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FLORISTIC STUDIES ON ALGAE FROM INLAND WATERS OF ANTARCTICA: II. LAKE Ô-IKE, WEST ONGUL ISLAND

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Abstract: Lake Ô-ike in West Ongul Island, Antarctica was surveyed for algal flora. Ten water and 3 algal mat samples were collected at 2 sites in March, August and October 1983. A total of 31 taxa identified and their vertical distribution are described here: Cyanophyceae, 18; Chrysophyceae, 3; Bacillariophyceae, 6; Chlorophyceae, 4. Among these, *Synechococcus brunneolus* RABH., *Phormidium luridum* (KÜTZ.) GOM. and *Paraphysomonas imperforata* LUCAS fo. No. 2 TAKAHASHI are the first records from Antarctica, and *Chroococcus turgidus* (KÜTZ.) NÄG., *Phormidium angustissimum* W. *et* G. S. WEST, *P. crouani* GOM., *P. pristleyi* FRITSCH, *P. retzii* (AG.) GOM. and *Lyngbya limnetica* LEMM. are new to the Ongul Islands. Cyanophycean algae were most abundant in March. *Cosmarium clepsydra* var. *dissimile* FRITSCH (Chlorophyceae) was dominant in August and October.

1. Introduction

There are several fresh water lakes, ponds and pools in West Ongul Island in Lützow-Holm Bay, Antarctica. Lake Ô-ike is located in the eastern part of this island. Concerning with fresh water algae in Lake Ô-ike, FUKUSHIMA *et al.* (1974) recorded 15 taxa of the Bacillariophyceae, AKIYAMA (1974) *Staurastrum* spp., *Cosmarium* spp. and *Oedogonium* sp. (Chlorophyceae), and WATANUKI and KARASAWA (1975) *Navicula muticopsis* (Bacillariophyceae).

Vertical distribution of freshwater algae in the Ongul Islands has not been investigated, because many lakes and ponds in these islands are shallow (HIRANO, 1965). As Lake Ô-ike 10 meters deep is suitable for investigation of the vertical distribution of algae, we examined water and algal mat samples collected from two or four layers which differ in depth at two sampling stations of this lake in 1983 using light and electron microscopes. In this paper, 31 taxa of freshwater algae including three species new to Antarctica and their vertical distribution are described.

2. Materials and Methods

A total of ten water samples were collected from the surface layer and the bottom layer at a station near the north coast (Station 1) in March, and from the surface layer, layers at 2 m, 5 m, 8 or 9 m depth and the bottom layer in the central region (Station 2) in August and October, and three algal mat samples from the surface layer

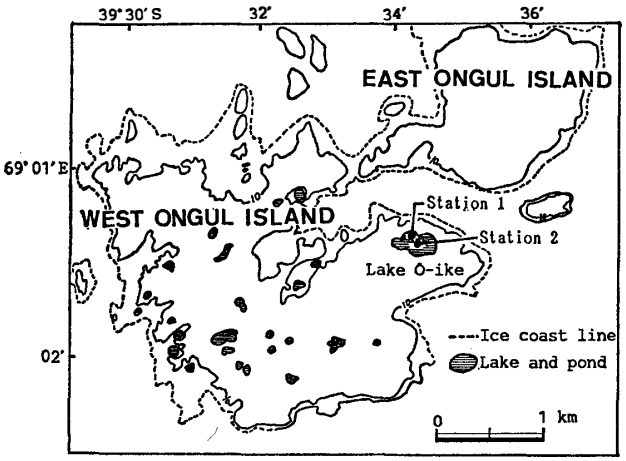

Fig. 1. Map showing sampling sites (●).

at Station 1 in March and from the bottom layer at Station 2 in October 1983 (Fig. 1). Collection of the water samples from each depth and algal mat samples from the bottom were made with a Van Dorn sampler through the ice hole drilled in the first-year ice, and part of algal mat samples were taken in polyethylene bottles from the surface layer. Water samples of 0.5 *l* and algal mat samples were fixed immediately with 10% formalin. The depth of the lake was about 1 m at Station 1 and 10 m at Station 2. The thickness of ice at Station 1 was about 0.2 m in March, 1.3 m in August, and at Station 2 it was 1.5 m in October. These water and algal mat samples were examined using both light and electron microscopy according to the methods described previously (OGUNI *et al.*, 1987).

