT & TAMÁS (1959b) found it in the same biotope on the southern shore of this lake. Feeds on diatoms, according to GELLÉRT & TAMÁS (1959b, 1961) exclusively on *Navicula cryptocephala*, and small globular green algae.

Tachysoma bicirratum (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (Fig. 139h)

1932 *Tachysoma furcata* KAHL, Tierwelt Dtl., 25: 605 (Fig. 139h).

1972 *Tachysoma furcata* KAHL, 1932 – BORROR, J. Protozool., 19: 15.

1988 *Tachysoma furcatum* KAHL, 1932 – FOISSNER, Hydrobiologia, 166: 30 (emendation).

1991 *Oxytricha bicirrata* FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 302 (new name for *T. furcata* KAHL; see taxonomy).

1991 *Tachysoma bicirratum* (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 302 (see nomenclature).

Nomenclature and taxonomy: KAHL (1932) classified *Tachysoma* as subgenus of *Oxytricha*, so that the correct name in the original description is *Oxytricha (Tachysoma) furcata* KAHL, 1932. However, this is a junior primary homonym of *O. furcatus* SMITH, 1897b, which was emended to *O. furcata* by KAHL 1932. KAHL's (1932) species therefore required a new name (FOISSNER et al. 1991).

Tachysoma bicirratum differs from the somewhat doubtful *T. balatonica*, which also has two elongated posterior-most marginal cirri, in body size, number of micronuclei, and length of dorsal cilia.

Tachysoma furcata sensu GELEI (1954) has short dorsal cilia; furthermore, I believe that the elongated cirri at the posterior end of GELEI's (1954) specimens are caudal cirri, suggesting a classification in *Oxytricha* (see *O. pseudofurcata*, Fig. 53a, b). *Tachysoma bicirratum* should not be confused with *Oxytricha setigera* or *O. balladyna*, which also have a small size, long dorsal cilia, and a single micronucleus between the macronuclear nodules. Detailed redescription necessary.

Morphology: In life 60–90 µm long. Slender ovoid, especially anteriorly distinctly flattened. Adheres to substrate with elongated posterior-most marginal cirri during food gathering. All adoral membranelles conspicuously strong. Dorsal cilia delicate and soft.

Occurrence and ecology: Rare in the aufwuchs, detritus, and sapropel of freshwater habitats. Europe. After KAHL (1932) common but always only scattered in the

sapropel, according to FOISSNER (1979b) characteristic for eutrophic, temporal small water bodies.

Locus classicus not indicated (KAHL 1932). DINGFELDER (1962) found *Tachysoma bicirratum* in puddles with decaying plant material mainly during summer and in flooded meadows near Erlangen, Germany, sometimes up to 70 ind. ml⁻¹ (pH 7.0–7.4); possibly he confused it with a terrestrial form, for example, *T. humicola*. TAMÁS & GELLÉRT (1958) recorded *T. bicirratum* from the periphyton of the littoral stones of Lake Balaton, Hungary. Further records: Maritza River, Bulgaria (DETCHÉVA 1981); running waters in Czechoslovakia (BILÝ et al. 1952).

Feeds on bacteria (“Rhodobacteria”) and small algae (KAHL 1932). Biomass of 10⁶ individuals about 15 mg (FOISSNER et al. 1991). MADONI & GHETTI (1981a) observed *T. bicirratum* scattered in a betamesosaprobic to alphamesosaprobic portion of an Italian brook at 18–21 °C, pH 7.4–8.0, 440–470 µS cm⁻¹ specific conductivity, 8.3–9.7 mg l⁻¹ O₂, 11–13 mg l⁻¹ COD, 0.49–0.79 mg l⁻¹ NH₄⁺-N, 0.09–0.16 mg l⁻¹ NO₂⁻-N, 1.6–5 mg l⁻¹ NO₃⁻-N, and 0.1–0.18 mg l⁻¹ PO₄³⁻-P. DETCHÉVA (1983c) found it with low frequency (0.6 %) in the Maritza River, Bulgaria, under following conditions: b–a, pH 6.8–7.4, 3.4 to 10.1 mg l⁻¹ O₂, (39–89 % O₂ saturation), 12.5 mg l⁻¹ BOD₅, 50–69 mg l⁻¹ Ca²⁺, 0 to 19 mg l⁻¹ Mg²⁺, 91–293 mg l⁻¹ HCO₃⁻, 14–107 mg l⁻¹ SO₄²⁻, 8.5–23 mg l⁻¹ Cl⁻, 7–14 °dH, 0.03–0.05 mg l⁻¹ NH₄⁺, 1–1.5 mg l⁻¹ NO₃⁻, 0–0.02 mg l⁻¹ NO₂⁻, 0.03–0.05 mg l⁻¹ Fe²⁺.

Tachysoma bicirratum is classified as alphameso- to polysaprobic indicator of water quality (a–p; b = 2, a = 4, p = 4, I = 2, SI = 3.2; FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). This does not agree very well with the above mentioned habitats and autecological data, except with that of KAHL (1932), who found it in the sapropelic area. Since his record is the only one which is substantiated by an illustration, the classification is preliminarily accepted; however, it has to be verified on reliably determined populations.

Tachysoma terricola HEMBERGER, 1985 (Fig. 139i–n, Tables 3, 25)

1982 *Tachysoma terricola* HEMBERGER, Dissertation, p 257 (Fig. 139i–n).

1985 *Tachysoma terricola* HEMBERGER, Arch. Protistenk., 130: 414 (Fig. 139i; 1 slide of holotype-specimens is deposited in the Institut für landwirtschaftliche Zoologie of the University of Bonn, Germany).

Taxonomy: The present species is reminiscent of *T. pellionellum* as concerns body size and long dorsal cilia; however, they can be easily distinguished by the number of micronuclei and dorsal kineties, the beginning of morphogenesis, the habitat, and some minor differences in the infraciliature. Live observations necessary.

Morphology and biology: In life (?) 70–100 × 28–40 µm. Elliptical, slightly sloped posteriorly. Invariably 2 micronuclei. Cytoplasm granulated. Adoral zone of membranelles about 25 % of body length. Frontal cirri not enlarged. Marginal cirri about 12 µm long. Invariably 2 pretransverse ventral cirri and 5 enlarged, about 20 µm long

Fig. 139j–n *Tachysoma terricola* (from HEMBERGER 1982. j–n, morphogenetic stages after protargol impregnation). j) Very early stage showing the 4 oral primordia. k, l) Early stages. Note that all postoral ventral cirri are involved in primordia formation. m, n) These middle stages differ significantly from that of *T. pellionellum* in that no primary primordia are formed. OP = oral primordium; p 458.

transverse cirri, which are not as steeply arranged as in *T. pellionellum*. Three dorsal kineties of body length and 1 shortened kinety. Dorsal cilia about 10 µm long.

Morphogenesis commences with proliferation of basal bodies at four sites (Fig. 139j). Some middle stages show that no so-called primary primordia are formed as in *T. pellionellum*, indicating that *Tachysoma* is not monophyletic (Fig. 139k–n). This is supported by the fact that dorsal morphogenesis is in *Urosomoida* pattern (Fig. 24b) and not in *Tachysoma* pattern.

Occurrence and ecology: Locus classicus is the soil of a woodland in Peru. Not found since. Biomass of 10^6 individuals about 45 mg (FOISSNER 1987a).

Tachysoma granuliferum BERGER & FOISSNER, 1987 (Fig. 140a–e, Table 25)

1987 *Tachysoma granulifera* BERGER & FOISSNER, Zool. Jb. Syst., 114: 228 (Fig. 140a–e; 1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1988 *Tachysoma granuliferum* BERGER & FOISSNER 1987 – FOISSNER & FOISSNER, Catalogus Faunae Austriae, 1c: 92 (emendation).

Taxonomy: *Tachysoma granuliferum* can be easily distinguished from the other *Tachysoma* species by the conspicuous cortical granules. In life it may be confused with some species of *Cyrtohymena* (for example, *C. citrina*) because the colour and arrange-

Fig. 140a-e *Tachysoma granuliferum* (from BERGER & FOISSNER 1987a. a-c, from life; d, e, protargol impregnation). a-c) Ventral, right lateral, and dorsal view, a = 77 μ m, b, c = 80 μ m. The yellow to orange-yellow, about 0.5 μ m sized cortical granules are shown in (c) only. d, e) Ventral and dorsal infracapitulum, 55 μ m. Note the linear arrangement of frontoventral cirri (arrow) which is reminiscent of *Urosoma*; p 459.

ment of the granules are rather similar; furthermore, *Tachysoma granuliferum* has a peristomial lip simulating a *Cyrtohymena*-like oral apparatus.

M o r p h o l o g y a n d b i o l o g y: In life about $70\text{--}85 \times 25\text{--}35 \mu\text{m}$. Elliptical, both ends rounded. Macronuclear nodules after protargol impregnation $13 \times 6 \mu\text{m}$ on average, with small nucleoli. Constantly ($n = 11$) two, in life about $3 \times 2 \mu\text{m}$ sized micronuclei. Contractile vacuole with an anterior collecting canal. Cortical granules $0.5 \mu\text{m}$ across, yellow to orange-yellow, irregularly distributed in loosely arranged groups (Fig. 140c); in small, perhaps precystic specimens they are distinctly orange. Cytoplasm with some small crystals, many $2\text{--}5 \mu\text{m}$ sized homogenous globules, and food vacuoles. Rapid movement.

Adoral zone of membranelles about 35 % of body length, bases of largest membranelles in life about $6 \mu\text{m}$ broad, cilia of distal membranelles in life about $15 \mu\text{m}$ long. Buccal area small, deep, and rather distinctly curved anteriorly. Undulating membranes bent, superimposed anteriorly. Bases of frontal cirri only slightly enlarged. Frontoventral cirri arranged in a line. Invariably ($n = 11$) only 1 pretransverse ventral cirrus, arranged very close to the slightly enlarged, in life about $22 \mu\text{m}$ long transverse cirri. Marginal cirri in life about $15 \mu\text{m}$ long, going backward bases become smaller and distances between them become wider; marginal rows distinctly separated posteriorly. Dorsal cilia in life about $4 \mu\text{m}$ long; dorsal kinety 1 slightly shortened anteriorly (Fig. 140d, e).

O c c u r r e n c e a n d e c o l o g y: Very likely autochthonous soil species (FOISSNER 1987a). Locus classicus is an arable soil near Vienna, Austria. We found *Tachysoma granuliferum* also in an arable soil in Styria, Austria (FOISSNER et al. 1990). Feeds on amoebas and their cysts, fungal spores ($7 \times 2 \mu\text{m}$), green algae, and heterotrophic flagellates. Biomass of 10^6 individuals about 26 mg (FOISSNER 1987a).

Marine species

Tachysoma rigescens (KAHL, 1932) BORROR, 1972 (Fig. 141a–c)

1932 *Tachysoma* ? (ev. *Oxytricha*) *rigescens* KAHL, 1932, Tierwelt Dtl., 25: 605 (Fig. 141a).

1933 *Tachysoma rigescens* KAHL 1932 – KAHL, Tierwelt N.- u. Ostsee, 23: 113.

1967 *Tachysoma rigescens* KAHL, 1932 – ALADRO LUBEL & LÓPEZ-UCHOTERENA, Revta Soc. mex. Hist. nat., 28: 63 (Fig. 141b).

1972 *Tachysoma rigescens* KAHL, 1932 – BORROR, J. Protozool., 19: 15.

1990 *Tachysoma rigescens* KAHL, 1932 – ALADRO LUBEL, MARTÍNEZ MURILLO & MAYÉN ESTRADA, Manual de ciliados, p 139 (Fig. 141c; includes only data from ALADRO LUBEL & LÓPEZ-UCHOTERENA 1967).

N o m e n c l a t u r e a n d t a x o n o m y: KAHL (1932) classified *Tachysoma* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Tachysoma) rigescens* KAHL, 1932. I fix BORROR (1972a) as the author of the combination with

Fig. 141a-c *Tachysoma rigescens* (a, from KAHL 1932; b, from ALADRO LUBEL & LÓPEZ-OCHOTERENA 1967; c, from ALADRO LUBEL et al. 1990. a-c, from life). a-c) Ventral views, a = 160 μ m, b = 200 μ m, c = 175 μ m; p 461.

Tachysoma. Detailed description necessary, especially the lack of the caudal cirri has to be checked.

Morphology and biology: In life 150 to 180 $\times$ 30–40 μ m (KAHL 1932), according to ALADRO LUBEL & LÓPEZ-OCHOTERENA (1967) 175–260 $\times$ 39–55 μ m. Outline long elliptical, at level of buccal vertex slightly broadened. Moderately flattened dorsoventrally. Macronuclear nodules 17–23 $\times$ 9 μ m (ALADRO LUBEL & LOPEZ-OCHOTERENA 1967). Very likely two micronuclei (KAHL 1932). ALADRO LUBEL & LÓPEZ-OCHOTERENA (1967) described a 7 μ m sized contractile vacuole in the posterior end of the cell, which is very likely a misobservation. Ring-shaped cytoplasmic inclusions (“Reservekörper”). According to KAHL (1932) *Tachysoma rigescens* is easily recognisable because it often lies immobile on the detritus.

Adoral zone of membranelles about 1/3 of body length, extends far along right body margin. Marginal cirri short and strong, protrude beyond body margin only posteriorly. Five distinctly enlarged transverse cirri, protrude by 1/3 to 1/2 beyond posterior end of cell.

Occurrence and ecology: Locus classicus is Heligoland, Germany, where KAHL (1932) discovered *Tachysoma rigescens* in the betamesosaprobic detritus of a water tank. ALADRO LUBEL & LÓPEZ-OCHOTERENA (1967) found it in a brackish lagoon, Mandinga, near the port of Veracruz, Mexico (see also LÓPEZ-OCHOTERENA & ROURE-CANE 1970).

Records not substantiated by illustrations: with a frequency of 4.3 % in the mesopsammon of the Bulgarian coast of the Black Sea at 23–27.5 $^{\circ}$ C and 0.5 to 1.78 % salinity (DETCHIEVA 1977, 1980, 1982a, 1983d); sediment of the Caspian Sea (AGAMALIEV 1971); brackish waters in Spain (MARGALEF LÓPEZ 1945).

The records from a Donor water reservoir (ALEKPEROV 1989) and from agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988) are also not substantiated by illustrations and are very likely misidentifications.

Fig. 141d–i *Tachysoma dragescoi* (from SONG & WILBERT 1997. d, g–i, from life; e, f, protargol impregnation). d) Ventral view, 47 μm . e, f) Ventral and dorsal infraciliature, 36 μm . Arrow in (e) marks anterior end of right marginal row, arrowhead denotes anterior-most postoral ventral cirrus (cirrus IV/2). Tiny arrows in (f) denote very small micronuclei. g) Dorsal view showing long transverse cirri, which protrude distinctly beyond posterior body end, and short rows of cortical granules. h) Part of pellicle showing dorsal cilia and cortical granules about 1 μm across. i) Lateral view. BC = buccal cirrus, TC = transverse cirri.

***Tachysoma dragescoi* SONG & WILBERT, 1997 (Fig. 141d–i, Table 25)**

1997 *Tachysoma dragescoi* SONG & WILBERT, Europ. J. Protistol., 33: 58 (1 holotype and 2 paratype slides of protargol-impregnated specimens are deposited in the Laboratory of Protozoology, College of Fisheries, Ocean University of Qingdao, China).

Morphology and biology: In life about $40\text{--}50 \times 20\text{--}25 \mu\text{m}$. Outline elliptical to oval, shape and size of life specimens quite constant. Body rigid (which is not typical for a member of the Oxytrichinae and possibly due to the small size). Macronuclear nodules oval with large nucleoli, widely separated from each other; each nodule with 1 very small micronucleus (Fig. 141f). Contractile vacuole not present. Cytoplasm colourless and very transparent, with several to many large food vacuoles. Cortical granules in life

about 1 μm across, usually in groups of 2–4 and arranged in irregular lines (Fig. 141g, h); colour unfortunately not mentioned, possibly more or less colourless. Movement typically slow to medium-fast and continuous on bottom of Petri dish.

Adoral zone of membranelles about 33–40 % of body length, basis of largest membranelles about 5 μm wide. Buccal area very narrow. Endoral and paroral short and almost straight. Buccal cirri in front of undulating membranes. Frontoventral cirri in life 8–10 μm long. Arrangement of frontal-ventral-transverse cirri, see Figure 141e. Invariably ($n = 16$) 8 frontal, frontoventral, and buccal cirri, and 5 postoral and pretransverse ventral cirri; that is, in total 17 frontal-ventral-transverse cirri because invariably ($n = 16$) 4 transverse cirri present; transverse cirri distinctly enlarged, about 15–20 μm long, protrude distinctly beyond posterior end of cell, sometimes used as thigmotactic structures with which ciliate anchors to substrate. Marginal cirri distinctly separated posteriorly, right row begins slightly above mid-body (Fig. 141e, arrow). Dorsal kinetics as long as body, cilia in life about 3–4 μm long.

Occurrence and ecology: Marine. Locus classicus is Taipingjiao (the Peace Cape) of Qingdao, China, where SONG & WILBERT (1997) discovered *T. dragescoi* in a eutrophic pond used for storing marine shellfish in mid-October, using a polyurethane foam unit for collecting. Feeds on flagellates and bacteria.

Tachysoma ovata SONG & WILBERT, 1997 (Fig. 141j–q, Table 25)

1997 *Tachysoma ovata* SONG & WILBERT, Europ. J. Protistol., 33: 55 (1 holotype and 2 paratype slides of protargol-impregnated specimens are deposited in the Laboratory of Protozoology, College of Fisheries, Ocean University of Qingdao, China).

Morphology and biology: In life about $35\text{--}50 \times 20\text{--}30 \mu\text{m}$. Delicate and slightly contractile. Outline elliptical, that is, both ends usually slightly narrowed (Fig. 141j, o), although shapes as shown in Figures 141l, m not seldom observed. Slightly twisted due to spiral arrangement of marginal cirral rows (Fig. 141l, m). Ventral side slightly concave (Fig. 141k). Macronuclear nodule closely spaced, with few large nucleoli, always lying left of median. One large micronucleus between macronuclear nodules (Fig. 141p, q). No contractile vacuole to be recognised. Cytoplasm colourless, packed with 2–3 μm sized, shining granules and several food vacuoles. Cortical granules ellipsoid, about 1.2–1.5 μm long, sparse and irregularly arranged either singly or in pairs and not in distinct lines (Fig. 141l–o). Movement typically slow and continuous on bottom of Petri dish.

Adoral zone of membranelles 40–50 % of body length (which is rather long for a member of the Oxytrichinae), bases of largest membranelles (in life?) about 5 μm wide. Buccal area very narrow; paroral and endoral of usual length, slightly curved. Cirri usually associated with pronounced argyrophilic fibres. Frontoventral cirri in life about 8–10 μm long. Arrangement of frontal-ventral-transverse cirri, see Figure 141p. Invaria-

Fig. 141j–o *Tachysoma ovata* (from SONG & WILBERT 1997. j–o, from life). **j)** Ventral view, 35 μm . **k)** Left lateral view showing concave ventral surface (arrow). **l, m)** Ventral views showing arrangement of cortical granules and variability of body shape. Note furrows caused by spiral marginal cirral rows. **n, o)** Part of pelticle and dorsal view (35 μm) showing ellipsoid, 1.2–1.5 μm long, cortical granules and arrangement of dorsal cilia; p 464.

bly ($n = 16$) 8 frontal, frontoventral, and buccal cirri and 5 postoral ventral and pretransverse ventral cirri, that is, a typical 18-cirri oxytrichid, because invariably ($n = 16$) 5 transverse cirri present (Table 25). Postoral ventral and pretransverse ventral cirri not distinctly separated (Fig. 141p). Transverse cirri in life about 12 μm long, protrude only slightly beyond posterior end of cell. Marginal rows distinctly spiral and widely separated posteriorly. Right marginal cirral row beginning dorsally near anterior end of cell, terminating close to rightmost transverse cirrus. Left marginal cirral row curved from ventral to dorsal side, making nearly a half turn to posterior end of cell (Fig. 141p, q). Three complete dorsal kineties each with only 4–6 pairs of widely spaced basal bodies, some in-

Fig. 141p, q *Tachysoma ovata* (from SONG & WILBERT 1997. p, q, protargol impregnation). p) Ventral infraciliature and nuclear apparatus, 34 μ m. Tiny arrows mark frontoventral cirri, which are not distinctly separated from postoral ventral cirri. Arrowhead denotes right frontal cirrus. q) Dorsal infraciliature and nuclear apparatus, 34 μ m. Arrow denotes micronucleus; p 464.

dividual basal body pairs in anterior half of cell; cilia in life about 4–5 μ m long (Fig. 141q).

Occurrence and ecology: Marine. Locus classicus is Taipingjiao (the Peace Cape) of Qingdao, China, where SONG & WILBERT (1997) discovered *T. ovata* in the open water (salinity 32 ‰, pH 8.1–8.3, 5–13 °C) in early December, using a polyurethane foam unit for collecting. Feeds on diatoms and flagellates.

Species indeterminata

Tachysoma parvistylum STOKES, 1887, Ann. Mag. nat. Hist., 20: 109 (Fig. 225a). Remarks: The body shape, the arrangement of the cirri, and especially the single macronuclear nodule indicate a misobservation; perhaps a postconjugant of another species. KAHL (1932, p 605) considered this form as valid (*T. parvistyla*); the correct name in his revision is *Oxytricha (Tachysoma) parvistyla* because he classified *Tachysoma* as subgenus of *Oxytricha*. In life about 63 μ m long; pyriform; colourless; 20 frontal, ventral, and

transverse cirri in a very unusual arrangement; contractile vacuole in about mid-body; dorsal cilia short; rapid movement. Locus classicus is a shallow pool near Trenton in New Jersey, USA. Further records from freshwater habitats: Greece (STEPHANIDES 1948); Italy (MADONI & GHETTI 1977); Latvian rivers (LIEPA 1978); China (SHEN 1980); USA (BOVEE 1960, CAIRNS & YONGUE 1973a, EDMONDSON 1920, MURRAY 1974, RUTHVEN 1972, WANG 1928); Antarctica (HAWTHORN & ELLIS-EVANS 1984). DETCHEVA (1979c, 1981, 1983c) provided some autecological data of this unreliable species. According to CURDS (1975), *Tachysoma parvistylum* occurs also in activated sludge. AGAMALIEV (1975) recorded it from the west coast of the Central Caspian.

Insufficient redescriptions

Unless otherwise indicated, the following taxa are very poorly described and/or illustrated or the habitats do not match (especially the terrestrial records of *T. pellionellum*), so that the identifications cannot be accepted.

Oxytricha agilis STOKES – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 225f). Remarks: Freshwater habitats in Connecticut, USA.

Oxytricha parvistyla STOKES – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 225b, c). Remarks: Freshwater habitats in Connecticut, USA.

Oxytricha pellionella (O. F. M) EHRLG. – BRODSKY & YANKOWSKAYA, 1929, Acta Univ. Asiae mediae, 6: 33 (Fig. 226f). Remarks: Incorrect subsequent spelling. Two micronuclei. Soil from Central Asia.

Oxytricha pellionella, EHR. – BELTRAN, 1928, Mems Revta Soc. cient. 'Antonio Alzate', 49: 133 (Fig. 228c). Remarks: In life 70–110 × 35–66 µm. Two micronuclei. Lake Xochimilco, Mexico.

Oxytricha pellionella – DUJARDIN, 1841, Zoophytes, p 417, Planche 11, fig. 10. Remarks: STEIN (1859b) already mentioned the insufficiency of this drawing.

Oxytricha pellionella – QUENNERSTEDT, 1865, Acta Univ. lund., 2: 58 (Fig. 225n). Remarks: Freshwater habitats in Sweden (see also QUENNERSTEDT 1869).

Oxytricha pellionella – SMITH, 1978, Scient. Rep. Falkld Isl. Depend. Surv., No. 95: 75, 77 (Fig. 225m). Remarks: Edaphic habitats in Antarctica.

Oxytricha pellionella EHRENBERG – BUISÁN, 1944, Publins Inst. Biol. apl., 1: 20 (Fig. 233d). Remarks: Among *Cladophora* and *Spirogyra* in freshwater habitats near Barcelona, Spain.

Oxytricha pellionella MÜLL. – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 60 (Fig. 225i). Remarks: Freshwater habitats in Connecticut, USA.

Oxytricha pellionella MÜLL. – EDMONDSON, 1906, Proc. Davenport Acad. Sci., 11: 100 (Fig. 234i). Remarks: Freshwater habitat in Iowa, USA.

Oxytricha pellionella MÜLL. – FELLERS & ALLISON, 1920, Soil Sci., 9: 9 (Fig. 225r). Remarks: Soils near New Brunswick, New Jersey, USA.

Oxytricha pellionella, MÜLL. – KOFFMAN, 1926, Acta zool., Stockh., 7: 310, Fig. 87. Remarks: Garden soil near Stockholm, Sweden.

Oxytricha pellionella MÜLLER – SAMANO & SOKOLOFF, 1931, Monografias Inst. Biol. Univ. nac. Mex., 1: 34 (Fig. 225g). Remarks: Pond in Mexico.

Oxytricha pellionella MULL. – SMITH, 1914, Kans. Univ. Sci. Bull., 9: 166 (Fig. 233g). Remarks: In life 86–160 µm long. Two micronuclei. Possibly an *Oxytricha*. Infusion of hay and leaves in Kansas, USA.

Oxytricha pellionella MULLER – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 50 (Fig. 242d). Remarks: Pond in Nanking, China.

Oxytricha pellionella (O. F. MÜLL) EHR. – BIERNACKA, 1959, Polskie Archwm Hydrobiol., 5: 54, 57 (Fig. 225t). Remarks: Perhaps a *Sterkiella histriomuscorum*. Sewage-treatment plant in Danzig, Poland.

Oxytricha pellionella STEIN, 1859 – LEPINIS, GELTZER, TSCHIBISOVA & GEPTNER, 1973, Key to soil protozoa, p 155 (Fig. 225j). Remarks: Soil in the USSR.

Tachysoma (Oxytricha) pellionella (MÜLLER-STEIN) – SOKOLOFF & ANCONA, 1937, An. Inst. Biol. Univ. Méx., 8: 175 (Fig. 234j). Remarks: Drinking water from towns in Mexico.

Tachysoma parvistyla STOCK. – CHARDEZ, 1971, Revue verviét. Hist. nat., 28: 38 (Fig. 234n). Remarks: Freshwater habitat in Belgium.

Tachysoma parvistyla STOKES – LUNDIN & WEST, 1963, Free-living protozoa, p 67 and WEST & LUNDIN, 1963, Pap. Mich. Acad. Sci., 48: 108 (Fig. 225d). Remarks: The outline does, in fact, remind of the STOKES (1887) drawing (see Fig. 225a). The macronucleus of the present form, however, obviously consists of several nodules. Freshwater habitats in the Upper Peninsula of Michigan, USA.

Tachysoma pellionella (O. F. MÜLLER, 1786) – ALADRO LUBEL, MARTÍNEZ MURILLO & MAYÉN ESTRADA, 1990, Manual de ciliados, p 138 (Fig. 241d). Remarks: Dorsal cilia rather short. Marine habitats in Mexico.

Tachysoma pellionella – FERNÁNDEZ-LEBORANS & CASTRO DE ZALDUMBIDE, 1985, Microbios, 42: 225, Fig. 1–11. Remarks: Two micronuclei. Soil near Madrid, Spain. Morphogenesis very insufficiently described.

Tachysoma pellionella (MÜLLER-STEIN) – LOUSIER & BAMFORTH, 1990, Soil protozoa, p 129, Fig. 6.29g. Remarks: Soil of North America.

Tachysoma pellionella MÜLLER-STEIN – ROSA, 1957, Lesn. Čas., 3: 228, 235, 236 and ROSA, 1957, Přírodov. Sb. ostrav. Kraje, 18: 45 (Fig. 233a, c). Remarks: Soil of woodland in Czechoslovakia.

Tachysoma pellionella – TCHANG, PANG & GU, 1984, Zool. Res., 5: 189 (Fig. 232j, k). Remarks: The following characters indicate that this form is not identical with *T. pellionellum*: (i) the bases of the transverse cirri are not distinctly enlarged; (ii) the number of marginal cirri is distinctly higher; (iii) the frontoventral cirri and the dorsal kineties are differently arranged; and (iv) the morphogenesis deviates from the description by HEMBERGER (1982), who determined the species correctly (Fig. 135h–o). Furthermore, TCHANG et al. (1984) did not figure the nuclear apparatus and the length of the dorsal cilia, the most important characters for a reliable identification of *T. pellionellum* (however, the Chinese text was not translated, so that I cannot exclude that these two characters are mentioned there!). China.

Tachysoma sp. – LEPSI, 1957, Trav. Mus. Hist. nat. Gr. Antipa, 1: 90 (Fig. 225e). Remarks: LEPSI (1957) found this unreliable form in a mesosaprobic culture with roots from a mountain lake in Romania. According to him, perhaps a “form” of *T. pellionellum* or an unknown species which could not be studied sufficiently. In life $70 \times 20 \mu\text{m}$, both ends rounded. Only one (!) ellipsoidal macronuclear nodule in mid-body. The 3 left transverse cirri are longer than the 2 right ones, which have a knob (?) at their posterior end.

Tachysoma sp. – LEPSI, 1965, Protozoologie, p 736 (Fig. 241c). Remarks: In life 100–160 μm long. No description. Romania?

***Australocirrus* BLATTERER & FOISSNER, 1988**

1988 *Australocirrus* BLATTERER & FOISSNER, Stapfia, 17: 65 – Type (original designation): *Australocirrus oscitans* BLATTERER & FOISSNER, 1988.

1997 *Australocirrus* BLATTERER & FOISSNER, 1988 – BERGER & FOISSNER, Arch. Protistenk., 148: 145.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles formed like a question mark. Undulating membranes curved, not distinctly intersecting. Frontoventral cirri form V-shaped pattern. Postoral ventral cirri behind buccal vertex. Two pretransverse ventral and 5 transverse cirri. One right and 1 left row of marginal cirri. More than 6 dorsal kineties. Caudal cirri present. Dorsal morphogenesis in *Oxytricha* pattern, however, more than 2 dorsomarginal kineties and kinety 3 not with simple, but with multiple fragmentation.

T a x o n o m y: The characterisation is according to BERGER & FOISSNER (1997); for detailed description of patterns mentioned, see chapter 2 in the general section. BLATTERER & FOISSNER (1988) included two species, namely *A. oscitans* (type) and *A. octonucleatus*. Both show multiple fragmentation of dorsal kinety 3, but differ significantly in body flexibility. In the very flexible *A. oscitans*, cirrus V/3 is involved in primordia formation (W. FOISSNER, unpubl. data; see also BERGER & FOISSNER 1997), supporting the classification in the Oxytrichinae. Conversely, the body of *A. octonucleatus* is rigid, suggesting that it is not the sister group of *A. oscitans*. I thus transfer *A. octonucleatus* to a new taxon (*Rigidocortex*) belonging to the Stylonychinae. Multiple fragmentation of dorsal kineties occurs also in the rigid taxa *Pattersoniella*, *Laurentiella*, and *Onychodromus*, and in the flexible *Territricha*, indicating parallel evolution of this character. The large oral apparatus of *A. oscitans* does not match the basic pattern of the flexible oxytrichids, where the adoral zone is usually only 1/3 of body length; possibly, this is a further apomorphy (beside the multiple fragmentation of dorsal kinety 3) of *Australocirrus*.

Single species***Australocirrus oscitans* BLATTERER & FOISSNER, 1988 (Fig. 142a–j, Table 29)**

1988 *Australocirrus oscitans* BLATTERER & FOISSNER, Stapfia, 17: 66 (the slide of holotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

T a x o n o m y: At superficial live observation *A. oscitans* can be confused with *Holosticha stueberi* FOISSNER, 1987b (mid-ventral cirri present), which also has a very large buccal area; furthermore, the resting cysts are very similar. *Oxytricha longissima* has more marginal cirri and only 5 dorsal kineties (no multiple fragmentation).

Fig. 142a-e *Australocirrus oscitans* (from BLATTERER & FOISSNER 1988. a-c, in life; d, e, protargol impregnation). a, c) Ventral views, a = 260 μ m. The large oral apparatus suggested the species name *oscitans* (= yawning). b) Right lateral view. d, e) Ventral and dorsal infracapitulum, d = 205 μ m, e = 165 μ m. Arrow marks distal end of adorad zone of membranelles. Arrowhead denotes posterior ventral cirrus V/3 which is involved in primordia formation; the latter character and the flexible body strongly indicate that *A. oscitans* belongs to the Oxytrichinae although the adorad zone is exceptionally long, as in members of the Stylonyehinae; p 470.

Fig. 142f-h Cyst of *Australocirrus oscitans* (original micrographs, kindly supplied by W. FOISSNER. f-h, Normarski differential interference contrast). **f)** Total view, diameter about 70 μm . **g)** Conspicuous crystals in wall. **h)** Cyst wall; p 470.

M o r p h o l o g y a n d b i o l o g y: In life 180–260 $\times$ 80–120 μm . Broad elliptical, that is, both ends broadly rounded, right and left body margin almost straight to slightly convex, body usually slightly converging posteriorly. Flexible like, for example, *Oxytricha granulifera*, flattened about 2:1, ventral side plain, dorsal convex. Invariably two ($n = 10$) ellipsoidal macronuclear nodules, in life about 31–48 $\times$ 17–23 μm , arranged slightly left of median; numerous small spherical nucleoli. Usually 2, sometimes 3, in life about 7–8 $\times$ 6–7 μm sized micronuclei adjacent to macronuclear nodules. Contractile vacuole in about mid-body, during diastole often with conspicuous, bulbous collecting canals. Pellicle colourless, distinct cortical granules lacking. Endoplasm densely granulated, with moderately many, 1–5 μm sized, greasily shining globules and about 8 μm sized cytoplasmic crystals. Movement rapid.

Adoral zone of membranelles about 45 % or more of body length, makes a 3/4 turn (Fig. 142d). Buccal area very broad. Bases of largest membranelles in life about 22 μm broad, distance between adoral membranelles conspicuously large. Undulating membranes distinctly curved, arranged almost in parallel but widely separated, intersecting at proximal end, both membranes probably consist of 2 rows of basal bodies each. Invariably ($n = 10$ –11) 18 frontal-ventral-transverse cirri. Frontal cirri arranged almost longitudinally, distinctly enlarged, in life about 30–40 μm long. Buccal cirrus immediately left of right frontal cirrus, about in middle of paroral (Fig. 142d). Postoral ventral cirrus V/3

Fig. 142i, j *Australocirrus oscitans* (original photomicrographs, kindly supplied by W. FOISSNER. i, j, protargol impregnation). i) Ventral infraciliature of a late morphogenetic stage. Large arrows mark caudal cirri at new dorsal kineties 1, small

arrow denotes new transverse cirrus VI/1 of opisthe, and arrowhead marks dorsomarginal kineties of opisthe. j) Multiple fragmentation of dorsal kinety 3; p 470.

displaced distinctly posteriad (Fig. 142d) but, nevertheless, involved in primordia formation (see taxonomy of genus section). Transverse cirri distinctly enlarged, arranged in hook-shape, displaced distinctly anteriad and thus not protruding beyond posterior end of cell (Fig. 142a). Ventral and marginal cirri in life about 25 μ m long. Marginal rows almost confluent posteriorly; right marginal row shortened anteriorly, that is, terminates beside frontoventral cirrus VI/3. Dorsal kineties 1 and 2 of about body length; fragments of

Table 29 Morphometric data of *Australocirrus oscitans* (from BLATTERER & FOISSNER 1988). All data are based on protargol impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	208.7	16.8	8.1	190	250	10
Body, width	82.6	5.7	6.9	72	90	10
Macronuclear nodule, length	27.3	4.0	14.6	20	32	10
Macronuclear nodule, width	14.3	2.1	14.8	12	18	10
Micronuclei, number	2.1	0.3	14.4	2	3	11
Micronucleus, length	6.7	0.7	10.4	6	8	10
Micronucleus, width	4.8	0.3	6.3	4.5	5.3	10
Adoral zone of membranelles, length	89.4	2.6	2.9	85	94	10
Adoral membranelles, number	34.1	1.4	4.3	33	38	10
Right marginal row, number of cirri	21.2	0.9	4.3	20	23	10
Left marginal row, number of cirri	22.7	1.5	6.6	21	26	10

kinety 3 rather irregularly arranged in left half (in dorsal view) of cell (Fig. 142e). During morphogenesis 3 dorsal primordia and more than 2 (3–5) dorsomarginal kineties occur in both proter and opisthe (Fig. 142i). Dorsal cilia about 3 µm long. Three caudal cirri, one each at posterior end of kineties 1 and 2 and at posterior-most fragment originating from kinety 3 (Fig. 142j); sometimes (2 of 15 specimens) 4 caudal cirri.

Cyst spherical, about 70–80 µm across (Fig. 142f). Wall smooth, with a bluish shimmer, about 5 µm thick, consists of many thin layers. In the wall many conspicuous, about 2 µm sized crystals with 6 regularly arranged arms, each with an distinct knob at its distal end (Fig. 142g, h). Mucous layer lacking.

Occurrence and ecology: Locus classicus is the Royal National Park south of Sydney, Australia, where BLATTERER & FOISSNER (1988) discovered *A. oscitans* in the upper soil layer (0–5 cm; pH 4.5) with much litter and brown sand of a woodland (“bush”). Further records: soil (0–8 cm, pH 5.1) from black-water inundation primary (?) rain forest on Anavilhanas archipelagos in the Rio Negro, Brazil (FOISSNER 1997b); light brown soil mixed with much leaf litter (pH 6.2) from Amazonian rain forest near Iquitos, Peru (FOISSNER 1997b); soil from South Africa (W. FOISSNER, pers. comm.).

Feeds on fungal spores, testaceans (*Euglypha* sp., *Trinema lineare*), ciliates (*Colpoda* sp., *Blepharisma hyalinum*), heterotrophic flagellates, and small green algae. Biomass of 10⁶ individuals about 570 mg.

Onychodromopsis STOKES, 1887

- 1887 *Onychodromopsis* STOKES, Ann. Mag. nat. Hist., 20: 107 – Type (by monotypy): *Onychodromopsis flexilis* STOKES, 1887.
- 1888 *Onychodromopsis*, STOKES – STOKES, J. Trenton. nat. Hist. Soc., 1: 280.
- 1932 *Onychodromopsis* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 620.
- 1974 *Onychodromopsis* STOKES – STILLER, Fauna Hung., 115: 107.
- 1985 *Onychodromopsis* – SMALL & LYNN, Ciliophora, p 458.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes short, straight, and arranged almost side by side. Frontoventral cirri in short transverse row or lacking. Postoral ventral cirri in longitudinal row right of buccal vertex. Usually 2 pretransverse ventral and 5 transverse cirri. Two or more (marginal and frontoventral) cirral rows right of median and 2 left rows of marginal cirri. Caudal cirri (very likely) present.

Nomenclature and taxonomy: “*Onychodronum* sp.” in BUCHHOLZ & BUCHHOLZ (1974, p 251) is likely an incorrect subsequent spelling of *Onychodromopsis* or *Onychodromus*.

The taxonomy of *Onychodromopsis* is rather complicated. It was accepted by KAHL (1932), STILLER (1974b), CORLISS (1979), and TUFFRAU (1987), but was differently classified. CORLISS (1979), for instance, mentioned it as incertae sedis in the Sporadotrichina, whereas TUFFRAU (1987) classified *Onychodromopsis* in the Holostichidae. BÜTSCHLI (1889), BORROR (1972a, p 14), and CURDS et al. (1983) synonymised it with *Pleurotricha*, which has, however, a rigid body and a different cirral pattern.

PETZ & FOISSNER (1996) redefined *Onychodromopsis*, identifying their Sub-Antarctic population, which has a typical *Oxytricha* cirral pattern (Fig. 92h), with the type, *Onychodromopsis flexilis* (Fig. 143a). They assumed that the illustrations by STOKES (1887b, 1888; Fig. 143a, b), KAHL (1932; Fig. 143c), and SMALL & LYNN (1985; Fig. 143d) lack some frontoventral cirri and are thus very likely incomplete, or, more likely, influenced by STOKES’ (1887b) figure. Thus, and in the absence of any type material, PETZ & FOISSNER (1996) fixed their population as neotype of *Onychodromopsis*.

By contrast, I consider the original description of *O. flexilis* as more or less correct because (i) STOKES usually made rather detailed and accurate descriptions, (ii) the protargol stained *Onychodromopsis* sp. in SMALL & LYNN (1985; Fig. 143d) matches the figure in STOKES (1888; Fig. 143a) in every detail (thus it is incomprehensible that they did not identify their population as *O. flexilis*), (iii) the STOKES (1887b) and SMALL & LYNN (1985) populations are very likely from the same geographic area, namely North America, whereas the PETZ & FOISSNER (1996) populations are Sub-Antarctic, and (iv) *Paraurostyla viridis* sensu PÄTSCH (1974) has almost the same infraciliature as *O. flexilis* (see below), indicating that this cirral pattern is not a misobservation as supposed by PETZ & FOISSNER (1996). The protargol-impregnated specimen has rather short and straight undulating membranes (Fig. 143d); possibly the reason STOKES (1887b) did not illustrate

these structures, although he wrote “peristome about one third as long as the body, the inner or right-hand margin bearing a large and, in lateral view, conspicuous membrane”.

Accordingly, *O. flexilis* sensu PETZ & FOISSNER (1996) and some other taxa classified with *Onychodromopsis* (for example, *Pleurotricha variabilis* REUTER) by these authors have to be removed from *Onychodromopsis*. Since all have a typical *Oxytricha* cirral pattern, I reactivate *Allotricha* STERKI (for details, see there). *Parurosoma* also has more than 2 marginal rows, but the frontoventral cirri are arranged as in *Urosoma*, that is, in a line. *Apoamphisiella* has 2 frontoventral rows and lacks distinct pretransverse ventral cirri.

Two further *Onychodromopsis* species have been described, namely *O. kahli* and *O. tihanyiensis*. The latter species is described in detail by FOISSNER (1997b) and transferred to *Apoamphisiella* (see p 782). Both species now included in *Onychodromopsis* have to be redescribed in detail. I have no idea about the phylogenetic relationships, that is, the sister-group of *Onychodromopsis*. It is included in this book because it can be easily confused with some taxa (for example, *Allotricha*, *Parurosoma*) which unequivocally belong to the flexible oxytrichids.

Key to species

Identifications of these little-known species should be substantiated by protargol impregnation. For flexible oxytrichids with more than two cirral rows, see also *Allotricha*, *Parurosoma*, *Paraurostyla*, *Apoamphisiella* or even *Gastrostyla*.

- 1 3–4 distinctly enlarged frontoventral cirri (including buccal cirrus) behind the 3 frontal cirri (Fig. 143a, d) *Onychodromopsis flexilis* (p 476)
- Only 1 enlarged cirrus (= buccal cirrus?) behind the 3 frontal cirri (Fig. 143e)
..... *Onychodromopsis kahli* (p 478)

Onychodromopsis flexilis STOKES, 1887 (Fig. 143a–d)

1887 *Onychodromopsis flexilis* STOKES, Ann. Mag. nat. Hist., 20: 107 (Fig. 143a).

1888 *Onychodromopsis flexilis*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 280 (Fig. 143b).

1932 *Onychodromopsis flexilis* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 620; in part: Fig. 113₁ = redrawing from STOKES 1888 (Fig. 143c); not Fig. 110₈ (see *O. kahli*).

1985 *Onychodromopsis* sp. – SMALL & LYNN, Ciliophora, p 458 (Fig. 143d).

Taxonomy: See relevant chapter in genus section for complicated taxonomy. BORROR (1972a) synonymised *Onychodromopsis flexilis* with *Pleurotricha grandis*, which has, however, a larger, rigid body and a different cirral pattern. The KUSANO (1985) and LUNDIN & WEST (1963; Fig. 223b) populations are insufficiently redescribed. Detailed redescription necessary. *Onychodromopsis kahli* (Fig. 143e, f; see below) is possibly a junior synonym. *Onychodromopsis flexilis* sensu PETZ & FOISSNER (1996) is the authoritative description of *Allotricha antarctica*.

Fig. 143a–d *Onychodromopsis flexilis* (a, b, from STOKES 1887b, 1888; c, after STOKES 1888 from KAHL 1932; d, from SMALL & LYNN 1985. a–c, from life; d, protargol impregnation). a–c) Ventral view, 125 μ m. The illustration by STOKES (1888) differs from the original (a) in that the frontal-ventral-transverse cirri are enlarged and in that the transverse cirri are distinctly separated from the inner left marginal row. It is unknown if these alterations are only due to redrawing, or if STOKES (1888) made use of new observations. d) Ventral infraciliature, 120 μ m. Note that the cirral pattern matches the original illustration exactly; p 476.

Fig. 143e, f *Onychodromopsis kahli* (e, from KAHL 1932; f, from ŠRAMEK-HUŠEK 1957). Ventral views in life, e = 120 μ m, f = 130 to 180 μ m. Note single cirrus (= buccal cirrus?) at anterior end of undulating membranes; p 478.

M o r p h o l o g y: In life about 90–130 μ m long, about 1/3 as broad as long; after protargol impregnation 120 μ m long. Soft and flexible. Elliptical, that is, both ends rounded. Two ellipsoidal macronuclear nodules near left body margin, in either anterior or posterior body-half. Contractile vacuole in about mid-body. No cortical granules mentioned.

Adoral zone of membranelles about 1/3 of body length. Undulating membranes not illustrated (Fig. 143a, b) but mentioned in the text by STOKES (1887b, 1888; see taxonomy chapter in the genus section); according to SMALL & LYNN (1985; Fig. 143d) inconspicuous, that is, short and more or less straight. Buccal area narrow. Three distinctly enlarged frontal cirri, somewhat behind (about at level of anterior end of undulating membranes) 3 transversely arranged cirri; the left one is very likely the buccal cirrus. Three or 2 longitudinally arranged postoral ventral cirri, anterior one possibly always slightly in front of level of buccal vertex (Fig. 143a, d). Two or 3 longitudinally arranged pretransverse ven-

tral cirri. Five transverse cirri, often furcate or fimbriate, protrude beyond posterior end of cell. The almost "transverse" arrangement of the transverse cirri is rather unusual, but of course not impossible! Cirri of outermost marginal rows longest and strongest. Left outer cirral row almost overlapping on right margin, possibly posterior-most cirri of this row are caudal cirri. Dorsal cilia "short" (that is, likely 2–4 μm).

Occurrence and ecology: Obviously very rare; possibly confined to freshwater. Locus classicus is a *Lemna* pond in the USA, probably near Trenton, New Jersey, where STOKES lived and worked. SMALL & LYNN (1985) mentioned no sample site, but very likely they also found *Onychodromopsis flexilis* in North America. Further records from the USA, which are, however, not substantiated by illustrations: Conestoga River Basin in Lancaster County, Pennsylvania (CAIRNS 1965a); Douglas Lake Region, Michigan (CAIRNS & YONGUE 1966); Copper Creek, Colorado (CAIRNS & YONGUE 1973b); predominantly in cold sites (2–3 °C) of limestone waters in Kentucky (GITTLESON & FERGUSON 1971).

PATRICK et al. (1967) found *Onychodromopsis flexilis* at two stations of the Savannah River, USA, at following conditions: 23–28 °C, 5–<10 mg l⁻¹ Cl⁻, >3–7.5 mg l⁻¹ CO₂, 5–7 mg l⁻¹ O₂, 0.1–0.4 mg l⁻¹ Fe²⁺, 0.02–0.04 mg l⁻¹ NH₃-N, 0.001–<0.007 mg l⁻¹ NO₂-N, 0.07–0.2 mg l⁻¹ NO₃-N, 0.03–0.08 mg l⁻¹ PO₄³⁻, 6–12 mg l⁻¹ SiO₂, 10–<30 mg l⁻¹ SO₄³⁻, 0.5–1 mg l⁻¹ BOD₅. MADONI & GHETTI (1977) counted 16 ind. cm⁻² in an alphamesosaprobic to polysaprobic section of the Parma River, Italy. Two records from terrestrial habitats, namely Abaco Island, Bahamas, and Italy are also not substantiated by illustrations (CAIRNS & RUTHVEN 1972, LUZZATTI 1938). Biomass of 10⁶ individuals about 43 mg (NES-TERENKO & KOVALCHUK 1991; incorrectly spelled as "*Pleurotrycha flexilis*").

Onychodromopsis kahli ŠRÁMEK-HUŠEK, 1957 (Fig. 143e, f)

1932 *Onychodromopsis flexilis* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 620; in part: Fig. 110₈ (Fig. 143e); not Fig. 113₁.

1957 *Onychodromopsis kahli* ŠRÁMEK-HUŠEK, Věst. čsl. zool. Spol., 21: 15 (Fig. 143f).

Nomenclature and taxonomy: ŠRÁMEK-HUŠEK (1957) established this species on his own and KAHL's observations. Thus the expression "nom. nov." in the table and in the headline in ŠRÁMEK-HUŠEK (1957, p 3, 15) is wrong. It differs from the type species mainly in that it has only one enlarged frontoventral cirrus, which is very likely the buccal cirrus. However, synonymy with *Onychodromopsis flexilis* or *Allotricha* (frontoventral cirri overlooked?) cannot be excluded. Detailed redescription necessary.

Morphology: After KAHL (1932) in life 120 μm , according to ŠRÁMEK-HUŠEK (1957) 130–180 μm long. Elliptical, posterior end broadly to narrowly rounded, left margin slightly indented at level of buccal vertex. Contractile vacuole slightly in front of mid-body. No cortical granules mentioned. Behind the 3 frontal cirri only 1 enlarged cirrus,

probably the buccal cirrus. After KAHL (1932) anterior cirrus of middle and inner right marginal row possibly also enlarged. Three (KAHL 1932) or 2 (ŠRÁMEK-HUŠEK 1957) postoral ventral cirri. Two pretransverse ventral cirri. Five transverse cirri arranged in hook-shape project slightly beyond posterior end of cell. Very likely 3 slightly elongated caudal cirri.

Occurrence and ecology: Locus classicus of this rare species is a beta- to alphamesosaprobic brook (Schwarzbach) in the Morava River system in Czechoslovakia (ŠRÁMEK-HUŠEK 1957). KAHL (1932) isolated *O. kahli* from “mesosapropel” water bodies, probably near Hamburg, Germany, where KAHL lived and worked. Feeds on rhodobacteria and flagellates (KAHL 1932) and diatoms (ŠRÁMEK-HUŠEK 1957).

Insufficient redescriptions

Onychodromopsis flexilis STOKES – LUNDIN & WEST, 1963, Free living protozoa, p 68 (Fig. 223b). Remarks: Poorly figured so that identification is impossible. Natural waters of the Upper Peninsula of Michigan, USA (see also WEST 1953 and WEST & LUNDIN 1963).

Onychodromopsis sp. (*flexilis* STOKES) – KUSANO, 1985, Rep. Inst. nat. Stu., 16: 107, 110, Fig. 2b. Remarks: The scanning electron micrographs do not confirm the identification. About 110–125 µm long, obviously only 1 left cirral row. Feeds on bacteria, flagellates, and algae. Litter layer of Mizutori-no-numa pond in Tokyo (?), Japan.

Rubrioxysteria gen. nov.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Frontoventral cirri form V-shaped pattern. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral and 5 transverse cirri. One right and 1 left row of marginal cirri. Four or 5 dorsal kineties. One or 2 caudal cirri. Cytoplasm usually distinctly, rarely only slightly homogeneously orange to reddish or brownish.

Type species: *Oxytricha haematoplasma* BLATTERER & FOISSNER, 1990.

Additional characters: In life 150–260 µm long, about 3.5–4.0 times as long as broad. Body margins more or less parallel, both ends rounded. Flattened about 2:1. Very flexible, scarcely contractile. Two macronuclear nodules. Usually 2, *R. ferruginea* rarely with 3 micronuclei. Contractile vacuole distinctly in front of mid-body, during diastole with short collecting canals. Cortical granules present (see, however, taxonomy chapter in *R. ferruginea*). Adoral zone of membranelles about 1/3 of body length. Buccal

area rather small but deep. Peristomial lip anteriorly hooked to the left, similarly to in *Cyrtohymena* and *Notohymena*; however, paroral only slightly curved. Undulating membranes consist of 2 rows of basal bodies each. Buccal cirrus near anterior end of undulating membranes, about at level of right frontal cirrus, which is arranged very close to distal end of adoral zone of membranelles (Fig. 144b, arrow). Rather invariably full set (18) of frontal-ventral-transverse cirri. Anterior frontoventral cirrus (VI/4) slightly separate from the other 3 cirri. Postoral ventral cirri arranged in a short longitudinal row. Transverse cirri arranged in hook-shape and distinctly displaced anteriad, protrude only slightly, if at all, beyond posterior end of cell. Dorsal cilia short, that is, in life 2–5 µm long. Caudal cirrus (cirri) inconspicuous. Probably confined to freshwater habitats.

Taxonomy: For the description of the *Oxytricha* pattern mentioned in the characterisation, see chapter 2 in the general section. *Rubrioxxytricha* differs from *Oxytricha* mainly in that it usually has only 1 or 2 caudal cirri and from *Urosomoida* in that it invariably has 5 transverse cirri. *Tachysoma* has no caudal cirri. Furthermore, no species of these taxa has a homogeneously coloured cytoplasm. In *Oxytricha aeruginosa* and *Cyrtohymena muscorum* the reddish colour of the cytoplasm is induced by small granules. The classification of *Rubrioxxytricha ferruginea* in *Steinia* and *Cyrtohymena* was based on the anteriorly distinctly curved peristomial lip; the undulating membranes, however, are only slightly curved and arranged as in *Oxytricha* (Fig. 144b). The latter feature separates *Rubrioxxytricha* from *Cyrtohymena* and *Notohymena*.

The cortical granules, the flexible body, and the loss of fragmentation of dorsal kinety 3, that is, a simplification of dorsal morphogenesis (at least in *R. haematoplasma*), assigns *Rubrioxxytricha* to the Oxytrichinae. This position can, however, only be elucidated after the detailed description of divisional morphogenesis.

Key to species

The colours of the cytoplasm and the cortical granules are similar in both species (use bright field for studying the colours!). Species distinction thus requires counting of dorsal kineties (use Normarski interference contrast or protargol impregnation).

- 1 Cortical granules lemon-yellow, sometimes with a greenish shimmer, regularly arranged in single rows; cytoplasm usually distinctly, rarely only slightly homogeneously orange to reddish coloured; 4 dorsal kineties (Fig. 144c, d) *R. haematoplasma* (p 481)
- Cortical granules brownish, irregularly arranged in broad longitudinal rows; cytoplasm homogeneously rusty brown; 5 dorsal kineties (Fig. 145c, d) *R. ferruginea* (p 484)

***Rubrioxytricha haematoplasma* (BLATTERER & FOISSNER, 1990) comb. nov.**
(Fig. 144a–k, Tables 3, 30)

- 1990 *Oxytricha haematoplasma* BLATTERER & FOISSNER, Arch. Protistenk., 138: 106 (Fig. 144a–h; 1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
- 1991 *Oxytricha haematoplasma* BLATTERER & FOISSNER, 1990 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 287.
- 1993 *Oxytricha haematoplasma* BLATTERER & FOISSNER, 1990 – SHIN & KIM, Korean J. Zool., 36: 227 (Fig. 144i–k, see taxonomy).
- 1994 *Oxytricha haematoplasma* – BLATTERER, Kataloge des Oberösterreichischen Landesmuseums Linz, 71: 155, Abb. 14 (colour microphotograph of a living specimen).
- 1994 *Oxytricha haematoplasma* BLATTERER & FOISSNER, 1990 – SHIN, Dissertation, p 139 (Fig. 144i–k; incorrect spelling of BLATTERER; see taxonomy; mixed up the figures of *Oxytricha hymenostoma* and *R. haematoplasma*).

T a x o n o m y: Unfortunately, SHIN & KIM (1993b) did not mention the cortical granules and the colour of the cytoplasm. Their population has a distinctly lower number of adoral membranelles (26 against 38; Table 30) and there are also some minor differences in the dorsal ciliature (dorsal kinety 1 shortened anteriorly, kinety 4 interrupted) which are possibly a kind of geographic variation. For comparison with other coloured oxytrichids, see the relevant chapter in *Rubrioxytricha ferruginea*.

M o r p h o l o g y a n d b i o l o g y (see also genus section): In life 120–180 × 40–55 µm (BLATTERER & FOISSNER 1990), after SHIN & KIM (1993b) 100–180 × 50–90 µm. Macronuclear nodules in life up to 35 × 20 µm, with moderately sized nucleoli. Invariably 2 (n = 13, type material; n = 8, Korean population) micronuclei, in life up to 8 × 5 µm. Cortical granules 0.5–1.4 µm across, absent around cirri (Fig. 144d). Cytoplasm often with many colourless, 1–5 µm sized, greasily shining globules, so that cells appear darkish at low magnification. Moderately rapid movement, usually creeping on detritus.

Bases of all cirri of about same size. Usually 4 (very rarely only 1; mean = 3.8; n = 18; BLATTERER & FOISSNER 1990) frontoventral cirri. One of 20 specimens with only 2 postoral ventral cirri. Usually 5, rarely 6 (mean = 5.1, n = 18, BLATTERER & FOISSNER 1990) transverse cirri, in life about 20–30 µm long, only posterior-most cirrus reaches end of cell (Fig. 144a, b). Marginal cirri in life 15–20 µm long, marginal rows slightly overlapping because left row terminates just on right margin. Dorsomarginal row (dorsal kinety 4) only slightly shortened at both ends. Usually 1 caudal cirrus at end of kinety 3, somewhat elongated (Fig. 144c, h, arrow).

Morphogenesis is only incompletely known (Fig. 144f–h). However, a middle stage shows a peculiarity in comparison to other taxa of the Oxytrichinae, namely cirrus V/3 (posterior postoral ventral cirrus) is not involved in primordia formation (Fig. 144f, arrow). This would assign *R. haematoplasma* to the Stylonychinae (Fig. 25a, Tables 4, 5). It cannot be excluded that this detail in Figure 144f is a misobservation because cirrus

Fig. 144a-e *Rubrioxytricha haematoplasma* (from BLATTERER & FOISSNER 1990. a, d, e, from life; b, c, protargol impregnation). a) Ventral view, 170 μm . b, c) Ventral and dorsal infraciliature, b, c = 100 μm . Arrows mark right frontal cirrus and caudal cirrus. d) Ventral view. The lemon yellow, about 0.5–1.4 μm sized cortical granules are arranged in longitudinal rows. e) Lateral view; p 481.

V/3 is displaced distinctly posteriad, whereas all postoral ventral cirri are arranged rather close to the buccal vertex during interphase (Fig. 144b). Detailed morphogenetic studies are needed to check the behaviour of this cirrus.

Occurrence and ecology: Common in the aufwuchs and detritus of freshwater habitats, especially in running waters. Locus classicus is the Amper River, Bavaria, Germany, about 1 km below a lake (Ammersee). According to BLATTERER & FOISSNER (1990) and FOISSNER et al. (1992b) this slow flowing river is strongly eutrophic and beta-

Fig. 144f–h *Rubrioxyticha haematoplasma* (from BLATTERER & FOISSNER 1990. f–h, protargol impregnation). **f**) Ventral infraciliature of a middle morphogenetic stage, 105 μ m. The arrow marks the (unchanged) parental postoral ventral cirrus V/3 which is usually involved in primordia formation in the Oxytrichinae (see taxonomy); possibly a misobservation. **g, h**) Ventral and dorsal infraciliature of a late morphogenetic stage, 130 μ m. Arrow marks the single caudal cirrus at posterior end of dorsal kinety 3 of proter; p 481.

to alphamesosaprobic. AOÖLR (1996, 1996a, b, 1997, 1997a, b), BLATTERER (1994), FOISSNER (1997a), FOISSNER & MOOG (1992) and FOISSNER et al. (1991, 1992a) found *Rubrioxyticha haematoplasma* in mesosaprobic rivers and brooks in Upper Austria and Bavaria. BLATTERER (1989) observed it in the hypertrophic pond at Salzburg University, Austria. I found it, for instance, in the Glaserbach, an oligo- to betamesosaprobic brook near the city of Salzburg and in a slow flowing part of the alpha- to betamesosaprobic Salzach River in Salzburg, Austria. SHIN & KIM (1993a, b) isolated *R. haematoplasma* from the Han River, Seoul, Korea, in summer.

Feeds on *Oscillatoria* sp., diatoms (*Synedra ulna*), coccale green-algae, *Euglena spirgyra*, *E. viridis*, testaceans (*Trinema* sp.), and ciliates (*Chlamydonella* sp.). Biomass of 10^6 individuals about 80 mg (FOISSNER et al. 1991).

Fig. 144i–k *Rubrioxxytricha haematoplasma* (from SHIN & KIM 1993b. i, from life; j, k, protargol impregnation). i) Ventral view, 130 µm. j, k) Ventral and dorsal infraciliature, 135 µm; p 481.

Rubrioxxytricha haematoplasma is classified as beta- to alphamesosaprobic indicator of water quality: b–a; b = 6, a = 4, I = 3, SI = 2.4 (FOISSNER et al. 1991). This has to be proved by further autecological and saprobiological investigations on reliably determined populations.

***Rubrioxxytricha ferruginea* (STEIN, 1859) comb. nov. (Fig. 145a–o, Table 30)**

1859 *Oxytricha ferruginea* STEIN, Organismus der Infusionsthierie I, p 187 (Fig. 145f, g).

1862 *Oxytricha ferruginea* STEIN – ENGELMANN, Z. wiss. Zool., 11: 365 (Fig. 145k).

1865 *Oxytricha ferruginea* – QUENNERSTEDT, Acta Univ. lund., 2: 59 (Fig. 145h).

Fig. 145a–e *Rubrioxxytricha ferruginea* (from SONG & WILBERT 1989. a, d, from life; b, c, e, protargol impregnation). a) Ventral view, 205 µm. b, c) Ventral and dorsal infraciliature, b, c = 135 µm. The arrow marks the 3 posterior frontoventral cirri. d) Posterior portion of cell in dorsal view. The cortical granules are arranged irregularly in longitudinal rows. e) Ventral infraciliature of anterior portion, bar = 50 µm. BC = buccal cirrus, CC = caudal cirri, e = endoral, p = paroral, l = dorsal kinety 1.

145a

d

b

c

e

Table 30 Morphometric data of *Rubrioxystrecha ferruginea* (fer, from SONG & WILBERT 1989), *Rubrioxystrecha haematoplasma* (ha1, from BLATTERER & FOISSNER 1990; ha2, from SHIN & KIM 1993b), and *Pseudostrombidium planctonicum* (pla, from WILBERT 1986a). All data are based on protargol-impregnated material (pla, after WILBERT's 1975 method). All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	fer	143.4	12.9	9.0	122	162	10
	ha1	113.3	16.4	14.5	91	143	19
	ha2	133.2	18.1	13.6	112	160	9
	pla	223.8	18.1	8.1	194	267	20
Body, width	fer	47.2	3.9	8.3	39	51	10
	ha1	41.4	6.8	16.6	29	51	19
	ha2	62.8	13.6	21.8	42	80	9
	pla	86.0	11.2	13.0	67	108	20
Macronuclear nodule, length	ha1 ¹	15.9	3.2	20.4	11	21	19
	ha2	19.6	1.9	9.6	17	22	9
	pla	44.9	7.7	17.1	32	52	20
Macronuclear nodule, width	ha1 ¹	8.6	1.3	15.2	7	12	19
	ha2	10.7	1.1	10.5	9	12	9
	pla	19.7	3.7	18.8	16	26	20
Macronuclear nodules, distance between	ha1	9.8	4.2	43.0	0	21	19
	ha2	-	-	-	-	-	0
	pla	21.9	2.8	12.8	16	24	20
Micronucleus, length	ha1 ¹	4.2	0.7	17.2	3	5	13
	ha2	3.3	0.5	15.0	3	4	9
	pla	9.6	1.9	19.8	7	12	10
Micronucleus, width	ha1 ¹	3.6	0.7	18.8	3	5	13
	pla	6.6	0.8	12.1	6	8	10
Adoral zone of membranelles, length	fer	45.1	3.8	8.5	40	49	7
	ha1	35.8	4.0	11.0	30	46	19
	ha2	44.0	6.1	13.9	34	51	9
	pla	111.4	8.9	8.0	98	125	17
Adoral membranelles, number	fer	38.3	1.6	4.2	35	41	8
	ha1	38.4	4.3	11.2	30	48	19
	ha2	25.8	3.5	13.6	21	30	10
	pla	51.2	2.4	4.5	48	55	17
Right marginal row, number of cirri	fer	32.7	3.3	10.2	28	38	12
	ha1	33.4	3.6	10.9	25	39	18
	ha2	31.0	3.0	9.6	27	35	10
	pla	26.7	2.2	8.2	20	30	15
Left marginal row, number of cirri	fer	33.0	1.6	4.9	31	36	12
	ha1	35.8	3.9	11.0	28	45	18
	ha2	32.3	2.4	7.4	27	35	9
	pla	20.8	1.0	4.8	20	22	15
Dorsal kineties, number	fer	5.0	0	0	5	5	11
	ha1	4.0	0	0	4	4	15
	ha2	4.1	0.4	8.6	4	5	8
	pla	6.0	-	-	6	6	20

Table 30 Continued

Character	Species	mean	SD	CV	Min	Max	n
Caudal cirri, number	fer	1.7	0.6	92.1	1	2	15
	ha1	0.8	0.4	44.5	0	1	19
	ha2	0.7	0.5	69.0	0	1	10
	pla ²	6.5	0.9	13.8	5	8	20
	pla ²	4.8	1.0	20.8	3	6	20
	pla ²	4.1	0.9	21.9	3	6	20

¹ Anterior one.

² Caudal cirri on dorsal kineties 1 (fourth line), 2 (fifth line), and 4 (sixth line).

- 1866 *Steinia ferruginea* DIESING – DIESING, Sber. Akad. Wiss. Wien, 53: 114.
 1901 *Oxytricha ferruginea* St. – ROUX, Mém. Inst. natn. génev., 19: 102 (Fig. 145o).
 1908 *Oxytricha ferruginea* STEIN – BÖRGER, An. Univ. Chile, 122: 187 (Fig. 145m; incorrect subsequent spelling).
 1932 *Steinia (Oxytricha) ferruginea* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 612 (Fig. 145i).
 1961 *Steinia ferruginea* STEIN, 1859 – REUTER, Acta zool. fenn., 99: 19 (Fig. 145j).
 1968 *Oxytricha (Steinia) ferruginea* STEIN, 1859 – CHORIK, Free-living ciliates, p 137 (Fig. 145l).
 1972 *Oxytricha ferruginea* STEIN, 1859 – BORROR, J. Protozool., 19: 13.
 1974 *Oxytricha ferruginea* STEIN, 1859 – JONES, Univ. South Alabama Monogr., 1: 41 (Fig. 145n).
 1989 *Cyrtohymena ferruginea* (STEIN, 1859) – FOISSNER, Sber. Öst. Akad. Wiss., 196: 239.
 1989 *Oxytricha ferruginea* STEIN, 1859 – SONG & WILBERT, Lauterbornia, 3: 162 (Fig. 145a–e).
 1991 *Oxytricha ferruginea* STEIN, 1859 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 283.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Steinia) ferruginea*. Incorrect subsequent spellings: *Oxytricha feruginea* (SONG & WILBERT 1989, p 219); *Oxytricha terruginea* STEIN (ALIEV 1982a, p 807).

STEIN (1859b) stated that this species is easily recognisable by its body shape and the more or less intense rusty colour of the cytoplasm. He assumed that the colour is due to digestion products and did not mention a cortical granulation. It is hardly imaginable (but not impossible!) that he overlooked the granules because he described them exactly in *Urostyla grandis* and *Paraurostyla weissei*. By contrast, KAHL (1932) stated that the brown colour is caused by granules lying close underneath the pellicle and in the cytoplasm. SONG & WILBERT (1989) described a (homogeneous?) brownish colour and a cortical granulation. That means, if a population without cortical granulation is found a new species has to be established for the KAHL (1932) and SONG & WILBERT (1989) populations. Each future record of this problematic species should contain a remark about the colour of the cytoplasm and whether cortical granules are present or not! The marine population described by WANG & NIE (1932, p 360; Fig. 145p) is probably not *R. ferruginea* because the cytoplasm is yellowish and the cirri are differently arranged (see insufficient redescrptions). The redescription in PENARD (1922, Fig. 223e–g) is insufficient.

Fig. 145f-l *Rubrioxxytricha ferruginea* (f, g, after STEIN 1859b; h, after QUENNERSTEDT 1865; i, from KAHL 1932; j, after REUTER 1961; k, from ENGELMANN 1862; l, from CHORIK 1968. f-l, from life). f-j, l) Ventral views, f-h = size not indicated, i = 250 μ m, j = 160-180 μ m, l = 150 μ m. Note that in (f, i, j) an increased number of postoral and pretransverse ventral cirri is shown. k) Conjugation, 200 μ m; p 484.

The infraciliature of *Rubrioxxytricha ferruginea* differs from that of the type species mainly in the number of dorsal kineties (5 against 4); consequently, dorsal morphogenesis must also be different. *Rubrioxxytricha haematoplasma* shows the *Urosomoida* pattern, that is, no fragmentation of kinety 3 and only 1 dorsomarginal kinety occur (Fig. 144g, h). Conversely, in *R. ferruginea* the 5 dorsal kineties very likely originate according to the *Oxytricha* pattern, that is, fragmentation of kinety 3 and 1 dorsomarginal row occur.

Rubrioxxytricha spp. remind on *Oxytricha aeruginosa* and *Cyrtohymena muscorum*; however, in these species the reddish colour of the cytoplasm is not homogeneous, but caused by granules. Furthermore, *C. muscorum* has an anteriorly distinctly curved paroral and lives in terrestrial habitats only.

Fig. 145m–o *Rubrioxysteria ferruginea* (m, from BÜRGER 1908; n, from JONES 1974; o, from ROUX 1901). Ventral views from life, m = size not indicated, n = 160 μm , o = 170 μm ; p 484.

Fig. 145p *Oxytricha ferruginea* sensu WANG & NIE (1932). Ventral view from life, 150 μm ; p 491.

M o r p h o l o g y: According to STEIN (1859) large specimens 170 μm long; length after SONG & WILBERT (1989) about 150–200 μm , after KAHL (1932) 180–260 μm . Margins sometimes slightly concave (Fig. 145f). Cortical granules (not described by STEIN 1859b; see taxonomy) in life about 1 μm sized, colour not mentioned by SONG & WILBERT (1989), according to KAHL (1932) they cause a brownish colour. Frontal and transverse cirri distinctly enlarged. Marginal rows not overlapping posteriorly. All 5 dorsal kineties of about body length indicating that only 1 dorsomarginal row is formed.

O c c u r r e n c e a n d e c o l o g y: According to the numerous records, which are, however, not substantiated by morphological data, widely distributed but only moderately frequent in the aufwuchs and detritus of freshwater habitats; also inhabits brackish and marine waters. Obviously prefers stagnant and slow running oligosaprobic and betamesosaprobic waters.

Locus classicus is a brook (Puffbach) at Niemegk, Brandenburg, Germany, where STEIN (1859b) discovered it in *Oscillatoria* tufts. Furthermore, he found *R. ferruginea* rather frequently in similar habitats near Prague, Czechoslovakia. Records documented by illustrations: brackish water (salinity 0.5 ‰) of a shallow bay (Kalvassa) in the Baltic Sea, Finland (REUTER 1961); near Leipzig, Germany (ENGELMANN 1862); on plants of rather clean ditches and in non-putrefying detritus of large water bodies, probably in Germany (KAHL 1932); rarely in a eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany, in August (SONG & WILBERT 1989); Sweden (QUENNERSTEDT 1865); ponds and Lake Geneva, Switzerland (ROUX 1901; see also ANDRÉ 1912, 1916, BOURQUIN-LINDT 1919, FOREL 1904); small water bodies and cooling plant in Moldova (CHORIK 1968, CHORIK & VIKOL 1973); at a salinity of 0.2–3.0 ‰ in Mobile Bay, Alabama, USA (JONES 1974); Chile (BÜRGER 1908). Records not documented by illustrations: mosses from springs near Vienna, Austria (KÜHN 1940); pool with ground water near Eisenstadt, Austria (SPANDL 1926a); Belgium (BERVOETS 1940); freshwater mosses and rain puddle in Czechoslovakia (TIRJAKOVÁ & MATIS 1987a, SPANDL 1926a); near Perth, England (CRAIGIE 1921); pond with mosses in Estonia (JACOBSON 1928); brackish and sea-water in Finland (LEVANDER 1894a, b, 1901); aufwuchs of mesotrophic and eu- to polytrophic Eifelmaar lakes, Germany (PACKROFF 1992, PACKROFF & WILBERT 1991); Latvian rivers (LIEPA 1978, 1990); freshwater and brackish water in the Netherlands (VERSCHAFFELT 1930); rain-wet mosses from Espegrend, Norway (REUTER 1963a); littoral of Lake Majeur and up to 100 ind. l⁻¹ in Swiss ponds in September (ANDRÉ 1915, RIGGENBACH 1922); Ukrainian pond during winter (KOVALCHUK & SVINTSOVA 1994); rivers in the USSR (NEISWESTNOWA-SHADINA 1935, SASSUCHIN 1930, SASSUCHIN et al. 1927, SHADIN et al. 1931); running waters in Azerbaijan (ALIEV 1982a); saline lake near the coast of the Black Sea (DAGAJEVA 1930); River Plate, Argentina (CARBONELL 1935); Brazil (CUNHA 1913).

Terrestrial records unreliable (FANTHAM & PATERSON 1926, HEINIS 1959, TIRJAKOVÁ & MATIS 1987a); probably, confused with *Notohymena rubescens* or *Cyrtohymena muscorum*, which are rather common in edaphic mosses and soil.

Feeds on bacteria, cyanobacteria, and diatoms. Biomass of 10⁶ individuals about 125 mg (FOISSNER et al. 1991). Swims with about 400 µm s⁻¹ (BULLINGTON 1925). MADONI & GHETTI (1981a) recorded *Rubrioxxytricha ferruginea* in a betamesosaprobic brook in northern Italy under the following conditions: SI = 2.1, 23–25 °C, pH 8.1–8.4, 700 to 800 µS cm⁻¹ specific conductivity (25 °C), 8.1–11.8 mg l⁻¹ O₂, 19–21 mg l⁻¹ COD, 0.2 to 0.38 mg l⁻¹ PO₄³⁻-P, 0.16–1.33 mg l⁻¹ NH₃, 0.63–1.6 mg l⁻¹ NO₃⁻-N, 0.02–0.03 mg l⁻¹ NO₂⁻-N, 40–43 mg l⁻¹ Cl⁻. MATIS (1975) found *Rubrioxxytricha ferruginea* during the summer in running waters in Czechoslovakia at low oxygen levels (1.2–2.6 mg l⁻¹ O₂, pH 6.7–6.9, 12.5–17 °C). NOLAND (1925) reported it from various freshwater habitats in Wisconsin at 4.5–28.5 °C (mean = 15.6 °C; n = 5), pH 7.5–9.8 (pH 8.2), 4.1–9.9 mg l⁻¹ O₂ (6.9 mg l⁻¹), and 53–174 ‰ O₂ saturation (99 %).

Rubrioxxytricha ferruginea is classified as oligosaprobic indicator (FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGE 1983): o; o = 7, b = 3, I = 4, SI = 1.3. This has to be verified on reliably determined populations.

Insufficient redescriptions

Oxytricha ferruginea STEIN 1859 – PENARD, 1922, *Études Infusoires*, p 237 (Fig. 223e–g). Remarks: In life 125–150 µm long. Possible a *Holosticha* or *Pseudokeronopsis* species. Terrestrial(?) mosses in Switzerland.

Oxytricha ferruginea STEIN 1859 – WANG & NIE, 1932, *Contr. biol. Lab. Sci. Soc. China*, 8: 360 (Fig. 145p). Remarks: In life 150 × 35 µm. Body linearly oblong, about five times as long as broad, widest at mid-body or slightly in front of posterior end, bluntly pointed anteriorly, rounded posteriorly. More flexible than freshwater population. Two macronuclear nodules, one in front of contractile vacuole, the other centrally or sub-centrally. Contractile vacuole without canals. Cytoplasm deeply, homogeneously yellowish. Buccal area rather wide, about one third of body length; undulating membranes (obviously paroral) curved to the left anteriorly. 18 frontal-ventral-transverse cirri arranged as shown in Figure 145p; frontal and transverse cirri distinctly enlarged, transverse cirri not or only slightly projecting beyond posterior end of cell. Marginal cirri uninterrupted, projecting posteriorly only. Feeds on diatoms and other marine algae. Rather abundant in the sea nearby Amoy, China.

According to WANG & NIE (1932), this population may be recognised as a marine variety of *Rubrioxytricha ferruginea*. It differs from the type population in that it has a deeply, homogeneously yellowish tint which definitely did not result of the temporary retention of coloured food particles. Detailed redescription necessary.

Parurosoma GELEI, 1954

1954 *Parurosoma* GELEI, *Acta biol. hung.*, 5: 332 – Type (by monotypy): *Holosticha* (*Parurosoma*) *dubium* GELEI, 1954.

1997 *Parurosoma* GELEI, 1954 – BERGER & FOISSNER, *Arch. Protistenk.*, 148: 148.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles, undulating membranes, and frontoventral cirri similar to in *Urosoma*. Postoral ventral cirri in dense cluster behind buccal vertex. Two pretransverse ventral and five transverse cirri. Two right and 2 left rows of marginal cirri. Four, sometimes 5 dorsal kineties. Caudal cirri present. Dorsal morphogenesis very likely in *Urosomoida* pattern.

T a x o n o m y: The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of patterns, see chapter 2 in the general section. *Parurosoma* is monotypic, that is, includes only the type species. GELEI (1954b) classified *Parurosoma* as subgenus of *Holosticha*, that is, *Holosticha* (*Parurosoma*); thus, CORLISS (1979) and TUFFRAU (1987) included it in the Holostichidae. TUFFRAU & FLEURY (1994, p 141) classified *Parurosoma* without foundation in the Amphisiellidae. However, according to the

ventral infraciliature it is a typical member of the Oxytrichidae. This was already recognised by BORROR (1972a), who synonymised *Parurosoma* with *Pleurotricha*, which has, however, a rigid body and lacks caudal cirri.

Parurosoma tekirghiolica mentioned in TUCOLESCU (1965, p 178) is obviously a *nomen nudum*, that is, a new species without description. Very likely, the same holds for *Leptocirra tekirghiolica* (TUCOLESCU 1965, p 178), a new genus name not mentioned in CORLISS (1979).

Single species

Parurosoma dubium (GELEI, 1954) comb. nov. (Fig. 146a–c)

- 1954 *Parurosoma dubium* GELEI, Acta biol. hung., 5: 332 (Fig. 146a; for the correct name in the original description, see nomenclature).
 1954 *Holosticha mononucleata* GELEI, Acta biol. hung., 5: 327 (Fig. 146b, c).
 1972 *Pleurotricha dubium* (GELEI, 1954) – BORROR, J. Protozool., 19: 15.
 1972 *Pleurotricha mononucleata* (GELEI, 1954) – BORROR, J. Protozool., 19: 15.
 1974 *Paruroleptus dubium* GELEI – STILLER, Fauna Hung., 115: 86, 87.
 1974 *Pleurotricha mononucleata* (GELEI, 1954) – STILLER, Annls hist.-nat. Mus. natn. hung., 66: 132.

Nomenclature and taxonomy: *Parurosoma* was classified as subgenus of *Holosticha* (GELEI 1954b); the correct name in the original description is thus *Holosticha (Parurosoma) dubium*. It was never formally transferred to *Parurosoma*, which is here undertaken. Incorrect spelling: *Parurosoma dubia* (GELEI 1954b, p 342).

The linear arrangement of the frontoventral cirri is reminiscent of *Urosoma*, indicating that they are sister-groups which differ in the number of marginal rows. Detailed re-description necessary.

GELEI (1954b) found *Holosticha mononucleata* together with the rather fragile *Parurosoma dubium*; I thus assume that *H. mononucleata* is simply the anterior portion of *P. dubium*. This is indicated especially by the corresponding infraciliature, the position of the contractile vacuole, and the single macronuclear nodule. Furthermore, many specimens are pointed at the right posterior cell portion, which is typical of hypotrich fragments. PETZ & FOISSNER (1996) assumed that *H. mononucleata* is a reorganiser. BORROR (1972a) transferred *H. mononucleata* to the *Pleurotricha*; obviously erroneously, STILLER (1974a) repeated this nomenclatural act.

Morphology and biology: In life 150–250 × 50–60 µm. Anterior end rounded, posterior portion with an “immovable” tail-like process. Moderately flexible. Rather fragile, that is, bursts rather easily in thin water-layers. Two ellipsoidal macronuclear nodules, about 20 µm long with large spherical nucleoli; each nodule with a single micronucleus usually at distal, rarely at proximal end. Contractile vacuole with short collecting canals, located at end of anterior third of cell. Cytoplasm near cytostome and at

Fig. 146a–c *Parurosoma dubium* (from GELEI 1954b; formaldehyde-sublimate fixation). a) Ventral infraciliature, 215 μm . b, c) The synonym, *Holosticha mononucleata*, in ventral and dorsal view; very likely it is only the anterior portion of the rather fragile *Parursoma dubium*; p 492.

base of tail granulated grey-brownish by pigments (cortical granules?) and cytoplasmic crystals; after fixation with formaldehyde-sublimate entire cell shows a “cortical granulation”(?). Usually creeping but also swimming; often stands still for long periods.

Adoral zone of membranelles approximately 25 % of body length, about 30 adoral membranelles. Buccal field narrow. Usually 9, rarely 8 frontoventral cirri, that is, 3 frontal cirri, 1 buccal cirrus, 2 cirri behind right frontal cirrus (that is, one more than in *Urosoma*), and 3 cirri right behind them; however, protargol impregnation is needed to ascertain correct cirral pattern. Three postoral and 2 pretransverse ventral cirri. Invariably 5 fringed transverse cirri at base of tail-like process; usually they protrude beyond left body margin. Outer right marginal row with 35–50, inner right marginal row with 20 (up to 31) cirri. 34–45 cirri in outer left marginal row. Three dorsal kineties of body length, 1 or 2 dorsomarginal kineties with only 4–5 basal body pairs. Dorsal cilia “short”, that is, about 2–4 μm . One, rarely 2 caudal cirri.

Occurrence and ecology: Rare species. Locus classicus is an ephemeral, hypertrophic pond (“Tümpel I”) on a meadow in the Börzsöny Mountains, Hungary, where GELEI (1954b) discovered *Parurosoma dubium* in the benthal and in dry mud from the littoral. Furthermore, he found it in the pelagial of another pond (“Tümpel V”) in the same area. For detailed description of these habitats and synecological data, see GELEI (1954a)

and GELEI et al. (1954). Feeds mainly on flagellates, rarely on diatoms and unicellular green algae (GELEI 1954b, GELEI et al. 1954). No further records published.

Pseudostrombidium HORVÁTH, 1933

1933 *Pseudostrombidium* HORVÁTH, Arch. Protistenk., 80: 291 – Type (by monotypy): *Pseudostrombidium planctonicum* HORVÁTH, 1933.

1997 *Pseudostrombidium* HORVÁTH, 1933 – BERGER & FOISSNER, Arch. Protistenk., 148: 148.

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes almost straight and side by side. Frontoventral cirri in V-shaped pattern. Postoral ventral cirri behind buccal vertex. Two pretransverse ventral and 5 transverse cirri. One right and 1 left row of marginal cirri. Six dorsal kineties. Number of caudal cirri distinctly increased (>4). Dorsal morphogenesis in *Oxytricha* pattern.

Taxonomy: The characterisation is according to BERGER & FOISSNER (1997). For a description of the *Oxytricha* pattern of dorsal morphogenesis, see chapter 2 in the general section. Further details on taxonomy, see single species *P. planctonicum*.

Single species

Pseudostrombidium planctonicum HORVÁTH, 1933 (Fig. 147a–n, Table 30)

1933 *Pseudostrombidium planctonicum* HORVÁTH, Arch. Protistenk., 80: 291 (Fig. 147a–g).

1935 *Urosoma* (für *Parastrombidium*) *planctonicum* J. HORVATH, 1933 – KAHL, Tierwelt Dtl., 30: 841 (incorrect subsequent spelling, see also taxonomy).

1972 *Parastrombidium planctonicum* HORVATH, 1933 – BORROR, J. Protozool., 19: 13 (incorrect subsequent spelling).

1972 *Urosoma* (= *Parastrombidium*) *planctonicum* (HORVATH 1933), KAHL 1935 – BICK, Binnengewässer, 26: 76 (incorrect subsequent spelling).

1986 *Oxytricha planctonica* (HORVATH, 1933) – WILBERT, Arch. Protistenk., 131: 67: (Fig. 147h–j).

1994 *Urosoma planktonicum* – SKIBBE, Arch. Hydrobiol., 130: 346 (Fig. 147k, l; incorrect subsequent spelling).

1999 *Pseudostrombidium planctonicum* HORVÁTH, 1933 – FOISSNER, BERGER & SCHAUMBURG, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, in press (Fig. 147m, n).

Nomenclature and taxonomy: KAHL (1935) obviously confused *Pseudostrombidium* with *Parastrombidium* FAURÉ-FREMIET, 1924, an oligotrich. Many incorrect subsequent spellings: *Oxytricha planctonica* (FOISSNER & O'DONOGHUE 1990, p 692; WILBERT 1986a, p 67); *Urosoma pelagica* (WILBERT 1969, p 459; probably he mixed up the names *Urottricha pelagica* and *Urosoma planctonicum*); *Urosoma planctonica* HORVATH (STILLER 1974b, p 115, 116); *Urosoma planctonicum* J. HORVATH (WILBERT 1969, p 458); *Urosoma planctonisum* HORV. (LEPSI 1965, p 975); *Viosoma planctonicum* (HORVATH, 1933) (DRAGESCO 1970, p 129).

Monotypic, that is, includes only the euplanktonic type species. BORROR (1972a) synonymised *P. planctonicum* with *Urosoma acuminata*, which is clearly different (see there). It should not be confused with *Oxytricha longicirrata*, which has only three caudal cirri and only one micronucleus between the two macronuclear nodules. According to the original description and the redescription by WILBERT (1986a), the undulating membranes of *Pseudostrombidium* are rather straight and do not intersect, similarly to in *Stylonychia* (Fig. 147a, h). However, the micrographs of a protargol-impregnated specimen in SKIBBE (1994) indicate an oral apparatus almost in the *Oxytricha* pattern. *Pseudostrombidium* differs from *Stylonychia* spp. not only by the supple body but also by the significantly higher number of caudal cirri.

The phylogenetic relationships of *Pseudostrombidium* are unknown. The flexible body (HORVÁTH 1933) assigns it to the Oxytrichinae. By contrast, the long adoral zone of membranelles, the straight undulating membranes (see, however, above), and the somewhat posteriorly displaced postoral ventral cirrus V/3 (Fig. 147h) support a classification within the Stylonychinae. A further investigation (flexibility of body; pattern of undulating membranes; exact arrangement of cirri; symbiotic algae and cortical granules absent or not, see below) and a morphogenetic study are needed to clarify the systematic position of this curious oxytrichid.

Morphology and biology: After HORVÁTH (1933) in life about 120–160 μm long, according to WILBERT (1986a) after protargol impregnation 194–267 $\times$ 67–108 μm ; broadest at adoral zone of membranelles. Outline variable (Fig. 147c–g), usually anterior end broad, posterior end very narrowly rounded, that is, margins taper towards posterior end. Ventral surface only flattened in area of adoral zone of membranelles, posterior portion $\pm$ round in cross-section. Body flexible (HORVÁTH 1933). Invariably ($n = 20$) 2 macronuclear nodules with one micronucleus each. Contractile vacuole at about level of buccal vertex; slightly behind a smaller vacuole which discharges somewhat earlier (HORVÁTH 1933). Cytoplasm after HORVÁTH (1933) greyish, filled with numerous large food vacuoles. He also mentioned uniformly distributed symbiotic algae (“Zoochlorellen”) between food vacuoles and in distal portion of cell; however, *Pseudostrombidium* is pelagic, so that it cannot be excluded that HORVÁTH observed specimens with ingested coccale planktonic algae; WILBERT (1986a) did not describe symbiotic algae. Slowly swimming under rotation (from right to the left) about longer axis of cell, always ascending or descending. During swimming adoral zone of membranelles turned up; only rarely continuously creeping.

Adoral zone of membranelles about 45–50 % of body length. Buccal area small and flat. Undulating membranes almost straight and arranged in parallel, similarly to in *Stylonychia* (Fig. 147a, h); however, in the micrograph by SKIBBE (1994; Fig. 147k) the undulating membranes seem to be curved as in *Oxytricha*. Frontal, ventral, and transverse cirri slightly to distinctly enlarged. Left and middle frontal cirrus at about same level, right frontal cirrus just behind distal end of adoral zone of membranelles. Invariably ($n = 20$) 18 frontal-ventral-transverse cirri; arrangement of cirri (for example, frontoventral cirri

Fig. 147a-j *Pseudostrombidium planctonicum* (a-g, from HORVATH 1933; h-j, from WILBERT 1986a. a, sublimate-toluidinblue stain; b, opalblue stain after BRESSLAU; c-g, from life; h, i, composite from life and after protargol impregnation; j, protargol impregnation). a, b) Ventral and dorsal view, 190–200 μm . Very likely, HORVATH did not recognise the dorsal pattern correctly. c–g) Shape variants in ventral, lateral, and dorsal view. h, i) Ventral and dorsal infraciliature, h, i = 200 μm . Arrangement of posterior frontoventral cirri and posterior postoral ventral cirrus very likely not exactly shown (cp. Fig. 147k). j) A single adoral membranelle from middle portion of adoral zone; CC = caudal cirri; p. 494.

Fig. 147k, l *Pseudostrombidium planctonicum* (from SKIBBE 1994 and original of same population, kindly supplied by O. SKIBBE. k, l, protargol impregnation). Ventral and dorsal infraciliature and nuclear apparatus. Arrows in (k) mark frontoventral cirri III/2 and IV/3, arrowhead denotes posterior postoral ventral cirrus (V/3). The location of these cirri matches the original description (Fig. 147a) but differs slightly from WILBERT's illustration (Fig. 147h). Arrowheads in (l) mark caudal cirri on posterior end of dorsal kineties 1, 2, and 4; p 494.

III/2 and IV/3 and postoral ventral cirrus V/3) in Figure 147h possibly not exactly shown, because slightly different from original description (Fig. 147a) and SKIBBE's micrograph (Fig. 147k). Posterior postoral ventral cirrus (cirrus V/3) displaced slightly (Fig. 147a, k) to distinctly (Fig. 147h; likely a preparation artefact) posteriad. After HORVÁTH (1933) posterior-most 2 transverse cirri protrude beyond posterior end of cell, after WILBERT (1986a) obviously no transverse cirrus protrudes (Fig. 147a, h). Right marginal row begins at level of right frontal cirrus. Bases of anterior-most 2 cirri of left marginal row slightly enlarged (4–5 kineties, all other marginal cirri consist of 2 kineties only; WILBERT

1986a). Dorsal cilia in life about 2 μm long; after HORVÁTH (1933) 5 dorsal kineties of body length, after WILBERT's (1986a) table also only 5 rows (misleadingly designated as "Zahl der Dorsalcirren"); however, the WILBERT illustration unequivocally shows the normal pattern with 6 dorsal kineties (Fig. 147i); very likely, HORVÁTH could not recognise the exact pattern with the method used (147b). Caudal cirri form a rather dense corona around posterior end of cell because 3–8 cirri on each dorsal kinety (Fig. 147a, h, l–n). Cyst globular with smooth wall.

Morphogenesis commences near the left transverse cirrus. Later, 5 longitudinal anlagen (probably streak I not counted!) originate (WILBERT 1986a).

Occurrence and ecology: Rare species, pelagic, prefers probably eutrophic water bodies. Abundant occurrence is possibly confined to cold seasons, that is, winter and spring (algal blooms?). Locus classicus is Szeged, Hungary, where HORVÁTH (1933) discovered *Pseudostrombidium planctonicum* in the drain of the Cserepesisorer Pond at 6 °C in late March, together with *Litonotus lamella*, *Chilodonella uncinata*, and *Stentor roeselii*. WILBERT (1969, 1972, 1986a) found *Pseudostrombidium planctonicum* (about 1000 ind. l⁻¹) in a eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany, only from February to April. SKIBBE (1994) gave no site; probably he found it in north Germany. Dr. HABERMEHL (Ansbach, Germany) observed a mass occurrence under ice in a eutrophic lake (Altmühlsee) in Bavaria, Germany (autecological data, see FOISSNER et al. 1999).

Feeds on flagellates, planktonic diatoms and coccale algae (HORVÁTH 1933, WILBERT 1986a); possibly, HORVÁTH misinterpreted the latter as symbiotic green algae (see above).

Biomass of 10⁶ individuals 110 mg. WILBERT (1986a) found *P. planctonicum* at 0.4–11.2 °C, pH 7.7–8.3, 4.9–12.5 mg l⁻¹ O₂, 0 to 0.5 mg l⁻¹ NH₄⁺-N, 0 mg l⁻¹ NO₂⁻-N, 3.5–14.0 mg l⁻¹ NO₃⁻-N. The Altmühlsee population was heavily infected by a parasitic suctor (FOISSNER et al. 1999).

Fig. 147m, n *Pseudostrombidium planctonicum* (from FOISSNER et al. 1999. m, n, protargol impregnation). m, n) Ventral and dorsal infraciliature. Arrows in (n) mark caudal cirri rows. CC = caudal cirri, LMR = left marginal cirri row; p. 494.

Stylonychinae BERGER & FOISSNER, 1997

1997 Stylonychinae BERGER & FOISSNER, Arch. Protistenk., 148: 149. – Type (original designation): *Stylonychia* EHRENBERG, 1830.

Characterisation: Oxytrichidae with rigid body. Cortical granules lacking. Adoral zone of membranelles usually >40 % of body length. Primarily 18 frontal-ventral-transverse cirri clustered to six distinct groups, secondarily number of these cirri slightly to distinctly increased or slightly decreased. Cirrus V/3 not involved in primordia formation. Dorsal morphogenesis primarily in *Oxytricha* pattern, secondarily with multiple fragmentation and/or retention of parental kineties.

Remarks: BERGER & FOISSNER (1997) established this taxon as subfamily, as also indicated by the defined ending -inae. Here I ignore the category (for details, see Ax 1995, p 18 and WESTHEIDE & RIEGER 1996, p VII). However, to avoid inflation of names I use the name without any change.

Cladistic analysis using mainly morphological and morphogenetic data divided the 18-cirri oxytrichids in two groups, namely the Stylonychinae and its sister group, Oxytrichinae (Fig. 25a). Autapomorphies of the Stylonychinae are the rigid body, the lack of cortical granules, and an adoral zone of membranelles which is usually more than 40 % of body length. The autapomorphy “origin of proter’s primordia V and VI from cirrus V/4” was proposed by the PAUP-program (Fig. 25b), but not supported by manual analysis because of different definition of the plesiomorphic state.

The consistency of the body was already used by STEIN (1859b) and later by KENT (1882), KAHL (1932), BORROR (1972a), and SMALL & LYNN (1985) to distinguish several oxytrichids. Suppleness is typical for the sister group of the Stylonychinae, the Oxytrichinae, and for very many (all? except for euplotids and the curious *Psilotricha*) other hypotrichs. This strongly indicates that a flexible body is the plesiomorphic, and a stiff one the apomorphic state. I am rather sure that this character evolved only once, inasmuch as it is supported by two other autapomorphies. The difference in the body consistency is due to ultrastructural specialisation. Oxytrichids with a rigid body have several, in *Stylonychia* arranged crosswise, layers of subpellicular microtubules (CALVO et al. 1986a, PUYTORAC et al. 1976), while hypotrichs with a supple body have only a single sheet of parallel, polar microtubules (GRIMES 1972, WIRNSBERGER-AESCHT & FOISSNER 1989). The consistency of the body is not only of high cladistic value, but also important in identification practice. Flexible hypotrichs bend laterally while moving unhampered on the substratum, when swimming they are often curved and when touching an obstacle their anterior half contracts slightly. Conversely, rigid hypotrichs never bend in any direction while creeping and look like a rotating board when swimming.

Cortical granules (previously often called subpellicular granules) are widespread in flexible oxytrichids and non-oxytrichid hypotrichs, except euplotids (see FOISSNER et al. 1991 and Table 2), strongly suggesting, that the possession of such structures is a plesio-

morphy. Conversely, cortical granules are entirely lacking in rigid oxytrichids. Obviously, the granules were lost in the last common ancestor of the rigid oxytrichids, possibly in consequence of the altered ultrastructural architecture.

The third autapomorphy of the Stylonychinae is the relative elongation of the adoral zone of membranelles. It is less than 40 % (usually 25–35 %) in oxytrichids having a flexible body and in most other hypotrichs (except euplotids), suggesting that such values are plesiomorphic. Exceptions are rare, for example, *Cyrtohymena quadrinucleata* and *Gonostomum* spp., whose adoral zone is 40–50 % of body length, as in all oxytrichids with a rigid body. A correlation between the relative length of the adoral zone and the mode of nutrition is neither known nor apparent.

All other features mentioned in the characterisation of the Stylonychinae are either plesiomorphies (for example, cirrus V/3 not involved in primordia formation) or conspicuous autapomorphies of “atypical” members of this group (for example, number of frontal-ventral-transverse cirri secondarily increased in *Laurentiella strenua*, *Onychodromus* spp., *Pattersoniella vitiphila*). It was mainly the paper by SCHLEGEL et al. (1991) that encouraged me to include “atypical” taxa in the Stylonychinae, inasmuch as there is no conflict with the three autapomorphies discussed above. However, it is very likely rather difficult to find their exact placement in the cladogram and I thus arrange them at the end of the Stylonychinae section.

The 18-cirri oxytrichids *Pleurotricha*, *Rigidocortex*, and the little-known *Parastylonychia* have a rigid body, no cortical granules, and a long oral apparatus. These features assign them unequivocally to the Stylonychinae. However, they cannot be considered in the cladistic analysis because detailed morphogenetic data are lacking; thus, the cladograms presented in Figure 25 are rather incomplete and they will change more or less significantly as further taxa are analysed.

Still, some genera are not defined by a unique character (autapomorphy), but by a specific combination of plesiomorphies, that is, their monophyly is questionable. Thus, and because I did not name and characterise the sister groups within the Stylonychinae, the characterisation of a genus includes all features necessary to separate it from the other genera of this group.

Recently, EIGNER (1997) transferred most taxa of the Stylonychinae to the Parakahliellidae EIGNER.

Key to genera

For identification of genera, see key at the beginning of the systematic section (p 104–113). Most (all?) rigid, non-euplotid hypotrichs belong to the Stylonychinae.

***Stylonychia* EHRENBURG, 1830**

- 1829 *Stylonychia cimex* EHRENBURG, Abh. preuss. Akad. Wiss., year 1829: 12, 17, 19 (see nomenclature and taxonomy).
- 1830 *Stylonychia mytilus* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1830: 43 – Type (subsequent designation by FROMENTEL 1875, p 163): *Trichoda mytilus* MÜLLER, 1773.
- 1830 *Stylonychia histrio* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1830: 43.
- 1838 *Stylonychia* – EHRENBURG, Infusionsthierchen, p 370.
- 1859 *Stylonychia*. EHRBG. – STEIN, Organismus der Infusionsthier I, p 146.
- 1875 *Stylonychia* – FROMENTEL, Études microzoaires, p 162.
- 1882 *Stylonychia*, EHRENBURG – KENT, Manual Infusoria, p 790.
- 1932 *Stylonychia* EHRENBURG, 1838 – KAHL, Tierwelt Dtl., 25: 617 (classified as subgenus of *Oxytricha*).
- 1972 *Stylonychia* EHRENBURG, 1830 – BORROR, J. Protozool., 19: 15.
- 1974 *Stylonychia* EHRENBURG – STILLER, Fauna Hung., 115: 153.
- 1997 *Stylonychia* EHRENBURG, 1830 – BERGER & FOISSNER, Arch. Protistenk., 148: 151.

Characterisation: Undulating membranes in *Stylonychia* pattern. One right and 1 left row of marginal cirri, distinctly separate posteriorly. Six dorsal kineties. Caudal cirri present and often distinctly elongated. Primordium II of proter originates from oral primordium. Primordia V and VI of proter originate from frontoventral cirrus IV/3 or from postoral ventral cirrus V/4. Primordium IV of opisthe originates from postoral ventral cirrus V/4. Dorsal morphogenesis in *Oxytricha* pattern.

Additional characters: Body rigid. Two ellipsoidal macronuclear nodules, except *S. nodulinucleata* which has a moniliform macronucleus. Contractile vacuole in about mid-body. Cortical granules lacking. Rapid movement. Adoral zone of membranelles about 40–50 % of body length. Dorsal cilia short, that is, 3–5 µm.

Nomenclature and taxonomy: *Stylonychia* was mentioned for the first time in EHRENBURG (1829) in combination with the epithet *cimex* as follows: “*Stylonychia? cimex*. n. sp.” (p 17) and “*Stylonychia cimex*. n. G.” (p 19). Since this is the only originally included species in the nominal genus-group *Stylonychia* it would be its type species by indication (type by monotypy; Article 68 [d] of the ICZN 1985). However, somewhat later this species (which is obviously identical with *Trichoda cimex* MÜLLER, 1773) was classified as *Euplotes* (EHRENBURG 1838, p 380); FROMENTEL (1876) mentioned this species for the last time. In 1830, EHRENBURG transferred *Trichoda mytilus* MÜLLER, 1773 and *Paramaecium histrio* MÜLLER, 1773, to *Stylonychia*. This paper (EHRENBURG 1830) is the generally accepted original description of *Stylonychia* (for example, BORROR 1972a, CORLISS 1979). *Trichoda mytilus* was subsequently designated as type by FROMENTEL (1875, p 163) and any change in this situation would disturb stability and cause great confusion. KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Stylonychia)*.

Incorrect subsequent spellings: *Stilonichia* (EDDY 1925, p 85); *Stilonychia* (HENTSCHEL 1916, p 25); *Stilonychia mytilus* (ASPER & HEUSCHER 1886, p 170); *Stylochia* (SCHLICHTING

1961, p 87); *Stylometra pustulata* (JENNINGS & MOORE 1902a, p 191); *Stylomychia* (CAIRNS et al. 1976, p 265); *Stylonchia* (GIESE & ALDEN 1938, p 125; LEE & KUGRENS 1992, p 538; ZAKIAN 1989, p 584); *Stylonchia curvata* (SEN et al. 1967); *Stylonchia lemnae* (WEN et al. 1995, p 1704); *Stylonchia mytilus* E. (CIENKOWSKY 1855, p 302; TORRES et al. 1979a); *Stylonichia* EHRENBURG (this is the most frequent incorrect subsequent spelling: for example ANON 1965; AWERINZEW 1900, p 324; BAILY 1845, p 34; BRUGEROLLE & ADOUTTE 1988, p 257; BUDINGTON & HARVEY 1915, p 305; CHÉNEVEAU & BOHN 1903, p 800; FABRE-DOMERGUE 1887, p 798; FAURÉ-FREMIET 1910, p 46; LÓPEZ-UCHOTERENA 1967, p 165; MAUPAS 1883, p 619; PERKINS 1956, p 59; SCHULZ 1961, p 51; SCOURFIELD 1897, p 790; SERNOV 1929, p 557; SIMON 1988, p 16; SLÁDEČEK et al. 1958, p 74; SUDZUKI 1978, p 90; TURNER 1954, p 19; VAN HOLDE et al. 1979, p 391; WANG 1925, p 51; WATSON 1946a, b, p 46, 127); *Stylonichnia mytilus* (BALDENSBERGER 1927, p 295); *Stylonichus mytilus* (SHARAVINA 1978, p 1573); *Stylonycha* (KURASAWA 1958, p 119); *Stylonychi lemnae* (WEFES & LIPPS 1990, p 25); *Stylonychna mytilus* (BALDENSBERGER 1927, p 211); *Stylonychnia mytilus* (BALDENSBERGER 1927, p 197, 229, 272, 283); *Stylonychnia pustulata* (BALDENSBERGER 1927, p 283); *Stylonyehia* sp. (DUTTA et al. 1990, p 22); *Styloychia mytilus* EHR. (GUHL 1987, p 455); *Stynolychia monostylus* (FROMENTEL 1876, p 359).

The characterisation of the genus is according to BERGER & FOISSNER (1997). For description of “patterns”, see chapter 2 in the general section. Morphogenetic data suggest that *Stylonychia* is not monophyletic (Table 4; Fig. 25), that is, species of the *S. mytilus* complex are very likely more closely related to *Coniculostomum* and *Steinia* than to other well-known stylonychias, like *S. pustulata*. However, molecular biological data on *Steinia* and *Coniculostomum* and morphogenetic data on further stylonychias should be awaited before changing names. Recently, EIGNER (1997) transferred *Stylonychia pustulata* and *S. vorax* to the Parakahliellidae. Consequently he had to establish a new genus, *Clara* (type species: *Kerona pustulata* MÜLLER, 1786), which is, however, a junior homonym that has to be replaced.

In the present book, *Stylonychia* includes 11 species, largely confined to freshwater. Only four of them are described in detail, namely *S. mytilus*, *S. lemnae*, *S. pustulata*, and *S. bifaria*. The remaining species need detailed redescription, that is, live observations, protargol impregnation, morphometric characterisation. Furthermore, study of morphogenesis is recommended to show whether they belong to the *S. mytilus* or to the *S. pustulata* clade. Species of the *S. mytilus* complex and *S. pustulata* are one of the most common oxytrichids in lentic and lotic waters (FOISSNER et al. 1991).

When I wrote the main part of the *Stylonychia* section I did not have all papers now included in the lists of synonyms. Thus, not all illustrations concerning a species are arranged in succession.

Key to species

R e m a r k s: Some species, especially *Stylonychia putrina*, *S. vorax*, *S. curvata*, and the very common and well described *S. pustulata* are rather difficult to distinguish. Because

conspicuous and unambiguous differences are lacking, I had to use mainly the body shape, which is of course unsatisfactory. Thus, use only healthy specimens, look at the body shape without squeezing, and read the descriptions carefully. If identification is uncertain, for example in water pollution assessment when only one or few specimens have been observed, I recommend writing *Stylonychia* sp. or *S. pustulata* group. If caudal cirri inconspicuous, see also *Sterkiella* and *Rigidocortex*, which have, however, undulating membranes in *Oxytricha* pattern.

- 1 Macronucleus moniliform *S. nodulinucleata* (p 552)
- 2 macronuclear nodules 2
- 2 Invariably 1 micronucleus between macronuclear nodules (Fig. 167b–d)
..... *S. stylomuscorum* (p. 595)
- 2 or more micronuclei 3
- 3 Caudal cirri inconspicuous, that is, not distinctly longer than marginal cirri (Fig. 157a, i–k) *S. bifaria* (p 557)
- Caudal cirri distinctly longer than marginal cirri (for example, Fig. 148c, 159e) .. 4
- 4 Transverse cirri distinctly separated into 2 groups (for example, Fig. 148d, 149a) . 5
- Transverse cirri arranged like a hook, that is, do not form 2 distinct groups (for example, Fig. 160c, 161a, c) 7
- 5 Body distinctly broader anteriorly than posteriorly, tapering backwards from centre, posterior end usually truncated, left margin usually concave, right convex; postoral ventral cirrus V/4 in front of level of postoral ventral cirrus IV/2; caudal cirri widely separated (for example, Fig. 148a–c, o, 150k, 151k)
..... 6 (*S. mytilus* complex, p 504)
- Body roughly parallel-sided, posterior end rounded; postoral ventral cirrus V/4 arranged behind level of postoral ventral cirrus IV/2; caudal cirri closely spaced (Fig. 159e, 166c) *S. notophora* (p 553)
- 6 About 44–66 and 40–56 basal body pairs in dorsal kinety 3 and 4 respectively (Table 31) *S. mytilus* (p 549)
- About 33–40 and 30–39 basal body pairs in dorsal kinety 3 and 4 respectively (Table 31) *S. lemnae* (p 550)
- 7 (4) Usually 10–12 frontal, frontoventral, and buccal cirri left of and beside adoral zone of membranelles; caudal cirri displaced slightly forward on right margin (Fig. 167a; little-known, uncertain species) *S. pseudograndis* (p 564)
- Rather invariably 8 frontal, frontoventral, and buccal cirri; caudal cirri almost exactly terminal (for example, Fig. 161a) 8
- 8 Outline ovoid, that is, posterior end broadly rounded (Fig. 167f) . *S. curvata* (p 593)
- Outline elliptical, parallel-sided or slightly converging posteriorly but never ovoid, posterior end rounded or somewhat tapered 9
- 9 Posterior half of cell tapering and obtusely pointed (Fig. 166a, b) . *S. vorax* (p 591)
- Outline parallel-sided or elliptical, posterior end of cell usually rounded (for example, Fig. 162a, 166a) 10

- 10 Outline usually elliptical, posterior end often narrowly rounded; caudal cirri indistinctly separate; left frontoventral cirrus III/2 immediately beside other frontoventral cirri (Fig. 162a, c, x) *S. pustulata* (p 565)
- Outline usually pronouncedly parallel-sided, both ends broadly rounded; caudal cirri distinctly separate; left frontoventral cirrus III/2 arranged immediately beside undulating membranes and distinctly separate from the 3 other frontoventral cirri, which are arranged in a short oblique row (Fig. 165a, c, d) *S. putrina* (p 586)

***Stylonychia mytilus* complex** (Fig. 7a, b, 13a–p, 17a–k, 18b, 27a–h, 148a–p, 149a–d, 150a–z, 151a–z, 152a–o, q–t, 153a–l, 154f–p, 155, 159g, 163e, Tables 3, 4, 18, 28, 31–35)

- 1773 *Trichoda mytilus* MÜLLER, Vermium Terrestrium et Fluviatilium, p 87.
- 1773 *Trichoda silurus* MÜLLER, Vermium Terrestrium et Fluviatilium, p 88.
- 1786 *Kerona mytilus* – MÜLLER, Animalcula Infusoria, p 242 (Fig. 150d–f).
- 1786 *Kerona silurus* – MÜLLER, Animalcula Infusoria, p 244, Tab. XXXIV, Fig. 9, 10.
- 1830 *Stylonychia mytilus* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1830: 43.
- 1833 *Stylonychia mytilus* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1833: 174, 330 (Fig. 150g; “Waffenthierchen”).
- 1838 *Stylonychia mytilus* – EHRENBURG, Infusionsthierchen, p 370 (Fig. 150h, i).
- 1838 *Stylonychia silurus* – EHRENBURG, Infusionsthierchen, p 372, Tafel XLII, Fig. II.
- 1841 *Kerona mytilus* – DUJARDIN, Zoophytes, p 425, Planche XII, fig. 2, 3.
- 1852 *Cerona mytilus* M. – PERTY, Zur Kenntniss kleinster Lebensformen, p 155.
- 1858 *Stylonychia mytilus* EHR. – CLAPARÈDE & LACHMANN, Mém. Inst. natn. génév., 5: 158 (Fig. 150j).
- 1858 *Stylonychia mytilus* – EBERHARD, Programm der Realschule zu Koburg, Jahr 1858: 50 (Fig. 152t; very low quality).
- 1859 *Stylonychia mytilus*. EHRBG. – STEIN, Organismus der Infusionsthiere I, p 147 (Fig. 150k, l).
- 1860 *Stylonychia mytilus* – BALBIANI, Journal de la physiologie de l'homme et des animaux, 3: 86, Planche IV, Fig. 1–8.
- 1862 *Stylonychia mytilus* – ENGELMANN, Z. wiss. Zool., 11: 359 (Fig. 151a).
- 1865 *Stylonychia mytilus* – QUENNERSTEDT, Acta Univ. lund., 2: 56 (Fig. 151x–z).
- 1867 *Stylonychia mytilus*. EHR. – WRZEŚNIEWSKIEGO, Rozprawa, Kraków, p 113 (Fig. 151u).
- 1867 *Stylonychia mytilus*. EHR. – WRZEŚNIEWSKIEGO, Rocznik ces. król. Towarzystwa Naukowego Krakowskiego. (Krakow). Poczet trzeci, 12: 341 (Fig. 151u).
- 1876 *Kerona dubius* FROMETEL, Études microzoaires, p 270, Planche XIII, fig. 3.
- 1876 *Stylonychia mytilus* – FROMETEL, Études microzoaires, p 275, Planche XIV, fig. 10, 10a.
- 1877 *Stylonychia mytilus* O. F. MÜLLER. EHR. – MERESCHKOWSKY, Trudy imp. S-peterb. Obshch. Estest., 8: 234 (Fig. 152c).
- 1882 *Stylonychia mytilus*, EHR. – KENT, Manual infusoria II, p 790.
- 1899 *Stylonichia mytilus* EHRENBURG – SCHUSTER, Sci. Gossip, 5: 202 (Fig. 154n; incorrect subsequent spelling).
- 1900 *Stylonychia mytilus* – WALLENGREN, Bih. K. svenska VetenskAkad. Handl., 26: 14 (Fig. 152f; incorrect subsequent spelling).
- 1900 *Stylonychia mytilus* MÜLL. – PÜTTER, Arch. Anat. Physiol., 1900: 267 (Fig. 152j).
- 1901 *Stylonychia mytilus* (O.-F. MÜLL.) – ROUX, Mém. Inst. natn. génév., 19: 103 (Fig. 151v).
- 1902 *Stylonychia mytilus* – WALLENGREN, Zool. Jb., 15: 20 (Fig. 163f).
- 1905 *Stylonychia* sp. (?) – CONN, Bull. Conn. St. geol. nat. Hist. Surv., 2: 61 (Fig. 152n).

- 1905 *Stylonychia mytilus* MÜLL. – CONN, Bull. Conn. St. geol. nat. Hist. Surv., 2: 61 (Fig. 154o).
- 1905 *Stylonychia fissieta* C. & L. – CONN, Bull. Conn. St. geol. nat. Hist. Surv., 2: 61 (Fig. 152o; incorrect subsequent spelling).
- 1906 *Stylonychia mytilus* EHR. – EDMONDSON, Proc. Davenport Acad. Sci., 11: 101 (Fig. 152q).
- 1906 *Stylonychia* sp. – EDMONDSON, Proc. Davenport Acad. Sci., 11: 102 (Fig. 152r).
- 1908 *Stylonychia mytilus* O. F. MÜLL. – BÜRGER, An. Univ. Chile, 122: 188 (Fig. 154m).
- 1909 *Stylonychia mytilus* – FAURÉ-FREMIET, Arch. Protistenk., 13: 127 (Fig. 151w).
- 1912 *Stylonychia mytilus* – LEWIN, Proc. R. Soc., 84: 336 (Fig. 152a).
- 1914 *Stylonychia mytilus* EHR. – SMITH, Kans. Univ. Sci. Bull., 9: 166 (Fig. 154f).
- 1920 *Stylonichia mytilis* EHRBG. – FELLERS & ALLISON, Soil Sci., 9: 9, 24 (Fig. 152g; incorrect subsequent spelling; identification uncertain).
- 1922 *Stylonychia mytilus* – PFEIFFER, Mitteilungen der Märkischen mikrobiologischen Vereinigung, 11: 131, Abb. A, B.
- 1925 *Stylonichia mytilus* EHRENBURG – WANG, Contr. biol. Lab. Sci. Soc. China, 1: 51 (Fig. 152d; incorrect subsequent spelling).
- 1925 *Stylonychia mytilus* – DEMBOWSKA, Arch. mikrosk. Anat. EntwMech., 104: 185 (Fig. 163e).
- 1928 *Pleurotricha lanceolata* – RAO, J. Indian Inst. Sci., 11A: Legend of plate II (Fig. 151o; misidentification).
- 1931 *Stylonychia mytilus* EHRBG. – TAI, Sci. Rep. natn. Tsing Hua Univ., 1: 52 (Fig. 154i).
- 1932 *Stylonychia mytilus* EHRENBURG, 1838 – KAHL, Tierwelt Dtl., 25: 618 (Fig. 151k, l).
- 1932 *Stylonychia* spec. – KAHL, Tierwelt Dtl., 25: 619 (Fig. 151m).
- 1938 *Stylonychia mytilus* – DEMBOWSKA, Arch. Protistenk., 91: 89 (Fig. 151p).
- 1944 *Stylonychia mytilus* – CHEN, J. Morph., 75: 338 (Fig. 150n).
- 1944 *Stylonychia mytilus* MÜLLER – BUISÁN, Publ. Inst. Biol. apl., 1: 20 (Fig. 154l).
- 1954 *Stylonychia claviformis* GELEI, Acta biol. hung., 5: 336 (Fig. 151e, f, t; was establish in *Oxytricha*, thus the correct name is *O. (Stylonychia) claviformis*).
- 1955 *Stylonychia mytilus* EHRENBURG – BARWICK, BEVERIDGE, BRAZIER, CLOSE, HIRSCHFELD, PILLAI, RAMSAY, ROBINSON, STEVENS & TODD, Tuatara, 5: 96 (Fig. 154p).
- 1960 *Stylonychia mytilus* STEIN – STILLER, Fauna Hung., 57: 11, 13. ábra, B (redrawing after BÜTSCHLI).
- 1961 *Stylonychia mytilus* EHRENBURG, 1838 – REUTER, Acta zool. fenn., 99: 21 (Fig. 151s).
- 1961 *Stylonychia mytilus* EHR. – BUCK, Jh. Ver. vaterl. Naturk. Württ., 116: 212 (Fig. 151n).
- 1963 *Stylonychia mytilus* EHRB. – BIERNACKA, Polskie Archw. Hydrobiol., 11: 50 (Fig. 154k).
- 1965 *Stylonychia mytilus* (MÜLLER) – TCHANG & PANG, Kexue Tongbao, 4: 358 (Fig. 150m).
- 1965 *Stylonychia mytilus* Varietät 1 – AMMERMAN, Arch. Protistenk., 108: 111 (Fig. 149d).
- 1965 *Stylonychia mytilus* Varietät 2 – AMMERMAN, Arch. Protistenk., 108: 111 (Fig. 150c).
- 1965 *Stylonychia mytilus* EHRENBURG – MACHEMER, Arch. Protistenk., 108: 153 (Fig. 152h).
- 1965 *Stylonychia mytilus* – TUFFRAU, Arch. Zool. exp. gén., 105: 84 (Fig. 152i).
- 1965 *Stylonichia mytilus* EHRENBURG, 1838 – LÓPEZ-UCHOTERENA, Revta Soc. mex. Hist. nat., 24: 160 (Fig. 152k, l; incorrect subsequent spelling).
- 1966 *Stylonychia mytilus* EHR. – DRAGESCO, Protistologica, 2: 90 (Fig. 150s–z).
- 1967 *Stylonichia mytilus* MÜLLER – CHARDEZ, Revue Écol. Biol. Sol., 4: 294 (Fig. 154g; incorrect subsequent spelling).
- 1968 *Oxytricha (Stylonychia) mytilus* EHRENBURG, 1838 – CHORIK, Free-living ciliates, p 139 (Fig. 151g).
- 1969 *Stylonychia mytilus* – TUFFRAU, Protistologica, 5: 230, 235 (Fig. 151i).
- 1969 *Stylonychia mytilus* EHRENBURG, 1838 – CURDS, Wat. Pollut. Res., No. 12: 70 (Fig. 151q).
- 1971 *Stylonychia putrina* STOKES (?) – DRAGESCO & NJINE, Annls Fac. Sci. Univ. fédération Cameroun, No. 7–8: 130; in part: “grande variété”, Fig. 27; not “petit variété”, Fig. 28 (Fig. 159g; misidentification).
- 1971 *Stylonychia mytilus* EHRENBURG – CHARDEZ, Revue venviét. Hist. nat., 28: 38 (Fig. 154j; incorrect subsequent spelling).
- 1972 *Stylonychia mytilus* (MÜLLER, 1773) EHRENBURG, 1830 – BORROR, J. Protozool., 19: 15.
- 1972 *Stylonychia mytilus* EHRENBURG – BICK, Ciliated protozoa, p 174 (Fig. 151b).

- 1973 *Stylonychia mytilus* – AMMERMAN, Cell development, p 51 (Fig. 148q, r).
- 1974 *Stylonychia mytilus* (MÜLLER, 1773) EHRENBURG, 1830 – JONES, Univ. South Alabama Monogr., 1: 41 (Fig. 152e).
- 1974 *Stylonychia steinii* STILLER, Annls hist.-nat. Mus. natn. hung., 66: 133 (see nomenclature and taxonomy).
- 1975 *Stylonychia mytilus* – WILBERT, Mikrokosmos, 64: 176, Bild 9.
- 1977 *Stylonychia mytilus* EHRB. 1838 – BERECKZY, Annls Univ. Scient. bpest. Rolando Eötvös, 18–19: 170 (Fig. 152m).
- 1979 *Stylonychia mytilus* EHRB., 1838 – MAMAEVA, Infusoria of the Volga Basin, p 72 (Fig. 154h; incorrect subsequent spelling).
- 1981 *Stylonychia mytilus* – TUFFRAU, FRYD-VERSAVEL & TUFFRAU, Protistologica, 17: 387 (Fig. 13a–p, 151r).
- 1982 *Stylonychia mytilus* EHRENBURG, 1838 – FOISSNER, Arch. Protistenk., 126: 107 (Fig. 150o–r).
- 1982 Spirotrich – JEFFRIES, J. biol. education, 16: 37, Fig. 6 (microphotograph).
- 1983 *Stylonychia mytilus*, EHRENBURG 1838 – AMMERMAN & SCHLEGEL, J. Protozool., 30: 292 (Fig. 148n, o, 151j).
- 1983 *Stylonychia lemnae* AMMERMAN & SCHLEGEL, J. Protozool., 30: 291 (Fig. 148m, p, 149c).
- 1983 *Stylonychia mytilus* EHRENBURG, 1838 – STEINBRÜCK & SCHLEGEL, J. Protozool., 30: 294.
- 1983 *Stylonychia lemnae* STEINBRÜCK & SCHLEGEL, J. Protozool., 30: 296 (see nomenclature and taxonomy).
- 1986 *Stylonychia mytilus* – WIRNSBERGER, FOISSNER & ADAM, Arch. Protistenk., 132: 169 (Fig. 149a, b, 153d).
- 1986 *Stylonychia lemnae* AMMERMAN & SCHLEGEL, 1983 – WIRNSBERGER, FOISSNER & ADAM, Arch. Protistenk., 132: 167 (Fig. 150a, b, 153a–c, e–j).
- 1986 *Stylonychia mytilus* (O. F. MÜLLER, 1773) EHRENBURG, 1830 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 486.
- 1986 *Stylonychia putrina* STOKES, 1885 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 487, in part: Planche 145 A; not Planche 145 B–F (misidentification).
- 1987 *Stylonychia mytilus* EHRENBURG, 1838 – TUFFRAU, Annls Sci. nat., Zoologie, 8: 113 (Fig. 151h).
- 1987 *Stylonychia mytilus* – MACHEMER & DEITMER, Progr. Protistol., 2: 217 (Fig. 151c, d; also figured in SLEIGH 1989).
- 1987 *Stylonychia mytilus* EHRENBURG, 1838 – LOKOT, Ökologie der Wimpertiere, p 74 (Fig. 152s).
- 1988 *Stylonychia mytilus* (O. F. MÜLLER, 1773) – SHIN & KIM, Korean J. syst. Zool., Special Issue No. 2: 71, 3A–F.
- 1991 *Stylonychia mytilus*-Komplex – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 315 (Fig. 148a–l).
- 1993 *Stylonychia mytilus* EHRENBURG – YOSHINO, Island Studies in Okinawa, 11:63, Plate VIII, Fig. 7 (microphotograph).
- 1997 *Stylonychia mytilus*-Komplex – BERGER, FOISSNER & KOHMANN, Bestimmung und Ökologie der Mikrosaprobien, p 163.

Nomenclature and taxonomy: AMMERMAN (1965a) reported that the widespread and very well-known species *Stylonychia mytilus* consists of 2 morphologically inseparable but distinguishable genetic species. He followed SONNEBORN (1957) and used the term “syngen” and “variety”, respectively, to designate these sibling species. About 20 years later, a fully distinctive taxonomic name for the *S. mytilus* syngen 1, namely *Stylonychia lemnae* was proposed. Unfortunately, this name was published several times by various authors with the appendix “n. sp.” (AMMERMAN & SCHLEGEL 1983; STEINBRÜCK &

Fig. 148a–g *Stylonychia mytilus* complex (from FOISSNER et al. 1991. a–c, f, g, from life, bright field; d, e, → protargol impregnation). a, f) Ventral views. b, c) Dorsal views. d) Ventral infraciliature of a specimen with

only 2 frontal cirri. The transverse cirri are separated into two distinct groups (arrows). e) Dorsal view showing adoral zone of membranelles, caudal cirri, and nuclear apparatus; arrows mark micronuclei. g) Lateral view of specimen creeping on detritus. AZM = adoral zone of membranelles, CC = posteriorly fringed caudal cirri, FC = frontal cirrus, LMR = left marginal cirral row, Ma = macronuclear nodule, RMR = right marginal cirral row, TC = transverse cirri, VC = right pretransverse ventral cirrus (cirrus VI/2); p 504.

Fig. 148h-l *Stylonychia mytilus* complex (from FOISSNER et al. 1991. h, i, k, l, scanning electron micrographs; j, from life, bright field). h, l) Ventral views. Note that transverse cirri are distinctly separated into two groups. i) Anterior half in ventral view. Note large, bowl-shaped buccal area. Large arrow marks buccal cirrus. This specimen has a supernumerary frontoventral cirrus (small arrow). j) Resting cyst. k) Right lateral view. Large arrow marks "collar", small arrow denotes dorsal kinety 5. AZM = adoral zone of membranelles, CC = caudal cirri, FC = right frontal cirrus, p = paroral, pVC = posterior postoral ventral cirrus (V/3), TC = right transverse cirrus; p 504.

Fig. 148m, p *Stylonychia lemnae* (from AMMERMAN & SCHLEGEL 1983. m, scanning electron micrograph; p, phase contrast micrograph). m) Ventral view, 240 μ m. p) Dorsal view of a cell starved for one day, 240 μ m; p 504.

Fig. 148n, o *Stylonychia mytilus* (from AMMERMAN & SCHLEGEL 1983. n, scanning electron micrograph; o, phase contrast micrograph). n) Ventral view, 290 μ m. o) Dorsal view of a cell starved for one day, 310 μ m; p 504.

Fig. 148q, r *Stylonychia mytilus* complex (from AMMERMAN 1973). q) Macronucleus anlage after conjugation, about 20 h old, with short spiralled and long de-spiralled chromosomes. r) Portion of a giant chromosome of a macronucleus anlage, about 40 h old, with a large heterochromatin block; p 504.

