Polar Biol (1986) 6:197–205

Polar Biology

Testate Amoebae Communities from Aquatic Habitats in the Arctic

L. Beyens[1], **D. Chardez**[2] and **R. De Landtsheer**[1], with collaboration of **D. De Baere**[3]

[1] Department of Botany, RUCA, Groenenborgerlaan 171, B-2020 Antwerp, Belgium
[2] Laboratoire de Zoologie Générale et Faunistique, Faculté des Sciences Agronomiques de l'Etat, B-5800 Gembloux, Belgium
[3] Department of Biology, UIA, Universiteitsplein 1, B-2610 Wilrijk, Belgium

Received 3 March 1986; accepted 1 May 1986

Summary. Forty taxa of testate amoebae were found in 15 aquatic samples collected in East Greenland (Angmagssalik Region), Jan Mayen and N.W. Spitsbergen. The number of species per sample is rather small, and the contribution of strictly aquatic species to the fauna is limited. A geographical shift in the importance of some genera can be demonstrated. *Centropyxis aerophila* and *Paraquadrula irregularis* are two of the most frequent species. The first-named is characteristic for acid-oligotrophic waters, while the latter belongs to an alkaline-mesotrophic community. A third community is named after the commonest species, *Trinema lineare*. It seems to prefer a somewhat intermediate type of water.

Introduction

In a previous paper, the present authors have treated the testate amoebae communities from some moss- and lichen habitats from different parts of the Arctic (Beyens et al. 1986). It was demonstrated that environmental parameters such as pH, humidity of the substratum, and the degree of continentality were determining factors for the structure of these communities. In the present paper data are presented based on the aquatic samples from the same localities, i.e. the East coast of Greenland (Angmagssalik region), the Island Jan Mayen and the Northwest coast of Spitsbergen.

Only five publications are known to us, dealing with the testate amoebae from aquatic habitats in the Arctic (geographically delineated according to V. Alexandrova 1980). Levander (1901) made a survey of the coastal region near Murmansk, at the southern limit of the low-arctic tundra (or sub-arctic sensu Alexandrova). He mentioned the presence of 21 different taxa, and already noticed an unspecified "negative" arctic influence on the testate amoebae fauna.

In 1907 Awerinzew published two papers on this subject: one with faunistic data from Vaygach Island, east of the Murmansk region, the other dealing with the freshwater protozoa of Bear Island. According to him, the specific climatic properties of Bjørnøya do not affect the organisation of the rhizopods.

Half a century elapsed before the next paper appeared: the study of Decloître (1956) made of a locality on the West coast of Greenland. He points out that most species are common, cosmopolitan ones with a rather large ecological amplitude. The most recent work appeared in 1966 dealing with samples from the Northwest coast of Spitsbergen. Schönborn stated in this article that the testate amoebae from sediments in small ponds belong to the *Arcella hemisphaerica*-association. According this author, the melt-water pools probably played an important role in the genesis of the spineless aerophytic *Centropyxis* species. These organisms, colonizing such melt-water pools which only have a semi permanent character, had also to be adapted to a terrestrial way of life.

Material and Methods

The list of samples is shown in Table 1. Measured conductivity and hydrogen-ion values appear in Fig. 6. The locations of the sampling sites are indicated in Figs. 1–3.

Hydrogen-ion concentration was measured with the Lab-Center portable pH-meter L101, fitted with the combined electrode A213. To determine the conductivity, a WTW LF56 meter, with a LTA 100/k electrode was used.

Plankton samples were obtained by filtering a (variable) amount of water through a net with meshes of 25 µm width. Scraping the bottom with a PVC-bottle yielded the sapropelium. Fixation of the material was carried out using 3% formalin solution. After centrifugation, microscopic analysis was performed with a reverse microscope.

To investigate the relationships among the species and samples we applied a principal component analysis in which the original data matrix was transformed into a dispersion or S matrix (Seal 1968; Morrison 1967; Dagnelie 1975). This ordination method condenses the mass of raw data in such a manner that a minimum of information is lost. The cumulative percentage of variance on the third principal component gives a good estimate of the information held in only two planes of the hyperspace (Table 2). We did not use the second P.C. since its meaning is obscure.

Table 1. List of samples examined

No. Sample/site	Locality	Date of collection	Plankton/ Benthos/ Sapropelium	Description of habitat Temperature water (near surface)
East-Greenland				
Gr27/1-G	Tasîlagfjord	16/07/1978	P	small pool: 100 cm × 60 cm, max. depth: 20 cm. 15 °C
Gr28/1-G			S	
Gr29/1-G	Tasîlagfjord	16/07/1978	P	brooklet, 190 cm broad, max. depth: 25 cm. 16 °C
Gr30/2-G	Tasîlagfjord	20/07/1978	P	brook, 170 cm broad, max. depth: 50 cm. 8.5 °C
Gr33/2-G	Tasîlagfjord	20/07/1978	S	pool, 400 cm × 360 cm, max. dept: 30 cm,
Gr35/2-G			B	subaquatic mosses 16 °C; 10 °C (bottom)
Gr36/1-G	Tasîlagfjord	20/07/1978	B	brook; 15 cm – 20 cm deep. 12 °C
Jan Mayen				
S26/S-12	Rekvedsletta	20/06/1983	S	superficial flowing melt-water brook
N.W. Spitsbergen				
S32/S-19	Ny-Ålesund	26/06/1983	P	medium sized pool (10 m × 5 m)
S33/S-19			B	max. depth: 15 cm. 4.5 °C
S34/S-21	Ny-Ålesund	26/06/1983	P	medium sized pool (8 m × 8 m)
S35/S-21			B	max. depth: 15 cm. 6.6 °C
S40/S-23	Bockfjorden	27/06/1983	S	small warm water spring 80 cm × 55 cm; sample from the outlet, depth: 12 cm. 22 °C
S41/S-24	Bockfjorden	27/06/1983	B	melt water pool, with green filamentous algae 80 cm × 40 cm; max. depth: 10 cm. 6 °C
S45/S-28	Amsterdamøya	29/06/1983	S	melt water pool 400 cm × 200 cm, max. depth: 15 cm. 9 °C

