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Panagrolaimus magnivulvatus Boström, 1995 in nest material, algae and soils from inland nunataks in western Dronning Maud Land, Antarctica

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Panagrolaimus magnivulvatus Boström, 1995 is reported from habitats on inland nunataks in western Dronning Maud Land, continental Antarctica. This species was recorded in lithosols of three of the 11 nunataks (Marsteinen, Lorentzenpiggen and Valterkulten) sampled during the 1992–93 summer. In addition, it was found in high numbers in material from inside the nests of the snow petrel *Pagodroma nivea* and in the algae *Prasiola crispa* at nest entrances on nunataks of the Robertskollen group. *Panagrolaimus magnivulvatus* from Robertskollen is described, scanning electron micrographs of its morphology are given and the specimens are compared with the type population from the Steinnabben nunatak in Dronning Maud Land, as described by Boström (1995). It is especially those Robertskollen specimens found in nest material that differ from specimens of the type population, mainly in longer and thicker bodies, longer tails and longer spicules in males. Novelty characters of the present specimens are the single adanal papilla situated on the anterior lip of the cloaca and the tail tips which are either pointed or bifurcated.

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Despite extreme environmental conditions, a variety of microbial organisms, including algae, fungi, protozoa, tardigrades, nematodes and bacteria, inhabit the Antarctic continent (Friedman 1993; Sohlenius, Boström & Hirschfelder 1995). Much of the research on microbial communities of Antarctica has been directed towards coastal and maritime regions (Vincent 1988; Ramsay 1983). These regions experience relatively mild conditions compared to inland areas which are characterized by low temperatures, desiccation, high winds and low nutrient input (Walton 1984; Wynn-Williams 1990). Studies on the microbial communities of inland Antarctic habitats has been concentrated on waterbodies (e.g. Vincent, Howard-Williams & Broady 1993; Suren 1990) and the Dry Valleys (Schwarz, Green, Green & Seppelt 1993; Freckman & Virginia 1993; Overhoff, Freckman & Virginia 1993), with only a few studies investigating the microbial communities on inland nunataks (e.g. Ryan, Watkins, Lewis Smith, Dastych, Eicker, Foissner, Heatwole, Miller & Thompson 1989, Sohlenius *et al.* 1995).

Preliminary species lists for algae, fungi and tardigrades on the inland nunataks at Robertskollen in the Ahlmannryggen, western Dronning Maud Land were provided by Ryan *et al.* (1989), and while nematodes were recorded these were not identified. Further sampling has been conducted at Robertskollen as part of the South African Antarctic terrestrial biology research programme (Cooper, Siegfried, Ryan, Crafford & Stock 1991), and collections during the 1991–92 summer revealed the presence of three species of nematodes, viz: *P. antarcticus* de Man, 1904, a new species *Eudorylaimus nudicaudatus* Heyns, 1994 and a new genus and species *Chiloplacoides antarcticus* Heyns, 1994 in soils at Robertskollen (Heyns 1995; Heyns 1994b and Heyns 1994a respectively). In addition Boström (1995) found *Plectus acuminatus* Bastian, 1865 and *Panagrolaimus magnivulvatus* Boström, 1995 from the nunataks Basen, Haldorsentoppen and Steinnabben in soil and organic soil material (mosses, lichens and mycelia), Dronning Maud Land.

The present study reports the presence of *Panagrolaimus magnivulvatus* in nest and algal material from nunataks of the Robertskollen group and in soils of three other nunataks in the Ahlmannryggen, western Dronning Maud Land, collected during the austral summer of 1992–93. These specimens are compared with the type material (Boström 1995) and some novel characteristics of the Robertskollen population are described.

Study site (Figure 1)

Soil samples were collected from soil polygons (Washburn 1979) on the northern slopes of 10 nunataks in Dronning Maud Land, Antarctica, namely in the Ahlmannryggen mountain range: Darien, Marsteinen, Lorentzenpiggen, Johnsbrotet, Valterkulten, Kleinbergie; in the Borgmassivet: Nashornet, Hornet; in the Kirwanveggen: Neumayerskarvet, Enden. Material from inside nests (of the snow petrel *Pagodroma nivea)* and the algae *Prasiola crispa* (from nest entrances) were collected from Ice Axe Peak and Cairn Peak at Robertskollen (71°27'S, 3°15'W) in the Ahlmannryggen.

Methods and materials

Surface soil samples (1 cm depth, *ca.* 40 g wet weight) and nest and algal material (*ca.* 20 cm^3) were collected during January and December 1993, and kept frozen under ice in the field (up to 2 months). Samples were then stored frozen at –20°C.

