Evidence from testate amoebae for changes in some local hydrological conditions between c. 5000 BP and c. 3800 BP on Edgeøya (Svalbard)

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Beyens, L. & Chardez, D. 1987: Evidence from testate amoebae for changes in some local hydrological conditions between c. 5000 BP and c. 3800 BP on Edgeøya (Svalbard). *Polar Research 5 n.s.*, 165–169.

The study of a subfossil peat from the northwestern part of Edgeøya (Svalbard) enabled a reconstruction of the changes in the testate amoebae communities from c. 5000 BP to c. 3800 BP to be made. Two stratigraphical zones are recognized. The ecological interpretation of these sequences revealed rather humid and unstable hydrological conditions at the bog surface in the oldest zone, which presumably lasted until about 4500–4300 BP. The communities in the upper zone indicated a more stable and drier environment.

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Recent testate amoebae communities in the Arctic are mostly dominated by cosmopolitan, readily distributed species, and it seems probable that colonization of new areas after the last glaciation tended to be limited by the availability of suitable habitats rather than by immigration rates. The degree of moisture in the habitat is a parameter of prime importance, and changes in the local hydrological conditions can be detected by studying fossil assemblages. Fossil peat layers, although not so frequently encountered in the High Arctic, are therefore important archives. Such a fossil peat was observed during our 1984 field season on Edgeøya, while working on the present distribution and ecology of testate amoebae and diatoms. The results (in prep.) of that fieldwork permit us to interpret the ecological significance of the community changes represented in the time span of this peat.

Material and methods

The site is located on the northwestern side of Edgeøya, Svalbard (Fig. 1), in the valley Rosenbergdalen, approximately 1300 m from the coast. The peat layer was found in the exposed slope of a glacial terrace, south of the river. This 2 m thick peat layer was sampled by Dr. W. O. van der Knaap (Utrecht), who kindly made the material available to us. A vertical series of 24 samples was taken at regular intervals, and numbered 1 to 24 from the top downwards. Two radiocarbon datings were made by Prof. W. G. Mook, Isotope Physics Laboratory, Groningen (van der Knaap 1986):

—sample No. 1 (top): 3810 ± 40 years BP (GrN-13349)

Fig. 1. Sketch map of Svalbard (excluding Bear Island), showing the location of Rosenbergdalen on Edgeøya.

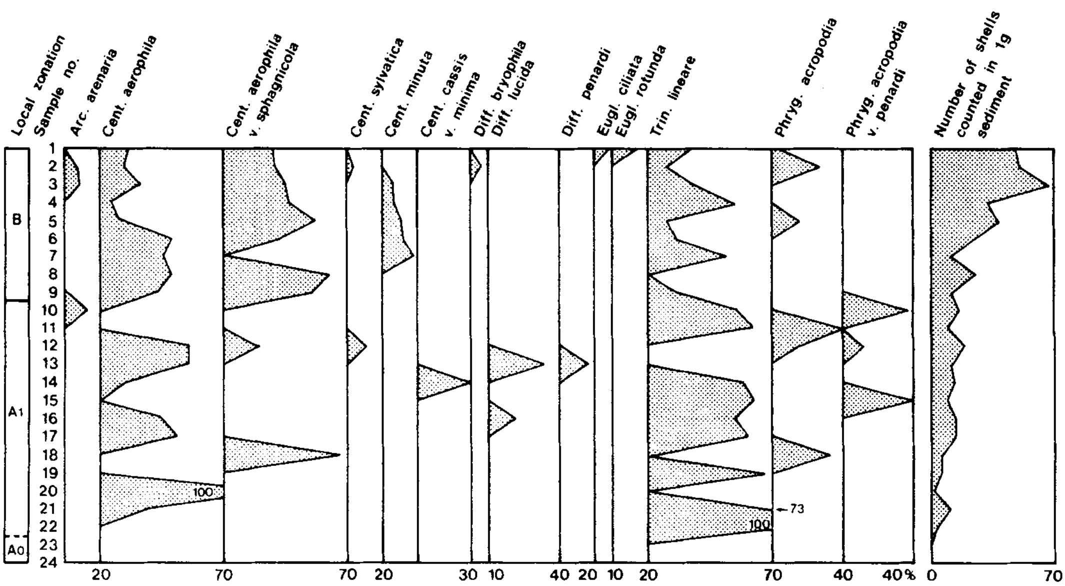

Fig. 2. Testate amoebae diagram from Rosenbergdalen.