Results and Discussion

The composition of the fauna is given in Table 3. A comparison of these assemblages with those from more temperate regions (Fig. 4) reveals a shift in the importance of some genera with regard to the number of species. While *Difflugia* is the predominant genus in temperate regions, arctic aquatic communities tend to be characterized by several genera, in particular *Euglypha* and *Nebela*. The dominance of *Nebela* in some arctic samples indicates a resemblance to the alpine fauna as found by Laminger (1972) in the Austrian Alps. As early as 1901 Levander indicated a striking similarity between the rhizopod-fauna of the coastal area of Murmansk and that of the Swiss Alps. *Trinema* is little influenced by the climate and thus gains in importance in arctic regions.

Table 2. Cumulative percentages of variance

Principal component	Cumulative percentage of variance
1.	19.9
2.	36.1
3.	47.1

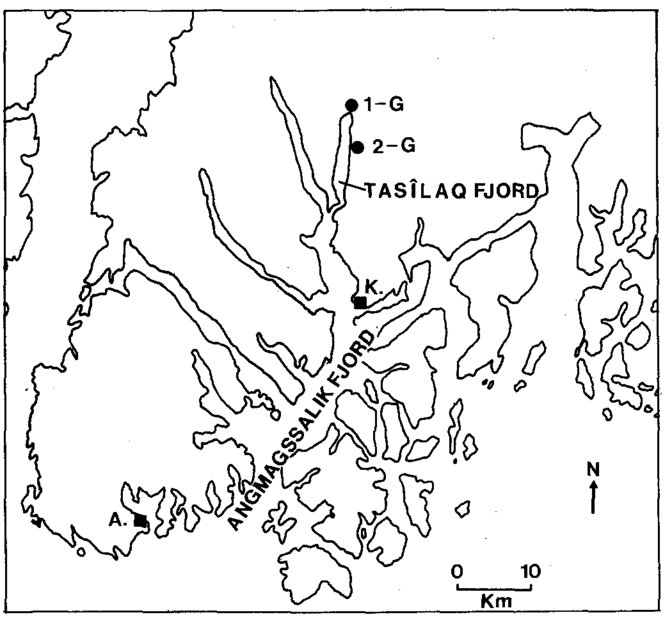

Fig. 1. Sketch map of the Angmagssalik region in East Greenland, showing the locations of the sampling sites and of the settlements Angmagssalik (A.) and Kûngmiut (K.)

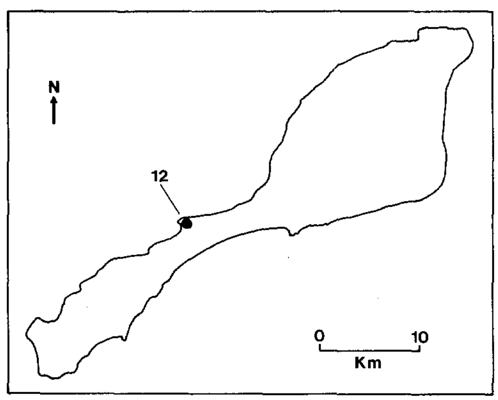

Fig. 2. Sketch map of Jan Mayen showing the location of the sampling site

The number of species is fairly small, as was to be expected since the numbers of species in most phyla diminish towards the poles. This has already been demonstrated for testate amoebae in moss- and lichen habitats in the Arctic (Beyens et al. 1986), and for antarctic terrestrial habitats by Smith (1982). Increasing depauperisation is mainly attributed to the disappearance of typical aquatic species. Only 15 of the 40 species (37.5%) here observed are bound to the aquatic environment. By way of comparison: 62.6% in a study in Belgium (Chardez and Gaspar 1976) and 52.6% in S.W. Ireland (Beyens and Chardez 1984). This illustrates the more ubiquist nature of the faunal elements.

The most important species is *Trinema lineare*, both in terms of presence as in numbers of individuals. The species is found in 11 of the 15 samples (73%). There are indications that this proportion is smaller in temperate regions: 35.7% in S.W. Ireland (op. cit.), 29.4% in the Belgian Campine (unpublished data). A striking similarity exists with the situation in the Austrian Alps (Laminger 1972), where *T. lineare* was observed in 89% of the aquatic sediments. Moreover, as the number of species

Table 3. Percentages of the species in the samples. Species sequence according decreasing sum of the relative frequencies. The typical aquatic species are marked with an asterisk. The species name is preceded by its code in Fig. 8. –: absent; r: <6%; +: 6–10%; 1: 11–20%; 2: 21–40%; 3: 41–60%; 4: 61–80%; 5: 81–100%

