Soil Organisms 98 (SI 2) 2026

pp. 57–64
DOI 10.25674/521

RESEARCH ARTICLE

First records of terrestrial enchytraeids in Patagonia, South Chile

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Received 24 June 2026 | Accepted 8 October 2026 | Published online 10 November 2026

Abstract

The enchytraeid fauna in South America remains poorly explored despite the continent's extensive habitat diversity and high level of endemism. As part of PERMACHILE, an international, multidisciplinary, long-term research initiative, a faunistic survey of Chilean Patagonia was initiated to address this knowledge gap. Preliminary results from Yendegaia National Park revealed 15 enchytraeid species, including 14 species recorded for the first time in Chile and Patagonia. Two new species of *Achaeta* and three new species of *Christensenidrilus* have also been discovered so far and are to be described elsewhere. The finding of *Christensenidrilus* is notable as it represents the first record of the genus outside the type locality of the type species in the South Orkney Islands. Although species abundance was generally low, likely due to local environmental conditions, the results demonstrate that Chilean Patagonia harbors considerable undocumented diversity and warrants further faunal research.

Keywords

Annelids | potworms | *Christensenidrilus* | *Nothofagus* | Yendegaia

1 Introduction

The project PERMACHILE is an international, multidisciplinary, and long-term research program (www.permachile.com). In the 15 years since its launch, the research focus has expanded both geographically and in terms of research topics. Thus, research that began in the dry Andes of Chile is now being carried out across much of Patagonia, including Torres del Paine and Yendegaia National Parks. PERMACHILE focuses on permafrost changes and their associated environmental effects, drawing on extended field data collection and long-term monitoring. Integrated geomorphological and geophysical analyses used electrical resistivity tomography (ERT) and seismic refraction tomography (SRT) to characterize permafrost conditions and active-layer dynamics (Carrera et al. 2026, Ruiz-Pereira et al. 2026). Microbiological studies have revealed considerable taxonomic diversity in active permafrost layers and demonstrated that climatic fluctuations influence the composition and diversity of extremophilic bacterial communities (Faragó et al. 2024, 2026).

To complement these investigations, soil zoological studies were initiated in 2024, which currently include

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the nematode, enchytraeid, and lumbricid fauna. This is significant because the enchytraeid fauna of South America – concerning the size and the extraordinary diversity of habitats of the continent – is still understudied. Less than one hundred terrestrial or semi-aquatic species of enchytraeids have been recorded from Latin America (Schmelz et al., 2013). This number is particularly striking when compared, for instance, to a more thoroughly surveyed country: 123 species are known from Hungary (Dózsa-Farkas, 2019), even though its territory is approximately 192 times smaller and its habitats are far less diverse.

One of the first records of enchytraeids from South America and Patagonia was published by Ude (1896), who reported five marine littoral species from the Magellan Strait (Argentina and Chile). About 30 years later, Černosvitov described new species and two new genera, *Hemienchytraeus* and *Guaranidrilus,* from soils in Northern Argentina (1928, 1934, 1937). After decades of relative inactivity, Brasil came into focus from the 1970s: more than 20 new species were described by Righi, Christoffersen and Bittencourt (Christoffersen 2009, Schmelz et al., 2013). Species knowledge increased with the SOLOBIOMA project, a large-scale sampling campaign, which was executed across different land-use systems, such as pastures and old-growth forests (Römbke et al., 2005). Sixty-one species were found, most of them new to science, and a new genus, *Xetadrilus,* was also described (Schmelz et al., 2011). New species were also described from Ecuador by Dózsa-Farkas (1989).

The above review is not complete, as, for example, most of the marine littoral enchytraeids are not mentioned. However, there are still no data on enchytraeid worms from several Latin American countries. At any rate, the continent would be a very promising area of research, as former studies found that 74% of enchytraeids were registered as native species to Latin America. (Christoffersen, 2010). For this reason, one of the expedition's objectives – alongside the previously mentioned geophysical surveys – was to explore the local terrestrial enchytraeid fauna in Patagonia.