3. Results and Discussion

3.1. Algae in water samples

A total of 27 taxa were identified in 10 water samples from Lake Ô-ike (Table 1): these were Cyanophyceae 14 species, Chrysophyceae 3 species, Bacillariophyceae 6 species and Chlorophyceae 4 taxa (2 species and 2 varieties) (Table 2). Almost all of them except three species of the Chrysophyceae were benthic algae.

The species number of the Cyanophyceae was large at Station 1 (10 species) compared to 5 species at Station 2. This might be based on a difference of seasons when the samples were collected. In fact, members of the Cyanophyceae were found not in August but in October at Station 2. Of these species, *Phormidium laminosum* was also found in algal mat collected from Station 1 at the same time as shown in Table 2 and it appeared to be a contaminant from the algal mat.

Paraphysomonas imperforata fo. No. 2 and *Paraphysomonas vestita* (Chrysophyceae) were found in 5 m and 9 m depth samples, both collected in October. However, only the scales, not cells or cysts, were detected. Since cells and many scales of *Paraphysomonas vestita* were collected from Lake Midori, East Ongul Island, in December 1983 and January 1984 (OGUNI *et al.*, 1987), it is probable that the present species grows also in Lake Ô-ike in the austral summer season. The same species was also found in sea

Table 1. Taxa found in water samples collected from Lake Ô-ike in West Ongul Island, Antarctica, 1983.

Taxon identified	Date and site	1 March, St. 1		6 August, St. 2				31 October, St. 2			
	Depth (m)	*S	1	S	5	8	10	S	5	9	10
CYANOPHYCEAE											
Anabaena sp.			●								
****Chroococcus turgidus*										●	
Nodularia quadrata			●								
Nostoc sp. 1											●
****Phormidium angustissimum*			●								
****P. crouani*			●								
P. laminosum			●								
******P. luridum*										●	●
***P. pristleyi*			●								
****P. retzii*			●								
P. tenue			●								
P. uncinatum			●							●	
Schizothrix coriaceae			●								
Synechocystis aquatilis										●	
CHRYSOPHYCEAE											
Paraphysomonas vestita									●	●	
******P. imperforata* fo. No. 2									●	●	
P. sp.									●		
BACILLARIOPHYCEAE											
Amphora veneta			●				●			●	
Hantzschia amphioxys			●				●			●	
Navicula molesta				●			●				
N. muticopsis		●									
N. sp.							●				
Stauroneis anceps							●				
CHLOROPHYCEAE											
Cosmarium clepsydra var. *dissimile*			●			●	●			●	●
Oedogonium sp.							●				●
Sphaerocystis schroeteri var. *nivalis*										●	●
Staurastum sp.			●			●	●			●	●
Total 27		1	14	1	0	2	8	0	3	11	6

* Surface layer of water
** New to the Ongul Islands.
*** New to Antarctica.

water samples from the coastal fast-ice area north of East Ongul Island (TAKAHASHI, 1987).

Navicula muticopsis (Bacillariophyceae) found in samples from Station 1 appeared to be the contaminants from algal mats for the same reason mentioned before. *Navicula molesta* was found in samples from the surface and bottom layers at Station 2 and this species in the surface layer floated up probably from the bottom. *Amphora veneta* and *Hantzschia amphioxys* were found in March, August and October. *A. veneta* was most abundant representing the diatom flora of Lake Ô-ike. The maximum cell number of

Table 2. Taxa found in algal mat samples collected from Lake Ô-ike in West Ongul Island, Antarctica, 1983.

Taxon identified	Date and site / Depth (m)	1 March, St. 1 *S	1 March, St. 1 1	31 October, St. 2 10
CYANOPHYCEAE				
***Lyngbya limnetica*			●	●
Nostoc sp. 2			●	●
Phormidium frigidum			●	
P. laminosum			●	●
****Synechococcus brunneolus*			●	
BACILLARIOPHYCEAE				
Navicula muticopsis		●		
CHLOROPHYCEAE				
Cosmarium clepsydra var. *dissimile*				●
Staurastrum sp.				●
Total 8		1	5	5

* Surface layer of water.
** New to the Ongul Islands.
*** New to Antarctica.

the Bacillariophyceae, about 5000 per m*l*, was observed in March.