Region		Greenland							Jan Mayen	Spitsbergen						
No. of sample																
Species		27	28	29	30	33	35	36	26	32	33	34	35	40	41	45
30.	*Trinema lineare* Penard	1	1	4	3	–	–	4	2	4	1	–	–	3	r	2
9.	*Centropyxis aerophila* Deflandre	1	1	2	2	–	r	–	2	–	–	–	–	–	r	2
23.	*Paraquadrula irregularis* (Archer) Deflandre*	–	–	–	–	–	–	–	–	–	3	–	3	–	1	–
6.	*Arcella rotundata* Playfair*	–	–	–	–	–	–	–	–	–	+	3	2	–	–	–
36.	*Centropyxis aerophila* v. *sphagnicola* Deflandre	–	r	–	–	3	+	–	–	–	–	–	–	–	–	–
37.	*Cyclopyxis leclerqi* Beyens et Chardez*	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–
31.	*Trinema enchelys* (Ehrenberg) Leidy	–	–	–	–	3	–	–	r	–	–	–	–	–	–	–
4.	*Microchlamys patella* Claparède et Lachman*	–	–	–	–	–	–	–	–	2	1	–	–	–	–	–
7.	*Arcella rotundata* f. *undulata* Stepanek*	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–
19.	*Nebela militaris* Penard	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–
33.	*Phryganella acropodia* (Hertwig et Lesser) Hopk.	–	–	–	2	–	–	–	1	–	–	–	–	–	–	–
40.	*Trinema lineare* f. *truncatum* Chardez	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
18.	*Nebela lageniformis* Penard	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
39.	*Euglypha tuberculata* Dujardin	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
17.	*Nebela collaris* Leidy	r	1	–	–	–	–	–	–	–	–	–	–	–	+	–
22.	*Nebela tincta* (Leidy) Awerinzew	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
15.	*Difflugia pulex* Penard*	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
25.	*Euglypha acanthophora* (Ehrenberg) Perty*	+	–	–	–	–	–	–	+	–	–	–	–	–	r	–
8.	*Centropyxis aculeata* Stein*	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
34.	*Arcella arenaria* Greeff	1	r	–	–	–	–	–	–	–	–	–	–	–	–	–
28.	*Euglypha strigosa* f. *glabra* Wailes	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–
13.	*Difflugia lucida* Penard*	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
26.	*Euglypha rotunda* Wailes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
11.	*Plagiopyxis callida* Penard	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
10.	*Centropyxis aerophila* v. *minuta* Chardez	–	–	–	–	–	–	–	–	–	+	–	–	–	r	–
21.	*Nebela penardiana* Deflandre	r	+	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	*Nebela dentistoma* Penard	+	r	–	–	–	–	–	–	–	–	–	–	–	–	–
35.	*Pyxidicula cymbalum* Penard*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
2.	*Cochliopodium opalinum* Penard*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
14.	*Difflugia linearis* (Penard) Gauthièr-Lièvre & Thomas*	–	–	–	–	–	r	–	–	–	–	–	–	–	r	–
27.	*Euglypha strigosa* (Ehrenberg) Leidy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
1.	*Cochliopodium obscurum* Penard*	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
20.	*Nebela nobilis* (Cash) Deflandre	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
5.	*Microchlamys patella* v. *arctica* Penard*	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–
38.	*Plagiopyxis penardi* Thomas	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32.	*Trinema complanatum* Penard	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
29.	*Assulina muscorum* Greeff	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
3.	*Microcorycia flava* Greeff	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
24.	*Heleopera petricola* v. *amethystea* Penard	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
12.	*Difflugia lacustris* (Penard) Jung*	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–

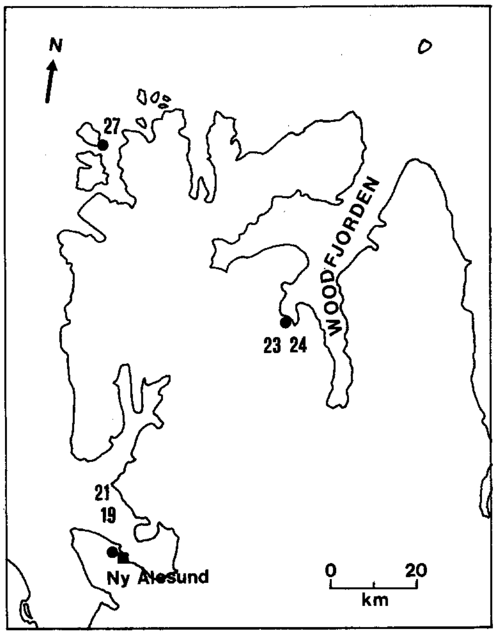

Fig. 3. Sketch map of Northwest Spitsbergen, showing the locations of the sampling sites

diminishes *T. lineare*, if present, tend to become the dominant species (r = −0.91) (see Fig. 5). Although this may seem quite evident, it is not true for *Centropyxis aerophila* (r = −0.45), the second most important species.

According to Schönborn (1973), *Centropyxis aerophila* is an oligotrophic species. Since it is not present in all samples, the possibility must be borne in mind that its presence/absence is related to the trophic state of the water. In Fig. 6 the pH values are plotted against the conductivities. It was only possible to construct a relevant linear regression line after disregarding sample S40. This was taken in a warm water spring, with $CaCO_3$-precipitation along the margins. Two groups of waters can be distinguished: slightly acidic, with low conductivity (oligotrophic) and alkaline, with higher conductivity (mesotrophic). The aberrant position of sample 41 is due to the fact that this habitat belongs to the biologically interesting group of alkaline, oligotrophic waters. This is reflected in the curious species composition: the highest number of species is found here, including four *Difflugia* species.