The nematodes were extracted using the modified Baermann method (Whitehead & Hemming 1965).

Specimens for study by light microscope were killed by the gentle application of heat, fixed in TAF (formaldehyde 4%, triethanolamine 2%, distilled water) and mounted in anhydrous glycerine between coverslip slides.

For examination by scanning electron microscope specimens were fixed in TAF, dehydrated in a graded ethanol

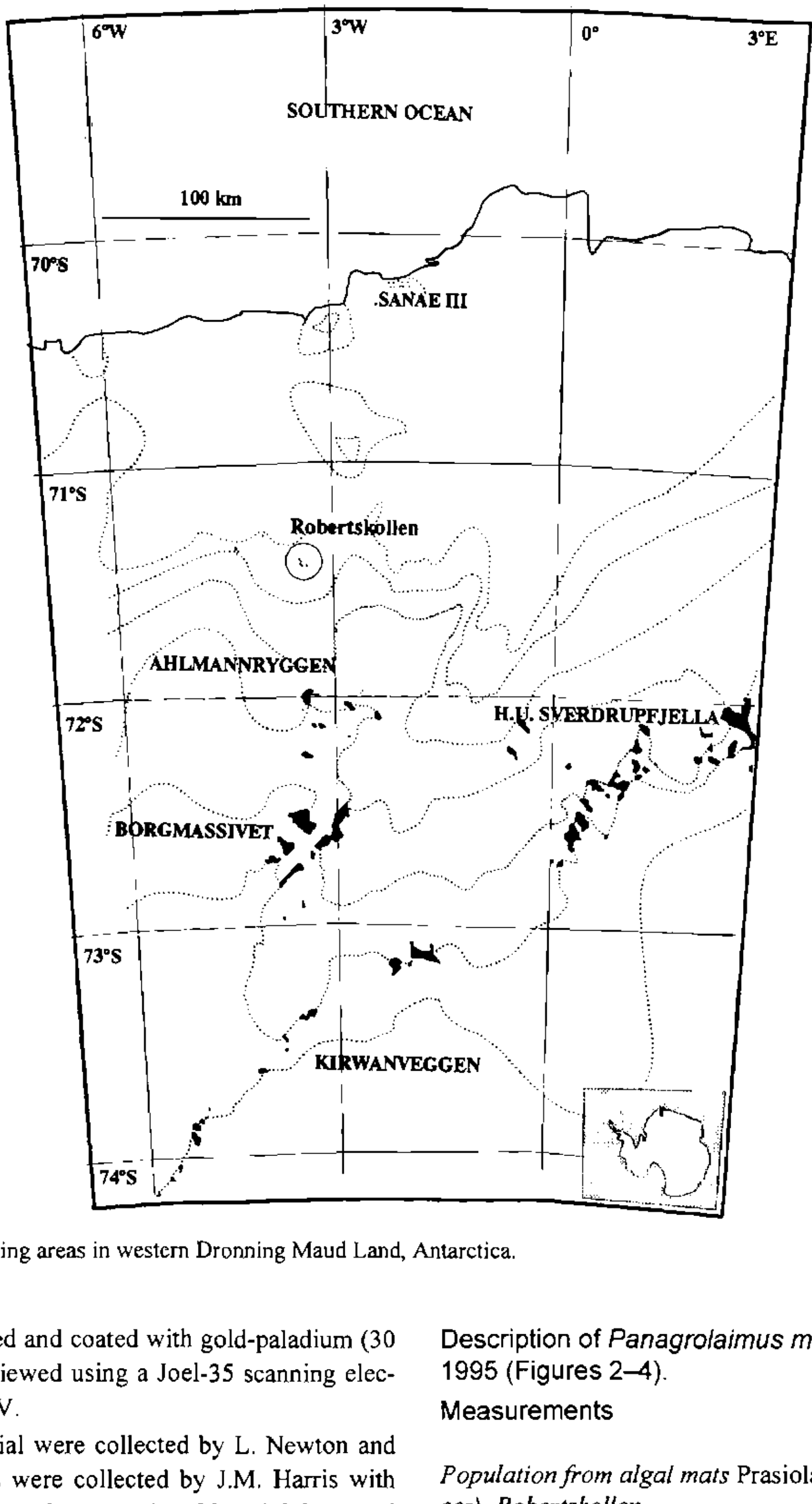

Figure 1 Map of the sampling areas in western Dronning Maud Land, Antarctica.

series, critical point dried and coated with gold-paladium (30 nm). Specimens were viewed using a Joel-35 scanning electron microscope at 15 kV.

