Hydrobiologia **269/270**: 327–333, 1993.
H. van Dam (ed.), Twelfth International Diatom Symposium.

Diatom communities in the Vanishing and Ornithologist Creek, King George Island, South Shetlands, Antarctica

B. Kawecka[1] & M. Olech[2]
[1] *Institute of Freshwater Biology, Polish Academy of Sciences, Sawkowska 17, 31-016 Kraków, Poland;*
[2] *Institute of Botany, Jagiellonian University, Lubicz 46, 31-512 Kraków, Poland*

Key words: Antarctica, King George Island, Arctowski Station, stream, diatoms, taxonomy, ecology

Abstract

In the diatom communities of the Vanishing and Ornithologist Creek 74 taxa were found. Most of the taxa have a cosmopolitan range and are resistant to various environmental stresses. For example, *Achnanthes lanceolata* var. *lanceolata*, is found in all types of waters and in several ecological conditions. *Achnanthes delicatula* ssp. *delicatula*, *Nitzschia frustulum*, *N. capitellata*, *Navicula mutica*, and *N. gregaria* develop both in fresh and brackish waters. Some of the organisms also settle in terrestrial environments. *Navicula atomus*, *N. mutica*, *Pinnularia borealis*, and *Hantzschia amphioxys* are common soil algae. *Navicula digitulus*, *N. contenta*, *N. cohnii* and *Achnanthes coarctata* also live in an aerial environment. *Navicula atomus* is well developed in eutrophic waters and *Nitzschia capitellata* can tolerate a high level of pollution, while *Nitzschia gracilis*, *Fragilaria capucina*, and *F. alpestris* appear both in oligotrophic, and enriched waters. Stenotopic ecological features are shown by *Achnanthes marginulata* and *Navicula digitulus* – known from the Alps and the North, and *Navicula muticopsis* characteristic for Antarctic and Subantarctic.

The index of diatom biomass, usually of low and medium value, was highest in the area of possible impact by a penguin colony.

Introduction

Interest in the ecosystem of running waters in Antarctica has recently increased. The algae of the habitat have not yet been thoroughly studied, and so far the research works conducted on the Antarctic continent have outnumbered those conducted on the neighbouring islands. Algological studies concerned taxonomy and ecology (Broady, 1982, 1989; Hawes 1989; Howard-Williams, *et al.*, 1986), ecophysiology (Vincent & Howard-Williams, 1986, 1989) and also productivity (Howard-Williams & Vincent, 1989).

The running waters of King George Island have not yet been investigated. The aim of the present work is to describe the structure of diatom communities living in Vanishing and Ornithologist Creek.

Study area

The investigation were conducted on King George Island (the South Shetlands Archipelago), in the region of Admiralty Bay, where the Arctowski Polish Polar Station is situated. The island is composed mainly of volcanic rocks and more than 90% of the surface is covered with ice. The average annual temperature is −2.2 °C. In the summer (December to March) the warmest month is

January (average + 2.4 °C. and in winter (June to September) the coldest months are July and August (−8.1 °C.). However, there are no frostless periods in this region, hence there is a constant freezing and thawing of the water. The air is strongly saturated with water vapour, this causing considerable cloudiness. The monthly average values of relative humidity are between 76 and 86%. In Admiralty Bay there is abundant precipitation mainly in the period from December to April, winter being more dry. The maximum monthly total exceeds 145 mm, while the minimum is only 10.9 mm. The winds are very strong, and predominantly easterly. The region is characterized by a great variation in exposure to solar energy on account of the substantial differences in the lenght of the day from 15 hours in the summer to a few hours in the wintertime. Besides the angle of incidence of the solar radiation ranges from about 51° (December 22) to 4.5° (June 22) (Marsz & Rakusa-Suszczewski, 1987).

The creeks originate from the melting snow and ice cap and flow only during the summer. Their length does not exceed 1250 m., they are shellow with a bed composed of stones, gravel, and sand, and they flow on the surface, but in certain places they vanish in the swallow holes of thermokarstic channels. The waters are transparent, and the water-flow varies, the average monthly flow in Vanishing Creek in January and February being respectively 60 and 25 l s^{-1} and the maximum 150 l s^{-1} (Kozik, 1982).