2 Materials and Methods

2.1 Study site

Yendegaia National Park (YNP) is a comparatively new protected area, founded in 2013 by the Government of Chile and the Yendegaia Foundation (https://www.tompkinsconservation.org). It is situated in the UNESCO Cape Horn Biosphere Reserve, the southern part of the Isla Grande de Tierra Del Fuego, Chile. The park covers approximately 150,000 hectares, stretching from the Beagle Channel to the Darwin mountain range, including glaciers, fjords, rivers, forests, and open grasslands. The area is in the Antiboreal Magellanian biogeographic province as part of the Pacific and Austro-Atlantic South American region (Rivas-Martínez et al. 2011). YNP has a subpolar oceanic climate according to the Köppen-Geiger climate classification system (Peel et al., 2007), and the area is classified as wet tundra (Sarricolea et al., 2017). The climate of Yendegaia National Park is strongly affected by the Cordillera Darwin and the prevailing westerly winds. Moist Pacific air undergoes orographic uplift over the mountain range, resulting in high precipitation at higher elevations and on the western slopes, while a pronounced rain-shadow effect produces substantially drier conditions in the Yendegaia Valley and toward Yendegaia Bay (Moreno et al. 2023). Consequently, precipitation varies markedly across the park, from approximately 350–400 mm yr^{-1} near Yendegaia Bay to 2,000–5,000 mm yr^{-1} in the upper glaciated areas of the Cordillera Darwin (Temme et al., 2025). This results in diverse sample areas, even within short geographical distances (5–10 km).

The mean annual air temperature is low, approximately 4–6 °C. Summer temperatures are cool, usually averaging 8–10 °C, although exceptionally warm days may briefly reach 20–24 °C. Winter temperatures are generally close to freezing, with typical averages around 0 °C and occasional lows near –11 °C between June and September. Mean annual ground temperatures range between −2 and 0 °C (Bartsch et al., 2016). Annual precipitation is generally around 600 mm, although the western and mountainous sectors near the glaciers probably receive considerably more because of orographic rainfall (https://meteostat.net). The soil is very shallow and developing over a metamorphic bedrock that is intruded by plutonic elements, such as granite, granodiorite, and tonalite (Esteban et al., 2014).

The sub-Antarctic forests of the park are dominated by the beech species of lenga (*Nothofagus pumilio*), coigüe (*N. dombeyi*) and guindo or Magellan's beech (*N. betuloides*) (Promis et al., 2008). A further common species is the canelo or Winter's bark (*Drimys winteri*). Due to the precipitation and high moisture, the region is rich in peat bogs, and over 130 species of mosses (Contreras, 2025) and 51 species of parmelioid lichens (Elvebakk et al., 2014) can be found.

2.2 Sample collection

Samples were collected from three distinct areas (Fig. 1). In 2024, twelve samples were collected on the

Northwestern side of Cerro Skottsberg (1022 m) (Fig. 2), which lies about 50 km northwest of the mountainous core of the Cordillera Darwin, where moist Pacific air is still being forced upward. Orographic uplift therefore maintains relatively high humidity with approximately 700 mm annual precipitation (Soto-Rogel, 2022). Sampling sites were on the northwest side of Cerro Skottsberg between the elevations of 330–940 m. The tree line is around 600 m a.s.l. (own measurements).

In 2025, the Southern slopes of Cerro Cóndor (1155 m) and the North shore of Yendegaia Bay were sampled (Fig. 3), with 11 and 9 samples, respectively. These sites are the same distance from the Cordillera Darwin but lie farther downwind, so the air's moisture has already

