DIATOMS IN A POSTGLACIAL CORE FROM THE BOTTOM OF THE LAKE GRANE LANGSØ, DENMARK

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FOGED, NIELS, Diatoms in a postglacial core from the bottom of the lake Grane Langsø. *Bull. geol. Soc. Denmark,* vol. 19, pp. 237–256, Copenhagen, December 17th, 1969.

In 10 samples from a depth of 50–430 cm. below the present bottom of the Jutlandic lake Grane Langsø 201 diatom forms are shown to occur. From the ecological spectra calculated it may be deduced that at the time when the sedimentation took place, the lake was rather poor in nutritious matter (oligotrophic to slightly eutrophic), with a rather varying pH, which was most alkaline when Samples 9 and 10 from the greatest depth settled, and most acid when Sample 7 settled in rather acid water.

As usual when the environment is rather poor in nutritious matter, the diatom flora is fairly poor in species. All forms shown are given in table 8 together with their relative frequency.

Some notable or so far rare species are discussed.

The making of preparations, microscopical analysis, and treatment of the results of analyses have taken place in the same way as described in my paper on the core from the lake Esrom Sø (Foged, 1968).

The material from Esrom Sø (Foged, 1968) and from Grane Langsø has kindly been left me for examination by Professor Dr Kaj Berg, the Freshwater Biological Laboratory of the University of Copenhagen, Hillerød, whom I offer my most cordial thanks.

The samples examined have in the presentation below been numbered 1–10 in accordance with their origin from the following depths (below the present bottom of the lake) in the core:

No. 1.	50 cm
– 2.	100 –
– 3.	150 –
– 4.	200 –
– 5.	255 –
– 6.	275 –
– 7.	315–316 –
– 8.	382 –
– 9.	420 –
– 10.	430 –

A total of 201 different forms of diatoms belonging to 164 species and 33 genera were found.

The flora mainly consists of freshwater diatoms; only one halophilous, one mesohalobous, and one polyhalobous form were found. Among these only the halophilous form *Nitzschia frustulum* var. *perpusilla* can be considered certainly autochthonous whereas the mesohalobous species *Rhopalodia musculus* perhaps is allochthonous (only a single valve found in one sample), and the polyhalobous *Diploneis coffaeiformis* of which, too, only one valve was found, can with certainty be considered adventive.

Thus the flora is poorer in species than the one shown to occur in the series from the bottom of Esrom Sø, and it appears from the following tables and diagrams that with regard to the composition of the flora there are conspicuous differences between the two places.

The possibilities of deducing something from halobion and pH spectra and diagrams are fairly restricted. They are shown in tables 1 and 2 and diagrams 1–4. In tables 3 and 4 halophobous and acidophilous diatoms, respectively, have been detached from the list of species in table 8. The halobion spectra, however, indicate a freshwater environment rather poor in electrolytes. Sample 7 differs most from the other samples, as the halophobous and acidophilous species *Melosira distans* amounts to 17.6 % of the valves counted in this sample. Furthermore, the species *Tabellaria*

Grane Langsø. Diagram 1.

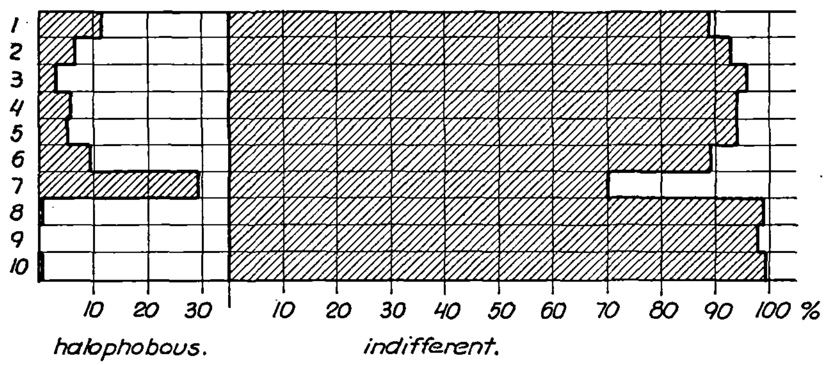


Diagram 2.

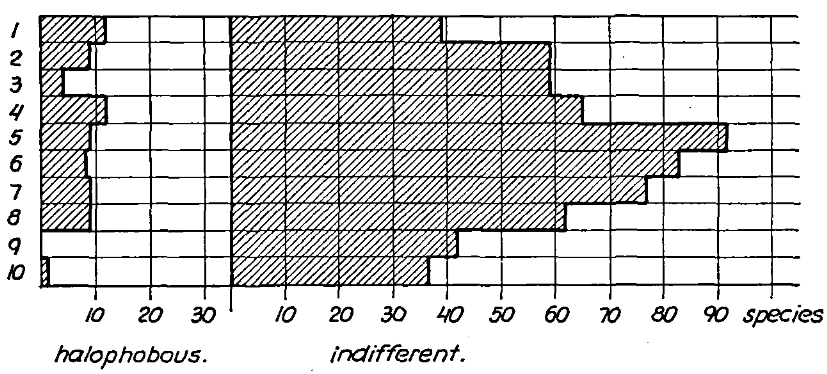


Table 1. Halobion spectra, Grane Langsø.