Nest and algal material were collected by L. Newton and J.E. Crafford, and soils were collected by J.M. Harris with assistance from members of the South African Biology and Geology teams during January and February of 1993.

Results

Table 1 shows the distribution and abundance of *P. magnivulvatus* in samples collected during this study. Adult specimens of both sexes were found in all samples of nest material (n = 3) and algal mats (*P. crispa)* (n = 5) examined. No adult specimens were found in soils from the 10 different nunataks (n = 1) sampled. However, juveniles were obtained in soils from three of the nunataks sampled, i.e. Marsteinen, Lorentzenpiggen and Valterkulten.

Description of *Panagrolaimus magnivulvatus* Boström, 1995 (Figures 2–4).

Measurements

Population from algal mats Prasiola crispa *(at nest entrances), Robertskollen*

Female (n = 46); L = 930 ± 0.03 (870–1 000) µm; a = 16,3 ± 1,7 (12,3–20,3); b = 4,1 ± 0,2 (3,8–4,5); c = 17,6 ± 1,2 (15,8–20,7); c' = 2,3 ± 0,22 (1,9–2,8); V = 60,7 ± 0,9 (59,1–63,0).
Male (n = 31): L = 870 ± 0,07 (750–1 000) µm; a = 22,1 ± 2,3 (18,8–28,1); b = 4,1 ± 0,2 (3,7–4,5); c = 18,2 ± 1,3 (16,3–21,1); c' = 1,6 ± 0,09 (1,5–1,7); T = 37,1 ± 3,4 (34–48); spicules = 43,4 ± 2,3 (39,5–47) µm; gubernaculum = 15,9 ± 2,02 (13,5–21) µm.

