



# Morphological and molecular diversity at a regional scale: A step closer to understanding Antarctic nematode biogeography



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## ABSTRACT

Antarctica is one of the harshest environments on earth and yet life has managed to persist on the continent for millions of years. While most of the continent is covered by snow and ice, in some coastal and mountain regions that do not have permanent cover terrestrial invertebrate fauna dominate. Nematodes are one of the most common taxa present in these environments, but despite their abundance very little work on diversity and distribution has been performed for the Phylum across the Antarctic continent. We examined nematodes from 123 limno-terrestrial samples from the vicinity of the Australian Antarctic Stations (62.8°E–110.5°E) using the mitochondrial cytochrome c oxidase subunit I (COI) gene, and morphological analyses. We identified the nematodes *Plectus murrayi*, *Pl.cf. frigophilus*, *Scottinema cf. lindsayae*, *Halomonhystera cf. halophila*, *H. cf. continentalis* and *Eudorylaimus* spp. The distribution of these species appears to be determined by habitat type and salinity. We also made comparisons using the COI gene with nematodes from localised sampling from Dronning Maud Land, Francis Island (Antarctic Peninsula), and Tierra del Fuego (TF), and also with COI sequences from other worldwide locations. Contrasting levels of COI sequence divergence were identified among genera and species, ranging from low levels for *Pl. murrayi* ( $\leq 0.5\%$ ), medium levels for *S. cf. lindsayae* ( $\leq 2.1\%$ ) and *Halomonhystera* ( $\leq 4.3\%$ ), and high within *Pl.cf. frigophilus* ( $\leq 8.4\%$ ). Distribution ranges varied according to the species, with widespread ranges within Antarctica for *Pl. murrayi* and *Scottinema cf. lindsayae* (a range of over 2000 km); and distribution beyond Antarctica to TF for *Pl.cf. frigophilus*. Our results reveal the presence of cryptic species even when conservative approaches are applied in species delimitation.

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## 1. Introduction

Nematodes are a major component of the Antarctic limno-terrestrial fauna, and have been described as one of the most dominant groups of metazoan found throughout the frozen continent (e.g. [Sohlenius et al., 1996](#); [Powers et al., 1998](#); [Freckman and Virginia, 1998](#); [Adams et al., 2006](#)). Despite their worldwide dominance, little is known about the diversity of these micro-invertebrates highlighting the need for further comprehensive research to assess biogeographical distribution of species and how these relate to the global fauna. Historically, most research has focussed on regions close to permanent stations, especially on the Antarctic Peninsula (AP) and Victoria Land (VL), and more recently

in nunataks and coastal regions across the continent. The nematode fauna in Antarctica is now reported to include 67 species, 37 of which are found on the AP or its offshore islands (Maritime Antarctica), and 33 in Continental Antarctica ([Table 1](#)). Currently there is no apparent overlap among the nematode fauna from Maritime Antarctica (Sector 4) with the rest of the Antarctic continent (Sectors 1,2,3; [Table 1](#)). The exception are three unconfirmed records: the terrestrial species *Pl. murrayi* and the aquatic/semi-aquatic *Pl. frigophilus* from AP (Sector 4; [Maslen and Convey, 2006](#)), and the maritime species *Teratocephalus tilbrookii* from Sector 1 ([Verlecar et al., 1996](#)). Unfortunately with such records, without molecular or morphological data it is difficult to confirm species identifications and examine species connectivity and distributional ranges (see [Table 1](#)).

When considering the biogeographic distributions of all 67 Antarctic nematode species it becomes challenging to undertake continental-wide studies covering soil and water environments and relate these to biota from elsewhere in the world. Recent work

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**Table 1**  
Geographical location of all nematode species recorded in continental and maritime Antarctica.

