Freshwater benthic diatoms from the south-western part of the Hornsund fiord area, SW Spitsbergen

JOANNA PICIŃSKA-FAŁTYNOWICZ

Picińska-Fałtynowicz, J. 1988: Freshwater benthic diatoms from the south-western part of the Hornsund fiord area, SW Spitsbergen. *Polar Research 6*, 19–34.

The epipelic diatoms from various water bodies from the south-western part of the Hornsund fiord area are presented. Altogether, 157 taxa (127 species together with their variants and forms) have been identified. The flora consists almost entirely of diatoms from the order Pennales which is represented predominantly by Biraphidineae, chiefly by the genera *Navicula*, *Pinnularia* and *Cymbella*. Also some information about the ecology and phytogeography of the diatom flora analysed is given. Most of the species are typical indifferent or alkaliphilous freshwater forms with low trophic requirements. Nearly 55% of the diatoms examined are arctic-alpine or nordic-alpine species.

Joanna Picińska-Fałtynowicz, Department of Plant Ecology and Nature Protection, University of Gdańsk, Czołgistów 46, 81-378 Gdynia, Poland; February 1987 (revised August 1987).

The earliest papers on the freshwater diatoms of Spitsbergen (Cleve 1867; Lagerstedt 1873) contain scant information based on a very small number of samples. A paper by Hustedt (1937) does not contain much information either; it discusses diatoms on the basis of the analysis of one sample from a stream near Kongsfiord. Krasske (1938) was the first to provide a more complete picture of the diatom flora. He identified 180 taxa in a considerable amount of material collected from various water bodies, i.a. in western parts of Spitsbergen. But the most extensive investigation was carried out by Foged (1964) who distinguished 572 taxa of freshwater diatoms from a wide variety of habitats in a large area of western Spitsbergen. He has given the fullest description of the freshwater diatom flora of Spitsbergen so far. Similarly, little work has been done on freshwater diatoms from other Arctic regions. Nevertheless, Foged's work in Greenland (1953, 1955, 1958) and Kharitonov's studies of the microphytobenthos of Wrangel Island (1981) are of great value.

The present article discusses the freshwater benthic diatoms from the south-western part of the Hornsund fiord area, and is based on material collected during the Spitsbergen expedition organized by the Polish Academy of Sciences and the Oceanographical Institute at the University of Gdańsk in 1983.

None of the studies published in the above papers covered the Hornsund fiord area. Moreover, only Foged (1964) gives any data on the microphytobenthos, one of the communities of epipelic algae, that is, algae living on and within the soft sediments (Round 1973).

Even though this community of algae has been studied for many years, and in other climatic zones as well, the research effort in this direction is still insufficient. In his work on the ecology of diatoms, Cholnoky (1968) says that every important textbook on hydrobiology always contains a detailed treatment of phytoplankton, but that information on benthic algae, and microscopic algae in particular, is omitted altogether, or is at best extremely sparse, as if the authors of these books were quite unaware of the significance of these communities.

Characteristics of the study area

In the terminal moraine of the glaciers in the Hornsund fiord region, there exists a quite well developed network of rivers, streams, lakes and pools. Some of the water bodies, like the rivers and the larger lakes are permanent, whereas the ponds, pools and streams are generally ephemeral, that is, their formation during the summer period is accidental, and depends on the current state of the relief. The bottoms of these water bodies are largely stony; soft sediments are found

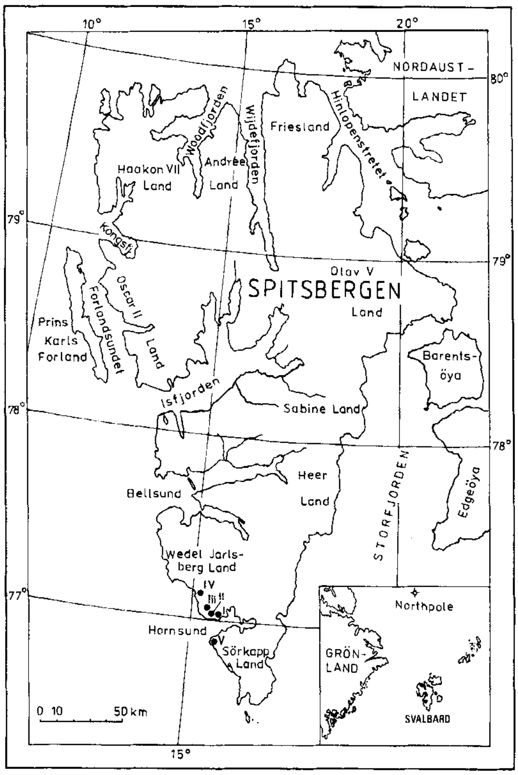

Fig. 1. Map of Spitsbergen with location of areas studied at the Hornsund fiord (I–V). After Foged (1964), changed.

only in small patches in the littoral zone at the inflows of streams into lakes and pools, or filling the gaps between the larger fragments of rock. These sediments are composed of sand in varying degrees of coarseness, and mud, with admixtures of finely crushed feldspars (muscovite and biotite) which give the sediments a characteristic dark reddish-brown, dark grey or even black colour.

The present investigations covered both permanent and seasonal water bodies, grouped into five areas. Each body was treated as a single locality (Fig. 1):

Area I: 1. small lake, 2. stream flowing into this lake, 3. waterlogged ground adjacent to the stream.

Area II: 4. small lake, 5. small lake, 6. stream flowing into lake no. 5, 7. small lake, 8. small lake, 9. small lake, 10. pool about 100 m^2 in area situated between lakes no. 5 and 7.

Area III: 1. stream flowing into Lake Revvatnet, 12. Lake Revvatnet, 13. Revelva river.

Area IV: 14. lake near Warenhus, drying out.

Area V: 15. a large lake near Palffyodden.

The water bodies in areas I and II were ephemeral, the others permanent. The areas of the bodies termed ‘small lake’ ranged from 900 to 2000 m^2, their maximum depths were 1–2 m. The water temperature in all bodies at the time of study oscillated between 2 and 5°C. The sediment characteristics are presented in Table 1.

Material and methods

The research material was collected between 2 and 31 August 1983: twice, at the beginning and the end of August, in areas I, II (localities 4, 5 and 7–9) and III (locality 12), and once in the

Table 1. Characteristics of sediments of investigated water bodies of the south-western part of the Hornsund fiord.

Area	Locality	Description of sediment
	1	fine sand with admixture of detritus
I	2	fine sand
	3	fine sand with admixture of mud
	4	fine sand with admixture of detritus
	5	fine sand with large admixture of detritus
	6	fine sand with admixture of rock pieces and detritus
II	7	fine sand, mud with admixture of sand and detritus
	8	mud with admixture of sand, fine sand with admixture of detritus
	9	mud with admixture of fine sand, fine sand with large admixture of detritus
	10	fine sand with large admixture of detritus
	11	fine sand
III	12	fine sand with admixture of grit and mud
	13	fine sand
IV	14	mud with admixture of fine sand and detritus
V	15	mud with admixture of fine sand

Table 2. Number of taxa of systematic groups and their percentage in the diatom flora of Hornsund (orig.) and Bellsund (after Foged 1964).

Systematic groups	Hornsund Number of taxa	%	Bellsund Number of taxa	%
Centrales	1	0.6	1	0.5
Pennales	156	99.4	197	99.5
Araphidineae	13	8.3	21	10.6
Raphidioidineae	4	2.5	17	8.5
Monoraphidineae	11	7.0	9	4.5
Biraphidineae	128	81.5	150	75.7
Naviculaceae	77	49.0	92	46.5
Cymbellaceae	36	28.0	33	16.7
Epithemiaceae	2	1.3	2	1.0
Nitzschiaceae	12	7.6	19	9.6
Surirellaceae	1	0.6	4	2.0
Total	157		198	

other localities. During the first days of August, some of the water bodies were totally or partly frozen over, so it was not always possible to take samples.

Samples were obtained by inserting a plastic corer into the sediment to a depth of 9–10 cm, additionally with the aid of plastic Petri dishes with perforated bottoms, placed carefully on the surface of the sediment and cut off underneath using a rigid plate. The water depth from which the research material was taken ranged from 5 to 50 cm. In the field, samples were preserved with Lugol's iodine solution, but when having been brought back to the laboratory, they were treated with 4% formalin.

To prepare the diatom material for analysis, the sediment was washed a few times with distilled water, and the filtrate concentrated by centrifuging for 3 minutes at 1500 revolutions per second. Part of each sample was set aside for chemical treatment, as a result of which etched diatom frustules were obtained (Gerlach 1972).

