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MICRO-INVERTEBRATE COMMUNITY STRUCTURE WITHIN A MARITIME ANTARCTIC LAKE

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Abstract: The data set discussed here was obtained from a transect across a depth profile in Sombre Lake (Signy Island, South Orkney Islands). The fauna, composed of benthonic micro-invertebrates, was readily observed grazing on the surface of the cyanobacterial mats that form a thin cover on the surface of the sediments. Algal mat composition varied in response to factors such as light, climate, and ice scour. Micro-invertebrate species diversity was limited, but population numbers were high. The results indicated a degree of substrate selectivity by the invertebrate community as illustrated by the distribution of tardigrades—a major component of the faunal community. Comparison is made between samples, collected at the same time, which were either examined fresh or preserved by freezing then thawed for examination in the U.K.

1. Introduction

Signy Island (64°43′S, 45°38′W) is a small island in the South Orkney Island group (Fig. 1) lying within the northern Maritime Antarctic climatic zone (LEWIS SMITH, 1984). It is the most deglaciated of the islands within the group and has 17 small lakes and numerous pools. The lakes range from ultra nutrient-poor to highly enriched systems (HEYWOOD *et al.*, 1980), and are ice-covered, to a depth of 1–2 m, for 8–12 months of the year.

The British Antarctic Survey (BAS) has been studying these lakes at Signy Island for nearly 20 years, and in particular nutrient-poor Sombre Lake and nutrient-rich Heywood Lake. The work reported here focusses on Sombre Lake and forms part of a much larger study of the micro-invertebrate ecology of Maritime Antarctic lakes. The study aims to establish whether faunal distribution is largely a function of substratum. An important methodological component of the present investigation was to determine whether or not reliable counts could be obtained from frozen material.

2. Site Description

The data for this study were collected, in February 1987, from Sombre Lake (Fig. 1b), a small oligotrophic lake at the northern end of Signy Island. This lake has been the subject of an intensive long-term study by BAS (*e.g.*, HAWES, 1983, 1985; ELLIS-EVANS, 1984). Sombre Lake is one of the larger lakes on Signy Island, having a surface area of *ca.* 25000 m² and a maximum depth of 10.8 m. It lies at the end of a chain of three lakes whose catchment is largely composed of rock, scree and permanent ice fields. In recent years the marked increase in numbers of fur seals (*Arctocephalus gazella*) reaching Sombre Lake during the summer months, has begun to change the trophic status of this lake. Robin Peak (261 m) bounds the northern and western shores, causing extensive shading, and these steep slopes extend down to *ca.* 9 m depth in the lake, before levelling to the deep spot. There is an extensive shallow and rocky sub-lacustrine shelf, derived from morainic debris, lying at the eastern and southern shores.

A transect line was stretched from the eastern shore to the deep spot, at right angles to the inflow. The depth profile of this transect (Fig. 2) was divided very broadly into three zones. The shallow shelf zone is an unstable site as it is subject to wind turbulence during open water, and is highly seasonal as it freezes solid during the winter period. The vegetation here is dominated by *Phormidium* spp., perennial mat-forming cyanobacteria, with which filamentous green algae are associated in summer. The two sites

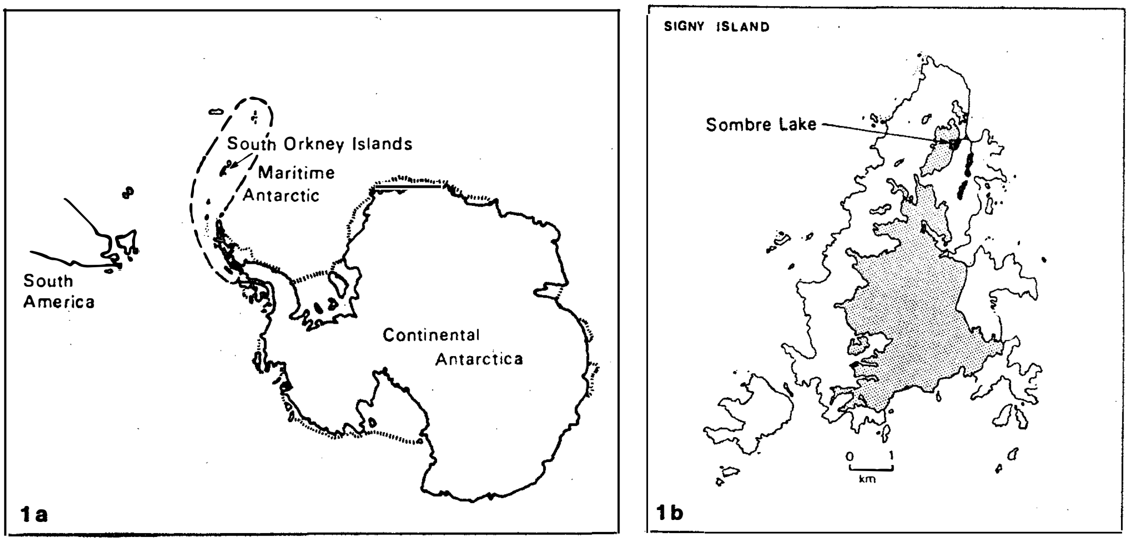


Fig. 1. Map to show the location of Signy Island, South Orkney Islands and the position of Sombre Lake, the study site.