|   | Area | Sector 1 (45°W–45°E)   |         | Sector 2 (45°E–135°E) |       |    |       |                    | Sector 3 (135°E–135°W) |                      |                              | Sector 4 (135°W–45°W) |                    |    |    |       |
|---|------|------------------------|---------|-----------------------|-------|----|-------|--------------------|------------------------|----------------------|------------------------------|-----------------------|--------------------|----|----|-------|
|   |      | DML                    | POC     | MtV                   | MS-FM | SI | VH-LH | BH                 | CS                     | RI                   | VL                           | TM                    | M-AP               | CS | TF | eW    |
| <b>Order Rhabditida</b>   |      |                        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Chiloplacoides antarcticus</i> Heyns, 1994                     | C    | 15 <sup>ˆ</sup>        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Cuticularia firmata</i> Andr ssy, 1998                         | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Dolichorhabditis tereticorpus</i> Kito & Ohyama, 2008          | C    |                        |         |                       |       |    |       |                    | 17 <sup>ˆ</sup>        |                      |                              |                       |                    |    |    |       |
| <i>Panagrolaimus davidi</i> Timm, 1971                            | C    |                        |         |                       |       |    |       |                    |                        | 26,29 <sup>ˆ</sup>   | 1, 29                        |                       |                    |    |    |       |
| <i>Panagrolaimus magnivulvatus</i> Timm, 1971                     | C    | 4,27,28,9 <sup>ˆ</sup> |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Rhabditis krylovi</i> Tsalolikhin, 1989                        | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Scottinema lindsayae</i> Timm, 1971                            | C    | NR                     | 25, 2   |                       | NR    |    | NR    |                    |                        | 4,11,26,29           | 1,4,11,12,13,29 <sup>ˆ</sup> | 2                     |                    |    |    |       |
| <b>Order Plectida</b>   |      |                        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Ceratoplectus armatus</i> (Butschli, 1873) Andr ssy, 1984      | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20              |    |    | 20?   |
| <i>Chiloplectus masleni</i> Bostr m, 1997                         | C    | 4,10 <sup>ˆ</sup>      |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Plectus antarcticus</i> de Man, 1904                           | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Plectus belgicae</i> de Man, 1904                              | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Plectus frigophilus</i> Kirjanova, 1958                        | C-M  |                        | 25, 18  |                       | NR    |    | 8     | 16,31 <sup>ˆ</sup> | NR                     | 4, 29                | 1,4,29                       |                       | 20?                |    | NR |       |
| <i>Plectus insolens</i> Andr ssy, 1998                            | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Plectus meridianus</i> Andr ssy, 1998                          | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Plectus murrayi</i> Yeates, 1970                               | C-M  | 4,27,28,9              | 4,25,18 |                       | NR    | NR | 23    | 7,16               | 7                      | 4,29,30 <sup>ˆ</sup> | 1,4,13                       |                       | 20?                |    |    |       |
| <i>Plectus telekii</i> Mulik & Coomans, 1978                      | C    | 21                     |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Plectus tolerans</i> Andr ssy, 1998                            | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Teratocephalus pseudolirellus</i> Maslen, 1979                 | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 20 <sup>ˆ</sup>    |    |    |       |
| <i>Teratocephalus rugosus</i> Maslen, 1979                        | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 20 <sup>ˆ</sup>    |    |    |       |
| <i>Teratocephalus tilbrooki</i> Maslen, 1979                      | C-M  | 32?                    |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <b>Order Dorylaimida</b>  |      |                        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Amblydorylaimus isokaryon</i> Loof, 1975                       | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Calcaridorylaimus signatus</i> (Loof, 1975) Andr ssy, 1986     | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4 <sup>ˆ</sup>     |    |    |       |
| <i>Enchodelus signyensis</i> Loof, 1975                           | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Eudorylaimus antarcticus</i> (Steiner, 1916) Yeates, 1970      | C    |                        |         |                       |       |    |       |                    |                        | 4,6,29               | 1,4,6,13,29 <sup>ˆ</sup>     |                       |                    |    |    |       |
| <i>Eudorylaimus coniceps</i> Loof, 1975                           | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Eudorylaimus glacialis</i> Andr ssy, 1998                      | C    |                        |         |                       | 6     |    |       | x                  |                        | 30                   | 1,6 <sup>ˆ</sup>             |                       |                    |    |    |       |
| <i>Eudorylaimus nudicaudatus</i> Heyns, 1993                      | C    | 4,6 <sup>ˆ</sup>       |         |                       | x     |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Eudorylaimus pseudocarteri</i> Loof, 1975                      | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Eudorylaimus quintus</i> Andr ssy, 2008                        | C    |                        |         |                       |       |    |       | x,6 <sup>ˆ</sup>   |                        |                      | 6                            |                       |                    |    |    |       |
| <i>Eudorylaimus sabulophilus</i> Tijepkema, Ferris & Ferris, 1971 | C    | 21                     |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Eudorylaimus sextus</i> Andr ssy, 2008                         | C    |                        |         |                       |       |    |       | x,6 <sup>ˆ</sup>   |                        |                      |                              |                       |                    |    |    |       |
| <i>Eudorylaimus shirasei</i> Kito, Shishida & Ohyama, 1996        | C    |                        | 6, 19   | 4,6,19 <sup>ˆ</sup>   | x     |    |       |                    |                        |                      | 1                            |                       |                    |    |    |       |
| <i>Eudorylaimus spauli</i> Loof, 1975                             | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Eudorylaimus verrucosus</i> Loof, 1975                         | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Mesodorylaimus antarcticus</i> Nedelchev & Peneva, 2000        | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 22 <sup>ˆ</sup>    |    |    |       |
| <i>Mesodorylaimus chipevi</i> Nedelchev & Peneva, 2000            | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 22 <sup>ˆ</sup>    |    |    |       |
| <i>Mesodorylaimus imperator</i> Loof, 1975                        | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <i>Mesodorylaimus masleni</i> Nedelchev & Peneva, 2000            | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 22 <sup>ˆ</sup>    |    |    |       |
| <i>Mesodorylaimus signatus</i> Loof, 1975                         | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 20 <sup>ˆ</sup>    |    |    |       |
| <i>Rhysocolpus paradoxus</i> (Loof, 1975) Andr ssy, 1986          | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20 <sup>ˆ</sup> |    |    |       |
| <b>Order Monhysterida</b>   |      |                        |         |                       |       |    |       |                    |                        |                      |                              |                       |                    |    |    |       |
| <i>Eumonhystera vulgaris</i> (de Man, 1880) Andr ssy, 1981        | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4,20,3             |    |    | 3,20? |
| <i>Geomonhystera antarctica</i> Andr ssy, 1998                    | C    |                        |         |                       |       |    |       |                    |                        | 29                   | 1,4,29 <sup>ˆ</sup>          |                       |                    |    |    |       |
| <i>Geomonhystera villosa</i> (Butschli, 1873) Andr ssy, 1981      | M    |                        |         |                       |       |    |       |                    |                        |                      |                              |                       | 4, 20              |    |    | 3,20? |
| <i>Halomonhystera antarctica</i> Cobb, 1914                       | C    |                        |         |                       |       |    |       |                    |                        | 5 <sup>ˆ</sup>       |                              |                       |                    |    |    |       |
| <i>Halomonhystera continentalis</i> Andr ssy, 2006                | C    |                        |         |                       |       |    |       | 5,8 <sup>ˆ</sup>   |                        |                      |                              |                       |                    |    |    |       |

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