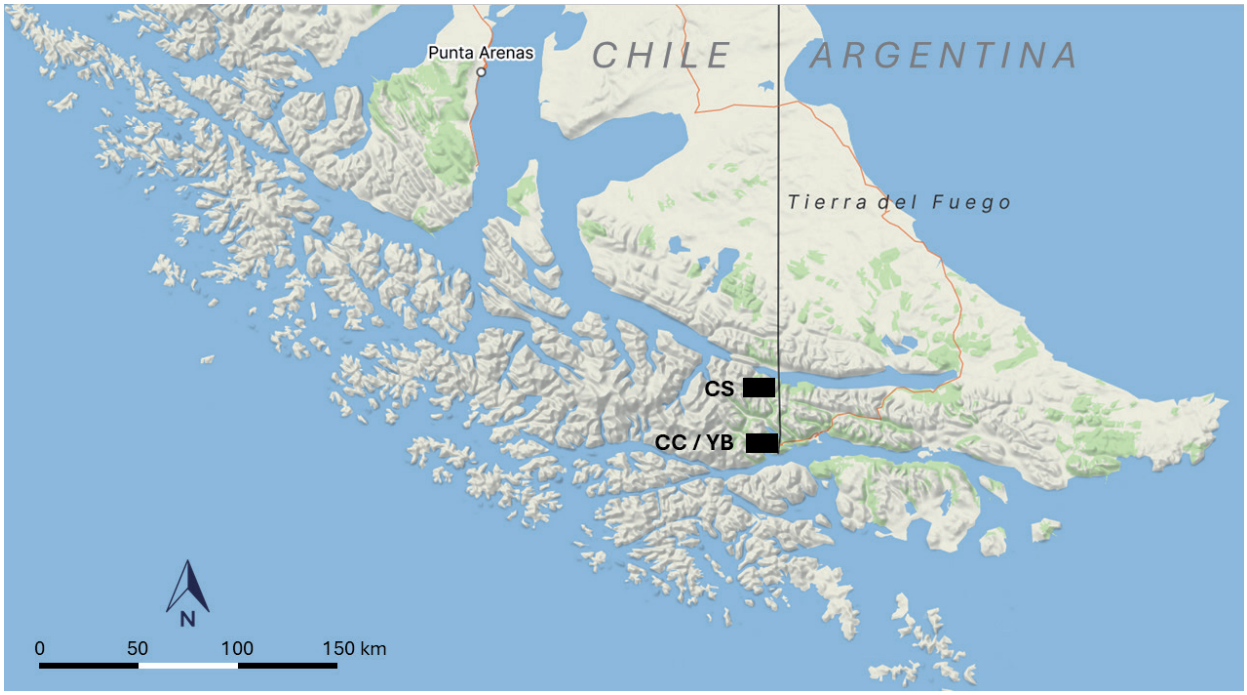


Figure 1. Location of the sampling areas in South Patagonia, Chile. (CS – Cerro Skottsberg, CC – Cerro Cóndor, YB – Yendegaia Bay)

