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# Invertebrates associated with moss communities at Canada Glacier, southern Victoria Land, Antarctica

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**Abstract.** The invertebrate faunal composition of moss-dominated flushes near the Canada Glacier was, as in similar habitats in continental Antarctic regions, numerically dominated by protozoa, rotifers, nematodes and tardigrades. Mites were of lesser abundance. Although collembola occur in the Taylor Valley, none were found at the study site. The finding of a catenulid flatworm is significant as microturbellarians have only rarely been recorded from Antarctica. Nematode, tardigrade and rotifer densities recorded were comparable to those in other Antarctic regions. These groups were found at a mean depth ranging from 5 to 10.83 mm in the moss. A greater percentage of all groups were in the upper 5 mm of moss cores in post-melt samples than in pre-melt samples.

In the Antarctic region, in areas free of permanent snow and ice, there is an abundant invertebrate fauna. Arthropods, especially Collembola, dominate the macroscopic fauna and various microscopic invertebrates, including nematodes, tardigrades, mites and rotifers, are abundant (Block 1984).

Ecological investigations on these communities include studies of the distribution, habitats and physiology of arthropods, and their interactions with the environment (e.g. Block 1984, and references therein; Usher and Booth 1984, 1986; Block 1985). Quantitative studies of nematodes, rotifers and tardigrades have been conducted on Signy Island (e.g. Jennings 1979; Spaull 1973; Maslen 1981) and in the Vestfold Hills (Rounsevell 1981; Rounsevell and Horne 1986). Aquatic microfaunas have been described from the Vestfold Hills by Everitt (1981), from Signy Island by McInnes and Ellis-Evans (1990), from melt ponds on the Ross Ice Shelf by Suren (1990) and at Schirmacher Oasis (Ingole and Parulekar 1990).

During the austral summer of 1989/90, we carried out a preliminary study of the invertebrates inhabiting bryophyte-dominated flushes at Canada Glacier in the lower Taylor Valley, southern Victoria Land. The study concentrated on distribution and abundance of animals in relation to habitat as indicated by plant species dominance and location.

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## *Site description*

The flushes lie within the Site of Special Scientific Interest (S.S.S.I) No. 12, located on the eastern margin of the lower part of the Canada Glacier. The study was carried out in accordance with a New Zealand D.S.I.R. permit regulating access to the S.S.S.I. The site contains areas of rich plant growth associated with the summer melt runoff from the Canada Glacier. The two principal areas of plant growth selected for study were along the eastern flank of the glacier, separated by Canada Pond, and designated as the "upper" flush and "lower" flush as described in Schwarz et al. (1992).

The lower flush slopes downhill, northeast from the glacier, toward Canada Pond with an overall fall in elevation of 5.4 m. The flush is delimited by the peripheral extent of plant growth and covers an area of around 7150 $m^2$ (130 m long and 55 m wide). The main watercourse flowing onto the flush divides into two courses approximately 45 m from the glacier face, rejoining 30 m further downslope and narrowing overall to a 10 m-wide band draining into Canada Pond. The upper flush slopes uphill north and northwest of Canada Pond and is fed from the northern lateral face of the glacier and an ice-cored lateral moraine. In late November 1989, melt water first began to flow onto the flushes and by early December much of the vegetation in lower lying areas was completely submerged.

Four ecological zones, based on pattern of water flow and plant distribution, were assigned to the lower flush (Schwarz et al. 1992). Zone 1: Area receiving earliest meltwater. Generally the lowest lying ground dominated by *Nostoc* spp. and other Cyanobacteria, and *Bryum argenteum*. Zone 2: Receiving seepage meltwater during early weeks of flow. Transitional zone from *B. argenteum* to *Pottia heimii* dominance. Zone 3: Receiving water only during full flow and mostly via seepage from adjacent areas. Dominated by *P. heimii.* Zone 4: Driest area. Dominated by mineral salts-encrusted *P. heimii*, receiving water largely from subsurface permafrost melt. Salt encrustations are derived from surface water evaporation.

### *Climate*

In the Dry Valleys, relatively warm temperatures and the predominance of light winds blowing up or down the valleys keeps the area substantially free of snow in summer. At the Canada Glacier site, a number of factors contribute to an amelioration of the local climate experienced. The glacier provides protection from strong westerly katabatic winds and acts as a deflecting barrier to the gentler easterly winds. Effective temperatures are thus warmer than those experienced by more exposed sites. The close proximity of the glacier also provides protection from the abrasive effects of wind-blown ice crystals or sand.