The species number of the Chlorophyceae was only two or four in samples from Stations 1 and 2, but the species was rich in quantity especially at Station 2. Of these four species, *Cosmarium clepsydra* var. *dissimile* was dominant in both August and October. The intact cell number of the present variety was about 2000 per m*l* of water at 8 m depth and 10000 at the bottom in August, and 18000 at 9 m depth and 30000 at the bottom in October. A large number of empty cells were also observed in the water samples collected from the surface layer and from the bottom in March, and from the surface layer and from 5 m depth in August and October. The cell density of this variety far exceeds that of *Synechococcus maior* SHRÖTER (Cyanophyceae) which dominated in the bottom water in Lake Kamome (5400 cells per m*l*) in East Ongul Island (OGUNI *et al.*, 1987). It is clear that such dominant taxa as *C. clepsydra* var. *dissimile* in Lake Ô-ike and *S. maior* in Lake Kamome reproduce at the bottom of these lakes.

3.2. Algae in algal mat samples

A total of 8 taxa were identified from algal mat samples (Table 2): these were Cyanophyceae 5 species, Bacillariophyceae 1 species and Chlorophyceae 2 species. *Lyngbya limnetica* (Cyanophyceae) was abundant in bottom samples in both March and October.

Only one species of the Bacillariophyceae, *Navicula muticopsis*, was found together with many dead bodies of tardigrades in a sample collected from the surface of the water under the ice in March. As ZANEVELD (1969) reported that algal mats move to the surface due to a small oxygen bubble formed by the photosynthesizing algae, this mat sample seems to have floated up to the surface from the bottom.

Oedogonium sp. and *Staurastrum* sp. (Chlorophyceae) were found in the algal mat

from 10 m depth. ZANEVELD (1969) found *Ulothrix* sp. (Chlorophyceae) in algal mats from lakes at Cape Bird, Antarctica. AKIYAMA (1974) observed *Oedogonium* sp. in the algal mats from some lakes in West Ongul Island, Skarvsnes and Skallen. These taxa of the Chlorophyceae such as found in the present study are important elements of the algal mats as well as the taxa of the Cyanophyceae and appear to grow and reproduce during warm seasons in Lake Ô-ike.

3.3. Characteristics of taxa

A total of 32 taxa was found in water samples and algal mat samples from Lake Ô-ike, West Ongul Island.

CLASS Cyanophyceae

Order Chroococcales

Chroococcus turgidus (KÜTZING) NÄGELI: GEITLER, Süsswasserflora. **12**, 77, Fig. 71, (1925). (Fig. 4).

A single cell or 2–4 cells enclosed in the mucous envelope which consists of three layers; envelope colorless, distinct or sometimes indistinct; each cell 15–28 μm in diameter. New to the Ongul Islands. Recorded from Skarvsnes (HIRANO, 1983).

Synechococcus brunneolus RABENHORST: GEITLER, Süsswasserflora. **12**, 111, (1925). (Fig. 3).

Cells cylindrical, 5 μm wide, 14–17 μm long, solitary or united pole to pole to form colonies of 2–4 cells. New to Antarctica. Distributed in Europe and Asia.

Synechocystis aquatilis SAUVAGEAU: GEITLER, Süsswasserflora. **12**, 110, Fig. 130, (1925), (Fig. 2).

Cells solitary or aggregated in colonies of a few cells, spherical in shape except immediately after division, without an evident gelatinuous sheath; cells 2.5–4.25 μm in diameter. Recorded from the Ongul Islands (AKIYAMA, 1967).

Order Nostocales

Anabaena sp. (Fig. 8).

Trichomes 2–5 μm wide; cells ellipsoidal, 4–4.5 μm long.

Lyngbya limnetica LEMM.: GEITLER, Süsswasserflora. **12**, 399, Fig. 504, (1925), (Fig. 18).

Trichomes straight or slightly curved, not constricted at the cross walls and not attenuated toward the end, 1.3 μm wide; sheath narrow, cells 1.5–1.8 μm long; apical cell rounded. New to the Ongul Islands. Distributed in Festland, Victoria Land (PRESCOTT, 1979).

Nodularia quadrata FRITSCH: GEITLER, Süsswasserflora. **12**, 288, Fig. 340, (1925). (Fig. 5).

Trichomes constricted at the junction, 4 μm wide; cells 2–4 μm long; heterocyst quadrate, 4.2–4.5 μm wide. Recorded from Langhovde, Skarvsnes (HIRANO, 1979, 1983) and East Ongul Island (OGUNI *et al.*, 1987).

Nostoc sp. 1. (Fig. 6).

Colony ellipsoidal, bright blue-green in color; trichomes flexuous in colorless sheath, 3–3.5 μm wide; cells ellipsoidal, 4.5–5 μm long. Present material may be the young stage or germinating hormogonia from akinetes of undetermined species.

