

Rhinoglena kutikovae n.sp. (Rotifera: Monogononta: Epiphanidae) from the Bunger Hills, East Antarctica: a probable relict species that survived Quaternary glaciations on the continent

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Abstract A new species of rotifer, *Rhinoglena kutikovae* n.sp. (Monogononta: Epiphanidae), is described from a freshwater lake in the Bunger Hills, East Antarctica. The new taxon is characterized by the following combination of characters: body conical to vase-shaped; a single toe; distal foot pseudosegment bulged; tail prominent, semi-circular; two small spherical pedal glands with common duct, forming a complex with caudal ganglion; trophi with seven major teeth with offset head and two smaller teeth without offset head. The new species is compared with *R. fertoeensis*, *R. frontalis* and *R. tokioensis*, of which scanning electron microscopic information is presented of the trophi. *R. kutikovae* n.sp. is probably a relict species that survived Quaternary glaciations in glacial lacustrine refugia on the Antarctic continent.

Keywords *Rhinoglena kutikovae* n.sp. · Taxonomy · Rotifera · Antarctica

Introduction

In spite of numerous publications on the limnetic rotifers of the Antarctic continent, our knowledge of this taxon is

fragmentary. Information accumulated to date suggests that the rotifer fauna is limited, with only 13 bdelloid and 29 monogonont taxa reported, including four endemic species [*Encentrum forcipatum* Dartnall, 1997; *Notholca verae* Kutikova, 1958; *Philodina alata* Murray, 1910; *Philodina gregaria* Murray, 1910; W.H. De Smet, unpublished]. This observation is undoubtedly correct, but rotifer diversity and endemism is unquestionably underestimated, due to the poor state of areal coverage, taxonomical misinterpretations and force-fitting of taxa into existing species descriptions. Here we describe an apparently endemic *Rhinoglena* from a freshwater lake in the Bunger Hills, East Antarctica, and present information on the trophi morphology of known representatives of the genus. Relevance of its discovery is formulated in light of the presence of refugia on the continent during Quaternary glaciations.

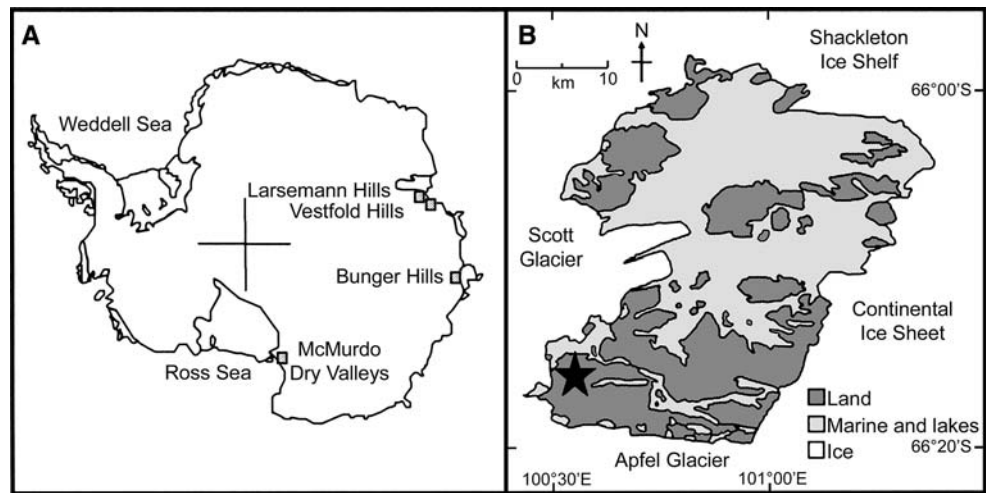
Materials and methods

The study site is located in the Bunger Hills, East Antarctica, which is nominally a coastal oasis located at 66°S, 101°E (Fig. 1). The exposed rock has an area approaching 500 km² (Wisniewski 1983), and is made up of an extensive southern area and smaller islands and peninsulas abutting the ice cap to the north. The rock is bound by ice on all sides: polar ice sheet and glaciers to the east, south and west, and floating Shackleton Ice Shelf to the north. The terrain of the southern Bunger Hills varies from rugged hills (maximum height ca. 180 m) with little soil development in the valleys in the south, to a more gentle landscape with extensive areas of till to the north. Lakes and ponds make up an important component of the landscape. Over 200 water bodies occur, ranging in size from small, shallow ponds a few tens of metres across that freeze to the

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Fig. 1 **a** Map of Antarctica showing location of the Bunge Hills. **b** Map of the Bunge Hills showing the exposed land and marine area surrounded by permanent ice; sampling site indicated



bottom during winter, to Algae (or Figurnoye) Lake, which is one of the largest and deepest freshwater lakes in Antarctica.

Sparse information on the rotifers of this area has been published by Kutikova (1958) and Korotkevich (1964), who reported *Epiphanes senta* (Müller, 1773); *Lepadella patella* (Müller, 1786); *N. verae* Kutikova, 1958; *P. alata* Murray, 1910; *Philodina* sp.; *Proales reinhardti* (Ehrenberg, 1834) and *Rhinoglana fertoeensis* (Varga, 1929).