## Methods

### *a) Microclimate*

Moss and air temperatures were recorded using a "Fluke" digital thermometer with 0.1°C resolution. Recordings were made over four diel periods at 2 h intervals during November and December 1989. The measurement site was in an area of *B. argenteum* turf, on the lower flush, at an elevation of 3.8 m from Canada Pond. Air temperatures were measured 10 cm above the moss surface. Temperatures in the moss turf were measured at depths of 5, 10 and 15 mm.

### *b) Invertebrates*

(*i*) *Community composition.* All samples for quantitative analysis were obtained from the lower flush. For overall species composition, a small number of additional samples were taken from the upper flush. Transects were laid across the main flow channel of the lower flush at five locations (Schwarz et al. 1992). At least five core samples were obtained per transect for invertebrate population assays. The cores were extracted with a 1 cm diameter cork borer which was pushed into the plant material to the substrate. The samples were kept to this small size to minimize disturbance at the site. Although small core size complicates interpretation of scales of pattern (Usher and Booth 1986), an indication of invertebrate distribution can be obtained. Cores were placed in sterile 'whirl-paks' (NASCO Ltd) and, if necessary, stored frozen until analysis. The shallow depth of the plant material permitted total animal counts in each core sample. Core samples were teased out in a thin layer of water in a petri dish. Animal counts were made in a perspex Bogorov chamber (channel width 10 mm) using a dissecting microscope (× 50 magnification). Rotifers, nematodes and tardigrades were identified to genus level using Dartnall and Hollowday (1985), Timm (1971) and Dastych (1984).

(*ii*) *Invertebrate abundance and distribution.* To obtain an estimate of invertebrate distribution across different plant community types, cores were taken from each recognizable community zone. Within each community sampling was non-random. Invertebrate numbers in each core were determined as described above. The most extensive sampling (14/15 November) was prior to meltwater flow across the flush (pre-melt), when invertebrates from one core per zone from each transect were counted. At this time, the moss and algal vegetation was in a freeze-dried condition. Animals were dormant but activity resumed within a few minutes of wetting core samples of vegetation in the field laboratory. Samples were also taken post-melt (8–10 December) after meltwater had been on the flush for 14 days. Most samples were assayed soon after collection in a field laboratory, although some were transported frozen to New Zealand for analysis.

Each core was sectioned into three layers 5 mm thick, wetted and left at around 2°C for 1 h before counting. A 1 h emergence period was chosen after a preliminary series of hourly counts over 24 h indicated little increase in numbers after 1 h. Mean densities per core were calculated from 20 pre-melt and 16 post-melt cores and expressed as densities (numbers per square metre) to enable comparisons with other studies. To determine if interzonal differences in animal densities were significant, pre-melt counts were analysed using the non-parametric Friedman test. If significant differences in densities were found between zones, multiple comparisons were carried out between zone pairs (Steel and Torrie 1960).

The vertical distribution of rotifers, nematodes and tardigrades within the moss turf cores was calculated from counts of each 5 mm section of both pre- and post-melt cores. The vertical distribution in four samples from each zone is summarised using the mean depth statistic ($\bar{D}$) (Usher and Booth 1984), given by $\bar{D} = \sum_{i=1}^{3} n_i (5i - 2.5) \Big/ \sum_{i=1}^{3} n_i = 5\left(\sum_{i=1}^{3} i n_i \Big/ \sum_{i=1}^{3} n_i\right) - 2.5$. Where $n_i$ is the number of invertebrates in the i-th layer, $i = 1$ for the uppermost layer (central depth 2.5 mm) and $i = 3$ for the lowermost layer (central depth at 12.5 mm), and $5 =$ depth in mm of layer.

## Results

### *a) Microclimate*

There was a consistent diel temperature fluctuation with an increase in average temperature as the summer progressed (Fig. 1). Between 2200 and 0400 hours, when the

