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Moss-living nematodes from an Alpine summit (Dachstein, Austria)

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A survey was undertaken of the nematode fauna associated with moss (*Schistidium grande*, Fam. Grimmiaceae) at the summit of the mountain Dachstein (2995 m), Austrian Alps. The objective of this study was to examine which nematodes are capable of living under most extreme alpine conditions.
The nematode community consisted of two genera: the omnivore/predator *Eudorylaimus* sp. (Fam. Qudsianematidae) and the microbial-feeding nematode *Plectus* sp. (Fam. Plectidae). Additionally, one detritivorous, one phytophagous, and one predatory tardigrade species completed the microfaunal components of the food chain of these very small, isolated moss habitats.

HOSCHITZ M., 2003: Untersuchungen von im Moos lebenden Nematoden des Dachstein-Gipfels (österreichische Alpen).
Die Nematodenfauna von am Gipfel des Dachsteins (2995 m) wachsenden Moospolstern (*Schistidium grande*, Fam. Grimmiaceae) wurde untersucht. Ziel dieser Studie war es zu untersuchen welche Nematoden unter diesen extremen Bedingungen existieren können.
Die gefundene Nematodengemeinschaft setzte sich aus zwei Gattungen zusammen: den omnivoren/ räuberischen Nematoden *Eudorylaimus* sp. (Fam. Qudsianematidae) und den bakteriovoren Nematoden *Plectus* sp. (Fam. Plectidae).
Zusätzlich wurde in den Moospolstern je eine detritophage, eine phytophage und eine räuberische Tardigradenart gefunden. Gemeinsam mit den Nematoden vervollständigen sie die mikrofaunale Nahrungskette dieser in sich geschlossenen Kleinstlebensräume.

Keywords: nematode community, moss, extreme habitat, tardigrades, Alps.

Introduction

Organisms living at the top of high mountains are subject to some of the most extreme environmental conditions on earth, including freezing, desiccation but also high solar radiation. Due to their continuous exposure to these extreme conditions, some animals and plants have developed well adapted but still sensitive live forms and community structures which respond in characteristic ways to environmental changes. Climate change has profound implications for the composition, functional ecology, taxonomic diversity and feeding habits of the soil fauna (YEATES 1987; HODKINSON 1998) and floral communities (GRABHERR ET AL. 2000) of these altitudes. Alpine moss ecosystems are simple, with faunas consisting almost entirely of soil invertebrates including rotifers, tardigrades and nematodes. Due to their simplicity, bounded and isolated position, these moss systems are useful objects to study implications of global warming "in small".

Nematodes are key components of all soil food webs, playing a significant role in several ecosystem processes. In temperate systems for example, many nematode genera interact in the soil food web within four to five trophic groups: bacterial, fungal, and plant feeders, omnivores and predators. In temperate and tropical ecosystems nematodes are extremely diverse with up to several hundred species (ETTEMA 1998). Nematodes are also an important component of soil fauna in extreme ecosystems (FRECKMAN AND MANKAU 1986, WALL AND VIRGINIA 1999, LIANG ET AL. 2000) although often occurring as low-diversity communities. Studies of such naturally occurring low diversity nematode communities could provide a link and insights into the basic principles of complex soil systems and their complex relationship among diversity, stability, productivity and to the factors determining the length of food chains (MOORE ET AL 1996, FRECKMAN AND VIRGINIA 1997). The objective of this survey was to obtain information about (1) the nematodes which are able to live under extreme harsh conditions present at the top of high mountains and (2) their community structure. This paper is part of a first step to investigate nematode communities of extreme habitats of the Austrian Alps and their use as indicator organisms for global change studies.

Materials and Methods

Eleven moss samples (*Schistidium grande*, Fam. Grimmiaceae) growing on the upper most rock at the summit of the mountain Dachstein, Austrian Limestone Alps (2995 m, 13°36′23.3″ O; 47°28′32″ N), were collected. Sampling date was 12. 7. 2002. The sampled mosses were small isolated habitats of approximately 3cm in diameter. They represented the upper most vegetation and no organic input from above or from the ground which was approximately 1.5 m beneath, was possible. The samples were weighed and the seven most similar mosses (between 3.0 cm–3.4 cm in diameter and 1.4–1.9 g weight) were chosen for nematode extraction, by placing them in a Baermann funnel (BAERMANN, 1917) for 48 h at 18°C. A sieve with mesh size of 2 mm covered by a single layer of a "clinex paper" was used. Animals were killed and fixed in 4% formaldehyde and studied in glycerin slides. Water content of the mosses was 53%–60% (drying at 104°C for 10h). Other microfauna (tardigrades, rotifers, protozoa) in the sample were recorded.