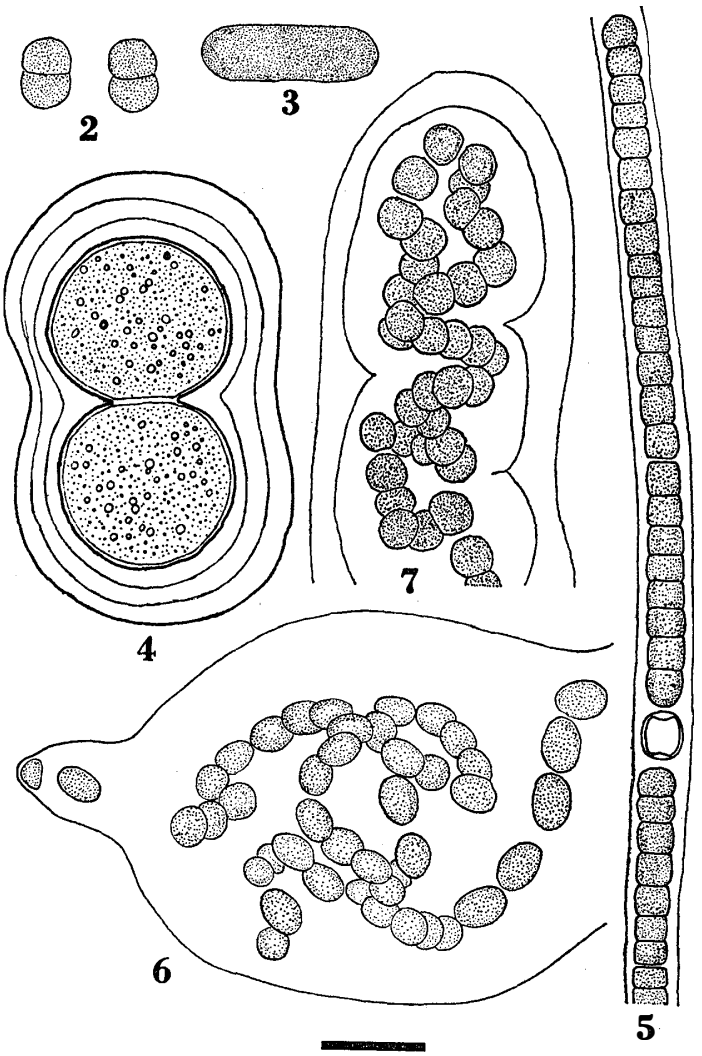

Fig. 2. Synechocystis aquatilis *SAUV.*
Fig. 3. Synechococcus brunneolus *RABH.*
Fig. 4. Chroococcus turgidus (*KÜTZ.*) *NÄG.*
Fig. 5. Nodularia quadrata *FRITSCH*
Fig. 6. Nostoc *sp. 1.*
Fig. 7. Nostoc *sp. 2.*
(*Scale bar: 10 μm*).

Nostoc sp. 2. (Fig. 7).

Colonies elliptical; trichomes blue-green colored, entangled in colorless sheath; cells spherical, 4.5–5 μm in diameter.

Phormidium angustissimum W. *et* G.S. WEST: GEITLER, Süsswasserflora. **12**, 377, (1925). (Fig. 9).

Trichomes curved, constricted at the junction, not attenuated toward the end, 1 μm wide; sheath colorless; cells cylindrical, 1.5–3 μm long. New to the Ongul Islands. Distributed in Skarvsnes (HIRANO, 1983).

Phormidium crouani GOMONT: GEITLER, Süsswasserflora, **12**, 386, Fig. 484, (1925). (Fig. 10).

Trichomes slightly curved, not constricted at the cross walls, with straight and short attenuated end, 7.5–8 μm wide; terminal cells conical without calyptra, the length of the cells 4–8 μm to 1/2 times the width. New to the Ongul Islands. Distributed in Skarvsnes (HIRANO, 1983).

Phormidium frigidum FRITSCH: GEITLER, Süsswasserflora. **12**, 377, Fig. 468, (1925). (Fig. 11).

Trichomes constricted at the junction, not attenuated toward the end, with granules along the cross walls, 0.6–0.8 μm wide 1.5–2.5 μm frequently. Recorded from Langhovde (HIRANO, 1979) and East Ongul Isalnd (OGUNI *et al.*, 1987).