—sample No. 24 (bottom): 4995 ± 45 years BP (GrN-13350)

From every sample, an equal weight of air-dried peat (1 g) was shaken with 100 cc distilled water, and filtered through sieves with meshes of 1 mm and 0.250 mm. Testate amoebae in the filtrate were counted with the reverse microscope. Results are shown in Fig. 2, expressed as percentages of the total number of tests at each level. We must stress that the number of tests is sometimes very low, a fact which should be borne in mind when evaluating the results.

Results and discussion

The following taxa were found: *Arcella arenaria* Greeff, *Centropyxis aerophila* Deflandre, *Centropyxis aerophila* var. *sphagnicola* Deflandre, *Centropyxis sylvatica* (Deflandre) Thomas, *Centropyxis minuta* Deflandre, *Centropyxis cassis* var. *minima* van Oye, *Difflugia bryophila* (Penard) Jung, *Difflugia lucida* Penard, *Difflugia penardi* (Penard) Hopkinson, *Euglypha ciliata* Ehrenberg, *Euglypha rotunda* Wailes, *Trinema lineare* Penard, *Phryganella acropodia* (Hert. et Less.) Hopkinson, *Phryganella acropodia* var. *penardi* Decloître.

A few taxa dominate the faunal assemblage throughout the sequence (Fig. 2), particularly *Centropyxis aerophila*, its variety *sphagnicola* and *Trinema lineare*. The following observations on their representation (summarized in Table 1) can be made:

- —the curve of *Centropyxis aerophila* becomes continuous from level 9 to 1.
- —*Centropyxis aerophila* var. *sphagnicola* shows the same trend, except for a minimum at level 7.
- —*Trinema lineare* is better represented in the lower half of the section.

Based on the presence and representation of the various taxa, two stratigraphical zones are distinguished; the first zone A includes A_0 where no tests were found, and A_1 (level 22 to 10) with *Trinema lineare* as the dominant species. The second, zone B, is characterized by *Centropyxis aerophila* and its variety. This zonation is confirmed by the curve for Jaccard similarities between samples (Fig. 3A), where continuously high values of similarity only occur from level 7 upwards. The minimum between levels 8 and 7

Table 1. Mean percentual frequencies of the main species in both zones.

	A_1	B
Centr. aerophila + var. *sphagnicola*	31.3	60.9
Trinema lineare	43.9	22.4

Table 2. Ecology of some species based on recent observations on Edgeøya (Beyens & Chardez in prep.) F: moisture content class according to Jung (1936). (FIII = very wet—water drips from the sample without pressure; FIV = wet—water drips on application of only slight pressure; FVII = quasi-dry—only a few drops of water can be squeezed out; FVIII = dry—no water is exuded even after high pressures are applied.)

Species	Numbers of samples in which encountered	Moisture content of the moss habitat
Centropyxis aerophila var. *sphagnicola*	29	in 72%; less humid to dry
Centropyxis minuta	2	dry: FVII–FVIII
Difflugia lucida	7	in 85%: FIII–FIV
Difflugia bryophila	8	in 75%: FIII–FIV
Difflugia penardi	13	in 84%: FIII–FIV
Difflugia penardi + *Difflugia lucida*	3	FIII, FIV, FIII–IV

is due to the absence of *Centropyxis aerophila sphagnicola*.

