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Short research contribution

Krassimira ILIEVA-MAKULEC[1*], Grzegorz GRYZIAK[1,2]

[1] Centre for Ecological Research PAS, Dziekanów Leśny, 05-092 Łomianki, Poland
*e-mail: krassi.makulec@cbe-pan.pl (*corresponding author*)
[2] Department of Antarctic Biology PAS, Ustrzycka 10/12, 02-141 Warsaw, Poland

RESPONSE OF SOIL NEMATODES TO CLIMATE-INDUCED MELTING OF ANTARCTIC GLACIERS

ABSTRACT: Nematode colonization and establishment of nematode communities on ice-free areas created by the recession of Antarctic glaciers were studied on the Antarctic Specially Protected Area (ASPA) No. 128 (Western coast of Admiralty Bay, King George Island, South Shetlands Islands). Soil samples were taken along three transects marked between sea shore and Ecology Glacier, Baranowski Glacier and Windy Glacier and assigned to four age-class intervals: 0-7, >7–29, >29–52 and >52 years after the retreat of the glaciers. Changes in nematode communities, in terms of abundance, diversity and trophic structure were related to the duration of the ice-free period. The abundance of nematodes increased with the age of ice-free areas. The highest numbers of nematodes were found on the sites free of ice for more than 52 years. Taxonomic and trophic diversity of nematodes on these sites was also significantly higher in comparison to the rest sites. Nematode communities on the sites from the first three age-class intervals were poor in genera (up to 6 genera) while on the oldest sites in total 16 genera of nematodes were found. A trend of increasing the number of nematode trophic groups along the age classes was also apparent – from community of nematodes belonging to only two trophic groups (bacterial and fungal feeders) on younger ice-free sites to more complex community of nematodes (belonging to five trophic groups), at the oldest sites.

KEY WORDS: soil nematodes, global climate change, glacier melting

There is an increasing evidence supporting climate warming trends in the Antarctica over the last 50 years (King and Harangozo 1998). Acceleration of retreat in some valley-type tidewater glaciers at Admiralty Bay (especially Ecology Glacier and Baranowski Glacier) and its closest vicinity (Windy Glacier) in the past five decades might be also response to global climate change (Birkenmajer 2002). The recession of glaciers has freed from the ice considerable areas – potentionally new habitats for colonization by different soil animal groups.

Nematodes are a dominant group of terrestrial fauna in Antarctic ecosystems and they play an important role in these systems (Wall and Virginia 1999). Most of the nematological studies conducted in the maritime or continental parts of Antarctica have been concentrated on taxonomic diversity and distribution of nematode fauna (Spaull 1973, Andrássy 1998, Andrássy and Gibson 2007). Nematode fauna of Antarctica – 54 identified nematode species - consists of two separate groups. Thirty two nematode

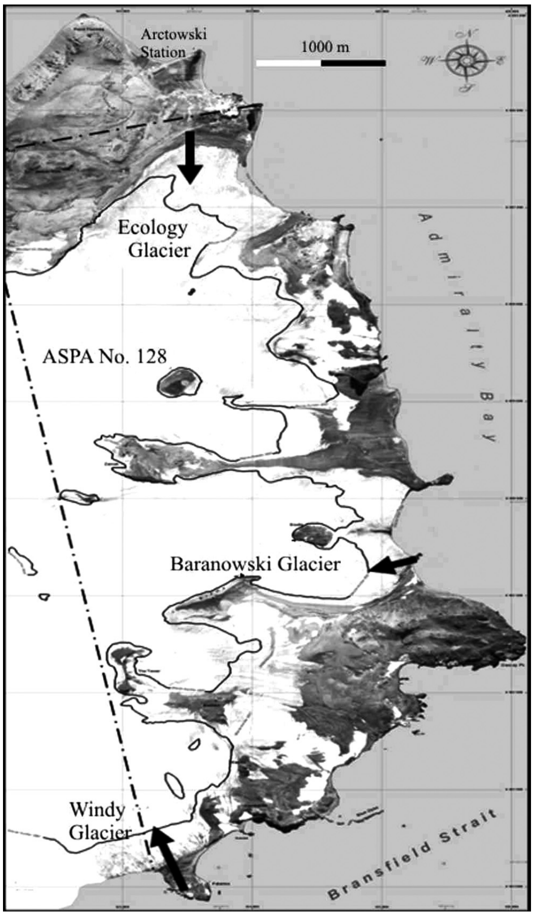

Fig. 1. Ortophotomap (1979) of Antarctic Specially Protected Area (ASPA) No. 128 with the location of the studied transects (solid arrows); the present (2007/2008) border of the glacier range is marked; (Pudełko 2007; modified).