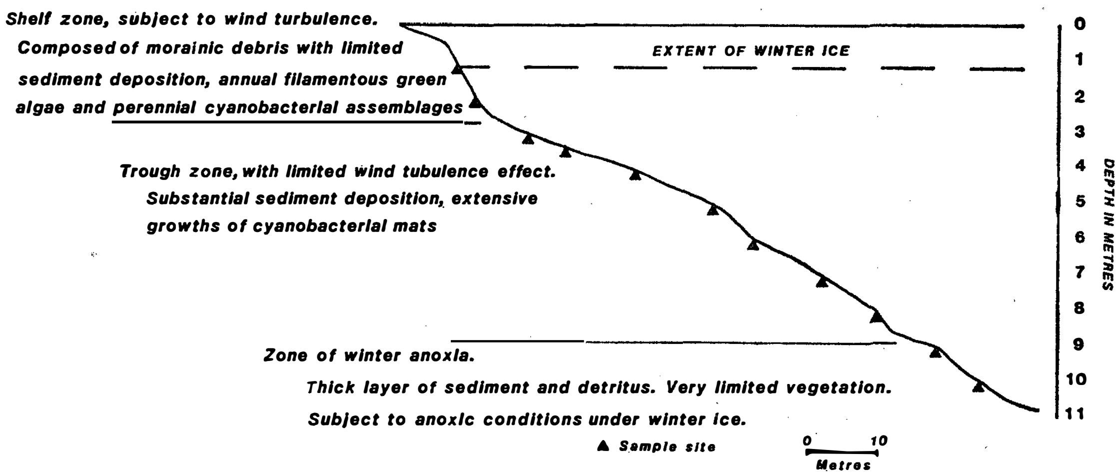


Fig. 2. Description of the general site characteristics along the depth profile in Sombre Lake.

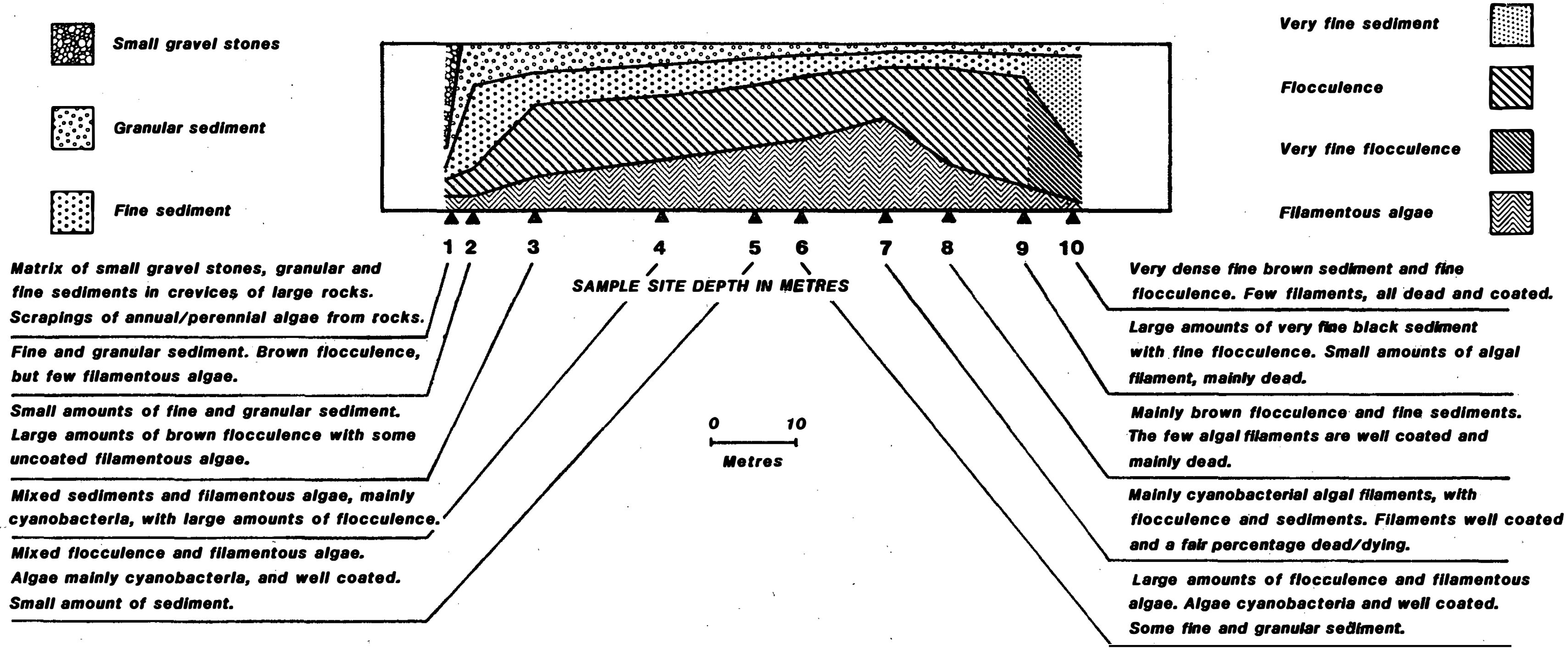


Fig. 3. Representation of the organic/inorganic composition of each sampling site along the transect.