Population from nest material, snow petrel Pagodroma nivea, *Robertskollen*

Female (n = 22): L = 1290 ± 0,1 (1 050–1470) µm; a = 19,4 ±

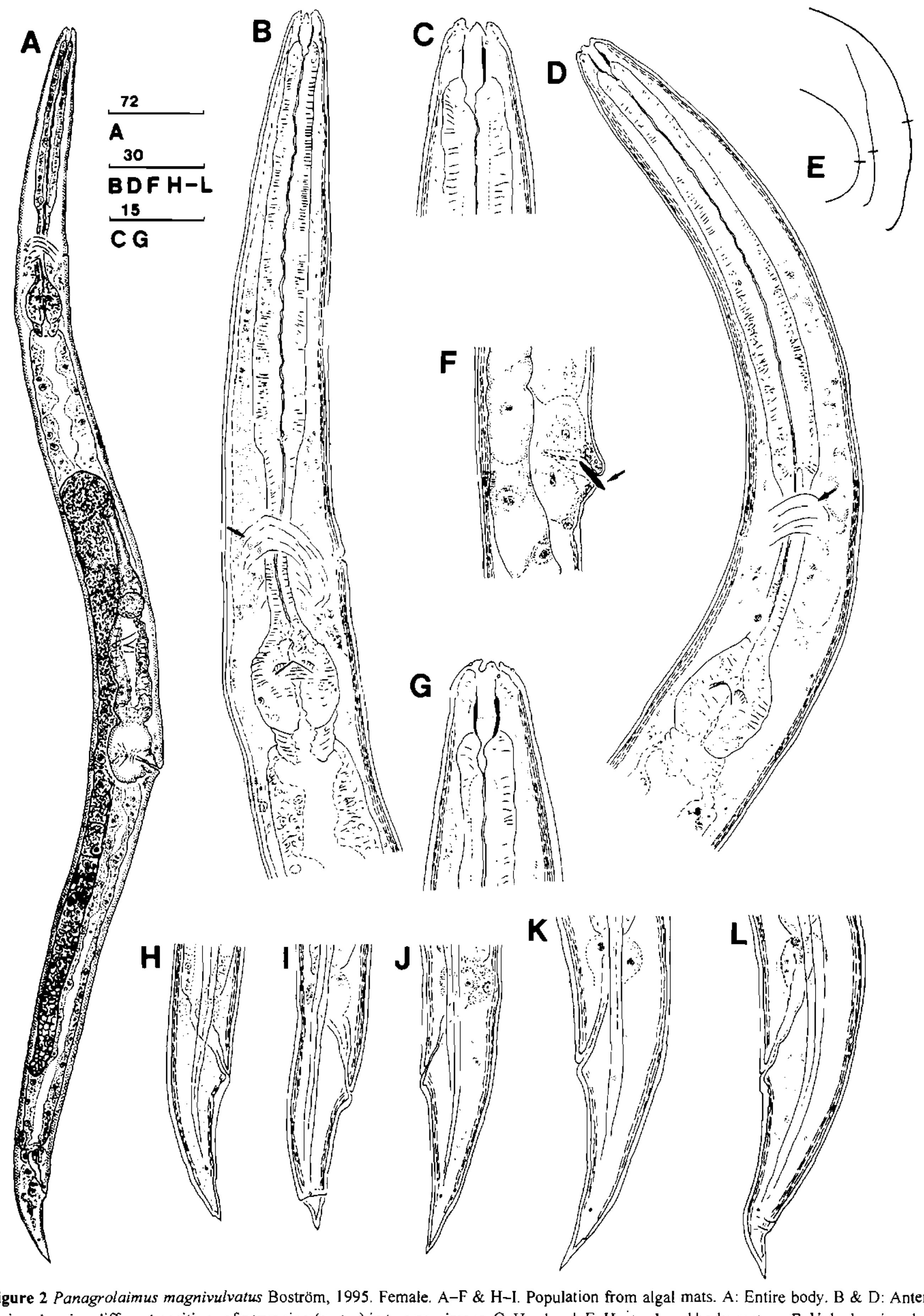

Figure 2 *Panagrolaimus magnivulvatus* Boström, 1995. Female. A–F & H–I. Population from algal mats. A: Entire body. B & D: Anterior region showing different positions of nerve ring (arrow) in two specimens. C: Head end. E: Heat-relaxed body posture. F: Vulval region showing refractive object protruding from vulva. H-I: Tails of different specimens, showing bifurcated tail tip (H) and retracted tail tip (J). G & K–L. Population from nest material. G: Head end. K–L: Tails of different specimens.