The first stage of microscopic analysis involved observing the unetched algae to eliminate species represented solely by empty or crushed frustules. The remaining species were identified from the etched material, on Styrax and Pleurax solid slides. Each slide was exhaustively examined. A total of 50 samples was examined.

The keys and papers by Hustedt (1930a,b), Huber-Pestalozzi (1942), Cleve-Euler (1952, 1953a,b, 1955), Foged (1964), Siemińska (1964), Patrick & Reimer (1975), Lange-Bertalot & Simonsen (1978), Lange-Bertalot (1980a,b), Lange-Bertalot & Ruppel (1980) and Kennett & Hargraves (1984) were used during the identification of the diatom species.

Results

The freshwater diatom flora in the microphytobenthos of the south-western part of the Hornsund fiord area comprised 157 taxa (127 species together with their variants and forms, see Table 3).

The diatom flora consisted in 99.4% of species of the order Pennales. Centric diatoms were represented by one species – *Cyclotella antiqua* W. Smith. Most of the Pennales taxa were from the sub-order Biraphidineae; few representatives of the other sub-orders were present (Table 2). Biraphidineae were represented mainly by two families: *Naviculaceae*, with *Navicula* (36 taxa) and *Pinnularia* (21 taxa) being the most common genera, and *Cymbellaceae*, the most abundant genus of which was *Cymbella* (28 taxa).

Frequency analysis of the diatom species in localities 1–15 showed that only a small number of taxa was present in all the water bodies examined. After excluding the lake in the Palffyodden area, a larger group of species was found to be common (Table 3). Beside those common taxa, a large number of species occurred in ephemeral as well as in permanent water bodies, but not every taxon was observed in all water bodies. Moreover, different groups of species were noted exclusively in ephemeral small lakes and streams, in ephemeral and permanent lakes, and in streams and the Revelva river. In addition, some diatom taxa were present in a particular water body type, in one of the five areas distinguished, or in a single locality (Tables 3 and 4).

The most abundant diatom flora was observed in ephemeral small lakes. The largest number of diatom species living in sandy sediments was present in lake no. 4, the smallest one in lakes no. 1 and 9 (Table 4).

Diatom assemblages in the sand of ephemeral small lakes were partly composed of an exclusive group of species, the largest one in comparison to the other water body types (Tables 3 and 4). This phenomenon was particularly distinct in lakes in the second area (localities 4, 5 and 7–9). Comparison of the diatom assemblages from all the small lakes revealed a different kind of

Table 3. Occurrence of the benthic diatoms in different freshwater bodies in the Hornsund fiord area.

Taxon	Trophic status	pH-dependence	Geographical element	Water body type: Ephemeral: Streams (2, 6)[x]	Ephemeral: Small lakes (1, 4, 5, 7, 9)	Permanent: Lakes: Revvatnet (12)	Permanent: Lakes: Near Warenhus (14)	Permanent: Lakes: In Palffyodden area (15)	Permanent: Stream (11)	Permanent: Revelva river (13)
Achnanthes lapponica Hust.	o	acid.	n-a	+	+	+	+	+	+	+
A. minutissima Kütz.	o-m	indiff.	c	+	+	+	+	+	+	+
Cymbella minuta Hilse ex Rabh. var. *minuta*	o-m	indiff.	c	+	+	+	+	+	+	+
Fragilaria intermedia Grun.	o	alkal.	c	+	+	+	+	+	+	+
Achnanthes austriaca Hust.	o	alkal.	a-a	+	+	+		+	+	+
Tabellaria flocculosa (Roth) Kütz. var. *flocculosa* (Roth) Knut.	o	acid.	a-a		+	+	+	+	+	+
Ceratoneis arcus (Ehr.) Kütz.	o	alkal.	a-a	+	+	+	+		+	+
C. arcus var. *amphioxys* (Rabh.) Grun.	o	alkal.	a-a	+	+	+	+		+	+
C. arcus var. *linearis* Holmboe	o	alkal.	a-a	+	+	+	+		+	+
Diatoma elongatum (Lyngbye) Agardh var. *tenue* (Agardh) van Heurck	o-m	indiff.	n-a	+	+	+	+		+	+
Nitzschia communis Rabh.	m	alkal.	c	+	+	+	+		+	+
N. frustulum (Kütz.) Grun.	m	alkal.	c	+	+	+	+		+	+
N. frustulum var. *perpusilla* (Rabh.) Grun.	m	alkal.	c	+	+	+	+		+	+
N. thermalis Kütz. var. *minor* Hilse	m	alkal.	c	+	+	+	+		+	+
Cymbella cistula (Hempr.) Grun.	o-m	alkal.	c	+	+	+	+			+
Caloneis silicula (Ehr.) Cleve	o-e	alkal.	c	+	+	+	+	+	+	
Stauroneis anceps Ehr.	o-e	indiff.	c		+	+	+	+	+	
Fragilaria pinnata Ehr.	o-e	alkal.	c	+	+		+	+	+	
F. virescens Ralfs	o	indiff.	n-a	+	+	+	+		+	
Achnanthes kryophila Boye Petersen	o	indiff.	a-a	+	+	+			+	
A. linearis W. Smith	o-m	indiff.	n-a	+	+	+			+	
Cymbella minuta var. *silesiaca* (Bleisch ex Rabh.) Reimer	o			+	+	+			+	
Navicula gregaria Donkin	m	alkal.	c	+	+	+				+
Achnanthes flexella (Kütz.) Grun.	o	indiff.	a-a	+	+	+	+			
Diatoma elongatum	o-m	indiff.	n-a	+	+	+	+			
Pinnularia viridis (Nitzsch) Ehr.	o-m	indiff.	c	+	+	+		+		
P. divergentissima (Grun.) Cleve var. *wulffii* Boye Petersen	o	acid.	a-a	+	+			+		
Cymbella cuspidata Kütz.	o	indiff.	c	+	+		+	+		
C. gracilis (Rabh.) Cleve	o	indiff.	a-a	+	+		+		+	
Meridion circulare Agardh	o	alkal.	c	+	+		+		+	
Pinnularia microstauron (Ehr.) Cleve	o	indiff.	n-a	+	+		+		+	
Achnanthes microcephala (Kütz.) Grun.	e	indiff.	c?	+	+		+			
Amphora ovalis Kütz. var. *pediculus* Kütz.	o-m	alkal.	c	+	+		+			
Caloneis schumanniana (Grun.) Cleve var. *linearis* (Hust.) Mayer	o	alkal.		+	+		+			
Cymbella minuta f. *latens* (Kras-ske) Reimer	o	acid.	a-a	+	+		+			

Table 3. *continued*

Taxon	Trophic status	pH-dependence	Geographical element	Water body type						
				Ephemeral		Permanent				
						Lakes				
				Streams (2, 6)[x]	Small lakes (1, 4, 5, 7, 9)	Revvatnet (12)	Near Warenhus (14)	In Palffyodden area (15)	Stream (11)	Revelva river (13)
C. naviculiformis Auersw.	o	indiff.	a-a	+	+		+			
C. proxima Reimer	o			+	+		+			
C. sinuata Greg.	o	indiff.	n-a	+	+		+			
Hantzschia amphioxys (Ehr.) Grun.	m	indiff.	c	+	+		+			
Navicula amphibola Cleve	o	alkal.	n-a	+	+		+			
N. cryptocephala Kütz.	o-m	alkal.	c	+	+		+			
N. hungarica Grun. var. *capitata* (Ehr.) Cleve	o	alkal.	c	+	+					+
N. slesvicensis Grun.	m	alkal.	c	+	+					+
N. mutica Kütz.	o	indiff.	c	+	+				+	
Caloneis bacillum (Grun.) Cleve	o	alkal.		+	+	+				
Navicula cincta (Ehr.) Kütz.	o	alkal.	c	+	+	+				
Pinnularia viridis var. *sudetica* (Hilse) Hust.	o-m	indiff.	n-a	+	+	+				
Achnanthes lanceolata (Bréb.) Grun.	m	indiff.	c	+	+					
Amphora normanii Rabh.	o	alkal.	n-a	+	+					
Caloneis alpestris (Grun.) Cleve	o	alkal.	n-a	+	+					
C. silicula var. *minuta* Grun.	o-e	alkal.	c?	+	+					
Cymbella laevis Naegeli		alkal.	a-a	+	+					
Denticula tenuis Kütz.	o-m	alkalib.	n-a	+	+					
D. tenuis var. *crassula* (Naegeli) Hust.	o-m	alkalib.	n-a	+	+					
Didymosphaenia geminata (Lyngbye) W. Smith	o	indiff.	a-a	+	+					
Diploneis ovalis (Hilse) Cleve	o-e	alkal.	c	+	+					
Fragilaria capucina Desmaziéres	o-m	alkal.	c	+	+					
Hantzschia amphioxys var. *maior* Grun.	m	indiff.	c	+	+					
Navicula anglica Ralfs	o-e	alkal.		+	+					
N. bryophila Boye Petersen var. *lapponica* Hust.	o	indiff.	a-a	+	+					
N. cryptocephala var. *veneta* (Kütz.) Grun.	o-m	alkal.	c	+	+					
N. peregrina (Ehr.) Kütz.		alkal.		+	+					
N. peregrina var. *polaris* Lagst.		alkal.	a-a	+	+					
N. rhynchocephala Kütz.		alkal.	c	+	+					
N. rhynchocephala f. *elegans* A. Cleve-Euler	o?	alkal.		+	+					
N. viridula (Kütz.) Ehr.	m	alkal.	c	+	+					
N. vulpina Kütz.	o-e	alkal.		+	+					
Neidium dubium (Ehr.) Cleve	o	indiff.	a-a	+	+					
N. kozlowii Mereschk.		indiff.		+	+					
Nitzschia gracilis Hantzsch	m	indiff.	c	+	+					
Pinnularia gracillima Greg.	o-e	indiff.		+	+					
P. microstauron f. *diminuta* Grun.	o	indiff.	n-a	+	+					
Cymbella perpusilla A. Cleve	o-m	acid.	n-a		+	+	+			+
Nitzschia palea (Kütz.) W. Smith	m	indiff.	c		+	+			+	
Pinnularia borealis Ehr.	o	indiff.	n-a		+			+	+	