	Sample No:	1	2	3	4	5	6	7	8	9	10
halophobous	number of species..	12	9	4	12	9	8	9	9	1	2
	valves %.........	11.2	6.6	3.0	5.8	5.4	9.8	29.4	1.2	0.0	0.2
indifferent	number of species..	39	59	59	63	92	83	77	61	42	36
	valves %.........	88.8	93.2	96.2	94.2	94.6	89.4	69.8	98.8	97.8	98.4
halophilous	number of species..	0	1	2	1	0	1	1	0	0	0
	valves %.........	0.0	0.2	0.8	0.0	0.0	0.8	0.6	0.0	0.0	0.0
mesohalobous	number of species..	0	0	0	0	0	0	1	0	0	0
	valves %.........	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
polyhalobous	number of species..	0	1	0	0	0	0	0	0	1	0
	valves %.........	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
?	number of species..	0	0	0	0	0	0	0	0	1	1
	valves %.........	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.4
	number of species total.............	51	70	65	76	101	92	88	70	45	39

Table 2. pH-spectra

	Sample No:	1	2	3	4	5	6	7	8	9	10
acidophilous	number of species..	9	5	1	8	8	6	6	4	0	1
	valves %.........	8.8	1.6	0.8	2.0	4.6	8.2	29.4	0.6	0.0	0.2
indifferent	number of species..	24	27	32	32	41	41	37	34	17	10
	valves %.........	63.6	53.6	19.8	19.8	17.4	18.4	27.4	22.0	5.8	2.4
alkaliphilous	number of species..	17	37	31	35	50	44	43	31	22	22
	valves %.........	27.2	44.8	77.6	77.8	77.4	73.2	43.0	77.4	83.6	87.8
alkalibiontic	number of species..	1	1	0	0	2	0	1	0	4	4
	valves %.........	0.4	0.0	0.0	0.0	0.6	0.0	0.2	0.0	6.2	3.6
	number of species..	0	0	1	1	0	1	1	1	2	2
	valves %.........	0.0	0.0	1.8	0.4	0.0	0.2	0.0	0.0	4.4	6.0
	number of species total.............	51	70	65	76	101	92	88	70	45	39

Grane Langsø. Diagram 3.

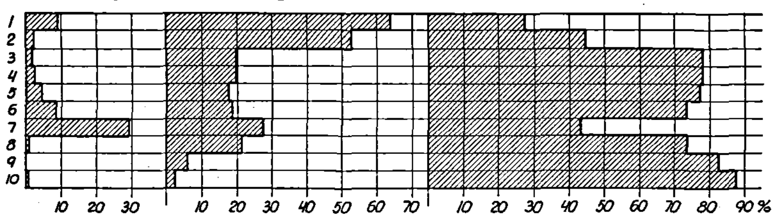
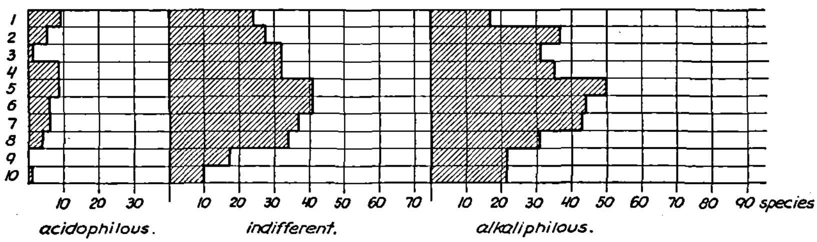


Diagram 4.



fenestrata and *T. flocculosa*, also halophobous and acidophilous, amount to 6.4 and 3.8 %, respectively, and hence together are more frequent in sample 7 than in the other samples. There can hardly be any doubt that during the depositing of sample 7 there was an environment in the lake basin which was rather poor in nutritious matter and which was slightly acid. During the depositing of sample 1 the tendency must have been in the same direction, although less pronounced.

A comparison between the spectra and diagrams of Grane Langsø and the corresponding ones from the bottom of Esrom Sø clearly shows that the two environments in question must have been rather different. In the samples from Esrom Sø the halophobous diatoms thus at a maximum amount to 1.4 % of all valves counted and belong to six species, whereas the samples from Grane Langsø have up to 29.4 % halophobous valves, and in two of the samples from this lake 12 different halophobous species were found.

In the pH spectra the differences stand out still more clearly, acidophilous species being extremely rare in the samples from Esrom Sø, whereas in the samples from Grane Langsø there are up to 9 different acidophilous species and up to 29.4 % acidophilous species counted in a single sample (no. 1 and no. 7, respectively).

In the samples from Esrom Sø no acidophilous species was found in four out of the seven samples, and only a single acidophilous valve was found in each of the three other samples.

The number of species of diatoms found also to some degree is characteristic of the various localities. Usually the number of species will

Table 3. Halophobus diatoms, Grane Langsø

	Valves % in sample no:									
	1	2	3	4	5	6	7	8	9	10
Amphipleura pellucida					0.2		0.2	+		
Cocconeis diminuta								+		
Cymbella hebridica		+								
Denticula tenuis var. crassula		+								
Eunotia gracilis				0.2						
– monodon var. bidens	0.4									
– parallela	0.4									
– robusta	0.4									
– tenella				0.2				0.2		
– veneris	2.0	1.0		0.2	0.2					
Fragilaria virescens	0.4	0.2				0.2	0.2			+
– – var. elliptica	0.8					0.4	0.2			
Frustulia rhomboides var. saxonica								+		
Melosira distans	0.4						17.6			
Navicula disjuncta (?)					0.4					
– vitabunda (?)							0.4			
– wittrockii		0.6	1.2	1.8	1.0	1.4	0.2	0.4	+	
Nitzschia hantzschiana (?)				+						
Pinnularia braunei var. amphicephala				1.0						
– divergens	1.6			+	0.2	0.2	0.4			
– – var. elliptica					+	+				
– hemiptera	1.6	0.4						+		
– legumen	0.4	0.2	0.2	0.2	+					
– nobilis	0.4	3.8	0.8	0.8				0.2		
– nodosa						+				
Tabellaria binalis				+				+		
– fenestrara	2.4	0.4	0.8	1.0	2.4	3.0	6.4	0.4		
– flocculosa				0.4	1.0	4.6	3.8			0.2
Valves % total	11.2	6.6	3.0	5.8	5.4	9.8	29.4	1.2	0.0	0.2
Number of species	12	9	4	12	9	8	9	9	1	2

be largest in localities with neutral, or slightly alkaline water rich in nutritious matter. In the samples from Esrom Sø a total of 242 different forms of diatoms were found, and in the sample richest in species (no. 6) 155 different forms were found. In the samples from Grane Langsø only 206 different forms of diatoms were found, and the sample richest in species (no. 5) contains 101 different forms only. This fact thus would also point the way indicated above.