The interpretation of these fossil assemblages is made possible through our studies of recent moss-dwelling communities in the Arctic. Macrobotanical analyses revealed great numbers of moss-remains (van der Knaap 1986). Thus, we may assume that most testate amoebae were related to the moss habitat. In a previous study it was shown that *Trinema lineare* occupies a range from humid to moderately humid conditions, while the *Centropyxis aerophila* association was found to live in drier conditions (Beyens et al., 1986). Some ecological observations related to other species made during the field seasons of 1984 and 1985 are compiled in Table 2.

The specific differences in ecology with regard to the moisture content of the substratum lead to the conclusion that, on the whole, more humid conditions prevailed in zone A than in zone B. More detailed analyses reveal that in A_1 there were also periods during which drier conditions existed, as indicated by the frequencies of *Centropyxis aerophila* and *Centropyxis aerophila sphagnicola*. Hydrological conditions at the bog surface were thus rather unstable, as reflected in the lower similarity between the associations of the successive layers. The low diversity indices (Fig. 3B) are also suggestive of environmentally stressful situations resulting from the alternation between more humid and drier phases. The most humid conditions probably occurred at level 13, where *Difflugia lucida* and *Difflugia penardi* are found together. At the present day on Edgeøya they were observed together in mosses which were so wet that the water dripped from the sample without pressure. In the diagram there

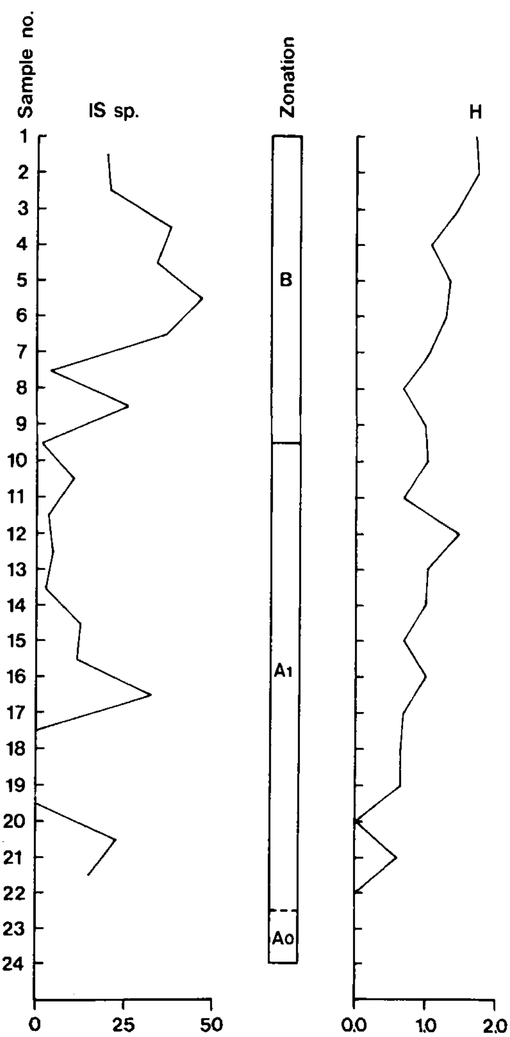

Fig. 3. A: The similarity (IS_s) between the successive communities, computed according to the formula of Jaccard as modified by Spatz (1970). B: The diversity index (H), computed according to the Shannon–Weiner formula.

are no indications of a subaquatic bog surface. The main similarity and diversity are here 8.13 and 0.57, respectively.

An important change in hydrological conditions happened between level 10 and level 9, i.e. from here on the bog surface seems to remain only moderately humid to dry. Over long periods there were no dramatic changes, as confirmed by the higher similarity and diversity indices (mean values of 27.86 and 1.13, respectively).