The pH of the creek waters ranges from 6.6 to 6.9 and they are usually slightly mineralized (from 14.2 to 45 mg l^{-1}). They also possess an increased concentration of chloride ions (12.8–35.8 mg l^{-1}) (Kozik, 1982). One may suppose that in regions where there are bird colonies, the waters are subject to enrichment in nutrients, but there are no chemical data concerning this matter. In the aggregation of algae diatoms and blue-green, mainly *Phormidium favosum* (Bory) Gomont prevailed.

Vanishing Creek is formed in a valley situated on the northern slopes of the Kasprowy Wierch massif. It flows through an erosive gulley and then disappears under a snow/ice patch in the vicinity of the lateral moraine of the Ecology Glacier above the Ubocz elevation (stations 1 and 2). Ornithologist Creek forms several hundred metres below the snow/ice patch, flows all the time on the surface and falls into a pond situated on the sea-shore (stations 3 to 6) (Fig. 1, Table 1).

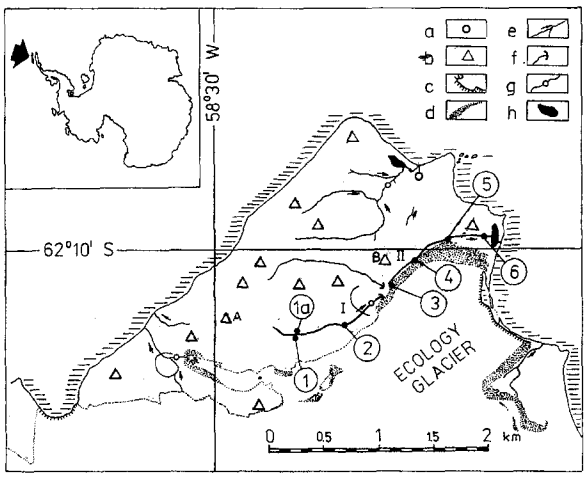

Fig. 1. Situation of the Vanishing (I) and Ornithologist Creek (II) basins, with sampling stations (numbers), *a* – Arctowski station main building, *b* – peaks and hills; A. Kasprowy Wierch, B. Ubocz, *c* – glacier fronts, *d* – present-day moraine ridges, *e* – stream with a marked current direction, *f* – thermokarstic channel swallow holes, *g* – places of water level registration, *h* – pond (modified after Kozik, 1982).

Material and methods

The materials were collected on March 23, 1987, December 28, 1987, as well as on January 23, 1988 by M. Olech during the XI Antarctic Expedition of the Polish Academy of Sciences to the Arctowski Station. The algae were removed from stones and bottom sediment, together with pieces of moss. They were preserved in a 4%-solution of formalin. The diatoms were macerated in a mixture of sulphuric acid and potassium dichromate in the ratio 3:1. The material was then washed with distilled water, cleaned by sedimentation and centrifuged at 3000 R $min.^{-1}$. The slides were made using "Pleurax", a synthetic resin.

The structure of the diatom community was characterized according to methods recom-

Table 1. Characteristics of the stations.

Creek	Vanishing			Ornithologist			
Station	1	1a	2	3	4	5	6
Localization	outflow of the snow patches		below snow patches situated on the creek	below channel swallow holes	in the region of Ubocz hill	a few metres above pond	close to the pond
Substrate	mud, sand, stones	mud	stones	stones	mud	mud, stones	mud, gravel, sand, stones
Depth (cm)	5	5	10–20	c. 30	3–5	5	5
Current	slow	stagnant water	turbulent	turbulent	slow	slow	slow
Water Temp. (°C)	0.9–1	1.8	1.3	1.8	0.9	2–5.4	2–5.8
Effect of birds						possible	possible
Coverage of algae (%)	10–20	90	10–20	50	60	80	50–70