Samples were collected with a 35 µm plankton net from the edge of a largely ice covered freshwater lake at 66°16'41.7"S, 100°31'39.5"E, altitude 45 m, 25 December 2006, and fixed with 95% ethanol. Specimens were examined and drawn using a Leitz Orthoplan microscope with camera lucida. Trophi preparation for light and scanning electron microscopy (SEM) was done following De Smet (1998) using NaOCl solution. SEM was performed with a Philips SEM-515 microscope operated at 20 kV.

The trophi of the new species are compared with those of *Rhinoglana frontalis* Ehrenberg, 1853 collected at arctic Bjørnøya (Bear Island) (7 September 1985) and the subantarctic Îles Kerguelen (8 February 1998), *R. fertoeensis* (Varga, 1929) from Lake Mogan, Ankara, Turkey (May 2005) and *R. tokioensis* Sudzuki, 1975 from Cava Vecchia, Casalmaggiore, Cremona, Italy (13 November 2001).

Taxonomic report

- Phylum Rotifera Cuvier, 1812
- Class Eurotatoria De Ridder, 1957
- Subclass Monogononta Plate, 1889
- Order Ploima Hudson and Gosse, 1886
- Family Epiphanidae Harring, 1913
- Genus *Rhinoglana* Ehrenberg, 1853
- *Rhinoglana kutikovae* n.sp.

Material examined

Fifty-three parthenogenetic females, all from type locality.

Type locality

Bunge Hills, East Antarctica, unnamed freshwater lake, 66°16'41.7"S, 100°31'39.5"E, 25 December 2006.

Holotype

A parthenogenetic female in a permanent glycerine glass slide mount deposited in the Koninklijk Belgisch Instituut voor Natuurwetenschappen (KBIN), Brussels, Belgium, Reg. No. IG 30815, RIR 175.

Paratypes

Fifty-two parthenogenetic females from type locality: two slides containing female and trophi preparation in KBIN (RIR 176, 177), and one in American Academy of Natural Sciences of Philadelphia, catalogue number ANSP 1970; several specimens in glycerine and glycerine glass slide mounts, and eight stubs each with trophi preparation for SEM in Department of Biology, University of Antwerp.

Etymology

The species is dedicated to Professor Ludmila Kutikova, to reflect her early role in Antarctic rotifer research.

Diagnosis

Body conical to vase-shaped, tapering to single conical toe. Foot with two pseudosegments, distal pseudosegment

bulged. Tail prominent, semi-circular. Two small spherical pedal glands with common duct. Two, apparently colourless, eyespots. Trophi malleate; unci with seven major teeth with head, gradually decreasing in length from ventral to dorsal, terminating with two smaller dorsal teeth without offset head.

Description

Parthenogenetic female (Fig. 2a, b). Illoricate, very transparent. Body stout, conical to vase-shaped, usually weakly constricted below corona, tapering to foot. Tail prominent, semi-circular. Foot stout, fairly long, 1/5–1/6 total length, two weakly offset pseudosegments, distal pseudosegment bulging laterally. Toe single, small, conical, terminating in a short tubulus. Corona made of two broad lobes ventro-laterally to the mouth, and a single broad dorsal proboscis; each lobe bordered by C-shaped, densely ciliated part of cingulum, and two concentric arched rows of cirri belonging to pseudotrochus. Proboscis with two small colourless eyespots. Dorsal antenna small, near posterior 1/3 of proboscis, anteriorly to weak dorsal fold. Lateral antennae in posterior 1/3 of body. Caudal antenna very small, at distal margin of distal foot pseudosegment. Brain saccate, extending into proboscis, with distinct retrocerebral organ and

ducts. Oesophagus fairly long, ending in cellular stomach; stomach and intestine separated by constriction. Gastric glands large, rounded, short-stalked. Bladder present, normal. Two small spherical pedal glands with long common duct (Fig. 2c, d); glands and proximal half of duct with associated cellular mass of foot ganglion. Vitellarium with eight nuclei.

Trophi (Fig. 2e, 3) malleate, almost symmetrical. Rami triangular, each with two very small alulae, one of which is often hook-shaped; inner margins with uniform zigzag like reinforced ridge (Fig. 3e), composed of fused scleropili, ridge complementary to the major unci teeth; basal apophyses (Fig. 3e, ba) composed of row of ~12 fused scleropili; basifenestrae (Fig. 3b, bf) and subbasifenestrae large (Fig. 3a, sf); rami tips weakly decurved frontally; rami and fulcrum forming a weak angle. Fulcrum short, slightly broadened frontally. Unci teeth fused by their shafts; each unci (Fig. 3g) with seven major teeth showing a distinct offset head and gradually decreasing in length to dorsally, followed by a smaller tooth without offset head, and terminating with a two to three knobbed dorsal tooth; the last but one toothlet is weakly recurved posteriorly, by which a small gap is formed between the major teeth and the most dorsal tooth, grasping the frontally decurved rami tips; outside of teeth with seam (Fig. 3g), inside with rib