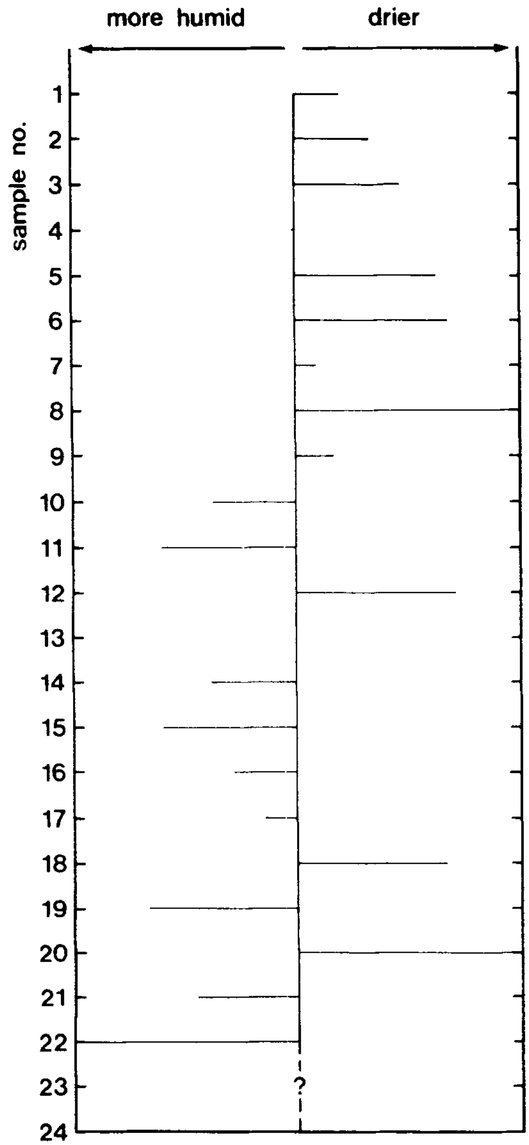

Fig. 4. The evolution of the moisture content at the bog surface, as reflected by differences in percentual frequencies between the more humid and the drier living species.

We have tried to represent these fluctuations diagrammatically, computing the differences between the sum of the percentages of the moderate to dry living taxa and the sum of more humid ones (Fig. 4). Although it is a rough method, it gives what may be a reliable picture of the succession. Comparison with the similarity curve shows that this index is, as expected, generally higher during periods with stable moisture conditions at the bog surface.

It is obvious that from level 9 upwards, some environmental change has induced the dry conditions. Local events such as the diminution of run-off caused by some geomorphological features may be involved. On the other hand, a more general factor such as climatic change is also plausible. This would have a direct influence on e.g. the amount of precipitation, the melting of snowfields, and the depth of the active layer. In this context, the number of tests preserved in 1 g of peat (Fig. 2) is instructive. It is probable that there was some selective destruction, especially when the tests were still in the active layer. But once in the permafrost, it is unlikely that chemical or mechanical destruction occurs. In the upper part of zone B, from level 6 on, which corresponds with a depth of c. 66 cm, numbers remain high. If a cooling trend is assumed from level 9 on, then the permafrost table must have risen, and shells must have been incorporated more quickly into the permafrost. However, this is still no more than a hypothesis. In a well-developed moss tundra on Edgeøya we have observed active layer depths of 25 cm.

Another problem is the dating of the major hydrological change. When we extrapolate between the two radiocarbon dates, we find that level 10 is situated around 4245 BP. However, such a linear peat-growth rate is unlikely, since zone B was drier than zone A. We must therefore assume that the transition between A and B is older, and probably falls into the range of 4500–4300 BP.

It is worth noting that from other regions (e.g. N.W. Greenland) indications of changes in the climatological conditions are known for the period 4500 BP–3500 BP (Fredskild 1985), and although it is tempting to link our result to some of these, this is impossible at the present stage of our research. Further testate amoebae analyses from Edgeøya as well as from other parts of the Arctic are planned in the future.

Acknowledgements. – We wish to thank Mrs. Pooters, Mrs. A. Torfs, and Mr. R. Neefs for their technical assistance. Dr. P. Oosterveld (Netherlands Foundation for Arctic Biological Research) provided logistic support at the Kapp Lee scientific station. We are also grateful to Dr. W. O. van der Knaap (Utrecht) for the peat samples. Prof. Dr. D. K. Ferguson kindly corrected the English text. One of us (L.B.) received grants from the National Science Foundation (Belgium) for the Edgeøya-expeditions.

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