species are recorded in Maritime Antarctica and 22 are found only in East Antarctica (Andrássy and Gibson 2007).

So far, little is known about the rate of colonization and establishment of nematode communities on the ice-free areas created after the retreat of the glaciers.

Our aim was i) to study nematode colonization and establishment of nematode communities on ice-free areas created by the recession of Antarctic glaciers ii) to find out if any relation between nematode abundance, diversity and trophic structure and the duration of the ice-free period (the time available for probable colonization) exists. Here we present some preliminarily results from a single sampling conducted during the 32nd Polish Antarctic Expedition on the Antarctic Specially Protected Area (ASPA) No. 128 (62°11´S, 58°27´W (Western coast of Admiralty Bay, King George Island, the biggest island of South Shetland Islands, about 120 km from the Antarctic Peninsula and about 900 km from Cape Horn). The mean annual air temperature is −1.6°C. The lowest temperature noted in area of ASPA No. 128 was −32.3°C and the highest +16.7°C (Marsz and Rakusa-Suszczewski 1987, Martianov and Rakusa-Suszczewski 1990). The mean temperature of the 5 cm surface layer of soil is +4.0°C (in January) and −1.8 °C in September (Zwolska and Rakusa-Suszczewski 2002). Soils at Admiralty Bay region are variable: cambisols, umbrisols, regosols, podzols, leptosols, gleysols and relic ornithogenic soils are found (Bölter *et al.* 1997). The soil pH is moderately acid; pH decreases from surface to deeper horizons. Soil is influenced by permafrost in the top 200 cm. Dominant plant species on the oldest ice-free areas are *Deschampsia antarctica* E.Desv. and *Colobanthus quitensis* (Kunth) Bartl. as well as mosses (mainly *Drepanocladus* sp. and *Polytrichum* sp.). The newest ice-free areas have no plant cover.

Windy Glacier, Baranowski Glacier and Ecology Glacier are the parts of Warszawa Icefield. During the past five decades retreats of these valley-type tidewater glaciers have been observed (Fig. 1). The recession of Ecology Glacier was described in detail by Birkenmajer (2002).

Soil samples were taken in January 2008 along three transects marked between sea shore and Ecology Glacier, Baranowski Glacier and Windy Glacier (Fig. 1). Samples (100 g wet weight of soil) from the surface few centimetres of soil were collected from different points along each transect. Using available data from the maps of Pudełko (2002, 2007) the glaciers' retreat in 1956, 1979, 2001 and 2008 (*i.e.* 52, 29, 7, and 0 years ago) were determined and sampling points relative to these dates were marked. Thus our samples were assigned to four age-class intervals: 0–7, >7–29, >29–52 and >52 years after the retreat of the glaciers (Table 1).

Nematode extraction was processed in the laboratory of the Polish H. Arctowski Antarctic Station, situated next to ASPA No. 128. Nematodes were extracted using a modified Baermann method (Flegg and Hooper

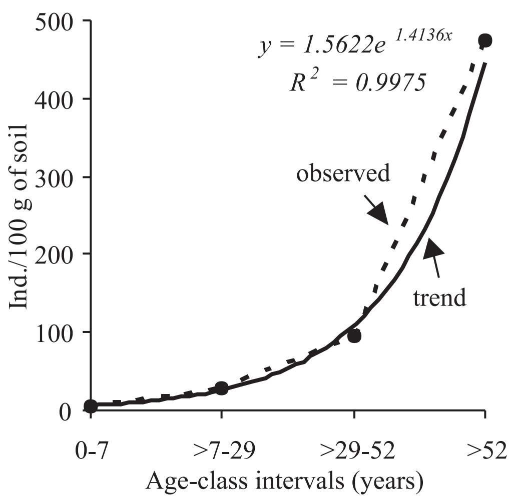

Fig. 2. Nematode abundance in relation to duration of the ice-free period. Dotted line shows observed dynamics, solid line – the fitted trend.