Table 3. *continued*

Taxon	Trophic status	pH-dependence	Geographical element	Water body type						
				Ephemeral		Permanent				
						Lakes				
				Streams (2, 6)[x]	Small lakes (1, 4, 5, 7, 9)	Rev-vatnet (12)	Near Warenhus (14)	In Palffyodden area (15)	Stream (11)	Revelva river (13)
Navicula bacillum Ehr.	o	indiff.	c		+				+	
Cymbella amphicephala Naegeli	o-e	indiff.	c		+			+		
C. heteropleura Ehr. var. *minor* Cleve		acid.	n-a		+			+		
C. obtusa Greg.		indiff.			+			+		
Neidium iridis (Ehr.) Cleve	o	indiff.	c		+			+		
N. ladogense (Cleve) Foged	o	indiff.			+			+		
Pinnularia mesolepta (Ehr.) W. Smith	o	indiff.	c?		+			+		
P. subsolaris (Grun.) Cleve	o	indiff.			+			+		
Amphora libyca Ehr.		alkal.	c		+		+			
Cymbella aequalis W. Smith var. *subaequalis* Grun.	e	alkal.	n-a		+		+			
C. gaeumanni Meister	o	indiff.	n-a		+		+			
C. sinuata f. *ovata* Hust.	o	indiff.	n-a		+		+			
C. turgida (Greg.) Cleve		alkal.	n-a		+		+			
Nitzschia dissipata (Kütz.) Grun.	m	alkal.			+		+			
Pinnularia viridis var. *minor* Cleve	o-m	indiff.			+		+			
Stauroneis phoenicentron (Nitzsch) Ehr.	m	indiff.	c		+		+			
S. smithii Grun. var. *incisa* Pant.	o	alkal.			+		+			
Hantzschia amphioxys f. *capitata* O. Müller	m	indiff.	c		+	+	+			
Cymbella parva (W. Smith) Cleve		alkal.	n-a		+	+	+			
C. norvegica Grun.	o	indiff.	a-a		+	+				
Achnanthes lanceolata var. *elliptica* Cleve	m	indiff.	n-a		+					
Amphora ovalis	m	alkal.	c		+					
Cyclotella antiqua W. Smith	o	acid.	a-a		+					
Cymbella angustata (W. Smith) Cleve		indiff.			+					
C. angustata var. *hybrida* Ross	o	indiff.	n-a		+					
C. delicatula Kütz.	o-m	alkal.	n-a		+					
C. leptoceros (Ehr.) Grun. var. *rostrata* Hust.	e	alkal.?			+					
Navicula cari Ehr.	o	alkal.	c		+					
N. cuspidata Kütz. var. *ambigua* (Ehr.) Cleve	m	alkal.	c		+					
N. hungarica var. *lüneburgensis* Grun.	o	alkal.			+					
N. radiosa Kütz.	o-m	indiff.	c		+					
N. reinhardtii Grun.	m	alkal.	c		+					
N. tuscula (Ehr.) Grun.	o-e	alkalib.	c		+					
Pinnularia divergens W. Smith	o	indiff.	n-a		+					
P. spitsbergensis Cleve	o	indiff.?	a-a		+					
Stauroneis javanica (Grun.) Cleve var. *oblonga* Østrup	o	indiff.	a-a		+					
Navicula minima Grun.	o	alkal.		+			+			
Anomoeoneis exilis (Kütz.) Cleve	o	alkal.	a-a				+			+

Table 3. *continued*

				Water body type						
				Ephemeral		Permanent				
						Lakes				
Taxon	Trophic status	pH-dependence	Geographical element	Streams (2, 6)[x]	Small lakes (1, 4, 5, 7, 9)	Revvatnet (12)	Near Warenhus (14)	In Palffyodden area (15)	Stream (11)	Revelva river (13)
Surirella gracilis (W. Smith) Grun.	m?	indiff.?	n-a				+			+
Navicula avenacea Bréb.	m	alkal.	c	+						+
N. søhrensis Krasske	o	alkal.	a-a	+					+	+
Gomphonema angustatum (Kütz.) Rabh. var. *productum* Grun.	o-m	alkal.	c			+	+		+	+
Navicula rotaeana (Rabh.) Grun.	o	indiff.	n-a			+			+	+
N. contenta Grun. var. *biceps* Arnott	o	alkal.				+			+	
Achnanthes fragilarioides Boye Petersen	o	indiff.	a-a			+			+	
Anomoeoneis serians (Bréb.) Cleve var. *brachysira* (Bréb.) Hust.	o	acid.	a-a			+			+	
Navicula mutica f. *rhomboidea* Playfair	o	indiff.	a-a	+		+			+	
Pinnularia molaris Grun.	o	indiff.	a-a			+		+	+	
Neidium bisulcatum (Lagst.) Cleve	o	indiff.	n-a					+	+	
Pinnularia parva (Greg.) Cleve var. *minuta* Østrup	m	acid.?				+	+			
Stauroneis anceps f. *gracilis* Rabh.	o-e	acid.					+	+		
Pinnularia interrupta W. Smith f. *minutissima* Hust.		indiff.						+		

Species exclusive for one locality: 2 – *Achnanthes coarctata* (Bréb.) Grun., o, indiff., n-a; *Pinnularia intermedia* Lagst., o, indiff., a-a; *P. krockei* Grun., o, indiff.; 4 – *Cymbella austriaca* Grun., o, indiff., n-a; *C. helvetica* Kütz. var. *genuina* Mayer, o, alkal.; *Navicula gastrum* Ehr., m-e, indiff., c; *N. interglacialis* Hust., indiff.; *N. placentula* (Ehr.) Kütz., alkal., c; *Gomphonema truncatum* Ehr. var. *truncatum*, o-m, indiff.; 6 – *Hantzschia amphioxys* var. *vivax* (Hantzsch) Grun., m, indiff., c; 7 – *Eunotia praerupta* Ehr., o, acid., a-a; *Pinnularia divergens* var. *elliptica* Grun., o, indiff., n-a; 8 – *Navicula paludosa* Hust., indiff.; 10 – *Cymbella similis* Krasske, o, indiff., n-a; *Pinnularia isostauron* (Grun.) Cleve, o, n-a; 12 – *Eunotia tenella* (Grun.) Hust., o, acid., a-a; 13 – *Nitzschia commutata* Grun., m, indiff.; 14 – *Diatoma vulgare* Bory var. *linearis* Grun., alkalib.; *Fragilaria vaucheriae* Boye Petersen, o-m, alkal., c; *Gomphonema angustatum* var. *undulatum* Grun., o-m, indiff.; *Navicula mutica* var. *binodis* Hust., o, indiff., c; *Neidium distincte-punctatum* Hust., o, indiff.; *Stauroneis anceps* var. *hyalina* Brunth. et Perag., o-e, indiff.; 15 – *Diatoma vulgare* var. *ovalis* (Fricke) Hust., o-m, alkalib.; *Eunotia parallela* Ehr., o, acid., n-a; *E. polydentula* Brun., o, acid., c; *Navicula pseudoscutiformis* Hust., indiff., n-a; *N. scutiformis* Grun., o, indiff., n-a; *Pinnularia divergentissima* (Grun.) Cleve, o, indiff., a-a; *P. interrupta* W. Smith, indiff.

