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Studies on Antarctic soil invertebrates: Preliminary data on rotifers (Rotatoria), with notes on other taxa from Edmonson Point (Northern Victoria Land, Continental Antarctic)

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Abstract. This work reports preliminary data on the biology and chemistry of soil habitats at Edmonson Point, Wood Bay, Northern Victoria Land, Ross Sea Sector of the Continental Antarctic. Forty-one soil samples were collected from 5 different soil habitats during summer in 2003/04 and 2004/05. Altogether 19 species of soil invertebrates were identified including 9 Rotifera, 4 Nematoda, 5 Oribatida and 1 springtail (Collembola). In general, soil invertebrate communities were dominated by rotifers with nematodes and tardigrades significantly less numerous. Abundances of all invertebrates varied and ranged from 0 to 7,760, 2,312 and 1,824 individuals per 100 g of soil for rotifers, nematodes and tardigrades, respectively. There were no invertebrates in 22% of the soil samples, the majority of which were soils from active and relic penguin rookeries. Although the physical and chemical characteristics of the soils differed, high soil water content (>20%) seemed to be the major factor determining distribution and abundance of invertebrates in Antarctic soils.

Key words. Soil zoology, ecology, soil biodiversity, Rotifera, Nematoda, Tardigrada, Oribatida, Collembola, Antarctic, Northern Victoria Land.

INTRODUCTION

On Continental Antarctic, soil habitats are among the most physically and chemically demanding environments on Earth and were once considered to be devoid of life. Despite being subjected to extreme environmental stresses (i.e., freezing and desiccation), these soils do support life. There are no vascular plants so the communities are dominated by microbiota such as algae, cyanobacteria, bacteria and microfungi, and a mesofauna consisting of springtails, mites, rotifers, nematodes,

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tardigrades and protozoans (Beyer & Bolter, 2002, Adams et al. 2006). Compared with soil habitats in other parts of the world, the diversity of Antarctic soil biotic communities is very low. As they are taxonomically and functionally simple, they are considered to be good bioindicators of environmental change. Given that climate change and human induced perturbations are likely to have a substantial effect on the functioning of Antarctic soil habitats studies on their biodiversity are needed (Wall 2005).

Although diversity, ecology and distribution patterns of soil invertebrates have been investigated in Victoria Land, much effort has focused on the areas within McMurdo Dry Valleys and Ross Island in Southern Victoria Land with little information available from Northern Victoria Land. Moreover, nematodes and microathropods (Acari and Collembola) have received the most attention while other taxonomic groups (i.e., tardigrades and rotifers) are less well studied (Adams et al. 2006). The primary objective of this research was to increase the knowledge on the occurrence, diversity and distribution of these least studied soil invertebrate taxa. This preliminary report of a survey of all soil invertebrates, with emphasis on rotifers, conducted in the Edmonson Point area (Northern Victoria Land), will provide a baseline for comparisons with other Antarctic sites.

MATERIALS AND METHODS

Study area

Edmonson Point (74°20'S, 165°08'E) is located in Wood Bay on the western coast of the Ross Sea, Northern Victoria Land, Continental Antarctic (Fig. 1). Being 1.79 km^2 in area it is one of the most extensive non-mountainous, coastal ice-free sites in Northern Victoria Land. The landscape of Edmonson Point was considerably modified by glacial and periglacial activity, resulting in a mosaic of hills (up to 300 m high), knolls and moraines, separated by small valleys with several ephemeral small melt-water streams, ponds and a few larger lakes. Such a range of freshwater habitats is unusual and the stream network is the most extensive in Victoria Land. Most of the area, however, is extremely dry with the ground covered by salt encrustations. The ground is dark coloured and consists of volcanic materials (scoria, pumice, tuff, lavas) which originated from past volcanic activity of Mount Melbourne. The soil is coarse textured (fine gravel or coarse sand) with a very low proportion of silt and clay. It is generally poor in nutrients however, due to the presence of breeding birds and abandoned penguin colonies, concentrations of nitrogen and phosphate can reach very high levels. The climate is typical of coastal areas in Continental Antarctic, with low temperatures (average monthly ranging from –2°/–5° C in January to –26°/–30° C in August), low humidity and low precipitation (100–200 mm). But Edmonson Point is well sheltered from local katabatic winds and its climate is milder than that of neighboring areas where the temperature during summer ranges between –15° and +5°C (Harris & Grant 2003).