at 1 m and 2 m are also on a relatively steep slope which adds to the instability of this region. Below two meters the slope becomes less steep. In this trough zone wind-induced turbulence is limited and the region does not freeze in the winter. Substantial sediment deposition has resulted in a more homogeneous substrate upon which extensive developments of cyanobacterial mats (dominated by *Tolypothrix/Plectonema* associations) proliferate. At the deep stations (below 8 m) anoxic conditions may occur under winter ice conditions, and there is very limited vegetation.

A representation of the organic/inorganic composition found at each sampling site is shown in Fig. 3. The 1 m site was markedly different from all the other sites as it comprised a mainly rock substrate with boulders and small stones, which was difficult to sample quantitatively. The 2 m site, on a steep slope (Fig. 2), had more sediment and flocculence, but little in the way of vegetation. Sites 3–8 m were all composed of deep sediment overlaid by the cyanobacterial mats. As depth increased so did the numbers of epiphytes coating the individual filaments of algae. At the deep sites (9–10 m) the sediment and flocculence became much finer in appearance, and the small amounts of vegetation were largely dead and decaying.

3. Methods

Using the transect line as a guide, small samples of the sediment-water interface were collected at each metre depth using SCUBA techniques. Five samples were taken at each site, four of which were frozen at $-20°C$ and returned to U. K. for analysis, the fifth being analysed immediately.

The micro-invertebrates were extracted using a modified silica gel floatation technique (McInnes and Ellis-Evans, 1987), and identified under low power microscopy.

4. Results and Discussion

In this study no attempt has been made to name fully all the species present and certain species have been grouped (*e.g. Diphascon* spp. and *Dactylobiotus* spp. amongst the tardigrades, and in the rotifers the "Bdelloid group", and *Lepadella* spp., *Cephalodella* spp., etc.). The main reason for this was the difficulties encountered in identifying these groups to species level. Details of taxonomy are discussed further in Dartnall and Hollowday (1985) for the rotifers, and in McInnes and Ellis-Evans (1987) for the tardigrades. Protozoa were excluded from this study, as they have been described earlier by Hawthorn and Ellis-Evans (1984).

In comparison with temperate and arctic lake environments Antarctic lakes are characterised by very short food chains (Heywood, 1987) and it is noticeable that there is a very limited species diversity amongst the micro-invertebrates (9 species of tardigrade, 16–17 species of rotifer, 4 nematodes, 4 gastrotrichs, 1 enchytraeid, 4 cladocerans and 1 ostracod, in this study). Lake Myvatn, as an example of a sub-arctic lake in Iceland, has much longer food chains and a richer invertebrate species diversity (Lindegaard, 1979; Jonasson, 1979). The relative lack of predation pressures, and the abundance of substrate (algal filaments, associated epiphytes or bacteria) found in Sombre Lake, have allowed substantial populations of invertebrates to develop, as the results indicate (Figs. 4 and 5).

The four main groups of benthic micro-invertebrates found in the freshly sampled material are shown in Fig. 4a. All groups are expressed as total numbers per cm^3, with the exception of the tardigrades which also includes the number of live animals. In all groups the most substantial numbers were found between 5–8 m, corresponding to the most extensive areas of perennial algal mat assemblages (Fig. 3). Rotifers were most broadly distributed, but in common with the other groups virtually excluded from the deep sites (9–10 m). Significant numbers of tardigrades were found in these deep sites, but almost all were dead.

Five additional groups observed in this study are shown in Fig. 4b. Most of these are nektobenthic and were therefore more widely distributed, though again they were excluded from the deep sites. In contrast, significantly high numbers were found in the 1 m site, despite the marked seasonality of a site which freezes solid during the winter months.

A more detailed study of the tardigrades (Fig. 4c) showed obvious trends. *Isohypsibius* "smooth" and *Dactylobiotus* spp. were both restricted to the trough sites, with *I.* "smooth" the dominant species, whilst *I.* "rough" dominated the shallow sites and was rarely found outside the top 2 m. The resting stage of *I.* "smooth", recorded here as cysts, were found only in the deepest sites (9–10 m). It was noted that these cysts were live and "hatched" fully adult forms of *I.* "smooth" after several days in oxygen-rich freshwater.