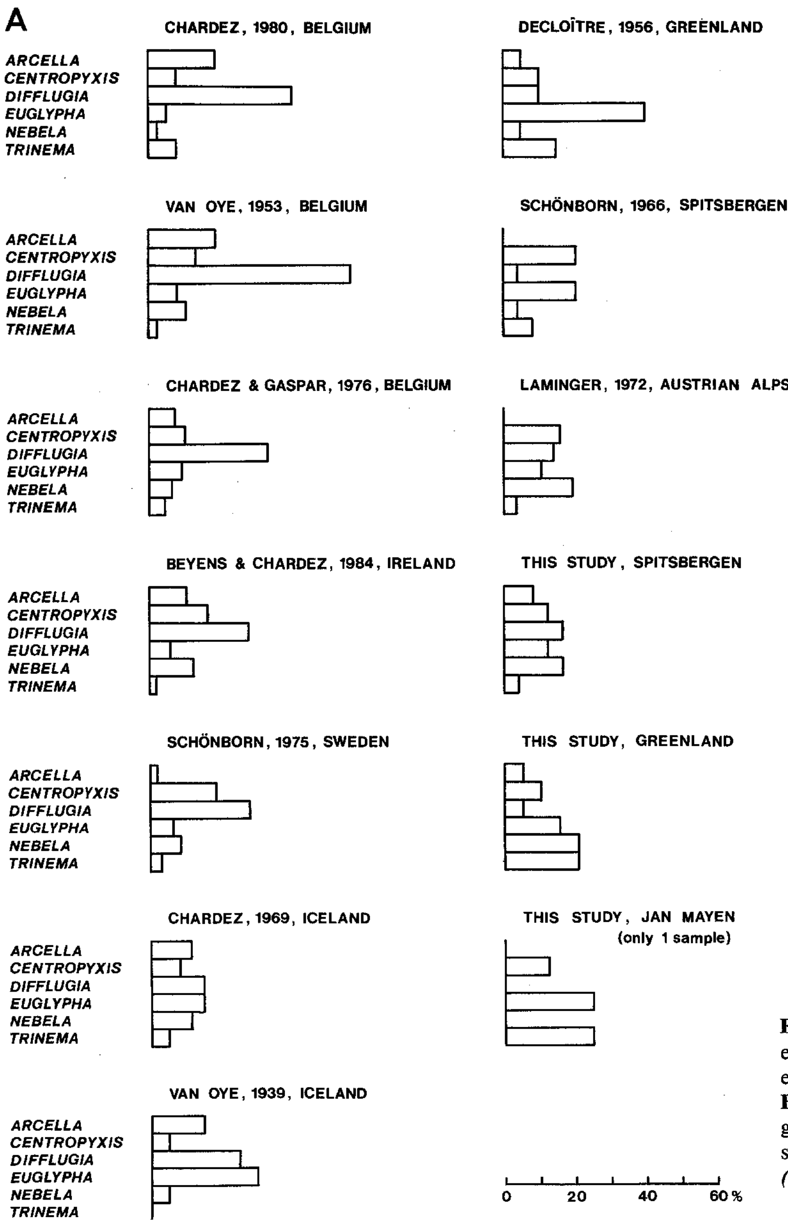

Fig. 4. **A** Histograms indicating the most important genera in each study, according to their number of species. This is expressed for each genus as a percentage of the total number of species. **B** Histograms summarizing the observations made in **A** for each geographical region. The scale (1–4) indicates the number of studies in which the genus is dominant *(shaded)* or subdominant *(open)*

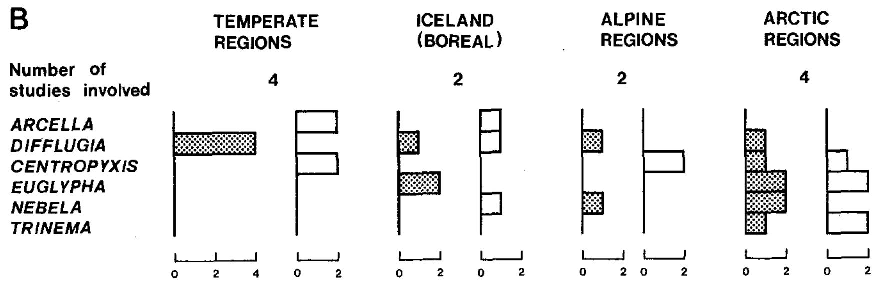

Fig. 4

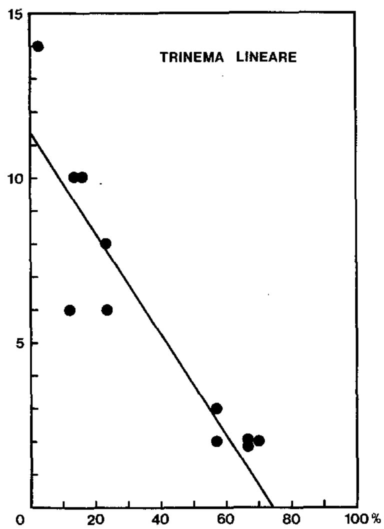

Fig. 5. The percentual representation of *Trinema lineare*, plotted against the total number of species (n) in each sample. Regression line y = −0.15x + 11.33; r = −0.91

A comparison of these ecological data with the faunistic list reveals that the occurrence of *Centropyxis aerophila* is indeed restricted to tho low-conductivity habitats. Although this rhizopod is found in the oligotrophic but alkaline sample 41, its presence there in small numbers suggests a preference for rather acidic aquatic habitats.

On the other hand, high percentages of *Paraquadrula irregularis* are only found in the alkaline, more conductive waters, with its still important presence in sample 41 being accounted for by the extraordinary character of this habitat.