Explanations: a-a – arctic-alpine, acid. – acidophilous, alkal. – alkaliphilous, alkalib. – alkalibiontic, c – cosmopolitan, e – eutrophic, indiff. – indifferent, m – mesotrophic, n-a – nordic-alpine, o – oligotrophic, x – numbers of localities. Referred to for information about ecology and phytogeography are Cleve-Euler (1952, 1953a, b, 1955), Foged (1964), Kalbe (1973) and Kharitonov (1981).

similarity to those assemblages. Each of the analysed assemblages comprised a particular number of species common also to assemblages from the other lakes (Table 5). The diatom floras of lakes 1 and 7–9 comprised from 71% to more than 88% of taxa common to the floras of lakes 4 and 5. Moreover, distinct similarity between diatom assemblages from lakes 4 and 5, 8 and 7, and 9 and 7 was observed.

Analysis of the benthic diatom flora in sandy and muddy sediments from lakes 7, 8 and 9 showed that in sand larger numbers of taxa were noted (Table 6, Fig. 2A). The smallest difference in numbers of species from both types of

Table 4. Occurrence of benthic diatoms in sandy sediments of ephemeral small lakes (localities 1, 4, 5, 7–9), streams (localities 2 and 6), waterlogged area (locality 3) and pool (locality 10) at the beginning and the end of August 1983.

Locality	1		2		3		4		6	5		10	7	8	9
Taxon — Date: 83. 08.	02	24	02	24	02	24	02	26	02	02	26	31	02	26	26
Achnanthes minutissima	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
A. microcephala	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Caloneis silicula	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cymbella minuta var. *minuta*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Fragilaria capucina	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
F. pinnata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitzschia frustulum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
N. frustulum var. *perpusilla*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Didymosphaenia geminata	+	+	+	+	+	+	+		+	+		+	+	+	+
Cymbella naviculiformis	+	+	+	+	+		+	+	+	+	+	+	+	+	+
Pinnularia viridis	+	+	+	+	+	+	+	+	+	+		+	+	+	+
Nitzschia communis	+	+	+	+	+	+	+	+	+	+	+		+	+	+
Navicula cryptocephala	+	+	+	+	+	+	+	+	+	+	+		+	+	+
N. cincta	+	+	+	+	+	+	+	+	+	+	+		+	+	
Cymbella cistula	+	+	+	+	+	+	+	+	+	+	+		+	+	
Diatoma elongatum var. *tenue*	+	+	+	+	+	+	+		+	+	+		+	+	
Cymbella minuta var. *silesiaca*	+	+	+	+	+	+	+	+		+			+	+	
Amphora ovalis var. *pediculus*	+	+	+	+	+		+	+		+	+		+	+	+
Navicula cryptocephala var. *veneta*	+	+	+	+	+	+	+	+		+	+		+	+	+
Nitzschia gracilis	+	+		+	+	+	+	+		+	+		+	+	+
Achnanthes lapponica	+	+	+	+		+	+		+			+		+	+
Fragilaria intermedia	+	+	+	+	+	+			+	+	+	+		+	+
Ceratoneis arcus	+	+	+	+	+	+	+	+	+	+	+	+		+	
C. arcus var. *amphioxys*	+	+	+	+	+	+	+	+	+	+	+	+		+	
C. arcus var. *linearis*	+	+	+	+	+	+	+	+	+	+	+	+		+	
Fragilaria virescens	+	+	+	+	+	+		+	+	+		+			
Achnanthes kryophila	+	+	+		+	+		+	+	+	+	+	+		
Cymbella minuta f. *latens*	+	+	+	+	+	+	+	+				+	+		
C. sinuata	+	+	+	+	+	+			+	+	+				
Meridion circulare	+	+	+	+	+	+			+	+				+	
Diatoma elongatum	+	+	+	+	+	+			+					+	
Nitzschia thermalis var. *minor*	+	+	+	+	+	+								+	
Hantzschia amphioxys	+	+	+	+					+	+					+
H. amphioxys f. *capitata*	+	+								+		+			+
H. amphioxys var. *maior*		+							+			+	+		
Stauroneis anceps	+	+					+	+		+		+		+	+
Pinnularia spitsbergensis	+	+					+	+				+			
Cymbella gaeumanni		+						+			+				
Achnanthes lanceolata var. *elliptica*	+	+								+	+				
Navicula anglica	+	+			+	+	+		+	+					
Cymbella norvegica	+	+			+		+	+					+	+	
Achnanthes linearis			+	+	+	+	+		+	+	+	+	+	+	+
Diploneis ovalis			+	+		+	+	+			+	+	+	+	+
Achnanthes flexella			+	+	+	+	+	+				+	+	+	+
Navicula viridula			+	+	+	+	+	+	+	+	+		+	+	+
Cymbella gracilis			+	+	+	+	+	+	+	+	+		+	+	
Achnanthes austriaca			+	+	+	+	+	+	+	+	+	+	+		
Pinnularia viridis var. *sudetica*			+	+	+	+	+	+		+	+			+	+
Caloneis silicula var. *minuta*			+	+	+	+	+	+	+	+		+			
Cymbella cuspidata			+		+		+	+	+	+				+	
Pinnularia microstauron			+	+	+							+	+	+	+
Navicula rhynchocephala f. *elegans*			+	+	+	+				+	+				+
N. peregrina			+	+	+	+				+	+	+			
N. gregaria			+	+	+	+	+			+			+		
N. vulpina			+	+	+	+	+	+		+	+				
Cymbella proxima			+		+		+	+		+					
Caloneis schumanniana var. *linearis*			+	+	+	+	+	+		+					
Achnanthes lanceolata			+	+	+	+				+	+				

Table 4. *continued*

Locality	1		2		3		4		6	5		10	7	8	9
Taxon / Date: 83. 08.	02	24	02	24	02	24	02	26	02	02	26	31	02	26	26
Navicula hungarica var. *capitata*			+	+	+	+				+					
Caloneis bacillum			+	+	+	+		+	+						
Navicula slesvicensis			+	+	+	+		+							
N. amphibola			+	+			+	+		+	+	+	+	+	+
Caloneis alpestris			+	+			+	+	+	+	+	+			
Navicula bryophila var. *lapponica*			+	+			+	+					+		
N. peregrina var. *polaris*			+	+						+	+	+			
Pinnularia microstauron f. *diminuta*			+	+								+	+		
Neidium kozlowii			+										+		
Amphora normanii			+	+				+			+				
Navicula mutica			+	+				+							
Pinnularia divergentissima var. *wulffii*			+	+				+							
Neidium dubium			+	+			+								
Cymbella parva					+	+	+	+		+		+	+	+	
C. perpusilla						+	+	+		+		+	+	+	
Navicula bacillum					+			+		+		+	+	+	+
Cymbella angustata					+		+	+				+	+	+	
C. angustata var. *hybrida*					+		+	+				+	+	+	
Pinnularia divergens					+	+						+	+		
Cymbella turgida					+	+	+	+		+					
Tabellaria flocculosa var. *flocculosa*					+	+				+					
Navicula avenacea			+	+	+	+									
N. minima			+	+	+	+									
N. hungarica var. *lüneburgensis*	+	+			+	+									
Pinnularia gracillima	+	+	+	+											
Denticula tenuis							+	+	+	+	+	+	+	+	+
D. tenus var. *crassula*							+	+	+	+	+	+	+	+	+
Amphora libyca							+	+			+	+	+	+	+
Neidium iridis							+			+		+	+	+	+
Amphora ovalis							+	+		+	+		+	+	+
Stauroneis javanica var. *oblonga*							+	+		+	+		+	+	+
Cyclotella antiqua							+	+			+		+	+	+
Navicula reinhardtii							+	+		+	+		+		+
Nitzschia palea							+	+		+	+	+	+		+
Cymbella aequalis var. *subaequalis*							+	+			+	+	+		+
C. amphicephala							+	+				+	+		+
C. delicatula							+	+			+	+	+		
Nitzschia dissipata							+	+			+	+	+		
Navicula cari							+	+				+	+		
Cymbella obtusa							+	+				+	+	+	
Navicula radiosa							+	+					+	+	+
Cymbella heteropleura var. *minor*							+	+			+			+	
C. leptoceros var. *rostrata*							+	+			+			+	
Navicula tuscula							+	+					+		
Neidium ladogense							+	+		+					
Pinnularia viridis var. *minor*								+		+	+	+			
Cymbella laevis									+			+	+		
Navicula cuspidata var. *ambigua*										+				+	+

Species occurring at one of the analysed localities only: 2 – *Achnanthes coarctata*, *Navicula mutica* f. *rhomboidea*, *N. søhrensis*, *Pinnularia intermedia*, *P. krockei* (08. 02); 3 – *Neidium bisulcatum* (08. 02), *Pinnularia interrupta* f. *minutissima*, *Surirella gracilis*; 4 – *Cymbella austriaca* (08. 26), *C. helvetica* var. *genuina* (08. 26), *Gomphonema truncatum* var. *truncatum*, *Navicula gastrum* (08. 26), *N. interglacialis* (08. 26), *N. placentula* (08. 26), *Stauroneis phoenicentron* (08. 26), *S. smithii* var. *incisa* (08. 26); 5 – *Cymbella sinuata* f. *ovata* (08. 26), *Pinnularia borealis* (08. 02), *P. mesolepta* (08. 26); 6 – *Hantzschia amphioxys* var. *vivax*; 7 – *Eunotia praerupta*, *Pinnularia divergens* var. *elliptica*, *P. subsolaris*; 8 – *Navicula paludosa*; 10 – *Cymbella similis*, *Pinnularia isostauron*, *Gomphonema angustatum* var. *productum*.