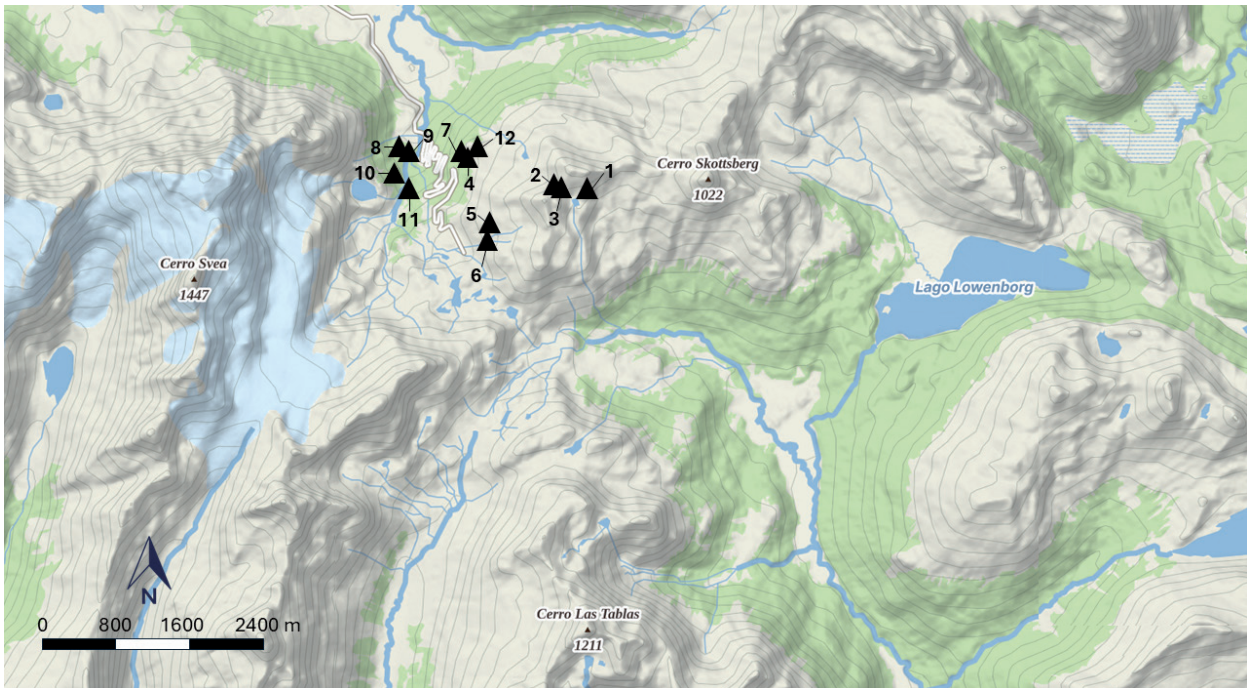


Figure 2. Sampling sites around Cerro Skottsberg. (Enlargement of Figure 1, part CS)

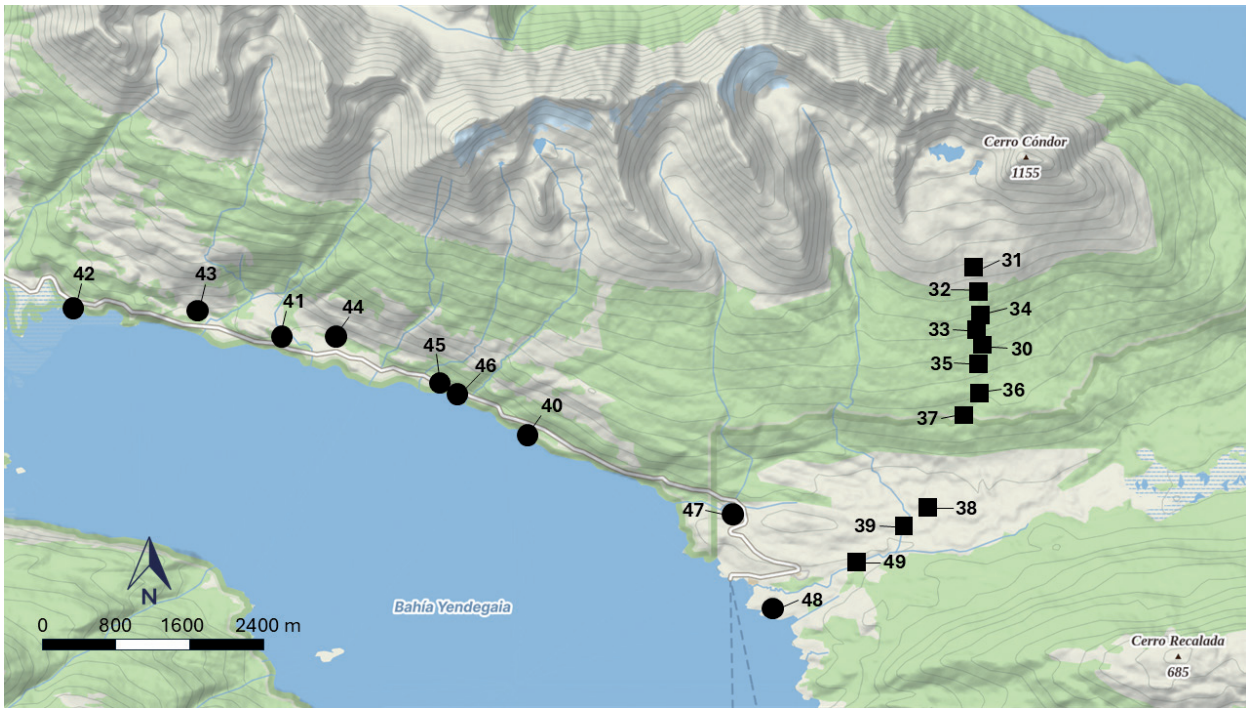


Figure 3. Sampling sites next to Cerro Cóndor and Yendegaia Bay. (Enlargement of Figure 1, part CC/YB)