Table 5 shows Centrales : Pennales figures and quotients. The highest quotient calculated on the basis and numbers of valves is 1.69 in sample 4, the flora of which thus would indicate a "moderate" eutrophic environment. Sample 5 has the percentage quotient 0.79, on the basis of which I should characterise the sample as having been deposited in a slightly eutrophic environment. All the other quotients are so small as undoubtedly to indicate a markedly oligotrophic environment.

The centric genera in table 6 point the same way. Thus in sample 4 *Melosira ambigua* and in sample 5 *Melosira granulata* var. *angustissima*

Table 4. Acidophilous diatoms, Grane Langsø

	Valves % in sample no:									
	1	2	3	4	5	6	7	8	9	10
Achnanthes lapponica					0.4	0.2				
Cymbella hebridica		+								
Eunotia monodon var. bidens	0.4									
– parallela	0.4									
– pectinalis var. minor	0.8	+		0.2	0.4	0.2	1.0			
– – – fo. impressa				+	+		0.2			
– robusta	0.4									
– tenella				0.2				0.2		
– veneris	2.0	1.0		0.2	0.2					
Frustulia rhomboides var. saxonica								+		
Melosira distans	0.4						17.6			
Navicula järnefeltii	0.4	0.2								
Pinnularia divergens	1.6			+	0.2	0.2	0.4			
– – var. elliptica					+	+				
Tabellaria binalis				+				+		
– fenestrata	2.4	0.4	0.8	1.0	2.4	3.0	6.4	0.4		
– flocculosa				0.4	1.0	4.6	3.8			0.2
Valves % total	8.8	1.6	0.8	2.0	4.6	8.2	29.4	0.6	0.0	0.2
Number of species	9	5	1	8	8	6	6	4	0	1

are dominants, and both point towards a moderately eutrophic environment, whereas *Melosira distans* which is the dominant form in sample 7, fairly clearly points towards an oligotrophic environment.

In Nygaard 1956 an attempt was made, by means of new methods of calculation on the basis of the diatomaceous flora, of giving a characterization of the pH environment in which the flora lived, for the purpose of estimating the pH of a locality in the past by a diatomaceous analysis of fossile and subfossile material. As to calculation of the three indices used reference is made to Nygaard (1956, pp. 55–57).

Table 5. Grane Langsø

	Centrales		Pennales		*Centrales* / Pennales	
Sample No.	number of species	valves %	number of species	valves %	species	valves %
1	7	8.8	46	91.6	0.15	0.09
2	5	3.8	65	96.2	0.08	0.04
3	7	22.2	58	77.8	0.12	0.29
4	7	62.8	69	37.2	0.10	1.69
5	8	44.4	93	55.6	0.09	0.79
6	8	8.0	84	92.0	0.09	0.09
7	7	24.4	81	75.6	0.08	0.32
8	10	4.6	60	95.4	0.02	0.01
9	5	0.4	40	99.6	0.12	0.00
10	6	0.4	33	99.6	0.18	0.00

Table 6. Grane Langsø

	Cyclotella		Melosira		Stephanodiscus	
Sample No.	number of species	valves %	number of species	valves %	number of species	valves %
1	1	0.8	2	7.2	2	0.4
2	2	0.4	2	3.4	1	+
3	3	0.2	2	22.0	2	+
4	2	6.6	3	56.2	2	+
5	3	+	3	44.4	2	+
6	2	+	5	8.0	1	+
7	1	0.2	4	23.2	2	1.0
8	6	4.0	2	0.6	2	+
9	3	0.2	2	0.2	0	0
10	3	+	1	0.2	2	0.2

$$(\text{Index } \alpha = \frac{\text{acid units}}{\text{alkaline units,}} \quad \text{index } \omega = \frac{\text{acid units}}{\text{number of acid species,}}$$

$$\text{index } \varepsilon = \frac{\text{alkaline units}}{\text{number of alkaline species)}} \quad .$$

In Meriläinen 1967 (pp. 51–58) Nygaards method has been applied to recent material from 14 Finnish lakes and ponds. The results obtained there, in the case of all the three indices are in fairly close agreement with the pH values measured.

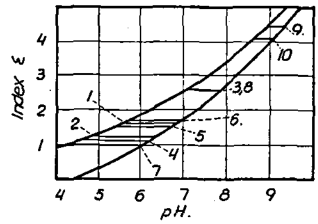
In table 7 the three indices are calculated for the ten bottom samples of Grane Langsø.

From the table it appears, by comparison with Meriläinen's diagram (1967, p. 57), that the α and ω indices calculated for Grane Langsø correspondingly give the information that pH during the depositing of sample 7 was < 7.0 (the α value according to Meriläinen's diagram indicates a pH of about 6.5 and Index ω indicates a pH of about 4.0), whereas indices for the other samples indicate pH values > 7.0 (or alkaline environment) without any possibility of a greater differentiation.

Table 7. Grane Langsø

Index Sample No:	α	ω	ε
1	0.30	0.98	1.62
2	0.003	0.32	1.21
3	0.01	0.80	2.50
4	0.003	0.17	1.12
5	0.05	0.57	1.55
6	0.11	1.37	1.66
7	0.67	4.90	1.00
8	0.008	0.15	2.50
9	0	0	4.41
10	0	0	4.07

Diagram 5.



In diagram 5, which corresponds to Meriläinen's index ε diagram, the index ε values for the samples 1–10 of Grane Langsø have been inserted.

This diagram shows rather a conspicuous differentation between the 10 samples. In accordance with this diagram Grane Langsø should have had most acid stage (pH between 4 and 6) during the depositing of sample 7, and the lake should have been most alkaline (pH about 9.0) during the depositing of samples 9 and 10.