Results

Nematodes were present in all moss samples collected. In total only two nematode species were found. *Plectus* sp. (Fam. Plectidae) was the eudominant (93%) species with a mean abundance of 27±7 individuals per moss sample (Fig. 1). Most of the individuals were mature females with eggs (sex ratio female/juvenile was 1.8 : 1), males were not found. The nematode *Eudorylaimus* sp. (Fam. Qudsianematidae) was found with a mean

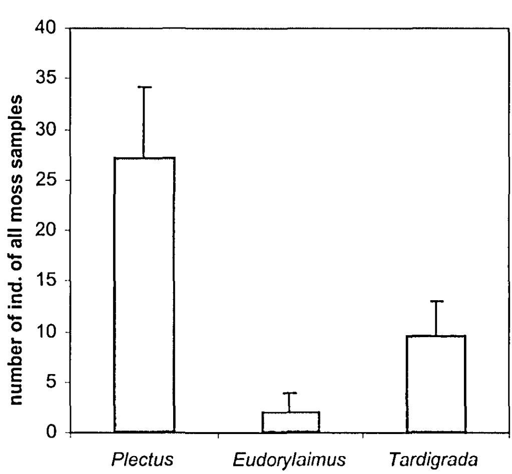

Fig. 1: Mean values and standard deviation of nematodes and tardigrades* of rock-dwelling mosses.* *values of tardigrades are the individual numbers found in the nematode suspension and are not quantitative because the extraction method used for nematodes was not appropriate for the extraction of tardigrades. – Mittelwerte und Standardabweichungen von Nematoden und Tardigraden* in Felsen besiedelnden Moosen. * Die Tardigradenzahlen beziehen sich auf die in den Nematoden-Suspensionen gefundenen Individuen und sind nicht quantifizierbar, da Extraktionsmethoden für Nematoden auf Tardigraden nicht anwendbar sind.

abundance of 2±2 per moss sample. Sex ratio female/juvenile/male was 1.5:1:1. The numbers of nematodes per sample were relatively similar (Fig. 2).

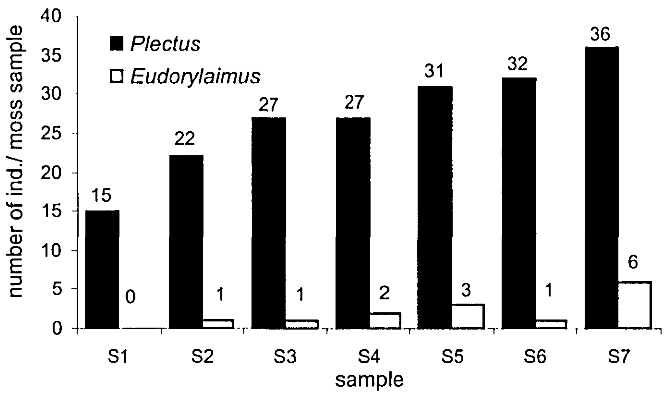

Fig 2: Individual numbers of the two nematode species found in the single moss samples. – Individuenzahlen der beiden Nematodenarten in den einzelnen Moosproben.

The nematode community presented here is one of the simplest, and those with the lowest number of species, found in alpine mosses until now. Compared with other records of moss-living nematodes, the diversity of these nematode communities was most similar to those of polar regions (Tab. 1).

Tab 1: Species richness of the nematode fauna in mosses of different regions. – Artenvielfalt der Nematodenfauna aus Moosen verschiedener Regionen

Number of species	**Sample locality**	**Reference**
Grassland and other non-woody land type		
48	Seeland, Denmark	MICOLETZKY, 1929
30	Signi Island, South Orkney Island	SPAULL, 1973
27	Mols, Denmark	NIELSEN, 1949
10	Pamir, Asia	MICOLETZKY, 1929
Polar land type		
6	Ross Island, Antarctica	WHARTON & BROWN, 1989
4	Dry Valleys, Antarctica	FRECKMANN & VIRGINIA, 1993
2	Ross Island, Antarctica	YEATES, 1970
Alpine summit		
2	Dachstein, Austria	this paper