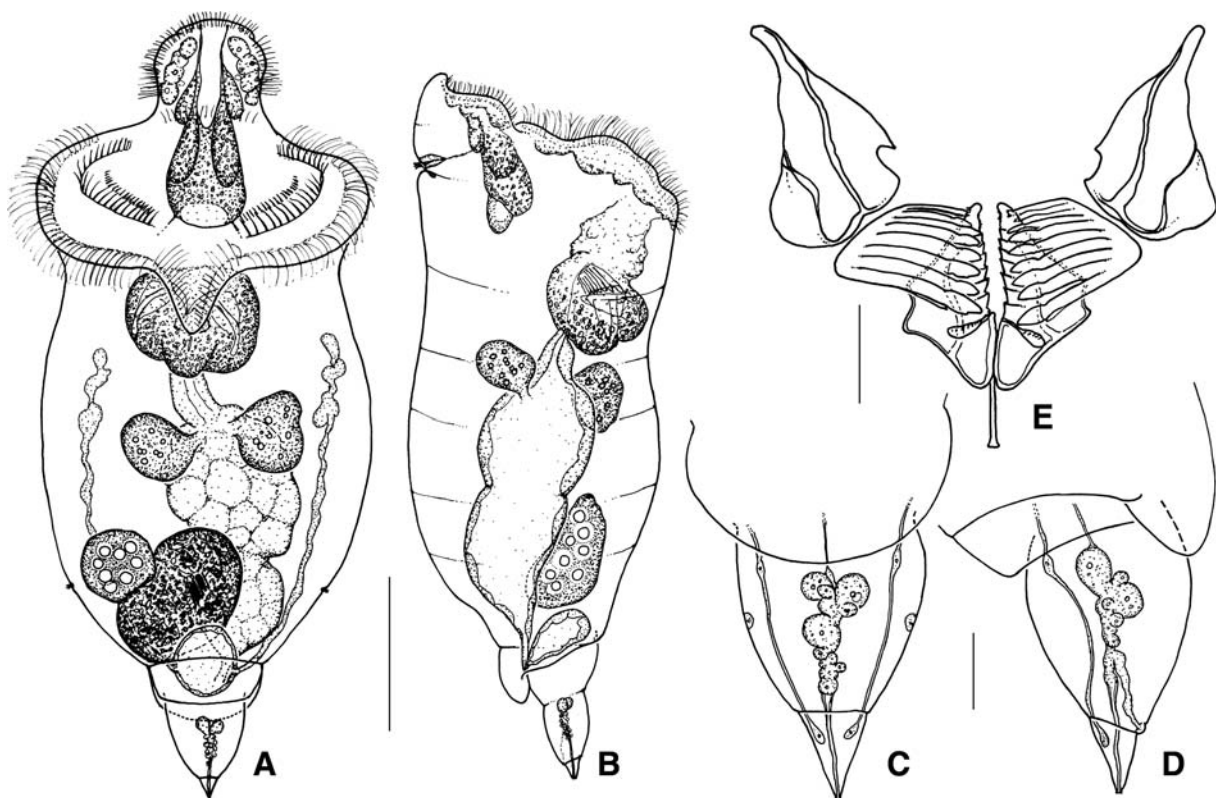


Fig. 2 *Rhinoglana kutikovae* n.sp. **a** Female ventral view. **b** Female lateral view. **c** Foot and tail, dorsal view (proximal foot pseudosegment omitted). **d** Foot and tail, lateral view. **e** Trophi (light microscopy),

incus and unci frontal view; manubria, outer view. Scale bars: A, B—50 μ m; C–E—10 μ m