1970) and than preserved in 4% formaldehyde solution. Nematodes were identified to genus and assigned to five trophic groups according to Yeates *et al.* (1993). Maturity index (MI) based on the nematode community composition and life-history traits of nematodes (Bongers 1990) was also calculated in aim to check its usefulness as an indicator of the conditions of the soil ecosystems in Antarctica:

$$MI = \sum_{i=1}^{n} v(i) f(i) \quad (1)$$

where *v(i)* is the c-p value of the taxon (c-p value varies between 1 to 5 in relation to the place of the taxon on a coloniser/persister scale) and *f(i)* is the frequency of the taxon in the sample. An analysis of variance (ANOVA) was applied to test the effect of the duration of the ice-free period on nematode abundance.

We found that the frequency of nematode occurrence in the samples depended on the age of ice-free sites. While on sites from two younger age-classes nematodes were recovered from about 50% of the samples, on the older sites nematodes occurred almost in 100% of the samples (Table 2).

Although nematode densities were highly variable across the samples from each age-class interval (Table 2) we found that mean abundance of nematodes was significantly influenced by the age of free-ice sites (F = 4.58, P = 0.04). Nematodes numbers were positively correlated with the duration of the ice-free period and increased almost in an exponentional way (r^2 = 0.99) (Fig. 2). The highest numbers of nematodes were found on the sites free of ice for more than 52 years (Fig. 2).

Generic diversity of nematode fauna on the oldest sites was also significantly higher in comparison to the rest sites. Nematode communities on the sites from the first three classes were poor in genera (4–6 genera) while on the oldest sites in total 16 genera of nematodes were found (Table 2). The dominance of two nematode genera *Panagrolaimus* and

Table 1. Number of soil samples taken on the deglaciated areas at the three Antarctic glaciers.

Study glaciers	Age-class intervals (years after the retreat of the glaciers)			
	0–7	>7–29	>29–52	>52
Ecology Glacier	1	2	0	3
Baranowski Glacier	0	5	4	3
Windy Glacier	6	2	1	9
Total number	7	9	5	15

Table 2. Parameters of nematode communities on ice-free sites created by the recession of the glaciers. Maturity Index – see formula (1).

Parameter	Age-class intervals (years after the retreat of the glaciers)			
	0–7	>7–29	>29–52	>52
Frequency of nematode occurrence (% of all samples)	43	56	100	93
Abundance range (min–max) (ind./100 g soil)	0–18	0–87	6–432	0–2952
Number of genera	4	6	6	16
Maturity Index	1.92	2.23	1.37	2.50

Plectus was extremely sharp and it was characteristic for all sites younger than 52 years (Table 3).

A trend of increasing the number of nematode trophic groups along the age-class gradient was also apparent – from community of nematodes belonging to only two trophic groups (bacterial and fungal feeders) at the young sites to more complex community of nematodes (belonging to five trophic groups), at the older sites (Fig. 3). In all age-class intervals the highest relative abundance had bacterial feeders, which were following by fungal feeders. A relatively high percent share of omnivores, especially on younger sites was also noted (Fig. 3).

The values of Maturity Index were low and they did not correlate with the age of ice-free sites (Table 2).