In Fig. 7, which is the result of the P.C.A. performed on the percentual faunistic data of Table 3, the samples are plotted against the two axes. If we code each sample according the physico-chemical features of the habitat, expressed in terms of pH and conductivity, it becomes obvious that several clusters are distinguishable: an oligotrophic-acidic one, the mesotrophic-alkaline one, and the isolated oligotrophic-alkaline sample. The suggestion that these communities are ordered according

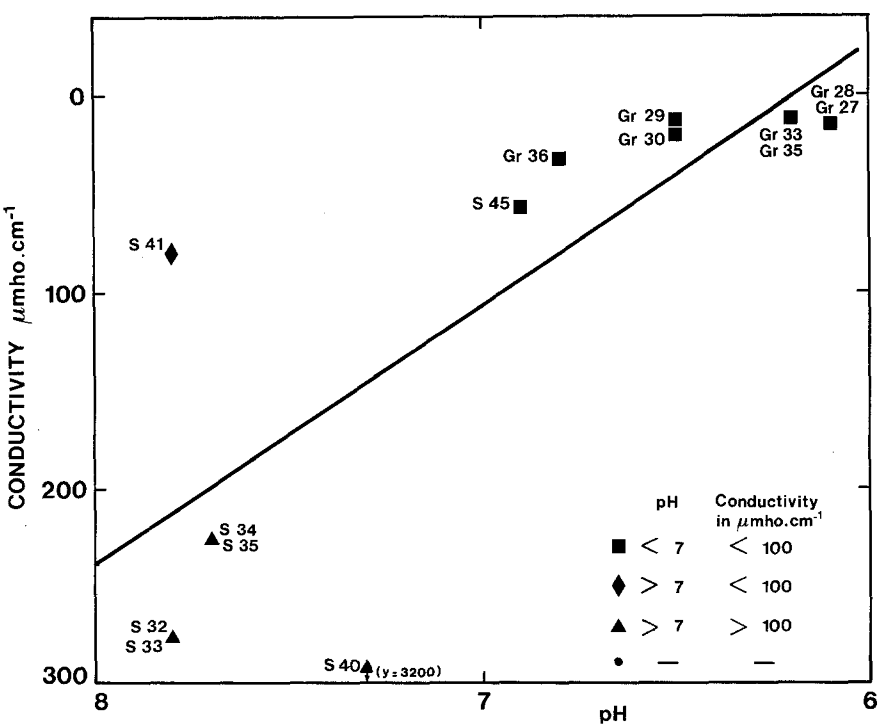

Fig. 6. Diagram of the measured pH and conductivity of the samples (L. R.: y = 130.75x − 808.5; r = 0.87).

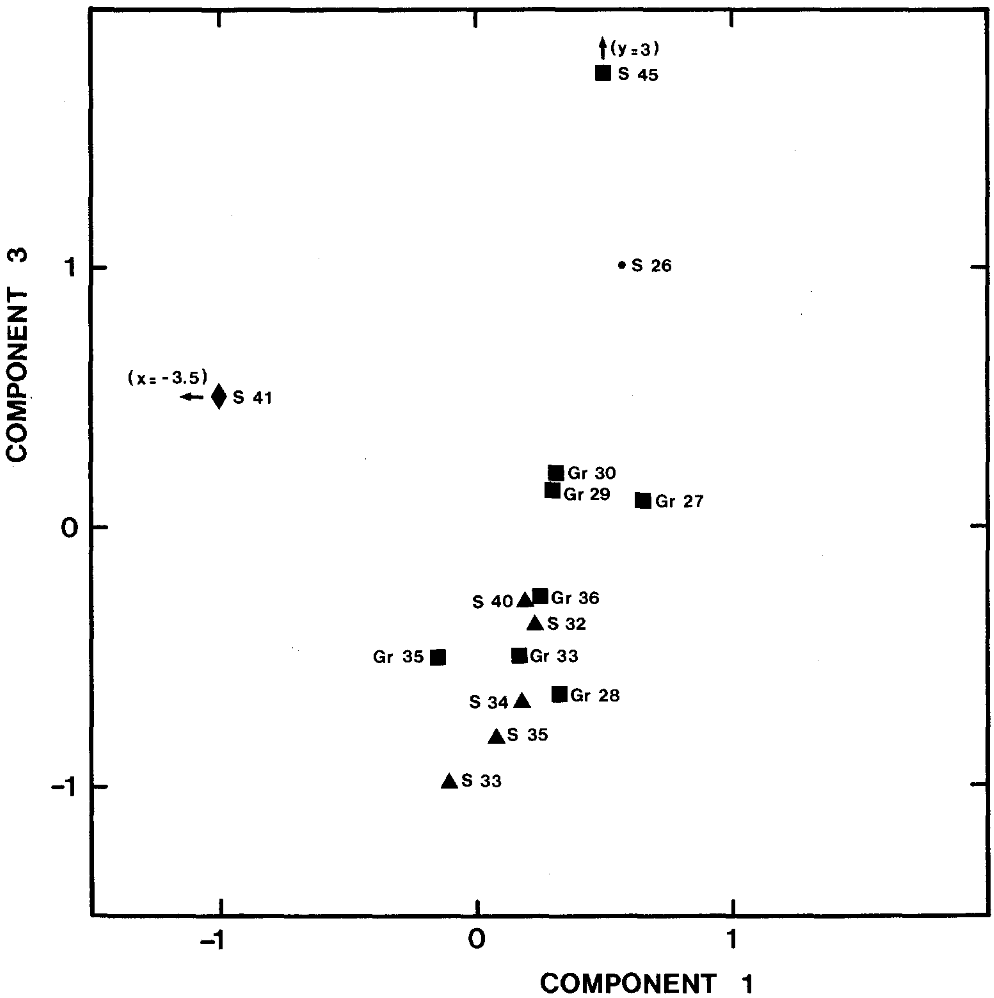

Fig. 7. Distribution of the different samples based on the components 1 and 3, which seems to correlate with the increasing acidity and the diminishing conductivity of the habitat (for symbols see Fig. 6)