precipitated over the mountains. Consequently, these sites have a considerably stronger rain-shadow effect, having only 200 mm yr^{-1} (Soto-Rogel, 2022).

Before taking samples, photos were taken of each sampling point-, and then the coordinates were recorded (Table 1). Photos of some of the sites are shown in the Supplements (Fig. S4–8). Qualitative soil samples were taken with a hand shovel from the litter-covered surface to about 10 cm depth. Field experience revealed that in the sample areas Cerro Skottsberg and Cerro Cóndor, the bedrock is only at a depth of 10–20 cm. Above this, there is a mixture of minimal mineral soil and varying amounts of decomposing litter and debris with a dense growth of fine roots and small rock particles. *Nothofagus* species occurring in the sample areas have both small canopies and small leaves (roughly 1–3 cm^2, calculated by own measurements and the data of Promis et al., 2008), so there is no significant replenishment of leaf litter biomass from the trees. Nevertheless, decaying organic matter is visible on the surface, which may be the result of slower decomposition.

Samples were put into plastic ziplock bags and stored in a cool place (5–10 °C). Samples were processed in the months following their collection. Enchytraeids were extracted by the O'Connor wet funnel method (O'Connor, 1962).

Enchytraeid specimens were first examined and measured alive, after which they were fixed and stored in either 70% ethanol or absolute alcohol for subsequent DNA analyses. Selected individuals were stained with borax-carmine, dehydrated through a graded ethanol series ranging from 70% to absolute ethanol, temporarily mounted in clove oil, and finally mounted permanently in Euparal between two coverslips. This preparation allowed both the dorsal and ventral sides to be examined (Schmelz 2003). Key morphological features were documented from living specimens, illustrated, and photographed using a Zeiss Axio Imager.A2 microscope equipped with differential interference contrast illumination and a Zeiss AxioCam MRc 5 digital camera. Images were processed with Axiovision software. Whole-mounted specimens were re-measured, re-examined, and photographed.

The maps were created by G. Boros using OpenStreetMap data and the Mapy.com platform.

3 Results

Samples were poor in both species and individual numbers, with 20 out of 32 containing no enchytraeid worms at all; therefore, Table 1 lists only those samples in which enchytraeids were present. In the YNP, fifteen species were found (Tab. 1). Among these, *Buchholzia appendiculata* (Buchholz, 1862), *Enchytraeus buchholzi* s.l. Vejdovskỳ, 1879, *Fridericia bisetosa* (Levinsen, 1884), *F. dura* (Eisen, 1879), *F. ratzeli* (Eisen, 1872), and *Henlea perpusilla* Friend, 1911 were found and reported here for the first time from Chile. All except *E. buchholzi*, which was previously reported from Argentinian Patagonia by Ude (1896), also

represent the first records from Patagonia. Also, this is the first find of *F. dura* in the Southern Hemisphere. Two new species of the genus *Achaeta* Vejdovskỳ, 1878 and three new species of the genus *Christensenidrilus* Dózsa-Farkas & Convey, 1998 were also found. The genus *Christensenidrilus* is new to both Chile and continental South America. Representatives of *Marionina* and *Mesenchytraeus*, unfortunately unidentifiable to species level, were found as well.

4 Discussion

A notable difference between the two *Nothofagus* forest sites is their aspect. At Cerro Skottsberg, the samples were collected from a northwest-facing slope, whereas at Cerro Cóndor, they originated from a south-facing slope. At high southern latitudes, south-facing slopes generally receive less direct solar radiation than north-facing slopes, with this contrast becoming particularly pronounced during periods of low solar elevation (Nunez, 1983; Tian et al., 2001). Reduced solar radiation may, in turn, decrease evapotranspiration and snowmelt, thereby contributing to higher soil moisture. As part of the PERMACHILE project, soil temperature loggers were installed at the time of sampling. Continued monitoring will provide a long-term dataset that will allow soil temperature dynamics to be compared between the study sites.