It is not surprising that Nygaard's indices point the same way, for the material used in the two methods of calculation is the same. The decisive question is whether these indices more precisely and surely than the spectra used so far can indicate the pH value of a freshwater environment of the past. Only the application of a method to a future more comprehensive material can decide this.

In table 8 all the forms of diatoms shown to occur in the 10 samples are listed. 500 valves have been counted in each sample. The percentage figures are stated. If a species was found after the counting was finished, a + has been added. All the forms found enter in the calculation of spectra and are used at the making of the diagrams. The placing in the halobion and pH systems has also been indicated: halobion rate: halophobous 1, indifferent 2, halophilous 3, mesohalobous 4, polyhalobous 5. pH-rate: acidophilous 1, indifferent 2, alkaliphilous 3, alkalibiontic 4.

Among the more remarkable species the following should be mentioned:

Achnanthes recurvata Hust. (A. Schmidt's Atlas 409: 34–37).
Hustedt 1950, p. 434, figs 28–30.

A widely distributed, actually easily recognizable species, which, however, has rarely been found. In my own material I have found it in many recent samples from Sweden, Norway, Iceland, and Ireland. Furthermore, in interglacial kieselguhr in Denmark. It is very common on the Varanger peninsula in Northern Norway, where the findings suggest that the species has a tendency towards acidophily. In the present paper it has in accordance with Hustedt been considered indifferent as regards pH. It is not rare in samples 5, 6, and 7.

Cymbella thumensis (A. Mayer) Hust. (Hustedt 1945, p. 938; 42: 60–62).
Syn.: *Amphora coffeaeformis* Ag. var. *thumensis* A. Mayer 1919, p. 208; 9: 68, 69. *Cymbella parvula* Krasske 1933, p. 92, fig. 3.

This characteristic small *C.* species has so far been found in only a few places in North Germany, in the Balkans, and in Sweden. In my own material I have found a few specimens in Ireland and Iceland, and in interglacial kieselguhr from Hollerup in Denmark.

In the two deepest samples dealt with here, it is rather common.

The findings of a number of very small *Navicula* species which have so far been found very rarely, are also particularly remarkable. In this connection it should be noted that all these species have been checked in collaboration with Mr. Max Møller, head dispenser, Odense, to whom I am very much obliged for valuable assistance through many years.

Navicula absoluta Hust. (1950).
Hustedt 1950, p. 435; 38: 80–85. 1961, p. 225, fig. 1343.

Previously found only in North Germany (Hustedt 1950) and in Spitzbergen (Foged 1964). The species resembles *N. vitabunda, N. laterostrata,* and *N. disjuncta,* which all of them are also found in the present material. All the four species were found in typical specimens, which are relatively easily distinguished.

Found only in sample 9, where it is not rare (0.8 %).

Navicula acceptata Hust. (1950).
Hustedt 1950, p. 398; 38: 66, 67. 1961, p. 247, fig. 1372.

A small, rather characteristic species, which has previously been found as recent and fossil in North Germany (Hustedt, 1950, 1954) and in Denmark (fossil, Foged, 1960, 1962, and subfossil in a drill sample from Esrom Sø). In the present material it is rare in samples 5 and 8. It is possible to mistake this species for *N. seminulum* Grun. and *N. submuralis* Hust., none of which has been found here.

Navicula disjuncta Hust. (1930).
Hustedt 1930, p. 274, fig. 451, 1961, p. 143, figs 1275 a-e.
A. Schmidt's Atlas 370: 45. 399: 51–53.

A fairly rarely, but widely distributed species, which I have shown to occur in material from Denmark (recent and fossil), Sweden, Norway, Greenland, and Afghanistan.

In this material fairly rare in sample 5 (0.4 %).

Navicula minusculoides Hust. (1942).
Hustedt 1942, p. 68, fig. 5. 1961, p. 255, fig. 1382.

So far only found in North Germany, and very rare (Hustedt, 1942). Differs clearly from the two somewhat similar species *N. minuscula* Grun. and *N. molestiformis* Hust.

In the present material found, but fairly rarely, in nos 2, 5, 6, and 7.

Navicula opportuna Hust. (1950).
Hustedt 1950, p. 436; 39: 21, 22.

Previously only found in North Germany, and very rare (Hustedt 1950), and in Denmark (fossil, Foged, 1962), in Norway (Foged, 1960), and in Greenland (Foged, 1958).

In the present material very rare, only found in sample 8.

Navicula paanaensis A. Cleve-Euler (1939).
A. Cleve-Euler 1939, p. 16, fig. 31.
Hustedt 1961, p. 274, fig. 1404.
Syn.: *N. obtusangula* Hust. in A. Schmidt's Atlas (1936), 403: 54, 55.

A fairly characteristic species, which has so far been described only from Finland (A. Cleve-Euler, 1939, Hustedt, 1936).

In the present material the species is fairly common in sample 9 (2.0 %), and rare in Sample 6.

Navicula tackei Hust. (1942).
Hustedt 1942, p. 194, figs 6, 7. 1961, p. 277, fig. 1467.

So far only found in two highly polluted localities in North Germany (Hustedt, 1942) and in nest material from a gray heron locality in North Funen, Denmark (Foged, 1951).

The species is rather common in sample 8.

Navicula utermöhlii Hust. (1936).
A. Schmidt's Atlas (1936), 404: 31, 32.
Hustedt 1961, p. 272, fig. 1401.

Previously found in alkaline localities in North Germany (Hustedt, 1936) and in Yugoslavia (Hustedt, 1945).

In the present material found only in sample 8, where the species is even very common.

A few valves not determined so far perhaps belong to species which have not formerly been described.