Fig. 149a–d *Stylonychia lemnae* (a, b, from WIRNSBERGER et al. 1986; c, from AMMERMAN & SCHLEGEL 1983; d, from AMMERMAN 1965a. a, b, protargol impregnation; c, redrawn from a scanning electron micrograph; d, from life). a–c) Ventral and dorsal infraciliature, a, b = 180 μ m, c = 215 μ m. Arrowhead in (a) marks fronto-ventral cirrus III/2, which is arranged slightly behind level of cirrus IV/3 (arrow); possibly an important difference to *S. mytilus* (cp. Fig. 150a and see text). Arrangement of cirri in (c) obviously incorrect (cp. Fig. 149a). The anterior end of dorsal kinetids 1–4 is obviously less curved than in *S. mytilus* (cp Fig. 150b). d) Ventral view, size not indicated; p 504.

SCHLEGEL 1983; PEYER & MACHEMER 1983, p 224; DEITMER et al. 1983, p 286). Since the description of the morphology, the reproductive behaviour, and the type location are provided by AMMERMAN & SCHLEGEL (1983) they have to be considered as the describers.

Of course it is impossible to determine which species of the *S. mytilus* complex MÜLLER saw in 1773. But, as in the case of the *Tetrahymena pyriformis* complex (CORLISS & DAGGETT 1983, NANNEY & MCCOY 1976), one variety, namely *S. mytilus* syngen 2 of AMMERMAN (1965a) has to retain the original taxonomic name. This is in agreement with Article 17 (1) of the ICZN (1985), which says, that the availability of a name is not affected even if it is found that the original description relates to more than one taxon. The authorship of *S. mytilus* is often erroneously credited to EHRENBURG (see list of syno-

Fig. 150a–c *Stylonychia mytilus* (a, b, from WIRNSBERGER et al. 1986; c, from AMMERMAN 1965a. a, b, protargol impregnation; c, from life). a, b) Ventral and dorsal infraciliature, a, b = 215 μ m. Arrowhead marks frontoventral cirrus III/2, which is situated slightly in front of level of cirrus IV/3 (arrow); possibly an important difference to *S. lemnae* (cp. Fig. 149a and see text). Furthermore, the dorsal kineties 1–4 are obviously somewhat more curved anteriorly than in the sister group, *S. lemnae* (cp. 149b). c) Ventral view, size not indicated; p 504.

nym). However, there is no doubt that it has to be attributed to MÜLLER (1773), as correctly stated by BORROR (1972a). The classification in *Stylonychia* was already done by EHRENBURG (1830) and not by EHRENBURG (1838), as often assumed.

KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Stylonychia) mytilus*. Incorrect subsequent spellings: *mitilus* (ENRIQUES 1912, p 425); *St. sylurus* (WEISSE 1848c, p 362); *Styloichia mitilus* (MAMAEVA 1979b, p 118); *Stylonichia mitilus* (MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA 1973, p 67; SKORIKOW 1902, p 563; WETZEL 1925, p 243); *Stylonichia mutilus* (KHLEBOVICH 1987, p 219); *Stylonichia mytillus* EHRENBURG (CHARDEZ 1984, p 21; TUCULESCU 1965, p 190); *Stylonichia mytylus* EHR. (SACCHI 1888, p 51); *Stylonychia clavata* GELEI (STILLER 1974b, p 156 instead of *S. claviformis*); *Stylonychia mutilis* (MULLER) (CAIRNS 1965b, p 48); *Stylonychia mutilus* (VEYLANDE & LIYEPÄ 1985, p 82); *Stylonychia mysilus* (DETCHIEVA 1979a, p 72); *Stylonychia mystilus* (SCHARF 1961, p 389); *Stylonychia mytilis* (BAMFORTH

Fig. 150o–r *Stylonychia mytilus* complex (from FOISSNER 1982. o, p, from life; q, r, protargol impregnation). o, p) Specimens creeping on a soil particle, o = 85 µm, p = 100 µm. q, r) Ventral and dorsal infraciliature, q = 90 µm, r = 95 µm. The arrangement of the two posterior-most frontoventral cirri and the curving of dorsal kineties is as in *S. lemnae* (cp. Fig. 149a, b); p 504.

1980b, p 148; BURKOVSKY 1984, p 10; FANG & CECHE 1991, p 5515; KUTIKOWA 1984, p 177; THOMPSON 1972, p 287); *Stylonychia mytilus* (DETCHEVA 1981, p 23; GRACIA et al. 1989, p 25); *Stylonychia mytilus* (NOMOTO et al. 1988, p 255); *Stylonychia mytilus* (MADONI 1988a, p 62).

The list of synonyms of *S. mytilus* (below) and *S. lemnae* (below) comprise – besides the works of MÜLLER (1773, 1786) and EHRENBURG (1830) – only those synonyms where

← Fig. 150d–f *Stylonychia mytilus* (after MÜLLER 1786). Various views from life, size not indicated; p 504, 549. g–n *Stylonychia mytilus* complex (g, after EHRENBURG 1833; h, i, after EHRENBURG 1838; j, after CLAPARÈDE & LACHMANN 1958; k, l, after STEIN 1859b; m, from TCHANG & PANG 1965a; n, from CHEN 1944. g–l, from life; m, method not indicated; n, haematoxylin stain). g–k, m, n) Ventral views, g–k, m = size not indicated, n = 905 µm! (obviously a wrong value). Figure g shows a specimen with an ingested filiform cyanobacterium. Figure h, i seen from dorsal. l) Resting cyst, 55–70 µm; p 504.

Fig. 150s-u *Stylonychia mytilus* complex (from DRAGESCO 1966b. s-u, protargol impregnation). s) Ventral infraciliature of a "normal specimen", size not indicated and caudal cirri not shown in full length. t) Dorsal infraciliature schematic. Dorsomarginal kineties obviously drawn too long. u) Ventral infraciliature of a "small variety" from Thonon with an additional frontoventral cirrus (arrow), about 180 μ m; p 504.

the identification is reliable. The other synonyms are shown in the comprehensive list of the *S. mytilus* complex (see above) because an unequivocally relation to one of these two species is impossible.

According to EHRENBERG (1838) and DIESING (1850, p 152) the following old taxa are also synonyms of *S. mytilus*: *Himantopus corona* MÜLLER, 1786 (= *Kerona corona* (MÜLLER, 1786) BORY, 1824²); *Kerona haustellum* MÜLLER, 1786; *Kerona haustrum* MÜLLER, 1786; *Plagiotricha diana* BORY, 1824; *Trichoda acarus* MÜLLER, 1773 (= *Himantopus acarus* (MÜLLER, 1773) MÜLLER, 1786 = *Kerona acarus* (MÜLLER, 1773) BORY, 1824); *Trichoda cypris* MÜLLER, 1773 (= *Kerona cypris* (MÜLLER, 1773) MÜLLER, 1786); *Trichoda erosa* MÜLLER, 1786 (= *Kerona erosa* (MÜLLER, 1786) BORY, 1824); *Trichoda fimbriata* MÜLLER, 1786 (= *Kerona fimbriata* (MÜLLER, 1786) BORY, 1824; = *Oxytricha fimbriata* (MÜLLER, 1786) FROMENTEL, 1876); *Trichoda ludio* MÜLLER, 1773 (= *Himantopus ludio* (MÜLLER, 1773) MÜLLER, 1786 = *Kerona ludio* (MÜLLER, 1773) BORY, 1824);

² BORY, 1824 = BORY DE SAINT-VINCENT in LAMOUROUX et al., 1924.

Fig. 150v–z *Stylonychia mytilus* complex (from DRAGESCO 1966b. v–x, z, protargol impregnation; y, Feulgen stain). v, x) Ventral and dorsal infraciliature, size not indicated. w) Nuclear apparatus. y) Resting cyst. z) Dorsal cilium including fibrillar system; p 504.

Trichoda rostrata MÜLLER, 1786 (= *Kerona rostrata* (MÜLLER, 1786) BORY, 1824);
Trichoda sannio MÜLLER, 1773 (= *Himantopus sannio* (MÜLLER, 1773) MÜLLER, 1786 =
Kerona sannio (MÜLLER, 1773) BORY, 1824).

Discussion of some synonyms of the *S. mytilus* complex (for a more comprehensive discussion of pre-1838 synonyms, see EHRENBERG 1838): *Stylonychia silurus* sensu EHRENBERG (1838) is rather small (87–117 μm), but the morphology, especially the conspicuous, widely spaced caudal cirri indicate that it is a member of the *S. mytilus* complex. The first detailed and comprehensive redescrptions of *S. mytilus* were provided by CLAPARÈDE & LACHMANN (1858, Fig. 150j) and especially by STEIN (1859b, Fig. 150k, l). STEIN studied the morphology, the morphogenesis, the conjugation, the cyst, and a suctorian infection. *Kerona dubius* FROMENTEL, 1876, is very likely a slightly deformed specimen of a species of the *S. mytilus* complex. This was already supposed by FROMENTEL (1876) himself; furthermore, in the legend to the figure he wrote “*Kerona mytilus*”. *Stylonychia mytilus* sensu MERESCHKOWSKY (1877, Fig. 152c) from a marine habitat has only 2 caudal cirri, an anomaly also occurring in freshwater populations. *Pleurotricha lanceolata* sensu RAO (1928, Fig. 151o) is rather surely a misidentification. Obviously, he misinterpreted a dorsal kinety as outer right marginal row; furthermore, *Pleurotricha* has no caudal cirri. *Stylonychia* spec. sensu KAHL (1932) is a redrawing of Tafel VIII, Fig. 3 of STEIN (1859b). The original figure by STEIN (1859b) shows a heavy suctorian infection causing a conspicuous indentation of the left body margin. Furthermore, three deformed macronuclear nodules are present. KAHL (1932) obviously neglected these details, separated it from *S. mytilus*, and stated that there is no closer relationship between *S. mytilus* and *Stylonychia* spec. STILLER (1974a) proposed the name *S. steinii* for this – in my opinion – invalid taxon.

Stylonychia claviformis GELEI, 1954 (Fig. 151e, f, t) has already been synonymised with *S. mytilus* by BORROR (1972a). The body shape and the arrangement of the transverse and caudal cirri of the “grande variété” of *S. putrina* sensu DRAGESCO & NJINE (1971, Fig. 159g; more or less identical with Planche 144 A in DRAGESCO & DRAGESCO-KERNÉIS 1986) are more reminiscent of a species of the *S. mytilus* complex than of *S. putrina*.

Stylonychia mytilus sensu MAUPAS (1888, Fig. 163a) is classified as *S. pustulata* because the overall morphology does not agree in the least with that of species of the *S. mytilus* complex. Obviously erroneously, MACHEMER (1966b, p 642) stated that AMMER-MANN (1965a) recognised 3 syngens (“Varietäten”) of *S. mytilus*.

The following redescrptions are insufficient: AGAMALIEV (1978; Fig. 230c, d), BALDENSPERGER (1927, Planche VI, 204), BATTISH (1992; his Fig. 55), CIENKOWSKY (1855; Fig. 222j), DUMAS (1929; Fig. 237f, i), LÓPEZ-POCHOTERENA (1964), LUNDIN & WEST (1963; identical with WEST & LUNDIN 1963; Fig. 234a), RAMIREZ DE GUERRERO (1970,

← Fig. 151a–d *Stylonychia mytilus* complex (a, from ENGELMANN 1862; b, from BICK 1972a; c, d, from MACHEMER & DEITMER 1987. a, from life; b–d, from life?). a, b) Ventral views, a = 265 μm , b = 265 μm . c) Lateral view (305 μm) showing adoral zone of membranelles (large arrow), that is, the most conspicuous part of the prominent oral apparatus, the cirri (arrowheads) on the $\pm$ flat ventral side, and the $\pm$ distinctly arched dorsal side with the dorsal kineties (small arrows). d) Ventral view mainly showing arrangement of cirri and oral apparatus, 305 μm . CC = caudal cirri at posterior end of dorsal kineties 1, 2, and 4, CV = contractile vacuole, p = paroral; p 504.

Fig. 151k–t *Stylonychia mytilus* complex (k, l, from KAHL 1932; m, after STEIN 1859b from KAHL 1932; n, after BUCK 1961; o, after RAO 1928; p, from DEMBOWSKA 1938; q, from CURDS 1969; r, from TUFFRAU et al. 1981; s, after REUTER 1961; t, from GELEI 1954b. k–q, s, from life; r, protargol impregnation; t, sublimate fixation). k–o, q, s) Ventral views, k, n = 250 μ m, l, s = 100 μ m, m, o = size not indicated, q = 155 μ m. p) Ventral infraciliature in dorsal view, 375 μ m. r) Ventral infraciliature of a specimen after conjugation, 95 μ m. Preceding stages, see Figures 13a–g. t) Dorsal view of a very small (75 μ m) specimen; p 504.

← Fig. 151e–i *Stylonychia mytilus* complex (e, f, from GELEI 1954b; g, from CHORIK 1968; h, after TUFFRAU 1965a from TUFFRAU 1987; i, from TUFFRAU 1969. e, sublimate fixation; f, g, from life; h, i, protargol impregnation). e, g) Ventral views, e = about 110 μ m, g = 150 μ m. f) Arrangement of transverse cirri in ventral view. h) Ventral infraciliature, 235 μ m. i) Early morphogenetic stage in ventral view showing oral primordium (arrow); p 504. j) *Stylonychia mytilus* (from AMMERMAN & SCHLEGEL 1983). Ventral infraciliature redrawn from a scanning electron micrograph, 300 μ m; p 504, 549.

Fig. 151u-z, 152a *Stylonychia mytilus* complex (u, after WRZESNIEWSKIEGO 1867a, b; v, after Roux 1901; w, from FAURÉ-FREMIET 1909; x-z, after QUENNERSTEDT 1865; a, after LEWIN 1912. u-z, a, from life). u-w, z, a) Ventral views, u = 330 μ m, v = 340 μ m, w, z = ? μ m, a = 205 μ m. x, y) Infection with suctors; p 504.

Fig. 152b–e *Stylonychia mytilus* complex (b, from DRAGESCO 1966b; c, after MERESCHKOWSKY 1877; d, after WANG 1925; e, from JONES 1974. b, protargol impregnation; c–e, from life). b) Ventral infraciliature of the supposed synonym *Stylonychia kahli*, 200 μm . c–e) Ventral views, c = size not indicated, d = 165 μm , e = 133 μm . Note that the specimen in (c) has only 2 caudal cirri, an anomaly which can be observed relatively often in *S. mytilus*; p 504.

Fig. 226l). The illustration in REDEKE (1948) is a redrawing from STEIN (1859b). *Stylonychia mytilus* in ALEKPEROV (1992, p 132) is a misidentification (possibly *S. pustulata*).

Morphology and biology: See also characterisation of *Stylonychia*, additional characters, and key to species for some characters. Size rather variable, for example, 87–347 μm (STEIN 1959b), 100–300 μm (KAHL 1932), 280–375 μm (BUISAN 1944), 200–400 μm (EDMONDSON 1906), 80–160 μm (JONES 1974), 100–130 $\times$ 40 μm (GELEI 1954). According to AMMERMAN & SCHLEGEL (1983), *S. lemnae* – the smaller of the two species of the complex – is about 230 μm long on average, whereas *S. mytilus* measures about 300 μm . However, WIRNSBERGER et al. (1986) demonstrated that body size and shape (see below) show transitions, indicating that they cannot be used for separation as suggested by AMMERMAN & SCHLEGEL (1983; Table 31).

Fig. 152f-h *Stylonychia mytilus* complex (f, from WALLENGREN 1900a; g, after FELLERS & ALLISON 1920; h, slightly modified from MACHEMER 1965b. f-h, from life). f) Arrangement of frontal, ventral, and transverse cirri. Cirri originating from the same streak are connected by a dotted line. g, h) Ventral views, g, h = size not indicated. Identification of (g) uncertain; p 504.

Outline usually very typical, namely with usually striking bulge in region of peristome (for example, Fig. 148a, o, 151k, n). Body margins slightly to distinctly converging posteriorly, left margin usually concave, right margin slightly to distinctly convex. Posterior end usually $\pm$ truncated, sometimes rather broadly rounded. Flattened about 2:1 dorsoventrally, first and last quarter of cell very thin (Fig. 151c); especially posterior portion thus usually rather translucent.

Fig. 152i *Stylonychia mytilus* complex (from TUFFRAU 1965a). Ventral infraciliature and associated fibrilles $\rightarrow$ after protargol impregnation. Explanation of original labels: A = "éventail" rétrociliaire perpendiculaire au plan des membranelles adorales, B1-B3 = lames fibreuse sous-ectoplasmiques issues des bases des cirres marginaux et ventraux, C1, C2 = fibres radiculaires des cirres de la face ventrale, D = fibres cytopharyngiennes, E1, E2 = grandes racines ciliaires des bases marginales, F = faisceau des fibres longitudinales issues des cirres transversaux, G = fibres de connexion adorales, H1, H2 = fibres tangentielles des plages antérieure et postérieure, I = "termina filament" de LUND, J = fibres ramifiées sous-adorales, K = petites racines ciliaires des cirres marginaux; p 504.

Fig. 152j-m *Stylonychia mytilus* complex (j, from PÜTTER 1900; k, l, from LÓPEZ-CHOTERENA 1965; m, from BEREZKY 1977a. j-l, from life; m, method not indicated). j-m) Ventral views, j, l, m = size not indicated, k = 115 μ m; p 504.

Macronuclear nodules often connected by fine strand, usually arranged about in median of cell. Anterior nodule sometimes displaced more to right than posterior nodule. Nodules in life about $40-45 \times 15-25 \mu$ m (in large to middle-sized populations), after protargol impregnation $28 \times 11 \mu$ m ($23-32 \times 9-13 \mu$ m; $n = 15 \mu$ m) to $39 \times 14 \mu$ m ($31-45 \times 11-17 \mu$ m; $n = 25$) in *S. mytilus* and $26 \times 10 \mu$ m ($19-38 \times 9-11 \mu$ m; $n = 15$) to $32 \times 13 \mu$ m ($25-39 \times 10-15 \mu$ m; $n = 25$) in *S. lemnae*. Usually 3-4, according to JICKELI (1884) up to 6 micronuclei; in life 6-7 μ m across. Cultivation at supra-optimum temperature (30 °C) yields a significantly higher number of micronuclei (namely 6) than in control cells (3 on average; KAUL & SAPRA 1986). Many small crystals homogeneously distributed in cytoplasm (HAUSMANN 1982). Contractile vacuole pulsates about every 8-13 s (GELEI 1935); takes 45 min at 18 °C to excrete the amount of water corresponding to cell volume (BRAND 1935, MAUPAS 1883). Rapid movement, comprising 4 fundamental forms, namely swimming, running, resting, and reversing movements (see MACHEMER 1965b for details).

Adoral zone of membranelles 50-55 % of body length. Frontal and transverse cirri and buccal cirrus distinctly enlarged. Frontal and transverse cirri in life about 40-50 μ m,

Fig. 152n, o *Stylonychia mytilus* complex (from CONN 1905). Ventral views from life, n = 170 μ m, o = 155 μ m; p 504. **p** *Stylonychia notophora* (from LÓPEZ-UCHOTERENA 1965). Ventral view from life (?), 120 μ m; p 553.

marginal cirri in life 20–30 μ m long. Frontoventral cirrus III/2 slightly behind level of frontoventral cirrus IV/3 (Fig. 149a) or somewhat in front of it (Fig. 150a); possible this is a small, but significant difference between *S. mytilus* and *S. lemnae* which can be seen even in live specimens. Only the 2 right transverse cirri protrude distinctly beyond posterior end of cell. Usually 6, rarely 7 dorsal kineties. Caudal cirri widely separated, in medium- and large-sized specimens in life about 50–70 μ m long, posteriorly usually fringed.

Resting cyst with a solid, wavy ectocyst (Fig. 148j, 150i; see also ILOWAISKY 1915, 1926b). After STEIN (1859b) in life 55–70 μ m, rarely up to 105 μ m, according to BRAND (1923) 108–128 μ m across, belongs to kinetosome-resorbing type (WALKER & MAUGEL 1976). All mineral concretions are eliminated from cell during encystment (RELIA et al. 1988). The observations of CIENKOWSKY (1855) on cyst formation are rather superficial.

Fig. 152q–t *Stylonychia mytilus* complex (q, r, from EDMONDSON 1906; s, from LOKOT 1987; t, from EBERHARD 1858. q–t, from life). Ventral views, q = 250 μ m, r = 245 μ m, s = 150 μ m, t = size not indicated. Figure q possibly shows a different species as correctly stated by EDMONDSON (1906) in that he identified it as “*Stylonychia* sp.”; p 504.

M o r p h o g e n e s i s. More or less comprehensive contributions to divisional morphogenesis of species of the *S. mytilus* complex are provided by BALBIANI (1860a), DEMBOWSKA (1925), FRICK (1968), GELEI (1927), HEMBERGER (1982), KAMRA & SAPRA (1993a), STEIN (1859b), TCHANG et al. (1965), WALLENGREN (1902), WATANABE & HORA (1983), QIU et al. (1996), and in most detail by WIRNSBERGER et al. (1986). The latter authors did not find any differences in morphogenesis of *S. mytilus* and *S. lemnae*. Thus, the following statements and drawings (Table 4, Fig. 23f, 153a–j) are valid for both species. Stomatogenesis commences with formation of a small group of basal bodies very close to the left transverse cirrus (cirrus II/1; Fig. 151i, 153a; TUFFRAU 1970). Sometimes, this group originates also very close to transverse cirrus III/1; however, transverse cirri

Fig. 153a–f *Stylonychia mytilus* complex (from WIRNSBERGER et al. 1986. a–c, e, f, *S. lemnae*; d, *S. mytilus*. → a–f, ventral infraciliature of morphogenetic stages after protargol impregnation). a) Very early stage with origin of oral primordium (arrowhead), 175 μ m. b, c) Early stages, b = 190 μ m, c = 195 μ m. Arrowhead marks postoral ventral cirrus V/4, which is modified to a primordium. Arrow marks oral primordium. d) Early stage. Only anterior portion of cell is shown. e, f) Middle stages with a supernumerary ventral cirrus (f, arrowhead), e = 215 μ m, f = 190 μ m; further explanation see text; p 504.

153a

Fig. 153k, l *Stylonychia mytilus* complex (from FLEURY & FRYD-VERSAVEL 1981. k, l. protargol impregnation). Ventral and dorsal infraciliature of a reorganiser, 200 μ m. Arrowhead in (l) marks fragmentation of new dorsal kinety 3. Details on reorganisation, see chapter 1·10·4 in the general section; p 504.

← **Fig. 153g–j** *Stylonychia lemnae* (from WIRNSBERGER et al. 1986. g–j, ventral infraciliature of morphogenetic stages after protargol impregnation). g, h) Late stages, g = 160 μ m, h = 200 μ m. i, j) Very late stage and opisthe immediately after cell division, i = 190 μ m, j = 150 μ m. Cirri originating from individual primordia are connected by a broken line; new structures black, parental white; further explanation, see text. DP = primordia of dorsomarginal kineties, MP = primordium of right marginal row of proter; p 504.

Fig. 154a–d *Stylonychia pustulata* (a, from TAI 1931; b, from CELA 1972; c, from YANO & SUHAMA 1991; d, after SMITH 1914. a, d, from life; b, from life and after silver impregnation (?); c, protargol impregnation). a, b, d) Ventral views, a = 130 μm , b = 60 μm , d = size not indicated. c) Ventral infraciliature of very early morphogenetic stage. OP = oral primordium; p 565.

Fig. 154e *Stylonychia notophora* (after SMITH 1914). Ventral view from life, size not indicated; p 553.

Fig. 154f–i *Stylonychia mytilus* complex (f, after SMITH 1914; g, from CHARDEZ 1967; h, from MAMAEVA 1979b; i, from TAI 1931. f–i, from life). f–i) Ventral views, f = size not indicated, g = 155 μm , h = 200 μm , i = 165 μm ; p 504.

Fig. 154j–p *Stylonychia mytilus* complex (j, from CHARDEZ 1971; k, from BIERNACKA 1963; l, from BUISÁN 1944; m, from BÜRGER 1908; n, from SCHUSTER 1899; o, from CONN 1905; p, from BARWICK et al. 1955. j–p, from life). Ventral views, j = 190 μ m, k = size not indicated, l = 315 μ m, m = 200 μ m, n = 240 μ m, o = size not indicated, p = 225 μ m; p 504.

remain unchanged. The number of basal bodies increases and a longish oral primordium is formed (Fig. 153b). Only the anterior portion of the parental undulating membranes are reorganized (Fig. 153h, i). The primordium for the undulating membranes of the opisthe originates from the oral primordium (Fig. 153e–g). At this time, the first new adoral membranelles occur. In the opisthe the frontal-ventral-transverse cirri primordia I–III originate from the oral primordium (Fig. 153f, g). The primordia IV–VI are produced by the right postoral ventral cirrus (cirrus IV/4; Fig. 153d–g). In the proter, primordium I originates from parental undulating membranes (Fig. 153g–i); primordium II from oral primordium of opisthe (Fig. 153d–f); primordium III from frontoventral cirrus III/2 (Fig. 153d, f, g); primordium IV from frontoventral cirrus IV/4 (Fig. 153d, f); primordia V and VI from right postoral ventral cirrus (Fig. 153d–f). The following cirri do not participate in the formation of primordia: frontal cirri I/1, II/3, III/3, the buccal cirrus II/2, the frontoventral cirri VI/3 and VI/4 (= migratory cirri), the postoral ventral cirri IV/2 and V/3, and the transverse cirri. The left frontoventral cirrus III/2 and the postoral ventral cirrus V/4 proliferate basal bodies and are partly dissolved (Fig. 153f–h). The rest is resorbed in later stages of division. The development of the dorsal infraciliature proceeds in *Oxytricha* pattern (Fig. 24a).

FRICK (1968) found that during regeneration of *S. mytilus* fragments different variations in the formation of cirri are possible. Especially primordium IV tends to vary. Sometimes all cirri of this row are lacking, sometimes only cirrus IV/2 or IV/3 is absent. Occasionally, 1–3 additional primordia occur, usually resulting in an increased number of postoral ventral, pretransverse ventral, and transverse cirri. FRICK (1967) made experiments on the regeneration of amiconucleate specimens obtained by β -irradiation and by microsurgery. He found that regeneration is strongly disturbed and that all specimens without micronucleus die after 3–4 divisions. Cells of a species of the *S. mytilus* complex cut in mid-body are completely regenerated after 5–7 h (DEMBOWSKA 1925, see also DOROSZEWSKI & RAABE 1966 and FAURÉ-FREMIET 1967); according to JANISCH (1959), this kind of regeneration takes 6–24 h. Detailed investigations on regeneration were also performed by ISHIKAWA (1912). TOTWEN-NOWAKOWSKA (1965) applied thermal shock consisting in the rise of temperature from 20 °C to 33–34 °C to *S. mytilus* cultures. As result, doublets of two different types appeared: (i) regular spherical doublets consisting of 2 individuals of a similar structure, joined together by their dorsal side, and (ii) irregular flat doublets composed of individuals of uneven dimensions and shape, connected by their sides. They reproduced by transversal cell division and could be maintained in culture for many generations, that is, for several months. In tap water without food, *S. mytilus* lived 14–19 d reorganising the whole body several times (DEMBOWSKA 1938). There are several papers concerning the morphogenetic processes during regeneration, reorganisation, and conjugation, including that of doublets (BALBIANI 1858, FENG et al. 1990; FLEURY & FRYD-VERSAVEL 1981, see Fig. 153k, l; FRANKEL 1989, 1991, GRIMES & ADLER 1978, GRIMES & L'HERNAULT 1979, GU et al. 1990, JERKA-DZIADOSZ & FRANKEL 1990, LU et al. 1991, NG 1990, PANG et al. 1984, PROWAZEK 1903, SCHILD 1921, SHI 1975, 1976, 1987, SHI & FRANKEL 1990, SHI et al. 1987, 1990, 1991a, b, TCHANG & PANG 1965a, b, TCHANG

et al. 1965, 1981, TOTWEN-NOWAKOWSKA 1969, 1973, TUFFRAU & TOTWEN-NOWAKOWSKA 1988, TUFFRAU et al. 1978a, b, ZHANG & PANG 1979, 1981, ZOU & NG 1991a–c, ZOU et al. 1989).

Species of the *Stylonychia mytilus* complex are sometimes attacked by parasitic suc-torians (see chapter 4 in the general section).

Further literature. Species of the *Stylonychia mytilus* complex are one of the most popular hypotrichous ciliates. Most of their popularity stems from their intensive use in experimental studies, especially in areas of genetics, physiology, biochemistry, and ultra-structure. Since no comprehensive compilation of the literature is available I will list ad-ditional papers, including some old ones; some further papers are mentioned at *S. lemnae*. Biochemistry, genetics: ALLEN & OLINS (1984), ALONSO (1975, 1978), ALONSO & JAREÑO (1974), ALONSO & PÉREZ-SILVA (1966a, b, 1969), AMMERMAN (1965b, 1967, 1969, 1970, 1971a, 1973 [see Fig. 148q, r], 1979), AMMERMAN et al. (1978, 1981), BALBIANI (1861, 1862), BÜTSCHLI (1876, p 324), CHADHA et al. (1978, 1979), CORLISS (1990), DAVIES & WALKER (1979), DUTTA et al. (1982), FAHN et al. (1998), FANG & CECHE (1991), FEDRIANI et al. (1976a), GRELL (1951, 1965), ILOWAISKY (1926a), JAREÑO (1972, 1974, 1976, 1990, 1993), JAREÑO & ALONSO (1973), JAREÑO et al. (1969a, b, 1970, 1972), KAUL (1989, 1991a, b), KAUL & SAPRA (1981), KAUL et al. (1990), KLOETZEL (1969), KNOWLES et al. (1978), KRAMER (1988), KRAUT & LIPPS (1984), KRAUT et al. (1986), LINGNER et al. (1994), LIPPS et al. (1974), MEYER & LIPPS (1980, 1981, 1984), MOLDENHAUER (1965), MURTI et al. (1972), OLINS et al. (1993), PÉREZ-SILVA et al. (1969), POPOFF (1907), PRESCOTT (1989), PRESCOTT et al. (1971), RAIKOV (1969), RAIKOV & AMMERMAN (1974), RESNITSCHKE (1972), RIEWE & LIPPS (1977), SALVINI et al. (1993), SAPRA & AMMERMAN (1973, 1974), SAPRA & KLOETZEL (1974, 1975), SAPRA et al. (1976), SCHLEGEL (1985), SCHLEGEL & STEINBRÜCK (1986), SHI et al. (1987), STEINBRÜCK (1980, 1981, 1990, 1993), STEINBRÜCK & JACOB (1997), TCHANG & PANG (1974, 1979a), TCHANG et al. (1981), TORRES et al. (1979a), TOTWEN-NOWAKOWSKA (1964), WATANABE et al. (1986), WILSON & SOMMERVILLE (1987), WÜNNING & LIPPS (1983), XU & SHI (1987), YOUNG (1926). Physi-ology: BALBIANI (1882), BUJWID-CWIK & DRYL (1971), DEITMER (1981a, 1983a, 1987, 1989), DEITMER et al. (1986), DEMBOWSKA (1939), DRYL (1963, 1965), DRYL & NOWAKOWSKA (1966), DRYL & TOTWEN-NOWAKOWSKA (1972, 1975, 1977, 1985), DRYL et al. (1981), EFIMOFF (1924), ENGELMANN (1880), GELTZER (1967), IVENS (1986), IZJUMOV (1948), JIROVEC & SOSNA (1954), KUBALSKI et al. (1978), LICHTENBERG (1955b), MACHEMER (1965c, 1966c, 1969a, b, 1970, 1980), MACHEMER & PEYER (1977), MEIER & KAUNAT (1954), MOGAMI & MACHEMER (1991a, b), MOGAMI et al. (1992), PEYER (1976), PEYER & HUGGEL (1973), PEYER & MACHEMER (1978a, 1979), POPOFF (1908, 1909), SAPRA & DASS (1978), SCHWALBE (1866), SLEIGH (1968), STATKEWITSCH (1904, 1905), TCHANG et al. (1964), TOTWEN-NOWAKOWSKA & DRYL (1976), VANK & MACHEMER (1996, 1996a), WESKAMP (1993), WESKAMP & MACHEMER (1993), ZAIKA (1970). Ultrastructure: CHADHA (1980), CHADHA et al. (1983), DASS et al. (1976, 1982), ENGELMANN (1875), ESTEVE (1972), FERNANDEZ-LEBORANS & MARTIN-GONZALEZ (1982), GIL (1976, 1979), GIL et al. (1972), GÖRTZ (1982), GRIMES (1982a, b), KAUL et al. (1982), KLOETZEL (1970), Kow-

Table 31 Morphometric data of *Stylonychia bifaria* (bi1, bi2, two populations from the Schlossalm area in Salzburg, Austria, from WIRNSBERGER et al. 1985a), *S. lemnae* (le1, population from gardening of Schilde in Wendelsheim, Germany; le2, population from Spitzberg near Tuebingen, Germany; both from WIRNSBERGER et al. 1986), *S. mytilus* (my1, population from a lake near Reutlingen-Gönnigen, Germany; my2, population from a valley of the Kirnbach, Olgahein, Germany; both from WIRNSBERGER et al. 1986), *S. pustulata* (pu1, population from a lake [Mondsee] in Upper Austria; pu2, pu3, clones of a large and a small specimen from population pu1; from WIRNSBERGER et al. 1985a. pu4, population from a lake [Lunzer See] in Lower Austria; from GSCHWIND 1991). All data are based on protargol-impregnated specimens. All data, except pu1, are from clones. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	bi1	80.0	6.0	8.0	70	91	28
	bi2	91.0	8.0	8.0	75	110	25
	le1	186.3	11.5	6.2	168	211	25
	le2	154.9	11.0	7.1	139	180	15
	my1	222.4	14.0	6.3	195	256	25
	my2	166.1	14.4	8.8	147	203	15
	pu1	65.0	13.0	21.0	43	90	25
	pu2	94.0	9.0	10.0	79	108	25
	pu3	79.0	8.0	10.0	64	93	25
	pu4	53.0	6.2	11.8	44	66	21
Body, width	bi1 ¹	42.0	4.0	11.0	36	52	28
	bi2 ¹	51.0	6.0	11.0	42	62	25
	le1 ²	78.7	5.4	6.8	70	95	25
	le2 ²	60.1	4.2	7.0	52	68	15
	my1 ²	110.9	8.9	8.1	96	127	25
	my2 ²	69.5	9.2	13.1	57	87	15
	pu1 ¹	34.0	6.0	18.0	22	50	25
	pu2 ¹	47.0	6.0	13.0	35	62	25
	pu3 ¹	36.0	5.0	15.0	27	48	25
	pu4 ¹	26.4	3.0	11.5	21	31	21
Body, width at level of middle transverse cirrus	le1	60.2	7.7	12.9	40	78	25
	le2	46.6	6.7	14.5	36	61	15
	my1	66.6	9.3	13.9	45	86	25
	my2	42.1	7.7	18.2	25	58	15
Macronuclear nodule, length	bi1	14.0	1.0	8.0	12	17	28
	bi2	14.0	2.0	14.0	12	17	25
	le1	31.6	3.6	11.4	25	39	25
	le2	26.4	4.6	17.3	19	38	15
	my1	38.5	4.9	12.7	31	45	25
	my2	27.7	2.5	9.1	23	32	15
	pu1	14.0	2.0	16.0	9	17	25
	pu2	18.0	5.0	28.0	10	28	25
	pu3	15.0	2.0	13.0	10	20	25
	pu4	11.5	1.5	13.3	9	14	21
Macronuclear nodule, width	bi1	7.0	1.0	15.0	4	9	28
	bi2	7.0	1.0	13.0	5	9	25
	le1	13.2	1.3	10.2	10	15	25
	le2	9.6	0.8	8.6	9	11	15
	my1	13.7	1.5	11.0	11	17	25

Table 31 Continued

Character	Species	mean	SD	CV	Min	Max	n
Macronuclear nodule, width	my2	10.9	1.4	12.5	9	13	15
	pu1	7.0	1.0	14.0	5	8	25
	pu2	9.0	2.0	17.0	7	13	25
	pu3	7.0	1.0	14.0	5	8	25
	pu4	6.1	0.5	7.3	6	8	21
Micronuclei, number	le1	3.4	0.6	18.9	2	5	25
	le2	3.5	0.7	21.4	2	5	15
	my1	3.7	0.5	14.2	3	5	25
	my2	3.9	1.0	24.4	3	6	15
	pu4	2.0	0.0	0.0	2	2	16
Adoral zone of membranelles, length	bi1	40.0	2.0	5.0	36	44	28
	bi2	44.0	4.0	10.0	35	53	25
	le1	98.4	3.9	4.0	88	105	25
	le2	78.7	5.5	7.0	69	88	15
	my1	118.6	7.7	6.5	102	131	25
Adoral membranelles, number	my2	92.3	7.6	8.2	82	112	15
	pu1	35.0	6.0	18.0	25	44	25
	pu2	49.0	4.0	9.0	40	56	25
	pu3	42.0	4.0	10.0	31	48	25
	pu4	29.0	3.5	12.2	24	37	21
	bi1	37.0	2.0	5.0	32	40	28
	bi2	34.0	2.0	7.0	30	39	25
	le1	61.4	2.3	3.7	57	65	25
	le2	58.5	2.5	4.4	52	61	15
	my1	76.3	2.5	3.3	71	81	25
	my2	68.1	6.1	9.0	52	76	15
	pu1	35.0	5.0	15.0	24	42	25
	pu2	38.0	2.0	6.0	34	42	25
	pu3	34.0	2.0	6.0	31	37	25
	pu4	32.1	2.8	8.6	27	39	21
Paroral, length	le1	61.2	4.9	8.0	55	71	15
	le2	65.4	9.8	15.0	47	84	15
	my1	72.4	6.4	8.9	59	81	15
	my2	72.8	6.6	9.1	65	85	15
Endoral, length	le1	51.4	4.0	7.8	46	57	15
	le2	57.5	8.9	15.5	42	73	15
	my1	62.4	4.3	6.9	56	70	15
	my2	62.4	7.1	11.3	46	74	15
Right marginal row, number of cirri	bi1	19.0	2.0	10.0	14	22	28
	bi2	19.0	2.0	8.0	16	21	25
	le1	34.3	1.6	4.6	31	37	25
	le2	35.5	3.1	8.7	31	41	15
	my1	37.4	1.9	5.2	33	42	25
	my2	39.3	2.9	7.5	33	44	15
	pu1	26.0	3.0	13.0	18	32	25
	pu2	31.0	2.0	5.0	28	34	25
	pu3	27.0	2.0	6.0	25	30	25
	pu4	24.2	2.7	11.0	20	29	21

Table 31 Continued

Character	Species	mean	SD	CV	Min	Max	n
Left marginal row, number of cirri	bi1	17.0	1.0	5.0	15	18	28
	bi2	17.0	1.0	6.0	15	19	25
	le1	25.0	1.1	4.5	23	27	25
	le2	26.5	1.6	6.0	24	29	15
	my1	26.7	1.3	5.0	24	29	25
	my2	28.0	1.6	5.9	25	30	15
	pu1	19.0	2.0	13.0	12	22	25
	pu2	21.0	2.0	8.0	18	24	25
	pu3	19.0	2.0	9.0	16	22	25
	pu4	14.9	1.4	9.5	12	18	21
Dorsal kinety 1, number of basal body pairs	le1	76.8	3.0	3.9	74	81	5
	le2	72.0	5.1	7.2	65	78	5
	my1	97.2	7.1	7.3	88	106	5
	my2	100.4	10.5	10.5	85	111	5
Dorsal kinety 3, number of basal body pairs	le1	36.8	2.8	7.5	33	40	5
	le2	37.6	0.9	2.4	37	39	5
	my1	64.0	13.8	21.6	44	66	5
	my2	60.6	5.8	9.5	53	66	5
Dorsal kinety 4, number of basal body pairs	le1	33.6	3.5	10.4	30	39	5
	le2	33.0	2.0	6.1	31	36	5
	my1	51.8	3.3	1.9	47	56	5
	my2	47.8	6.8	14.3	40	55	5
All dorsal kineties, total number of basal body pairs	le1	284.6	13.7	4.8	271	304	5
	le2	271.8	10.9	4.0	258	286	5
	my1	369.9	11.8	3.2	358	389	5
	my2	363.0	35.4	9.8	318	398	5
Distance between first and third caudal cirrus	le1	27.2	4.0	14.8	19	34	25
	le2	24.7	2.1	8.5	21	27	15
	my1	35.3	3.8	10.7	26	42	2
	my2	26.9	4.3	15.9	17	35	15

¹ Maximum width.² Width at level of buccal cirrus.

ALEWSKIEGO (1882), MAIER (1903), MAUPAS (1883), MURTI (1972, 1973, 1976), NOBILI & ROSATI RAFFAELLI (1971), OLINS et al. (1981), PESCHKOWSKY (1927), PROWAZEK (1899a), PUYTORAC & RODRIGUES DE SANTA ROSA (1976), PUYTORAC et al. (1976, 1994), STERKI (1878, see also LUND 1941), TAYLOR (1964), TUFFRAU (1964), TUFFRAU et al. (1968), WALKER (1976a), WALKER & GOODE (1975, 1976), WALKER et al. (1975).

Occurrence and ecology: Widely distributed in freshwater habitats throughout the year with peaks in spring and autumn (for example, BICK & KUNZE 1971, HECKMAN 1982, own observations). Common in the benthal of stagnant (lakes, reservoirs, ponds, temporal small water bodies) and running waters (for example, BICK & SCHMERENBECK 1971, CZAPIK 1982, KAHL 1932, RIGGENBACH 1922, SCHMERENBECK 1975, SPANDL

1926a). Sometimes planktonic in ponds and lakes (for example, FOISSNER et al. 1991) and large rivers (for example, PUJIN et al. 1984); rarely in brackish and sea water; only occasionally in terrestrial habitats.

Locus classicus is Denmark, where MÜLLER (1773, 1786) discovered *Stylonychia mytilus* in lentic water. EHRENBERG (1830, 1833, 1838) recorded it abundantly among *Oscillatoria* in all infusions and in waters in Berlin, Germany; he found it also in Copenhagen in sea water. STEIN (1859b) observed *S. mytilus* among *Lemna*, callitrichs, filamentous algae ("Conferven"), and decaying macrophytes, where largest specimens occurred. Locus classicus of the synonym, *S. claviformis*, is a eutrophic pond in the Börzsöny Mountain, Hungary (GELEI 1954, GELEI et al. 1954).

Further records substantiated by illustrations: alpine grassland (2310 m above sea level, alpine pseudogleyic on mica-slate) in the Glockner Area, Austria (FOISSNER 1981, 1982, 1987a); plankton of hypertrophic pond at Salzburg University, Austria (BLATTERER 1988, FOISSNER et al. 1991); Belgium (CHARDEZ 1971); very common in freshwater and in flood overflows in England (SCHUSTER 1899); rock pools with 0.1 to 3.6 ‰ NaCl in Finland (REUTER 1961); France (DRAGESCO 1966a, DUJARDIN 1841, FROMENTEL 1876, TUFFRAU et al. 1981); common, but usually only moderately abundant in mesosaprobic running waters in Germany (BUCK 1959, 1961); water bodies near Leipzig, Germany (ENGELMANN 1862); mesosaprobic Danube River in Hungary (BERECZKY 1977a); estuaries in the Danzig Bay with ≤ 4 ‰ salt (BIERNACKA 1963) and other sites in Poland (WRZESNIEWSKIEGO 1867a, b); among algae in stagnant water in Spain (BUISÁN 1944); among *Lemna* in Sweden (QUENNERSTEDT 1965); clear and polluted ponds near Geneva, Switzerland (ROUX 1901); plankton and benthos of large rivers (MAMAEVA 1979a, b) and other sites in the USSR (CHORIK 1968, LOKOT 1987); small stream on the campus of National South West Associated University, China (CHEN 1944); common in pond water from the campus of Tsing Hua University, China (TAI 1931); Lake Ho Hu and Lake Mo Chu Hu, Nanking, China (WANG 1925) and other sites in China (TCHANG & PANG 1965a); Mysore soils, India (RAO 1928); Han River and Ullung Island, Korea (SHIN & KIM 1988, 1993a, 1995); pond in Japan (YOSHINO 1993); freshwaters in Connecticut, USA (CONN 1905); infusions of pond water in Iowa, USA (EDMONDSON 1906); northern area of Mobile Bay, USA, with a salinity of 2 ‰ (JONES 1974); soils near New Brunswick, New Jersey, USA (FELLERS & ALLISON 1920); pond water in Kansas, USA (SMITH 1914); Mexico (LÓPEZ-UCHOTERENA 1965); Chile (BÜRGER 1908); Benin (DRAGESCO & DRAGESCO-KERNÉIS 1986); abundant among decaying vegetation in Waiwhetu stream, New Zealand (BARWICK et al. 1955).

Records from freshwater habitats (pools, ponds, lakes, brooks, rivers etc.) not substantiated by illustrations – Europe and Asia: Armenia (ZHARIKOV 1982, see also USSR); rarely in beta- and beta- to alphamesosaprobic brooks and rivers in Austria (AOÖLR 1994b, FOISSNER & MOOG 1992, HASLAUER & HAIDER 1976, HASLAUER & PICHLER 1979); littoral of Danube River in Vienna, Austria (HUMPESCH & MOOG 1994, KALTENBACH 1960); alpine lakes (2000 m above sea level) in Tyrol and clear lakes in Styria, Austria (DALLA TORRE 1891, KRAINER 1988, ZACHARIAS 1903b, ZSCHOKKE 1900); profundal (64 m) of Carinthian and Tyrolian lakes, Austria (FINDENEGG 1953, IMHOFF 1895); small lotic and

lentic waters in the Austrian Alps (FOISSNER 1980c, FOISSNER & ADAM 1979); in a several weeks old water with mouldy odour, Austria (SCHMARD 1846); infusion of submerged mosses from Upper Austria (FOISSNER 1974); abundant in long standing samples with mud, algae, and decaying macrophytes, Austria (VORNATSCHER 1938; further records from Austria: BRUNNTHALER et al. 1901, CZERNIN-CHUDENITZ 1985, FOISSNER & FOISSNER 1988, HASLAUER et al. 1979); rivers in Azerbaijan (ALIEV 1982a, 1984; see also USSR); Belgium (BERVOETS 1940, CHARDEZ 1987, SORGELOOS 1970); brooks, lakes, ponds, peat-bogs, marshland, pools, wet meadow, fishponds, road ditches, and rivers in Bulgaria (DETSCHewa 1979b, 1981, 1986, 1991, 1993, DETSCHewa 1972, RUSSEV et al. 1984); saprobic brooks and polluted river in Czechoslovakia (BUCHAR 1957, MATIS 1967, NOWAK 1940); moderately frequent in betamesosaprobic water bodies in Czechoslovakia (ŠRÁMEK-HUŠEK 1956b, 1957, VAŠIČEK 1964); common in the littoral of a pond in Czechoslovakia, large specimens especially in the foam on the water (ŠVEC 1897); submerged and wet mosses in Czechoslovakia (TIRJAKOVÁ & MATIS 1987a; further records from Czechoslovakia: BÍLÝ et al. 1952, HAEMPEL 1908, HANUŠKA 1962, KALMUS 1928, MATIS 1961, 1977, MATIS & TIRJAKOVÁ 1994, MORAVCOVA 1962, ŠRÁMEK-HUŠEK 1953, TIRJAKOVÁ 1992b); pond in Denmark (FENCHEL 1980a, c); chalk streams in England (BALDOCK et al. 1983, GRAY 1952); in 8 of 178 sites of sewage fungus outbreaks in England (CURTIS & CURDS 1971); eutrophic Esthwaite water, England (WEBB 1961; further records from England: CRAIGIE 1921, DIXON 1920); Estonia (JACOBSON 1928); polluted rivers in France (GROLIÈRE et al. 1990, ORMANCEY 1852, SPARAGANO & GROLIÈRE 1991); pond and peat-bog moss habitats in France (GROLIÈRE 1977, GROLIÈRE & NJINE 1973); in the clean Illach River in Germany (FOISSNER 1997a); common in Rhine River plankton, Germany (CZERNIN-CHUDENITZ 1958); rarely in the beta- to alphamesosaprobic Rhine River, Germany (MAUCH 1990); cooling system of a power station at the beta- to alphamesosaprobic Main River, Germany (BERNERTH 1982); aufwuchs and sandy sediment of betamesosaprobic Elbe River upstream of a dam, Germany (GRIMM 1968); among detritus and in surface film of ditches regularly contaminated with pesticide sprays and in unsprayed ditches in the Elbe River floodplain, Germany (CASPER & HECKMAN 1982); beta- to alphamesosaprobic ditch in Germany (HEUSS 1975); rarely to abundantly in beta- to alphamesosaprobic brooks and rivers in Germany (FOISSNER et al. 1992a, b, HEUSS et al. 1972, JUTRCZENKI 1982, MAUCH & WITTLING 1991, SCHEUBEL 1986, SCHÖNBORN 1996); abundant at 10 cm and sparse at 25 cm depth of Fulda River Headwater sediment, Germany (LÜPKES 1976); ponds near Bonn and 66 ind. ml⁻¹ in small basins under laboratory conditions, Germany (BICK 1958, 1964a, 1967b, KRAMER 1964); road pools, flooded meadows, and infusions of agricultural soils in Bavaria, Germany (DINGFELDER 1962); effluent ditch (3 mg l⁻¹ P_{total}, 13.4 mg l⁻¹ COD) of the Schillinger Lake, Germany (GUHL 1987); littoral of Lake Constance, Germany (KUTTNER 1923); mesotrophic lakes in Germany (MÜCKE 1979, PACKROFF 1992, PACKROFF & WILBERT 1991, ZACHARIAS 1902); rarely in an oligosaprobic to betamesosaprobic reservoir and about 40 ind. ml⁻¹ in an alphamesosaprobic reservoir in Germany (NUSCH 1970); pseudoperiphyton of a eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany (MICHIELS & WILBERT 1973, SONG & WILBERT 1989, WILBERT 1969);

very abundantly in a marshy ditch (mud contained H_2S) near the Schussen River, Germany (WETZEL 1928a); aufwuchs community and detritus in Hamburg Harbour, a highly stressed habitat in the freshwater section of the Elbe Estuary, Germany (BARTSCH & HARTWIG 1984, HECKMAN et al. 1990, RIEDEL-LORJÉ 1981, ROY 1938, TENT 1981); marshy ditch and lakes in Germany (ZACHARIAS 1893, 1894, 1903a; further records from Germany: BAUER 1987, DÖRR 1935, HENDERSON 1905, PACKROFF & ZWICK 1996, PÄTSCH 1974, QUIRMBACH 1912, SCHMIDT 1913, 1916, SCHNEIDER 1909, SCHÖNBORN 1984, ZACHARIAS 1897); Greece (STEPHANIDES 1948); up to 16 ind. l^{-1} in plankton of mesosaprobic Danube River and in a oxbow in Hungary (BERECZKY 1971, 1972, 1977b, c, 1979, 1991, NOSEK & BERECZKY 1981); aufwuchs and pelagial of Tisza River, Hungary (JÓSA 1974, STILLER 1942); at pH 8.1 in a fishpond in Hungary (JACZÓ 1939); common and together with *S. pustulata* in marshy areas, in the aufwuchs community, and detritus drifts of the littoral of Lake Balaton, Hungary (DADAY 1885, ENTZ 1897, FRANCÉ 1897, GELLÉRT & TAMÁS 1958, 1959b, 1960, TAMÁS & GELLÉRT 1959; further records from Hungary: BERCEK 1966, DADAY 1892, DUDICH 1947, HAMAR 1971, KREPUSKA 1917, VÖRÖSVÁRY 1950); river and lough in Clare Island, Ireland (DUNKERLY 1913); various waters in Northern Italy (CANELLA 1954, MADONI 1980, MADONI & ROSSI 1977); characteristic for medium hilly zone in Italy with narrow water course, pebbled bed with sand and with *Frontonia leucas* as typical species (MADONI 1984); 2 ind. cm^{-2} in an alphamesosaprobic area of the Po River, Italy (MADONI 1979); rarely in beta- to alphamesosaprobic running waters in Italy (MADONI & GHETTI 1980, 1981a); Lake Como, Italy (CATTANEO 1882); rice paddies in Italy (COPPA 1921, MADONI 1988b; further records from Italy: CUNEO 1891, ENRIQUES 1913, GARGIULO 1907, GRANDORI 1934, LONGHI 1894, 1895, MADONI 1983, MADONI & VIAROLI 1985, SACCHI 1888, STELLA & CAMPEA 1948); lakes and polluted rivers in Latvia (LIEPA 1981, 1983, 1990); the Netherlands (DORSMAN 1918, GRAAF 1956, 1957, GRAAF & MEIJER 1956); betamesosaprobic and polysaprobic areas in a river in Poland (CZAPIK 1982); with 35 % frequency in the *Sphaerotilus* community of a Polish river (HUL 1986); beta- to alphamesosaprobic and alphamesosaprobic areas of rivers in Poland (HUL 1987a, b, WIACKOWSKI 1981); reservoirs in Poland (CZAPIK 1962, KRZYŻANEK & KRZYŻANEK 1986); at a saprobic index of 1.9–2.6 in a Polish river (GRABACKA 1985); mud of polluted fish ponds and fish ponds with mowed plants in Poland (CZAPIK 1959, GRABACKA 1971, 1977, KWIATKOWSKA-GRABACKA 1964, 1965, SIEMIŃSKA & SIEMIŃSKA 1967); aquarium with *Lemna* and decaying algae in Poland? (WRZESNIWOSKI 1861; further records from Poland: CZAPIK & FYDA 1995, JAWOROWSKI 1893, KOMALA & PRZYBOS 1980, 1988, PAWLOWSKI 1980, WRZESNIEWSKIEGO 1866); Azores, Portugal (BARROIS 1896, IMHOF 1896); abundantly in mud from Danube River in Romania (SPANDL 1926a); Turiec River in Slovakia (TIRJAKOVÁ 1993); marshy ditch in Slovenia? (SCHMARD 1847); clean section of Henares River, Spain (SOLA et al. 1996); up to 6.6 ind. ml^{-1} in upper sediment and up to 2 ind. ml^{-1} in neuston of a eutrophic reservoir near Barcelona, Spain (SALVADÓ CABRÉ 1993, SALVADÓ & GRACIA 1991; further records from Spain: FERNANDEZ-LEBORANS et al. 1990, GRACIA & IGUAL 1987a, b, GRACIA et al. 1987a, 1989, IGUAL 1990, MARGALEF LÓPEZ 1945); Danube River in Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); Sweden (QUEN-

NERSTEDT 1869); with low abundance in clean and polluted running waters and in lake plankton in Switzerland (STEINMANN & SURBECK 1918, 1934); shallow lake with *Phragmites* and leaf litter in Switzerland (HEUSCHER 1890); fresh and old samples from marshy waters in Switzerland (PERTY 1852b); littoral and profundal of Lake Geneva (ANDRÉ 1916, FOREL 1904, ROUX 1900); alpine lakes in Switzerland (ASPER & HEUSCHER 1886); peat-bogs in Switzerland (MERMOD 1914); ponds and ditches near Bern and near Neuenburg and Lake Neuenburg, Switzerland (CDANN 1907, MONARD 1920, SAKOWSKY-CAMPIONI 1906, THIÉBAUD & FAVRE 1906; further records from Switzerland: ANDRÉ 1912, 1915, BOURQUIN-LINDT 1919, MESSIKOMMER 1954, RIGGENBACH 1922, ZSCHOKKE 1894); alphamesosaprobic aufwuchs in the Save River, Yugoslavia (PRIMC 1981; further records from Yugoslavia: DJUKIĆ et al. 1994, PROTIĆ 1933, PUJIN 1994); in the epiphyton of 50–75 % of collected samples from karstic running waters in Yugoslavia (PRIMC-HABDIJA & HABDIJA 1991); well in Yugoslavia (KARAMAN 1935); lake in China (SHEN 1980); together with *Paramecium aurelia* in long standing samples, USSR (EICHWALD 1844, 1847, 1849); meso- and eutrophic lakes in USSR (KORNIYENKO 1972); common in Lake Baikal (GAJEVSKAJA 1927, GAJEVSKAJA 1933); benthic and planktonic in slightly to distinctly polluted reservoirs and rivers of the USSR (ALEKPEROV 1980, 1981, 1982b, c, 1983, 1984b, c, BELOVA 1988, KRAVCHENKO 1969, MYLNIKOVA 1981, NEBRAT 1980, SHADIN et al. 1931; further records from the USSR: ADIL 1934, AGAMALIEV & ALIEV 1978, ALEKPEROV 1986, ALIEV 1988, BELIKHOFF 1936, CHORIK & VIKOL 1973, GORIDCHENKO 1984, KOSOVA 1965, MERESCHKOVSKY 1880, MINKÉWITSCH 1898, MOVCHAN & PROTASOV 1986, OLEKSIV 1985, PASHITNOWA 1935, SKORIKOW 1902, WEISSE 1845, ZHARIKOV 1992, ZOLOTAREV 1987, ZYKOFF 1903); alphamesosaprobic and polysaprobic puddles with high amounts of rotting leaves and flowers in Nagpur, India (KRISHNAMOORTHY 1969); Palestine (BODENHEIMER 1937, LEPSI 1929a); leaf litter of a small pond in Tokyo, Japan (HATANO & WATANABE 1981, KUSANO 1985); Sapporo, Japan (HAYASHI 1959); foul water in City of Hakodate, Japan (MURAMATSU 1957; further record from Japan: MATSUOKA et al. 1983).

America: ponds, pools, still areas along stream margins, polluted streams, tree or stump holes, marsh pools in USA (HAUSMAN 1917, LACKEY 1938a, SMITH 1878); soft to medium hard water rivers in the eastern USA (PATRICK 1961); abundant in tundra pools (Alaska) at 3–6 °C and pH 6–6.4 (FENCHEL 1975, SULLIVAN 1957); Brainard Lake (3140 m above sea level) and other sites in Colorado (BEARDSLY 1902, CAIRNS & YONGUE 1973b, EDMONDSON 1912, HAMILTON 1943); sphagnum swamp near the village of Pilatka and other sites in Florida (BAILEY 1851, EHRENBURG 1853); Iowa (SHAWHAN et al. 1947); south eastern Louisiana (BAMFORTH 1963); Potomac River, Maryland (CAIRNS 1966b); Salem, Massachusetts (COLE 1853); at 19–24 °C and pH 5.6–7.0 in Douglas Lake region, Michigan (CAIRNS & YONGUE 1966, PRATT et al. 1985); common in shore collections from East Twin Lake, Michigan (KOFIÖD 1896); wetland sites in Michigan (HENEERY & CAIRNS 1984, PRATT et al. 1989); mesotrophic lakes and marsh with *Typha* spp., Michigan (STEWART et al. 1986); natural waters of the Upper Peninsula of Michigan (WEST 1953); mud in a lake in New York? (MURRAY 1974); Scioto River, Ohio (LACKEY 1938b); Brush Lake, Ohio (RIDDLE 1905); common on floating algae in water well exposed to light, in

algae covered roots in clear, well lighted water, and on sand and algae in clear, fresh, slowly running water at Mirror Lake, Ohio (STEHLE 1920); rarely in November in a shallow area of Crystal Lake, Oklahoma (BRAGG 1960); common in the Conestoga drainage basin, Pennsylvania (CAIRNS 1965a); Reelfoot Lake, Tennessee (BEVEL 1938); Mountain Lake region, Virginia (BOVEE 1960); pond in Blacksburg, Virginia (McCORMICK & CAIRNS 1991, 1992); rarely in Lake Cromwell, Canada (PUYTORAC et al. 1972); Costa Rica (RUIZ 1961); Mexico (LÓPEZ-POCHOTERENA & ROURE-CANE 1970, MADRAZO-GARIBAY & LÓPEZ-POCHOTERENA 1973); Argentina (CARBONELL 1935, SECKT 1924); Brazil (CUNHA 1913, 1918, PROWAZEK 1910); Pantanal floodplains, Brazil (HARDOIM & HECKMAN 1996); running water near Amazon River, Colombia (BOVEE 1957); Paraguay (DADAY E. 1905; DADAY J. 1905); moss infusions, Venezuela? (SCORZA & NUÑEZ MONTIEL 1954).

Africa: East Africa and Madagascar (SONDHEIM 1929); Cameroon (NJINE 1977).

Australia, New Zealand: Waterloo Swamps, Port Jackson, Australia (WHITELEGGE 1889); Wellington (MASKELL 1886).

Antarctica: Coast Lake, Victoria Land (THOMPSON 1972).

Records from brackish water and marine habitats largely not substantiated by illustrations: saline lakes in Germany (ZACHARIAS 1888); Baltic Sea (ANDRUSHAITIS 1990, BERNACKA 1962, BOIKOVA 1984a, b, 1986, JACOBSON 1928, KUMSARE et al. 1974, LEVANDER 1894a, b, 1901); Gulf of Kola (GASSOVSKY 1916); salt-pit in Cagliari, Italy (PARONA 1883); saline lake in Romania (TUCOLESCO 1962b); Divichinsky Estuary with 3.5 ‰ salinity and pH 7.0–8.5, Caspian Sea (AGAMALIEV 1986); saline lakes and brackish water on Apsheron Peninsula, Azerbaijan (AGAMALIEV 1980); low salinity habitats (4 ‰, 27 °C) at Black Sea in Bulgaria (DETCHEVA 1981, 1983d, VALKANOV 1936); Bay of Kertsch, Black Sea (ANDRUSSOWA 1886); saline pools in central Asia (GURWITSCH 1934); polluted harbour on east coast of India (KALAVATI et al. 1995, RAMAN et al. 1993); Barents Sea (AZOVSKY 1996); attached, or in debris and in bottom samples from the wharf, Atlantic ocean at Woods Hole, USA (LACKEY 1936, 1938a); saline lakes in Canada (WILBERT 1995); Gulf of Mexico (ALADRO-LUBEL et al. 1988, 1990, BORROR 1962, MADRAZO-GARIBAY & LÓPEZ-POCHOTERENA 1985, SMITH 1904). The experimental data on the toleration of increased salinity are rather varying; according to FINLEY (1930) and HAMMER (1986), species of the *S. mytilus* complex tolerate a salinity of up to 1.6 ‰, after AX & AX (1961) 3 ‰, and after BICK (1967a, 1968b) only 1.8 ‰. On the other hand, records from marine habitats are available (see above). KLAPPER (1963) found *S. mytilus* in a brook with 6.6 g l⁻¹ Cl⁻, and ROSTKOWSKA (1961) stated that sodium chloride concentrations of more than 5 ‰ are noxious (Table 33). ALBRECHT (1983, 1984, 1986) classified *S. mytilus* as oligo- to euryhaline (up to 5 g l⁻¹ Cl⁻) with a freshwater preference. However, summarising the data listed above, species of the *S. mytilus* complex must be classified as holo-euryhaline (>3 ‰ salinity) with a freshwater optimum.

Records from terrestrial habitats: grey alluvial soil of a bottom-land in Lower Austria (FOISSNER 1982, FOISSNER et al. 1985); Belgium (CHARDEZ 1967; Fig. 154g); Bulgaria (DETCHEVA 1973, DETCHEVA 1972b); spruce-forest in Czechoslovakia (ROSA 1957a); Germany (GREEFF 1889, HARTMANN 1956); irrigated (?) agricultural soil in Romania (LEPSI

1951); garden soil from Stockholm, Sweden (KOFFMAN 1926, 1934); *Salix* litter and moss from Scoresby Land, East Greenland (STOUT 1970); USSR (NIKOLJUK & GELTZER 1972); Delta hardwood bottom-land forest soils in south-eastern Louisiana (BAMFORTH 1967); soil from shrub in a cedar glade, Tennessee (MARTIN & SHARP 1983); mosses near Montreal, Canada (FANTHAM & PORTER 1946); loamy soil with pH 6.4 in South Africa (FANTHAM 1929, 1931, FANTHAM & PATERSON 1926, FANTHAM & ROBERTSON 1928, FANTHAM & TAYLOR 1922, FANTHAM et al. 1927); pasture and seasonally flooded grassland in New Zealand (STOUT 1981, 1984).

Stylonychia mytilus is not very common in sewage treatment plants such as activated sludge (ALONSO et al. 1981, BANINA 1990, HARTMANN 1960; KUTIKOWA 1984, the figure is a redrawing from CURDS 1969, Fig. 151q; LACKEY 1938a, MADONI 1988a) and trickling filters (BANINA 1983, BARKER 1949, CURDS 1969, 1975, LACKEY 1938a). Not recorded from Imhoff tanks. SCHERB (1968a) counted up to 900 ind. ml⁻¹ in activated sludge with 351 mg l⁻¹ KMnO₄-consumption at influent and 91 % digestion; accordingly, *S. mytilus* was more abundant in plants treating dairy wastes than in plants treating municipal sewage. LIEBMANN (1936) counted 40 ind. ml⁻¹ in the Kahmhaut of 35 d and 60 d old, standing municipal sewage. KAUFMANN (1958) found it in the mud of an oxidation pond.

Other habitats: drinking water in Austria (LIEB et al. 1956); wells (SPANDL 1926c, VEJDOVSKÝ 1882); filter of drinking water plants in the Netherlands (VERSCHAFFELT 1930); caves in Germany, Scandinavia, France, and Italy (BOSCOLO 1968, GRIEPENBURG 1934, 1935, LÖFFLER 1951, MONIEZ 1889, TOSCO 1956; see also review by GITTLESON & HOOVER 1969).

Species of the *S. mytilus* complex are omnivorous, that is, they feed on bacteria (for example, *Bacillus subtilis*, rhodobacteria), cyanobacteria, algae (*Chlamydomonas reinhardtii*, *Chlorogonium elongatum*, *Euglena*, *Phacus caudata*, *Scenedesmus acutus*, spores of *Spirogyra* sp., diatoms), yeast (*Saccharomyces cerevisiae*), fungi, heterotrophic flagellates (*Chilomonas paramecium*), ciliates (*Colpidium* sp., *Cyclidium* sp., *Euplotes octocarinatus*, *Tetrahymena pyriformis*), starch, dried chicken egg yolk, and organic detritus (for example, BENIJTS-CLAUS 1974, see Table 32; BEREZKY 1969, BICK 1972a, BRAND 1923, CHADHA et al. 1978, CURTIS & CURDS 1971, CZAPIK 1975, DEMBOWSKA 1925, FENCHEL 1975, FRICK 1968, GAUSE 1934a, b, GELLÉRT & TAMAS 1959a, GRACIA & IGUAL 1987a, GROZDOV et al. 1982, HECKMANN 1995, JONES 1974, KAHL 1932, KAUL & SAPRA 1983, KOLKWITZ 1950, KUHLMANN & HECKMANN 1994, LICHTENBERG 1955a, LIYEPA 1984b, PFISTER 1995, PFISTER & ARNDT 1995, POSCH & ARNDT 1995, 1996, PRATT & CAIRNS 1985, PUYTORAC et al. 1976, RIGGENBACH 1922, SHIGENAKA et al. 1973, TUFFRAU et al. 1981, ZINGHER 1934). Also feeds on eggs of the maw-worm, *Ascaris suum* (SHARAVINA 1978). One specimen ingests 2400 diatoms and other algae per day with a total volume of 960 000 µm³ and 361 000 µm³ respectively (SCHÖNBORN 1981, 1982). Maximum ingestion rate per hour about 20 % of cell volume (FENCHEL 1980b).

KAUL & SAPRA (1983) found that *S. mytilus* does not ingest non-nutrient particles, such as charcoal, India ink, or carmine particles. Furthermore, they observed that the algae *Chlorella* sp. and the protists *Colpoda* sp. and *Chilomonas* sp. are not accepted as

Table 32 Influence of food concentration (*Chlamydomonas reinhardtii*) on abundance, relative growth constant (h^{-1}), and generation time (h) of a species of the *Stylonychia mytilus* complex (from BENJTS-CLAUS 1974)

	1.10 ⁶ algal cells/ml		0.5.10 ⁶ algal cells/ml		0.1.10 ⁶ algal cells/ml	
	light	dark	light	dark	light	dark
Number of <i>Stylonychia</i> /ml						
0 h	5	5	5	5	5	5
24 h	20	20	20	20	20	20
48 h	35	45	35	25	60	30
72 h	0		80		330	
Relative growth constant r						
24 h	0,058	0,065	0,058	0,058	0,058	0,058
48 h	0,041	0,046	0,041	0,034	0,052	0,037
72 h	0,000	0,029	0,032	0,033	0,047	0,000
96 h	0,000		0,030		0,044	
Generation time T						
24 h	12,0	10,7	12,0	12,0	12,0	12,0
48 h	17,1	15,1	17,1	20,7	13,4	18,6
72 h	—	24,0	21,7	20,8	14,7	—
96 h	—		23,5		15,9	

prey (see, however, previous paragraph). The feeding response towards various other food materials and the generation time at 23 °C in a modified Pringsheim medium are as follows: algae *Chlorogonium*, feeding response = good, average number of prey organisms or particles ingested within 5 min = 25, generation time = 10 ± 0.5 h; algae *Anacystis*: poor, 3, 480 ± 4 h; ciliate *Tetrahymena*: fair, 10, 20 ± 2 h; bacterium *Escherichia coli*: poor, 5, 36 ± 2 h; mixed bacterial flora (in hay infusion): poor, 5, 36 ± 2 h; dried egg yolk particles: fair, 10, 12 ± 1 h; dried egg albumin particles: fair, 10, 12 ± 1 h. On the other hand, KAUL et al. (1978a, b) stated that feeding continuously on *Tetrahymena* for several generations leads to many morphological and cytological abnormalities and finally to the death of *S. mytilus*; the changes ranged from cytoplasmic vacuolisation to breakdown in division process, abnormal micronuclear number, and reduced RNA synthesis. Morphologically, the changes are expressed as loss of cortical structures and alteration of cortical membrane resulting in loss of body form.

The water leaves the membranelles of the adoral zone with a velocity of somewhat more than 1 mm s^{-1} yielding a transport rate of $1.36 \times 10^6 \mu\text{m}^3 \text{ s}^{-1}$ or $4.9 \times 10^{-3} \text{ ml h}^{-1}$. Experiments with the ingestion of $5.7 \mu\text{m}$ sized latex beads yielded a maximum clearance of about $5.5 \times 10^{-3} \text{ ml h}^{-1}$ (FENCHEL 1980a, b). Maximum clearance per cell volume per hour about 8×10^4 ; free space between cilia of undulating membranes about $3.5 \mu\text{m}$ (FENCHEL 1980c).

Table 33 The reaction of a species of the *Stylonychia mytilus* complex adapted to sodium chloride (3 % of NaCl) and of control *Stylonychia* to various substances (from ROSTKOWSKA 1961)

The reaction of *Stylonychia mytilus* adapted to the sodium chloride (0.305% of NaCl) and of control *Stylonychia* of poison

Kind of substance concentration in %	Number of plasmolysed protozoa after 10 min.					Number of plasmolysed protozoa after 100 min.				
	Adapted protozoa		Control protozoa		The statistical significance of the difference after 10 min.	Adapted protozoa		Control protozoa		The statistical significance of the difference after 100 min.
	Absolute number	%	Absolute number	%		Absolute number	%	Absolute number	%	
Atebrin 0.001	0	0	0	0	no difference	12	6.59	78	53.79	p > 99%
Methylene Blue 0.01	8	7.01	21	13.18	p = 95%	69	42.70	84	65.9	p > 99%
Chinosol 0.02	0	0	0	0	no difference	20	11.1	165	100	p > 99%
Phenol 0.2	104	58	53	34	p > 99%	191	100	158	100	no difference
Mercuric chloride 0.0002	0	0	0	0	no difference	49	36.84	161	100	p > 99%

GRAY (1951) found that *S. mytilus* always exhibits maximum abundances in a chalk stream about 4–7 d before and after full moon, with slight evidence for a drop at full moon itself. He assumed that, in the particular stream examined, the *Stylonychia* were following a lunar periodicity of diatoms on which they fed. Maximum phases of the ciliate might therefore follow maximum phases of the diatoms, succeeded by periods of reproductive activity. BERECKZY (1977a) found maximum abundances in the Danube River at 4 am and at 8 pm.

Species of the *Stylonychia mytilus* complex can be easily cultured. AMMERMANN et al. (1974) used neutral Pringsheim solution and fed it with *Chlorogonium* grown under sterile conditions. WIRNSBERGER et al. (1986) used tap water as culture medium and yeast, *Chlorogonium elongatum*, and a species of the *Tetrahymena pyriformis* complex as food. MACHEMER (1965b) cultured it in 10 % soil-peat-medium and 0.06–0.1 % yolk as food supply.

TOTWEN-NOWAKOWSKA (1981) observed 1.6 ± 0.4 cell divisions per day in Pringsheim medium at about 20 °C and a species of the *Tetrahymena pyriformis* complex as food. For dorsal doublets she found 1.5 ± 0.5 and for lateral doublets 0.7 ± 0.3 divisions per day. CHADHA et al. (1978) and KAUL & SAPRA (1989) estimated a generation period of about 10.5 ± 0.5 h (n = 100) at 23 °C as well as at 30 °C and with *Chlorogonium elongatum* as food. Further data on generation time (see also Table 32): 3 divisions in 24 h at 20 ± 2 °C (GROZDOV et al. 1982); 13.5 h at 23 °C with *Chlamydomonas reinhardtii* as food (BENJITS-CLAUS 1974). MACHEMER (1965a) stated that below 10 °C nearly no more divi-

Table 34 Autecological data of species of the *Stylonychia mytilus* complex. References: column 1, from NOLAND (1925; investigated in all 80 samples from margins of lakes, a pond, an artificial lagoon, permanent pools, temporary pools, a river, creeks, swamp ditches, and a spring in Wisconsin, USA); column 2, from CAIRNS (1964; in all 202 analyses from various rivers and streams, mostly in the USA); column 3, from CAIRNS & YONGUE (1973a; data from "Station 1 and year 1970" from the Cape Fear River near Fayetteville, North Carolina, USA, sample size not indicated); column 4, from BICK & KUNZE (1971; summary of literature data); column 5, from DETCHEVA (1972a, 1975a–c, 1976b, 1978, 1979a, c, 1982b, 1983a, b, c; many analyses from Bulgarian running waters); column 6, from MADONI & GHETTI (1981a; Torrente Stirone in Northern Italy; sample size not indicated); column 7, from FOISSNER et al. (1982a; 9 analyses from small, stagnant alpine water bodies in Austria)

Parameter ¹	Reference						
	1	2	3	4	5	6	7
Frequency (%)	12.5	31	-	-	1.0–9.8	-	-
Temperature (°C)	4.0–23	4–40	24.5–26	2–25	0.6–31	17.5–21	2.5–20
pH	7.3–8.7	6.0–9.5	6.7–7.3	4.0–8.4	6.3–8.5	8.0–8.5	4.9–5.6
O ₂ (mg l ⁻¹)	2.6–15.3	3–15	6.6–8.7	0–22.5	3.0–14.3	9.5–11.3	6.7–11.3
O ₂ (% saturation)	23–169	-	-	-	30–103	-	86–148
BOD ₅ (mg l ⁻¹)	-	<0.5–20 ²	1.4–2.4	2–25	1.3–49	7–13 ⁴	4–76 ⁵
NH ₄ ⁺ -N (mg l ⁻¹)	-	<0.001–20 ³	0.005–0.12 ³	0–20	0.025–8.2 ³	0.25–1.4 ³	0–6.2
NO ₂ ⁻ -N (mg l ⁻¹)	-	<0.001–1.5	-	-	0–0.3	0.006–0.1	0–3
NO ₃ ⁻ -N (mg l ⁻¹)	-	0.001–7	0.37–0.65	-	0–11.7	0.1–0.8	0–0.45
PO ₄ ³⁻ -P (mg l ⁻¹)	-	0.033–3.3	0.09–0.135	-	-	0.13–0.69	0–0.09

¹ The figure "0" denotes only that the parameter in question could not be detected with the analytical method used.

² In CAIRNS (1964) this parameter is designated as BOD only.

³ NH₃-N.

⁴ COD.

⁵ KMnO₄-consumption.

sions could be observed. Amicronucleate cells have an increased division rate (LU & NG 1989). For effects of alcohol on the life cycle, see WOODRUFF (1908).

Respiration rate 2.33 nl O₂ cell⁻¹ h⁻¹ (condition unspecified, cell volume 900 000 µm³, corresponding to a biomass of 900 mg per 10⁶ individuals, which is rather high; CHORIC & SHUBERNETSKY 1978, FENCHEL & FINLAY 1983, KHLEBOVICH 1987, KLEKOWSKI 1981).

Data on biomass of 10⁶ individuals rather variable: 70 mg (FOISSNER 1987a; terrestrial population of FOISSNER 1982), 199 mg (MICHIELS 1974), 277 mg (DILLON & HOBBS 1973), 350 mg (FOISSNER et al. 1991; calculated from average size), 390 mg (NESTERENKO & KOVALCHUK 1991), 402 mg (SCHÖNBORN 1981, 1982), 900 mg (FENCHEL & FINLAY 1983). As a consequence, biomass should be calculated separately for each population in question.

Some data on community production and some autecological data are shown in Tables 28, 34, 35 and Figure 155. Further autecological data: <6–2500 mg l⁻¹ Cl⁻, 1 to 20 mg l⁻¹ CO₂ free, <0.01–1 mg l⁻¹ Fe²⁺, <3–450 mg l⁻¹ Ca²⁺, <3–200 mg l⁻¹ Mg²⁺ (CAIRNS 1964); 4–28.5 °C, pH 5.8–6.9, 2–10.8 mg l⁻¹ O₂ (MATIS 1975); 7–38 °C, pH 5.0–7.5 (MA-

Table 35 Autecological data of species of the *Stylonychia mytilus* complex (columns 1–4) and *Stylonychia putrina* (columns 5–7). References: column 1, from BERECKY (1977a; ? analyses from the betamesosaprobic Danube River in Hungary); column 2, from RUTHVEN (1972) and CAIRNS & DICKSON (1972; with low abundance in 4 stations in the South River, Virginia, USA, n = ?); column 3, from MIHAILOWITSCH (1989; 11–13 analyses from salt loaded running waters in Germany); column 4, from FOISSNER et al. (1991; running waters in Austria, n = number of analyses); column 5, from BICK (1960, 1968a, 1972a) and BICK & KUNZE (1971; summary of literature data, supplemented with data from BICK & BERTRAM 1973, BICK & DREWS 1973, GREISER 1974, PRIMC 1983, and WILBERT 1977); column 6, from DETCHEVA (1983c; several analyses from alphamesosaprobic areas of the Maritza River, Bulgaria); column 7, from PATRICK et al. (1967; few analyses from the Savannah River, USA) and from RUTHVEN (1972) and CAIRNS & DICKSON (1972; ? analyses from 4 stations in the South River, Virginia, USA)

Parameter ¹	Reference						
	1	2	3	4/n	5	6	7
Frequency	-	-		15	-	-	-
Temperature (°C)	2–20	-	4–20	0.2–12/20	2–30	18–25	23–28
pH	6.7–8.1	7.6–8.2	7.4–8.0	7.1–8.7/20	4.7–9.4	7.2–7.4	7.5–9.0
O ₂ (mg l ⁻¹)	7–14.4	-	4.5–9.3	6–13/20	0–12.6	5.5–7.7	1–7
O ₂ (% saturation)	-	-	-	55–105/20	-	67–80	-
BOD ₅ (mg l ⁻¹)	2.4–5.1 ²	1.1–2.3	-	1–>7/19	-	-	0.5–9.1
NH ₄ ⁺ -N (mg l ⁻¹)	0.7–1.1	0	0.07–0.5	0–1.3/20	0–40	0.05–0.21	0–0.05 ³
NO ₂ ⁻ -N (mg l ⁻¹)	0.017–0.07	0.002–1.3	0.03–0.8	0–0.02/16	-	0.03–0.46	0–1
NO ₃ ⁻ -N (mg l ⁻¹)	0.47–1.6	0.004–0.39	0.3–6	0.5–2.2/19	-	0.23–0.34	0.03–0.4
PO ₄ ³⁻ -P (mg l ⁻¹)	-	0.115–2.2	-	0.02–0.27/13	-	-	0.016–2.2

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

² “O₂-consumption”.

³ NH₃-N.

TIS & STRAKOVÁ-STRIEŠKOVÁ 1991); pH 6.8–8.0 (DINGFELDER 1962); 13.5–89 mg l⁻¹ CO₂ free, 40–265 mg l⁻¹ Cl⁻, 573–1,514 µS cm⁻¹ specific conductivity (MIHAILOWITSCH 1989; salt polluted running waters in Germany); 0–28 mg l⁻¹ CO₂ free (BERECZKY 1977a; Danube River in Hungary); 21.5–28 °C, >1–10 mg l⁻¹ CO₂ free >5–9 mg l⁻¹ O₂, 0.01–<0.9 mg l⁻¹ Fe²⁺ (PATRICK et al. 1967); 0.36–0.74 mg l⁻¹ Fe²⁺, 0.05–0.08 mg l⁻¹ Mn²⁺, 32–34 mg l⁻¹ HCO₃⁻, 7–18 mg l⁻¹ SO₄²⁻, 15–17.5 mg l⁻¹ Cl⁻ (CAIRNS & YONGUE 1973a; Savannah River, USA); 70–218 mg l⁻¹ loss of ignition, 93–310 mg l⁻¹ total solids, 124–189 mg l⁻¹ total hardness, 9–103 mg l⁻¹ SO₄²⁻, 1.8–34 mg l⁻¹ Cl⁻, 0.09–0.4 mg l⁻¹ Fe²⁺, 0.008–0.063 mg l⁻¹ Cu, 0.022–0.067 mg l⁻¹ Zn, 0.007–0.036 mg l⁻¹ Cr, 0.008–0.018 mg l⁻¹ Pb (RUTHVEN 1972 and CAIRNS & DICKSON 1972; South River, Virginia). FOISSNER et al. (1982a) found *Stylonychia mytilus* once with high abundance in an alpine water body at 10 × 10⁶ bacteria ml⁻¹ (direct counting), 9.7 °C, pH 5.3, 10.8 mg l⁻¹ O₂ (123 % saturation), 2.6 mg l⁻¹ CO₂ free, 2 °dH total hardness, 76 mg l⁻¹ KMnO₄-consumption, 6 mg l⁻¹ NH₄⁺-N, 0.09 mg l⁻¹ PO₄³⁻-P, 1.2 mg l⁻¹ Fe²⁺, 0 mg l⁻¹ H₂S. According to STÖSSEL (1979), species of the *S. mytilus* complex preferred a DOC range of 2.6–7.2 mg l⁻¹ (total range 0.5–7.2 mg l⁻¹). BICK & KUNZE (1971), FOISSNER et al. (1982a), and FOISSNER et al. (1991) provided following bac-

Fig. 155 Distribution expressed as percentage of n records of species of the *Stylonychia mytilus* complex in the spectra of some physical and chemical factors (from HEUSS 1976). 1 = temperature, 2 = pH, 3 = specific conductivity, 4 = O_2 , 5 = O_2 -saturation, 6 = BOD_5 , 7 = $KMnO_4$ -consumption, 8 = Cl^- , 9 = PO_4^{3-} , 10 = NH_4^+ .

terial counts (cells ml^{-1}): 6000 to 500 0000 (plate method), 500 000–10 000 000 (direct counting with phase-contrast microscopy), 1000–1300 000 (plate method).

Eurythermic (Table 34, 35; BICK & BERTRAM 1973, JAROSHENKO & CHORIK 1969, MATIS 1975, MÜNCH 1970, WILBERT 1977). However, PRIMC (1983) found *S. mytilus* in laboratory experiments only at 5 °C, indicating insufficient culture conditions. WANG (1928) and LICHTENBERG (1955b) mentioned 18–20 °C as favourable temperature. DINGFELDER (1962) even found *S. mytilus* in road pools at 47 °C! KAUL & SA-

PRA (1989) reported that 30 °C is the maximum temperature to which *S. mytilus* can adapt without visible consequence to their cortical anatomy or generation time. However, they found that the macronuclear area is significantly higher in cells grown at 30 °C ($1075.7 \pm 43 \mu m^2$) than in cells grown at 23 °C ($781.4 \pm 19 \mu m^2$). Heat shock induced ultrastructural alterations are described by KAUL & SAPRA (1991).

Maximum survival time in an atmosphere of pure carbon dioxide <15 min and at very low oxygen tension about 1 h (NIKITSKY & MUDREZOWA-WYSS 1930, STOUT 1956).

FERNANDEZ-LEBORANS et al. (1985) found 1.2–1.8 μm sized lead deposits in specimens which lived in samples treated with 500 $\mu g l^{-1}$ lead acetate. According to BOYKOVA (1982), *S. mytilus* tolerated 20 $mg l^{-1}$ Pb (2.6 divisions per day), however, a conspicuous physiological polymorphism occurred; after a few days with 10 $mg l^{-1}$ Zn the growth rate

was as high as in the control (BOIKOVA 1990). *Stylonychia mytilus* did not tolerate more than 100 $\mu\text{g l}^{-1}$ zinc chloride, at least when 50 $\mu\text{g l}^{-1}$ lead acetate was present (FERNANDEZ-LEBORANS & ANTONIO-GARCIA 1986). Minimal inhibitory concentration and minimal lethal concentration of tinidazole 1 mg l^{-1} (incubation time 2 d) and 3 mg l^{-1} (incubation time 3 d) respectively (ALONSO 1979). Presence of 0.001–0.01 % NiSO_4 -ions in culture medium did not change spiralling direction as it did in some other species (SERAVIN 1970).

MACHEMER (1966a, b) demonstrated a very weak but significant avoidance of light (1000 lx) over 1 h and a weak avoidance of rough over 80 min. For further ethological data, see ALVERDES (1937, 1938), BRAMSTEDT (1935), RICCI (1994).

KITCHING (1957b) studied the effect of high hydrostatic pressure. At 28 700 kPa, and more especially at 35 900 kPa, the membranelles and cirri, previously motionless, began to flicker. At 43 000–50 200 kPa all cirri and membranelles beat wildly and the body turned in circles, but towards the end of the period at 50 200 kPa movement of cirri and body almost ceased. There was instant recovery of movement when the pressure was released, and the animals swam with an irregular rolling or circling motion. At 57 400 kPa there was some disintegration of the posterior end of the organism, with loss of cirri, but considerable measure of normal activity was recovered by 3 h after release of pressure. For the effect of ultraviolet radiation, see TCHAKHOTINE (1936).

Species of the *S. mytilus* complex are usually classified as alphamesosaprobic indicators of water quality (FOISSNER 1979b, 1988a, KOLKWITZ 1950, KOLKWITZ & MARSSON 1902, 1909, MARSSON 1903, SLÁDEČEK 1964, 1969, 1973, SLÁDEČEK et al. 1981, ŠRÁMEK-HUŠEK 1958, STJERNA-POOTH 1981, WEGL 1983). PRIMC (1984) observed the highest abundances under alphamesosaprobic to polysaprobic conditions. VOSS (1978) obviously erroneously designated it as “Faulwasser-Bewohner”. MAUCH (1976), MAUCH et al. (1985; Si = 2.5), MORAVCOVÁ (1977; b = 4, a = 6, I = 3, SI = 2.6), and ŠRÁMEK-HUŠEK (1956a) classified *S. mytilus* as beta- to alphamesosaprobic, BUCK (1971) even as betamesosaprobic with a corrected saprobic index of 1.96 ± 0.36 . According to FRIEDRICH (1990; see also BERGER et al. 1997 and DIN 38410 Teil 2) the *S. mytilus* complex is classified as follows: o–b = 2, b = 8, b–a = 6, a = 4, I = 4, SI = 2.3. FOISSNER et al. (1991) found it mainly in beta- to alphamesosaprobic or alphamesosaprobic running waters with a saprobic index of 1.9–3.2. The highest abundance was observed in an alphamesosaprobic area (6.8 mg l^{-1} O_2 , 65 % O_2 -saturation, 30 mg l^{-1} COD) of a river in Upper Austria heavily polluted by paper-mill effluents. Considering the autecological data given in Tables 34, 35 and the faunistic records, the alphamesosaprobic classification as suggested by SLÁDEČEK et al. (1981) and FOISSNER et al. (1991) seems justified (a; b = 1, a = 9, I = 5, SI = 2.9). Possibly, *S. mytilus* and *S. lemnae* have somewhat different saprobic preferences, which has to be verified by autecological and saprobiological investigations on reliably determined material. *Stylonychia mytilus* does not tolerate hydrogen-sulphide (WETZEL 1928b).

Supposed synonyms: *Stylonychia virgula* FROMENTEL, 1876, Études micro-zoaires, p 273, Planche XIV, fig. 3. Remarks: “*Stynolychia virgula*” in FROMENTEL (1876, p 359) is an incorrect subsequent spelling of *Stylonychia*. Especially the body shape is

reminiscent of species of the *S. mytilus* complex; possibly a slightly damaged specimen. In life about 115 µm long. France? The drawing in DUMAS (1929, on p 83 as “*Stylonichia virgula*”, in the legend to Planche XXIX, fig. 8 designated as *Stylonychia auriformis*) is obviously a redrawing from the original description (Fig. 237d).

Stylonychia kahli DRAGESCO, 1966, *Protistologica*, 2: 92 (Fig. 152b). Remarks: Body shape, size (about 200 µm long), and arrangement of transverse cirri are reminiscent of species of the *S. mytilus* complex. 66–71 adoral membranelles, 38–43 right and about 28 left marginal cirri. 2–4 micronuclei. Six dorsal kineties; two long caudal cirri, which is rather surely an anomaly. Locus classicus is a limnetic habitat near Thonon-les-Bains, France. BORROR (1972a) synonymised it with *S. pusilla* STERKI, 1878, which is here considered as supposed synonym of *S. notophora*.

***Stylonychia mytilus* (MÜLLER, 1773) EHRENBERG, 1830 (Fig. 148n, o, 150a–f, 151j, 153d, Table 31)**

1773 *Trichoda mytilus* MÜLLER, *Vermium Terrestrium et Fluviatilium*, p 87.

1786 *Kerona mytilus* – MÜLLER, *Animalcula infusoria*, p 242 (Fig. 150d–f).

1830 *Stylonychia mytilus* – EHRENBERG, *Abh. preuss. Akad. Wiss.*, year 1830: 43.

1965 *Stylonychia mytilus* Varietät 2 – AMMERMAN, *Arch. Protistenk.*, 108: 111 (Fig. 150c).

1983 *Stylonychia mytilus*, EHRENBERG 1838 – AMMERMAN & SCHLEGEL, *J. Protozool.*, 30: 292 (Fig. 148n, o, 151j).

1983 *Stylonychia mytilus* EHRENBERG, 1838 – STEINBRÜCK & SCHLEGEL, *J. Protozool.*, 30: 294.

1985 *Stylonychia mytilus* – AMMERMAN, *Memoire Soc. tosc. Sci. nat.*, 92: 17, Fig. 1.

1986 *Stylonychia mytilus* – WIRNSBERGER, FOISSNER & ADAM, *Arch. Protistenk.*, 132: 169 (Fig. 150a, b, 153d; 1 slide of neotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: See also relevant chapter in the *S. mytilus* complex. Neither AMMERMAN & SCHLEGEL (1983) and WIRNSBERGER et al. (1986) nor anyone else designated a clone of a true *S. mytilus* as neotype. Furthermore, they did not fix a type location. To eliminate these shortcomings the following statements are made to satisfy the qualifying conditions (1)–(6) of Article 75 (d) of ICZN (1985): (1) for the characterisation of the species, see bibliographic references in the list of synonyms; (2) the specimen from clone C1 figured in WIRNSBERGER et al. (1986; Fig. 2, 4; here Fig. 150a, b) is designated as neotype specimen; (3) a careful study of the post 1965 literature revealed that no type was designated; (4) the specimen designated is consistent with that known from the original description and many redescrptions; (5) the neotype came from a locality which is not too far away from MÜLLER's (1773) locality (Denmark); (6) the slide containing the neotype specimen is deposited in a scientific institution. General description see also key and *S. mytilus* complex. *Stylonychia mytilus* and *S. lemnae* are separated since 45×10^6 years (SCHLEGEL & STEINBRÜCK 1986).

Morphology and biology: Length after AMMERMAN & SCHLEGEL (1983) in life $300 \pm 22 \mu\text{m}$ after 1 day starvation and about $370 \mu\text{m}$ before division. Left margin with a conspicuous bulge at about level of frontal cirri. This outline is more pronounced in starved than in well feed animals. However, the results by WIRNSBERGER et al. (1986) proved that neither shape nor size provide criteria for separation from *S. lemnae*. Both macronuclear nodules together in G1 contain $1004 \pm 33 \text{ pg}$ ($n = 10$) DNA. 3–6 (mean = 3.7; $n = 25$) micronuclei, each containing in G1 about $24.8 \pm 0.5 \text{ pg}$ DNA (C-value: 12.4 pg; AMMERMAN & SCHLEGEL 1983, RAIKOV 1989). Intracloal conjugation common. For a detailed biochemical characterisation comprising isoenzyme patterns and macronuclear and micronuclear DNA banding patterns after restriction enzyme digestion, see STEINBRÜCK & SCHLEGEL (1983). Anterior portion of dorsal kinetics 1–4 more curved than in *Stylonychia lemnae* (cp Fig. 149b with 150b).

Occurrence and ecology: Common in freshwater habitats, prefers lentic waters. Type location: lake near Reutlingen-Gönnigen, Germany (clone "C1" of WIRNSBERGER et al. 1986). AMMERMAN (1965a) and AMMERMAN & SCHLEGEL (1983) found it in various limnetic habitats around Tuebingen and Cuxhaven, in Muenster, in Lake Federsee, in 4 lakes in Upper Swabia (Germany), in a lake near the Lake Neusiedlersee (Austria), in a lake south of Gdansk (Poland), in moss from West Africa, in fish ponds near Harbin (China), and in Cashmere (India). AMMERMAN et al. (1989) isolated *Stylonychia mytilus* from a pond near Ithaca, USA. Tolerates more than 0.3 % NaCl and occurs also in brackish water (AMMERMAN 1965a).

***Stylonychia lemnae* AMMERMAN & SCHLEGEL, 1983** (Fig. 3a, 4, 5, 11a, b, 26a–j, 148m, p, 149a–d, 153a–c, e–j, Tables 18, 31)

1965 *Stylonychia mytilus* Varietät 1 – AMMERMAN, Arch. Protistenk., 108: 111 (Fig. 149d).

1983 *Stylonychia lemnae* AMMERMAN & SCHLEGEL, J. Protozool., 30: 291 (Fig. 148m, p, 149c; some slides of the type material are deposited in the Smithsonian Institute, Washington D. C., USA).

1983 *Stylonychia lemnae* STEINBRÜCK & SCHLEGEL, J. Protozool., 30: 294.

1985 *Stylonychia lemnae* – AMMERMAN, Memoire Soc. tosc. Sci. nat., Serie B, 92: 17, Fig. 1.

1986 *Stylonychia lemnae* AMMERMAN & SCHLEGEL, 1983 – WIRNSBERGER, FOISSNER & ADAM, Arch. Protistenk., 132: 167 (Fig. 149a, b, 153a–c, e–j).

Nomenclature and taxonomy: See key and *S. mytilus* complex for these topics and a general description.

Morphology and biology: Length in life $230 \pm 12 \mu\text{m}$ after starvation for 1 day, about $120 \mu\text{m}$ minimal length after 3 days of starvation, and about $270 \mu\text{m}$ before division. According to original description body margins almost in parallel (Fig. 149c, d), the micrographs, however, show that the outlines of *S. lemnae* and *S. mytilus* are identical (cp. Fig. 148o, p). Both macronuclear nodules together in G1 contain $788 \pm 28 \text{ pg}$ DNA

($n = 10$). 2–5 (mean = 3.4; $n = 25$) micronuclei, each containing in G1 about 18.4 pg DNA (C-value: 9.2 pg; mean of 20 clones and 10 nuclei of each clone measured). Deviations of micronuclear DNA content between clones about $\pm 15\%$ from mean (18.4 pg; RAIKOV 1989, STEINBRÜCK et al. 1981). AMMERMAN et al. (1989) isolated clones with micronuclei without function, with small micronuclei, or with no micronuclei at all. Intraclonal conjugation rare and in most cases temporary (AMMERMAN 1982). Anterior portion of dorsal kineties 1–4 less curved than in *S. mytilus* (cp. Fig. 149b with 150b).

A detailed biochemical characterisation comprising isoenzyme patterns and macro-nuclear and micronuclear DNA banding patterns after restriction enzyme digestion is provided by STEINBRÜCK & SCHLEGEL (1983).

Stylonychia lemnae is sometimes infected by the host-specific suctorian ectoparasite, *Podophrya grelli* DIECKMANN, 1985. For further details see the parasitism chapter in the general section (Fig. 26a–j) and MATTHES (1988).

Stylonychia lemnae is intensively used in experimental studies, especially in areas of genetics, biochemistry, and physiology: AMMERMAN (1964, 1968, 1971b, 1987a, b, 1988, 1990, 1993), AMMERMAN et al. (1974), ASCENZIONI & LIPPS (1986), BALLANYI & DEITMER (1984), BAROIN-TOURANCHEAU et al. (1992, 1995), BESSLER & LIPPS (1976), BIERBAUM et al. (1991), CALLEN et al. (1994), CONZELMANN & HELFTENBEIN (1987), DEITMER (1981b, 1982, 1983b, 1984, 1986a, b), DEITMER et al. (1983, 1984), EDER et al. (1993), ELSEVIER et al. (1978), FLEURY et al. (1995), GAUDE (1981), GAUNITZ et al. (1992), GRIMES et al. (1981), HARPER & JAHN (1989), HELFTENBEIN (1985), HELFTENBEIN & MÜLLER (1988), HELFTENBEIN et al. (1989), HERRICK (1992), IVENS & DEITMER (1986), KRAUT et al. (1986), LIPPS (1975, 1977, 1980), LIPPS & BESSLER (1977), LIPPS & EDER (1996), LIPPS & ERHARDT (1981), LIPPS & HANTKE (1975), LIPPS & MORRIS (1977), LIPPS & STEINBRÜCK (1978), LIPPS et al. (1978), MACHEMER & SUGINO (1989), MAERCKER & LIPPS (1993, 1994a, b), MAERCKER et al. (1997a, b), MEYERS & HELFTENBEIN (1988), NOCK (1981), PEYER & DEITMER (1980), PEYER & MACHEMER (1977, 1978b, 1982b, 1983), SAPRA et al. (1985, 1994), SCHLEGEL (1985), SCHLEGEL & STEINBRÜCK (1986), SCHLEGEL et al. (1989, 1990), SCHMIDT et al. (1991), STEINBRÜCK (1983, 1990), STEINHILBER & LIPPS (1986), STOLL et al. (1991, 1993), SUGINO & MACHEMER (1990), WEFES & LIPPS (1990), WEGNER et al. (1989), WEN et al. (1995), WITTE & KNEER (1990), WITTE et al. (1995). Some other papers are mentioned in the last paragraph of the relevant chapter of the *S. mytilus* complex.

Occurrence and ecology: Common in freshwater habitats, prefers lentic waters. Locus classicus is pond IV of the “Spitzberg forest” near Tuebingen, Germany. AMMERMAN (1965a), AMMERMAN & SCHLEGEL (1983), and AMMERMAN et al. (1989) found *S. lemnae* in 10 different water bodies in Germany, namely around Tuebingen, in Rohrsee, in the Wutachschlucht, Black Forest, in Erbach near Ulm, oxbow of the Danube River, in Taubergießen, oxbow of the Rhine River, in Muenster, in 6 different waters around Cuxhaven; furthermore, they found it in Bornholm (Denmark), in China, and in Greenbelt Lake, College Park, Maryland and near Ithaca, USA. AMMERMAN et al. (1989) investigated 12 North-American ponds, 7 of them contained species of the *S. mytilus*

Fig. 156 *Stylonychia nodulinucleata* (from SHI & LI 1993). The original description of this species is in Chinese. The meagre original English legend runs as follows: "Morphological comparison of three species of *Stylonychia* with regard to the ventral cirral patterns, adoral zone of membranelles and undulating membrane (drawn according to the protargol preparations)". Unfortunately, SHI & LI (1993) omitted to translate the species names, obviously assuming that everybody can read Chinese. I suppose that the left illustration shows *S. nodulinucleata*. Broken lines should connect frontal-ventral-transverse cirri originating from same streak, which is, however, incorrectly shown (see Fig. 152f, 153j for correct co-ordination). Explanation of original labels: C = caudal cirri, F₁₋₈ = frontal cirri (F₁₋₃), buccal cirrus (F₈), and frontoventral cirri (F₄₋₇), LMC = left marginal cirral row, TC₁₋₅ = transverse cirri, uM = undulating membranes, V₁₋₅ = postoral (V₁₋₃) and pretransverse (V_{4,5}) ventral cirri.

after one day cells accumulated $185 \mu\text{g g}^{-1}$ Cd of dry mass; only 25 % of the metal concentration was in the cytosol. Chromatographic analysis did not reveal any chelating molecule (see Table 18 for data on metal accumulation). Treatment with the DNA cross-linking agent Cis. dichlorodiamine Platinum (cis platin) at a concentration of $150 \mu\text{g ml}^{-1}$ for 30 min resulted in amiconuclearity of cells without impairing macronuclear activity (SAPRA et al. 1989).

Stylonychia nodulinucleata SHI & LI, 1993 (Fig. 156)

1993 *Stylonychia nodulinucleata* SHI & LI, Zool. Res., 14: 11 (see taxonomy).

complex. *Stylonychia mytilus* was found only in 1 pond, indicating that *S. lemnae* is possibly more common in North America than *S. mytilus*. Attempts by AMMERMAN et al. (1989) to find species of the *S. mytilus* complex in other regions of the USA failed. *Stylonychia lemnae* tolerates not more than 0.3 % NaCl (AMMERMAN 1965a), suggesting that the marine and brackish records of a species of the *S. mytilus* complex deal with *S. mytilus*. TAKAHASHI & SUHAMA (1991) found *S. lemnae* in Japan in soil from paddy fields.

Length of cell cycle about 12 h ($23 \pm 2^\circ\text{C}$, Pringsheim medium, *Chlo-rogonium elongatum*; AMMERMAN & MUENZ 1982). IRATO et al. (1991) exposed *S. lemnae* to 5 and $2.5 \mu\text{M}$ Cd as $\text{CdCl}_2 \cdot \text{H}_2\text{O}$. The first dose killed cells. The second was well tolerated and

Nomenclature and taxonomy: This name was first mentioned in FENG et al. (1990, p 95), however, very likely without description (I did not read the work, because it is in Chinese). Unfortunately, the original description is also in Chinese. According to the summary, *S. nodulinucleata* matches *S. mytilus* exactly except for the macronucleus, which is moniliform (noduliform) like in *Coniculostomum*. However, *Coniculostomum* has two or more right marginal rows. Redescription (please in English) necessary.

Morphology: Size (in life? 270–310 × 95–110 µm), shape, and infraciliature as in *S. mytilus* (see there). LI & SHI (1993) reported on amiconucleate specimens.

Occurrence: Locus classicus is Morshan Town, Heilongjiang Province, China, where SHI & LI (1993) discovered *Stylonychia nodulinucleata* in marsh water. W. FOISSNER (pers. comm.) found it in a floodplain in Australia.

***Stylonychia notophora* STOKES, 1885 (Fig. 152p, 154e, 159d–f, 166c, d)**

1885 *Stylonychia notophora* STOKES, Ann. Mag. nat. Hist., 15: 446 (Fig. 159e).

1888 *Stylonychia notophora*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 299.

1914 *Stylonychia notophora* STOKES – SMITH, Kans. Univ. Sci. Bull., 9: 166 (Fig. 154e; incorrect subsequent spelling).

1932 *Stylonychia notophora* STOKES, 1885 – KAHL, Tierwelt Dtl., 25: 620.

1935 *Stylonychia notophora* STOKES 1885 – WANG & NIE, Sinensia, Shanghai, 6: 505 (Fig. 159f).

1945 *Stylonychia notophora* – ŠRÁMEK-HUŠEK, Veda přír., 23: 302 (Fig. 159d).

1965 *Stylonychia notophora* STOKES, 1885 – LÓPEZ-UCHOTERENA, Revta Soc. mex. Hist. nat., 24: 161 (Fig. 152p; incorrect subsequent spelling of *Stylonychia*).

1971 *Stylonychia putrina* STOKES (?) – DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 130; in part: “petite variété”, Fig. 28 (Fig. 166d); not “grande variété”, Fig. 27.

1986 *Stylonychia putrina* STOKES, 1885 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 487; in part: Planche 145 B (Fig. 166c); not Planche 145 A, C–F.

Nomenclature and taxonomy: KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Stylonychia) notophora*. According to BORROR (1972a) and WIRNSBERGER et al. (1985a), *S. notophora* is a synonym of *S. pustulata*. In my opinion, however, *S. notophora* is a valid species, which differs from *S. pustulata* mainly in the arrangement of the transverse cirri. In *S. notophora* they are arranged in two groups, similarly to in *S. bifaria* and *S. mytilus* (cp. Fig. 149a, 166c, 157a). Conversely, in *S. pustulata* they form a hook (Fig. 161c). *Stylonychia bifaria* has only inconspicuous caudal cirri, whereas they are distinctly elongated in *S. notophora*, similarly to in *S. mytilus*. It differs from the species of the *S. mytilus* complex mainly in body shape and size, the narrowly spaced caudal cirri, and the arrangement of the postoral ventral cirri (Fig. 159d–f, 166d). Detailed redescription necessary for final elucidation of validity. The populations by CONN (1905; Fig. 229b), EDMONDSON (1906; Fig. 226h), and WANG (1925; Fig. 242c) are insufficiently redescribed. The populations

described by BARY (1950; Fig. 161y) and SAPRA & DASS (1970a; Fig. 162i) are classified as *S. pustulata*.

M o r p h o l o g y a n d b i o l o g y: In life about $120\text{--}140 \times 50 \mu\text{m}$, after BUCHAR (1957) only $90 \mu\text{m}$ long, after MORAVCOVÁ (1962) $100\text{--}115 \times 34\text{--}50 \mu\text{m}$. Elliptical or with more or less parallel margins. Posterior end rounded and sometimes slightly emarginate on right-hand side, anterior end obliquely truncated at left-hand side.

About 33–36 adoral membranelles. Postoral ventral cirrus V/4 arranged behind level of cirrus IV/2 (Fig. 166c, d), which is a conspicuous difference to species of *Stylonychia mytilus* complex (for example, Fig. 149a). According to original description, the two left transverse cirri do not protrude beyond posterior end, whereas the three right ones project slightly to distinctly. About 12–15 left and 18–22 right marginal cirri. Caudal cirri about 25 % of body length.

O c c u r r e n c e a n d e c o l o g y: Throughout the year in lotic and lentic waters; much more seldom than *Stylonychia pustulata* and species of the *S. mytilus* complex. STOKES (1885b) discovered *S. notophora* in lentic water with dead leaves and various aquatic plants. STOKES did not give the specific locality where he found it; however, he lived and worked in Trenton, New Jersey, USA, and it is assumed that the locus classicus is near there.

Further records substantiated by illustrations: polysaprobic running water in Czechoslovakia (ŠRÁMEK-HUŠEK 1945, 1953); in old standing cultures from ponds and pools with dead leaves and filamentous algae from Nanking, China (WANG & NIE 1935); Kansas, USA (SMITH 1914); mesosaprobic habitats in Chapultepec, Mexico (LÓPEZ-POCHTERENA 1965, LÓPEZ-POCHTERENA & ROURE-CANE 1970); ponds near Yaounde, Cameroon (DRA-GENCO & NJINE 1971, NJINE 1977).

Records not substantiated by illustrations: pelagial of clear lakes in Styria, Austria (KRAINER 1988); limnocrene Slatna Panega and rivers in Bulgaria (DETSCHEVA 1981, DETSCHEVA 1972, RUSSEV 1988, RUSSEV et al. 1976, 1984); pond, saprobic brook near Prague, and alphamesosaprobic area of the Moldavia River, Czechoslovakia (BUCHAR 1957, HASSDENTEFUELOVÁ-MORAVCOVÁ 1955, MORAVCOVÁ 1962); on submerged macrophytes in a mesotrophic to eutrophic lake (Heiliges Meer) in Germany (MÜCKE 1979); limnetic habitats near Ferrara and paddy field with water from the Po River, Italy (CANELLA 1954, MADONI 1987, 1988b; further record from Italy: GRISPINI 1938); Turiec River in Slovakia (TIRJAKOVÁ 1993); China (SHEN & GONG 1989, SHEN & JIANG 1979, YANG 1989; SU et al. 1988, as *S. notophora*); India (JACOB et al. 1993); Japan (EDMONDSON & KINGMAN 1913); Lake Corona (3400 m above sea level) and Boulder Creek, Colorado, USA (EDMONDSON 1912, HAMILTON 1943); Iowa, USA (SHAWHAN et al. 1947); among algae in Creel Bay, Devil's Lake Complex, North Dakota, USA (EDMONDSON 1920); Norman, Oklahoma, USA (TROWBRIDGE & STAMBAUGH 1935); Conestoga Basin and from May to July $0.02\text{--}1.3 \text{ ind. ml}^{-1}$ in a pond at University of Pennsylvania, USA (CAIRNS 1965a, WANG 1928); Venezuela (SCORZA & NUÑEZ MONTIEL 1954); Lake Chad, Chad

(DRAGESCO 1972b; as *S. putrina* "petite forme" of DRAGESCO & NJINÉ 1971). STAMM (1984) recorded *S. notophora* from activated sludge plants in Switzerland.

Feeds on bacteria, unicellular algae, including diatoms (LÓPEZ-UCHOTERENA 1965, PRATT & CAIRNS 1985, PRATT et al. 1989, WANG & NIE 1935). Food vacuoles usually crowded in posterior half of well-fed specimens (WANG & NIE 1935). Biomass of 10^6 individuals about 85 mg.

DETCHEVA (1978, 1979a, c, 1983c) found *S. notophora* in various rivers in Bulgaria under following conditions: o, b, a, frequency 1.3–2.1 %, 10–24 °C, pH 6.3–7.6, 3.0–9.8 mg l⁻¹ O₂ (30–87 % saturation), 1.2–12.4 mg l⁻¹ BOD₅, 22–92 mg l⁻¹ Ca²⁺, 0 to 44 mg l⁻¹ Mg²⁺, 28–287 mg l⁻¹ HCO₃⁻, 38–167 mg l⁻¹ SO₄²⁻, 8–29 mg l⁻¹ Cl⁻, 0.04 to 7.8 mg l⁻¹ NH₄⁺-N, 0–0.18 mg l⁻¹ NO₂⁻-N, 0–1.54 mg l⁻¹ NO₃⁻-N, 0.02–1.5 mg l⁻¹ Fe²⁺. PATRICK et al. (1967) recorded it from the Savannah River, USA, under following conditions (n = ?): pH 6.5–7.0, 23–28 °C, 7–9 mg l⁻¹ O₂, 1–<5 mg l⁻¹ BOD₅, ≤1 µg l⁻¹ NH₄⁺-N, ≤0.007 mg l⁻¹ NO₂⁻-N, 0.2–<0.7 mg l⁻¹ NO₃⁻-N, 0.1–0.5 mg l⁻¹ PO₄³⁻, 5 to <10 mg l⁻¹ Cl⁻. According to AX & AX (1960), *S. notophora* tolerates up to 0.3 % salinity.

Saprobic classification: b; b = 7, a = 3, I = 4, SI = 2.3 (SLÁDEČEK et al. 1981, WEGL 1983); b; b = 10, a = +, I = 5, SI = 2.3 (MORAVCOVÁ 1977; SI obviously incorrectly calculated); alphamesosaprobic (MORAVCOVÁ 1962; see also MAUCH 1976). Taking into consideration the autecological and faunistic data, the classifications proposed by SLÁDEČEK et al. (1981) and MORAVCOVÁ (1977) are possibly too good; further studies on reliably determined populations recommended. FOISSNER et al. (1991) excluded *S. notophora* from the list of indicators of water quality.

Supposed synonym: *Stylonychia mytilus* var. *pusilla* STERKI, 1878, Z. wiss. Zool., 31: 56. Remarks: Incorrect subsequent spellings: *Stylonychia pusilus* (BICK & SCHOLTYSECK 1960, p 201); *Stylonychia pussila* KAHL (KRAVCHENKO 1969, p 73). KAHL (1932, p 618, Fig. 167e) considered it as valid species and mentioned it as "*Stylonychia pusilla* spec. n." expressly for the variety by STERKI. However, BORROR (1972a, p 15) stated correctly that STERKI (1878) is the author of this taxon. Since KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*, the correct name in his revision is *Oxytricha (Stylonychia) pusilla*. KAHL is the only one who gives an illustration of this form (Fig. 167e), which strongly resembles *S. notophora*. After STERKI (1878) 90–120 µm, according to KAHL (1932) in life 75–90 µm long and about 2.5 times as long as broad. Body margins distinctly converging posteriorly, left one slightly convex or straight. Both ends rounded. Moves hastily to and fro. 12–18 right and 10–14 left marginal cirri (STERKI 1878). Caudal cirri rather likely widely separated and fringed, similarly to in species of the *S. mytilus* complex. SCHLEGEL (1985) and SCHLEGEL & STEINBRÜCK (1986) studied the macronuclear DNA and the allozyme variation, however, the identification is not substantiated by an illustration. LYNN & CORLISS (1991, p 355) provided a scanning electron micrograph of the dorsal surface of the SCHLEGEL population. The ecological data are rather fragmentary. STERKI (1878) found it somewhere in Switzerland, and KAHL (1932) observed it together with *S. mytilus*. Records not substantiated by illustrations: Main River

Fig. 157a-d *Stylomysia bifaria* (from WIRNSBERGER et al. 1985a. a, from life; b-d, protargol impregnation). a) Ventral view, 135 μ m. Note the inconspicuous caudal cirri. b, c) Ventral and dorsal infraciliature, b, c = 80 μ m. Note that the transverse cirri are separated into two distinct groups as in species of the *S. mytilus* complex. Arrow = pretransverse ventral cirrus VI/2. d) Ventral infraciliature of a very early morphogenetic stage, 95 μ m. Arrowhead marks oral primordium. TC = transverse cirrus VI/1; p 557.

and sewage ponds in Germany (BERNERTH 1982, BICK & SCHOLTYSECK 1960, KAUFMANN 1958); Lake Dong Hu, Wuhan, China (SHEN 1980). Does not feed on algae (KAHL 1932).

***Stylonychia bifaria* (STOKES, 1887) comb. nov. (Fig. 157a–p, 159a, Tables 3, 4, 31)**

- 1887 *Oxytricha bifaria* STOKES, Ann. Mag. nat. Hist., 20: 110 (Fig. 157i).
 1888 *Oxytricha bifaria*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 292.
 1931 *Oxytricha bifaria* STOKES – SAMANO & SOKOLOFF, Monografias Inst. Biol. Univ. nac. Méx., 1: 35, Fig. 71.
 1932 *Oxytricha bifaria* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 602.
 1945 *Oxytricha bifaria* STOKES – KAY, Trans. Am. microsc. Soc., 64: 91 (Fig. 157j, l).
 1953 *Oxytricha bifaria* STOKES (1887) – JIROVEC, WENIG, FOTT, BARTOŠ, WEISER & ŠRÁMEK-HUŠEK, Protozoologie, p 511, 512 (Fig. 157p).
 1961 *Histrio muscorum* KAHL, 1930/35 – REUTER, Acta zool. fenn., 99: 21 (Fig. 159a; misidentification).
 1962 *Oxytricha bifaria* STOKES – MORAVCOVÁ, Sb. vys. Šk. chem.-technol. Praze, 6: 380 (Fig. 157n, o).
 1963 *Oxytricha bifaria* STOKES – LUNDIN & WEST, Free-living protozoa, p 67 (Fig. 157k).
 1985 *Stylonychia vorax* STOKES, 1885 – WIRNSBERGER, FOISSNER & ADAM, J. Protozool., 32: 261 (Fig. 157a–h, m; misidentification; authoritative redescription).

Nomenclature and taxonomy: The correct name in KAHL (1932) is *Oxytricha* (*Oxytricha*) *bifaria* because he divided *Oxytricha* into several subgenera. “*Diophrys bifaria*” and “*Oxytricha scutum*” in CHADHA et al. (1978, p 9) are erroneously combinations; the correct names should probably be “*Oxytricha bifaria*” and “*Diophrys scutum*”.

STOKES (1887b) classified the present species in *Oxytricha*, very likely because of the inconspicuous caudal cirri. However, the arrangement of the frontal, ventral, and transverse cirri and the straight, parallel undulating membranes indicate that it is a *Stylonychia*. According to the original description, *S. bifaria* is about 1/160 inch (= 159 µm) long. Conversely, STOKES (1888) and subsequently KAHL (1932) gave a length of 1/100 inch (= 254 µm; par lapsus?). Probably this last value is too large, although two redescriptions exist, both giving a length of 250 µm (KAY 1945, LUNDIN & WEST 1963). According to other redescriptions, *S. bifaria* is 100–216 µm long.

I have no doubt that *S. vorax* sensu WIRNSBERGER et al. (1985a) is in fact *S. bifaria*. This is indicated by the very good agreement in body shape, the inconspicuous caudal cirri, and the arrangement of the transverse cirri (cp. Fig. 157a, b, i). Thus, the detailed redescription by WIRNSBERGER et al. (1985a) should be considered as authoritative. “*Oxytricha bifaria*” of the Italian protozoologists (for example, ROSATI et al. 1988) is (very likely) identical with *Stylonychia pustulata* (see there). The populations by CONN (1905; Fig. 228g, 231i, j), SMITH (1914; Fig. 233f), SOKOLOFF (1931; Fig. 228b), and WANG (1925; Fig. 242h) are insufficiently redescribed.

Morphology and biology: Size in life obviously rather variable (see, however, taxonomy): about 160 µm (REUTER 1961, STOKES 1887b), 140 µm (SAMANO & SOK-

Fig. 157e-h *Stylonychia bifaria* (from WIRNSBERGER et al. 1985a; protargol impregnation). e) Early morphogenetic stage in ventral view, 95 μ m. f-h) Morphogenesis of dorsal infraciliature proceeds in *Oxytricha* pattern, f = 100 μ m, g = 90 μ m, h = 110 μ m. Arrows mark new dorsomarginal kinetids; dorsomarginal kinetids of opisthe are still on ventral surface; p 557.

Fig. 157i-m *Stylonychia bifaria* (i, after STOKES 1887b; j, from KAY 1945a; k, from LUNDIN & WEST 1963; l, after KAY 1945b; m, from WIRNSBERGER et al. 1985a. i-m, from life). i-k) Ventral views, i = 156 μ m, j = 216 μ m, k = 250 μ m (length from WEST & LUNDIN 1963). l) Resting cyst, 71 μ m. m) Lateral view; p 557.

OLOFF 1931), 100–250 μ m (KAY 1945a), 140–180 $\times$ 70–120 μ m (MORAVCOVÁ 1962), about 250 μ m (WEST & LUNDIN 1963), 93–137 $\times$ 48–55 μ m (WIRNSBERGER et al. 1985a). Right margin convex, left straight (Fig. 157a) or even slightly concave (Fig. 157i) and with striking bend in posterior part, thus posterior end somewhat pointed. Flattened about 3:1 dorsoventrally, first and last quarter of cell very thin, anterior part distinctly erected (Fig. 157m, o). Macronuclear nodules in life about 17 $\times$ 12 μ m, arranged along median or even slightly right of it, filled with about 2 μ m sized chromatin bodies. Two micronuclei, in life about 4 μ m across. Rapid and erratic movement.

Frontal cirri, buccal cirrus, frontoventral cirri III/2 and IV/3, and the 2 right transverse cirri distinctly enlarged. For arrangement of cirri, see Figure 157b. Right pretransverse ventral cirrus at level of middle transverse cirrus. Transverse cirri in life 17–21 μ m long, characteristically arranged in a group of 3 left cirri forming an oblique row and hardly reaching posterior end of cell and a detached group of 2 cirri protruding distinctly beyond posterior end of cell. Left marginal row terminates rather exactly at posterior end, right one terminates slightly behind level of posterior-most transverse cirrus. Marginal and frontal cirri in life 17–23 μ m long. Invariably 6 dorsal kineties. Rows 1 and 2 of

Fig. 157n–p *Stylonychia bifaria* (n, o, after MORAVCOVÁ 1962; p, from JIROVEC et al. 1953. n–p, from life). n, p) Ventral views, n = 170 μ m, p = 200 μ m. o) Lateral view, 155 μ m; p 557.

body length, rows 3 and 4 slightly shortened posteriorly and anteriorly respectively. Caudal cirri not fringed, rather closely arranged, in life only about 19–22 μ m long and thus hardly discernible from marginal cirri.

Cyst globular, 60 to 80 μ m across. Ectocyst brownish, with 6–8 rows of long spines (Fig. 157l). Further details on cyst formation, see KAY (1945b). Excystment can usually be induced by washing the cysts clean of old medium and debris with several changes of tap-water and placing them in fresh nutritive solution. Two solutions have proved suitable: 0.01 % tryptone in tap water exposed to air for

8–12 h before use, or tap-water in which few grains of polished rice have stood for several days. In either of these solutions a bacterial flora develops which is readily ingested by the young excystants. The entire process of excystment usually takes about 18 h (KAY 1945b).

Conjugation can frequently be observed (WIRNSBERGER et al. 1985a). To induce this part of life cycle, diverse cultures were provided with sufficient nutrient to allow 0.5 to 1 fission per day, and were mixed in a depression slide when they had exhausted most of the available bacteria. SIEGEL (1956) found 9 mating types (see also MIYAKE 1981). Nuclear behaviour during conjugation see KAY (1946); she found that the diploid number of chromosomes is 24.

M o r p h o g e n e s i s of cell division commences with the formation of the oral primordium close to the intact one or two leftmost transverse cirri (Fig. 157d). Somewhat later this primordium extends close to the cytostome (Fig. 157e). The next stages are identical with those of *S. pustulata* (see Fig. 162f–n; WIRNSBERGER et al. 1985a), indicating a very close relationship of these species. The origin of some primordia is rather different from that of *S. mytilus* (Table 4, cp. Fig. 23a with 23f), suggesting the *Stylonychia* is not monophyletic (see Fig. 25a). Morphogenesis of dorsal infraciliature shows no peculiarities and follows the *Oxytricha* pattern (Fig. 157f–h). For details on macronuclear division, see SESHACHAR & PADMAVATHI (1956) and SOKOLOFF (1930).

SHIGENAKA et al. (1973) tested different fixation techniques for electron-microscopic studies on *S. bifaria*. Furthermore, they show cross-sections of cilia and mitochondria. VAN WAGTENDONK & SOLDÓ (1965) stated that *S. bifaria* contains self-duplicating, rod-like particles which take up nuclear stains such as aceto-orcein.

Occurrence and ecology: In freshwater, obviously prefers stagnant waters; according to my experience not as common as *S. pustulata*. Probably cosmopolitan. STOKES (1887b) discovered *S. bifaria* in an infusion of hay; STOKES did not give the specific locality where he found it, however, he lived and worked in Trenton, New Jersey, USA, and it is thus assumed that the locus classicus is near there.

Further records substantiated by illustrations: pasture ponds in the Schlossalm area, Bad Hofgastein, Austria (WIRNSBERGER et al. 1985a); diverse cultures (biocleins, culture with grains of wheat or barley, Pringsheim biphasic culture), Czechoslovakia (MORAVCOVÁ 1962, JIROVEC et al. 1953); rock pools in Finland (REUTER 1961); debris collected in a pool in the Drug Garden of the University of Washington, USA (KAY 1945a); various freshwater habitats from the Upper Peninsula of Michigan, USA (LUNDIN & WEST 1963, WEST 1953, WEST & LUNDIN 1963); ponds in Mexico (SAMANO & SOKOLOFF 1931).

Records from freshwater habitats not substantiated by illustrations: Armenia (AMBARTZUMYAN 1962, ZHARIKOV 1982); Czechoslovakia (ŠRAMEK-HUŠEK 1953); eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany, from summer to early December (SONG & WILBERT 1989, as "*S. vorax* which agrees with the redescription of WIRNSBERGER et al. 1985a"); Hiroshima, Japan (MATSUOKA et al. 1983); in freshwater bodies of the rocky supra-littoral zone of the White Sea (BURKOVSKY 1971a); Conestoga River Basin, Pennsylvania, USA (CAIRNS 1965a); ponds and lake on Mount Desert Island, USA (MCCASHLAND 1956); bottom debris of a pond in Sandy Point area on Abaco Island, Bahamas (CAIRNS & RUTHVEN 1972); abundant in Creel and Whipple Bay of Devil's Lake complex, North Dakota, USA (EDMONDSON 1920, HAMMER 1986); soft water Escambia River, Florida, USA (PATRICK 1961); rarely in a pond in the botanical garden of the University of Pennsylvania, USA (WANG 1928); rare in clear springs and streams and clear small pools with abundant decomposing organic sediment, New York, USA (HAUSMAN 1917, 1934); Mexico (LOPEZ-POCHOTERENA & ROURE-CANE 1970); brook and artificial pool in Colombia (BOVEE 1957); Venezuela (SCORZA & NUÑEZ MONTIEL 1954); soil from flood plain primary (?) rain forest and from blackwater inundation primary (?) rain forest near Manaus, Brazil (FOISSNER 1997b); $<10 \text{ ind. ml}^{-1}$ in mud surface (pH 5.8) of a volcanic lake on Raoul Island, New Zealand (BROWN & PEART 1973).

Records from brackish, marine, or terrestrial habitats not substantiated by illustrations: freshened site of the White Sea (salinity about 1 ‰; BURKOVSKY 1976); rarely in the Logy Bay, Newfoundland, Canada, a marine habitat (LACKEY & LACKEY 1970); soils in Sweden and New Jersey, USA (KOFFMAN 1926, FELLERS & ALLISON 1920); soil from flood plains in Brazil, see previous paragraph.

PATRICK et al. (1967) recorded *S. bifaria*, rarely, from the Savannah River, USA, under following conditions: 23–28 °C, $>5\text{--}7 \text{ mg l}^{-1} \text{ O}_2$, $1\text{--}<5 \text{ mg l}^{-1} \text{ BOD}_5$, $0.05\text{--}<1 \text{ mg l}^{-1}$

Fig. 158a–c *Oxytricha phytophaga*, a supposed synonym of *Stylonychia bifaria* (from GELEI & SZABADOS 1950. a, sublimate fixation; b, c, opal-blue stain after BRESSLAU). a) Ventral view, 105 µm. b, c) Ventral and dorsal infraciliature, b = 60 µm, c = 50 µm.

$\text{NH}_3\text{-N}$, 0.001–<0.007 mg l⁻¹ $\text{NO}_2\text{-N}$, 0.2–<0.7 mg l⁻¹ $\text{NO}_3\text{-N}$, 0.1–0.5 mg l⁻¹ $\text{PO}_4\text{-P}$. CAIRNS & YONGUE (1973) found *Stylonychia bifaria* in the Cape Fear River near Fayetteville, North Carolina, USA, at 23–26 °C, pH 6.2–7.1, 5.8 to 8.5 mg l⁻¹ O_2 , 0.9–3.8 mg l⁻¹ BOD (probably BOD₅), 5.7–14.7 mg l⁻¹ Cl⁻, 0.17 to 0.68 mg l⁻¹ $\text{NH}_4^+\text{-N}$, 0.05–0.8 mg l⁻¹ $\text{NO}_3\text{-N}$, 0.07–0.3 mg l⁻¹ $\text{PO}_4\text{-P}$ (summary of the extreme values of 3 sites).