Number of taxa in the series	41	43	71	67	66	60	71	81	41	67	55	56	64	56	43
Total number of taxa	43		72		69		89		41	79		56	64	56	43

Table 5. Number of common taxa of diatom assemblages from sandy sediments of the ephemeral small lakes studied.

1 (43)[x]	4 (89)	5 (79)	7 (64)	8 (56)	9 (43)
1	32	33	24	29	21
	4	63	55	47	37
		5	45	43	38
			7	41	35
				8	35

x – total number of species.

sediments was observed in lake no. 7 (Fig. 2A). Diatom assemblages in mud comprised the same taxa which occurred in sand (Table 6). As regards the trophic requirements and the pH dependence of diatoms in mud compared to sand, the percentage of strict oligosaprobes declined markedly. Simultaneously the percentage of oligo-mesosaprobes and oligo-eusaprobes increased (Fig. 2B). In lake no. 7 pH-indifferent diatoms dominated in both sediment types, whereas in lakes no. 8 and 9 the percentage of alkaliphilous taxa increased in muddy sediment (Fig. 2C).

The species composition of a pool (locality 10) situated between small lakes no. 5 and 7 showed similarity to the floras of both lakes (Table 4). The diatom assemblage was composed in more than 48% of species occurring in both lakes, in about 20% of taxa identical with the diatoms found in lake no. 5 and in 21% of taxa identical with those noted in lake no. 7. Two of the remaining species were observed in the pool only (Table 4).

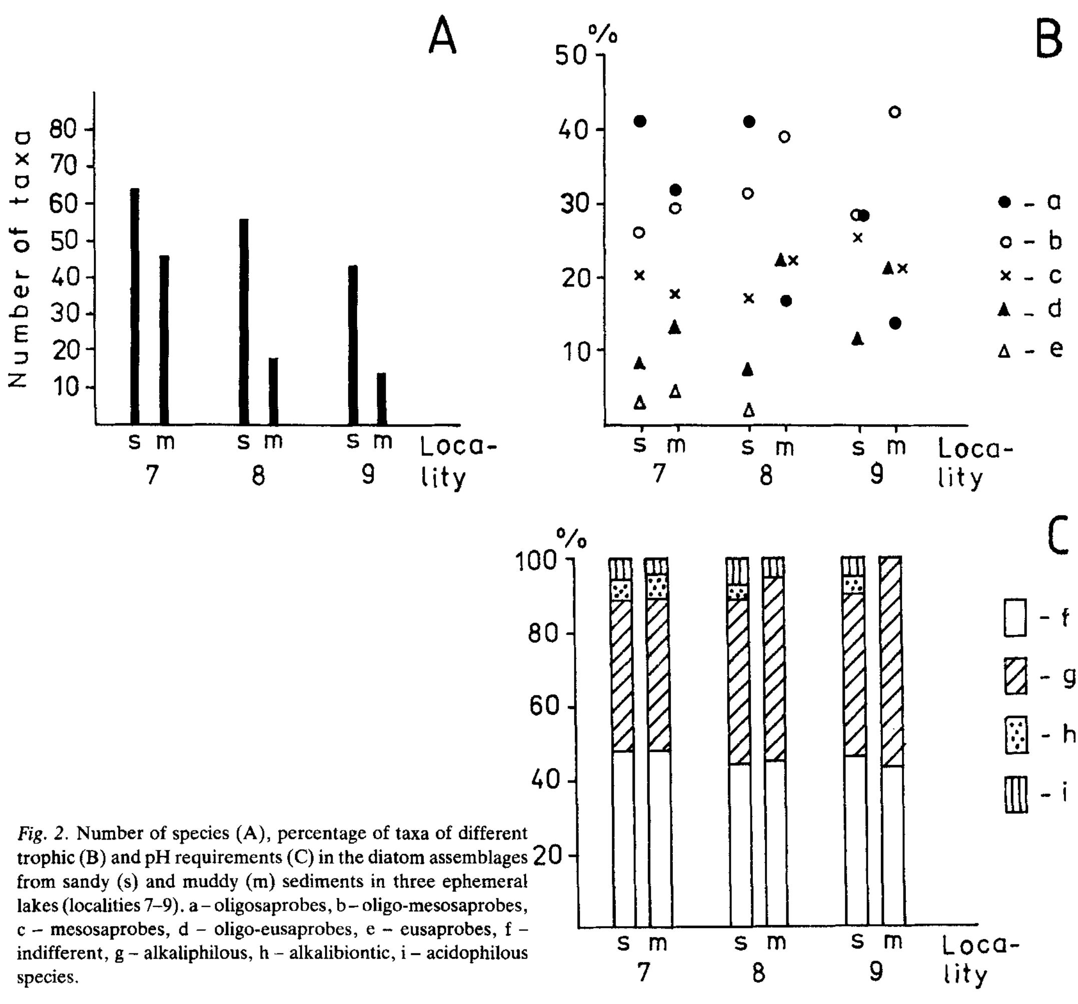

Fig. 2. Number of species (A), percentage of taxa of different trophic (B) and pH requirements (C) in the diatom assemblages from sandy (s) and muddy (m) sediments in three ephemeral lakes (localities 7–9). a – oligosaprobes, b – oligo-mesosaprobes, c – mesosaprobes, d – oligo-eusaprobes, e – eusaprobes, f – indifferent, g – alkaliphilous, h – alkalibiontic, i – acidophilous species.

Table 6. Diatom assemblages in two sediment types of three ephemeral small lakes.

Taxon	Sediment type / Locality	Sand 7	Sand 8	Sand 9	Mud 7	Mud 8	Mud 9
Achnanthes linearis		+	+	+	+	+	+
A. minutissima		+	+	+	+	+	+
Amphora ovalis var. *pediculus*		+	+	+	+	+	+
Caloneis silicula		+	+	+	+	+	+
Cymbella minuta var. *minuta*		+	+	+	+	+	+
Fragilaria capucina		+	+	+	+	+	+
F. pinnata		+	+	+	+	+	+
Diploneis ovalis		+	+	+	+	+	+
Navicula cryptocephala		+	+	+	+	+	+
N. viridula		+	+	+	+	+	+
Nitzschia gracilis		+	+	+	+	+	+
Didymosphaenia geminata		+	+	+		+	+
Nitzschia communis		+	+	+	+	+	
Navicula radiosa		+	+	+	+	+	
Achnanthes flexella		+	+	+	+		
Amphora libyca		+	+	+	+		
Cyclotella antiqua		+	+	+	+		
Cymbella naviculiformis		+	+	+	+		
Denticula tenuis		+	+	+	+		
D. tenuis var. *crassula*		+	+	+	+		
Navicula amphibola		+	+	+	+		
N. bacillum		+	+	+	+		
Neidium iridis		+	+	+	+		
Nitzschia frustulum		+	+	+	+		
N. frustulum var. *perpusilla*		+	+	+	+		
Pinnularia viridis		+	+	+	+		
Stauroneis javanica var. *oblonga*		+	+	+	+		
Amphora ovalis		+	+	+			+
Pinnularia microstauron		+	+	+			+
Cymbella gracilis		+	+		+	+	
Stauroneis anceps			+	+	+	+	
Achnanthes microcephala		+		+	+		
Cymbella amphicephala		+		+	+		
C. aequalis var. *subaequalis*		+		+	+		
C. angustata		+	+		+		
C. angustata var. *hybrida*		+	+		+		
C. perpusilla		+	+		+		
Diatoma elongatum var. *tenue*		+	+		+		
Navicula cincta		+	+		+		
N. rhynchocephala		+			+	+	
N. cryptocephala var. *veneta*		+	+	+			
Achnanthes lapponica			+	+		+	
Cymbella norvegica		+	+		+		
C. cistula		+	+				
C. minuta var. *silesiaca*		+	+				
C. parva		+	+				
C. obtusa		+	+				
Fragilaria intermedia			+	+			
Navicula cuspidata var. *ambigua*			+	+			
Pinnularia viridis var. *sudetica*			+	+			
Navicula reinhardtii		+		+			
Nitzschia palea		+		+			
Achnanthes austriaca		+			+		
Cymbella delicatula		+			+		
Hantzschia amphioxys var. *maior*		+			+		
Navicula bryophila var. *lapponica*		+			+		
N. cari		+			+		
N. tuscula		+			+		