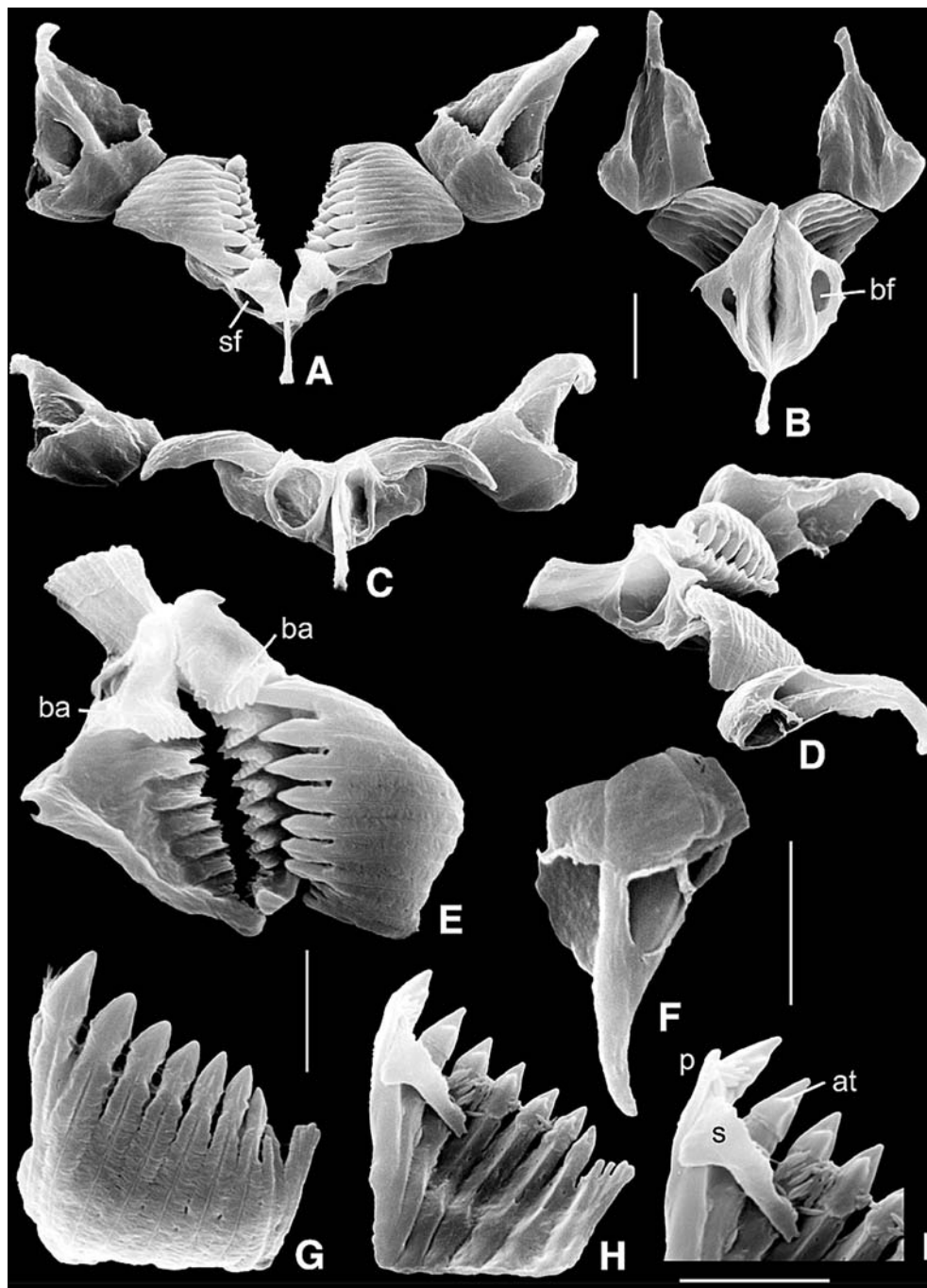


Fig. 3 *Rhinoglana kutikovae* n.sp., SEM photographs of trophi. **a** Complete set of trophi, incus frontal view; unci and manubria outer view. **b** Incus, caudal view; unci and manubria inner view. **c** Same as (a), ventral view. **d** Same as (a), lateral view. **e** Detail incus and right

uncus, frontal view. **f** Right manubrium, outer view. **g** Left unci, outer view. **h** Right unci, inner view. **i** Detail, subuncus. Scale bars: A–D, F–10 μm ; E, G–I—5 μm . *at* accessory toothlet, *ba* basal apophysis, *bf* basifenestra, *sf* subbasifenestra, *p* preuncinal toothlet, *s* subuncus

(Fig. 3h, i); first major teeth with small preuncinal toothlet (Fig. 3i, p); head of major teeth more or less bifid, with shorter accessory toothlet at inner side (Fig. 3i, at); subuncus (Fig. 3i, s) composed of an elongate, more or less triangular platelet and a few individual scleropili. Manubria (Fig. 3f) with large and broad head and short rod-shaped cauda; head with three chambers: dorsal and medial

chamber large, with large opening, ventral chamber small; caudae weakly incurved towards trophi axis, occasionally with very weak crutch.

The amictic females are viviparous, and bore mostly one to two, rarely three developing embryos in the body cavity.

Male, mictic female and resting egg unknown.

Measurements

Embryo bearing females ($N=15$): total length 198–268 μm , mean 235 μm , toe 7–12 μm , mean 9 μm ; trophi see Table 2.

Distribution and ecology

Rhinoglana kutikovae n.sp. occurred in the littoral plankton of a largely ice covered freshwater lake in the Bunger Hills, East Antarctica. This lake was recorded during

an earlier study to have a conductivity of 715 $\mu\text{S cm}^{-1}$ and pH 8.3, with the ionic composition dominated by Na^+ and Cl^- (Klokov et al. 1990). The littoral microbial mat of this species also contained nematodes (*Plectus frigophilus* Kirjanova, 1958), tardigrades and bdelloid rotifers (*Philodina* sp.). The rotifers *L. patella* (Müller, 1786), *N. verae* Kutikova, 1958 and unidentified bdelloids also were present in the plankton samples. Examination of the gut content revealed that *R. kutikovae* n.sp. had been feeding on small (6–8 μm), spherical algal cells.