mended by Starmach (1969); see also Kawecka (1980). The abundance of species was obtained by counting specimens in 10 microscope fields. The slide was prepared in such a way that there was no overlap between the diatom cells. The percentage of the species in the community was calculated, and the most numerous organisms (over 5%) were indicated, while those remaining were regarded as sporadic. The coefficient of coverage was calculated by multipyling the number of specimens by the average size of a cell. The cell size was determined by comparing it with the mesh size in a micrometric grid built in the microscope's eyepiece. The size was expressed as fractions or multiples of the grid squares. The index of diatom biomass was calculated by summing the coefficient of coverage of all the species in the sample, and multiplying this value by two, in order to obtain the accepted assimilation area of the organisms. The biomass index is treated as a value to be used in comparing diatom communities in particular stations. It was regarded as very low at a value under 400; low from 401–800; medium from 801–1200; high from 1201–1600, and very high over 1600. The diatoms were identified by using the keys of Cleve-Euler (1952–1955) and Krammer & Lange-Bertalot (1986–1991). The nomenclature of diatoms was according to Krammer & Lange-Bertalot (1986–1991).

Results

At this point of analysis 74 taxa of diatoms were found in the investigated creeks. A large group consists of sporadic taxa, mainly species of the genera *Navicula, Pinnularia* and *Achnanthes*. Many organisms are hard to identify and are the subject of taxonomical study by scanning microscopy. The complete list of species occuring in the running waters of the King George Island in the area of Arctowski station will be given elsewhere.

The following eleven organisms were defined as most numerous (Fig. 2):

Achnanthes delicatula (Kütz.).Grun. ssp. *delicatula* (Figs 3, 4): 19.8–22 × 6.6–7.7 μm, on the raphe valve 13 striae in 10 μm, on the rapheless valve 13–14 striae in 10 μm.

Achnanthes lanceolata (Bréb.) Grun. var. *lanceolata:* 14.3–19.8 × 5.5, on the raphe valve 13 striae in 10 μm, on the rapheless valve 13–15 in 10 μm.

Achnanthes marginulata Grun. (Figs 5, 6): 12.1–13.0 × 4.4–6.6 μm; 28–30 striae on both valves. In the population of *A. marginulata* there may also occur *A. daonensis* Lange-Bertalot: (10–26 × 5–8 μm; according to Krammer & Lange-Bertalot (1991) and *A. metacryophila* Schmidt, Mäusbacher & Müller: (9–12 × 4.5–5, 26–28 striae in 10 μm, according to Schmidt *et al.*, 1990), all these organisms resemble each other.

Fragilaria alpestris Krasske ex Hustedt (Fig. 7): 19.8–22.8 × 3.3 μm, 12–13 striae in 10 μm. Some cells are wider than is indicated in the diagnosis of the species; according to Krammer & Lange-Bertalot (1991) the width of cells is 2.5–3 μm., and according to Cleve-Euler (1953) is 2–3 μm.

Fragilaria capucina Desmazières (Fig. 8): 15.4–33 × 3.3–4.4 μm, 15–18 striae in 10 μm.

Navicula atomus (Kütz.) Grun. (Fig. 9): 12.1–14.3 × 4.95–5.5μm, 16–22 striae in 10 μm.

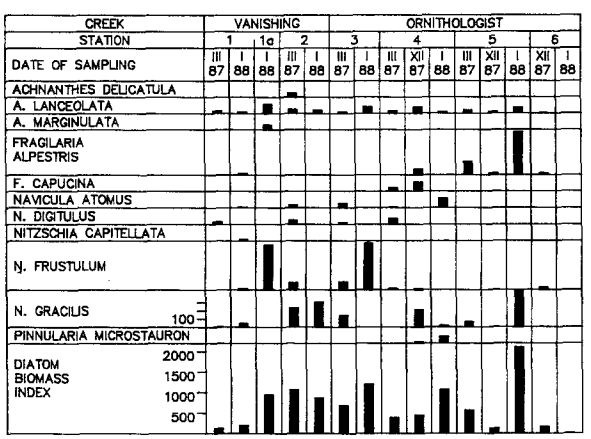

Fig. 2. Diatom communities of Vanishing and Ornithologist Creeks; The most numerous species (> 5%) and their abundance.