As a result of the relatively mild climate, the abundance of melt water and bird-derived nutrients, Edmonson Point is characterized by a wide range of terrestrial habitats and relatively diverse biota. Flora of this area is entirely cryptogamic, consisting mainly of bryophytes (6 mosses, 1 liverwort) and lichens (ca. 30 species). The wide range of freshwater habitats account for the highest diversity of algae in Victoria Land, with over 120 species recorded there. The terrestrial fauna is limited to soil protozoans, rotifers, nematodes, tardigrades, springtails and mites (Harris & Grant 2003). Because of all these outstanding ecological features, Edmonson Point has been designated as an Antarctic Specially Protected Area (ASPA) No. 165 and therefore an exceptional site for research on biotic communities.

Soil sampling and processing

Sampling sites at Edmonson Point were surveyed during the summers of 2003/04 and 2004/05. The sampling locations represented a range of habitats with a diversity of soil physical and chemical characteristics, including soils of dry and bare fellfields, bryophyte communities, seepage areas and active and relic penguin colonies and their surroundings. The samples were collected from the upper 0–10 cm layer of soil using a sterile scoop, then placed in a sterile polyethylene bag (Whirl-Pack®) and mixed thoroughly. In addition, the undersides of several randomly chosen stones were inspected for microarthropods, mites and springtails, which were collected into ethanol using an aspirator. Within several hours of collecting, all samples were transported to the laboratories of the Italian Station "*Mario Zucchelli*" at Terra Nova Bay and frozen by reducing temperature over 48-h period from 1 to –20 °C. Frozen samples were shipped to the United States of America and Poland for processing.

A total of forty one soil samples were collected and the composition of invertebrate species subsequently determined. Soil invertebrates were extracted from subsamples of ~100-g of soil by wet-sieving followed by centrifugation (Freckman & Virginia 1993). Extracted invertebrates were counted and identified to species using morphological features.

RESULTS AND DISCUSSION

Overall, the soil biotic communities were very abundant and relatively complex. They consisted of bacteria, cyanobacteria, algae, microfungi, protozoans, nematodes, rotifers, tardigrades, mites and springtails. Among the soil invertebrates 19 taxa were identified including: 9 rotifers, 4 nematodes, 5 oribatid mites and 1 springtail. However, the list of soil invertebrate taxa is still incomplete as tardigrades and protozoans, and some specimens of rotifers and mites are still being studied.

In general, the soil invertebrate communities were dominated by rotifers (mean = 981.9 individuals/100 g soil) (Fig. 2). All the recorded rotifers belonged to the Bdelloidea represented by: (1) *Adineta grandis* Murray, 1910 (ca. 34% of all rotifers); (2) *Habrotrocha constricta* Dujardin, 1841 (ca. 24%); (3) *Habrotrocha* cf. *elusa* Milne, 1916 (ca. 36%); (4) *Habrotrocha* sp. 1 (ca.