Nematodes were found in association with tardigrades, and rotifers. The tardigrad *Milnesium tardigradum* (Fam. Milnesiidae), found in all investigated moss samples represents the top of the soil food web of this small habitat together with the nematode *Eudorylaimus* sp. (Fam Qudsianematidae). *M. tardigradum* is a carnivorous tardigrade, feeding on rotifers, nematodes and other tardigrades. Members of the genus *Eudorylaimus* are known to feed on a variety of foods including also other nematodes and are classified as omnivores/predators by YEATES ET AL. (1993). The trophic group of bacterial feeders was represented by the nematode *Plectus* sp. (Fam. Plectidae), the most abundant component of the microfauna dominated food web. The tardigrad *Echiniscus* sp. (Fam. Echiniscidae), a detritus and plant feeder, was also common, and in one sample the exuviae of *Hypsibius* sp. (Hypsibiidae) or *Macrobiotus* sp. (Fam. Macrobiotidae) was found. The food web documented here is very simple, with each trophic level occupied by more or less one microfaunal species.

Discussion

While moss-living nematode communities of temperate habitats were found to consist up to 48 different species (MICOLETZKY 1929), regions of extreme climatic conditions show only a fraction of these numbers. Low temperature and desiccation stress in alpine and arctic ecosystems have provided a selective filter. This filter has eliminated many organisms that might have dispersed to these regions (CHAPIN AND KÖRNER 1994). An interesting result of this study was that exactly the same genera of nematodes have been able to pass this filter in the Antarctic ecosystem on the one hand and in the Alps on the other hand. One main reason could be that the representatives of the genera *Plectus* and *Eudorylaimus* can use anhydrobiosis as a mean of coping with desiccating conditions or freezing conditions that occur when no water is present (PICKUP 1990). The tardigrades are also well adapted to these problems. They are tolerant to freezing conditions, surviving temperatures below freezing through the presence of cryptotectant compounds such as trehalose and ice nucleating compounds (WESTH AND KRISTENSEN 1992). Rotifers are able to survive both desiccation and freezing by entering anhydrobiotic state (RICCI 1987, SØMME 1995).

Based on the general feeding characteristics assigned to the genera, the nematode community of the mosses at the mountain Dachstein was found to be a bacterial feeder dominated food chain. This is similar to findings reported by FRECKMANN AND VIRGINIA (1990, 1991) at the Mc Murdo dry valleys, Antarctica and MOURATOV ET AL. (2001) at King George Island, Antarctica. In general, this alpine nematode community seems to be, beside the Antarctic nematode community of the Dry valley region and Ross Island (FRECKMANN &VIRGINIA 1997, FRECKMANN &VIRGINIA 1998, YEATES 1970), one of the simplest soil-living nematode assemblages on earth. Due to high diversity of soil living nematodes in most soils, usually more than one nematode species occupy a single trophic level in temperate soil systems. Especially the bacterial feeding nematodes are comprised of many species, with different metabolic requirements (SCHIEMER 1983, FERRIS ET AL. 1995) and habitat preferences (GRIFFITHS 1994). This complexity of nematode diversity and their connectivity to other phyla in the food web of most soils makes the identification of the control mechanisms on nematode diversity and their role in soil processes very difficult. Work with low diversity systems will allow a better understanding of the basic processes underlining this complexity.

The low invertebrate diversity of the investigated high mountain-mosses and their trophic groups, consisting of only one species each, suggest that this system will be highly disrupted by the loss or decline of even a single species that is sensitive to environmental change. Further studies of extreme habitats at high altitudes and/or high latitudes are necessary to understand their role and the potential of their organisms as bioindicators of a changing climate.

References

BAERMANN G., 1917: Eine einfache Methode zur Auffindung von Ankylostomum (Nematoden)-Larven in Erdproben. Meded. Geneesk. Lab. Weltevreden, 41–47.

CHAPIN F.S. & KÖRNER, C., 1994: Arctic and alpine biodiversity: patterns, causes and ecosystem consequences. Tree 9, 39–78.

ETTEMA C. H., 1998: Soil nematode diversity species coexistence and ecosystem function. Journal of Nematology 30, 159–169.

FERRIS H., LAU S. & VENETTE R., 1995: Population energetics of bacterial-feeding nematodes: respiration and metabolic rates based on carbon dioxide production. Soil Biology and Biochemistry 27, 319–330.

FRECKMAN D. W. & MANKAU R., 1986: Abundance, distribution, biomass and energetics of soil nematodes in a Northern Mojave Desert ecosystem. Pedobiologia 29, 129–142.

FRECKMAN D. W. & VIRGINIA R. A., 1990: Nematode ecology of the McMurdo Dry Valley ecosystem. Antarctic Journal of the U.S. 25(5), 229–230.