Although our data is based on a single sampling the preliminary results show that changes in nematode communities, in terms of abundance, diversity and trophic structure were related to the duration of the ice-free period. Moreover our results indicate that nematode colonisation of deglaciated areas is not a fast process. The colonisation success of nematodes even 30 years after the deglaciation is low, and that was confirmed by the lack of nematodes in almost half of samples. The patchy distribution of nematodes is well known, but it seems to be extremely evident

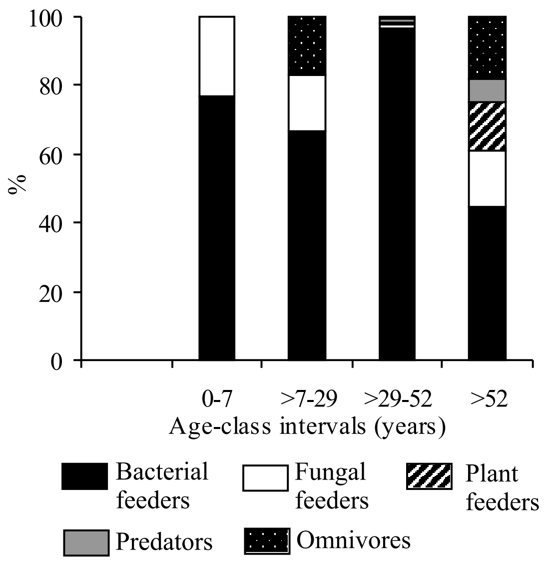

Fig. 3. Relative abundance of nematode trophic groups on the deglaciated sites.

in Antarctica (Wall and Virginia 1999, Sohlenius *et al.* 2004). The number of habitats suitable for nematodes increased with the age of ice-free areas and that could be related with the development of soil, vegetation and microclimate conditions in these areas. In Antarctic ecosystems the highest nematode numbers were found in patches of mosses, lichens and algae or the organic material in the surrounding of bird colonies (Sohlenius *et al.* 2004). The importance of mosses and the microclimate they create (higher temperature, and water content) for nematodes was apparent, especially for *Plectus* (Sohlenius *et al.* 2004), the genus which evidently dominated in our study. Some relationships between the distribution of plant and fungi communities and the activity of substrate and animals on the deglaciated areas at Windy Glacier were also found by Olech and Angiel (2009). A strong relation of mites colonization with development of vegetation and edaphic factors on the same as in this study ice-free sites was observed by Gryziak (2009).

The low values of the Maturity Index indicate weak organisation and the low maturity of nematode communities on ice-free areas created by the recession of Antarctic glaciers even more then 50 years ago. Our results also show that Maturity Index was not a good indicator for differentiating between age-class intervals. The fact that MI of nematode community on younger ice-free sites was higher than in older ones can be explained with the higher numbers of omnivorous nematodes on the first sites. High abundance of omnivores in temperate ecosystems is an indicator of high organization and stable environment, but here in Antarctica the presence of that trophic group can be related to the increase of soil microalgae and bryophytes which provide resources required by omnivores.

In conclusion, the climate-induced melting recession of Antarctic glaciers expose new ice-free areas on which the rate of colonisation and establishment of nematode communities could be observed. The colonisation process seems to be slow, but our results show that the diversity and community structure parameters of nematodes in good way reflect all changes which the glaciers recession brings in abiotic (temperature, wind, hydra-

Table 3. Dominance structure of nematode communities on the deglaciated sites. Bold letters indicate genera with relative abundance ≥20%.

Age-class intervals (years after the retreat of the glaciers)							
0–7		>7–29		>29–52		>52	
Genus	%	Genus	%	Genus	%	Genus	%
Plectus	**44**	*Plectus*	**43**	*Panagrolaimus*	**65**	Panagrolaimus	**21**
Aphelenchoides	**23**	*Panagrolaimus*	18	*Plectus*	**31**	*Mesodorylaimus*	15
Panagrolaimus	**20**	*Aphelenchoides*	16	*Filenchus*	1	*Aphelenchoides*	14
Monhystera	13	*Eudorylaimus*	11	*Mesodorylaimus*	<1	*Coslenchus*	14
		Mesodorylaimus	6	*Clarcus*	<1	*Plectus*	10
		Monhystera	6	*Ditylenchus*	<1	*Cervidellus*	7
						Rhabditis	7
						Clarcus	5
						Tylencholaimus	2
						Dorylaimus	2
						Mononchus	1
						Eudorylaimus	1
						Prismatolaimus	<1
						Thonus	<1
						Filenchus	<1
						Monhystera	<1

tion, UV exposition) and biotic (plant colonisation, microbial activity) factors of the deglaciated areas.

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