Table 6. *continued*

Taxon	Sediment type / Locality	Sand 7	Sand 8	Sand 9	Mud 7	Mud 8	Mud 9
Nitzschia dissipata		+			+		
Pinnularia microstauron f. *diminuta*		+			+		
Achnanthes kryophila		+					
Cymbella laevis		+					
C. minuta f. *latens*		+					
Eunotia praerupta		+					
Navicula gregaria		+					
Neidium kozlowii		+					
Pinnularia divergens		+					
P. divergens var. *elliptica*		+					
P. subsolaris		+					
Ceratoneis arcus			+				
C. arcus var. *amphioxys*			+				
C. arcus var. *linearis*			+				
Cymbella cuspidata			+				
C. heteropleura var. *minor*			+				
C. leptoceros var. *rostrata*			+				
Diatoma elongatum			+				
Meridion circulare			+				
Navicula paludosa			+				
Nitzschia thermalis var. *minor*			+				
Hantzschia amphioxys				+			
H. amphioxys f. *capitata*				+			
Navicula rhynchocephala f. *elegans*				+			

The diatom flora of ephemeral streams (localities 2 and 6) consisted mainly of species which were found in small ephemeral lakes, to which those streams were adjacent. The diatom assemblage of stream no. 2, flowing into lake no. 1, was composed in 47.2% of taxa observed in that small lake. However, the diatom assemblages of the stream and the waterlogged area adjacent to it (locality 3) were much more similar (76.4% of common taxa). Furthermore, the respective numbers of species in the two last mentioned localities were nearly the same and much higher than in lake no. 1 (Table 4). The diatom flora of stream no. 6 connected with small lake no. 5 was greatly similar to the flora of that lake, as 85.4% of the stream diatoms were identical with those living in the lake. A similar correlation was observed between the permanent stream or river Revelva and Lake Revvatnet, to which both the stream and the river were adjacent (Table 3). In the streams and the Revelva river exclusive species were noted (Tables 3 and 4).

The diatom assemblages of three permanent lakes, that is Lake Revvatnet, the lake near Warenhus and the lake in the Palffyodden area, partly consisted of taxa common to all the water bodies examined. Furthermore, in those lakes were noted species which also occurred in ephem-

Table 7. Percentage of species with various trophic requirements in the diatom assemblages from sandy (localities 1–13) and muddy (localities 14 and 15) sediments of the water bodies studied.

Locality	Trophic requirements o^x	o-m	m	o-e	e
1	41.9	23.2	20.9	11.6	2.3
2	55.1	17.4	17.4	8.7	1.4
3	50.0	20.3	18.7	9.4	1.6
4	46.9	22.2	13.6	11.1	4.9
6	42.5	27.5	17.5	10.0	2.5
5	43.8	21.9	20.5	9.6	4.1
10	49.0	22.4	12.2	12.2	4.1
7	41.4	25.9	20.7	8.6	3.4
8	41.2	31.4	17.6	7.8	2.0
9	28.6	28.6	26.2	11.9	4.7
11	64.9	13.5	13.5	8.1	
12	51.2	24.4	19.5	4.9	
13	42.3	23.1	34.6		
14	45.4	21.8	20.0	9.1	3.6
15	65.4	15.4		19.2	

o^x – oligosaprobes, o-m – oligo-mesosaprobes, m – mesosaprobes, o-e – eusaprobes, e – eusaprobes.

eral small lakes and streams (Table 3). About 78% of the taxa observed in both Lake Revvatnet and the lake near Warenhus were found in small lakes as well. In the lake in the Palffyodden area the percentage of taxa common to that lake and the small lakes was lower (64.5%). A comparison of the species composition of those three permanent lakes showed that diatom assemblages of Lake Revvatnet and the lake near Warenhus were more similar to each other (24 common taxa) than each of them to the assemblage of the third lake (in both cases 10 common taxa) (Table 3). In that last lake, no *Nitzschia* species were found, but the largest number of *Pinnularia* taxa occurred. There was an occurrence of exclusive taxa in permanent lakes also here, as was the case in the localities analysed previously.

The maximum number of species in sandy sediments, summed up in both series of samples if possible, was noted in ephemeral small lakes no. 4 (89 taxa) and 5 (79 taxa), the minimum number being in the Revelva river (26 taxa). The diatom flora at localities 2, 3, 7, 8 and 10 was quite abundant. The maximum number of species in muddy sediments was noted in the permanent lake near Warenhus (59 taxa), the minimum number in small lake no. 9.

Comparison of results from the beginning and the end of August (localities 1–5 and 12) concerning sandy sediments showed that differences in the number of species usually were negligible, except diatom assemblages from lakes no. 4 and 5. In lake no. 4 the number of taxa increased, whereas in lake no. 5 it decreased markedly by the end of August (Table 4).

The great majority of species found in the Hornsund fiord area were typical freshwater (74.3%) and freshwater-brackish (22.4%) diatoms. The exceptions were *Navicula gregaria*, *Nitzschia commutata* and *Surirella gracilis*, which are regarded as typical brackish water species, and *Navicula peregrina* together with its *polaris* variant, which are saline diatoms.

As regards the dependence of the species composition of the diatoms on the degree of trophicity of the habitat, it was found that at all localities, excluding muddy sediments in small lakes no. 8 and 9, strict oligosaprobes dominated. Species characteristic to oligo- to mesotrophic, mesotrophic or oligo- to eutrophic waters were also present, but their percentages were usually much lower than the percentage of oligotrophic diatoms. Only a few taxa were of eutrophic status (Tables 3 and 7).

As far as the pH requirements of the diatoms are concerned, the dominant groups in the diatom assemblages studied were indifferent and alkaliphilous taxa, with acidophilous and alkalibiontic species definitely in minority (Table 8).

Phytogeographic analysis of the species composition of the Hornsund microphytobenthos

Table 8. Percentage of species with different pH-requirements in the diatom assemblages from sandy (localities 1–13) and muddy (localities 14 and 15) sediments of the water bodies studied.

Locality	pH-dependence indiff.^{x}	alkal.	alkalib.	acid.
1	50.0	45.2		4.8
2	42.8	52.8		4.3
3	40.3	53.7		6.0
4	43.7	46.0	3.4	6.9
6	41.5	51.2	4.9	2.4
5	38.5	52.5	2.6	6.4
10	47.3	43.6	3.6	5.4
7	47.6	41.3	4.8	6.3
8	43.6	45.4	3.6	7.3
9	46.5	44.2	4.6	4.6
11	50.0	41.7		8.3
12	43.9	41.5		14.6
13	23.1	65.4		11.5
14	43.1	44.8	1.7	10.3
15	61.3	12.9	3.2	22.6

indiff.^{x} – indifferent, alkal. – alkaliphilous, alkalib. – alkalibiontic, acid. – acidophilous species.

showed that nearly 55% of the diatoms are arctic-alpine or nordic-alpine species (Table 3).

Discussion

Foged's (1964) investigations covered western Spitsbergen, but he did not include the Hornsund fiord area in his work; the closest point to Hornsund that he reached was the Bellsund fiord area. Here he recorded 198 diatom taxa occurring in various freshwater bodies. One should add that Foged described not only epiphytic diatoms (collected from mosses and macroalgae), but epilithic and epipelic diatoms as well. The present article deals exclusively with the last mentioned group of algae.