KAY (1945a) established cultures on tryptone solution and rice infusion with bacteria as food. As a culture medium tap water can be used, with yeast and a species of the *Tetrahymena pyriformis* complex grown on dry egg yolk added as the food supply (WIRNSBERGER et al. 1985a). SIEGEL (1956) maintained mass cultures and isolation lines in lettuce or Cerophyl infusions inoculated with *Aerobacter cloacae*. Biomass of 10⁶ individuals about 54 mg (population by

WIRNSBERGER et al. 1985a). Swims about 1.2 mm s⁻¹ (BULLINGTON 1925, identification uncertain, because cells 235–329 µm long).

Stylonychia bifaria is not included in the lists of indicators of water quality by SLÁDEČEK et al. (1981), WEGL (1983), and FOISSNER (1988a). According to MORAVCOVÁ (1962, 1977) it is confined to alphamesosaprobic areas ($s = a$; $b = +$, $a = 10$, $I = 5$, $SI = 2.8$). The faunistic and ecological data mentioned above suggest the following classification: $a-b$; $o = 1$, $b = 5$, $a = 4$, $I = 3$, $SI = 2.3$; however, this has to be verified by further saprobiological and ecological studies on reliably determined populations.

Supposed synonym: *Oxytricha phytophaga* GELEI & SZABADOS, 1950, Annls biol. Univ. szeged., 1: 261, 282 (Fig. 158a–c). Remarks: BORROR (1972a) already proposed synonymy with *S. bifaria*, however, since there are some minor differences, I provide a short characterisation of this Hungarian population. Large specimens in life about

Fig. 159a *Stylonychia bifaria* (after REUTER 1961). Ventral view from life, about 150 µm; p 557. b, c *Stylonychia vorax* (from DRAGESCO 1966b. b, c, protargol impregnation). b) Ventral view, 125 µm. Caudal cirri not shown in full length. c) Posterior end with caudal cirri in dorsal view; p 591. d–f *Stylonychia notophora* (d, after ŠRÁMEK-HUŠEK 1945; e, after STOKES 1885b; f, after WANG & NIE 1935. d–f, from life). d) Ventral ciliature in dorsal view, size not indicated. e, f) Ventral views, e = 125 µm, f = 105 µm; p 553. g *Stylonychia mytilus* complex (from DRAGESCO & NJINE 1971). Ventral infraciliature, protargol impregnation, 125 µm; p 504.

140 × 90 µm, starved specimens about 110 × 50–55 µm. Especially starved specimens often triangular in shape. Anterior part of cell distinctly erected. Two macronuclear nodules connected by a conspicuous fibre; very likely 2 micronuclei. Contractile vacuole about in mid-body. Feeds mainly on phytoplankton, especially on volvocales. Vivacious and persistently swimming, obviously a typical planktonic form. Arrangement of frontal, ventral, and transverse cirri, see Figure 158b; looks very similar to in *S. bifaria*. Invariably 5 transverse cirri. A distinct separation of the transverse cirri into 2 groups is only discernible in Figure 158b (thus not synonymous with *Pseudostrombidium planctonicum*). 15–21 right and 12–18 left marginal cirri. Caudal cirri obviously rather inconspicuous. Six dorsal kineties, dorsal cilia 2–4 µm long (Fig. 158c). Figure 158b probably shows a young postdivider because the dorsomarginal kineties are still visible on the ventral surface. Locus classicus is a rain puddle in Szeged, Hungary. "*Oxytricha phytofaga*" in RAMIREZ-MONTESINOS & PEREZ-SILVA (1966) is an incorrect subsequent spelling.

***Stylonychia pseudograndis* WANG & NIE, 1935 (Fig. 167a)**

1935 *Stylonychia pseudograndis* WANG & NIE, Sinensia, Shanghai, 6: 507.

Taxonomy: The increased number of cirri indicates misobservation or observation of atypical specimens of another species. However, since WANG & NIE (1935) found this pattern in numerous individuals, I would rather not, at this point, classify it as species indeterminata. Possibly a giant of *Stylonychia pustulata* (cp Fig. 164c). Detailed redescription necessary. BORROR (1972a) did not mention *S. pseudograndis*.

Morphology: In life 140–200 × 60–100 µm. Elliptical, broadest at or slightly behind mid-body, ± obliquely truncated anteriorly, rounded posteriorly. Macronuclear nodules ovoid or elongate ellipsoidal, often connected by a thread. Cytoplasm appears slightly darkish.

Usually 10 or 12 frontal, frontoventral, and buccal cirri. Frontal cirri distinctly enlarged. As in 18-cirri oxytrichids invariably 5 postoral and pretransverse ventral and 5 transverse cirri, the latter not conspicuously enlarged and scarcely projecting beyond posterior end of cell. Left marginal row J-shaped. Caudal cirri in life about 30 µm long and conspicuously shifted to the right.

Occurrence and ecology: Locus classicus is Nanking, China, where WANG & NIE (1935) discovered *S. pseudograndis* in an old standing culture of a sample from a freshwater habitat, together with high numbers of *Glaucoma* sp., *Ophryoglena* sp., and *Paramecium* sp., indicating that *S. pseudograndis* prefers saprobic conditions. Not found since. Voracious feeder (bacteria, *Glaucoma* sp., other ciliates). Biomass of 10⁶ individuals about 215 mg.

Stylonychia pustulata (MÜLLER, 1786) EHRENBURG, 1835 (Fig. 3b, 20d, 22a, 154a–d, 160a–j, 161a–z, 162a–j, 163a–d, g–l, 164a–e, 165e–g, Tables 3, 4, 18, 31, 36)

- 1786 *Kerona pustulata* MÜLLER, *Animalcula Infusoria*, p 246 (Fig. 161r).
- 1830 *Kerona pustulata* MÜLLER – EHRENBURG, *Abh. preuss. Akad. Wiss.*, year 1830: 43, Tafel VI, Fig. I_{1–13} (see also EHRENBURG 1831, p 119).
- 1835 *Stylonychia pustulata* – EHRENBURG, *Abh. preuss. Akad. Wiss.*, year 1835: 164.
- 1838 *Stylonychia pustulata* – EHRENBURG, *Infusionsthierchen*, p 371 (Fig. 161s).
- 1852 *Cerona pustulata* – PERTY, *Kenntniß kleinster Lebensformen*, p 154.
- 1858 *Stylonychia pustulata* EHR. – CLAPARÈDE & LACHMANN, *Mém. Inst. natn. génev.*, 5: 161 (Fig. 161t).
- 1858 *Stylonychia fissiseta* CLAPARÈDE & LACHMANN, *Mém. Inst. natn. génev.*, 5: 163 (Fig. 161u).
- 1859 *Stylonychia pustulata* EHRBG. – STEIN, *Organismus der Infusionsthier* I, p 161 (Fig. 161x, 162b).
- 1862 *Stylonychia pustulata* – ENGELMANN, *Z. wiss. Zool.*, 11: 354 (Fig. 162d).
- 1865 *Stylonychia pustulata* EHRBG. – QUENNERSTEDT, *Acta Univ. lund.*, 2: 57 (Fig. 161p, 162c).
- 1882 *Stylonychia pustulata*, EHR. – KENT, *Manual infusoria* II, p 791.
- 1882 *Stylonychia fissiseta*, C. & L. – KENT, *Manual infusoria* II, p 791.
- 1888 *Stylonichia pustulata* – MAUPAS, *Archs Zool. exp. gén.*, 6: 196 (Fig. 161v; incorrect subsequent spelling of *Stylonychia*).
- 1888 *Stylonichia mytilus* – MAUPAS, *Archs Zool. exp. gén.*, 6: 212 (Fig. 162a; misidentification; incorrect subsequent spelling of *Stylonychia*).
- 1899 *Stylonychia pustulata* EHRB. – PROWAZEK, *Arb. zool. Inst. Univ. Wien*, 11: 225 (Fig. 163a).
- 1901 *Stylonychia pustulata* (O.-F. MÜLL.) – ROUX, *Mém. Inst. natn. génev.*, 19: 104 (Fig. 162e).
- 1905 *Stylonychia pustulata* (O.F. MÜLL.) – BÜRGER, *An. Univ. Chile*, 117: 435 (Fig. 163b).
- 1906 *Stylonychia pustulata* EHR. – EDMONDSON, *Proc. Davenport Acad. Sci.*, 11: 102 (Fig. 234c).
- 1914 *Stylonychia pustulata* EHR. – SMITH, *Kans. Univ. Sci. Bull.*, 9: 166 (Fig. 154d).
- 1931 *Stylonychia pustulata* EHRBG. – TAI, *Sci. Rep. natn. Tsing Hua Univ.*, 1: 52 (Fig. 154a).
- 1932 *Stylonychia pustulata* EHRENBURG, 1838–STEIN, 1859 – KAHL, *Tierwelt Dtl.*, 25: 619 (Fig. 161q, 162h).
- 1932 *Stylonychia fissiseta* CLAPAREDE u. L., 1958 – KAHL, *Tierwelt Dtl.*, 25: 618.
- 1934 *Stylonychia pustulata* – CALKINS, *Biol. Bull. mar. biol. Lab.*, 67: 411 (Fig. 163k, l).
- 1935 *Stylonychia pustulata* – SUMMERS, *Arch. Protistenk.*, 85: 190 (Fig. 161z; in legend to plates on p 206 obviously erroneously designated as *Oxytricha fallax*).
- 1942 *Stylonychia pustulata* – LILLY, *Physiol Zool.*, 15: 147 (Fig. 162j; possibly *S. vorax*!).
- 1950 *Stylonychia notophora* STOKES – BARY, *Trans. R. Soc. N. Z.*, 78: 317 (Fig. 161y; misidentification).
- 1950 *Stylonychia putrina* STOKES – BARY, *Trans. R. Soc. N. Z.*, 78: 317 (Fig. 163d; misidentification?).
- 1952 *Stylonychia pustulata* EHRBG – HASHIMOTO, *Zool. Mag., Tokyo*, 61: 332 (Fig. 163c).
- 1961 *Stylonychia pustulata* EHRENBURG, 1838–STEIN, 1859 – REUTER, *Acta zool. fenn.*, 99: 21 (Fig. 162f).
- 1968 *Oxytricha (Stylonychia) pustulata* EHRENBURG, 1838 – CHORIK, *Free-living ciliates*, p 139 (Fig. 162w).
- 1969 *Stylonychia pustulata* EHRENBURG, 1838 – CURDS, *Wat. Pollut. Res.*, No. 12: 70 (Fig. 162g).
- 1970 *Stylonychia notophora* STOKES – SAPRA & DASS, *Acta Protozool.*, 7: 193 (Fig. 162i; misidentification).
- 1972 *Stylonychia pustulata* EHRENBURG, 1838 – CELA, *Physis*, 31: 576 (Fig. 154b).
- 1974 *Stylonychia putrina* STOKES – PÄTSCH, *Arb. Inst. landw. Zool. Bienenkd.*, 1: 63 (Fig. 165g; misidentification).
- 1976 *Stylonychia (Oxytricha) pustulata* EHRB. – KORNIYENKO, *Hydrobiol. J.*, 12: 62.
- 1985 *Stylonychia pustulata* (MÜLLER, 1786) EHRENBURG, 1838 – WIRNSBERGER, FOISSNER & ADAM, *J. Protozool.*, 32: 262 (Fig. 161a–o; authoritative redescription).
- 1986 *Stylonychia putrina* STOKES, 1885 – DRAGESCO & DRAGESCO-KERNÉIS, *Faune tropicale*, 26: 487; in part, Planche 145 C–E (Fig. 165e, f); not Planche 145 A, B, F.
- 1988 *Oxytricha bifaria* – ROSATI, GIARI & RICCI, *Europ. J. Protistol.*, 23: 343 (Fig. 164a–c; misidentification).

- 1988 *Stylonychia pustulata* (O. F. MÜLLER, 1786) – SHIN & KIM, Korean J. syst. Zool., Special Issue No. 2: 73, Fig. 4A–F.
- 1991 *Stylonychia pustulata* (MUELLER, 1786) EHRENBURG, 1835 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 323 (Fig. 160a–j).
- 1991 *Stylonychia pustulata* – FOISSNER, Europ. J. Protistol., 27: 323, Fig. 32, 33 (Fig. 160c).
- 1991 *Stylonychia pustulata* (MÜLLER, 1786) EHRENBURG, 1838 – GSCHWIND, Diplomarbeit, p 48 (Fig. 163g–j).
- 1991 *Stylonychia pustulata* – YANO & SUHAMA, J. Protozool., 38: 111 (Fig. 154c).
- 1997 *Clara pustulata* (MÜLLER, 1786) – EIGNER, J. Euk. Microbiol., 44: 568 (new combination with *Clara* EIGNER, 1997, a junior homonym).

Nomenclature and taxonomy: *Stylonychia pustulata* was originally described by MÜLLER (1786) from a marine habitat. EHRENBURG (1838), the first reviser, recorded *S. pustulata* from various freshwater habitats and from the sea near Copenhagen. He mentioned some older synonyms (for example, *Trichoda silurus* MÜLLER, 1773, *Trichoda cyclidium* MÜLLER, 1773) in his comprehensive list of synonyms, and it is unclear why he did not use one of these senior names for the designation of the present taxon. Somewhat later, STEIN (1859b) even questioned the identity of MÜLLER's (1786) marine species and the freshwater form. According to STEIN (1859b), the freshwater species *Kerona silurus* in MÜLLER (1786, p 244) – originally described by MÜLLER (1773, p 88) as *Trichoda silurus* – agrees better with the form figured by EHRENBURG (1838). But despite his doubts, STEIN (1859b) finally accepted EHRENBURG's (1838) unfounded nomenclatural act of ignoring senior synonyms. The experiments by FINLEY (1930; identification not substantiated by illustration!) on the tolerance of freshwater protozoa to increased salinity indicated that *S. pustulata* can live in the sea. Thus, the identification of the common freshwater form with the marine species, *S. pustulata*, as done by EHRENBURG (1838) should be accepted. This is a typical case where Article 23 (b) of the ICZN (1985) has to be applied, that is, the principle of priority is not intended to be used to upset a long accepted name in its accustomed meaning through the introduction of an unused name that is its senior synonym. Thus, the following senior synonyms of EHRENBURG's (1838) list of synonyms are nominated to be suppressed ("nomina oblita"): *Trichoda cyclidium* MÜLLER, 1773, *T. pulex* MÜLLER, 1773, *T. calvitium* MÜLLER, 1773, *T. acarus* MÜLLER, 1773, *Volvox oniscus* ELLIS, 1769, *Cyclidium radians* HERMANN, 1784 (the papers of ELLIS and HERMANN are not cited in my reference list!). Another very detailed list of old synonyms is given by DIESING (1850, p 163).

KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct names in his revision are thus *Oxytricha (Stylonychia) pustulata* and *O. (Stylonychia) fissiseta*. Incorrect subsequent spellings: *Stylonichia postulata* (ENRIQUES 1905b, p 391; PATIL et al. 1993, p 316); *Stylonichia pustulata* (BHATIA 1924, p 2; BRODSKY 1928, p 135); *Stylonychia postulata* (DILLER 1965a, p 231; GRACIA et al. 1987a, p 26; KOWALEWSKIEGO 1882, p 397, 402); *Stylonychia pustula* (GÜNKEL 1997, p 222); *Stylonychia pusulata* (HUNTER 1958, p 23); *Stylonychia pustalata* (CLAPARÈDE & LACHMANN 1858, p 158); *Stylonychia pustutata* (SUMMERS 1935, p 175); *Stylonychia pastulata* (DUTTA 1961, p 212); *Stylonychia pustulatus* (BODENHEIMER 1937, p 270); *Stylonychnia pustulatus* (BALDENSBERGER 1927, p 205).

Fig. 160a–f *Stylonychia pustulata* (from FOISSNER et al. 1991. a, b, d, scanning electron micrographs; c, f, protargol impregnation; e, from life, bright field micrograph). a, c) Ventral infraciliature. Arrows in (a) mark left frontoventral cirrus (= cirrus III/2) and posterior postoral ventral cirrus (V/3), respectively. b, f) Dorsal infraciliature; arrows in (b) mark caudal cirri which are arranged at the posterior end of dorsal kineties 1, 2, and 4. d) Resting cyst. e) Ventral view of a specimen containing many food vacuoles. BC = buccal cirrus, CC = caudal cirri, FC = right frontal cirrus, LMR = left marginal row, Ma = posterior macronuclear nodules, RMR = right marginal row, TC = left transverse cirrus, 1, 6 = dorsal kineties 1 and 6; p 565.

The first detailed redescription of *S. pustulata* was provided by STEIN (1859b, Fig. 161x) and included a description and illustrations of the morphogenesis and the conjugation. He stated that CLAPARÈDE & LACHMANN (1858) obviously overlooked a frontoventral cirrus and the right transverse cirrus (Fig. 161t). STEIN (1859b) and KAHL (1932) considered *S. fissiseta* CLAPARÈDE & LACHMANN as valid species (Fig. 161u); conversely, I agree with BORROR (1972a) that it is very likely identical with *S. pustulata*, although the fringed caudal cirri remind somewhat on the species of the *S. mytilus* complex. KAHL (1932) stated that in *S. pustulata* no transverse cirrus protrudes beyond the posterior end of the cell, indicating a misobservation since this is in contradiction to almost all other descriptions. *Stylonychia pustulata* sensu TATEM (1870) is rather surely identical with *Ancystropodium maupasi* (Fig. 198h, i).

I agree with WIRNSBERGER et al. (1985a) that *S. notophora* sensu SAPRA & DASS (1970; Fig. 162i) is a *S. pustulata* and therefore all other papers concerning the "*S. notophora*" of the Indian group are mentioned here.

The scanning electron micrographs of the "*Oxytricha bifaria*" by some Italian workers (for example, BANCHETTI & RICCI 1986, ROSATI et al. 1988; see also AMMERMANN 1985) strongly suggest that this intensively investigated form is also a *Stylonychia pustulata* (Fig. 164b, 231f). This is mainly indicated by the arrangement of the transverse cirri, which are obviously not separated into two distinct groups as in *S. bifaria*; however, a detailed description of this Italian population is needed before final assignment, especially since RICCI et al. (1991c, p 1184) found both *Stylonychia pustulata* and "*Oxytricha bifaria*" in field samples.

I suggest the detailed redescription of WIRNSBERGER et al. (1985a) as authoritative because (i) the description agrees very well with that by STEIN (1859b), (ii) the population is characterised both by live observations and after protargol impregnation, (iii) the population is well characterised morphometrically, (iv) the morphogenesis is studied in great detail, and (v) slides of protargol-impregnated specimens are deposited in a museum.

The redescrptions of CARTER (1859; Fig. 220d), CHEN (1944; Fig. 242i), CIENKOWSKY (1855; Fig. 222k, l), CONN (1905; Fig. 228f), DUJARDIN (1838, 1841), DUMAS (1929; Fig. 237a), ECKHARD (1846; Fig. 232h), FROMENTEL (1876), KOFFMAN (1926; Fig. 231e), LUNDIN & WEST (1963; Fig. 230e), and NAIDU (1965; Fig. 224l) are insufficient. *Histriculus similis* sensu CHARDEZ (1986, Fig. 178u-w) is possibly identical with *S. pustulata* since the body shape, the cirral pattern, and the resting cyst are very similar.

Stylonychia pustulata is rather difficult to distinguish from *S. putrina* (see key); however, synonymy is very unlikely because *S. pustulata* forms spiny cysts (Fig. 160d, 161o-q, 162b, 163k), whereas smooth ones are described for *S. putrina* (STOKES 1885a). *Stylonychia vorax* and *S. curvata* are also rather similar.

Fig. 160g-j *Stylonychia pustulata* (from FOISSNER et al. 1991. g-j, scanning electron micrographs). g, h) Ventral view of a broad and a slender specimen. Arrow in (g) marks a caudal cirrus. i) Buccal area. j) Posterior end in dorsal view to show attachment of caudal cirri (arrows) at posterior end of dorsal kineties 1, 2, and 4. AZM →

= adoral zone of membranelles, BC = buccal cirrus, e = endoral, p = paroral, TC = transverse cirri, VC = pre-transverse ventral cirri, 1-4 = dorsal kinetics 1-4; p 565.

Fig. 161a-f *Stylonychia pustulata* (from WIRNSBERGER et al. 1985a. a, b, from life; c-f, protargol impregnation). a, b) Ventral and lateral view, a = 80 µm, b = 105 µm. c, d) Ventral and dorsal infraciliature, c, d = 80 µm. Arrow marks pretransverse ventral cirrus VI/2. e) Ventral infraciliature of a very early morphogenetic stage (70 µm) showing de novo formation of oral primordium (arrow). f) Ventral infraciliature of a middle

BERGER & FOISSNER (1997) stated that *Stylonychia* is very likely not monophyletic, that is, *Stylonychia pustulata* and *S. bifaria* are probably not the sister group of the type species, *S. mytilus* (Fig. 25a). *Stylonychia mytilus* is obviously very closely related to *Coniculostomum* and *Steinia*. We suggested that molecular biological data on *Coniculostomum* and *Steinia* should be awaited before splitting *Stylonychia*. Later, EIGNER (1997) transferred *Stylonychia pustulata* and *S. vorax*, but not *S. mytilus*, to the Parakahliellidae EIGNER, 1997. Thus, he had to establish a new taxon, *Clara* EIGNER, 1997, which is, however, a junior homonym that has to be replaced. I preliminary prefer my conservative classification, that is, I do not accept *Clara* EIGNER (further comments on the classification proposed by EIGNER 1997, see p 929).

Morphology and biology: Size rather variable: 86–208 μm long, on average $148 \times 69 \mu\text{m}$ (PROWAZEK 1899a, STEIN 1859b), $230 \times 96 \mu\text{m}$ (BÜRGER 1905), 180–220 times $85\text{--}105 \mu\text{m}$ (ROUX 1901), $150\text{--}230 \mu\text{m}$ (BHATIA 1936), $100\text{--}120 \mu\text{m}$ (REUTER 1961), $48\text{--}124 \times 26\text{--}83 \mu\text{m}$ (WIRNSBERGER et al. 1985a); according to ZINGHER & NARBUTT (1931) and ZINGHER et al. (1932) size varies between $74 \times 34 \mu\text{m}$ in starved and $166 \times 81 \mu\text{m}$ in well-feed specimens. ZHINGHER (1935) found that *S. pustulata* is somewhat longer at low temperatures (7°C : mean = $99 \mu\text{m}$; $n = 925$) than at high ones (25°C ; mean = $90 \mu\text{m}$; $n = 308$), possibly due to lower generation time. RICCI & RIGGIO (1984) stated that linear dimensions of giants ($200\text{--}220 \times 90\text{--}100 \mu\text{m}$) are almost twice those of normal cells ($100 \times 50 \mu\text{m}$); for detailed morphometric comparison of normal cells and giants of the Italian "*Oxytricha bifaria*", see ROSATI et al. (1988). Body margins usually slightly convex, that is, outline normally elliptical, sometimes, however, almost in parallel, as in *S. putrina*; rarely left margin slightly concave. Anterior end broadly, posterior usually narrowly rounded. Flattened about 2:1 dorsoventrally, central dorsal portion often strongly bulging (Fig. 161b). Macronuclear nodules in life about $16 \times 7 \mu\text{m}$, lie about in median or slightly left of it. Usually 2, in life $4 \times 3 \mu\text{m}$ sized micronuclei (DENNAKER & HUNTER 1965, WIRNSBERGER et al. 1985a). Contractile vacuole pulsates about every 8–11 s at 20°C (GELEI 1935, KANITZ 1907, PROWAZEK 1899a, SMYTH 1942); takes 20 min at 24°C to excrete the amount of water which corresponding to cell volume (BRAND 1935, MAUPAS 1883). Cytoplasm usually densely filled with cytoplasmic crystals. Movement gliding and often standing still for some time, left rotation about longer axis (BULLINGTON 1925, VERWORN 1889). RICCI (1981b, 1990) measured an apparent velocity (= velocity of the ciliate along the central axis of the helicoid) of $750 \pm 300 \mu\text{m s}^{-1}$. RICCI (1989) found that his "*Oxytricha bifaria*" (see taxonomy) is a species whose behaviour is strongly affected by the dimensional quality of the substrate – namely by its granulometry. Singlets avoid sands with grains ranging from $50\text{--}100 \mu\text{m}$ in diameter, while conjugating pairs also avoid those with grains $100\text{--}200 \mu\text{m}$ in diameter. Moreover, in sand

← morphogenetic stage, $75 \mu\text{m}$. Arrowhead marks disintegrated posterior-most frontoventral cirrus (cirrus IV/3), arrow denotes primordium of frontal, ventral, and transverse cirri streaks of opisthe originating from oral primordium; p 565.

Fig. 161g-k *Stylonychia pustulata* (from WIRNSBERGER et al. 1985a. g-k, ventral infraciliature of morphogenetic stages after protargol impregnation). g, h) Middle stages, g, h = 75 μ m. Arrow marks primordium of frontal, ventral, transverse cirri streaks of proter originating from parental cirrus IV/3. i-k) Late stages, i-k =

Fig. 161l–q *Stylonychia pustulata* (l–o, from WIRNSBERGER et al. 1985a; p, after QUENNERSTEDT 1865; q, from KAHL 1932. l–n, protargol impregnation; o–q, from life). l) Ventral infraciliature of a very late morphogenetic stage, 85 µm. Cirri originating from individual primordium are connected by a broken line; parental structures white, new ones black. m, n) Ventral infraciliature of proter and opisthe, m = 55 µm, n = 50 µm. o–q) Resting cysts, o = 42 µm, p, q = size not indicated; p 565.

with grains of diameter <50 µm, singlets behave in much the same way as on flat substrates; the effect appears to be due to body length.

Frontal and transverse cirri distinctly enlarged, in life about 19–24 µm long. Left frontoventral cirrus (III/2) arranged immediately beside other frontoventral cirri (Fig. 161c), which is very likely an important difference to the rather similar *S. putrina*. All transverse cirri protrude distinctly beyond posterior end of cell. Right pretransverse ventral cirrus arranged immediately in front of right transverse cirrus (Fig. 161c, arrow). Marginal cirri in life about 15 µm long. Six dorsal kineties, rows 1–4 of about body length, composed of 19–29 pairs of basal bodies each. Dorsomarginal rows (kineties 5 and 6) rather short. Caudal cirri in life 16–25 µm long, not fringed, very stiff, indistinctly

← 80 µm. Cirri originating from individual primordium are connected by a broken line; parental structures white, new ones black. DP = primordium of dorsomarginal kineties, MP = primordium of marginal row; p 565.

Fig. 161r–z, 162a, b *Stylonychia pustulata* (r, after MÜLLER 1786; s, after EHRENBURG 1838; t, u, after CLAPARÈDE & LACHMANN 1858; v, a, after MAUPAS 1888; w, from CHORIK 1968; x, b, after STEIN 1859b; y, after BARY 1950; z, from SUMMERS 1935. r–z, a, b, from life). I am not quite sure if all these figures in fact represent *S. pustulata*. Thus, identification should be according to the authoritative redescription by WIRNSBERGER et al. (1985a). r) Dorsal view, size not indicated. s–t, x = size not indicated, u = about 100 µm, v, a = 145 µm, w = 140 µm, y = 130 µm, z = 105 µm. b) Resting cyst, size not indicated; p 565.

separate; distance between caudal cirri of kineties 1 and 2 always smaller than that between cirri of kineties 2 and 4 (Fig. 161d).

Cyst with spiky surface and fine bright cytoplasm, in life about 40–55 µm across (Fig. 160d, 161o–q, 162b, 163k, 164d, e; BALBIANI 1861, CALKINS 1934, FERMOR 1913, FOISSNER et al. 1991, KAHL 1932, PROWAZEK 1899a, QUENNERSTEDT 1865, RICCI et al.

Fig. 162c-j *Stylonychia pustulata* (c, after QUENNERSTEDT 1865; d, from ENGELMANN 1862; e, after ROUX 1901; f, after REUTER 1961; g, from CURDS 1969; h, from KAHL 1932; i, from SAPRA & DASS 1970a; j, from LILLY 1942. c-h, j, from life; i, wet silver impregnation). c, e-h) Ventral views, c, f = ? μm , e = 95 μm , g, h = 150 μm . d) Conjugation, 190 μm . i) Very early morphogenetic stage in ventral view showing oral primordium (arrow), ? μm . j) This population could also be a *S. vorax*, as indicated by the tapered posterior end; p 565.

1985, STEIN 1859b, VERNI et al. 1984, WIRNSBERGER et al. 1985a). The cyst figured by STEIN (1854) has no spines, indicating that it is a very young one. PROWAZEK (1899a) observed cysts infected with flagellates and amoebas. Cysts formed in aged cultures are not

viable (KAUSHAL & SAXENA 1978). 15 and 30 % NaOH destroyed ecto- and endocyst (ILOWISKY 1926b), and continuous reduction of oxygen content induced encystment (MICHELSON 1928). According to LACHMANN (1856, p 380, footnote 3), *Discodella multipes* WEISSE, 1845 is only the cyst of *S. pustulata*.

M o r p h o g e n e s i s of cell division is described by HASHIMOTO (1952), SAPRA & DASS (1970a), STEIN (1859b), WALLENGREN (1902, p 50), and in great detail by WIRNSBERGER et al. (1985a) and YANO & SUHAMA (1991). The oral primordium originates de novo between the left marginal row and the postoral ventral cirri (Fig. 154c, 161e, 162i, arrows). This is the unique difference in cortical morphogenesis between *S. pustulata* and *S. bifaria* (WIRNSBERGER et al. 1985a). Therefore, Figures 161f–n are valid for both species. Only the anterior third of the parental undulating membranes is reorganised (Fig. 161g–k). The primordium of the undulating membranes of the opisthe is formed by a group of basal bodies extending toward to the anterior right of the oral primordium (Fig. 161f, arrow). The pharyngeal fibres of the proter are not visible with protargol in later stages of morphogenesis (Fig. 161l, n); probably they are reorganised. The frontal-ventral-transverse cirri streaks develop in chronological order as follows: 3 streaks in the proter originate from the posterior-most of the frontoventral cirri (cirrus IV/3, Fig. 161f, g, arrowhead and arrow). At the same time, 3 anlagen in the opisthe separate from the oral primordium (Fig. 161f). Two streaks evolve from the dispersion of the right and one from the left postoral ventral cirrus (Fig. 161g, h). In the proter, additional basal bodies from the undulating membranes, the buccal cirrus, and the left frontoventral cirrus (III/2) participate in the formation of the primordia (Fig. 161h). Uniformly, 6 streaks are produced in each filial product (Fig. 161i, j). See Table 4 and Figure 23a for a summary of the morphogenesis. The development of the marginal primordia always starts within the right row and proceeds more rapidly than in the left row in the earlier stages (Fig. 161h, i). Morphogenesis of dorsal kinetics proceeds identically to in *S. bifaria* (Fig. 161f–h), that is, in *Oxytricha*

Fig. 163k, l *Stylonychia pustulata* (from CALKINS 1934). k) Resting cyst from life. l) Ventral view, size not indicated; p 565.

← Fig. 163a–d, g–j *Stylonychia pustulata* (a, after PROWAZEK 1899a; b, after BÜRGER 1905; c, after HASHIMOTO 1952; d, after BARY 1950; g–j, from GSCHWIND 1991. a, after alum or borax carmine stain; b, d, g, h, from life; c, method?; i, j, protargol impregnation). a–d, g) Ventral views, a, c = size not indicated, b = 230 μ m, d = 100 μ m, g = 90 μ m. h) Lateral view. i, j) Ventral and dorsal infraciliature, 60 μ m. Arrow marks anteriorly slightly shortened dorsal kinety 4; p 565.

Fig. 163e, f *Stylonychia mytilus* complex (e, after DEMBOWSKA 1925; f, after WALLENGREN 1902. e, f, from life). e) Arrangement of cirri in dorsal view, size not indicated. f) Ventral view, size not indicated. Caudal cirri not shown; p 504.

pattern. Scanning electron micrographs of these events are provided in GRIMES & ADLER (1976).

Pattern formation in mirror-image doublets is described by YANO & SUHAMA (1991, see also FRANKEL 1991) and division and reorganisation of the nuclear apparatus was investigated by IVANIĆ (1931a), SUMMERS (1935), and TCHANG (1931). Replication bands move synchronously at a uniform rate and take about 6 hours (SHARMA et al. 1986). Macronuclear S phase occupies 1/3–1/2 of cellular cycle (DINI et al. 1975). Further papers concerning nuclear apparatus: ENRIQUES (1912), PROWAZEK (1899b).

GRIMES & ADLER (1978) studied the regeneration of the ciliary pattern in longitudinal fragments. Conjugation was studied by BÜTSCHLI (1876, p 324), ENGELMANN (1862; Fig. 162d), PÄTSCH (1974), PIERI (1966), and PROWAZEK (1899a). ENRIQUES (1905a, b) and MAUPAS (1888, see also JENNINGS 1939) described senile degeneration.

WATANABE (1959) performed some experiments on the reversal action of cirri induced by treatment with calcium and potassium ions, and on the relation of the reversal action of the cirri to the macronucleus.

The complete small subunit rRNA sequence for *S. pustulata* is 1771 bases long, which is identical to *Oxytricha nova* (identical with *Sterkiella histriomuscorum*) and *Onychodromus quadricornutus*; G + C content 45 % (LEIPE et al. 1994). There are many other new and old papers on genetics, sexual phenomena, including mating type of determination, biochemistry, ultrastructure: BALBIANI (1858, 1862, 1882), BÜTSCHLI (1875), CANELLA (1959), DAWSON et al. (1983), DENNAKER & HUNTER (1965; see also DUTTA 1974), ELWOOD et al. (1985), ENGELMANN (1875), ENTZ (1901, 1904b), FERREIRA & PEREZ (1936), GAJADHAR et al. (1991), GREENWOOD et al. (1991b), HALL (1931), IVANIĆ (1931a, b), KAZANCEV (1928), KLOBUTCHER et al. (1981), KRAUT et al. (1986), KUZNICKI & WALNE (1993), LYNN & SOGIN (1988), MAUPAS (1887, 1888, 1889), OKA & HONJO (1983), PIERI (1965), PRESCOTT et al. (1979, 1982), RAO (1958), SCHLEGEL (1985, 1991), SCHLEGEL & STEINBRÜCK (1986), SCHLEGEL et al. (1991), SIMPSON (1901), STEINBRÜCK (1990), SWANTON et al. (1980b, 1982), YANO (1979, 1985a–d, 1986, 1989), YANO & SUHAMA (1990a, b, 1992).

As mentioned above, WIRNSBERGER et al. (1985a) synonymised *S. notophora* sensu SAPRA & DASS (1970a) with *S. pustulata*. There are various other papers by these Indian protozoologists using “*S. notophora*” as model organism: DASS & SAPRA (1966, 1967, 1968), KAUSHAL & SAXENA (1978), RUP LAL & SAXENA (1980), RUP LAL et al. (1981), SAPRA & DASS (1969, 1970b, 1971), SAXENA & RUP LAL (1981), SHIVAJI et al. (1975, 1976, 1978).

The “*Oxytricha bifaria*” of some protozoologists in Pisa, Italy (Fig. 164a–e; see taxonomy) is the subject of many genetical, biochemical, physiological, and ultrastructural investigations (culturing technique: RICCI et al. 1980b; biochemistry: KRAMER 1988, SCHLEGEL & STEINBRÜCK 1986; nuclear phenomena: RICCI & BANCHETTI 1981; homopolar doublets: BANCHETTI & RICCI 1986, BANCHETTI et al. 1985, 1996, RICCI et al. 1996; cannibalism, giants: BANCHETTI & RICCI 1987, BRAVI et al. 1991, GRANDINI et al. 1991, RICCI & BANCHETTI 1989, 1993, RICCI et al. 1979a, b, 1989a, 1991b, RIGGIO et al. 1987a, b, ROSATI

Fig. 164a, b *Stylonychia pustulata* (from ROSATI et al. 1988. a, b, scanning electron micrographs). Normal cells in dorsal and ventral view, scale bars = 20 μ m. This is the "*Oxytricha bifaria*" of the Italian protozoologists; however, the transverse cirri are not arranged in two separate groups, strongly suggesting that their identification is incorrect. Further data are needed for final decision. Explanation of original labels: FC = frontal and frontoventral cirri and buccal cirrus, TC = transverse cirri including pretransverse ventral cirri, VC = post-oral ventral cirri, 1–6 = dorsal kineties 1–6; p 565.

et al. 1987, 1988; conjugation: BANCHETTI et al. 1978a, 1982b, DINI & LUPORINI 1974, ESPOSITO & NOBILI 1982, ESPOSITO & RICCI 1975, ESPOSITO et al. 1976b, LUPORINI & DINI 1975, RICCI 1981a, 1982, RICCI & BANCHETTI 1982, RICCI & CETERA 1978, RICCI et al. 1975a, b, 1977, 1980a, c; cyst: RICCI et al. 1985, ROSATI et al. 1984, VERNI et al. 1984; motile behaviour and cell-substrate interactions in locomotion: BARBANERA et al. 1997, ERRA et al. 1989, 1990, 1996, PINTO et al. 1991, RICCI 1981b, 1985, 1987, 1989, 1990, 1992, RICCI & ERRA 1996, RICCI et al. 1989b, c, 1991c, 1992a, b, RUSSO et al. 1988, 1989a–c, 1990, 1992). According to RICCI et al. (1991a) the heteromorphic life cycle of this hypotrich comprises at least 3 phases: conjugating pairs, resting cysts, and carnivorous giants. The gigantic forms represent unique adaptive devices which enable the species to survive in a certain environment when the normal bacterial food is exhausted.

Fig. 164c–e *Stylonychia pustulata* (c, from Rosati et al. 1988; d, e, from Ricci et al. 1985. c, scanning electron micrograph; d, bright field; e, interference contrast). c) Giant cell in ventral view. The shape and the supernumerary frontoventral cirri (arrows) are reminiscent of *Stylonychia pseudograndis* (cp. Fig. 167a). Scale bar = 20 μm . d, e) Resting cysts, scale bars = 45 μm , 10 μm . Explanation of original labels: FC = frontal and frontoventral cirri and buccal cirrus, M = macronucleus, m = micronucleus, TC = transverse cirri including pretransverse ventral cirri, VC = postoral ventral cirri; p 565.

Occurrence and ecology: One of the most common freshwater oxytrichids, often rather abundant in the aufwuchs and detritus; prefers mesosaprobic, slowly running and eutrophic, stagnant waters; sometimes pelagic and in the air-water interface (Ricci et al. 1991c), and also marine (see locus classicus and Patterson et al. 1989). Avoids hydrogen sulphide (Wetzel 1928b).

Locus classicus is the sea near Denmark, where Müller (1786) found *Stylonychia pustulata* together with *Uronychia transfuga*. Ehrenberg (1838) recorded it from infusions and from freshwater habitats with *Oscillatoria* at Berlin, Germany, but also from the sea near Copenhagen, Denmark. Locus classicus of the synonym, *Stylonychia fis-*

siseta, is a peat-bog (Jungfernheide) near Berlin, Germany (CLAPARÈDE & LACHMANN 1858).

Records from freshwater habitats substantiated by illustrations: in putrefying, stagnant water bodies, especially in shallow ponds with decaying leaves, and once in the drinking water of Vienna, Austria (PROWAZEK 1899a); lakes (Lunzer-See, Mondsee) in Austria (GSCHWIND 1991, WIRNSBERGER et al. 1985a); putrescent infusions, dung-pools, and other stagnant waters in Czechoslovakia (STEIN 1859b); rock pools (salinity <0.01–1 %) in Finland (REUTER 1961); France (MAUPAS 1888); aufwuchs of freshwater habitats in Bonn, Germany (PÄTSCH 1974); Leipzig, Germany (ENGELMANN 1862); oligosaprobic to betamesosaprobic brooks and beta- to alphamesosaprobic brooks and rivers in Bavaria, Germany (FOISSNER 1997a, FOISSNER et al. 1991, 1992a, b); Sweden (QUENNERSTEDT 1865); common in clear and polluted lentic waters near Geneva, Switzerland (ROUX 1901); USSR (CHORIK 1968, LOKOT 1987); pond in Chieh-Pei-Tze Yuan, China (TAI 1931); Han River, Korea (SHIN & KIM 1988, 1993a); India (BHATIA 1936, SAPRA & DASS 1970a); Japan (HASHIMOTO 1952); vegetable infusions, Kansas, USA (SMITH 1914); New York (SUMMERS 1935); common in infusions of lentic water, USA (EDMONDSON 1906); freshwater pond at Woods Hole (Massachusetts) and from various freshwater habitats near Providence, Rhode Island, USA (LILLY 1942); Argentina (CARBONELL 1935, CELA 1972); Chile (BÜRGER 1905, 1908); Cotonou, Benin (DRAGESCO & DRAGESCO-KERNÉIS 1986); stream at Beatrix Bay, Pelorus Sound, and from the Wainui-o-mata Reservoir, New Zealand (BARY 1950).

The "*Oxytricha bifaria*" of the Italian protozoologists was originally collected from a freshwater canal in San Rossore, Pisa, Italy (DINI et al. 1975, RICCI et al. 1975a).

Numerous records from various freshwater habitats not substantiated by illustrations. Europe and Asia: drinking water, Linz, Upper Austria (SCHIEDERMAYR 1882); Danube River in Vienna, Austria (KALTENBACH 1960); mesosaprobic Traun River in Upper Austria (FOISSNER & MOOG 1992); ponds, rivers, and many other habitats in Austria (BLATTERER 1989, DALLA TORRE 1891, FOISSNER & FOISSNER 1988, SCHMARD 1846, SPANDL 1926a, own observations); Belgium (CHARDEZ 1987); rivers, brooks, lakes, ponds, bogs, ditches in Bulgaria (DETCHIEVA 1979b, 1981, 1991, 1993, DETSCHEWA 1972); common in the Moldau River, Czechoslovakia (KALMUS 1928); together with *S. mytilus* and among putrefying material in a pond, Czechoslovakia (ŠVEC 1897; further record from Czechoslovakia: ŠRÁMEK-HUŠEK 1953); with 0.6 % frequency in moderate (10–100 ind. ml⁻¹) and small numbers (<10 ind. ml⁻¹) in sites with sewage fungus outbreaks in England (CURTIS & CURDS 1971); backwaters of River Earn and other freshwater sites near Perth, England (CRAIGIE 1921); pond in England (DIXON 1920); puddle and pond in Estonia (JACOBSON 1928); lentic small water bodies on an island in Finland (LEVANDER 1900); France (ORMANCEY 1852); caves in Germany (GRIEPENBURG 1939, see also GITTLESON & HOOVER 1969); polluted Hamburg harbour, Germany (HECKMAN et al. 1990); small water bodies, peat-bog, and dystrophic lakes in Germany (SCHMIDT 1913, 1916, STRÜDER-KYPKE 1996); hay infusion (?; probably with water from a pond or brook) in Germany (BRAND 1923; further record from Germany: HENDERSON 1905); moraine lake and other sites in Green-

land (ELLINGER 1914, LARSEN 1992); plankton of the mesosaprobic Danube River in Hungary (BERECZKY 1969, 1977c, 1979, BERECZKY et al. 1983, NOSEK & BERECZKY 1981); distinctly polluted Tisza River in Hungary (JÓSA 1974, STILLER 1942); Lake Balaton, Hungary (ENTZ 1897, FRANCE 1897, GELLÉRT & TAMÁS 1958; further records from Hungary: HORVÁTH 1933, KREPUSKA 1917); on surface (max. 226 ind. cm⁻²) and bottom (max. 16 ind. cm⁻²) of a productive *Lemna* pond in Italy mainly in summer (MADONI 1991a, b); Lake Como, Italy (CATTANEO 1882; further records from Italy: CANELLA 1954, CUNEO 1891, ENRIQUES 1913, GRISPINI 1938, LONGHI 1894, MOLA 1928, 1935, STELLA 1947); common in the Netherlands (VERSCHAFFELT 1930, WIERSMA-VERSCHAFFELT 1936); Poland (JAWOROWSKI 1893, WRZESNIEWSKI 1861, WRZESNIEWSKIEGO 1866); very abundant in mud samples from the Danube River in Romania (SPANDL 1926b; further record from Romania: LEPSI 1932); Lobregat River, Spain (GRACIA et al. 1987a); Sweden (QUENNERSTEDT 1869); alpine lakes and brook about 2065 m above sea level in the Swiss (?) Alps (BAUMANN 1910, ZSCHOKKE 1900); ponds and peat-bogs in Switzerland (MERMOD 1914, MESSIKOMMER 1948, 1954, PERTY 1852b); littoral of Lake Geneva, Switzerland (ANDRÉ 1916, FOREL 1904, ROUX 1900, SCHNETZLER 1854); in September up to 10 ind. ml⁻¹ in the botanical garden of Basle, Switzerland (RIGGENBACH 1922; further records from Switzerland: ANDRÉ 1912, 1915, BOURQUIN-LINDT 1919, SAKOWSKY-CAMPIONI 1906, STEINMANN & SURBECK 1918); sandy sediment from Oka River, Russia (SASSUCHIN et al. 1927; further record from Russia: AVERINTZEV 1899); very common in the littoral area of Lake Baikal at 5–19 °C (GAJEVSKAJA 1927, GAJEVSKAJA 1933); benthal and pelagial of reservoirs in Azerbaijan (ALEKPEROV 1980, 1982b, 1983, 1984b, c); Volga River, USSR (MAMAEVA 1979a, ZYKOFF 1903); plankton of pond in Kiev, Ukraine, during winter (KOVALCHUK & SVINTSOVA 1994); on silt in small rivers in Latvia (VEYLANDE & LIYEPA 1985); Turkestan (DADAY 1903, 1904); mesotrophic reservoir and eutrophic lake in Kuban Region, USSR (KORNIYENKO 1972; further records from the USSR: BELOVA 1990, CHORIK & VIKOL 1973, EICHWALD 1844, 1852, MAMAEVA 1979b, MINKÉWITSCH 1898, WEISSE 1845, 1848a); in December in lentic water from a burrow close to a garden well in the Gol Bagh, India, together with *Bursaria truncatella* (BHATIA 1922; further records from India: BHATIA 1924, BHATIA & MULLICK 1930, KHAJURIA 1951); Palestine (BODENHEIMER 1937, LEPSI 1929a); Kandy, Sri Lanka (DADAY 1898).

America: Costa Rica (RUIZ 1961); tap water (22 °C, pH 7) from Mexico City (RIVERA et al. 1979; further record from Mexico: LÓPEZ-UCHOTERENA & ROURE-CANE 1970); abundant at 3–6 °C and pH 6.0–6.4 in pools near Point Barrow, Alaska (SULLIVAN 1957); Iowa (SHAWHAN et al. 1947); Kansas (CRAGIN 1889); at 20–24 °C and pH 6.5–7.0 in upper Black River and Douglas Lake, Michigan (CAIRNS & YONGUE 1966); natural waters in Upper Peninsula of Michigan (WEST 1953); Brush Lake, Ohio (RIDDLE 1905); abundant in polluted zones of the Scioto River in Ohio (LACKEY 1938b); tree holes in Ohio and North Alabama (LACKEY 1940); Oklahoma (GABEL 1927); common in the Conestoga drainage basin, Pennsylvania (CAIRNS 1965a); pond in the botanical garden of the University of Pennsylvania (WANG 1925); in a metal tank on hillside farm with much cyanobacteria and sulphur bacteria at 22 °C and in a rapid, turbid mountain stream over rocks with

high O₂-content in Virginia (BOVEE 1960); shallow streams with medium hard water in eastern USA (PATRICK 1961); ponds, pools, still areas along stream margins, and polluted streams in USA (LACKEY 1938a); marsh pools, probably in USA (HAUSMAN 1917); Argentina (BUSTOS 1933, SECKT 1924); cistern in Rio de Janeiro, Brazil (OLIVEIRA et al. 1954; further records from Brazil: CUNHA 1913, PROWAZEK 1910); Rio Rondos, Peru (CAIRNS 1966a); Venezuela (SCORZA & NUÑEZ MONTIEL 1954).

Africa: basin with *Chlorogonium* in Egypt (SCHMARD 1854); pond, lake, rice field, and ditch in East Africa and Madagascar (SONDHEIM 1929).

Records from saline inland waters and marine habitats (see also locus classicus): shallow brackish pools at Leasowe, Cheshire, England (GALLIFORD & WILLIAMS 1948); in salt marshes of the Dee Estuary at Parkgate, Cheshire, England, in April (WEBB 1956); salt-pit in Cagliari, Italy (PARONA 1883); saline lakes in Germany, Transylvania (Romania), and Central Asia (ZACHARIAS 1888, ENTZ 1900, 1904a, GURWITSCH 1934); Baltic Sea (EICHWALD 1849, 1852); White Sea (MERESCHKOWSKY 1877, CIENKOWSKY 1881); Logy Bay, Newfoundland (LACKEY & LACKEY 1970); Gulf of Mexico (SMITH 1904; see also BORROR 1962).

Not very common in sewage treatment plants like activated sludge (BANINA 1983, CURDS 1969, 1975, KUTIKOWA 1984, SIMAKOV 1986, VERSCHAFFELT 1930) and trickling filters (CURDS 1975, RICHARDS & CUTLER 1933). OBERSCHMIDLEITNER & AESCHT (1996) found *S. pustulata* 4–30 d after sampling in the activated sludge plant of the town of Linz, Upper Austria. LACKEY (1938a) counted 100 to 2000 ind. ml⁻¹ in trickling filters and about 200 ind. ml⁻¹ in activated sludge samples. SCHERB & BRAUN (1971) observed *Stylonychia pustulata* in activated sludge supplied with water from intensive fish culture. PATIL et al. (1993) found it in stabilisation ponds in India with influent BOD₅ of up to 300 mg l⁻¹.

Records from terrestrial habitats unreliable although resting cysts are formed (BRODSKY 1928, EHRENBERG 1869, FELLERS & ALLISON 1920, NIKOLJUK & GELTZER 1972, TROITZKY & ZÉREN 1926, VARGA 1936, 1961, YAKIMOFF & ZÉREN 1924, 1926); very likely confused with *Sterkiella histriomuscorum*, which is rather common in soil. According to VARGA (1961), cysts of *Stylonychia pustulata* survived 8 years of dryness. WEISSE (1856) reported encystment from 1-year-old dry mud samples.

Feeds on bacteria, algae (*Chlamydomonas reinhardtii*, *Chlorogonium elongatum*, diatoms), amoebas, heterotrophic flagellates, and ciliates such as *Colpoda*, *Cyclidium*, species of the *Tetrahymena pyriformis* complex, and zooids of small *Vorticella* (BEERS 1933, CURTIS & CURDS 1971, DAWSON et al. 1983, GRIMES & ADLER 1976, LILLY & CEVALLOS 1956, LILLY et al. 1953, NOLAND 1925, PRATT & CAIRNS 1985, PROWAZEK 1899a, WEBB 1956, YANO & SUHAMA 1990b). *Stylonychia pustulata* also attacks *Paramecium caudatum*, and the digestion of flagellates takes about 1.5 h. PROWAZEK (1899a) observed that 7–15 specimens of *Cyclidium* sp. were ingested successively. Cannibalism occurs under culture conditions at 340 cells ml⁻¹ and more (RICCI et al. 1989a). Detailed information on the nutritional and supplementary growth factors is given by LILLY (1942) and LILLY et al. (1949, 1952, see also JOHNSON 1956, p 201). For culture they used a solution of Brewers' yeast; accordingly, living yeast cells, *Euglena gracilis*, *Astasia klebsii*,

Tetrahymena pyriformis, *T. vorax*, and *Dexiostoma campylum*, are adequate as food. *Glaucoma scintillans*, *Chilomonas paramaecium*, and the algae *Stichococcus bacillaris* and *Chlorella* sp. did not support growth of *S. pustulata*. REILLY & LILLY (1957) found some differences between *S. pustulata* and *S. putrina* in the preferred food organisms; both species were able to utilise the flagellates *Polytoma uvella* and *P. agilis*. *Stylonychia pustulata* also utilised *Euglena gracilis* and *Dexiostoma campylum*, whereas *S. putrina* did not feed on these organisms, but did use *Chilomonas paramaecium*.

Stylonychia pustulata is able to oxidise xanthine and it was found that it contains an amylase system capable of the hydrolysis of starches from rice, potatoes, corn, and glycogens. The adenosinetriphosphatase was most active at a pH of about 7.6 at 30 °C; phosphorylase was more active at pH 6.2 than at pH 7.2, 8.2, or 9.2 (HUNTER 1958, 1959, 1960, 1963a, b, 1964, 1965). SHAPIRO (1927) found that pH in the food vacuoles ranges from pH 4.8 to 7.0. The time of complete digestion in giants of "*Oxytricha bifaria*" (see taxonomy) is about 4 h (VERNI & ROSATI 1992). *Stylonychia pustulata* is captured and killed by bladders of *Utricularia* (HEGNER 1926) and by the suctorion *Podophrya collini* (HULL 1961). Larvae of the fish *Hypothalmichthys molitrix* (silver carp), *Aristichthys nobilis* (big head), and *Ctenopharyngodon idella* (grass carp) feed on *S. pustulata* (KORNIYENKO 1971).

Rather easily to culture (BICK & KUNZE 1971, SUMMERS 1935). WIRNSBERGER et al. (1985a) used tap water as a culture medium with yeast and a species of the *Tetrahymena pyriformis* complex grown on dry egg yolk added as food. Others used tap water and a few drops of milk (ZINGHER 1935, ZINGHER et al. 1932) or alfalfa hay infusion (ALEXANDER 1985, HUNTER 1958) as culture medium. OKA et al. (1980) found a generation time of 24 h under the following conditions: 0.1 mM sodium phosphate (pH 7.1) at 25 °C supplemented with the algae *Chlorogonium elongatum* as food; a 500 ml culture of *S. pustulata* (about 5×10^3 cells ml⁻¹) was fed with about 5×10^9 cells of *C. elongatum* per day, and the medium was changed daily. Further culture methods and notes on nutrition and digestion, see LILLY (1953, 1967), LILLY & CEVALLOS (1956), LILLY et al. (1949), LITTLE et al. (1951), LUCCHESI & LILLY (1957), PROVASOLI et al. (1958), RICCI et al. (1980b), RICE & LILLY (1960), VAN WAGTENDONK (1955).

GREENLEAF (1926), DARBY (1930), and BEERS (1933) studied the influence of the volume of the culture medium and cell proximity on the rate of reproduction (see also KITCHING 1957a and ZAIKA 1970). DARBY (1929) found, in hay infusions, a higher division rate at pH 8.0 (44 divisions per 10 days) than at pH 6.1–6.5 (31–33 division per 10 days). Conversely, GAUSE (1936a, b) found no conspicuous difference in growth at pH 6.3 or 7.9. DASS & SAPRA (1965), DINI et al. (1975), RICCI (1981c), and RUP LAL & SAXENA (1980) reported a generation time of about 8–9 h at 22 °C and 28 °C; according to LILLY (1942), divisions occurred at intervals from 8–12 h at about 26 °C. SUMMERS (1935) found a mean daily fission rate of 3.6 for 2 successive 10-day periods; the maximum daily fission rate, using 3-day old media, was 5.0. BAITSELL's (1911, 1912; see also RICHARDS 1964) cultures of *S. pustulata* reached a maximum of about 3.1 (beef extract culture) and 2.4 (beef extract and hay infusion culture) divisions per day for a single 10-

Table 36 Autecological data of *Stylonychia pustulata*. References: column 1, from BICK & KUNZE (1971; summary of literature data, including FINLEY 1930, NOLAND 1925, REUTER 1961, and some dissertations); column 2, from DETCHEVA (1972a, 1975b, 1978, 1979a, c, 1982b, 1983a–c; many analyses from beta- and al-phamesosaprobic Bulgarian running waters); column 3, from PATRICK et al. (1967; ? analyses from the Savannah River, USA); column 4, from RUTHVEN (1972) and CAIRNS & DICKSON (1972; ? analyses from the South River in Virginia, USA); column 5, from CAIRNS & YONGUE (1973; unknown number of analyses in June and September from the Cape Fear River near Fayetteville, North Carolina, USA); column 6, from MIHAILOWITSCH (1989; 29–33 analyses from salt polluted running ditches in Germany)

Parameter ¹	Reference					
	1	2	3	4	5	6
Frequency (%)	-	0.9–3.6	-	-	-	-
Temperature (°C)	1–23	4–28	>8–23	-	23–26	3–20
pH	-	6.9–8.3	6.5–7.0	8.2	6.7–7.3	6.7–7.9
O ₂ (mg l ⁻¹)	0.1–11.8	3.5–12	7–10	-	6.6–8.7	1.2–19.6
O ₂ (% saturation)	-	45–100	-	-	-	-
BOD ₅ (mg l ⁻¹)	-	1.2–28	-	1.1	1–2.4	-
NH ₄ ⁺ -N (mg l ⁻¹)	0.15–0.39	0.05–0.8	0.009–<1	0	0.005–0.68	0.07–1.3
NO ₂ ⁻ -N (mg l ⁻¹)	-	0–0.13	<0.007	0.002	-	0.01–0.8
NO ₃ ⁻ -N (mg l ⁻¹)	-	0–1.6	0.07–0.2	0.39	0.35–0.84	2.2–6.2
PO ₄ ³⁻ -P (mg l ⁻¹)	-	-	0.01–0.033	0.08	0.09–0.28	-

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

day period. MIDDLETON (1915a, b, 1918) recorded a maximum of about 3.2 divisions per day for one 10-day period at 28–32 °C (further data on generation time, see CALKINS 1923 and MAUPAS 1888). Specimens which have been treated for 15 s with 5 mA alternating-current (i) increase temporarily in volume, (ii) often spin under treatment, and (iii) tend to orient between the electrodes so that the current passes across the short body axis rather than anteriorly-posteriorly (HUTCHINGS 1937, 1946); furthermore, HUTCHINGS found no statistically significant difference between experimental and control groups as regards the total number of animals produced after such treatment.

Biomass of 10⁶ individuals: 400–2000 mg (KORNIYENKO 1971, 1976; obviously wrongly calculated or misidentification), about 80 mg (FOISSNER et al. 1991), 40 mg (NESTERENKO & KOVALCHUK 1991).

Autecological data are summarised in Table 36. Some further data: 0–22 mg l⁻¹ CO₂ free, salinity up to 3.09 % (BICK & KUNZE 1971); 16–100 mg l⁻¹ Ca²⁺, 4.8–46 mg l⁻¹ Mg²⁺, 110–235 mg l⁻¹ HCO₃⁻, 35–116 mg l⁻¹ SO₄²⁻, 10–23 mg l⁻¹ Cl⁻, 0.02–1 mg l⁻¹ Fe²⁺ (DETCHEVA 1975b, 1978, 1979a, c, 1982b, 1983a–c); 11–89 mg l⁻¹ CO₂ free, 37–939 mg l⁻¹ Cl⁻, 56 to 381 mS m⁻¹ specific conductivity (MIHAILOWITSCH 1989); at 19.5 °C, pH 7.3, 51 ppm total hardness, and 8 mg l⁻¹ O₂ in the New River, Virginia, USA (YONGUE & CAIRNS 1979). GITTLESON & FERGUSON (1971) recorded *S. pustulata* from a slow-moving stream with leaf-type debris at a temperature of 2–3 °C. Low temperature (10 ± 1 °C) for 7 days caused high mortality; the survivors exhibited erratic binary fission during the course of

treatment resulting in daughter cells with abnormal body shape and nuclear apparatus; some of them remained as doublets (SHIVAJI et al. 1976). MATONIČKIN (1957) found *S. pustulata* in thermal waters in Yugoslavia at 42.2 °C. The same temperature was used by YANO & SUHAMA (1991) to obtain doublets by a heat shock treatment consisting of incubation at 42 °C for 10 min and at room temperature for 1 min.

STROM et al. (1974) recorded *S. pustulata* in an experiment on the purification of effluents from the production of alkylphenol additives. 50 and 100 ppm DDT inhibited growth and cell division (sterilised hay infusion, 22 °C, *Klebsiella aerogenes*; RUP LAL & SAXENA 1980); in specimens exposed for 6 h to 100 ppm DDT, synthesis of RNA and protein was inhibited throughout the cell cycle (SAXENA & RUP LAL 1981); maximum concentration of total DDT residue was obtained within 1 h and accumulation factor varied from 97 to 295 (RUP LAL et al. 1981). For cadmium accumulation, see Table 18. Of 14 acids tested, salicylic and hydrochloric were most toxic, while valeric and butyric are among the least toxic (COLLETT 1919). For the toxicity of dyes and arsenic acid, see FERREIRA & PEREZ (1937) and ZACHARIAS (1902b). Supersonic waves with a frequency of 3 MHz and an intensity of 2.18 W cm⁻² killed *S. pustulata* within 1 min (ŽIVANOVIĆ 1959).

The saprobic classification is not uniform. Originally, *S. pustulata* was classified as oligosaprobic indicator (KOLKWITZ & MARSSON 1909, KOLKWITZ 1950, see also MAUCH 1976). KAHL (1932) designated it as katharobic to moderately saprobic. This classification is supported, for example by the record of KÜHN (1950), who found *S. pustulata* in springs near Vienna, Austria. However, STEIN (1859b) observed it mainly in distinctly organically polluted habitats. According to SLÁDEČEK et al. (1981) and WEGE (1983), *S. pustulata* is confined to betamesosaprobity: b; b = 10, I = 5, SI = 2.0. FOISSNER (1988) classified it as follows: b; b = 9, a = 1, I = 5, SI = 2.1. Considering the rather different habitats mentioned above, FOISSNER et al. (1991) proposed the following classification: b; o = 1, b = 7, a = 2, I = 4, SI = 2.1.

Stylonychia putrina STOKES, 1885 (Fig. 165a–d, h, Table 3)

1885 *Stylonychia putrina* STOKES, Am. mon. microsc. J., 6: 187 (Fig. 165a).

1888 *Stylonychia putrina*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 298 (Fig. 165a).

1932 *Stylonychia putrina* STOKES, 1885 – KAHL, Tierwelt Dtl., 25: 619.

1963 *Stylonychia putrina* STOKES – LUNDIN & WEST, Free-living protozoa, p 68 (Fig. 165h; see also WEST & LUNDIN 1963).

1969 *Stylonychia putrina* – GROLIÈRE, Annls Stn limnol. Besse, 4: 347 (Fig. 165c, d).

Fig. 165a–d *Stylonychia putrina* (a, from STOKES 1885a; b, from CURDS 1969; c, d, from GROLIÈRE 1969. a, b, → from life; c, d, protargol impregnation). a, b) Ventral views, a = 125 µm, b = 150 µm. Note distinctly separate caudal cirri; probably an important difference to *S. pustulata*. c) Ventral infraciliature, size not indicated. Arrow marks posterior postoral ventral cirrus. d) Ventral infraciliature of middle morphogenetic stage, size not indicated. Arrow denotes left frontoventral cirrus which is inconspicuously separate from the other frontoventral cirri both in the protargol preparations by GROLIÈRE and in the type population (see Fig. a).

Fig. 165e–g *Stylonychia pustulata* (e, f, from DRAGESCO & DRAGESCO-KERNÉIS 1986; g, after PATSCH 1974 from DRAGESCO & DRAGESCO-KERNÉIS 1986. e–g, protargol impregnation). e–g) Ventral infraciliature, e = 80 μ m, f = 100 μ m, g = size not indicated; p 565.

1969 *Stylonychia putrina* STOKES, 1885 – CURDS, Wat. Poll. Res., No. 12: 70 (Fig. 165b).

1991 *Stylonychia putrina* STOKES, 1885 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 329.

Nomenclature and taxonomy: KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Stylonychia) putrina*. “*Stylonychia putrinum*” in PROVASOLI et al. (1958) is an incorrect subsequent spelling.

Non-dividing specimens of *S. putrina* are very similar to *S. pustulata*; however, the validity of *S. putrina* is beyond doubt because the cyst wall is smooth and not spiky as in *S. pustulata*; furthermore, morphogenesis commences with the proliferation of basal bodies close to the left transverse cirrus (Fig. 165d), and not in the area left of the postoral ventral cirri as in *S. pustulata* (Fig. 161e). *Stylonychia vorax* and *S. curvata* are also rather similar (see key).

Although the illustration by LUNDIN & WEST (1963; Fig. 165h) is somewhat superficial, the identification can be accepted. *Stylonychia putrina* sensu BARY (1950) does not match the original description very well, which was already stated by BARY (1950) himself; it is classified as *Stylonychia pustulata* (Fig. 163d). The populations described by DRAGESCO & NJINE (1971) are classified as species of the *Stylonychia mytilus* complex (“grande variété”; Fig. 159g) and *Stylonychia notophora* (“petite variété”; Fig. 166d), respectively, because the transverse cirri are arranged in two distinctly separated groups.

Stylonychia putrina sensu DRAGESCO & DRAGESCO-KERNÉIS (1986; Fig. 165e, f) and PÄTSCH (1974; Fig. 165g) are classified as *Stylonychia pustulata*, because the ventral infraciliature is much more similar to that of *Stylonychia pustulata* sensu WIRNSBERGER et al. (1985a) than to that of *Stylonychia putrina* sensu GROLIÈRE (1969). The redescrptions by BARWICK et al. (1955; Fig. 223h), BURKOVSKY (1984; Fig. 233k), CONN (1905; Fig. 228e), SAMANO & SOKOLOFF (1931; Fig. 241i), and WANG (1925; Fig. 242f) are insufficient. Detailed redescription necessary.

Fig. 165h *Stylonychia putrina* (from LUNDIN & WEST 1963). Ventral view from life, 125–150 μm ; p 586.

Morphology and biology: In life about 120–150 μm long and three times as long as broad. Outline usually parallel sided; however, sometimes anterior end slightly broader than posterior one; both ends usually broadly rounded. Cytoplasm often filled with dark granules. Rapid and erratic movement. Adoral zone of membranelles 40–45 % of body length, 50–55 membranelles. The 4 right transverse cirri protrude slightly to distinctly beyond posterior end of cell. 45–53 right and 28–32 left marginal cirri (GROLIÈRE 1969). Caudal cirri about 15 % of body length, rather distinctly separate. Formation of oral primordium commences adjacent to left transverse cirrus (GROLIÈRE 1969; Fig. 165d). Cyst wall smooth (STOKES 1885a). DNA con-

tent of nuclei and cellular protein content, see AMMERMAN & MUENZ (1982; identification not substantiated by an illustration; see also RAIKOV 1989).

Occurrence and ecology: In the aufwuchs and detritus of lentic and lotic waters with decomposing plant material; much less frequent than *S. pustulata*. Rare in sewage treatment plants.

Locus classicus is a stale vegetable infusion; STOKES (1885a) did not give the specific locality where he found *S. putrina*, however, he lived and worked in Trenton, New Jersey, USA, and it is thus assumed that the locus classicus is nearby. LUNDIN & WEST (1963) collected it from various freshwater habitats in the Upper Peninsula of Michigan, USA. GROLIERE (1969) found *S. putrina* between decaying aquatic plants in Lake Chambou, France.

Records not substantiated by illustrations: beta- to alphamesosaprobic Traun River in Upper Austria (FOISSNER & MOOG 1992); brook in Upper Austria (BLATTERER 1994); Maritza River, Bulgaria (DETCHIEVA 1981); benthal of the Bulgarian Ossam River during fall (RUSSEV et al. 1984); in small numbers (<10 ind. ml^{-1}) in 2.5 % of 178 sites of sewage fungus outbreaks in England (CURTIS & CURDS 1971); mud of Loch Leven, England (BRYANT & LAYBOURN 1974); rare in Neckar River, Germany (BUCK 1959, 1961); rare in an alphamesosaprobic brook in the southern Black Forest, Germany (BAUER 1987); small lakes near Münster, Germany (NUSCH 1970); aufwuchs in mesotrophic lakes in Germany (MÜCKE 1979, PACKROFF 1992, PACKROFF & WILBERT 1991); cooling system of a power station at the beta- to alphamesosaprobic Main River, Germany (BERNERTH 1982); about 400 ind. ml^{-1} in experiments with decomposition of cellulose (BICK 1967b, 1973, VOSS 1978); unpolluted foothill stream (Breitenbach) near the village of Schlitz, Germany (PACKROFF & ZWICK 1996); Tisza River in Hungary (STILLER 1942); well in Italy (GRISPINI 1938); 8 ind. cm^{-2} in the mesosaprobic Baganza River and in a shallow macrophyte covered basin near Reggio Emilia, Italy, fed with sewage from a pig farm (MADONI & GHETTI 1977, MADONI & VIAROLI 1985); alphamesosaprobic areas of the Save River and alphameso- to polysaprobic zone of a mountain brook in Yugoslavia (PRIMC 1981, 1984); up to 160 ind. l^{-1} in the neuston of a eutrophic reservoir near Barcelona, Spain (SALVADÓ CABRÉ 1993, SALVADO & GRACIA 1991; further records from Spain: FERNANDEZ-LEBORANS et al. 1990, FINLAY et al. 1993, MARGALEF-LÓPEZ 1945); Azerbaijan (ALEKPEROV 1986); polysaprobic to alphamesosaprobic puddles and in rivers in India (KAUR & MEHRA 1998, KRISHNAMOORTHY 1969, RANGANATHAN & SHREEDHARAN 1986); rare in small clear pools with much decomposing organic sediment, USA (HAUSMAN 1917; determination uncertain because only 50 μm long); Iowa, USA (SHAWHAN et al. 1947); rivers in eastern United States with soft and medium hard water (PATRICK 1961); Conestoga drainage basin, Pennsylvania, USA (CAIRNS 1965a); Mexico (LÓPEZ-CHOTERENA & ROURE-CANE 1970); tributary of the Amazon River, Colombia (BOVEE 1957); with a frequency of 9 % in a pond with leaf litter in Cameroon (NJINE 1977).

GRAY (1952) found *Stylonychia putrina* in a soil surrounding a brook. No further terrestrial records available.

Stylonychia putrina is an oligo- to meso-euryhaline species with freshwater optimum, that is, tolerates $5 \text{ g l}^{-1} \text{ Cl}^{-}$ and 14 g l^{-1} salt (ALBRECHT 1983, 1984, 1986, BICK 1967a, 1972a). BICK (1968b) counted about 750 ind. ml^{-1} during the decomposition of cellulose in brackish water with 0.7 % salinity. DZHURUBAYEV (1977) found 3 ind. cm^{-2} in the upper sediment layer (0–1 cm) of the Odessa Bay (Black Sea), and RAMAN et al. (1993) and KALAVATI et al. (1995) recorded *S. putrina* with a frequency of 10 % in a polluted harbour on the east coast of India.

Stylonychia putrina occurs also in sewage treatment plants such as activated sludge (ANTONIETTI et al. 1982, BANINA 1983, CURDS 1969, CURDS & COCKBURN 1970a, KUTIKOWA 1984, MACEK 1987, 1989, 1991, MADONI 1981, 1988a, MADONI & GHETTI 1981b, STAMM 1979, 1984), rotating biological contactors (MADONI & GHETTI 1981b), stabilisation ponds with $50\text{--}80 \text{ mg l}^{-1} \text{ BOD}_5$ (KRISHNAMOORTHY & SARKAR 1981), and other systems (BEGER 1935). RIVERA et al. (1987) counted $37\,000 \text{ ind. ml}^{-1}$ bottom sample from a waste water stabilisation pond in Mexico at $11\text{--}17^\circ\text{C}$ and $\text{pH } 7.1\text{--}8.7$. Not recorded from percolating filters and Imhoff tanks (CURDS 1975). VARGA (1953) found *S. putrina* in fermented farmyard manure.

Feeds on bacteria, diatoms, filamentous growths, heterotrophic flagellates (*Chilomonas paramecium*), and ciliates (BICK 1972a, CURTIS & CURDS 1971, MACEK 1989, REILLY & LILLY 1957). *Stylonychia putrina* does well in a monoxenic culture of sterile lettuce extract plus K_2HPO_4 and KH_2PO_4 ($\text{pH } 6.8\text{--}7.2$) and a species of the *Tetrahymena pyriformis* complex as food (PROVASOLI et al. 1958). DOWNS (1952, 1956, 1959), studying the mating types in *S. putrina*, used a species of *Chlamydomonas* and *Aerobacter cloacae* as food. REILLY & LILLY (1957) found some differences between *S. putrina* and *S. pustulata* concerning the food organisms (see *S. pustulata*). Duration of cell cycle about 12 h at 23°C in Pringsheim medium and with *Chlorogonium elongatum* as food (AMMERMAN & MUENZ 1982). Biomass of 10^6 individuals about 68 mg (FOISSNER et al. 1991). SCHMERENBECK (1975) found *S. putrina* at flowing velocities of up to 0.6 m s^{-1} .

Data on the autecology and saprobiology of *S. putrina* have to be used with some care because it cannot be excluded that it was sometimes confused with the rather similar and more common *S. pustulata* (Table 35). Further autecological data: $\text{pH } 6.5\text{--}7.0$ (optimal range), $0.1\text{--}1 \text{ mg l}^{-1} \text{ O}_2$ (optimal range), $0\text{--}56 \text{ mg l}^{-1} \text{ CO}_2 \text{ free}$, $0\text{--}2 \text{ mg l}^{-1}$ free NH_3 , $1000\text{--}20\,000\,000 \text{ bacteria ml}^{-1}$ (plate counts on peptone agar; BICK & KUNZE 1971, BICK 1972a); 0.9 % frequency, $41\text{--}60 \text{ mg l}^{-1} \text{ Ca}^{2+}$, $7\text{--}38 \text{ mg l}^{-1} \text{ Mg}^{2+}$, $116\text{--}214 \text{ mg l}^{-1} \text{ HCO}_3^-$, $19\text{--}113 \text{ mg l}^{-1} \text{ SO}_4^{2-}$, $10\text{--}20 \text{ mg l}^{-1} \text{ Cl}^-$, $0.03\text{--}0.05 \text{ mg l}^{-1} \text{ Fe}^{2+}$ (DETCEVA 1983c). REINHARTH (1979) found *S. putrina* in a eutrophic pond in the upper layer of a mud-water interface at $\text{pH } 7.1$, $+181 \text{ mV}$ redox potential, $0.13 \text{ mg l}^{-1} \text{ NH}_4^+\text{-N}$, and $1.2 \text{ mg l}^{-1} \text{ NO}_3^-\text{-N}$. Cysts are killed at temperatures between 40 and 45°C (MOLTMANN 1978). NUSCH (1970) counted about 40 ind. cm^{-2} at 10°C in an aquarium three weeks after addition of 100 mg l^{-1} peptone. GREISER (1974) found *S. putrina* in laboratory ecosystems in areas with low oxygen content and high NH_4^+ -concentrations together with *Dexiostoma campylum*, *Glaucoma scintillans*, *Tetrahymena pyriformis*, *Trimyema compressum*, and *Vorticella microstoma*.

In agreement with the faunistic and ecological data, *S. putrina* is classified as indicator of alphamesosaprobic conditions: $a; b = 2, a = 7, p = 1, I = 3, SI = 2.9$ (FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). However, this has to be verified on reliably determined populations.

Stylonychia vorax STOKES, 1885 (Fig. 159b, c, 166a, b, e)

- 1885 *Stylonychia vorax* STOKES, Am. mon. micros. J., 6: 188 (Fig. 166a).
 1888 *Stylonychia vorax*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 298 (Fig. 166a).
 1932 *Stylonychia vorax* STOKES, 1885 – KAHL, Tierwelt Dtl., 25: 619.
 1957 *Stylonychia vorax* STOKES 1885 – ŠRÁMEK-HUŠEK, Věst. čsl. zool. Spol., 21: 23 (Fig. 166b).
 1966 *Stylonychia ovalis* DRAGESCO, Protistologica, 2: 93 (Fig. 159b, c).
 1973 *Stylonychia vorax* STOKES, 1885 – MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA, Revta Soc. mex. Hist. nat., 34: 66 (Fig. 166e; incorrect subsequent spelling of *Stylonychia*).
 1991 *Stylonychia vorax* STOKES, 1885 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 334.

Nomenclature and taxonomy: KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Stylonychia) vorax*, which is a secondary homonym of *Oxytricha (Histrio) vorax* in KAHL (1932, p 617). *Clara vorax* (STOKES, 1885) in EIGNER (1997, p 568) is a new combination with the junior homonym *Clara* EIGNER, 1997 (details see *Stylonychia pustulata*). This transference is based on the morphogenetic data of *S. vorax* sensu WIRNSBERGER et al. (1985a), which is, however, a *Stylonychia bifaria*.

The populations described by STOKES (1885a), ŠRÁMEK-HUŠEK (1957), and DRAGESCO (1966b) agree very well in the slightly tapered posterior end, the long, rather narrowly arranged caudal cirri, and the transverse cirri which are not separated in two groups. Especially the more or less pointed posterior end seems to exclude synonymisation with the rather similar *Stylonychia pustulata*. Thus, *S. pustulata* sensu LILLY (1942, Fig. 162j) could be *S. vorax*. Synonymy of *Stylonychia. vorax* and *S. ovalis* was suggested by BORROR (1972a). Detailed redescription necessary. Difficult to distinguish from *Stylonychia pustulata*, *S. putrina*, and *S. curvata*!

Morphology: In life about $71\text{--}85 \times 43 \mu\text{m}$, according to DRAGESCO (1966b) after protargol impregnation $110 \mu\text{m}$ long on average, about 2.3 times as long as broad. Elliptical or obovoid, posterior end rather narrowly rounded or even pointed (Fig. 159b, c, 166a, b). Two micronuclei.

41–60 adoral membranelles. Frontal and transverse cirri distinctly enlarged; all transverse cirri protrude beyond posterior end of cell. According to DRAGESCO (1966b) 30–36 left and only 23–25 right marginal cirri; however, in his illustration (Fig. 159b) 36 right marginal cirri are shown. Marginal rows only slightly separated posteriorly. Caudal cirri stout, about 28 % of body length, rather narrowly spaced and, after STOKES (1885a), they

Fig. 166a, b, e *Stylonychia vorax* (a, from STOKES 1885a; b, after ŠRÁMEK-HUŠEK 1957; e, from MADRAZO-GARIBAY & LÓPEZ-POCHTERENA 1973). a, b, e) Ventral views from life, a = 125 μ m, b = size not indicated, e = 71 μ m; p 591.

Fig. 166c, d *Stylonychia notophora* (c, after DRAGESCO & NJINE 1971 from DRAGESCO & DRAGESCO-KERNÉIS 1986; d, from DRAGESCO & NJINE 1971). c, d) Ventral infraciliature, protargol impregnation, c = 80 μ m, d = 100 μ m. In *S. notophora* postoral ventral cirrus IV/2 is placed more anteriorly than postoral ventral cirrus V/4; a conspicuous difference to species of the *S. mytilus* complex, where cirrus V/4 is placed more anteriorly (see Fig. 149a); p 553.

arise directly from posterior end and not from the dorsal surface, as for instance in *S. mytilus*, *S. notophora*, and *S. putrina*.

Occurrence and ecology: Probably confined to freshwater, obviously preferring lentic waters. Locus classicus is a shallow pond, where STOKES (1885a) discovered *S. vorax* in early spring. STOKES did not give the specific locality where he found it;

however, he lived and worked in Trenton, New Jersey, USA, and it is thus assumed that the locus classicus is nearby. Locus classicus of the synonym, *S. ovalis*, is a freshwater habitat near Thonon-les-Bains, Lake Geneva, France (DRAGESCO 1966b). KAHL (1932) did not find *S. vorax*. ŠRÁMEK-HUŠEK (1956b, 1957, 1958) isolated *S. vorax* from a betamesosaprobic habitat of the Moravice River system, Czechoslovakia. MADRAZO-GARIBAY & LÓPEZ-POCHOTERENA (1973) found it in the San Anton waterfall in Morelos State, Mexico.

Records not substantiated by illustrations: spring area of the Melbbach ($<1 \text{ mg l}^{-1}$ BOD₅), a small brook near Bonn, Germany (JUTRCZENKI 1982); brook in Hungary (VÖRÖSVÁRY 1950); urban runoff of Hickey Run, District of Columbia, USA (SAYRE et al. 1986, as “*Stylonychia ovale*”); soil of the Apsheron peninsula, Azerbaijan (AGAMALIEV & MUSAYEV 1988).

Voracious predator on flagellates (STOKES 1885a; the remarkable appetite suggested the species name), but also feeds on bacteria and diatoms (VÖRÖSVÁRY 1950); also cannibalistic. Biomass of 10^6 individuals about 57 mg (FOISSNER et al. 1991). WENRICH (1918) reported *S. vorax* impaled on a fungal filament; many specimens were located at points basal to branches of the filaments, indicating that they had been held prisoner for some time.

SLÁDEČEK et al. (1981), WEGE (1983), FOISSNER (1988a), and FOISSNER et al. (1991) classified *S. vorax* as betamesosaprobic indicator of water quality: b; b = 10, I = 5, SI = 2.0. This strict classification has to be verified by further autecological and saprobiological data on reliably determined populations.

Stylonychia curvata (KAHL, 1932) BORROR, 1972 (Fig. 167f, 234m)

1932 *Stylonychia curvata* KAHL, Tierwelt Dtl., 25: 619 (Fig. 167f).

1971 *Stylonichia curvata* KAHL – CHARDEZ, Revue verviét. Hist. nat., 28: 38 (Fig. 234m; incorrect subsequent spelling of *Stylonychia*).

1972 *Stylonychia curvata* KAHL, 1932 – BORROR, J. Protozool., 19: 15.

Nomenclature and taxonomy: KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Stylonychia) curvata*. Although BORROR (1972a) did not use the phrase “comb nov.” as he did in other cases, I consider him as combining author. *Stylonychia curvata* sensu GIESE & ALDEN (1938) does not have the characteristic oval outline and has only inconspicuous caudal cirri; it is classified as *Sterkiella histriomuscorum* (Fig. 186f). The illustration in CHARDEZ (1971) looks like a redrawing from KAHL (1932; cp. Fig. 167f, 234m). Detailed redescription necessary. Difficult to distinguish from *S. pustulata*, *S. putrina*, and *S. vorax*.

Morphology: In life about 60–80 μm long, about 2.5 times as long as broad. Distinctly ovoid, that is, posteriorly more broadly rounded than anteriorly, anterior portion

Fig. 167a *Stylonychia pseudograndis* (after WANG & NIE 1935). Ventral view from life, 170 μm ; p 564.

Fig. 167b–d *Stylonychia stylomuscorum* (b, after ŠRÁMEK-HUŠEK 1957; c, d, from KAHL 1932). Ventral views from life, b = size not indicated, c, d = 80 μm . Note single micronucleus between macronuclear nodules; p 595.

Fig. 167e *Stylonychia pusilla*, a supposed synonym of *S. notophora* (from KAHL 1932). Ventral view from life, 85 μm ; p 555.

Fig. 167f *Stylonychia curvata* (from KAHL 1932). Ventral view from life, 80 μm ; p 593.

slightly bent to the left. Adoral zone of membranelles about 40 % of body length. Anterior part of undulating membranes possibly curved to the left, indicating that it possible belongs to another genus. Transverse cirri protrude distinctly beyond posterior end of cell. Caudal cirri about 30 % of body length.

Occurrence and ecology: Probably confined to freshwater habitats. Locus typicus not fixed; KAHL (1932) discovered *Stylonychia curvata* with high abundance in a trench containing decaying plants, probably somewhere in Germany. CHARDEZ (1971) found it in the Ardennes, Belgium. Further records: lentic waters of the Tibetan Plateau (WANG 1977); Yuelushan Area, China (YANG 1989); soil from paddy field in Japan (TAKAHASHI & SUHAMA 1991).

PATRICK et al. (1967) found *Stylonychia curvata*, rarely, in the Savannah River, USA, at 20–23 °C, pH 6.5–7.0, 7–9 $\text{mg l}^{-1} \text{O}_2$, 1–<5 $\text{mg l}^{-1} \text{BOD}_5$, 5–<10 $\text{mg l}^{-1} \text{Cl}^-$, 0.001 mg l^{-1}

$\text{NH}_3\text{-N}$, $<0.007 \text{ mg l}^{-1}$ $\text{NO}_2\text{-N}$, $0.2\text{--}0.7 \text{ mg l}^{-1}$ $\text{NO}_3\text{-N}$, $0.017\text{--}0.033 \text{ mg l}^{-1}$ $\text{PO}_4^{3-}\text{-P}$, $>1\text{--}10 \text{ mg l}^{-1}$ SO_4^{2-} .

Temporary fasting can result in the formation of giant cannibalistic individuals (TUF-FRAU 1965b). SEN et al. (1967) cultivated *Stylonychia curvata* in a bacterised proteose-peptone-cerophyl-wheat broth diluted 1:18 (v/v) with distilled water; synchronous cell division was induced by exposure to low temperature.

Stylonychia stylomuscorum (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (Fig. 167b–d)

1932 *Stylonychia muscorum* KAHL, Tierwelt Dtl., 25: 619 (Fig. 167c, d).

1957 *Stylonychia muscorum* KAHL 1932 – ŠRÁMEK-HUŠEK, Věst. čsl. zool. Spol., 21: 23 (Fig. 167b).

1972 *Stylonychia muscorum* KAHL, 1932 – BORROR, J. Protozool., 19: 15.

1991 *Oxytricha stylomuscorum* FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 332.

1991 *Stylonychia stylomuscorum* (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 332.

Nomenclature and taxonomy: KAHL (1932) classified *Stylonychia* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Stylonychia) muscorum*, which is a primary homonym of 3 other *Oxytricha muscorum* established by KAHL (1932). For further details on this nomenclatural problem, see the relevant chapter in *Sterkiella histriomuscorum*.

The most important species character of *Stylonychia stylomuscorum* is the single micronucleus between the 2 macronuclear nodules. Thus, identity with the rather similar and very common *Sterkiella histriomuscorum* can be excluded because this species always has more than 1 micronucleus. ALONSO & PEREZ-SILVA (1963a, b) described 2–4 micronuclei and CHARDEZ (1967; Fig. 233j) and MATIS & DANIŠKOVÁ (1972; Fig. 230f, g) did not mention the number; consequently, these identifications can not accepted. Latter records by MATIS, however, are listed here. Detailed redescription necessary.

Morphology: In life 60–100 μm long, about 2.1 times as long as broad. Elliptical, slightly converging posteriorly, or even with parallel margins, posterior end rounded. Contractile vacuole in about mid-body or slightly in front of it. Transverse cirri not (Fig. 167d) to distinctly enlarged (Fig. 167b, c) and possibly arranged in 2 groups (Fig. 167c), indicating that perhaps 2 closely related species exist. Transverse cirri protrude slightly (left) to distinctly (right) beyond posterior end of cell. Caudal cirri only slightly longer than marginal cirri (Fig. 167c, d).

Occurrence and ecology: In terrestrial habitats (mosses, soil) and in the aufwuchs and detritus of freshwater. Locus classicus not fixed. KAHL (1932) discovered *S. stylomuscorum* in mosses from Europe and North America. ŠRÁMEK-HUŠEK (1953, 1956b,

1957) observed it in one alphamesosaprobic and seven betamesosaprobic waters in Czechoslovakia. Records not substantiated by illustrations: with a frequency of 19 % in submerged and 12 % in wet mosses in Czechoslovakia (TIRJAKOVÁ & MATIS 1987a; see taxonomy); pond and fishponds in Czechoslovakia and Poland (HASSDENTEUFELOVÁ-MORAVCOVÁ 1955; MATIS 1973, see taxonomy; SIEMIŃSKA & SIEMIŃSKA 1967); agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988; further records from Czechoslovakia: MATIS & TIRJAKOVÁ 1994, TIRJAKOVÁ 1992b, 1993); various, mostly heavily polluted rivers in Nordwürttemberg, Germany, once highly abundant in the Fils River (BUCK 1959, 1961); among detritus and in the surface film of ditches regularly contaminated with pesticide sprays and in unsprayed ditches in the Elbe flood plain, Germany (CASPER & HECKMAN 1982); cooling towers of power stations in Germany (SCHARF 1961); aufwuchs and detritus-drifts in the littoral of Lake Balaton, Hungary (GELLÉRT & TAMÁS 1958, 1959a, 1960, TAMÁS & GELLÉRT 1958); soil under mosses in Hungary (GELLÉRT 1956); freshwater in Italian caves (BOSCOLO 1968, GITTLESON & HOOVER 1969, STELLA & SALVADORI 1953); in the bottom of a fish pond in Poland (KWIATKOWSKA-GRABACKA 1965); freshwater habitats in the Tibetan Plateau (WANG 1977); freshwater in Yuelushan Area, China (YANG 1989); soil from paddy fields in Japan (TAKAHASHI & SUHAMA 1991).

Feeds on algae (including diatoms) and heterotrophic flagellates (GELLÉRT 1956, GELLÉRT & TAMÁS 1958, TAMÁS & GELLÉRT 1958). Biomass of 10^6 individuals about 30 mg (FOISSNER et al. 1991). According to the experiments of PRIMC (1983) on the influence on water temperature, *S. stylomuscorum* was present only at about 20 °C. SCHARF (1961), however, reported an upper temperature limit of 36 °C. ŠRÁMEK-HUŠEK (1954) found *S. stylomuscorum* scattered in grey, moderately saprobic depositions at 5.4 °C and pH 7.1, and sporadically in the littoral sediments of the March River, Czechoslovakia. MATIS (1975; identification uncertain, see taxonomy) observed it in road pools and running waters near Bratislava at 3–28.5 °C, pH 5.8–6.9, and 1.2–12.4 mg l⁻¹ O₂. MATIS & STRAKOVÁ-STRIEŠKOVÁ (1991) recorded *Stylonychia stylomuscorum* from a brook and two thermal lakes in Czechoslovakia at 7–40.5 °C and pH 6.0–7.3.

According to ŠRÁMEK-HUŠEK (1958, see also MAUCH 1976) typical for betamesosaprobity. SLÁDEČEK et al. (1981), WEGE (1983), FOISSNER (1988a), and FOISSNER et al. (1991) give the following values: b; b = 10, I = 5, SI = 2.0. The restriction to betamesosaprobity has to be verified by further autecological and saprobiological data on reliably determined specimens, because BUCK (1959, 1961) found *S. stylomuscorum* in various heavily polluted rivers and thus classified it as alphamesosaprobic.

Species transferred to a genus not treated in this book

Stylonychia appendiculata EHRENBERG, 1838, Infusionsthierchen, p 373, Tafl. XLII, Fig. III. Remarks: Now *Diophrys appendiculata*. Marine.

Species indeterminata

DUMAS (1929, 1930, 1937), a French amateur protistologist, described about 550 new species, mainly ciliates from various habitats of the French Massif Central. Very likely, most of the about 80 hypotrichous species, mainly assigned to *Kerona*, *Oxytricha*, and *Stylonychia*, are species indeterminata. A list of DUMAS' names is provided by FOISSNER (1995a).

Ceratidium cuneatum EHRENBERG, 1838, Infusionsthierchen, p 367, Tafel XLI, Fig. VI. Remarks: *Ceratidium* EHRENBERG, 1838, was established for a small (50–60 µm) organism, probably a fragment of a hypotrichous ciliate. FOISSNER & FOISSNER (1988) considered it a synonym of *Stylonychia mytilus*. EHRENBERG (1838) found it only once in 1820 in ponds near Berlin. EICHWALD (1844) and WEISSE (1848c) apparently observed this form in Russia. However, these records are not substantiated by illustrations. CORLISS (1979; p 208) considered *Ceratidium* as nomen oblitum.

Hypotrichen (nov. spec.?) – FORTNER, 1934, Arch. Protistenk., 81: 284 (Fig. 240h). Remarks: In life 225–270 µm long and only one macronucleus 50–60 µm across; possible a post-conjugant of a large *Stylonychia*. In the surface layer of a saprobic infusum (Prague, Czechoslovakia).

Stylonichea bistyllus DUMAS, 1930, Microzoaires, Planche XXX, fig. 4 (Fig. 238n). Remarks: Incorrect subsequent spelling of *Stylonychia*. Without description.

Stylonichia anfracta DUMAS, 1929, Microzoaires, p 84 (Fig. 238a). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia auriformis DUMAS, 1937, Microzoaires, p 25 (Fig. 240a). Remarks: Incorrect subsequent spelling of *Stylonychia*. See also *S. virgula*.

Stylonichia bicaudatus DUMAS, 1937, Microzoaires, p 27 (Fig. 240c, d). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia capucinus DUMAS, 1930, Microzoaires, Planche XXIX, fig. 1 (Fig. 238m). Remarks: Incorrect subsequent spelling of *Stylonychia*. Without description.

Stylonichia corniculata DUMAS, 1929, Microzoaires, Planche XXXI, fig. 5 (Fig. 238d). Remarks: Incorrect subsequent spelling of *Stylonychia*. Without description.

Stylonichia cornifrons DUMAS, 1929, Microzoaires, p 85 (Fig. 238b). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia dupla DUMAS, 1929, Microzoaires, p 82 (Fig. 237g). Remarks: Incorrect subsequent spelling of *Stylonychia dupla* (legend to Planche XXIX, fig. 3). A middle morphogenetic stage.

Stylonichia ellipsoides DUMAS, 1929, Microzoaires, p 84 (Fig. 237j). Remarks: Incorrect subsequent spelling of *Stylonychia* (in the legend to Planche XXX, fig. 7 designated as "*Stylonichia pustulata*"). The shape is reminiscent of *S. pustulata*, whereas the widely spaced and very long caudal cirri are typical for species of the *S. mytilus* complex.

Stylonichia excavata DUMAS, 1930, Microzoaires, p 61 (Fig. 238l). Remarks: Incorrect subsequent spelling of *Stylonychia*. The outline is reminiscent of *Psilotricha* (see FOISSNER 1983b).

Stylonichia fastigiata DUMAS, 1929, Microzoaires, p 83. Remarks: Incorrect subsequent spelling of *Stylonychia fastigiata* (legend to Planche XXIX, fig. 9). Two elongated caudal cirri. Anterior end with a small process; possible an opisthe of a *Stylonychia*.

Stylonichia fronte-albens DUMAS, 1937, Microzoaires, p 26 (Fig. 239v). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia frontosus DUMAS, 1937, Microzoaires, p 25 (Fig. 240b). Remarks: Incorrect subsequent spelling of *Stylonychia*. Possible a somewhat deformed *S. mytilus*.

Stylonichia globifrons DUMAS, 1930, Microzoaires, p 61 (Fig. 238e). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia gyринiformis DUMAS, 1930, Microzoaires, Planche XXIX, fig. 4 (Fig. 238p). Remarks: Incorrect spelling of *Stylonychia*. Without description.

Stylonichia labiata DUMAS, 1930, Microzoaires, p 61 (Fig. 238k). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia limbiformis DUMAS, 1930, Microzoaires, p 60 (Fig. 238i, q). Remarks: Incorrect subsequent spelling of *Stylonychia*. "*Stylonichia limbifrons*" in the legend to the figures (Planche XIV, fig. 6) is an incorrect original spelling. Possibly synonymous with *Stylonychia mytilus*.

Stylonichia mamillata DUMAS, 1929, Microzoaires, p 85 (Fig. 238c). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia massula DUMAS, 1929, Microzoaires, p 84, Planche XXXVII, fig. 1 and not Planche XXXI, fig. 1 (Fig. 237e). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia membranaceus DUMAS, 1937, Microzoaires, p 27 (Fig. 239w). Remarks: Incorrect subsequent spelling of *Stylonychia*. Possibly a *S. mytilus*.

Stylonichia mutabunda DUMAS, 1930, Microzoaires, p 59, Planche XIV, fig. 1 and not Planche XVI, fig. 1 (Fig. 238f–h). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia núm. 1 – IZQUIERDO, 1906, Protozoos, p 191 (Fig. 229a). Remarks: Incorrect subsequent spelling of *Stylonychia*. 190 µm long. Freshwater in Chile.

Stylonichia octonistylus DUMAS, 1937, Microzoaires, p 28 (Fig. 240e). Remarks: Incorrect subsequent spelling of *Stylonychia*. 8 (4 + 4) prominent (transverse) cirri at posterior end.

Stylonichia reclinis DUMAS, 1930, Microzoaires, p 60 (Fig. 238j). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia rostrata DUMAS, 1929, Microzoaires, p 83 (Fig. 237c). Remarks: Incorrect subsequent spelling of *Stylonychia rostrata* (legend to Planche XXIX, fig. 6).

Stylonichia trochiformis DUMAS, 1929, Microzoaires, p 81 (Fig. 237b). Remarks: Incorrect subsequent spelling of *Stylonychia trochiformis* (legend to Planche XXIX, fig. 1). One macronucleus, 2 contractile vacuoles.

Stylonichia truncata DUMAS, 1930, Microzoaires, Planche XXX, fig. 6 (Fig. 238o). Remarks: Incorrect subsequent spelling of *Stylonychia*. Without description.

Stylonichia unguiculus DUMAS, 1930, Microzoaires, Planche XXVI, fig. 23 (Fig. 238r). Remarks: Incorrect subsequent spelling of *Stylonychia*. Without description.

Stylonichia viridis DUMAS, 1937, Microzoaires, p 26 (Fig. 239p). Remarks: Incorrect subsequent spelling of *Stylonychia*. Possible a morphogenetic stage of a *Stylonychia*. Green due to ingested algae.

Stylonychia calva FROMENTEL, 1876, Études microzoaires, p 273, Planche XIV, fig. 2. Remarks: Probably the posterior part of a species of the *Stylonychia mytilus* complex. France.

Stylonychia harbinensis FENG, GU & ZHANG, 1990, Zool. Res., 11: 95. Remarks: This name is mentioned (as “*S. harbinensis* n. sp.”) without description and is thus a nomen nudum. I do not know the description.

Stylonychia makrostyla STERKI, 1878, Z. wiss. Zool., 31: 36, 56. Remarks: *Stylonychia makrostyla* WRZES. in MERMOD (1914) is an incorrect subsequent spelling of both the genus and the species name. Furthermore, MERMOD obviously erroneously mentioned WRZESNIOWSKI as author of this species (or did he mean *Oxytricha makrostyla* WRZESNIOWSKI?). KAHL (1932) considered *S. makrostyla* as valid species (subsequently incorrectly spelled as *Stylonychia makrostyla*) in the subgenus *Oxytricha* (*Stylonychia*); the correct name in KAHL (1932, p 618) is thus *Oxytricha* (*Stylonychia*) *makrostyla*. KAHL (1932) did not realise the secondary homonymy with "*Oxytricha* (*Urosoma*) *makrostyla* WRZESNIOWSKI, 1870" (KAHL 1932, p 607), now classified in *Urosoma*. STERKI (1878) provided only a short description, but no figure of his species: resembles *Stylonychia mytilus*, however, has a metabolic (!) body, anteriorly regularly rounded and posteriorly widely truncated; all cirri extremely long, frontal cirri located more posteriorly; caudal cirri about 1/2 of body length, loose, posteriorly not fringed; cytopharynx long, obliquely arranged. REID (1969) recorded *S. makrostyla* in activated sludge.

Stylonychia monostylus FROMENTEL, 1876, Études microzoaires, p 275, Planche XIV, fig. 12. Remarks: Probably a fragment of a hypotrich. France.

Stylonychia regularis FROMENTEL, 1876, Études microzoaires, p 274, Planche XIV, fig. 6. Remarks: According to arrangement and number of ventral cirri surely not a *Stylonychia*. The drawing in DUMAS (1929, p 82; as *Stylonychia regularis*; Fig. 237h) is a redrawing from the original description; he found it in a bog in France. LONGHI (1895), MOLA (1928, 1935), and PARONA (1883) found this rather doubtful form in freshwater habitats in Italy.

Stylonychia sphaerica FROMENTEL, 1876, Études microzoaires, p 274, Planche XIV, fig. 5. Remarks: Rather certainly a fragment of a hypotrich. France.

Insufficient redescriptions

Kerona pustulata – DUJARDIN, 1841, Zoophytes, p 423, Planche VI, fig. 10, 11, 14, 18, Planche XIII, fig. 7. Remarks: 180 µm long!

Kerona pustulata, MÜLL. *Stylonychia pustulata*, EHR. – CARTER, 1859, Ann. Mag. nat. Hist., 3: 247 (Fig. 220d). Remarks: Certainly not a *Stylonychia* because it is "soft in consistence". About 130 µm long. Macronucleus consists of a single cylindrical part, or often divided into 2 parts. Cyst without spines. Salt and freshwater habitats in Bombay, India.

Kerona silurus – DUJARDIN, 1841, Zoophytes, p 427, Planche XIII, fig. 4. Remarks: In life 120 µm long. Reminiscent of a species of the *Stylonychia mytilus* complex.

Kerona silurus – FROMENTEL, 1876, Études microzoaires, p 273, Planche XIV, fig. 8. Remarks: The outline of this superficially described, in life about 77 µm long form is reminiscent of species of the *Stylonychia mytilus* complex.

Kerone pustulata – DUJARDIN, 1838, Annls Sci. nat., Zoologie, 10: 313, Planche 14, fig. C, D. Remarks: Very poorly described.

Oxytricha bifaria – SOKOLOFF, 1931, An. Inst. Biol. Univ. Mex., 2: 167 (Fig. 228b). Remarks: The figure does not show the characteristic arrangement of the transverse cirri. Mexico.

Oxytricha bifaria STOKES – CONN, 1905, Bull. Conn. St. geol nat. Hist. Surv., 2: 60 (Fig. 228g, 231i, j). Remarks: The larger form (Fig. 228g) is reminiscent of *Gastrostyla* since it has many postoral ventral cirri. Freshwater habitats in Connecticut, USA.

Oxytricha bifaria STOKES – SMITH, 1914, Kans. Univ. Sci. Bull., 9: 165 (Fig. 233f). Remarks: The flexible body and the 4 macronuclear nodules indicate that the identification is incorrect. Freshwater habitats in Kansas, USA.

Oxytricha bifaria STOKES – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 51 (Fig. 242h). Remarks: The five transverse cirri are arranged in an oblique row and not in two distinctly separated groups, as is typical for *Stylonychia bifaria*. Small pond in Pe Ji Keh, Nanking, China.

Stylonichia muscorum KAHL – CHARDEZ, 1967, Revue Écol. Biol. Sol, 4: 294 (Fig. 233j). Remarks: Incorrect subsequent spelling of *Stylonychia*. Nothing indicates that the identification is correct. The rather long caudal cirri and the body shape suggest that it is possible a post-divider or an abnormal specimen of the *S. mytilus* complex. Soils in Belgium (CHARDEZ 1987).

Stylonichia mytilus, EHR. – DUMAS, 1929, Microzoaires, p 82 (Fig. 237f, i). Remarks: Incorrect subsequent spelling of *Stylonychia*.

Stylonichia notophora STOKES – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 51 (Fig. 242c). Remarks: Incorrect subsequent spelling of *Stylonychia*. The body shape and the rather distinct separate caudal cirri are reminiscent of species of the *S. mytilus* complex. Lake Ho Hu and small ponds in Nanking, China.

Stylonichia pustulata, EHR. – DUMAS, 1929, Microzoaires, p 81 (Fig. 237a). Remarks: Incorrect subsequent spelling of *Stylonychia*. Rather surely not a *Stylonychia* because ventral rows are present.

Stylonichia putrina STOKES – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 52 (Fig. 242f). Remarks: Incorrect subsequent spelling of *Stylonychia*. The tapered posterior end and the size (95 μm) are reminiscent of *S. vorax*. Lake Ho Hu near Nanking, China.

Stylonichia sp. – OLIVEIRA, KRAU & NASCIMENTO, 1954, Mems Inst. Oswaldo Cruz, 51: 409 (Fig. 234p). Remarks: Incorrect subsequent spelling. Cistern in Rio de Janeiro, Brazil.

Stylonichia sp. – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 52 (Fig. 242e). Remarks: Incorrect subsequent spelling. About 150 μm . Lake Mo Chu Hu, Nanking, China.

Stylonichia tricornis (TAGLIANI, 1922) – MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA, 1973, Revta Soc. mex. Hist. nat., 34: 67 (Fig. 240j). Remarks: Incorrect subsequent spelling of *Stylonychia*. I could not find the basionym; possibly mixed up with *Oxytricha tricornis* MILNE, 1886. In life 128 $\times$ 57 μm . Certainly a deformed specimen of another species. San Anton waterfall in Morelos State, Mexico.

Stylonychia muscorum KAHL, 1932 – MATIS & DANIŠKOVÁ, 1972, Acta Fac. Rerum nat. Univ. comen. Bratisl., 17: 51 (Fig. 230f, g). Remarks: The identification cannot be accepted because the characteristic single micronucleus between the two macronuclear nodules is not described. Furthermore, it is questionable if the 2 specimens figured are conspecific because the transverse and caudal cirri are somewhat differently arranged. In life 75–130 μm long. Macronuclear nodules hardly discernible because numerous dark granules (food vacuoles?) present. 5 transverse cirri arranged in 2 groups (Fig. 230g). Caudal cirri only slightly longer than marginal cirri, reminiscent of *Stylonychia bifaria*. Pools on roads and meadows and in an artificial gravel lake near Bratislava, Czechoslovakia.

Stylonychia mytilus EHRENBERG, 1838 – AGAMALIEV, 1978, Acta Protozool., 17: 440 and AGAMALIEV, 1983, Ciliates of Caspian Sea, p 111 (Fig. 230c, d). Remarks: Identification with a species of the *Stylonychia mytilus* complex should be avoided because the transverse cirri are not arranged in 2 groups. AGAMALIEV (1978) provided following data: size after wet silver nitrate impregnation 90–120 $\times$ 40 μm . 2 micronuclei. Adoral zone of membranelles almost half of body length with about 36–38 adoral membranelles. Arrangement and number of frontal, ventral, and transverse cirri, see Figure 230c. Each 23–37 left and right marginal cirri. Only 3 dorsal kineties, which is rather surely a misobservation possibly due to the inadequate impregnation method; each kinety with 13–19 basal body pairs only. Periphyton and pelagial of low salinity regions of the Caspian Sea.

Stylonychia mytilus – LÓPEZ-UCHOTERENA, 1964, Trans. Am. microsc. Soc., 83: 430, 431, Fig. 10, 18. Remarks: In my opinion, these two micrographs do not show a species of the *S. mytilus* complex; possibly *S. pustulata*.

Stylonychia mytilus – LUNDIN & WEST, 1963, Free-living protozoa, p 68 (Fig. 234a). Remarks: Freshwater from the Upper Peninsula of Michigan, USA.

Stylonychia mytilus EHRENBURG, 1838 – RAMIREZ DE GUERRERO, 1970, *Revta Soc. mex. Hist. nat.*, 31: 85 (Fig. 226l). Remarks: $150 \times 60 \mu\text{m}$. Mexico.

Stylonychia notophora STOKES – CONN, 1905, *Bull. Conn. St. geol. nat. Hist. Surv.*, 2: 61 (Fig. 229b). Remarks: The body shape and the very long caudal cirri are reminiscent of the *S. mytilus* complex. Freshwater in Connecticut, USA.

Stylonychia notophora STOKES – EDMONDSON, 1906, *Proc. Davenport Acad. Sci.*, 11: 102 (Fig. 226h). Remarks: Probably not a *S. notophora* because transverse cirri not distinctly separate and caudal cirri not narrowly spaced. Freshwater in Iowa, USA.

Stylonychia patula, EHR. – LONGHI, 1892, *Atti Soc. ligust. Sci. nat. geogr.*, 3: 155. Remarks: I could not find the basionym; probably he meant *S. pustulata*.

Stylonychia pustulata – BATTISH, 1992, *Freshwater zooplankton of India*, p 58, Fig. 55. Remarks: Very superficially illustrated. Planktonic. India.

Stylonychia pustulata – CHEN, 1944, *J. Morph.*, 75: 341 (Fig. 242i). Remarks: The arrangement of the frontoventral, ventral, and transverse cirri is not in accordance with the authoritative descriptions of *S. pustulata*. China.

Stylonychia pustulata E. – CIENKOWSKY, 1855, *Z. wiss. Zool.*, 6: 304 (Fig. 222k, l). Remarks: The body shape and the obviously rather inconspicuous caudal cirri suggest that he did not observe *S. pustulata*, although CIENKOWSKY described a “star-shaped” cyst.

Stylonychia pustulata EHRBG. – CONN, 1905, *Bull. Conn. St. geol. nat. Hist. Surv.*, 2: 60 (Fig. 228f, 229c). Remarks: Freshwater in Connecticut, USA.

Stylonychia pustulata – ECKHARD, 1846, *Arch. Naturgesch.*, 12: 231 (Fig. 232h). Remarks: Probably a *Euplotes* species.

Stylonychia pustulata – FROMENTEL, 1876, *Études microzoaires*, p 274, Planche XIV, fig. 9. Remarks: *Stylonychia pustullata* (p 359) is an incorrect subsequent spelling. The outline, the very prominent transverse cirri, and the conspicuously widely separated caudal cirri are reminiscent of the *S. mytilus* complex.

Stylonychia pustulata, EHRBG. – KOFFMAN, 1926, *Acta Zool.*, Stockh., 7: 312 (Fig. 231e). Remarks: The parallel body margins and the rather inconspicuous caudal cirri are reminiscent of *Sterkiella histriomuscorum*, which is common in terrestrial habitats, whereas *S. pustulata* is not reliably recorded from soil. Garden soil near Stockholm, Sweden.

Stylonychia pustulata EHRENBERG – LUNDIN & WEST, 1963, Free-living protozoa, p 68 (Fig. 230e). Remarks: See also WEST & LUNDIN (1963, p 108). Freshwater from the Upper Peninsula of Michigan, USA.

Stylonychia pustulata EHRENBERG – NAIDU, 1965, Hydrobiologia, 25: 562 (Fig. 224l). Remarks: In life $130\text{--}169 \times 60\text{--}70\text{ }\mu\text{m}$. Body shape and arrangement of ventral cirri unreliable. Gutter water in Vijayawad, India.

Stylonychia putrina STOKES – BARWICK, BEVERIDGE, BRAZIER, CLOSE, HIRSCHFELD, PILLAI, RAMSAY, ROBINSON, STEVENS & TODD, 1955, Tuatara, 5: 96 (Fig. 223h). Remarks: Fishpond in Wellington area, New Zealand.

Stylonychia putrina STOKES – BURKOVSKY, 1984, Ecology of free-living ciliates, p 167 (Fig. 233k). Remarks: The size ($200\text{ }\mu\text{m}$), the arrangement of the cirri, and the lack of caudal cirri indicate misidentification.

Stylonychia putrina STOKES – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 61 (Fig. 228e). Remarks: The tapered posterior end of the cell is reminiscent of *S. vorax*, whereas the somewhat broadened anterior portion indicates similarity with a species of the *S. mytilus* complex. Freshwater in Connecticut, USA.

Stylonychia putrina STOKES – SAMANO & SOKOLOFF, 1931, Monografias Inst. Biol. Univ. nac. Méx., 1: 36 (Fig. 241i). Remarks: The body shape does not match the original description. Mexico.

Stylonychia sp. – ALONSO & PEREZ-SILVA, 1963, Microbiologia esp., 16: 56 (Fig. 231g). Remarks: ALONSO & PEREZ-SILVA (1963b) mention that their population is very similar to *Stylonychia stylomuscorum*. But, according to ALONSO & PÉREZ-SILVA (1963a, 1965b), their population has 2–4 micronuclei, whereas *S. stylomuscorum* is characterised by a single micronucleus (see Fig. 167b–d). The general morphology, the body size, and the infraciliature are reminiscent of *Sterkiella histriomuscorum*; however, in this species the 3 caudal cirri are not as long as described by the Spanish authors. ALONSO & PEREZ-SILVA (1963b) population rather variable in size; normal specimens in life $80\text{--}100 \times 40\text{--}60\text{ }\mu\text{m}$; cannibal giants measure $175 \times 98\text{ }\mu\text{m}$, smallest specimens $45 \times 15\text{ }\mu\text{m}$. Arrangement of cirri, see Figure 231g. About 20–30 right and 15–20 left marginal cirri. Stagnant water near Charmatin, Madrid, Spain. ALONSO (1965), ALONSO & PÉREZ-SILVA (1965a, 1966a, b, 1967, 1969), JAREÑO et al. (1969b, 1970), and PÉREZ-SILVA & ALONSO (1966) studied mainly the polytene chromosomes in the macronuclear anlage of this population. Minimal inhibitory concentration of tinidazole is 0.5 mg ml^{-1} , minimal lethal concentration 1 mg ml^{-1} (ALONSO 1979).

Stylonychia sp. (n. sp.) – LEPSI, 1951, Buletin sti. Acad. Repub. pop. rom., 3: 521 (Fig. 220f). Remarks: LEPSI (1965, p 218, legend of his Fig. 97m) figured a “*Stylonychia* n. sp.” which is identical with the LEPSI (1951) form. A conspicuous cirral row right of the undulating membranes. Soil from Temesvar, Romania.

Stylonychia sp. – NIKOLJUK & GELTZER, 1972, Pocvennye prostejsie SSSR, p 133 (Fig. 240f). Remarks: Soil in the USSR.

Stylonychia sp. – VUXANOVICI, 1963, Studii cerc. Biol., 15: 212 (Fig. 220g). Remarks: In life about 100–120 μ m long; adoral zone of membranelles 1/3 of body length; 5 transverse cirri protruding about 2/3 beyond posterior end of cell; 3 conspicuous caudal cirri; 18–20, about 9 μ m long marginal cirri; contractile vacuole near mid-body; cytoplasm very transparent, filled with 6–8 μ m sized symbiotic algae! Freshwater in Bucharest, Romania. The illustration shows an anteriorly distinctly curved undulating membrane, indicating that it perhaps belongs to *Cyrtohymena* or *Steinia*. Differs from *Oxytricha chlorelligera* in that it has longer caudal cirri and transverse cirri which protrude beyond posterior end of cell.

Stylonychia sp. – VUXANOVICI, 1963, Studii. Cerc. Biol., 15: 212 (Fig. 220h–j). Remarks: In life 120–180 μ m long; number and arrangement of ventral cirri unreliable; body elastic but not contractile and not metabolic; cytoplasm transparent, with 3–10 μ m sized symbiotic algae(?). Freshwater habitat in Bucharest, Romania.

Stylonychia sp. – WEST & LUNDIN, 1963, Pap. Mich. Acad. Sci., 48: 109 (Fig. 220a). Remarks: See also LUNDIN & WEST (1963, p 166). Perhaps a *Gastrostyla* because about 26 frontal, ventral, and transverse cirri present. Limnetic habitats in Michigan, USA.

Stylonychia (?) sp. – NANSEN, 1906, Sci. Res. Norw. N. Polar Exped., 5: 16, Plate IV, Fig. 1–5. Remarks: In accumulations of algae from ponds on the ice of the North Polar Sea.

Stylonychia steini – HAYASHI, 1959, Zool. Mag., Tokyo, 68: 239 and MURAMATSU, 1957, Misc. Rep. Yamashina Inst. Orn. Zool., 11: 467. Remarks: MURAMATSU mentioned this name in a paper on the protozoa of the city of Hakodate and Oonuma Park, Japan, where he found it in foul water, together with *Glaucoma scintillans* and *Colpidium colpoda*. I do not know which species they meant, possibly *Histrio steinii* STERKI, 1878. *Stylonychia steinii* STILLER was only established in 1974.

Coniculostomum NJINE, 1979

- 1977 *Coniculostomum monilata* – NJINE, Annls Stn limnol. Besse, 11: 24 (see nomenclature).
 1978 *Coniculostomum monilata* – NJINE, Dissertation, p 167 (see nomenclature).
 1979 *Coniculostomum* NJINE, Protistologica, 15: 353 – Type (by monotypy): *Laurentia monilata* DRAGESCO & NJINE, 1971.
 1979 *Laurentiella (Laurosticha)* JANKOWSKI, Trudy zool. Inst., Leningr., 86: 57 – Type (original designation): *Laurentia monilata* DRAGESCO & NJINE, 1971.
 1986 *Coniculostomum* NJINÉ, 1978 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 455.
 1990 *Coniculostomum* NJINÉ, 1978 – KAMRA & SAPRA, Europ. J. Protistol., 25: 264.
 1994 *Coniculostomum* – KAMRA, SAPRA & AMMERMAN, Europ. J. Protistol., 30: 63.
 1997 *Coniculostomum* NJINE, 1979 – BERGER & FOISSNER, Arch. Protistenk., 148: 149.

Characterisation: Undulating membranes in *Stylonychia* pattern. Two or more right and 1 or more left rows of marginal cirri, distinctly separate posteriorly. Six or more dorsal kineties. Caudal cirri present and usually distinctly elongated. Primordium II of proter originates from oral primordium. Primordia V and VI of proter, and primordium IV of opisthe originate from postoral ventral cirrus V/4. Parental marginal cirri partially retained after division. Dorsal morphogenesis in *Coniculostomum* pattern.

Additional characters: Large to very large. Outline *Stylonychia mytilus*-like, that is, anteriorly distinctly broader than posteriorly. Flattened about 2:1 dorso-ventrally. Body rigid, not contractile. Macronucleus moniliform, anteriorly usually curved to the right (in ventral view) and thus often formed like a question mark. Contractile vacuole about in mid-body. Cortical granules lacking. Cytoplasm colourless. Adoral zone of membranelles about 55 % of body length. Buccal area very large, *Stylonychia mytilus*-like! Frontal and transverse cirri and buccal cirrus enlarged. Cirri of left and outer right marginal row rather closely arranged, inner right marginal row(s) (= retained parental rows) distinctly more widely spaced. Dorsal kineties 1–3 distinctly curved anteriorly. Invariably 3 very long caudal cirri on dorsal kineties 1, 2, and 4. Dorsal cilia about 2–4 µm long.

Nomenclature and taxonomy: The name *Coniculostomum* was mentioned for the first time in NJINE (1977). Because it was published without sufficient descriptive information to satisfy the criteria of availability, it has to be considered a nomen nudum (ICZN 1985). *Coniculostomum* was mentioned, for the second time, in the thesis by NJINE (1978) and, finally, NJINE (1979) published it in the Protistologica. Therefore I assume that his thesis is unpublished and does not constitute a publication according to Article 9 of the ICZN (1985). Thus, 1979, and not 1978, as supposed by TUFFRAU (1979, 1987), is the correct date of publication. The problem is complicated somewhat further since JANKOWSKI (1979) created the subgenus *Laurentiella (Laurosticha)* to include the same species. JANKOWSKI informed me that his paper was published on September 17, 1979. Both JANKOWSKI (pers. comm.) and I wrote to the publishers of the “Protistologica” asking for the exact date of publication of vol. 15, fasc. 3 of this journal. Regrettably, we never re-

ceived a reply, so that I could not finally clarify priority. However, in agreement with other authors, I (preliminarily) consider *Coniculostomum* as the senior synonym. Incorrect subsequent spellings: *Conicyclostomum* NJINÉ, 1979 (HEMBERGER 1982, p 275); *Cuniculostomum monilata* (DRAGESCO 1985); *Lautosticha* (DRAGESCO & DRAGESCO-KERNÉIS 1986, p 455).

The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of patterns, see chapter 2 in the general section. Previously, *Coniculostomum monilata* was classified in the Holostichidae, especially because of the longitudinal cirral rows (DRAGESCO & DRAGESCO-KERNÉIS 1986, DRAGESCO & NJINE 1971, TUFFRAU 1979, 1987). HEMBERGER (1982, p 223; unpublished thesis) proposed a classification within the oxytrichid taxon *Pleurotricha* (*P. monilata* is thus an unpublished combination), which has, however, no caudal cirri. Furthermore, in *Pleurotricha* the cirri of all right marginal rows are nearly equally spaced (for example, Fig. 189e, h, i) due to a different morphogenesis (all marginal rows are new, that is, no parental right marginal rows are retained after division).

The oxytrichid lineage of *Coniculostomum* was fully recognised only recently by detailed morphogenetic studies (KAMRA & SAPRA 1989, 1990, KAMRA et al. 1994) showing several conspicuous morphological and morphogenetical synapomorphies with the *Stylo-nychia mytilus* complex (Fig. 25a; BERGER & FOISSNER 1997). Conversely, a classification within the amphisiellids (TUFFRAU & FLEURY 1994, p 141), the kahliellids (EIGNER 1995, p 363), or the parakahliellids (EIGNER 1997) is very likely artificial. According to EIGNER (1995), *C. monilata* is closely related to *Neogeneia* EIGNER, 1995, *Kahliella* CORLISS, 1960, *Engelmanniella* FOISSNER, 1982, and *Parakahliella* BERGER, FOISSNER & ADAM, 1985 because in all of these parental (old) cirral rows are retained after division. However, parallel evolution of this rather simple character (parental ciliature is not reabsorbed after division) is a much more parsimonious explanation than parallel evolution of the rather complicated 18 frontal-ventral-transverse cirral pattern (including identical morphogenesis!) together (!) with the fragmentation of dorsal kinety 3. Furthermore, amphisiellids and kahliellids are flexible, whereas *Coniculostomum* has a firm body. This character separates *Coniculostomum* also from the oxytrichids *Allotricha*, *Parurosoma*, and *Onychodromopsis*, which also have an increased number of marginal rows. Furthermore, *Coniculostomum* should not be confused with *Pleurotricha* (Fig. 189), which lacks caudal cirri and has two macronuclear nodules, or with *Laurentiella* (Fig. 196) and *Onychodromus* (Fig. 193–195), which do not have, among other things, the typical 18-cirri pattern.

Two species have been assigned to *Coniculostomum*, namely the type, *C. monilata* and *C. bimarginata*. The latter is very likely the junior synonym of *Pleurotricha indica*. Identification needs morphometric data, that is, protargol impregnated specimens.

Key to species

- 1 Usually more than 2 right marginal rows; dorsal kinety 4 not distinctly curved anteriorly, 5–7 dorsomarginal kineties (Fig. 168a, e, f, i) *C. monilata* (p 608)
- Usually 2, rarely 3 right marginal rows; dorsal kinety 4 distinctly curved anteriorly, 2–4 dorsomarginal kineties (Fig. 170a–d) *C. indica* (p 620)

Coniculostomum monilata (DRAGESCO & NJINE, 1971) NJINE, 1979 (Fig. 15a–t, 168a–z, 169a–h, Tables 4, 37)

- 1971 *Laurentia monilata* DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 124 (Fig. 168a, c, d, g, h).
- 1971 *Laurentiella monilata* DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 97.
- 1972 *Laurentiella monilata* DRAGESCO & NJINÉ – DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun, 9: 118.
- 1977 *Coniculostomum monilata* – NJINE, Annls Stn limnol. Besse, 11: 24 (see nomenclature of genus section).
- 1978 *Coniculostomum monilata* – NJINE, Dissertation, p 167 (unpublished, see nomenclature of genus section).
- 1979 *Coniculostomum monilata* – NJINE, Protistologica, 15: 353.
- 1979 *Laurentiella (Laurosticha) monilata* (DRAGESCO et NJINÉ, 1971) – JANKOWSKI, Trudy zool. Inst., Leningr., 86: 57.
- 1986 *Coniculostomum monilata* (DRAGESCO & NJINÉ, 1981) – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 456 (Fig. 168b).
- 1989 *Coniculostomum monilata* NJINÉ, 1979 – KAMRA & SAPRA, Int. Congr. Protozool., 8: 104.
- 1990 *Coniculostomum monilata* (DRAGESCO & NJINÉ, 1971) NJINÉ, 1978 – KAMRA & SAPRA, Europ. J. Protistol., 25: 264 (Fig. 168e, f, i–z, 169a–h).
- 1991 *Coniculostomum monilata* – KAMRA & SAPRA, Europ. J. Protistol., 27: 331 (Fig. 15a–t).

Nomenclature and taxonomy: Nomenclature, see relevant chapter in genus section. I do not agree with EIGNER (1995), who supposed synonymy of *C. monilata* and *C. bimarginata* (the latter is here classified as junior synonym of *C. indica*) because several characters show significant differences (see key and Table 37). Furthermore, KAMRA et al. (1994) reported reproductive isolation of *C. monilata* and *C. bimarginata*, that is, they did not conjugate. Comparison with other taxa (*Laurentiella*, *Onychodromus*), see *Coniculostomum* section.

Morphology and biology: Unfortunately no live size available; according to measurements of protargol impregnated material length of live specimens may vary between 250–350 µm; about 2.1 times as long as broad. Beads of macronucleus about

Fig. 168a–d *Coniculostomum monilata* (a, c, from DRAGESCO & NJINE 1971; b, from DRAGESCO & DRAGESCO-KERNÉIS 1986; d, after DRAGESCO & NJINE 1971 from DRAGESCO & DRAGESCO-KERNÉIS 1986. a–c, protargol impregnation; d, Feulgen stain). a, b) Ventral infraciliature, a = 295 µm, b = 280 µm. c) Ventral infraciliature of posterior part of cell. d) Different shapes of nuclear apparatus. CC = caudal cirri. →

Fig. 168i–k *Coniculostomum monilata* (from KAMRA & SAPRA 1990. i, j, protargol impregnation; k, Feulgen stain). i, j) Ventral and dorsal infraciliature. Because of the widely spaced cirri of the inner right (= parental) marginal rows, the typical oxytrichid 18 frontal-ventral-transverse cirral pattern is difficult to recognise. Arrowheads in (j) mark caudal cirri at end of dorsal kineties 1, 2, and 4. k) Nuclear apparatus in dorsal view. Ma = bead of the moniliform macronucleus, Mi = micronucleus; p 608.

10–16 μm long (Fig. 168a, d, k). Posterior part of paroral distinctly curved to the left and thus optically crossing endoral (Fig. 168a, e, i). Cirrus III/2 distinctly enlarged. Arrangement of frontal, ventral, and transverse cirri rather invariably as shown in Figure 168e, almost identical to in species of the *Stylonychia mytilus* complex (cp. with Fig. 149a, 150a). According to KAMRA & SAPRA (1990) usually 8, rarely 10 “frontal” cirri (comprising frontal, buccal, and frontoventral cirri; mean = 8.1; n = 20). Invariably 5 ventral (3

← **Fig. 168e–h** *Coniculostomum monilata* (e, f, from KAMRA & SAPRA 1990; g, h, from DRAGESCO & NJINE 1971. e–h, protargol impregnation). e) Ventral infraciliature, 287 μm . The 18 frontal, ventral, and transverse cirri are black. Arrow marks posterior transverse cirrus (cirrus V/I). f, h) Dorsal infraciliature, f = 255 μm , h = 340 μm . (f) is seen from the ventral side. Arrows denote outer dorsomarginal kinety. Kinety 4 is anteriorly more or less straight; an important difference to *C. indica*, where it is distinctly curved. g) Fibrillar system around a basal body pair. BC = buccal cirrus, CC = caudal cirri, e = endoral, FC = right frontal cirrus, p = paroral, PRVC = posterior pretransverse ventral cirrus, PVC = posterior postoral ventral cirrus, R1–R4 = right marginal rows 1–4, 1–4 = dorsal kineties 1–4; p 608.

Fig. 1681-o *Coniculostomum monilata* (from KAMRA & SAPRA 1990. l-o, ventral infracapitulum of morphogenetic stages, protargol impregnation). l, m) Very early stages, l = 330 μ m, m = 325 μ m, n = 345 μ m, o = 330 μ m. The 3 small arrows in (n) mark the 3 parental cirri which participate in primordia formation. MP = primordium of right marginal row of proter, OP = oral primordium; p 608.