For technical reasons, the sample collections were at the end of the summer period (late February), which made the sample areas drier compared to average local conditions. This may explain the low numbers of individuals.

Table 1. List of the enchytraeid genera and species found with exact location data and habitat type.

Sample No.	Sampling Area	Coordinates	Altitude (a.s.l.).	Habitat type	Date of collection	Species
4	Skottsberg	54.6239494 S; 68.7410057 W	550 m	*Nothofagus* forest, leaf litter, moss	25/02/2024	*Christensenidrilus* sp. 1, sp. 2
9	Skottsberg	54.6232877 S; 68.7494235 W	350 m	*Nothofagus* forest, leaf litter and decayed wood	28/02/2024	*Christensenidrilus* sp. 1, sp. 2, *Enchytraeus buchholzi* s.l., *Fridericia dura, Henlea heleotropha* (juv)
10	Skottsberg	54.6256903 S; 68.7514862 W	430 m	*Nothofagus* forest, leaf litter	28/02/2024	*Christensenidrilus* sp. 1, sp. 3, *Enchytraeus buchholzi* s.l., *Fridericia dura*
36	Cerro Cóndor	54.8482774 S; 68.6530350 W	293 m	*Nothofagus* forest, leaf litter	19/02/2025	*Christensenidrilus* sp. 1
38	Cerro Cóndor	54.8597080 S; 68.6626002 W	58 m	Temporary water meadow	19/02/2025	*Enchytraeus buchholzi* s.l., *Fridericia dura, Henlea perpusilla, Marionina* sp.
39	Cerro Cóndor	54.8628982 S; 68.6646497 W	44 m	Meadow (clearing in former woods)	19/02/2025	*Achaeta* sp. 1, *Achaeta* sp. 2, *Fridericia dura, Henlea perpusilla*
40	Yendegaia Bay	54.8521223 S; 68.7277616 W	6 m	Coastal meadow	20/02/2025	*Christensenidrilus* sp. 1, sp. 3, *Enchytraeus buchholzi* s.l., *Fridericia dura, Henlea ventriculosa*
41	Yendegaia Bay	54.8435814 S; 68.7710987 W	0 m	Coastal meadow	20/02/2025	*Buchholzia appendiculata* (juv.), *Enchytraeus buchholzi* s.l., *Fridericia dura, Henlea perpusilla*
43	Yendegaia Bay	54.8410258 S; 68.7856344 W	26 m	Mixed forest with understory layer	20/02/2025	*Fridericia ratzeli, Henlea perpusilla*
44	Yendegaia Bay	54.8439440 S; 68.7608661 W	16 m	Tussock	20/02/2025	*E. buchholzi* s.l., *Henlea perpusilla*
48	Yendegaia Bay	54.8693913 S; 68.6883639 W	5 m	Coastal organic sediment	21/02/2025	*Mesenchytraeus* sp.
49	Cerro Cóndor	54.8653925 S; 68.6717513 W	36 m	Mixed forest soil with leaf litter	22/02/2025	*Enchytraeus buchholzi* s.l., *Fridericia bisetosa, F. dura, F. ratzeli*

Abundance cannot be estimated due to qualitative sampling. However, during sample processing, we observed that *Christensenidrilus* species were dominant, accounting for more than half of the individuals found in the sample. The discovery of the genus *Christensenidrilus* is of particular interest because it is the first time it has been found outside the type locality of the type species. So far, only one species, *Christensenidrilus blocki* has been described from Signy Island, one of the South Orkney Islands in the maritime Antarctic (Dózsa-Farkas & Convey, 1997), but based on our findings, it is not an isolated genus on one of the Subantarctic islands. The presence of *Christensenidrilus* with several species may indicate that it may be typical of the biogeographic region, but more extensive sampling would be needed to confirm this. Interestingly, the type species *C. blocki* was not among the species found in Patagonia.