I. papillifer, *Hypsibius arcticus* and *Diphascon* spp. all showed a more uniform profile over the whole depth transect. All three species of *Isohypsibius*, with *Dactylobiotus* spp., are considered "hydrophilous" forms (Ramazzotti and Maucci, 1983) and have rarely been found outside the aquatic habitat on Signy Island (Jennings, 1976;

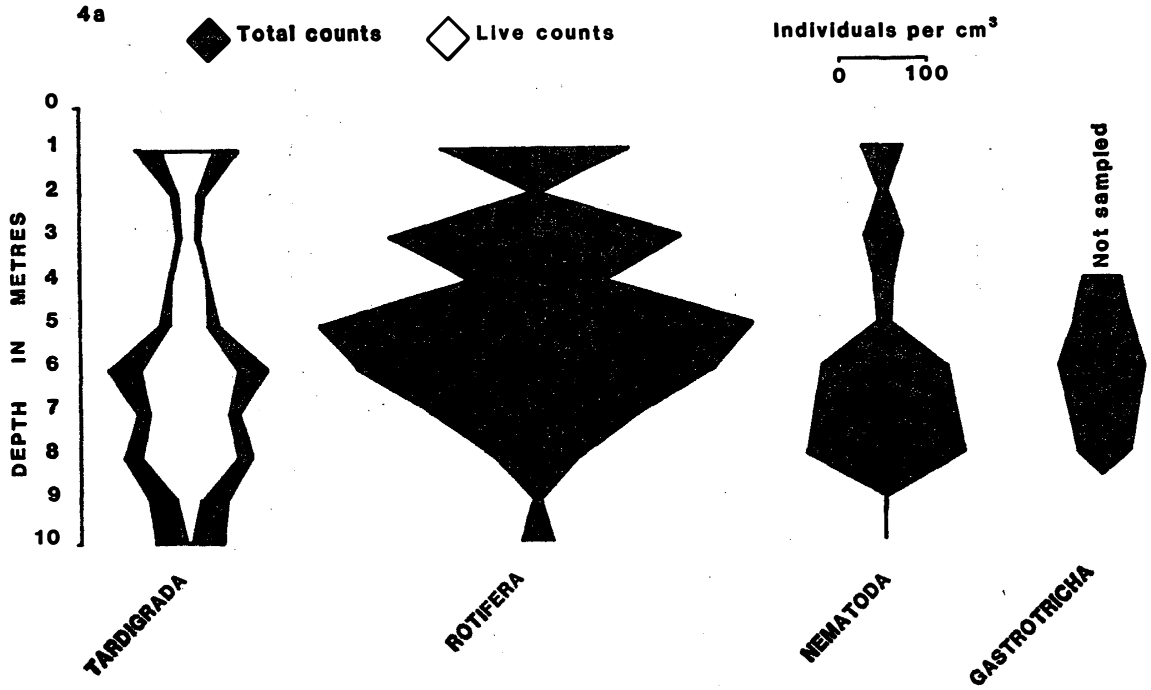


Fig. 4a. Four main benthic groups found in the freshly sampled material.

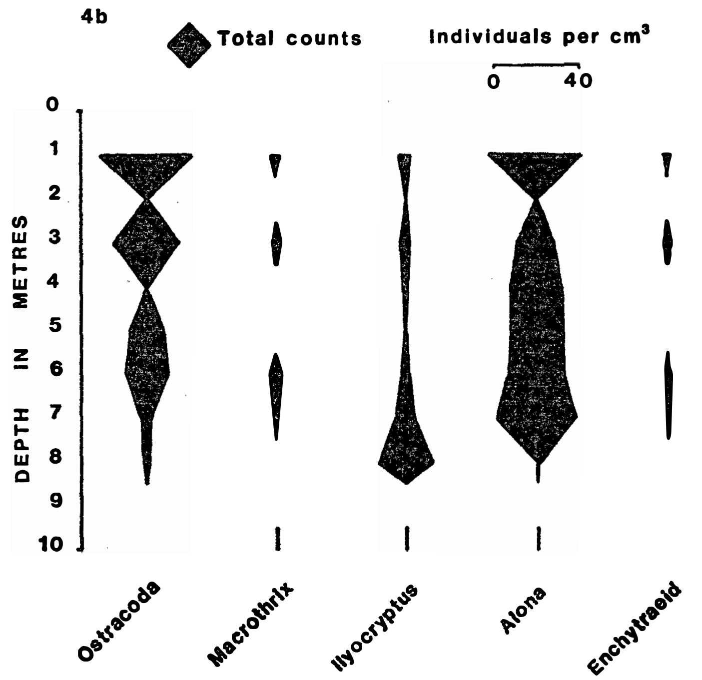


Fig. 4b. *Additional micro-invertebrate groups observed in freshly sampled material.*