Dansk sammendrag

I 10 prøver fra ÷ 50 cm til ÷ 430 cm under nuværende bund i Grane Langsø i Jylland er påvist 206 forskellige diatoméarter. Af de beregnede økologiske spektre fremgår at søen under afsætningen af de 10 prøver har været ret næringsfattig (oligotrof eller svagt eutrof), og at pH har været ret variabel. Mest alkalisk har søen været under afsætningen af de nederste prøver (nr. 9 og nr. 10), og mest sur under afsætning af prøve nr. 7. Også den øverste prøve (nr. 1) synes at være afsat i ret surt milieu. Diatoméfloraen er som sædvanlig i ret næringsfattigt milieu temmelig artsfattig. Alle de fundne arter er anførte i tabel 8, hvori den enkelte arts halobie- og pH-relation samt relative hyppighed i de 10 prøver er angivet. Nogle bemærkelsesværdige eller hidtil sjældent fundne arter er omtalte.

Aarestrupsvej 20,
5000 Odense
April 11th, 1969

Table 8. Postglacial diatoms from Grane Langsø

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
Achnanthes												
clevei Grun.	2	3	.	.	.	.	+	.	.	.	3.2	1.8
exigua Grun.	2	3	.	0.8	0.2	0.8	+	+	+	.	0.4	0.4
flexella (Kütz.) Brun. var *alpestris* Brun	2	3	.	.	.	.	.	0.4	.	.	.	.
lanceolata (Bréb.) Grun.	2	3	.	.	.	.	0.2	.	0.2	.	.	.
– var *elliptica* Cleve	2	3	0 4	6.6	4.6	3.0	2.0	1.2	4.0	2.2	13.4	11.4
– var. *rostrata* (Østrup) Hust.	2	3	.	.	.	.	0.2	.	0.2	.	.	.
lapponica Hust.	2	1	.	.	.	.	0.4	0.2	.	.	.	.
laterostrata Hust.	2	2	.	.	.	.	0.6	+	0.2	.	.	.
linearis (W. Smith) Grun.	2	2	.	.	.	.	.	0.2	.	.	.	.
minutissima Kütz.	2	2	.	.	.	.	+	2.0	0.8	.	.	.
– var. *cryptocephala* Grun.	2	2	.	+	.	.	+	0.6	.	.	.	.
peragallii Bruun	2	2	.	.	.	.	0.2	.	.	.	.	.
recurvata Hust.	2	2	.	.	.	.	0.4	0.8	0.4	.	.	.
suchlandtii Hust.	2	2	.	.	.	.	.	.	0.2	.	.	.
østrupii (A. Cleve) Hust.	2	2	.	.	.	.	2.4	2.0	0.8	.	.	.
Amphipleura												
pellucida Kütz.	1	3	.	.	.	.	0.2	.	0.2	+	.	.
Amphora												
ovalis Kütz.	2	3	.	.	0.2	.	+	+	.	+	.	.
– var. *libyca* (Ehr.) Cleve	2	3	0.4	7.8	1.8	3.0	1.6	2.2	3.4	0.6	0.2	0.2
– var. *pediculus* Kütz.	2	3	0.4	0.2	.	.	.	0.2	0.2	+	13.4	12.8
sp.	?	?	.	.	.	.	.	.	.	.	2.2	1.4
Anemoeoneis												
exilis (Kütz.) Cleve	2	2	.	.	.	0.4	.	.	.	.	.	.
Asterionella												
formosa Hassall	2	3	.	.	.	.	+	1.2	1.2	.	.	.
Caloneis												
bacillum (Grun.) Mereschk.	2	3	0,4	.	.	.	.	.	.	+	.	.

Table 8 (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
schummaniana (Grun.) Cleve var. *biconstricta*												
Grun.	2	3	.	.	.	.	.	.	+	.	.	.
silicula (Ehr.) Cleve	2	3	.	1.0	0.4	0.2	0.4	0.2	0.2	0.2	.	.
– var. *alpina* Cleve	2	3	.	.	.	0.2	0.6	+	0.4	.	.	.
– var. *truncatula* Grun.	2	3	.	0.2	.	+	.	.	.	.	.	.
Cocconeis												
diminuta Pant.	1	3	.	.	.	.	.	.	.	+	.	.
placentula Ehr.	2	3	2.0	1.2	+	.	.	.	.	.	.	0.2
– var. *lineata* (Ehr.) Cleve	2	3	9.6	3.4	0.2	.	.	0.2	.	+	+	.
Cyclotella												
comensis Grun.	2	2	.	.	.	.	+	.	.	+	.	+
comta (Ehr.) Kütz.	2	2	0.8	.	0.2	6.6	+	+	0.2	0.6	0.2	+
kützingiana Thwaites	2	2	.	.	.	+	.	.	.	+	.	+
– var. *parva* Fricke	2	2	.	.	.	.	+	.	.	2.6	+	.
– var. *planetophora* Fricke	2	2	.	.	.	.	.	.	.	0.4	+	.
– var. *schumanni* Grun.	2	2	.	.	+	.	.	.	.	.	.	.
meneghiniana Kütz.	3	3	.	.	0.2	.	.	.	.	.	.	.
ocellata Pant.	2	2	.	0.4	.	.	.	.	.	0.4	.	.
pseudostelligera Hust.	2	2	.	.	.	.	.	+	.	.	.	.
Cymatopleura												
solea (Bréb.) W. Smith	2	3	.	.	+	.	.	.	.	.	.	.
Cymbella												
affinis Kütz.	2	3	.	2.0	0.2	2.0	0.2	0.8	1.0	+	.	.
cistula (Hempr.) Grun.	2	2	.	.	+	0.2	.	.	.	.	.	.
ehrenbergii Kütz.	2	3	.	.	.	.	.	.	.	.	0.2	.
gracilis (Ralfs) Cleve	2	2	.	0.2	0.2	+	0.6	0.8	0.8	0.2	+	.
hebridica (Greg.) Grun.	1	1	.	+	.	.	.	.	.	.	.	.
helvetica Kütz.	2	3	.	.	.	0.2	.	.	.	+	.	0.2
microcephala Grun.	2	3	.	.	.	.	0.2	1.0	0.2	.	.	.