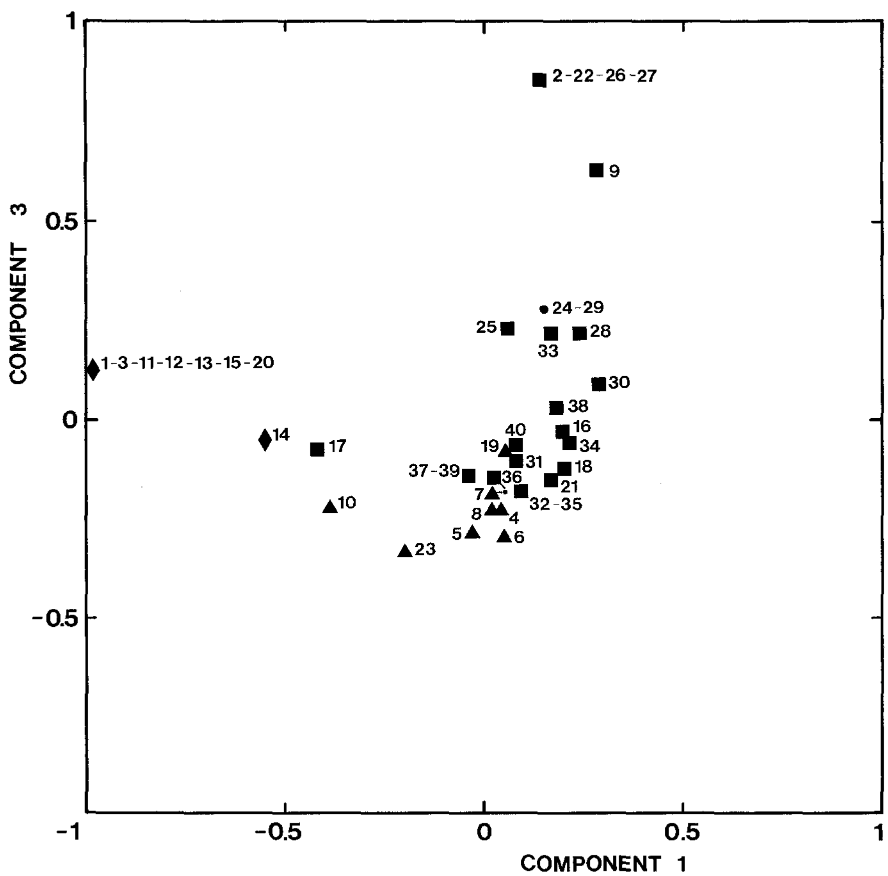

Fig. 8. Distribution of various species along the components 1 and 3. These components are positively correlated with the increasing acidity (1) and increasing oligotrophy (3) (for symbols see Fig. 6) 1: Coch obsc; 2: Coch opal; 3: Mic flar; 4: Mic pat; 5: Mic pat arc; 6: Ar rotun; 7: Ar rot und; 8: Cen acul; 9: Cen aer; 10: Cen aer min; 11: Pl cal; 12: Dif lac; 13: Dif luc; 14: Dif lin; 15: Dif pul; 16: N den; 17: N col; 18: N lagen; 19: N mil; 20: N nob; 21: N pen; 22: N tin; 23: Paraq ir; 24: Hel pet am; 25: E acan; 26: E rot; 27: E strig; 28: E strig gl; 29: As mus; 30: Trin lin; 31: Trin ench; 32: Trin com; 33: Phryg acrop; 34: Ar aren; 35: Pyx cym; 36: Cen aer sph; 37: Cyc lecl; 38: Pl pen; 39: E tuber; 40: Trin lin trun