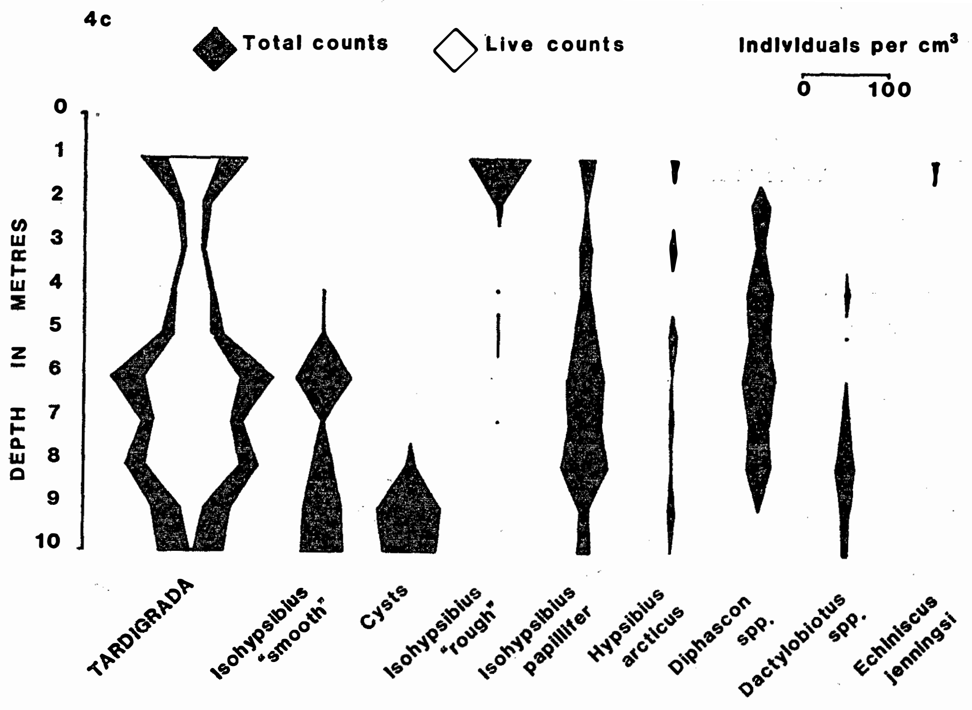


Fig. 4c. *More detailed study of the tardigrades from freshly sampled material.*

McINNES and ELLIS-EVANS, 1987). *Hypsibius arcticus* and *Diphascon* spp. are classified as "hygrophilous", having a wider tolerance of varying moisture conditions, whilst *Echiniscus jenningsi* is a xerophile which, not surprisingly therefore, only occasionally occurred in the 0–1 m sites.

Previous work (McINNES and ELLIS-EVANS, 1987) had noted that micro-invertebrates did not survive rapid freezing to $-20°C$ (storage temperature of preserved samples). Such rapid temperature changes ($+4$ to $-20°C$ in 10–15 min) are not experienced in the stable lake environments nor even the more unstable terrestrial environment. To establish if reliable counts could be obtained from frozen material two sets of data (Figs. 4 and 5), derived from samples obtained at the same time, were compared. The general trends described above for Fig. 4, are also evident in Fig. 5a–c (*e.g. Isohypsibius* "smooth" and *Dactylobiotus* spp. are found in the deeper sites and *I.* "rough" in the shallow sites, etc.). As may be expected with a non-uniform substrate, the total numbers at each site vary between the two samples. However, in the tardigrades (Fig. 5a) there was a remarkable similarity in population numbers between the two samples at each site, with the exceptions of sites at 6 m and 10 m. The frozen 6 m site sample had much less algal mat than the fresh sample, and so had correspondingly low numbers of all the microinvertebrates. In the case of the 10 m sample, although there was no visible difference in substrate between fresh and frozen 10 m site samples, tardigrade numbers were affected.

Further work, not presented in this paper, has shown that the basic trends described above are to be observed in all samples, and the population numbers, which are essentially very similar, vary from sample to sample, usually in association with slight variations in the substrate. The results therefore indicate that reliable counts can be made