Table 8. (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
naviculiformis Auerswald	2	2	2.4	+	0.4	+	+	0.2	0.2	+	.	.
obtusa Greg.	2	2	.	.	.	.	0.2	.	.	.	.	.
reinhardtii Grun.	2	2	.	.	.	.	.	+	0.4	6.8	1.0	.
sinuata Greg.	2	2	.	.	+	+	+	+	.	0.2	0.8	.
thumensis (A. Mayer) Hust.	2	2	.	.	.	.	.	.	.	.	1.2	1.0
turgida (Greg.) Cleve	2	3	.	3.8	0.8	0.8	1.0	0.4	0.4	.	.	.
ventricosa Kütz.	2	2	.	2.4	0.2	0.6	+	0.2	0.6	.	0.6	0.2
Denticula												
tenuis Kütz. var *crassula* (Naeg.) Hust.	1	4	.	+	.	.	.	.	.	.	.	.
Diploneis												
coffaeiformis (A. S.) Cleve	5	3	.	+	.	.	.	.	.	.	.	.
oculata (Bréb.) Cleve	2	2	.	.	.	.	.	.	+	.	.	.
ovalis (Hilse) Cleve	2	3	.	.	.	+	.	.	.	.	.	.
Epithemia												
zebra (Ehr.) Kütz.	2	3	.	0.2	.	.	+	.	0.2	.	.	0.2
– var. *porcellus* (Kütz.) Grun.	2	3	.	.	.	+	0.2	.	.	.	.	.
– var. *saxonica* (Kütz.) Grun.	2	3	.	.	.	0.6	+	+	0.2	+	.	.
Eunotia												
arcus Ehr.	2	2	.	.	+	+	+	+	.	.	.	.
formica Ehr.	2	2	.	+	.	.	.	.	.	.	.	.
gracilis (Ehr.) Rabh.	1	2	.	.	.	0.2	.	.	.	.	.	.
lunaris (Ehr.) Grun.	2	2	.	.	.	+	.	+	0.4	.	.	.
– var. *subarcuata* (Naeg.) Grun.	2	2	.	+	.	+	0.2	+	+	.	.	.
monodon Ehr. var. *bidens* (Greg.) W. Smith.	1	1	0.4	.	.	.	.	.	.	.	.	.
parallela Ehr.	1	1	0.4	.	.	.	.	.	.	.	.	.
pectinalis (Kütz.) Rabh. var. *minor* (Kütz.) Rabh.	2	1	0.8	+	.	0.2	0.4	0.2	1.0	.	.	.
– – fo. *impressa* (Ehr.) Hust.	2	1	.	.	.	+	+	.	0.2	.	.	.
robusta Ralfs	1	1	0.4	.	.	.	.	.	.	.	.	.

Table 8. (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
tenella (Grun.) Hust.	1	1	.	.	.	0.2	.	.	.	0.2	.	.
veneris (Kütz.) O. Müller	1	1	2.0	1.0	.	0.2	0.2	.	.	.	.	.
Fragilaria												
bicapitata A. Mayer	2	2	.	.	.	.	0.2	.	.	.	.	.
brevistriata Grun.	2	3	.	1.6	0.8	0.6	0.4	+	0.4	.	0.4	.
capucina Desmaz.	2	3	.	.	.	.	1.8	.	.	.	.	.
construens (Ehr.) Grun.	2	3	.	0.6	29.4	1.4	2.0	2.0	4.4	39.2	4.6	4.0
– var. *binodis* (Ehr.) Grun.	2	3	.	.	+	0.6	.	.	.	1.6	1.8	.
– var. *subsalina* Hust.	2	3	0.8	.	.	0.8	+	0.8	0.6	0.6	0.2	1.2
– var. *venter* (Ehr.) Grun.	2	3	.	0.2	.	.	.	0.2	3.4	3.2	.	0.2
crotonensis Kitton	2	3	.	.	.	.	6.0	38.0	.	.	.	.
inflata (Heid.) Hust. var. *istvanfyffi* (Pant.) Hust.	2	3	.	.	.	.	+	.	.	.	.	.
intermedia Grun.	2	3	.	.	.	.	0.6	.	.	.	.	.
lapponica Grun.	2	?	.	.	1.8	0.4	.	0.2	+	.	7.2	4.6
pinnata Ehr.	2	3	0.8	.	10.6	.	0.8	3.4	3.4	4.2	44.0	51.8
virescens Ralfs	1	2	0.4	0.2	.	.	.	0.2	0.2	.	.	+
– var. *elliptica* Hust.	1	2	0.8	.	.	.	.	0.4	0.2	.	.	.
Frustulia												
rhomboidea (Ehr.) De Toni var. *saxonica* (Rabh.) De Toni	1	1	.	.	.	.	.	.	.	+	.	.
Gomphonema												
acuminatum Ehr.	2	3	0.4	1.4	+	1.0	0.8	0.2	2.0	.	+	.
– var. *brébissonii* (Kütz.) Cleve	2	3	1.6	0.8	.	+	0.2	+	+	.	.	.
– var. *trigonocephala* (Ehr.) Grun.	2	3	.	+	.	.	+	+	+	.	.	.
angustatum (Kütz.) Rabh.	2	3	.	.	.	.	.	0.2	.	.	.	.
– var. *producta* Grun.	2	3	.	.	.	+	.	.	.	.	.	.
constrictum Ehr.	2	3	0.8	2.4	0.2	0.2	0.2	+	0.4	.	.	.
– var. *capitata* (Ehr.) Cleve	2	3	.	0.4	.	.	.	.	.	.	.	.
gracile Ehr.	2	3	0.8	.	.	.	0.2	0.4	0.2	.	.	.