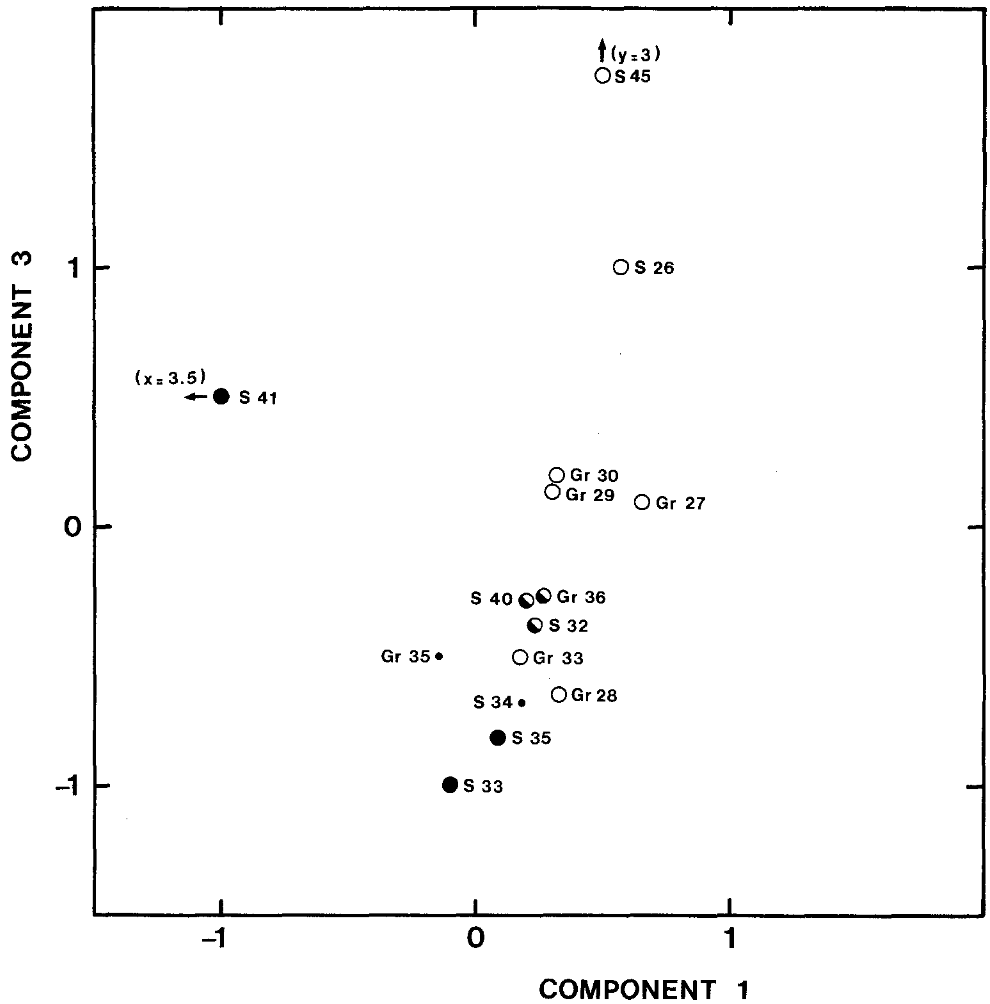

Fig. 9. Ordination diagram of the samples, coded according to the association recognized. Component 1 is the acidity, increasing to the right. Component 3 the trophic state, decreasing in vertical direction. ◐ *Trinema lineare*-association; ○ *Centropyxis aerophila*-association; ● *Paraquadrula irregularis*-association

these physico-chemical parameters becomes fully apparent when we compare this diagram with Fig. 6. The samples in the P. C.A. are plotted in a similar sequence to the pH-conductivity diagram. Thus both parameters influence the composition of the different communities.

The second P. C.A. diagram (Fig. 8) reflects the same ecological parameters. In this case a number of species is represented by their percentual presence in the different habitats. We have, in this diagram, consecutively coded each species according the mean pH/conductivity of the samples it was recorded in. Sample 40, the warm water spring, was excluded from this computation. Although some caution must be excercised regarding species with only one observation, this diagram again reflects a division into the same three main categories of waters, and thus gives also the preferential distribution of the species in relation to the parameters considered.

Is there a difference between the structure of aquatic testate amoebae communities from the different parts of the Arctic? Our present state of knowledge does not permit us to make any conclusions on that score. Although Decloître (1956) pointed to apparent differences between the faunas observed by different authors in the Arctic, this author included Finland, Lapland and Iceland in his study. According to V. Alexandrova these regions do not belong to this geobotanical area (the position of Iceland or at least part of it is however questionable).

Although it was possible to reveal the effect of increasing continentality (Low Arctic-High Arctic) in the moss- and lichen dwelling communities (Beyens et al. 1986), the differences we find between the water-samples from Greenland, Jan Mayen and Spitsbergen are mainly due to the physico-chemical conditions of the water, reflecting local geological features.

An attempt to distinguish separate associations was carried out using the most frequent species as a starting point.

In the samples with *Trinema lineare*, (the most frequent one), the presence/absence of *Centropyxis aerophila* (the second most frequent species) proved to be the decisive criterion, reflecting the ecological conditions of the habitat. On the other hand, the presence of *Paraquadrula irregularis* (the third most frequent species) can be used to differentiate the remaining samples. This resulted in the following ordination:

1. The *Trinema lineare*-association: including the samples No. S32, S40 and Gr36.

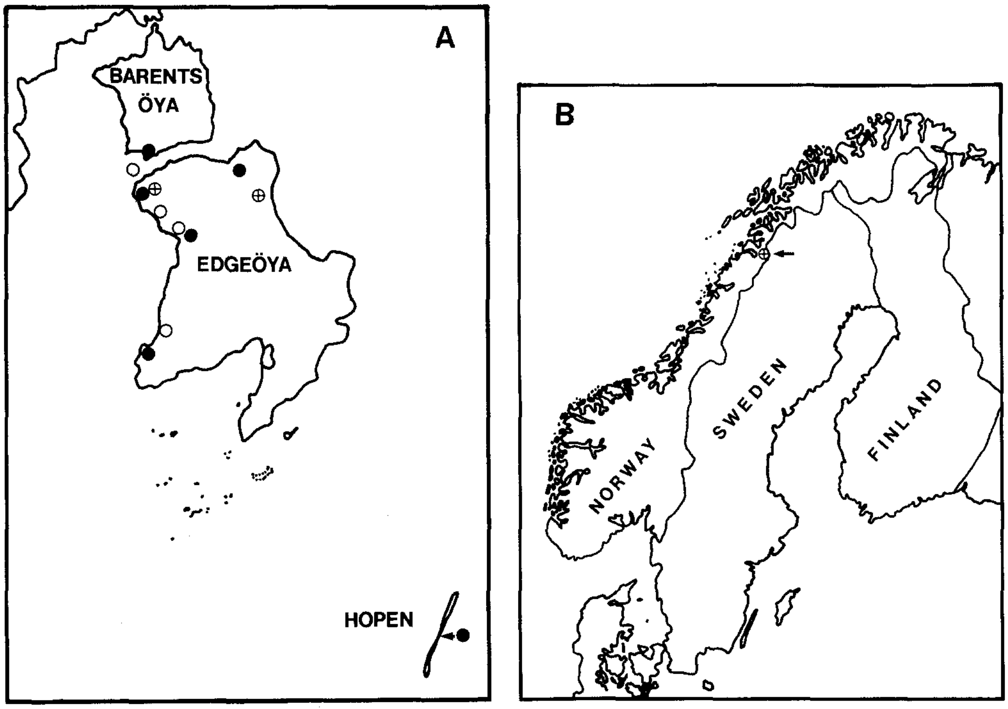

Fig. 10. Present distribution of *Centropyxis pontigulasiformis* in S. E. Svalbard (**A**) and in Scandinavia (**B**). ● in aquatic habitats; ⊕ in very wet mosses; ○ not observed at this site

2. The *Centropyxis aerophila*-association: samples No. S26, S45, Gr27, Gr28, Gr29, Gr30 and Gr33.
3. The *Paraquadrula irregularis*-association: samples No. S33, S35 and S41.