Phormidium laminosum (AGARDH) GOMONT: GEITLER, Süsswasserflora. **12**, 382,

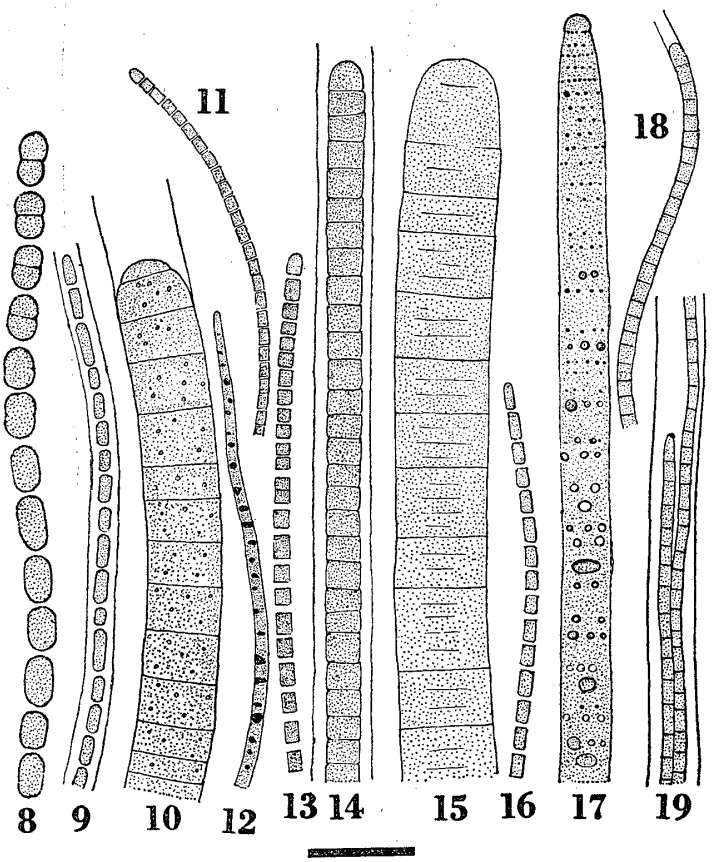

Fig. 8. Anabaena *sp.*
Fig. 9. Phormidium angustissimum *W. et G. S. WEST.*
Fig. 10. Phormidium crouani *GOM.*
Fig. 11. Phormidium frigidum *FRITSCH*
Fig. 12. Phormidium laminosum (*AG.*) *GOM.*
Fig. 13. Phormidium luridum (*KÜTZ.*) *GOM.*
Fig. 14. Phormidium pristleyi *FRITSCH*
Fig. 15. Phormidium retzii (*AG.*) *GOM.*
Fig. 16. Phormidium tenue (*MENEGH.*) *GOM.*
Fig. 17. Phormidium uncinatum (*AG.*) *GOM.*
Fig. 18. Lyngbya limnetica *LEMM.*
Fig. 19. Schizothrix coriaceae (*KÜTZ.*) *GOM.*
(*Scale bar: 10 μm*).

Fig. 482, (1925). (Fig. 12).
Trichomes curved, not constricted at the cross walls, attenuated at the apical part, with a granule at both side of the cross walls, 0.8–1.5 μm wide; apical cells conical without calyptra. Recorded from East Ongul Island, Langhovde and Skarvsnes (HIRANO, 1959, 1979, 1983).

Phormidium luridum (KÜTZING) GOMONT: GEITLER, Süsswasserflora. **12**, 380, Fig. 475, (1925). (Fig. 13).
Trichomes curved, slightly constricted at the cross walls, without granules along the cross walls, 1.8 μm wide; cells almost quadrate or longer than wide, 1.8–3 μm long. New to Antarctica. Cosmpolitan species.

Phormidium pristleyi FRITSCH: GEITLER, Süsswasserflora. **12**, 378, Fig. 472, (1925). (Fig. 14).
Trichomes densely entwined with each other, constricted at the cross walls, not attenuated toward the end, without granules along the cross walls, 3.2 μm wide; apical cell with a rounded end without calyptra; cells 2.2–2.8 μm long. New to the Ongul Islands. Distributed in Langhovde and Skarvsnes (HIRANO, 1979, 1983).

Phormidium retzii (AGARDH) GOMONT: GEITLER, Süsswasserflora. **12**, 383, Fig. 485, (1925). (Fig. 15).
Trichomes almost straight, not or slightly constricted at the cross walls, not attenuated toward the end, without granules along the cross walls, 9 μm wide; apical cell with a slightly thickened wall without calyptra; cells 3.6–7 μm long. New to the Ongul Islands. Distributed in Langhovde and Skarvsnes (HIRANO, 1979, 1983).