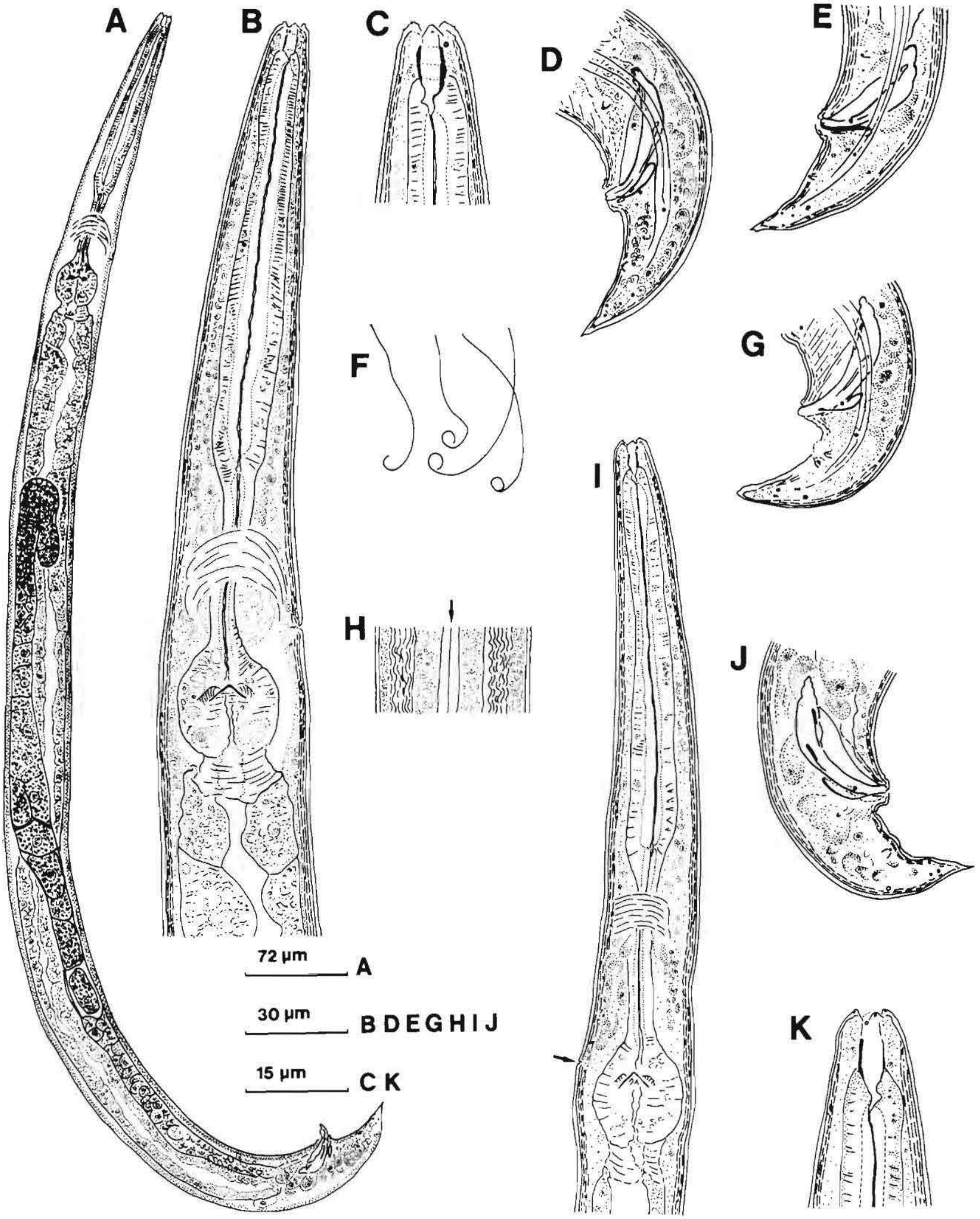

Figure 3 *Panagrolaimus magnivulvatus* Boström, 1995. Male. A–H: Population from algal mats. A: Entire body. B: Anterior region. C: Head end. D–G: Tails showing bifurcated tail tip (E) and aberrant male with atypical tail tip and arrangement of caudal papillae (G). F: Heat-relaxed body posture. H: Three lateral incisures (arrow) in lateral field. I–K: Population from nest material. I: Anterior region showing excretory pore located in a very posterior position (arrow). J: Tail. K: Head end.

4,2 (15,3–20,4); b = 5,5 ± 0,4 (4,5–6,0); c = 20,2 ± 2,1 (16,6–23,1); c' = 2,4 ± 0,2 (1,9–2,7); V = 60,4 ± 1,1 (58,3–63,4).

Male (*n* = 20): L = 1100 ± 0,1 (890–1290) µm; a = 25,2 ± 3,6 (18,5–30,2); b = 5,1 ± 0,4 (4,3–6,1); c = 23,6 ± 4,2 (17,5–33,2); c' = 1,5 ± 0,1 (1,2–1,9); T=33,5 ± 3,8 (25–39); spicule = 46,3 ± 2,6 (42–50) µm; gubernaculum = 17,3 ± 1,2 (15–19) µm.