Of the 157 taxa which I recorded, 99 are identical to those which Foged (1964) reported from the Bellsund area, and a further 52 we both found elsewhere on Spitsbergen. The remaining 6

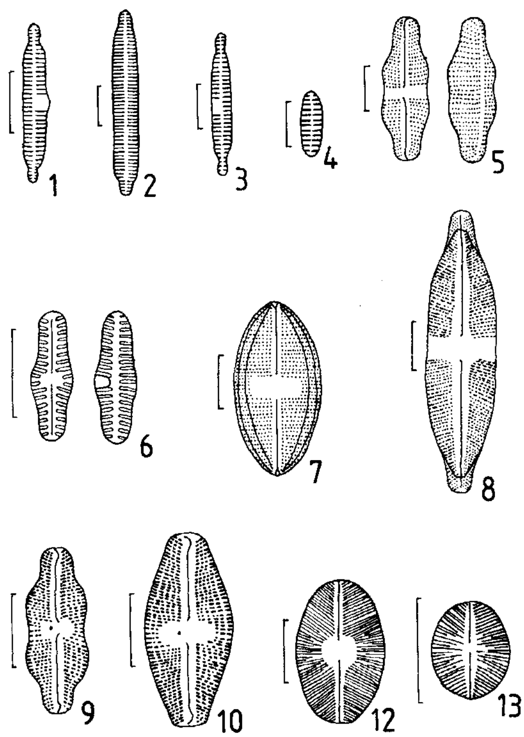

Fig. 3. 1. *Fragilaria vaucheriae* Boye Petersen, 2. *F. virescens* Ralfs, 3. *F. intermedia* Grun., 4. *F. pinnata* Ehr., 5. *Achnanthes coarctata* (Bréb.) Grun., 6. *A. fragilarioides* Boye Petersen, 7. *Neidium ladogense* (Cleve) Foged, 8. *Stauroneis javanica* (Grun.) Cleve var. *oblonga* Østrup, 9. *Navicula mutica* Kütz. var. *binodis* Hust., 10. *N. mutica* f. *rhomboidea* Plyfair, 12. *N. scutiformis* Grun., 13. *N. pseudoscutiformis* Hust.

species *(Cymbella helvetica* var. *genuina, C. minuta* var. *silesiaca, C. proxima, Navicula peregrina* var. *polaris, Pinnularia spitsbergensis, Stauroneis javanica* var. *oblonga)* he did not mention. Moreover, the list of species compiled by Foged contains more taxa from genera like *Eunotia* and *Gomphonema*, which are typical epiphytes.

Percentages of systematic groups in the diatom flora of the Hornsund fiord area are quite the same as those which Foged (1964) established in the Bellsund fiord area. Of the 198 taxa which he found there, 197 (99.5%) are from the Pennales. Likewise, Biraphidineae, with the genera *Navicula*, *Pinnularia* and *Cymbella* are prevalent (Table 2).

Kharitonov (1981), in his paper on the benthic diatoms of Wrangel Island, says that as one moves from the south northwards, Monoraphidineae diatoms are replaced by taxa from the other Pennales sub-orders. But he believes the reason for the disappearance of Monoraphidineae species is to be sought in their insufficient ecological fitness, that is to say in the high stenotopicity and inter-specific competition typical of the majority of these taxa. Hence the number of Monoraphidineae in the composition of the Arctic freshwater flora is negligible. According to Kharitonov, the ecologically strongest group among the Pennales are the Biraphidineae, the families *Naviculaceae* and *Cymbellaceae* in particular. He suggests that the small number of species from the other Biraphidineae families *(Amphiproraceae, Epithemiaceae, Nitzschiaceae* and *Surirellaceae)* in Arctic waters is due to their excessive specialisation. My own results and Foged's data (1964) confirm Kharitonov's hypothesis (1981) to a large extent.

Foged (1964) believes that the freshwater diatom flora of Spitsbergen is of postglacial origin. He also states that he does not know anything about immigrants in this flora, although he does not exclude the possibility that species may have migrated here from neighbouring territories like Fennoscandia, Greenland or Frans Josef Land. But such genera as *Tetracyclus*, *Amphicampa*, *Peronia* or *Stenopterobia*, characteristic of many localities in Fennoscandia, have not yet been discovered on Spitsbergen. Kharitonov (1981) considers that the families to which these genera belong are not vigorous enough ecologically. But he does include taxa from *Naviculaceae* and *Cymbellaceae* among these diatoms which currently

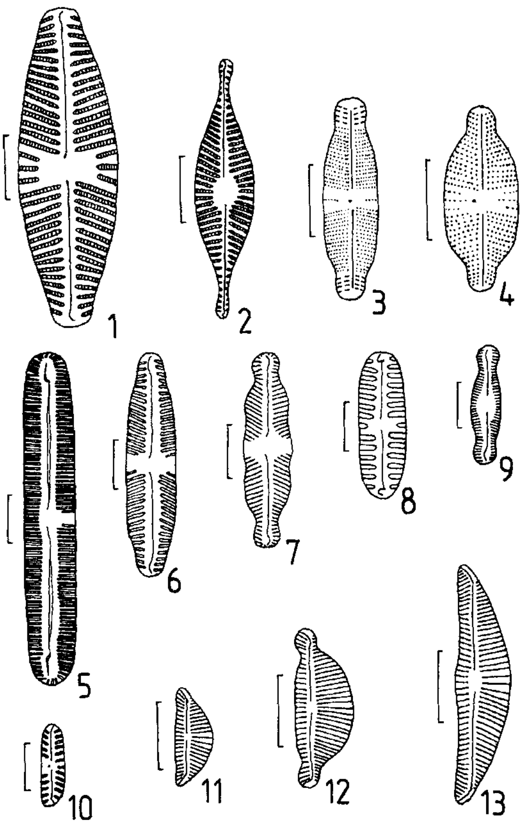

Fig. 4. 1. *Navicula peregrina* (Ehr.) Kütz. var. *polaris* Lagst., 2. *N. rhynchocephala* Kütz. f. *elegans* Cleve-Euler, 3. *N. paludosa* Hust., 4. *N. interglacialis* Hust., 5. *Pinnularia spitsbergensis* Cleve, 6. *P. microstauron* (Ehr.) Cleve, 7. *P. mesolepta* (Ehr.) W. Smith, 8. *P. borealis* Ehr., 9. *P. krockei* Grun., 10. *Cymbella sinuata* Greg. f. *ovata* Hust., 11. *C. minuta* Hilse ex Rabh. var. *minuta*, 12. *C. minuta* f. *latens* (Krasske) Reimer, 13. *C. minuta* var. *silesiaca* (Bleisch ex Rabh.) Reimer.

dominate fresh waters in the Arctic. Confirmation of this hypothesis could be the phytogeographical composition of the diatom flora in the Hornsund fiord area, which shows that the majority of arctic-alpine and nordic-alpine species are from *Naviculaceae* and *Cymbellaceae*. Moreover, the fact that some cosmopolitan species belonging to these two families, e.g. *Caloneis silicula, Cymbella minuta* var. *minuta*, *Diploneis ovalis*, *Neidium iridis* and *Stauroneis anceps*, occur over wide areas, is an additional argument in favour of the ecological fitness of the members of these two families.

The dominant group among the freshwater benthic diatom assemblages of various water body types in the Hornsund fiord area was formed by species with low trophic requirements, that is, strict oligosaprobes and oligo-meso- and mesosaprobes. They include taxa with the lowest possible saprobicity index (from 0.0 to 0.5) such as *Meridion circulare*, *Ceratoneis arcus*, *Cymbella gracilis*, *Achnanthes lanceolata* and *A. coarctata* (Kharitonov 1981). This confirms that the Arctic waters investigated are unpolluted.

The abundance of the benthic diatom flora in the area studied can be correlated with the pH values of sediments. Foged (1964) is of the opinion that the main factors affecting the abundance of the diatom flora of western Spitsbergen are chemical, the determining one being the pH of the environment. In the area that he studied, the pH of the water was generally 7 or oscillated about that value; this allowed a large number of taxa to flourish. The diatom assemblages pre-

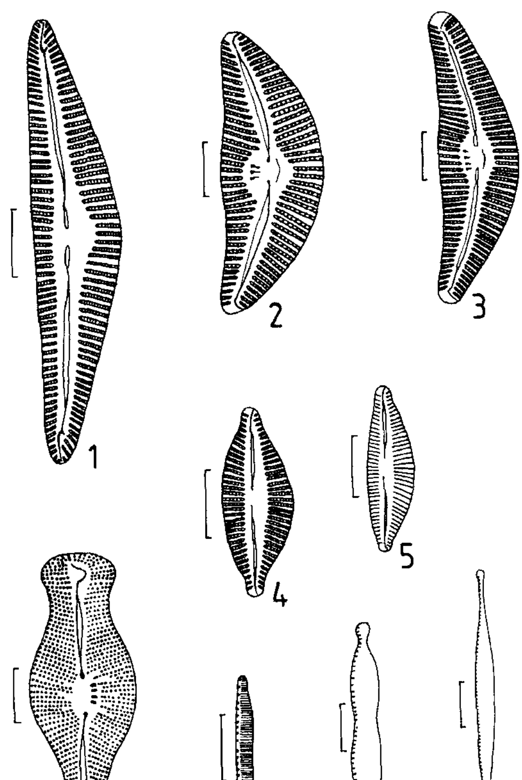

Fig. 5. 1. *Cymbella helvetica* Kütz. var. *genuina* Mayer, 2. *C. proxima* Reimer, 3. *C. cistula* (Hempr.) Grun., 4. *C. leptoceros* (Ehr.) Grun. var. *rostrata* Hust., 5. *C. laevis* Naegeli, 6. *Didymosphaenia geminata* (Lyngbye) W. Smith, 7. *Nitzschia frustulum* (Kütz.) Grun. var. *perpusilla* (Rabh.) Grun., 8. *N. thermalis* Kütz. var. *minor* Hilse, 9. *N. gracilis* Hantzsch.

sented in this paper consisted mainly of indifferent and alkaliphilous species, which would suggest that the pH at the localities analysed was also neutral or nearly so. This could explain the occurrence of a quite numerous diatom flora in the Hornsund fiord area.