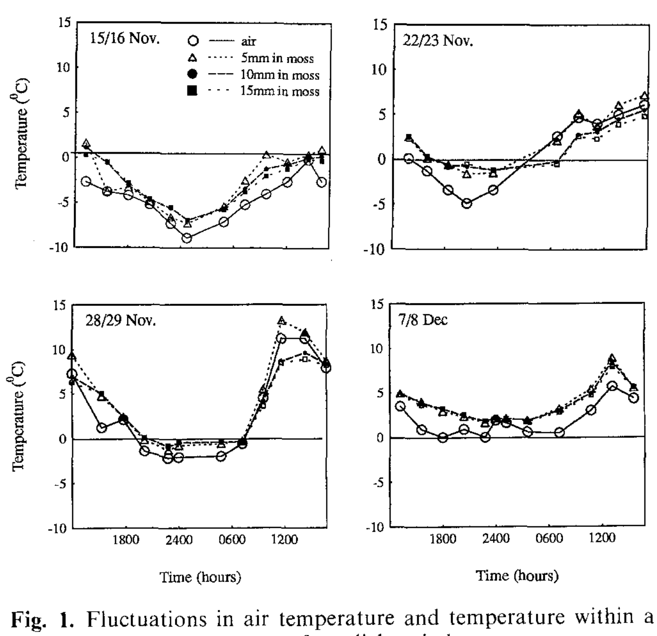


**Fig. 1.** Fluctuations in air temperature and temperature within a bed of *Bryum argenteum* over four diel periods

air temperature was lowest for the diel period, moss temperatures consistently remained higher than air temperatures. The capacity of the moss to buffer against air temperature changes means that, during the diel study periods, the mosses had a higher average temperature than the air. As water flow increased over the flush, temperature differences between the different sampled layers of the moss turf disappeared.

Daytime air temperature increased between 15/16 November and 22/23 November (Fig. 1) and, after 22/23 November, meltwater became visible on the flush itself. Subsequently, as temperatures fluctuated about 0°C with cloudy or clear skies, the amount of water on the flush varied. By 7 December, following extended periods of temperatures above 0°C, water was flowing over the entire flush.

### *b) Invertebrates*

*Community composition.* Protozoa, rotifers, nematodes and tardigrades were the dominant groups found in both the upper and lower flush (Table 1). A single turbellarian specimen, apparently of the Order Catenulida (Edmondson 1966), was recovered from a core of *Nostoc* over *Bryum argenteum* from zone 3, at an elevation of 3.6 m on the lower flush. Mites were not observed in the field but were seen in samples examined later in New Zealand, presumably being present as eggs or in a larval state in the samples and thus not noted at the time of field examination. Mites were found only in samples from one transect, in the encrusted *Pottia* zone that had been wetted for up to 10 days. Their densities reached 23 animals per 1 cm core. Although the identification of the mites has not been confirmed, Strandtmann et al. (1973) and Block (1985) have reported *Stereotydeus mollis* from the Canada Glacier flush. Collembola were not observed in either the upper or lower flush but have been recovered from ephemeral stream courses in the lower Taylor Valley, and were recovered from samples taken from north facing slopes between the Crescent and Howard Glaciers on the south side of the valley.

**Table 1.** Invertebrate taxa from Site of Special Scientific Interest No. 12

| Phylum | | Genus |
|---|---|---|
| Protozoa | | |
| Platyhelminthes | Class: Turbellaria | |
| | Order: Catenulida | |
| Rotifera | Class: Bdelloidea | *Philodina* sp. |
| | | *Habrotrocha* sp. |
| | Class: Monogononta | *Epiphanes* sp. |
| Nematoda | Order: Araeolaimida | *Plectus* spp. |
| Tardigrada | | *Macrobiotus* spp. |
| Arthropoda | Class: Arachnida | *Stereotydeus* spp. |

*Invertebrate abundance and distribution.* Animals were not active within the flush pre-melt and counts from samples taken at this time are therefore an indication of the potential inoculum which would become active as soon as free water became available. Protozoa were observed but not quantified. They appeared to be present in greater numbers than other groups. Pre-melt densities of rotifers (Table 2) ranged from a maximum of $112 \times 10^3\ m^{-2}$ in zone 2, to a minimum of $66 \times 10^3\ m^{-2}$ in zone 4. Pre-melt nematode densities ranged from $122 \times 10^3\ m^{-2}$ in zone 2 to $18 \times 10^3\ m^{-2}$ in zone 4. Tardigrade counts ranged from $60 \times 10^3\ m^{-2}$ in zone 3 to $14 \times 10^3\ m^{-2}$ in zone 4. Only for nematodes were significant differences found between zones, with numbers significantly lower in zone 4 (encrusted *Pottia*) than in zones 2 and 3 ($P < 0.05$).

With meltwater flowing over the flush, rotifers emerged from their overwintering state and were observed actively