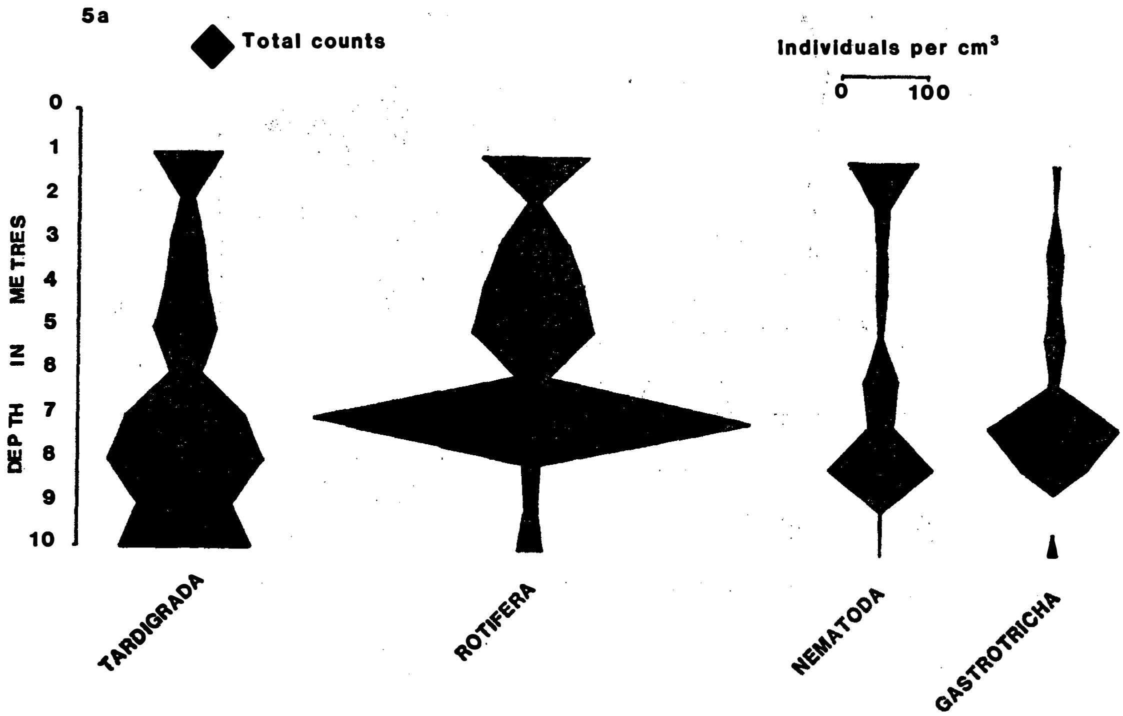


Fig. 5a. Four main benthic groups found in the frozen material.

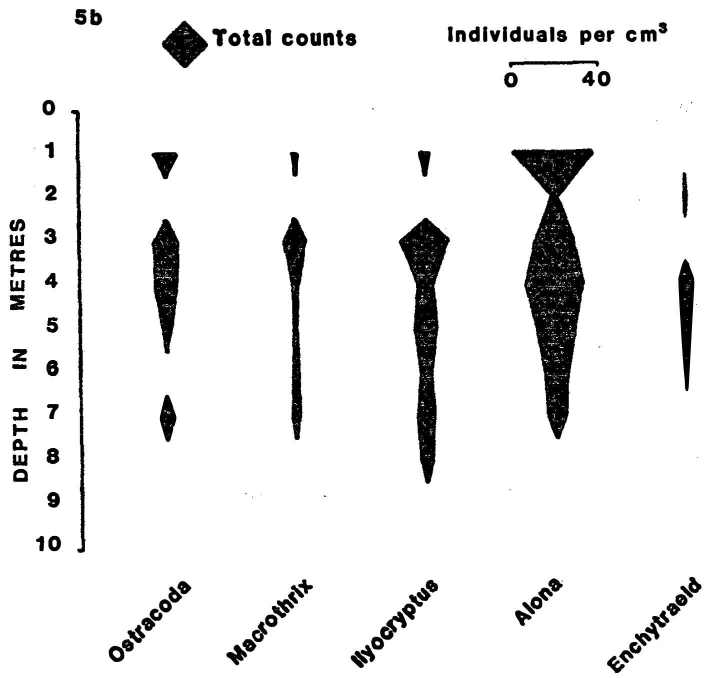


Fig. 5b. Additional micro-invertebrate groups observed in the frozen material.