Fig. 168p-s *Coniculostomum monilata* (from KAMRA & SAPRA 1990. p-s, ventral infracapitulum of morphogenetic stages, protargol impregnation). p, q) Middle stages, p = 310 µm, q = 335 µm. The arrows mark the primordia of the marginal rows. r, s) Late stages, r = 325 µm, s = 365 µm. Parental cirri white, new cirri black. DP = primordia of dorsomarginal kineties of proter; p 608.

Fig. 168t-x *Coniculostomum monilata* (from KAMRA & SAPRA 1990. t-x, ventral and dorsal infracapitulum of morphogenetic stages, protargol impregnation). t, u) Very late stages, t = 330 μ m, u = 310 μ m. v, w) Proter and opisthe, v = 155 μ m. x) Early stage of dorsal morphogenesis, 325 μ m; p 608.

Fig. 168y, z, 169a-c *Coniculostomum monilata* (from KAMRA & SAPRA 1990. y, z, a-c, dorsal infraciliature of morphogenetic stages, protargol impregnation). y, z, a) Middle, late, and very late stage, y = 340 μ m, z = 365 μ m, a = 345 μ m. Arrowheads in (y) mark the fragmentation site of dorsal kinety 3. b, c) Proter and opisthe, b = 165 μ m, c = 175 μ m. Arrowheads denote new inner dorsomarginal row. CC = caudal cirri, 1-4 = dorsal kineties 1-4; p 608.

Fig. 169d–h *Coniculostomum monilata* (from KAMRA & SAPRA 1990). Diagrams showing retention of right marginal rows and their fate during morphogenesis of cell division. **d**) A non-dividing cell with 4 rows (P1–P4). **e**) A single new row (N1) arises for each daughter cell. **f**) At cytokinesis, P4 is reabsorbed; P1–P3 are cleaved in the middle. **g**) Each of the 2 daughter cells shows 1 new (N1) and 3 retained parental (P1–P3) right marginal rows. **h**) Next generation; another new right marginal row (N2) is added and P3 will be resorbed. (**h**) shows same stage as (**e**); p 608.

postoral and 2 pretransverse) and usually 5, rarely 6 (mean = 5.1; n = 20) transverse cirri. Transverse cirrus V/I distinctly displaced posteriad (Fig. 168e, arrow). In total about 9–12 dorsal kineties. Between dorsal kinety 4 and the two outermost (= new) dorsomarginal kineties a rather variable (3–6) number of parental (= old) dorsomarginal kineties. Anterior end of dorsal kinety 4 not distinctly curved (Fig. 168f, h, j).

Cyst spherical, after protargol impregnation 76–94 μm across (mean = 86 μm , SD = 5.2 μm , $n = 10$); diameter of protoplast 52–63 μm (KAMRA & SAPRA 1991). Cyst wall made up of 4 layers, the ectocyst thrown into several folds making hexagonal patterns (Fig. 15a). For the morphogenetic process during excystment, see chapter 1:103 (general section) and Figures 15b–t.

M o r p h o g e n e s i s: This part of life cycle is described in great detail by KAMRA & SAPRA (1990). Cell division commences with the formation of an oral primordium in the proximity of the left transverse cirrus and occasionally even close to the next transverse cirrus (Fig. 168l, m). Some basal bodies in the anterior portion of the oral primordium proliferate to form the anlage I, which differentiates into the undulating membranes and the left frontal cirrus of the opisthe (Fig. 168n–p). The anterior portion of the parental paroral reorganises and forms the left frontal cirrus of the proter (Fig. 168o–q). The endoral also undergoes reorganisation (Fig. 168q). The parental adoral zone of membranelles is retained intact for the proter.

The origin of the frontal, ventral, and transverse primordia is shown in Table 4. Cirri III/2, IV/3, and V/4 are involved in streak formation, identically to in the species of the *Stylonychia mytilus* complex (Fig. 168n, Table 4). Cirri III/2 and V/4 remain partly retained until primordia differentiation begins (Fig. 168q).

Two primordia originate to the right of the anterior ends of the outer right and the left marginal row by disaggregation of 1, and sometimes 2 parental marginal cirri. Two more primordia arise similarly near mid-body (Fig. 168o–q). These 4 primordia form a new right and a new left marginal row for each filial product. The parental left marginal row is resorbed in a posteriad direction. The parental right marginal rows are retained. Their fate is depicted in Figures 169e–h. The parental outer right marginal row (P1 in Fig. 169d) simply takes up position 2 in the 2 daughter cells as the new row is formed to its right (Fig. 169e); the cirri in P1 move apart as the cell elongates and the row is equatorially cleaved during cytokinesis. Likewise, the other parental right marginal rows (P2 and P3 in Fig. 169d–h) are also reoriented to occupy the inner positions 3 and 4 respectively. The innermost parental right marginal row P4 may be partially or completely resorbed. Thus, the “new” marginal cirri formed during morphogenesis persist for 3–5 generations. For instance, a non-dividing cell possessing 4 right marginal rows actually has persistent ciliary structures of the previous 3 generations. Retention of parental (old) marginal cirri occurs also in kahliliids (BERGER & FOISSNER 1987a, EIGNER 1995), which is, however, very likely a typical case of parallel evolution.

Morphogenesis of dorsal kineties proceeds in *Coniculostomum* pattern (see character 23 in chapter 2 of general section). Briefly, kineties 1–4 show no peculiarities and divide according to the widely distributed *Oxytricha* pattern, that is, simple fragmentation of kinety 3 (Fig. 168x–z, 169a–c). Furthermore, similarly to in other oxytrichids, for example, *Stylonychia*, *Sterkiella*, two dorsomarginal kineties for each daughter cell arise right of the right marginal primordium (Fig. 168r, s). However, parental dorsomarginal kineties are retained in the post dividers, which is a peculiarity within the oxytrichids (Fig. 168z,

Table 37 Morphometric data of *Conicostomum indica* (ind, from AMMERMAN et al. 1987; bim, the synonym, *C. bimarginata*, from KAMRA et al. 1994) and *C. monilata* (mo1, from DRAGESCO & DRAGESCO-KERNÉIS 1986; mo2, from KAMRA & SAPRA 1990). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated. If only one value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD ⁷	CV	Min	Max	n
Body, length	bim	169.6	7.8	4.6	155	183	20
	mo1 ¹	-	-	-	210	300	9
	mo2	252.2	20.3	8.0	211	284	20
Body, width	bim	83.3	4.6	5.5	76	93	20
	mo1 ¹	-	-	-	115	141	9
	mo2	107.8	13.0	12.1	85	128	20
Adoral zone of membranelles, length	bim	89.6	3.6	4.0	84	98	20
	mo1 ²	164.0	-	-	-	-	1
	mo2	136.1	9.3	6.8	123	157	20
Adoral membranelles, number	bim	62.7	2.4	3.9	58	67	20
	ind	73.0	5	-	69	79	10
	mo1	-	-	-	78	104	?
	mo2	88.2	5.3	6.0	78	98	20
Left marginal row, number of cirri	bim	27.3	2.0	7.2	24	31	20
	ind	28.0	9	-	25	32	10
	mo1	-	-	-	30	44	?
	mo2	36.2	4.0	11.2	27	42	20
Right marginal rows, number	bim	2.3	0.5	20.4	2	3	20
	mo1 ³	-	-	-	4	5	?
	mo2	4.2	0.4	8.9	3	5	20
Right marginal row 1, number of cirri	bim	39.9	2.8	7.1	37	47	20
	ind	44.0	10	-	40	48	10
	mo1	47.0	-	-	25 ⁵	60	?
	mo2	56.2	4.7	8.3	48	65	20
Right marginal row 2, number of cirri ⁴	bim	10.3	1.6	15.1	7	13	20
	ind	15.0	10	-	13	16	10
	mo1	-	-	-	11	51	?
	mo2	28.2	10.4	37.0	17	50	20
Right marginal row 3, number of cirri ⁴	bim	0.6	1.0	174.4	0	3	20
	mo1	-	-	-	5	27	?
	mo2	11.8	4.8	40.6	5	24	20
Right marginal row 4, number of cirri ⁴	mo1	-	-	-	2	12	?
	mo2	4.1	2.2	59.2	0	9	20
Right marginal row 5, number of cirri ⁴	mo1	-	-	-	0	5	?
	mo2	0.3	0.7	288.0	0	3	20
Macronucleus, number of beads	bim	8.1	0.7	8.5	7	10	20
	ind	-	-	-	2	6	?
	mo1	-	-	-	9	16	?
	mo2	12.9	2.0	15.6	9	18	20
Micronuclei, number	ind	6.0	26	-	3	10	10
	mo1	-	-	-	3	6	?
	mo2	4.5	1.6	36.2	2	8	20

Table 37 Continued

Character	Species	mean	SD ⁷	CV	Min	Max	n
Micronuclei, diameter	ind	3.0	-	-	-	-	?
	mo1	-	-	-	4	6	?
	mo2	5.5	0.4	7.7	5	6	20
Dorsal kineties, number	bim	4.0	0	0	4	4	20
	ind	4.0	-	-	-	-	?
	mo2	4.0	0	0	4	4	10
Dorsomarginal kineties, number	bim	3.1	0.9	28.2	2	4	10
	ind	2.0	-	-	-	-	?
	mo2	6.0	0.8	13.7	5	7	10
Dorsal kinety 1, number of basal body pairs ⁶	bim	72.8	4.7	6.4	63	81	10
	ind	68.0	12.0	-	60	79	5
	mo2	102.4	19.1	8.9	88	115	10
Dorsal kinety 2, number of basal body pairs ⁶	bim	59.6	4.0	6.7	54	65	10
	ind	57.0	16.0	-	42	60	5
	mo2	75.4	7.8	10.3	65	86	10
Dorsal kinety 3, number of basal body pairs ⁶	bim	46.6	3.1	6.6	42	51	10
	ind	49.0	12.0	-	41	58	5
	mo2	58.8	4.2	7.2	51	66	10
Dorsal kinety 4, number of basal body pairs ⁶	bim	39.3	5.0	12.7	32	47	10
	ind	31.0	16.0	-	26	39	5
	mo2	52.5	5.7	10.9	45	61	10
Dorsomarginal kinety 1, number of basal body pairs ⁶	bim	21.8	2.9	13.1	18	26	10
	ind	18.0	22.0	-	12	21	5
	mo2	20.2	4.1	20.5	14	26	10
Dorsomarginal kinety 2, number of basal body pairs ⁶	bim	39.8	2.9	7.3	36	44	10
	ind	35.0	14.0	-	31	44	5
	mo2	36.0	4.9	13.7	27	44	10
Dorsomarginal kinety 3, number of basal body pairs ⁶	bim	7.1	5.4	75.8	0	14	10
	mo2	16.4	8.0	48.6	7	29	10
Dorsomarginal kinety 4, number of basal body pairs ⁶	bim	2.0	2.7	133.3	0	6	10
	mo2	17.5	5.8	33.1	6	25	10
Dorsomarginal kinety 5, number of basal body pairs ⁶	mo2	6.9	5.1	73.8	2	20	10
Dorsomarginal kinety 6, number of basal body pairs ⁶	mo2	3.6	3.0	81.9	0	9	10
Dorsomarginal kinety 7, number of basal body pairs ⁶	mo2	1.1	1.8	162.7	0	4	10

¹ Population from Benin.² From Figure 168a.³ From DRAGESCO & NJINÉ (1971). Row "V₅" in DRAGESCO & DRAGESCO-KERNÉIS (1986) is likely a ventral cirrus.⁴ For designation of right marginal rows, see Figure 168e.⁵ This value is from DRAGESCO & NJINÉ (1971). DRAGESCO & DRAGESCO-KERNÉIS (1986) gave (erroneously?) 11 as minimum value.⁶ For designation of dorsal kineties and dorsomarginal kineties, see Figures 168f, h and 170h. Dorsomarginal kinety 1 in *Coniculostomum monilata* is the outer one. In Table 1 of KAMRA et al. (1994) the values of dorsomarginal kineties 1 and 2 are confused.⁷ In *Coniculostomum indica* the standard deviation is given in %.

169a–c). The row(s) arranged closest to dorsal kinety 4 is (are) resorbed during morphogenesis.

KAMRA & SAPRA (1990) also described morphogenesis of reorganisation, which is in many ways similar to that of division. However, the two outermost right marginal rows of a newly reorganised cell have about the same number of cirri because there is no cellular elongation associated with reorganisation. This explains why some non-dividing cells have adjacent rows with equally spaced cirri.

Occurrence and ecology: Rather certainly confined to limnetic habitats and possibly common in tropical Africa and Asia. Locus classicus is a wheel-track near the La Méfou River, Cameroon (DRAGESCO & NJINE 1971). DRAGESCO (1972) recorded *Coniculostomum monilata* from Uganda and DRAGESCO & DRAGESCO-KERNÉIS (1986) from Benin. KAMRA & SAPRA (1990) isolated *C. monilata* from freshwater near Delhi, India. Feeds also on *Arcella* sp. (DRAGESCO 1972). Cultures can be maintained at 23 °C in Pringsheim medium and with *Chlorogonium elongatum* as food (KAMRA & SAPRA 1990). Biomass of 10⁶ individuals about 1000 mg. NJINE (1977) found *C. monilata* at 23–26 °C with a frequency of 36 % in a temporary pond in Cameroon.

***Coniculostomum indica* (AMMERMAN, SAPRA & SCHLEGEL, 1987) comb. nov.**
(Fig. 170a–j, 171a–c, Table 37)

1987 *Pleurotricha indica* AMMERMAN, SAPRA & SCHLEGEL, J. Protozool., 34: 31 (Fig. 170a–j; the slide of holotype material is deposited in the Zoological Collection of the University of Tuebingen, Germany).

1994 *Coniculostomum bimarginata* KAMRA, SAPRA & AMMERMAN, Europ. J. Protistol., 30: 55 (Fig. 171a–c; new synonym; the holotype, that is a slide with protargol impregnated cells of a clone is deposited in the British Natural History Museum, London, accession number 1993:8:10:1).

Taxonomy: *Pleurotricha indica* has caudal cirri so that the classification in *Pleurotricha*, which lacks such cirri, is incorrect. The cirri of the inner right marginal row are distinctly more widely spaced than those of the outer row (Fig. 170b, c, e, g), strongly indicating that it belongs to *Coniculostomum*. KAMRA et al. (1994) emphasised the validity of both *P. indica* and *Coniculostomum bimarginata*; however, they omitted to transfer *P. indica* to *Coniculostomum*, which is hereby undertaken. They quoted the cell size, the number of adoral membranelles, and the number of beads in the macronucleus as main differences, stressing that these are definitely not due to culture conditions or age factors because both species were grown under identical laboratory conditions (Table 37). Conversely, I assume that these and other differences (for example, lack of parental dorso-marginal kineties in *Pleurotricha indica*) are too indistinct for species separation. Furthermore, both taxa were discovered in the same locality. The only significant difference is the higher number of frontal-ventral-transverse cirri streaks in *P. indica* (7 against 6 in other oxytrichids; Fig. 170f). However, KAMRA et al. (1994) found reorganisers of *P. indica* in the type slides showing unambiguously only 6 frontal-ventral-transverse cirri

Fig. 170a-f *Coniculostomum indica* (from AMMERMAN et al. 1987; f, schematic redrawing from Fig. 170g, original. a, from life?; b-e, protargol impregnation). a) Ventral view, 235 μ m. b, d) Ventral and dorsal infraciliature of a representative specimen, 215 μ m. Dorsal kinety 4 (arrowhead) is distinctly curved anteriorly; an important difference to *C. monilata*. c, e) Ventral infraciliature of "aberrant" specimens, c, e = 215 μ m. f) Presumed origin of the frontal-ventral-transverse cirri. Cirri which originate from the same streak are connected by a broken line. The arrowhead marks that streak which is very probably lacking in the synonym, *C. bimarginata* and in the type species, *C. monilata*; p 620.

Fig. 171a-c *Coniculostomum indica* (from KAMRA et al. 1994. a, after live observation, protargol impregnation, and Feulgen stain; b, c, protargol impregnation). a) Ventral view, 145 µm. b, c) Ventral and dorsal infra-ciliature, 165 µm. Arrows mark marginal rows. Arrowheads mark inner (= parental) dorsomarginal kineties. CC = caudal cirri, e = endoral, p = paroral, 1-4 = dorsal kineties 1-4; p 620.

streaks (Fig. 32, 33 in KAMRA et al. 1994). Because of these uncertainties, I provide both descriptions separately. Reinvestigation of further populations recommended to check variability of these characters.

Morphology and biology: Slightly starved cells of “*Pleurotricha indica*” in life $220 \times 119 \mu\text{m}$ ($\pm 15\%$ standard deviation; Table 37). Micronuclei about $3 \mu\text{m}$

← Fig. 170g-j *Coniculostomum indica* (from AMMERMAN et al. 1987. g, h, scanning electron micrographs; i, j, protargol impregnation). g, h) Ventral and dorsal view. Arrows mark inner right marginal row (= right marginal row 2 of Table 37). i, j) Variability of moniliform macronucleus. CC = caudal cirri, 1-6 = dorsal kineties 1-6 (kinety 6 is identical with dorsomarginal kinety 1 of Table 37); p 620.

across. Rarely specimens with more than 1 left marginal row (Fig. 170e). One supernumerary frontal-ventral-transverse streak, making ventral ciliature somewhat deviating from typical 18-cirri pattern (Fig. 170a–c, e, f); see, however, taxonomy for further details. No parental dorsomarginal kineties? Dorsal kinety 6 (= outer dorsomarginal kinety) distinctly shortened at both ends (Fig. 170d, h). Rarely 5 caudal cirri. See STEINBRÜCK (1990) for the molecular biology of some macronuclear genes.

Average size of non-dividers of "*C. bimarginata*" $167.3 \times 84.1 \mu\text{m}$ (from protargol stained G₁ cells after complete growth; Table 37). Eight macronuclear beads in 80–85 % of cells. Rarely additional ventral and/or transverse cirri and occasionally 1 or 2 supernumerary frontal cirri. Usually 2 right marginal rows, rarely a third right row with distinctly reduced number of cirri.

Morphogenesis of cell division of the synonym, *C. bimarginata* proceeds essentially similarly to that in *C. monilata*. For a detailed description and documentation, see KAMRA et al. (1994). SAPRA et al. (1985) characterised the gene sized DNA molecules (designated as *Pleurotricha* sp.).

Occurrence and ecology: Locus classicus of both "*Pleurotricha indica*" (collected on February 26, 1984) and its synonym, "*Coniculostomum bimarginata*" (collected on March 1991) are marshes in Keoladeo Ghana Bird Sanctuary, Bharatpur, Rajasthan, India (lat 27°15'N, long 77°30'E). Although these waters dry out during summer AMMERMAN et al. (1987) could not observe any cyst formation; furthermore, they found no stages of sexual reproduction in their cultures, which were maintained at 23 °C in Pringsheim solution with *Chlorogonium elongatum* as food. Generation time under laboratory conditions about 10 h (AMMERMAN et al. 1987) and 9 h (KAMRA et al. 1994).

Steinia DIESING, 1866

- 1866 *Steinia* DIESING, Sber. Akad. Wiss. Wien, 52: 520 – Type (by subsequent designation, FOISSNER 1989, p 235): *Oxytricha platystoma* EHRENBURG, 1831.
- 1866 *Steinia* DIESING – DIESING, Sber. Akad. Wiss. Wien, 53: 113.
- 1932 *Steinia* DIESING, 1866 – KAHL, Tierwelt Dtl., 25: 611 (in part).
- 1986 *Steinia* DIESING, 1866 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 477, in part (incorrect date).
- 1989 *Steinia* DIESING, 1866 – FOISSNER, Sber. öst. Akad. Wiss., 196: 235.
- 1997 *Steinia* DIESING, 1866 – BERGER & FOISSNER, Arch. Protistenk., 148: 150.

Characterisation: Undulating membranes in *Steinia* pattern. One right and 1 left row of marginal cirri, separate posteriorly. Caudal cirri present. Six dorsal kineties. Primordia V and VI of the proter and opisthe originate from postoral ventral cirrus V/4. Dorsal morphogenesis in *Oxytricha* pattern.

Additional characters: Right body margin convex, left straight, margins usually converging posteriorly. Anterior end broadly, posterior narrowly rounded. Flattened

about 2:1 dorso-ventrally. Body firm. Two ellipsoidal macronuclear nodules. Contractile vacuole in about mid-body or slightly in front of it. Cortical granules absent, pellicle colourless. Cytoplasm colourless or yellowish, usually with numerous greasily shining globules and cytoplasmic crystals. Detailed description of large buccal area, see *S. sphagnicola*. Left and middle frontal cirrus about at same level, right frontal cirrus displaced posteriorly. Posterior-most 2 frontoventral cirri (cirri III/2 and IV/3) located at about same level. Dorsal cilia 2–4 µm long. Resting cysts with spines (*S. bivacuolata?*). Probably confined to lentic or slow flowing waters.

Nomenclature and taxonomy: KAHL (1932) classified *Steinia* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Steinia)*. Incorrect subsequent spellings: *Steina* DIESING, 1866 (JANKOWSKI 1979, p 65); *Steina platystoma* (GROLIÈRE 1978, p 309).

The correct date of publication is 1866 because “Band 52, Jahrgang 1865, Heft VI bis X of the Sitzungsberichte” was only published in 1866. DIESING (1866a) did not include any species in *Steinia*. Somewhat later he made two new combinations, namely *S. platystoma* and *S. ferruginea* but did not fix a type (DIESING 1866b). Type fixation was also omitted by later workers (FROMENTEL 1875, 1876, KAHL 1932) or *Steinia* was included in *Oxytricha* (for example, BORROR 1972a, BÜTSCHLI 1889, JANKOWSKI 1979, KENT 1882). Unfortunately, BORROR (1972a) proposed *O. platystoma* as type of *Oxytricha*. FOISSNER (1989) thus clarified the confused situation definitively in that he fixed *Oxytricha granulifera* as type of *Oxytricha* and *O. platystoma* as type of the reactivated *Steinia*. Most species originally assigned to *Oxytricha (Steinia)* or *Steinia* do not have a fragmented endoral and a pit in the buccal area; FOISSNER (1989) thus transferred them to *Cyrtohymena*.

The characterisation is according to BERGER & FOISSNER (1997). See chapter 2 in the general section for detailed explanation of patterns. Morphogenesis of *S. sphagnicola* revealed that *Steinia* is very likely the sister group of *Stylonychia mytilus* and *Conicostomum* (Fig. 25a, Table 4). The strange fragmentation of the endoral in *Steinia* is one of the most impressive autapomorphies within the oxytrichids. Furthermore, all species have a conspicuous cavity (pit) at the anterior end of the buccal area so that *Steinia* species can be separated by accurate live observation from *Cyrtohymena* and *Notohymena* species, which usually also have large, anteriorly curved, and deep buccal areas. Furthermore, *Cyrtohymena* and *Notohymena* have a flexible body (see, however, *Cyrtohymena*) and (often) cortical granules and thus belong to the Oxytrichinae.

Key to species

Remarks: See also *Cyrtohymena inquieta* (Fig. 101a, b).

- 1 Transverse cirri arranged in 2 distinctly separate groups (Fig. 173a, c, k, 174k) ...
 S. sphagnicola (p 632)

- Transverse cirri not arranged in 2 groups (for example, Fig. 172k) 2
- 2 5 transverse cirri (Fig. 172c–n) *S. platystoma* (p 626)
- Usually only 4 transverse cirri (Fig. 175a, b) *S. bivacuolata* (p 641)

***Steinia platystoma* (EHRENBERG, 1831) DIESING, 1866 (Fig. 172a–r, Table 38)**

- 1831 *Oxytricha platystoma* EHRENBERG, Abh. preuss. Akad. Wiss., year 1831: 118 (no figure).
 1838 *Oxytricha platystoma* – EHRENBERG, Infusionsthierchen, p 365 (Fig. 172f–h).
 1838 *Oxytricha eurystoma* – EHRENBERG, Infusionsthierchen, p 365, legend to Tafel XLI (junior objective synonym).
 1859 *Oxytricha platystoma*. EHRBG. – STEIN, Organismus der Infusionsthier I, p 190; in part: Tafel XII, Fig. 17, 19, 20 (Fig. 172i, j); not Tafel XII, Fig. 16, 18.
 1866 *Steinia platystoma* DIESING – DIESING, Sber. Akad. Wiss. Wien, 53: 114.
 1906 *Oxytricha platystoma* EHR. – EDMONDSON, Proc. Davenport Acad. Sci., 11: 100 (Fig. 172r).
 1932 *Steinia (Oxytricha) platystoma* EHRB.-STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 612 (Fig. 172a–d).
 1953 *Steinia platystoma* EHRENBERG-STEIN (1859) – JIROVEC, WENIG, FOTT, BARTOŠ, WEISER & ŠRAMEK-HUŠEK, Protozoologie, p 511, 513 (Fig. 172p).
 1955 *Steinia platystoma* – BARWICK, BEVERIDGE, BRAZIER, CLOSE, HIRSCHFELD, PILLAI, RAMSAY, ROBINSON, STEVENS & TODD, Tuatara, 5: 96 (Fig. 172e).
 1969 *Steinia platystoma* – GROLIERE, Annls Stn limnol. Besse, 4: 343 (Fig. 172k–o).
 1971 *Steinia platystoma* KAHL – CHARDEZ, Revue verviét. Hist. nat., 28: 38 (Fig. 172q).
 1991 *Steinia platystoma* (EHRENBERG, 1831) DIESING, 1866 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 336.

Nomenclature and taxonomy: EHRENBERG (1838) wrote that he discovered this species on January 23, 1832. However, accepting the decision of CORLISS (1979, p 371) to date the original description with 1831, I cite this year after the binomen. EHRENBERG (1831) described *O. platystoma* on p 118 and not on p 111 as erroneously written in the list of synonyms in EHRENBERG (1838). KAHL (1932) classified *Steinia* only as subgenus of *Oxytricha*; the correct name in his revision is thus *O. (Steinia) platystoma*. Incorrect subsequent spellings: *Oxytricha plastystoma* EHRENBERG, 1830 (JANKOWSKI 1979, p 65); *Oxytricha platysoma* EHRBG. (DIXON 1937, p 450); *Steinia platysoma* EHRENBERG (BAMFORTH 1963, p 134); *S. platyitoma* (DRAGESCO 1970, p 121). Obviously erroneously, FOISSNER & FOISSNER (1988, p 91) stated an incorrect subsequent spelling by KALTENBACH (1960, p 172).

As already remarked by STEIN (1859b), *S. platystoma* is so insufficiently described by EHRENBERG (1831, 1838) that any identification must be provisional. I thus agree with FOISSNER (1989) that the redescrptions by STEIN (1859b), who mixed it up with *Cyrtolymena inquieta* (see Fig. 100a, b), and KAHL (1932) are authoritative. Both STEIN and KAHL draw transverse cirri which are not arranged in 2 distinctly separated groups. This

Fig. 172a–j *Steinia platystoma* (a–d, from KAHL 1932; e, from BARWICK et al. 1955; f–h, after EHRENBERG → 1838; i, j, after STEIN 1859b. a–j, from life). a, b) Buccal area in ventral view and in cross section. c, d) Ventral view of a slender and a short specimen, c = 160 µm, d = 120 µm. e) Ventral view, 102 µm. f–j) Dorsal and ventral views, f–h = 105 µm, i, j = about 150 µm. BC = buccal cirrus, e = endoral, G = cavity.

Fig. 172k-n *Steintia platystoma* (from GROLIERE 1969. k-n, ventral infraciliature after protargol impregnation, sizes not indicated). k) Non-dividing specimen. Arrow marks frontoventral cirrus III/2 which is arranged more posteriorly than all other frontoventral cirri. l-n) Early morphogenetic stages (reinvestigation necessary); p 626.

Fig. 172o–r *Steinia platystoma* (o, from GROLIERE 1969; p, from JIROVEC et al. 1953; q, from CHARDEZ 1971; r, from EDMONDSON 1906. o, protargol impregnation; p–r, from life). o) Buccal area. Arrowheads mark fragmented endoral. p–r) Ventral views, p = 100 μ m, q = 115 μ m, r = 140 μ m. G = cavity; p. 626.

difference to *S. sphagnicola* is confirmed by GROLIERE (1969) on protargol impregnated material. The DRAGESCO (1970) population is probably not conspecific with *S. platystoma* because he draws neither a cavity and a helical structure in the anterior part of the buccal area nor a fragmented endoral. Furthermore, the arrangement of the frontoventral cirri deviates. In my opinion, DRAGESCO's (1970) population is identical with *Cyrtohymena primicirrata* (Fig. 98h–j). *Oxytricha platystoma* sensu ROUX (1901; Fig. 101e) and sensu BUITKAMP (1977b; Fig. 99j) are classified as *Cyrtohymena aestuari* and *C. candens* respectively. *Oxytricha platystoma* sensu GU & ZHANG (1992) is very likely *Cyrtohymena inquieta*. The HORVÁTH (1933) population is rather surely identical with *Histiculus histrio* (Fig. 177m', n). The redescrptions by FROMENTEL (1875), DUMAS (1929, Fig. 236e), and BIERNACKA (1959; Fig. 225s) are insufficient. A redescription of *S. platystoma* must comprise a morphometric characterisation and an illustration of the dorsal infraciliature.

M o r p h o l o g y a n d b i o l o g y: After EHRENBURG (1831, 1838) in life about 105 μm long, after STEIN (1859b) about 150 μm , after KAHL (1932) 80–130 μm . According to GROLIÈRE (1969) after protargol impregnation 110–170 μm long (mean = 150 μm ; $n = 100$). About 2–2.5 times as long as broad. Macronuclear nodules after protargol impregnation $30\text{--}40 \times 15\text{--}20 \mu\text{m}$. Two micronuclei, 10 μm across on average (GROLIÈRE 1969). Cytoplasm yellowish. Cytopyge slightly subterminally on left body margin. Swims about $520 \mu\text{m s}^{-1}$ (BULLINGTON 1925).

Adoral zone of membranelles about 40 % of body length, consists of about 42–45 membranelles (Fig. 172o). Frontoventral cirrus III/2 somewhat behind level of frontoventral cirrus IV/3 (Fig. 172k, arrow). Two rightmost transverse cirri (cirri V/1 and VI/1) protrude about 2/3 beyond posterior end of cell; left transverse cirri not (STEIN 1859b) to distinctly (KAHL 1932) protruding. About 22 right and 17 left marginal cirri.

Very likely, the formation of the oral primordium commences near the left transverse cirrus (Fig. 172l–n). CHAKRABORTY (1967) studied the macronuclear organisation and the ultrastructure of "*Oxytricha platystoma*". The microphotographs and the locality (lettuce leaves!), however, do not support his identification.

O c c u r r e n c e a n d e c o l o g y: Rare, but if present then usually abundant and persistent in stagnant (especially peat-bogs) and running waters (KAHL 1932). Probably cosmopolitan.

Locus classicus is a marsh near Berlin, Germany (EHRENBURG 1831, 1838). Records documented by illustrations: freshwater in the Ardennes, Belgium (CHARDEZ 1971); marshy meadow in Tharandt near Dresden, Germany, marshy ditch near Prague and village of Wirschowitz (Czechoslovakia) in a brook on sites choked with mud (STEIN 1859b); running waters in Czechoslovakia (JÍROVEC et al. 1953); forest pond in France (GROLIÈRE 1969); freshwater in Iowa, USA (EDMONDSON 1906); New Zealand (BARWICK et al. 1955).

Records from freshwater habitats not substantiated by illustrations: oxbow of Danube River in Vienna, Austria (FOISSNER & FOISSNER 1988, HELD 1937); ditch, brook, rivers, wet meadow, and fish pond in Bulgaria (DETCHEVA 1979b, 1993, DETSCHEVA 1972, RUSSEV et al. 1976); rain puddle near Brunn, Czechoslovakia (SPANDL 1926a); pond and wet mosses in Czechoslovakia (HASSDENTEUFELOVÁ-MORAVCOVÁ 1955, TIRJAKOVÁ & MATIS 1987a); creek in England (WHITELEGGE 1889); infusion of willow branches, Estonia (JACOBSON 1928); peat-bog in France (GROLIÈRE 1977, 1978); lentic water and Schussen River, Germany (SCHMIDT 1916, WETZEL 1928a); Danube River and other sites in Hungary (BERCZIK 1966, KREPUSKA 1917, 1930); spring in Italy (STELLA 1947); lake in Italy during July (LONGHI 1895); with low abundance in a beta- to alphamesosaprobic brook, up to 32 000 ind. l^{-1} in an alphameso- to polysaprobic water course of the Val Parma, and in other running waters in northern Italy (MADONI 1980, 1983, 1984, MADONI & GHETTI 1977, 1980); Poland (JAWOROWSKI 1893, WRZESNIEWSKIEGO 1866); rare in mud infusions from the Danube River in Romania and in wells (SPANDL 1926a–c); Sweden (QUENNERSTEDT 1869); between *Sphagnum* in alpine bogs (up to 1900 m above sea level) in

Switzerland (HEINIS 1945, MESSIKOMMER 1954; further records from Switzerland: ANDRÉ 1912, 1916, BOURQUIN-LINDT 1919, MERMOD 1914, PERTY 1849a, 1852b, SAKOWSKY-CAMPIONI 1906, THIÉBAUD 1906, WOLFF 1948); USSR (WEISSE 1848a, b); Canada (PUYTORAC et al. 1972); well in Yugoslavia (KARAMAN 1935); abundant in a three months old culture of floating *Spirogyra* from Lake Mirror, Ohio, USA (SHAWHAN et al. 1947, STEHLE 1920); between detritus at the bottom of shallow pools in Trenton, New Jersey, USA (STOKES 1884; = locus classicus of *Trachelophyllum tachyblastum*); South Eastern Louisiana, USA (BAMFORTH 1963); up to 3400 ind. l⁻¹ in a Pennsylvanian pond (USA) from August to September (WANG 1928); Brazil (CUNHA 1913, 1916).

Records from terrestrial habitats are unreliable; very likely it was confused with *Cyrtohymena* species which are common in soil and mosses (for example, DAWSON & MITCHELL 1929, DECHEVA 1970, DETCHEVA 1972b, DIXON 1937, TIRJAKOVÁ & MATIS 1987a). FOISSNER (1987a) listed the record by BUITKAMP (1977b), a population which is likely identical with *Cyrtohymena candens*.

Feeds on algae (diatoms), flagellates, and small ciliates. GROLIÈRE (1969) cultured *Steinia platystoma* in Eau d'Evian with *Chlamydomonas* sp. as food. Biomass of 10⁶ individuals about 75 mg (FOISSNER et al. 1991).

DETCHEVA (1972a, 1975c) found *Steinia platystoma* in the Ogosta River, Bulgaria, under the following conditions: frequency 1.8 %, pH 7.7, 12.7 mg l⁻¹ O₂ (100 % saturation), 5 mg l⁻¹ BOD₅, 4 mg l⁻¹ NH₃, 11.7 mg l⁻¹ NO₃⁻-N, 0.04 mg l⁻¹ NO₂⁻-N, 0.12 mg l⁻¹ Fe²⁺. GROLIÈRE & NJINE (1973) counted about 3000 ind. l⁻¹ in a French peat-bog in May under following conditions: 13 °C, pH 5.0, 1.5 mg l⁻¹ O₂ (15 % saturation), 0.033 mg l⁻¹ PO₄³⁻-P, 0.77 mg l⁻¹ NH₄⁺-N, 3.2 mg l⁻¹ NO₃⁻-N. MADONI & GHETTI (1981a) found it occasionally in three alphamesosaprobic to polysaprobic sites of the Torrente Stirone, northern Italy, at 3.8–19 °C, pH 7.4–8.5, 26–1094 mg l⁻¹ Cl⁻, 6.0–12.1 mg l⁻¹ O₂, 22–71 mg l⁻¹ COD, 0.5–3.7 mg l⁻¹ NH₃, 0.03–2.2 mg l⁻¹ NO₂⁻-N, 0.5–2.6 mg l⁻¹ NO₃⁻-N, 0.22 to 1.40 mg l⁻¹ PO₄³⁻-P. Hydrogen sulphide is not tolerated (WETZEL 1928b). MÜCKE (1979) counted 28 000 ind. l⁻¹ in a *Sphagnum*-pond in Germany; when the pond began to dry up in late August the abundance briefly increased to 1.4 × 10⁶ ind. l⁻¹; in moist *Sphagnum* 84 000 ind. l⁻¹ were present. STATKEWITSCH (1904) studied the effect of electrical current on *Steinia platystoma*.

Steinia platystoma indicates beta- to alphamesosaprobic conditions of water quality (b-a; b = 6, a = 4, I = 3, SI = 2.4; SLÁDEČEK et al. 1981, WEGL 1983, FOISSNER 1988a). This classification deviates somewhat from the statement by KAHL (1932) that it occurs only in rather putrescent waters. The autecological data by GROLIÈRE & NJINE (1973) and MADONI & GHETTI (1977, 1981a) also indicate that it obviously prefers lower quality sites (15 % O₂ saturation!, 22–71 mg l⁻¹ COD, alphameso- to polysaprobic conditions). Thus, the saprobic classification has to be verified on reliably determined populations (FOISSNER et al. 1991).

Steinia sphagnicola FOISSNER, 1989 (Fig. 14b, 20f, 21f, 22b, 173a–y, 174a–k, Tables 3, 4, 38)

- 1986 *Steinia platystoma* (EHRENBERG-STEIN, 1859) – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 479; in part: Planche 142, Fig. E; not Fig. A–D (misidentification; Fig. 173k).
 1989 *Steinia sphagnicola* FOISSNER, Sber. öst. Akad. Wiss., 196: 235 (Fig. 173a–i; 1 slide of holotype specimens and 3 slides of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
 1994 *Steinia sphagnicola* – FOISSNER, PETZ, UNTERWEGER, HERZOG, SIMONSBERGER, KRAUTGARTNER & ZANKL, Katalog des Oberösterreichischen Landesmuseums Linz, 71: 109 (colour-microphotograph of a protargol-impregnated specimen).
 1996 *Steinia sphagnicola* FOISSNER, 1989 – VOSS & FOISSNER, Europ. J. Protistol., 32: 31 (Fig. 173j–y, 174a–j).

Nomenclature and taxonomy: AESCHT (1994, p 50) mentioned this species, obviously erroneously, under the binomen “*Cyrtohymena sphagnicola* (FOISSNER, 1989)”. DRAGESCO & DRAGESCO-KERNÉIS (1986) mixed up three species, namely *Cyrtohymena primicirrata*, *Steinia platystoma*, and *S. sphagnicola*. The latter two can be separated unequivocally by the different arrangement of the transverse cirri. According to EIGNER (1997), *Steinia sphagnicola* belongs to the Parakahliellidae (details on this classification, see Addendum 3).

Morphology and biology: In life about $130\text{--}160 \times 50\text{--}80\ \mu\text{m}$ (FOISSNER 1989), cultured population from Germany $160 \times 80\ \mu\text{m}$ (VOSS & FOISSNER 1996). Elliptical, ventral surface flat, dorsal side distinctly arched. Contractile vacuole with conspicuous canals during diastole. Pellicle fragile, many specimens break during impregnation. Movement moderately rapid.

Adoral zone of membranelles about 50 % of body length, distance between membranelles conspicuously large (about $2\ \mu\text{m}$). Buccal area broad and deep, that is, extending almost to dorsal surface (Fig. 173e, f, i, l), distal portion semicircularly curved to left and spirally rolled up to form peculiar circular cavity (pit) also extending to dorsal surface, so that it appears very bright at low magnification. Function of cavity unknown, neither in life nor after protargol impregnation any specific structure recognisable. Paroral less distinctly curved than buccal area, commences left of left frontal cirrus and extends left of narrow ridge (buccal lip) to proximal fifth of adoral zone of membranelles, made of zigzagging basal bodies; cilia $25\ \mu\text{m}$ long, forming a conspicuous membrane (Fig. 173e, f). At distal end of this lip an elliptical orifice leading into the cavity (Fig. 173f, l). Endoral sinusoidal and fragmented (!), made up of a single row of basal bodies, commences about at same level as paroral but terminates more posteriorly, namely near proximal end of adoral zone of membranelles; cilia of anterior-most fragment in life about $17\ \mu\text{m}$ long, beat into cavity; cilia of small fragments about $5\ \mu\text{m}$, cilia of posterior-most and longest fragment about $10\ \mu\text{m}$ long; from each fragment a strong bundle of fibres extends rightward to centre of bow formed by paroral (Fig. 173i, l).

Fig. 173a-d *Steinia sphagnicola* (from FOISSNER 1989. a, b, from life; c, d, protargol impregnation). a, b = 155 μ m. c, d) Ventral and dorsal infraciliature, 140 μ m. Arrow marks posterior postoral ventral cirrus (cirrus V/3). Note the curious arrangement of the transverse cirri. e = fragmented endoral, G = cavity (function unknown), p = paroral, PRVC = right pretransverse ventral cirrus, TCl, TCr = left and right transverse cirrus, 1-6 = dorsal kineties 1-6; p 632.

Fig. 173j, k *Steinia sphagnicola* (from Voss & FOISSNER 1996. j, scanning electron micrograph; k, protargol impregnation). Ventral views, bar = 50 µm. The right half of the buccal field is covered by the cilia of the paroral (arrow in j). Arrowhead in (k) marks postoral ventral cirrus V/3. Explanation of original labels: AFC = right frontal cirrus, AZM = adoral zone of membranelles, BC = buccal cirrus, EM = endoral, LMR = left row of marginal cirri, MA = macronuclear nodule, MI = micronucleus, PFC = posterior frontoventral cirri (cirri III/2 and IV/3), PM = paroral, POC = postoral ventral cirrus V/4, RMR = right row of marginal cirri, TC = transverse cirri, VC = pretransverse ventral cirrus VI/2; p 632.

← **Fig. 173e-i** *Steinia sphagnicola* (from FOISSNER 1989. e, f, interference contrast; g, bright field; h, i, protargol impregnation). e) Ventral view. Arrow marks cavity. f) Buccal area in ventral view. Large arrow denotes paroral, small arrows mark fragmented endoral. g) Resting cyst. h) Ventral view. i) Buccal area with fragmented endoral (arrows). Dc = basal body pairs of dorsal kineties, G = cavity; p 632.

Fig. 173l, m *Steinia sphagnicola* (from VOSS & FOISSNER 1996. l, scanning electron micrograph; m, protargol impregnation). l) The curious buccal pit (cavity) is recognisable only in specimens with paroral cilia moved upwards (bar = 20 μ m). m) Oral area showing uninterrupted paroral and fragmented endoral (arrows; bar = 20 μ m). Explanation of original labels: AZM = adoral zone of membranelles, EM = endoral, LMR = left row of marginal cirri, MA = anterior macronuclear nodule, P = cavity (buccal pit), PM = paroral; p 632.

Invariably 18 frontal, ventral, and transverse cirri in 14 (FOISSNER 1989) and 25 (VOSS & FOISSNER 1996) specimens. Frontal, ventral, and marginal cirri in life about 30 μ m, transverse and caudal cirri about 35 μ m long. Transverse cirri slightly enlarged, left 3 cirri arranged in a rather steep row, posterior-most cirrus of this row located slightly in front (!) of level of right pretransverse ventral cirrus (Fig. 173c, l); this pretransverse ventral cirrus and the 2 right transverse cirri are arranged in an almost longitudinally extending row. Right marginal row begins at level of right frontal cirrus, terminates slightly subterminally, left one terminates at posterior end. Caudal cirri located slightly right of median (in ventral view), arranged at posterior end of dorsal kineties 1, 2, and 4. Kineties 1–4 about of body length, kineties 5 and 6 (dorsomarginal rows) only 1/2 and 1/3 of body length respectively (Fig. 173d).

Resting cysts yellowish, spherical to slightly ellipsoidal, in life 48–62 $\times$ 45–56 μ m (mean = 53.2 $\times$ 51.7 μ m, without spines; n = 12). Ectocyst 1.4 μ m thick, with many about

Fig. 173n, o *Steinia sphagnicola* (from VOSS & FOISSNER 1996. n, o, protargol impregnation). Very early dividers, n = 115 μ m, o = 118 μ m. Arrow in (n) marks oral primordium close to transverse cirrus II/1. OP = oral primordium; p 632.

7 μ m long, hollow spines (Fig. 14b). Older cysts with detritus and bacteria between spines, indicating that a thin mucous layer is present.

Morphogenesis (Fig. 173n–y, 174a–j): This process is described in great detail by VOSS & FOISSNER (1996) and includes many scanning electron micrographs. Briefly, im-

Fig. 173p–y *Steinia sphagnicola* (from VOSS & FOISSNER 1996. p–y, protargol impregnation). **p)** Early divider → showing anlage originating from oral primordium (arrow). Arrowhead marks disaggregating postoral ventral cirrus V/4. **q–u)** Frontal-ventral-transverse cirri anlagen 5 and 6 originate from postoral ventral cirrus V/4 in both proter and opisthe. A small field of basal bodies splits off from the dissolving postoral ventral cirrus V/4, migrates anteriorly (s, t, arrows), and organises to proter's anlagen 5 and 6 (u, v). **v–y)** Anlagen 3 and 4 of the proter originate from frontoventral cirri III/2 and IV/3 (v, x, arrow). The opisthe's anlagen 3 and 4 originate from the oral primordium (x, arrowhead) and, respectively, from postoral ventral cirrus IV/2 (y), which dis-

solves later than postoral ventral cirrus V/4. The whole process is accompanied by cortical growth as indicated by increasing distances between postoral ventral cirri IV/2 and V/4 and between frontoventral cirri and postoral ventral cirri. Postoral ventral cirrus V/3 is not involved in primordia formation; an apomorphy of the Stylyonchinae. Bar = 10 μ m. Explanation of original labels: FC = frontoventral cirri III/2 and IV/3 (obviously erroneously designated anterior frontal cirri in the original paper), POC1–3 = postoral ventral cirri IV/2, V/4, V/3, 3–6 = frontal-ventral-transverse cirri anlagen; p 632 (begin of legend, see p 637).

Fig. 174a-c *Steinia sphagnicola* (from Voss & Foissner 1996. a-c, protargol impregnation). a) Middle divider (138 μ m) with 7 anlagen in the opisthe because the left frontal cirrus has separated from the anlage of the undulating membranes. The parental paroral furrow commences to reorganise (arrow) and the buccal cirrus (open arrow) and some right marginal cirri in the prospective division furrow (arrowhead) disaggregate to anlagen. b) Middle divider showing anlagen (arrows) for dorsal kinetid 5 which originate from parental marginal cirri. Arrowheads mark primordia in left marginal row. c) Middle divider showing segregation of new cirri and reorganisation of the proter's undulating membranes. Note that fragmentation of endoral gradually disappears. Parental structures white, new ones black. AD_{5,6} = primordia of dorsomarginal kinetids (dorsal kinetids 5, 6), POC1 = postoral ventral cirrus IV/2; p 632.

Fig. 174d, e *Steinia sphagnicola* (from VOSS & FOISSNER 1996. d, e, protargol impregnation). Middle dividers (d = 150 μ m, e = 175 μ m) showing developing dorsal kineties 5 and 6 (arrowheads), migration of cirri, and re-organising undulating membranes in the proter. The fragmentation and sinusoidal bending of the endoral have disappeared. Arrow in (d) marks postoral ventral cirrus V/3, which is not involved in primordia formation (an apomorphic character of the Stylonychiinae). Parental structures white, new ones black; p 632.

portant morphogenetic details are identical to in the *Stylonychia mytilus* complex and in *Coniculostomum* suggesting monophyly of these taxa (Fig. 25a). For details, see legends to figures and Table 4.

Occurrence and ecology: Not very common in freshwater. Locus classicus is the village of Koppl, Salzburg, Austria, where FOISSNER (1989) discovered *S. sphagnicola* in a *Sphagnum* pond of a bog. FRYD-VERSAVEL (in DRAGESCO & DRAGESCO-KERNÉIS 1986) found it in Paris, France, and VOSS & FOISSNER (1996) collected it in spring in a small tributary (Windach) to the Amper River near Munich, Germany, about 100 m above the sewage treatment plant of the village of Eching. CZAPIK & FYDA (1995) found *Steinia sphagnicola* in two Polish lakes.

Fig. 174f, g *Steinia sphagnicola* (from VOSS & FOISSNER 1996. f, g, protargol impregnation). f) Late divider (190 µm) showing intersecting undulating membranes. The parental cirri (white) which were not involved in the formation of anlagen are gradually reabsorbed. g) Very late divider, 165 µm. The anterior end of the paroral becomes curved, the endoral fragments, and most parental cirri have been reabsorbed; p 632.

Steinia sphagnicola feeds on other protists (*Astasia* sp., *Dexiostoma campylum*) and probably also on bacteria. FOISSNER (1989) and VOSS & FOISSNER (1996) cultured it in lettuce medium with some squeezed wheat grains to support growth of bacteria and small ciliates. Biomass of 10^6 individuals about 150 mg.

***Steinia bivacuolata* (GELEI & SZABADOS, 1950) FOISSNER, 1989**
(Fig. 175a–c)

1950 *Oxytricha bivacuolata* GELEI & SZABADOS, Annls biol. Univ. szeged., 1: 263, 283 (Fig. 175a–c).

1989 *Steinia bivacuolata* (GELEI & SZABADOS, 1950) – FOISSNER, Sber. öst. Akad. Wiss., 196: 235.

Taxonomy: I agree with FOISSNER (1989) that this is a true *Steinia* (and not a *Cyrtohymena*) because GELEI & SZABADOS (1950) draw the conspicuous cavity in the anterior part of the buccal area. It differs from *S. platystoma*, with which it was synonymised by BORROR (1972a), in that it usually has only 4 transverse cirri. *Steinia sphagnicola* has a different arrangement of transverse cirri. *Steinia bivacuolata* should not be confused with *Cyrtohymena tetracirrata*, which also has only 4 transverse cirri (Fig. 102a–i). However, latter species is confined to terrestrial habitats, whereas *S. bivacuolata* was discovered in freshwater. Detailed redescription necessary.

Fig. 175a–c *Steinia bivacuolata* (from GELEI & SZABADOS 1950. a, opalblue stain after BRESSLAU; j, k, sublimate fixation). Ventral and dorsal infraciliature, a = 150 μ m, j, k = 105 μ m. Differs from the other two species of *Steinia* in that it has only 4 transverse cirri; p 641.

Morphology and biology: Large specimens in life (?) about 150 μ m long, about 2.4 times as long as broad (Fig. 175a). Anterior portion of cell slightly turned to left and somewhat broader than posterior part. However, outline of small specimens usually elliptical, causing GELEI & SZABADOS (1950) to assume that they are another variety or even species. I also doubt that the specimen shown in Figure 175b is conspecific with that of Figure 175a because the body shape is different and no cavity is shown. Each macronuclear nodule with 2 hemispherical micronuclei, smaller specimens with only 2 micronuclei. Perhaps 2 contractile vacuoles; one about in mid-body, another somewhat in front of level of cytostome. Rapid creeping or slow or fast swimming.

Adoral zone of membranelles about 40 % of body length, consists of approximately 35 membranelles. In anterior part of buccal area an almost transversely arranged row of 6

← Fig. 174h–k *Steinia sphagnicola* (h–j, from VOSS & FOISSNER 1996; k, from DRAGESCO & DRAGESCO-KERNÉIS 1986. h–k, protargol impregnation). h) Early postdivider, 80 μ m. The curved paroral crosses (intersects) the endoral, which fragments and becomes sinusoidal. i) Late postdivider (110 μ m) showing how the paroral moves rightward, producing the *Steinia*-specific arrangement of the undulating membranes. The buccal pit (cavity) develops. j) Middle divider (145 μ m) showing separation and development of dorsal kinety 4 from kinety 3, that is, dorsal morphogenesis is in *Oxytricha* pattern. k) Ventral infraciliature, size not indicated. Arrow marks paroral, arrowhead fragmented endoral. AD₄ = young dorsal kinety 4, P = cavity (buccal pit); p 632.

Table 38 Morphometric data of *Steinia sphagnicola* (line 1, from FOISSNER 1989; line 2, from VOSS & FOISSNER 1996). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1	140.7	11.3	8.0	122	157	14
	2	143.0	17.5	12.2	112	176	25
Body, width	1	60.4	7.6	12.6	46	72	14
	2	68.5	10.3	15.0	55	99	25
Macronuclear nodule, length	1	21.1	2.8	13.5	17	28	14
	2	25.9	2.9	11.2	22	28	25
Macronuclear nodule, width	1	11.2	2.2	19.6	8	15	14
	2	10.4	1.9	18.3	9	18	25
Macronuclear nodules, distance between	1	17.7	4.8	27.4	11	28	14
	2	9.9	3.9	39.4	4	20	25
Micronuclei, number	1	1.7	-	-	1	2	14
	2	2.4	0.6	25	2	4	25
Micronucleus, diameter	1	3.9	0.4	10.0	3	5	14
	2	3.8	0.9	23.7	2	7	25
Adoral zone of membranelles, length	1	66.9	4.7	7.1	56	72	14
	2	70.0	10.2	14.6	53	94	25
Adoral membranelles, number	1	36.4	2.3	6.3	31	39	14
	2	36.4	2.3	6.3	32	40	25
Endoral, number of fragments	1	10.4	1.6	15.4	7	13	14
	2	10.4	0.9	8.7	9	12	25
Distance between transverse cirrus V/1 and end of cell	1	9.3	2.4	25.8	6	13	14
	2	-	-	-	-	-	-
Right marginal row, number of cirri	1	21.9	1.3	6.1	20	24	14
	2	23.2	1.1	4.7	21	25	25
Left marginal row, number of cirri	1	19.6	2.3	11.8	14	23	14
	2	20.0	1.3	6.5	18	24	25

cilia, very likely a part of fragmented endoral (Fig. 175a). Transverse cirri protrude distinctly beyond posterior end of cell. Apparently only 2 caudal cirri.

Occurrence and ecology: Locus classicus of *Steinia bivacuolata* is a puddle on the Ski. Istvan Square in Szeged, Hungary (GELEI & SZABADOS 1950). Feeds on autotrophic and heterotrophic flagellates. Biomass of 10^6 individuals about 150 mg. Not found since.

Species indeterminata

Steinia fenestrata LEPSI, 1957, Trav. Mus. Hist. nat. Gr. Antipa, 1: 90 (Fig. 225p, q). Remarks: In life $100\text{--}122 \times 33\text{--}43 \mu\text{m}$. Oval, left margin usually straight, right convex. Not contractile. Two spherical to ellipsoidal macronuclear nodules. Extrusomes or cortical

granules lacking, cytoplasm densely granulated. Always swimming, does not jump. Adoral zone of membranelles about 1/3 of body length. Buccal area large and deep, undulating membranes anteriorly curved. Frontal cirri distinctly enlarged, in "common arrangement". Marginal cirri distinctly separate. About 5 transverse cirri, protrude distinctly beyond posterior end of cell. LEPSI (1957) found numerous specimens in a slightly mouldy smelling, 11 month old culture of mosses (not *Sphagnum*) from a pond with distinctly acid, slightly brown water near the mountain lake "St. Anna" in Romania. In spite of the extensive information on this taxon, I believe that it can never be identified unequivocally because the drawings are too superficial and the description is too general. FOISSNER (1989, p 239) transferred it to *Cyrtohymena*, *C. fenestrata*.

Insufficient redescriptions

Oxytricha platystoma, EHR – DUMAS, 1929, Microzoaires, p 70 (Fig. 236e). Remarks: Probably a redrawing from FROMENTEL (1876). Bog in France.

Oxytricha platystoma – FROMENTEL, 1876, Études Microzoaires, p 266, Planche XIII, fig. 6, 6a. Remarks: The drawings do not give any indication that the determination is correct.

Steinia platystoma EHR. – BIERNACKA, 1959, Polskie Archwm Hydrobiol., 5: 57 (Fig. 225s). Remarks: The shape of the buccal area does not indicate a relationship to *Steinia* or *Cyrtohymena*. Activated sludge plant of Danzig, Poland.

Histriculus CORLISS, 1960

1878 *Histrio* STERKI, Z. wiss. Zool., 31: 56 (junior homonym) – Type (by monotypy): *Histrio steinii* STERKI, 1878.

1882 *Histrio*, STERKI – KENT, Manual infusoria II, p 789.

1932 *Histrio* STERKI, 1878 – KAHL, Tierwelt Dtl., 25: 614 (in part; see nomenclature and taxonomy).

1960 *Histriculus* CORLISS, J. Protozool., 7: 275 (in part) – Type (original designation): *Histrio steinii* STERKI, 1878.

1972 *Histriculus* CORLISS, 1960 – BORROR, J. Protozool., 19: 14 (in part).

1974 *Histriculus* CORLISS – STILLER, Fauna Hung., 115: 149.

1975 *Parahistriculus* GROLIÈRE, Protistologica, 11: 493 – Type (by monotypy): *Parahistriculus minimus* GROLIÈRE, 1975.

1997 *Histriculus* CORLISS, 1960 – BERGER & FOISSNER, Arch. Protistenk., 148: 149.

Characterisation: Undulating membranes in *Oxytricha* pattern. One right and one left row of marginal cirri, posteriorly confluent. Six dorsal kineties. Caudal cirri absent. Dorsal morphogenesis in *Oxytricha* pattern.

Additional characters: Two macronuclear nodules. Contractile vacuole about in mid-body. Pellicle and cytoplasm colourless. Dorsal cilia in life 2–4 μm long. Probably confined to freshwater and marine habitats.

Nomenclature and taxonomy: *Histiculus* CORLISS is a new name for the preoccupied name *Histrio* STERKI. *Parahisticus minimus* in GROLIÈRE (1975, p 481) is an incorrect original spelling. KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Histrio)*. Incorrect subsequent spellings: *Historio* STERKI and *Historia* sp. (WANG 1925, p 52 and explanation of figures of plate XI); *Histiculux vorax* (DIVE 1973, p 348); *Histrichulus vorax* (BANINA 1983, p 81).

STERKI (1878) established *Histrio* to separate *Stylonychia histrio* (basonym *Paramaecium histrio*; *Histrio steinii* is probably only a new name for that species to honour STEIN, who provided the first detailed description of *Histiculus histrio*) from other *Stylonychia* species because the marginal cirral rows are posteriorly confluent and caudal cirri are lacking. However, later KAHL (1932) and BORROR (1972a) added species with inconspicuous caudal cirri, obviously assuming that STEIN (1859b) and STERKI (1878) overlooked them. Morphogenetic studies proved that such species indeed have inconspicuous caudal cirri, especially “*Histiculus muscorum*” (now *Sterkiella histriomuscorum*), one of the most widespread oxytrichids. A detailed redescription of the type species of *Histiculus*, *H. histrio* (GSCHWIND 1991; see also BERGER & FOISSNER 1997) exactly matched the original diagnosis by STERKI (1878), demanding that species with caudal cirri assigned to *Histiculus* by KAHL (1932) and BORROR (1972a) be referred to a new genus, *Sterkiella* (FOISSNER et al. 1991).

The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of patterns, see chapter 2 in the general section. The characterisation is based mainly on the morphology of the type species, the only morphologically completely defined species. The validity of the other species listed in the key has to be checked by detailed redescriptions.

Histrio inquietus STOKES belongs to *Cyrtohymena*. *Histrio lemani* DRAGESCO is a synonym of *Gastrostyla steinii*, *Histrio macrostoma* GELLÉRT & TAMAS a synonym of *Sterkiella histriomuscorum*. “*Histrio muscorum* KAHL”, *Histrio quadrinucleatus* SICK, *Histiculus admirabilis* FOISSNER, *H. similis tricirratu*s BUITKAMP, and *H. tricirratu*s DRAGESCO & DRAGESCO-KERNÉIS have been, or have to be, transferred to *Sterkiella* because caudal cirri are present. *Histrio acuminatus* MASKELL (Fig. 222f) and *Histiculus polycirratu*s AGAMALIEV (Fig. 229d) are considered as species indeterminata.

Parahisticulus differs from *Histiculus* in the number of dorsal kineties (4 against 6) and in that the left marginal row terminates on the right margin, that is, the marginal rows distinctly overlap (Fig. 178b); the proposed synonymy is thus somewhat uncertain.

Pleurotricha also lacks caudal cirri and is thus possibly the sister-group of *Histiculus*. However, detailed morphogenetic studies on both taxa are needed to test this hypothesis.

Key to species

- 1 Marine *H. similis* (p 665)
- Limnetic 2
- 2 In life only about 30–40 µm long (Fig. 178b, c) *H. minimus* (p 658)
- In life >80 µm long 3
- 3 Posterior end rather broadly truncated, sometimes even slightly indented (Fig. 178i, j) *H. vorax* (p 659)
- Posterior end rounded or slightly tapered (for example, Fig. 177e, 178d, g) 4
- 4 Body margins in middle area almost parallel, in posterior quarter converging and narrowly rounded; transverse cirri very prominent, displaced distinctly anteriad so that only the 2 posterior-most cirri reach posterior end of cell (Fig. 176a–e, 177a–p)
..... *H. histrio* (p 647)
- Outline elliptical or with posteriorly converging margins; transverse cirri not very prominent, at least the 2 posterior-most cirri protrude beyond posterior end of cell (Fig. 178d–g) 5
- 5 Outline elliptical; in life about 80 µm long (Fig. 178g) *H. complanatus* (p 657)
- Body margins converging posteriorly, left margin sometimes indented; in life about 110 µm long (Fig. 178d–e) *H. sphagni* (p 655)

Histriculus histrio (MÜLLER, 1773) CORLISS, 1960 (Fig. 22d, 176a–j, 177a–q, Tables 3, 39, 41)

- 1773 *Paramaecium histrio* MÜLLER, Vermium Terrestrium et Fluviatilium, p 55 (no figure).
- 1786 *Kerona histrio* – MÜLLER, Animalcula Infusoria, p 235 (Fig. 177a, b).
- 1803 *Trichoda histrio* – SCHRANK, Fauna Boica, p 98.
- 1830 *Stylonychia histrio* – EHRENBURG, Abh. preuss. Akad. Wiss., year 1830: 43.
- 1838 *Stylonychia histrio* – EHRENBURG, Infusionsthierchen, p 373 (Fig. 177c).
- 1852 *Cerona histrio* M. – PERTY, Kenntniss kleinster Lebensformen, p 155.
- 1859 *Stylonychia histrio*. EHRBG. – STEIN, Organismus der Infusionsthier I, p 166 (Fig. 177d).
- 1861 *Stylonychia histrio* (EHR. STEIN) – WRZESNIOWSKI, Annls Sci. nat., Zoologie, 16: 336 (Fig. 177l).
- 1862 *Stylonychia histrio* EHREN. – ENGELMANN, Z. wiss. Zool., 11: 357 (Fig. 177j).
- 1865 *Stylonychia histrio* – QUENNERSTEDT, Acta Univ. lund., 2: 57 (Fig. 177g).
- 1878 *Histrio steinii* STERKI, Z. wiss. Zool., 31: 56 (objective? synonym).
- 1882 *Histrio steinii*, MÜLL. sp. – KENT, Manual infusoria II, p 789.
- 1887 *Histrio erethisticus* STOKES, Proc. Am. phil. Soc., 24: 252 (Fig. 177h).
- 1888 *Histrio erethisticus*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 297 (incorrect subsequent spelling).
- 1901 *Histrio steinii* STERKI – ROUX, Mém. Inst. natn. génev., 19: 105 (Fig. 177i).
- 1906 *Histrio steinii* MÜLL. – EDMONDSON, Proc. Davenport Acad. Sci., 11: 101 (Fig. 177k).
- 1932 *Histrio (Kerona) histrio* (O. F. MÜLLER, 1786) STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 615 (incorrect dating).
- 1932 *Histrio erethisticus* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 615 (incorrect subsequent spelling; Fig. 177e).
- 1933 *Histrio histrio* (O. F. MÜLLER) STEIN 1859 – WANG & NIE, Contr. biol. Lab. Sci. Soc. China, 10: 62 (Fig. 177f).

Fig. 176a-e *Histriculus histrio* (a, from BERGER & FOISSNER 1997; b-e, from GSCHWIND 1991; a, d, e, from life; b, c, protargol impregnation). a) Ventral view, 110 µm. b, c) Ventral and dorsal infraciliature, 80-120 µm. Arrow marks confluent marginal rows. Note the very prominent, distinctly anteriorly displaced transverse cirri. d) Right lateral view. e) Dorsal view showing oral apparatus and very prominent transverse cirri; p 647.

Fig. 176f-j *Histriculus histrio* (f, g, from BERGER & FOISSNER 1997; h-j, from GSCHWIND 1991; f-j, protargol → impregnation). f) Very early divider in ventral view, 115 µm. g) Middle divider in ventral view, 120 µm. Post-oral ventral cirrus V/3 is not involved in primordia formation. Parental structures white. h-j) Early, middle, and late stage of dorsal morphogenesis, which proceeds in *Oxytricha* pattern, h = 125 µm, i = 130 µm, j = 140 µm. Note that no caudal cirri are formed at the posterior ends of the new dorsal kineties (arrows in j). Arrowheads in (i) mark fragmentation of dorsal kinety 3, arrowhead in (j) denotes new dorsomarginal kineties (kineties 5 and 6) of the proter. OP = oral primordium, V/3 = postoral ventral cirrus V/3, 1-6 = dorsal kineties 1-6; p 647.

- 1950 *Histrio hyalinus* VÖRÖSVÁRY, Annls biol. Univ. szeged., 1: 377, 384 (Fig. 177o, p; new synonym).
 1960 *Histriculus histrio* – CORLISS, J. Protozool., 7: 275.
 1960 *Histriculus erethisticus* (STOKES, 1887) – CORLISS, J. Protozool., 7: 275 (incorrect subsequent spelling).
 1960 *Histriculus hyalinus* (VÖRÖSVÁRY, 1950) – CORLISS, J. Protozool., 7: 275.
 1968 *Oxytricha (Histriculus) histrio* (STEIN, 1859) CORLISS, 1960 – CHORIK, Free-living ciliates, p 137 (Fig. 177m).
 1976 *Oxytricha fallax* STEIN, 1859 – SCHMALL, Diplomarbeit, p 38 (Fig. 177q; misidentification).
 1991 *Histriculus histrio* (MÜLLER, 1773) CORLISS, 1960 – GSCHWIND, Diplomarbeit, p 52 (Fig. 176b–c, h–j; collection, determination, and live observations were done by W. FOISSNER).
 1997 *Histriculus histrio* – BERGER & FOISSNER, Arch. Protistenk., 148: 136 (Fig. 22d, 176a, f, g).

Nomenclature and taxonomy: CALKINS (1926, p 392) erroneously designated the present species as “*Histrio pellionella*”. KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct names in his revision are thus *Oxytricha (Histrio) histrio* and *O. (Histrio) erethisticus*. Incorrect subsequent spellings: *Histrio erecthisticus* STOKES (MÜCKE 1979, p 273); *Histrio erethysticus* STOKES (EDMONDSON 1920, p 186); *Histrio steini* STERKI (ANDRÉ 1912, p 138); *O. (Histrio) erethisicus* STOKES (MARGALEF LÓPEZ 1945, p 377); *S. histrie* (WRZESNIEWSKI 1861, p 334); *Stylonichia histrio* (MAUPAS 1883, p 619); *Stylonichia histrix* (SERNOV 1929, p 557); *Stylonichia hystrio* (ENRIQUES 1913, p 105); *Stylonychnia histria* (BALDENSBERGER 1927, p 200); *Stylonychnia histrio* (BALDENSBERGER 1927, p 229).

The identity of *Histriculus histrio* and *H. erethesticus* was already supposed by HEMBERGER (1982, p 237) and FOISSNER in GSCHWIND (1991) although STOKES (1887a) illustrated and mentioned 9 frontoventral cirri (Fig. 177h), similar to in *H. sphagni*. However, all other characters of *Histriculus histrio* and *H. erethesticus* agree almost perfectly so that synonymy is very likely. The arrangement of the postoral and pretransverse ventral cirri in *Histriculus hyalinus* is rather probably misobserved (Fig. 177o, p), and “*Oxytricha platistoma*” sensu HORVÁTH (1933) is presumably also *H. histrio* (Fig. 177m', n). I have never observed specimens with 9 frontoventral cirri. The redescrptions by BÜRGER (1905; Fig. 232f), CONN (1905; Fig. 232b), and FROMENTEL (1876) are insufficient.

Histriculus histrio should not be confused with *Sterkiella* or *Stylonychia* species; it is easily identified by its trembling movement, the tapered posterior end, and the prominent transverse cirri which do not protrude beyond posterior end of cell.

Morphology and biology: In life 90–140 × 40–70 µm (GSCHWIND 1991), 86–115 µm long (EHRENBERG 1838), larger specimens 130–150 µm long (STEIN 1859b), 175–215 × 70–80 µm (WANG & NIE 1933), 150–170 × 70–80 µm (original measurements), 100 × 40 µm (VÖRÖSVÁRY 1950). Almost parallel-sided or slightly elliptical, somewhat tapered posteriorly, anteriorly moderately broadly rounded. Right margin slightly convex, left straight or slightly concave. Flattened about 2:1 dorso-ventrally, anterior and posterior part rather thin and thus very translucent. Two folds parallel to posterior margin, recognisable in life, possibly due to outer dorsal kineties (Fig. 176a). Macronuclear nodules in median of cell, ellipsoid, in life about 30 × 15 µm, finely granulated. Each macronuclear nodule invariably (n = 20; GSCHWIND 1991) with an ellipsoid, in life

Fig. 177a–m *Histiculus histrio* (a, b, after MÜLLER 1786; c, after EHRENBERG 1838; d, after STEIN 1859b; e, from KAHL 1932; f, from WANG & NIE 1933; g, after QUENNERSTEDT 1865; h, from STOKES 1887a; i, after ROUX 1901; j, from ENGELMANN 1862; k, from EDMONDSON 1906; l, after WRZESNIEWSKI 1861; m, from CHORIK 1968). Ventral views in life, a–d, g, h = size not indicated, e = 150 μ m, f = 200 μ m, i, j = 170 μ m, k = 160 μ m, l = 210 μ m, m = 155 μ m. The specimen in (l) is defecating; p 647.

Fig. 177m'-p *Histriculus histrio* (m', n, from HORVÁTH 1933; o, p, from VÖRÖSVÁRY 1950. m', sublimate-toluidinblue stain after HORVÁTH; n-p, opal-blue stain). m', o) Ventral and lateral view, m' = 110 μ m, n = 115 μ m. o, p) Ventral and dorsal infraciliature, 155 μ m. The arrangement of some cirri is unreliable and very likely dorsal kinety 6 is too long, possibly due to inappropriate stain method; p 647.

about $5-6 \times 4-5 \mu$ m sized micronucleus. According to HASHIMOTO (1953; identification not documented by illustrations) ectoplasm with so-called refractile bodies, $4-6 \mu$ m in diameter, which have an affinity to lead. Contractile vacuole with inconspicuous canals. Cytoplasm usually with many greasily shining, $3-5 \mu$ m sized globules, except in very thin anterior and posterior part of cell. Food vacuoles $5-15 \mu$ m or more in diameter. Movement very characteristic: swims continuously forward, moves back like a flash in a wide curve, then repeatedly swims back and forth very rapidly, the distances becoming shorter and shorter, that is, appears to be trembling.

Adoral zone of membranelles about 50 % of body length. Buccal area flat and moderately broad. Undulating membranes only moderately curved and almost not intersecting (that is, nearly parallel), endoral shorter than paroral (Fig. 176b). Invariably 18 frontal, ventral, and transverse cirri (n = 20; GSCHWIND 1991), arranged as shown in Figure 176b. Frontal cirri and buccal cirrus distinctly enlarged. Buccal cirrus at anterior end of paroral. Transverse cirri in life $25-30 \mu$ m long, very prominent and thus easily recognisable even at low magnification, displaced distinctly antieriad so that only cirri IV/1 and V/1 reach posterior end (rarely protrude slightly), sometimes fringed. Transverse cirrus VI/1 some-

what separate from cirrus V/1, usually slightly larger than other transverse cirri (WANG & NIE 1933, own observations). Usually all transverse cirri point toward posterior tip of cell. Marginal cirri in life about 12–20 μm long, anteriorly thicker than posteriorly. Marginal rows confluent posteriorly in median of cell. Right row begins at level of distal end of adoral zone of membranelles. Dorsal cilia in life about 3–4 μm long. Invariably ($n = 20$; GSCHWIND 1991) 6 dorsal kineties (including 2 dorsomarginal rows = kineties 5, 6). Kineties 1–5 about of body length, kinety 6 terminates in about mid-body. Distance between kineties 3 and 4 distinctly wider than between other kineties (Fig. 176c). VÖRÖSVÁRY (1950) illustrated 6 kineties of body length, which is probably a misobservation due to inappropriate stain method (Fig. 177p).

The formation of the oral primordium commences near the left transverse cirrus (Fig. 176f). The posterior postoral ventral cirrus V/3 is not involved in primordia formation, as in all other Stylonychinae (Fig. 176g). Dorsal morphogenesis is in *Oxytricha* pattern (Fig. 176h–j). As already stated by STEIN (1859b), no caudal cirri are formed. There are some older papers concerning adoral zone of membranelles (MAIER 1903), morphogenesis (HASHIMOTO 1957, NUSSBAUM 1886, STERKI 1878), conjugation (BALBIANI 1882, p 17; ENGELMANN 1862, 1876, STEIN 1859b), refractile bodies at the cystic stage, and encystment (HASHIMOTO 1956, 1960).

Occurrence and ecology: Common in eutrophic lentic freshwater such as ponds, lakes, and in slow running waters rich in macrophytes and filamentous algae; usually absent in alpine, fast flowing brooks and rivers.

Locus classicus is a freshwater habitat in Denmark, where MÜLLER (1773, 1786) discovered *Histriculus histrio* between filamentous algae. STOKES (1887a) discovered the synonym *H. erethesticus* in shallow pools with *Lemna* and algae, probably near Trenton, New Jersey, USA, where he lived. Locus classicus of the synonym *H. hyalinus* is a brook in Hungary, where VÖRÖSVÁRY (1950) discovered it on the water surface of lentic areas during summer.

Records documented by illustrations: in old samples with living filamentous algae in Copenhagen, Denmark, and in Berlin and Landshut, Germany (EHRENBERG 1838); on tufts

Fig. 177q *Histriculus histrio* (from SCHMALL 1976). Ventral infraciliature after protargol impregnation, 160 μm ; p 647.

Table 39 Morphometric data of *Histriculus histrio* (from GSCHWIND 1991). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	102.2	10.3	10.0	81	122	21
Body, width	49.2	5.0	10.1	40	60	21
Macronuclear nodule, length	22.5	2.4	10.7	17	27	20
Macronuclear nodule, width	8.4	1.2	14.4	6	10	20
Adoral membranelles, number	47.1	2.0	4.2	41	50	18
Right marginal row, number of cirri	42.2	1.9	4.6	39	46	20
Left marginal row, number of cirri	29.0	1.7	5.9	26	33	20

of *Beggiatoa* and in the upper layer of small basins filled with water from a eutrophic pond (Poppelsdorfer Weiher) in Bonn, Germany (SCHMALL 1976); running and stagnant waters near Leipzig, Germany (ENGELMANN 1862); common among *Lemna* and algae in Germany (KAHL 1932); in clear running waters among Callitrichaceae, *Lemna*, and filamentous algae (often very abundant in several day old samples from such sites) in Prague, Czechoslovakia, and near Tharand, Germany, abundant in a trout pond supplied with clear spring water (STEIN 1859b; see also ŠRÁMEK-HUŠEK 1953); moderately frequent in the periphyton of a lake (Teufelsee) near Berlin, Germany, in August (GSCHWIND 1991; collector: W. FOISSNER); pool containing sodium hydroxide in Hungary, cultivated in straw infusion (HORVÁTH 1933, see taxonomy); Poland (WRZESNIEWSKI 1861, WRZESNIEWSKIEGO 1866); Sweden (QUENNERSTEDT 1865, 1869); various clear waters in Switzerland (ROUX 1901, STERKI 1878); frequent in the water of an aquarium, collected from various ponds in Nanking, China (WANG & NIE 1933). I found it in small, eutrophic ponds with many macrophytes in the city of Salzburg, Austria.

Records not documented by illustrations: Austria (FOISSNER & FOISSNER 1988); in September in a pond near a lake (Grabensee) in Austria (GSCHWIND 1991; collector: W. FOISSNER); rare in running waters in Upper Austria (BLATTERER 1994); surface layer (Kahnhaut) of an infusion from the hypertrophic pond of the Salzburg University, Austria (BLATTERER 1989); in mud and on putrefying leaves in a spring near Vienna, Austria, in April (KÜHN 1940); Belgium (BERVOETS 1940, CHARDEZ 1987); Bulgarian running waters (DETCHIEVA 1981, 1986, RUSSEV et al. 1976, 1984; see also Table 41); saprobic brook near Prague, Czechoslovakia (BUCHAR 1957); at 29–32 °C and pH 5.7–7.2 in a brook in Czechoslovakia (MATIS & STRAKOVÁ-STRIEŠKOVÁ 1991); ponds in England (CRAIGIE 1921, DIXON 1920); meadow pond in Estonia (JACOBSON 1928); mouth of the Schussen River, Germany (WETZEL 1928a); drainage canal with a saprobic index of 2.4 in Germany (HEUSS 1975); among detritus and in the surface film of ditches regularly contaminated with pesticide sprays and in unsprayed ditches in the Elbe flood plain, Germany (CASPER & HECKMAN 1982); in beta- to alphamesosaprobic brooks and in Amper River in Germany (FOISSNER et al. 1992a, GSCHWIND 1991, HEUSS 1976); with low abundance in basins with largely mineralised water and in clear pond water near Bonn, Germany (GREISER

1974, SCHMIDT 1913, 1916); mesotrophic lake and ponds in Germany (LEVANDER 1892, MÜCKE 1979); caves and mines in Germany (GRIEPENBURG 1933, 1934, 1935, WETZEL 1929); aquariums in Germany (GÜNKEL 1989a, b, 1990, 1991); ponds (oxbows) of the Rhine River, Germany (BAIER 1934); periphyton of unpolluted foothill stream (Breitenbach) near the village of Schlitz, Germany (PACKROFF & ZWICK 1996); Tisza River, probably in still areas of flooded parts, Hungary (STILLER 1942; further record from Hungary: DUDICH 1947); Italy (CUNEO 1891); betamesosaprobic area of a lowland river in Poland (WIACKOWSKI 1981); Russia (EICHWALD 1844, 1847, WEISSE 1845, 1848a, c); Danube River, Slovakia (SZENTIVÁNY & TIRJAKOVÁ 1994); waters rich in organic matter, Spain (MARGALEF LOPEZ 1945); in September abundant in the botanical garden of Basle, Switzerland (RIGGENBACH 1922); old infusion, Switzerland (PERTY 1852b; further records from Switzerland: ANDRÉ 1912, MERMOD 1914, THIÉBAUD & FAVRE 1906); pond in Kiev and reservoirs of the Seversky Donets Basin, Ukraine (KOVALCHUK & SVINTSOVA 1994, KRAYCHENKO 1969); at 4–19 °C among algae (*Ulothrix*, *Tetraspora*) in lentic water of the littoral of Lake Baikal (GAJEVSKAJA 1927, GAJEWSKAJA 1933, ROSSOLIMO 1923); Iowa, USA (SHAWHAN et al. 1947); among *Ruppia* in Devil's Lake complex, North Dakota, USA (EDMONDSON 1920); in April, June, July, and November in small numbers in a fresh water pond in Pennsylvania, USA (WANG 1928); Argentina (SECKT 1924); swamps in Australia (WHITELEGGE 1889). Records from terrestrial habitats (MARTIN & SHARP 1983) are certainly misidentifications.

Feeds on bacteria, diatoms (*Synedra acus*), *Chlorella*-like green algae, and flagellates (ANDRÉ 1912, GSCHWIND 1991, VÖRÖSVÁRY 1950, WANG & NIE 1933, own observations). Biomass of 10⁶ individuals about 120 mg (NESTERENKO & KOVALCHUK 1991). Some autecological data are shown in Table 41. MATIS (1975) found *H. histrio* occasionally in temporary pools and brooks near Bratislava, Czechoslovakia, under the following conditions: 7–23.5 °C, pH 6.0–6.9, 1.5–2.7 mg l⁻¹ O₂. GROLIÈRE et al. (1990) counted 13 000–15 000 ind. l⁻¹ in beta- to alphamesosaprobic and polysaprobic areas of a running water at following conditions: 10–90 mg l⁻¹ COD, 0–4.6 mg l⁻¹ NH₄⁺-N, 0.1–0.26 mg l⁻¹ PO₄³⁻-P. According to WETZEL (1928b), hydrogen sulphide is not tolerated.

Histriculus histrio is not classified in recent lists of indicator species of water quality (FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981, WEGL 1983). Previously, *H. histrio* was classified as oligosaprobic (KOLKWITZ & MARSSON 1909, KOLKWITZ 1950, MAUCH 1976, MEZ 1898). According to the faunistic and ecological data *H. histrio* can be found in oligosaprobic to beta- to alphamesosaprobic waters; I thus suggest the following classification: b–o; o = 4, b = 4, a = 2, I = 2, SI = 1.8.

Histriculus sphagni (STOKES, 1891) CORLISS, 1960 (Fig. 178d–f)

1891 *Histrio sphagni* STOKES, Jl R. microsc. Soc., year 1891: 702 (Fig. 178d, f).

1932 *Histrio sphagni* STOKES, 1891 – KAHL, Tierwelt Dtl., 25: 617.

1960 *Histriculus sphagni* (STOKES, 1891) – CORLISS, J. Protozool., 7: 275.

1975 *Histriculus sphagni* (STOKES, 1891) CORLISS, 1961 – GROLIÈRE, Protistologica, 11: 492 (Fig. 178e).

Fig. 178a, g *Histriculus complanatus* (a, from VUXANOVICI 1961; g, after STOKES 1887b). Ventral views in life, a = 110 μ m, g = 80 μ m; p 657. b, c *Histriculus minimus* (from GROLIÈRE 1975. b, c, protargol impregnation). Ventral and dorsal infraciliature, 35 μ m; p 658. d–f *Histriculus sphagni* (d, f, after STOKES 1891; e, from GROLIÈRE 1975. d, f, from life; e, protargol impregnation). Ventral views and left margin, d, e = 110 μ m. Arrow-heads mark an additional cirrus behind the middle frontal cirrus; p 655. h–j *Histriculus vorax* (h, j, from CURDS 1966a; i, after STOKES 1891. h–j, from life). h) A small cell in ventral view, 115 μ m. i, j) Ventral views of typical specimens, i = 180 μ m, j = 205 μ m. eb = endogenous bud, Ma = macronuclear nodule; p 659.

Nomenclature and taxonomy: KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Histrio) sphagni*. This is a senior secondary homonym of *O. (Opisthotricha) sphagni* in KAHL (1932). The GROLIÈRE (1975; Fig. 178e) population agrees rather well with the original description (Fig. 178d), especially in that both STOKES and GROLIÈRE found an additional cirrus in the frontal area, which should be checked once more. The undulating membranes are almost in *Stylonychia* pattern; however, GROLIÈRE (1975) did not observe caudal cirri, indicating that the classification in *Histriculus* is appropriate. Identity of *H. sphagni* and *H. complanatus* cannot be excluded, whereas BORROR (1972a) synonymised it with the type species, *H. histrio*. *Histriculus sphagni* sensu GROLIÈRE (1969; Figure 10 on Planche III) is probably a different species because the transverse cirri are separated into two groups. Redescription necessary.

Morphology and biology: In life about 110 µm long (1/225 inch; STOKES 1891 wrote, obviously erroneously, 1/1225 inch). According to GROLIÈRE (1975) in life (?) 85–115 × 40–50 µm. Macronuclear nodules after protargol impregnation 10–12 times 5–6 µm. Two micronuclei. Adoral zone of membranelles about 45–50 % of body length, 35–42 membranelles. Undulating membranes rather straight, that is, similar to in *Stylonychia* (see taxonomy). Frontal and transverse cirri distinctly enlarged. One additional cirrus behind frontal cirri (Fig. 178d, e, arrowhead). 50–60 left and right marginal cirri, according to STOKES (1891) slightly elongated posteriorly, after GROLIÈRE (1975) all of same length. Five dorsal kineties (GROLIÈRE 1975). ALONSO (1975) and ALONSO & PÉREZ SILVA (1966a) described the polytene chromosomes in the macronuclear anlage; however, their identifications are not documented by illustrations.

Occurrence and ecology: Rare freshwater species. Locus classicus is probably Trenton in New Jersey, USA, where STOKES (1891) discovered *Histriculus sphagni* in standing water with decaying *Sphagnum*, collected from shallow pools and ponds. GROLIÈRE (1975, 1977, 1978) and GROLIÈRE & NJINE (1973) found it in ponds and peat-bog moss in France. Records not substantiated by illustrations: 16 ind. cm² in the Parma River, Italy (MADONI & GHETTI 1977, as *Oxytricha sphagni* STOKES); brook and pond in Bulgaria (DETCHEVA 1976a); lakes in Canada (PUYTORAC et al. 1972); Amazon River, Peru (CAIRNS 1966a). Feeds on small algae such as *Chlamydomonas* sp. (GROLIÈRE 1975).

***Histriculus complanatus* (STOKES, 1887) CORLISS, 1960 (Fig. 178a, g)**

1887 *Histrio complanatus* STOKES, Ann. Mag. nat. Hist., 20: 113 (Fig. 178g).

1888 *Histrio complanatus*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 296.

1932 *Histrio complanatus* STOKES, 1887 – KAHL, Tierwelt Dtl., 25: 615.

1960 *Histriculus complanatus* (STOKES, 1887) – CORLISS, J. Protozool., 7: 275.

1961 *Histrio complanatus* STOKES, 1887 – VUXANOVICI, Studii Cerc. Biol., 13: 437 (Fig. 178a).

Nomenclature and taxonomy: KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Histrio) complanatus*. Incorrect subsequent spelling: *Histrio companatus* STOKES, 1887 (BORROR 1972a, p 14).

This species shows no peculiarities so that definite identification is rather difficult. Identity with *H. sphagni* or *Sterkiella histriomuscorum* cannot be excluded. The redescrptions by CHORIK (1968; Fig. 232g), CONN (1905; Fig. 232a), and LEPSI (1965; Fig. 222g, 224f) are insufficient. Detailed redescription necessary.

Morphology and biology: In life about $80 \times 40 \mu\text{m}$, according to VUXANOVICI (1961) $80\text{--}120 \mu\text{m}$ long. Twice as long as broad. Outline elliptical, anterior end evenly rounded, posterior inconspicuously pointed. Typical 18 frontal, ventral, transverse cirral pattern. Three rightmost transverse cirri protruding beyond posterior end of cell. Marginal cirri "uninterrupted, longest and largest posteriorly" (STOKES 1887b), indicating that inconspicuous caudal cirri are present.

Occurrence and ecology: Rare freshwater species. Locus classicus is Trenton, New Jersey, USA, where STOKES (1887b) discovered *Histriculus complanatus* in a shallow pool in early spring. VUXANOVICI (1961) found some specimens in a culture with marsh-plants in a lake in Bucharest, Bulgaria, in December.

Records not documented by illustrations: pelagial of a clear lake in Styria, Austria (KRAINER 1988); sandy soil from the flood plains of the Tisza River in Szeged, Hungary, an area inundated at most once a year (HORVÁTH 1950); 1000 ind. l^{-1} in activated sludge of a Polish plant with a Sheffield aeration tank (KLIMOWICZ 1973); low salinity lagoons of the Caspian Sea (AGAMALIEV 1973, 1986); at 22°C in a metal tank with much blue-green algae and sulphur bacteria on a hillside farm in the Mountain Lake region, Virginia, USA (BOVEE 1960).

Feeds on bacteria and algae (HORVÁTH 1950). DAWSON (1926, 1928) and RICHARDS & DAWSON (1927) found an average daily division rate of 1.24 (maximum value about 1.8) in a culture medium of dried timothy hay and wheat; usually a grain of wheat was added. See also ZAIKA (1970) for rate of reproduction. DETCHEVA (1979c) found *H. complanatus* once in the Strouma River, Bulgaria, under the following conditions: 17°C , pH 7.7, $9 \text{ mg l}^{-1} \text{ O}_2$ (79 % saturation), $9.2 \text{ mg l}^{-1} \text{ BOD}_5$, $88 \text{ mg l}^{-1} \text{ Ca}^+$, $25 \text{ mg l}^{-1} \text{ Mg}^+$, $72 \text{ mg l}^{-1} \text{ SO}_4^{2-}$, $23 \text{ mg l}^{-1} \text{ Cl}^-$, $0.04 \text{ mg l}^{-1} \text{ NH}_4^+\text{-N}$, $1.7 \text{ mg l}^{-1} \text{ NO}_3\text{-N}$, $0.17 \text{ mg l}^{-1} \text{ NO}_2\text{-N}$, $0.26 \text{ mg l}^{-1} \text{ Fe}^{2+}$.

***Histriculus minimus* (GROLIÈRE, 1975) BERGER & FOISSNER, 1997**
(Fig. 178b, c)

1975 *Parahistriculus minimus* GROLIÈRE, Protistologica, 11: 493.

1997 *Parahistriculus minimus* GROLIÈRE, 1975 – BERGER & FOISSNER, Arch. Protistenk., 148: 149 (see nomenclature).

Nomenclature and taxonomy: BERGER & FOISSNER (1997) synonymised *Parahistriculus* with *Histriculus*; they are thus considered as combining authors of the only included species. Incorrect subsequent spelling: *Parahistriculus minimum* (GROLIÈRE 1977, p 347). *Histriculus minimus* is very similar to *Oxytricha setigera* and *O. balladyna* in terms of the small size and the single micronucleus (Fig. 178b). However, both *Oxytricha* species have caudal cirri and 10–15 µm long dorsal cilia. Redescription, especially live observation necessary.

Morphology: Very small, after protargol impregnation 30–40 × 15–20 µm (mean = 36 × 17 µm). Oval. Not contractile. Often 1 micronucleus between macronuclear nodules (Fig. 178b); however, sometimes 1–6 micronuclei per nodule (Fig. 178c). This extreme variability is very uncommon and indicates that possibly two species were mixed up. Adoral zone of membranelles about 50 % of body length, 22–30 membranelles. 18 frontal, ventral, and transverse cirri. Frontal and transverse cirri slightly to distinctly enlarged, latter protrude beyond posterior end of cell. Buccal cirrus near anterior end of rather straight undulating membranes. Pretransverse ventral cirri displaced distinctly anteriorly. 18–21 right marginal cirri; left marginal row with 20–26 cirri, terminates on right side; marginal rows thus overlapping. Four dorsal kineties of about body length. Dorsal cilia 2–3 µm long.

Occurrence: *Locus classicus* is a peat-pit at Landie, France (GROLIÈRE 1975, 1977). Not found since.

***Histriculus vorax* (STOKES, 1891) CORLISS, 1960 (Fig. 178h–s, 179a–n, 180)**

1891 *Histrio vorax* STOKES, Jl R. microsc. Soc., year 1891: 703 (Fig. 178i).

1932 *Histrio vorax* STOKES, 1891 – KAHL, Tierwelt Dtl., 25: 617.

1960 *Histriculus vorax* (STOKES, 1891) – CORLISS, J. Protozool., 7: 275.

1966 *Histriculus vorax* (STOKES) CORLISS – CURDS, J. Protozool., 13: 155 (Fig. 178h, j–s, 179a–n).

1969 *Histriculus vorax* CORLISS, 1960 – CURDS, Wat. Pollut. Res., No. 12: 68 (incorrect author).

1991 *Histriculus vorax* (STOKES, 1891) CORLISS, 1960 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 309.

Nomenclature and taxonomy: KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Histrio) vorax*, which is a secondary homonym of *O. (Stylonychia) vorax* in KAHL (1932, p 619).

The CURDS (1966a) population is described after wet silver impregnation. A detailed redescription of the live aspect and after protargol impregnation is thus necessary. CURDS (1965b, c, 1966a) described endogenous bud formation (see below), a very unusual (doubtful?) form of reproduction in hypotrichs. The illustration in KUTIKOWA (1984) is a redrawing from CURDS (1966a).

Fig. 178k-s *Histriculus vorax* (from CURDS 1966a). **k, l**) Ventral and dorsal infraciliature after wet silver nitrate impregnation, sizes not indicated. **m**) Lateral view of a large specimen containing a mature endogenous bud. **n-s**) Reorganisation and division of the nucleus apparatus during endogenous bud formation. Replication bands form at extreme outer ends of the 2 macronuclear nodules, move centrally, and disappear. Micronuclei in anaphase (n-p). One macronuclear nodule bends toward budding area (q, arrow). Constriction of macronuclear nodules continues, the nodules divide and migrate to budding area (r, arrows). Large specimen carrying bud containing 2 macronuclear nodules and 4 micronuclei (s); p 659. **t** *Histriculus similis* (after QUENNERSTEDT 1867). Ventral view in life, 135 μ m; p 665. **u-w** *Histriculus similis* (insufficient redescription; from CHARDEZ 1986). **u**) Ventral infraciliature after nickel sulphate fixation, size not indicated. **v, w**) Lateral view of a specimen without and with endogenous bud. eb = endogenous bud, rp = replication band; p 667.

Fig. 179a-f *Histriculus vorax* (from CURDS 1966a). a) Growth showing occurrence of large adult cells in a clonal culture. b) Size distribution in the same clonal culture at various ages. c-f) Cyst development of *Histriculus vorax*. c) Newly encysted bud; period of rest. d) Developing cyst 3-4 h after end of resting period. e) Developing cyst 6 h after end of resting period. Rotation (arrow) begins and contractile vacuole becomes apparent. f) Developing cyst 12 h after end of rest period and 12 h before excystment. Cirri noted for first time (arrow). CV = contractile vacuole; p 659.

Morphology and biology: After STOKES (1891) in life about 170 μm long. According to CURDS (1966a) size and shape rather variable (Fig. 178h, j, 179a, b). Small adult cells 70-140 $\times$ 50-60 μm , large adult cells 190-250 $\times$ 100-120 μm . KAHL (1932), obviously erroneously, stated 80 μm in the legend to the figure, which is a redrawing from STOKES (1891). Large cells broader and blunter than small cells (Fig. 179g, h). Broadly elliptical, often almost rectangular, then left margin concave and right one convex (Fig. 178i, j, 179h). Posterior end in large specimens often indented. Flattened about 2:1 dorso-ventrally. Large cells usually with dark cytoplasm rich in small, dark granules (no cortical granules; Fig. 179h). Each macronuclear nodule usually with 2 micronuclei. Contractile vacuole in about mid-body or slightly in front.

Adoral zone of membranelles about 50 % of body length. Frontal cirri, buccal cirrus, and 1 or 2 left frontoventral cirri distinctly enlarged. Transverse cirri enlarged, displaced somewhat anteriad so that only the 3 rightmost cirri protrude beyond posterior end of cell. Comparatively few marginal cirri, widely spaced, longer and more prominently projecting beyond posterior end of cell (possibly redescription will show that caudal cirri are

Fig. 179g-l *Histriculus vorax* (from CURDS 1966a). **g)** Small adult. **h)** Large adult. The outline is very similar to that in Figure 178i, indicating that the identification is correct. **i)** Large adult containing developing endogenous buds. **j)** Large adult containing a large, single endogenous bud just prior to deposition. **k)** Non-trophic embryo approximately 30 min after excystment. **l)** Trophic embryo approximately 4 h after excystment. e.b. = endogenous bud; p 659.

present, demanding that it be transferred to *Sterkiella*). Six dorsal kineties, kineties 5 and 6 (= dorsomarginal rows) only 1/2 and 1/3 of body length (Fig. 178l).

CURDS (1965b, c, 1966a) described endogenous bud formation (Fig. 178m-s, 179c-f, i-n). PANG & ZHANG (1981) assumed that CURDS observed cannibalism induced by over-feeding. Conversely, it cannot be excluded that this type of reproduction, which is, for example, common in some suctorians (MATTHES 1988), also evolved in hypotrichs. Another example of parallel evolution of a curious reproductive strategy is the division in cysts, a

Fig. 179m, n *Histriculus vorax* (from CURDS 1966a. m, n, basic fuchsin stain). **m**) Division of the macronucleus during bud formation. Reorganised macronucleus nodule nearest oral region constricts first and bends toward budding area. **n**) Large adult bearing 2 buds, each with its own macronuclear nodules; p 659.

common strategy, for example, in some colpodids (FOISSNER 1993), but only known from *Keronopsis* and *Paraholosticha* (DIECKMANN 1989) within the hypotrichs. I have thus provided some of CURDS' figures and micrographs (see legends for some details). CHARDEZ (1986) reported a similar phenomenon in "*Histriculus similis*" (Fig. 178u–w).

Occurrence and ecology: Rare; probably confined to freshwater. Locus classicus is a pond with decaying vegetation in the USA, probably near Trenton in New Jersey, USA, where STOKES lived. CURDS (1965b, c, 1966a) found *Histriculus vorax* in an activated-sludge sample collected from the Northern Outfall Sewage Works of the London County Council, England. CURDS et al. (1968) reported on 2×10^6 to 3×10^6 ind. l⁻¹ activated sludge in a small scale plant. CURDS & COCKBURN (1970a) found it with a frequency of 21 % in the effluent of 52 percolating filters. Not recorded from Imhoff-tanks (CURDS 1975). Records not documented by illustrations: pond in California, USA (STOUT 1980); activated sludge (BANINA 1983, REID 1969).

CURDS (1965a) and CURDS & VANDYKE (1966) studied the feeding habits and growth rates. They tested 19 strains (15 species) of bacteria and found that *Klebsiella aerogenes*, *Azotobacter chroococcum*, *Bacillus cereus*, *B. subtilis*, *B. subtilis* var. *niger*, *Escherichia*

Fig. 180 Complete asexual life cycle of *Histriculus vorax* (from CURDS 1966a). **a)** Small adult. **b)** Division of small adult. **c)** Large adult. **d)** Division of large adult. **e)** Development of endogenous bud within large adult. **f)** Large adult after deposition of bud. **g)** Newly deposited bud. **h)** Encysted bud. **i)** Developing cyst. **j)** Newly hatched embryo. **k)** Embryo becomes trophic. **l)** Trophic embryo grows to become small adult; p 659.

coli, *Proteus vulgaris*, *Pseudomonas ovalis*, *P. putrefaciens*, *P. fluorescens*, *Streptococcus faecalis*, and *Vibrio cuneatus* are favourable. *Enterobacter cloacae* is unfavourable and *Chromobacterium violaceum* killed the ciliates within 3 h. Number of divisions per

day varied between 2 and 6 when feeding on *Pseudomonas ovalis* and cultured at 25 °C. CURDS (1966a) cultured a clone in an infusion of 0.15 % dried lettuce in tap water with *Bacillus cerus* as the sole food organism. Upper temperature limit 40 °C (NISBET 1984). Biomass of 10⁶ specimens about 350 mg (FOISSNER et al. 1991).

Histriculus vorax is classified as strict alphamesosaprobic indicator of water quality: a; a = 10, I = 5, SI = 3.0 (SLÁDEČEK et al. 1981, WEGL 1983, FOISSNER 1988a, FOISSNER et al. 1991). This classification has to be verified by detailed autecological and saprobio-logical investigations on reliably determined populations.

Marine species

Histriculus similis (QUENNERSTEDT, 1867) CORLISS, 1960 (Fig. 178t)

1867 *Stylonychia similis* QUENNERSTEDT, Acta Univ. lund., 4: 38 (Fig. 178t).

1932 *Histrio similis* QUENNERSTEDT, 1867 – KAHL, Tierwelt Dtl., 25: 615, in part Fig. 121, 6; not Fig. 116, 2.

1960 *Histriculus similis* (QUENNERSTEDT, 1867) – CORLISS, J. Protozool., 7: 275.

Nomenclature and taxonomy: KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *O. (Histrio) similis*, which is a secondary homonym of *O. (Opisthotricha) similis* in KAHL (1932, p 611). I agree with FOISSNER (1988a) that KAHL's (1932) identification with a marine, quadrinucleate form (Fig. 186b) cannot be accepted; the fact that SICK (1933) established a new species for KAHL's taxon, namely *Histrio quadrinucleatus*, was always overlooked.

According to WENZEL (1953), *Sterkiella histriomuscorum* is the junior synonym of *H. similis*. However, this has to be proved on a detailed redescription of a marine population. At this stage, I propose classifying *H. similis* (marine, 2 macronuclear nodules!) and *Sterkiella histriomuscorum* as separate species. Since it cannot be excluded that *H. similis* in fact lacks caudal cirri, I do not transfer it to *Sterkiella*. There is some faunistic and ecological literature available on "*H. similis*". When it concerns freshwater or terrestrial populations it is listed in *Sterkiella histriomuscorum*. When it concerns marine populations and if the determination was done expressly according to KAHL (1932) it is listed in *Sterkiella quadrinucleatus* (illustrations from BORROR 1972b, MARGALEF 1948, REUTER 1961). The populations in NIETO et al. (1984; Fig. 232l) and CHARDEZ (1986; Fig. 178u–w) are insufficiently redescribed.

Morphology: In life 110–130 µm long, about 3 times as long as broad. Long elliptical to parallel sided. Two (and not four!) macronuclear nodules. Contractile vacuole about at level of cytostome. Adoral zone of membranelles about 38 % of body length. Undulating membranes slightly curved. According to Figure 178t three frontal cirri, 1 buccal cirrus, 4 frontoventral cirri, 6 postoral and pretransverse ventral cirri, and 5 some-

what enlarged transverse cirri. Transverse cirri protrude slightly beyond posterior end of cell. Caudal cirri lacking (?; see taxonomy).

O c c u r r e n c e: Locus classicus is the Kattegat (connection between Northern and Eastern Sea) near Varberg, Sweden (QUENNERSTEDT 1867, 1969). No other reliable records known (see taxonomy).

Species indeterminata

*Histriculus polycirratu*s AGAMALIEV, 1978, Zool. Zh., 57: 606 (Fig. 229d). Remarks: See also AGAMALIEV (1983, p 111). *Histrio polycirratu*s in AGAMALIEV (1976a, p 91) is a nomen nudum. I doubt that this taxon is correctly described. About 80–90 × 50 µm. 40–42 adoral membranelles. According to illustration about 30 right and 36 left marginal cirri. Number of frontoventral cirri increased (6 against 4 in typical oxytrichids). Caspian Sea (locus classicus) and Bay of Biscay, Atlantic Ocean (FERNANDEZ-LEBORANS & NOVILLO-VILLAJOS 1993).

Histrio acuminatus MASKELL, 1886, Trans. Proc. N. Z. Inst., 19: 59 (Fig. 222f). Remarks: See also MASKELL (1887a). In life about 140 µm long. Margins almost in parallel, posterior end somewhat pointed. Buccal area large. Frontal cirri distinctly enlarged. Five transverse cirri, protrude beyond posterior end of cell. Only 1 macronuclear nodule! (possible an exconjugant). Freshwater in Wellington, New Zealand. KAHL (1932, p 617) assumed that it is a valid species because of the pointed posterior end. Since KAHL classified *Histrio* only as subgenus of *Oxytricha*, the correct name in his revision is *Oxytricha (Histrio) acuminatus*. CORLISS (1960, p 275) transferred it to *Histriculus*, *H. acuminatus*. BORROR (1972a) stated that BRANDON is the author of this species. However, since it is not clear from the contents of the publication that BRANDON alone is responsible both for the name and for satisfying the criteria of availability other than publication, MASKELL and not BRANDON is the author of the name (ICZN 1985, Article 50 a). BRANDON is probably the collector of the sample.

Insufficient redescriptions

Historio sp. – WANG, 1925, Contr. biol. Lab. Sci. Soc. China, 1: 53 (Fig. 242g). Remarks: Perhaps a *Sterkiella histriomuscorum*. Small pond in Nanking, China.

Histriculus similis – NIETO, CALVO, MARTIN & TORRES, 1984, Acta Protozool., 23: 188 (Fig. 232l). Remarks: NIETO et al. (1984) found this quadrinucleate population in a small stream at Puebla del Rio, Sevilla, Spain. Thus I do not believe that it is identical with the marine species of QUENNERSTEDT (1867) which has only 2 macronuclear nodules or with the marine form of KAHL (1932) now classified as *Sterkiella quadrinucleatus*. The straight undulating membranes and the body shape in Figure 232l strongly resemble *Sty-*

lonychia sp. Conversely, the micrographs in NIETO et al. (1984) and CALVO et al. (1986a) indicate that it is possibly identical with *Sterkiella cavicola*, which, however, prefers terrestrial habitats. In life $140\text{--}180 \times 60\text{--}85\text{ }\mu\text{m}$, rigid; 4 macronuclear nodules; 35–44 adoral membranelles; rather invariably 18 frontal, ventral, transverse cirri; 52–58 left and right marginal cirri. Further literature on this taxon: CALVO et al. (1983, 1984, 1986b, 1988).

Histriculus similis (QUENNERSTEDT) CORLISS 1960 – CHARDEZ, 1986, *Acta Protozool.*, 25: 33 (Fig. 178u–w). Remarks: CHARDEZ (1986) found his population in a running water in Belgium. Thus I do not believe that it is identical with the marine species of QUENNERSTEDT (1867). The body shape and the resting cyst in some micrographs in CHARDEZ (1986, Planche I, Fig. 12, 15, 16) remind strongly of *Stylonychia pustulata*. He also described endogenous bud formation (Fig. 178w), which is, however, possibly a misobservation. It cannot be excluded that he observed specimens feeding on their own cysts. The deposition of the endogenous bud is possibly only the defecation of an undigested cyst (see also *H. vorax* for some details, where CURDS 1966a reported a similar curiosity). Small specimens $85\text{--}95\text{ }\mu\text{m}$, large individuals $100\text{--}130\text{ }\mu\text{m}$ long. Two macronuclear nodules, $16\text{--}20\text{ }\mu\text{m}$ long. 35–40 adoral membranelles. 29–32 right and 22–27 left marginal cirri. Number and arrangement of frontal, ventral, and transverse cirri, see Figure 178u. 3–4 somewhat elongated caudal cirri, a further indication that it is possibly *Stylonychia pustulata*.

Histriculus (sp. nov.?) – WICKLOW, 1991, *J. Protozool.*, 38: 2A, Abstract 11. Remarks: WICKLOW (1991) observed predator-induced polymorphism in a (possibly new) species of *Histriculus*. Freshwater, USA?

Histrio complanatus STOKES – CONN, 1905, *Bull. Conn. St. geol. nat. Hist. Surv.*, 2: 60 (Fig. 232a). Remarks: Freshwater in Connecticut, USA.

Histrio complanatus STOKES – LEPSI, 1965, *Protozoologie*, p 35, 977 (Fig. 222g, 224f). Remarks: Romania.

Histrio erethisticus STOKES – CONN, 1905, *Bull. Conn. St. geol. nat. Hist. Surv.*, 2: 60 (Fig. 232b). Remarks: Incorrect subsequent spelling. The body shape and the arrangement of the cirri is not at all as in *H. histrio*, the senior synonym. Freshwater in Connecticut, USA.

Histrio sp. – CONN, 1905, *Bull. Conn. St. geol. nat. Hist. Surv.*, 2: 60 (Fig. 232c). Remarks: The arrangement of the cirri is surely incorrect. Freshwater in Connecticut, USA.

Kerona histrio – FROMENTEL, 1876, *Études microzoaires*, p 272, Planche XIV, fig. 7, 11.

Oxytricha (Histriculus) complanatus STOKES, 1887 – CHORIK, 1968, Free-living ciliates, p 137 (Fig. 232g). Remarks: The drawing is very general so that the identification is uncertain. Freshwater in Moldova.

Stylonychia histrio (O. F. MÜLL.) – BÜRGER, 1905, An. Univ. Chile, 117: 436 (Fig. 232f). Remarks: Because of the large size (in life about $280 \times 140 \mu\text{m}$) and the body shape I doubt that BÜRGER's identification is correct, although he mentions that caudal cirri are lacking. Chile (see also BÜRGER 1908).

***Sterkiella* FOISSNER, BLATTERER, BERGER & KOHMANN, 1991**

1991 *Sterkiella* FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 311 – Type (original designation): *Oxytricha cavicola* KAHL, 1935.

1997 *Sterkiella* FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 – BERGER & FOISSNER, Arch. Protistenk., 148: 151.

C h a r a c t e r i s a t i o n: Undulating membranes in *Oxytricha* pattern. One right and 1 left row of marginal cirri, distinctly separate posteriorly. Six dorsal kineties. Caudal cirri present. Primordia V and VI of the opisthe originate de novo. Dorsal morphogenesis in *Oxytricha* pattern.

A d d i t i o n a l c h a r a c t e r s: Both ends rounded, flattened about 2:1 dorso-ventrally. Body firm to slightly flexible. Pellicle and cytoplasm colourless, cortical granules lacking. Movement usually rapid. Posterior postoral ventral cirrus distinctly displaced posteriorly. Transverse cirri protrude distinctly beyond posterior end of cell. Usually 3 inconspicuous, that is, not distinctly elongated caudal cirri, in life and sometimes even after protargol impregnation difficult to distinguish from marginal cirri. Dorsal cilia in life 2–4 μm long.

T a x o n o m y: The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of patterns, see chapter 2 in the general section. The type species of *Histriculus*, *H. histrio* has no caudal cirri. Thus, we established *Sterkiella* to include those *Histriculus* species which have (usually inconspicuous) caudal cirri. *Sterkiella* is well defined by a unique, but sophisticated combination of morphological characters, that is, body rigid or only slightly flexible, undulating membranes curved and intersecting, marginal rows separate posteriorly, and caudal cirri present. However, the only autapomorphy so far known is the new formation of primordia V and VI of the opisthe (character 18 in the cladogram, Fig. 25a). *Sterkiella* differs from *Stylonychia* in that it has distinctly bent undulating membranes and (less important) in that the caudal cirri are rather short.

Seven taxa are assigned to *Sterkiella*; however, only 3 of them are well defined, namely *S. cavicola*, *S. histriomuscorum*, *S. thompsoni*. *Sterkiella histriomuscorum* is a sibling species complex (FOISSNER & BERGER 1998) comprising possibly also *S. tricirrata*

(5 dorsal kineties) and *S. terricola* (4 macronuclear nodules). In ecological studies we suggest designating them as *Sterkiella histriomuscorum* complex.

Key to species

- 1 2 macronuclear nodules 2
- 3 or 4 macronuclear nodules 3
- 2 3 transverse cirri; 5 dorsal kineties *S. tricirrata* (p 693)
- 4–5 transverse cirri; 6 dorsal kineties (Fig. 183c, d, g) . *S. histriomuscorum* (p 683)
- 3 (1) 3 macronuclear nodules *S. thompsoni* (p 679)
- 4 macronuclear nodules 4
- 4 In life about 400 µm long (Fig. 182a) *S. admirabilis* (p 677)
- In life 100–250 µm long 5
- 5 Saline waters (Fig. 186b) *S. quadrinucleatus* (p 694)
- Freshwater or terrestrial habitats 6
- 6 In life 140–250 µm long; 5 transverse cirri (Fig. 181a–l) *S. cavicola* (p 669)
- In life about 120 µm long; only 3 transverse cirri (Fig. 184n) .. *S. terricola* (p 682)

Sterkiella cavicola (KAHL, 1935) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (Fig. 6a, 7f, g, 21b, 181a–q, Table 40)

- 1888 *Onychodromus grandis* – MAUPAS, Archs Zool. exp. gén., 6: 217 (Fig. 181o–q; misidentification, see nomenclature and taxonomy).
- 1932 *Stylonychia (Onychodromus) grandis* MAUPAS – KAHL, Tierwelt Dtl., 25: 620 (see nomenclature and taxonomy).
- 1935 *Oxytricha cavicola* KAHL, Tierwelt Dtl., 30: 841 (Fig. 181n).
- 1950 *Oxytricha magna* GELEI & SZABADOSZ, Annls biol. Univ. szeged., 1: 269, 288 (Fig. 181m).
- 1969 *Opisthotricha monspessulana* CH. et S., 1940 – GROLIÈRE, Annls Stn limnol. Besse, 4: 335 (Fig. 181j–l; misidentification).
- 1970 *Opisthotricha monspessulana* CH. et S. 1940 – GROLIÈRE, C. r. hebd. Sénac. Acad. Sci., Paris, 270: 366 (misidentification).
- 1972 *Oxytricha cavicola* KAHL, 1935 – BORROR, J. Protozool., 19: 13.
- 1984 *Histriculus muscorum* – MATSUSAKA, NAKAMURA & NAGATA, J. Electron Microsc., 33: 218 (misidentification; Fig. 7f, g).
- 1987 *Histriculus cavicola* (KAHL, 1935) – BERGER & FOISSNER, Zool. Jb. Syst., 114: 213 (Fig. 181a–g; authoritative redescription; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
- 1991 *Sterkiella cavicola* (KAHL, 1935) – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 311.
- 1992 *Histriculus cavicola* – LEHLE, Mikrokosmos, 81: 21, Bild 7 (microphotograph of a protargol-impregnated specimen).
- 1994 *Histriculus cavicola* (KAHL, 1935) – SHIN & KIM, Korean J. Zool., 37: 114 (Fig. 181h, i).
- 1994 *Histriculus cavicola* (KAHL, 1935) – SHIN, Dissertation, p 124 (Fig. 181h, i).

Fig. 181h, i *Sterkiella cavicola* (h, i, from SHIN & KIM 1994. h, from life; i, protargol impregnation). h) Ventral view, 160 µm. i) Ventral (left) and dorsal (right) infraciliature, 150 µm; p 669.

Taxonomy: There is no doubt that the identification by MAUPAS (1888) is incorrect because his population lacks dorsal horns. KAHL (1932) intended making a new species for *Onychodromus grandis* sensu MAUPAS (1888). Unfortunately, he only transferred the species name “*grandis*” to *Stylonychia* and attributed it to MAUPAS (1888) instead of establishing a new species. Furthermore, he classified *Stylonychia* only as subgenus of *Oxytricha* so that the correct name in his revision is *Oxytricha (Stylonychia) grandis*. I am not entirely sure that the synonymisation with *Sterkiella cavicola* is correct because “*Stylonychia grandis*” has straight undulating membranes. Conversely, the size, the nuclear apparatus, and the cyst are almost identical. Because of the uncertainty, I provide a separate description of “*Onychodromus grandis*” sensu MAUPAS (1888).

The synonymy of *S. cavicola* and *Oxytricha magna* is evident and was already suggested by BORROR (1972a). *Sterkiella admirabilis* also has 4 macronuclear nodules but is

← Fig. 181a–g *Sterkiella cavicola* (from BERGER & FOISSNER 1987a. a–d, from life; e–g, protargol impregnation. a–d, f, g, Austrian population; e, Japanese population). a–c) Ventral, lateral, and dorsal view, a = 195 µm, b = 145 µm, c = 165 µm. d) Cyst, diameter without protrusions about 53 µm. e–g) Ventral and dorsal infraciliature, e = 105 µm, f = 150 µm, g = 135 µm; p 669.

Fig. 181j, k *Sterkiella cavicola* (from GROLIERE 1969. j, k, protargol impregnation). **j)** Ventral infraciliature. Arrowhead marks posterior postoral ventral cirrus. **k)** Very early morphogenetic stage in ventral view. OP = oral primordium, TC = left transverse cirrus; p 669.

distinctly longer (390–450 μm) and has more adoral membranelles (50–60) and marginal cirri. However, synonymy cannot be excluded.

Morphology and biology: In life 140–220 $\times$ 70–100 μm (BERGER & FOISSNER 1987a), according to KAHL (1935) 180–250 μm long, after GELEI & SZABADOSZ (1950) 200 $\times$ 90 μm , after GROLIERE (1969) 220–250 $\times$ 100–120 μm , after SHIN & KIM (1994) 150–220 $\times$ 70–100 μm . Ovoid or margins almost in parallel. Flattened about 2.5:1

Fig. 181l–q *Sterkiella cavicola* (l, from GROLIERE 1969; m, from GELEI & SZABADOS 1950; n, from KAHL 1935; o–q, from MAUPAS 1888. l, protargol impregnation; m, sublimate fixation; n–q, from life). l) Ventral infraciliature, size not indicated. One of the 3 undulating membranes is likely a misobservation (cp. Fig. 181j). m, n) Ventral views, m = 140 μ m, n = 200 μ m. o) Ventral view of a “normal” specimen, 150 μ m. p) Large specimen with supernumerary frontoventral cirri, 235 μ m. q) Cyst, 55 μ m; p 669.

dorso-ventrally, anterior and posterior part very thin. Dorsal furrow pronounced, even in overfed specimens. Macronuclear nodules in life about $20 \times 15 \mu$ m, located along median or slightly left of it. Anterior macronuclear nodule usually slightly larger than posterior one (Fig. 181e, g, Table 40). 2–6, usually 3–5, in life about 4 μ m sized, spherical micronuclei. Contractile vacuole in about mid-body, during diastole with 2 large, dilated collecting canals.

Adoral zone of membranelles 40–45 % of body length, bases of largest membranelles in life about 11 μ m wide. Buccal area rather broad. According to GROLIERE (1969, 1970) and FERNANDEZ-LEBORANS (1985) a third undulating membrane is present (Fig. 181l); however, in the micrographs by GROLIERE (1969) it is not discernible (Fig. 181j), indicating a misobservation. Invariably 3 frontal and 4 frontoventral cirri and 1 buccal cirrus, genus-specifically arranged; frontal and ventral cirri in life about 25 μ m long. Usually 5, rarely up to 7 postoral and pretransverse ventral cirri. Usually 5, rarely 6,

Table 40 Morphometric data of *Sterkiella cavicola* (ca1 = Austrian population, ca2 = Japanese population, both from BERGER & FOISSNER 1987a; ca3, from SHIN & KIM 1994), *S. histriomuscorum* (hi1 = population from Guttal, Glockner area, Austria, hi2 = population from the Schloßalm area, Bad Hofgastein, Austria, from BERGER et al. 1985; hi3, from AUGUSTIN & FOISSNER 1992; hi4, from SHIN & KIM 1994), *S. thompsoni* (tho, from FOISSNER 1996b), and *S. terricola* and *S. tricirrata* (ter, tri, from BUTKAMP 1977b). All data are based on protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	ca1	135.3	25.2	18.6	88	186	21
	ca2	102.9	8.3	8.1	87	121	16
	ca3	155.6	13.9	8.9	123	180	16
	hi1	81.7	4.5	5.5	72	88	15
	hi2	64.9	5.4	8.3	57	75	15
	hi3	99.0	13.2	13.3	85	129	20
	hi4	105.6	4.9	4.6	100	114	10
	tho	97.0	10.3	10.7	82	115	15
Body, width	ca1	73.9	18.4	24.9	42	112	21
	ca2	53.7	6.8	12.7	43	67	16
	ca3	74.4	5.7	7.6	61	82	16
	hi1	42.8	5.8	13.4	33	50	15
	hi2	32.7	4.0	12.1	28	42	15
	hi3	47.7	4.9	10.3	41	62	20
	hi4	53.0	3.6	6.8	47	59	10
	tho	40.1	7.1	17.7	31	56	15
Adoral zone of membranelles, length	ca1	60.5	15.2	25.2	39	96	21
	ca2	41.6	2.1	4.9	39	46	16
	ca3	66.6	5.3	7.9	60	80	16
	hi1	31.1	2.6	8.2	27	37	15
	hi2	27.5	1.9	6.9	25	32	15
	hi3	45.2	3.8	8.5	39	53	20
	hi4	43.4	2.0	4.6	41	47	10
	tho	40.3	3.0	7.4	35	48	15
Adoral membranelles, number	ca1	48.1	9.3	19.3	32	70	21
	ca2	33.3	1.5	4.5	30	36	16
	ca3	37.8	1.9	5.1	35	43	16
	hi1	31.0	2.3	7.4	26	34	9
	hi2	29.2	1.7	5.9	27	32	9
	hi3	39.3	22.9	7.3	34	44	20
	hi4	28.4	1.3	4.5	27	31	10
	ter	-	-	-	22	23	?
	tho	34.4	2.1	6.0	32	39	15
	tri	-	-	-	23	25	?
Right marginal row, number of cirri	ca1	24.8	1.9	7.7	22	29	21
	ca2	23.3	1.2	5.1	22	26	16
	ca3	24.2	2.3	9.5	17	26	16
	hi1	20.7	2.1	10.2	17	24	12
	hi2	19.0	1.0	5.5	17	21	12
	hi3	27.2	2.0	7.4	24	32	20
	hi4	21.6	1.2	5.4	20	23	10

Table 40 Continued

Character	Species	mean	SD	CV	Min	Max	n
Right marginal row, number of cirri	ter	20.0	-	-	-	-	?
	tho	22.3	1.8	8.2	19	25	15
	tri	-	-	-	11	13	?
Left marginal row, number of cirri	ca1	21.6	2.6	12.1	18	28	21
	ca2	21.3	1.2	5.6	19	24	16
	ca3	21.4	2.5	11.6	15	24	16
	hi1	19.0	1.1	5.8	17	21	11
	hi2	15.9	1.6	10.3	12	18	11
	hi3	22.7	1.9	8.4	18	25	20
	hi4	18.2	1.6	8.5	15	20	10
	ter	17.0	-	-	-	-	?
	tho	17.8	2.2	12.4	15	24	15
	tri	-	-	-	10	13	?
Transverse cirri, number	hi1	4.0	0.4	10.2	3	5	13
	hi2	4.2	0.4	9.0	4	5	13
	hi3	4.7	0.6	12.6	4	6	20
	hi4	4.0	0	0	4	4	10
1st macronuclear nodule, length ¹	ca1	22.3	5.4	24.4	12	29	15
	ca2	14.5	1.1	7.5	13	17	16
	ca3	17.9	2.5	14.0	13	23	16
1st macronuclear nodule, width	ca1	16.0	4.2	26.1	9	23	15
	ca2	10.7	1.1	9.8	9	13	16
	ca3	10.1	1.6	15.7	7	12	16
2nd macronuclear nodule, length	ca1	17.4	5.0	28.7	10	25	15
	ca2	12.1	1.5	12.2	10	15	16
2nd macronuclear nodule, width	ca1	14.3	3.6	25.6	9	20	15
	ca2	9.2	0.7	7.1	8	10	16
3rd macronuclear nodule, length	ca1	18.1	5.6	30.8	10	28	15
	ca2	12.9	2.0	15.3	10	16	16
3rd macronuclear nodule, width	ca1	13.6	2.8	20.5	9	19	15
	ca2	8.9	0.6	7.3	8	10	16
4th macronuclear nodule, length	ca1	20.4	5.4	26.6	12	28	15
	ca2	12.1	1.5	12.0	10	14	16
	ca3	15.8	2.4	15.4	12	20	16
4th macronuclear nodule, width	ca1	13.2	2.7	20.7	9	18	15
	ca2	9.2	1.0	10.8	7	11	16
	ca3	9.2	1.3	14.5	7	12	16

¹ This is the anterior macronuclear nodule.

in life about 35 μm long, slightly enlarged transverse cirri. Marginal cirri in life 20 μm long; right marginal row begins almost at level of right frontal cirrus, anterior-most cirrus of this row usually slightly detached and not involved in primordia formation of right marginal row of proter (Fig. 181e, f). Dorsal kineties 3 and 4 slightly shortened anteriorly, kineties 5 and 6 distinctly shortened posteriorly (Fig. 181g). Caudal cirri in life about 20 μm long, arranged at end of dorsal kineties 1, 2, and 4 (Fig. 181g).

Cysts spherical, in life about 48–62 μm (mean = 55 μm ; $n = 25$) across, with an irregularly serrated surface, teeth about 2.5 μm high. Inner wall about 1.4 μm thick. Cytoplasm densely filled with small globules (Fig. 181d). In most strains several days are needed for the cysts to respond to excystment stimuli (NAKAMURA 1989). The results by NAKAMURA & MATSUSAKA (1991) suggested that excystment is influenced, among other things, by the age of the cysts, strain differences, and the medium in which the cysts were formed or aged. Further details on the cyst and on en- and excystment, see CALVO & DE MIGUEL (1995/96), CALVO et al. (1992), LOPEZ et al. (1995), MATSUSAKA (1977, 1979), MATSUSAKA & HONGO (1984), MATSUSAKA & KIMURA (1981), MATSUSAKA et al. (1984), NAKAMURA & MATSUSAKA (1985, 1992a, b), and VELASCO et al. (1992, 1995).

Southern hybridisation analysis using an α -tubulin probe from *Stylonychia lemnae* have been performed in order to estimate the number of α -tubulin genes present in the genome of *Sterkiella cavicola* (DELGADO et al. 1994, 1995). The analysis revealed a close relation between *Euplotes* and *Sterkiella* and suggested that both taxa are really closer than generally suggested by rRNA analysis. Further literature: PEREZ-ROMERO et al. (1998).

Morphogenesis of cell division is described by GROLIERE (1969, 1970); however, I doubt that all illustrations are correct. Figure 5A in GROLIERE (1969), for instance, shows a late stage with 8 frontal-ventral-transverse cirral streaks. The oral primordium originates near the left transverse cirrus (Fig. 181k).

Morphology and biology of “*Onychodromus grandis*” sensu MAUPAS (1888; Fig. 181o–q): Well-fed specimens (giants) in life about $300 \times 150 \mu\text{m}$ (Fig. 181p), small (probably normal) specimens about 150 μm long and 2.3 times as long as broad (Fig. 181o). Large specimens are bulging, small ones with parallel margins. Both ends rounded. Contractile vacuole in about mid-body. Cytoplasm cloudily granulated. Large specimens with about 12 frontal, buccal, and frontoventral cirri (Fig. 181p), small specimens with the typical number of 8 cirri (Fig. 181o). Invariably 5 postoral and pretransverse ventral cirri and 5 transverse cirri. “*Stylonychia grandis*” sensu HEMBERGER (1982, p 233), however, usually has 4 transverse cirri. According to the illustration by MAUPAS (1888) only the posterior-most transverse cirrus protrudes distinctly beyond posterior end of cell. Caudal cirri arranged slightly right of median. Cyst in life about 50 μm across, with prominent, blunt processes (Fig. 181q).

Occurrence and ecology: Widely distributed in terrestrial habitats and sometimes in the aufwuchs and detritus of freshwater. In litter of beech-forests often associated with *Rigidocortex octonucleatus* and *Territricha stramenticola*. Probably cosmopolitan.

Locus classicus is a tree hole with water in Germany, presumably near Hamburg, where KAHL lived. GELEI & SZABADOS (1950) discovered the synonym, *Oxytricha magna*, in rain puddles in Szeged, Hungary. Further records, largely substantiated by illustrations: upper soil layer of an arable field near the town of Salzburg, Austria (BERGER & FOISSNER 1987a, “Versuchsfläche D” in FOISSNER et al. 1987a); litter of beech-forests in Germany and Austria (BONKOWSKI 1996, LEHLE 1989, 1992, own observations); pond in a forest near Clermont-Ferrand, France (GROLIERE 1969, 1970, GROLIERE & NJINE 1973); soil on

the campus of the Faculty of Science, Kumamoto University, Japan (MATSUSAKA 1977, MATSUSAKA et al. 1984); terrestrial habitats near Seoul and on Ullung Island, Korea (SHIN & KIM 1994, 1995); soil in Amazonian rain forest near Iquitos, Peru (FOISSNER 1997b); soil (0–3 cm, pH 4.7) from cloud rain forest near summit of Monteverde Preserve, Costa Rica (FOISSNER 1997b); soil south of Sydney, Australia (BLATTERER & FOISSNER 1988). Records by ROHNERT (1951; *Oxitricha cavicola* par lapsus) from tree holes of Austria and Germany are not substantiated by illustrations.