Table 1 Diagnostic characters in *Rhinoglana*

	<i>R. fertoeensis</i>	<i>R. frontalis</i>	<i>R. kutikovae</i>	<i>R. tokioensis</i>
Body shape	Cylindrical	Conical to vase-shaped	Conical to vase-shaped	Fusiform
Foot pseudosegments	1, Conical	1, Conical	2, Bulged	2, Conical
Toes	2	2	1	1
Tail	Absent	Indistinct	Prominent	Prominent
Gastric glands	Smooth	Smooth	Smooth	Lobed distally
Pedal glands	Absent	2	2	2
Ducts of pedal glands	Absent	2, Separate	1	1
Eyespots	Red	Red	? Colourless	Red
Uncus teeth (major + minor)	8 to 9 + 2	6 to 7 + 2	7 + 2	5 to 6 + 2

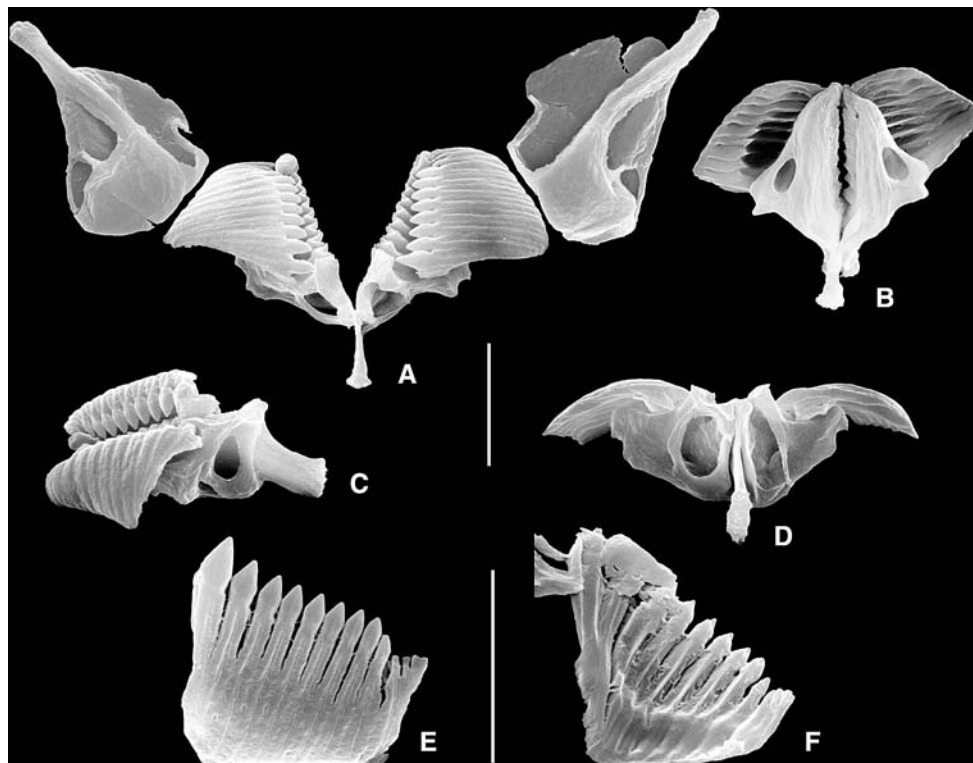


Fig. 4 *Rhinoglana fertoeensis* (Varga), SEM photographs of trophi. **a** Complete set of trophi, incus frontal view; unci and manubria outer view. **b** Incus, caudal view; unci inner view. **c** Same as (a), incus

lateral view. **d** Same as (a), incus, ventral view. **e** Left uncus, outer view. **f** Right uncus, inner view. Scale bars: 10 μm

Comments

To date three species of *Rhinoglana* have been described: *R. fertoeensis* (Varga, 1929), *R. frontalis* Ehrenberg, 1853 and *R. tokioensis* Sudzuki, 1975. The taxonomically relevant characters of these species and *R. kutikovae* n.sp. are summarized in Table 1. *R. kutikovae* n.sp. shares a single toe with *R. tokioensis*, whereas two small toes are present in *R. frontalis* and *R. fertoeensis*. The body shape is wide and conical to vase-shaped in *R. kutikovae* n.sp. and *R. frontalis*, fusiform in *R. tokioensis*, and more or less cylindrical in *R. fertoeensis*. The tail is semi-circular and bulging in the new species, prominent and more or less rectangular in *R. tokioensis*, and inconspicuous in the others. A distinct foot is present in *R. kutikovae* n.sp., *R. frontalis* and *R. tokioensis*, whereas a very small foot, usually retracted inside the body, is characteristic of *R. fertoeensis*. *R. kutikovae* n.sp. and *R. tokioensis* have two foot pseudosegments, but one only is observed in *R. fertoeensis*. Pedal glands are reported absent in *R. fertoeensis* (Varga 1929, 1930;