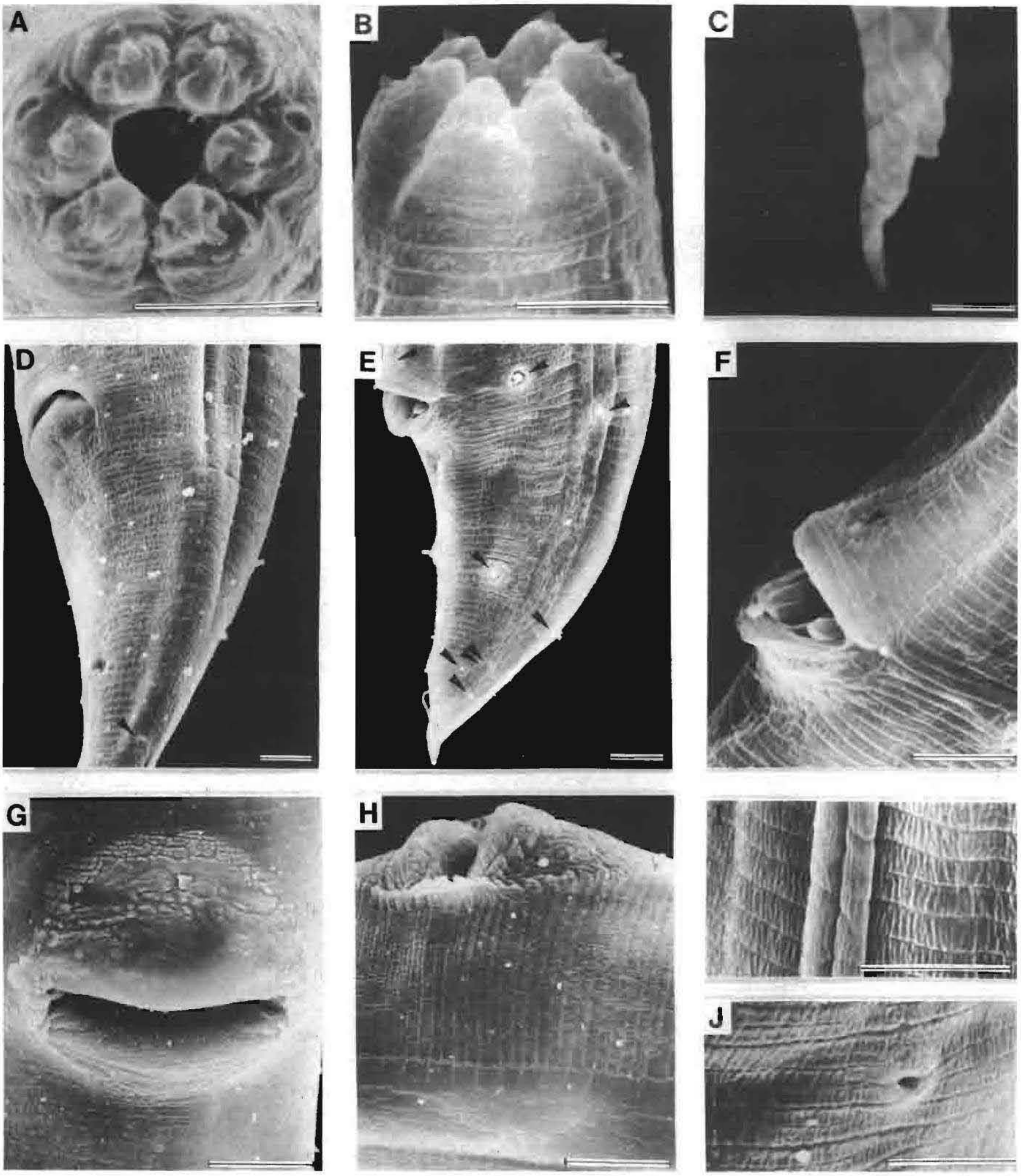

Figure 4 *Panagrolaimus magnivulvatus* Boström, 1995. Population from algal mats. A: Female head in frontal view. B: Female head in ventro-lateral view. C: Bifurcated tail tip (female). D: Anal region of female showing phasmid (arrow). E: Male tail showing caudal pores (single arrow) and phasmid (double arrow). F: Cloacal opening showing adanal papilla (arrow). G: Vulva in ventral view. H: Vulva in lateral view. I: Lateral incisures in female in midbody region. J: Excretory pore in male. Bar equals 5 μm in all photomicrographs except in C where bar equals 1 μm.

Populations from nunatak soils (only juveniles)

Marsteinen (71°26'S, 01°42'W): Juvenile (n = 1): L = 390 μm; a = 19,7; b = 2,9; c = 13,8; c' = 2,2; gonad primordium length: 13 μm.

Lorentzenpiggen (71°45'S, 02°50'W): J4? (n = 2): L = 730 & 660 μm; a = 21,4 & 21,5; b = 3,6 & 3,4; c = 14 & 17,7; c' = 2,9 & 2,2; future vagina position (%) = 60 & 62.

Juvenile (n = 1): L = 550 μm; a = 23,1; b = 3,2; c = 15,4; c' = 2,1; gonad primordium length = 19 μm.

Juvenile (n = 1): L = 550 μm; a = 19,6; b = 3,3; c = 14,8; c' =

Table 1 Presence and abundance of *Panagrolaimus magnivulvatus* Boström, 1995 in samples collected during the 1992/93 austral summer from western Dronning Maud Land, Antarctica. Except for algal and nest material at Robertskollen, all samples are surface soils collected from north-facing slopes

Locality	*n*	*Panagrolaimus magnivulvatus*
Ahlmannryggen		
Robertskollen		
Algal mat *(Prasiola crispa)*	5	95 female, 37 male, 49 juv.
Nest material *(Pagodroma nivea)*	3	55 female, 38 male, 45 juv.
Darien	1	–
Marsteinen (= Div No 2)	1	1 juv.
Lorentzenpiggen (= Div No 7)	1	4 juv.
Johnsbrotet	1	–
Valterkulten (= Div No 12)	1	1 juv.
Kleinbergie (Grunehogna)	1	–
Borgmassivet		
Nashornet	1	–
Hornet	1	–
Kirwanveggen		
Neumayerskarvet	1	–
Enden	1	–

2,4: gonad primordium length = 66 µm.

Valterkulten (71°54'S, 03°13'W): Juvenile (n = 1): L = 470 µm; a = 24,7; b = 3,6; c = 9,6; c' = 4,3; gonad primordium length = 52 µm.