Phormidium tenue (MENEGHINI) GOMONT: GEITLER, Süsswasserflora. **12**, 381, Fig. 478, (1925). (Fig. 16).
Trichomes straight or slightly curved, slightly constricted at the cross walls, attenuated near the end, without granules along the cross walls, 1.2–1.8 μm wide; sheath narrow; the length of the cells attains 3 times the width, apical cells long-conical without calyptra. Recorded from East Ongul Island (HIRANO, 1959).

Phormidium uncinatum (AGARDH) GOMONT: GEITLER, Süsswasserflora. **12**, 388, Fig. 493, (1925). (Fig. 17).
Trichomes staright, not constricted at the junction, gradually attenuated toward the end, 4–5.5 μm wide; end cell forms a calyptra; the length of the cells 1/2–1/5 times the width. Recorded from Langhovde, Skarvsnes (HIRANO, 1979, 1983) and East Ongul Island (OGUNI *et al.*, 1987).

Schizothrix coriaceae (KÜTZ.) GOMONT: GEITLER, Süsswasserflora. **12**, 417, Fig. 534, (1925). (Fig. 19).
Mucous sheath distinct, colorless, contains a few trichomes; trichomes constricted at the junction, 1.1–1.5 μm wide; cells 3–5 μm long. Recorded from Skarvsnes (HIRANO, 1983) and East Ongul Island (OGUNI *et al.*, 1987).

CLASS Chrysophyceae

Order Ochromonadales

Paraphysomonas vestita DE SAEDELER: TAKAHASHI, Electron microscopical studies of the Synuraceae (Chrysophyceae) in Japan. 81, Fig. 60, Pl. 62, Figs. 255–270, (1978). (Fig. 20).

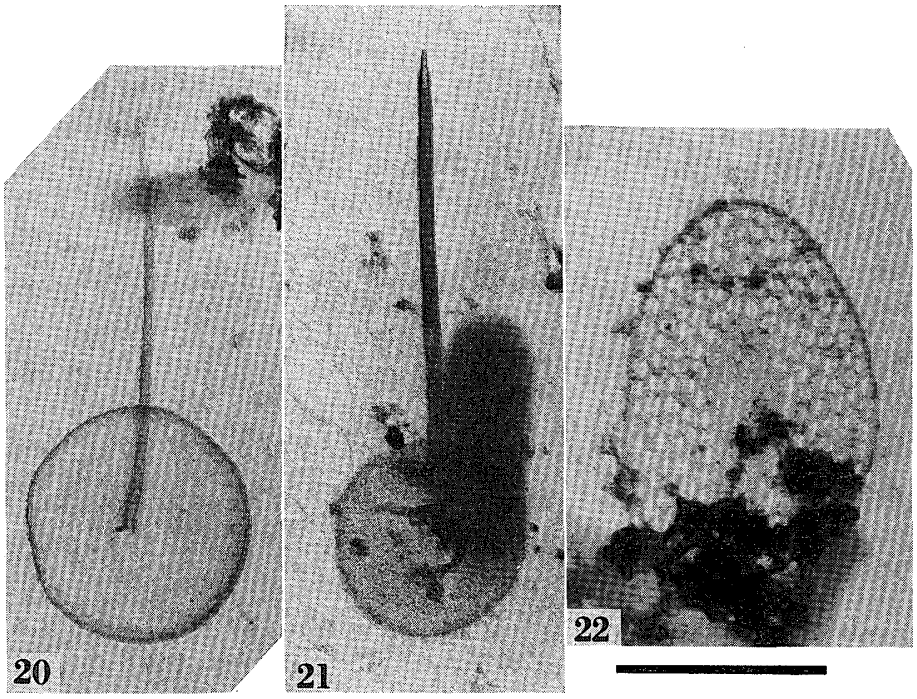

Fig. 20. A scale of Paraphysomonas vestita *DE SAEDELER.*
Fig. 21. A scale of Paraphysomonas imperforata *LUCAS fo. No. 2 TAKAHASHI.*
Fig. 22. A scale of Paraphysomonas *sp.*
(Scale bar: 1 μm).

The scale consists of a circular plate with wide upturned margin and a tapering spine terminating in a rounded end. Basal plates 1.1–1.2 μm in diameter; spines 2.4–2.5 μm long and 0.05 μm thick. Cosmopolitan species. Scales differ from typical form of *P. vestita* by the slightly slender spine and its rounded tip. Recorded from East Ongul Island (OGUNI *et al.*, 1987).