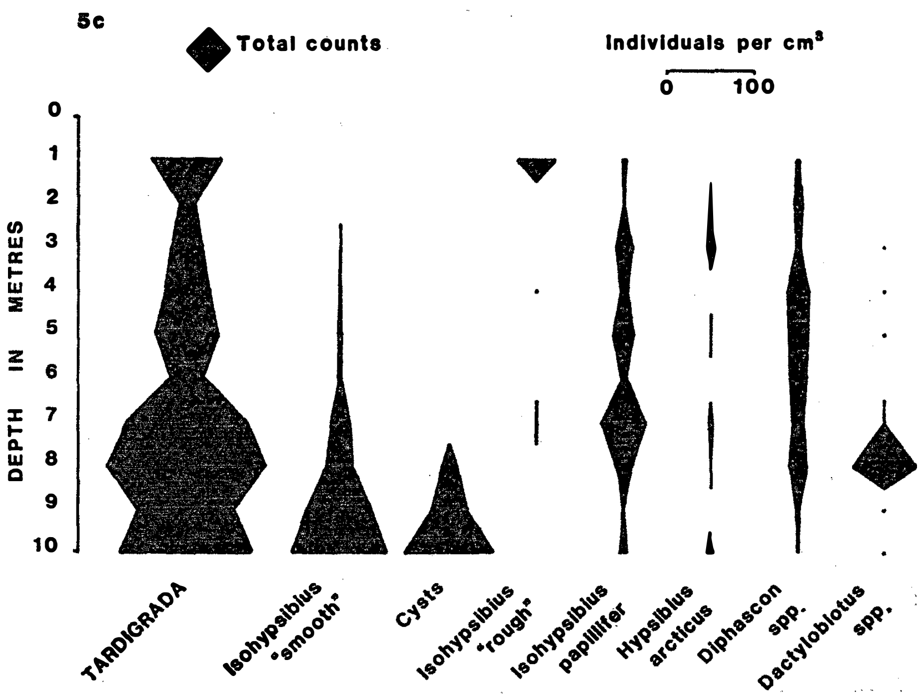
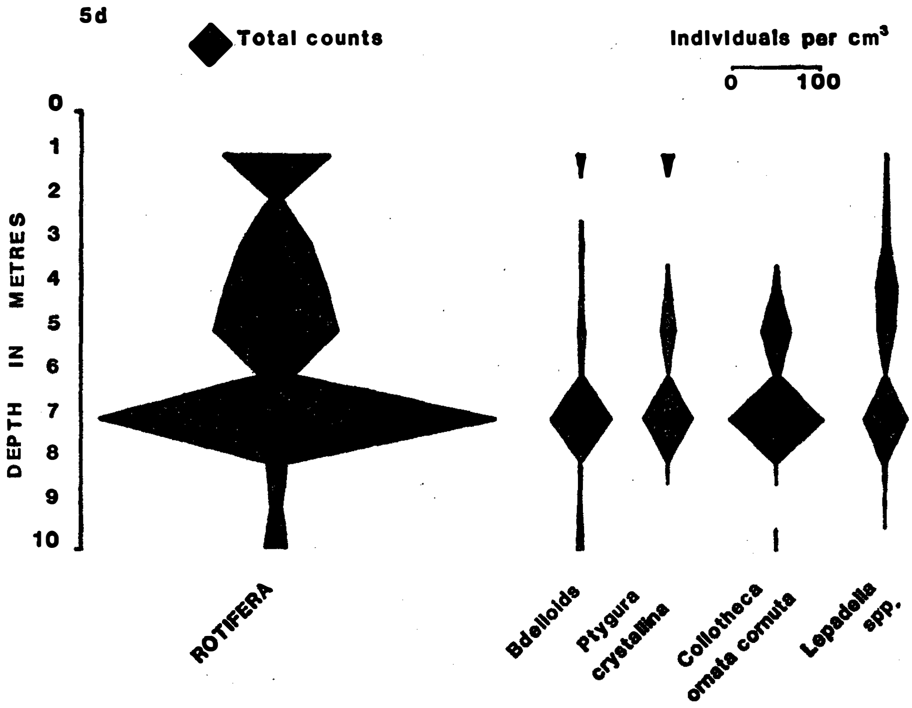


Fig 5c. More detailed study of the tardigrades from frozen material.



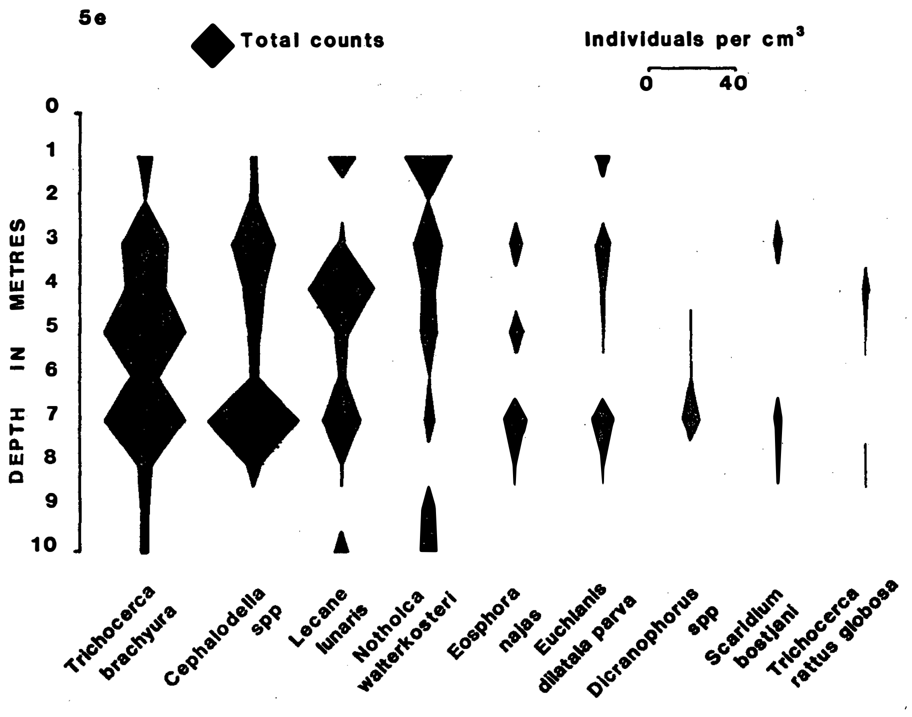


Fig. 5d, e. More detailed study of the rotifers from frozen material.

from the frozen material, but, due to the mortality of the micro-invertebrates in the frozen samples, no indication of the live to dead ratio can be made. This obviously restricts the scope of the data from frozen material, and results, such as those observed from the deep site in the fresh material (Fig. 4a, 10 m site) particularly in relation to the tardigrades, would be lost.