Female: Body curved ventrad when heat relaxed, from almost straight to an open C. Cuticle thin, 0,8–1,0 µm in neck region, 1–1,5 µm at midbody and 1–1,5 µm on tail. Lateral field prominent, 4,5–6 µm wide, consisting for most part of three incisures, the outermost lines with faintly crenulate margins. Incisures end before level of phasmid. Cuticle finely annulated, each annule 1,5–2 µm wide at midbody, smaller near head. Head 10,5–13 µm wide with six prominent, distinctly separated tapered lips. Lateral lips somewhat lower and smaller than subventral and subdorsal lips. Amphids small, located on lip region, slightly dorsal to midline. Stoma panagrolaimoid, 12–15 µm long in females from algal mats, 13-17 µm long in females from nests. Cheilostom almost as long as wide, not sclerotized. Promesostom elongated with sclerotized rhabdions, sclerotization seems more prominent on dorsal side of stoma. Meta- and telostom not sclerotized in most specimens, anterior part of metastom slightly sclerotized in a few. Pharynx panagrolaimoid, 226,0 ± 9,3 (209–241) µm in females from algal mats, 228,4 ± 22,4 (220–251) µm in females from nests. Pharyngeal collar extends to base of pro-mesostom. Corpus cylindroid, becoming slightly wider in posterior one-third. Corpus/isthmus ratio 2,5 ± 0,16 (2,2–2,7) in females from algal mats, 2,5 ± 0,2 (2,2–2,8) in females from nests. Excretory pore located posterior to nerve ring, 164–193 µm from anterior end in females from algal mats and 179–221 µm in females from nests. Position from anterior end to nerve ring 155–191 µm and 150–191,5 µm respectively for females from algal mats and nests. Nerve ring encircling isthmus anteriad to about midway between corpus and basal bulb. Hemizonid difficult to see, where visible located just posterior of and adjacent to excretory pore. Dierids obscure. Basal bulb rounded, 33–42 µm long and 26–35 µm wide with valvular apparatus. Cardia 8,5–14 µm long. Anal aperture a crescent-shaped slit with protuberant posterior lip. Reproductive system panagrolaimoid, monodelphic, prodelphic. Ovary reflexed past vulva, reaching in some specimens almost to level of anus. Uterus with one egg only; 64–108 µm long and 38–50 µm wide. Posterior uterine branch less than one body diameter long. Vulval lips protruding, anterior lip more prominent than ventral lip. A peculiar refractive object visible inside vagina or projecting from vulva (Figure 2F) in many females. The nature and function of this object is not known. Body narrows behind vulva. Body diameter about 50 µm anterior to vulva and about 44 µm posterior of vulva in females from algal mats outside nests, about 59 µm anterior and 54 µm posterior of vulva in females from nest material. Distance from vulva to anus 5,9 ± 0,5 (5,3–7,0) times tail length in females from algal mats, 7,1 ± 0,7 (6,0–7,3) times tail length in females from nests. Tail conoid, 53,1± 3,6 (46–57) µm in females from algal mats, 63,7 ± 5,2 (51–74,5) µm in females from nests. Tail slightly dorsally convex with a pointed or bifurcated tip. Posterior part of tail in some specimens retracted (Figure 2I) or curved dorsad. Phasmid at 65,5 ± 3,3 (57–70)% of tail length in females from algal mats, 68 ± 3,5 (63–75)% in females from nests. No caudal pores observed.

Male: Morphology as in female but with the following differences. Relaxed body posture curved ventrad or irregular, curvature of tail much more pronounced than in female, curled back on itself in some males. Oesophagus somewhat shorter, 210,8 µm ± 8,1 (195–222) µm in males from algal mats; 214 ± 7,3 (201–228) µm in males from nests. Tail shorter than in female, 47,8 ± 3,0 (41–52) µm in males from algal mats; 47,6 ± 6,8 (32–55) µm in males from nests. Phasmids prominent, at 69 ± 6,3 (60–78)% of tail length. Lateral field with three incisures, central incisure normally ending at phasmid. Caudal papillae numerous: one pair preanal subventral at level of the proximal part of the spicule; one pair subventral at level of or just anterior to cloacal opening; one pair laterally at level of cloaca; one pair subventral and one pair subdorsal about midway along tail, the subdorsal pair always more posterior than subventral pair; two pairs near tail tip. One male from algal mats (Figure 3G) had a rounded tail tip, two pairs of subventral papillae midway along tail, no subdorsal pair in this position, and four small papillae near tail tip. This seems to be an aberrant male as no other male or female shares these features. A single adanal papilla observed on anterior protuberant lip of cloacal opening (Figure 4F). Reproductive system monorchic, testis reflexed anteriorly. Spicules and gubernaculum panagrolaimoid.