Hermes 1932; Althaus 1957); two, each with their own duct, are present in *R. frontalis*, whereas the two pedal glands in *R. tokioensis* and *R. kutikovae* n.sp. have a single common duct. The proximal part of the duct of the pedal glands is smooth in *R. frontalis* and *R. tokioensis*, whereas irregular in *R. kutikovae* n.sp., due to the close association of the cells of the caudal ganglion [see Hermes (1932) and Stossberg (1932) for the nervous system in *R. frontalis* and *R. fertoeensis*]. *Rhinoglana tokioensis* is also reported (Sudzuki 1975) to have gastric glands with five distal lobes, a character not shared with the other congeners.

Analysis by SEM of the trophi of the four *Rhinoglana* species (Figs. 3, 4, 5 and 6) shows an almost identical morphology of the different elements, reflecting their close relationship, and the general description as given for *R. kutikovae* n.sp. applies to the others as well. The only additional diagnostic feature concerns the number of the uncinial teeth. All species show two minor teeth, and a varying number of major teeth: five in *R. tokioensis* ($N=5$), six to seven in *R. frontalis* ($N=5$), seven in

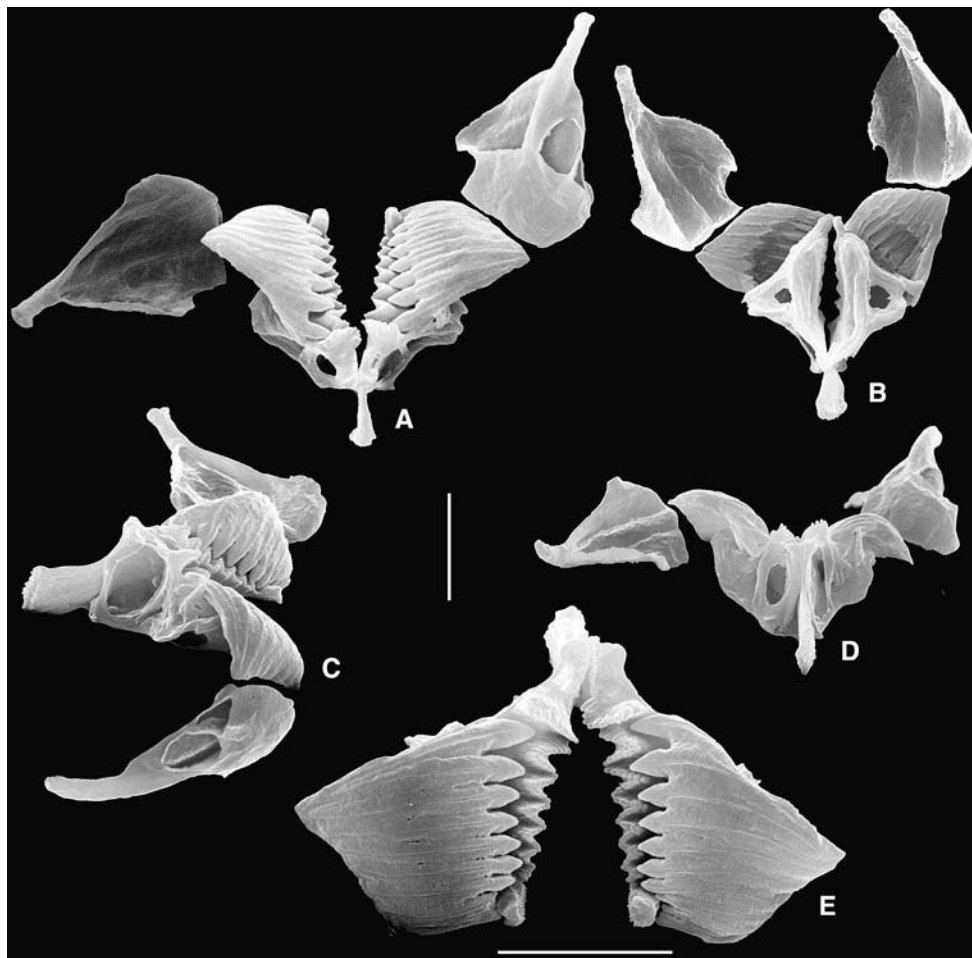


Fig. 5 *Rhinoglana frontalis* Ehrenberg, SEM photographs of trophi. **a** Complete set of trophi, incus frontal view; unci and left manubrium outer view; right manubrium inner view. **b** Incus, caudal view; unci

and manubria inner view. **c** Same as (a), lateral view. **d** Same as (a), ventral view. **e** Detail, incus frontal view; unci, outer view. Scale bars: 10 μ m