Navicula digitulus Hustedt (Fig. 10): 14.3–17.6 × 3.3–3.8, 40–41 striae in 10 μm.

Nitzschia capitellata Hustedt (Figs 13, 14): 28–37.6 × 4.1–4.9 μm, fibulae 10–12 in 10 μm, 2 fibulae in the middle part of the cells are separated, striae 40 in 10 μm.

Nitzschia frustulum (Kütz.) Grun. (Figs 15, 16): 6.6–23.7 × 2.5–3 μm, fibulae 10–14 in 10 μm, striae 29–30 in 10 μm.

Nitzschia gracilis Hantz. (Figs 17, 18): 28.6–57.2 × 2.5–3.4 μm, fibulae 12–18 in 10 μm, striae 54–56 in 10 μm. Krammer & Lange-Bertalot (1988) give 38–42 striae in 10 μm, and also about 50, but with doubt.

Pinnularia microstauron (Ehrenb.) Cleve (Figs 19, 20): 34–62.5 × 8–11 μm, 11–13 striae in 10 μm.

Among sporadic species worth mentioning is *Navicula muticopsis* Van Heurck (Figs 11, 12): 19–26.7 × 9–10.8 μm, 15–18(19) striae in 10 μm; about 20 points in 10 μm. The cells possess a conspicuous isolated point situated in their central parts. Some cells are larger than in the diagnosis in Krammer & Lange-Bertalot (1986) where the dimensions are 10–25 × 6–10 μm; 15–18 striae in 10 μm.

In the upper section of the creek (stations 1, 1a), in the vicinity of its efflux the diatom communities are characterized by the greatest species numbers (c. 60 taxa). Their quantitative development depends upon local environmental conditions. In the lotic parts of the creek (station 1) the diatom growth is very poor, this being expressed by a very low biomass index. However, *Nitzschia frustulum* occurs abundantly in a branch of the creek, in an area of stagnant water (station 1a). Farther down the creek, the number of species is relatively even (c. 40) at all the stations. *Nitzschia frustulum, N. gracilis,* and *Fragilaria alpestris* grow well locally in the middle section of the creek. The mean value of the diatom biomass index is low (station 4) to medium (stations 2, 3, 5). However, in January at station 5 it reached a very high level. Still farther on downstream close to the pond, the diatom growth is poor, this also being expressed by a very low biomass index. A comparison of