Table 8. (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
intricatum Kütz. var. *pumila* Grun.	2	3	.	.	.	.	.	0.2	0.2	.	.	.
longiceps Ehr. var. *subclavata* Grun. fo. *gracilis* Hust.	2	3	.	.	.	.	0.2	.	.	.	.	.
olivaceum (Lyngbye) Kütz.	2	3	.	.	+	.	.	.	.	.	.	.
parvulum Kütz.	2	2	0.4	.	.	.	0.6	0.6	0.2	+	.	.
Gyrosigma												
attenuatum (Kütz.) Rabh.	2	4	.	.	.	.	.	.	.	.	0.4	.
Mastogloia												
sp.	?	?	.	.	.	.	.	.	.	.	+	.
Melosira												
ambigua (Grun.) O. Müller	2	3	6.8	3.4	19.0	56.2	.	.	.	0.4	.	.
arenaria Moore	2	3	.	.	.	+	+	+	.	.	.	.
distans (Ehr.) Kütz.	1	1	0.4	.	.	.	.	.	17.6	.	.	.
granulata (Ehr.) Ralfs	2	3	.	+	3.0	+	.	0.4	0.4	0.2	0.2	0.2
– var. *angustissima* Müller	2	3	.	.	.	.	38.2	6.4	1.4	.	.	.
italica (Ehr.) Kütz. subsp. *subarctica* O. Müller	2	3	.	.	.	.	14.2	1.2	3.8	.	.	.
roeseana Rabh.	2	3	.	.	.	.	.	+	.	.	.	.
Meridion												
circulare Agardh	2	3	0.4	.	.	.	.	.	.	.	.	.
– var. *constricta* (Ralfs) Van Heurck	2	3	.	.	.	.	.	.	0.2	.	.	.
Navicula												
absoluta Hust.	2	3	.	.	.	.	.	.	.	.	0.8	.
acceptata Hust.	2	3(?)	.	.	.	.	+	.	.	+	.	.
bacillum Ehr.	2	2	.	.	+	.	0.4	+	1.8	0.6	.	.
cari Ehr. var. *angusta* Grun.	2	3	0.8	.	.	.	.	.	.	.	.	.
cryptocephala Kütz.	2	3	.	.	.	.	+	1.4	0.8	.	.	.
– var. *intermedia* Grun.	2	3	.	.	.	.	.	.	+	0.2	.	+
cuspidata Kütz.	2	3	.	.	0.4	.	.	.	.	0.2	+	0.2

Table 8 (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
dicephala (Ehr.) W. Smith	2	3	.	+	.	.	.	.	.	.	.	.
disjuncta Hust.	1(?)	4	.	.	.	.	0.4	.	.	.	.	.
explanata Hust.	2	2(?)	.	.	.	+	0.4	0.2	+	0.4	.	.
gastrum Ehr.	2	2	.	.	.	.	.	.	.	.	+	.
graciloides A. Mayer	2	4	.	.	.	.	.	.	.	.	0.8	0.6
hustedtii Krasske	2	3	.	.	.	.	.	+	.	.	.	.
– var. *obtusa* Hust.	2	3	.	0.2	1.0	1.8	1.8	1.6	1.0	0.4	.	0.2
järnefeldtii Hust.	2	1	0.4	0.2	.	.	.	.	.	.	.	.
laterostrata Hust.	2	2(?)	.	.	1.2	.	.	.	1.0	+	.	0.6
minusculoides Hust.	2	3(?)	.	0.4	.	.	0.2	0.4	0.4	.	.	.
opportuna Hust.	2	?	.	.	.	.	.	.	.	+	.	.
paanaensis A. Cleve-Euler	2	2(?)	.	.	.	.	.	+	.	.	2.0	.
perventralis Hust.	2	3	.	.	.	.	.	.	.	4.4	.	.
placentula (Ehr.) Grun. fo. *rostrata* A. Mayer	2	3	.	.	.	.	.	.	.	.	+	0.2
pseudoscutiformis Hust.	2	2	.	1.2	1.0	0.2	0.8	0.6	2.4	1.4	+	0.2
pupula Kütz.	2	2	1.2	0.2	0.4	+	0.2	0.4	1.4	0.6	+	0.2
– var. *capitata* Hust.	2	2	.	0.4	1.6	.	.	0.2	0.4	0.2	.	.
– var. *rectangularis* (Greg.) Grun.	2	2	.	0.2	+	.	.	.	.	.	.	.
radiosa Kütz.	2	2	7.2	24.6	8.0	6.6	6.4	5.8	10.0	1.6	+	0.2
rotunda Hust.	2	3	.	.	.	.	.	.	.	9.0	.	.
schönfeldii Hust.	2	3	.	+	0.4	+	.	+	+	0.2	0.2	1.8
scutelloides W. Smith	2	4	.	.	.	.	.	.	0.2	.	0.8	0.2
subrotundata Hust.	2	3	.	2.8	1.8	1.8	1.4	5.6	6.0	.	0.6	0.2
tackei Hust.	2	2(?)	.	.	.	.	.	.	.	2.8	.	.
tantula Hust.	2	2	.	.	.	.	1.0	0.2	0.4	.	.	.
tuscula (Ehr.) Grun. fo. *minor*	2	4	.	.	.	.	0.2	.	.	.	4.2	2.6
utermöhlii Hust.	2	3	.	.	.	.	.	.	.	10.2	.	.
variostriata Krasske	1	2	.	.	.	.	.	.	.	.	.	+
viridula Kütz.	2	3	.	.	.	.	+	.	.	.	.	.
vitabunda Hust.	1	3	.	.	.	.	.	.	0.4	.	.	.
wittrockii (Lagst.) A. Cleve-Euler	1	3	.	0.6	1.2	1.8	1.0	1.4	0.2	0.4	+	.