In the rotifer group (Fig. 5d, e) detailed study indicated the greatest diversity and numbers again occurred between 5–8 m, and that certain groups/species, such as the "Bdelloids", and *Ptygura crystallina* and *Collotheca ornata cornuta*, were almost exclusively linked with the perennial algal mats. Perhaps it is significant that these are mainly sessile organisms, whereas the more mobile species *e.g. Trichocerca brachyura, Cephalodella* spp. and *Notholca walterkosteri*, and predatory species *e.g. Eosphora najas* and *Euchlanis dilatala parva*, show a broader distribution on the whole. It was noted that the very seasonal shallow site was dominated by *Notholca walterkosteri*, a preference not previously reported. In Dartnall and Hollowday (1985) *Notholca salina*, in the absence of *N. walterkosteri*, was reported from the shallow pool sites, but was absent from the shallow lake sites.

It is clear from the data presented here that sampling only in the shallow shelf region includes terrestrial species whilst omitting those species which prefer the deeper sites. Similarly sampling only mid-depth or deep sites (a popular limnological practice) would show only part of the complex structure of micro-invertebrate population ecology. Given the considerable range of substrata and the associated fluctuations in benthic micro-invertebrates along a depth-related transect in this "simple" polar lake system, single site sampling to assemble whole lake species lists, and/or discern population trends, will clearly give very misleading information.

5. Conclusion

1) There is a considerable range in both substrate type and the degree of seasonal change in environmental variables experienced along a depth transect in this supposedly simple Antarctic freshwater lake.

2) For micro-invertebrates, species diversity was limited, but population numbers could be high.

3) Highest numbers were associated with those depths which had the most extensive coverage of perennial vegetation.

4) Throughout the transect distinct depth/habitat preferences were noted within groups and species. In the shallow sites, which are ice-free only in summer, *Isohypsibius* "rough" and *Notholca walterkosteri* occurred in high numbers. In the deep sites there occurred species apparently capable of tolerating winter anoxia, these being largely comprised of tardigrades, and in particular *Isohypsibius* "smooth".

5) Clearly frozen material can be used for qualitative distribution studies, so permitting larger numbers of samples to be taken, but equally it cannot be used to indicate the proportions of live and dead animals, as in the case of the deep spot (10 m, Fig. 4a), where large total counts belie the few live specimens.

6) Single site sampling will potentially give very misleading data on faunal diversity and population numbers within a lake.

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References

DARTNALL, H. J. G. and HOLLOWDAY, E. D. (1985): Antarctic rotifers. Br. Antarct. Surv. Sci. Rep., **100**, 46 p.

ELLIS-EVANS, J. C. (1984): Methane in maritime Antarctic freshwater lakes. Polar Biol., **3**, 63–71.

HAWES, I. (1983): Nutrients and their effects on phytoplankton populations in lakes on Signy Island, Antarctica. Polar Biol., **2**, 115–126.

HAWES, I. (1985): Factors controlling phytoplankton in maritime Antarctic lakes. Antarctic Nutrient Cycles and Food Webs, ed. by W. R. SIEGFRIED *et al.* Berlin, Springer, 245–252.

HAWTHORN, G. R. and ELLIS-EVANS, J. C. (1984): Benthic Protozoa from maritime Antarctic freshwater lakes and pools. Br. Antarct. Surv. Bull., **62**, 67–81.

HEYWOOD, R. B. (1987): Limnological studies in the Antarctic Peninsula region. Antarctic Aquatic Biology, Biomass Volume 7, ed. by S. Z. EL-SAYED. Cambridge, SCAR, 157–173.

HEYWOOD, R. B., DARTNALL, H. J. G. and PRIDDLE, J. (1980): Characteristics and classification of the lakes of Signy Island, South Orkney Islands, Antarctica. Freshwater Biol., **10**, 47–59.

JENNINGS, P. G. (1976): The Tardigrada of Signy Island, South Orkney Islands, with a note on the Rotifera. Br. Antarct. Surv. Bull., **44**, 1–25.

JONASSON, P. M. (1979): The lake Myvatn ecosystem, Iceland. Oikos, **32**, 289–305.

LEWIS SMITH, R. I. (1984): Terrestrial plant biology. Antarctic Ecology, Vol. 1, ed. by R. M. LAWS. London, Academic Press, 61–163.

LINDEGAARD, C. (1979): The invertebrate fauna of Lake Myvatn, Iceland. Oikos, **32**, 151–161.

MCINNES, S. J. and ELLIS-EVANS, J. C. (1987): Tardigrades from maritime Antarctic freshwater lakes. Biology of Tardigrades, ed. by R. BERTOLANI. Selected Symposia and Monographs U.Z., W.I., 1. Modena, Mucchi, 111–123.

RAMAZZOTTI, G. and MAUCCI, W. (1983): Il philum Tardigrada. (III edizione riveduta e aggiornata). Mem. Ist. Ital. Idrobiol., **41**, 1012 p.

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