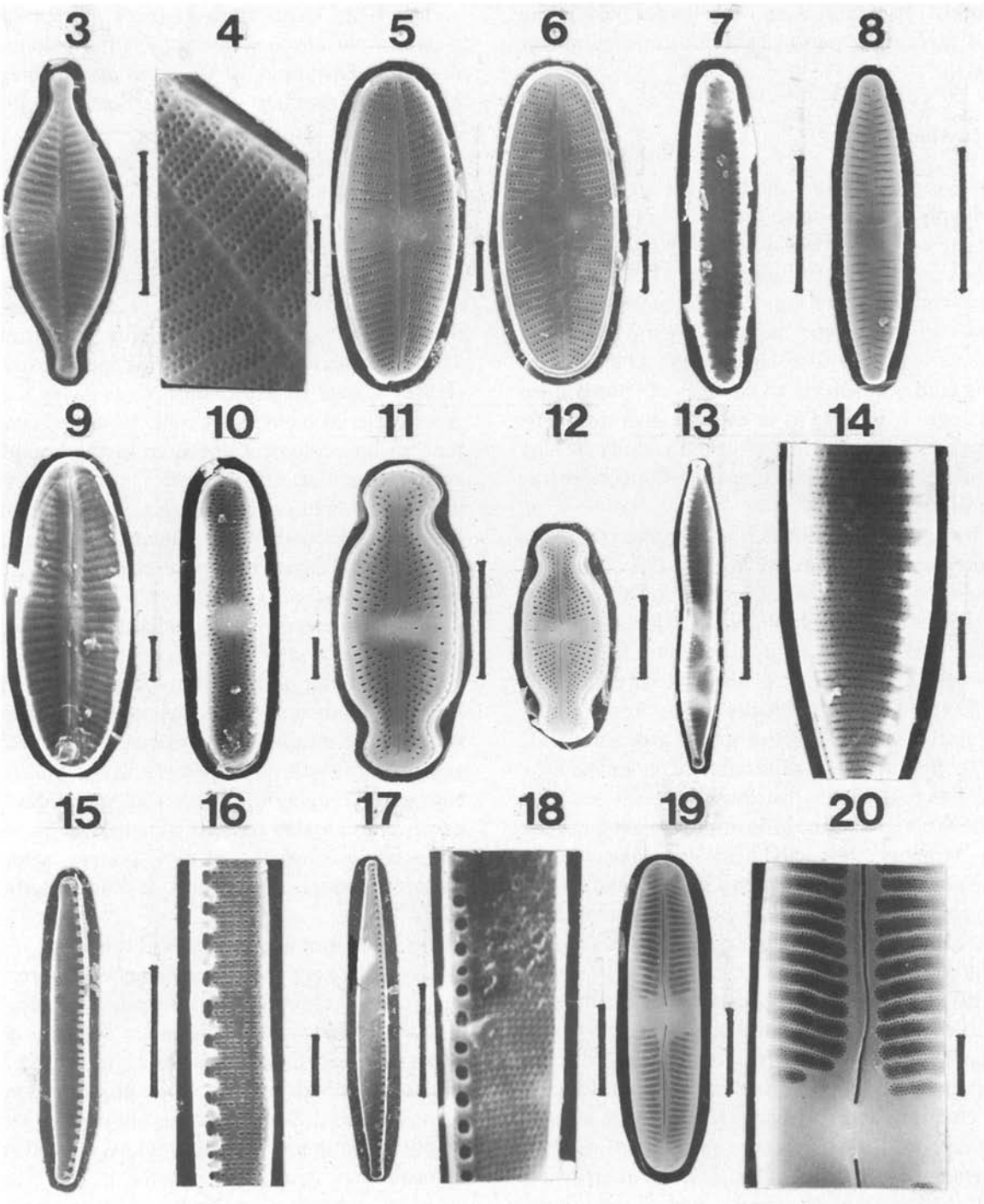

Fig. 3. Figs. 3–20. Figs 3, 4. *Achnanthes delicatula* ssp.*delicatula*. Figs 5, 6. *A. marginulata* (5 raphe valva, 6 rapheless valva). Fig. 7. *Fragilaria alpestris*. Fig. 8. *F.capucina*. Fig. 9. *Navicula atomus*. Fig. 10. *N. digitulus*. Figs 11, 12. *N. muticopsis*. Figs 13, 14. *Nitzschia capitellata*. Figs 15, 16. *N. frustulum*. Figs 17, 18. *N. gracilis*. Figs 19, 20. *Pinnularia microstauron*. Black bars near SEM photographs: 4, 5, 6, 9, 10, 14, 16, 18, 20 represent 2 μm, and near 3, 7, 8, 11, 12, 13, 15, 17, 19 represent 10 μm.

monthly observations shows that January is the most favourable period for diatom development (Fig. 2).

Discussion

The living conditions in the investigated creeks are highly specific, since the creeks of Antarctica form an ephemeral ecosystem with unstable conditions and a short growth period. Totally frozen in the winter, they reform from the melting ice and snow-cap during the summer, in the period of extreme exposure to solar eneregy. Their waters being cold and subject to changes of temperature and volume, varying from extreme oligotrophy to more eutrophic conditions in the vicinity of bird colonies, and with an increase in the concentration of chloride ions.

The algal communities are characterized by a moderate species variety, in this respect, resembling those of the small creeks of Greenland (Kawecka & Leo, 1985) and the glacial streams of the European mountains (Kawecka, 1980). However, the structure of the diatom communities in the Antarctica creeks differs from that of the glacial streams in Europe (Kawecka, 1974, 1980). For instance neither *Achnanthes minutissima* Kütz., a widely distributed species and one of the most abundant in European glacial mountain streams, nor *Diatoma hyemalis* (Roth) Heiberg, *D. mesodon* (Ehrenb.) Kütz. and *Fragilaria arcus* (Ehrenb.) Cleve, known as stenothermal, cold water organisms, grow abundantly in Antarctica.