Feeds on bacteria (*Enterobacter aerogenes*, *E. cloacae*, *Chromobacter violaceus*), autotrophic and heterotrophic flagellates (*Chlamydomonas* sp., *Chilomonas* sp., *Pandorina morum*, *Gonium* sp.), fungal spores, cysts of naked amoebas, ciliates (*Nassula* sp., *Hastatella* sp., *Tetrahymena* sp.); also cannibalistic (BERGER & FOISSNER 1987a, GELEI & SZABADOSZ 1950, GROLIERE 1969, KAHL 1935). MATSUSAKA et al. (1984) cultured *Sterkiella cavicola* at 25 °C in 0.1 % (w/v) lettuce extract in Petri dishes with *Tetrahymena* sp. as food. SENDO & MATSUSAKA (1982) used following culture method to obtain mass culture: a 200 ml aliquot of 0.1 % lettuce extract in a 500-ml Erlenmeyer flask was inoculated with 2.8×10^6 *Tetrahymena* sp. and incubated for 30–40 h at 25 °C. The flask was then maintained at 25 °C while positioned on a reciprocal shaker set for 70 strokes min⁻¹ with an amplitude of 3 cm. After a lag phase of 10 h, the cultures entered an exponential growth phase. Subsequent to a short period during which the growth rate decelerated, the cultures reached a stationary phase about 60 h after inoculation. The cell density at the stationary phase was about 1000 cells ml⁻¹, and generation time during exponential phase was about 6 h. Biomass of 10⁶ individuals about 540 mg (FOISSNER 1987a).

Records of "*Onychodromus grandis*" sensu MAUPAS (1888): MAUPAS found it in an infusion of cress collected in Algeria. Records not substantiated by illustrations: once with high abundance at a water temperature of 10 °C in the Tiber River, Italy (STELLA & CAMPEA 1948); mud of a fishpond in Poland (CZAPIK 1959); in sand, gravel, and silt sediments of small rivers in Latvia (LIEPA 1990, VEYLANDE & LIYEPÄ 1985); freshwater habitats in Japan (MATSUOKA et al. 1983); Copper Creek, Colorado, USA (CAIRNS & YONGUE 1973a). Feeds on small and large ciliates.

Sterkiella admirabilis (FOISSNER, 1980) comb. nov. (Fig. 182a–e)

1979 *Histiculus admirabilis* – FOISSNER & ADAM, Jb. Univ. Salzburg, 1977–1979: 153 (nomen nudum).

1980 *Histiculus admirabilis* FOISSNER, Ber. Nat.-Med. Ver. Salzburg, 5: 108 (Fig. 182a–c).

1988 *Stylonychia quadrinucleata* ALEKPEROV & MUSAYEV, Zool. Zh., 67: 1907 (Fig. 182d, e; new synonym).

Nomenclature and taxonomy: FOISSNER & ADAM (1979) published *Histiculus admirabilis* in a species list without description. The large size, the limnetic habitat, the shape of the undulating membranes, and many morphometric data separate it from other quadrinucleate species of the Oxytrichidae, such as *Sterkiella cavicola*, *S. quadrinucleatus*, or *Cyrtohymena quadrinucleata*. Redescription necessary.

Fig. 182a–e *Sterkiella admirabilis* (a–c, from FOISSNER 1980a; d, e, from ALEKPEROV & MUSAYEV 1988. a–c, from life; d, wet silver impregnation; e, Feulgen stain). a, b) Ventral and lateral view, a = 415 µm, b = 430 µm. c, d) Ventral infracapitulum, c = ? µm, d = 350 µm (according to bar 490 µm long!). Note that in (d) only 2 post-toral ventral cirri are shown. e) Nuclear apparatus. CV = contractile vacuoles, Ma = posterior macronuclear nodule, Mi = micronucleus; p 677.

The superficially described *Stylonychia quadrinucleata* is very likely not a *Stylonychia* because the undulating membranes are distinctly curved. (Fig. 182d). The size, the nuclear apparatus (two pairs of nodules), and the number of adoral membranelles (55–60) are rather similar to in *S. admirabilis*, indicating synonymy.

Morphology and biology: In life 390–450 µm long, about 2.5–3.1 times as long as broad (FOISSNER 1980a), according to ALEKPEROV & MUSAYEV (1988) about 350 µm long (see, however Fig. 182d). Body margins more or less parallel. Anterior and posterior strongly flattened dorso-ventrally (Fig. 182b). Slightly flexible (but never as much as in *Oxytricha* species). Macronuclear nodules usually arranged in 2 distinct pairs slightly left of median. Usually 4, sometimes only 2 micronuclei. Two contractile vacuoles, namely a small one at distal end of undulating membranes, and a large one at level of cytostome. Cytoplasm with few, large, orange-yellow inclusions and opaque by many irregularly shaped granules.

Adoral zone of membranelles almost 50 % of body length, about 50 membranelles (FOISSNER 1980a), according to ALEKPEROV & MUSAYEV (1988) 55–60 membranelles. Rather invariably 3 frontal and 4 frontoventral cirri and 1 buccal cirrus. Usually 3 post-toral and 2 pretransverse ventral cirri; however, occasionally up to 10 ventral cirri. Usu-

ally 5, sometimes 6 transverse cirri. All frontal, ventral, and especially transverse cirri distinctly enlarged. About 30 left and 42 right marginal cirri (ALEKPEROV & MUSAYEV 1988). Three inconspicuous caudal cirri in median of cell (FOISSNER 1980a).

Occurrence and ecology: Locus classicus is a melt water pool (pond 23 in FOISSNER 1980c) north of the Fuschertörl, Großglockner Hochalpenstraße, Austrian Alps, about 2400 m above sea-level. FOISSNER (1980a, 1980c) found *S. admirabilis* also in the benthic area, the periphyton, and the pelagial of some other small water bodies near the Großglockner. Locus classicus of the synonym, *Stylonychia quadrinucleata*, is a garden soil on the Apsheron peninsula, Azerbaijan (ALEKPEROV & MUSAYEV 1988).

Feeds on bacteria and coccale green algae (FOISSNER 1980a, c). FOISSNER & ADAM (1979) and FOISSNER et al. (1982a) provided following autecological data (6 analyses): b-a, 0.2×10^6 to 5×10^6 bacteria ml⁻¹ (direct counting), 4.6–14.4 °C, 8.1–9.9 mg l⁻¹ O₂ (85–124 % saturation), pH 4.8–5.0, 1.1–2.0 °dH total hardness, 36–54 mg l⁻¹ KMnO₄-consumption, 0–0.31 mg l⁻¹ NH₄⁺-N.

Sterkiella thompsoni FOISSNER, 1996 (Fig. 182f–k, Table 40)

- 1964 *Opisthotricha* sp. – SUDZUKI, Sci. Rep. Jap. Antarctic Res. Expedition, 19: 5, 11 (Fig. 224g; see taxonomy).
 1972 *Oxytricha* sp. – THOMPSON, Antarctic Terrestrial Biology Antarctic Res. Ser., 20: 283 (Fig. 182i, 222a; see taxonomy).
 1996 *Sterkiella thompsoni* FOISSNER, Acta Protozool., 35: 112 (type slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: THOMPSON (1972) provided a description of this species after silver impregnation, but did not name it because he considered his data insufficient. However, they match the original description very well. Conversely, SUDZUKI's (1964a) population is rather superficially described; only the number of macronuclear nodules and the location (Antarctica) indicate that it is *S. thompsoni*. Three macronuclear nodules are very rare in hypotrichs and ciliates in general. However, the detailed morphometric characterisation (see below) and the records by SUDZUKI and THOMPSON prove that *S. thompsoni* is not a teratological population of the very common *S. histriomuscorum* (2 nodules) or *S. cavicola* (4 nodules). SESHACHAR & KASTURI BAI (1963) very briefly described a "new species of *Oxytricha*" from India also having 3 macronuclear nodules; however, this still unnamed population is much larger, namely 200–450 × 100–150 µm (Fig. 222c).

The classification of *S. thompsoni* is somewhat uncertain because the dorsal ciliature originates in the *Urosomoida* pattern (fragmentation of kinety 3 lacking; Fig. 24b), which is common in the Oxytrichinae, especially in *Urosomoida* and *Urosoma*. All other characters (body inflexible, lack of cortical granules, long adoral zone of membranelles, distinct fibres around dorsal cilia) strongly indicate that it is a Stylonychinae. The present classification implies that the *Urosomoida* pattern (loss of fragmentation of kinety 3)

evolved twice independently. Perhaps detailed ontogenetic data will reveal more insight into the true position of this species.

M o r p h o l o g y a n d b i o l o g y: In life about $90\text{--}130 \times 40\text{--}60\text{ }\mu\text{m}$. Usually broadly parallel-sided, rarely slightly bursiform, anterior end broadly rounded, posterior one narrowly rounded and often inconspicuously pointed. Rather rigid like, for example, *S. histriomuscorum* and *Stylonychia pustulata*, dorsoventrally flattened up to 2:1. Usually 3, very rarely 2 (in 6 out of 120 specimens; possibly postdividers) or 4 slightly to distinctly ellipsoidal macronuclear nodules in median of middle third of cell; middle nodule often slightly smaller than anterior and posterior ones; nodules after protargol impregnation $11\text{--}18\text{ }\mu\text{m}$ long (mean = $13.1\text{ }\mu\text{m}$, SD = $3.5\text{ }\mu\text{m}$, CV = 26.5 %, n = 15) and $7\text{--}12\text{ }\mu\text{m}$ broad (mean = $8.9\text{ }\mu\text{m}$, SD = $1.5\text{ }\mu\text{m}$, CV = 17.0 %, n = 15). Micronuclei almost spherical, after protargol impregnation $2\text{--}3 \times 1.5\text{--}2.1\text{ }\mu\text{m}$, number highly variable (1–6, mean = 2.0, SD = 1.7, CV = 84.2 %, n = 13), however, most specimens have only one. Contractile vacuole in mid-body with 2 long collecting canals extending anteriorly and posteriorly, anterior canal often with small dilations at level of buccal cavity. Cortex colourless, rigid, without special granules. Cytoplasm colourless, contains many small, yellowish crystals, some $2\text{--}6\text{ }\mu\text{m}$ sized, colourless fat globules, and food vacuoles up to $10\text{ }\mu\text{m}$ in diameter. Moves moderately fast, often resting for some time and thus easy to observe.

Adoral zone of membranelles about 42 % of body length. Buccal cavity rather large and deep, right margin thickened, possibly by fibres or backward directed endoral cilia, right half of cavity covered by hyaline lip. Paroral and endoral slightly curved, inconspicuously to distinctly intersecting optically, both very likely composed of dikinetids. Pharyngeal fibres inconspicuous. Frontal cirri and transverse cirri in life about $30\text{ }\mu\text{m}$ long. Frontal and transverse cirri slightly enlarged. Arrangement of frontal-ventral-transverse cirri as in other *Sterkiella*'s (Fig. 182j). Invariably 3 frontal, 4 frontoventral, and 2 pretransverse ventral cirri (n = 15), 1 buccal cirrus (n = 15), usually 3 (mean = 3.1, SD = 0.6, CV = 19.3 %, Min = 2, Max = 5, n = 15) postoral ventral cirri and usually 5 (mean = 5.1, Min = 5, Max = 6, n = 15) transverse cirri. Marginal rows distinctly separate posteriorly, gap occupied by caudal cirri right of cell median. Invariably 4 (n = 15) dorsal kineties. Kineti 1 slightly shortened anteriorly, kineties 2 and 3 $\pm$ as long as body, kineti 4 slightly shortened posteriorly. Dorsal cilia in life about $3\text{ }\mu\text{m}$ long, associated with distinct, oblique fibrillar structures. Invariably 2 (n = 15), in life about $30\text{ }\mu\text{m}$ long caudal cirri, one each on kineties 1 and 3 (Fig. 182k). Dorsal morphogenesis probably in *Urosomoida* pattern (Fig. 24b), that is, fragmentation of kineti 3 lacking.

← **Fig. 182f–k** *Sterkiella thompsoni* (f–h, j, k, from FOISSNER 1996b; i, from THOMPSON 1972. f, g, h, from life; i, wet silver impregnation; j, k, protargol impregnation). f) Ventral view of representative specimen, $105\text{ }\mu\text{m}$. h, g) Ventral and lateral view of oviform specimen showing oral apparatus and contractile vacuole (g). i, j) Ventral infraciliature, i = about $100\text{ }\mu\text{m}$, j = $110\text{ }\mu\text{m}$. k) Dorsal infraciliature, $110\text{ }\mu\text{m}$. Large arrow marks posterior end of dorsal kineti 4 (which is possibly a dorsomarginal row), tiny arrows denote fusiform fibre bundles surrounding dorsal cilia; p 679.

Opisthotricha sp. sensu SUDZUKI (1964a; Fig. 224g) in life $96\text{--}120 \times 40\text{--}80\text{ }\mu\text{m}$. 2–3 macronuclear nodules. More than 23 micronuclei (misobservation?). 20–26 right marginal cirri, marginal rows separate posteriorly. Three caudal cirri.

Oxytricha sp. sensu THOMPSON (1972; Fig. 182i) after wet silver nitrate impregnation $91\text{--}120 \times 39\text{--}50\text{ }\mu\text{m}$ (mean = $108 \times 43\text{ }\mu\text{m}$; $n = 25$). Both ends rounded. 3–4 oval to elongate macronuclear nodules in posterior 2/3 of cell. Adoral zone of membranelles $51\text{ }\mu\text{m}$ long on average. Four dorsal kineties.

Occurrence and ecology: Possibly endemic to Antarctica. Locus classicus is a *Drepanocladus uncinatus* moss from Signy Island, South Orkney Islands, Antarctica (FOISSNER 1996b). THOMPSON (1972) found *S. thompsoni* in a rock pool at the highest elevation behind Old Palmer Station, Antarctic Peninsula. SUDZUKI (1964a) isolated it from a moss sample from Langhovde, Antarctica. Further records: moss near Casey Station and fellfield south-west of Casey Station, Wilkes Land, continental Antarctica (PETZ & FOISSNER 1997a). Feeds on bacteria, heterotrophic flagellates, green algae, diatoms and wheat starch (FOISSNER 1996b).

Sterkiella terricola nom. nov. (Fig. 184n, o, Table 40)

1977 *Histiculus similis* (QUENN.) CORLISS, forma *tricirratu*s BUITKAMP, Acta Protozool., 16: 273 (Fig. 184n, o).

1986 *Histiculus tricirratu*s BUITKAMP, 1977 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 485 (see nomenclature).

Nomenclature and taxonomy: BUITKAMP (1977b) published the name “*tricirratu*s” expressly only for a “forma” of *Histiculus similis*. Thus, according to Articles 10c, 23j, 45g, and 50c (i) of the ICZN (1985) DRAGESCO & DRAGESCO-KERNÉIS (1986) are the authors of *Histiculus tricirratu*s because they first used this name for the species rank. However, both *H. tricirratu*s DRAGESCO & DRAGESCO-KERNÉIS, 1986 and *Oxytricha tricirrata* BUITKAMP, 1977 have to be transferred to *Sterkiella* so that they become secondary homonyms and the junior is invalid. Thus, the DRAGESCO & DRAGESCO-KERNÉIS (1986) species requires a replacement name in *Sterkiella*: *S. terricola* nom. nov. (basionym: *Histiculus tricirratu*s). *Histiculus tricirratu*s BUITKAMP, 1977 in DRAGESCO & DRAGESCO-KERNÉIS (1986, p 485) is an incorrect spelling. Differs from *Sterkiella histriomuscorum* in the number of macronuclear nodules and transverse cirri; however, synonymy cannot be excluded. Detailed redescription necessary.

Morphology and biology: In life (?) about $120\text{ }\mu\text{m}$ long, elliptical. Macronuclear nodules arranged in a chain left of median. 4 micronuclei. Contractile vacuole in about mid-body. Arrangement of frontal, ventral, and transverse cirri *Sterkiella*-typical, but with small cirrus between middle and right frontal cirrus (Fig. 184n, arrow). Cirri in life about $15\text{ }\mu\text{m}$ long. 6 dorsal kineties. Oral primordium originates at left transverse cirrus.

Occurrence and ecology: Locus classicus is the soil of a unburned savannah in the Ivory Coast. Not found since. Feeds on bacteria and cyanobacteria. Biomass of 10^6 individuals about 234 mg (FOISSNER 1987a; value to high), according to BUITKAMP (1979, as *Histriculus similis*) only 84 mg. BUITKAMP (1979) found 29 and 54 ind. g⁻¹ dry soil in cultures incubated at 20 °C and 35 °C, respectively.

Sterkiella histriomuscorum (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (Fig. 6b, 10a–v, 20a, 183a–l, 184a–m, 186e, f, Tables 3, 4, 40, 41, 52, Addendum 2)

- 1932 *Histrio muscorum* KAHL, Tierwelt Dtl., 25: 617 (Fig. 184k).
- 1938 *Stylonychia curvata* – GIESE & ALDEN, J. exp. Zool., 78: 117 (Fig. 186f; misidentification).
- 1950 *Opisthotricha terrestris* HORVÁTH, Anns Inst. Biol. hung., 19: 157, 158 (nomen nudum; see nomenclature).
- 1953 *Histrio similis* (QUENNERSTEDT 1867) – WENZEL, Arch. Protistenk., 99: 113 (Fig. 184h; misidentification).
- 1954 *Oxytricha minor* – MOTE, Proc. Iowa Acad. Sci., 61: 578, 588 (Fig. 184l; misidentification).
- 1954 Ciliate sp. No. 1 – MOTE, Proc. Iowa Acad. Sci., 61: 578, 588 (Fig. 184m).
- 1956 *Opisthotricha terrestris* HORVÁTH, Arch. Protistenk., 101: 275 (Fig. 183i, j; new synonym; incorrect subsequent spelling of *Opisthotricha*).
- 1957 *Oxytricha histrioides* GELLÉRT, Anns Inst. biol. Tihany, 24: 20 (Fig. 183l; new synonym).
- 1958 *Histrio macrostoma* GELLÉRT & TAMÁS, Anns Inst. biol. Tihany, 25: 229, 240 (Fig. 183k; new synonym).
- 1960 *Histriculus muscorum* (KAHL, 1932) – CORLISS, J. Protozool., 7: 275.
- 1970 *Opisthotricha terrestris* HORVATH – DELHEZ & CHARDEZ, Anns Spéleol., 25: 135 (Fig. 186e; incorrect subsequent spelling of *Opisthotricha*).
- 1970 *Histriculus muscorum* KAHL, 1932 – DRAGESCO, Anns Fac. Sci. Univ. féd. Cameroun (Numéro hors-série): 116 (Fig. 184g).
- 1972 *Histriculus muscorum* (KAHL, 1932) CORLISS, 1960 – BORROR, J. Protozool., 19: 14.
- 1972 *Oxytricha bimembranata* SHIBUYA, 1929 – MATIS & DANIŠKOVÁ, Acta Fac. Rerum nat. Univ. comen., Bratisl., 17: 49 (Fig. 184i, j; misidentification).
- 1982 *Histriculus muscorum* KAHL, 1932 – FOISSNER, Arch. Protistenk., 126: 80 (Fig. 184a–f; authoritative re-description; 1 slide of protargol-impregnated specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
- 1985 *Histriculus muscorum* (KAHL, 1932) – BERGER, FOISSNER & ADAM, Protistologica, 21: 303 (Fig. 10a–v).
- 1986 *Histriculus muscorum* KAHL, 1932 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 483.
- 1986 *Oxytricha terrestris* (HORWATH, 1958) – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 471.
- 1989 *Oxytricha trifallax* GRESLIN, PRESCOTT, OKA, LOUKIN & CHAPPELL, Proc. natn. Acad. Sci. U. S. A., 86: 6264 (see nomenclature).
- 1991 *Oxytricha histriomuscorum* – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 311 (see nomenclature).
- 1991 *Sterkiella histriomuscorum* (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 311 (see nomenclature).
- 1992 *Histriculus muscorum* – LEHLE, Mikrokosmos, 81: 21, Bild 6 (microphotograph of a protargol-impregnated specimen).

- 1992 *Sterkiella histriomuscorum* (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 – AUGUSTIN & FOISSNER, Arch. Protistenk., 141: 279 (Fig. 183a–e).
 1994 *Histriculus muscorum* KAHL, 1932 – SHIN & KIM, Korean J. Zool., 37: 115 (Fig. 183f–h).
 1994 *Histriculus muscorum* KAHL, 1932 – SHIN, Dissertation, p 131 (Fig. 183f–h).

Nomenclature and taxonomy. KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in the original description is thus *Oxytricha (Histrio) muscorum*. Consequently, it is a primary homonym of 3 other *O. muscorum* species described by KAHL (1932; namely *O. (Steinia) muscorum*, *O. (Opisthotricha) muscorum*, and *O. (Stylonychia) muscorum*) because the presence of a subgeneric name does not affect homonymy between species group names (ICZN 1985, Article 57d). This was always overlooked and replacement names were only provided by FOISSNER et al. (1991). At that time I did not consider “*Opisthotricha terrestris*”, *Oxytricha histrioides*, *Histrio macrostoma*, or *Oxytricha trifallax* as synonyms of “*Histrio muscorum*” and thus proposed the replacement name *Oxytricha histriomuscorum* (ICZN 1985, Article 60a). After the addition of these synonyms it would seem appropriate to use the name of the oldest synonym, namely “*Opisthotricha terrestris*” HORVÁTH (ICZN 1985). Nevertheless, I continue to use the replacement name in order to stabilise the nomenclature of this common species (FOISSNER & BERGER 1999). HEMBERGER (1982, p 239) proposed “*Stylonychia parallela*” as replacement name for “*Histrio muscorum* KAHL”. However, since his thesis is unpublished, this name is not available. “*Stylonychia parallela*” in DRAGESCO & DRAGESCO-KERNÉIS (1986, p 485) is an incorrect subsequent spelling of HEMBERGER’s name.

The name *Opisthotricha terrestris*, published by HORVÁTH (1950), was not accompanied by a description allowing a differentiation from other taxa so that it must be considered as nomen nudum. The body size, the outline of the cell, and the ventral (especially the distinctly posteriorly displaced postoral ventral cirrus V/3 and the 4 transverse cirri) and dorsal infraciliature are reminiscent of *Sterkiella histriomuscorum*. However, according to Table B in HORVÁTH (1950) *O. terrestris* has a flexible body, whereas it is almost firm in *S. histriomuscorum*. Nevertheless, I consider them as synonyms as both species were discovered in terrestrial habitats.

The synonymy of *S. histriomuscorum* and *Histrio macrostoma* is evident and was already proposed by HEMBERGER (1982, p 239). The little-known, terrestrial *Oxytricha histrioides* invariably has 4 transverse cirri and is very likely a further synonym of *S. histriomuscorum*, although GELLÉRT (1957) interpreted the body as metabolic and the postoral ventral cirrus V/3 is not very distinctly posteriorly displaced. It could thus also be a synonym of *Oxytricha auripunctata* or *O. quadricirrata*, which also have only 4 transverse cirri but are smaller and have cortical granules. BORROR (1972a) synonymised *O. histrioides* with *O. fallax*, which is, however, confined to limnetic habitats and has 5 transverse cirri.

WENZEL (1953) synonymised *S. histriomuscorum* with *Histriculus similis*, which is in fact rather similar (Fig. 178t). However, I avoid a synonymisation because no detailed redescription of a marine population exists. Since it cannot be excluded that *H. similis* in fact lacks caudal cirri, it is preliminarily not transferred to *Sterkiella*.

Fig. 183a–c *Sterkiella histriomuscorum* (from AUGUSTIN & FOISSNER 1992. a, b, from life; c, protargol impregnation). a, b) Ventral and left lateral view, a = 105 μ m, b = 120 μ m. c) Ventral infraciliature, 105 μ m. BC = buccal cirrus, FVC = frontoventral cirri, LMR = left marginal row, PVC = postoral ventral cirri, RMR = right marginal row, TC = transverse cirri; p 683.

Histiculus muscorum sensu DRAGESCO (1970; Fig. 184g) and ZOU & ZHANG (1992) have, among other things, undulating membranes in *Stylonychia* pattern, indicating misidentification. Morphogenetic features (formation of oral primordium left of postoral ventral cirri; origin of primordia from frontoventral cirrus IV/3) in ZOU & ZHANG (1992) suggest that the Chinese population is possibly *Stylonychia pustulata*. *Histiculus muscorum* sensu REUTER (1961) also has straight undulating membranes and the transverse cirri are arranged in two distinct groups; it is thus classified as *Stylonychia bifaria* (Fig. 159a).

Recently, we (FOISSNER & BERGER 1998) studied an original strain of “*Oxytricha trifallax*”, a nomen nudum species (see p 254) because no morphological data are published. We found no significant differences to *Sterkiella histriomuscorum*. GRESLIN et al. (1989) got it from Robert HAMMERSMITH, Ball State University. Further literature and information on “*O. trifallax*”, see p 254. *Oxytricha nova* also belongs to the *Sterkiella his-*

Fig. 183i–l *Sterkiella histriomuscorum* (i, j, from HORVÁTH 1956; k, from GELLÉRT & TAMÁS 1958; l, from GELLÉRT 1957. i–l, opal-blue stain after BRESSLAU). Ventral and dorsal infraciliature, i, j = 80 μ m, k = 110 μ m, l = 140–150 μ m; p 683.

triomuscorum complex (FOISSNER & BERGER 1999); further details and literature, see species indeterminata in *Oxytricha* (p 250).

Morphology and biology: In life 80–160 $\times$ 40–70 μ m, after KAHL (1932) 100–150 μ m, according to WENZEL (1953) up to 180 μ m long, after HORVÁTH (1956) 80 μ m long and 2 times as long as broad, after GELLÉRT (1957) about 140–150 μ m long and 2.5 times as long as broad, according to FOISSNER (1982) 100–150 $\times$ 40–60 μ m. Body usually slightly flexible, that is, not as rigid as, for example, in *Stylonychia mytilus* but not as flexible as, for example, in *Oxytricha granulifera*; very probably because of this intermediate state of flexibility it was often classified in *Oxytricha*. Body margins usually parallel, both ends rounded. Macronuclear nodules in life about 20–30 $\times$ 12–20 μ m, after protargol impregnation 9–21 $\times$ 5–12 μ m (mean = 14–17 $\times$ 7–10 μ m; n = 60), arranged slightly left of median. Distance between macronuclear nodules after protargol impregnation 2–15 μ m (mean = 6–9 μ m; n = 60). 1–3, usually 2 micronuclei, after protargol impregnation 2–3 μ m across. Contractile vacuole slightly in front of mid-body.

← Fig. 183d–h *Sterkiella histriomuscorum* (d, e, from AUGUSTIN & FOISSNER 1992; f–h, from SHIN & KIM 1994. d, g, h, protargol impregnation; e, silver carbonate impregnation; f, from life). d, h) Dorsal infraciliature, d = 105 μ m, h = 110 μ m. e) Adoral zone of membranelles and undulating membranes. f, g) Ventral view and ventral infraciliature, f = 100 μ m, g = 110 μ m. AM = adoral membranelles, CC = caudal cirri, e = endoral, Ma = macronuclear nodule, Mi = micronucleus, p = paroral; p 683.

Adoral zone of membranelles about 35–40 % of body length. Buccal area medium sized (Fig. 183a, 184a, k). Undulating membranes according to AUGUSTIN et al. (1986) and AUGUSTIN & FOISSNER (1992) composed of a double row of basal bodies (Fig. 183e), after FERNANDEZ-LEBORANS (1985) and FERNANDEZ-LEBORANS & MARTIN-GONZALEZ (1982) consist of a single row with a parallel fibre. Frontal and transverse cirri in life about 30 μm , marginal cirri about 20 μm long. Usually 5, rarely 4 or 6 postoral and pretransverse ventral cirri. Some populations predominantly with 4, some predominantly with 5 transverse cirri. Rather invariably 6 (Fig. 10b, 183b), according to AUGUSTIN & FOISSNER (1992) rarely 7 dorsal kineties. Kinetid 4 slightly shortened anteriorly, kineties 5 and 6 distinctly shortened posteriorly. Kinetid 1 consists of 16–28 ($n = 40$) basal body pairs, kinetid 2 of 17–26 ($n = 32$), kinetid 3 of 11–19 ($n = 32$), kinetid 4 of 7–19 ($n = 36$), kinetid 5 of 6–14 ($n = 40$), and kinetid 6 of 2–7 ($n = 52$). Invariably 3 caudal cirri on dorsal kineties 1, 2, and 4.

Morphogenesis of cell division is described by NIETO et al. (1984; without figures), BERGER et al. (1985), and PETZ & FOISSNER (1997a; see Addendum 2). It proceeds very similarly to in related species, so that only some details are mentioned (Fig. 10a–v, Table 4). Stomatogenesis commences just left of the left transverse cirrus and the proliferation of basal bodies yields a long and narrow oral primordium. About 88 % of the specimens investigated by BERGER et al. (1985) possess 4 transverse cirri, 6 % have 5, and 6 % have only 3 transverse cirri. The highly dominant set of 17 frontal, ventral, and transverse cirri arises within the streaks I–VI as follows: 1, 2, 3, 3, 4, 4. The right marginal primordium of the proter originates from the second (from anterior) cirrus (Fig. 10i). Morphogenesis of dorsal ciliature is in *Oxytricha* pattern (Fig. 10o).

Occurrence and ecology: Very common in terrestrial habitats (soil, moss) and in the benthal of running waters and lakes, rarely in waste water treatment plants. Probably cosmopolitan.

KAHL (1932) gave no exact locality; he discovered "*Histrio muscorum*" in alpine mosses from Germany but found it also in mosses from California, USA. I hereby fix a locality from FOISSNER's (1982; Fig. 184b) authoritative redescription as locus classicus, namely "SO3", an Alpine pasture at the Hochmaisalm near the Großglockner Hochalpenstraße, Austrian Alps (about 1850 m above sea-level). This site is heavily eutrophied by cattle manure and thus densely stocked with *Rumex* sp. and *Urtica* sp. Locus classicus of the synonym "*Opisthotricha terrestris*" is Szeged, Hungary, where HORVÁTH (1956) discovered it in the soil of the garden of the educational college. Locus classicus of the synonym *Oxytricha histrioides* is the humus layer of a Hungarian deciduous forest

← **Fig. 184a–g** *Sterkiella histriomuscorum* (a–f, from FOISSNER 1982; g, after DRAGESCO 1970 from DRAGESCO & DRAGESCO-KERNÉIS 1986. a, d, e, from life; b, c, f, g, protargol impregnation). a) Ventral view, 130 μm . b, c) Ventral and dorsal infraciliature, b, c = 65 μm . d, e) Dorsal and left lateral view, d, e = 140 μm . f) Ventral infraciliature of posterior part, width = 25 μm . g) Ventral infraciliature, 65 μm . The identification is somewhat uncertain because the undulating membranes are straight and arranged in parallel; reminiscent of *Stylonychia*. CC = caudal cirri, PRVC = pretransverse ventral cirri, TC = transverse cirri; p 683.

Fig. 184h–m *Sterkiella histriomuscorum* (h, from WENZEL 1953; i, j, from MATIS & DANIŠKOVÁ 1972; k, from KAHL 1932; l, m, after MOTE 1954. h, l, m, various staining methods; i–k, from life). Ventral views, h = 140 μ m, i, j, l, m = sizes not indicated, k = 100 μ m; p 683. **n, o** *Sterkiella terricola* (from BUTKAMP 1977b). Ventral infraciliature and nuclear apparatus after protargol impregnation, 120 μ m. Tiny arrow marks a very small cirrus between middle and right frontal cirrus; p 682.

Table 41 Autecological data of *Sterkiella histriomuscorum* (columns 1–3), *Histiculus histrio* (columns 4, 5), and *Urosoma caudata* (columns 6–8). References: column 1, from DETCHEVA (1972a, 1975a, 1979a, 1983c; many analyses from Bulgarian running waters); column 2, from FERNANDEZ-LEBORANS (1982; 36 analyses from the Manzanares River in Madrid, Spain); column 3, from FOISSNER et al. (1991; 10–15 analyses from various running waters in Austria); column 4, from DETCHEVA (1978, 1983c; many analyses from Bulgarian running waters); column 5, from PATRICK et al. (1967; 2 analyses from the Savannah River, USA); column 6, from RUTHVEN (1972) and CAIRNS & DICKSON (1972; 1 analysis from an American running water); column 7, from DETCHEVA (1983c; Bulgarian running waters; number of analyses not indicated); column 8, from RECK (1987; total range from a eutrophic lake in Germany; number of analyses not indicated)

Parameter ¹	Reference							
	1	2	3	4	5	6	7	8
Saprobity	a–b	a–p	b–p	b–a	-	-	a	-
Frequency (%)	0.3–2.5	66	11	0.6–1	-	-	0.6	-
Temperature (°C)	11–21	-0.5–28	0.3–13	13–16	17–20	23	18–22	4–9
pH	7.2–8.3	6.8–9.5	6.6–8.3	6.8–7.4	-	7.6	7.2–7.4	7.3–7.8
O ₂ (mg l ⁻¹)	0.8–10.4	0.8–10.2	3.4–13.3	7.4–8	7–9	3.6–4.5	4.6–7.4	3–7.8
O ₂ (% saturation)	9–95	-	31–115	70–80	-	-	53–78	23–65
BOD ₅ (mg l ⁻¹)	3.6–27	-	1.7–8	2.8–12	0.3–<3	2.3	8.5	-
NH ₄ ⁺ -N (mg l ⁻¹)	0.03–0.3	0–32	0.01–9	0.06–0.5	<0.009 ²	0	0.3–0.6	0.06–0.32
NO ₂ -N (mg l ⁻¹)	0.01–0.1	0–35	0–0.06	0.02–0.25	-	0.04	0.04–0.36	-
NO ₃ -N (mg l ⁻¹)	0–1.3	0–4.5	0.4–10.6	0–0.02	0.14–<0.5	0.06	0	-
PO ₄ ³⁻ -P (mg l ⁻¹)	-	-	0.02–2.8	-	0.016–0.03	1.9	-	-

¹ The figure “0” denotes only that the parameter in question could not be detected with the analytical method used.

² NH₃-N.

(GELLÉRT 1957; no further records are available of this synonym!). Locus classicus of the synonym *Histrio macrostoma* is the eastern shore of the Tihany peninsula in Lake Balaton, Hungary, where GELLÉRT & TAMÁS (1958) discovered it in detritus drifts (see also TAMÁS & GELLÉRT 1959).

Further records substantiated by illustrations: various terrestrial and limnetic habitats and activated sludge samples from Austria (AUGUSTIN & FOISSNER 1992, AUGUSTIN et al. 1986, 1987, FOISSNER 1987b, c, FOISSNER & FOISSNER 1988, FOISSNER et al. 1990); limnetic habitat in a cave in Belgium (DELHEZ & CHARDEZ 1970); Bavaria, Germany (WENZEL 1953); beech forest and limed spruce forest in Germany (LEHLE 1989, 1992, 1993); shallow rain water pool in Czechoslovakia (MATIS & DANIŠKOVÁ 1972); Turiec River in Slovakia (TIRJAKOVÁ 1993); soils in Himalayan region (FOISSNER 1986a); moss-covered soil on a wall near Seoul and in mosses from Ullung Island, Korea (SHIN & KIM 1994, 1995); soil of a virgin prairie near Crocker, Iowa, USA (MOTE 1954); soils in Australia (BLATTERER & FOISSNER 1988).

Records not substantiated by illustrations: garden soil in Upper Austria (PETZ et al. 1988); in activated sludge plant (Asten near Linz) in Upper Austria 3–30 d after sampling (OBERSCHMIDLEITNER & AESCHT 1996); soil in Belgium (CHARDEZ 1967, 1987); soil

and lotic waters in Bulgaria (DECHEVA 1968, 1970, DETCHEVA 1972b, 1979b, 1981, TOMESCU 1987); oligosaprobic to betamesosaprobic brooks and beta- to alphamesosaprobic rivers in Upper Austria and Bavaria (FOISSNER 1997a, FOISSNER & MOOG 1992, FOISSNER et al. 1992b); backwash sludge from oxidators and filters of a water works in Germany (FOISSNER 1996a); activated sludge from the sewage treatment plant Marburg-Cappel, Germany (ETTL 1996); soils in Hungary (GELLÉRT 1957); mesosaprobic rivers in Spain (FERNANDEZ-LEBORANS et al. 1990, NIETO et al. 1984); freshwater in Azerbaijan (ALEKPEROV 1988); various sites of a Donor water reservoir, USSR (ALEKPEROV 1989); temporary pool (32 % frequency, 23–27 °C) in Cameroon (NJINE 1977); limnetic habitats in Hunan Province, China (SHEN & GONG 1989); soil in Japan (TAKAHASHI & SUHAMA 1991); soil from Venezuela, Brazil, Costa Rica, Australia, and Tasmania (FOISSNER 1997b); soil from Marion Island, South Atlantic Ocean (FOISSNER 1996c); soil from Antarctica (FOISSNER 1996b, SUDZUKI 1979).

Feeds on bacteria (*Pseudomonas ovalis*), algae (green algae, diatoms, *Chlorogonium* sp.), fungi, flagellates, amoebas, and ciliates (*Colpidium colpoda*, *Pseudocryptolophosis alpestris*, *Pseudochilodonopsis mutabilis*, *Tetrahymena* sp., *Vorticella astyloformis*; FOISSNER 1981, 1982, GIESE 1951, HORVÁTH 1950, 1956, NIETO et al. 1982, TAMÁS & GELLÉRT 1958, WENZEL 1953); also cannibalistic (GIESE & ALDEN 1938). Up to 4.47 divisions per day at 26 °C when fed on *Colpidium colpoda* (GIESE & ALDEN 1938); according to NIETO et al. (1982), length of life cycle 6 ± 1 h ($\pm$ SD?) at 20 °C. Biomass of 10^6 individuals about 70 mg (FOISSNER 1987a).

Some autecological data of freshwater populations are summarised in Table 41, for autecological data of terrestrial populations, see FOISSNER (1981) and FOISSNER & PEER (1985). FERNANDEZ-LEBORANS (1982) counted up to 16 000 ind. l⁻¹ in the Manzanares River in Spain; he found the following optimum values of occurrence: 12.5 °C, pH 7.5, 3.5 mg l⁻¹ O₂, 0 mg l⁻¹ NH₄⁺-N, 0.14 mg l⁻¹ NO₂⁻-N, 0.13 mg l⁻¹ NO₃⁻-N. FOISSNER et al. (1991) found *S. histriomuscorum* once with high abundance in a polysaprobic brook (saprobic index of total biocoenosis = 3.4) under the following conditions: 8.7 °C, pH 8.1, 540 µS cm⁻¹ (20 °C), 13.8 °dH total hardness, 20 mg l⁻¹ Cl⁻, 20 mg l⁻¹ SO₄²⁻, 9 mg l⁻¹ NH₄⁺-N, 0.06 mg l⁻¹ NO₂⁻-N, 0.065 mg l⁻¹ NO₃⁻-N, 0.16 mg l⁻¹ PO₄³⁻-P, 2.2 mg l⁻¹ P_{total}, 3.4 mg l⁻¹ O₂ (31 % saturation), >3.4 mg l⁻¹ BOD₂, 30 mg l⁻¹ KMnO₄-consumption, 55 mg l⁻¹ COD, 184 000 bacteria ml⁻¹ (plate method, 22 °C), 330 000 endotypic coli per 100 ml (plate method, 44 °C). MATIS & STRAKOVÁ-STRIEŠKOVÁ (1991) recorded it from a brook and two thermal lakes in Czechoslovakia at 9–42 °C and pH 5.7–7.2. 100 µg l⁻¹ lead acetate and 20 µg l⁻¹ zinc chloride were lethal (FERNANDEZ-LEBORANS & ANTONIO-GARCIA 1986). Further data on the effect of heavy metals such as lead, zinc, and mercury, see FERNANDEZ-LEBORANS et al. (1987). Much less sensitive to ultraviolet radiation than *Euplotes patella* (GIESE 1938).

FERNANDEZ-LEBORANS (1982) classified *S. histriomuscorum* as alphamesosaprobic: a; a = 7, p = 3, I = 4, SI = 3.3. This agrees largely with the experience of FOISSNER et al. (1991) and the autecological data (Table 41), that is, *S. histriomuscorum* usually occurs in organically polluted waters. It is, however, also found in old soil suspensions contain-

ing many bacteria as well as in betamesosaprobic waters. Thus, FOISSNER et al. (1991) proposed the following classification: a; b = 2, a = 6, p = 2, I = 3, SI = 3.0. This has to be checked on reliably determined populations.

In this paragraph some faunistic records and ecological data of limnetic and terrestrial populations of "*Histriculus similis*" are listed because these are very likely misidentified *Sterkiella histriomuscorum*. Faunistic records: inundated meadow in Belgium (BERVOETS 1940); submerged, wet, moist, and dry mosses in Czechoslovakia (TIRJAKOVÁ & MATIS 1987a); Manzanares River, Spain (FERNANDEZ-LEBORANS & ANTONIO-GARCIA 1988, FERNANDEZ-LEBORANS & NOVILLO-VILLAJOS 1993); mountain lake in Romania (LEPSI 1957); percolating filters and activated sludge in England (CURDS 1975, CURDS & COCKBURN 1970a); freshwater in China (YANG 1989); water samples with detritus from the Mountain Lake Region, Virginia (BOVEE 1960); grassland soils in Canada (BICK & BUTTKAMP 1976). Ecology: according to CURDS & COCKBURN (1970b), "*Histriculus similis*" indicated an effluent BOD₅ range of 0–10 mg l⁻¹ in activated sludge plants. NOLAND (1925) found it in various types of freshwater in Wisconsin, USA, at 8.5–22.5 °C, 1.5–8.3 mg l⁻¹ O₂ (18–132 % saturation), pH 7.0–8.7. FERNANDEZ-LEBORANS et al. (1985) found 4–8, about 1.2–2.4 µm sized lead particles in specimens treated with 500 µg l⁻¹ lead acetate.

Sterkiella tricirrata (BUTTKAMP, 1977) comb. nov. (Fig. 185, Table 40)

1977 *Oxytricha tricirrata* BUTTKAMP, Acta Protozool., 16: 273.

T a x o n o m y: The only slightly flexible body, the arrangement of the frontoventral cirri, and the distinctly posteriorly displaced postoral ventral cirrus V/3 indicate that the species belongs to *Sterkiella*. It differs from *S. terricola*, which also has only three transverse cirri, in that it has only two macronuclear nodules. *Sterkiella histriomuscorum* has more adoral membranelles, more marginal cirri (Table 40), and more (6) dorsal kineties; nevertheless, synonymy cannot be excluded. Redescription necessary, especially live observations and morphometric characterisation.

M o r p h o l o g y: In life (?) about 80 µm long. Elliptical. Two micronuclei. Contractile vacuole in about mid-body. Undulating membranes each consist of a single row of basal

Fig. 185 *Sterkiella tricirrata* (from BUTTKAMP 1977b). Ventral infraciliature and nuclear apparatus after protargol impregnation, 80 µm.

bodies. Arrangement of frontal, ventral, and transverse cirri as in some other *Sterkiella* species. Invariably ($n = ?$) only 3 transverse cirri. Cirri in life about 10 μm long. Dorsal cilia 2 μm long, arranged in 5 kineties, however, it cannot be excluded that BUITKAMP (1977b) overlooked the short kinety 6.

Occurrence and ecology: Locus classicus is the soil of a burnt savannah in the Ivory Coast; not found since. Feeds on small amoebas and ciliates. Biomass of 10^6 individuals about 55 mg (FOISSNER 1987a), according to BUITKAMP (1979) only 24 mg. BUITKAMP (1979) found 115 and 29 ind. g^{-1} dry soil in cultures incubated at 20 °C and 25 °C respectively.

***Sterkiella quadrinucleatus* (SICK, 1933) comb. nov. (Fig. 186a–c, g)**

1932 *Histrio similis* QUENNERSTEDT, 1867 – KAHL, Tierwelt Dtl., 25: 615; in part, Fig. 116, 2 (Fig. 186b) ; not Fig. 121, 6.

1933 *Histrio similis* QUENNERSTEDT 1867 – KAHL, Tierwelt N.- u. Ostsee., 23 (Teil II.c): 114.

1933 *Histrio quadrinucleatus* KAHL n. sp. – SICK, Z. wiss. Zool., 2: 66 (see taxonomy).

1948 *Oxytricha (Histrio) similis*. QUENN. – MARGALEF, Publins Inst. Biol. apl., Barcelona, 5: 70 (Fig. 186g).

1961 *Histrio similis* QUENNERSTEDT, 1867 – REUTER, Acta zool. fenn., 99: 20 (Fig. 186a).

1972 *Histriculus similis* (QUENNERSTEDT, 1867) – BORROR, Acta Protozool., 10: 64 (Fig. 186c).

Nomenclature and taxonomy: KAHL (1932) classified *Histrio* as subgenus of *Oxytricha*; the correct name in his revision is thus *Oxytricha (Histrio) similis*, which is a secondary homonym of *Oxytricha (Opisthotricha) similis* in KAHL (1932).

Histriculus similis was originally described with two macronuclear nodules (Fig. 178t). KAHL (1932, Fig. 186b) designated a very similar, but quadrinucleate species as *H. similis*, assuming a misobservation by QUENNERSTEDT (1867). Recognising this shortcoming, SICK (1933) established a new species for the KAHL (1932) population, namely *Histrio quadrinucleatus*. It is probably confined to saline habitats. Thus, all records of “*Histriculus similis*” or “*Histrio similis*” from marine or inland saltwater which were identified according to KAHL (1932) are adjudged *Sterkiella quadrinucleatus*.

The BORROR (1972b; Fig. 186c) population agrees rather well with REUTER’s (1961; Fig. 186a) population, especially in body shape and in that they have an increased number of postoral ventral cirri and 6 transverse cirri. However, since KAHL (1932) mentioned that his populations sometimes also had 6–8 transverse cirri, I preliminarily avoid a further splitting. The REUTER (1961) and BORROR (1972b) populations are reminiscent of *Gastrostyla steinii* (rather invariably 4 transverse cirri) and *Territricha stramenticola* (2 macronuclear nodules, lives in beech litter). Detailed redescription necessary.

Morphology and biology: According to KAHL (1932) in life 150–250 μm , after MARGALEF (1948) 125–150 μm , after REUTER (1961) 110–130 μm long, after BORROR (1972b) 83–150 $\times$ 40–59 μm . Body margins parallel or slightly converging posteri-

Fig. 186a–c, g *Sterkiella quadrinucleatus* (a, after REUTER 1961; b, from KAHL 1932; c, from BORROR 1972b; g, from MARGALEF 1948. a, b, g, from life; c, from life and after nigrosin-mercuric-formalin method). **a, b, g)** Ventral views, a = 110–130 μ m, b = 150 μ m, g = 125–150 μ m. The small figure shows a lateral view. **c)** Ventral infraciliature of a specimen with supernumerary cirri, 90 μ m; p 694. **d)** *Oxytricha durhamiensis* (from BORROR 1972b). Ventral view from life and after nigrosin-mercuric-formalin method, 90 μ m; p 228. **e, f** *Sterkiella histriomuscorum* (e, from DELHEZ & CHARDEZ 1970; f, from GIESE & ALDEN 1938. e, f, from life). **e, f)** Ventral views, e = 80 μ m, f = 105 μ m. Nuclear apparatus in (f) stained with FEULGEN reaction; p 683.

only. Contractile vacuole in about mid-body (Fig. 186b), according to BORROR (1972b) numerous water expulsion vesicles aborally, in a series slightly left of median, indicating that this population is possibly a species of its own. BORROR (1972b) also mentioned small cortical granules.

Adoral zone of membranelles about 40 % of body length, about 40 membranelles (BORROR 1972b). Frontal and transverse cirri distinctly enlarged. Number and arrangement of cirri according to Figure 186b more or less *Sterkiella* specific; according to REUTER (1961) and BORROR (1972b) 2 or 3 supernumerary postoral ventral cirri and an additional transverse cirrus present. However, KAHL (1932) also mentioned that the number of transverse cirri is occasionally 6–8. At least 4 dorsal kineties (BORROR 1972b).

Occurrence and ecology: KAHL (1932, 1933) found *Sterkiella quadrinucleatus* in the Northern Sea near Sylt, Germany (locus classicus) and also in the Bay of Kiel, Eastern Sea, and in saline sites in Oldesloe near Hamburg, Germany. MARGALEF (1948) observed it in the littoral of a brackish pond near Barcelona, Spain. REUTER (1961, 1963a) recorded it from Scandinavian rock pools with a salinity of 0.43–1.09 ‰. BORROR (1972b) collected *S. quadrinucleatus* from New Hampshire tidal marshes, USA.

Records not substantiated by illustrations: brackish water in the Bay of Kiel, Germany (SICK 1933); sub-littoral sediments in the Eastern Sea (BOCK 1952, HARTWIG 1974); rarely in the aufwuchs community of a heavily polluted site in a harbour (Königshafen) near List, Sylt, Germany (KÜSTERS 1974); regularly in ground water (0.54–0.79 ‰ salinity) up to the 8 m isotele of the coast of Hiddensee Island, Eastern Sea (MÜNCH 1956); saline lake in Romania (TUCULESCO 1962b). STELLA (1947) found "*Histrio similis*" in a spring in Italy (misidentification?).

Feeds on green algae and diatoms (BORROR 1972b). MIHAILOWITSCH (1989) recorded it from small, saline running waters in Germany under the following conditions ($n = 7$): 12.3–17.8 °C, pH 7.4–7.7, 12–35 mg l⁻¹ CO₂, 2.5–9.8 mg l⁻¹ O₂, 0.05–0.39 mg l⁻¹ NH₄⁺-N ($n = 6$), 0.04–0.1 mg l⁻¹ NO₂⁻-N ($n = 5$), 1.7–6.9 mg l⁻¹ NO₃⁻-N ($n = 6$), 36 to 410 mg l⁻¹ Cl⁻, and 418–1943 µS cm⁻¹ specific conductivity. KAHL (1932) classified *Sterkiella quadrinucleatus* as meso- to polysaprobic; however, this has to be verified by further autecological studies on reliably determined populations.

Parastylonychia DRAGESCO, 1963

1963 *Parastylonychia* DRAGESCO, Cah. Biol. mar., 4: 263 – Type (original designation): *Parastylonychia plouneouri* DRAGESCO, 1963.

1972 *Parastylonychia* DRAGESCO, 1963 – BORROR, J. Protozool., 19: 14.

1985 *Parastylonychia* – SMALL & LYNN, Phylum Ciliophora, p. 460.

1997 *Parastylonychia* DRAGESCO, 1963 – BERGER & FOISSNER, Arch. Protistenk., 148: 149.

C h a r a c t e r i s a t i o n: Undulating membranes in *Stylonychia* pattern, that is, more or less straight and parallel. One right and 1 left row of marginal cirri, distinctly separate posteriorly. Caudal cirri absent.

T a x o n o m y: The characterisation is according to BERGER & FOISSNER (1997). Description of *Stylonychia* pattern, see chapter 2 in the general section. Monotypic; for details, see *Parastylonychia plouneouri*.

Single species

***Parastylonychia plouneouri* DRAGESCO, 1963 (Fig. 187)**

1963 *Parastylonychia plouneouri* DRAGESCO, Cah. Biol. mar., 4: 263.

1972 *Parastylonychia pleuneouri* DRAGESCO, 1963 – BORROR, J. Protozool., 19: 14 (incorrect subsequent spelling).

T a x o n o m y: The firm body indicates that it is a Stylonychinae. However, a detailed redescription and morphogenetic data are needed for a more exact classification of this marine species. Reminiscent of “*Stylonychia grandis*”, which, however, has caudal cirri (Fig. 181o).

M o r p h o l o g y: In life about 200 μm long, approximately 2.5 times as long as broad. Elliptical to parallel-sided, both ends broadly rounded. Body firm. Four macronuclear nodules, 1 or 2 micronuclei. Contractile vacuole not mentioned. Adoral zone of membranelles about 37 % of body length. Three enlarged frontal cirri, 5–6 frontoventral cirri (including buccal cirrus), 4–5 postoral ventral cirri, 2–3 pretransverse ventral cirri, and 5 distinctly enlarged transverse cirri, which protrude beyond posterior end of cell. 25–38 right and 16–20 left marginal cirri (according to the illustration, however, 31 left marginal cirri!). Four dorsal kineties, dorsal cilia very likely short, because neither mentioned nor drawn.

Fig. 187 *Parastylonychia plouneouri* (from DRAGESCO 1963). Ventral view in life and after protargol impregnation (“aspect général schématique”), 200 μm .

O c c u r r e n c e: Locus classicus is the Atlantic Ocean near the town of Roscoff, France, where DRAGESCO (1963) discovered *Parastylonychia plouneouri* in the saprobic psammal at “de Plounéour-Trez”. Not found since.

Pleurotricha STEIN, 1859

- 1859 *Pleurotricha* STEIN, Lotos, 9: 4 – Type (original designation): *Stylonychia lanceolata* EHRENBURG, 1835.
 1859 *Pleurotricha*. STEIN – STEIN, Organismus der Infusionsthier I, p 168.
 1932 *Pleurotricha* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 593.
 1972 *Pleurotricha* STEIN, 1859 – BORROR, J. Protozool., 19: 14 (see nomenclature and taxonomy).
 1974 *Pleurotricha lanceolata* STEIN – STILLER, Fauna Hung., 115: 105 (in part).
 1979 *Pleurotricha* s. str., subgen. n. – JANKOWSKI, Trudy zool. Inst., Leningr., 86: 62 – Type (original designation): *Pleurotricha grandis* STEIN, 1859 (see nomenclature and taxonomy).
 1997 *Pleurotricha* STEIN, 1859 – BERGER & FOISSNER, Arch. Protistenk., 148: 149.

C h a r a c t e r i s a t i o n: Undulating membranes in *Oxytricha* pattern. Two or more right and one or more left rows of marginal cirri. Caudal cirri absent. No parental marginal cirri retained after division. Dorsal morphogenesis in *Oxytricha* pattern.

A d d i t i o n a l c h a r a c t e r s: Large to very large. Body firm. Two macronuclear nodules. Contractile vacuole at about level of cytostome. Cortical granules lacking. Cytoplasm colourless, however, after STEIN (1859b) the cytoplasm of *P. lanceolata* is usually pale and bluish-grey. Adoral zone of membranelles 40–45 % of body length, buccal area large. 18 frontal-ventral-transverse cirral pattern. Left and middle frontal cirrus arranged at about same level, right one displaced distinctly posteriad. Postoral ventral cirrus V/3 near anterior pretransverse ventral cirrus (V/2). Transverse cirri arranged in 2 distinctly separated groups with 3 left (cirri II/1, III/1, IV/1) and 2 right (cirri V/1, VI/1) cirri respectively; only cirri of right group protrude distinctly beyond posterior end of cell. Frontal, pretransverse ventral, and transverse cirri and buccal cirrus distinctly enlarged. Outer marginal rows almost confluent posteriorly. Dorsal cilia 2–4 µm long. Freshwater, lentic waters obviously preferred.

N o m e n c l a t u r e a n d t a x o n o m y: STEIN (1859a) established *Pleurotricha* unequivocally for *Stylonychia lanceolata* and not for *Pleurotricha grandis*, as erroneously assumed by BORROR (1972a) and JANKOWSKI (1979). The latter author established the subgenera *Pleurotricha* (*Pleurotricha*) (see above) and *Pleurotricha* (*Allotricha*) (JANKOWSKI 1979, p 50, 62). However, the type species were wrongly fixed (ICZN 1985, Article 44a). Furthermore, *Pleurotricha* (*Allotricha*) was already classified as subgenus, albeit with some doubt, by BÜTSCHLI (1889). Incorrect subsequent spellings: *Pleurosticha* (HYMAN 1931, p 56); *Pleurtricha* (BUCHHOLZ & BUCHHOLZ 1974, p 251).

The characterisation is according to BERGER & FOISSNER (1997). For a detailed description of patterns mentioned, see chapter 2 in the general section. *Pleurotricha* has the typical 18 frontal-ventral-transverse cirral pattern of the oxytrichids, but additional mar-

ginal rows and no caudal cirri (the latter character, however, is not substantiated by morphogenetic data). The lack of caudal cirri (and the almost confluent outer marginal rows) indicate that it is possibly the sister-group of *Histriculus*. However, detailed morphogenetic studies are needed for clarifying the cladistic relationships. *Laurentiella*, *Onychodromus*, and *Coniculostomum*, all of which usually also have an increased number of cirral rows, differ (among other things) in that they have prominent caudal cirri. *Coniculostomum* has, furthermore, a different mode of marginal row formation, namely parental cirri are retained after division. *Allotricha* STERKI, 1878 was often considered to be a junior synonym of *Pleurotricha* (for example, BERGER & FOISSNER 1997, BORROR 1972a, KAHL 1932). However, it has a flexible body and cortical granules and thus belongs to the Oxytrichinae.

Pleurotricha includes two valid species, namely *P. lanceolata* and *P. grandis*. *Pleurotricha planensis* FERNANDEZ-LEBORANS, 1984 is a species indeterminata. *Pleurotricha indica* AMMERMAN, SAPRA and SCHLEGEL, 1987 is classified as *Coniculostomum* because it has caudal cirri. *Pleurotricha variabilis* REUTER, 1961 is flexible and thus classified in *Allotricha*. *Pleurotricha setifera* ENGELMANN, 1862 belongs to *Gastrostyla*. *Pleurotricha macrostoma* DRAGESCO, 1970, was transferred to *Holosticha* by BORROR (1972a).

Key to species

1. 1 left marginal row (for example, Fig. 188f) *P. lanceolata* (p 699)
- More than 1, usually 3 left marginal rows (Fig. 190a, b) *P. grandis* (p 712)

Pleurotricha lanceolata (EHRENBERG, 1835) STEIN, 1859 (Fig. 188a–z, 189a–x, Tables 27, 42)

- 1835 *Stylonychia lanceolata* EHRENBERG, Abh. preuss. Akad. Wiss., year 1835: 164 (no illustration).
 1838 *Stylonychia lanceolata* – EHRENBERG, Infusionsthierchen, p 373 (Fig. 188a–d).
 1841 *Kerona lanceolata* – DUJARDIN, Zoophytes, p 427.
 1852 *Cerona lanceolata* – PERTY, Zur Kenntniss kleinster Lebensformen, p 155.
 1859 *Pleurotricha lanceolata* – STEIN, Lotos, 9: 4 (combining author).
 1859 *Pleurotricha lanceolata*. STEIN – STEIN, Organismus der Infusionsthiere I, p 170 (Fig. 188e–g).
 1862 *Pleurotricha lanceolata* STEIN – ENGELMANN, Z. wiss. Zool., 11: 364 (Fig. 188h, i, o).
 1882 *Pleurotricha lanceolata*, EHR. sp. – KENT, Manual infusoria II, p 783.
 1898 *Pleurotricha lanceolata* (EHBG). – JOUKOWSKY, Verh. naturh.-med. Ver. Heidelb., 6: 21 (Fig. 188m).
 1925 *Pleurotricha grandis* STEIN – GULATI, J. Bombay nat. Hist. Soc., 30: 752 (Fig. 189l; misidentification).
 1928 *Pleurotricha lanceolata* – MANWELL, Biol. Bull. mar. biol. Lab., 54: 417 (Fig. 188l, 189n).
 1928 *Pleurotricha lanceolata* (STEIN) – MANWELL, Biol. Bull. mar. biol. Lab., 55: 433 (Fig. 188k).
 1932 *Pleurotricha lanceolata* (EHRB., 1838) – KAHL, Tierwelt Dtl., 25: 593 (incorrect dating).
 1932 *Pleurotricha* spec. – KAHL, Tierwelt Dtl., 25: 593, 601 (Fig. 188n).
 1933 *Pleurotricha lanceolata* (EHRENBERG) STEIN 1859 – WANG & NIE, Contr. biol. Lab. Sci. Soc. China, 10: 60 (Fig. 189k).
 1942 *Pleurotricha lanceolata* – LILLY, Physiol. Zool., 15: 147 (Fig. 188j).
 1963 *Pleurotricha lanceolata* (EHRENBERG) – LUNDIN & WEST, Free-living protozoa, p 68 (Fig. 189m).

Fig. 188a–d: *Pleurotricha lanceolata* (after EHRENBURG 1838. a–d, from life). a) Ventral view, 170–210 μm . b) “Dissolving” specimen. c) Lateral view. d) Dorsal view; p 699.

- 1968 *Pleurotricha lanceolata* – JEFFRIES & MELLOTT, J. Protozool., 15: 741 (Fig. 188s–z, 189a–f).
 1970 *Pleurotricha lanceolata* (EHRENBURG, 1838) – DRAGESCO, Anns Fac. Sci. Univ. féd. Cameroun (Numéro Hors-série): 125 (Fig. 188p–r).
 1972 *Pleurotricha tchadensis* DRAGESCO, Anns Fac. Sci. Univ. féd. Cameroun, 11: 85 (Fig. 189g; new synonym).
 1979 *Pleurotricha* (*Allotricha*) *lanceolata* – JANKOWSKI, Trudy zool. Inst., Leningr., 86: 62 (erroneously fixed as type of subgenus, see nomenclature of genus).
 1980 *Pleurotricha lanceolata* – GRIMES, MCKENNA, GOLDSMITH-SPOEGLER & KNAUPP, Science, 209: 281, Fig. 1a (scanning electron micrograph).
 1984 *Pleurotricha lanceolata* – MARTÍN-GONZÁLEZ, SERRANO & FERNÁNDEZ-GALIANO, J. Protozool., 31: 347 (Fig. 189i, j).
 1986 *Pleurotricha lanceolata* (EHRENBURG, 1838) STEIN, 1859 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 476 (Fig. 189h).
 1986 *Pleurotricha tchadensis* DRAGESCO, 1972 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 477.

Nomenclature and taxonomy: Incorrect subsequent spellings: *Pleurotricha lanccolata* STEIN (GURWITSCH 1934, p 17); *Pleurotricha lanceolatam* (KAY 1945b, p 272; KAY 1946, p 133); *Pleurotricha tchadiensis* (DRAGESCO 1972b, p 71).

Pleurotricha lanceolata is insufficiently described by EHRENBURG (1835, 1838) so that the identification by STEIN (1859a, b) is somewhat uncertain. STEIN (1859b) even supposed the insufficiently known *Trichoda calvitium* MÜLLER, 1773 (= *Kerona calvitium* in

Fig. 188e–g: *Pleurotricha lanceolata* (after STEIN 1859b). Ventral views from life, 170–297 μm . STEIN, one of the most outstanding protozoologists, recognized almost every detail of the infraciliature, including the lack of caudal cirri; p 699.

MÜLLER 1786) to be identical with the present species. *Pleurotricha* spec. sensu KAHL (1932) is very likely also *P. lanceolata* because it has the same ventral infraciliature and size; a third right marginal row is not as unusual as supposed by KAHL (1932; see Fig. 188e, n, z).

Pleurotricha tchadensis differs slightly from *P. lanceolata* in the arrangement and number of frontoventral and postoral ventral cirri, which is very likely, at least to some extent, due to inexact observations on the African population. Furthermore, DRAGESCO (1970) drew 7 dorsal kineties, which is probably a further misobservation; he obviously confused the outer right marginal row with a dorsal kinety (Fig. 188r). I thus synonymise *P. tchadensis* with the type, as already proposed by HEMBERGER (1982, p 222). However, further African populations should be studied.

Fig. 188h–o: *Pleurotricha lanceolata* (h, i, o, after ENGELMANN 1862; j, from LILLY 1942; k, l, from MANWELL 1928a, b; m, after JOUKOWSKY 1898; n, from KAHL 1932. h–j, m–o, from life; k, l, fixation with SCHAUDINN's fixative and haematoxylin staining). **h)** Conjugation, 260 μ m. **i)** Exconjugant with macronucleus anlage (arrowhead), 220 μ m. **j)** Ventral view, 145 μ m. **k, l)** Ventral infraciliature as seen from dorsal, 127 μ m. **m, n)** Ventral views, m = size not indicated, n = 220 μ m. **o)** Resting cyst with its distinct spines, 100 μ m; p 699.

Fig. 188p-r: *Pleurotricha lanceolata* (from DRAGESCO 1970. p-r, protargol impregnation). p, q) Ventral infraciliature, p, q = 150 µm. r) Dorsal infraciliature, 150 µm. The long dorsal kinety on the left margin (arrowhead) is very likely a misinterpreted right marginal row; p 699.

Fig. 188s–z, 189a, b: *Pleurotricha lanceolata* (from JEFFRIES & MELLOTT 1968. s–z, a, b, protargol impregnation). s–z, a, b) Variability of ventral infraciliature (see also Fig. 189c–f). However, note that the number and arrangement of the 18 frontal-ventral-transverse cirri is usually rather invariable; p 699.

Pleurotricha lanceolata sensu RAO (1928) is classified as a species of the *Stylomychia mytilus* complex because prominent caudal cirri are present. Furthermore, RAO (1928) possibly misinterpreted the dorsal cilia as outer right marginal row (Fig. 151o).

The CIENKOWSKY (1855; Fig. 222m, n) and EDMONDSON (1906; Fig. 234k) populations are insufficiently redescribed. *Pleurotricha lanceolata* sensu SMITH (1978, Fig. 92k) is classified as *Allotricha antarctica*. *Allotricha mollis* STERKI is a valid species belonging to the Oxytrichinae; it is thus excluded from the synonymy of *P. lanceolata* (BORROR 1972a).

Morphology and biology: Size obviously rather variable, in life 100–300 times 50–120 μm : 173–208 μm (EHRENBERG 1838), 170–297 μm (STEIN 1859b), 100 to 165 μm (MANWELL 1928a), 170–300 μm and 200–250 μm (Fig. 188n; KAHL 1932), 225–235 $\times$ 88–94 μm (WANG & NIE 1933), 128–200 $\times$ 52–84 μm (JEFFRIES & MELLOTT

Fig. 189c–f: *Pleurotricha lanceolata* (c, d, from JEFFRIES & MELLOTT 1968; e, f, after JEFFRIES & MELLOTT 1968. c–f, protargol impregnation). c, d) Variability of ventral infraciliature (cp. Fig. 188s–z, 189a, b). e, f) Ventral and dorsal infraciliature of representative specimens, sizes not indicated. CV = position of contractile vacuole, RMR1, RMR2 = right marginal row 1 and 2, respectively; p 699.

1968), 200–250 × 100–120 µm (MARTÍN-GONZÁLEZ et al. 1984). Elliptical to elongate lancet-shaped, anterior end rounded or obliquely truncated, posterior usually narrowly rounded, sometimes even slightly tapered. Body margins slightly to distinctly converging posteriorly; left margin almost straight or convex, right usually much more convex. Macronuclear nodules after protargol impregnation about 15–29 µm long. 2–3 micronuclei, about 2.5 µm across. Contractile vacuole opens dorsally between kineties 1 and 2, cytopyge between dorsal kineties 2 and 3 (JEFFRIES & MELLOTT 1968). Rapid movement, rather similar to in *Histriculus histrio* (STEIN 1859b).

Both undulating membranes consist of zigzagging basal bodies. Arrangement of frontal, ventral, and transverse cirri rather invariable (cp. Fig. 188f, i, n, 189e, i) and almost identical to in *Steinia sphagnicola* (cp. Fig. 189e and Fig. 173c). Bases of frontal, ventral, and transverse cirri composed of rather differing numbers of basal bodies (Fig. 189j). Right marginal row 1 (= outer one) begins at level of distal end of adoral zone of membranelles, terminates at posterior end of cell. Right marginal row 2 of rather varying length, but always present. Row 3, if present at all, usually distinctly shortened anteriorly and posteriorly. DRAGESCO (1972b) population sometimes with a fourth right marginal row with up to 3 cirri (Fig. 189g). Cirri in all marginal rows about equidistant; an impor-

Fig. 189g, h: *Pleurotricha lanceolata* (g, from DRAGESCO 1972b; h, from DRAGESCO & DRAGESCO-KERNÉIS 1986). Ventral infracapitulum after protargol impregnation, g = 180 μ m, h = 125 μ m; p 699.

tant difference to *Coniculostomum monilata*, where the cirri of the inner rows are distinctly more widely spaced than in the outer row. This is due to the different morphogenesis in *Pleurotricha* and *Coniculostomum*. Invariably 6 dorsal kineties, kineties 1–4 about of body length, dorsomarginal rows (= kineties 5 and 6) only 1/3 of body length (Fig. 189f, Table 42). For details on the fibrillar system, see MARTÍN-GONZÁLEZ et al. (1984).

Resting cyst spherical; ectocyst with prominent, about 6 μ m long, spine-like projections (Fig. 188o, 189n–u, x). Cysts average 56 μ m in diameter (without spines; JEFFRIES 1956; Fig. 189p–x); however, after ENGELMANN (1862) up to 100 μ m across. PENN (1935) investigated the effect of various factors (food, temperature, acidity, alkalinity, age of hay-rye infusion, excretion products of different organisms, bacteria, crowding, urine, ammonia, salts, extraction of water from the organism) on the rate of encystment. This part of the life cycle was studied by MANWELL (1928a), who stated that the old macronu-

Fig. 189i, j: *Pleurotricha lanceolata* (i, after MARTÍN-GONZÁLEZ et al. 1984; j, from MARTÍN-GONZÁLEZ et al. 1984. i, j, silver carbonate impregnation). i) Ventral infraciliature, size not indicated. j) Diagram of different cirri showing number and arrangement of basal bodies. F1 = cirrus I/1, F2 = II/3, F3 = III/3, F4 = II/2, F5 = VI/4, F6 = VI/3, F7 = III/2, F8 = IV/4, LMC = left marginal cirrus, RMC = right marginal cirrus, T1 = II/1, T2 = III/1, T3 = IV/1, T4 = V/1, T5 = VI/1, V1 = IV/2, V2 = V/4, V3 = V/3, V4 = V/2, V5 = VI/2 (see Fig. 6a for designation of cirri); p 699.

cleus and apparently 1 micronucleus is extruded during encystment. However, this could not be confirmed by JEFFRIES (1956), who studied mainly excystment (Fig. 189p–x). He found that the optimal rate of excystment is obtained at 20–23 °C. The time required for the completion of the excystment process averages 5–8 hours. Citric acid is a very good excysting agent (JEFFRIES 1959, 1962).

Morphogenesis of cell division and conjugation were studied by ENGELMANN (1862) and MANWELL (1928a, b), however, only live and hematoxylin-stained material was used. According to MANWELL (1928a) morphogenesis commences with the formation of an oral primordium in about mid-body, and not adjacent to the left transverse cirrus as is the case in many other Stylonychinae. However, this must be confirmed on protargol-impregnated material. The inner right marginal row develops from part of a streak in the outer parental right marginal row (BORROR & WICKLOW 1982). Regeneration and dorsi-conjugant formation were studied by HEWITT (1914) and TCHANG & PANG (1979a).

Mirror-imaged doublets can be obtained either by heat-shocking (41 °C, 17 min) random cultures of cells in the "log phase" and sub-cloning or by sub-cloning surgically induced longitudinal fragments of cells in the "log phase" of growth (GRIMES et al. 1980).

Occurrence and ecology: According to the literature common in detritus and aufwuchs of freshwater; much more common than *Pleurotricha grandis*. I have never seen this species and there is also no recent record from Austria (FOISSNER & FOISSNER 1988). Probably cosmopolitan.

Locus classicus of *Pleurotricha lanceolata* is a freshwater habitat near Berlin, Germany, where EHRENBURG (1835, 1838) discovered it among algae and cyanobacteria. Locus classicus of the synonym, *P. tchadensis*, is a pond in a reservation in Chad (DRAGESCO 1972b; see also DRAGESCO 1980). STEIN (1859a, b) found *P. lanceolata* together with *P. grandis* in the locus classicus of the latter species (see there), in a fish pond covered with *Lemna* sp. near Tharand (Germany), and, like EHRENBURG, highly abundantly between tufts of *Oscillatoria* and *Spirogyra* in a brook near the village of Niemeck, Czechoslovakia. Further records substantiated by illustrations: environs of Leipzig, Germany (ENGELMANN 1862); Madrid, Spain (MARTÍN-GONZÁLEZ et al. 1984); abundantly among decaying organic matter and aquatic plants in Lake Ho Hu, Nanking, China, during September (WANG & NIE 1933); infusion of dry leaves, Lahore, India (GULATI 1925); culture of leaves and swamp water from Orient Springs near Amherst, Massachusetts, USA (MANWELL 1928a, b); freshwater near Providence, Rhode Island, USA (LILLY 1942); Upper Peninsula of Lake Michigan, USA (LUNDIN & WEST 1963, WEST 1953); stream near Carlisle and spring-fed stream on the campus of the University of North Carolina, USA (JEFFRIES 1956, JEFFRIES & MELLOTT 1968); Cameroon (DRAGESCO 1970).

Records from freshwater habitats not substantiated by illustrations: Vienna and Upper Austria and font of the cemetery in Innsbruck, Austria (DALLA TORRE 1891, RIESS 1840); Belgium (BERVOETS 1940); Denmark (NIELSEN 1960); near Perth, England (CRAIGIE 1921); Ferrara and Sardinia, Italy (CANELLA 1954, PARONA 1883); Madrid and Barcelona, Spain (FERNÁNDEZ-LEBORANS & ANTONIO-GARCÍA 1988, MARGALEF LÓPEZ 1945); Bern and near Basle, Switzerland (PERTY 1852, RIGGENBACH 1922); saline lakes and various freshwater habitats in the USSR (EICHWALD 1844, GURWITSCH 1934, WEISSE 1848a, b); Palestine (BODENHEIMER 1937); at pH 3.0 in surface waters polluted by acid

← **Fig. 189k-x:** *Pleurotricha lanceolata* (k, from WANG & NIE 1933; l, after GULATI 1925; m, from LUNDIN & WEST 1963; n, from MANWELL 1928a; o, after ILOWAISKY 1926; p-x, from JEFFRIES 1956. k-m, o-x, from life; n, haematoxylin stain). k-m) Ventral views, k = 240 µm, l, m = size not indicated. n) A cyst containing 7 micronuclei, several of which appear to be in mitosis, 80 µm. o) Cyst, diameter without spines about 70 µm. p-x) Successive stages of excystment. p, q) Resting cyst (p) and cyst after 50 min in excystment medium (q), contractile vacuole and auxiliary fluid vacuoles present. r) Cyst immediately after one of the early systoles of the contractile vacuole. s) Organism now free in cyst membranes. t) Rupture of ectocyst, exposed endocyst with enclosed organism. u) Endocyst and enclosed organism escaping ectocyst. v) Folded organism free in endocyst. w) Trophozoite almost fully differentiated, macronuclear nodules and micronuclei discernible. x) Empty ectocyst. CV = contractile vacuole, EC = ectocyst, Ma = macronucleus, SB = storage body; p 699.

Table 42 Morphometric data of *Pleurotricha lanceolata* (lines 1, 2c, 2m, clone I-20, clone II-8, and mixed population II from JEFFRIES & MELLOT 1968; lines 3, 4, population from Cameroon and Benin respectively, from DRAGESCO & DRAGESCO-KERNÉIS 1986; line 5, from DRAGESCO 1972b). All data from protargol-impregnated specimens. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1 ²	105.1	-	-	90	120	>50
	2c ²	106.3	-	-	80	136	>50
	3 ¹	-	-	-	140	165	?
	4 ¹	-	-	-	115	135	?
	5 ¹	-	-	-	130	185	?
Body, width	1 ²	51.5	-	-	40	66	>50
	2c ²	43.9	-	-	32	60	>50
Adoral membranelles, number	3 ³	53.0	-	-	50	61	10
	5	-	-	-	54	79	?
Right marginal row 1, number of cirri	1	30.7	-	-	24	37	>50
	2c	30.8	-	-	15	36	>50
	2m	33.4	-	-	19	42	>50
	3	-	-	-	30	35	9
	4	-	-	-	30	40	?
Right marginal row 2, number of cirri	5	-	-	-	33	37	?
	1	14.9	-	-	8	23	>50
	2c	14.6	-	-	7	20	>50
	2m	17.5	-	-	9	25	>50
	3	-	-	-	19	25	?
Right marginal row 3, number of cirri	4	-	-	-	20	27	?
	5	-	-	-	25	30	?
	3	-	-	-	2	12	?
	5	-	-	-	12	21	?
	1	25.1	-	-	18	39	>50
Left marginal row, number of cirri	2c	25.8	-	-	12	32	>50
	2m	26.9	-	-	20	35	>50
	5	-	-	-	21	27	?
	1	28.5	-	-	22	36	>50
Basal body pairs in dorsal kinety 1, number	2c	28.3	-	-	21	34	>50
	2m	34.7	-	-	23	41	>50
	1	25.6	-	-	22	31	>50
Basal body pairs in dorsal kinety 2, number	2c	26.0	-	-	19	32	>50
	2m	31.5	-	-	23	38	>50
	1	25.3	-	-	21	31	>50
Basal body pairs in dorsal kinety 3, number	2c	25.8	-	-	22	31	>50
	2m	30.3	-	-	23	39	>50
	1	22.2	-	-	16	27	>50
Basal body pairs in dorsal kinety 4, number	2c	22.8	-	-	18	29	>50
	2m	27.5	-	-	20	38	>50
	1	10.9	-	-	7	15	>50
Basal body pairs in dorsal kinety 5, number	2c	11.6	-	-	8	17	>50
	2m	13.7	-	-	8	19	>50

Table 42 Continued

Character		mean	SD	CV	Min	Max	n
Basal body pairs in dorsal	1	6.6	-	-	4	10	>50
kinety 6, number	2c	6.8	-	-	5	10	>50
	2m	6.0	-	-	1	11	>50

¹ After protargol impregnation.

² After fixation with Bouin.

³ It is not clear if these values are valid for the population of Cameroon or Benin.

mine drainage, Indiana, USA (LACKEY 1938c); at 20–24 °C and pH 6.5–7.0 in the Douglas Lake and in a small stream in this region (Michigan) and in the Cape Fear River, North Carolina, USA (CAIRNS & YONGUE 1966, 1973a); spring-fed pond with bottom of leaf and twig litter, silt and a white marly clay-sand mixture, North Carolina, USA (YONGUE & CAIRNS 1971); Devil's Lake complex, North Dakota, USA (EDMONDSON 1920); pond in the botanical garden of the University of Pennsylvania, USA, during winter (WANG 1928); Rock Creek River with medium hard water, Pennsylvania, USA (PATRICK 1961); Reelfoot Lake, Tennessee, USA (BEVEL 1938); New River at 19 °C, pH 7.3, 8 mg l⁻¹ O₂ (YONGUE & CAIRNS 1979) and pond in Virginia, USA (HENEERY & CAIRNS 1980); Brazil (CUNHA 1913).

RICHARDS & CUTLER (1933) recorded *Pleurotricha lanceolata* from filters for the purification of waste waters from beet sugar factories.

Records from marine (EICHWALD 1852, FERNANDEZ-LEBORANS & NOVILLO 1993) and terrestrial habitats (BODENHEIMER 1935, CHAUDHURI 1929, DIXON 1937, 1939, GOODEY 1911, HARTMANN 1956, LOUSIER & BAMFORTH 1990, NIKOLJUK & GELTZER 1972, RICO FERRAT 1985, ROSA 1957a, SUDZUKI 1979, VARGA 1936) not documented by original illustrations.

Feeds on bacteria, algae (diatoms), flagellates (*Trachelomonas* sp., *Euglena gracilis*, *Astasia klebsii*), and ciliates like *Tetrahymena* and *Dexiostoma campylum* (HALL 1943, LILLY 1942, LILLY et al. 1949, RIGGENBACH 1922, WANG & NIE 1933). However, in bacteria-free cultures *P. lanceolata* failed to grow on *Tetrahymena* sp. (LILLY 1953). PENN (1935) obtained extraordinarily large specimens (300–350 µm) by feeding the pleurotrichs their own cysts. Cannibalism is also reported by LILLY (1942). *Glaucoma scintillans* and *Chilomonas paramaecium* are inadequate as food, and the algae *Stichococcus bacillaris* and *Chlorella* sp. and a number of single strains of bacteria did not support continued growth of *P. lanceolata* (LILLY 1942, see also KIDDER 1951).

Average division rate 1–2.05 (GREENLEAF 1926, WOODRUFF 1905a, see also HAMMOND 1938). BAITSELL (1914) found a remarkably high rate of 4 divisions per day for a 40 d period with hay infusion as culture medium (see also JENNINGS 1939, ZAIKA 1970). JEFFRIES (1956) used a 0.15 % (w/v) extract of Cerophyl for cultivation. Sterile Cerophyl solutions were added to sterile 60 mm petri dishes and inoculated with *Enterobacter aerogenes*. A

day or two later they were inoculated with *Tetrahymena* sp. and set aside until large numbers of well-feed animals were present. Each of these cultures were seeded with several specimens of *P. lanceolata*. MARTÍN-GONZÁLEZ et al. (1984) used the following culture procedure: test tubes containing 10 ml sterile lettuce infusion (1.5 g of lettuce powder and 1.5 ml CaCO_3 per litre distilled water, pH 7.0) were inoculated with *E. aerogenes* and incubated 24 h at 37 °C; 1 ml of a rich *Glaucoma scintillans* culture was added as food 24 h later, and 30 specimens of *P. lanceolata* from the original samples were put into each tube. Populations were kept at an optimum by sub-culturing every 2–3 days.

According to PENN (1959) *P. lanceolata* may be cultured in a hay-rye infusion with *Colpidium* or in a physiological medium with *Chlorogonium* as food. For experimental work, the latter method is preferred. A 0.2 % hay and 0.2 % rye infusion is prepared by boiling 1 g of hay and 1 g of rye in 600 ml of spring water for 8 min. After boiling and cooling, there are about 500 ml of solution. Then half of the rye grains are removed, leaving the other half with all the hay in the solution. This is then transferred to a 1 litre battery jar and left for 2 d in order to allow bacteria to grow. When the infusion is 2 d old and contains many bacteria, it is inoculated with *Colpidium* (or *Chilomonas*). After 24 h there are numerous colpidia present in the infusion. This is then inoculated with *Pleurotricha*. From time to time rich cultures of separately raised colpidia are added to the jar as additional food supply.

When doing physiological work where bacteria and organic matter are to be avoided, PENN (1959) recommends a physiological medium consisting of inorganic salts may be prepared according to the following formula: CaCl_2 0.0008 N, NaNO_3 0.0003 N, MgSO_4 0.0002 N, K_2HPO_4 0.0001 N, KH_2PO_4 0.0001 N, NH_4NO_3 0.0008 N. Boveri dishes of 50 ml capacity provided with covers may be used for culturing *Pleurotricha*. Place 20 ml of the medium in each Boveri dish. Add one pipette of concentrated culture of *Chlorogonium*, cultivated separately with the same medium, to each dish. Then transfer one or several pleurotrichs into each dish. Cover and place the cultures in a well-lit part of the room. Pleurotrichs so cultivated are morphologically and physiologically large and uniform. They divide four times a day. Some autecological data are shown in Table 27.

It is somewhat strange that *Pleurotricha lanceolata* is not classified saprobiologically, whereas *P. grandis*, which occurs much more rarely, can be found in many lists. According to the faunistic and ecological data, *P. lanceolata* probably prefers eutrophic stagnant waters. LACKEY (1938a) found it in ponds, pools and still areas along stream margins, polluted streams, and in trickling filters in the USA, indicating a distribution over a wide saprobic range with a preference of beta- and alphamesosaprobic areas.

Pleurotricha grandis STEIN, 1859 (Fig. 190a, b)

1859 *Pleurotricha grandis* STEIN, Lotos, 9: 4 (no illustration).

1859 *Pleurotricha grandis*. STEIN – STEIN, Organismus der Infusionsthiere I, p 169 (Fig. 190a).

1882 *Pleurotricha grandis*, STEIN – KENT, Manual infusoria II, p 782.

1932 *Pleurotricha grandis* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 593.

- 1935 *Pleurotricha grandis* STEIN 1859 – WANG & NIE, Sinensia, Shanghai, 6: 495 (Fig. 190b).
1979 *Pleurotricha (Pleurotricha) grandis* – JANKOWSKI, Trudy zool. Inst., Leningr., 86: 62 (erroneously fixed as type of subgenus, see nomenclature of genus).
1991 *Pleurotricha grandis* STEIN, 1859 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 275.

Taxonomy: Detailed redescription necessary. *Pleurotricha grandis* sensu KOFFMAN (1926) is only about 98 µm long and occurred in the soil of a garden. Since the size is not even the half of STEIN's (1859b) smallest specimens and since *P. grandis* is not reliably recorded from terrestrial habitats (see FOISSNER 1987a), the identification is rather doubtfully. It is thus classified as an insufficient redescription (Fig. 226b), together with the populations by GOODEY (1911; Fig. 223a), RAO (1928; Fig. 231a), and SCHMALL (1976; Fig. 226g).

Morphology and biology: After STEIN (1859b) in life 210–415 µm long, after WANG & NIE (1935) 300 × 140 µm on average. Broad elliptical, anterior end rounded, posterior slightly tapered. According to STEIN (1859b) body firm, after WANG & NIE (1935) however “rather flexible”. Usually 2 micronuclei. Rapid movement. 3–4 (usually 4) left and right marginal rows respectively. Rows become shorter at both ends from outside to inside. Inner right marginal row begins at about level of cytostome, terminates near pretransverse ventral cirri, consists of only about 9 cirri. Inner left marginal row located beside postoral ventral cirri, made up of 3–5 cirri only. Dorsal pattern unknown.

Occurrence and ecology: Rare; in detritus of eutrophic (mesosaprobic) stagnant waters. Eurasia. Locus classicus is a trout-pond in the village of Tharand near Dresden, Germany, where STEIN (1859a, b) discovered *Pleurotricha grandis* among *Callitriche* sp. The highest number and the largest specimens occurred 8 days after sampling, when the plants began to decompose. WANG & NIE (1935) found it in great abundance among decaying organic matter and aquatic plants in Lake Ho Hu, Nanking, China.

Records from freshwater habitats not substantiated by illustrations: rather abundant in a lake (Lanserssee) in Tyrol, Austria (DALLA TORRE 1891); puddle in Estonia (JACOBSON 1928); polluted font in Germany with green, foul water (GERSCHLER 1910); caves and bogs in Germany and Switzerland (GITTLESON & HOOVER 1969, GRIEPENBURG 1934, 1935, 1939, MESSIKOMMER 1954, SCHMIDT 1916); lake (Großes Heiliges Meer) in Germany (KEMPER 1930); Hamburg harbour, Germany (ROY 1938); Italy (ENRIQUES 1913; see also DINI et al. 1995); rare in May in the botanical garden of Basle, Switzerland (RIGGENBACH 1922); Ukraine (DOBROVLIANSKI 1914); periphyton of Lake Dong Hu, China (SHEN 1980); infusion of dry leaves in Lahore, India (BHATIA 1920); pond near Lake Erie, Ohio, USA (STEHLE 1923).

BOUTCHINSKY (1895) and BUTSCHINSKY (1897) found *Pleurotricha grandis* in saline inland waters in the USSR, AZOVSKY (1996) in the Barents Sea. Records from terrestrial habitats are unreliable (BHATIA 1936, CHAUDHURI 1929, KOFFMAN 1934, RAO 1928, SANDON 1927, SHIBUYA 1927).

Fig. 190a, b: *Pleurotricha grandis* (a, after STEIN 1859b; b, from WANG & NIE 1935). Ventral views from life, a = 210–415 μm , b = 275 μm ; p 712.

Voracious feeder devouring mainly diatoms and other unicellular algae. Half digested remnants are usually found crowding the cytoplasm. Biomass of 10^6 individuals about 1300 mg (FOISSNER et al. 1991). GAUSE (1936a, b) found *Pleurotricha grandis* at pH 6.3–7.9; at pH 7.6 he counted up to 6000 ind. l⁻¹. Hydrogen sulphide is not tolerated (WETZEL 1928b).

FOISSNER (1988a), MAUCH (1976), SLÁDEČEK (1963), SLÁDEČEK et al. (1981), and WEGEL (1983) classified *P. grandis* as betamesosaprobic indicator of water quality (b; b = 10, I = 5, SI = 2.0). However, according to the data by STEIN (1859b) and WANG & NIE (1935) beta- to alphamesosaprobic or

alphamesosaprobic conditions were preferred. Thus, the saprobic classification has to be verified on reliably determined populations (FOISSNER et al. 1991).

Fig. 191a, b: *Pleurotricha planensis*, a species indeterminata (from FERNANDEZ-LEBORANS 1984. a, from life (?); b, silver carbonate impregnation). a) Ventral view, about 105 μ m. b) Ventral infraciliature, size not indicated. Explanation of original labels: AM = anterior microtubule bundle, AZM = adoral zone of membranelles, BC = buccal cirrus, CC = caudal cirri, FC = frontal cirri (including some frontoventral cirri), IMF = intermembranellar fibres, Kd = kinetodesmal fibre, LMC = left marginal cirral row, Ma = macronucleus, Mi = micronucleus, PF1,2 = undulating membranes, PM = postcirral microtubule bundle, RMC1,2 = inner and outer right marginal cirral row respectively, SOF = suboral fibres, TC = transverse cirri, V1,2 = pretransverse ventral cirri; p 715.

Species indeterminata

Pleurotricha planensis FERNANDEZ-LEBORANS, 1984, J. nat. Hist., 18: 939 (Fig. 191a, b). Remarks: In life (?) 102–108 $\times$ 57–60 μ m. The description, the illustrations, and the micrographs are of very poor quality. Postoral ventral cirri obviously absent (or overlooked because of the low quality of the impregnation). Caudal cirri very prominent, conse-

quently classification in *Pleurotricha* certainly incorrect. I doubt that the infraciliature is correctly shown. I thus avoid any speculation as to which taxon it could belong. The undulating membranes are also described by FERNANDEZ-LEBORANS (1985). Locus classicus is the coast of the Mediterranean Sea in the Morro del Gos area, Castellon, Spain.

Insufficient redescriptions

Pleurotricha grandis ? (STEIN) – GOODEY, 1911, Proc. R. Soc., 84: 169 (Fig. 223a). Remarks: Has, unequivocally, only 1 left and 1 right marginal row. According to size, infraciliature, and edaphic habitat it could be a *Sterkiella histriomuscorum*, which is rather common in soil. England?

Pleurotricha grandis St. – KOFFMAN, 1926, Acta zool. Stockh., 7: 311 (Fig. 226b). Remarks: The small size (about 98 μm long) and the edaphic habitat (garden near Stockholm, Sweden) indicate a misidentification (see taxonomy of this species). Perhaps a redrawing from STEIN (1859b).

Pleurotricha grandis – RAO, 1928, J. Indian Inst. Sci., 11A: Plate II, Fig. 8 (Fig. 231a). Remarks: The figure shows only that it is a hypotrich ciliate. Soil in India.

Pleurotricha grandis STEIN 1859 – SCHMALL, 1976, Diplomarbeit, p 36 (Fig. 226g). Remarks: Possibly an *Allotricha*. 90–140 μm , 3 times as long as broad. Very flexible. Three right and 2 left cirral rows (including marginal ones). 32 adoral membranelles. 16–21 μm long transverse cirri protrude beyond posterior end of cell. Feeds mainly on sulphide bacteria (ciliates thus appear reddish), flagellates, single celled green algae, and diatoms were also ingested. Pool in Bonn, Germany.

Pleurotricha lanceolata EHR. – EDMONDSON, 1906, Proc. Davenport Acad. Sci., 11: 99 (Fig. 234k). Remarks: Possibly a *Histriculus* because only one right marginal row is present and caudal cirri are lacking. Freshwater, among algae. Iowa, USA.

Pleurotricha núm. 1 – IZQUIERDO, 1906, Protozoos, p 190 (Fig. 241f). Remarks: In life 280 μm long. Five conspicuous caudal cirri and thus certainly not a *Pleurotricha*. Freshwater in Chile.

Pleurotricha núm. 2 – IZQUIERDO, 1906, Protozoos, p 190 (Fig. 241g, h). Remarks: In life 100–140 μm long. Cyst 112 μm across. Feeds on *Arcella*. Possibly a *Pleurotricha lanceolata*. Freshwater in Chile.

Pleurotricha sp. – CHAUDHURI, 1929, Annls Protist., 2: Plate II, Fig. 31 (Fig. 226c). Remarks: Soil in India.

Pleurotricha sp. – CONN, 1905, Bull. Conn. St. geol. nat. Hist. Surv., 2: 59 (Fig. 226a). Remarks: According to the arrangement of the cirri it could be classified as *Pleurotricha grandis*, as recently suggested by FOISSNER et al. (1991). However, because of the small size (95 µm), I avoid such a synonymisation. Freshwater habitat in Connecticut, USA.

Pleurotricha sp. – NIKOLJUK & GELTZER, 1972, Pocvennye prostejsie SSSR, 1972, p 132 (Fig. 225k). Remarks: Soil in USSR.

Pleurotricha sp. – OLIVEIRA, KRAU & NASCIMENTO, 1954, Mems Inst. Oswaldo Cruz, 51: 409 (Fig. 234o). Remarks: In a cistern in Rio de Janeiro, Brazil.

Pleurotricha sp. – WEST & LUNDIN, 1963, Pap. Mich. Acad. Sci., 48: 108 (Fig. 220b). Remarks: See also LUNDIN & WEST (1963, p 167, Fig. 7). Freshwater in Michigan, USA.

Stylonychia lanceolata E. – CIENKOWSKY, 1855, Z. wiss. Zool., 6: 301, 306 (Fig. 222m, n). Remarks: Very likely not a *Pleurotricha lanceolata* because the cyst has a smooth surface.

***Rigidocortex* gen. nov.**

C h a r a c t e r i s a t i o n: Undulating membranes in *Oxytricha* pattern. One right and 1 left row of marginal cirri, slightly separate posteriorly. More than six dorsal kineties. Dorsal morphogenesis in *Oxytricha* pattern, however, kinety 3 not with simple, but with multiple fragmentation.

T y p e s p e c i e s: *Australocirrus octonucleatus* FOISSNER, 1988.

T a x o n o m y: BLATTERER & FOISSNER (1988) established *Australocirrus* with two species, namely *A. oscitans* (type) and *A. octonucleatus*, because both show multiple fragmentation of dorsal kinety 3. However, they differ significantly in body flexibility. Furthermore, in the very flexible *Australocirrus oscitans* cirrus V/3 (posterior postoral ventral cirrus) is involved in primordia formation, supporting the classification in the Oxytrichinae. Conversely, the body of *A. octonucleatus* is rigid, suggesting that it is not the sister group of *A. oscitans*. I thus transfer *A. octonucleatus* to the Stylonychinae. It differs from the rather similar *Sterkiella cavicola* in the higher number of macronuclear nodules and the multiple fragmentation of dorsal kinety 3. The latter character is the autapomorphy of *Rigidocortex*. It differs from other taxa of the Stylonychinae with multiple fragmentation (*Pattersoniella*, *Laurentiella*, *Onychodromus*) in that it has the typical 18-cirri pattern.

Single species

Rigidocortex octonucleatus (FOISSNER, 1988) comb. nov. (Fig. 192a–l, Table 43)

1988 *Australocirrus octonucleatus* FOISSNER, Stapfia, 17: 123 (the slide of holotype specimens is deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Taxonomy: See genus section.

Morphology and biology: FOISSNER (1988b) investigated 4 populations, one each from Kenya, Australia, Austria, and Germany. Because they agree very well in all important characters, they were not separately described in the original description. In all populations very small and very large specimens occurred; many characters thus show high coefficients of variability.

Type material (population from Kenya) in life about $180 \times 80 \mu\text{m}$, populations from Europe about $260\text{--}300 \times 130 \mu\text{m}$. Oval, that is, slightly converging anteriorly (Fig. 192c, h) or margins almost in parallel (Fig. 192a, d). Body rigid and not contractile. Flattened 2–3:1 dorso-ventrally. Cross-section with strongly flattened lateral areas, ventral side slightly concave, central dorsal part of cell distinctly arched (Fig. 192b, e). Macronuclear nodules spherical to slightly ellipsoidal, longitudinally arranged in about median of cell; number of nodules rather invariably on average: 7–9 (median = 8, $n = 16$; type material); 7–10 (median = 8, mean = 8.2, SD = 0.9, CV = 11.3 %, $n = 13$; population from Austria), 7–13 (median = 10, mean = 10.1, SD = 1.9, CV = 18.9 %, $n = 15$; population from Germany). Macronuclear nodules in life about $15\text{--}18 \times 14\text{--}15 \mu\text{m}$, after protargol impregnation $8\text{--}15 \times 7\text{--}13 \mu\text{m}$. 3–9, usually 5 micronuclei near macronucleus, in life about $4 \mu\text{m}$ across. Contractile vacuole about in mid-body, during diastole with conspicuous collecting canals; sometimes canals appear to consist of single vesicles (Fig. 192h). Cortical granules lacking (checked in live specimens and with methyl green-pyronin stain). Pellicle and cytoplasm colourless, latter densely filled with $2\text{--}10 \mu\text{m}$ sized, yellowish cytoplasmic crystals so that cells appear dark at low magnification and bright field illumination, sometimes many $4\text{--}6 \mu\text{m}$ sized, greasily shining globules in the marginal area (Fig. 192e). Moves hastily to and fro, stiff like a board.

Adoral zone of membranelles about 45 % of body length. Bases of largest membranelles in life $20\text{--}28 \mu\text{m}$ broad, cilia of membranelles up to $30 \mu\text{m}$ long. Buccal area broad, proximal part deep. Undulating membranes distinctly curved, in small specimens they intersect somewhat behind the middle (Fig. 192i), in large specimens they are arranged almost side by side and intersect in proximal quarter (Fig. 192l). Anterior and posterior fifth of paroral consists of basal bodies arranged in zigzag, middle part made up of short obliquely arranged kineties of 3–4 basal bodies each. Frontal cirri in life $30\text{--}35 \mu\text{m}$ long, usually arranged right of median, especially in large specimens. Com-

Fig. 192a–g *Rigidocortex octonucleatus* (from FOISSNER 1988b. a–g, from life. a, b, f, g, type material from Kenya; c, e, population from Germany; d, population from Austria). a, c, d) Ventral and dorsal views, a = 235 μ m. b) Right lateral view. e) Cross section. The small circles are globular inclusions in the marginal area of the cell. f) 2–10 μ m sized cytoplasmic crystals. g) Resting cyst, 60 μ m across; p 718.

paratively often (3 of 11) specimens with 2 (Fig. 192k) or 4 frontal cirri occur. 3–7, usually 5, in life 35–40 μ m long, slightly fringed transverse cirri, arranged almost longitudinally and sometimes subterminally, do not protrude (or only slightly) beyond posterior end of cell. Marginal cirri in life about 25 μ m long, rows almost confluent posteriorly. Two almost unshortened dorsal kineties, each with 1 caudal cirrus; other kineties slightly to very distinctly shortened, including posterior fragment of “kinety 3” which also bears a caudal cirrus (Fig. 192j). Some morphogenetic stages show that only 2 dorsomarginal ki-

Fig. 192h–j *Rigidocortex octonucleatus* (from FOISSNER 1988b, type material from Kenya. h, from life; i, j, protargol impregnation). **h)** Dorsal view showing contractile vacuole complex during diastole. **i, j)** Ventral and dorsal infraciliature, 115 µm; p 718.

neties are formed. Thus, the other shortened kineties probably originate by multiple fragmentation and/or by retention of parental kineties. All together about 9–13 dorsal kineties.

Resting cysts spherical, 50–62 µm (mean = 58 µm; SD = 4.0 µm; CV = 6.9 %; n = 8) across, covered by a 5–6 µm thick, irregularly folded wall (Fig. 192g).

Occurrence and ecology: Very common; rather certainly confined to terrestrial habitats, especially in litter of deciduous forests, where it is regularly associated with *Territricha stramenticola* (own observations). Locus classicus is a deciduous forest in Kenya, about 300 m from the shore of Lake Nakuru, where FOISSNER (1988b) discovered *Rigidocortex octonucleatus* in the upper soil layer (0–5 cm; brown-grey; high content of humus; densely grown with grass). FOISSNER (1988b) found it also in the litter of beech forests near Munich, Germany, and Salzburg city, Austria. BLATTERER & FOISSNER (1988) found *R. octonucleatus* in the upper soil layer with litter and roots of a *Eucalyptus* forest in the Belair National Park near Adelaide, Australia. Further records: soil (0–8 cm, pH 5.1) from blackwater inundation primary (?) rain forest on Anavilhanas archipelagos

Fig. 192k, l *Rigidocortex octonucleatus* (from FOISSNER 1988b. k, l, protargol impregnation). Ventral infraciliature of a large (k = 185 μ m) and a very large (l = 275 μ m) specimen of the type material from Kenya. Macronuclear nodules shown in outline only; p 718.

in the Rio Negro, Brazil (FOISSNER 1997b); dark brown soil mixed with much leaf litter (pH 7.1) from Amazonian rain forest near Iquitos, Peru (FOISSNER 1997b).

Feeds on ciliates (*Colpoda steinii*, *C. cucullus*, *Opercularia arboricolum*, *Vorticella astyliformis*, *Leptopharynx costatus*, hypotrichs, for example, *Euplotes* sp.) and hetero-

trophic flagellates. Sometimes bacteria, fungal spores, *Euglena* sp., and testaceans (*Euglypha* sp.) can be found in the voluminous food vacuoles. Biomass of 10^6 individuals about 900 mg (population from Europe).

Table 43 Morphometric data of *Rigidocortex octonucleatus* (from FOISSNER 1988b). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	142.6	9.0	20.9	108	195	11
Body, width	71.2	16.5	23.1	52	110	11
Adoral zone of membranelles, length	65.1	16.6	25.5	47	95	11
Adoral membranelles, number	49.4	8.7	17.6	38	67	11
Right marginal row, number of cirri	27.4	3.4	12.3	22	33	11
Left marginal row, number of cirri	24.6	1.9	7.8	21	27	11
Dorsal kineties, number	10.2	1.3	12.9	8	13	10

Onychodromus STEIN, 1859

1859 *Onychodromus* STEIN, Lotos, 9: 4 – Type (original designation): *Onychodromus grandis* STEIN, 1859.

1859 *Onychodromus* STEIN – STEIN, Organismus der Infusionsthier I, p 143.

1882 *Onychodromus*, STEIN – KENT, Manual infusoria II, p 766.

1932 *Onychodromus* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 621.

1972 *Onychodromus* STEIN, 1859 – BORROR, J. Protozool., 19: 14.

1974 *Onychodromus* STEIN – STILLER, Fauna Hung., 115: 163.

Characterisation: Undulating membranes in *Stylonychia* pattern. Number of frontal-ventral-transverse cirri increased, that is, more than 18. One right and 1 left row of marginal cirri, separate posteriorly. More than 6 dorsal kineties. Caudal cirri present. Cytoplasmic processes (horns) on dorsal surface. Frontal-ventral-transverse cirral primordia of proter and opisthe originate independently. At least 1 dorsal primordium with multiple fragmentation and 2 or more dorsomarginal kineties.

Nomenclature and taxonomy: Incorrect subsequent spellings: *Onchodromus grandis* STEIN (CONN 1905, legend to Plate XXVI; MAUCH 1976, p 432); *Onyochodromus* (WRIGHT & LYNN 1997, p 334); *Onichodromus grandis* (STEIN) (MADRAZO-GARIBAY & LÓPEZ-OCOTERENA 1973, p 67); *Onychdromus* (WICKLOW 1996); *Onychodomus grandis* (SONNEBORN 1964, p 696); *Onychodroma grandis* (ST.) (PROWAZEK 1910, p 154); *Onychodromas* (MCGRADY-STEED & MORIN 1996, p 97); *Onychodromas grandis* (for example, BAMFORTH 1963, p 133; SULLIVAN 1957, p 195); *Onychodromis grandis* STEIN (CAIRNS & YONGUE 1973b, p 190); *Onychodromous quadricornutus* (EMBLEY et al. 1995, p 88); *Onychodromus* (LANGLOIS & COATS 1997, p 174); *Onycodromus* STEIN

(GRANDORI & GRANDORI 1934, p 292); *Orynychodromus grandis* (KAHL) (SZTRANTOWICZ 1984, p 74); *Oxychodromus grandis*, STEIN (KENT 1882, p 766).

Onychodromus very probably belongs to the Stylonychinae because the body is rigid, the adoral zone of membranelles is more than 40 % of body length, and cortical granules are lacking (Fig. 25a). This position is supported by the *Stylonychia* pattern of the undulating membranes (Fig. 193p, y, 195e, h; see chapter 2 in the general section) and molecular biological data which suggest that *Onychodromus quadricornutus* is more closely related to *Stylonychia pustulata* and "*Oxytricha nova*" (a species of the *Sterkiella histriomuscorum* complex) than to *Oxytricha granulifera* (SCHLEGEL et al. 1991; see also BERNHARD et al. 1995, EMBLEY et al. 1992, GREENWOOD et al. 1991a, b, HIRT et al. 1995, LEIPE et al. 1994, SCHLEGEL 1991). Accordingly, the increased number of cirri per streak (*Onychodromus grandis*, *Onychodromus quadricornutus*) and the increased number of streaks (*O. quadricornutus*) evolved from the 18 frontal-ventral-transverse cirral pattern.

The synapomorphy of *Onychodromus grandis* and *O. quadricornutus* are the dorsal cytoplasmic processes, a curious character which is, unfortunately, not mentioned in the original description (STEIN 1859a), some revisions (for example, CURDS et al. 1983, KAHL 1932, KENT 1882), and redescrptions of the type species (JONES 1974, LUNDIN & WEST 1963, SMITH 1914, TUFFRAU & FLEURY 1994). The function of these processes is not completely understood, however, in *O. quadricornutus* these horns can prevent intraspecific predation (WICKLOW 1988b). *Aspidisca turrita* (EHRENBERG, 1831) CLAPARÈDE & LACHMANN, 1858 evolved a similar horn independently (FOISSNER 1994f, FOISSNER et al. 1991). Reviewers of the original description of *Onychodromus quadricornutus* considered the decision to ally this conspicuous species with *O. grandis* as being too conservative. They suggested a new genus, which would, however, not increase the understanding of the phylogenetic relationships of this species group.

Onychodromus quadricornutus also shows some conspicuous agreements with *Kerona pediculus*, the well-known ectocommensal on *Hydra* and on bryozoans: (i) Dorsal morphogenesis is more or less identical, that is, all 3 primordia show multiple fragmentation and 2 dorsomarginal kineties originate, resulting in a high number of dorsal kineties (FOISSNER et al. 1987b). (ii) New marginal rows originate without involvement of parental marginal cirri. This peculiarity is known only from these 2 species. (iii) The number of cirri per streak is distinctly increased. However, I failed to construct a plausible cladogram including *Onychodromus grandis*, *O. quadricornutus*, and *Kerona pediculus* without assuming too many parallelisms or reductions.

According to CORLISS (1979, p 311), *Peritromoides* BHATIA, 1936 is a junior synonym of *Onychodromus*. However, the rather superficially described type species, *Peritromoides simplex* BHATIA, 1936, is reminiscent of *Hypotrichidium* and was thus transferred to this taxon by JANKOWSKI (1979). CURDS et al. (1983, p 432) proposed synonymy with *Himantophorus* EHRENBERG, 1838, which is, however, very likely a euplotid because the contractile vacuole is in the right posterior portion of the cell (EHRENBERG 1838).

Key to species

- 1 2 dorsal processes; usually 4, sometimes up to 8 macronuclear nodules; 5 or 6 transverse cirri; 1 contractile vacuole in about mid-body; frontoventral cirri not in highly ordered rows (Fig. 193a, k, l, r) *O. grandis* (p 724)
- 3 or 4 dorsal processes; 10–30, usually 11–19 macronuclear nodules; 9–16 transverse cirri; several contractile vacuoles; frontoventral cirri in about 13 highly ordered rows (Fig. 195a–c, h, i) *O. quadricornutus* (p 738)

Onychodromus grandis STEIN, 1859 (Fig. 193a–y, 194a–n, Table 44)

- 1859 *Onychodromus grandis* STEIN, Lotos, 9: 4 (no illustration; dorsal processes not mentioned).
- 1859 *Onychodromus grandis* STEIN – STEIN, Organismus der Infusionsthiere I, 145 (Fig. 193a–f; dorsal processes illustrated and mentioned).
- 1914 *Onychodromus grandis* STEIN – SMITH, Kans. Univ. Sci. Bull., 9: 165 (Fig. 193g).
- 1932 *Onychodromus grandis* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 621 (Fig. 193h).
- 1934 *Onychodromus grandis* STEIN – GRANDORI & GRANDORI, Boll. Lab. Zool. agr. Bachic. R. Ist. sup. agr. Milano, 5: 292, Tavola XIII, fig. 280 (incorrect subsequent spelling of *Onychodromus*; very likely a redrawing).
- 1963 *Onychodromus grandis* STEIN – LUNDIN & WEST, Free-living Protozoa, p 68 (Fig. 193i).
- 1972 *Onychodromus grandis* STEIN, 1859 – BORROR, J. Protozool., 19: 14.
- 1974 *Onychodromus grandis* STEIN, 1859 – JONES, Univ. South Alabama Monogr., 1: 41 (Fig. 193j).
- 1991 *Onychodromus grandis* STEIN, 1859 – GSCHWIND, Diplomarbeit, p 43 (Fig. 193k–q).
- 1992 *Onychodromus grandis* var. *simplex* SZABO, Europ. J. Protistol., 28: 358 (no illustration, see taxonomy).
- 1994 *Onychodromus grandis* – TUFFRAU & FLEURY, Traite de Zoologie, 2: 142 (Fig. 194n).
- 1995 *Onychodromus grandis* STEIN 1859 – SZABÓ & WILBERT, J. Euk. Microbiol., 42: 50 (Fig. 193t–y, 194a–l).

Nomenclature and taxonomy: Incorrect subsequent spellings: *Onychodromus gradus* (WALKER & GRIM 1973, p 566); *Pnychodromus grandis* var. *simplex* (SZABÓ 1996). The redescriptions by GSCHWIND (1991) and SZABÓ & WILBERT (1995) agree largely with the STEIN (1859b) description, especially as concerns the dorsal processes. However, STEIN's (1859a, b) population had distinctly more frontal, buccal, and frontoventral cirri (16–28) and more postoral and pretransverse ventral cirri (15–21) than the GSCHWIND (1991) and SZABÓ & WILBERT (1995) populations, which have 10–14 and 6–10 cirri respectively (Table 44). SZABO (1992) therefore established the variety *simplex*. KAHL's (1932) illustration shows an intermediate number of 14 and 13 cirri respectively (Fig. 193h), indicating that all populations belong to the same species (GSCHWIND 1991). The dorsal processes are sometimes inconspicuous (GSCHWIND 1991, STEIN 1859b) and

Fig. 193a–f *Onychodromus grandis* (from STEIN 1859b. a–f, from life). **a, c, d** Ventral and dorsal (c) view, → 80–350 µm. Arrows mark dorsal processes. Figure (a) shows a specimen with 6, (c) with 7, and (d) with 5 transverse cirri. **b** Old, large specimen (300 × 210 µm) with 5 macronuclear nodules. **e, f** Late and very late morphogenetic stage.

193a

b

c

d

e

f

Fig. 193g–j *Onychodromus grandis* (g, after SMITH 1914; h, from KAHL 1932; i, from LUNDIN & WEST 1963; j, from JONES 1974. g–j, from life). Ventral views, g = 255 μ m, h = 250 μ m, i = size not indicated, j = 110 μ m. The identification by JONES (1974) is somewhat uncertain (small size, short adoral zone of membranelles, saline water); p 724.

were thus very likely overlooked by some workers (JONES 1974, KAHL 1932, LUNDIN & WEST 1963, SMITH 1914, TUFFRAU & FLEURY 1994).

Onychodromus grandis sensu BÜRGER (1980) and sensu CONN (1905) are insufficiently redescribed. The terrestrial (?) population of MAUPAS (1889; Fig. 181o–q) is possibly *Sterkiella cavicola* (see there).

The following chapter is based mainly on the redescription by GSCHWIND (1991), who used the SCHLEGEL & STEINBRÜCK (1986) population (Fig. 193r, s).

Morphology and biology: In life 120–235 μ m (mean = 185.9 μ m, SD = 36.6 μ m, CV = 19.7 %, n = 11) $\times$ 60–110 μ m (mean = 82.4 μ m, SD = 15.7 μ m, CV = 19.1 %, n = 11; GSCHWIND 1991); according to STEIN (1859b) large specimens 350 times 170 μ m, old cells broad, that is, 300 $\times$ 210 μ m (Fig. 193b), smallest specimens only 80 μ m long. Elliptical to almost rectangular (that is, parallel margins), anterior end distinctly obliquely truncated, posterior end slightly tapered to broadly rounded. Body margin thin and thus hyaline. Left margin straight, sometimes slightly indented at level of buccal vertex, right margin convex. Flattened about 2–3:1 dorso-ventrally, ventral side flat to

Fig. 193k-o *Onychodromus grandis* (from GSCHWIND 1991. k-n, from life; o, protargol impregnation). k) Ventral view, 160 μ m. l) Dorsal view showing dorsal horns (arrows) and contractile vacuole with canals. m) Transverse cirrus with fringed end. n) Right-lateral view. o) Dorsal infraciliature of a specimen with 8 macronuclear nodules, 195 μ m. Arrowheads mark caudal cirri; p 724.

slightly concave, dorsal side distinctly arched centrally. Dorsally left of median invariably 2 plug-shaped processes, anterior one about at same site as contractile vacuole and thus probably bearing the excretion pore, posterior one slightly in front of left transverse cirri; processes usually turned to left margin of cell, sometimes inconspicuous (GSCHWIND 1991, STEIN 1859b), rounded terminally and filled with a darkish, grained mass; in old specimens anterior process or both processes lacking (STEIN 1859b). Body firm. Usually 4, sometimes 5, 6, 7, or 8 macronuclear nodules (STEIN 1859b), ellipsoid to spherical, slightly left of median, with many tiny chromatin bodies. Usually 4 micronuclei (DOGIEL 1929, Table 44), almost spherical, usually near macronuclear nodules. Contractile vacuole slightly behind level of buccal vertex, about at same site as anterior dorsal process, during diastole with an anterior and posterior canal. Pellicle fragile and colourless. Cortical granules lacking. Cytoplasm with some crystals, in well fed specimens with many 1–2 μ m sized, spherical to lens-shaped bodies. Movement conspicuously jerky.

Fig. 193p, q *Onychodromus grandis* (from GSCHWIND 1991. p, q, protargol impregnation). p) Ventral infraciliature, 175 μ m. The undulating membranes are almost straight and arranged in parallel as in *Stylonychia*. Usually they are inconspicuously bent to the right (cp. Fig. 193a, d). q) Dorsal infraciliature and nuclear apparatus, 175 μ m. The great distance between some kineties is very likely due to the dorsal processes (cp. Fig. 193r, s). This specimen obviously has 3 dorsomarginal kineties, indicating that FOISSNER et al. (1987b, Table II) counted too many (namely 6) dorsomarginals; p 724.

Adoral zone of membranelles almost 50 % of body length, anteriorly arranged on a prominent collar, posteriorly covered by a peristomial lip. Bases of largest membranelles in life about 10–12 μ m broad. Buccal area flat and broad. Undulating membranes almost straight, sometimes crossing posteriorly. Invariably 3 ($n = 24$) distinctly enlarged, in life about 28 μ m long frontal cirri. Arrangement of frontoventral, postoral, and pretransverse ventral cirri as in Figures 193k, p, y. Anterior frontoventral and buccal cirri distinctly larger than posterior one. Buccal cirri and frontoventral cirri arranged in 3 rows, left (= buccal row) and middle row according to STEIN (1859b) with 5–10 cirri each (see taxonomy according to different number of cirri). Postoral and pretransverse ventral cirri ac-

Fig. 193r, s *Onychodromus grandis* (original scanning electron micrographs kindly supplied by M. SCHLEGEL, Leipzig; same population as Fig. 193k–q). Right lateral and dorsal view, 140 μ m. Note the 2 rounded dorsal processes near the left margin (arrows in r). Near the right margin is a further, however, less conspicuous elevation which was obviously overlooked in live observations; p 724.

cording to STEIN (1859b) usually arranged in 4 rows (Fig. 193a): right row with 4–5 cirri, next one with 6–9, next one with 2–3, and left row with 3–4 cirri. Transverse cirri in life 30–38 μ m long, distally fringed, hook-shaped arranged, protrude distinctly beyond posterior end of cell (Fig. 193k, m, p, y); according to STEIN (1859b) 5–7, usually 6 transverse cirri (this requires an additional cirral primordium). Marginal rows distinctly separated posteriorly, cirri in life about 20 μ m long. Dorsal cilia in life about 3 μ m long, arrange-

ment and number of kineties somewhat variable (Fig. 193o, q, s), according to SZABÓ & WILBERT (1995) usually ($n = 15$) 9 kineties, including 3 dorsomarginal kineties (Fig. 193x); according to FOISSNER et al. (1987b, Table II) 6 dorsomarginal kineties, which is, however, not in agreement with Figures 193o, q, s. Invariably 3 caudal cirri ($n = 24$ and 25; GSCHWIND 1991, STEIN 1859b, SZABÓ & WILBERT 1995), stiff, in life 20–30 μm long. Obviously erroneously, CURDS et al. (1983) state that caudal cirri are lacking.

Some ultrastructural observations are reported by TUFFRAU et al. (1968), however, identification is not supported by an illustration. TUFFRAU (1965b) found macrostome giants. Cyst contains chitin (BUSSERS & JEUNIAUX 1974).

M o r p h o g e n e s i s is described by STEIN (1859b; Fig. 193e, f) and SZABÓ & WILBERT (1995; Fig. 194a–l); however, reinvestigation is recommended because some important details (origin of primordia, relation of cirri to streaks) are very likely (at least partly) misobserved. Formation of the oral primordium begins somewhat left of the left transverse cirrus (Fig. 194a). Three frontal-ventral-transverse cirral primordia of the proter originate from the posterior-most cirrus of the right frontoventral row (Fig. 194b, c), indicating that this cirrus is homologous to cirrus IV/3 of some Stylonychinae with 18 cirri (see Fig. 153g). Furthermore, each one primordium originates in the buccal row (Fig. 194c) or slightly left of it (Fig. 194d; FOISSNER et al. 1987b, Table II) and in the cirral row behind the right frontal cirrus (Fig. 194c). However, it is uncertain if parental cirri are involved or not (Fig. 194d). The origin of opisthe's primordia is uncertain. According to Figures 194b–d only few (1 or 2) postoral ventral cirri are involved in primordia formation. The primordia I–III of the opisthe develop from the oral primordium, as in other

← **Fig. 193t–y** *Onychodromus grandis* (from SZABÓ & WILBERT 1995. t, from life; u–y, protargol impregnation). t) Ventral view, 190 μm . u) Dorsal view showing the 2 dorsal processes (horns). v) Dorsal horn. w) Nuclear apparatus. x, y) Dorsal and ventral infraciliature, x = 250 μm , y = 245 μm . Cirri originating from same streak are connected by a broken line; however, I doubt that the proposal is correct (cp. Fig. 194m). Explanation of original labels: I–VI = frontal-ventral-transverse cirral streaks I–VI, 1–3 = ventral rows; p 724.

Fig. 194a–d *Onychodromus grandis* (from SZABÓ & WILBERT 1995. a–d, morphogenetic stages in ventral view after protargol impregnation). a) Very early stage (260 μm) showing the beginning of the oral primordium formation (arrow). b, c) Early stages (b = 250 μm , c = 255 μm) showing 5 primordia each in both the proter and the opisthe. One frontoventral cirrus splits into 3 primordia (arrow), identically to in *Stylonychia pustulata* and *S. bifaria*. Arrowhead marks beginning of marginal primordia formation. d) Middle stage, 265 μm . Arrowheads denote beginning of cirral segregation and dorsomarginal kineties; p 724. Figures on p 732. →

Fig. 194e–h *Onychodromus grandis* (from SZABÓ & WILBERT 1995. e–h, morphogenetic stages with nuclear apparatus in ventral view after protargol impregnation). Late stages showing migration of cirri, 240–255 μm . Cirri which originate from the same streak are connected by a broken line; however, I doubt that the proposal is correct (cp. Fig. 194m). New structures black, parental white. I–VI = frontal-ventral-transverse cirral streaks; p 724. Figures on p 733. →

194a

b

c

d

Fig. 194m, n *Onychodromus grandis* (m, modified from GSCHWIND 1991, same as Fig. 193p; n, from TUFFRAU & FLEURY 1994. m, protargol impregnation; n, from life?). m) Proposal for the relationships of cirri to the frontal-ventral-transverse cirral streaks I–VI, that is, cirri which very likely originate from the same streak are connected by a broken line. Arrows mark cirri which are presumably homologous to the 18 frontal-ventral-transverse cirri of the typical oxytrichids. n) Ventral view, 100–300 μ m; p 724.

oxytrichids. I doubt that SZABÓ & WILBERT (1995) recognised the relation of the cirri to the primordia correctly (Fig. 193y, 194e, h, j). According to them, primordium II does not produce a transverse cirrus, whereas primordium VI develops 2 prominent cirri which is very unlikely. Unfortunately, the micrographs in SZABÓ & WILBERT (1995) do not show

← Fig. 194i–l *Onychodromus grandis* (from SZABÓ & WILBERT 1995. i–l, morphogenetic stages after protargol impregnation). i, j) Ventral infaciliature of a very late stage (i = 250 μ m) and a postdivider (j = 200 μ m). Cirri which originate from the same streak are connected by a broken line; however, I doubt that the proposal is correct (cp. Fig. 194m). New structures black, parental white. k, l) Dorsal infaciliature of a middle and a late stage; parental kineties omitted. Large arrow in (k) marks multiple fragmentation of primordium 1, small arrow denotes simple (= normal) fragmentation of primordium 3, arrowhead marks dorsomarginal kineties; p 724.

Table 44 Morphometric data of *Onychodromus grandis* (1, from GSCHWIND 1991; 2, from SZABÓ & WILBERT 1995). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1	161.8	23.0	14.2	100	218	24
	2	237.3	26.5	11.0	184	285	25
Body, width	1	96.9	16.4	16.9	70	115	24
	2	146.1	16.2	11.0	114	171	25
Macronucleus, number of nodules	1	4.5	1.0	23.4	4	8	39
	2	4.0	0	0	4	4	30
Macronuclear nodule, length	1	20.5	3.5	17.1	14	25	24
	2	28.2	4.0	14.0	28	32	25
Macronuclear nodule, width	1	10.4	1.7	16.3	7	15	24
	2	14.9	2.3	15.0	13	18	25
Micronuclei, number	1	3.5	0.7	20.4	2	6	24
	2	4.0	0	0	4	4	30
Micronucleus, length	1	4.9	0.5	10.1	3.5	5.5	24
	2	5.6	0.4	7.0	4.5	5.6	25
Micronucleus, width	1	4.2	0.5	11.6	3.5	5	24
	2	4.2	0.8	19.0	3.3	5.6	25
Adoral zone of membranelles, length	1	80.1	7.8	9.7	66	95	24
	2 ¹	164.4	9.4	6.0	154	180	30
Adoral membranelles, number	1	52.6	6.0	9.7	41	59	24
	2	64.3	3.9	6.0	54	67	30
Buccal cirri, number	1	3.1	0.7	23.7	2	4	24
	2 ⁴	-	-	-	3	4	?
Frontoventral cirri, number ³	1	6.2	0.6	9.2	5	7	24
Postoral ventral cirri, number	1	6.3	0.7	11.8	5	8	24
	2 ²	9.0	0	0	9	9	25
Pretransverse ventral cirri, number	1	1.9	0.3	14.7	1	2	24
Right marginal row, number of cirri	1	35.0	3.0	8.5	28	39	24
	2	37.3	2.8	8.0	35	43	25
Left marginal row, number of cirri	1	24.7	2.1	5.0	21	31	24
	2	26.3	0.8	3.0	25	28	25
Transverse cirri, number	1	5.0	0	0	5	5	24
	2	5.0	0	0	5	5	25

¹ According to these data the adoral zone is almost 70 % of body length, which does not agree with the illustrations (Fig. 193y, 194a).

² Very likely, pretransverse ventral cirri included.

³ Not mentioned in Table 1 of SZABÓ & WILBERT (1995).

⁴ From text.

any details. I propose a different origin of cirri based mainly on the assumption that *O. grandis* is a typical Stylonychinae with a slightly increased number of cirri per streak (Fig. 194m).

Parental marginal cirri are involved in primordia formation of new marginal rows (Fig. 194c–i), which is a significant difference to *O. quadricornutus*. Dorsal morpho-

genesis begins with the formation of 3 primordia. Primordium 1 (= near left body margin, large arrow in Fig. 194k) shows multiple, and primordium 3 simple fragmentation. Three (SZABÓ & WILBERT 1995; Fig. 194k) or 6 (FOISSNER et al. 1987b, possibly a misobservation) dorsomarginal kineties also occur. Caudal cirri originate at the posterior fragments of primordia 1 and 3 and at posterior end of primordium 2 (Fig. 194k, l).

Occurrence and ecology: Rare in freshwater. Locus classicus is the Baumgarten area near Prague, Czechoslovakia, where STEIN (1859a, b) discovered *Onychodromus grandis* very abundantly in a marshy ditch in October and November. He found it together with *Stylonychia mytilus*, *Tachysoma pellionellum*, *Paramecium aurelia*, and *Aspidisca lynceus*. According to KAHL (1932), strong saprobity preferred.

Records substantiated by illustrations: Germany?, exact sites not mentioned (GSCHWIND 1991, who studied the SCHLEGEL & STEINBRÜCK 1986 population; KAHL 1932); temporary, shallow alkaline water bodies of Pentezug, Hortobágy National Park, Hungary, with a dense growth of *Glyceria maxima* (SZABÓ & WILBERT 1995); pond water from Kansas, USA (SMITH 1914); New York, USA (HAUSMAN 1934); freshwater in the Upper Peninsula (counties Baraga and Marquette) of Michigan, USA (LUNDIN & WEST 1963); upper end of Mobile Bay, Alabama, USA, with a salinity of about 2 ‰ (JONES 1974).