Paraphysomonas imperforata LUCAS fo. No. 2: TAKAHASHI, Electron microscopical studies of the Synuraceae (Chrysophyceae) in Japan. 84, Fig. 283, (1978). (Fig. 21).
The scale consists of a circular plate and a long, straight cylindrical spine terminating in an abruptly and acutely pointed tip. Basal plate 0.9 μm in diameter; spine 2.5 μm long and 0.08 μm thick. New to Antarctica. Distributed in Japan and Alaska.

Paraphysomonas sp. (Fig. 22).
Scale elliptical, 1.3 × 2.0 μm, with a number of apertures. Cell bodies of the present species were not observed.

CLASS Bacillariophyceae

Order Pennales

Amphora veneta KÜTZ.: HUSTEDT, Süsswasser-Flora, **10**, 345, Fig. 631, (1930). (Fig. 23).
Valves lunate, with subrostrate ends, 6–8.1 μm wide, 26–40 μm long; transapical striae 21–23 in 10 μm. Cosmopolitan species. Recorded from West Ongul Island (FUKUSHIMA *et al.*, 1974).

Hantzschia amphioxys (EHR.) GRUN.: HUSTEDT, Süsswasser-Flora. **10**, 394, Fig. 747, (1930). (Fig. 24).

Valves 9.8–10 μm wide, 103–122 μm long; ventral margin slightly concave, dorsal margin slightly convex; keel puncta 10 in 10 μm, transapical striae indistinct. Widely distributed in Antarctica. Recorded from West Ongul Island (FUKUSHIMA *et al.*, 1974).

Navicula molesta KRASSKE: KO-BAYASHI, JARE Sci. Rep., Ser. E, **24**, 21, pls. 21–25, (1965). (Fig. 25).

Valves rhomboidal, attenuated toward poles, with capitate and rounded ends, 7.3 μm wide, 31–31.3 μm long; transapical striae 19 in 10 μm. Recorded from West Ongul Island (FUKUSHIMA *et al.*, 1974).

Navicula muticopsis VAN HEURCK: FUKUSHIMA *et al.*, A preliminary report on the diatom from East Ongul Island. Nankyoku Shiryô (Antarct. Rec.), **46**, 127, pl. 2, Figs. A–E, (1973). (Fig. 26).

Valves elliptic with rostrate and slightly capitate ends, 6–10 μm wide, 20–25 μm long; transapical striae 13–14 in 10 μm. Recorded from West Ongul Island (FUKUSHIMA *et al.*, 1974).

Navicula sp. (Fig. 27).

Valves elliptic with well rounded ends, about 3.5 μm wide, 13.5 μm long.

Stauroneis anceps HUST., Süsswasser-Flora. **10**, 394, Fig. 747, (1930). (Fig. 28).

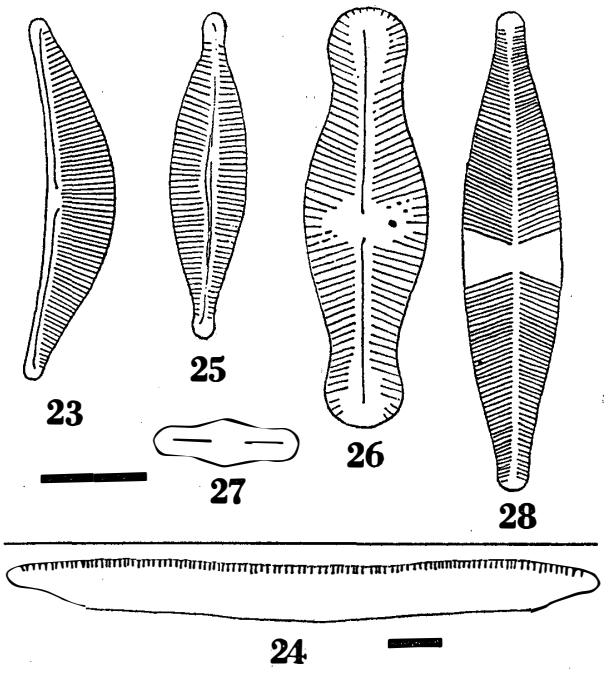

Fig. 23. Amphora veneta *KÜTZ.*
Fig. 24. Hantzschia amphioxys (*EHR.*) *GRUN.*
Fig. 25. Navicula molesta *KRASSKE*
Fig. 26. Navicula muticopsis *VAN HEURCK.*
Fig. 27. Navicula *sp.*
Fig. 28. Stauroneis anceps *HUST.*
(*Scale bar: 10 μm*).