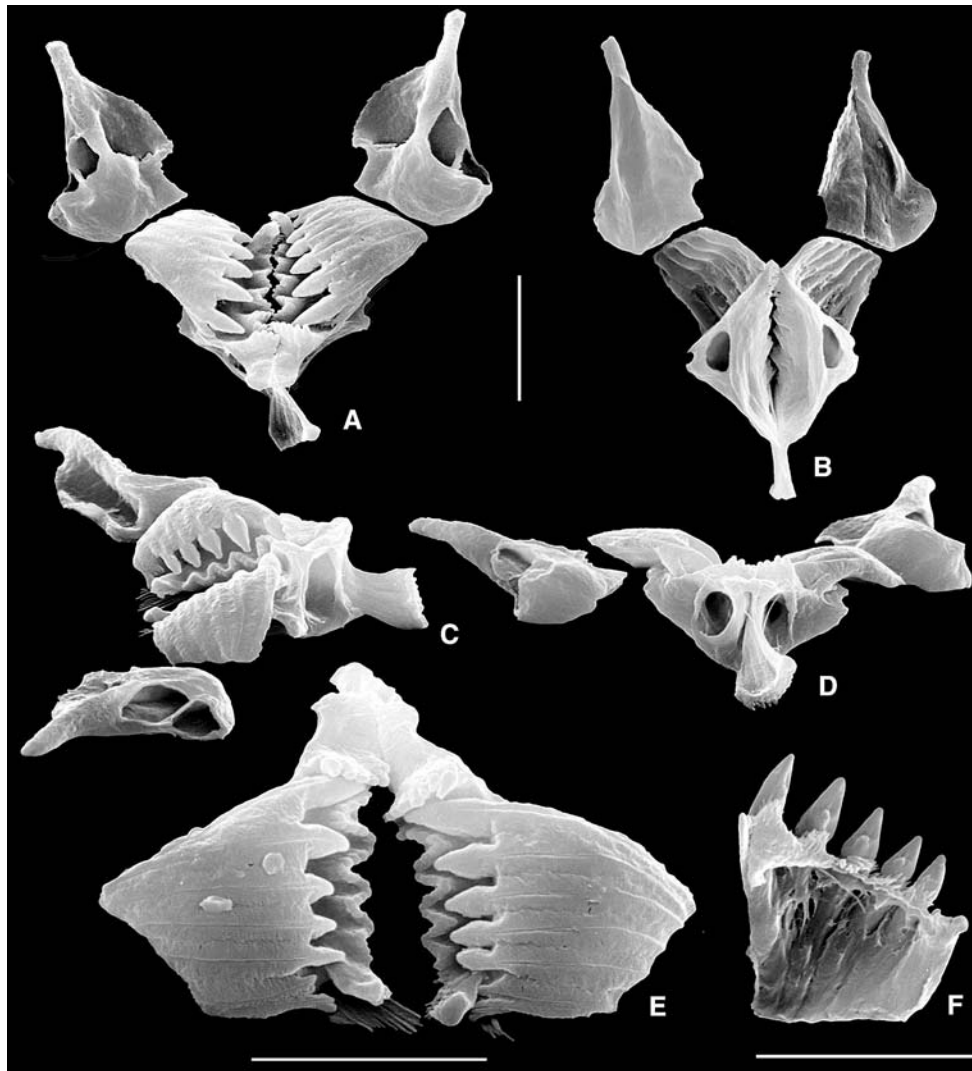


Fig. 6 *Rhinoglena tokioensis* Suzuki. SEM photographs of trophi. **a** Complete set of trophi, incus frontal view; unci and manubria outer view. **b** Incus, caudal view; unci and manubria inner view. **c** Complete

set; incus, lateral view. **d** Complete set; incus, ventral view. **e** detail incus and unci, frontal view. **f** Right unci, inner view. Scale bars: 10 μ m

Table 2 Comparative measurements (μ m) of trophi elements in *Rhinoglena*

	<i>R. fertoeensis</i>			<i>R. frontalis</i>			<i>R. kutikovae</i>			<i>R. tokioensis</i>		
	Length	Ave	<i>N</i>	Length	Ave	<i>N</i>	Length	Ave	<i>N</i>	Length	Ave	<i>N</i>
Ramus	16.0–17.5	16.5	6	15.0–18.0	16.5	5	14.0–17.5	16.0	5	14.5–18.0	16.0	4
Fulcrum	5.0–6.5	6.0	6	5.5–7.5	6.0	7	5.0–8.0	6.5	5	4.0–6.5	5.0	5
Uncus ^a	10.5–13.0	12.0	10	11.0–14.5	12.5	10	11.0–13.5	12.5	8	12.0–13.0	12.5	8
Manubrium	16.0–22.5	19.5	14	17.0–24.5	20.5	10	17.0–23.0	20.5	8	16.0–19.0	17.5	10

Ave average, *N* number of elements measured

^a Major tooth

R. kutikovae n.sp. (*N* = 8) and eight to nine in *R. fertoeensis* (*N* = 7). The dimensions of the trophi elements of the different species (Table 2) show wide overlap, and it is to be expected that, when further measurements are made that result in statistically significant differences, these will not be taxonomically reliable because of the overlap (Fig. 6).