Table 8 (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
Neidium												
affine (Ehr.) Cleve var. *amphirhynchus* (Ehr.)												
Cleve	2	3	.	0.2	.	+	+	.	.	0.2	.	.
bisulcatum (Lagerst.) Cleve	2	2	.	0.2	.	.	+	.	.	.	.	.
iridis (Ehr.) Cleve	2	2	1.2	1.0	0.2	0.4	0.2	0.2	0.2	0.2	+	.
– fo. *vernalis* Reichelt	2	2	.	0.2	+	0.2	+	+	.	.	.	.
– var. *amphighomphus* (Ehr.) Van Heurck	2	2	.	0.2	0.4	+	.	0.2	.	.	.	.
Nitzschia												
angustata (W. Smith) Grun. var. *acuta* Grun.	2	3	.	.	.	0.4	.	+	.	.	.	.
acula Hantzsch	2	3	.	.	.	.	+	.	.	.	.	.
fonticola Grun.	2	4	.	.	.	.	.	.	.	.	.	0.2
frustulum Kütz. var. *perpusilla* (Rabh.) Grun.	3	3	.	0.2	0.6	+	.	0.8	0.6	.	.	.
hantzschiana Rabh.	1(?)	3	.	.	.	+	.	.	.	.	.	.
recta Hantzsch	2	3	.	.	.	.	.	.	.	+	.	.
Opephora												
martyi Hérib.	2	3	.	1.8	0.4	0.4	0.4	0.2	0.6	.	.	+
Pinnularia												
borealis Ehr.	2	2	0.4	.	.	.	.	.	.	.	.	.
braunii (Grun.) Cleve var. *amphicephala*												
(A. Mayer) Hust.	1(?)	2	.	.	.	1.0	.	.	.	.	.	.
dactylus Ehr.	2	2	1.6	.	0.4	0.2	+	.	.	.	.	.
divergens W. Smith	1	1	1.6	.	.	+	0.2	0.2	0.4	.	.	.
– var. *elliptica* Grun.	1	1	.	.	.	.	+	+	.	.	.	.
gentilis (Donk.) Cleve	2	2	.	.	0.2	.	.	.	.	.	.	.
gibba Ehr.	2	2	8.0	0.4	1.0	0.4	.	+	.	+	.	.
– var. *linearis* Hust.	2	2	19.6	1.2	0.2	+	0.4	0.2	+	0.4	.	.
– var. *parva* (Ehr.) Grun.	2	2	0.4	.	.	+	.	0.2	0.8	.	.	.
hemiptera (Kütz.) Cleve	1	2	1.6	0.4	.	.	.	.	.	+	.	.
interrupta W. Smith	2	2	0.4	.	.	0.4	0.4	0.2	0.4	0.2	.	.
– fo. *minutissima* Hust.	2	2	3.2	.	.	.	.	.	.	0.4	.	.

Table 8 (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
legumen Ehr.	1	2	0.4	0.2	0.2	0.2	+	.	.	.	.	.
maior Kütz.	2	2	.	.	.	.	0.2	.	.	.	.	+
mesolepta (Ehr.) W. Smith	2	2	.	.	.	0.4	0.6	+	0.4	+	.	.
microstauron (Ehr.) Cleve	2	2	.	.	.	.	.	+	.	.	.	.
– var. *brébissonii* (Kütz.) Hust.	2	2	.	.	.	.	.	.	0.2	.	.	.
nobilis Ehr.	1	2	0.4	3.8	0.8	0.8	.	.	.	0.2	.	.
nodosa Ehr.	1	2	.	.	.	.	.	+	.	.	.	.
subsolaris (Grun.) Cleve	2	2	.	.	+	.	.	.	+	+	.	.
viridis (Nitzsch.) Ehr.	2	2	6.4	9.0	1.6	+	0.2	0.2	+	0.6	+	.
Rhopalodia												
gibba (Ehr.) O. Müller	2	4	0.4	.	.	.	.	.	.	.	.	.
musculus (Kütz.) O. Müller	4	2	.	.	.	.	.	.	0.2	.	.	.
Stauroneis												
anceps Ehr.	2	2	2.4	0.4	0.4	.	.	.	.	.	.	.
– var. *gracilis* (Ehr.) Cleve	2	2	0.8	.	.	+	+	0.8	+	0.4	.	.
– var. *hyalina* Brun & Perag.	2	2	.	.	.	.	+	.	.	.	.	.
– var. *sibirica* Grun.	2	2	0.8	1.6	0.4	0.6	0.4	0.8	0.4	+	+	.
kriegeri Patrick	2	2	.	.	.	.	0.2	.	1.0	.	.	.
phoenicenteron (Nitzsch) Ehr.	2	2	2.0	4.8	0.6	0.4	0.2	0.2	+	0.6	+	.
Stephanodiscus												
astraea (Ehr.) Grun.	2	3	.	+	+	+	+	+	0.8	+	.	+
– var. *minutula* (Kütz.) Grun.	2	3	0.4	.	+	+	+	.	0.2	+	.	0.2
Surirella												
angusta Kütz.	2	3	.	0.2	.	.	.	.	.	.	.	.
linearis W. Smith var. *constricta* (Ehr.) Grun.	2	2	.	.	+	.	+	.	.	.	.	.
robusta Ehr.	2	2	.	0.4	0.2	.	+	.	.	.	.	.
tenera Greg.	2	3	.	0.2	.	.	.	.	.	.	.	.
– var. *nervosa* Mayer	2	3	.	0.4	0.2	.	0.2	.	.	.	.	.

Table 8 (contd.)

	Hal.	pH	1	2	3	4	5	6	7	8	9	10
Synedra												
parasitica W. Smith var. *subconstricta* Grun.	2	3	.	+	+	.	+	0.4	.	.	.	.
ulna (Nitzsch.) Ehr.	2	3	0.4	+	.	+	+	.	.	.	+	.
vaucheriae Kütz.	2	3	.	.	.	+	+	.	.	.	.	.
Tabellaria												
binalis (Ehr.) Grun.	1	1				+				+		
fenestrata (Lyågbye) Kütz.	1	1	2.4	0.4	0,8	1.0	2.4	3.0	6.4	0.4		
flocculosa (Roth) Kütz.	1	1				0.4	1.0	4.6	3.8			0.2

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