Two samples remain unclassified: S34 is a monospecific population of *Arcella rotundata* along with its variety *undulata*, while Gr35 is dominated by *Cyclopyxis leclerqi.*

The ecological relevance of *Centropyxis aerophila* and *Paraquadrula irregularis* have already been discussed above, and the conclusions arrived at are also applicable to their associations. In Fig. 9, each sample is coded according to the association it belongs to. Comparison with Fig. 7 reveals the ecological distinction of these associations, caused by differences in acidity and trophic degree of the habitat. The *Trinema lineare*-association is found in intermediate habitats.

In general, the structure of the communities in the Arctic, whether aquatic or aerophytic/terrestrial, seems to be characterized by cosmopolitan species, as in alpine and antarctic situations.

Endemic species are rare, and mostly found only once. They thus form an insecure basis for making biogeographical conclusions. One species is however worthy of mention: the newly described *Centropyxis pontigulasiformis* (Beyens and Chardez 1986). It was first met with in 1984 at two different sites on Edgeøya (S.E. Svalbard). In 1985 this species was again encountered at 2 other places on this island, also on the neighbouring Barentsøya and on the island Hopen (Fig. 10). Meanwhile we have also found it in material from the Norwegian mountains (near Fauske, Nordland) well above the timberline. Could this be an arctic-alpine species such as known from studies on higher plants and animals?

Acknowledgements. We wish to thank Mrs. S. Pooters, Mrs. A. Torfs, Mr. F. Neefs and Mr. R. Neefs for their technical assistance. We are also much indebted to Prof. ir. J. De Sitter for his invaluable help with the computer programs. Prof. Dr. D. K. Ferguson kindly corrected the English text. Mr. P. De Bock collected for us samples in the Norwegian mountains. One of us (L. B.) received grants from the National Science Foundation (Belgium) for these expeditions.

References

Aleksandrova VD (1980) The Arctic and Antarctic: their division into geobotanical areas. Cambridge University Press, Cambridge London New York, 247 pp

Awerinzew S (1907a) Über die Süßwasserprotozoen der Insel Waigatsch. Zool Anz 31:306–312

Awerinzew S (1907b) Über einige Süßwasser-Protozoen der Bäreninsel. Zool Anz 31:243–247

Beyens L, Chardez D (1984) Testate Amoebae (Rhizopoda, Testaceae) from South-West Ireland. Arch Protistenk 128:109–126

Beyens L, Chardez D, with the collaboration of De Bock P (1986) Some new and rare Testate Amoebae from the Arctic. Acta Protozool 26:81–91

Beyens L, Chardez D, De Landtsheer R, with the collaboration of De Bock P, Jacques E (1986) Testate Amoebae populations from moss and lichen habitats in the Arctic. Polar Biol 5:165–173

Chardez D (1969) Contribution à la faune thécamoebienne de l'Islande (Protozoa Rhizopoda Testacea). Bull Inst R Sci Nat Belg 45:1–16

Chardez D (1980) Thécamoebiens de l'Etang de Thommen (Protozoa Rhizopoda Testacea). Nat Belg 61:88–91

Chardez D, Gaspar Ch (1976) Thécamoebiens aquatiques du domaine des Epioux (Ardenne, Belgique). Biol Jb Dodonaea 44:86–100

Dagnelie P (1975) Analyse statistique à plusieurs variables. Presses Agronomiques, Gembloux, 362 pp

Decloître L (1956) Les thécamoebiens de l'Eqe (Groenland). Hermann & Cie, Paris, 100 pp

Laminger H (1972) Ein Beitrag zur Kenntnis der Hochgebirgs-Testaceen Österreichs (Contribution to Knowledge of High Mountain Testacea of Austria). Arch Protistenk 114:101–151

Levander KM (1901) Beiträge zur Fauna und Algenflora der Süssen Gewässer an der Murmanküste. Acta Soc Fauna Flora Fenn 20:1–35

Morrison DF (1967) Multivariate statistical methods. McGraw-Hill, New York, 338 pp

Schönborn W (1966) Beitrag zur Ökologie und Systematik der Testaceen Spitzbergens. Limnologica 4:463–470

Schönborn W (1973) Paläolimnologische Studien an Testaceen aus Bohrkernen des Latnjajaure (Abisko-Gebiet; Schwedisch-Lappland). Hydrobiologia 42:63–75

Schönborn W (1975) Studien über die Testaceen-Besiedlung der Seen und Tümpel des Abisko-Gebietes (Schwedisch-Lappland). Hydrobiologia 46:115–139

Seal HL (1968) Multivariate statistical analysis for biologists. Methuen, London, 209 pp

Smith HG (1982) The terrestrial protozoan fauna of South Georgia. Polar Biol 1:173–179

Van Oye P (1939) Die Rhizopoden von Thingvallavatn und Umgebung. Biol Jb Dodonaea 6:171–185

Van Oye P (1953) Faune rhizopodique de l'étang de Beernem. Biol Jb Dodonaea 20:154–205