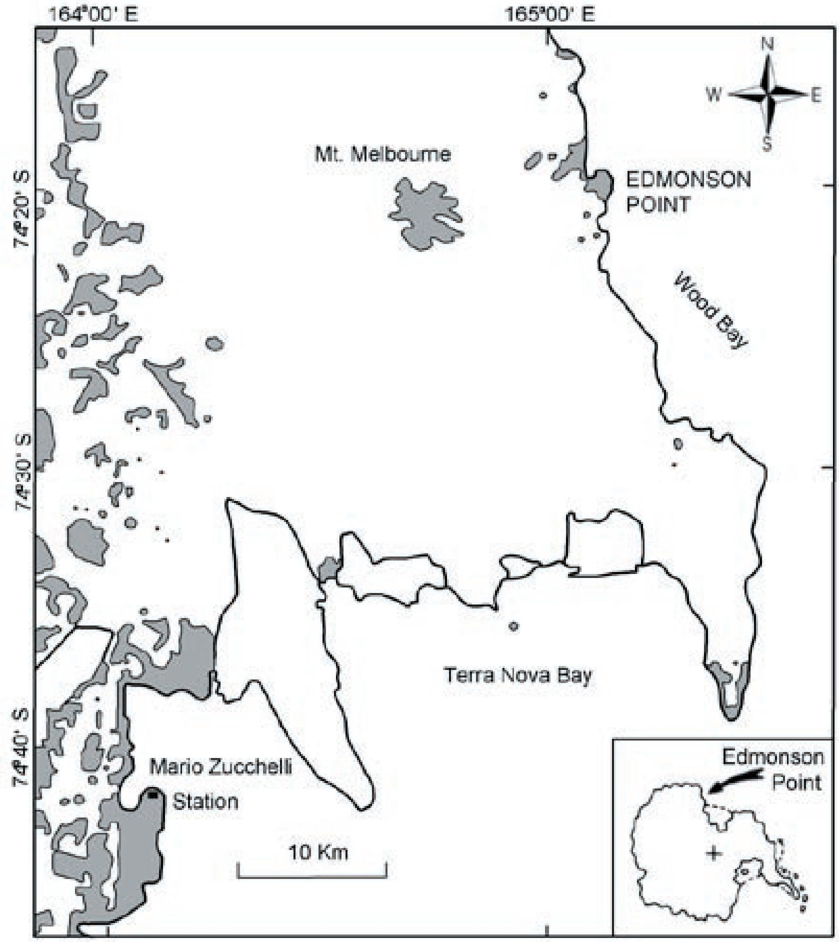

Fig. 1. Map showing the location of Edmonson Point in Northern Victoria Land. Insets show the position of Edmonson Point in the Antarctic.

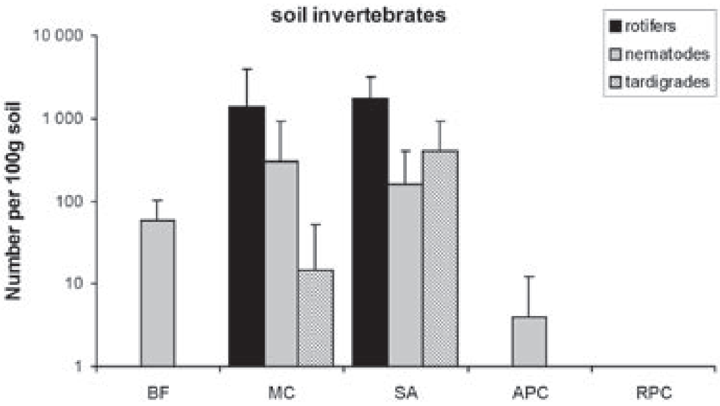

Fig. 2. Average number ± SD of invertebrates of particular taxa per 100-g of soil collected from different habitats. Data presented on a logarithmic scale. Abbreviations indicate: BF – barren fellfields, MC – moss communities, SA – seepage areas, APC – active penguin colonies, RPC – relict penguin colonies.

0.7%); (5) *Habrotrocha* sp. 2 (ca. 0.02%); (6) *Macrotrachela* cf. *insolita* De Koning, 1947 (ca. 4%); (7) *Macrotrachela* sp. (ca. 0.7%); (8) *Philodina* sp. (ca. 0.1%) and (9) *Rotaria rotatoria* Pallas, 1766 (ca. 0.1%). Previous studies report the occurrence of 11 Bdelloidea species in Victoria Land (Dartnall & Hollowday 1985, Adams et al. 2006). However, most of the reported rotifers came