Records from limnetic habitats not substantiated by illustrations: Tyrol, Austria (DALLA TORRE 1891); surface film and detritus of ditches regularly contaminated with pesticides and untreated ditches near Hamburg, Germany (CASPER & HECKMAN 1982); pond near Bonn, Germany (SCHMIDT 1913, 1916); plankton of Lake Prester near Magdeburg, Germany (HONIGMANN 1909); freshwater(?) habitat (Ober-Warnow) near Rostock, Germany (LEVANDER 1892); cooling system of a conventional power station at the Main River, Germany (BERNERTH 1982); with a dominance of 0.6–1.8 % in the plankton of a side-branch of the Danube River at Göd, Hungary, in September (BERECZKY 1991); plankton of Tisza River, Hungary (JÓSA 1974); Italy (MADONI & ULUHOGLIAN 1997); northern Russia (MERESCHKOWSKY 1877); rare in saline lakes near Odessa, Ukraine (BOUTCHINSKY 1895, BUTSCHINSKY 1897); Mexico (MADRAZO-GARIBAY & LÓPEZ-POCHTERENA 1973); rarely at 10 °C and pH 6.2 in a tundra pool in Alaska, USA (SULLIVAN 1957); at up to 14.2 mg l⁻¹ hydrogen sulphide in pools of the Silver Lake Bog and other sites in Iowa, USA (HEMPSTEAD & JAHN 1940, SHAWHAN et al. 1947); south-eastern Louisiana, USA (BAMFORTH 1963); in *Sphagnum* moss of Buell Bog, Minnesota, USA (BOVEE 1979); planktonic in the Scioto River in Ohio, USA (LACKEY 1938b); Cleveland county, Oklahoma, USA (GABEL 1927); Conestoga drainage basin, Pennsylvania, USA (CAIRNS 1965a); Mountain Lake region, Giles County and Potomac River, Virginia, USA (BOVEE 1960, PATRICK 1961); in clear, flowing water with abundant plant life in USA? (HAUSMAN 1917); Brazil (CUNHA 1913, PROWAZEK 1910); bottom area of test tubes, New Zealand (STOUT 1956); mud surface of Blue Lake, Raoul Island, New Zealand (BROWN & PEART 1973). LACKEY (1938a) found *Onychodromus grandis* with low frequency in a trickling filter in the USA.

GRANDORI & GRANDORI'S (1934) illustration of a specimen from soil matches Figure 193b rather well, indicating that their illustration is not an original. All other records from terrestrial habitats not substantiated by illustrations (JAMESON 1914, LÓPEZ-UCHOTERENA & ROURE-CANE 1970, NIKOLJUK & GELTZER 1972, SANDON & CUTLER 1924, STOUT 1981, SZTRANTOWICZ 1984); possibly confused with the quadrinucleate *Sterkiella cavicola*.

Feeds on bacteria, flagellates (for example, *Astasia*) and their cysts, testaceans (*Arcecella vulgaris*), ciliates like *Dexiostoma campylum*, *Tetrahymena pyriformis*, *Paramecium aurelia*, and in culture also on starch (FAURÉ-FREMIET 1961a, GSCHWIND 1991, SAXENA & SAXENA 1978, STEIN 1859b, SZABÓ & WILBERT 1995). Also cannibalistic (STEIN 1859b). According to FAURÉ-FREMIET (1961a) 12 °C was preferred in cultures. SAXENA & SAXENA (1978) cultured *Onychodromus grandis* in CHALKLEY'S medium and hay infusion previously inoculated with *Aerobacter aerogenes*. Culture medium was changed daily to maintain the animals in exponential growth phase otherwise stationary phase followed. They estimated a generation time of 20 h $\pm$ 35 min at 24 $\pm$ 2 °C ($\pm$ SD?). SZABÓ & WILBERT (1995) cultured it in mineral water enriched with rice grains. SZABÓ & WILBERT (1995) found *O. grandis* mainly in June and July together with *Bryophyllum tegularum*, *Spathidium amphoriforme*, *Loxophyllum meleagris*, *Calyptotricha pleuronemoides*, *Vorticella nebulifera*, *V. convallaria*, *Balladinopsis sphaericus* (a species indeterminata described by VUXANOVICI 1963) at the following conditions: pH 7.1–7.8, 9–19 °C, 6.2 to 8.5 mg l⁻¹ O₂, 430–650 μ S cm⁻¹, 0.25–0.5 ‰ salinity.

***Onychodromus quadricornutus* FOISSNER, SCHLEGEL & PRESCOTT, 1987** (Fig. 195a–z, Table 45)

1985 *Styx* sp. – LIN & PRESCOTT, J. Protozool., 32: 144 (see nomenclature and taxonomy).

1987 *Onychodromus quadricornutus* FOISSNER, SCHLEGEL & PRESCOTT, J. Protozool., 34: 150 (Fig. 195a–v; 1 slide of holotype specimens and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1993 *Onychodromus indica* KAMRA & SAPRA, Acta Protozool., 32: 107 (Fig. 195w, x).

Nomenclature and taxonomy: LIN & PRESCOTT (1985) named this species *Styx* sp. without giving a description that would satisfy the criteria of the ICZN (1985). This genus name is thus a nomen nudum needing no further consideration. In addition, it is a junior homonym of *Styx* STAUDINGER, a butterfly, and *Styx* OPPENHEIM, a mollusc

Fig. 195a–g *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. a–c, from life; d–g, protargol impregnation). **a)** Dorsal view showing the 4 dorsal horns (species name) and the contractile vacuoles which form a C-shaped figure, 400 μ m. **b, c)** Ventral and right lateral view, 435 μ m, 400 μ m. **d)** Adoral membranelle. **e, g)** Ventral and dorsal infraciliature and nuclear apparatus, e = 285 μ m, g = 320 μ m. Arrowhead marks left frontal cirrus (cirrus I/1). Anterior arrow denotes buccal row, posterior ones mark the 2 pretransverse ventral cirri which originate from the 2 rightmost cirral primordia and which are probably homologous with the 2 pretransverse ventral cirri of the 18-cirri oxytrichids. **f)** Each basal body pair of the dorsal side is surrounded by fibrils forming a rhomboid figure.

195a

b

c

d

e

f

g

Fig. 195h, i *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. h, i, scanning electron micrographs). Ventral and dorsal view showing the impressive cirral pattern and the 4 prominent dorsal horns. One caudal cirrus is inserted near the tip of the caudal horn (arrow). Bars = 100 μ m; p 738.

(FOISSNER et al. 1987b). Incorrect subsequent spellings: *Onychodromus quadricornatus* (HOFFMAN et al. 1995, p 1281); *Onychodromus quadricornutis* (EMBLEY et al. 1992, p 1483); *Onychodromus quedricornutus* (LEE & KUGRENS 1992, p 539).

Synonymy of *Onychodromus quadricornutus* and *O. indica* was already proposed by SZABÓ & WILBERT (1995, p 59) because qualitative differences are present neither during interphase nor during morphogenesis. They differ in some morphometric characters, including the nuclear apparatus (Table 45). The main deviations are the number of micro-

Fig. 195j *Onychodromus quadricornutus* (from FOISSNER et al. 1987b). Scanning electron micrograph showing the posterior end of the cell. One caudal cirrus is inserted almost at the tip of the caudal horn, bar = 20 μ m. CC = caudal cirri, Dc = dorsal cilia; p 738.

nuclei (4–26 against 3–4) and, according to KAMRA & SAPRA (1993) more importantly, their size (5 μ m against 6.4 μ m). However, it is well-known that size and shape and many other characters of these species depend strongly on culture conditions (FOISSNER et al. 1987b, KAMRA & SAPRA 1994, WICKLOW 1988b, 1997). Very likely, they are geographical races of the same species.

Onychodromus quadricornutus should not be confused with *Laurentiella strenua*, which lacks dorsal processes and has a distinctly lower number of cirri (Fig. 196). *Onychodromus quadricornutus* also shows some agreements with the ectocommensal *Kerona pediculus* (see relevant chapter in genus section). The comparison of small subunit ribosomal RNA sequences assigns *Onychodromus quadricornutus* very close to *Stylonychia* (SCHLEGEL et al. 1991; see also HAMMERSCHMIDT et al. 1996, LYNN 1996, RAGAN et al. 1996).

M o r p h o l o g y a n d b i o l o g y: Cells from spring-water cultures in life $370 \times 200 \times 70 \mu$ m ($n = 6$) and thus considerably smaller than those from Pringsheim's medium (Table 45; FOISSNER et al. 1987b), according to LIN & PRESCOTT (1986) and WICKLOW (1988b) cannibalistic giants in life up to 1 mm long. *Chlorogonium*-fed individuals of the synonym, *O. indica*, in life 205×136 ($n = 10$; KAMRA & SAPRA 1993), bacteria-fed specimens after protargol impregnation $145\text{--}191 \times 56\text{--}81 \mu$ m, cannibals $285\text{--}376 \times 153\text{--}205 \mu$ m (KAMRA & SAPRA 1994). Cell length frequencies in replicates of a well-fed clone of *O. quadricornutus* show normal distributions (Fig. 195y; WICKLOW

Fig. 195k-n *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. k-n, ventral infraciliature of morphogenetic stages after protargol impregnation). k-m) Development of the oral primordium. Note the round clusters of basal bodies near the upper transverse cirri (arrow). Bars = 30 μ m, 100 μ m, 100 μ m. n) Three streaks split off from the anterior end of the oral primordium. Cirral primordia originate within the parental ventral rows (except for the 2 rightmost rows and the buccal row; but see text) by disintegration of some cirri (arrow). Bar = 90 μ m; p 738.

Fig. 1950, p *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. o, p, ventral infraciliature of morphogenetic stages after protargol impregnation). Middle stages showing primordia formation within the parental rows and differentiation of new cirri within the cirral streaks. The left frontal cirrus splits from the primordium of the undulating membranes identically to in other hypotrichs (arrow). Bars = 90 μ m, 100 μ m. New structures black, parental white; p 738.

1988b); starvation followed by intraspecific predation, however, induces cells within a clone to split into two size classes: small lanceolate cells and cannibal giants. The same behaviour was observed by KAMRA & SAPRA (1994) on the synonym, *O. indica*.

Body shape in life and in growing cultures rather variable, outline elliptical to lanceolate, sometimes distinctly truncated posteriorly. Many undersized individuals of very variable shape develop in old cultures. Body stiff, only a little flexible under the cover glass, conspicuously (2–3:1) flattened dorso-ventrally, especially the rims. Invariably 4 ($n = 50$; FOISSNER et al. 1987b) prominent cone-shaped processes (horns, spines) on the dorsal surface (1 median horn in anterior half of body, 2 horns subterminally right and left of median, and 1 smaller caudal horn; Fig. 195a, c, g, i, j, x) and 3 ($n = 10$) in *Chlorogo-*

Fig. 195q, r *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. q, r, ventral infraciliature of morphogenetic stages after protargol impregnation). Late and very late stage showing positioning of new cirri, q = 350 μ m, r = 345 μ m. Arrow in (q) marks the 2 new dorsomarginal kineties of the proter. Large arrows in (r) point to the anteriorly migrating rightmost ventral rows, which are thus very likely homologous to the migratory cirri (cirri VI/3 and VI/4) of the typical (18-cirri) oxytrichids. The tiny arrow in (r) denotes the rest of the fibrils of the parental oral apparatus. New cirri black, parental ones white; p 738.

nium-fed cells of the synonym, *O. indica* (KAMRA & SAPRA 1993); however, the synonym also has a small elevation in the mid anterior region which becomes horn-shaped after turning cannibal (Fig. 195x; KAMRA & SAPRA 1993). Horns immotile, tips sometimes bifurcated. Number of horns did not change with culture conditions and culture age; however, length and shape of spines is regulated by intraspecific predator-released morphogens (WICKLOW 1990, 1991, 1993; see also FLINT et al. 1993). Induction experiments indicate that a substance released by cannibal giants stimulates horn growth in clone- and non-clonemates within 24 h (WICKLOW 1988b). Furthermore, *O. quadricornutus* cells ex-

Fig. 195s, t *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. s, t, dorsal infraciliature and nuclear apparatus of morphogenetic stages after protargol impregnation). Early and middle stage showing formation of 3 primordia each for the proter and the opisthe and multiple fragmentation of each primordium. Furthermore, 2 dorsomarginal kineties are formed in both filial products (Fig. 195q). Parental kineties have been omitted to make details clearer (cp. Fig. 195v); p 738.

posed to the predacious ciliate *Lembadion magnum* also develop hypertrophied spines. Selection experiments show that conspecific giants prey on cells with undeveloped spines (<20 μm in length) to a much greater extent than on cells with developed spines (>40 μm in length). Furthermore, WICKLOW (1988b) proposed that transformation of a population of similarly sized *O. quadricornutus* cells into 2 different size classes may function to increase the range of potential prey sizes available to the *O. quadricornutus* population; hypertrophied spines appear to function as an inducible defence against intermittent predators appearing in the system, including conspecific giants (Fig. 195z).

Macronuclear nodules ellipsoid, connected by a fine strand, arranged like a question mark left of median (Fig. 195g). Nodules do not increase in number during cannibalistic growth, but become much larger through extra rounds of DNA replication without nuclear division (LIN & PRESCOTT 1986). Micronuclei about 5.0–6.5 μm across, most near

Fig. 195u, v *Onychodromus quadricornutus* (from FOISSNER et al. 1987b. u, v, scanning electron micrographs). Ventral and dorsal view of late stages. The right parental marginal row and the rightmost parental ventral row are still unchanged. The oral apparatus of the proter shows clear symptoms of some reorganisation (cp. Fig. 195h), for example, lack of the cilia of the undulating membranes. The triangles in (v) mark the developing new dorsal kineties, which originate by multiple fragmentation of single main streaks (cp. Fig. 195s, t). Bars = 100 μ m; p 738.

macronucleus, some scattered in cytoplasm (FOISSNER et al. 1987b, KAMRA & SAPRA 1993, LIN & PRESCOTT 1986; further literature on nuclear apparatus: HOFFMAN et al. 1995, PRESCOTT 1994, SAPRA et al. 1985). About 4–6 contractile vacuoles along left and anterior

Fig. 195w, x *Onychodromus quadricornutus* (from KAMRA & SAPRA 1993. w, x, protargol impregnation). Ventral and dorsal infraciliature, w = 230 μ m, x = 215 μ m. Arrowheads in (x) mark dorsal horns at the posterior end of the cell and an inconspicuous elevation in the median of the anterior third. Explanation of original labels: AZM = adoral zone of membranelles, C₁₋₇ = crowned frontal-ventral-transverse cirral rows, CC₁₋₃ = caudal cirri, IUM = endoral, L = left marginal row of cirri, NC_{1,2} = non-crowned frontal-ventral-transverse cirral rows, OUM = paroral, RMC = right marginal row of cirri, RV_{1,2} = right frontal-ventral-transverse cirral rows, Tcirri = transverse cirri, V_{1,2} = pretransverse ventral cirri; p 738.

body margin (Fig. 195a). Pellicle very brittle, sharp-edged fragments can be broken out by touching cell with a hair or fine needle. Cortical granules lacking. Cytoplasm colourless, filled with numerous greasily shining globules, 1–5 μ m across. No cytoplasmic crystals. Movement strikingly slow and jerky, grazing along substratum, leaving it only with great difficulty following vigorous shaking (FOISSNER et al. 1987b, KAMRA & SAPRA 1993).

Adoral zone of membranelles almost 50 % of body length, posterior portion covered by pellicle. Bases of largest membranelles in life about 25 μ m broad, details as in other hypotrichs. Buccal area large, considerably deep, a small bulge at its right side. Undulating membranes straight and in parallel, cilia in life about 12 μ m long.

Fig. 195y, z *Onychodromus quadricornutus* (from WICKLOW 1988b). y) Cell length frequency distribution of 2 replicates (black and white circles) of cells cultured with abundant *Chlorogonium* (day 1) followed by 3 days of *Chlorogonium* deprivation (days 2–4). z) Susceptibility of different morphotypes to predation by cannibal giants. Populations of cells with undeveloped spines, <20 μm long (black and white triangle), were preyed on to a much greater extent than populations of cells with prominent spines, >40 μm long (black and white circle). $P < 0.001$, χ^2 . Control populations of both morphotypes cultured with-

out giants remained at, or slightly above 100 % survival. At about 18 h (arrow), in the presence of giants, cells initially with undeveloped spines attained spine length >30 μm, thereby decreasing susceptibility to predation; p 738.

Cirral pattern rather invariably, on average 10–11 frontal-ventral-transverse cirral rows, that is, no clustered cirri, except pretransverse and transverse cirri (Fig. 195e, h, w). Cirral rows elongate from right to left, except for rightmost one, which is almost as long as body. Thus, an inconspicuous suture is produced at right part of ventral ciliature field (Fig. 195e). First 2–4 cirri of leftmost rows conspicuously enlarged (“crowned” rows in Fig. 195w), about 25 μm long, form 2–3 arched “rows” along anterior body margin (these arched rows are, however, not homologous to the corona of *Kerona pediculus*, which originates only from one streak!). Marginal cirri in life about 20 μm long, those of right row sometimes irregularly distributed. Invariably 2 slightly enlarged pretransverse ventral cirri ($n = 25$; FOISSNER et al. 1987b). Transverse cirri conspicuously enlarged, in life only about 25 μm long, only posterior-most ones project slightly beyond posterior end of cell, rather motionless during movement of ciliate.

Dorsal cilia in life about 4 μm long, arranged in many (>20) rows invariably including 2 dorsomarginal kineties, most rows more or less shortened (Fig. 195g). This shorten-

ing and the small distances between rows prevent exact counting of kineties. All kineties appear composed of densely packed basal body pairs, only anterior ones being ciliated. Each pair surrounded by fibrils forming a rhomboid figure (Fig. 195f, x). Invariably 3 fine caudal cirri ($n = 25$, FOISSNER et al. 1987b; $n = 10$, KAMRA & SAPRA 1993), left one constantly inserted near tip of caudal horn (Fig. 195j; FOISSNER et al. 1987b); conversely, according to Figure 195x the posterior horn is situated between the middle and the right caudal cirrus in the synonym, *Onychodromus indica*.

M o r p h o g e n e s i s (Fig. 195k–v). Morphogenesis of cell division is both described for the type material (FOISSNER et al. 1987b) and the synonym, *Onychodromus indica* (KAMRA & SAPRA 1993). The following paragraphs are from FOISSNER et al. (1987b) unless otherwise indicated.

A few basal bodies develop at the left border of the first one to three transverse cirri, which appear intact (Fig. 195k). Basal bodies increase in number, forming a narrow patch that extends anteriorly and reaches the proximity of the buccal vertex. The resulting oral primordium is club-shaped, rounded anteriorly, and pointed posteriorly. About 50 % of the dividing cells show 1 or 2 rounded clusters of basal bodies at the posterior end of the oral primordium (Fig. 195l–n). From the anterior end of the oral primordium, 3 streaks separate; the left one becomes the primordium of the undulating membranes, the middle one the buccal row, and the right one develops the joining ventral row. The buccal row of the proter is formed by an anlage that develops near the parental row, whose cirri are reabsorbed at the end of the division process (FOISSNER et al. 1987b). Conversely, in the synonym *O. indica* some buccal cirri are involved in the formation of primordium II (Fig. 4 and 5 in KAMRA & SAPRA 1993). Some parental cirri of the ventral rows disintegrate and rearrange their basal bodies into the ciliary streaks appearing next, which average 13 for each tomite (Fig. 195n, o). Those of the proter evolve a little later than those of the opisthe. On average there are 2 frontal-ventral-transverse anlagen more in the filial products than ventral rows in the interphase individuals, suggesting that some reduction occurs in later division phases. This reduction probably begins after the new transverse cirri have been separated, because the number of transverse cirri of the non-dividers is on average the same as the number of frontal-ventral-transverse cirral anlagen. No anlagen develop within the two or three rightmost ventral rows, which remain unchanged during the whole division process. These rows are produced by splitting of some of the rightmost frontal-ventral-transverse cirral streaks in both the proter and the opisthe (Fig. 195o).

Development of cirral primordia is accomplished by growth, in both length and width, of thin streaks and by posterior fragmentation in cirri, which progresses as an anteroposterior wave, transverse cirri being the last and largest, except for the frontal cirri that derive from the approximately 8 leftmost cirral streaks (Fig. 195o–r). While this happens, the rest of the oral primordium differentiates into membranelles. Alignment of membranelles starts at the anterior right edge of the primordium. The primordium of the undulating membranes of the opisthe develops as a long anarchic field of basal bodies parallel to the right border of the oral primordium and remains connected with streaks II

Table 45 Morphometric data of *Onychodromus quadricornutus* (1, spring water culture from FOISSNER et al. 1987b; 2, from KAMRA & SAPRA 1993). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1 ¹	272.5	48.5	17.8	170	361	50
	1 ²	423.3	112.8	26.7	222	694	50
	2	205.3	24.3	11.8	180	226	10
Body, width	1 ¹	157.4	33.7	21.4	83	230	50
	1 ²	235.6	71.5	30.4	124	375	50
	2	136.6	15.5	11.4	119	166	10
Macronucleus, number of nodules	1	19.6	4.8	24.7	11	28	25
	2	11.4	1.3	11.1	10	13	10
Nuclear apparatus, length	1	192.4	34.6	18.0	143	270	25
Macronuclear nodule, length	1	18.3	4.8	26.2	11	28	25
Macronuclear nodule, width	1	9.2	2.0	22.2	6	14	25
Micronuclei, number	1	9.6	4.9	51.2	4	26	25
	2	3.3	0.5	14.6	3	4	10
Micronucleus, length	1	5.2	0.7	13.3	4	6	25
	2 ³	6.4	0.5	8.3	6	7	20
Micronucleus, width	1	4.9	0.6	13.0	4	6	25
Adoral zone of membranelles, length	1	134.3	20.2	15.0	92	165	25
	2	100.4	12.2	12.1	89	124	10
Adoral membranelles, number	1	130.5	21.7	16.6	89	180	25
	2	82.0	8.1	9.8	66	98	25
Ventral cirral rows, number	1	10.6	1.3	12.4	8	13	25
C rows, number ⁴	2	7.0	0.5	6.7	6	8	10
NC rows, number ⁴	2	1.9	0.3	16.6	1	2	10
FVT cirri, number ⁵	2	147.8	7.2	4.9	136	159	10
Buccal row, number of cirri	1	5.6	1.2	20.5	3	8	25
	2	5.0	0.7	13.4	4	6	25
C ₃ row, number of cirri ⁴	2	7.1	0.7	9.9	6	8	25
RV ₁ row, number of cirri ⁴	2	15.4	1.4	8.8	13	18	10
RV ₂ row, number of cirri ⁴	2	18.8	1.6	8.6	16	21	10
Right marginal row, number of cirri	1	57.7	7.1	12.2	45	74	25
	2	47.2	3.3	7.1	43	53	10
Left marginal row, number of cirri	1	43.5	5.3	12.3	34	54	25
	2	35.4	2.2	6.3	32	39	10
Transverse cirri, number	1	12.2	1.5	12.7	9	16	25
	2	10.0	0.7	7.3	9	12	25
Dorsal kineties, number	1	>20.0	-	-	-	-	?
	2	21.8	2.0	9.1	19	25	10

¹ From spring water culture.

² From Pringsheim's solution culture.

³ Diameter.

⁴ For of simplicity, the original labelling of KAMRA & SAPRA (1993) is used. C and NC means crowned and non-crowned frontal-ventral-transverse cirri rows respectively (see Fig. 195w).

⁵ Including all cirri, except marginal and caudal cirri.

and III until the start of organisation of the endoral and the first (leftmost) frontal cirrus (Fig. 195o-r). Thus, the frontal-ventral-transverse cirral system of the opisthe derives from usually 13 primordia: three of these come from the oral primordium and originate by proliferation and rearrangement of basal bodies from old ventral cirri. KAMRA & SAPRA (1993) found the following origins of the frontal-ventral-transverse cirral primordia for the proter (see Fig. 195w for designation of structures): primordium I from undulating membranes, II from C₂ (buccal row), III from C₃, IV from C₄, V from C₅, VI-IX/XII from or between C₆₋₈, NC₁ sometimes NC₂. For the opisthe KAMRA & SAPRA (1993) found: I-III from oral primordium, IV from C₄, V from C₅, VI-IX/XII from or between C₆₋₈, NC₁ and often NC₂.

The paroral and endoral, the buccal area, and some fibrillar structures of the proter undergo a partial disorganisation. The basal bodies temporarily lose their linear arrangement and later rearrange and reform the paroral and endoral and a new left frontal cirrus. The buccal area appears smaller, less deep, and the fibrils in the peristomial vertex disappear (Fig. 195q, r). The parental adoral zone of membranelles is inherited without any appreciable changes. Thus, the frontal-ventral-transverse cirral system of the proter evolves from 1 paroral primordium and, on average, 12 primordia which originate by proliferation and rearrangement of basal bodies from parental ventral cirri (Fig. 195o-r).

All cirral streaks of the proter develop without participation of the primordia of the opisthe, as indicated by the high number of unchanged parental cirri and the large gap between the 2 anlagen fields in the early and middle stages of division (Fig. 195n-q).

New marginal cirri appear a little later than the frontal-ventral-transverse cirral anlagen and are built from streaks always formed close to the right of the old rows at 2 sites on each side, one anterior and the other posterior to the future fission plane. No parental marginal cirri are involved in this process, as indicated by the unchanged parental right marginal row in the early and late division stages (Fig. 195o, q, r, u). This kind of marginal row formation is only known from the ectocommensal *Kerona pediculus* (HEMBERGER & WILBERT 1982; Fig. 208t). Furthermore, both species have the same, rather complicated dorsal morphogenetic pattern, indicating a close relationship. Dorsal morphogenesis commences with the formation of 3 primordia each in the proter and the opisthe (Fig. 195s). Later, all these primordia show multiple fragmentation and each posterior-most (rightmost) fragment bears a caudal cirrus (Fig. 195t, v). Furthermore, 2 dorsomarginal kineties are formed in each filial product (Fig. 195q, r).

All cirri and dorsal kineties which do not participate in morphogenesis disappear after cytokinesis. The dorsal horns develop at the end of the fission process. The macronuclear nodules fuse to a rod-like mass during middle stages. Later, this mass segregates into the typical nodulated macronucleus of the interphase individuals (Fig. 195q, s, t).

Morphogenesis during reorganisation is similar to that of cell division, but, of course, only one set of primordia is formed (KAMRA & SAPRA 1993).

Occurrence and ecology: Not very common in freshwater. Locus classicus of *Onychodromus quadricornutus* unknown because the population was obtained from a

freshwater aquarium at a local pet shop in Boulder, Colorado, USA, where tropical aquarium fish were sold, indicating that it is probably from some tropical climate (FOISSNER et al. 1987b, LIN & PRESCOTT 1985). CORLISS & PANG (unpublished) probably found the same species in Shanghai, China (FOISSNER et al. 1987b, footnote 2; WICKLOW 1988b). Locus classicus of the synonym, *O. indica*, is Delhi, India, where KAMRA & SAPRA (1993) discovered it in the Yamuna River at a point where a large amount of ash was discharged by a thermal power station. Surprisingly, two records are from Asia, indicating that *O. quadricornutus* is possibly confined to this continent. Unfortunately, the locus classicus of *O. quadricornutus* is unknown, however, it cannot be excluded that the aquarium was filled with material from tropical Asia.

Feeds on algae, heterotrophic flagellates, ciliates, and wheat starch (FOISSNER et al. 1987b, KAMRA & SAPRA 1993). Cannibalistic when starved (FOISSNER et al. 1987b, LIN & PRESCOTT 1985, WICKLOW 1988a, b). FOISSNER et al. (1987b) cultured *O. quadricornutus* at room temperature in bottled spring water (Eau de Volvic, France) enriched with wheat grains, small ciliates (*Chilodonella uncinata*, *Cyclidium glaucoma*, *Tetrahymena thermophila*), and heterotrophic flagellates as food, and in Pringsheim's solution with *Chlorogonium elongatum* as food; medium was changed every two weeks. KAMRA & SAPRA (1993) cultured the synonym, *O. indica* successfully at about 23 °C on mixed bacteria, *Tetrahymena thermophila*, *Stylonychia lemnae* and on *Chlorogonium elongatum*. Generation time of the synonym under optimal conditions 9 ± 0.5 h ($\pm$ SD?; KAMRA & SAPRA 1993). *Onychodromus quadricornutus* is one of the most voluminous hypotrichs at about $2 \times 10^6 \mu\text{m}^3$ (spring water culture) and $5 \times 10^6 \mu\text{m}^3$ (Pringsheim's culture) and reaching peak values of up to $20 \times 10^6 \mu\text{m}^3$ (FOISSNER et al. 1987b).

Insufficient redescrptions

Onychodromus grandis STEIN? – BÜRGER, 1908, An. Univ. Chile, 122: 186, Lámina XV, Fig. 4. Remarks: In life 126 μm long, 7 macronuclear nodules. Feeds on diatoms. Freshwater lagoon of San Cristóbal, Chile.

Onychodromus grandis STEIN – CONN, Bull. Conn. St. geol. nat. Hist. Surv., 2: 59, Plate XXVI, Fig. 247. Remarks: The illustration shows too many cirri to accept the identification. The cirral rows and the body shape are somewhat reminiscent of *Laurentiella*. Freshwater in Connecticut, USA.

Laurentiella DRAGESCO & NJINE, 1971

- 1966 *Laurentia macrostoma* DRAGESCO, Protistologica, 2: 85 – Type (original designation): *Laurentia macrostoma* DRAGESCO, 1966.
- 1971 *Laurentiella* DRAGESCO & NJINE, Annls Fac. Sci. Univ. féd. Cameroun, 7–8: 125 (see nomenclature).
- 1972 *Laurentia* DRAGESCO, 1966 – BORROR, J. Protozool., 19: 14.
- 1974 *Laurentia* DRAGESCO – STILLER, Fauna Hung., 115: 109.

- 1979 *Laurentiella* (*Laurentiella*) JANKOWSKI, Trudy zool. Inst., Leningr., 86: 57 – Type (original designation): *Laurentia macrostoma* DRAGESCO, 1966.

Characterisation: Undulating membranes in *Stylonychia* pattern. 5–7 frontal-ventral-transverse cirral rows. One right and 1 left row of marginal cirri. Caudal cirri present. Primordium II of proter originates from oral primordium. Dorsal kineties primordia 1 and 3 with multiple fragmentation, more than 2 dorsomarginal kineties.

Nomenclature and taxonomy: See relevant chapter in single species. For a detailed description of the *Stylonychia* pattern mentioned in the characterisation, see chapter 2 in the general section.

Single species

Laurentiella strenua (DINGFELDER, 1962) BERGER & FOISSNER, 1989 (Fig. 196a–v, Table 46)

- 1962 *Paruroleptus strenuus* DINGFELDER, Arch. Protistenk., 105: 617 (Fig. 196a).
 1966 *Parauroleptus strenuus* DINGFELDER, 1962 – MATIS, Acta Fac. Rerum nat. Univ. comen., Bratisl., 13: 238 (Fig. 196b; incorrect subsequent spelling of *Paruroleptus*).
 1966 *Laurentia macrostoma* DRAGESCO, Protistologica, 2: 85 (Fig. 196c–e; new synonym).
 1972 *Laurentia macrostoma* DRAGESCO, 1966 – BORROR, J. Protozool., 19: 14 (Fig. 196f; somewhat modified redrawing from DRAGESCO 1966b).
 1974 *Paruroleptus strenuus* DINGFELDER – STILLER, Fauna Hung., 115: 80.
 1974 *Laurentia macrostoma* DRAGESCO – STILLER, Fauna Hung., 115: 110.
 1975 *Onychodromus grandis* – JAREÑO, J. Protozool., 22: 82A (misidentification).
 1976 *Paruroleptus strenuus* DINGFELDER, 1962 – CZAPIK & JORDAN, Acta Protozool., 15: 284 (Fig. 196g).
 1976 *Laurentia acuminata* FEDRIANI, MARTIN & PÉREZ-SILVA, Boln R. Soc. esp. Hist. nat., 74: 67 (Fig. 196h, i).
 1977 *Onychodromus acuminatus* FEDRIANI et coll. 1976 – JAREÑO, Protistologica, 13: 188.
 1979 *Laurentiella* (*Laurentiella*) *macrostoma* (DRAGESCO, 1966) – JANKOWSKI, Trudy zool. Inst., Leningr., 86: 57.
 1983 *Laurentiella acuminata* – MARTIN, FEDRIANI & PÉREZ-SILVA, J. Protozool., 30: 519.
 1987 *Laurentiella acuminata* FEDRIANI et al. 1976 – SZABÁ & WILBERT, Debreceni Agrártudományi Egyetem Tudományos Közleményei, 27: 439 (Fig. 196j, k).
 1989 *Laurentiella strenua* (DINGFELDER, 1962) – BERGER & FOISSNER, Bull. Br. Mus. nat. Hist. (Zool.), 55: 29 (Fig. 196l, m; morphometric data and line drawings of ventral and dorsal infraciliature of type population of *Laurentia acuminata*, kindly supplied by J. MARTIN, University of Cordoba, Spain).

Nomenclature and taxonomy: *Laurentia acuminaba* in FEDRIANI et al. (1976b, p 73) is an incorrect original spelling. Incorrect subsequent spellings: *Onychodromus acuminatus* (PÉREZ-PRÍETO et al. 1981, p 290); *Paruroleptus strenua* (BERGER & FOISSNER 1989a, p 29); *strenuus* DINGFELDER (*Puraropeltus*) (STILLER 1974b, p 3).

Synonymy of *Paruroleptus strenuus* and *Laurentia acuminata* was already suggested by HEMBERGER (1982, p 196) and BERGER & FOISSNER (1989a). *Laurentia macrostoma* is

also evidently a further junior synonym of *L. strenua*, although there are some differences between the three original descriptions, as in the number of macronuclear nodules and cirral rows. However, both characters show a high variability (Table 46); furthermore, DINGFELDER (1962) made only live observations, indicating that he underestimated the number of cirral rows. Conversely, DRAGESCO (1966b) had only low quality protargol slides and thus presumably also did not recognise the exact arrangement of the cirri (Fig. 196e). Furthermore, neither DRAGESCO (1966b) nor FEDRIANI et al. (1976b) compared their species with *P. strenuus*, very likely because they overlooked DINGFELDER's (1962) paper. BORROR (1972a) also overlooked DINGFELDER's paper and diagnosed *Laurentia* erroneously with 2 rows each of right and left marginal cirri.

Laurentia monilata DRAGESCO & NJINE, 1971 has the 18 frontal-ventral-transverse cirral pattern of the "typical" oxytrichids and was thus transferred to a separate taxon, *Coniculostomum* NJINE, 1979 (see there). *Laurentiella strenua* is possibly closely related to *Coniculostomum monilata* and the *Stylonychia mytilus* complex because cirral streak II of the proter originates from the oral primordium (Table 4) in all these taxa. Furthermore, the prominent oral apparatus is almost identical. This implies that in *L. strenua* the increased number of cirri per streak, the multiple fragmentation of some dorsal primordia, and the increased number of dorsomarginal kineties are apomorphies. *Laurentiella strenua* can be easily separated in life and at low magnification from both, about equal sized, taxa (*Coniculostomum*, *Stylonychia*) by the non-elongated caudal cirri, the pointed posterior end of the cell, and from the very common *S. mytilus* also by the increased number of macronuclear nodules.

HEMBERGER (1982, p 196), in his unpublished thesis, transferred *Paruroleptus strenuus* to *Onychodromus* (*O. strenuus*); however, *Onychodromus* has dorsal horns as autapomorphy. Furthermore, in *Onychodromus* spp. streak II of the proter originates independently from the oral primordium (FOISSNER et al. 1987b, SZABÓ & WILBERT 1987). *Pattersoniella* has curved and intersecting undulating membranes and a distinctly higher number of cirral streaks which, however, segregate only 3 or 4 cirri each (Fig. 197).

The following chapter includes some unpublished observations kindly supplied by W. FOISSNER (Fig. 196n-v) and own observations, mainly concerning the live aspect.

M o r p h o l o g y a n d b i o l o g y: In life 100–500 µm long: 103–326 µm (DINGFELDER 1962), 250–500 µm (CZAPIK & JORDAN 1976b), 250–320 × 100–150 µm (FEDRIANI et al. 1976b), 250–320 × 100–140 µm (SZABÓ & WILBERT 1987), 250–300 times 120–160 µm (own observations), 300 × 160 µm (W. FOISSNER, pers. comm.). Body stiff as a board, almost triangular, that is, anterior end broad, posterior very narrowly rounded

← **Fig. 196a–f** *Laurentiella strenua* (a, from DINGFELDER 1962; b, from MATIS 1966; c–e, from DRAGESCO 1966b; f, after DRAGESCO 1966b from BORROR 1972a. a, b, from life; c–f, protargol impregnation). a, b) Ventral view, a = 280 µm, b = 250 µm. c, d) Variability of body shape and macronucleus. e, f) Ventral infraciliature, 200 µm. In BORROR's redrawing the arrangement of some cirri is changed, for example, in his figure (f) a distinct second left marginal row is recognisable which is unequivocally lacking in the original figure (e); p 753.

Fig. 196g-k *Laurentiella strenua* (g, from CZAPIK & JORDAN 1976b; h, i, from FEDRIANI et al. 1976b; j, k, from SZABÓ & WILBERT 1987. g-k, protargol impregnation). g, h, j, k) Ventral infraciliature, g = size not indicated, h = 290 μ m, j, k = 250 μ m. Arrowheads in (h) mark a discontinuity in the rightmost frontal-ventral-transverse cirral row. Arrows in (h, j) denote an enlarged cirrus which is very likely not a true transverse cirrus (that is, the posterior-most cirrus of a cirral streak) but a pretransverse ventral cirrus, assuming that each cirral row produces 1 transverse cirrus (otherwise a "surplus" streak must have produced a transverse cirrus but no ventral cirri, which is very unlikely). i) Somewhat deviating arrangement of transverse cirri in the population from the "Parque del Retiro" (Madrid) of the synonym, *Laurentia acuminata*. 1-5 = numbering of frontal-ventral-transverse cirral rows for morphometrical analysis (see Table 46; this numeration does not coincide with the one usually used, that is, 1 corresponds to streak II); p 753.

Fig. 196l, m *Laurentiella strenua* (from BERGER & FOISSNER 1989a. l, m, protargol impregnation). Ventral and dorsal infraciliature (250 μ m) of the type population of *L. acuminata*, drawn from slides kindly supplied by J. MARTIN, University of Cordoba, Spain. Arrowhead marks caudal cirri. The dorsal infraciliature is rather complicated in non-dividing specimens and originates by multiple fragmentation of 2 dorsal kineties and formation of 6 new dorsomarginal kineties. Possibly some parental basal body pairs are still retained after fission, as indicated by the great distance between them (left margin of figure); p 753.

or tapered. Anterior end of cell distinctly turned dorsally, posterior quarter very strongly flattened and thus translucent as in *Stylonychia mytilus* (Fig. 196n-r). Number of macronuclear nodules rather variable (Table 46); according to FEDRIANI et al. (1976b) usually 4, sometimes – possibly depending on physiological state – 5 or even up to 12 nodules present in non-dividers; nodules ovoid to spherical, in life of rather different size, for example, 20 $\times$ 15 μ m, 30 $\times$ 12 μ m, 15 $\times$ 15 μ m, 47 $\times$ 15 μ m, 38 $\times$ 20 μ m (own observations); nodules usually arranged like the figure 7, according to FEDRIANI et al. (1976b) connected by fine threadlike structures. Usually 7–9 globular micronuclei (FEDRIANI et al. 1976b), according to DINGFELDER (1962) about 3.0–3.5 μ m, according to own observations in life 4–5 μ m across. For the macronuclear cycle stages the following approximate lengths were estimated: G₁ = 7.5 h, S = 1 h, division = 1 h, G₂ = very short or lacking. Times for micronuclear cycle: G₁ = 7.5 h, S = 1 h, division = 1h; G₂ = absent. Total macronuclear

Fig. 196n, o *Laurentiella strenua* (n, o, original scanning electron micrographs kindly supplied by W. FOISSNER). Ventral view showing the almost triangular outline, the giant oral apparatus with the straight paroral and endoral (arrow), and the arrangement of the cirri; p 753.

DNA content per cell (average = 154.65 times micronucleus) found in cells with 4 macronuclear nodules was not significantly different from that found in cells with 5 nodules (average = 157.93 times micronucleus; TORRES et al. 1979b). One contractile vacuole in about mid-body, that is, about at level of buccal vertex (Fig. 196a, b), during diastole with an anterior and posterior canal (W. FOISSNER, pers. comm.). Cortical granules lacking. Cytoplasm usually dark at low magnification due to numerous cytoplasmic crystals. Creeps on the substratum or swims like a moderately fast rotating board.

Adoral zone of membranelles about 50 % of body length, distal end distinctly overlapping on right body margin. Membranelles in life up to 22 μm broad. Buccal area very broad and deep (bowl-shaped), often with conspicuous fold (Fig. 196p), similar to in the *Stylonychia mytilus* complex (Fig. 148i). Undulating membranes 120–180 μm long (CZAPIK & JORDAN 1976b). Cilia of paroral in life about 25 μm long, organised in slanting pairs resulting in a zigzag pattern; endoral composed of a single row of basal bodies with postciliary microtubules (TORRES et al. 1986). Invariably 3 distinctly enlarged frontal cirri ($n = 11$, BERGER & FOISSNER 1989a; $n = 15$, SZABÓ & WILBERT 1987), in life about 40 μm long (W. FOISSNER, pers. comm.). Buccal cirri (cirral row 1 in Fig. 196j) and cirri of cirral row behind right frontal cirrus (row 2 in Fig. 196j) somewhat larger than cirri of remaining frontoventral rows (MARTIN et al. 1983; Fig. 196l). Arrangement of frontal-ventral-transverse cirral rows, see Figures 196h, j, l, o. Rightmost cirral row (= row 5 in Fig. 196j) often with a discontinuity (Fig. 196h), strongly indicating that it is homologous to cirral row VI of the typical oxytrichids, where 2 cirri (= migratory cirri) are widely separated from the pretransverse ventral cirrus (VI/2) and transverse cirrus (VI/1). According to DINGFELDER (1962) only 3 cirral rows (with 12–18 cirri each), which is, however, very likely an underestimation due to live observation (Fig. 196a). The ventral infraciliature of the synonym *Laurentia macrostoma* (Fig. 196e) shows either a somewhat deviating specimen or includes some inaccuracies because of low quality impregnation. Transverse cirri in life about 40–45 μm long, slightly fringed, distinctly enlarged, arranged almost longitudinally in median of cell, the anterior-most inserting rather close to buccal vertex (Fig. 196l), and thus only posterior-most cirrus distinctly protruding beyond posterior end of cell (Fig. 196a, n). Marginal cirri in life about 30 μm long, marginal rows only slightly separated posteriorly (Fig. 196l), right one running parallel to body margin, left one begins close to buccal vertex and reaches left body margin asymptotically. Dorsal cilia short (DINGFELDER 1962, FEDRIANI et al. 1976b), that is about 4 μm (own observations; W. FOISSNER, pers. comm.), only the anterior basal body of a pair is ciliated (TORRES et al. 1986). Arrangement of kineties and kinety fragments rather complicated due to multiple fragmentation during morphogenesis (see below). Invariably 3 caudal cirri (BERGER & FOISSNER 1989a, DINGFELDER 1962, FEDRIANI et al. 1976b, SZABÓ & WILBERT 1987), in life about of same length (30 μm) as marginal cirri and thus rather inconspicuous. The ultrastructure of the oral apparatus and ventral and dorsal infraciliature shows only minor differences to other hypotrichs (TORRES et al. 1986).

Resting cysts spherical, about 80–100 μm ($85 \pm 0.77 \mu\text{m}$ [mean $\pm$ SD?], $n = 123$) across, spines about 4–8 μm long. Cyst belongs to the kinetosome-resorbing type (Fig. 196s–v). Cyst volume about 1/3 of vegetative cell, contains only one disc or band-shaped macronucleus and several (3.6 ± 0.12 [mean $\pm$ SD?], $n = 180$) micronuclei which are morphologically similar to the micronuclei of the vegetative cell (GUTIERREZ & PEREZ-SILVA 1983b, GUTIERREZ et al. 1981; W. FOISSNER, pers. comm.). Resting cyst wall, as is usual, composed of 4 layers; ectocyst about 0.3 μm , mesocyst about 3.3 μm , and endocyst about 0.4 μm thick, granular layer of rather varying thickness (GUTIERREZ et al. 1983a). For detailed description of ultrastructure and chemical composition of cyst wall

Fig. 196p–r *Laurentiella strenua* (p–r, original scanning electron micrographs kindly supplied by W. Foissner). **p)** The oral apparatus consists of a very prominent adoral zone of membranelles, straight undulating membranes, and a very large and deep, bowl-shaped buccal area traversed by a conspicuous fold in scanning electron microscopy preparations. **q)** Left lateral view showing the distinctly dorsally curved anterior part and the very flat posterior quarter of the cell. **r)** Dorsolateral view showing the almost perpendicularly erected anterior end of the cell and the complicated dorsal infraciliature; p 753.

see GUTIÉRREZ et al. (1980a, b, 1983a, 1984). Encystment is faster at 37 °C (70–80 % after 6–10 h) than at 20 °C (10 % after 6–10 h). At about 4 °C and 45 °C vegetative cells failed to encyst and eventually died (GUTIÉRREZ et al. 1981).

M o r p h o g e n e s i s of cell division, reorganisation, and regeneration are described by MARTIN (1982) and MARTIN et al. (1983), however, no line drawings are given. Morphogenesis commences in usual manner in that some basal bodies appear immediately left of the left transverse cirrus (= anterior-most one). Number of basal bodies increases, forming a club-shaped oral primordium. From its anterior end, a group of basal bodies diverges and parallels the right peristomial margin and finally segregates as a line of basal bodies, the anterior part of which, after separating, becomes the ciliary streak II of the proter. This matches *Coniculostomum* and the *Stylonychia mytilus* complex (see Table 4 and taxonomy). The posterior part becomes the ciliary streak II of the opisthe and two more primordial streaks arise, one at each side of its enlarged base: the left one becomes the primordium of the undulating membranes, the right one becomes the ciliary streak III of the opisthe. Some parental cirri disintegrate and rearrange their basal bodies into the ciliary streaks appearing next, usually 3 for each tomit. Some of these streaks initially are continuous with those corresponding to the other tomit. Sometimes more than 6 streaks develop. Frequently no transverse cirri or no ventral cirri arise from these "surplus" primordia, explaining the variation and discordance between number of transverse cirri and number of cirral rows. The frontal-ventral-transverse streaks of the opisthe usually derive from 6 cirral primordia; three of them coming from the oral primordium and 3 (sometimes more) originate by proliferation and rearrangement of basal bodies from parental ventral cirri.

The parental adoral zone of membranelles and the endoral are inherited by the proter without any appreciable change. The paroral undergoes a partial disorganisation of its anterior tract; the basal bodies of this tract temporarily lose their linear arrangement and, later on, rearrange and reform the paroral and a new left frontal cirrus (cirrus I/1).

The frontal-ventral-transverse cirral streak II of the proter is the anterior part of the row of basal bodies extending from the oral primordium. Basal bodies of the remaining streaks result, as in the opisthe, from disintegration of parental frontal cirri. These primordia are also arranged in a variable number (usually 6) of parallel streaks.

FOISSNER et al. (1987b, p 157, footnote 3) studied protargol-impregnated specimens of the synonym *Laurentia acuminata* (supplied by J. MARTIN, Spain). The reinvestigation clearly showed multiple fragmentation of dorsal primordia. Dorsal kinety primordium 1 (the primordium closest to the left marginal row) fragments into several pieces as in *Onychodromus quadricornutus*, the middle primordium does not fragment, and primordium 3 has a simple fragmentation, like kinety 3 in the *Oxytricha* pattern. Furthermore, the posterior fragment of kinety 3 (= "kinety 4" in, for example, the *Oxytricha* pattern) shows some multiple fragmentation at its anterior end. Six dorsomarginal kineties complete dorsal morphogenesis. Caudal cirri originate in principle as, for example, in the *Oxytricha* pattern (Fig. 24a), however, in non-dividing specimens their origin is not recognisable (Fig. 196m). All parental frontal-ventral-transverse cirri, marginal cirri, and dorsal kineties

Fig. 196s-v *Laurentiella strenua* (s-v, originals kindly supplied by W. FOISSNER. s, t, from life; u, v, scanning electron micrographs). s) Young cyst with still smooth ectocyst. t, v) Old cysts with long spines. Arrowhead marks fused macronucleus. u) Middle-aged cyst; p 753.

which do not participate in morphogenesis disappear after cytokinesis (MARTIN et al. 1983).

Morphogenesis during excystment is described by JAREÑO & TUFFRAU (1979). JAREÑO (1977, 1981b) described a process referred to as joint encystment, that is, encystment takes place after pairing of two cells, whereby cytoplasm fuses in a manner similar to total conjugation. Nevertheless, this process is not a sexual one since it lacks macronuclear degeneration and neither meiosis nor caryogamy could be detected. Excystment generates doublets which are capable of fission: the anterior part of a doublet gives rise to 2 single cells, whereas the posterior part gives rise to 1 doublet. The singlet condition is recovered

after a varying number of divisions. Joint encystment may be held as one step in a life-cycle because it generates very vigorous lines and a strain is maintained without any symptom of senility through an alternation of growth periods and starvation periods during which joint encystment occurs. Further literature on the synonym, *Laurentia acuminata*, mainly concerning the cyst: GUTIERREZ et al. (1980c–e, 1982a, b, 1983b), JAREÑO (1979, 1980, 1981a, 1984, 1985, 1987b, c, 1988, 1992), JAREÑO & TUFFRAU (1978), NOGUCHI & MATSUSAKA (1989), TORRES et al. (1979a, b, 1982).

Occurrence and ecology: Common in temporary waters. According to DINGFELDER (1962) beside *Colpoda magna*, *Nassula plantiformis*, and *Maryna cardioides* a key species for track and meadow puddles.

Locus classicus is a lane south of the city Forchheim, Bavaria, Germany, where DINGFELDER (1962) discovered *Laurentiella strenua* in puddles with hay. He also found it in other track and meadow puddles, especially in putrid sites at pH 6.8–7.4. Locus classicus of the synonym *Laurentia macrostoma* is a small saprobic puddle near the Lake of Geneva, Thonon-les-Bains, France, where DRAGESCO (1966b) found it in summer. Locus classicus of the synonym *Laurentia acuminata* is Seville, Spain, where FEDRIANI et al. (1976b) discovered it in a sample of water from the “Parque de M.^a Luisa”. They also found it in samples of water collected in the “Estación Biológica de Doñana”, Huelva, Spain, and in the “Parque del Retiro” in Madrid.

Records substantiated by illustrations: eutrophic meadow puddle with cyanobacteria near a lake (Seewaldsee) in Salzburg, Austria (own observations); abundantly in some meadow pools in St. Georg-Moorwald near Bratislava, Czechoslovakia, in November (MATIS 1966); in the plant community “*Agrosti-Bachmannietum erucaciformis*” in the Hortobágy National Park, Hungary, together with the ciliates *Colpoda cucullus*, *Blepharisma lateritium*, *B. steini*, *Dileptus anser*, *Halteria grandinella*, *Strombidium sulcatum* (SZABÓ & WILBERT 1987); very abundantly in September at 8–12 °C in a small meadow puddle near the Institute of Zoology of the University Jagiellone, Krakow, Poland (CZAPIK & JORDAN 1976b); desiccated brook in Hawaii, USA (W. FOISSNER, pers. comm.); Australia (W. FOISSNER pers. comm.; Fig. 196n–v).

Records not substantiated by illustrations: with about 2 % frequency in submerged mosses from standing and running waters in Czechoslovakia (TIRJAKOVA & MATIS 1987a); with 5.9 % frequency in paddy fields in Japan (TAKAHASHI & SUHAMA 1991). SZABÓ & WILBERT (1987) stated, obviously erroneously, that *Laurentia acuminata* is known from water samples in Cameroon (very likely confused with *L. monilata*, now *Coniculostomum monilata*).

Feeds on bacteria, cyanobacteria, small algae, diatoms, flagellates, and ciliates like *Halteria* and *Tetrahymena* (CZAPIK & JORDAN 1976b, DINGFELDER 1962, own observations). FEDRIANI et al. (1976b) and MARTIN et al. (1983) cultivated it in Pringsheim medium at about 20 °C and fed it daily with *Colpidium* sp., grown in the same medium with integral flour added and previously filtered, or with *Chlorogonium* sp. that had been concentrated by centrifugation. W. FOISSNER (pers. comm.) cultivated *Laurentiella stre-*

Table 46 Morphometric data of *Laurentiella strenua* (1, from DINGFELDER 1962; 2, from DRAGESCO 1966b; 3, from CZAPIK & JORDAN 1976b; 4, from FEDRIANI et al. 1976b; 5, from SZABÓ & WILBERT 1987; 6, type population of the synonym *Laurentia acuminata* from BERGER & FOISSNER 1989a). All data are based on protargol-impregnated specimens unless otherwise indicated. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1 ¹	-	-	-	103	326	?
	2	200.0	-	-	-	-	?
	3 ¹	-	-	-	250	500	?
	4	-	-	-	250	320	?
	5	288.5	21.0	7.3	250	320	15
	6	268.6	28.7	10.7	240	325	11
Body, width	4	-	-	-	100	150	?
	5	122.4	12.0	9.8	100	140	15
	6	159.6	16.6	10.4	150	196	11
Macronucleus, number of nodules	1	8.0	-	-	-	-	?
	2	-	-	-	3	6	?
	3	4.0	-	-	-	-	?
	4	4.0	-	-	-	-	?
	5	5.9	1.1	18.6	5	7	15
	6	4.6	1.8	38.6	2	7	11
Macronuclear nodule, diameter	1 ¹	20.0	-	-	-	-	?
	6 ⁶	36.1	11.7	32.5	20	56	11
	6 ⁷	22.4	6.6	29.3	11	32	11
Micronuclei, number	1	8.0	-	-	-	-	?
	2	-	-	-	3	6	?
	4	-	-	-	3	21	?
	5	5.9	1.1	18.6	5	7	15
	6	7.5	7.1	94.7	2	24	11
	3 ¹	-	-	-	180	200	?
Adoral zone of membranelles, length	6	134.3	9.5	7.1	120	150	11
	3 ¹	-	-	-	180	200	?
Adoral membranelles, number	1	-	-	-	50	60	?
	2	-	-	-	50	60	?
	3	-	-	-	60	70	?
	4	60.0	-	-	-	-	?
	5	63.5	1.7	2.7	62	66	15
	6	65.8	1.9	2.9	64	70	11
Cirral row 1, number of cirri ²	4 ⁴	5.0	-	-	4	6	?
	5 ⁵	3.5	0.5	14.3	3	4	15
Cirral row 2, number of cirri ²	4 ⁴	7.0	-	-	6	7	?
	5 ⁵	5.0	0	0	5	5	?
Cirral row 3, number of cirri ²	4	-	-	-	7	8	?
	5	10.0	0	0	10	10	15
Cirral row 4, number of cirri ²	4	-	-	-	6	8	?
	5	10.0	0	0	10	10	15
Cirral row 5, number of cirri ²	4 ³	-	-	-	6	11	?
	5	14.0	0	0	14	14	15

Table 46 Continued

Character		mean	SD	CV	Min	Max	n
Right marginal row, number of cirri	1	41.0	-	-	-	-	?
	2	-	-	-	36	44	?
	3	-	-	-	40	44	?
	4	-	-	-	40	45	?
	5	45.8	1.2	2.6	40	49	15
	6	39.7	1.9	4.8	37	42	11
Left marginal row, number of cirri	1	-	-	-	20	23	?
	2	-	-	-	20	23	?
	3	-	-	-	22	23	?
	4	-	-	-	26	30	?
	5	27.2	0.5	1.8	25	28	15
	6	28.8	1.7	5.8	27	32	11
Transverse cirri, number	1	-	-	-	5	6	?
	2	-	-	-	6	10	?
	3	-	-	-	2	6	?
	4	-	-	-	5	6	?
	5	6.0	0	0	6	6	15
	6	5.6	0.8	14.4	5	7	11

¹ From life.² For numbering of cirral rows, see Figure 196j.³ Anterior part with 3-5, posterior one with 3-6 cirri (see Fig. 196h).⁴ Anterior-most enlarged cirrus (frontal cirrus) included.⁵ Anterior-most enlarged cirrus (frontal cirrus) not included.⁶ Posterior macronuclear nodule, length.⁷ Posterior macronuclear nodule, width.

nua in Eau de Volvic with *Tetrahymena rostrata* as food. The cell cycle of *L. strenua* requires 9.5 ± 1 h (mean $\pm$ SD?) at about 20 °C (TORRES et al. 1979b, 1980b).

Laurentiella strenua captured the vaccine virus if it was added to the culture medium. The medium was completely decontaminated and the virus was inactivated in the ciliate; however, in the cytoplasm a proliferation of membranous cisternae occurred 2 h after culture inoculation by vaccine virus (JAREÑO 1987a, JAREÑO et al. 1985, 1986, PEREZ-PRIETO et al. 1981, 1983).

MARTIN et al. (1983) induced full reorganisation of the ciliature by (i) starvation for more than 24 h, after which cells ceased motion, sank, altered their shape, and began physiological reorganisation, (ii) treating starved cells (having no food in cytoplasm) with urea (3 % [w/v] final concentration) for 30 s, causing lysis of most of the adoral zone of membranelles and subsequent synchronous regeneration, and (iii) micro-surgical removal of a cell fragment.

DINGFELDER (1962) observed *L. strenua* in track puddles at temperatures of up to 43 °C. SZABÓ & WILBERT (1987) found it in water of the “β-limno, Na-HCO₃-SO₄ type” at

20.5 °C, pH 7.2–7.6, 6.5 mg l⁻¹ O₂ (70.6 % saturation), and 0.075 % salinity. Small doses of UV-radiation (about 240 and 360 J m⁻²) produced a considerable increase of the reproductive rate, that is, the growth constant was about 11–16 % higher than in the control (GUTIERREZ & PEREZ-SILVA 1980, 1983a); LD₅₀ was between 720 and 1200 J m⁻² and LD₁₀₀ was about 2400 J m⁻² (mean time of death was 95 h). About 88 % of the resting cysts obtained from vegetative cells irradiated with doses of 720–960 J m⁻² lacked the characteristic spines and their cyst walls were thicker (6.5 µm) than those of the normal cysts (3.7 µm).

***Pattersoniella* FOISSNER, 1987**

1987 *Pattersoniella* FOISSNER, Zool. Beitr., 31: 207 – Type (original designation): *Pattersoniella vitiphila* FOISSNER, 1987.

C h a r a c t e r i s a t i o n: Undulating ± membranes in *Oxytricha* pattern. Number of frontal-ventral-transverse cirri distinctly increased. One right and 1 left row of marginal cirri, almost confluent posteriorly. More than 6 dorsal kineties. Caudal cirri present. Number of frontal-ventral-transverse cirral streaks distinctly increased (9–11 against 6 in “typical” oxytrichids); however, only 3 or 4 cirri originate per streak. Dorsal morphogenesis in *Oxytricha* pattern; however, kinty 3 not with simple, but with multiple fragmentation and very likely some parental kineties retained after division.

T a x o n o m y: See single species. For a detailed description of the *Oxytricha* patterns mentioned in the characterisation, see chapter 2 in the general section.

Single species

***Pattersoniella vitiphila* FOISSNER, 1987 (Fig. 197a–u, Table 47)**

1987 *Pattersoniella vitiphila* FOISSNER, Zool. Beitr., 31: 207 (Fig. 197a–s; type slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

1994 *Pattersoniella vitiphila* – FOISSNER, Kataloge des O. Ö. Landesmuseums, Linz, 71: 192 (Fig. 197t).

T a x o n o m y: The ventral cirral pattern, especially the “bicorona” and the ventral cirri which are arranged in pairs, is reminiscent of the holostichids (Fig. 197g). However, fragmentation of dorsal kinty 3 assigns *Pattersoniella* unequivocally to the Oxytrichidae (Fig. 197q). Furthermore, morphogenesis of the ventral infraciliature proceeds rather similarly to in typical (18-cirri) oxytrichids, that is, the frontal-ventral-transverse cirri originate from longitudinal streaks (Fig. 197k, l); FOISSNER (1987e) hence classified it in the superfamily Oxytrichoidea. The rigid cortex, the lack of cortical granules, and the large oral apparatus (about 50 % of body length) assigns *Pattersoniella* to the Stylonychi-

Fig. 197a–e *Pattersoniella vitiphila* (a–d, from FOISSNER 1987e; e, original kindly supplied by W. FOISSNER. a–e, from life). **a)** Ventral view of a normal specimen, 200 µm. **b)** Ventral view of a very large specimen (macrostome form, 390 µm) showing the oral apparatus and the contractile vacuoles. **c)** Right lateral view showing convex dorsal and concave ventral side. **d, e)** Resting cysts, diameter about 50 µm. (d) from type material, (e) from Australian population. The macronucleus is fused in the resting cyst (W. FOISSNER, pers. comm.) and not fragmented in nodules as shown in (d); p 766.

nae (Fig. 25a), implying that the number of frontal-ventral-transverse streaks has secondarily increased (Fig. 197u). However, the relationship to the other members of this group are uncertain. *Pattersoniella* differs from *Onychodromus* spp. and *Laurentiella strenua*, among other things, in that the number of cirri originating per streak is not increased and in the shape of the undulating membranes (*Oxytricha* against *Stylonychia* pattern). *Territricha stramenticola* (Fig. 219), *Holosticha camerounensis* DRAGESCO, 1970, and *H. macrostoma* (DRAGESCO, 1970) BORROR, 1972 have only 3 distinctly enlarged frontal cirri, 2 macronuclear nodules, and 1 contractile vacuole.

Morphology and biology: In life $140\text{--}330 \times 70\text{--}150\ \mu\text{m}$ (FOISSNER 1987e). Australian (Fig. 197e, t) population in life $300\text{--}350 \times 125\text{--}140\ \mu\text{m}$. Outline broadly elliptical, left margin usually more convex than right, often distinctly narrowed at level of buccal vertex, both ends broadly rounded. Body firm, flattened about 2:1 dorso-ventrally, ventral side slightly concave, dorsal side distinctly convex (Fig. 197c, t). In cultures FOISSNER (1987e) occasionally found very large specimens with a very expansive oral apparatus and a rather high number of ventral cirri (Fig. 197h; Table 47). This macrostome form shows all transitions to the normal form and was not observed in raw cultures. The following description refers only to the normal form. Macronuclear nodules ellipsoid, in life about $20\ \mu\text{m}$ large, arranged in median or slightly left of it, nodules with many small chromatin bodies. Micronuclei spherical to ellipsoid, located close to macronuclear nodules. Several contractile vacuoles near left body margin and in buccal area (Fig. 197b), during diastole connected by canals. Cytopyge at posterior end of cell, slightly right of median. Pellicle rigid, shining, cortical granules lacking. Endoplasm colourless, coarsely granulated, in well-fed specimens dark at low magnification due to many $7\text{--}40\ \mu\text{m}$ sized food vacuoles and $2\text{--}4\ \mu\text{m}$ sized, yellowish crystals. Movement rapidly gliding, clumsily swimming like a rotating board.

Adoral zone of membranelles about 50 % of body length, formed distinctly like a question mark, widely overlapping on right body margin and thus only slightly separate from anterior end of right marginal row. Bases of largest membranelles in life about $17\text{--}25\ \mu\text{m}$ broad. Pharyngeal fibres short, in life inconspicuous. Buccal area broad but flat (Fig. 197t). Undulating membranes curved and intersecting, middle section of paroral consists of short kineties with 3 basal bodies each; cilia of undulating membranes in life about $25\ \mu\text{m}$ long. Frontal cirri (usually 6) and cirri right of buccal cirrus (usually 4) distinctly enlarged and thus very prominent in life, forming a so called "bicorona", frontal cirri in life $25\text{--}30\ \mu\text{m}$ long (Fig. 197a, t). Usually 6 frontoventral cirri, namely 2 migra-

← **Fig. 197f-i** *Pattersoniella vitiphila* (from FOISSNER 1987e. f-i, protargol impregnation). f, g) Ventral and dorsal infraciliature of a normal specimen, $240\ \mu\text{m}$. See Figure 197u for detailed explanation of ventral ciliature. Arrows in (f) mark cirri of the anterior and posterior corona, together forming the bicorona. Arrowhead in (g) marks a kinety with widely spaced basal body pairs, indicating that it is a retained parental kinety. h) Ventral infraciliature of a "macrostome" specimen, $370\ \mu\text{m}$. i) Ventral infraciliature of the posterior part of a very early morphogenetic stage, bar = $17\ \mu\text{m}$. Stomatogenesis commences with formation of basal bodies immediately left of the anterior-most transverse cirri (arrows); p 766.

tory cirri near anterior end of right marginal row and 2 pairs of cirri. Three postoral ventral and 2 pretransverse ventral cirri, identical to, for instance, in *Histiculus* or *Sterkiella*; ventral cirri in life about 20 μm long. Transverse cirri in life 25–40 μm long, fringed, distinctly enlarged, only posterior-most reach posterior end of cell (Fig. 197a, t). Marginal

Fig. 197n, o *Pattersoniella vitiphila* (from FOISSNER 1987e. n, o, ventral infraciliature of morphogenetic stages after protargol impregnation). Late and very late stage, n = 185 μm , o = 265 μm . Arrows mark dorsomarginal kineties originating at anterior end of right marginal primordia. Cirri originating from the same streak are connected by a broken line. New structures black, parental ones white; p 766.

- ← **Fig. 197j–m** *Pattersoniella vitiphila* (from FOISSNER 1987e. j–m, ventral infraciliature of morphogenetic stages after protargol impregnation). j) Very early stage, bar = 55 μm . The figure shows a specimen with an increased number of postoral ventral cirri (cp. Fig. 197f). Arrows mark newly formed basal bodies immediately left of left postoral ventral cirri. k) Early stage, 200 μm . Arrowhead marks migratory cirri, that is, the anterior-most 2 cirri of the rightmost streak which are never involved in primordia formation. Arrow denotes posterior postoral ventral cirrus which also does not participate in primordia formation in the Stylonychinae. l, m) Middle and late stage, l = 265 μm , l = 230 μm . Arrow in (l) marks posterior postoral ventral cirrus which is not involved in primordia formation. Primordia of proter and opisthe originate independently. Note the complete reorganisation of the parental undulating membranes; p 766.

cirri in life about 20–25 μm long. Dorsal cilia in life 3 μm long, arranged in 4 kineties of body length and in several short kineties (see morphogenesis for further details); altogether about 15 kineties on average. Invariably ($n = 28$) 3 caudal cirri, arranged optically rather exactly in the gap between the marginal rows, marginal and caudal cirri thus forming a rather homogeneous seam (Fig. 197a, t).

Resting cyst about 50 μm across (Table 47). Wall about 2–3 μm thick, finely folded (Fig. 197d, e). Macronucleus fused (W. FOISSNER, pers. comm.) and not divided in nodules as shown in Figure 197d. Micronuclei not fused.

M o r p h o g e n e s i s commences with the proliferation of basal bodies very close to the leftmost (= anterior-most) transverse cirri which are retained unchanged (Fig. 197j; FOISSNER 1987e). Number of basal bodies increases to form a narrow oral primordium. The anterior postoral ventral cirri are modified to primordia (Fig. 197j–l), that is, the posterior-most postoral ventral cirrus is not involved in primordia formation as this is typical for all Stylonychinae! Simultaneously the cirri of the posterior corona (cirri left of buccal cirrus) and the frontoventral cirri (except migratory ones) are involved in primordia formation of the proter (Fig. 197k–m). Both in the proter and in the opisthe, some primordia split so that altogether 9–11 streaks each occur, including streak I, which forms the undulating membranes (Fig. 197l–n). The primordia of the proter and the opisthe originate independently, whereas, for example, in *Laurentiella strenua* streak II of the proter originates from the oral primordium. In middle stages the parental undulating membranes are completely reorganised, including the formation of the left frontal cirrus (cirrus I/1; Fig. 197l–n). Parental pharyngeal fibres are reabsorbed and new ones appear immediately prior to cytokinesis. The 9–11 frontal-ventral-transverse cirral streaks segregate the following number of cirri (from 6 specimens): 1, 3, 3, 3, 3, 3, 3, 4, 4 (3 times); 1, 3, 3, 3, 3, 3, 3, 4, 4; 1, 3, 3, 3, 3, 3, 3, 4, 4, 4; 1, 3, 3, 3, 3, 3, 3, 3, 4, 4. This pattern agrees largely with the well known pattern in typical oxytrichids having 18 frontal-ventral-transverse cirri, except that 3 surplus streaks (compared with the most common case having 9 streaks) with each 3 cirri are formed. I thus have no doubt that *Pattersoniella* is a Stylonychinae with a secondarily increased number of streaks (Fig. 197u). Morphogenesis of marginal rows proceeds as usual (Fig. 197l–o).

Dorsal morphogenesis proceeds primarily as in the *Oxytricha* pattern (Fig. 24a) with, however, important modifications. Primordia formation occurs in kineties which correspond to the kineties 1–3 of the *Oxytricha* pattern (Fig. 197p). Later “kinety 3” divides not by simple, but by multiple fragmentation (Fig. 197q–s), similarly to in *Laurentiella strenua*, *Onychodromus quadricornutus*, and *Territricha stramenticola*. Furthermore, invariably 2 dorsomarginal kineties occur (Fig. 197n, o, s). Consequently, usually about 9 kineties and kinety fragments are newly formed. However, most non-dividing specimens

← Fig. 197p–s *Pattersoniella vitiphila* (from FOISSNER 1987e. p–s, dorsal infraciliature of morphogenetic stages after protargol impregnation). Early, middle, and late stage, p = 175 μm , q = 182 μm , r = 260 μm , s = 265 μm . Arrows in (q) mark beginning multiple fragmentation in kinety 3. Arrows in (s) mark dorsomarginal kineties, arrowheads denote new caudal cirri. Detailed description, see text; p 766.

Fig. 197t *Pattersoniella vitiphila* (from FOISSNER 1994a. Scanning electron micrograph; Australian population). Ventral infraciliature of a specimen with a slightly reduced number of frontoventral cirri, 165 μm . Note the short (3 μm) dorsal cilia on the left body margin; p 766.

Fig. 197u *Pattersoniella vitiphila* (same as Fig. 197f, slightly modified). Ventral infraciliature. This figure illustrates the origin of *Pattersoniella* from "typical" oxytrichids with 18 frontal-ventral-transverse cirri (cp. Fig. 6a). These 18 cirri, originating from 6 streaks, are connected by broken lines, that is, the streaks I–VI of Figure 6a very likely correspond to streaks 1, 2, 6, 8, 9, 10 of *Pattersoniella*. Additional cirri are connected by dotted lines; corresponding additional transverse cirri are marked with arrows. The anterior-most 2 cirri of streak 10 are the migratory cirri, the anterior-most cirri of streaks 1–6 form the anterior corona (= frontal cirri), the middle cirri of streaks 2–5 form the posterior corona (both coronas form the "bi-corona" of *Pattersoniella*). 1–10 = frontal-ventral-transverse cirral streaks; p 766.

have about 15 kineties (Fig. 197g). This can be explained only in that parental kinety fragments are retained after fission, which is also indicated by the widely spaced basal body pairs (Fig. 197g). Retention of parental kineties is also known in *Coniculostomum*. Caudal cirri occur, identically to in the *Oxytricha* pattern, at the posterior end of kineties 1 and 2 and the posterior-most part originating from the multiple fragmentation of kinety 3 (Fig. 197s).

The nuclear apparatus of *Pattersoniella vitiphila* shows no peculiarities, that is, in the middle stages of morphogenesis the macronuclear nodules fuse and divide in later stages (Fig. 197p–s).

Occurrence and ecology: Possibly confined to terrestrial habitats of the southern hemisphere. Locus classicus is Suva on the Fiji Island Viti Levu, South Pacific Ocean, where FOISSNER (1987e) discovered *Pattersoniella vitiphila* in the soil (pH 5.4; collector D. J. PATTERSON) of the rain forest. FOISSNER (1987e) cultivated it in Eau de Volvic; some salad medium and squeezed wheat grains were added to support growth of bacteria and small protozoa. W. FOISSNER (pers. comm.) found *P. vitiphila* in an Australian soil (Fig. 197e, t).

Feeds on a wide variety of food like heterotrophic flagellates, testaceans (*Trinema lineare*), green algae, soil particles, ciliates (*Colpoda* spp., *Tetrahymena pyriformis*), fungal spores and hyphae. In cultures even starch and *Paramecium aurelia* were ingested. Biomass of 10^6 specimens about 700 mg.

Table 47 Morphometric data of *Pattersoniella vitiphila* (from FOISSNER 1987e. line 1, normal specimens; line 2, giant specimens, that is, macrostome form). All data are based on protargol-impregnated specimens unless otherwise indicated. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character		mean	SD	CV	Min	Max	n
Body, length	1	230.5	31.0	13.5	170	295	25
	2	348.0	-	-	336	364	3
Body, width	1	108.8	16.6	15.3	70	140	25
	2	161.7	-	-	150	180	3
Nuclear apparatus, length	1	172.4	26.5	15.4	120	230	25
	2	255.0	-	-	240	280	3
Macronucleus, number of nodules	1	15.6	1.1	7.2	13	18	25
	2	17.3	-	-	16	19	3
Macronuclear nodule, length	1	17.4	4.3	24.6	11	27	25
	2	28.0	-	-	28	28	3
Macronuclear nodule, width	1	13.2	2.1	16.1	9	20	25
	2	20.3	-	-	17	24	3
Micronuclei, number	1	6.0	3.0	50.0	2	12	25
	2	17.7	-	-	15	21	3
Micronucleus, diameter	1	4.1	0.5	12.3	3.5	5.6	25
	2	4.7	-	-	4	6	3
Adoral zone of membranelles, length	1	107.4	21.1	19.6	70	140	25
	2	197.0	-	-	190	205	3
Adoral membranelles, number	1	60.4	8.4	14.0	44	83	25
	2	105.7	-	-	98	119	3
Frontal cirri, number ²	1	5.8	0.7	11.5	5	8	25
	2	7.3	-	-	7	8	3
Ventral cirri, number ³	1	14.6	1.2	8.2	13	18	25
	2	18.7	-	-	18	20	3
Right marginal row, number of cirri	1	31.5	2.5	8.0	27	36	25
	2	41.0	-	-	36	47	3
Left marginal row, number of cirri	1	29.1	2.9	9.9	22	34	25
	2	38.7	-	-	34	42	3
Transverse cirri, number	1	9.0	0.8	9.4	8	11	25
	2	10.0	-	-	9	11	3
Distance 1 ¹	1	22.4	5.1	22.9	11	32	25
	2	34.3	-	-	15	60	3
Resting cyst, diameter (in life)	1	49.2	4.5	9.1	43	60	17

¹ Distance from base of posterior-most transverse cirrus to posterior end of cell.

² The anterior corona of the bicorona (see Fig. 197u).

³ All cirri excluding frontal (anterior corona) and transverse cirri.

Taxa of Unknown Position within the Oxytrichidae

Apoamphisiella, *Gastrostyla*, *Kerona*, *Paraurostyla*, *Parentocirrus*, *Pseudouroleptus*, and *Territricha* have at least one fragmenting dorsal kinety and are thus included in the Oxytrichidae. In *Gastrostyla*, *Paraurostyla*, *Parentocirrus*, and *Pseudouroleptus* dorsal morphogenesis is in the *Oxytricha* pattern which is very likely the plesiomorphic state (Fig. 24a). *Territricha* (and *Apoamphisiella*?) shows not simple, but multiple fragmentation in kinety 3, and in the ectocommensal *Kerona* pronounced multiple fragmentation occurs in kineties 1–3. However, not only dorsal, but also ventral morphogenesis of these taxa provides some evidences that they belong to the Oxytrichidae, as already suggested in previous classifications (see Table 13). The little-known *Ancyrostopodium* is also included, because the ventral ciliature is reminiscent of *Gastrostyla*. EIGNER (1997) classified *Gastrostyla*, *Kerona*, *Paraurostyla*, and *Parentocirrus* in the Parakahliliellidae.

Since I could not find out where these taxa branch off within the Oxytrichidae, I have arranged them at the end of the book as taxa of unknown position within Oxytrichidae. I prefer this arrangement to highly speculative ones, such as *Paraurostyla* is a “primitive” member of the Oxytrichidae (that is, branches off at the base of the cladogram), which is of course not impossible. However, I could just as well assume that it branches off within the Oxytrichinae having an increased number of frontal-ventral-transverse cirri as apomorphy. Very likely, as in *Onychodromus*, molecular biological data are needed to clarify the situation.

Ancyrostopodium FAURÉ-FREMIET, 1907

- 1907 *Ancyrostopodium* FAURÉ-FREMIET, C. r. Séanc. Soc. Biol., 63: 377 – Type (by monotypy): *Ancyrostopodium maupasi* FAURÉ-FREMIET, 1907.
 1909 *Ancyrostopodium* FAURÉ-FREMIET, Arch. Protistenk., 13: 121.
 1932 *Ancyrostopodium* FAURÉ-FR., 1909 – KAHL, Tierwelt Dtl., 25: 598.
 1972 *Ancyrostopodium* FAURÉ-FREMIET, 1907 – BORROR, J. Protozool., 19: 14.
 1974 *Ancyrostopodium* FAURÉ-FREMIET – STILLER, Fauna Hung., 115: 110.
 1983 *Ancyrostopodium* FAURÉ-FREMIET, 1909 – CURDS, GATES & ROBERTS, British and other freshwater ciliated protozoa, p 428.

Provisional characterisation: Adoral zone of membranelles formed like a question mark. Body irregularly shaped, roughly like an upturned pyramid borne on a contractile stalk-like process. Transverse cirri at posterior end of process, used to attach to substrate. Most frontoventral and postoral ventral cirri form a continuous, slightly oblique (frontoventral) row. One right and 1 left row of marginal cirri. Caudal cirri at base of stalk-like process.

Taxonomy: See single species, *Ancyrostopodium maupasi*.

Single species

Ancystropodium maupasi FAURÉ-FREMIET, 1907 (Fig. 198a-i)

- 1870 *Stylonychia pustulata* – TATEM, Mon. microsc. J., 4: 314 (misidentification; Fig. 198h, i).
 1907 *Ancystropodium maupasi* FAURÉ-FREMIET, C. r. Séanc. Soc. Biol., 63: 377 (no illustration).
 1909 *Ancystropodium maupasi* FAURÉ-FREMIET, Arch. Protistenk., 13: 121 (Fig. 198a-g).
 1910 *Ancystropodium maupasi* – MENZEL, Kleinwelt, 1: 34 (short German translation of FAURÉ-FREMIET's paper without own observations).
 1932 *Ancystropodium maupasi* FAURÉ-FR., 1909 – KAHL, Tierwelt Dtl., 25: 598 (incorrect date).
 1974 *Ancystropodium maupasi* FAURÉ-FREMIET – STILLER, Fauna Hung., 115: 112.
 1983 *Ancystropodium maupasi* FAURÉ-FREMIET, 1909 – SHEN, Protozoa of the Tibetan Plateau, p 209, Plate XLIV, Fig. 369 (see nomenclature and taxonomy; incorrect date).

Nomenclature and taxonomy: FAURÉ-FREMIET (1907) established this species without illustration but with a sufficient description. 1907 is thus the correct year of publication (BORROR 1972a, CORLISS 1979, JANKOWSKI 1979, TUFFRAU 1987, TUFFRAU & FLEURY 1994).

Ancystropodium is one of the most curious species of hypotrichs, which has, however, never been redescribed (except the misidentified *Stylonychia pustulata* sensu TATEM 1870!). Thus, all available drawings, including SHEN's (1983), are from FAURÉ-FREMIET (1909). The ventral cirral pattern and its proposed morphogenetic origin indicate a close relationship to *Gastrostyla* (Fig. 198e), whereas the prominent caudal cirri at the base of the retractable tail-like process are reminiscent of *Stylonychia* (FAURÉ-FREMIET 1909, MENZEL 1910). *Ancystropodium maupasi* was thus always classified in the Oxytrichidae (BORROR 1972a, CORLISS 1979, CURDS et al. 1983, KAHL 1932, TUFFRAU 1987, TUFFRAU & FLEURY 1994). JANKOWSKI (1979, p 78) established the subfamily Ancystropodiinae.

The body shape, especially the tail-like process, is reminiscent of *Psammomitra*, which has, however, a narrowed anterior end and very likely an *Oxytricha*-like cirral pattern with only 18 frontal-ventral-transverse cirri (KAHL 1933, 1935). When feeding, this marine psammobiont species is also attached to the substrate by a stalk-like process (KAHL 1932, PÁRDUZ 1938). KAHL (1932) and HEMBERGER (1982) supposed synonymy of *Oxytricha longicirrata* (Fig. 46a, b) and *A. maupasi*. However, *O. longicirrata* has 18

Fig. 198a–g *Ancystropodium maupasi* (a–e, g, after FAURÉ-FREMIET 1909; f, from FAURÉ-FREMIET 1909. a–g, → from life). **a)** Ventral view of an attached specimen, size not indicated. **b)** Ventral view of a swimming specimen, 110 µm. **c, d)** Dorsal and ventro-lateral view of attached specimens, sizes not indicated. **e)** Arrangement of cirri in a specimen with a retracted process. Cirri which originate during morphogenesis from the same streak are connected by a broken line (exception: transverse cirri II/1–V/1). **f)** Frontal view. **g)** Macronuclear nodules and micronucleus, bar = 10 µm. CC = caudal cirri, TC = left transverse cirrus II/1, I–VI = frontal-ventral-transverse cirri streaks I–VI.

Fig. 198h, i *Ancystropodium maupasi* from life (after TATEM 1870). Ventral views (sizes not indicated) of a specimen with extended and retracted process; p 778.

frontal-ventral-transverse cirri and, furthermore, KAHL (1932) did not describe a retractable process (the most important character of *Ancystropodium*) in this species. All speculations about the validity of *Ancystropodium* can only be resolved by a detailed redescription.

Morphology and biology: Size without process in life $110 \times 45 \mu\text{m}$. Body club-shaped. Flattened about 1.5:1 dorso-ventrally (Fig. 198a, e, f, h). Process about $90 \mu\text{m}$ long, $2\text{--}3 \mu\text{m}$ broad, posterior end club-shaped, with distinct fibres at attachment site (Fig. 198a, c, d). Invariably 2 spherical, about $15 \mu\text{m}$ sized macronuclear nodules with large spherical nucleoli; invariably 1 spherical, about $6 \mu\text{m}$ sized micronucleus between nodules, stains intensely with methyl green-pyronin (Fig. 198g); CURDS et al. (1983), obviously erroneously, mentioned several macronuclear nodules. Contractile vacuole at about level of cytostome. During feeding specimens attach to substrate by means of transverse cirri at end of tail-like process; according to FAURÉ-FREMIET (1909), *A. maupasi* can even make stepping movements in this state. Swims rapidly with retracted process (Fig. 198c, d, i).

Adoral zone of membranelles about 40 % of body length (without process), proceeds distally on prominent collar and makes a three-quarter turn (Fig. 198e, f). Membranelles about $25 \mu\text{m}$ long. Buccal area more or less funnel-shaped. Cirri on frontal area, and transverse and caudal cirri distinctly larger than remaining cirri (Fig. 198e). Frontal cirri I/1, II/3, and III/3 about $45 \mu\text{m}$, other cirri on frontal area about $25 \mu\text{m}$ long. Invariably 5, about $25 \mu\text{m}$ long, very motile transverse cirri and only 1 pretransverse ventral cirrus at posterior end of process. Ventral and marginal cirri about $20 \mu\text{m}$ long. Cirri of streaks III, IV, and V form a slightly obliquely arranged frontoventral row (Fig. 198e; more detailed observations are needed to confirm these data). Only right marginal row extends to posterior end of process; thus, in contracted specimens right marginal cirri more closely arranged posteriorly than anteriorly (Fig. 198a–e). Three conspicuous (like in *Stylonychia mytilus*), about $35 \mu\text{m}$ long caudal cirri at base of process (Fig. 198a, e). During morphogenesis 1, 3, 3, 5, 6, 3 cirri originate from streaks I–VI (Fig. 198e; FAURÉ-FREMIET 1909, 1961b).

Occurrence and ecology: Extremely rare, probably confined to freshwater. Locus classicus is Rambouillet near Paris, France, where FAURÉ-FREMIET (1907, 1909)

discovered *Ancystropodium maupasi* in a peat-bog near a pond (étangs de Pontras aux Essarts-le-Roi) in September. TATEM (1870) did not mention the collecting site of "*Stylonychia pustulata*", presumably it is in the USA. GRABACKA (1973) recorded *Ancystropodium maupasi* from a fishpond in Poland, used for the treatment of sugar factory wastes. WANG (1977) and SHEN (1983) found it in various freshwater habitats of the Tibetan Plateau. Feeds on bacteria and small flagellates (FAURÉ-FREMIET 1909).

Apoamphisiella FOISSNER, 1997

1997 *Apoamphisiella* FOISSNER, Biol. Fertil. Soils, 25: 335 – Type (original designation): *Onychodromopsis tihanyiensis* GÉLLERT & TAMÁS, 1958.

C h a r a c t e r i s a t i o n: Adoral zone of membranelles formed like a question mark. Undulating membranes almost in *Cyrtohymena* pattern. Number of distinct frontoventral cirri rather low (2 cirri), arranged in oblique row. One or more slightly enlarged postoral ventral cirri. Five or more transverse cirri. Two frontoventral rows. One right and 1 left row of marginal cirri. Caudal cirri present. Both frontoventral rows participate in anlagen formation. Dorsal morphogenesis likely roughly in *Oxytricha* pattern, but probably not with simple but with multiple fragmentation.

T a x o n o m y: FOISSNER (1997b) suggested that *Apoamphisiella tihanyiensis* is an amphisiellid because of the postoral (= postperistomial) cirrus. He diagnosed *Apoamphisiella* as follows: "Amphisiellidae (?) with two long ventral cirral rows, a short, oblique row of transverse cirri and at least one cirrus left of anterior end of ventral rows. Postperistomial and caudal cirri present. With dorsomarginal kineties producing irregular field of dorsal bristles near left anterior end. Both ventral rows participate in anlagen formation during ontogenesis, and the postperistomial cirrus obtains its characteristic position by distinct anlagen migration during cytokinesis." I classify *Apoamphisiella* in the Oxytrichidae as indicated by the fragmentation of dorsal kinety 3. Thus, I had to modify the characterisation which is of course only provisional because detailed morphogenetic data are lacking.

When I wrote the *Apoamphisiella* section I found that *Holosticha hymenophora* STOKES, 1886, previously classified in *Paraurostyla*, is very similar to the type species, *Apoamphisiella tihanyiensis*. I have great problems to find differences and thus separate them by the cortical granules (present or absent). However, this character has to be checked in detail in further populations from the type locations (for details, see *A. hymenophora*).

Onychodromopsis has a different pattern of undulating membranes, distinct pretransverse ventral cirri, and 2 or more left marginal rows (Fig. 143d). In *Parentocirrus hortualis* the rightmost frontoventral row is not involved in primordia formation (Fig. 218h). *Paraurostyla* has more than 2 frontoventral rows (for example, Fig. 212r).

Key to species

- 1 Cortical granules present (Fig. 198.1a–g, and Fig. 49 in FOISSNER 1997b) *A. tihanyiensis* (p 782)
- Cortical granules lacking (Fig. 215a–d) *A. hymenophora* (p 786)

Apoamphisiella tihanyiensis (GELLÉRT & TAMÁS, 1958) FOISSNER, 1997 (Fig. 198.1a–g, Table 47.1)

- 1958 *Onychodromopsis tihanyiensis* GELLÉRT & TAMÁS, Annls Inst. biol. Tihany, 25: 230, 240 (Fig. 198.1e).
 1997 *Apoamphisiella tihanyiensis* (GÉLLERT and TAMÁS 1958) – FOISSNER, Biol. Fert. Soils, 25: 335 (Fig. 198.1a–d, f, g; two neotype slides of protargol-impregnated specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: “*Pleurotricha tihanyiensis*” in FERNÁNDEZ-LEBORANS & NOVILLO (1993, p 216) is an incorrect subsequent spelling and a new combination, which is, however, not founded. This species is not mentioned by BORROR (1972a) and STILLER (1974b).

The long cirral rows of *Apoamphisiella tihanyiensis* are reminiscent of *Onychodromopsis flexilis* and *Allotricha* spp. However, *Onychodromopsis flexilis* (Fig. 143a–d) has short and straight undulating membranes and *Allotricha* (Fig. 91c, 92h) has the 18-cirri pattern of the typical oxytrichids. HEMBERGER (1982, p 223) assumed that GELLÉRT & TAMÁS (1958) had overlooked some ventral cirri and thus classified it as senior synonym of *Pleurotricha variabilis* REUTER (Fig. 91s), a supposed synonym of *Allotricha mollis*.

The FOISSNER (1997b) population from Peru (Fig. 198.1a–d, f, g) is very similar to the European type population, indicating a cosmopolitan distribution. There are, however, also some differences discussed in detail by FOISSNER (1997b). The most important one is the yellowish colour of the Peruvian population due to the cortical granules. GELLÉRT & TAMÁS (1958) did not mention such granules, very likely because they did not make careful live observations, but studied mainly specimens prepared with opal blue. Thus, they might simply have overlooked the cortical granules, which are sometimes less distinctly yellowish (Brazilian populations mentioned by FOISSNER 1997b). There are also several differences in the cirral pattern of the European and Peruvian population, namely, 2 postoral ventral cirri against 1 cirrus and the length of the left frontoventral row (cp. Fig. 198.1e, f). Furthermore, the type population has distinct pretransverse ventral cirri (arrow in Fig. 198.1e) which is reminiscent of *Onychodromopsis* (Fig. 143d). As with the cortical granules, FOISSNER (1997b) and I (preliminary) interpret these differences as being a result of the different methodology used by the Hungarian workers. Detailed re-description of further populations recommended. Synonymy with *Apoamphisiella hymenophora* cannot be excluded (see there).

Fig. 198.1a–e *Apoamphisiella tiharyiensis* (a–d, from FOISSNER 1997b; e, from GELLÉRT & TAMÁS 1958. a–d, in life; e, opal blue preparation after BRESSLAU). a) Ventral view, 175 μ m. b) Right lateral view. c) Cytoplasmic crystals. d) Arrangement of cortical granules, which have a yellow colour. e) Ventral ciliature of type population, 220 μ m. Arrow marks some “pretransverse ventral cirri” (possibly a misobservation) not present in Fig. 198.1f. DB = dorsal bristles, RM = right marginal row; p 782.

Morphology and biology: Hungarian population: In life (?) about 220 μ m long. Elliptical (Fig. 198.1e). Two macronuclear nodules, each with a micronucleus. No cortical granules mentioned, very likely overlooked because probably not studied in life. About 50 adoral membranelles. Undulating membranes strongly curved. Three distinctly enlarged frontal cirri, 1 buccal cirrus, 2 frontoventral cirri, 2 postoral ventral cirri, 3 pre-transverse ventral cirri. According to text 5 fringed transverse cirri which protrude

Fig. 198.1f, g *Apoamphisiella tihanyiensis* (from FOISSNER 1997b. f, g, protargol impregnation). f, g) Ventral and dorsal infraciliature, 151 μ m. Arrow in (f) marks single postoral ventral cirrus (= postperistomial cirrus in FOISSNER 1997b). Arrow in (g) marks caudal cirri at posterior-most fragment of dorsal kinety 3. Arrowhead denotes field of disorganised dorsal bristles due to multiple fragmentation in dorsal kinety 3 and/or parental bristles; p 782.

beyond posterior end of cell, in the illustration, however, they do not!. Marginal rows converge posteriorly, indicating that caudal cirri are present.

FOISSNER (1997b) population: In life 150–210 $\times$ 50–80 μ m, dorsoventrally flattened up to 2:1, very flexible but acontractile. Elliptical, both ends broadly rounded, right margin almost straight, left slightly convex (Fig. 198.1a). Distinctly yellowish at low magnification ($\leq 100\times$) due to cortical granules. Invariably ($n = 11$) 2 macronuclear nodules

rather close together in central third of body slightly left of mid-line, after protargol impregnation $23\text{--}30 \times 10\text{--}15 \mu\text{m}$ (mean = $26.4 \times 13.0 \mu\text{m}$, $n = 11$), with many $0.5\text{--}2.0 \mu\text{m}$ sized nucleoli. 4–8 (mean = 6, $n = 11$) spherical to slightly ellipsoidal (after protargol impregnation $4.0 \times 3.7 \mu\text{m}$, $n = 11$) micronuclei close to macronuclear nodules, compact and thus easy to recognise in life (Fig. 198.1a, g). Contractile vacuole distinctly above mid-body, with 2 lacunar collecting canals. Cortical granules $0.5\text{--}1.0 \mu\text{m}$ across, conspicuous because brightly citrine, as, for example, in *Holosticha multistilata*, arranged in rather widely spaced, longitudinal stripes, including cirral and bristle rows (Fig. 198.1d); do not stain with protargol. Cytoplasm colourless, with many $2\text{--}4 \mu\text{m}$ sized, yellowish crystals (Fig. 198.1c) and food vacuoles. Glides quickly on slide and on soil particle.

Adoral zone of membranelles about 37 % of body length, proximal half slightly spoon-like broadened with bases of largest membranelles about $12 \mu\text{m}$ wide and of conventional fine structure; proximal end covered by buccal lip. Buccal cavity moderately wide but deep and semicircularly curved anteriorly, posterior half covered by bay-like projecting buccal lip (Fig. 198.1a, f). Undulating membranes distinctly curved, especially paroral, both very likely composed of narrowly spaced dikinetids; endoral optically intersects paroral in mid-portion and traverses buccal cavity, forming bow-string to strongly curved anterior portion of paroral (Fig. 198.1f); this arrangement strongly resembles the *Cyrtohymena* pattern (Fig. 19g). Pharyngeal fibres short, inconspicuous.

Invariably ($n = 11$) 3 frontal cirri, 1 buccal cirrus, 2 cirri left of anterior end of right frontoventral row, and 1 postoral ventral cirrus (Fig. 198.1f, arrow); some specimens from Brazil with 2 postoral ventral cirri (FOISSNER 1997b). Frontal cirri distinctly enlarged, in life about $20 \mu\text{m}$ long, rightmost cirrus very close to distal end of adoral zone of membranelles. Cirri left of anterior portion of right ventral row and isolated postoral ventral cirrus slightly enlarged. Cirri of frontoventral rows in life about $15 \mu\text{m}$ long, right row almost as long as body, begins near distal end of adoral zone of membranelles, terminates in front of rightmost transverse cirrus; posterior-most cirrus slightly enlarged (possibly it is homologous with the pretransverse ventral cirrus VI/2 of the typical oxytrichids; Fig. 6a). Left frontoventral row in parallel with right but distinctly separate, begins slightly in front of buccal vertex, extends to transverse cirri. Transverse cirri distinctly enlarged, in life about $30 \mu\text{m}$ long and with frayed distal end, project above posterior body margin, form slightly curved, oblique row slightly left of median. Marginal cirri in life about $25 \mu\text{m}$ long, become gradually thinner posteriorly. Left marginal row J-shaped, that is, terminates in median of cell, the posterior-most cirri thus easily confused with caudal cirri. Right marginal row commences at level of buccal cirrus, terminates about at level of posterior-most transverse cirrus, thus being separated from left marginal row by small but distinct break.

Dorsal cilia in life about $3 \mu\text{m}$ long. Dorsal kineties 1–3 almost of body length; remaining kineties (posterior fragments of kinety 3 and dorsomarginal kineties) forming conspicuous field of scattered bristles indicating that multiple fragmentation occurs and/or parental kineties are retained (Fig. 198.1g). Ten caudal cirri on average on

Table 47.1 Morphometric data of *Apoamphisiella tihanyiensis* (from FOISSNER 1997b). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	163.1	13.8	8.5	147	190	11
Body, width	62.6	8.8	14.0	47	76	11
Adoral membranelles, number	56.5	3.3	5.8	52	62	11
Adoral zone of membranelles, length	60.8	4.1	6.7	55	65	11
Left marginal row, number of cirri	38.4	2.8	7.2	33	43	11
Right marginal row, number of cirri	35.4	4.2	11.9	28	43	11
Anterior end to left frontoventral row, distance	41.6	1.9	4.5	40	45	11
Anterior end to right frontoventral row, distance	20.2	2.0	10.1	15	22	11
Left frontoventral row, number of cirri	24.2	1.9	8.0	21	27	11
Right frontoventral row, number of cirri	33.4	2.9	8.6	27	37	11
Transverse cirri, number	6.6	0.8	12.5	5	8	11
Caudal cirri, number	10.0	3.3	32.9	3	14	11

posterior end of kineties 1 and 2, and probably on end of posterior-most fragment of kinety 3; caudal cirri about of same length as marginal cirri.

FOISSNER (1997b) found in Brazilian freshwater populations that, as in *Apoamphisiella hymenophora* (GRIMES & L'HERNAULT 1978), both ventral rows develop cirral anlagen and the parental ventral infraciliature is completely resorbed.

Occurrence and ecology: Locus classicus is the eastern shore of Lake Balaton, Hungary, where GELLÉRT & TAMÁS (1958) discovered *Apoamphisiella tihanyiensis* in drift material. GELLÉRT & TAMÁS (1959b, 1960) and TAMÁS & GELLÉRT (1959, 1960) observed it in other habitats (for example, hydropsammon) of Lake Balaton. FOISSNER (1997b) found *A. tihanyiensis* in a soil sample (light brown mixed with much leaf litter, pH 6.2) from the Amazonian rain forest near the town of Iquitos, Peru (about lat 4°S, long 74°W); he found it also in two freshwater sites in Rio de Janeiro and Praia do Forte, Brazil. The marine record from the sub-littoral of the Bay of Biscay, Atlantic Ocean, Spain, is questionable (FERNÁNDEZ-LEBORANS & NOVILLO 1993).

Feeds on diatoms and small ciliates (GELLÉRT & TAMÁS 1958), according to FOISSNER (1997b) on coccal cyanobacteria, fungal spores and hyphae, heterotrophic flagellates, naked amoebae, testate amoebae (*Tracheleuglypha* sp., *Trinema lineare*, *Euglypha rotunda*, *E. compressa*), ciliates (*Blepharisma hyalinum*, *Vorticella* swarms), and even on cysts or eggs of gastrotrichs.

Apoamphisiella hymenophora (STOKES, 1886) comb. nov. (Fig. 215a–d)

- 1888 *Holosticha hymenophora*, STOKES – STOKES, J. Trenton nat. Hist. Soc., 1: 282 (Fig. 215a).
 1932 *Holosticha hymenophora* STOKES, 1886 – KAHL, Tierwelt Dtl., 25: 586 (see nomenclature).
 1963 *Holosticha hymenophora* STOKES – LUNDIN & WEST, Free-living protozoa, p 68 (Fig. 215b).
 1972 *Paraurostyla hymenophora* (STOKES, 1886) – BORROR, J. Protozool., 19: 10.
 1978 *Paraurostyla hymenophora* (STOKES) – GRIMES & L'HERNAULT, J. Protozool., 25: 65 (Fig. 215c, d; morphology and morphogenesis after electron microscopy).

Nomenclature and taxonomy: *Holosticha himenophora* STOKES 1886 in GRISPINI (1938, p 153) is an incorrect subsequent spelling. KAHL (1932) divided *Holosticha* into several subgenera; the correct name in his revision is thus *Holosticha (Holosticha) hymenophora*.

BORROR (1972a) proposed synonymy with *Uroleptus ellipticus* WANG & NIE, 1933, which, however, lacks prominent transverse cirri. *Onychodromopsis flexilis* has more scattered cirri right of the adoral zone of membranelles and 2 distinct pretransverse ventral cirri, indicating that it is not synonymous with the species described by STOKES (1886).

When I made the layout of the book, I found that “*Paraurostyla hymenophora*” belongs to *Apoamphisiella* (thus the illustrations are not arranged within the description!). It is even rather difficult to find a difference between the type species, *A. tihanyiensis*, and *A. hymenophora*, and synonymy thus cannot be excluded. STOKES (1886), who made detailed live observations (in contrast to GELLÉRT & TAMÁS 1958, the authors of the type species, who used likely opal blue stained material only!) did not mention a colour or granules, indicating that his species lacks cortical granules. This is the only (uncertain!) difference between *A. tihanyiensis* (with cortical granules according to the redescription by FOISSNER 1997b) and *A. hymenophora*. GRIMES & L'HERNAULT (1978) also do not mention cortical granules. However, some of their TEM-micrographs (their Figures 8–10) show conspicuous structures close to the cirri, indicating that such granules are present. The GRIMES & L'HERNAULT (1978) population differs in some further details from the original description (left frontoventral row longer, undulating membranes curved, more [6 against 5] transverse cirri). Thus, further redescrptions, including live observations and detailed line drawings and biometry of protargol-impregnated specimens are needed to ascertain if *A. tihanyiensis* is the junior synonym of *A. hymenophora*.

Morphology and biology: In life 170–205 µm long, three to four times as long as broad. Elliptical, slightly narrowed anteriorly and slightly curved towards left-hand side. Soft and flexible and somewhat extensible. Two ellipsoid macronuclear nodules. Two contractile vacuoles in mid-body (probably the main vacuole and the posterior canal). Cytopyge subterminally, presumably dorsal.

Adoral zone of membranelles about 35 % of body length. Undulating membranes according to STOKES (1886; Fig. 215a) and LUNDIN & WEST (1963; Fig. 215b) almost straight, according to GRIMES & L'HERNAULT (1978; Fig. 215c, d) distinctly curved (as in *A. tihanyiensis*!). Three prominent frontal cirri, 1 buccal cirrus, and 1 prominent cirrus behind right frontal cirrus (STOKES 1886), according to GRIMES & L'HERNAULT (1978)

anterior-most cirrus of left frontoventral row also distinctly enlarged. Two frontoventral rows, according to original description and LUNDIN & WEST (1963) left one beginning at buccal vertex, right one near distal end of adoral zone of membranelles. According to GRIMES & L'HERNAULT (1978; Fig. 215c) left frontoventral row begins about at same level as right row (however, Fig. 1 in GRIMES & L'HERNAULT 1978 gives the impression that the left row is distinctly shortened anteriorly, identical as in Fig. 198.1f). Both rows terminate immediately in front of right transverse cirri. Usually 1, sometimes up to 4 postoral ventral cirri (Fig. 215c). Five (STOKES 1886, LUNDIN & WEST 1963) to 6 (sometimes 7; GRIMES & L'HERNAULT 1978) moderately enlarged transverse cirri, only right one slightly protruding beyond posterior end of cell. Marginal rows obviously not distinctly separate posteriorly because they are described as confluent in all descriptions (very likely, the inconspicuous caudal cirri are inserted in the gap between the marginal rows). Dorsal cilia short, immobile, arranged in 6 kineties; kinety 3 fragmented (GRIMES & L'HERNAULT 1978) as in *A. tihanyiensis*. Ultrastructural details of ciliature, see GRIMES & L'HERNAULT (1978). Ultrastructure of cyst similar to that of 18-cirri oxytrichids, including the lack of basal bodies (GRIMES & L'HERNAULT 1978).

Morphogenesis was studied by GRIMES & L'HERNAULT (1978) after protargol impregnation and scanning electron microscopy. However, the line drawings are too inaccurate to recognise important details. Thus, reinvestigation necessary. Frontal-ventral-transverse primordia obviously develop independently in the proter and the opisthe. Both frontoventral rows participate, as in *Apoamphisiella tihanyiensis*, in anlagen formation. The presence of 6 or 7 transverse cirri indicates that 7 or 8 anlagen are present (anlage I does not make a transverse cirrus!).

Occurrence and ecology: Rare. Locus classicus not defined, but very likely near Trenton, New Jersey, USA, where STOKES lived and worked; he found it in shallow pools during early spring. Records documented by illustrations: freshwater from the Upper Peninsula of Michigan, USA (LUNDIN & WEST 1963, WEST 1953); Meadowbrook, a small stream, where it crosses Hempstead Turnpike in Uniondale, New York, USA (GRIMES & L'HERNAULT 1978; identified by A. C. BORROR). Records not documented by illustrations: 16 ind. cm⁻² in running water in northern Italy (MADONI & GHETTI 1977); in a well in Italy (GRISPINI 1938); Conestoga drainage basin, Pennsylvania, USA (CAIRNS 1965a). According to CURDS (1975) also in activated sludge.

GRIMES & L'HERNAULT (1978) maintained their population on phosphate-buffered Cerophyl inoculated with *Enterobacter aerogenes* 2 d before use, and diluted 50 % (v/v) with the Chapman-Andresen modification of Pringsheim's solution. *Tetrahymena pyriformis* was added to the above solution immediately before use.

Gastrostyla ENGELMANN, 1862

- 1862 *Gastrostyla* ENGELMANN, Z. wiss. Zool., 11: 383 – Type (by monotypy): *Gastrostyla steinii* ENGELMANN, 1862.
- 1866 *Nothopleurotricha* DIESING, Sber. Akad. Wiss. Wien, 52: 521.
- 1866 *Nothopleurotricha* DIESING – DIESING, Sber. Akad. Wiss. Wien, 53: 117 – Type (by monotypy): *Pleurotricha setifera* ENGELMANN, 1862.
- 1882 *Gastrostyla*, ENGELMANN – KENT, Manual infusoria II, p 783.
- 1932 *Gastrostyla* ENGELMANN, 1861 – KAHL, Tierwelt Dtl., 25: 593.
- 1972 *Gastrostyla* ENGELMANN, 1862 – BORROR, J. Protozool., 19: 14.
- 1974 *Gastrostyla* ENGELMANN – STILLER, Fauna Hung., 115: 108.
- 1994 *Gastrostyla* ENGELMANN, 1862 – EIGNER & FOISSNER, J. Euk. Microbiol., 41: 260 (see taxonomy).

Characterisation: Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Number of frontoventral and postoral ventral cirri distinctly higher than 7. All frontoventral and postoral ventral cirri (usually except of III/2 and IV/2) form a more or less continuous, slightly oblique (frontoventral) row. Two pretransverse ventral and 4 or 5 transverse cirri. One right and 1 left row of marginal cirri. Five or 6 dorsal kineties. Caudal cirri present. Frontoventral cirral row originates from primordia IV–VI. Dorsal morphogenesis in *Oxytricha* pattern.

Additional characters: Both ends more or less broadly rounded, flattened about 2:1 dorso-ventrally. Contractile vacuole in about mid-body or slightly in front of it. Cytoplasm colourless. Rapid movement. Adoral zone of membranelles almost 40 % of body length, except in *Gastrostyla stenocephala*, where it is only 25 %. Frontal cirri, buccal cirrus, frontoventral cirrus behind right frontal cirrus (that is, cirrus III/2), and transverse cirri usually distinctly enlarged. Frontoventral row at least half of body length, composed of cirri of streaks VI, IV, and V (from anterior). Dorsal cilia short, that is, 3–5 µm, except in *G. stenocephala* where they are 16 µm long.

Nomenclature and taxonomy: KAHL (1932) and TUFFRAU & FLEURY (1994, p 143) misdate *Gastrostyla* with 1861. Incorrect subsequent spellings: *Gasterostyla steinii* (ENGLM.) (TCHANG 1931, p 71); *Gasterostyla steini* ENGELMANN (MAUCH et al. 1985, p 47); *Gastostyla steini* (HORVÁTH 1950, p 153); *Gastrostila* (SERNOV 1929, p 557); *Gastrostylus* (ALLISON 1924, p 345); *Gastrosyla* sp. ENGELMANN (SMITH 1978, p 27); *Gastrosyla stenocephala* (BORROR, 1963) (ALADRO LUBEL et al. 1988, p 439); *Gastrotyla stenocephala* (BORROR) (ALADRO LUBEL 1985, p 28, 56).

For a detailed description of the patterns mentioned in the characterisation, see chapter 2 in the general section. A relationship of *Gastrostyla* to the oxytrichids was already supposed by several authors (for example, BORROR 1972a, CORLISS 1979, HEMBERGER 1982, STILLER 1974b, TUFFRAU & FLEURY 1994). In my opinion, *Gastrostyla* is unequivocally an oxytrichid because of the fragmentation of dorsal kinety 3. Furthermore, the morphogenetic pattern of the ventral infraciliature proceeds identically to in typical (18-cirri) oxytrichids, except that the 3 rightmost primordia IV–VI produce a higher number of

cirri to form a more or less continuous frontoventral row. However, it is difficult to establish the exact position of *Gastrostyla* within the oxytrichids. At least 2 possibilities exist: (i) *Gastrostyla* is, simply, the sister-group of the typical (18-cirri) oxytrichids, that is, the 18-cirri pattern evolved from a *Gastrostyla*-like pattern by a reduction of the number of cirri originating from primordia IV–VI. This “primitive” position is generally supposed, for example, by KAHL (1932), MARTIN (1982), and WIRNSBERGER et al. (1986). (ii) *Gastrostyla* evolved from flexible 18-cirri oxytrichids (that is, Oxytrichinae, for example, *Oxytricha*) by an increase of the number of cirri originating from primordia IV–VI. A relationship to the Stylonychinae is unlikely because species with cortical granules exist (for example, *Gastrostyla pulchra*). Furthermore, the body is usually not as rigid as in the Stylonychinae because there is only one layer of (longitudinally oriented) subpellicular microtubules (GRIM 1972). Because I can not decide for either of the two hypothesis, I classify *Gastrostyla* as taxon of uncertain position within the oxytrichids.

Conversely, EIGNER & FOISSNER (1994) considered the possession of a frontoventral row as sufficient to assign *Gastrostyla* to the amphisiellids. However, they failed to construct a plausible cladogram indicating an uncertain classification. Furthermore, this hypothesis assumes that fragmentation of dorsal kinety 3 evolved twice, which is very unlikely. Moreover, *Gastrostyla* spp. can be separated from most amphisiellids (unfortunately not from the type species, *Amphisiella marioni*; GOURRET & ROESER 1888, WICKLOW 1982a, b) not only by the dorsal pattern but also by the usually prominent, obliquely arranged transverse cirri. Possibly, oxytrichids and amphisiellids are more closely related than at present assumed.

The ventral infraciliature of *Gastrostyla* is reminiscent of *Ancystropodium maupasi* (Fig. 198e). However, detailed redescription of this curious species is needed for further speculations on phylogenetic relationship.

Synonymy of *Gastrostyla* and *Nothopleurotricha* was already proposed by KENT (1882); according to CORLISS (1979, p 208) the junior synonym is a nomen oblitum. STERKI (1878, p 57) proclaimed two new *Gastrostyla* species, which were, however, never described.

Key to species

1	Marine	7
-	Limnetic or edaphic	2
2	2 macronuclear nodules	4
-	More than 2 macronuclear nodules	3
3	4 macronuclear nodules (Fig. 199a, d)	<i>G. steinii</i> (p 791)
-	8, rarely only 6 macronuclear nodules (Fig. 205a)	<i>G. muscorum</i> (p 808)
4	(2) Transverse cirri arranged in 2 distinctly separated groups with 3 and 2 cirri each (Fig. 204a–c)	<i>G. setifera</i> (p 816)
-	Transverse cirri arranged in a rather oblique, J-shaped pattern (e.g., Fig. 202b) ..	5
5	3 caudal cirri (Fig. 203a, b, e)	6

- 7–12, usually 10 caudal cirri (Fig. 202a, g) *G. dorsicirrata* (p 803)
- 6 Pyriform to ovoid, that is, anterior third of cell narrowed, posterior end broadly rounded; frontoventral row terminates near transverse cirri (Fig. 203a, b)
..... *G. mystacea* (p 808)
- Prolate ellipsoidal, that is, widest in mid-body; frontoventral row terminates distinctly in front of transverse cirri (Fig. 203e, f, h) *G. minima* (p 810)
- 7 (1) Anterior portion of cell cephalised, that is, distinctly narrowed; transverse cirri terminally (Fig. 207a, f) *G. stenocephala* (p 822)
- Anterior portion not cephalised; transverse cirri extremely displaced anteriorly (Fig. 206a, b, e, h) *G. pulchra* (p 818)

***Gastrostyla steinii* ENGELMANN, 1862 (Fig. 2a, b, 7a, b, 199a–z, 200a–d, 201a–p, Tables 3, 48)**

- 1862 *Gastrostyla steinii* ENGELMANN, Z. wiss. Zool., 11: 383 (Fig. 199a).
 1882 *Gastrostyla steinii*, ENG. – KENT, Manual infusoria II, p 784.
 1886 *Gastrostyla vorax* NUSSBAUM, Arch. mikr. Anat., 26: 494 (Fig. 199g; new synonym).
 1899 *Gastrostyla steinii* ENGELMANN – SCHUSTER, Sci. Gossip, 5: 203 (Fig. 201m).
 1901 *Gastrostyla steinii* ENGLM. – ROUX, Mém. Inst. natn. génev., 19: 100 (Fig. 199h).
 1906 *Gastrostyla steinii* ENG. – EDMONDSON, Proc. Davenport Acad. Sci., 11: 99 (Fig. 201k).
 1914 *Gastrostyla steinii* ENGELMANN – SMITH, Kans. Univ. Sci. Bull., 9: 165 (Fig. 201p).
 1924 *Gastrostyla steinii* ENGELMANN – BRAVO, Revta mex. Biol., 4: 165 (Fig. 201n).
 1926 *Gastrostyla steinii*, ENGELM. – KOFFMAN, Acta zool., Stockh., 7: 312 (Fig. 201o).
 1930 *Gastrostyla steinii* ENGELMANN – WEYER, Arch. Protistenk., 71: 139 (Fig. 199x).
 1931 *Gastrostyla philippinensis* SHIBUYA, Proc. imp. Acad. Japan, 7: 126 (Fig. 199l, m; new synonym).
 1932 *Gastrostyla steini* ENGELMANN, 1861 – KAHL, Tierwelt Dtl., 25: 595 (Fig. 199k; incorrect date and incorrect subsequent spelling).
 1933 *Gastrostyla steini* ENGELM. – HORVÁTH, Arch. Protistenk., 80: 290 (Fig. 199i, j; incorrect subsequent spelling).
 1945 *Gastrostyla steini* ENG. – SOKOLOFF, An. Esc. nac. Cienc. biol., Méx., 4: 41 (Fig. 199p; incorrect subsequent spelling).
 1948 *Gastrostyla steini* ENGELM. – STELLA, Riv. Biol., 40: 144 (Fig. 201i; incorrect subsequent spelling).
 1966 *Histrio lemani* DRAGESCO, Protistologica, 2: 89 (Fig. 199u; new synonym).
 1970 *Gastrostyla steinii* – GRIM, Trans. Am. microsc. Soc., 89: 486 (Fig. 199r, s).
 1972 *Gastrostyla steini* ENGELMANN – BICK, Ciliated protozoa, p 184 (Fig. 199q; incorrect subsequent spelling).
 1972 *Gastrostyla steinii* ENGELMANN, 1862 – BORROR, J. Protozool., 19: 14.
 1972 *Gastrostyla philippinensis* SHIBUYA, 1931 – BORROR, J. Protozool., 19: 14.
 1972 *Histriculus lemani* (DRAGESCO, 1966) – BORROR, J. Protozool., 19: 14.
 1973 *Gastrostyla steinii* – WALKER & GRIM, J. Protozool., 20: 566 (Fig. 199t, 200a–d).
 1982 *Gastrostyla steinii* ENGELMANN, 1862 – FOISSNER, Arch. Protistenk., 126: 71 (Fig. 199b–f; detailed redescription; slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).
 1985 *Gastrostyla parasteinii* SMALL & LYNN, Ciliophora, p 455 (Fig. 199t; for *Gastrostyla steinii* of WALKER & GRIM 1973; new synonym).
 1991 *Gastrostyla steinii* ENGELMANN, 1862 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 272.

Fig. 199a–c *Gastrostyla steinii* (a, after ENGELMANN 1862; b, c, from FOISSNER 1982. a, b, from life; c, protargol impregnation). a, b) Ventral views, a = 240 μ m, b = 170 μ m. *Gastrostyla steinii* usually has only 4 transverse cirri and 4 macronuclear nodules. c) Ventral infraciliature, 90 μ m. Arrow marks postoral ventral cirrus which is homologous with cirrus IV/2 of the 18-cirri oxytrichids; p 791.

Nomenclature and taxonomy: Incorrect subsequent spellings: the most common is “*Gastrostyla steini*” (for example, ANDRÉ 1912, p 134, 1916; BURKOVSKY 1984, p 21; HORVÁTH 1933; KAHL 1932; PUYTORAC et al. 1994, p 3; SOKOLOFF 1930, p 262; STILLER 1974b, p 108); *Gastrostyla steinni* (BORROR & WICKLOW 1982, p 285A).

Gastrostyla vorax, *G. philippinensis*, and *G. parasteinii* were established mainly because of minor differences in the number and arrangement of the frontal, ventral, and transverse cirri. However, the available data show that these characters are rather variable in *Gastrostyla steinii* (Fig. 200a–d), indicating that all these species are synonyms. DRAGESCO (1966b) compared *Histrio lemani* only with the marine “*Histriculus similis*” (now *Sterkiella quadrinucleatus*, Fig. 186b). The number and the arrangement of the ventral cirri, however, suggest that it is *G. steinii*. The only conspicuous difference is the long adoral zone of membranelles, which is about 50 % of body length in *Histrio lemani*.

Fig. 199d–f *Gastrostyla steinii* (from FOISSNER 1982. d, protargol impregnation; e, f, from life). d) Dorsal infraciliature, 90 μm . e, f) Dorsal (showing contractile vacuole) and left lateral view; p 791.

The populations by BALDENSPERGER (1927, Planche VI, 202) and SCHNEIDER (1930; Fig. 233h) are insufficiently redescribed.

M o r p h o l o g y a n d b i o l o g y: Size rather variable, that is, in life 140–320 $\times$ 45–100 μm ; 150–320 μm (ENGELMANN 1862), up to 300 $\times$ 130 μm (NUSSBAUM 1886), about 200 $\times$ 100 μm (SHIBUYA 1931), 130–160 μm long (DRAGESCO 1966b), about 140–200 $\times$ 50–80 μm (FOISSNER 1982), according to STELLA (1948; Fig. 2011) only 70 μm long. Elliptical, often with parallel margins, sometimes posteriorly slightly broader than anteriorly. After ENGELMANN (1862) and FOISSNER (1982) only slightly, according to NUSSBAUM (1886) and HORVÁTH (1950) rather flexible. Usually 4, rarely 6, in life about 15 $\times$ 10 μm sized macronuclear nodules, bounded by a common macronuclear envelope with a narrow connecting isthmus between G_1 interphase nuclei (WALKER & GOODE 1975). Usually 3–6, rarely up to 14 (WALKER & GOODE 1975) micronuclei; according to WEYER (1930) the number of micronuclei varies between 1 and 7 within clones. Contractile vacuule with 2 long collecting canals; takes about 43 min at 23 $^{\circ}\text{C}$ to excrete the amount of water corresponding to cell volume (BRAND 1935). Cortical granules lacking. Posterior half of cell often packed with reddish-yellow, about 2–5 μm long crystals and

Fig. 199g–k *Gastrostyla steinii* (g, after NUSSBAUM 1886; h, from ROUX 1901; i, j, from HORVÁTH 1933; k, after ENGELMANN 1862 from KAHL 1932. g, from life, arrangement of cirri after osmium fixation and pikrocarmine staining; h, j, k, from life; i, osmium toluidinblue stain). g–i, k) Ventral views, g, i = size not indicated, h = 245 μm , k = 240 μm . j) Right lateral view; p 791.

with some 2–7 μm sized, shiny globules. Food vacuoles up to 35 μm in diameter. Defecation vacuoles with loose, granulated content, when ejected at right margin of posterior third of cell (WEYER 1930). Usually glides, never stands still.

Bases of largest membranelles in life about 12 μm wide. Buccal area moderately broad and rather deep. Undulating membranes consist of 2 rows of basal bodies each, distinctly curved (KNAIPPE et al. 1989); intersect about halfway. All cirri rather strong. Frontal and transverse cirri about 25 μm , marginal cirri about 20 μm long. Arrangement of frontoventral cirri rather invariable, usually 5 or 6 frontoventral cirri and 9–11 postoral and pretransverse ventral cirri. Usually 4, sometimes 5 (very rarely 6) transverse cirri; however, it can not be excluded that pretransverse ventral cirri were counted as transverse cirri. Dorsal kineties 1 and 3 distinctly, kineties 2 and 4 only slightly shortened anteriorly. Kineties 5 and 6 (= dorsomarginal rows) strongly shortened posteriorly (Fig. 199d). For details on fibrillar system and ultrastructure of cortex, see TUFFRAU (1965a) and GRIM (1971, 1972).

Resting cysts spherical with strongly wrinkled surface, in life about 40–50 μm in diameter (FOISSNER 1987a, HAUSMANN & FOISSNER 1986, NUSSBAUM 1886; Fig. 199v–z), ac-

Fig. 199l–q *Gastrostyla steinii* (l, m, from SHIBUYA 1931; n, o, from HORVÁTH 1942; p, after SOKOLOFF 1945; q, after BICK 1972a. l, m, p, q, from life; n, o, carmine acetic-acid staining). l, p, q) Ventral views, l, p = size not indicated, q = 265 μ m. SOKOLOFF (1945, [p]) draws none and BICK (1972a, [q]) 2 postoral ventral cirri. m) Buccal area. n, o) Doubling (n) of the number of macronuclear nodules by means of micro-operation; p 791.

cording to WALKER et al. (1980) only 27–29 μ m in diameter. Cyst wall 1.4–2.0 μ m thick, composed of 4 distinct layers (ROSATI et al. 1983). The cyst belongs to the kinetosome-resorbing type (WALKER 1976a, WALKER & MAUGEL 1976, 1980, WALKER et al. 1980). Volume of resting cyst about 13 % of volume of an interphase specimen; volume of fused macronucleus about 20 % of interphase value (GUTIERREZ 1985, GUTIERREZ & PEREZ-SILVA 1981). According to WENZEL & OMILIAN-ROSSO (1982) the most effective means for activation of cysts is to offer *Tetrahymena pyriformis* (reactivation rate about 78 % after 4 h). Cysts which were dry preserved for 12 years did not excyst (NUSSBAUM 1897). Morphogenesis during encystment and excystment was analysed by KNAIPPE (1989) and KNAIPPE et al. (1990).

M o r p h o g e n e s i s of cell division commences with the proliferation of basal bodies near the left transverse cirrus (Fig. 201a, Table 3; HEMBERGER 1982, p 182; TUFRAU 1969, 1970, WALKER & GRIM 1973). Frontal-ventral-transverse cirral primordia probably originate independently in the proter and the opisthe (Fig. 201b–d). Altogether about 25 frontal-ventral-transverse cirri are formed from streaks I–VI (Fig. 201a, e–h). The distinctly interrupted frontoventral row (Fig. 199c, 201a) consists of the migratory cirri of streak VI, of the anterior-most cirrus of streak IV, and all cirri of streak V, except

199r

s

t

u

Fig. 199v–z *Gastrostyla steinii* (v, after ENGELMANN 1862; w, after SOKOLOFF 1945; x, after WEYER 1930; y, after SOKOLOV 1917; z, from FOISSNER 1987a. v–y, from life; z, differential interference contrast). v–z) Resting cysts, v, w, y = size not indicated, x = 46 μ m, z = 51 μ m; p 791.

the pretransverse ventral and transverse cirrus (Fig. 201f–h; BORROR & WICKLOW 1982). Dorsal morphogenesis is in *Oxytricha* pattern, that is, simple fragmentation of kinety 3 and two dorsomarginal kineties occur (Fig. 201e, f, i, j; CALVO et al. 1981, HEMBERGER 1982). WALKER & GRIM (1973) probably overlooked the dorsomarginal rows (= kineties 5 and 6). Further details on *Gastrostyla* morphogenesis, see *G. minima*. The changes of the nuclear apparatus during morphogenesis were described by NUSSBAUM (1886), TCHANG (1931), WALKER (1976b), WALKER & GOODE (1973, 1976), WALKER et al. (1978), and WEYER (1930; see also RAIKOV 1982). The papers by MAUPAS (1888), NIETO et al. (1981), and TORRES et al. (1980a) deal with regeneration and cell cycle.

Occurrence and ecology: Common, but usually with low abundance in detritus and aufwuchs of stagnant and running waters and in terrestrial habitats. Cosmopolitan. Locus classicus is Leipzig, Germany, where ENGELMANN (1862) discovered *Gastrostyla steinii* in the so-called Diebesgraben together with *Cyclidium glaucoma*. Locus classicus of the synonym *Gastrostyla vorax* is Bonn, Germany, where NUSSBAUM (1886) discovered it in a hay infusion. Locus classicus of the synonym *Gastrostyla philippinesis* is an agricultural soil of the Los Banos agricultural College in the Philippines (SHIBUYA 1931). Locus classicus of the synonym *Histrio lemani* is a freshwater habitat near Thonon, France (DRAGESCO 1966b). Locus classicus of the last synonym, *Gastrostyla parasteinii*, is Sedona, Arizona, USA, where GRIM (1970) discovered it in a horse pond (see also SMALL & LYNN 1985, WALKER & GRIM 1973).

← Fig. 199r–u *Gastrostyla steinii* (r, s, from GRIM 1970; t, from WALKER & GRIM 1973; u, from DRAGESCO 1966b. r–u, protargol impregnation). r–u) Ventral infraciliature, r–t = size not indicated, u = 135 μ m. Arrows in (t) are for morphometric characterisation in Figure 200a–d; p 791.

Fig. 200a–d Morphometric characterisation of *Gastrostyla steinii* (from WALKER & GRIM 1973). **a)** Total number of frontal-ventral-transverse cirri (that is, all cirri except marginals and caudals). **b)** Number of “frontal cirri”, that is, all frontoventral cirri which are, in Figure 199t, in front of the anterior arrow. **c)** Number of “medial cirri”, that is, all ventral cirri between the 2 arrows in Figure 199t. **d)** Number of “anal cirri”, that is, all ventral and transverse cirri behind the posterior arrow in Figure 199t; p 791.

Further records substantiated by illustrations: various soils in Tullnerfeld and Styria, Austria (FOISSNER 1982, FOISSNER et al. 1985, 1990); freshwater in England (SCHUSTER 1899); dunghill mixed with soil in the garden of the Kaiser Wilhelm Institute of Biology in Berlin-Dahlem, Germany (WEYER 1930); various soils near Szeged, Hungary (HORVÁTH 1933, 1950); Asinara River near Noto, Sicily, and in soil and hay infusions from Italy (ROSATI et al. 1983, STELLA 1948); freshwater from Puebla del Rio, Seville, Spain (GUTIERREZ 1985); stagnant waters and hay infusions near Geneva and littoral of Lake Geneva, Switzerland (ANDRÉ 1916, ROUX 1900, 1901); Mexico (BRAVO 1924); freshwater in Iowa and Kansas, USA (EDMONDSON 1906, SMITH 1914).

Records from freshwater habitats not substantiated by illustrations: Brennersee, a small lake in Tyrol, Austria (DALLA TORRE 1891); moderately polluted river in Lower Austria (HAEMPEL & WITTMANN 1910); Belgium (BERVOETS 1940); in the aufwuchs of the Moldau River, Czechoslovakia, with highest abundance in January (KALMUS 1928); near Perth, England (CRAIGIE 1921); mineral and thermo-mineral waters in France (CHAOUITE et al. 1990); peat-bog in Germany (SCHMIDT 1916); infrequent in a moderately polluted brook near Bonn, Germany (JUTRCZENKI 1982); Elbe River in Hamburg, Germany (BARTSCH & HARTWIG 1984, ROY 1938); among *Cladophora glomerata* in the Rhine River in Coblenz, Germany (MARSSON 1910); Italy (LONGHI 1892, 1894, 1895); water tanks in the Netherlands (VERSCHAFFELT 1930); mesosaprobic river in Spain (FERNANDEZ-LEBORANS & NOVILLO-VILLAJOS 1993, FERNANDEZ-LEBORANS et al. 1990); up to 100 ind. l⁻¹ in the botanical garden and in a gutter in Basle, Switzerland (RIGGENBACH 1922); with low abundance in running waters and in lake plankton in Switzerland (STEINMANN & SURBECK 1918, 1934); polluted freshwater habitats in Japan (MURAMATSU 1957); Iowa, USA (SHAWHAN et al. 1947); hay infusion in Massachusetts, USA (WOODRUFF 1905a); Mexico (LÓPEZ-POCHOTERENA & ROURE-CANE 1970); Brazil (CUNHA 1913); New Zealand (MASKELL 1886).