The most abundant species of the algal communities of the investigated creeks are eurytopic species with a wide, cosmopolitan range. Moreover, many of the organisms are resistant to various environmental stresses (Krammer & Lange-Bertalot, 1986–1991; Lowe, 1974).

Achnanthes lanceolata var. *lanceolata*, growing at all station along the creeks, has an exceptionally wide ecological spectrum, since it can be found in all types of freshwaters. Such abundant species as *Achnanthes delicatula* ssp. *delicatula, Nitzschia capitellata, N. frustulum*, and some sporadic ones, e.g. *Navicula gregaria* Donkin and *N. mutica* Kütz. grow both in fresh and brackish waters. *Pinnularia microstauron,* a fairly common diatom in Ornithologist Creek, is also defined as halophil (Krammer & Lange-Bertalot, 1986–1991).

The species which grow in aquatic habitats subject to desiccation and wet terrestrial biotopes, are quite abundant here. *Navicula atomus*, occurring in great numbers, and the sporadic *N. mutica, Hantzschia amphioxys* (Ehrenb.) Grun., and *Pinnularia borealis* (Ehrenb.) Grun., belong to a group of very common soil algae (Behre & Schwabe, 1970). The sporadically occurring species *N.cohni* (Hilse) Lange-Bertalot and *N. contenta* Grun. grow in aerial habitats as well. *Navicula contenta* reaches an ecological optimum in the boundary zone between air and water. It is also able to live in very low light conditions (Krammer & Lange-Bertalot, 1986–1991). *Achnanthes coarctata* (Bréb.) Grun., growing sporadically in the studied creeks, is also typical aerophilic species, known from extremely dry habitats (Krammer & Lange-Bertalot, 1991).

In Vanishing and Ornithologist Creek, there are also organisms which live both in oligotrophic waters, and in those rich in electrolytes (*Nitzschia gracilis*), or mesotrophic (*Fragilaria capucina*) and eutrophic (*Fragilaria alpestris*) as well. *Nitzschia capitellata* can also tolerate a high level of pollution, while *Navicula atomus* prefers strongly eutrophic waters (Krammer & Lange-Bertalot, 1986–1991).

In the diatom communities at this point in the analysis there are only a few forms with narrower geographical range and with stenotopic ecological characteristics. Such a species is *Navicula muticopsis* forming small populations in the creeks. This species is defined as a one characteristic of Antarctica and Subantarctica, although it grows on other continents as well (Pankow *et al.*, 1987). *Navicula digitulus*, fairly common in the investigated streams is known in the middle and higher mountains (the Alps) of Northern Europe and Japan. Worth mentioning also is *Achnanthes marginulata*, a species regarded as northern-alpine, prefering oligotrophic, slightly to moderately acid waters.

The values of the index of diatom biomass in the investigated creeks ranges from very low to very high. The average value of the index is low (c. 600), but it is far higher than those of other European glacial streams. For instance, in the creeks of Greenland, the index reaches a peak value of 460 (Kawecka & Leo, 1985), in the streams of Lapland, 354, and in Alpine streams, 106 (Kawecka, 1980). The highest peak index value (c. 2100) is at Station 5 in Ornithologist Creek. It exceeds the value of the index of diatom biomass recorded in European mountain streams exposed to the impact of organic pollution coming from tourist accomodation (Kawecka, 1974, 1980). This indicates that the creek is strongly enriched with nutrients in that particular place probably by the nearby bird colonies.

Acknowledgements

The SEM photographs were taken in the Department of Otolaryngology, Laboratory of Scanning Electron Microscopy, N. Copernicus Academy of Medicine in Krakow. Cordial thanks are due to the Head of the Laboratory, Prof. Adam Miodoński, for the possibility of using SEM, and to Dr Maria Nowogrodzka-Zagórska for her photographs. We also express our gratitude to Dr Konrad Wołowski, Head of the Department of Phycology of the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków, for enabling us to use its Iconotheca of Algae.

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