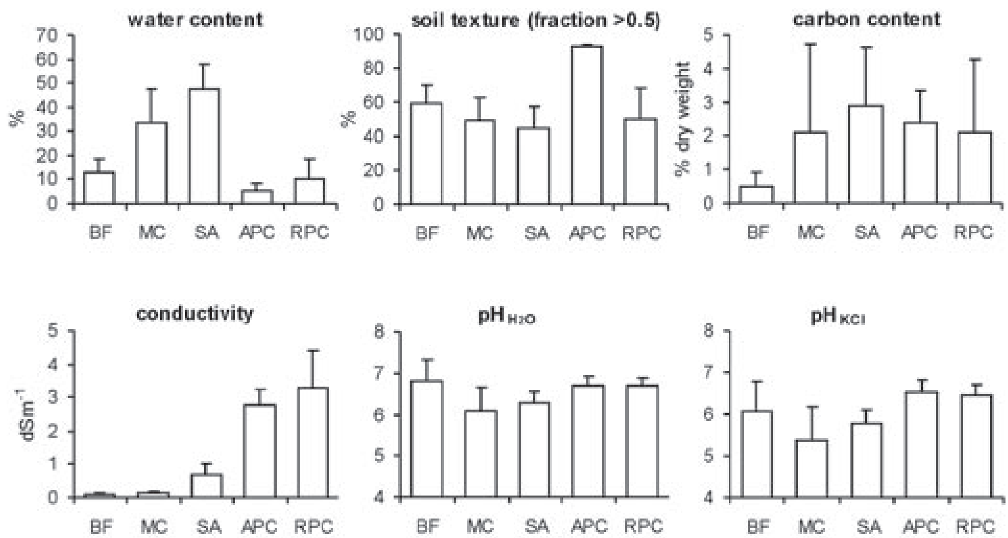

Fig. 3. Physico-chemical characteristics of soil habitats. Error bars denote SD. Abbreviations indicate: BF – barren fellfields, MC – moss communities, SA – seepage areas, APC – active penguin colonies, RPC – relict penguin colonies.

from aquatic environments with only 4 species from soil environments (Schwarz et al. 1993). The results presented indicate that the diversity of soil rotifers may be high.

Other invertebrate taxa, such as nematodes (mean = 162.5) and tardigrades (mean = 112.4), were less numerous than rotifers (Fig. 2). Nematodes are represented by: (1) *Eudorylaimus antarcticus* (Steiner, 1916) Yeates, 1970; (2) *Panagrolaimus davidi* Timm, 1971; (3) *Plectus antarcticus* de Man, 1904 and (4) *Scottnema lindsayae* Timm, 1971. Oribatid mites represented by: (1) *Liochthonius australis* Covarrubias, 1968; (2) *Neomycobates* sp.; (3) *Oppia loxolineata longipilosa* Covarrubias, 1968; (4) *Oppia* sp. and (5) *Quadroppia* sp. Springtails were only represented by: (1) *Gressittacantha terranova* Wise, 1967. While the same nematode and springtail species were reported previously from Victoria Land (Adams et al. 2006), the information on the mite species is novel. The only oribatid mite species (*Maudheimia petronia* Wallwork, 1962) reported before from this region (Sinclair & Stevens, 2006) was not recorded in this study.

Abundances of all invertebrates varied and ranged from 0 to 7,760, 2,312, and 1,824 individuals per 100 g of soil for rotifers, nematodes and tardigrades, respectively (Fig. 2). Rotifers were recorded in 25 (61%), nematodes in 29 (71%) and tardigrades in 14 (34%) of the samples. Springtails and mites were also recorded however, their abundances could not be determined using the method applied. Invertebrates were completely absent in 9 (22%) of the soil samples, majority of which came from active and relic penguin rookeries. Although the physical and chemical characteristics of the soil samples differed among the soil habitats investigated (Fig. 3), high soil water content (>20%) seemed to be the major factor determining the distribution and abundance of invertebrates.

Rotifers were recorded across a range of habitats and environmental gradients. Results indicate that rotifers are often the most numerous soil invertebrates with a wide distribution across Victoria Land and nearby islands (Adams et al. 2006). The abundance of rotifers can be very variable. The highest abundance of over 3,700 individuals per 100-g of dry sediment was recorded in cryoconite holes (Porazinska et al. 2004). However, despite the apparent similarities between cryoconite sediment and soil, water in cryoconite holes is not a limiting factor, which was confirmed by the presence of species of rotifer typical of aquatic environments (Adams et al. 2006). In soils, rotifer abundance is usually much lower, e.g. 0–147.6 (Porazinska et al. 2002), 4.9–607.9 (Gooseff et al. 2003) or 0–2.7 (Courtright 2001) individuals per 100-g of dry soil. In comparison, the numbers of rotifers recorded in this study are relatively high and this is probably because of the relatively high water availability in the soils investigated. Because soil rotifers inhabit soil particle water films, it is not surprising that soil moisture appears to be the most important factor determining their abundance. However, other environmental factors such as pH, nutrient availability, altitude (Porazinska et al. 2004) and soil organic matter (Sinclair & Sjursen 2001) also affect rotifer abundance.

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