Valves rhomboidal, attenuated toward the poles, with stauros and narrow axial field, about 9 μm wide, 45.3–47.5 μm long; apices capitate and rounded; parallel striations 23 in 10 μm. Cosmopolitan species. Recorded from West Ongul Island (FUKUSHIMA *et al.*, 1974).

CLASS Chlorophyceae

Order Tetrasporales

Sphaerocystis schroeteri CHODAT var. *nivalis* FRITSCH, J. Linn. Soc. London, Bot., **11,** 123, textf. 1, f. F, (1910). (Fig. 29).

Colony spherical contains 4 cells in the common envelope; cells elliptical in shape, 7–13.8 × 8.1–10 μm; chloroplast with one pyrenoid. Recorded from Langhovde (HIRANO, 1979) and East Ongul Island (OGUNI *et al.*, 1987).

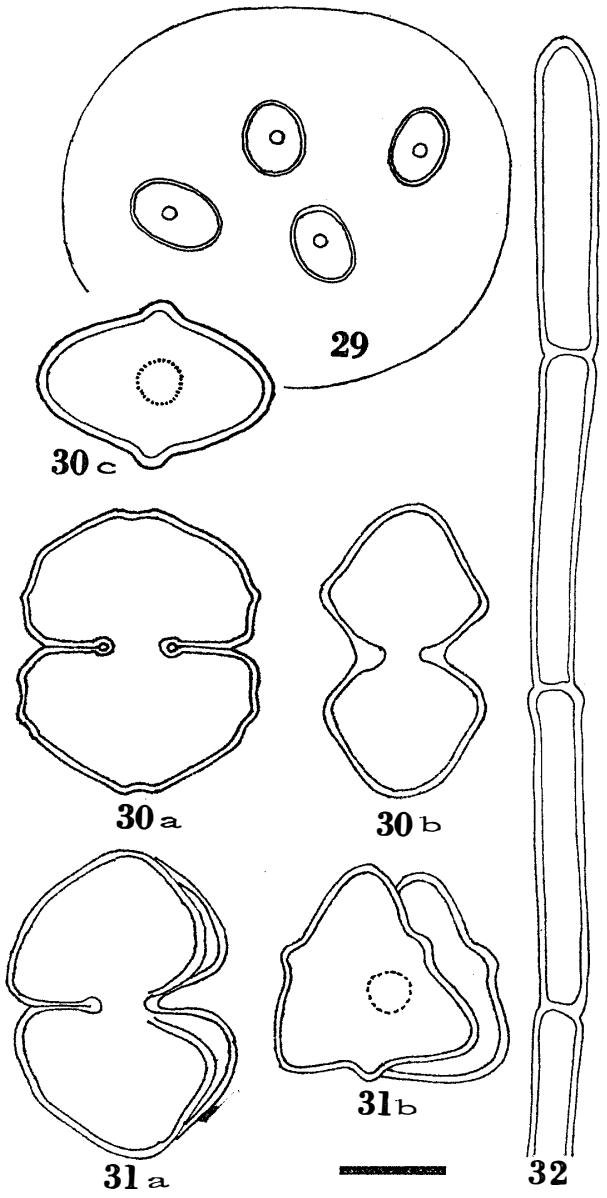

Fig. 29. Sphaerocystis schroeteri *CHODAT var.* nivalis *FRITSCH*
Fig. 30a–c. Cosmarium clepsydra *var.* dissimile *KRIEGER and GERLOFF*
Fig. 31a, b. Staurastrum *sp.*
Fig. 32. Oedogonium *sp.*
(*Scale bar: 10 μm*).

Order Oedogoniales

Oedogonium sp. (Fig. 32).

Filaments unbranched; cells 3.5–6 μm wide, 27.5–35.5 μm long, fruiting materials or zygotes not observed.

Order Zygnematales

Cosmarium clepsydra NORDST. var. *dissimile* (RACIB.) KRIEGER and GERLOFF, Die Gattung *Cosmarium*. Part 2, 145, pl. 30, Fig. 9, (1965). (Fig. 30).

Semicells somewhat reinform, apex narrow and slightly retuse; vertical view of semicell elliptic with a prominent papilla-like projection on each side. Cells 19.5–25.5 μm wide, 21.5–27.0 μm long; ismuth 4.5–6 μm. Distributed in Langhovde and Skarvsnes (HIRANO, 1979, 1983).

Staurastrum sp. (Fig. 31).

Cells about 21 μm wide, 28 μm long.

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