Juvenile: Similar to female in general morphology. Developing gonads in many juveniles obscure and larval stages difficult to determine.

Remarks

Panagrolaimus magnivulvatus from Robertskollen is morphologically very close to the type population described by Boström (1995) from organic soil material at the nunatak

Steinnabben, except that the females found in nest material are on average longer with thicker bodies than those of the type material. These females are on average longer (1 050–1470 µm *vs* 683–1 187 µm), the a-value is lower (15,4–20,4 *vs* 19–25); slightly higher b-value (4,6–6,0 *vs* 3,8–5,8) and a longer tail (51–74,5 µm *vs* 37–58 µm). The males in the population from Robertskollen differ from the males from Sivorgfjella (type material) in the following: slightly shorter tail (32–55 µm *vs* 42–62 µm); longer spicules in males from nest material (42–50 µm *vs* 33–45 µm) and the presence of an adanal papilla on the anterior lip of the cloaca not observed in type populations presumably because of small size. The tail tips of the Robertskollen-specimens are either pointed or bifurcated whilst those of the type populations are pointed only.

The presence of a single adanal papilla on the anterior protuberant lip of the cloacal opening (Figure 4F) has never been reported in *Panagrolaimus* before. Several authors, i.e. Timm 1971 and Boström 1988, described adanal papillae in *Panagrolaimus* but they referred to those papillae on either side of the cloacal opening. We have refrained from calling these two lateral papillae in this region 'adanal' in this paper to avoid confusion with the single adanal papilla just anterior of the cloacal opening in *P. magnivulvatus*. This adanal papilla may also be a fairly constant feature in *Panagrolaimus* (it is for example very common in cephalobid males) but could have been overlooked by authors because of its small size (Boström, pers. comm).

The difference in body size between *P. magnivulvatus* from populations within algal mats and those from nest material can be attributed to the greater availability of food within nest material. These nematodes are saprophagous and are especially abundant where decaying plant debris is present.

Discussion

At Robertskollen, *P. magnivulvatus* appears to be associated exclusively with the nests of the snow petrel *P. nivea*. In the present study, samples collected from inside nests and from algal mats just outside these nests contained high densities of this nematode species (see Table 1). In contrast, 19 soil samples collected from Robertskollen (during the summer of 1991–92) from soil polygons 5 m away from nests on nunataks with breeding birds and from nunataks without breeding birds did not contain any specimens of this species (Heyns, pers. comm.). The presence of panagrolaimid species in association with bird breeding sites has been reported previously. Sohlenius *et al.* (1995) have reported the presence of *P. magnivulvatus* in nitrogen-rich soil with algae in the vicinity of nests of the snow petrel *P. nivea* in the Sivorgfjella, Dronning Maud Land. In addition, Boström (1988) found *Panagrolaimus* spp. in nests of herring/glaucous gull hybrids and Timm (1971) reported *P. davidi* at an Adelie penguin rookery and in soil covered by moss and algae. Freckman & Virginia (1990) reported that in Dry Valley soils the maximum densities of nematodes were found in ornithogenic soils.

The presence of *P. magnivulvatus* in soils from three of the other nunataks sampled is interesting, especially as birds are not known to breed on these nunataks (Steele, pers. comm.). While only juveniles were found in soils from Marsteinen, Lorentzenpiggen and Valterkulten during the present study, two adult females were obtained in soil samples collected from the nunatak Snokjerringa during 1991–92 (Heyns, pers. comm.). Thus, while relatively high densities were found in association with birds, this species can exist in the absence of breeding birds and of increased nutrients from ornithogenic products.

The presence of this nematode species only on nunataks in the northerly Ahlmannryggen, and not on any of the nunataks of the more southern Borga and Kirwanveggen mountain ranges suggests that its distribution may be restricted by the climatic conditions. However, the distribution and abundance of microbial organisms in terrestrial habitats in Antarctica have been reported to be very patchy and variable (Miller, Horne, Heatwole, Miller & Bridges 1988; Freckman & Virginia 1990; Bolter 1992). P. magnivulvatus was found in soils of three of the six nunataks sampled in the Ahlmannryggen in the present study. However, previous investigations did not reveal the presence of this species in soils from six other nunataks (Passat, Vesleskarvet and four nunataks at Robertskollen) in this notherly mountain range (Heyns & Harris, unpubl. data). Thus sampling of soils from more nunataks along altitudinal and along nutrient gradients is needed before conclusions can be reached about the factors affecting the distribution of this nematode species.

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