FRECKMAN D. W. & VIRGINIA R. A., 1991: Nematodes in the McMurdo Dry Valleys of southern Victoria Land. Antarctic Journal U.S. 26(5), 233–234.

FRECKMAN D. W. & VIRGINIA R. A., 1993: Extraction of nematodes from dry valley antarctic soils. Polar Biology 13(7), 483–487.

FRECKMAN D. W. & VIRGINIA R. A., 1997. Low-diversity Antarctic soil communities: Distribution and response to disturbance. Ecology 78, 363–369.

FRECKMAN D. W. & VIRGINIA R. A., 1998: Soil biodiversity and community structure in the McMurdo Dry Valleys, Antarctica. Pages 323–336 in J. C. Priscu, ed. Ecosystem Dynamics in a Polar Desert. The McMurdo Dry Valleys, Antarctica. American Geophysical Union, Washington, DC.

GRABHERR G., GOTTFRIED M. & PAULI H., 2000: GLORIA: A Global Observation Research Initiative in Alpine Environments. Mountain Research and Development 20(2), 190–191.

GRIFFITHS B. S., 1994: Microbial-feeding nematodes and protozoa in soil: Their effects on microbial activity and nitrogen mineralization in decomposition hotspots and the rhizosphere. Plant and Soil 164, 25–33.

HODKINSON I. D., 1998: Global change and Arctic ecosystems – Conclusions and predictions from experiments with terrestrial invertebrates on Spitsbergen. Arctic & Alpine Research 30, 306–313.

LIANG W., PINHASI-ADIV Y., SHTULTZ H. & STEINBERGER Y., 2000: Nematode population dynamics under the canopy of desert halophytes. Arid Soil Research and Rehabilitation 44(2), 183–192.

MICOLETZKY H., 1929: Zoologische Ergebnisse der Deutsch-Russischen Alai-Pamir-Expedition 1928. Zool. Anz. 84, 244–252.

MOORE J. C., DE RUITER P. C., HUNT H. W., COLEMAN D. C. & FRECKMAN D. W., 1996: Microcosms and soil ecology: critical linkages between field studies and modeling food webs. Ecology 77, 694–705.

MOURATOV S., LAHAV I., BARNESS G. & STEINBERGER Y., 2001: Preliminary study of the soil nematode community at Machu Picchu Station, King George Island, Antarctica. Polar Biol. 24, 545–548.

NIELSEN C. O. 1949: Studies on the microfauna II The soil inhabiting nematodes. Natura Jutl. 2, 1–132.

PICKUP J. 1990: "Seasonal variation in the cold hardiness of three species of free-living Antarctic nematodes" Functional Ecology 4(2), 257–264.

RICCI C. N. 1987: Ecology of bdelloids: how to be successful. Hydrobiologia 147, 117–127.

SCHIEMER F., 1983: Comparative aspects of food dependence and energetics of free living nematodes. OIKOS 41, 32–42.

SØMME L., 1995: Invertebrates in hot and cold arid environments. Springer-Verlag, Berlin, 275 pp.

SPAULL V. W., 1973: Qualitative and quantitative distribution of soil nematodes of Signy Island, South Orkney Islands. Br Antarct. Sur. Bull. 34–35, 177–184.

WALL D. H. & VIRGINIA R. A., 1999: Controls on soil biodiversity: insights from extreme environments. Applied Soil Ecology 13, 137–150.

WESTH P. & KRISTENSEN R. M., 1992: Ice formation in the freeze-tolerant eutardigrades *Adorybiotus coronifer* and *Amphibolus nebulosus* studied by differential scanning calorimetry. Polar Biology 12, 693–699.

WHARTON D. A. & BROWN I. M., 1989: A survey of terrestrial nematodes from the McMurdo Sound region, Antarctica. New Zealand Journal of Zoology 16, 467–470.

YEATES G. W., 1970: Two terrestrial nematodes from the McMurdo Sound region Antarctica, with a note on *Anaplectus arenicola* Killick, 1964. Journal of Helminthology 44(1), 27–34.

YEATES G. W., 1987: How plants affect nematodes. Advances in Ecological Research 17, 61–113.

YEATES G. W., BONGERS T., DE GOEDE R. G. M., FRECKMAN D. W. & GEORGIEVA S. S., 1993: Feeding habits in soil nematode families and genera – An outline for soil ecologists. Journal of Nematology 25(3), 315–331.

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