Absent in marine brackish water (BICK 1967a); however, according to HERFS (1922) *Gastrostyla steinii* tolerates 2 % NaCl (see also WEATHERBY 1964). Not recorded from sewage treatment plants (CURDS 1975).

Records from terrestrial habitats not substantiated by illustrations: garden soil in Upper Austria (PETZ et al. 1988); various agricultural soils in Czechoslovakia (TIRJAKOVÁ 1988); England (DIXON 1937, GOODEY 1911); Italy (COPPA 1921); Sweden (KOFFMAN 1934); USSR (DIXON 1937); Japan (TAKAHASHI & SUHAMA 1991).

Feeds on bacteria, algae (diatoms, *Chlorogonium elongatum*, *Gonium pectorale*), fungi, flagellates (*Chilomonas paramecium*), and ciliates, like *Colpidium*, *Glaucoma*, *Vorticella*, *Colpoda cucullus* (BICK 1968a, DRAGESCO & DRAGESCO-KERNÉIS 1986, FOISSNER 1982, GOODEY 1911, HORVÁTH 1933, 1950, NUSSBAUM 1886, SCHMERENBECK 1975, WEYER 1930). In cultures *Gastrostyla steinii* also attacks active and encysted specimens of its own species (NUSSBAUM 1886, WENZEL 1974, WEYER 1930). WENZEL & KORFF (1981) obtained thriving cultures with species of the *Tetrahymena pyriformis* complex as food and a suspension of yeast cells or hay-extract. Good cultures were also obtained with *Chlorogonium elongatum* and *Escherichia coli*, *Enterobacter aerogenes*, or *Acine-*

Fig. 201k-p *Gastrostyla steinii* (k, from EDMONDSON 1906; l, from STELLA 1948; m, from SCHUSTER 1899; n, from BRAVO 1924; o, after KOFFMAN 1926; p, after SMITH 1914. k-p, from life). k-p) Ventral views, k = 250 μ m, l = 70 μ m, m = 150–300 μ m, n = size not indicated, o = 230 μ m, p = 150–330 μ m; p 791.

tobacter calcoaceticus as food. 0.01 % Knop's-solution (HORVÁTH 1939, WEYER 1930), Pringsheim-medium (for example, NIETO et al. 1981), or cerophyl and wheat grain extract (DRAGESCO & DRAGESCO-KERNÉIS 1986, GRIM 1970) were successfully used as culture media. Polysaccharides were stored as paraglycogen granules with 0.5 μ m diameter (VERNI & ROSATI 1980). Generation time about 19 h at 16 °C and with *Chlorogonium elongatum*

← Fig. 201a-j *Gastrostyla steinii* (from HEMBERGER 1982. a-j, protargol impregnation). a-h) Ventral infraciliature of morphogenetic stages, bar = 20 μ m; details, see text. (f-h) and (a) show migration of some cirri. Small arrows in (a, h) mark cirrus III/2 and IV/3 respectively. Large arrow denotes anterior-most cirrus of streak V (probably homologous to cirrus V/4 of the 18-cirri oxytrichids) and arrowhead marks postoral ventral cirrus IV/2. New structures black, parental white. i, j) Dorsal morphogenesis showing simple fragmentation of kinety 3 (arrowheads) and 2 dorsomarginal kineties (arrows); parental kineties omitted. Fragmentation strongly indicates that *Gastrostyla* is an oxytrichid. OP = oral primordium; p 791.

Table 48 Morphometric data of *Gastrostyla dorsicirrata* (do1, from FOISSNER 1982; do2, original data), *G. minima* (mi1, from HEMBERGER 1985; mi2, from FOISSNER 1997a), and *G. steinii* (st1, from DRAGESCO 1966b; st2, from FOISSNER 1982). All data are based on protargol-impregnated material. All measurements in micrometres. ? = sample size not indicated; if only 1 value is known it is listed in the mean column, if 2 values are available they are listed as Min and Max. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	do1	106.7	9.8	9.1	90	122	8
	do2	110.9	10.8	6.7	93	134	30
	mi1	-	-	-	120	145	?
	mi2	75.5	9.3	12.4	62	97	15
	st1	-	-	-	130	160	?
	st2	78.3	10.3	13.1	67	95	10
Body, width	do1	37.5	3.8	10.1	29	42	8
	do2	37.6	4.0	10.5	31	45	30
	mi1	-	-	-	40	70	?
	mi2	29.4	4.1	13.8	22	37	15
	st2	43.0	5.6	13.1	33	51	10
	do1	18.9	2.1	11.1	16	22	8
Macronuclear nodule, length	do2 ²	26.1	2.7	10.3	22	31	27
	mi2	13.4	2.6	19.3	9	19	15
	st2	11.5	1.9	16.3	8	15	10
	do1	9.4	1.3	14.3	8	12	8
Macronuclear nodule, width	do2 ²	10.7	1.1	10.7	9	13	27
	mi2	3.2	0.2	7.3	3	4	15
	st1	7.4	0.9	12.1	7	9	10
	do1	39.5	3.1	7.8	37	47	8
Adoral zone of membranelles, length	do2	42.6	3.2	7.6	38	52	30
	mi2	26.5	2.2	8.2	23	31	15
	st2	33.2	5.3	15.9	27	42	10
	do1	35.1	1.5	4.4	33	37	8
Adoral membranelles, number	do2	36.0	2.2	6.1	30	40	30
	mi1	-	-	-	32	35	?
	mi2	32.2	2.0	6.6	29	37	15
	st1	-	-	-	34	38	?
	st2	34.4	3.3	9.5	31	40	10
	do1	28.5	1.6	5.5	26	31	8
Right marginal row, number of cirri	do2	27.5	2.8	10.3	21	32	30
	mi1	-	-	-	28	33	?
	mi2	32.2	3.9	12.0	25	39	15
	st1	about 30					?
	st2	27.7	2.3	8.4	23	31	10
	do1	28.9	1.9	6.6	26	32	8
Left marginal row, number of cirri	do2	29.1	1.8	6.1	25	32	30
	mi1	-	-	-	28	31	?
	mi2	31.7	2.1	6.6	28	34	15
	st2	27.7	1.5	5.4	25	30	10
	do1	5.0	0	0	5	5	8
Transverse cirri, number	do2	5.1	0.4	7.9	5	7	30

Table 48 Continued

Character	Species	mean	SD	CV	Min	Max	n
Transverse cirri, number	mi1	5.0	-	-	-	-	?
	mi2 ³	5.1	-	-	5	6	15
	st1	5.0	-	-	-	-	?
	st2	4.0	0	0	4	4	10
Dorsal kineties, number	do1 ¹	4.0	0	0	4	4	8
	do2 ¹	4.0	0	0	4	4	22
	mi1	5.0	-	-	-	-	?
	mi2	6.0	-	-	6	6	15
	st1	6.0	-	-	-	-	?
	st2	6.0	0	0	6	6	10

¹ Kiny 3 shows incomplete simple fragmentation; new kiny 4 is thus not counted separately; see Figures 202c, i and description.

² Posterior nodule.

³ Higher value found in 1 out of 15 specimens investigated.

as food, 14 h at 21 °C, 11 h at 26 °C (WEYER 1930); according to TORRES et al. (1980a) about 10 h at 20 °C and with *Chlorogonium* sp. as food. Cultivation failed at 6–8 °C and at 32 °C (WEYER 1930). K₂HPO₄ accelerated the division-rate during the early part and retarded it toward the end of the life-cycle (WOODRUFF 1907). Biomass of 10⁶ individuals about 120 mg (FOISSNER 1987a).

BICK (1967a, b, 1968a, b, 1972a, 1973), BICK & DREWS (1973), BICK & KUNZE (1971), BICK & SCHMERENBECK (1971), BICK & BERTRAM (1973), and WILBERT (1977) provided following autecological data: 5–35 °C, pH 5.0–9.5, 0–9 mg l⁻¹ O₂, 0–72 mg l⁻¹ CO₂ free, 0.1–43 mg l⁻¹ NH₄⁺-N, 60 000 to 8 × 10⁶ bacteria ml⁻¹ (plate method). MÜNCH (1970) counted about 1400 ind. ml⁻¹ in experiments on the decomposition of 0.25 g ml⁻¹ peptone at very low oxygen content and at 20 mg l⁻¹ NH₄⁺-N. Autecological data for edaphic populations, see FOISSNER et al. (1985).

In agreement with SLÁDEČEK et al. (1981) and WEGE (1983), FOISSNER (1988a) and FOISSNER et al. (1991) classified *Gastrostyla steinii* as alphamesosaprobic indicator of water quality (b = 2, a = 7, p = 1, I = 3, SI = 2.9).

Gastrostyla dorsicirrata FOISSNER, 1982 (Fig. 202a–p, Tables 3, 48)

1982 *Gastrostyla dorsicirrata* FOISSNER, Arch. Protistenk., 126: 69 (1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature: FOISSNER (1981, p 18) mentioned this taxon in a faunal list as “*Amphisiella dorsicirrata* FOISSNER”; this is a nomen nudum because no description was provided (FOISSNER & FOISSNER 1988). The following chapter includes data from the original

Fig. 202a–c *Gastrostyla dorsicirrata* (from FOISSNER 1982. a, from life; b, c, protargol impregnation). a) Ventral view, 150 μm . b, c) Ventral and dorsal infraciliature, b = 110 μm , c = 120 μm . Note the postoral ventral cirrus (arrow). For correct arrangement of dorsal kineties 3 and 4, see Figure 202i (see text for explanation); p 803.

description, unpublished data from the FOISSNER (1986a) population, and own observations (Fig. 202h–p).

Morphology and biology: In life about $130\text{--}180 \times 45\text{--}80 \mu\text{m}$ (FOISSNER 1982). Population from Himalayan Mountains $110\text{--}140 \times 45\text{--}70 \mu\text{m}$ (FOISSNER 1986a, W. FOISSNER, pers. comm.), according to own observations $150\text{--}180 \times 70\text{--}80 \mu\text{m}$. Long elliptical, sometimes with $\pm$ parallel margins. Not contractile, but rather flexible. Macronuclear nodules in life $19\text{--}30 \times 9\text{--}13 \mu\text{m}$, finely granulated or with large, clod-like nucleoli. 2–4, usually 3, in life about $3 \mu\text{m}$ sized spherical, strongly refractile micronuclei. Contractile vacuole with collecting canals. Cytopyge right laterally near posterior end of cell. Cortical granules lacking. Cytoplasm often packed with yellowish, cylindrical crystals, especially in posterior portion of cell so that specimens appear dark at low magnification.

Fig. 202d–g *Gastrostyla dorsicirrata* (from FOISSNER 1982. d, e, from life; f, g, protargol impregnation). d, e) Dorsal and lateral view, d, e = 160 μm . f) Ventral infraciliature of posterior cell portion, bar = 20 μm . g) Dorsal infraciliature of posterior cell portion showing increased number of caudal cirri. FB = faecal ball; p 803.

Bases of largest adoral membranelles in life about 11–14 μm wide. Buccal area deep. Buccal cirrus near anterior end of distinctly curved and intersecting undulating membranes. Frontal cirri 25–30 μm , frontoventral, postoral ventral, and marginal cirri 15–20 μm long in life. Left marginal row J-shaped,

right one terminates at level of posterior-most transverse cirrus. Transverse cirri in life about 20–25 μm long, protrude distinctly beyond posterior end of cell. Frontoventral row with $2 \pm$ distinct interruptions, terminates slightly behind mid-body. Behind cytostome a single cirrus left of frontoventral row (Fig. 202b, arrow), which is certainly homologous to cirrus IV/2 of the 18-cirri oxytrichids having only 3 postoral ventral cirri. Invariably 2 pretransverse ventral cirri ($n = 30$).

The arrangement of the dorsal kineties was not completely clear in the original description (Fig. 202c). Slides from another population and the reinvestigation of the type-material showed that kinty 3 is distinctly curved in the posterior third (Fig. 202i; arrowhead). Kinty 1 distinctly shortened anteriorly, kinty 4 (= dorsomarginal row) terminates in about mid-body. Dorsal cilia in life about 3 μm long. 3–6 (mean = 3.7; $n = 23$) caudal cirri on kinty 1, 2–4 (mean = 2.8; $n = 21$) on kinty 2, and 1–3 (mean = 2.1; $n = 20$) on kinty 3. Caudal cirri in life about 30 μm long, energetically motile.

Cysts (culture material) spherical, about 45 μm in diameter. Wall 1 μm thick, rather smooth, surrounded by an about 10 μm thick, inconspicuous mucous layer.

M o r p h o g e n e s i s of cell division commences with the proliferation of basal bodies in the posterior third of the cell, probably near the left transverse cirrus (Fig. 202j, Table 3). The streaks I–VI produce the following number of cirri: 1, 3, 3, 4–7 (mean = 5.6), 6–10 (mean = 7.4), and 6–9 (mean = 6.7; Fig. 202k). The frontoventral row is formed by

Fig. 202h–k *Gastrostyla dorsicirrata* (originals. h–k, protargol impregnation). **h, i)** Ventral and dorsal infra-ciliation of a non-dividing specimen, 115 μ m. The arrowhead in (i) marks the incomplete simple fragmentation in dorsal kinety 3 (see text for further explanation). **j)** Early morphogenetic stage in ventral view, 130 μ m. **k)** Late morphogenetic stage in ventral view, 135 μ m. The arrowhead marks the primordium of the dorsomarginal row (= dorsal kinety 4) of the opisthe. New structures black, parental white. 1–4 = dorsal kineties 1–4 (i; because of incomplete fragmentation [arrowhead] of kinety 3 the posterior part [usually “kinety 4”] was not counted separately. Thus, altogether only 4 dorsal kineties present), 1–6 = frontal-ventral-transverse cirri streaks I–VI of the opisthe (k); p 803.

the cirral rows of the streaks VI, IV, and V (from anterior to posterior) only in the postdividers (Fig. 202m, o). Dorsal morphogenesis is practically in *Oxytricha* pattern, that is, new kineties 1–3 originate within the parental kineties 1–3, kinety 3 shows simple (incomplete; see below) fragmentation, and 1 dorsomarginal kinety occurs (Fig. 202l, k). Incomplete, simple fragmentation means that the posterior portion with the caudal cirrus does not distinctly separate from the anterior portion (Fig. 202i, n, arrowheads) as is the case in the typical *Oxytricha* pattern.

Occurrence and ecology: Probably confined to terrestrial habitats (soil, mosses). Europe and Asia. Locus classicus is an alpine, grazed and mowed meadow on alluvial soil near the Glockner Road, Austria (site SO 1 in FOISSNER 1981). FOISSNER & PEER (1985) provided some autecological data of an alpine population from the Gastein

Fig. 202l–p *Gastrostyla dorsicirrata* (originals. l–p, protargol impregnation). **l)** Late morphogenetic stage in dorsal view, 130 μm . **m)** Very late stage in ventral view, 135 μm . **n)** Very late stage in dorsal view, 150 μm . Arrowheads mark bend in posterior portion of new kineties 3 (= incomplete simple fragmentation). Some fragments of parental kineties are still preserved. **o, p)** Proter in ventral and dorsal view, 85 μm . The arrowhead marks the posterior part of dorsal kinety 3 (in normal *Oxytricha* pattern this is kinety 4). New structures black, parental white; p 803.

area, Austria. I found *Gastrostyla dorsicirrata* in mosses from rocks in a wood near the village of Garsten, Upper Austria (Fig. 202h–p) and in a sub-alpine grassland near Aigen, Styria, Austria (FOISSNER et al. 1990). FOISSNER (1986a) found it in soil from the Pisang Peak (2200 m and 4500 m above sea level) in the Himalayan Mountains.

Feeds on cyanobacteria, fungal spores, and ciliates (FOISSNER 1982, own observations). According to FERNANDEZ-LEBORANS et al. (1987) rather insensitive to increased concentrations of mercury. Biomass of 10^6 medium-sized specimens about 96 mg (FOISSNER 1987a).

***Gastrostyla muscorum* KAHL, 1932 (Fig. 205a, Table 17)**

1932 *Gastrostyla muscorum* KAHL, Tierwelt Dtl., 25: 595 (Fig. 205a).

1972 *Gastrostyla muscorum* KAHL, 1932 – BORROR, J. Protozool., 19: 14.

Nomenclature and taxonomy: Incorrect subsequent spelling: *Gastrostyla muscororum* (BOVEE 1979, p 621). Detailed redescription necessary. It cannot be excluded that *Gastrostyla muscorum* is a *G. steinii* with an increased number of macronuclear nodules resulting from caryokinesis without corresponding cortical development (WALKER & GOODE 1976).

Morphology: In life 130–200 µm long. Ovoid, left margin straight, right convex. Three anterior-most cirri of frontoventral row separated by a gap from posterior portion of row. Five transverse cirri, protrude distinctly beyond posterior end of cell.

Occurrence and ecology: Rare species, in soil and freshwater. Europe and North America. The locus classicus is near Hamburg, Germany, where KAHL (1932) found *Gastrostyla muscorum* only once and with high abundance in terrestrial (?) mosses.

Records not substantiated by illustrations: Roussenski Lom River and other rivers in Bulgaria (DETCHIEVA 1972a, 1975a, 1979b, RUSSEV et al. 1976; autecological data, see Table 17); soil of a beech wood in Denmark (STOUT 1968); limnetic habitat in Italy (GRANDORI 1934); litter layer of a pond in Japan (KUSANO 1985); soil of Great Abaco Island, Bahamas, and soil of a cedar glade in Tennessee, USA (CAIRNS & RUTHVEN 1972, MARTIN & SHARP 1983); forest mosses from Lake Itasca Area, Minnesota, USA (BOVEE 1979). Feeds on algae (*Melosira* sp., diatoms <65 µm), flagellates, and ciliates (KAHL 1932, KUSANO 1985). Polysaprobic (RUSSEV et al. 1976).

***Gastrostyla mystacea* (STEIN, 1859) STERKI, 1878 (Fig. 203a–d)**

1859 *Oxytricha mystacea* STEIN, Organismus der Infusionsthier I, p 188 (Fig. 203a–c).

1877 *Oxytricha mystacina*, STEIN – WRZESNIOWSKI, Z. wiss. Zool., 29: 278 (mentions relationship to *Holosticha*; incorrect subsequent spelling).

1878 *Oxytricha mystacea* STEIN – STERKI, Z. wiss. Zool., 31: 57 (mentions relationship to *Gastrostyla*).

1882 *Holosticha mystacea* STEIN sp. – KENT, Manual infusoria II, p 769.

1882 *Oxytricha mystacina* (STEIN) – KOWALEWSKIEGO, Pam. fizyogr., 2: 411 (mentions relationship to *Amphisia*; incorrect subsequent spelling).

1889 *Gastrotricha mystacea* STEIN – BÜTSCHLI, Protozoa, legend to Tafel LXXI, Fig. 7b (misspelling).

1932 *Holosticha mystacea* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 585 (Fig. 203d; redrawn after STEIN 1859b).

1972 *Holosticha mystacea* (STEIN, 1858) KAHL, 1932 – BORROR, J. Protozool., 19: 14.

1983 *Holosticha mystacea* (STEIN, 1859) – BORROR & WICKLOW, Acta Protozool., 22: 115.

1991 *Gastrostyla mystacea* (STEIN, 1859) STERKI, 1878 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte Bayer. Landesamtes für Wasserwirtschaft, 1/91: 270 (in part, see nomenclature and taxonomy).

Fig. 203a–d *Gastrostyla mystacea* (a, b, from STEIN 1859b; c, after STEIN 1859b; d, after STEIN 1859b from KAHL 1932. a–d, from life). a, b) Ventral views, sizes not indicated. Arrow in (b) marks the conspicuous post-toral ventral cirrus. c) Cyst. d) Ventral view, 150 μ m. The redrawing by KAHL (1932) is rather superficially feigning a midventral row; p 808.

Nomenclature and taxonomy: Incorrect subsequent spellings: *Holosticha mystacina* (JÍROVEC et al. 1953, p 512); *Oxytricha mistacea* ST. (GAYEWSKAYA 1924, p 243); *Oxytricha nuptacina* STEIN (KOWALEWSKI 1883, p 243). STERKI (1878) first recognised that this species could belong to *Gastrostyla*. The authorship of the combination should thus be credited to him although he did not use the binomen *Gastrostyla mystacea*.

The frontoventral row and the single, slightly enlarged cirrus just behind the cytostome (Fig. 203b, arrow), which is very likely homologous to cirrus IV/2 of the 18-cirri oxytrichids, are the most important characters indicating a classification in *Gastrostyla*. This conspicuous cirrus left of the frontoventral row is lacking in *Holosticha*, where *Gastrostyla mystacea* was classified by KAHL (1932), BORROR (1972a), and HEMBERGER (1982, p 91). This misclassification was supported especially by KAHL (1932) in that he interpreted the frontoventral row as a holostichid midventral row (Fig. 203d).

Gastrostyla minima agrees rather well with the original description by *G. mystacea*, especially in that the transverse cirri are displaced antieriad (cp. Fig. 203a, f). I thus synonymised them in FOISSNER et al. (1991). However, FOISSNER (1997a) found a population which matches *G. minima* better than *G. mystacea*, indicating that the synonymisation was premature. Detailed redescription of *G. mystacea* necessary. The CHORIK (1968; Fig. 233e) and VUXANOVICI (1963; Fig. 205d) populations are insufficiently redescribed.

Morphology and biology: In life about $120\text{--}170 \times 40\text{--}70 \mu\text{m}$. Ovoid, right margin convex, left slightly concave, sometimes straight. Anterior third of cell often narrowed (Fig. 203a). No cortical granules mentioned. Cytoplasm according to STEIN (1859b) with a bluish shimmer. Frontoventral row according to Figures 203a, b with

about 20 cirri. Five transverse cirri, slightly displaced anteriad so that they terminate at about posterior cell margin. Caudal cirri inconspicuous. STEIN (1859b) described cysts, sometimes infected by Chytridiomycetes, probably belonging to this species (Fig. 203c).

Occurrence and ecology: Rare, in freshwater. Europe, Asia, Australia. Locus classicus is Tharandt near Dresden, Germany, where STEIN (1859b) discovered *Gastrostyla mystacea* with high abundance in a pool with liquid manure in community with a mass occurrence of *Euglena viridis* and *Chlamydomonas pulvisculus*. STEIN (1859b) also found it abundantly in similar habitats in Niemegek, a village near Berlin, Germany, and in a pond (also polluted with liquid manure) in Prague, Czechoslovakia; *Didinium nasutum* occurred at both sites.

Records not substantiated by illustrations: Latvian rivers (LIEPA 1978); freshwater and marine (?) habitats in the Netherlands (VERSCHAFFELT 1930); more than 100 ind. l⁻¹ at 0.8–17.8 mg l⁻¹ O₂ in the surface layer of a basin and up to 10 000 ind. l⁻¹ at 2 °C, 3.2 mg l⁻¹ O₂, 16.2 mg l⁻¹ CO₂ free, and 14 °dH carbon-hardness in the deep area of this basin in Basle, Switzerland (RIGGENBACH 1922); polluted reservoirs in Azerbaijan (ALEKPEROV 1981, 1982a, 1989); pond water and infusions of dried (submerged or edaphic?) moss in Sri Lanka (BHATIA 1936; DADAY 1898, determined by G. ENTZ); Lake Erie, USA (JENNINGS 1899a); according to a table in DADAY (1898, p 9) also recorded from Australia. GREEFF (1889) found *Gastrostyla mystacea* in an edaphic habitat – but where? The marine record from the harbour of Genoa, Italy (GRUBER 1884), is uncertain.

Feeds on euglenoid flagellates and peritrichous ciliates (STEIN 1859b). Biomass of 10⁶ specimens about 120 mg (FOISSNER et al. 1991). *Gastrostyla mystacea* is a polysaprobic indicator of water quality (p–a; a = 3, p = 7, I = 4, SI = 3.7; FOISSNER 1988a, FOISSNER et al. 1991, SLÁDEČEK et al. 1981). KOLKWITZ & MARSSON (1909) and KOLKWITZ (1950) classified it as alphamesosaprobic. Probably all classifications are based mainly on the data by STEIN (1859b) and RIGGENBACH (1922), who found it in heavily polluted habitats (for example, dung pools). However, these sparse data must be checked on reliably determined populations.

Gastrostyla minima HEMBERGER, 1985 (Fig. 203e–q, Table 48)

- 1985 *Gastrostyla minima* HEMBERGER, Arch. Protistenk., 130: 406 (Fig. 203f; see taxonomy; slides of the type material are deposited in the Institut für landwirtschaftliche Zoologie und Bienenkunde, University Bonn, Germany).
- 1997 *Gastrostyla minima* HEMBERGER, 1985 – FOISSNER, Limnologica, 27: 225 (Fig. 203e, g–q; 8 voucher slides with morphostatic and dividing, protargol-impregnated cells are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

Nomenclature and taxonomy: Previously, I classified *Gastrostyla minima* as junior synonym of *G. mystacea* because of similar size and slightly anteriad displaced transverse cirri (FOISSNER et al. 1991, p 270). However, FOISSNER (1997a) found speci-

Fig. 203e–h *Gastrostyla minima* (e, g, h, from FOISSNER 1997a; f, from HEMBERGER 1985. e, from life; f, h, protargol impregnation; g, wet silver nitrate impregnation). e) Ventral view, 108 μm . f, h) Ventral infraciliature and nuclear apparatus, f = 125 μm , h = 88 μm . Arrow in (f) marks postoral ventral cirrus IV/2. g) Narrowly meshed silverline system and cortical granules rows (arrowheads); arrow marks cirral row; p 810.

mens in Bavarian running waters with a ciliary pattern that matches *G. minima* better than *G. mystacea*, indicating that my synonymisation was premature. The FOISSNER populations have cortical granules, which are, however, not recognisable in life or after protargol impregnation but stain deeply with methyl green-pyronin and silver nitrate. HEMBERGER studied only specimens impregnated with protargol and thus could not see this special granules. FOISSNER (1997a) found further similar populations in soils of the USA and the Galapagos Islands. These specimens lack cortical granules and thus would match HEMBERGER's description of *Gastrostyla minima*. However, they have only 3–4 cirri in the post-peristomial portion of the frontoventral cirral row, which is dissimilar to *G. minima*.

Fig. 203i-k *Gastrostyla minima* (i-k, from FOISSNER 1997a. i-k, protargol impregnation). i) Dorsal ciliature and nuclear apparatus, 108 μ m. j) Ventral view of a very early morphogenetic stage with long, narrow oral primordium extending from left transverse cirrus to the enlarged postoral ventral cirrus. k) Early morphogenetic stage. Arrow marks disintegrating enlarged postoral ventral cirrus; p 810.

These data indicate, that further, very similar species exist; thus, both descriptions of *G. minima* are given separately.

M o r p h o l o g y a n d b i o l o g y: Type material after protargol impregnation 120–145 $\times$ 45–60 μ m (HEMBERGER 1982, p 188; 1985). Outline oval. Two macronuclear nodules, two micronuclei. No cortical granules mentioned (see taxonomy). Contractile vacuole not observed, probably about in mid-body. Adoral zone of membranelles about 33 % of body length. 22–26 frontal, buccal, frontoventral, postoral, and pretransverse ventral cirri. Transverse cirri (in life?) about 17 μ m long, slightly displaced anteriorly. Marginal cirri (in life?) 15–17 μ m long. Bases of 3 posterior-most left marginal cirri reduced. “3 plus 2 $\times$ 1/2 dorsal kineties”, indicating that an *Oxytricha* pattern (with only 1 dorsomarginal kinety) is present; possibly, HEMBERGER overlooked the very short kinety 6 (see Fig. 203i). Dorsal cilia 5–6 μ m long, last (posterior-most?) cilia slightly longer. In-

Fig. 203l–n *Gastrostyla minima* (l–n, from FOISSNER 1997a. l–n, protargol impregnation). l, m) Ventral cilia-ture of an early and a middle morphogenetic stage. n) Dorsal view of a middle morphogenetic stage. Parental structures white, new structures black; p 810.

variably 3 inconspicuous, (in life?) 15–17 μm long caudal cirri, distinctly displaced to right (in ventral view).

FOISSNER (1997a) population from Bavaria in life 70–120 $\times$ 25–40 μm . Prolate ellip-soidal, ratio of length to width about 3:1, left side more distinctly convex than right, both ends evenly rounded, rather flexible. Invariably ($n = 15$) 2 macronuclear nodules, ellip-soidal (1.5:1), rather close (mean = 6.7 μm , SD = 2.0 μm , CV = 30.4 %, Min = 3 μm , Max = 10 μm , $n = 15$; protargol impregnation) together in middle third of body to left of midline; nucleoli scattered, globular. 2–3 (mean = 2.1, $n = 15$) micronuclei, conspicuous because rather large (after protargol impregnation 3–5 $\times$ 3–4 μm , mean = 3.6 $\times$ 3.2 μm , $n = 15$) and compact, one each attached to macronuclear nodules in variable position. Con-tractile vacuole slightly in front of mid-body. Cortex colourless, contains, as usual, nar-rowly meshed silverline system (Fig. 203g). Cortical granules in narrowly spaced short and long rows on ventral and dorsal side, do not stain with protargol but contrast as whit-ish, punctate lines with dark brown pellicle in over-impregnated specimens; granules col-

ourless, about 1 μm across, not recognisable in live specimens, even with interference contrast optics, but stain dark blue with methyl green-pyronin and brown with silver nitrate (Fig. 203g). Cytoplasm colourless, contains some 1–4 μm long yellowish crystals and food vacuoles 5–10 μm across. Movement moderately rapid, scrabbling amongst debris.

Adoral zone of membranelles about 36 % of body length. Buccal cavity rather narrow and flat, posterior right half covered by hyaline lip. Pharyngeal fibres distinct. Invariably 3 frontal cirri, in life about 17 μm long. Invariably ($n = 15$) 1 buccal cirrus near at anterior end of paroral. Usually 1 cirrus slightly behind right frontal cirrus and left of anterior end of frontoventral row (certainly homologous to cirrus III/2 of 18-cirri oxytrichids; see Fig. 6a). Constantly 1 slightly enlarged cirrus close behind buccal vertex (certainly homologous to cirrus IV/2 of 18-cirri oxytrichids; see Fig. 6a). 9–15 (mean = 12.4, SD = 1.9, CV = 15.2 %, $n = 15$), in life about 14 μm long cirri in slightly sigmoid frontoventral row, which terminates usually about near mid-body in midline of cell (distance between anterior end of cell and posterior end of frontoventral row after protargol impregnation 37–55 μm , mean = 42.1 μm , SD = 5.1 μm , CV = 12.0 %, $n = 15$); frequently some cirri strongly reduced in size and/or slightly out of line. Invariably ($n = 15$) 2 pre-transverse ventral cirri. Transverse cirri in life about 20 μm long, close together, rather distant from but projecting above posterior end; distance from posterior end of cell to bases of posterior-most transverse cirrus after protargol impregnation 7–16 μm (mean = 9.4 μm , SD = 2.5 μm , CV = 26 %, $n = 15$). However, the scanning electron micrograph shows that transverse cirri do not protrude (Figure 17h in FOISSNER 1997a). Marginal rows open at posterior end, gap occupied by caudal cirri right of cell midline, right row ends subterminally, left ends terminally in midline, posterior-most marginal cirri distinctly reduced in size, especially in left row. Dorsal cilia in life about 4 μm long, kinety 6 (= outer dorsomarginal row) very short, that is, consists of 2–4 dikinetids only.

M o r p h o g e n e s i s: Ontogenesis is described by FOISSNER (1997a, Fig. 203j–q). It commences with the development of an oral primordium close to the frontoventral row. Basal body proliferation occurs simultaneously in a long, narrow area between the buccal vertex and the anterior-most transverse cirrus (Fig. 203j). Next, six cirral anlagen each develop in the proter and opisthe (Fig. 203k, l). The anlagen of the proter originate from the anterior end of the paroral, the buccal cirrus, the cirrus left of the frontoventral row (= cirrus III/2), and from the posterior cirri of the upper half of the frontoventral row. The anterior cirri of the frontoventral row are homologous to the migratory (= frontoterminal) cirri of the 18-cirri oxytrichids and are thus not involved in primordia formation. The anlagen of the opisthe originate from the oral primordium and the postoral ventral cirri, that is, the prominent, isolated cirrus behind the buccal vertex (= cirrus IV/2 of the 18-cirri oxytrichids) and the posterior half of the frontoventral row, whose cirri are, as in the Oxytrichinae, completely incorporated into the oral primordium and the cirral streaks (Fig. 203k, l). In middle and late dividers cirri segregate within the anlagen. The cirri of the three rightmost streaks arrange one behind the other: the anterior portion is made by an-

Fig. 203o-q *Gastrostyla minima* (from FOISSNER 1997a. Protargol impregnation). o, p) Ventral ciliature of a late and a very late morphogenetic stage. Arrows in (p) mark movements of some cirri of streaks IV (anterior) and V (posterior) forming the middle and posterior portion of the frontoventral row. Curved arrow denotes migration of the conspicuous postoral ventral cirrus, which is homologous with cirrus IV/2 of the 18-cirri oxytrichids (cp. Fig. 6a). Figure 203o does not show a typical specimen because in the proter 7 anlagen are present; furthermore, streak IV of the opisthe has produced 3 cirri only. q) Dorsal ciliature of a late morphogenetic stage. Dorsal morphogenesis is in *Oxytricha* pattern (cp. Fig. 24a). Parental structures white, new black; p 810.

lage VI, the middle portion by anlage IV, and the posterior portion of anlage V (Fig. 203m, o, q). This pattern corresponds completely with the pattern of the 18-cirri oxytrichids, where the “frontoventral row” consists of 5 cirri only, namely (from anterior) VI/4, VI/3, IV/3, V/4, and V/3 (Fig. 6a). The posterior-most cirrus of anlage IV (corresponding transverse cirrus not considered) migrates behind the buccal vertex (Fig. 203p), identical as cirrus IV/2 of the 18-cirri oxytrichids (cp. Fig. 10q). Thus, I am convinced that *Gastrostyla* is very closely related to the 18-cirri oxytrichids. The resemblance of *Gastrostyla* with some amphisiliellids, mainly caused by the frontoventral row and the “postperistomial

cirrus" (EIGNER & FOISSNER 1994, FOISSNER 1997a), is either a convergence or the amphiellids evolved from the oxytrichids. Dorsal morphogenesis is, as in other *Gastrostyla* species, in *Oxytricha* pattern (Fig. 203i, n, q).

Occurrence and ecology: Locus classicus is a freshwater habitat in Peru; however, HEMBERGER (1985) also found *Gastrostyla minima* in a soil sample from this region. FOISSNER (1997a) found it in two brooks in Bavaria, Germany, namely the Rößlau (periodically acidified, pH 3.9–6.6) and the Zinnbach (permanently acidified, pH 3.4 to 4.9). Both brooks are strongly shaded by spruces. Some physicochemical characteristics from these clean running waters are given by FOISSNER (1997a). Feeds on bacteria, diatoms, and *Euglena* sp. (FOISSNER 1997a).

Gastrostyla setifera (ENGELMANN, 1862) KENT, 1882 (Fig. 204a–c)

1862 *Pleurotricha setifera* ENGELMANN, Z. wiss. Zool., 11: 385 (Fig. 204a).

1866 *Nothopleurotricha setifera* DIESING – DIESING, Sber. Akad. Wiss. Wien, 53: 118.

1882 *Gastrostyla setifera*, ENG. sp. – KENT, Manual infusoria II, p 784.

1889 *Gasterostyla setifera* ENGELM. sp. – BÜTSCHLI, Protozoa, p 1248 (incorrect subsequent spelling of *Gastrostyla*).

1900 *Gastrostyla setifera* – WALLENGREN, Bih. K. svenska VetenskAkad. Handl., 26: 11 (Fig. 204b).

1909 *Gastrostyla setifera* – FAURÉ-FREMIET, Arch. Protistenk., 13: 126 (Fig. 204c).

1932 *Gastrostyla (Pleurotricha) setifera* (ENGELMANN, 1861) – KAHL, Tierwelt Dtl., 25: 595.

1972 *Gastrostyla setifera* (ENGELMANN, 1862) n. comb. – BORROR, J. Protozool., 19: 14 (see nomenclature).

1974 *Pleurotricha setifera* ENGELMANN – STILLER, Fauna Hung., 115: 107.

Nomenclature and taxonomy: ENGELMANN (1862) assigned this species to *Pleurotricha*, presumably because of the transverse cirri which are distinctly separated into two groups, as in *Pleurotricha lanceolata* and *P. grandis*. However, KENT (1882) recognised that the arrangement of the other cirri is as in *Gastrostyla* and thus transferred it to this taxon. This was obviously overlooked by BORROR (1972a), who transferred it once more to *Gastrostyla*. The illustrations by WALLENGREN (1900a; Fig. 204b) and FAURÉ-FREMIET (1909; Fig. 204c) are probably redrawings from the original (Fig. 204a). HEMBERGER (1982, p 187) found a population in a freshwater habitat in Peru. However, the transverse cirri are not very distinctly separated into two groups, indicating that further species exist. The GULATI (1925; Fig. 205e) population is insufficiently redescribed. Detailed redescription necessary.

STOUT (1978, p 15, 17) recorded an "*Oxytricha setifera*" from irrigated soil in New Zealand; since he did not mention the author of the species, it is uncertain if he observed the present species, or if he made an incorrect subsequent spelling of *Oxytricha setigera*, which is common in edaphic habitats.

Morphology and biology: In life about 270 µm long. Elliptical. Cell according to ENGELMANN (1862) "formbeständig", a term which is not identical with rigid or

Fig. 204a–c *Gastrostyla setifera* (a, after ENGELMANN 1862; b, from WALLENGREN 1900a; c, from FAURÉ-FREMIET 1909. a–c, from life). a–c) Ventral views, 260 μ m. Cirri which originate from the same streak are connected by a dotted line (b). I–VI = frontal-ventral-transverse cirri streaks I–VI; p 816.

firm because he used it also to describe the consistency of the very flexible *Urosomoida agilis*. Two postoral ventral cirri left of the frontoventral row. Transverse cirri distinctly separate in two groups; only the 2 right transverse cirri protrude distinctly beyond posterior end of cell. Dorsal cilia neither mentioned nor drawn indicating that they are short ($<5 \mu$ m).

According to WALLENGREN (1900a) 1, 3, 4, 5, 6, 6 (in total 25) cirri originate from frontal-ventral-transverse cirral streaks I–VI during morphogenesis (Fig. 204b). Frontoventral row consists of cirri from streaks VI, IV, and V (from anterior to posterior), as in *Gastrostyla dorsicirrata*, *G. minima*, and *G. steinii*.

O c c u r r e n c e: Very rare species. Locus classicus is the town of Leipzig, Germany, where ENGELMANN (1862) discovered *Gastrostyla setifera* in a lentic site covered with *Lemna* sp. in the Elster River. DUPLAKOFF (1933) mentioned it in a study on periphyton. No further records known.

Fig. 205a *Gastrostyla muscorum* (from KAHL 1932). Ventral view from life, 160 μ m; p 808.

Fig. 205b–e Species indeterminata (b) and insufficient redescrptions (c–e). b) *Gastrostyla hebbalica* (from RAJASEKARASETTY & KASTURI BAI 1961). Ventral view, various fixation and staining methods, 56 μ m; p 824. c) *Gastrostyla hebbalica* (from NAIDU 1965). Dorsal view after fixation, 65 μ m; p 824. d) *Holosticha mystacea* (from VUXANOVICI 1963). Ventral view from life, 145 μ m; p 825. e) *Gastrostyla setifera* (from GULATI 1925). Ventral view from life, 90 μ m; p 824.

Marine species

Gastrostyla pulchra (PEREYASLAWZEWA, 1886) KAHL, 1932 (Fig. 206a–n)

- 1886 *Stilonichia pulchra* PEREYASLAWZEWA, Zap. novoross. Obshch. Estest., 10: 90 (Fig. 206a, g; incorrect subsequent spelling of *Stylonychia*).
- 1886 *Stylonychia pulchra* PEREYASLAWZEWA, Zap. novoross. Obshch. Estest., 10: 97.
- 1900 *Gastrostyla sterkii* WALLENGREN, 1900, Acta Univ. Lund., 36: 21 (Fig. 206b–d, f).
- 1932 *Gastrostyla (Stylonychia) pulchra* (PEREYASLAWZEWA, 1885) – KAHL, Tierwelt Dtl., 25: 596 (Fig. 206e).
- 1933 *Gastrostyla pulchra* (PEREYASLAWZEWA 1885) – KAHL, Tierwelt N.- und Ostsee, 23: 112 (Fig. 206h).
- 1963 *Gastrostyla pulchra* (PEREYASLAWZEWA, 1885) – BORROR, Trans. Am. microsc. Soc., 82: 128 (Fig. 206i–k).
- 1970 *Gastrostyla pulchra* PEREYASLAWZEWA, 1885 – BURKOVSKY, Acta Protozool., 8: 60 (Fig. 206l–n).
- 1972 *Gastrostyla pulchra* (PEREYASLAWZEWA, 1886) KAHL, 1932 – BORROR, J. Protozool., 19: 14.
- 1973 *Gastrostyla pulchra* (PEREYASLAWZEWA, 1885) – HARTWIG, Abh. math.-naturw. Kl. Akad. Wiss. Mainz, 18: 66.

Fig. 206a–h *Gastrostyla pulchra* (a, from PEREYASLAWZEWA 1886; b–d, from WALLENGREN 1900b; e, from → KAHL 1932; f, after WALLENGREN 1900b from KAHL 1932; g, after PEREYASLAWZEWA from KAHL 1932; h, from KAHL 1933. a, b, e–h, from life; c, sublimate fixation and borax-carmin staining; d, sublimate fixation and haemalum staining). a, b, e–h) Ventral views, a, g, h = size not indicated, b = 170 μ m, e, f = 250 μ m. Arrow in (b) marks the conspicuous single postoral ventral cirrus IV/2. c, d) Nuclear apparatus.

Nomenclature and taxonomy: PATTERSON et al. (1989, p 210) misdated *Gastrostyla pulchra* with 1883, some other authors with 1885 (see list). However, according to the Zoological Record and the first page of the "Zap. novoross. Obshch. Etest., volume 10" 1886 is the correct year.

Synonymy of *Gastrostyla pulchra* (Fig. 206a) and *G. sterkii* (Fig. 206b) is very likely, and indicated especially by the extremely anteriorly displaced transverse cirri and the length of the frontoventral row. Synonymy was thus already supposed by KAHL (1932), although a different number of macronuclear nodules was originally described. However, both KAHL (1932, 1933) and BURKOVSKY (1970c) found specimens with 2 and 4 nodules, indicating intraspecific variability. Unfortunately, three important contributions (BURKOVSKY 1970c, PEREYASLAWZEWA 1886, WALLENGREN 1900b) are written not in English or German, making a thorough study difficult and time consuming. I therefore used only some morphometric data from these papers; most information presented below is from KAHL (1932) and BORROR (1963b). Detailed redescription necessary because several characters are only superficially (for example, dorsal infraciliature) or contradictorily (for example, nuclear apparatus) described.

Morphology and biology: In life $170 \times 50 \mu\text{m}$ (WALLENGREN 1900b), $170\text{--}250 \mu\text{m}$ long (KAHL 1932), $140\text{--}210 \times 55\text{--}67 \mu\text{m}$ (BORROR 1963b), 240–300 times $50\text{--}60 \mu\text{m}$ and $160\text{--}200 \times 50\text{--}60 \mu\text{m}$ (BURKOVSKY 1970c); PEREYASLAWZEWA (1886) gives no size. Usually oblong, sometimes elliptical, margins slightly to distinctly converging posteriorly. Right anterior margin usually slanted. Two or 4 macronuclear nodules, in life about $32 \times 15 \mu\text{m}$ (BORROR 1963b). Several micronuclei, in life about $10 \mu\text{m}$ across (WALLENGREN 1900b; Fig. 206a, c–h, k, m, n). Contractile vacuoles at about level of buccal vertex (Fig. 206a, e, h). Cortical granules rod-shaped (KAHL 1932), according to BORROR (1963b) "2 μm long, oval, in bands between marginal cirri, clustered along median edge of membranelles; one granule row 3–4 μm broad between marginal and ventral cirri, and to right of right lateral cirri" (Fig. 206k, m). Food vacuoles 15–20 μm across, remainder of cytoplasm darkly granular (BORROR 1963b). Moves hastily to and fro, sometimes torpid (KAHL 1932).

Adoral zone of membranelles conspicuously overlapping on right margin, about 50 (BORROR 1963b) or 42–50 (BURKOVSKY 1970c) membranelles. Paroral kinety about 40 μm long. Frontoventral and especially transverse cirri rather prominent. Frontal cirri in life 20 μm long. Frontoventral row terminates somewhat behind level of buccal vertex, consists of about 8 cirri (KAHL 1932). One single postoral ventral cirrus (Fig. 206b, i, n), very likely overlooked by PEREYASLAWZEWA (1886; Fig. 206a) and not illustrated in KAHL's (1932, 1933; Fig. 206e, h) populations. Two pretransverse ventral cirri. Invariably 5 fimbriate, in life 25–30 μm long transverse cirri, insert at beginning of posterior third to fifth of cell (according to BORROR 1963b 30–65 μm from posterior end), do not protrude beyond posterior end of cell. Marginal rows overlapping posteriorly. At least 4 dorsal kineties (BORROR 1963b; Fig. 206j).

Fig. 206i–n *Gastrostyla pulchra* (i–k, from BORROR 1963b; l–n, from BURKOVSKY 1970c. i, j, l, n, Chatton-Lwoff silver nitrate impregnation; k, m, haemalum staining). i, n) Ventral infraciliature, i = 150 μ m, n = 280 μ m. Arrows mark single postoral ventral cirrus IV/2 (cp. Fig. 206b). In (i) the transverse cirri are not very distinctly displaced anteriorly; possibly a stain artefact. j) Dorsal infraciliature. Very likely dorsomarginal kineties have been overlooked. k, m) Ventral views showing nuclear apparatus and cortical granules. l) Ventral infraciliature of anterior cell portion; p 818.

Occurrence and ecology: Marine; no record from inland salt waters. Locus classicus is the Black Sea (PEREYASLAWZEWA 1886). Locus classicus of the synonym, *Gastrostyla sterkii*, is the Baltic Sea at Malmö, Sweden (WALLENGREN 1900b).

Records largely substantiated by illustrations: mesosaprobic detritus from Heligoland, Sylt, and Kiel, Germany (KAHL 1932, 1933); mesopsammon of the Kandalaksha Gulf, White Sea, and other marine sites in the USSR (BURKOVSKII & AZOVSKII 1985, BURKOVSKY 1968, 1970a–c, 1971a, b, 1976, 1987, 1990, BURKOVSKY & EPSHTEIN 1982; these papers include much ecological data, however, in Russian); Barents Sea (AZOVSKY 1996); detritus at the bottom of two sea water tanks filled with material from Alligator Harbor, Florida, and New Hampshire tidal marshes, USA, Atlantic Ocean (BORROR 1963a, b).

Records not substantiated by illustrations: periphyton of the Königshafen, Sylt (Germany), Northern Sea (KÜSTERS 1974); Gulf of Naples, Italy, Mediterranean (NOBILI 1957); lagoon of Venice, Italy, Adriatic Sea (KIESSELBACH 1936); mesopsammon near island Jordsand, Denmark, Northern Sea (AZOVSKII 1987, HARTWIG 1973, 1974); polluted intertidal areas of Kandalakshsky Bay, White Sea (AZOVSKY et al. 1996); mesopsammon of the Peter the Great Bay, Japan Sea (MYSKOVA 1976); Gulf of Mexico (BORROR 1962).

Feeds on algae, mainly on diatoms (BORROR 1963b, FENCHEL 1968, KAHL 1932); according to BURKOVSKY et al. (1980) food vacuoles contained 30.8 % *Protoceratium* sp., 30.5 % Peridinales, 0.7 % *Navicula salinarium*, and 11.3 % *N. ammophila*.

Gastrostyla stenocephala (BORROR, 1963) BORROR, 1972 (Fig. 207a–f)

- 1963 *Oxytricha (Urosoma) stenocephala* BORROR, 1963, Arch. Protistenk., 106: 512 (Fig. 207a–d; the Chatton-Lwoff silver nitrate-impregnated holotype is deposited in the United States National Museum, Smithsonian Institution, Washington, D. C.; CORLISS 1972).
- 1968 *Oxytricha stenocephala* BORROR, 1963 – BORROR, Trans. Am. microsc. Soc., 87: 236 (Fig. 207a).
- 1972 *Gastrostyla stenocephala* (BORROR, 1963) – BORROR, J. Protozool., 19: 14.
- 1985 *Gastrostyla stenocephala* (BORROR, 1963) – ALADRO LUBEL, An. Inst. Biol. Univ. Méc., 55: 28 (Fig. 207f; incorrect subsequent spelling of *Gastrostyla*).
- 1990 *Gastrostyla stenocephala* (BORROR, 1963) – ALDORO LUBEL, MARTINEZ-MURILLO & MAYÉN ESTRADA, Manual de ciliados, p 137 (Fig. 207e).

Nomenclature and taxonomy: *Oxytricha stephanocephala* BORROR, 1963 in HARTWIG (1980, p 128) is an incorrect subsequent spelling. The ventral infraciliature of this species is in fact reminiscent of *Gastrostyla*; however, a detailed redescription is needed to clarify the systematic position finally. Recently transferred to *Hemigastrostyla* by SONG & WILBERT (1997a; see Addendum 5).

Morphology: In life 160–220 × 37–44 µm (BORROR 1963a), 194 × 42 µm (ALADRO LUBEL 1985, ALADRO LUBEL et al. 1990). Cephalised region about 20 × 20 µm. Margins almost in parallel, anterior end abruptly narrowed (that is, more or less cephalised), posterior narrowly rounded and usually distinctly curved to the right, which is often not visible in specimens under coverslip as body is extremely fragile, often losing posterior end prior to examination. *Gastrostyla stenocephala* may fragment within minutes following removal from its natural habitat, making observation rather difficult. Ventral side flat, dorsal one rounded. Macronuclear nodules in life about 20 × 10 µm, each with an adjacent, in life about 6 × 4 µm sized micronucleus. No contractile vacuole. Ectoplasm 1 µm thick, clear. Rosettes of cortical granules at bases of dorsal cilia and some cirri. Cytoplasm filled with remains of diatoms and small, oval, 1 µm sized bodies. Extremely thigmotactic, adhering with the aid of caudal cirri and posterior dorsal cilia. Bends ventrally but not laterally, when swimming freely.

Adoral zone of membranelles only about 25 % of body length, about 40 membranelles. Anterior membranelles in life 25 µm long, covered basally by clear ectoplas-

Fig. 207a–f *Gastrostyla stenocephala* (a–d, from BORROR 1963a; e, from ALADRO LUBEL et al. 1990; f, from ALADRO LUBEL 1985. a, d, shape from life and ciliature after Chatton-Lwoff silver nitrate impregnation; b, c, f, from life; c, Chatton-Lwoff silver nitrate impregnation). a, e, f) Ventral view, a = 200 μ m, e = 215 μ m, f = 195 μ m. Note the abruptly narrowed (cephalised) anterior end. Arrow in (a) marks postoral ventral cirrus. b) Ventral view showing nuclear apparatus, pharyngeal fibres, and ingested food, 200 μ m. c, d) Ventral and dorsal infraciliature, c = 146 μ m, d = 200 μ m. Tiny arrow in (c) = postoral ventral cirrus, large arrow = cirri right of right transverse cirri, arrowhead = caudal cirri. See text for details; p 822.

mic plate. Paroral (kinety?) about 32 μ m long, conspicuous. Endoral on bottom of buccal cavity. Cytopharynx in life at least 20 μ m long. Arrangement of cirri as in Figure 207a, c. Frontoventral row consists of about 8 cirri, usually 2 distinctly separated cirri behind frontal row. According to original description a single cirrus immediately behind buccal vertex (Fig. 207a, c, tiny arrow) which is very likely homologous to the prominent postoral ventral cirrus of the other *Gastrostyla* species; however, it is lacking in populations described by ALADRO LUBEL (1985; Fig. 207f) and ALADRO LUBEL et al. (1990; Fig. 207e). Five distinctly enlarged, in life about 25 μ m long transverse cirri, overlapping posterior end by almost half their length. Marginal cirri in life about 12 μ m long, a fibre extends 12 μ m anteriorly from median edge of right marginal cirri. 4–6 dorsal kineties; however, such a high variability is very unlikely, indicating misobservation by BORROR (1963a).

Dorsal cilia in life 16 μm long. Two extremely fimbriate caudal cirri to right of posterior end (in ventral view; Fig. 207c, arrowhead). Figure 207c (large arrow) shows, as in *Oxytricha enigmatica*, a pair of cirri right of right transverse cirri (details, see Addendum 5).

Occurrence and ecology: Marine. Locus classicus is Alligator Harbor, Florida, USA, Atlantic Ocean (BORROR 1963a, 1968). *Gastrostyla stenocephala* occurred regularly and was very common in sand, especially in the uppermost layer where pore spaces may have been large enough to permit its entry, and where the diatom population was highest; did not occur in diatom detritus, although feeding exclusively on diatoms (BORROR 1963a, FENCHEL 1968). Highest abundance (13 ind. ml^{-1}) at late January. Records substantiated by illustrations: in sediment (0–2 cm) of the *Thalassia testudinum* zone at Enmedio Island (Gulf of Mexico near Veracruz) and other sites in Mexico (ALADRO LUBEL 1985, ALADRO LUBEL et al. 1990).

Species indeterminata

Gastrostyla hebbalica RAJASEKARASETTY & KASTURI BAI, 1961, J. zool. Soc. India, 13: 238 (Fig. 205b). Remarks: In life 60–80 $\times$ 30–35 μm . Ovoid. Three (?) spherical macronuclear nodules, 2 micronuclei. Contractile vacuole in right posterior portion of cell. Three enlarged frontal cirri. Ventral cirri irregularly arranged. Five transverse cirri. Some observations (for example, position of contractile vacuole) indicate that it is not a valid species. Freshwater in Hebbal, Bangalore, India.

Insufficient redescriptions

Gastrostyla hebbalica RAJASEKHARASETTY & KASTURIBAI, 1961 – NAIDU, 1965, Hydrobiologia, 25: 560 (Fig. 205c). Remarks: Freshwater in Vijayawada, India.

Gastrostyla (Stylonychia) pulchra (PEREJASLAWZEWA, 1886) WAHLGREN, 1890 – JONES, 1974, Univ. South Alabama Monogr., 1: 41 (Fig. 242j). Remarks: Transverse cirri not displaced anteriorly! Mobile Bay, USA.

Gastrostyla setifera ENGELMANN – GULATI, 1925, J. Bombay nat. Hist. Soc., 30: 752 (Fig. 205e). Remarks: The transverse cirri are not separated into two distinct groups. In life 90 $\times$ 30 μm . Small pond near Data Ganj Bakhsh, India.

Gastrostyla sp. – LEPSI, 1927, Studii Cerc. Acad. RPR, 12: 122 (Fig. 226k). Remarks: In life 76 $\times$ 30 μm . Among algae. Romania.

Gastrostyla steini? – SCHNEIDER, 1930, Arch. Protistenk., 72: 523 (Fig. 233h). Remarks: Incorrect subsequent spelling. Rather invariably 6 macronuclear nodules. After addition of iodine ink some specimens excreted a homogeneous mucous layer. Infusions of grass. Germany?

Holosticha mystacea STEIN, 1859 – CHORIK, 1968, Free-living ciliates, p 130 (Fig. 233e). Remarks: Possible a redrawing of KAHL's (1932) redrawing (cp. Fig. 203d). Freshwater in Moldova.

Holosticha mystacea STEIN, 1859 – VUXANOVICI, 1963, Studii Cerc. Biol., 15: 208 (Fig. 205d). Remarks: Certainly not identical with *Gastrostyla mystacea* since it obviously has more than 2 macronuclear nodules. Stagnant water body in Bucharest, Romania.

Kerona MÜLLER, 1786

- 1786 *Kerona* MÜLLER, Animalcula Infusoria, p 233 (see nomenclature) – Type (subsequent designation by EHRENBURG 1838; see nomenclature): *Cyclidium pediculus* MÜLLER, 1773.
 1838 *Kerona* – EHRENBURG, Infusionsthierchen, p 368.
 1852 *Alastor* PERTY, Mitt. naturf. Ges. Bern, year 1852: 64 – Type (by monotypy): *Kerona polyporum* EHRENBURG, 1835.
 1852 *Alastor* PERTY, Zur Kenntniss kleinster Lebensformen, p 155.
 1859 *Kerona*. EHRBG. – STEIN, Organismus der Infusionsthier I, p 171.
 1882 *Kerona*, EHRENBURG – KENT, Manual infusoria II, p 763.
 1932 *Kerona* EHRENBURG, 1838 – KAHL, Tierwelt Dtl., 25: 569.
 1972 *Kerona* EHRENBURG, 1835 – BORROR, J. Protozool., 19: 9.
 1974 *Kerona* EHRENBURG – STILLER, Fauna Hung., 115: 44.
 1982 *Kerona* EHRENBURG, 1825 – HEMBERGER & WILBERT, Arch. Protistenk., 125: 269.

Characterisation: Undulating membranes almost straight and in parallel. Numerous frontal and frontoventral cirri arranged in 6 slightly to distinctly curved rows. Usually 5 transverse cirri. One left and 1 right row of marginal cirri almost confluent posteriorly. Numerous dorsal kineties covering dorsal side almost completely. Caudal cirri present. Six frontal-ventral-transverse cirral streaks segregating numerous frontal and frontoventral cirri. Three dorsal primordia, each showing multiple fragmentation and 2 dorsomarginal kineties. Ectocommensal on hydras and bryozoans.

Nomenclature: *Alaster polyporum* PERTY, 1852 in HEMBERGER & WILBERT (1982, p 262) is an incorrect subsequent spelling. There is great confusion about *Kerona*, which was established by MÜLLER (1786) comprising 14 species of hypotrichous ciliates. However, *Kerona pediculus* was not included. In EHRENBURG's early days one of these 14 species was in *Kerona*, namely *K. pustulata* (see EHRENBURG 1838 for details of the time between MÜLLER and EHRENBURG). EHRENBURG (1835) transferred this last species to *Stylonychia*. Simultaneously, he introduced the name *Kerona polyporum* for the hypotrichous ciliate living on hydras. Thus, *Kerona* sensu EHRENBURG was differently defined than *Kerona* sensu MÜLLER (which was almost not defined). This caused later workers (for example, STEIN 1859b, KENT 1882, KAHL 1932) to treat EHRENBURG as the author and thus the founder of *Kerona*. However, this is incorrect because EHRENBURG never establish a genus *Kerona*. Considering EHRENBURG as the author of *Kerona* is of course unacceptable because it would be the junior homonym of *Kerona* MÜLLER. There are two ways to solve this nomenclatural problem: (i) MÜLLER (1786) is accepted as the author of *Kerona* with *Cyclidium pediculus* MÜLLER, 1773 as type species, ignoring the problem that none of MÜLLER's species is now in *Kerona*. (ii) The synonym, *Alastor* PERTY, 1852 is used which

was expressly established for *Kerona polyporum* EHRENBERG and *Cyclidium pediculus* MÜLLER. This solution was proposed by JANKOWSKI (1979, p 49; see also CURDS et al. 1983, p 426). I prefer the first proposal, mainly to preserve the well established name *Kerona*. Furthermore, *Alastor* PERTY, 1852 is a nomen oblitum (CORLISS 1979, p 208). The taxonomy of *Kerona* is discussed in the relevant chapter of the single species.

Single species

Kerona pediculus (MÜLLER, 1773) BLOCHMANN, 1886 (Fig. 208a–y, 209a, b)

- 1773 *Cyclidium pediculus* MÜLLER, Vermium Terrestrium et Fluviatilium, p 54 (no illustration).
- 1786 *Cyclidium pediculus* – MÜLLER, Animalcula Infusoria, p 84, Tab. XI, Fig. 15–17 (see taxonomy).
- 1835 *Kerona polyporum* EHRENBERG, Abh. preuss. Akad. Wiss., year 1835: 164 (no illustration).
- 1838 *Kerona polyporum* EHRENBERG, 1835 – EHRENBERG, Infusionsthierchen, p 368 (Fig. 208c, d).
- 1850 *Kerona polyporum* EHRENBERG – DIESING, Systema Helminthum I, p 161.
- 1852 *Alastor polyporum* – PERTY, Zur Kenntniss kleinster Lebensformen, p 155.
- 1859 *Kerona polyporum* EHRBG. – STEIN, Organismus der Infusionsthier I, p 173 (Fig. 208a).
- 1860 *Kerona polyporum* – BALBIANI, Journal de la physiologie de l'homme et des animaux, 3: Planche IV, Fig. 16–18.
- 1882 *Kerona polyporum*, EHR. – KENT, Manual infusoria II, p 763.
- 1886 *Kerona pediculus* O. F. MÜLL. – BLOCHMANN, Mikroskopische Thierwelt, p 76.
- 1930 *Kerona polyporum* EHRENB. – CAVALLINI, Archo zool. ital., 14: 1 (Fig. 208j–l).
- 1932 *Kerona polyporum* EHRENBERG – KAHL, Tierwelt Dtl., 25: 569, Fig. 86₁₄ (redrawing from STEIN 1859b).
- 1933 *Kerona pediculus* (O. F. MÜLLER) EHRENBERG – WANG & NIE, Contr. biol. Lab. Sci. Soc. China, 10: 53 (Fig. 208b).
- 1965 *Kerona* – HILL, Rep. Oundle Sch. nat. Hist. Soc., 1965: 95, Fig. 2 (low quality sketch).
- 1973 *Kerona polyporum* – SCHLICK, Mikrokosmos, 62: 201, Bild 4 (low quality illustration).
- 1974 *Kerona polyporum* EHRENBERG – PÄTSCH, Arb. Inst. landw. Zool. Bienenkd., 1: 54 (Fig. 208h).
- 1974 *Kerona polyporum* EHRENBERG – STILLER, Fauna Hung., 115: 44.
- 1975 *Kerona polyporum* – WILBERT, Mikrokosmos, 64: 175, Bilder 7, 8 (micrographs of ventral and dorsal infraciliature after protargol impregnation).
- 1982 *Kerona polyporum* EHRENBERG, 1835 – HEMBERGER & WILBERT, Arch. Protistenk., 125: 261 (Fig. 208e–g, n–v, x, y).
- 1982 *Kerona polyporum* EHRENBERG, 1835 – HEMBERGER, Dissertation, p 62 (Fig. 208e–g, n–y).
- 1983 *Peritromus hydrarum* CHARDEZ, Protistologica, 19: 231 (Fig. 209a, b; new synonym).
- 1985 *Kerona polyporum* EHRENBERG, 1838 – FLEURY, IFTODE, DEROUX & FRYD-VERSAVEL, Protistologica, 21: 508 (Fig. 208i).
- 1985 *Kerona polyporum* – SCHNEIDER, Mikrokosmos, 74: 313, Bilder 1–5 (micrographs of living specimens).
- 1987 *Kerona pediculus* (O. F. MÜLLER, 1773) nov. comb. – FOISSNER, Arch. Protistenk., 133: 225 (see nomenclature).
- 1991 *Kerona pediculus* (MUELLER, 1773) BLOCHMANN, 1886 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 265.

Nomenclature and taxonomy: Incorrect subsequent spellings: *Kerona polymorphum* (FOISSNER 1979b, p 3); *Kerona polypora* (ESTÈVE 1982, p 519).

MÜLLER (1786) provided three small illustrations which rather distinctly show a hypotrichous ciliate living on hydras. EHRENBURG (1838) described *Kerona polyporum* assuming that MÜLLER's (1773, 1786) *Cyclidium pediculus* is the peritrichous ciliate also living on hydras. EHRENBURG's error was recognised already by STEIN (1859b), however, without suppressing the junior synonym, *Kerona polyporum* EHRENBURG. Thus, the name *K. polyporum* was used until recently, when FOISSNER (1987d) reintroduced the older name, *K. pediculus*, obviously overlooking that *Cyclidium pediculus* had already been transferred to *Kerona* by BLOCHMANN (1886; see list of synonyms).

Kerona pediculus is usually classified in the Keronidae DUJARDIN, 1841 (for example, CORLISS 1979, HEMBERGER & WILBERT 1982, SMALL & LYNN 1985, TUFFRAU 1987, TUFFRAU & FLEURY 1994). However, the morphogenesis shows the main apomorphy of the oxytrichids, namely fragmentation of dorsal kineties (Fig. 208w). I thus include it in the oxytrichids, assuming that parallel evolution of this conspicuous character is rather unlikely. Furthermore, the frontal-ventral-transverse cirri originate from six longitudinal streaks (Fig. 208s, t) like in the 18-cirri oxytrichids. The inclusion of *Kerona* in the oxytrichids requires the assumption of parallel or convergent evolution of a corona of frontal cirri because there is no evidence that the second taxon of the Keronidae, *Keronopsis* PÉ-NARD, 1922, is also an oxytrichid. *Keronopsis* (and its sister-group or synonym, *Paraholosticha* KAHL, 1932) divides in cysts and lacks fragmentation of dorsal kineties (DIECKMANN 1989), indicating that it branches outside the oxytrichids.

As in some other taxa (for example, *Gastrostyla*, *Paraurostyla*), I was unable to find the sister-group of this presumably highly specialised species. It thus is classified as taxon of unknown systematic position in the oxytrichids. The multiple fragmentation in all 3 dorsal kinety anlagen (Fig. 208x, y) reminds of *Onychodromus quadricornutus* (FOISSNER et al. 1987b). This species also has several frontal cirri, which, however, originate from several streaks, whereas in *Kerona* they are (largely) the descendants of the leftmost streak, that is, the left frontal cirrus is split (see below). Furthermore, lack of cortical granules, the (rather) inflexible body, the long (50 % of body length) adoral zone of membranelles, and some details of the ventral morphogenesis indicate that *Kerona* possibly belongs to the Stylonychinae, implying that the number of frontal-ventral-transverse cirri increased secondarily. The confluent marginal rows are reminiscent of *Histriculus*, the undulating membranes are almost in *Stylonychia* pattern. EIGNER (1997) classified "*Kerona polyporum*" in the Parakahliellidae.

The synonymy of *Peritromus hydrarum* CHARDEZ, 1983 and *Kerona pediculus* is rather evident, especially concerning the body shape, the number of adoral membranelles, and the habitat, namely freshwater hydras. The semischematic illustration after silver impregnation probably shows the dorsal kinety pattern (Fig. 209a, b).

Kerona pediculus is very easily identified by the kidney-shaped body, the unique infraciliature, and especially the extraordinary habitat. *Kerona polyporum* sensu DUMAS (1929) and FROMENTEL (1876) are insufficiently redescribed.

Fig. 208a-g *Kerona pediculus* (a, from STEIN 1859b; b, from WANG & NIE 1933; c, d, from EHRENBURG 1838; e-g, from HEMBERGER & WILBERT 1982. a-d, from life; e-g, protargol impregnation). a, b, d) Ventral views, a = 130–205 μm , b = 150 μm , d = up to 170 μm . c) Several specimens (arrows) creeping on a hydra. e-g) Dorsal and ventral infraciliature and nuclear apparatus, e, f = 190 μm . Arrow in (e) marks caudal cirri, small arrows in (f) mark interruption in frontoventral rows 3 and 4. Large arrow marks buccal cirri. 1–6 = frontoventral rows 1–6 (very likely homologous to the cirral streaks I–VI of 18-cirri oxytrichids, cp Fig. 6a); p 826.

Fig. 208h, i *Kerona pediculus* (h, from PÄTSCH 1974; i, from FLEURY et al. 1985. h, i, protargol impregnation). Ventral infraciliature, h = 150 μ m, i = 140 μ m. The specimen in (h) has only 4 transverse and 2 caudal cirri. BC = buccal cirri, RMR = right marginal row, TC = transverse cirri, uM = undulating membranes, 1–6 = frontoventral cirral rows 1–6; p 826.

Morphology and biology: In life 120–205 $\times$ 70–110 μ m, usually about 180 $\times$ 95 μ m; 130–150 $\times$ 70–80 μ m (CAVALLINI 1930); 150–180 μ m long (PÄTSCH 1974), 150 $\times$ 80 μ m on average (WANG & NIE 1933), 120 μ m long (CHARDEZ 1983). Kidney or bean-shaped, that is, right margin convex, left deeply indented centrally, anterior end evenly, posterior narrowly rounded to slightly pointed; plano-convex, strongly flattened dorso-ventrally. Margins rather thin and flexible, attach to body of hydras, remaining body of *Kerona*, however, rather firm than flexible, but not as rigid as, for example, in *Stylonychia*. Two macronuclear nodules (16–17 μ m long; CHARDEZ 1983), about in median of cell; each nodule with a micronucleus (about 5 μ m across; CHARDEZ 1983). Contractile vacuole about at level of buccal vertex. Cortical granules lacking. Rapid movement, about 500 μ m s⁻¹ (BULLINGTON 1925).

Adoral zone of membranelles about 50 % of body length, arranged at body margin, except proximal portion which points to mid-body. 30–74, usually around 60 adoral membranelles; 30–35 (PÄTSCH 1974), 35–60 (WARREN & ROBSON 1986), 60–64 (HEMBERGER & WILBERT 1982), 68–74 (CHARDEZ 1983). Undulating membranes slightly curved. Usually 4 (2–6) slender buccal cirri immediately in front of undulating membranes;

Fig. 208j, k *Kerona pediculus* (from CAVALLINI 1930. j, k, from life). **j)** *Hydra* sp. with many specimens of *K. pediculus*. **k)** Ventral view showing arrangement of cirri and nuclear apparatus, about 130 μ m; p 826.

Fig. 2081 *Kerona pediculus* (from CAVALLINI 1930). *Hydra* sp. with many specimens of *K. pediculus*; p 826.

Fig. 208m *Kerona pediculus* (original scanning electron micrograph kindly supplied by C. BARDELE, University of Tuebingen, Germany). Ventral view showing the arrangement of cirri, about 75 μ m. Arrow marks the almost straight paroral. AZM = adoral zone of membranelles, TC = transverse cirri; p 826.

sometimes they are almost not separated, giving the impression of a large buccal cirrus. Six slightly to distinctly curved rows of frontal and frontoventral cirri which very likely correspond (are homologous) with the cirri originating from the 6 primordia of the 18-cirri oxytrichids (for arrangement and numbering, see Fig. 208f). Row 1 with about 18

(17–19) cirri, homologous with frontal cirrus I/1 of the 18-cirri oxytrichids; row 2 about 15–16 cirri, homologous with middle frontal cirrus; row 3 with 17–18 cirri, usually interrupted and thus possibly homologous to right frontal cirrus (III/3) and frontoventral cirrus III/2 of the 18-cirri oxytrichids; row 4 with 20–21 cirri, usually slightly interrupted at level of buccal vertex; row 5 usually with 27 (25–29) cirri, terminates near left transverse cirrus; row 6 usually with 25 cirri (25–27), begins about at level of buccal vertex, terminates at right transverse cirrus. Five prominent transverse cirri, becoming larger from left to right (Fig. 208m); according to PÄTSCH (1974) only 4 transverse cirri. Left marginal row with about 40 (38–45), right one with about 62 (60–67) cirri, almost confluent posteriorly; marginal cirri distinctly longer than frontoventral cirri. Dorsal cilia 2–4 μm (WARREN & ROBSON 1986), according to HEMBERGER & WILBERT (1982) 5–6 μm long, arranged in numerous (about 16–20) indistinct rows, that is, dorsal side completely ciliated (Fig. 208e). Three (HEMBERGER & WILBERT 1982) or 2 (PÄTSCH 1974) caudal cirri very closely arranged at posterior end of cell (Fig. 208e, f). Some ultrastructural details are shown in FLEURY et al. (1985).

M o r p h o g e n e s i s of cell division is described by WICKLOW (1979), HEMBERGER (1982; Fig. 208n–y), and HEMBERGER & WILBERT (1982). It commences with the formation of an distinctly invaginated oral primordium immediately behind the buccal vertex (Fig. 208n, o). Simultaneously 2 primordia are formed right and left of the anterior end of the undulating membranes (Fig. 208o). Somewhat later one primordium each occurs within the parental rows 3 and 4 (Fig. 208p). The primordium in row 4 splits up into 3 streaks to form the frontoventral transverse primordia IV–VI of the proter, which is reminiscent of *Stylonychia pustulata* (Fig. 161g). In the opisthe the primordia V and VI originate from the middle portion of the parental row 5 (Fig. 208r). The exact origin of the other frontal-ventral-transverse cirri streaks is difficult to ascertain (Fig. 208r, s) but very likely it proceeds rather similarly to in 18-cirri oxytrichids, for example, *Stylonychia pustulata*. A late stage shows 6 streaks in both the proter and the opisthe, each forming a rather high number of cirri. Row 6 does not, as in the 18-cirri oxytrichids, participate in primordia formation. The cirral rows originating from streaks II–IV are distinctly separated; the posterior part of streak II forms the buccal cirri (Fig. 208g). New marginal rows originate, as in *Onychodromus quadricornutus*, distinctly right of the parental rows, which are completely retained in late stages (Fig. 208s, t).

Dorsal morphogenesis commences, as is usual, with the formation of 3 longitudinal anlagen in both the anterior and posterior half of the cell. Because of the complex interphasic pattern it is impossible to ascertain if a correlation with certain parental kineties exists (Fig. 208v). Later, all anlagen begin with multiple fragmentation, forming large fields of usually parallel kinety fragments. Simultaneously, 2 dorsomarginal kineties occur (Fig. 208w–y). In interphasic specimens, the kinety fragments cover the dorsal side almost completely (Fig. 208u). One caudal cirrus originates at the posterior end of each of the 3 dorsal anlagen.

Division of nuclear apparatus is described by BALBIANI (1860a) and conjugation is figured and described by BALBIANI (1861, 1862).

Fig. 208n–q *Kerona pediculus* (from HEMBERGER 1982. n–q, morphogenetic stages in ventral view after pro-targol impregnation). **n)** Very early stage, about 90 μm . Arrow marks oral primordium. **o)** Early stage. Arrows mark 2 primordia left and right of the buccal row. They become the primordia I and II of the proter. **p)** Early stage showing one primordium each in row 3 and 4. **q)** Middle stage showing 2 primordia right of the oral primordium; p 826.

Fig. 208r–u *Kerona pediculus* (from HEMBERGER 1982. r–t, morphogenetic stages in ventral view after protargol impregnation; u, protargol impregnation). r) Middle stage showing 6 primordia both in the proter and the opisthe. Arrows mark rightmost anlagen (3 in the proter, 2 in the opisthe) originating from frontoventral row 4 (proter) and 5 (opisthe). This pattern is reminiscent of the 18-cirri oxytrichids like *Stylonychia pustulata* (cp Fig. 161g). s, t) Late and very late stages showing 6 primordia and segregation of cirri. Transverse cirri became larger from left to right. Note that new marginal cirral rows originate right of parental ones which are almost completely retained even in late stages. u) Interphasic pattern of dorsal infraciliature; p 835.

Fig. 208v–y *Kerona pediculus* (from HEMBERGER 1982. v–y, morphogenetic stages in dorsal view after protargol impregnation). v) Early stage with 3 longitudinal anlagen for both the proter and the opisthe. Parental basal body pairs omitted. w) Anlagen 2 and 3 begin with fragmentation. x) All anlagen show multiple fragmentation. Arrows mark dorsomarginal kineties. y) Each primordium produces several kineties which later cover the whole dorsal surface (cp Fig. 208u); p 826.

Occurrence and ecology: Ectocommensal on freshwater hydras (*Hydra attenuata*, *H. circumcincta*, *H. fusca*, *H. vulgaris*, *H. viridissima*; Fig. 208c, j, l) and thus often in company with the peritrich, *Trichodina pediculus* (for example, BRECKENFELD 1886, FOISSNER et al. 1991, 1992c, HILL 1965, KEISER 1921, MEUCHE 1939, PÄTSCH 1974, SCHNEIDER 1994); but also on the bryozoans *Plumatella* and *Cristatella mucedo* (WARREN & ROBSON 1986, 1987, ŠVEC 1897); single specimens sometimes swim freely or creep near the host. Obviously prefers the body to the arms of the hydras (SCHLICK 1973, SCHNEIDER 1985).

Locus classicus is very likely Denmark, where MÜLLER (1773, 1786) discovered *Kerona pediculus* on *Hydra pallida*. Locus classicus of the synonym *Kerona polyporum* is Berlin, Germany, where EHRENBURG (1838) discovered it with high abundance on *Hydra vulgaris* and *H. oligactis*. CHARDEZ (1983) found the synonym *Peritromus hydrarum* on the same hydras in a pond in the village of Waremmé, Prov. de Liège, Belgium, in January at 4–6 °C and pH 7.6.

Records substantiated by illustrations: Mare Nozay, a pond in France? (FLEURY et al. 1985); very abundant on *Hydra viridissima* in a trout pond in Germany (?) and also very abundant on *H. fusca* and *H. grisea* in Prague, Czechoslovakia (STEIN 1859b); meso-saprobic brook in Germany (PÄTSCH 1974); numerous on *Hydra attenuata* and *H. viridissima* in a clay-pit in Germany (SCHNEIDER 1985); Italy (CAVALLINI 1930); rarely in freshwater in Nanking, China (WANG & NIE 1933).

Records not substantiated by illustrations: oligotrophic and eutrophic ponds in Austria (KRAINER 1988, own observations); on *Hydra attenuata* in a side branch of the Danube River in Vienna, Austria (VORNATSCHER 1938; further records from Austria: AOÖLR 1995c, BLATTERER 1994, DALLA TORRE 1891, MITIS 1941); rather abundant on bryozoans and hydras in a pond in Czechoslovakia during autumn (ŠVEC 1897); saprobic brook near Prague and Moldau River, Czechoslovakia (BUCHAR 1957, KALMUS 1928); England

Fig. 209a, b *Peritromus hydrarum* (from CHARDEZ 1983a. a, b, silver impregnation, schematic). This is very likely a synonym of *Kerona pediculus*. The dotted lines are probably the dorsal infaciliature; p 826.

(CRAIGIE 1921); mesosaprobic running waters in Germany (HEUSS 1976, SCHMITZ 1986); Hamburg Harbour, Germany (BARTSCH & HARTWIG 1984); lake (Plöner See) in Germany (ZACHARIAS 1893, 1894); unpolluted foothill stream (Breitenbach) near the village of Schlitz, Germany (PACKROFF & ZWICK 1996); numerous and in masses in oligosaprobic and oligosaprobic to betamesosaprobic reservoirs in Germany (NUSCH 1970; further records from Germany: HENDERSON 1905, SONG & WILBERT 1989, WETZEL 1928b, WILBERT 1969); on *Hydra fusca* in Lake Balaton and in Budapest, Hungary (FRANCÉ 1897, KREPUSKA 1917); beta- to alphamesosaprobic running water in Italy (MADONI & GHETTI 1980; further records from Italy: CANELLA 1954, LONGHI 1895); Switzerland (ANDRÉ 1912); Volga Basin and reservoirs in the USSR (KRAVCHENKO 1969, MAMAEVA 1979b, MYLNIKOVA 1981, ZYKOFF 1903); at 13 °C abundantly on *Hydra* in Lake Baikal, USSR (GAJEVSKAJA 1927, GAJEVSKAJA 1933); rare in a pond in the botanical gardens of the Pennsylvania University, USA, in March and October (WANG 1928); New Zealand (MASKELL 1887b).

It was originally presumed that *K. pediculus* preyed upon the living tissues of the polyp which serves it as host, the characteristic nematocysts of the hydras being frequently found inside it. These cells, however, are only incepted with other waste matter thrown off from the surface of the polyp's integument, and in the removal of which *Kerona* undoubtedly plays the role of a useful scavenger. Other food, especially algae (*Euastrum*, *Euglena*, *Phacus*, *Trachelomonas*, desmids, diatoms like *Amphora*, *Fragilaria*, *Navicula*), are devoured with equal avidity, and form an important addendum to its customary bill of fare (CHARDEZ 1983, KAHL 1932, KENT 1882, SCHLICK 1973, STEIN 1859b). STEIN (1859b) supposed that the hydras are only a temporary dwelling for the keronas, the available food being insufficient there.

The nematocysts of the hydras are not released by *Kerona* (for example, HILL 1965, SCHNEIDER 1985, ZICK 1932), whereas they are released by other ciliates, for example, the rather small *Coleps hirtus*. Possibly, the special infraciliature (and the flexible body margins) of *Kerona* are adaptations for undisturbed living (and thus protected against predators) on the hydras. Biomass of 10⁶ individuals about 230 mg (FOISSNER et al. 1991).

One *Hydra* is usually colonised by 8–18 keronas; according to CAVALLINI (1930) and COLEMAN (1965), however, up to 100 or 200 individuals per *Hydra* are possible (Fig. 208j, l); but in this case the growth rates of the keronas are rather low and many of them leave the *Hydra*. HILL (1965) stated that *Kerona* harmed hydras when dominant, and that an infested *Hydra* would lose its ciliates if it became very strong, and keronas transferred to a healthy *Hydra* had little chance of remaining there. Conversely, SCHLICK (1973) stressed that heavily colonised hydras also reproduce. According to COLEMAN (1965), *Kerona* did not survive on intact, starved hydras.

Kerona pediculus is used as indicator of water quality (FOISSNER 1988a, SLÁDEČEK et al. 1981, WEGL 1983). The above mentioned hydras and bryozoans live in oligo- to betamesosaprobic standing and running waters (HEITKAMP 1986, WEGL 1983). FOISSNER et al. (1991) thus classified *Kerona pediculus* as follows: b-o; o = 4, b = 5, a = 1, I = 2, SI = 1.7.

Species transferred to genera not treated in this book

Kerona ciliata GOURRET & ROESER, 1888, Archs Biol., 8: 178, Planche XIV, Fig. 11, 12. Remarks: According to KAHL (1932, p 482), a supposed synonym of *Peritromus faurei* KAHL, 1932.

Kerona rotunda FROMENTEL, 1876, Microzoaires, p 271, Planche XIII, fig. 11. Remarks: Probably a synonym of *Aspidisca lynceus*.

Kerona vannus MÜLLER, 1786, Animalcula Infusoria, p 240, Tab. XXXIII, Fig. 21–23. Remarks: Now *Euplotes vannus*.

Species indeterminata

DUMAS (1929, 1930, 1937) and FROMENTEL (1876) described many “*Kerona*” species. If not otherwise indicated, it is either a fragment, a deformed hypotrich, or the description and the illustration are so insufficient that identification is impossible.

Kerona absidata DUMAS, 1930, Microzoaires, p 59 (Fig. 243h).

Kerona anfracta DUMAS, 1929, Microzoaires, p 78 (Fig. 227j, 243l). Remarks: “Redescribed” by DUMAS (1937, p 24).

Kerona aper FROMENTEL, 1876, Microzoaires, p 271, Planche XIII, fig. 15.

Kerona arcuata DUMAS, 1929, Microzoaires, p 79 (Fig. 227p).

Kerona becciformis DUMAS, 1929, Microzoaires, p 77 (Fig. 227f, g).

Kerona bicaudata DUMAS, 1937, Microzoaires, p 21 (Fig. 243k).

Kerona bipes DUMAS, 1937, Microzoaires, p 21 (Fig. 243j).

Kerona calvaeformis DUMAS, 1929, Microzoaires, p 80 (Fig. 243b).

Kerona caudata DUMAS, 1929, Microzoaires, p 76 (Fig. 227b).

Kerona congyrans DUMAS, 1929, Microzoaires, p 80 (Fig. 227o). Remarks: Possibly a *Stylonychia* because, in the legend to Planche XXXVII, DUMAS designated it as *Kerona silurus (congyrans)*.

Kerona cuneata DUMAS, 1930, Microzoaires, p 57 (Fig. 243c). Remarks: Possibly a *Stylonychia*.

Kerona curvata DUMAS, 1929, Microzoaires, p 76 (Fig. 227e). Remarks: Possibly a *Gonostomum*. Very likely not identical with the next "species".

Kerona curvata DUMAS, 1930, Microzoaires, p 58 (Fig. 243e). Remarks: Very likely not identical with the previous species.

Kerona cylindrica DUMAS, 1929, Microzoaires, p 75 (Fig. 243a).

Kerona diademata DUMAS, 1929, Microzoaires, p 77 (Fig. 227c).

Kerona elongata FROMENTEL, 1876, Microzoaires, p 270, Planche XIII, fig. 7.

Kerona epalxiformis DUMAS, 1937, Microzoaires, p 22 (Fig. 243m).

Kerona extuberans DUMAS, 1930, Microzoaires, p 58 (Fig. 243f).

Kerona lacerata FROMENTEL, 1876, Microzoaires, p 269, Planche XII, fig. 11.

Kerona mamillata DUMAS, 1929, Microzoaires, p 78 (Fig. 227n). Remarks: The illustration is shown on Planche XXVIII, and not on Planche X as indicated. In 1937, DUMAS described a further species with the same name (see next entry).

Kerona mamillata DUMAS, 1937, Microzoaires, p 23 (Fig. 243o, p). Remarks: DUMAS probably did not realise that he had already described a species having the same name (see previous entry).

Kerona oblonga DUMAS, 1929, Microzoaires, Legend to Planche XXVIII (Fig. 227h). Remarks: According to the text (p 78) it is *Kerona elongata* FROMENTEL.

Kerona undulata DUMAS, 1930, Microzoaires, p 58 (Fig. 243g).

Kerona ovata DUMAS, 1929, Microzoaires, p 79 (Fig. 227k).

Kerona rastellum MÜLLER, 1786, Animalcula Infusoria, p 233, Tab. XXXIII, Fig. 1, 2. Remarks: I did not find this name in the comprehensive index by EHRENBURG (1838). Perhaps an *Aspidisca*?

Kerona rostrata DUMAS, 1937, Microzoaires, p 24 (Fig. 243i).

Kerona subrotundata DUMAS, 1930, Microzoaires, p 58 (Fig. 243d). Remarks: *Kerona subrotundata* in the legend to Planche XVI is another original spelling. The same name

occurred already in DUMAS (1929, legend to Planche XXVIII), which is, according to the text (DUMAS 1929, p 79), *K. rotundata* FROMENTEL (Fig. 227i; incorrect subsequent spelling).

Kerona tremula DUMAS, 1929, Microzoaires, p 76 (Fig. 227a).

Kerona triangularis FROMENTEL, 1876, Microzoaires, p 272, Planche XII, fig. 5.

Kerona truncata DUMAS, 1929, Microzoaires, p 77 (Fig. 227d).

Kerona unguicularis DUMAS, 1937, Microzoaires, p 22 (Fig. 243n).

Insufficient redescriptions

Kerona polyporum EHRENBERG – DUMAS, 1929, Microzoaires, p 76, Planche XXVI, fig. 6.

Kerona polyporum EHRENBERG – FROMENTEL, 1876, Microzoaires, p 270, Planche XIII, fig. 10.

Paraurostyla BORROR, 1972

1972 *Paraurostyla* BORROR, J. Protozool., 19: 4, 9 – Type (original designation): *Urostyla weissei* STEIN, 1859.

1986 *Paraurostyla* BORROR, 1972 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropical, 26: 435 (revision of African species).

C h a r a c t e r i s a t i o n: Body flexible. Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Numerous frontoventral cirri arranged in 3–7 longitudinal rows. Usually 6–9 transverse cirri. One left and 1 right row of marginal cirri. 5–7 dorsal kineties. Caudal cirri present. More than six frontoventral-transverse cirri primordia, and number of cirri each originating from the fourth to the rightmost primordium usually distinctly >4. Dorsal morphogenesis in *Oxytricha* pattern.

N o m e n c l a t u r e a n d t a x o n o m y: Incorrect subsequent spellings: *Paraurostula weissei* (STEIN) and *Paraurostula* sp. (YANG 1989, p 157); *Parurostyla weissei* STEIN (DETCHÉVA 1981, p 24; 1986, p 63).

For a detailed description of the patterns mentioned in the characterisation, see chapter 2 in the general section. BORROR (1972a) established *Paraurostyla* within the Urostylidae to include species previously thought to be closely related to *Urostyla grandis*, but with decidedly different appearance of the cirri of the frontal area, as well as entirely different morphogenesis. Somewhat later, he transferred *Paraurostyla* to the Oxytrichidae

because the morphogenetic pattern reminds of that of the 18-cirri oxytrichids (BORROR 1979). Furthermore, fragmentation of dorsal kinety 3 is a very strong evidence that *Paraurostyla* belongs to the oxytrichids. However, the exact position within this group is uncertain. WIRNSBERGER et al. (1986) considered it as sister-group of all other oxytrichids, but without giving an autapomorphy for *Paraurostyla*. This position is supported by some characters of the resting cyst (see there). Another possibility is that *Paraurostyla* evolved from flexible 18-cirri oxytrichids (that is, the Oxytrichinae) by a secondary increase of the number of frontal-ventral-transverse cirri streaks and an increase of the number of cirri originating from the right streaks. A similar origin is proposed for *Onychodromus* within the rigid oxytrichids. Conversely, SMALL & LYNN (1985, p 457) and TUFFRAU & FLEURY (1994, p 141) considered *Paraurostyla* as member of the amphisiellids. However, this group lacks fragmentation of dorsal kinety 3. EIGNER (1997) classified it in the Parakahliellidae.

Originally, ten species were transferred to *Paraurostyla* (BORROR 1972a). However, some of these deviate distinctly from the type species, and in several species some important characters are unknown (for example, fragmentation of dorsal kinety 3) or not substantiated by silver impregnation (for example, lack of midventral cirri). These species, briefly discussed in the following paragraphs, are omitted in the present revision.

Paraurostyla dispar (KAHL, 1932) BORROR, 1972 (basionym: *Urostyla dispar* KAHL, 1932, Tierwelt Dtl., 25: 565, Fig. 98). Remarks: Many frontal cirri, very likely arranged in a bicorona, indicating that a midventral row is present. Marine.

Paraurostyla gibba (MÜLLER, 1786) BORROR, 1972 (basionym: *Trichoda gibba* MÜLLER, 1786, Animalcula Infusoria, p 179, Tab. 16–20). Remarks: According to the first detailed redescription (STEIN 1859b, p 184) a marine urotylid.

Paraurostyla latissima (DRAGESCO, 1970) BORROR, 1972 (basionym: *Urostyla latissima* DRAGESCO, 1970, Annls Fac. Sci. Univ. féd. Cameroun (Numero Hors-serie): 100, Fig. 73). Remarks: Very likely a synonym of "*Paraurostyla viridis*".

Paraurostyla marina (KAHL, 1932) BORROR, 1972 (basionym: *Urostyla marina* KAHL, 1932, Tierwelt Dtl., 25: 567, Fig. 100). Remarks: Both the original description and the redescription by BORROR (1979) show that midventral cirri are present, that is, it is an urotylid. Marine.

Paraurostyla naumanni (LEPSI, 1935) BORROR, 1972 (basionym: *Urostyla naumanni* LEPSI, 1935, Bul. Muz. natn. Ist. nat. Chisinău, 6: 16, 1 fig). Remarks: Exact arrangement of cirri unknown, thus transfer to *Paraurostyla* unfounded. No redescription available. About 6 left marginal rows. Marine.

Paraurostyla rubra (ANDRUSSOWA, 1886) BORROR, 1972 (basionym: *Urostyla rubra* ANDRUSSOWA, 1886, Trudy imp. S-peterb. Obshch. Estest., 17: 246, plate II, fig. 10). Re-

marks: Superficially described. No redescription available. Obviously no transverse cirri and numerous macronuclear nodules. Marine.

Paraurostyla viridis (STEIN, 1859) BORROR, 1972 (basionym: *Urostyla viridis* STEIN, 1859, Organismus der Infusionsthiere I, p 206, Taf. XIII, Fig. 13, 14). Remarks: See *Paraurostyla enigmatica*.

The following 5 more recent species were originally classified in *Paraurostyla*. However, they differ significantly from the type species and were thus transferred to other taxa.

Paraurostyla buitkampii FOISSNER, 1982, Arch. Protistenk., 126: 40, Abb. 4a–f. Remarks: BERGER & FOISSNER (1987a, p 197) transferred it to *Pseudouroleptus* HEMBERGER, 1985 because of the deviating ventral infraciliature. Furthermore, *P. buitkampii* has only 3 dorsal kineties, that is, fragmentation of kinety 3 and dorsomarginal rows are lacking.

Paraurostyla enigmatica DRAGESCO & DRAGESCO-KERNÉIS, 1986, Faune tropicale, 26: 437, Planche 125C. Remarks: This conspicuous species from saline marshes in Benin has about 9 cirral rows left of the median. DRAGESCO & DRAGESCO-KERNÉIS (1986) thus proposed a new genus, namely *Mixotricha* (*M. enigmatica*). However, this name is preoccupied by *Mixotricha* SUTHERLAND, 1933, a termite inhabiting flagellate. JANKOWSKI (1989) thus introduced the replacement name *Ponturostyla*. *Ponturostyla enigmatica* is not treated in this book because nothing is known about the dorsal morphogenesis (that is, if fragmentation of kinety 3 is present or absent). Very likely related to *Urostyla viridis* STEIN, 1859.

Paraurostyla macrostoma FOISSNER, 1982, Arch. Protistenk., 126: 43, Abb. 5a–e and *Paraurostyla terricola* BUITKAMP, 1977, Decheniana, 130: 118, Abb. 2. Remarks: Now in the kahliellid taxon *Parakahliella* BERGER, FOISSNER & ADAM, 1985, which differs from *Paraurostyla* by the lack of transverse cirri and in that dorsal kinety 3 does not fragment. The number of left marginal cirral rows is increased and some parental dorsal kineties are retained after division.

Paraurostyla pulchra BUITKAMP, 1977, Decheniana, 130: 119, Abb. 3. Remarks: Lacks caudal cirri and has only 3 dorsal kineties, that is, fragmentation of kinety 3 and dorso-marginal kineties are very likely absent. Thus, a classification in *Paraurostyla* and in the Oxytrichidae is unfounded. JANKOWSKI (1979, p 83) transferred it to *Bakuella*, which is also unfounded because midventral cirri are lacking.

Consequently, *Paraurostyla* comprises four species. Two form the *Paraurostyla weissei* complex, namely *P. weissei* and *P. polymicronucleata*. FOISSNER (1997b) established *Apoamphisiella* for *Onychodromopsis tihanyiensis* (Fig. 198.1a–g). When I made the layout of the book, I recognised that *Paraurostyla hymenophora* (STOKES) BORROR

(Fig. 215a–d) is very similar (possibly synonymous) to that species; thus, it is also transferred to *Apoamphisiella* (however, it was too late to change the figure numbers). *Apoamphisiella* differs from *Paraurostyla* mainly in that it has only two frontoventral rows against three or more in *Paraurostyla*.

Key to species

- 1 About 9 macronuclear nodules (Fig. 218a) *P. polynucleata* (p 877)
 - Usually 2 macronuclear nodules 2
- 2 Two frontoventral rows (for example, Fig. 215a–d) *Apoamphisiella* (p 781)
 - 3–7 frontoventral rows (for example, Fig. 210g, 211a) 3
- 3 Cortical granules yellow-green, spherical, about 1 µm across (Fig. 212i; *Paraurostyla weissei* complex; p 844) 4
 - Cortical granules colourless; rod-shaped, about 2 × 1 µm (Fig. 216c, d) *P. granulifera* (p 874)
- 4 Usually 3 distinctly enlarged anterior frontal cirri and 3 enlarged posterior frontal cirri; usually 6 transverse cirri; third frontoventral row begins near distal end of adoral zone of membranelles; rightmost frontoventral row (usually the fourth from left) not interrupted in the middle region (Fig. 211d, e) ... *P. polymicronucleata* (p 844)
 - Usually 4 distinctly enlarged anterior frontal cirri and 2 enlarged posterior frontal cirri; usually 8 transverse cirri; third frontoventral row begins at about level of buccal vertex; rightmost frontoventral row often interrupted in the middle region (Fig. 212r) *P. weissei* (p 844)

Paraurostyla weissei complex (Fig. 8, 9a, b, 210a–x, 211a–k, 212a–x, 213a–l, 214, Table 49)

- 1859 *Urostyla weissei* STEIN, Organismus der Infusionsthier I, p 192 (Fig. 210a–c).
 1866 *Urostyla weissei* STEIN – DIESING, Sber. Akad. Wiss. Wien, 53: 120.
 1866 *Urostyla* sp. nov? – WRZEŚNIEWSKIEGO, Wykaz Szkoty Głownej Warszawskiej, 5: 19 (Latin description, no illustration).
 1867 *Urostyla flavicans* WRZEŚNIEWSKIEGO, Rozprawa, p 65 (Fig. 212a, b).
 1867 *Urostyla flavicans* WRZEŚNIEWSKIEGO, Rocznik ces. król. Towarzystwa Naukowego Krakowskiego, 12: 293 (Fig. 212a, b).
 1870 *Urostyla flavicans* WRZEŚNIEWSKI, Z. wiss. Zool., 20: 480 (Fig. 212c).
 1877 *Urostyla weissei* STEIN, nova varietas – MERESCHKOWSKY, Trudy imp. S.-peterb. Obshch. Estest., 8: 239 (variety not named; no illustration).
 1879 *Urostyla weissei* STEIN, nova varietas – MERESCHKOWSKY, Arch. mikrosk. Anat. EntwMech., 16: 166 (variety not named; no illustration; translation of MERESCHKOWSKY 1877).
 1882 *Urostyla weissii*, STEIN – KENT, Manual Infusoria II, p 764 (incorrect subsequent spelling).
 1882 *Urostyla flavicans*, WRZ. – KENT, Manual Infusoria II, p 766.
 1894 *Urostyla vernalis* STOKES, Proc. Am. phil. Soc., 33: 342 (Fig. 211k).
 1930 *Urostyla paragrandidis* WANG, Contr. biol. Lab. Sci. Soc. China, 6: 9 (Fig. 212d).

- 1932 *Urostyla vernalis* STOKES, 1894 – KAHL, Tierwelt Dtl., 25: 568.
- 1932 *Urostyla weissei* STEIN, 1859 – KAHL, Tierwelt Dtl., 25: 568 (Fig. 210g).
- 1932 *Urostyla flavicans* WRZESNIEWSKI, 1870 – KAHL, Tierwelt Dtl., 25: 568.
- 1936 *Urostyla weissei* STEIN – BHATIA, Protozoa: Ciliophora, p 366.
- 1937 *Urostyla polymicronucleata* MERRIMAN, Arch. Protistenk., 88: 427 (Fig. 212e).
- 1939 *Urostyla coei* TURNER, Trans. Am. microsc. Soc., 58: 395 (Fig. 212g).
- 1939 *Urostyla lynchi* HORVÁTH, Arch. Protistenk., 92: 544 (Fig. 212f; new synonym).
- 1945 *Urostyla weissei*, STEIN – FAURÉ-FREMIET, Bull. biol. Fr., Belg., 79: 112 (Fig. 210h).
- 1961 *Urostyla weissei* STEIN – BUCK, Jh. Ver. vaterl. Naturk. Württ., 116: 211 (Fig. 210e).
- 1962 *Urostyla weissei* STEIN – LIEBMANN, Handbuch der Frischwasser- und Abwasser-Biologie I, p 360 (Fig. 210d, f).
- 1963 *Urostyla weissei* STEIN, 1859 – VUXANOVICI, Studii Cerc. Biol., 15: 203 (Fig. 210i).
- 1965 *Urostyla hologama* HECKMANN, Arch. Protistenk., 108: 55 (Fig. 212h).
- 1965 *Urostyla weissei* STEIN – JERKA-DZIADOSZ, Acta Protozool., 3: 345 (Fig. 210k).
- 1966 *Urostyla weissei* STEIN – DRAGESCO, Protistologica, 2: 81 (Fig. 210l, n-s).
- 1968 *Urostyla weissei* STEIN, 1859 – CHORIK, Free-living ciliates, p 128 (Fig. 211h).
- 1969 *Urostyla weissei* – JERKA-DZIADOSZ & FRANKEL, J. Protozool., 16: 612 (Fig. 211d).
- 1970 *Urostyla weissei* STEIN, 1859 – DRAGESCO, Annls Fac. Sci. Univ. féd. Cameroun (Numero Hors-série): 102 (Fig. 210w, x).
- 1972 *Urostyla weissei* STEIN – BICK, Ciliated Protozoa, p 178.
- 1972 *Paraurostyla weissei* (STEIN, 1859) – BORROR, J. Protozool., 19: 4, 9.
- 1974 *Urostyla weissei* STEIN – STILLER, Fauna Hung., 115: 42.
- 1974 *Paraurostyla weissei* (STEIN) BORROR – PÄTSCH, Arb. Inst. landw. Zool. Bienenkd., 1: 55 (Fig. 211g; incorrect subsequent spelling of *Paraurostyla*).
- 1983 *Paraurostyla weissei* (STEIN, 1859) – SHEN, Protozoa of the Tibetan Plateau, p 203 (Fig. 211i, j).
- 1985 *Paraurostyla weissei* (STEIN, 1859) – WIRNSBERGER, FOISSNER & ADAM, Zool. Scr., 14: 1 (Fig. 212o-x, 213a-l; detailed redescription of *P. weissei*).
- 1986 *Paraurostyla weissei* (STEIN, 1859) BORROR, 1972 – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 435 (Fig. 210m, 211f).
- 1988 *Paraurostyla weissei* (STEIN, 1859) – SHIN & KIM, Korean J. syst. Zool., 2: 70 (Fig. 210t-v).
- 1988 *Paraurostyla weissei* – KRAMER, Diplomarbeit, p 19 (Fig. 211e).
- 1991 *Paraurostyla weissei* (STEIN, 1859) BORROR, 1972 – FOISSNER, BLATTERER, BERGER & KOHMANN, Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft, 1/91: 260 (Fig. 212i-n; see also Abb. 16, 17 on p 264, showing 2 large scanning electron micrographs of the ventral and dorsal side).
- 1994 *Paraurostyla weissei* (STEIN, 1859) – SHIN, Dissertation, p 53 (Fig. 211a-c).

Nomenclature and taxonomy: Incorrect subsequent spellings: *Paraurostyla eissei* (STEIN) (DETCHOVA 1993, p 34); *Paraurostyla weisei* (STEIN) (BEER 1958, p 196; MATIS 1975, p 586); *Urostila weissei* St. (AWERINTZEV 1899, p 244); *Urostyla hologamma* (JERKA-DZIADOSZ & JANUS 1975, p 311); *Urostyla wessei* STEIN (SHADIN et al. 1931, p 72); *Urostyla weissii* STEINII (COPPA 1921, p 184; GULATI 1925, p 753); *Urostyla weissii* STEIN (DADAY 1891, p 111; DADAY 1903, p 324; GULATI 1925, p 752; LEPSI 1929b, p 269; LEVANDER 1892, p 117; SCHEFFELT 1922, p 116; ZACHARIAS 1888, p 222).

Paraurostyla weissei is very likely a complex of at least two species (WIRNSBERGER et al. 1984, 1985b). Significant differences occur mainly between European and American populations and concern especially ventral infraciliature and number of dorsomarginal kineties (see following paragraphs for details). Furthermore, JERKA-DZIADOSZ (pers. comm. to WIRNSBERGER et al. 1985b) and KRAMER & SCHLEGEL (1989) observed conjugation only

Fig. 210a–f *Paraurostyla weissei* complex (a–c, from STEIN 1859b; d, f, from LIEBMANN 1962; e, from BUCK 1961. a–f, from life). a, b, d–f) Ventral views, a, b = up to 300 μ m, d = 170 μ m, e = size not indicated, f = 140 μ m. Specimen in (b) with an ingested *Paramecium aurelia*. c) Late morphogenetic stage in dorsal view. The dotted longitudinal rows are the cortical granules; p 844.

among European and among American strains, but not between them. Furthermore, KRAMER (1988) found a genetic identity which is typical for morphologically separable species. European populations agree rather well with the original description by STEIN (1859b) and should thus be designated as *Paraurostyla weissei* (STEIN, 1859) BORROR, 1972. American populations should be determined as *Paraurostyla polymicronucleata* (MERRIMAN, 1937) comb. nov. because this is the first (oldest) description of this deviating type (Fig. 212e; *Urostyla vernalis* STOKES, 1894 from America is older, however, it is more like the European type than on the deviating American type). *Urostyla coei* TURNER, 1939 (Fig. 212g), *Paraurostyla weissei* sensu JERKA-DZIADOSZ & FRANKEL, 1969 (Fig.

Fig. 210g–m *Paraurostyla weissei* complex (g, from KAHL 1932; h, from FAURÉ-FREMIET 1945b; i, from VUX- → ANOVICI 1963; j, after BORROR 1979 from DRAGESCO & DRAGESCO-KERNÉIS 1986; k, from JERKA-DZIADOSZ 1965; l, from DRAGESCO 1966b; m, from DRAGESCO & DRAGESCO-KERNÉIS 1986. g–i, from life; j, l, m, protargol impregnation; k, Parducz fixation). g–m) Ventral views, g = 280 μ m, h = 220 μ m, i = 200–240 μ m, j = 185 μ m, k = size not indicated, l = 165 μ m, m = 175 μ m; p 844.

210 g

h

i

j

k

l

m

211d), and *P. weissei* syngen 2 of KRAMER (1988; Fig. 211e) are surely conspecific with *P. polymicronucleata*.

WIRNSBERGER et al. (1985b) proposed the name *Paraurostyla hologama* (HECKMANN, 1965) for populations with cortical granules, 4 anterior frontal cirri, generally 4 fronto-ventral rows, and 8 transverse cirri arranged like a J. The name *Paraurostyla weissei* was proposed for populations probably without cortical granules (for example, “*U. weissei* sensu STEIN 1859”), but with 6 frontal cirri arranged in 2 rows of 3 cirri each, 6 or 7 transverse cirri in a straight row, and a number of frontoventral rows varying from 4 to 7. However, this proposal is somewhat confusing because STEIN (1859b, p 193) unequivocally described and illustrated cortical granules (Fig. 210c).

Synonymy of *Urostyla coei*, *U. flavicans*, *U. hologama*, *U. paragrandidis*, *U. polymicronucleata*, and *U. vernalis* with the *Paraurostyla weissei* complex is evident and was already proposed by BORROR (1972a) and WIRNSBERGER et al. (1985b). *Urostyla lynchi* HORVÁTH, 1939 is surely a further synonym of *Paraurostyla weissei* (Fig. 212f). HORVÁTH (1939a) assumed that the number of macronuclear nodules and micronuclei is reduced during cultivation in KNOP's solution, that is, in nature he found this species always having numerous macronuclear nodules and many micronuclei. Very likely, he confused *Urostyla grandis* and *Paraurostyla weissei*. According to HEMBERGER (1982, p 30) *Trichotaxis fossicola* (having only 3 frontoventral rows), is a further synonym of *Paraurostyla weissei*. I consider it as supposed synonym of *Paraurostyla granulifera* (see there for details). *Oxytricha multipes* CLAPARÈDE & LACHMANN, 1858 is considered as supposed synonym of *Paraurostyla weissei* to retain stability in nomenclature (see below).

MERESCHKOWSKY's (1877, 1879) unnamed variety differs from STEIN's (1859b) description in that 6 (against 5) cirral rows are present. However, this is within the range of clonal populations (Table 49). The redescrptions by GULATI (1925; Fig. 218c) and ROSA (1957a; Fig. 218b) are insufficient.

At superficial live observation species of the *Paraurostyla weissei* complex can be easily confused with *Allotricha mollis* because it is very similar in size, shape, cortical granulation, the nuclear apparatus, and, most importantly, the 2 or 3 marginal rows of *A. mollis* feign frontoventral rows. However, after careful checking of the ventral ciliature they can be easily distinguished because *Allotricha* has the typical 18 frontal-ventral-transverse cirri pattern of, for example, *Oxytricha* (Fig. 91a–c).

The following chapter is largely based on the detailed redescription of an Austrian population by WIRNSBERGER et al. (1985b) unless otherwise indicated.

M o r p h o l o g y a n d b i o l o g y: In life 150–300 µm long, usually 200 to 250 × 50–80 µm; up to 220 µm long (DRAGESCO 1966b), 180–205 µm (DRAGESCO 1970; fixed specimens), 120–180 × 35–55 µm (HECKMANN 1965), 200–300 × 90–100 µm (JERKA-DZIADOSZ 1965), 225 × 65 µm (MERRIMAN 1937), 200–250 µm (PÄTSCH 1974), 150–250 × 50–90 µm (SHIN & KIM 1988), up to 300 µm (STEIN 1859b), 254–340 µm (STOKES 1894), 200 × 50 µm (TURNER 1939), 100–260 µm (VUXANOVICI 1963), 158 to

Fig. 210n–v *Paraurostyla weissei* complex (n–s, from DRAGESCO 1966b; t–v, from SHIN & KIM 1988. n–s, v, protargol impregnation; t, u, from life?). n–s) Variability of ventral infraciliature. t–v) Nuclear apparatus, ventral view (225 µm), and ventral infraciliature of Korean population; p 844.

Fig. 210w, x *Paraurostyla weissei* complex (from DRAGESCO 1970. Protargol impregnation). Ventral infraciliature of specimens from Cameroon, w = 210 µm, x = 140 µm. The majority of the population had 2 macro-nuclear nodules and not 3 as illustrated. I doubt that the arrangement of the cirri is correctly drawn; p 844.

Fig. 211a-c *Paraurostyla weissei* complex (from SHIN 1994. a, from life; b, c, protargol impregnation). Ventral view and ventral and dorsal infraciliature, a = 245 μ m, b, c = 240 μ m. (b, c) agree almost completely with Figures 212r, s, indicating that SHIN's illustrations are redrawings; p 844.

200 μ m (WANG 1930), 220 μ m (WRZESNIEWSKI 1870), poorly nourished specimens only 80 μ m long (TURNER 1939).

Body slender elliptical, narrowing and sometimes tapering towards posterior end. Right margin straight to slightly concave, left slightly convex. Flattened about 2:1 dorso-ventrally. Body rather flexible, very likely because cortex with only one layer of (longitudinal) microtubules (JERKA-DZIADOSZ 1982). Usually 2 macronuclear nodules with numerous little nucleoli, nodules in life about $20-30 \times 10-15 \mu$ m, both lying left of median; however, sometimes only 1 nodule or 3 nodules are present (Fig. 210w, x). DNA content of macronucleus 348 ± 12.3 pg (mean $\pm$ SD), GC content of macronucleus DNA about 32 % (STEINBRÜCK et al. 1981). Usually 3-6, in life about $6.5 \times 5 \mu$ m sized micronuclei (WIRNSBERGER et al. 1985b), according to AMMERMAN & MUENZ (1982) 5.6 micronuclei per cell on average, *Paraurostyla polymicronucleata* with 3-11 micronuclei (MERRIMAN 1937). Contractile vacuole above mid-body, during diastole with 2 canals, which almost reach the ends of the cell (Fig. 212o). Cortical granules about 1 μ m in diameter, yellow-

Fig. 211d, e *Paraurostyla weissei* complex (d, after Fig. 1A from JERKA-DZIADOSZ & FRANKEL 1969; e, from KRAMER 1988. d, e, protargol impregnation). Ventral infraciliature of American populations (that is, *P. polymicronucleata*), d = 220 μ m, e = 192 μ m. In (d) the anterior part of the right marginal row is out of focus. Cirri between arrowheads are caudal cirri. Anterior arrows mark the 3 enlarged "anterior" frontal cirri, posterior ones mark "posterior" frontal cirri comprising the buccal cirrus, the cirrus behind the right frontal cirrus (homologous to cirrus III/2 of the 18-cirri oxytrichids) and a further cirrus right of it. Further differences to *P. weissei*: third frontoventral row (arrow in e) begins near distal end of adoral zone of membranelles and right-most frontoventral cirrus shows no interruption, as is often the case in *P. weissei* (see Fig. 212r, arrow); p 844.

greenish, giving specimens a greenish-brown shimmer at low magnification, grouped mainly along cirral rows and dorsal kineties, turn pale when the cover glass exerts pressure for a while and water enters the cell (Fig. 210c, 212i); granules are extrusomes of the mucocyst type. HECKMANN (1965) misinterpreted them as symbiotic algae ("Zoochlorellen"). According to WIRNSBERGER et al. (1985b, p 9) several populations (for example, STEIN 1859b, WRZESNIEWSKI 1870, WANG 1930) probably without cortical granules. However, this is incorrect because STEIN (1859b, p 193) expressly mentioned them and others

Fig. 211f-k *Paraurostyla weissei* complex (f, from DRAGESCO & DRAGESCO-KERNÉIS 1986; g, from PÄTSCH 1974; h, from CHORIK 1968; i, j, from SHEN 1983; k, from STOKES 1894. f, g, protargol impregnation; h-k, from life?). f, g) Ventral infraciliature, f = 138 μ m, g = 213 μ m. h-k) Ventral views, h = 310 μ m, i, j = 176–200 μ m, k = 254–340 μ m; p 844.

Fig. 212a-d *Paraurostyla weissei* complex (a, after WRZESNIEWSKIEGO 1867a, b; c, from WRZESNIEWSKI 1870; d, from WANG 1930. a-d, from life). Ventral views, a-c = 220 μ m, d = 200 μ m; p 844.

described a yellow-brownish colour of the body. MERRIMAN (1937) wrote in the original description of *Paraurostyla polymicronucleata* that "living specimens invariably appear to be a dark green or brown and are very nearly opaque", strongly indicating that the American species of the *P. weissei* complex also has greenish cortical granules. Cytoplasm full of numerous intensely yellow shining inclusions of different shape, often aggregated in posterior portion of cell (Fig. 212q). Food vacuoles in life 8–26 μ m in diameter. Movement moderately rapid, nestling close to particles of mud.

Adoral zone of membranelles about 35 % of body length, 45–50 adoral membranelles on average (Table 49), according to JERKA-DZIADOSZ & FRANKEL (1969) 50–80 membranelles. Undulating membranes curved and intersecting, that is, in *Oxytricha* pattern. Ventral cirral pattern, especially number of ventral rows variable within a population. In addition, some significant differences between European and American populations exist, that is, between *Paraurostyla weissei* and *P. polymicronucleata*. The following description is based mainly on WIRNSBERGER et al. (1985b) and thus concerns the European populations (that is, *P. weissei*) unless otherwise indicated. Usually with 4 "an-

Fig. 212e–h *Paraurostyla weissei* complex (e, from MERRIMAN 1937; f, from HORVÁTH 1939a; g, from TURNER 1939; h, from HECKMANN 1965. e, g, h, from life; f, aniline blue-staining). e, g) *Paraurostyla polymicronucleata* (e; 225 μ m) and its synonym, *Urostyla coei* (g; 200 μ m). f, h) Two synonyms of *P. weissei*, namely *Urostyla lynchi* (f; 165 μ m) and *Urostyla hologama* (h; 120–180 μ m). Arrow in (h) marks the interruption in the rightmost frontoventral row which is caused by incomplete morphogenesis; p 844.

terior” frontal cirri (that is, the anterior-most cirri of streaks I–IV distinctly enlarged) and 2 “posterior” frontal cirri comprising the buccal cirrus and the cirrus behind the third frontal cirrus. Behind the fourth (rightmost) “anterior” frontal cirrus is the first frontoventral row (1. VR in Fig. 212r), which is separated into usually 3 slightly enlarged cirri in the frontal area and a short arched portion beginning near the buccal vertex (Fig. 212r; originating from same streak! See below). Second frontoventral row extends from frontal area to the left posterior quarter of the cell. Third row from pharynx to leftmost transverse cirri. Sometimes a very short ventral row follows (4. VR in Fig. 212r). Usually, 4th frontoventral row (5. VR in Fig. 212r) extends from distal end of adoral zone of membranelles to transverse cirri. Sometimes this row is interrupted or overlapping in mid-body, which is the result of incomplete morphogenesis (see below). Transverse cirri in

Fig. 212i–k *Paraurostyla weissei* (from FOISSNER et al. 1991. i, Normarski differential interference contrast; j, bright-field; k, scanning electron micrograph). i) Cortical granules, yellow-green, about 1 μm in diameter. j) Resting cyst with spines, 70–85 μm in diameter. k) Ventral view of anterior cell portion. AZM = adoral zone of membranelles, BC = buccal cirrus, p = paroral; p 844.

life about 20 μm long, hook-shaped arranged, rarely reaching posterior end of cell. Left marginal row J-shaped, approaches the dorsal side more or less. Dorsal cilia in life 3 μm long; number of kineties varying, Austrian population usually with 3 dorsomarginal kineties (Table 49, Fig. 212s). Caudal cirri in life about 11 μm long, often hardly distinguishable from cirri of left marginal row. Caudal cirri according to *Oxytricha* pattern (Fig. 24a), that is, on posterior end of dorsal kineties 1, 2, and 4; usually 3–5 cirri per kinety.

American populations (that is, *Paraurostyla polymicronucleata*) usually with only 3 enlarged “anterior” frontal cirri and 3 slightly enlarged “posterior” frontal cirri (Fig. 211d, e). Usually 4 frontoventral rows; third row begins near distal end of adoral zone of membranelles (Fig. 211e, arrow). Rightmost frontoventral row not composed of cirri of 2 streaks (WIRNSBERGER et al. 1985b). Transverse cirri not hook-shaped arranged. Usually 6 dorsal kineties, that is, only 2 dorsomarginal kineties.

JERKA-DZIADOSZ & BANACZYK (1983) described a naturally occurring variant with more than one left marginal row and having several phenotypic defects including modified shape, increased frequency of cortical reorganisations, slower growth rate (>24 h against 12–18 h; 20 °C), and formation of monsters.

Fig. 212l-n *Paraurostyla weissei* (from FOISSNER et al. 1991. l, m, scanning electron micrographs; n, protargol impregnation). l-n) Ventral infraciliature. Large arrow in (n) marks the discontinuity in the rightmost fronto-ventral row due to incomplete fusion of the cirri of the two rightmost cirral streaks. The small arrow marks fibrils originating from a cirrus. CC = caudal cirri, LMR = left marginal row, Ma = anterior macronuclear nodule, p = paroral, RMR = right marginal row, TC = transverse cirri; p 844.

Resting cyst spherical, in life about 70–85 μm across, with many spine-shaped, 4–6 μm long protuberances (Fig. 212j). Cyst wall in life about 4 μm thick, consists of 4 morphologically distinct layers. Ultrastructure and cytochemistry similar to that of other kinetosome-resorbing cysts. However, the cytoplasm shows characters of “urostyloid-type” cysts, indicating that *P. weissei* is a “transition ciliate” between the oxytrichids and urostylids (DELGADO et al. 1987). Specimens starving at 20 °C are unable to encyst (HECKMANN 1965).

M o r p h o g e n e s i s: This part of life cycle is described by JERKA-DZIADOSZ (1965), JERKA-DZIADOSZ & FRANKEL (1969), and WIRNSBERGER et al. (1985b). Morphogenesis of ventral ciliature is rather complicated, especially during early stages of streak formation. The general course is shown in Figures 212t–x, 213a–l. The following paragraphs are largely from WIRNSBERGER et al. (1985b), describing only important stages and differing observations to the paper by JERKA-DZIADOSZ & FRANKEL (1969).

Stomatogenesis: In the earliest stage of stomatogenesis small groups of basal bodies appear very close to the posterior-most cirri of the first frontoventral row (Fig. 212t). Somewhat later this anarchic field migrates slightly to the left (Fig. 212u). In the Austrian population the primordium of the undulating membranes of the opisthe is not formed “de novo”, as JERKA-DZIADOSZ & FRANKEL (1969) stated, but derives from disaggregation of 1–2 postoral cirri of the first frontoventral row.

Development of cirral primordia: The first 3 frontal-ventral-transverse streaks (without the primordium of the undulating membranes) in the proter originate either from the posterior 3 frontal cirri (JERKA-DZIADOSZ & FRANKEL 1969) or from the posterior 2 frontal cirri and the anterior-most cirri of the first frontoventral row (WIRNSBERGER et al. 1985b) proving that the right “posterior” frontal cirrus of the American populations (*P. polymicronucleata*) is homologous to the anterior part of the first frontoventral row of the European populations. Furthermore, this pattern agrees largely with the pattern of the 18-cirri oxytrichids (Table 4). The equivalent 3 frontal-ventral-transverse streaks in the opisthe separate from the posterior undulating membrane field, which develops from dispersion of basal bodies of 1–2 postoral cirri of the first frontoventral row (Fig. 212v, w, 213a). Later, these streaks later elongate (Fig. 213b, c). JERKA-DZIADOSZ & FRANKEL (1969) supposed that these streaks were apparently formed de novo, although involvement of some

Fig. 212u–x *Paraurostyla weissei* (from WIRNSBERGER et al. 1985b. u–x, morphogenetic stages after protargol → impregnation). u–w) Ventral infraciliature of very early and early stages, u = 170 μm , v = 230 μm , w = 200 μm . x) Dorsal infraciliature of an early stage, 205 μm . Explanation of original labels: DP = dorsal primordia within kineties 1–3, FVTP = frontal-ventral-transverse cirri primordia, UMP = primordium of the undulating membranes; p 844. Figures on p 860.

Fig. 213a–c *Paraurostyla weissei* (from WIRNSBERGER et al. 1985b. a–c, ventral infraciliature of morphogenetic stages after protargol impregnation). Middle stages showing formation of frontal-ventral-transverse cirri primordia and marginal primordia formation, a = 205 μm , b = 160 μm , c = 200 μm . 1–9 = frontal-ventral-transverse cirri primordia I–IX; p 844. Figures on p 861.

Fig. 213d–g. *Paraurostyloa weissei* (from WIRNSBERGER et al. 1985b. d–g, morphogenetic stages after protargol impregnation). d, f) Ventral infraciliature of middle stages showing segregation of new cirri and formation of dorsomarginal kineties, d = 180 μ m, f = 160 μ m. Parental structures white, new ones black. e, g) Dorsal infraciliature and nuclear apparatus of middle stages, e = 180 μ m, g = 208 μ m. Arrowheads mark fragmentation of dorsal kinety 3. DP = new dorsomarginal kineties of opisthe; p 844.

parental cirri cannot be completely ruled out. The remaining streaks develop from portions of the parental cirral rows (Fig. 213a, b). Typically, one streak originates within each row, except the 2 overlapping streaks associated with the farthest right ventral row in the anterior region (JERKA-DZIADOSZ & FRANKEL 1969). In the Austrian population the rule is that 2 streaks are built at a time in the 2 right ventral rows, in both proter and opisthe (Fig. 213c, d).

In the Austrian population usually 8, seldom 9, frontal-ventral-transverse cirri streaks are formed (WIRNSBERGER et al. 1985b), whereas JERKA-DZIADOSZ & FRANKEL (1969) report a greater variation of 5–9, mostly 6 or 7.

Differentiation of frontal-ventral-transverse cirri: European populations (*P. weissei*) usually have a higher number of transverse cirri (usually 8) than American populations (*P. polymicronucleata*; usually 6; Table 49). According to WIRNSBERGER et al. (1985b) the streaks segregate the following cirri: streak I (= streak 1 in Fig. 213c), left “anterior” frontal cirrus (homologous to cirrus I/1 of 18-cirri oxytrichids), undulating membranes; streak II, “anterior” frontal cirrus 2 (homologous to cirrus II/3 of 18-cirri oxytrichids), left “posterior” frontal cirrus (homologous to buccal cirrus [II/2] of 18-cirri oxytrichids), leftmost transverse cirrus; streak III, “anterior” frontal cirrus 3 (homologous to cirrus III/3) of 18-cirri oxytrichids), “right posterior” frontal cirrus (homologous to cirrus III/2 of 18-cirri oxytrichids), next transverse cirrus; streak IV, rightmost “anterior” frontal cirrus (often not very prominent), anterior (right of undulating membranes) and posterior (behind buccal vertex) part of first frontoventral row (1. VR in Fig. 212r), next transverse cirrus; streak V, second frontoventral row (2. VR in Fig. 212r), next transverse cirrus; streak VI, third frontoventral row (3. VR in Fig. 212r), next transverse cirrus; streak VII, posterior half of fourth frontoventral row (5. VR in Fig. 212r because this Figure shows a specimen with a “surplus” row [4. VR]), next transverse cirrus; streak VIII, anterior half of fourth frontoventral row, rightmost 2 transverse cirri (according to my terminology the anterior of these 2 transverse cirri is in fact a pretransverse ventral cirrus which is very likely homologous to cirrus VI/2 of the 18-cirri oxytrichids; furthermore, the conspicuous anteriad migration of the main portion of this streak implies that it is homologous to the migratory cirri [VI/3 and VI/4] of the 18-cirri oxytrichids).

The American populations differ from this pattern in the following details (JERKA-DZIADOSZ & FRANKEL 1969): the anterior part of the first frontoventral row consists of only 1 cirrus (instead of usually 3) and is thus considered as third (rightmost) posterior frontal cirrus (posterior-most arrow in Fig. 211d); the third frontoventral row begins more anteriorly, namely near the distal end of the adoral zone of membranelles (Fig. 211e, arrow) and not near the buccal vertex; the fourth (= rightmost) frontoventral row is the product of only 1 streak (very likely streak VII), that is, streak VIII, which produces 2 transverse cirri in the European strains, is lacking, resulting in usually 6 instead of 8 transverse cirri. The last difference especially (lack of streak VIII) is very conspicuous and should be checked again. The micrographs in JERKA-DZIADOSZ & FRANKEL (1969) do not allow an unequivocal interpretation because the stages are too early (Fig. 9) or too late (Fig. 10).

Fig. 213h-j *Paraurostyla weissei* (from WIRNSBERGER et al 1985b. h-j, morphogenetic stages after protargol impregnation). h, j) Ventral infraciliature of a late and a very late stage, h = 160 μ m, j = 187 μ m. Arrows mark the anterior portion of the rightmost streak which migrates anteriorly to fuse with streak on its left. In the opisthe of (j) this process is obviously already completed. Very likely, the anterior portion of the rightmost streak is homologous to the migratory cirri (VI/3, VI/4) of the 18-cirri oxytrichids. Parental structures white, new black. i) Dorsal infraciliature and nuclear apparatus of a late stage, 192 μ m; p 844.

Fig. 213k, l *Paraurostyla weissei* (from WIRNSBERGER et al. 1985b. k, l, protargol impregnation). Ventral and dorsal infraciliature and nuclear apparatus of an opisthe, 100 μ m. Parental structures white, new black; p 844.

Dorsal morphogenesis proceeds in *Oxytricha* pattern (JERKA-DZIADOSZ 1982), that is, kinety 3 shows simple fragmentation and 2 (American strains) or 3 (Austrian strains) dorsomarginal kineties occur. Division takes about 180 min (JERKA-DZIADOSZ 1965).