The abundance of the benthic diatom flora in the bodies examined can be correlated to some extent with the sediment type. Sediments of sand only or of sand and some mud usually harbour more species than do muddy sediments. Comparison of the numbers of taxa from sandy and muddy sediments in three small lakes showed that the diatom flora in mud was less numerous. Muddy sediments from the lake in the Palffyodden area harboured a poor diatom flora as well. However, the paucity of the diatom flora at these localities cannot be explained by one factor only. Comparison of mud and sand in two small lakes showed that the percentage of strict oligosaprobes distinctly decreased. Simultaneously, the percentage of oligo-meso and oligo-eusaprobes increased. It is probable that in this case, the mud was characterized by higher trophicity which could eliminate many oligotrophic species. On the other hand, the diatom flora in the lake in the Palffyodden area consisted mainly of oligotrophic species. Moreover, compared to the diatom assemblages of the remaining localities, pH-indifferent and acidophilous species in this flora had the highest percentage values. In this case, the pH of the habitat, which was possibly lower than in the other localities, could affect the small number of taxa. Furthermore, mud is more compact than sand and this propriety could make it difficult for a diatom flora to develop in it to any great extent. On the other hand, the presence of detritus in both muddy and sandy sediments possibly allowed a more abundant flora to appear. This may be confirmed by a quite numerous flora in mud from the lake near Warenhus and by rich diatom assemblages in sandy sediments at some localities.

But apart from the sediment type, other factors had to affect the development of a more or less abundant flora in different water bodies in the area studied. Results presented in this paper showed that ephemeral small lakes, compared to permanent large lakes, formed habitats for a more numerous diatom flora. The same tendency was observed when one compared ephemeral streams and permanent streams and rivers.

Analysis of the species composition of the freshwater epipelic diatoms in the Hornsund fiord area showed that only a small number of taxa was present in all the water bodies examined, but many species occurred simultaneously in several different water body types. The presence of many species in both small and large lakes may confirm that the diatom flora of ephemeral lakes partly originates from the flora of permanent lakes. The great similarity in the species composition of ephemeral streams and lakes to which those streams were adjacent may be explained by mutual interactions between those water bodies. The same explanation could be applied to the diatom assemblages from a permanent stream and the Revelva river connected with Lake Revvatnet. However, exclusive groups of the diatom taxa in some of the water bodies, particularly in ephemeral lakes and streams, could be distinguished. In addition, almost every locality examined, i.e. each of the water body types, was characterized by a certain number of exclusive diatom species. Round (1973) draws attention to the fact that within the littoral sediments microhabitats may form which enable specific communities of algae to develop, even when the sediments are apparently homogeneous. A similar differentiation in the species composition was observed by Foged (1964) at four localities in the Bellsund fiord area. It is also possible that many of those exclusive species occurred accidentally.

Acknowledgement. – It is my pleasant duty to express my gratitude to Dr. Adam Latała from the Institute of Oceanography at the University of Gdańsk for collecting algal samples in the Hornsund fiord area.

References

Cholnoky, B. J. 1968: Die Ökologie der Diatomeen in Binnen-Gewässern. *Lehre J. Cramer*, 110–127.

Cleve, P. T. 1867: Diatomaceer från Spetsbergen. *Öfvers. Kongl. Vet. Akad. Förh. 10.*

Cleve-Euler, A. 1952: Die Diatomeen von Schweden und Finnland V. *Kungl. Sv. Vet. Akad. Handl. 3(3).* 153 pp.

Cleve-Euler, A. 1953a: Die Diatomeen von Schweden und Finnland. II. *Kungl. Sv. Vet. Akad. Handl. 4(1).* 153 pp.

Cleve-Euler, A. 1953b: Die Diatomeen von Schweden und Finnland III. *Kungl. Sv. Vet. Akad. Handl. 4(5).* 255 pp.

Cleve-Euler, A. 1955: Die Diatomeen von Schweden und Finnland. IV. *Kungl. Sv. Vet. Akad. Handl. 5(4).* 232 pp.

Foged, N. 1953: Diatoms from West Greenland. *Medd. Grønl. 147*, 10.

Foged, N. 1955: Diatoms from Peary Land, North Greenland. *Medd. Grønl. 128*, 7.

Foged, N. 1958: The Diatoms in the Basalt Area and Adjoining Areas of Archean Rock in West Greenland. *Medd. Grønl. 156*, 4.

Foged, N. 1964: Freshwater Diatoms from Spitsbergen. *Tromsø Museums Skrifter 11.* 205 pp.

Gerlach, D. 1972: Zarys mikrotechniki botanicznej. *PWRiL. W-wa*, 214–219.

Huber-Pestalozzi, G. 1942: Das Phytoplankton des Süsswassers. Diatomeen. Pp. 425–524 in Thienemann, A. (ed.): *Die Binnengewässer XVI (2/2).*

Hustedt, F. 1930a: Bacillariophyta (Diatomeae). In Pascher, A. (ed.): *Die Süsswasser-Flora Mitteleuropas.* G. Fischer, Jena. 466 pp.

Hustedt, F. 1930b: Die Kieselalgen Deutschlands, Österreichs und der Schweiz. In Rabenhorst, L. (ed.): *Kryptogamen-Flora VII (3).* 816 pp.

Hustedt, F. 1937: Süsswasserdiatomen von Island, Spitsbergen und den Färöer-Inseln. *Bot. Arch. 38.*

Kalbe, L. 1973: *Kieselalgen in Binnengewässern.* A. Ziemsen Verlag, Wittenberg Lutherstadt. 206 pp.

Kennett, D. M. & Hargraves, P. E. 1984: Subtidal Benthic Diatoms from a Stratified Estuarine Basin. *Bot. Mar. XXVII*, 169–183.

Kharitonov, V. G. 1981: Diatomovye vodorosli bentosa vodoemov o. Vrangela. Pp. 33–39 in *Novosti sistematiki nizschich rastenij.* Nauka, Leningrad.

Krasske, G. 1938: *Beiträge zur Kenntnis der Diatomeen-Vegetation von Island und Spitsbergen.* Arch. Hydrobiol., Stuttgart.

Lagerstedt, N. G. W. 1873: Sötwattens-Diatomaceer från Spetsbergen och Beeren Eiland. *Bih. Kongl. Sv. Vet. Akad. Handl. 1*, 14.

Lange-Bertalot, H. 1980a: New Species, Combinations and Synonyms in the Genus Nitzschia. *Bacillaria 3*, 41–77.

Lange-Bertalot, H. 1980b: Zur taxonomischen Revision einiger ökologisch wichtiger 'Naviculae lineolatae' Cleve. Die Formenkreise um *Navicula lanceolata, N. viridula, N. cari. Cryptogamie: Algologie 1(1)*, 29–50.

Lange-Bertalot, H. & Simonsen, R. 1978: A Taxonomic Revision of the Nitzschiae lanceolatae Grunow. 2. European and Related Extra-European Fresh Water and Brackish Water Taxa. *Bacillaria 1*, 1–111.

Lange-Bertalot, H. & Ruppel, M. 1980: Zur Revision taxonomisch problematischer, ökologisch jedoch wichtiger Sippen der Gattung Achnanthes Bory. *Arch. Hydrobiol. Suppl. 60*, 1–31.

Patrick, R. & Reimer, C. W. 1975: The diatoms of the United States 2. *Monographs of the Academy of Natural Sciences of Philadelphia 21.* 215 pp.

Round, F. E. 1973: *The Biology of the Algae.* E. Arnold, London.

Siemińska, J. 1964: Chrysophyta II. Bacillariophyceae, Okrzemki. Pp. 79–609 in *Flora Słodkowodna Polski.* PWN, W-wa.