**Table 2.** Invertebrate densities on the lower flush before the summer melt (pre-melt) and after water was flowing over the plants (post-melt)

| Group | | Zone 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|---|
| | | $(\bar{x}) \times 10^3$ [a] (SE) ($n$) | $(\bar{x}) \times 10^3$ (SE) ($n$) | $(\bar{x}) \times 10^3$ (SE) ($n$) | $(\bar{x}) \times 10^3$ (SE) ($n$) | mean[b] (range) |
| Rotifera | Pre-melt | 84 | 112 | 110 | 66 | 92 |
| | | 23 (5) | 33 (5) | 39 (5) | 25 (5) | (0–230) |
| | Post-melt | 94 | 548 | 190 | 173 | 268.8 |
| | | 31 (5) | 146 (5) | 24 (3) | 154 (3) | (0–930) |
| Nematoda | Pre-melt | 80 | 122 | 102 | 18 | 88.5 |
| | | 32 (5) | 41 (5) | 25 (5) | 13 (5) | (0–270) |
| | Post-melt | 364 | 250 | 430 | 157 | 314.4 |
| | | 89 (5) | 80 (5) | 101 (3) | 36 (3) | (80–670) |
| Tardigrada | Pre-melt | 24 | 56 | 60 | 14 | 40 |
| | | 13 (5) | 24 (5) | 32 (3) | 8 (5) | (0–180) |
| | Post-melt | 62 | 48 | 123 | 17 | 65 |
| | | 38 (5) | 26 (5) | 36 (3) | 12 (3) | (0–210) |

SE, Standard error; $n$, number of samples
[a] Data are mean densities per $m^2$ in each zone
[b] Mean densities over all zones with ranges

feeding, moving about, or in a contracted state. Logistic constraints meant that insufficient samples could be taken after meltwater began affecting the flush to enable a Friedman test analysis. However, it is evident from Table 2 that there is a large increase in numbers of both rotifers and nematodes post-melt. Post-melt rotifer counts underestimate numbers since, to avoid non-viable individuals, only mobile or feeding animals were counted. To indicate the effect of counting all individuals, the inclusion of contracted individuals in two samples where *Philodina* dominated brought the counts from 40 and 48 individuals per core to 240 and 205 individuals respectively. The lower densities were used in analysis.

*Vertical distribution of invertebrates.* While there appeared to be no significant trends in rotifer densities with depth in pre-melt samples, nematodes were found deeper in zone 4 (driest) than in other zones. The mean depth for all groups of animals ranged from 5 to 10.83 mm. In post melt samples, rotifers were evenly distributed with depth in zones 1–3 but were closer to the surface in zone 4. Nematodes and tardigrades had a shallower $\bar{D}$ in all zones in post-melt samples than in pre-melt samples. In both pre- and post-melt samples, tardigrades had a shallower mean depth in zone 4 than in other zones.

Table 3 summarises the percentage contribution of each group of animals within each depth class. In the pre-melt samples there was little obvious difference between depths, although in zone 4 there were almost always fewer individuals in the deepest 5 mm of the moss core. There were few nematodes, no rotifers and no tardigrades found in the deepest 5 mm of zone 4 in post-melt samples. A greater percentage of all groups were in the upper 5 mm in post-melt samples than in pre-melt samples.

## Discussion

Despite the harshness of conditions in the Dry Valleys, the fauna of the bryophyte flushes is dominated by microscopic cryptobiotic invertebrates and is similar to that of moss felts elsewhere in Antarctica (Block 1984). The occurrence of a catenulid flatworm at the Canada Glacier is a significant find since microturbellarians have rarely been recorded from continental Antarctica. Dougherty and Harris (1963) reported microturbellarians in freshwater bodies of Ross Island and Victoria Land, but emphasized that while nearly all samples of wet algal felt they examined contained populations of rotifers, nematodes and tardigrades, the occurrence of microturbellarians was sporadic. However, Ingole and Parulekar (1990) reported turbellaria as being dominant over tardigrada and rotifera at Priyadarshani Lake, Schirmacher oasis, and putative Turbellarian eggs have been identified from freshwater bodies in the Bunger Hills (D. Hay, personal communication).

Mites were collected from the Lake Fryxell area in 1972 (Strandtmann et al. 1973), in 1980/81 (Greenfield and Wilson 1981), and in 1984/85 (Block 1985). Strandtmann (personal communication) found mites to be present in some areas and absent in other apparently identical areas, as also found in this study. That mites emerged from the core samples only under laboratory conditions in New Zealand may indicate that, for emergence from a larval state, they require a longer period of higher temperature and humidity than they had been subjected to naturally at the time of sampling.

The absence of Collembola at the Canada Glacier flush was also noted by Greenfield and Wilson (1981) although they have been collected from northerly facing slopes and ephemeral melt channels in the Taylor Valley. Where collembolans have been found in Antarctica they are often concentrated under stones in areas apparently devoid of macroscopic vegetation, although at least microscopic algae and fungi are usually present. When temperatures are sufficiently high, they may become more active among bare or lichen-covered rock surfaces or move into available areas of vegetation (Janetschek 1967). Block (1985) reported that arthropod activity in the Ross Island/McMurdo Dry Valleys region of southern Victoria Land was highest at microsites where both vegetative growth and moisture were present.