Conjugation is total in *Paraurostyla weissei*, that is, the left conjugant, the donor becomes absorbed into its mate, the recipient (Fig. 214; FRONTZAK-BANIEWICZ & JERKA-DZIADOSZ 1992, HECKMANN 1965, ILOWAISKY 1916, MOLDENHAUER 1965). It undergoes 3 rounds of cortical reorganisation. Remarkably, the first reorganisation is abortive: on the ventral surface only a minute adoral zone of membranelles primordium arises, which does not, however, give rise to membranelles; somatic cirral primordia are also absent. That the first reorganisation does occur is testified by the differentiation of bristle primordia on the dorsal surface. As in *Pseudourostyla cristata*, after the first cortical reorganisation the cell reabsorbs almost all ciliature, and rounds off to become a "zygocyst" before initiating the second reorganisation. The ciliature generated during the second reorganisation is incomplete, although the cell can feed. Normality is restored by the third reorganisation, which resembles a physiological reorganisation (NG 1990, p 40). Changes of cortical structures during conjugation and formation of single exconjugant were studied by HEUMANN (1975) and JERKA-DZIADOSZ & JANUS (1975).

Fig. 214a Total conjugation of *Paraurostyla weissei* (from JERKA-DZIADOSZ & JANUS 1975; continued in Fig. 214b). The open circles represent the frontal cirri, the striped fields the adoral zone of membranelles, the solid lines represent cirral rows. Primordial structures indicated as fields of fine dots. On left side of each drawing main features of nuclear apparatus. In 2-5 the drawing of the micronucleus applies to both mates, in 6-9 only to the right conjugant. On the right side of some drawings the time (in hours) since mating is indicated. 2) Formation of one common adoral zone of membranelles. 3) Beginning of resorption of the adoral zone of membranelles, micronuclei are swollen. 4) Resorption of ventral infraciliature in left mate. Micronuclei in early prophase. 5) Resorption of ventral and transverse cirri in the right mate. Tapering of both posterior ends. Micronucleus in parachute stage. 6) Proliferation of basal bodies on the ventral surface. Migration of pronuclei. 7) Proliferation of basal bodies of the dorsal primordia (small sketch at right side). Division of synkaryon; p 844.

Fig. 214b Schematic drawing of total conjugation of *Paraurostyla weissei* (from JERKA-DZIADOSZ & JANUS 1975; continued from Fig. 214a; see there for general remarks). 8) Resorption of ventral primordia and old ventral ciliature. Second division of synkaryon. 9) Formation of zygocyst. Resorption of ventral ciliature. Differentiation of new nuclei. 10) The zygocyst. The macronuclear anlagen and 2 micronuclei. 11) The primordia of ventral ciliature in the zygocyst. The anlagen of macronucleus and micronucleus in prophase. 12) Small exconjugant after the cortical reorganisation. Note the incomplete cortical pattern. Single macronucleus and 4 micronuclei. 13) The third cortical reorganisation. Formation of normal pattern. Micronucleus in telophase, macronucleus elongated. 14) The exconjugant after third cortical reorganisation showing normal pattern; p 844.

Table 49 Morphometric data of the two species of the *Paraurostyla weissei* complex (1, *P. weissei* from WIRNSBERGER et al. 1985b; 2, three *P. weissei* populations from Germany* and one from Poland from KRAMER 1988; 3, two Polish *P. weissei* populations from KRAMER 1988; 4, three North American *P. polymicronucleata* populations from KRAMER 1988). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	1	126.8	34.3	27.1	73	198	28
	2	162.5	-	-	130	212	135
	3	160.7	-	-	122	195	51
	4	172.6	-	-	141	206	73
Body, width	1	47.8	13.4	28.0	26	73	28
	2	50.3	-	-	22	72	133
	3	48.8	-	-	32	70	51
	4	50.8	-	-	35	76	72
Adoral membranelles, number	1	45.4	9.3	20.5	28	63	28
	2	48.2	-	-	35	62	59
	3	44.3	-	-	39	50	39
	4	52.5	-	-	49	58	28
Adoral zone of membranelles, length	1	47.1	10.2	21.7	30	66	28
Macronuclear nodules, number	1	2.0	0.2	9.3	2	3	28
	2	2.0	-	-	1	3	160
	3	1.8	-	-	1	3	51
	4	2.1	-	-	2	4	123
Macronuclear nodule, length	1	17.2	2.3	13.6	13	22	28
Macronuclear nodule, width	1	8.5	1.1	12.9	6	11	28
Micronuclei, number	1	4.0	0.9	21.8	3	6	28
	2	5.0	-	-	3	8	50
	3	4.2	-	-	0	11	25
	4	5.7	-	-	2	12	50
Micronucleus, length	1	5.0	0	0	5	5	28
Micronucleus, width	1	4.0	0	0	4	4	28
Left marginal row, number of cirri	1	34.8	7.2	20.6	20	59	28
	2	39.4	-	-	29	49	59
	3	39.4	-	-	28	47	37
	4	43.5	-	-	33	52	28
Right marginal row, number of cirri	1	35.0	6.1	17.4	24	46	28
	2	37.2	-	-	27	47	58
	3	37.3	-	-	29	44	36
	4	43.5	-	-	34	52	28
Frontoventral rows between marginal rows, number	1	3.9	0.54	13.7	3	5	28
	2	4.5	-	-	3	7	135
	3	4.1	-	-	3	5	51
	4	4.3	-	-	4	7	73
Frontoventral row 1, number of cirri	1	9.0	2.1	23.8	5	12	28
	2	9.2	-	-	2	14	59
	3	7.5	-	-	2	13	39
	4	7.4	-	-	4	11	27
Frontoventral row 2, number of cirri	1	15.3	2.4	15.9	10	19	28
	2	14.4	-	-	8	19	60

Table 49 Continued

Character	Species	mean	SD	CV	Min	Max	n
Frontoventral row 2, number of cirri	3	13.7	-	-	5	26	39
	4	14.7	-	-	8	18	27
Frontoventral row 3, number of cirri	1	14.4	4.4	30.1	6	27	28
	2	14.9	-	-	3	23	60
	3	13.7	-	-	5	26	39
	4	25.4	-	-	16	30	27
Frontoventral row 4, number of cirri	1	25.2	7.2	28.7	8	35	23
	2	21.2	-	-	2	34	58
	3	23.4	-	-	3	33	35
	4	32.5	-	-	22	39	27
Frontoventral row 5, number of cirri	1	24.3	7.5	30.8	20	33	3
	2	25.6	-	-	7	34	26
	3	27.3	-	-	25	30	6
	4	30.7	-	-	27	34	3
Frontoventral row 6, number of cirri	2	19.3	-	-	8	35	3
Frontoventral row 7, number of cirri	2	21.0	-	-	-	-	1
Ventral cirri, total number	1	61.9	14.3	23.1	34	86	28
Anterior frontal cirri, number	1	3.9	0.3	6.7	3	4	28
	2	3.9	-	-	3	5	135
	3	3.1	-	-	3	4	50
	4	3.0	-	-	3	3	73
Posterior frontal cirri, number	1	2.0	0	0	2	2	28
	2	2.0	-	-	2	2	135
	3	1.8	-	-	1	2	50
	4	3.0	-	-	3	3	73
Transverse cirri, number	1	7.8	0.7	9.0	6	9	28
	2	8.4	-	-	7	10	135
	3	7.3	-	-	5	9	50
	4	6.4	-	-	6	8	71
Dorsal kineties, number	1	7.2	0.9	12.0	6	8	28
	2	6.5	-	-	6	9	62
	3	6.1	-	-	6	7	40
	4	5.3	-	-	5	6	22
Caudal cirri, number	1	13.5	1.8	13.5	10	18	23
	2	11.4	-	-	9	16	69
	3	10.7	-	-	7	13	44
	4	13.4	-	-	11	16	32

Species of the *Paraurostyla weissei* complex are the object of numerous studies concerning mainly morphogenetic processes, ultrastructure, genetics, and biochemistry: BAKOWSKA (1980, 1981), BAKOWSKA & JERKA-DZIADOSZ (1977, 1978, 1980), BALBIANI (1862), BRÉ et al. (1994), BRUGEROLLE & ADOUTTE (1988), DELGADO & FLEURY (1993), DUBIELECKA & JERKA-DZIADOSZ (1989), ENGELMANN (1875), FAURÉ-FREMIET (1945a, 1948), FLEURY & GUYADER (1990), FLEURY & LAURENT (1993, 1994), FLEURY et al.

(1993), FRANKEL (1973, 1974, 1975), JERKA-DZIADOSZ (1967, 1972, 1974, 1976, 1977, 1980, 1981a–c, 1983, 1985, 1987, 1989, 1990), JERKA-DZIADOSZ & BEISSON (1990), JERKA-DZIADOSZ & CZUPRYN (1997), JERKA-DZIADOSZ & DUBIELECKA (1985), JERKA-DZIADOSZ & FRANKEL (1970), JERKA-DZIADOSZ & GOLIŃSKA (1977), JERKA-DZIADOSZ & WIERNICKA (1992), JERKA-DZIADOSZ et al. (1989a, b), KRAUT et al. (1986), LAURENT & FLEURY (1994), LAURENT et al. (1992), PUYTORAC et al. (1994), RAIKOV (1989), SAPRA et al. (1985), SCHLEGEL & STEINBRÜCK (1986), STEINBRÜCK (1990), TUFFRAU (1965a).

Occurrence and ecology: Very common all over the year in moderately to heavily polluted freshwater habitats; benthic. Locus classicus is Niemegek, a small town near Berlin, Germany, where STEIN (1859b) discovered *Paraurostyla weissei* in slowly running waters covered with *Lemna* sp. He also found it in Tharandt, a village near Dresden, Germany, and Prague, Czechoslovakia. According to STEIN (1859b) it was very abundant in shaded ditches and ponds, especially when they were almost desiccated, that is, when *Lemna* almost rested upon the decaying leaf litter. It also occurred very abundantly – together with *Stylonychia mytilus* and *Urostyla grandis* – in collecting jars when *Lemna* began to putrefy. Locus classicus of the synonym *Urostyla flavicans* is Warsaw, Poland, where WRZESNIEWSKIEGO (1867a, b; see also WRZESNIEWSKI 1870) discovered it in a small pond among *Lemna minor*. STOKES (1894) discovered the synonym *Urostyla vernalis* near Trenton, New Jersey, USA, in shallow wayside pools in the early spring. Locus classicus of the synonym *Urostyla paragrandidis* is Pe Ji Koh, Nanking, China, where WANG (1930) discovered it in great abundance in a shallow *Sphagnum* pond in May and June. Locus classicus of *Paraurostyla polymicronucleata*, the second species of the complex, is the Edgewood Park near the outskirts of New Haven, Connecticut, USA, where MERRIMAN (1937) discovered it in a small pool close to the edge of the West River in autumn. New Haven is also the locus classicus of the synonym *Urostyla coei*, where TURNER (1939) discovered it in the Mill River. Locus classicus of the synonym *Urostyla lynchi* is Lengyelkápólna near Szeged, Hungary, where HORVÁTH (1939a) discovered it in moss; unfortunately, he did not mention if the moss was from a freshwater or from a terrestrial habitat. Locus classicus of the synonym *Urostyla hologama* is probably a lake (Federsee) at the village of Bad Buchau, Germany (HECKMANN 1965).

Records of the *Paraurostyla weissei* complex substantiated by illustrations: on sediment on the shore of an oligotrophic lake (Mondsee) in Austria (WIRNSBERGER et al. 1985b); pond in Thonon-les-Bains, France (DRAGESCO 1966b); mesosaprobic running waters in Germany (FOISSNER et al. 1991, 1992a, b); common, but not very abundant in various running waters of Nordwürttemberg, Germany (BUCK 1959, 1961); ponds and small running waters near Bonn, Germany (PÄTSCH 1974); bog in Germany (MOLDENHAUER 1965); Moldova (CHORIK 1968); pond and rivers in Poland (JERKA-DZIADOSZ 1965); Bucharest, Romania (VUXANOVICI 1963); Swan Lake, Johnson County, Iowa, USA (JERKA-DZIADOSZ & FRANKEL 1969); Tibetan plateau (SHEN 1983).

Records not substantiated by illustrations: among algae and mosses in springs near Vienna, Austria (KÜHN 1940); among *Sphaerotilus* and detritus in heavily polluted run-

ning water in Austria (STRUHAL 1969); Tyrol, Austria (DALLA TORRE 1891); with 0.7–9.7 % frequency in Bulgarian rivers (DETCHIEVA 1979a–c, 1981, 1986, 1991); saprobic brook and Moldavia River near Prague, Czechoslovakia (BUCHAR 1957, KALMUS 1928, ŠRÁMEK-HUŠEK 1953); *Cymbella* aufwuchs on stalks of *Phragmites* in a lake (Obersee) near Reval and in ponds in Estonia (JACOBSON 1928, SCHNEIDER 1909); with very high abundance (10 800 ind. ml⁻¹) in the Kahmhaut of a 17 d old waste water, Leipzig, Germany (LIEBMANN 1936); alphamesosaprobic running waters in Germany (BEER 1958, CASPERS & SCHULZ 1962, KLAPPER 1963, REICHENBACH-KLINKE 1959, ZIEMANN 1985); benthal and aufwuchs of Hamburg Harbour and Elbe River upstream from Hamburg, Germany (BARTSCH & HARTWIG 1984, GRIMM 1968, TENT 1981); cooling plant of a power station in Germany (BERNERTH 1982); mesotrophic lake in Germany (MÜCKE 1979); bogs in Germany (SCHEFFELT 1922); rarely in mine-water and in caves in Germany (GITTLESON & HOOVER 1969, GRIEPENBURG 1934, 1935, WETZEL 1929; further records from Germany: LEVANDER 1892, WETZEL 1928a, b); Hungary (DADAY 1891); Latvian rivers (LIEPA 1978); the Netherlands (VERSCHAFFELT 1930, WIERSMA-VERSCHAFFELT 1936); Henares River, Spain (SOLA et al. 1996); Sweden (QUENNERSTEDT 1865); littoral of Lake Geneva, Switzerland (ANDRÉ 1912, 1916; further records from Switzerland: MERMOD 1914, RIGGENBACH 1922); reservoir in Azerbaijan (ALEKPEROV 1984b, c); cooling plant in Moldova (CHORIK & VIKOL 1973); moss-puddle near Helsinki, Finland (LEVANDER 1894a); Danube River in Romania (ENACEANU & BREZEANU 1970); Palestine (BODENHEIMER 1937, LEPSI 1929a); Tibet (WANG 1977); Lake Onega, USSR (MERESCHKOWSKY 1877, 1879); rivers (for example, Oka, Volga) in the USSR (MAMAEVA 1979a, b, NEISWESTNOWA-SHADINA 1935, SASSUCHIN 1924, 1930, SASSUCHIN et al. 1927, SHADIN 1940, SHADIN et al. 1931); amongst putrefying algae and other sites in Lake Baikal, USSR (GAJEVSKAJA 1927, GAJEVSKAJA 1933, ROSSOLIMO 1923); Turkestan, USSR (DADAY 1903, 1904; further record from the USSR: MINKÉWITSCH 1898); Yuelushan Area, China (YANG 1989); pond water in Punjab, Lahore, India (BHATIA 1936); paddy fields in Japan (TAKAHASHI & SUHAMA 1991); Argentina (SECKT 1924); Brazil (CUNHA 1913, PROWAZEK 1910); pond in Cameroon (NJINE 1977); paddy field near Tamatave, Madagascar (SONDHEIM 1929).

MIHAILOWITSCH (1989) found *Paraurostyla weissei* predominantly at low salinity (0–200 mg l⁻¹ Cl⁻), KLAPPER (1963) at up to 6.6 g l⁻¹ Cl⁻. BOUTCHINSKY (1895), BUTSCHINSKY (1897), WILBERT (1995), and ZACHARIAS (1888) recorded it from saline lakes in the USSR, Canada, and Germany.

Also in trickling filters (CURDS 1975, LIEBMANN 1962) and activated sludge (KLIMOWICZ 1973, LIEBMANN 1962); however, *Paraurostyla weissei* avoids water with liquid manure (LIEBMANN 1962). KLIMOWICZ (1972) counted 383 000 ind. l⁻¹ in an activated sludge plant under the following conditions: mean loading of aeration tank 0.144 kg BOD₅ m⁻³ d⁻¹; mean loading of activated sludge 0.0385 kg BOD₅ kg⁻¹ d⁻¹; mean concentration of activated sludge 3.9 kg m⁻³; time of sewage aeration about 20 h d⁻¹; destruction of organic matter 90.4 %; mean oxygen content in aeration tank 3.6 mg l⁻¹; mean temperature of activated sludge 4–9 °C; mean pH of effluent and affluent 7.8 and 7.3 respectively.

Records from terrestrial habitats (COPPA 1921, GREEFF 1889, ROSA 1957a, Fig. 218b; VARGA 1961) unreliable, although resting cysts are formed (Fig. 212j).

Feeds on bacteria, algae (green algae, diatoms, desmidiaceans), flagellates (*Chilomonas*), testaceans (*Arcella*), ciliates (*Tetrahymena pyriformis*, *Colpidium*), and detritus (BICK 1972a, BICK & KUNZE 1971, FAURÉ-FREMIET 1961a, JERKA-DZIADOSZ 1965, KAHL 1932, KALMUS 1928, MERRIMAN 1937, MOLDENHAUER 1965, WANG 1930, WIRNSBERGER et al. 1985b). Also ingests starch, which is digested within 3 days (STRUHAL 1969). TURNER (1939) observed a specimen ingesting a small nematode. The worm survived in an active condition within the ciliate until the latter died 3 days later without dividing. Also cannibalistic (MOLDENHAUER 1965).

WIRNSBERGER et al. (1985b) used tap water as culture medium, and yeast and a species of the *Tetrahymena pyriformis* complex, grown on dry egg yolk, was added as food. JERKA-DZIADOSZ & FRANKEL (1969) maintained long-term stocks of *P. polymicronucleata* as steady-state cultures containing Pringsheim solution and a food-chain made up of a few wheat and rice grains, bacteria, *Tetrahymena*, and *Paraurostyla*. Under these conditions the *Tetrahymena* population is kept at low density, and overfeeding of the *Paraurostyla* is avoided – overfed *P. weissei* cannot reproduce and eventually die. Length of cell cycle 24 h at about 23 °C in Pringsheim medium and fed daily with *Chlorogonium elon-*

Fig. 215a–d *Apoamphisiella hymenophora* (a, from STOKES 1886; b, from LUNDIN & WEST 1963; c, d, from GRIMES & L'HERNAULT 1978. a, b, from life; c, d, after protargol impregnation and scanning electron microscopy). a, b) Ventral views, a = 170–205 µm, b = size not indicated. c) Ventral infraciliature, size not indicated. Arrow marks the single postoral ventral cirrus. This population differs from (a, b) in that (i) the undulating membranes are distinctly curved, (ii) the left frontoventral row begins more anteriorly, and (iii) more (6–7 against 5) transverse cirri are present. d) Ventral infraciliature of an early morphogenetic stage; p 786.

gatum (AMMERMANN & MUENZ 1982). According to JERKA-DZIADOSZ (1965) well fed *P. weissei* divides 1–3 times per day at 18–20 °C.

BICK & KUNZE (1971) provided the following autecological data (summarised from literature): 0.3–7.8 mg l⁻¹ O₂, 13.5–24.5 mg l⁻¹ BOD₅. Avoids less than 3 mg l⁻¹ O₂ and pH < 6.5 (LIEBMAN 1962). Conversely, MATIS (1975) recorded *P. weissei* in a drainage at 1.3–2.2 mg l⁻¹ O₂ (15–20 °C, pH 6.9). DETCHEVA (1972a, 1975a, b, 1976b, 1979c, 1982b, 1983b, c, 1993) found it in Bulgarian running waters at following conditions: 0.9–3.3 % frequency, 9–24 °C, pH 7.4–7.8, 5.8–11 mg l⁻¹ O₂ (54–100 % saturation), 1.5–15.7 mg l⁻¹ BOD₅, 54–195 mg l⁻¹ Ca²⁺, 0–80 mg l⁻¹ Mg²⁺, 155–283 mg l⁻¹ HCO₃⁻, 58–941 mg l⁻¹ SO₄²⁻, 13–257 mg l⁻¹ Cl⁻, 0.02–1.53 mg l⁻¹ NH₄⁺-N, 0.3–11.2 mg l⁻¹ NO₃⁻-N, 0–0.12 mg l⁻¹ NO₂⁻-N, 0–1.5 mg l⁻¹ Fe²⁺. MIHALOWITSCH (1989) provided following autecological data (n = 4–5) from populations found in salt-polluted running waters in Germany: 4.2–20.5 °C, pH 7.6–7.9, 18.6–89.4 mg l⁻¹ CO₂, 8.0–9.3 mg l⁻¹ O₂, 0.09–0.5 mg l⁻¹ NH₄⁺-N, 0.04 to 0.1 mg l⁻¹ NO₂⁻-N, 2.3–3.0 mg l⁻¹ NO₃⁻-N.

Species of the *Paraurostyla weissei* complex are indicators of polluted waters (for example, KOLKOWITZ 1950, KOLKOWITZ & MARSSON 1909, MARSSON 1903, MAUCH 1976). SLÁDEČEK et al. (1983), WEGE (1983), and FOISSNER (1988a) classified it as strict alphamesosaprobic species (a = 10). However, *P. weissei* occurs in a rather wide BOD-range, proving that this classification is unrealistic. FOISSNER et al. (1991) thus changed it to a; b = 2, a = 7, p = 1, I = 3, SI = 2.9.

Supposed synonym of the *Paraurostyla weissei* complex

Oxytricha multipes CLAPARÈDE & LACHMANN, 1858

1858 *Oxytricha multipes* CLAPARÈDE & LACHMANN, Mém. Inst. natn. génev., 5: 143, Planche 5, Fig. 1.

1876 *Kerona multipes* – FROMENTEL, Microzoaires, p 271, Planche XIII, fig. 19 (insufficient redescription).

1932 *Urostyla (Oxytricha) multipes* CLAP. u. L., 1858 – KAHL, Tierwelt Dtl., 25: 567, Fig. 97₂₁ (redrawing from original description).

1972 *Urostyla multipes* (CLAPAREDE & LACHMANN, 1858) KAHL, 1932 – BORROR, J. Protozool., 19: 9.

1974 *Urostyla trichogaster* STOKES, 1885 var. *multipes* (CLAPAREDE & LACHMANN, 1858) comb. n. – STILLER, Annls hist.-nat. Mus. natn. hung., 66: 132.

Remarks: Synonymy of *Oxytricha multipes* and *Paraurostyla weissei* is evident and was already proposed by KENT (1882, p 765). Differences are very likely due to some minor misobservations both by CLAPARÈDE & LACHMANN (1858) and STEIN (1859b). To avoid suppression of the well established name *Paraurostyla weissei* I consider *Oxytricha multipes* as supposed synonym. Only 2 faunistic records (HASSDENTEUFLOVÁ-MORAVCOVÁ 1955, LIEPA 1978).

Previously, I also considered *Oxytricha urostyla* CLAPARÈDE & LACHMANN, 1858 (p 141, Planche 5, fig. 2) as supposed synonym of *Paraurostyla weissei* (FOISSNER et al.

1991, p 260). However, this species has about 10 frontal cirri arranged in a bicorona, strongly suggesting that it is not identical with *P. weissei* (see Fig. 227l, m).

***Paraurostyla granulifera* BERGER & FOISSNER, 1989 (Fig. 216a–f, Table 50)**

1989 *Paraurostyla granulifera* BERGER & FOISSNER, Bull. Br. Mus. nat. Hist. (Zool.), 55: 29 (type slides [holotype: reference number 1988:2:1:20; paratype: 1988:2:1:21] are deposited in the British Museum of Natural History in London).

Taxonomy: The ventral infraciliature is almost identical to that of *Trichotaxis fossicola* KAHL (Fig. 217; note that *Trichotaxis* is an incorrect subsequent spelling of *Trichototaxis*). However, we avoided an identification since KAHL (1932) did not mention extrusomes. But this argumentation is weak because KAHL (1932) did not even described the conspicuous mucocysts of *Paraurostyla weissei*. I thus propose *T. fossicola* as supposed synonym of *P. granulifera* (see below). Redescription of a European population should be awaited before definitive synonymisation.

Morphology and biology: In life 170–230 × 70–100 µm. Right margin straight, left convex and in the anterior portion markedly indented. Anterior and posterior end rounded. Flattened about 2:1 dorso-ventrally. Flexible. Invariably (n = 7) 2 macronuclear nodules, distinctly left of median. Micronuclei in life about 7 × 5 µm. Contractile vacuole in about mid-body, during diastole with canals. Perpendicular to pellicle very many, about 2 × 1 µm sized, colourless cortical granules (extrusomes). Individual extrusomes difficult to discern because very closely spaced, forming a distinct lucent seam giving the organism a brownish colour at low magnification. Extrusomes ejected after addition of methyl green-pyronin, stain red, U- or horseshoe-shaped; among these extrusomes many thin structures, probably fully exploded extrusomes. Cytoplasm colourless with many crystals and food vacuoles. Rapid movement.

Adoral zone of membranelles about 40 % of body length, bases of largest membranelles in life about 8 µm wide. Undulating membranes slightly curved, almost of same length, paroral consists of short oblique kineties, at least in middle part. Invariably 3 (n = 7) distinctly enlarged frontal cirri. Invariably 1 (n = 7) buccal cirrus near anterior end of paroral. Bases of buccal cirrus, the cirrus behind right frontal cirrus (invariably 1; n = 7), and the in life about 25 µm long frontal cirri distinctly enlarged. Left and right frontoventral row begin about at level of the cirrus behind right frontal cirrus, left one terminates about in mid-body, right one at the transverse cirri like the middle row, which begins at about level of buccal vertex. One or 2 slightly enlarged postoral ventral cirri (Fig. 216f, arrow). Transverse cirri in life about 30 µm long, terminate at posterior edge of cell. Marginal rows almost confluent posteriorly, cirri in life about 20 µm long. Invariably (n = 7) 3 caudal cirri. Dorsal cilia short. Dorsal infraciliature unknown because hidden by the extrusomes, which often stain with protargol.

Fig. 216a-f *Paraurostyla granulifera* (from BERGER & FOISSNER 1989a. a-d, from life; e, methyl green-pyronin stain; f, protargol impregnation). **a)** Ventral view, 195 μm . **b)** Right lateral view. **c)** Dorsal view showing the arrangement of the extrusomes (right half of illustration) and the contractile vacuole. **d, e)** Extrusomes in lateral view and after ejection. **f)** Ventral infraciliature, 225 μm . Arrow marks single postoral ventral cirrus, arrowhead marks caudal cirri; p 874.

Occurrence and ecology: Locus classicus is Ryu-Ga-Take Mountain, Amakusa, Kumamoto Prefecture, Japan, where we (BERGER & FOISSNER 1989a) discovered *Paraurostyla granulifera* in the soil of deciduous forest at 470 m above sea level. This is a brown soil with many fragments of leaves and roots and pH 4.8. Not found since. Feeds on fungal spores, flagellates, cysts of amoebas, and testaceans (*Trinema enchelys*).

Supposed synonym: *Trichotaxis fossicola* KAHL, 1932, Tierwelt Dtl., 25: 589 (Fig. 217). Remarks: KAHL (1932) classified *Tricho-*

Fig. 217 *Trichotaxis fossicola* from life (from KAHL 1932). Supposed synonym of *Paraurostyla granulifera*, 200 μm . Note the single postoral ventral cirrus between buccal vertex and anterior macronuclear nodule.

Table 50 Morphometric data of *Paraurostyla granulifera* (from BERGER & FOISSNER 1989a). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	211.9	17.4	8.2	195	240	7
Body, width	92.7	12.7	13.7	70	112	7
Adoral membranelles, number	59.9	3.2	5.4	55	65	7
Adoral zone of membranelles, length	84.0	5.4	6.4	73	90	7
Macronuclear nodules, distance between	35.0	4.4	12.5	27	39	7
Posterior macronuclear nodule, length	26.1	4.0	15.4	22	34	7
Posterior macronuclear nodule, width	13.9	0.9	6.5	13	15	7
Micronuclei, number	4.1	1.1	25.8	3	6	7
Posterior micronucleus, length	5.8	0.9	15.5	4	7	7
Posterior micronucleus, width	3.4	0.5	15.6	3	4	7
Left marginal row, number of cirri	48.0	5.3	11.0	40	56	7
Right marginal row, number of cirri	40.0	1.8	4.6	38	43	7
Frontoventral rows, number	3.0	0	0	3	3	7
Left frontoventral row, number of cirri	18.3	2.4	13.3	15	22	7
Middle frontoventral row, number of cirri	14.0	2.0	14.3	12	18	7
Right frontoventral row, number of cirri	31.1	1.7	5.4	30	34	7
Postoral ventral cirri, number	1.4	0.5	37.4	1	2	7
Ventral cirri near transverse cirri, number	2.0	0	0	2	2	7
Transverse cirri, number	7.0	0.6	8.2	6	8	7
Distance 1 ¹	30.0	6.7	22.3	21	39	7

¹ Distance between base of posterior-most transverse cirrus and posterior end of cell.

taxis (an incorrect subsequent spelling of *Trichototaxis*) as subgenus of *Holosticha*; the correct name in his revision is thus *Holosticha (Trichotaxis) fossicola*. BORROR (1972a, p 10) transferred it to *Paraurostyla*, *P. fossicola*. HEMBERGER (1982, p 30) proposed synonymy with *P. weissei*, which sometimes also has only 3 ventral rows. However, the single postoral ventral cirrus is reminiscent of *Paraurostyla granulifera*. I preliminarily avoid a final synonymisation with our species because KAHL (1932) did not mention extrusomes and it is known that almost identical species with and without cortical granules exist. Furthermore, his population is from freshwater. However, further studies are needed to solve this problem.

In life 200–220 µm long, slenderly elliptical. Two macronuclear nodules, each with a single micronucleus. 4–5 enlarged frontal cirri, that is, 3 frontal cirri, 1 buccal cirrus, and 1 cirrus behind right frontal cirrus. 7–8 transverse cirri, protrude only slightly beyond posterior end of cell (at first KAHL found 4 or 5 specimens without transverse cirri). Three frontoventral rows, middle one beginning at level of buccal vertex. Marginal cirri almost confluent posteriorly, distinctly protruding beyond posterior end of cell. Locus classicus unknown, but very likely near Hamburg, Germany, where KAHL (1932) lived and worked. He found it only once with high abundance in freshwater on dead leaves covered with al-

Fig. 218a *Paraurostyla polynucleata* (from ALEKPEROV 1993). Ventral infraciliature after Chatton-Lwoff silver impregnation and nuclear apparatus after Feulgen staining, 95 μm . Arrowhead marks curved cirral row behind frontal cirri. Large arrow marks pore of contractile vacuole. Tiny arrows mark anterior end of left and posterior end of middle frontoventral row respectively.

Fig. 218b, c Insufficient redescrptions of *Paraurostyla weissei* (b, from ROSA 1957a; c, from GULATI 1925; b, c, from life). Ventral views, b = size not indicated, c = 130 $\times$ 42 μm ; p 878.

gae during spring. Records not documented by illustrations: benthal of Hamburg harbour, Germany (BARTSCH & HARTWIG 1984); in a reservoir of the Seversky Donets Basin, Ukraine (KRAVCHENKO 1969). Feeds on diatoms (KAHL 1932).

***Paraurostyla polynucleata* ALEKPEROV, 1993 (Fig. 218a)**

1993 *Paraurostyla polynucleata* ALEKPEROV, Zoosystematica Rossica, 2: 26 (holotype slide L(S-R) No. 3 is deposited in the Institute of Zoology, Academy of Sciences of Azerbaijan, Baku).

T a x o n o m y: Detailed redescription and morphogenesis are needed to confirm the classification in *Paraurostyla*.

M o r p h o l o g y a n d b i o l o g y: In life 150–170 μm long, fixed cells up to 155 μm . Body elliptical to oval, slightly flattened dorso-ventrally. Nine ellipsoidal to reniform macronuclear nodules, 5–7 micronuclei. Contractile vacuole about at level of

buccal vertex. Cytoplasm (endoplasm) light brown, without inclusions. Adoral zone of membranelles about 37 % of body length, 55–60 adoral membranelles. Three distinctly enlarged frontal cirri. Behind them 6 slightly enlarged cirri form a curved row beginning near left frontal cirrus and terminating slightly in front of posterior end of buccal row. Four buccal cirri. Left cirral row beginning at level of buccal vertex, terminating close to right transverse cirrus. Middle frontoventral row beginning near distal end of adoral zone of membranelles, ending slightly behind mid-body. Right frontoventral row also beginning near distal end of adoral zone, slightly shortened posteriorly; according to original description this is the inner right marginal row (morphogenesis is needed to ascertain the correct terminus). Nine obliquely arranged transverse cirri. Four “complete” dorsal kineties and one shortened, that is, dorsal kineties very likely in *Oxytricha* pattern with 1 dorsomarginal row. Caudal cirri not mentioned, that is, either absent or almost indistinguishable from marginal cirri and thus overlooked.

O c c u r r e n c e: Locus classicus is Repino near St. Petersburg, Russia, where ALEKPEROV (1993) discovered *Paraurostyla polynucleata* in soil.

Insufficient redescriptions

Urostyla weissei – ROSA, 1957, Přírodov. Sb. ostrav. Kraje, 18: 45 (Fig. 218b). Remarks: In life 250 µm long. Soil in Czechoslovakia.

Urostyla weissii STEIN – GULATI, 1925, J. Bombay nat. Hist. Soc., 30: 752 (Fig. 218c). Remarks: Incorrect subsequent spelling. In life 130 × 42 µm. Long elliptical, slightly converging anteriorly. Very flexible. Many macronuclear nodules. Contractile vacuole slightly behind mid-body. Yellowish. Adoral zone of membranelles slightly more than one third of body length. 3–5 frontal cirri, 5 ventral rows, 7–8 transverse cirri. Marginal rows confluent posteriorly. Among filamentous algae in freshwater from Lahore, India. Especially the nuclear apparatus indicates that the identification is wrong.

Parentocirrus VOSS, 1997

1997 *Parentocirrus* Voss, Europ. J. Protistol., 33: 31 – Type (original designation): *Parentocirrus hortualis* Voss, 1997.

C h a r a c t e r i s a t i o n: Body little flexible. Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Numerous frontoventral cirri arranged in at least two longitudinal rows. One left and 1 right row of marginal cirri. Six dorsal kineties. Caudal cirri present. Six frontal-ventral-transverse cirri primordia, number of cirri originating from primordia II–VI distinctly increased (compared with 18-

cirri oxytrichids). Rightmost frontoventral row not involved in primordia formation. Dorsal morphogenesis in *Oxytricha* pattern.

T a x o n o m y: See relevant chapter of single species.

Single species

Parentocirrus hortualis VOSS, 1997 (Fig. 218d–k, Tables 50.1, 50.2)

1997 *Parentocirrus hortualis* Voss, Europ. J. Protistol., 33: 31 (Fig. 218d–h, j, k; two slides of protargol-impregnated specimens with the holotype and several paratypes and one slide with specimens in divisional morphogenesis are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria. Accession numbers: 27–29/1996).

T a x o n o m y: In *Parentocirrus hortualis* dorsal morphogenesis proceeds according to the *Oxytricha* pattern (Fig. 218k) strongly indicating that it is a member of the Oxytrichidae. Conversely, Voss (1997) assigned it to the Kahliellidae because three long ventral rows on the right side of the body and V-shaped primordia are present; furthermore, frontoventral row 6 (Fig. 218h) is not involved in primordia formation. However, all three characters are unspecific and do not prevent a classification in the Oxytrichidae. Unfortunately, as in some other taxa which do not have the typical 18-cirri pattern (for example, *Paraurostyla*, *Gastrostyla*), I am unable to decide whether *Parentocirrus* is a “primitive” member of the oxytrichids or a “18-cirri oxytrichid” with a secondarily increased number of cirri. EIGNER (1997) classified it in the Parakahliellidae.

M o r p h o l o g y a n d b i o l o g y: In life 160–225 × 75–105 µm. Outline elliptical, both ends broadly rounded, flattened about 2:1 dorso-ventrally. Body little flexible. Nuclear apparatus left of median. Contractile vacuole about in mid-body, with two inconspicuous collecting canals during diastole. Cytoplasm colourless, with many cytoplasmic crystals and yellowish fat globules; hence, cells darkish in bright field at low magnification. Cytoplasm of well-fed specimens with inconspicuous spherical inclusions, 1–2 µm across, do not stain with protargol or methyl green-pyronin, “no special cortical granules” (important note: according to the legend of Figure 3 in the Voss paper [= Fig. 218f in the present book] “Conspicuous cortical granules which do not stain with methyl green-pyronin”); consequently, this character has to be checked in further populations! Newly excysted specimens appear slim, anterior portion of body bent to the left, cytoplasm clear and colourless.

Adoral zone of membranelles about 50 % of body length (according to Table 50.1, about 46 %). Buccal area large and deep, opens and enlarges by shifting undulating membranes to right body margin; thus, cell is able to ingest very large food particles. Undulating membranes in *Oxytricha* pattern, that is, curved and crossing optically; endoral termi-

Fig. 218d–g *Parentocirrus hortualis* (from Voss 1997. d–g, from life). **d)** Ventral view, 200 μm . **e)** Resting cyst, 85 μm . **f)** Detail of surface showing “conspicuous cortical granules which do not stain with methyl green-pyronin” (original figure legend); however, according to text “no special cortical granules” present (bar scale division = 5 μm). **g)** Body shape of a recently encysted specimen; p 879.

nates at proximal end of adoral zone of membranelles, paroral slightly in front of it (Fig. 218h). Cirri in life about 25 μm long. Bases of frontal cirri distinctly enlarged. Arrangement of frontoventral rows, see Figure 218h. I have no doubt that the frontoventral cirral rows 1–6 (Fig. 218h) are homologous to the primordia I–VI of the 18-cirri oxytrichids (Fig. 6a). 3–4 only slightly enlarged transverse cirri (thus, the mean of 4.1 in Table 1 of Voss 1997 is probably incorrect), do not protrude beyond posterior end of cell (Fig. 218d). Marginal rows slightly separated posteriorly. Dorsal kineties 1–4 about as long as body, kinety 5 about half of body length with 10–13 basal body pairs, kinety 6 usually with 5–7 pairs; rarely a third dorsomarginal kinety (kinety 7) present. Dorsal cilia in life about 6 μm long. Usually 1 caudal cirrus each at posterior end of dorsal kineties 1, 2, and 4, that is, as in most oxytrichids.

Fig. 218h, i *Parentocirrus hortualis* (h, from Voss 1997; i, original kindly supplied by H. BLATTERER, Linz; h, protargol impregnation; i, from life). h) Ventral infraciliature (168 µm) and nuclear apparatus. Cirri originating from same cirral primordium are connected by a dashed line. Arrows mark filamentous tie between macronuclear nodules. i) Ventral view, 165 µm. 1–6 = frontal-ventral-transverse cirri anlagen I–VI; p 879.

Rarely specimens with a supernumerary cirral row: 1.1 % (17 of 1534 specimens) with a row between frontoventral row 6 and right marginal row, 0.6 % with a cirral row between frontoventral rows 5 and 6, 0.06 % with a cirral row between frontoventral rows 4 and 5, and 0.3 % with a supernumerary left marginal row. Slow movement, creeping and gliding on substratum, sometimes resting for a moment.

Resting cysts about 42–74 µm in diameter (Table 50.1; according to Fig. 218e, however, about 80–85 µm!), outer cyst wall covered with scaly, hyaline, mucous layer, inner wall smooth.

M o r p h o g e n e s i s: Detailed description and documentation with illustrations and micrographs of protargol-impregnated specimens, see Voss (1997). Some important data are summarised in Table 50.2. The right frontoventral row is not involved in primordia

Fig. 218j, k *Parentocirrus hortualis* (from Voss 1997. j, k, protargol impregnation). j) Dorsal infraciliature, 170 µm. k) Middle stage of dorsal morphogenesis, 190 µm. Arrows mark fragmentation of new dorsal kineties 3. CC = caudal cirri (on dorsal kineties 1, 2, and 4), 1-6 = dorsal kineties 1-6 (kineties 5 and 6 are dorsomarginal rows); p 879.

formation; this is a very important difference to *Apoamphisiella*, where both frontoventral rows are involved. Dorsal morphogenesis of *Parentocirrus* proceeds in *Oxytricha* pattern indicating that this species is closely related to the other taxa revised in the present book. Fragmentation of a dorsal kinety was never described in (typical) kahliliids, to which *Parentocirrus* was originally assigned.

Occurrence and ecology: Locus classicus is the village of Feldhausen in Bottrop, Germany, where VOSS (1997) discovered *P. hortualis* in a bird bath in August. H. BLATTERER (Fig. 218i) found it in the activated sludge of a paper-mill in Salzburg, Austria. VOSS (1997) isolated several specimens and put them into Petri dishes together with water and some leaf mud from the sampling site. Non-carbonated mineral water and squeezed wheat grains were added to establish raw cultures. Clone cultures were set up from these raw cultures in non-carbonated mineral water together with a few drops of

Chlorogonium elongatum concentrated by centrifugation and mixed with a suspension of baker's yeast as food. Feeds also on green algae, diatoms, mineral particles, cysts of amoebas and of conspecifics, and eggs of rotifers, for example, *Rotaria rotatoria*.

Table 50.1 Morphometric data of *Parentocirrus hortualis* (from Voss 1997). All data are based on protargol-impregnated specimens, except otherwise indicated. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length (in life)	186.6	22.2	11.8	163	223	10
Body, length	183.1	37.2	20.6	128	301	25
Body, width (in life)	86.9	11.1	12.8	74	104	10
Body, width	94.7	22.5	23.8	62	166	25
Macronuclear nodules, number	7.8	1.5	19.2	6	12	25
Macronuclear nodules, diameter	13.4	3.6	26.1	9	26	25
Micronuclei, number	3.5	1.0	28.6	2	6	25
Micronuclei, diameter	3.9	0.4	10.0	3	5	25
Adoral zone of membranelles, length	85.0	22.3	26.2	55	158	25
Adoral membranelles, number	45.0	4.6	10.2	38	57	25
Frontal cirri, number	3.0	0	0	3	3	25
Cirri behind right frontal cirrus, number	2.0	0	0	2	2	25
Buccal cirri, number	2.8	0.5	17.9	2	4	25
Frontoventral row 4, number of cirri ¹	4.2	1.3	31.0	3	9	25
Frontoventral row 5, number of cirri ¹	19.1	2.4	12.6	16	24	25
Frontoventral row 6, number of cirri ¹	24.3	2.2	9.1	19	30	25
Transverse cirri, number ²	4.1	0.3	7.3	3	4	25
Right marginal row, number of cirri	32.2	4.0	12.4	23	42	25
Left marginal row, number of cirri	32.0	4.4	13.8	23	43	25
Dorsal kineties, number	6.1	0.3	4.9	6	7	25
Caudal cirri, number	3.1	0.3	9.7	3	4	25
Cyst, diameter (in life)	49.6	10.2	20.6	42	74	10

¹ Designation, see Figure 218h. Without transverse cirrus (the posterior-most cirrus of the row).

² Uncertain data because mean (4.1) higher than maximum value (4).

Table 50.2 Origin of frontal-ventral-transverse cirri primordia and number of cirri produced in the primordia of *Parentocirrus hortualis* (from Voss 1997)

Primordium ¹	Proter	Opisthe	Number of cirri
1	undulating membranes	oral primordium	1
2	buccal cirri	oral primordium	3–5
3	posterior frontal cirri	oral primordium	4–5
4	frontoventral row 4	frontoventral row 4	5–7
5	frontoventral row 5 ²	frontoventral row 5	17–25
6	frontoventral row 5	frontoventral row 5	20–31

¹ Primordia 1–6 correspond to primordia I–VI of the 18-cirri oxytrichids (see Fig. 6a). Designation of frontoventral rows, see Figure 218h.

² Primordium 5 of proter is also generated by frontoventral row 4.

***Territricha* BERGER & FOISSNER, 1988**

1988 *Territricha* BERGER & FOISSNER, Zool. Anz., 220: 127 – Type (original designation): *Territricha stramenticola* BERGER & FOISSNER, 1988.

C h a r a c t e r i s a t i o n: Body flexible. Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Frontoventral cirri form V-shaped pattern. More than 3 postoral ventral cirri behind buccal vertex. Two pretransverse ventral cirri and more than 5 transverse cirri. One right and 1 left row of marginal cirri. More than six dorsal kineties. Caudal cirri present. Number of frontal-ventral-transverse cirri primordia >6. Dorsal morphogenesis in *Oxytricha* pattern, however, kinety 3 not with simple, but with multiple fragmentation.

T a x o n o m y: For a description of the patterns mentioned in the characterisation, see chapter 2 in the general section. Further details, see relevant chapter of single species.

Single species***Territricha stramenticola* BERGER & FOISSNER, 1988 (Fig. 219a–j, Table 51)**

1988 *Territricha stramenticola* BERGER & FOISSNER, Zool. Anz., 220: 128 (1 slide of holotype and 1 slide of paratype specimens are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria).

T a x o n o m y: *Territricha* is monotypic and was originally classified in the Urostylidae following BORROR & WICKLOW's (1983) definition in that in this group “frontal and mid-ventral cirri differentiate during pre-fission morphogenesis from the longitudinal field of more than 5 (without streak 1) oblique ciliary streaks”. We assumed that *Territricha stramenticola* links typical urostylids, such as *Holosticha*, with typical oxytrichids, like, for example, *Oxytricha* (BERGER & FOISSNER 1988a). A classification in the amphisiellids, as proposed by TUFFRAU & FLEURY (1994, p 141), is very likely artificial because a fragmentation of dorsal kineties and an arrangement of cirri in couples is unknown in this group.

I include *Territricha* in the Oxytrichidae because it shows, like all other oxytrichids, fragmentation of dorsal kinety 3. This character is so conspicuous that parallel evolution is very unlikely. However, I have no idea if the increased (that is, >6) number of cirral primordia is plesiomorphic or if it originated by secondary polymerisation (Fig. 219j), as, for example, in *Onychodromus quadricornutus*. A relationship to the Stylonychinae, however, can be excluded because the body is flexible and extrusomes are present.

Territricha stramenticola should not be confused with *Holosticha macrostoma* (DRAGESCO, 1972) BORROR, 1972 (needs redescription; very broad buccal area, 5 dorsal kineties) or *Pattersoniella vitiphila* (larger, rigid cortex, 13–15 macronuclear nodules, about 5 contractile vacuoles, Fig. 197a).

Fig. 219a–f *Territricha stramenticola* (from BERGER & FOISSNER 1988a. a–c, from life; f, methyl green-pyronin stain). **a)** Ventral view, 135 μm . The dorsal cilia of the anterior portion of kinety 1 (arrowhead) are distinctly longer (about 7 μm) than the remaining dorsal cilia (about 3 μm). Note distinctly anteriad displaced transverse cirri. **b)** Right lateral view. **c)** Dorsal view showing the contractile vacuole and the fringe of extrusomes. **d, e)** Side and surface view of extrusomes, 3–5 $\times$ 0.8–1 μm . **f)** Extrusomes after ejection; p 884.

FOISSNER (1993, p 7, 501; 1994e, p 225) confused *Territricha* with another similarly named hypotrich, namely *Terricirra*. The latter has fusiform food vacuoles like the colpodids *Parabryophrya* and *Notoxoma*.

M o r p h o l o g y a n d b i o l o g y: In life 100–175 $\times$ 50–75 μm . Right margin straight, left convex, in anterior portion markedly indented. Anterior and posterior end rounded. Flattened about 2:1 dorso-ventrally. Body flexible. Two macronuclear nodules, in life 25–35 $\times$ 10–17 μm , finely granulated, lying distinctly left of median of cell. Micro-nuclei in life about 6–8 $\times$ 3–5 μm . Contractile vacuole at about mid-body, during diastole with canals. Cells more or less brownish at low magnification. Very many fusiform, in life about 3–5 $\times$ 0.8–1 μm sized, colourless extrusomes arranged perpendicular to pellicle and making a bright fringe at middle magnification; extrusomes ejected after addition of methyl green-pyronin, stain blue, corniform (horn-shaped, hollow), about 5–8 μm long;

Fig. 219g-j *Territricha stramenticola* (from BERGER & FOISSNER 1988a. Protargol impregnation). g, h) Ventral infraciliature of specimens with 7 and 9 postoral ventral cirri, g = 110 μ m, h = 115 μ m. Arrows mark the 2 pretransverse ventral cirri. i) Dorsal infraciliature, 115 μ m. Dorsal kinety 3 shows multiple fragmentation and the posterior-most fragment with the caudal cirrus is denoted as kinety 4. Arrowheads mark the dorsomarginal kinety arranged next to kinety 4 and the right marginal row (see also Figure). j) Late reorganisation stage, 90 μ m. Arrowheads mark the right- and leftmost dorsomarginal kinety primordium (in i the same dorsomarginal kineties are marked with arrowheads). Omitting 2 of the frontal-ventral-transverse cirri streaks marked with an asterisk results in the well-known 18-cirri pattern of typical oxytrichids (cp. Fig. 6a). Old structures white, new ones black. Cirri originating from same primordium are connected by a broken line. 1-4 = dorsal kineties 1-4; p 884.

Table 51 Morphometric data of *Territricha stramenticola* (from BERGER & FOISSNER 1988a). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	111.5	6.7	6.0	99	126	22
Body, width	42.7	4.1	9.5	36	50	21
Adoral membranelles, number	42.2	2.5	5.8	39	47	15
Adoral zone of membranelles, length	44.8	3.0	6.6	39	50	21
Posterior macronuclear nodule, length	18.5	2.0	10.9	15	22	21
Posterior macronuclear nodule, width	10.0	1.1	10.9	8	12	21
Macronuclear nodules, distance between	5.4	2.2	41.7	2	10	21
Micronuclei, number	2.5	0.7	29.2	2	4	10
Posterior micronucleus, length	5.3	0.6	10.8	4	6	20
Posterior micronucleus, width	4.5	0.5	11.5	4	5	20
Left marginal row, number of cirri	32.8	2.4	7.2	29	38	15
Right marginal row, number of cirri	33.4	3.0	9.1	27	39	18
Frontal cirri, number	3.0	0	0	3	3	21
Buccal cirri, number	1.0	0	0	1	1	21
Transverse cirri, number	6.8	0.8	12.2	4	8	19
Distance 1 ¹	17.2	3.6	21.1	8	23	21

¹ Distance between posterior-most transverse cirrus and posterior end of cell.

do not impregnate with protargol (Fig. 219c–f). Posterior portion of cell with many 1–5 µm sized, yellowish cytoplasmic crystals and numerous homogenous 2–5 µm sized globules. Food vacuoles 10–20 µm across. Rapid movement.

Adoral zone of membranelles about 40 % of body length, bases of largest membranelles in life about 10 µm wide. Buccal area rather narrow, roofed by a prominent peristomial lip. Undulating membranes slightly curved, almost the same length. Frontal cirri in life about 25 µm long, bases distinctly enlarged. Buccal cirrus almost at anterior end of undulating membranes. Cirri right of adoral zone arranged as in typical oxytrichids (for example, *Oxytricha*). Number of postoral ventral cirri >3 (7–9) due to higher (usually 2 or 3) number of primordia and not due to increased number of cirri originating within a primordium. Arrangement of cirri rather invariably as shown in Figures 219g, h; postoral cirri in life about 20 µm long. Invariably (n = 14) 2 pretransverse ventral cirri. Transverse cirri in life about 30 µm long, bases distinctly enlarged and displaced anteriad so that only posterior transverse cirri sometimes protrude slightly beyond posterior end of cell. Marginal cirri in life about 20 µm long. Right marginal row begins at about level of buccal cirrus, posteriorly only slightly separate from left one. Dorsal infraciliature rather complicated (Fig. 219i). Basal body pairs, especially in kiny 1, very closely arranged. Dorsal cilia in anterior portion of kiny 1 about 7 µm, in posterior portion and remaining kiny 3 about 3 µm long (Fig. 219a, arrowhead). In posterior portion of cell, between kiny 3 and 4, about 3 short kiny 3; very likely they are the remainder (except kiny 3

and 4) of the multiple fragmentation of kinety 3. Constantly ($n = 9$) 3, in life 15–20 μm long caudal cirri, one each on posterior end of kineties 1, 2, and 4. About 4–5 dorsomarginal kineties (Fig. 219j).

Figure 219j shows a reorganisation stage, indicated by the presence of both the parental migratory cirri, the parental right frontal cirrus, and the parental transverse cirri. Eight frontal-ventral-transverse cirri primordia occur, from which the following number of cirri develop: 1, 3, 3, 3*, 3*, 3*, 4, 4 (Fig. 219j). Omitting two of the streaks marked with an asterisk results in the well-known 18-cirri pattern of typical oxytrichids.

Occurrence and ecology: Very common in litter (species name!) of beech forests and often associated with *Sterkiella cavicola* and *Rigidocortex octonucleatus* (own observations); very likely a character species of (Eurasian?) beech forests! *Locus classicus* is the Gaisberg (at about 800 m above sea level on the western ridge), a mountain near the city of Salzburg, Austria, where BERGER & FOISSNER (1988a) discovered *Tertriricha stramenticola* in the above mentioned habitat. BONKOWSKI (1996) found it in the same biotope in Germany. Feeds on fungal spores of different shape and size and ciliates like *Colpoda* sp. Biomass of 10^6 individuals about 140 mg.

Pseudouroleptus HEMBERGER, 1985

1985 *Pseudouroleptus* HEMBERGER, Arch. Protistenk., 130: 398 – Type (original designation): *Pseudouroleptus caudatus* HEMBERGER, 1985.

Characterisation: Body flexible? Adoral zone of membranelles formed like a question mark. Undulating membranes in *Oxytricha* pattern. Very many frontal-ventral cirri, most of them form two frontoventral rows. Postoral ventral cirrus (usually) present. Transverse cirri lacking or strongly reduced in number. Four dorsal kineties. Caudal cirri present. Left frontoventral row composed of cirri from streaks IV–VI. Right row originates from streak V, that is, right frontoventral row not involved in primordia formation. Dorsal morphogenesis with fragmenting kinety 3; dorsomarginal kinety lacking.

Taxonomy: Five species are assigned to *Pseudouroleptus*: *Pseudouroleptus caudatus* HEMBERGER, 1985 (type; see below); *Pseudouroleptus buitkampii* (FOISSNER, 1982) BERGER & FOISSNER, 1987 (basonym: *Paraurostyla buitkampii* FOISSNER, Arch. Protistenk., 126: 40, Abb. 4a–f, Tabelle 7); *Pseudouroleptus humicola* (GELLÉRT, 1956) HEMBERGER, 1985 (basonym: *Uroleptus humicola* GELLÉRT, Acta biol. hung., 6: 245, Abb. 10); *Pseudouroleptus procerus* BERGER & FOISSNER, 1987, Zool. Jb. Syst., 114: 195, Fig. 1–6, Table 2; *Pseudouroleptus terrestris* HEMBERGER, 1985, Arch. Protistenk., 130: 399, Abb. 2. However, I have some doubt that these 5 species form a monophyletic group because the dorsal ciliary pattern is rather different: 2 kineties in *P. procerus*, 3 kineties in *P. buitkampii*, unknown number in *P. humicola*, and 4 in *P. terrestris* and *P. caudata*. Such a high variability is unusual in oxytrichid genera. Furthermore, fragmentation of

dorsal kinety 3 – the sole synapomorphy of the species treated in the present book – is described only for the type species. Thus, I confine *Pseudouroleptus* to *P. caudatus*, however, without formally transferring the other species to a different taxon.

Pseudouroleptus was originally classified in the Amphisiellidae (HEMBERGER 1982, 1985) and later transferred to the Kahliellidae by TUFFRAU (1987, p 115; see also TUFFRAU & FLEURY 1994, p 137). EIGNER (1997) assigned it to the Oxytrichidae, because it shows “neokinetal 3” anlagen development (for explanation, see EIGNER 1997, p 555).

Pseudouroleptus caudatus HEMBERGER, 1985 (Fig. 219.1a–j)

1985 *Pseudouroleptus caudatus* HEMBERGER, Arch. Protistenk., 130: 398 (type slides are deposited in the Institut für landwirtschaftliche Zoologie, Bonn, Germany).

T a x o n o m y: See also same chapter in genus section. *Pseudouroleptus caudatus* is assigned to the Oxytrichidae because dorsal kinety 3 shows simple fragmentation (Fig. 219.1j), that is, the posterior portion of primordium 3 splits off from the anterior portion to form kinety 4 of the postdivider. Furthermore, morphogenesis of the ventral ciliature closely resembles that of *Gastrostyla*, because the left frontoventral row of *Pseudouroleptus caudatus* consists of the same parts as the frontoventral row of *Gastrostyla* (cp. Fig. 219.1i and Fig. 202k, m, o): the anterior portion is the anterior part of streak VI; the middle portion is streak IV, except the prominent postoral ventral cirrus (likely homologous to cirrus IV/2 of the 18-cirri oxytrichids, see Fig. 6a); the posterior portion is streak V. As in *Gastrostyla*, cirri of the anlage VI are not involved in primordia formation which is an important difference to *Apoamphisiella*.

Pseudouroleptus terrestris has 4 buccal cirri and 2 transverse cirri. *Pseudouroleptus buitkampii* has 4 macronuclear nodules, 2–4 buccal cirri, and 2–3 cirri behind the right frontal cirrus. *Pseudouroleptus humicola* has many (about 32) macronuclear nodules. *Pseudouroleptus procerus* has 3–4 buccal cirri and only 2 dorsal kineties.

M o r p h o l o g y: In life(?) about $250 \times 50 \mu\text{m}$. Body elongate, slightly spiralled, anterior end broadly rounded, posterior tapered. Body not contractile (HEMBERGER 1985), but very likely rather flexible. Two ellipsoidal macronuclear nodules, 2–3 micronuclei. Contractile vacuole in “standard position”, that is, on left body margin slightly behind buccal vertex. Cytoplasm brownish (possibly cortical granules are present). Adoral zone of membranelles about 25 % of body length, composed of 33–50 (mean = 40) membranelles. Invariably 3 distinctly enlarged frontal cirri, 1 buccal cirrus near anterior end of undulating membranes which are in *Oxytricha* pattern, and 1 enlarged cirrus behind right frontal cirrus (homologous to cirrus III/2 of the 18-cirri oxytrichids). One cirrus immediately behind buccal vertex (sometimes lacking). Left frontoventral row composed of about 42 cirri, right row consists of about 55 cirri; both rows begin near distal end of adoral zone of membranelles, left row terminates distinctly subterminally, right at posterior

Fig. 219.1a-g *Pseudouroleptus caudatus* (from HEMBERGER 1982. a-g, protargol impregnation). **a)** Ventral infraciliature and nuclear apparatus of a non-dividing specimen, 233 μm . Arrow marks postoral ventral cirrus which is very likely homologous to cirrus IV/2 of the 18-cirri oxytrichids. **b-g)** Ventral ciliature of early (b-d) and middle (e-g) morphogenetic stages. The primordia V and VI originate from the middle portion of the left frontoventral row. Note that the right frontoventral row is not involved in primordia formation. OP = oral primordia; p 889.

Fig. 219.1h-j *Pseudouroleptus caudatus* (from HEMBERGER 1982. h-j, protargol impregnation). **h)** Ventral infraciliature and nuclear apparatus of a late morphogenetic stage. Arrows mark the 6 frontal-ventral cirri primordia of the opisthe. **i)** Ventral infraciliature and nuclear apparatus of a very late morphogenetic stage. Anterior arrow marks the anterior portion of primordium VI which migrates to the left to form the anterior portion of the left frontoventral row in postdividers. The posterior arrow denotes the posterior-most cirrus of primordium IV which becomes the conspicuous postoral ventral cirrus of the interphasic specimen; the anterior cirri of primordium IV form the middle portion of the left frontoventral row. When morphogenesis is finished the left frontoventral row appears as continuous cirral row, although composed of three parts (Fig. 219.1a). **j)** Dorsal infraciliature of middle morphogenetic stage showing fragmentation (arrows) of kinety 3. Obviously no dorsomarginal kineties are formed in *Pseudouroleptus caudatus*; p 889.

end. Distinct transverse cirri lacking. About 55 right and 45 left marginal cirri, about 20 μm long. Dorsal cilia about 6 μm long, arranged in 4 kineties. Caudal cirri not distinctly longer than marginal cirri, that is, about 20 μm ; each one cirrus on dorsal kineties 1, 2, and 4.

M o r p h o g e n e s i s is described and illustrated by HEMBERGER (1982, p 36; see Fig. 219.1b-j). It commences with the formation of two oral primordia (Fig. 219.1b). As in many other oxytrichids the buccal cirrus, the cirrus behind the right frontal cirrus, and the postoral ventral cirrus are involved in primordia formation (Fig. 219.1c-e). The middle portion of the left frontoventral row is transformed to the primordia V and VI of the proter and the opisthe (Fig. 219.1d-f). Later, these primary primordia divide (Fig. 219.1g, h). As most other oxytrichids, *Pseudouroleptus caudatus* forms 6 frontal-ventral cirri

primordia (Fig. 219.1h, arrows). No cirrus of the right frontoventral row is involved in primordia formation. A late morphogenetic stage shows that the left frontoventral row originates, as in *Gastrostyla*, of cirri of streaks VI, IV, and V (from anterior; details see Fig. 219.1i). This strongly indicates a close relationship of *Pseudouroleptus* and *Gastrostyla*; by contrast EIGNER (1997) classified *Pseudouroleptus* in the Oxytrichidae and *Gastrostyla* in the Parakahliellidae. Dorsal morphogenesis shows a simple fragmentation in dorsal kinety 3 (Fig. 219.1j, arrows) resulting in 4 kineties during interphase because no dorsomarginal kineties are formed.

O c c u r r e n c e a n d e c o l o g y: Terrestrial and limnetic. Locus classicus is the suburb of Puerto Maldonado (about lat 12°36', long 69°12'), Peru, where HEMBERGER (1985) discovered *Pseudouroleptus caudatus* in a forest soil (details see HEMBERGER 1982, p 2). He found it also in the plankton of a river (Rio Tambopata) from this region, possibly due to soil erosion. No further records known. Biomass of 10⁶ specimens about 375 mg (FOISSNER 1987a).

Taxa not Considered

The following taxa, although included by some authors in the Oxytrichidae or Oxytrichidae sensu lato, were not considered in the present book because they lack the typical 18 frontal-ventral-transverse cirri and/or fragmentation of a dorsal kinety or they are species indeterminata.

Balladinopsis GHOSH, 1921, J. R. microsc. Soc., year 1921: 248 – Type (monotypy): *Balladinopsis nuda* GHOSH, 1921. Remarks: Classified in the Oxytrichinae by JANKOWSKI (1979). *Balladynopsis* and *Balladynopsis nuda* in KAHL (1932, p 592) are incorrect subsequent spellings. Contractile vacuole on right side (misobservation?). A species indeterminata.

Dipleurostyla ROUX, 1899, Revue suisse Zool., 6: 615 – Type (monotypy): *Dipleurostyla acuminata* Roux, 1899. Remarks: Both the type species and *D. tristyla* TAGLIANI, 1922 are species indeterminata. According to KAHL (1932, p 650) both species are regenerating stylonychias.

Drepanina SAVI, 1913, Monitore zool. ital., 24: 99 – Type (monotypy): *Drepanina falcata* SAVI, 1913 (Fig. 220c). Remarks: Species indeterminata. According to KAHL (1932, p 650) the anterior end of a large *Stylonychia*.

Engelmanniella FOISSNER, 1982, Arch. Protistenk., 126: 66 – Type (original designation): *Uroleptus mobilis* ENGELMANN, 1862. Remarks: *Engelmanniella* was only provisionally assigned to the Oxytrichidae. Later, morphogenetic data revealed that it is very likely a kahliellid (EIGNER 1995, WIRNSBERGER-AESCHT & FOISSNER 1989).

Hemisincirra HEMBERGER in FOISSNER, 1984, Stapfia, 12: 119 – Type (original designation): *Uroleptus kahli* BUTKAMP, 1977a. Remarks: FOISSNER (1984) used the name *Hemisincirra* before the original description was published (HEMBERGER 1985, p. 408). *Hemisincirra* comprises several, usually very slender soil inhabiting species, which do not, however, have a very uniform infraciliature (for example, BERGER & FOISSNER 1987a, 1989a, FOISSNER 1982, 1984, HEMBERGER 1982, 1985). I do not include it in the Oxytrichidae because both the fragmentation of a dorsal kinety and the typical 18 frontal-ventral-transverse cirri pattern are lacking. Morphogenetic data are needed to clarify the phylogenetic relationships of *Hemisincirra*. However, two species (*Hemisincirra polynucleata*, *Perisincirra similis*) have the frontoventral cirri arranged very similarly to *Urosoma* and were thus transferred to this taxon in the present book.

Lamtostyla BUTKAMP, 1977, Acta Protozool., 16: 270 – Type (original designation): *Lamtostyla lamottei* BUTKAMP, 1977. Remarks: *Lamtostyla* was originally classified in the Holostichidae and later transferred to the Cladotrichidae (SMALL & LYNN 1985), however, without detailed explanation. Previously, I proposed a classification in the Oxytrichidae because of morphogenetic similarities with typical oxytrichids (BERGER & FOISSNER 1987a, 1988a). PETZ & FOISSNER (1996) provided morphogenetic evidence that *Lamtostyla* belongs to the amphisiellids. However, some species (for example, *L. longa*, *L. raptans*) have the 18 frontal-ventral-transverse cirri pattern and possibly belong to *Tachysoma*, where they were originally established.

Prosopsenus ANDRÉ, 1916, Revue suisse Zool., 24: 632 – Type (monotypy): *Prosopsenus sinuatus* ANDRÉ, 1916. Remarks: Classified in the Oxytrichinae by JANKOWSKI (1979). A species indeterminata, as already supposed by KAHL (1932, p 650). No records available.

Psammomitra BORROR, 1972, J. Protozool., 19: 15 – Type (monotypy): *Mitra radiosa* QUENNERSTEDT, 1867. Remarks: *Psammomitra* is the replacement name for *Micromitra* KAHL, 1933, Tierwelt N.- u. Ostsee, 23: 112, which was the replacement name for *Mitra* QUENNERSTEDT, 1867, Acta Univ. lund., 4: 41. Some authors (for

example, KAHL 1935, BORROR 1972a) classified it in the Oxytrichidae because it has a ventral ciliature allegedly very similarly to 18-cirri oxytrichids. SONG & WARREN (1996), however, proved that it belongs to *Uroleptus* EHRENBERG, 1831.

Psilotricha STEIN, 1859, Lotos, 9: 5 – Type (original designation and monotypy, respectively): *Psilotricha acuminata* STEIN, 1859. Remarks: For a detailed description of this curious species, see STEIN (1859b) and FOISSNER (1983b) and references therein. The rigid body strongly suggests an inclusion in the Stylonychinae. However, neither ventral and dorsal infraciliature nor morphogenesis are reminiscent of that of oxytrichids. I have thus not considered it in the present book. FOISSNER (1983b) proposed a close relationship with *Uroleptoides*, *Pseudouroleptus*, *Kahliella*, *Cladotricha*, and *Kerona*. EIGNER (1997) classified it in the Orthoamphisiellidae.

Terricirra BERGER & FOISSNER, 1989, Bull. Br. Mus. nat. Hist., 55: 35 – Type (original designation): *Perisincirra viridis* FOISSNER, 1982. Remarks: *Terricirra* includes three soil inhabiting species with green to blue-green cortical granules and spindle-shaped food vacuoles, short undulating membranes which form an acute angle, and one short frontoventral row. The ventral infraciliature is reminiscent of that of *Lamtostyla*, which is now classified in the Amphisiellidae (PETZ & FOISSNER 1996). Because fragmentation of a dorsal kinety and the typical 18 frontal-ventral-transverse cirri pattern are lacking, I do not include it in the Oxytrichidae. Morphogenetic data are needed to clarify the phylogenetic relationships of *Terricirra*.

Trachelochaeta ŠRÁMEK-HUŠEK, 1954, Arch. Protistenk., 100: 265 – Type (original designation): *Trachelochaeta bryophila* ŠRÁMEK-HUŠEK, 1954. Remarks: Classified in the Oxytrichidae by BORROR (1972a). *Trachelochaeta sphagni* on p 256 of ŠRÁMEK-HUŠEK (1954) is probably a different (invalid) name for the type species. Ventral and dorsal ciliature not known in detail; thus, *Trachelochaeta* is not considered in the present book.

Trachelostyla BORROR, 1972, J. Protozool., 19: 15 – Type (original designation): *Stichochaeta pediculiformis* COHN, 1866. Remarks: Classified in the Oxytrichidae by BORROR (1972a). *Trachelostyla* was originally established by KAHL (1932, Tierwelt Dtl., 25: 596) with two species. Since he did not determine any as type, the taxon is invalid according to Article 13 (b) of the ICZN (1985); a fact overlooked by CORLISS (1979). I consider BORROR (1972a) as the author of *Trachelostyla* (although he did not realize that KAHL's taxon was invalid) because he fixed the type species. *Stichochaeta* CLAPARÈDE & LACHMANN, 1858 is not a synonym of *Trachelostyla*, as erroneously stated by CORLISS (1979, p 310), but of *Stichotricha* PERTY, 1849 (see BORROR 1972a, p 12). Neither the ventral nor the dorsal ciliature of *Trachelostyla pediculiformis* are known in detail; thus, *Trachelostyla* is not considered in the present book.

Tricholeptus FROMENTEL, 1875, Microzoaires, p 177 – Type (monotypy): *Tricholeptus aculeatus* FROMENTEL, 1875 (species description in FROMENTEL 1876, p 294). Remarks: Classified in the Oxytrichinae by JANKOWSKI (1979). Nomen oblitum (see p 397). LONGHI (1895, p 81) described the variety *T. aculeatus tetraculeatus*, which is also a species indeterminata.

Illustrations of Species Indeterminata and Insufficient Redescriptions

The following plates show species indeterminata – species that cannot be identified from the original description – and illustrations from redescrptions of valid species which deviate significantly from the original description or the authoritative redescription. Names are given as written in the original literature, that is, incorrect spellings or deviating combinations (for example, *Kerona pustulata* instead of *Stylonychia pustulata*) have not been corrected.

Fig. 220a–m Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). **a)** *Stylonychia* sp. (from WEST & LUNDIN 1963), 200 µm; p 605. **b)** *Pleurotricha* sp. (from WEST & LUNDIN 1963), 175 µm; p 717. **c)** *Drepanina falcata* (from SAVI 1913), ? µm; p 893. **d)** *Kerona pustulata* (after CARTER 1859), size not indicated; p 600. **e)** *Oxytricha furcatus* (after SMITH 1897b), ventral surface in dorsal view, 140 µm; p 248. **f)** *Stylonychia* sp. (from LEPSI 1965), 90–100 µm; p 605. **g)** *Stylonychia* sp. (from VUXANOVICI 1963), 120 µm; p 605. **h–j)** *Stylonychia* sp. (from VUXANOVICI 1963), 130 µm (**h**), conjugation pair (**i**), arrangement of transverse cirri (**j**); p 605. **k)** *Oxytricha fallax* (from WEST & LUNDIN 1963), 150 µm; p 605. **l)** *Oxytricha saprobia* (from VUXANOVICI 1963), 140 µm; p 259. **m)** *Oxytricha aeruginosa* (from PATSCH 1974), ventral infraciliature after protargol impregnation, 140 µm; p 256. Figures on p 901.

Fig. 221a–i Insufficient redescrptions (ventral view from life unless otherwise indicated). **a, b)** *Oxytricha aeruginosa* (from AGAMALIEV 1974), ventral and dorsal infraciliature, wet nitrate silver impregnation, 135 µm; p 256. **c)** *Oxytricha fallax* (after CONN 1905), 140 µm; p 257. **d)** *Oxytricha hymenostoma* (after CONN 1905), 55 µm; p 259. **e)** *Oxytricha fallax* (from SMITH 1978), 110 µm; p 257. **f)** *Oxytricha fallax* (from BISHOP 1943), size not indicated; p 257. **g)** *Oxytricha ludibunda* (from CURDS 1969), 100 µm; p 259. **h)** *Opisthotricha similis* (from CURDS 1969), 100 µm; p 255. **i)** *Oxytricha chlorigella* (after HORVÁTH 1939b), ventral view after opalblue stain after BRESSLAU, 140 µm; p 256. Figures on p 902.

Fig. 221j *Oxytricha hymenostoma* (after ESPOSITO et al. 1978). Ventral view after haematoxylin stain, size not indicated; p 150. Figure on p 902.

Fig. 222a–t Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). **a)** *Holosticha oxytrichoidea* (from GELEI 1950), ventral infraciliature, method and size not indicated; p 254. **b)** *Opisthotricha terricola* (from GELLÉRT 1957), ventral infraciliature, sublimate fixation and opalblue stain after BRESSLAU, 70 µm; p 245. **c, d)** *Oxytricha* sp. (from SESHACHAR & KASTURI BAI 1963), nuclear apparatus after Feulgen stain, sizes not indicated; p 245. **e)** *Oxytricha* sp. (after MOTE 1954), ventral surface in dorsal view, stain (?), size not indicated; p 260. **f)** *Histrio acuminatus* (after MASKELL 1886), 140 µm; p 666. **g)** *Histrio complanatus* (after LEPSI 1965), 70 µm; p 667. **h)** *Oxytricha ovalis* (after SCHMARD 1854), ventral and dorsal view from life, about 90 µm; p 252. **i)** *Oxytricha striata* (after SCHMARD 1854), ventral, dorsal, and lateral views from life, about 145 µm; p 253. **j)** *Stylonychia mytilus* (after CIENKOWSKY 1855, Z. wiss. Zool., 6: 302), 260 µm; p 517. **k, l)** *Stylonychia pustulata* (after CIENKOWSKY 1855), 123 µm (**k**), cyst from life, 45 µm (**l**); p 603. **m, n)** *Stylonychia lanceolata* (after CIENKOWSKY 1855), 275 µm (**m**), cyst from life, 75 µm (**n**); p 717. **o–t)** *Oxytricha truncata* (from VUXANOVICI 1963. **o–t**, from life). **o, p)** Ventral views, 140 µm. **q, r)** Ventral and lateral view of forma *dilatata*, 90 µm. **s, t)** Ventral and lateral view of forma *piriformis*, 120 µm; p 254. Figures on p 903.

Fig. 223a–n, p Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). a) *Pleurotricha grandis* (after GOODEY 1911), 120 µm; p 716. b) *Onychodromopsis flexilis* (from LUNDIN & WEST 1963), ventral surface in dorsal view, size not indicated; p 479. c) *Steinia inquieta* (from DINGFELDER 1962), 150 µm; p 324. d) *Steinia candens* (after CHARDEZ 1981), 135 µm; p 323. e–g) *Oxytricha feruginea* (after PENARD 1922), size not indicated (e), overall view and detail of cyst (f, g), size not indicated; p 491. h) *Stylonychia putrina* (from BARWICK et al. 1955), 100 µm; p 604. i, j) *Oxytricha* (?) *parvula* (from VUXANOVICI 1963), ventral and lateral view from life, i = 40 µm; p 252. k) *Oxytricha acuminata* (from VUXANOVICI 1963), 100 µm; p 246. l) *Oxytricha monstrosa* (from VUXANOVICI 1963), 85 µm; p 250. m, n) *Oxytricha formosa* (from ALEKPEROV 1984a), ventral infraciliature after wet nitrate silver impregnation, size not indicated (n), nuclear apparatus (m); p 248. p) *Oxytricha fallax* (from CHARDEZ 1967), 150 µm; p 258. Figures on p 904.

Fig. 224a–m Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). a, b) *Oxytricha immemorata* (from ALEKPEROV 1984a), ventral infraciliature after wet silver nitrate impregnation, size not indicated (a), nuclear apparatus (b); p 249. c) *Oxytricha furcata* (from DINGFELDER 1962), 110 µm; p 258. d) *Oxytricha lata* (after STERKI 1878), part of the fan-shaped adoral zone of membranelles, size not indicated; p 250. e) *Oxytricha oltenica* (from LEPSI 1965), size not indicated; p 251. f) *Histrio complanatus* (from LEPSI 1965), size not indicated; p 667. g) *Opisthotricha* sp. (after SUDZUKI 1964b), size not indicated. Possibly identical with *Sterkiella thompsoni* (see there); p 679. h) *Opisthotricha sordis* (from LEPSI 1965), size not indicated; p 245. i, j) *Oxytricha* sp. (after CONN 1905), i = 55 µm, j = 70 µm; p 260. k) *Opisthotricha procera* (after NAIDU 1965), ventral surface in dorsal view from life, 70 µm; p 255. l) *Stylonychia pustulata* (after NAIDU 1965), 140 µm; p 604. m) *Oxytricha ludibunda* (after NAIDU 1965), dorsal view from life, 85 µm; p 259. Figures on p 905.

Fig. 225a–u Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). a) *Tachysoma parvistylum* (after STOKES 1887b), 65 µm; p 466. b, c) *Oxytricha parvistyla* (after CONN 1905), sizes not indicated; p 467. d) *Tachysoma parvistyla* (from LUNDIN & WEST 1963), size not indicated; p 468. e) *Tachysoma* sp. (after LEPSI 1957), dorsal view from life, 70 µm; p 469. f) *Oxytricha agilis* (after CONN 1905), size not indicated; p 467. g) *Oxytricha pellionella* (after SAMANO & SOKOLOFF 1931), 70 µm; p 468. h) *Urosoma* sp. (from LEPSI 1965), 190 µm; p 431. i) *Urosoma cienkowski* (after CONN 1905), size not indicated; p 431. j) *Oxytricha pellionella* (from LEPINIS et al. 1973), size not indicated; p 468. k) *Pleurotricha* sp. (from NIKOLJUK & GELTZER 1972), size not indicated; p 717. l) *Oxytricha pellionella* (after CONN 1905), size not indicated; p 468. m) *Oxytricha pellionella* (from SMITH 1978), 80 µm; p 467. n) *Oxytricha pellionella* (after QUENNERSTEDT 1865), size not indicated; p 467. o) *Gonostomum* sp. (after MOTE 1954), 80 µm; p 395. p, q) *Steinia fenestrata* (after LEPSI 1957), ventral views after a “preserved object”, sizes not indicated; p 644. r) *Oxytricha pellionella* (after FELLERS & ALLISON 1920), 70–100 µm; p 468. s) *Steinia platystoma* (after BIERNACKA 1959), 70 µm; p 645. t) *Oxytricha pellionella* (after BIERNACKA 1959), 106 µm; p 468. u) Ciliate sp. (after MOTE 1954), size not indicated; p 367. Figures on p 906.

Fig. 226a–l Insufficient redescrptions (ventral view from life unless otherwise indicated). a, c) *Pleurotricha* sp. (a, after CONN 1905; c, after CHAUDHURI 1929), a = 95 µm, c = 80 µm; p 716, 717. b, g) *Pleurotricha grandis* (b, after KOFFMAN 1926; g, from SCHMALL 1976, protargol impregnation), b = 100 µm, g = 115 µm; p 716. d) *Oxytricha marina* (from BIERNACKA 1967), 120 µm; p 259. e) *Opisthotricha ovata* (from BIERNACKA 1967), 100–120 µm; p 255. f) *Oxytricha pellionella* (from BRODSKY & YANKOWSKAYA 1929), size not indicated; p 467. h) *Stylonychia notophora* (from EDMONDSON 1906), 120–160 µm; p 603. i) *Oxytricha* sp. (from JACOBSON 1931), 100 µm; p 260. j) *Urosoma* sp. (from LEPSI 1927), 146 µm; p 431. k) *Gastrostyla* sp. (from LEPSI 1927), 76 µm; p 824. l) *Stylonychia mytilus* (from RAMIREZ DE GUERRERO 1970), 150 µm; p 603. Figures on p 907.

Fig. 227a–p Species indeterminata (from DUMAS 1929. a–p, from life, sizes not indicated). a) *Kerona tremula*; p 841. b) *Kerona caudata*; p 834. c) *Kerona diademata*; p 840. d) *Kerona truncata*; p 841. e) *Kerona curvata*; p 840. f, g) *Kerona becciformis*; p 839. h) *Kerona oblonga*; p 840. i) *Kerona subrotundata*; p 841. j) *Kerona anfracta*; p 839. k) *Kerona ovata*; p 840. l, m) *Kerona urostyla*, an insufficient redescription of *Oxytricha urostyla* CLAPARÈDE & LACHMANN; p 244, 873. n) *Kerona mamillata*; p 840. o) *Kerona silurus* (*congyrans*); p 839. p) *Kerona arcuata*; p 839. Figures on p 908.

Fig. 228a–i Insufficient redescrptions and species indeterminata (ventral view from life). a) *Oxytricha marina* (from GANAPATI & RAO 1958), 175 µm; p 259. b) *Oxytricha bifaria* (from SOKOLOFF 1931), size not indicated; p 601. c) *Oxytricha pelliionella* (from BELTRAN 1928), size not indicated; p 467. d) *Gonostomum affine* (from DELHEZ & CHARDEZ 1970), 75 µm; p 395. e) *Stylonychia putrina* (from CONN 1905), 80 µm; p 604. f) *Stylonychia pustulata* (from CONN 1905), 125 µm; p 603. g) *Oxytricha bifaria* (from CONN 1905), 185 µm; p 601. h) *Gonostomum parvum* (from LEPSI 1947), 60–80 µm; p 393. i) *Oxytricha* sp. (from CZAPIK 1959), size not indicated; p 260. Figures on p 909.

Fig. 229a–h Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). a) *Stylonychia* núm. 1 (from IZQUIERDO 1906), 190 µm; p 599. b) *Stylonychia notophora* (from CONN 1905), size not indicated; p 603. c) *Stylonychia pustulata* var. (from CONN 1905), size not indicated; p 603. d) *Histriculus polycirratu*s (from AGAMALIEV 1978), ventral infraciliature after wet silver nitrate impregnation and nuclear apparatus after Feulgen stain, 80–90 µm; p 666. e) *Oxitricha* núm. 3 (from IZQUIERDO 1906), 92 µm; p 245. f) *Oxitricha* núm. 2 (from IZQUIERDO 1906), 140 µm; p 245. g) *Oxitricha* núm. 1 (from IZQUIERDO 1906), 130 µm; p 245. h) *Oxytricha fallax* (from HEBERER 1928), size not indicated; p 257. Figures on p 910.

Fig. 230a–h Insufficient redescrptions (ventral view from life unless otherwise indicated). a, b) *Oxytricha* (after MAUPAS 1888), 170 µm (a), cyst, 40 µm (b); p 256. c, d) *Stylonychia mytilus* (from AGAMALIEV 1978), ventral and dorsal infraciliature, wet silver nitrate impregnation, 90 µm; p 602. e) *Stylonychia pustulata* (from LUNDIN & WEST 1963), 150 µm (size from WEST & LUNDIN 1963); p 604. f, g) *Stylonychia muscorum* (from MATIS & DANIŠKOVÁ 1972), sizes not indicated; p 602. h) *Oxytricha similis* (from PATSCH 1974), ventral infraciliature, protargol impregnation, 120 µm; p 260. Figures on p 911.

Fig. 231a–j Insufficient redescrptions (ventral view from life unless otherwise indicated). a) *Pleurotricha grandis* (after RAO 1928), size not indicated; p 716. b, c) *Gonostomum* sp. (after CHAUDHURI 1929), dorsal and ventral view from life, 50 µm, 46 µm; p 395. d) *Oxytricha fallax* (after KOFFMAN 1926), ventral view of a fixed specimen, 125 µm; p 257. e) *Stylonychia pustulata* (after KOFFMAN 1926), ventral view of a fixed specimen, 115 µm; p 603. f) *Oxytricha bifaria* (from BANCHETTI & RICCI 1986), schematic drawing of the ventral surface, 100 µm; p 568. g) *Stylonychia* sp. (from ALONSO & PEREZ-SILVA 1963b), stain method?, 80 µm; p 604. h) *Oxytricha minor* (from CHORIK 1968), 85 µm; p 259. i, j) *Oxytricha bifaria* (after CONN 1905), 110–132 µm; p 601. Figures on p 912.

Fig. 232a–p Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). a) *Histrio complanatus* (after CONN 1905), 70 µm; p 667. b) *Histrio erethisticus* (after CONN 1905), 100 µm; p 667. c) *Histrio* sp. (after CONN 1905), 135 µm; p 667. d, e) *Holosticha setigera* (after CONN 1905), ventral and lateral view from life, 40 µm. Certainly not identical with *Oxytricha setigera* because midventral cirri present; possibly a new species. f) *Stylonychia histrio* (after BÜRGER 1905), 250 µm; p 668. g) *Oxytricha complanatus* (from CHORIK 1968), 80 µm; p 668. h) *Stylonychia pustulata* (after ECKHARD 1846), dorsal view from life, size not indicated; p 603. i) *Oxytricha fallax* (after BARKER 1949), 85 µm (?); p 257. j, k) *Tachysoma pelliionella* (from TCHANG et al. 1984), ventral and dorsal infraciliature, protargol impregnation, sizes not indicated. (j) shows an early morphogenetic stage; p 469. l) *Histriculus similis* (from NIETO et al. 1984), ventral

infraciliature (schematic), protargol impregnation, 160 μ m; p 666. **m**) *Oxytricha halophila* (from CZAPIK & JORDAN 1976a), ventral infraciliature, wet silver nitrate impregnation (?), size not indicated; p 258. **n**) *Oxytricha fallax* (from CELA 1972), ventral view from life (?), 62 μ m (?); p 258. **o**) *Oxytricha saltans* (from VUXANOVICI 1963), 45 μ m; p 253. **p**) *Oxytricha strenua* (after KOFFMAN 1926), ventral (?) view from life, 55 μ m; p 395. Figures on p 913.

Fig. 233a–m Insufficient redescrptions (ventral view from life unless otherwise indicated). **a**) *Tachysoma pellionella* (from ROSA 1957b), 80 μ m; p 468. **b**) *Gonostomum affine* (from ROSA 1957a), 60 μ m; p 395. **c**) *Tachysoma pellionella* (from ROSA 1957a), 100 μ m; p 469. **d**) *Tachysoma pellionella* (from BUISAN 1944), 80–100 μ m; p 467. **e**) *Holosticha mystacea* (from CHORIK 1968), 130 μ m; p 824. **f**) *Oxytricha bifaria* (after SMITH 1914), 200 μ m; p 601. **g**) *Oxytricha pellionella* (from SMITH 1914), 160 μ m; p 468. **h**) *Gastrostyla steini* (from SCHNEIDER 1930), dorsal view from life after addition of iodine-ink, about 200 μ m; p 824. **i**) *Uroleptus agilis* (after SMITH 1914), 160 μ m; p 367. **j**) *Stylonichia muscorum* (from CHARDEZ 1967), 88 μ m; p 601. **k**) *Stylonichia putrina* (from BURKOVSKY 1984), 200 μ m; p 604. **l, m**) *Oxytricha halophila* (from AGAMALIEV 1978), ventral and dorsal infraciliature after wet silver nitrate impregnation, **l** = 110 μ m, **m** = 100 μ m; p 258. Figures on p 914.

Fig. 234a, b, d–l, n–p Insufficient redescrptions and species indeterminata (ventral view from life unless otherwise indicated). **a**) *Stylonichia mytilus* (from LUNDIN & WEST 1963), size not indicated; p 602. **b**) *Oxytricha fallax* (from FORMISANO 1957), about 140 μ m; p 258. **d**) *Oxytricha acuminata* (from MAHAJAN 1977), 100–115 μ m; p 246. **e**) *Uroleptus agilis* (from EDMONDSON 1906), 300 μ m; p 367. **f–h**) *Steinia inquieta* (from VUXANOVICI 1961), ventral view, cortical granules, lateral view, 120–160 μ m; p 324. **i**) *Oxytricha pellionella* (from EDMONDSON 1906), 80–100 μ m; p 468. **j**) *Tachysoma pellionella* (from SOKOLOFF & ANCONA 1937), size not indicated; p 468. **k**) *Pleurotricha lanceolata* (from EDMONDSON 1906), 250 μ m; p 716. **l**) *Steinia caudens* (from CHARDEZ 1971), 145 μ m; p 324. **n**) *Tachysoma parvistyla* (from CHARDEZ 1971), 53 μ m; p 468. **o**) *Pleurotricha* sp. (from OLIVEIRA et al. 1954), 85 μ m; p 717. **p**) *Stylonichia* sp. (from OLIVEIRA et al. 1954), 125 μ m; p 602. Figures on p 915.

Fig. 234c *Stylonichia pustulata* (from EDMONDSON 1906). Ventral view from life, 150–170 μ m; p 565. Figure on p 915.

Fig. 234m *Stylonichia curvata* (from CHARDEZ 1971). Ventral view from life, 73 μ m; p 593. Figure on p 915.

Fig. 235A, B *Oxytricha nova* (from PRESCOTT 1983). **A**) Stained for DNA by the Feulgen procedure and counterstained with fast green. Four micronuclei and 2 macronuclear nodules are present. Bar = 30 μ m. This figure was already published in PRESCOTT (1977). **B**) Scanning electron micrograph of the ventral side. Recent studies by FOISSNER et al. (in preparation) strongly indicate that *O. nova* is a species of the *Sterkiella histriomuscorum* group. Bar = 30 μ m; p 250, 685. Figures on p 916.

Fig. 236a–r Insufficient redescrptions and species indeterminata (a–p, from DUMAS 1929; q, r, from DUMAS 1930. Ventral or dorsal views from life; sizes uncertain). **a, b, r**) *Oxytricha caudata*, 200 μ m; p 430. **c**) *Oxytricha ovalis*, 120 μ m; p 248. **d**) *Oxytricha cornipes*, 35 μ m; p 247. **e**) *Oxytricha platystoma*, 88 μ m; p 645. **f**) *Oxytricha lacrimula*, 70 μ m; p 249. **g**) *Oxytricha lacerata*, 115 μ m; p 249. **h**) *Oxytricha pistilloides*, 55 μ m; p 252. **i**) *Oxytricha subcylindrica*, 85 μ m; p 253. **j**) *Oxytricha oblonga*, 55 μ m; p 251. **k**) *Oxytricha curta*, 57 μ m; p 247. **l**) *Oxytricha becciformis*, 52 μ m; p 247. **m**) *Oxytricha*; p 256. **n**) *Oxytricha cornuta*, 103 μ m; p 247. **o**) *Oxytricha pleuronectes*, 70 μ m; p 252. **p, q**) *Oxytricha ovata*, (**q**) is reminiscent of *O. setigera*; p 251. Figures on p 917.

Fig. 237a–j Insufficient redescrptions and species indeterminata (from DUMAS 1929. Ventral or dorsal views from life; sizes uncertain). **a**) *Stylonichia pustulata*, ? μ m; p 601. **b**) *Stylonichia trochiformis*, 112 μ m; p 599. **c**) *Stylonichia rostrata*, 85 μ m; p 599. **d**) *Stylonichia virgula* (in the legend designated as *S. auriformis*),

102 µm; p 549. e) *Stylonichia massula*, 162 µm; p 598. f, i) *Stylonichia mytilus*, 175 µm, 142 µm; p 601. g) *Stylonichia dupla*, 112 µm; p 598. h) *Stylonichia regularis*, 200 µm; p 600; j) *Stylonichia ellipsoïdes*, ? µm; p 598. Figures on p 918.

Fig. 238a–r Species indeterminata und insufficient redescriptions (a–d, from DUMAS 1929; e–r, from DUMAS 1930. Ventral, dorsal, and lateral views from life; sizes uncertain). a) *Stylonichia anfracta*, 140 µm; p 597. b) *Stylonichia cornifrons*, 155 µm; p 597. c) *Stylonichia mamillata*, 212 µm; p 598. d) *Stylonichia corniculata*; p 597. e) *Stylonichia globifrons*; p 598. f–h) *Stylonichia mutabunda*; p 599. i, q) *Stylonichia limbiformis*; p 598. j) *Stylonichia reclinis*; p 599. k) *Stylonichia labiata*; p 598. l) *Stylonichia excavata*; p 598. m) *Stylonichia capucinus*; p 597. n) *Stylonichea bistyllus*; p 597. o) *Stylonichia truncata*; p 599. p) *Stylonichia gyriniformis*; p 598. r) *Stylonichia unguiculus*; p 599. Figures on p 919.

Fig. 239a–w Species indeterminata and insufficient redescriptions (a–o, r–t, from DUMAS 1930; p, q, u–w, from DUMAS 1937. Ventral, dorsal, and lateral views from life; sizes uncertain). a) *Oxytricha obtusa*; p 251. b, c) *Oxytricha fimbriata*; p 248. d, e) *Oxytricha arcuata*; p 246. f, n, u) *Oxytricha praeceps*; p 252. g) *Oxytricha caudata*; p 430. h) *Oxytricha stratiformis*; p 253. i) *Oxytricha longipes*; p 250. j) *Oxytricha labiata*; p 249. k) *Oxytricha barbula*; p 247. l) *Oxytricha exociformis*; p 248. m) *Oxytricha rostrata*; p 252. o) *Oxytricha anca*; p 246. p) *Stylonichia viridis*; p 599. q) *Oxytricha luteolucens*; p 250. r, s) *Oxytricha proboscis*; p 252. t) *Oxytricha acuminata*; p 246. v) *Stylonichia fronte-albens*; p 598. w) *Stylonichia membranaceus*; p 599. Figures on p 920.

Fig. 240a–n Species indeterminata and insufficient redescriptions (ventral view from life unless otherwise indicated). a) *Stylonichia auriformis* (from DUMAS 1937); p 597. b) *Stylonichia frontosus* (from DUMAS 1937); p 598. c, d) *Stylonichia bicaudatus* (from DUMAS 1937); p 597. e) *Stylonichia octonistylus* (from DUMAS 1937); p 599. f) *Stylonychia* sp. (from NIKOLJUK & GELTZER 1972), 96 µm; p 605. g) *Oxytricha tetranucleata* (after GELEI 1950; from life?); p 253. h) *Hypotrichen* (nov. spec.?) (from FORTNER 1934), 225–270 µm; p 597. i) *Opisthotricha parallela* (from SCHUSTER 1899), dorsal view?, 250 µm; p 255. j) *Stylonichia tricornis* (from MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA 1973), 128 µm; p 602. k) Abnormal reproduction in *Stylonychia* (from GREENAWAY 1916), 200 µm; p 28. l, m) *Oxytricha hengshanensis* (from SHEN et al. 1992; l, silver impregnation), 124–153 µm. Arrow marks postoral ventral cirri; p 249. n) *Oxytricha fallax* (after GREGORY 1923; haematoxylin stain), 85 µm; p 257. Figures on p 921.

Fig. 241a–i Insufficient redescriptions (ventral view from life unless otherwise indicated). a, b) *Oxytricha crassistilata* (from ALEKPEROV 1993). Ventral and dorsal infraciliature after wet silver nitrate impregnation and nuclear apparatus after Feulgen stain, 20 µm; p 257. c) *Tachysoma* sp. (from LEPSI 1965), 100–160 µm; p 469. d) *Tachysoma pelliionella* (from ALADRO LUBEL et al. 1990), 75 µm; p 469. e) *Gonostomum strenuum* (from MADRAZO-GARIBAY & LÓPEZ-UCHOTERENA 1973), 170 × 35 µm; p 395. f) *Pleurotricha* núm. 1 (from IZQUIERDO 1906), 280 µm; p 716. g, h) *Pleurotricha* núm. 2 (from IZQUIERDO 1906), g = 112 µm, h = 100–140 µm; p 716. i) *Stylonychia putrina* (from SAMANO & SOKOLOFF 1931), 140 µm; p 604. Figures on p 922.

Fig. 242a–i Insufficient redescriptions (ventral view from life unless otherwise indicated). a, b) *Oxytricha* sp. (after CHAUDHURI 1929), dorsal (?) and ventral (?) view, a = 90 µm, b = 80 µm; p 260. c) *Stylonychia notophora* (after WANG 1925), 110 µm; p 601. d) *Oxytricha pelliionella* (after WANG 1925), 105 µm; p 468. e) *Stylonychia* sp. (after WANG 1925), 150 µm; p 602. f) *Stylonychia putrina* (after WANG 1925), 95 µm; p 602. g) *Historio* sp. (after WANG 1925), 85 µm; p 666. h) *Oxytricha bifaria* (after WANG 1925), 70 µm; p 601. i) *Stylonychia pustulata* (from CHEN 1944), ventral view after haematoxylin stain, 80 µm; p 603. j) *Gastrostyla pulchra* (from JONES 1974), 185 µm; p 824. Figures on p 923.

Fig. 243a–p Species indeterminata (a, b, q–u, from DUMAS 1929; c–h, from DUMAS 1930; i–p, from DUMAS 1937. a–p, from life, sizes not indicated). **a)** *Kerona cylindrica*; p 840. **b)** *Kerona calvaeformis*; p 839. **c)** *Kerona cuneata*; p 840. **d)** *Kerona subrotundata*; p 841. **e)** *Kerona curvata*; p 840. **f)** *Kerona extuberans*; p 840. **g)** *Kerona undulata*; p 840. **h)** *Kerona absidata*; p 839. **i)** *Kerona rostrata*; p 840. **j)** *Kerona bipes*; p 839. **k)** *Kerona bicaudata*; p 839. **l)** *Kerona anfracta*; p 839. **m)** *Kerona epalxiformis*; p 840. **n)** *Kerona unguicularis*; p 841. **o, p)** *Kerona mamillata*; p 840. **q)** *Oxytricha gyrinioides*; p 249. **r)** *Oxytricha ephippioides*; p 248. **s)** *Oxytricha galeata*; p 249. **t)** *Oxytricha cypris*; p 247. **u)** *Oxytricha pisciunculiformis*; p 252. Figures on p 924.

Fig. 220a-m Legend on p 895.

Fig. 221a-j Legend on p 895.

Fig. 222a-t Legend on p 895.

Fig. 223a-p Legend on p 896.

Fig. 224a-m Legend on p 896.

Fig. 225a-i Legend on p 896.

Fig. 226a-l Legend on p 896.

Fig. 227a–p Legend on p 897.

Fig. 228a-i Legend on p 897.

Fig. 229a-h Legend on p 897.

Fig. 230a-h Legend on p 897.

Fig. 231a-j Legend on p 897.

Fig. 232a–p Legend on p 897.

Fig. 233a-m Legend on p 898.

Fig. 234a–p Legend on p 898.

Fig. 235A, B Legend on p 898.

Fig. 236a-r Legend on p 898.

Fig. 237a-j Legend on p 899.

Fig. 238a-r Legend on p 899.

Fig. 239a-w Legend on p 899.

Fig. 240a–n Legend on p 899.

Fig. 241a-i Legend on p 899.

Fig. 242a-i Legend on p 899.

Fig. 243a–p Legend on p 900.

Addenda

The data by EIGNER (1997), PETZ & FOISSNER (1997a), and SONG & WILBERT (1997a) became available too late for inclusion in the main text and thus are added here at the end of the book.

1. *Oxytricha opisthomuscorum* FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (see p 217; Fig. 244a–j, Table 52)

R e m a r k s: PETZ & FOISSNER (1997a, Polar Record, 33: 318) and PETZ & FOISSNER (1998) found this species in terrestrial habitats of Wilkes Land, Antarctica. Their population matches the brief descriptions based on living specimens given by KAHL (1932; Fig. 73a) and FOISSNER (1980a; Fig. 73b) in size, position of buccal cirrus, shape of peristomial lip, and habitat, but the marked contractility noted by FOISSNER (1980a) was not observed. However, Antarctic specimens soon became rounded and slowed down when

Fig. 244a–c *Oxytricha opisthomuscorum* (from PETZ & FOISSNER 1997a. a, b, from life; c, protargol impregnation). a, b) Ventral and right lateral view, a = 70 μ m. c) Ventral infraciliature, 63 μ m. Large arrow marks slightly postorally located posterior-most frontoventral cirrus (cirrus IV/3), small arrow denotes posterior-most postoral ventral cirrus. M = hook-shaped anterior margin of buccal cavity; p 217, 925.

Fig. 244d-j *Oxytricha opisthomuscorum* (from PETZ & FOISSNER 1997a. d-j, protargol impregnation). **d)** Dorsal infraciliature of same specimen as shown in Figure 244c. **e-g)** Dorsal views showing more or less distinct connections between dorsal kineties 3 (arrow) and 4 (arrowheads). **h-j)** Variability of body shape and nuclear apparatus, especially number and position of micronucleus. Ma = macronuclear nodule, Mi = micronucleus, 1-6 = dorsal kineties (5 and 6 are very likely dorsomarginal kineties); p 217, 925.

Table 52 Morphometric data of *Oxytricha opisthomuscorum* (opi) and *Sterkiella histriomuscorum* (his). All data (from PETZ & FOISSNER 1997a) are based on protargol-impregnated specimens from raw cultures. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	Species	mean	SD	CV	Min	Max	n
Body, length	opi	60.8	5.3	8.6	49	74	31
	his	83.7	8.4	10.1	66	102	31
Body, width	opi	26.6	3.1	11.7	21	38	31
	his	44.3	6.0	13.6	35	57	31
Anterior macronuclear nodule, length	opi	12.8	1.8	14.1	9	17	30
	his	20.1	3.1	15.3	14	29	31
Anterior macronuclear nodule, width	opi	6.9	1.1	15.6	5	9	30
	his	10.4	1.5	14.3	8	15	31
Micronuclei, number	opi	1.0	-	-	1	2	32
	his	1.8	-	-	1	2	31
Micronucleus, length	opi	3.8	0.4	11.1	2.5	4.5	30
	his	3.2	0.5	14.3	2.5	4.5	30
Adoral zone of membranelles, length	opi	22.5	1.5	6.7	20	26	31
	his	37.4	3.5	9.4	31	45	31
Adoral membranelles, number	opi	20.3	0.9	4.5	18	22	33
	his	27.9	1.1	4.0	26	31	31
Paroral, length	opi	9.7	1.0	10.0	7	12	32
	his	20.7	1.8	8.7	17	25	31
Endoral, length	opi	9.4	0.8	8.1	8	11	32
	his	19.6	2.1	10.7	14	23	31
Apex to buccal cirrus, distance	opi	9.9	1.1	11.1	8	12.5	31
Apex to paroral, distance	opi	8.3	0.9	11.4	6.5	10.5	31
Frontoventral cirri, number	opi	4.1	-	-	4	5	29
	his	4.0	-	-	4	4	31
Postoral ventral cirri, number	opi	3.3	0.7	22.5	2	5	31
	his	3.0	0.3	8.6	2	4	31
Transverse cirri, number	opi	5.1	-	-	5	6	31
	his	5.0	-	-	5	5	31
Right marginal row, number of cirri	opi	12.1	1.0	8.5	11	16	26
	his	20.5	1.1	5.3	18	22	31
Left marginal row, number of cirri	opi	13.1	1.0	7.6	11	15	23
	his	18.1	1.3	7.1	15	21	31

transferred from the refrigerator (5 °C) to the microscope (beginning encystment?). PETZ & FOISSNER (1997a) provided the following improved diagnosis: Size in life about 55–80 × 20–40 µm. Invariably (n = 31) 2 macronuclear nodules and one micronucleus in between. Buccal cirrus near anterior end of paroral. 20 adoral membranelles, 12 right marginal cirri, 13 left marginal cirri, 5 transverse cirri, and 3 caudal cirri on average. Six dorsal kineties with about 10 µm long cilia.

Redescription by PETZ & FOISSNER (1997a; slides are deposited in the Oberösterreichische Landesmuseum in Linz, Upper Austria): In life 65–70 × 25–30 µm, outline ellip-

soidal to fusiform because ends often narrowly rounded or bluntly pointed (Fig. 244a, h-j), dorsoventrally flattened up to 2:1 (Fig. 244b). Flexible, especially in anterior portion. Macronuclear nodules ellipsoidal to almost globular, in life about $16 \times 10 \mu\text{m}$, with nuclei $0.5\text{--}2.0 \mu\text{m}$ across. Micronucleus globular, in life about $4\text{--}5 \mu\text{m}$ in diameter, in 71 % of specimens ($n = 31$) between macronuclear nodules or slightly displaced laterally, in 16 %, respectively, 13 % adjacent to anterior or posterior nodule; one specimen had two micronuclei (Fig. 244a, d, h-j). Contractile vacuole near left margin in or slightly behind mid-body, with inconspicuous collecting canals. No cortical granules. Cytoplasm colourless but specimens rather dark at low magnification due to bright fat globules $3\text{--}4 \mu\text{m}$ long, and food vacuoles up to $10 \mu\text{m}$ across containing bright and dark green algae and heterotrophic flagellates. Crawls moderately fast in straight line interrupted by short backward jerks; rotates about main body axis when swimming.

Adoral zone of membranelles extends over about 37 % of body length; longest bases about $6\text{--}7 \mu\text{m}$ in life, cilia $15\text{--}23 \mu\text{m}$ long. Buccal cavity inconspicuous, narrow and flat, anterior margin curved hook-like in live cells, right margin covered by inconspicuous hyaline lip (Fig. 244a). Undulating membranes almost of same length, slightly curved, double-rowed paroral optically intersects apparently single-rowed endoral (Fig. 244c); paroral cilia $3\text{--}4 \mu\text{m}$ long. Pharyngeal fibres about $22 \mu\text{m}$ in life. Invariably ($n = 31$) 3 frontal cirri, 1 buccal cirrus, and 2 pretransverse ventral cirri. Frontal cirri each consisting of 3-4, transverse cirri of up to 5, and other cirral bases of 3 basal body rows. Buccal cirrus near anterior end of paroral. Posterior-most frontoventral cirrus usually slightly behind buccal vertex; 3, rarely 4 or 5 (19 %, $n = 31$) postoral ventral cirri in mid-body and 2 pretransverse ventral cirri in usual position; transverse cirri distinctly enlarged, $20\text{--}28 \mu\text{m}$ long in life and usually motionlessly trailing behind. Marginal cirral rows almost confluent posteriorly, cirri in life about $16 \mu\text{m}$ long, slightly elongated in rear portion of cell, bases composed of two basal body rows each. Invariably ($n = 25$) 6 dorsal kineties, kinary pattern as in other oxytrichids, that is, kineties 1 and 2 nearly as long as body; row 3 slightly to distinctly curved posteriorly and often indistinctly separated from its offspring, the very short kinary 4, which bears the rightmost caudal cirrus; row 5 extends from anterior end to mid-body; row 6 consists of 2-4 cilia only (Fig. 244d-g). Dorsal cilia $8\text{--}12 \mu\text{m}$ long and stiffly spread in life, do not beat like normal cilia but become soft and flexible under cover-slip pressure. Invariably ($n = 26$) 3 caudal cirri, fine, about $20\text{--}24 \mu\text{m}$ long, associated with dorsal kineties 1, 2, and 4 (Fig. 244d, g).

PETZ & FOISSNER (1997a) found *Oxytricha opisthomuscorum* in moss from Casey Station, Wilkes Land, Antarctica. They counted 152 active cells per gram dry mass of soil, comprising about 9 % of the ciliate community. Edaphic parameters: soil temperature $2.8\text{--}13.7^\circ\text{C}$, water content 65-87 % of wet mass, loss of ignition 16.6-34.7 % of dry mass, pH 5.2-5.4. Grew in the laboratory at room temperature (about 19°C) and in dried and moistened samples at 5°C . Biomass of 10^6 medium-sized specimens about 18 mg.

Recently, I recognised that *O. opisthomuscorum* is possibly a synonym of (or at least very closely related with) *O. balladyna* (p 126), as suggested by the redescrptions by Song & Wilbert (1989, Fig. 33b) and Petz & Foissner (1997a, Fig. 244c).

2. *Sterkiella histriomuscorum* (FOISSNER, BLATTERER, BERGER & KOHMANN, 1991) FOISSNER, BLATTERER, BERGER & KOHMANN, 1991 (see p 683; Table 52)

R e m a r k s: PETZ & FOISSNER (1997a, Polar Record, 33: 323) found this common species in a fell field, south-west of Casey Station, Wilkes Land, Antarctica. They provided the following additional observations (Table 52): In life $70\text{--}110 \times 40\text{--}60\text{ }\mu\text{m}$, that is, slightly smaller than other well studied populations. Marginal cirri about $15\text{ }\mu\text{m}$ long, frontal cirri about $17\text{ }\mu\text{m}$, transverse and caudal cirri $20\text{--}24\text{ }\mu\text{m}$, and dorsal cilia about $3\text{ }\mu\text{m}$. Adoral zone of membranelles extends over about 45 % of body length, longest bases $7\text{--}9\text{ }\mu\text{m}$; cilia $17\text{--}20\text{ }\mu\text{m}$ long. Biomass of 10^6 medium-sized specimens about $60\text{ }\mu\text{m}$. Several-days-old resting cysts spherical and entirely filled by cell, in life $33\text{--}44\text{ }\mu\text{m}$ (mean = $38.9\text{ }\mu\text{m}$, $n = 11$) in diameter; wall about $2.5\text{ }\mu\text{m}$ thick, surface smooth or slightly uneven. Macronuclear nodules fused; however, when cyst wall is ruptured two (disintegrated?) nodules sometimes stain with methyl green-pyronin. Cytoplasm contains numerous granules and some globules up to $4\text{ }\mu\text{m}$ across.

PETZ & FOISSNER (1997a) also studied the morphogenesis (see this paper for details and illustrations). They found some differences to the population described by BERGER et al. (1985a), indicating that populations with 4 transverse cirri (BERGER et al. 1985a) are not conspecific with those having 5 transverse cirri, as in the type population described by KAHL (1932, Fig. 184k). Note that *Sterkiella histriomuscorum* is a sibling species complex (FOISSNER & BERGER 1999).

3. Classification of the Oxytrichidae by EIGNER (1997)

EIGNER (1997) analysed the detailed descriptions of divisional morphogenesis of 40 hypotrichous species to establish a natural classification. He made schematised drawings which show the interphase and its morphogenesis in one image. EIGNER's classification differs significantly from my classification, simply because he used other characters. Here I discuss only some doubtful points of this most recent attempt to classify the hypotrichs.

- EIGNER (1997, p 553) stated that his results are in accordance with those obtained from molecular techniques (SCHLEGEL & STEINBRÜCK 1986, SCHLEGEL et al. 1991). However, Abb. 11 in SCHLEGEL & STEINBRÜCK (1986) shows that *Stylonychia mytilus* is more closely related to *S. pustulata* than to *Oxytricha granulifera* and not vice versa as suggested by EIGNER, who classified *Stylonychia mytilus* and *Oxytricha granulifera* in the Oxytrichidae and *Stylonychia pustulata* (as *Clara pustulata*) in the Parakahliliellidae (see EIGNER's Fig. 3). The dendrogram proposed by SCHLEGEL & STEINBRÜCK (1986) matches our (BERGER & FOISSNER 1997) separation of the Oxytrichidae in the Stylonychinae and Oxytrichinae (note that *Oxytricha nova*, *O. bifaria*,

and *O. fallax* in SCHLEGEL & STEINBRÜCK 1986 are in fact *Stylonychia* or *Sterkiella* species!). Figure 2 in SCHLEGEL et al. (1991) matches both our (BERGER & FOISSNER 1997) and EIGNER's classification.

- EIGNER (1997, p 553) assumed that the conspicuous 18 frontal-ventral-transverse cirral pattern (see my Fig. 6a) originated from at least two phylogenetic lineages. According to him, this pattern is the result of transformation series from little evolved Oxytrichidae and Parakahliellidae to their highly evolved state, and this pattern is therefore not an autapomorphy of a monophyletic group. Instead, he used differences in the neokinetal anlagen development to separate the Oxytrichidae from the Parakahliellidae. This hypothesis is the main reason why EIGNER's classification is very different from my proposal. However, I am rather certain that such a highly characteristic cirral pattern (Fig. 6a), including many morphogenetic details, is not the product of convergent evolution. Furthermore, EIGNER (1997, p 570) stated that fragmentation of a dorsal kinety cannot be used to characterise the most highly evolved hypotrich group (= oxytrichids). Conversely, fragmentation of a dorsal kinety (primarily kinety 3) is considered as the sole autapomorphy of the last common ancestor of all species treated in my book. Certainly, this character was modified several times (for example, multiple fragmentation in kineties 1–3 or loss of fragmentation) during the origin of the oxytrichids 300–400 million years ago (WRIGHT & LYNN 1997). But, as in the case of the 18-cirri pattern, I am certain that this curious dorsal pattern did not evolve convergently. In addition, I do not exclude that groups like the amphisiellids or kahliellids also belong to the oxytrichids, that is, they possibly evolved from oxytrichids in that they lost the fragmentation of dorsal kineties and changed the ventral ciliature more (for example, *Kahliella*) or less (for example, *Lamtosyla*) distinctly.

The cladogram proposed by EIGNER (1997, his Fig. 2) is not constructed according to the original cladistic method and, is thus somewhat confusing, showing several convergences. (i) EIGNER used the Holostichidae as outgroup. Many species of this group have transverse cirri indicating that the presence of transverse cirri is a plesiomorphy at the base of EIGNER's cladogram. Consequently, the loss of transverse cirri in the Orthoamphisiellidae would be an apomorphy and not a plesiomorphy (EIGNER's character 6). Furthermore, according to EIGNER's cladogram this character evolved convergently in the Oxytrichidae and Parakahliellidae because it is applied at the wrong level (it can be used to separate the Orthoamphisiellidae from the Oxytrichidae/Parakahliellidae group). (ii) In the holostichids, the outgroup used by EIGNER, the rightmost cirral row (= migratory cirri and right transverse cirrus and its corresponding pretransverse ventral cirrus) is not involved in primordia formation (for example, *Holosticha similis* in HEMBERGER 1982, p 105). Thus, the lack of an anlage in the rightmost ventral cirral row is very likely a synapomorphy at the base of EIGNER's cladogram. Consequently, the lack of an anlage in this row (character 1 in EIGNER's cladogram) is not an apomorphy but a plesiomorphy.

- According to EIGNER (1997, his Fig. 2), the lack of old (parental) cilia and cirri in the interphase cells of both the Oxytrichidae and Orthoamphisiellidae is an apomorphy, that is, a further convergence. In spite of this, he assigned *Kahliella simplex*, a species where many parental marginal cirri are retained, to the Oxytrichidae and *Engelmanniella mobilis*, which also has many parental marginal cirri, to the Orthoamphisiellidae. Thus, the Kahliellidae became a junior synonym of the Oxytrichidae and EIGNER had to establish a new (superfluous?) taxon, the Parakahliellidae.
- According to Figure 32 in EIGNER (1997, p 567), the buccal cirrus (cirrus II/2) of *Coniculostomum monilata* originates from the undulating membrane primordium. I do not understand this misinterpretation of the original data (KAMRA & SAPRA 1990). Presumably EIGNER confused the left frontal cirrus (cirrus I/1) and the buccal cirrus.
- According to Figure 41 in EIGNER (1997, p 571), the pretransverse ventral cirrus V/2 of *Oxytricha granulifera* is involved in primordia formation (indicated by a black square = symbol h in his Fig. 1). However, this is certainly incorrect because this cirrus is not involved in primordia formation in *Oxytricha granulifera* or other species. This cirrus is even present in an early postdivider (see Fig. 66a, d, f).
- According to Figure 42 in EIGNER (1997, p 571), *Urosoma macrostyla* has 3 pretransverse ventral cirri, which is due to a misinterpretation of the original illustrations. This species has, as is usual in oxytrichids, only 2 pretransverse ventral cirri (see p 411).

4. *Oxytricha saltans* (COHN, 1866) REES, 1881 (see p 236, Fig. 245a–e)

1997 *Oxytricha saltans* (COHN, 1866) – SONG & WILBERT, Arch. Protistenk., 148: 420 (Fig. 245a–e; 1 neotype slide of protargol-impregnated specimens is deposited in the Protozoological Laboratory, College of Fisheries, Ocean University of Qingdao, Qingdao, China).

R e m a r k s: *Oxytricha saltans* (COHN, 1866) REES, 1881 is a secondary homonym of *Oxytricha saltans* VUXANOVICI, 1963, a species determinata (see p 253). Thus, I do not replace the name of VUXANOVICI's species. SONG & WILBERT (1997a) found *O. saltans* many times in marine fish- and mollusc-farming ponds in Qingdao, China (morphological studies mainly based on a population collected on October 27, 1993). They provided the following additional description: Cell size varies considerably depending on diet or different populations, however, body shape almost constant, generally as shown in Figure 245a with inconspicuous tapering anterior end. Pellicle flexible, no cortical granules. Cytoplasm colourless to slightly greyish, often with a few large food vacuoles filled with green flagellates in specimens newly collected or containing many to numerous small (2–4 µm) shining globes mostly within posterior half of cells when cultured (fed with bacteria). Movement quite unique, usually very fast crawling (even jump-like) on bottom of Petri dish with frequent jerks. When resting, more or less thigmotactic, adhering on

Fig. 245a–e *Oxytricha saltans* (from SONG & WILBERT 1997a. a, b, from life; c–e, protargol impregnation). **a)** Ventral view. Note the very narrow buccal field. **b)** Ventral view of anterior portion showing spur-like (thorn-shaped) protrusion (arrow) of the buccal lip. **c)** Left lateral view showing nuclear apparatus. **d, e)** Ventral and dorsal infraciliature. Arrow in (d) denotes distinctly posteriorly displaced anterior end of right marginal row. The arrangement of the frontal and frontoventral cirri is not as in a “typical” *Oxytricha* species. Explanation of original labels DK = dorsal kineties, Ma = macronuclear nodule, Mi = micronucleus; p 236, 931.

substrate with the aid of transverse cirri. When swimming (only occasionally) always slowly rotating about main body axis. Adoral zone of membranelles about 33 % of body length, generally bipartite by 3–5 µm wide gap in anterior third, 5 (seldom 4) stiff membranelles (over 20 µm in length) forming a crown-shaped apical style radiating from anterior border of cell (Fig. 245a) in anterior portion, others in posterior with last 3 ones close together, often forming another separate group. Undulating membranes short and straight, parallel, almost equally long. Buccal field very narrow (Fig. 245a, b); buccal lip covers almost entire proximal part of adoral zone of membranelles, with conspicuous, flexible, spur-like protrusion (Fig. 245b, arrow) of unknown function, overlooked by previous authors. Cirral pattern very particular: invariably 7 frontal cirri, conspicuously shifted posteriorly with only about 4 within frontal

field; cirri generally fine except transverse ones, which are 20–30 µm long; right marginal row begins behind mid-body (Fig. 245d, arrow). Usually 5 (rarely 6) dorsal

kineties, leftmost row distinctly shortened posteriorly or with large gap (Fig. 245e). Dorsal cilia 8–10 µm long, conspicuous in life (Fig. 245a).

5. *Hemigastrostyla* SONG & WILBERT, 1997

1997 *Hemigastrostyla* SONG & WILBERT, Arch. Protistenk., 148: 421 – Type (original designation): *Oxytricha* (*Urosoma*) *stenocephala* BORROR, 1963.

C h a r a c t e r i s a t i o n: Marine or brackish water Oxytrichidae with slightly cephalised body shape; mostly 8–10 frontal, 5 ventral and a few extra lateroventral cirri which possibly derive from the 6th (rightmost) frontal-ventral-transverse cirral anlage during morphogenesis; caudal cirri present.

R e m a r k s: I did not change the characterisation proposed by SONG & WILBERT (1997a). Unfortunately, they did not fix *Oxytricha enigmatica* (which they redescribed in detail) as type species, but *Oxytricha stenocephala* (now *Hemigastrostyla stenocephala* (BORROR, 1963) SONG & WILBERT, 1997), an incompletely known species previously classified in *Gastrostyla* (see p 822). *Hemigastrostyla* has two apomorphies, namely the cephalised anterior end and the additional cirri right of the transverse cirri (“LVC” in Fig. 246e). According to SONG & WILBERT (1997a), an additional frontal-ventral-transverse cirri primordium (that is, in total 7 against 6 in other 18-cirri oxytrichids) is a further apomorphy. However, this assumption is obviously based only on two specimens in physiological reorganisation (Fig. 246i, j). Thus, divisional morphogenesis has to be studied to clarify the origin of the curious cirri right of the transverse cirri. *Oxytricha discifera* also has a cephalised anterior end (p 227, Fig. 81); however, KAHL (1932) did not describe the cirri right of the transverse cirri; thus, redescription is needed for final classification of this species, which also lives in the sea.

Hemigastrostyla enigmatica (DRAGESCO & DRAGESCO-KERNÉIS, 1986)

SONG & WILBERT, 1977 (see p 229, Fig. 246a–j, Table 53)

1997 *Hemigastrostyla enigmatica* (DRAGESCO & DRAGESCO-KERNEIS, 1986) – SONG & WILBERT, Arch. Protistenk., 148: 421 (Fig. 246a–j, Table 53)

R e m a r k s: SONG & WILBERT (1997a) collected *H. enigmatica* twice in a marine mollusc-farming water in Qingdao, China. The redescription clearly shows that *Hemigastrostyla enigmatica* is an 18-cirri oxytrichid with a somewhat unusual arrangement of the frontal and frontoventral cirri, possibly due to the cephalisation. SONG & WILBERT (1997a) provided a detailed redescription, which is given word for word (see also Table 53): “Cell shape elongate with both ends widely rounded, frontal portion more or less head-like; left margin only slightly convex while portion posterior to distal end of adoral zone of membranelles on right evidently convex (Fig. 246a). When viewed ventrally, one in-

Fig. 246a–e *Hemigastrostyla enigmatica* (from SONG & WILBERT 1997a. a–d, from life; e, protargol impregnation). a) Ventral view of a representative specimen, 105 μm . Note the cephalised anterior end. b) Detail of left and right marginal groove. c) Detail of cortical granulation. Arrowheads mark cortical granules, <1 μm across. d) Detail of dorsal side showing the dorsal cilia within the cup-shaped depression. e) Ventral infraciliature, 112 μm . Tiny arrows denote the 4 frontoventral cirri, arrowhead marks the anterior-most postoral ventral cirrus. Explanation of original labels: BC = buccal cirrus, CC = caudal cirri, LVC = curious cirri right of transverse cirri (an apomorphy of *Hemigastrostyla*), VC = pretransverse ventral cirri; p 229, 933.

conspicuous indentation (marginal groove) formed by right marginal row at about anterior 2/5 of cell length. Dorsoventrally significant flattened (about 1:3–4). Dorsal side uneven, with central part thicker than posterior and anterior ends, right and left often forming a projection-like border (Fig. 246g, h). Pellicle as shown in Fig. 246c, cortical granules very fine (<1 μm), generally grouped rosette-like and close to cilia (Fig. 246c, arrowheads). At high magnification (1250 $\times$), always numerous small (ca. 2 μm in size)

Fig. 246f-h *Hemigastrostyla enigmatica* (from SONG & WILBERT 1997a. f, protargol impregnation; g, h, from life). f) Dorsal infraciliature and nuclear apparatus, 112 μ m. Morphogenetic data are needed to "understand" this kiny pattern. g, h) Left lateral and dorsal view. Explanation of original labels DK_{1,4,5} = dorsal kineties, DKF = dorsomarginal kiny; p 229, 933.

vacuole-like, ellipsoid globules at deeper level (beneath cortical granules) recognisable (Fig. 246c). Cytoplasm hyaline and colourless; cells frequently with many lipid droplets, 5–8 μ m across, Food vacuoles rarely to recognise, contain mostly flagellates and diatoms. Contractile vacuole not observed. Constant two large macronuclear nodules, ellipsoid, located in about mid-body and left to cell margin, containing many spherical nucleoli; replication band often visible in non-dividing individuals (Fig. 246f). Micronuclei several to "many", small and near macronuclear nodules (Table 53).

Movement slow to moderate crawling on bottom of Petri dish. Sometimes more or less thigmotactic, adhering with the aid of transverse cirri on substrate. When swimming slowly rotating around its longitudinal axis. Character-

istically 2–3 (usually 2) right marginal cirri arising from border and slowly waving up and down, while all other ciliary organelles stationary.

Oral area narrow, posterior portion of adoral zone of membranelles always half covered by cytoplasmic lip on right margin of buccal field (Fig. 246a). Adoral zone of membranelles about half of cell length with distal end of zone extending back far onto right side (Fig. 246a, e). Paroral and endoral membranes slightly curved, almost in parallel to each other (Fig. 246e).

Three evidently enlarged cirri in anterior cell portion: 2 frontal cirri at most apical area of cell, one buccal cirrus at about middle way of frontal region, other 5 frontal cirri always grouped together, near distal end of adoral zone. Ventral cirri in two groups as in many other oxytrichids: 3 anterior ventral cirri located anterior to cytostome level and

Fig. 246i, j *Hemigastrostyla enigmatica* (from SONG & WILBERT 1997a. i, j, protargol impregnation). Physiological reorganisation. Dashed lines in (j) show possible cirral differentiation. However, detailed morphogenetic data are needed to elucidate the ontogenetic origin of the conspicuous cirri right of the transverse cirri ("LVC" in Fig. 246e). Explanation of original labels: CA = cirral anlagen, DKF = dorsomarginal kinety, UM = undulating membranes, UMA = primordium of undulating membranes, I, II, VI = cirral anlagen (note that anlage I corresponds to anlage II of Fig. 6a, because SONG & WILBERT 1997a did not count the anlage of the undulating membrane; p 229, 933).

close to frontal cirri; 2 posterior ventral cirri near to transverse ones. Except those 5 normal ventral cirri, always 2 extra lateroventral cirri (called "fimbriate caudal cirri" by BORROR) right to transverse cirri and posterior end of right marginal row (Fig. 246a). Transverse cirri strong, about 20 μm long, located subterminally. Marginal rows extending slightly spirally from upper-right to lower-left. Right row shortened anteriorly with its posterior end extending near to rightmost transverse cirrus (Fig. 246e). Left row turning onto dorsal side (at least on margin of cell) and almost confluent with caudal cirri posteriorly. All marginal cirri densely spaced, laying "firmly" on cell surface along marginal grooves (Fig. 246a, b). Bases of all cirri associated with well impregnated fibres (Fig. 246e).

Constant 5 dorsal kineties, kinety 1 shortened posteriorly while dorsal kinety 4 extending anteriorly only about halfway of cell (Fig. 246f). Apart from these 5 rows, one ciliary fragment anterior of right marginal cirral row consisting of several basal bodies. Dorsal cilia about 3 μm long, very characteristically located within cup-shaped depressions (Fig. 246d)."

Table 53 Morphometric data of *Hemigastrostyla enigmatica* (from SONG & WILBERT 1997a). All data are based on protargol-impregnated specimens. All measurements in micrometres. CV = coefficient of variation (in %), Max = maximum value, mean = arithmetic mean, Min = minimum value, n = sample size, SD = standard deviation

Character	mean	SD	CV	Min	Max	n
Body, length	131.2	17.7	13.5	108	165	20
Body, width	63.4	11.2	17.7	45	82	20
Adoral zone of membranelles, length	64.6	7.5	11.6	54	77	20
Adoral membranelles, number	42.4	4.2	9.9	34	50	20
Macronuclear nodules, number	2.0	0	0	2	2	20
Macronuclear nodules, length	21.5	4.2	19.5	16	30	20
Macronuclear nodules, width	15.8	2.0	12.9	13	18	20
Micronuclei, number	4.5	1.3	28.7	2	6	20
Cirri, number ¹	15.0	0	0	15	15	20
Transverse cirri, number	5.0	0	0	5	5	20
Left marginal cirri, number	20.3	1.0	5.1	17	21	18
Right marginal cirri, number	16.7	2.0	11.6	13	19	18
Dorsal kineties, number	5.0	0	0	5	5	12
Caudal cirri, number	3.0	0	0	3	3	18

¹ Including frontal cirri, buccal cirrus, frontoventral cirri, postoral ventral cirri, pretransverse ventral cirri, and cirri right of transverse cirri.