Discussion

The general distribution of the different *Rhinoglena* species has been compiled by De Ridder and Segers (1997) and Segers (2007). *R. tokioensis* has to date only been reported from freshwaters in the Palaearctic. The cold stenothermal and widespread, but rare *R. frontalis* is known from

freshwaters in the Palaearctic, Nearctic, Oriental, Australian and Antarctic region. Antarctic reports of this species are from the subantarctic Heard Island (Dartnall 1995a), Îles Kerguelen (De Smet 2001) and Macquarie Island (Dartnall 1993; Dartnall et al. 2005). However, the illustrated record of Macquarie Island (Dartnall 1993: Fig. 3c) shows an animal with a single spiniform toe and should be considered species inquirenda. The likewise cold stenothermal *R. fertoeensis* is a typical inhabitant of slightly saline inland waters in the Palaearctic, and has recently been found in Turkey as well (W.H. De Smet, personal observation). It also was reported occurring in considerable numbers in Figurnoye (or Algae) Lake by Kutikova (1958, 1991) and a small, unnamed lake by Korotkevich (1964) (rotifers identified by L.A. Kutikova) in the Bunger Hills, East Antarctica. Both are freshwater bodies, and thus an unusual habitat for the species. However, examination of the fairly incomplete description and figures by Kutikova (1991, p. 95, figs 3a–f) shows that it is definitely not *R. fertoeensis*: the large conical foot composed of two pseudosegments is about 1/4 (sic in text, but $\sim 1/5$ in the figures) of the total length (minute foot $\sim 1/10$ total length, and a single pseudosegment in *R. fertoeensis*); the toes (mentioned in plural) are reported indistinctly offset from the foot, but only one toe is shown in the figures (two very small toes in *R. fertoeensis*); there is only one elongate pedal gland (pedal glands absent *R. fertoeensis*), which looks normal to us if there is only one toe; unci with seven major teeth and two minor ones (eight to nine major + two minor in *R. fertoeensis*). The characters of the species observed by Kutikova (l.c.) and the general shape of the body are reminiscent of the new species, except for the eyes, which are reported as dark-purple. However, the value of the feature ‘colourless eyes’ as shown by our species needs to be shown. Preservation in ethanol may have resulted in bleaching of the pigment. On the other hand, eye colour may not be a good discriminating taxonomic feature within *Rhinoglena*, as in other species as well: e.g. in *Brachionus plicatilis* Müller, 1786 cultures, eye colour may depend on the food (E. Lubzens, personal communication), and in *Lindia torulosa* Dujardin, 1841 collected at the Crozet Islands, both specimens with colourless and red-coloured eyes were found (W.H. De Smet, unpublished). In view of the similarities between the species reported sub *R. fertoeensis* by Kutikova (1991) and *R. kutikovae* n.sp., and given that both were collected in freshwater habitats located in the same area, it seems plausible that they are identical.

The distribution of the members of the genus *Rhinoglena* consists of a series of generally widespread species and now *R. kutikovae* n.sp. While it is possible that this species does occur elsewhere in Antarctica or on other continents or islands, its absence from geographically similar areas in Antarctica such as the Vestfold Hills

(Dartnall 2000), Larsemann Hills (Dartnall 1995b) and the McMurdo Dry Valleys (Vincent and James 1996), as well as the subantarctic islands to the north, suggests that it is a species endemic to the Antarctic continent, possibly only occurring within the limited geographic range of the Bunger Hills. Such a distribution is not unprecedented: the calanoid copepod *Gladioferens antarcticus* Bayly, 1994 has been recorded from a small number of lakes in the Bunger Hills and nowhere else (Bayly 1994; Bayly et al. 2003). Bayly et al. (2003) concluded that this species (which is the most primitive of its subgenus) or its antecedents had been associated with the Antarctic continent since the break-up of Gondwanaland. Survival of both the copepod and the rotifer in the area implies the continual presence of freshwater environments. Gore et al. (2001) suggested that parts of the Bunger Hills remained ice-free at the Last Glacial Maximum (circa 20 000 years Before Present), and thus it is possible that lakes remained present. A similar situation occurred in the Larsemann Hills, East Antarctica, where evidence for the continued existence of an invertebrate community for up to 140 000 years old has been recorded (Cromer et al. 2006). *G. antarcticus* is only known to inhabit epishelf lakes, which are bodies of freshwater floating on seawater but dammed by an ice shelf (Gibson and Andersen 2002). These lakes occur at the margins of the Bunger Hills, and while the age of these lakes is not known, they have probably occurred around the Bunger Hills whenever ice-free land has been present.

There is increasing evidence of endemism amongst the fauna of Antarctica (Convey and Stevens 2007), and the occurrence of the new rotifer described here adds to the list of species found only on the continent. While Holocene colonization cannot be ruled out for *R. kutikovae* n.sp., its absence from the subantarctic islands and its taxonomic separation from the other members of its genus suggest that it has evolved with the Antarctic continent.

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