Our results showed that there were lower numbers of tardigrades than either rotifers or nematodes in both pre-

**Table 3a, b.** Percentage contribution of rotifers(R), nematodes(N) and tardigrades(T) at three depths within a moss core

**a** pre-melt

| Zone | 1 | | | 2 | | | 3 | | | 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | R | N | T | R | N | T | R | N | T | R | N | T |
| 0–5 | 33 | 46 | 45 | 29 | 38 | 35 | 37 | 44 | 25 | 26 | 25 | 50 |
| 5–10 | 45 | 22 | 18 | 13 | 38 | 30 | 16 | 22 | 44 | 37 | 67 | 50 |
| 10–15 | 22 | 32 | 36 | 58 | 24 | 35 | 47 | 33 | 31 | 37 | 8 | 0 |

**b** post-melt

| Zone | 1 | | | 2 | | | 3 | | | 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | R | N | T | R | N | T | R | N | T | R | N | T |
| 0–5 | 54 | 70 | 63 | 24 | 63 | 42 | 28 | 54 | 76 | 88 | 75 | 88 |
| 5–10 | 16 | 19 | 17 | 32 | 20 | 33 | 25 | 26 | 14 | 12 | 17 | 12 |
| 10–15 | 30 | 10 | 20 | 44 | 17 | 25 | 47 | 19 | 10 | 0 | 8 | 0 |

**Table 4.** Micro invertebrate densities ($\times 10^3$ m$^{-2}$) calculated from this study compared with published values

| Rotifers | 92/268.8 | This study (pre-melt/post-melt) |
|---|---|---|
| | 28 | Moss carpet (Jennings 1976) |
| | 931 | *Prasiola* (Jennings 1976) |
| | 426 | Cyanobacterial mat (Suren 1990) |
| Nematodes | 88.5/314.4 | This study (pre-melt/post-melt) |
| | 49.6 | (Suren 1990) |
| | 1200 | (Tilbrook 1967) |
| Tardigrades | 40/65 | This study (pre-melt/post-melt) |
| | 11 | Moss turf (Jennings 1976) |
| | 14130 | *Prasiola* (Jennings 1976) |
| | 309 | Dry moss turf (Jennings 1979) |
| | 713 | Wet moss carpet (Jennings 1979) |

and post-melt samples. Suren (1990) noted that nematodes were the least abundant of these three groups amongst cyanobacterial mats in ponds on the Ross Ice Shelf. Both pre- and post-melt rotifer densities calculated for the Fryxell flush are comparable with densities published for other areas of the Antarctic (Table 4). Nematode and tardigrade densities are also within the range of previously reported values (Table 4). Miller et al. (1988) reported a lack of association between tardigrades and plant species in the Vestfold Hills and that tardigrades occurred in a lesser number of samples than either rotifers or nematodes.

Our results confirm those of other studies which showed that the majority of invertebrates are usually found in the upper 1–3 cm of moss. Jennings (1979) found that 70% of tardigrades occurred within the upper 3 cm of moss on Signy Island, while Caldwell (1981) found the majority of nematodes to be in the upper 1 cm. Broady (1979) noted the presence of most algae in a restricted region of 0–6 cm down the bryophyte shoots on Signy Island, while Usher and Booth (1984) showed that the surface 1–1.5 cm of the moss turf is the zone where virtually all the primary production of mosses and algae occurs. These algae are potentially a major food source for grazing invertebrates.

The most abundant rotifers in the flush were bdelloids. Bdelloid rotifers have the ability to pass into a state of anabiosis when dried and may remain thus for years. Upon being rewetted they resume activity and are directly ready to deposit eggs. Parthenogenetic reproduction of bdelloid rotifers enables a rapid population increase early in the season as soon as free water is available (Everitt 1981). While no quantitative comparison was made in this study, monogonontid rotifers were more abundant in samples taken later in the sampling period.

Wetter zones of the Fryxell flush had significantly higher numbers of nematodes than the driest zone. A survey of terrestrial nematodes of the McMurdo Sound region by Wharton and Brown (1989) noted that numbers of animals varied considerably even in different samples from the same general area. In general, algal samples contained greater numbers of nematodes than moss samples. Tilbrook (1967) found, on Signy Island, that nematodes were more numerous in wetter mosses. However, Spaull (1973) showed that while this is true there is no direct correlation between water content of mosses and total number of nematodes. Our findings are similar. Our results showed little increase in tardigrade numbers between pre- and post-melt sampling possibly due to the comparatively long life cycle and thus slow development rate of these animals (Rounsevell and Horne 1986).

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