A comparison of the Patagonian enchytraeid fauna with that in similar climates but different geographic regions is difficult. As there is no other continent at this latitude in the Southern Hemisphere, consequently, the enchytraeid or mesofauna can only be compared with that observed in the Northern Hemisphere. The corresponding latitude (54.6°–54.8°) passes through southern Canada (British Columbia to Newfoundland) in North America. However, the altitudinal tree line is situated somewhat south: studies in the Mealy Mountains (Labrador) report the tree line at approximately 600 m elevation at 53.6° N latitude. Dash (1970) and Dash and Cragg (1972) reported 10 enchytraeid species from various habitats (aspen and coniferous woodland and fen area) further south, from Kananaskis Valley, Canadian Rocky Mountains (around 51°N). However, samples were collected at a higher altitude (1380 m). Further terrestrial enchytraeid data are from the vicinity of Montréal (Nurminen, 1973), and the more northerly regions of Canada. For example, Christensen and Dózsa-Farkas (2006) conducted research further north, examining areas in the Canadian Arctic Archipelago (CAA) in addition to northeastern Greenland. They described 19 species from the CAA; 12 of these are widely distributed, suggesting that they may also occur further south. Among these species, we also found *Henlea heleotropha* and *H. perpusilla*.

In Europe, the 54.6°–54.8° N latitude range passes through areas such as Northern Ireland, Denmark, or southern Lithuania. However, due to the warm ocean currents that moderate Europe‘s climate, conditions are not directly comparable to the Americas. For instance, the tree line at an elevation of 550–650 meters occurs around 67–69° N in Scandinavia (Fassl et al. 2024, Gustafson et al. 2021, Moen et al. 2008). Based on the vegetation transition (subarctic/subantarctic forest to tundra) and temperature conditions, our YNP study sites correspond roughly to the Abisko region in Sweden (Parker et al. 2014). In their comprehensive work examining the Swedish enchytraeid fauna, Rota et al. (1998) reported 22 species from the Abisko region. Among these, only widely distributed *Enchytraeus buchholzi s.l.* and *Buchholzia appendiculata* were found in Patagonia. Further overlapping genera are *Henlea, Fridericia* and *Mesenchytraeus*.

In Asia, the latitudes in question span Siberia, which has a subpolar continental climate with long winters, cool summers, and year-round precipitation (Dfc in the Köppen-Geiger system) (Peel et al., 2007). At the same time, given the continent‘s vast extent and local geographical conditions, this can entail a variety of vegetation types (mixed forests, deciduous needleleaf forests, wetlands, shrublands) (Beak et al., 2025). Thus, comparison with the Patagonian fauna has little relevance. The diversity and abundance of enchytraeid fauna of the northern Palaearctic region were presented in two studies (Degtyarev et al. 2024; Saifutdinov et al. 2025).

The first data presented here, and the ongoing species descriptions, show that this region harbors numerous new species of enchytraeids and is therefore definitely worth further faunistic research.

Funding

The project was funded by NKFIH 147424.

Acknowledgement

The authors are grateful to the Chilean Army (Ejército de Chile) for the permits to enter closed areas. We thank the honorary consul, Dr. Luis José Godoy González, for his indispensable help with the administration.

Supplementary Online Material

Figures S4–S8. (**Fig. S4**. The view of Cerro Cóndor through the Nothofagus forest., **Fig. S5**. A typical view of a *Nothofagus* stand on the southern slope of Cerro Cóndor, at an elevation of approximately 400 m a.s.l., **Fig. S6**. The view of Yendegaia Bay from Cerro Cóndor. Behind the bay, the easternmost summits of Cordillera Darwin are visible., **Fig. S7**. The view of Yendegaia Bay., **Fig. S8**. Coastal meadow and the edge of a mixed forest along the shore of Yendegaia Bay. Available at https://doi.org/10.25674/521.

References

Bartsch, A., Grosse, G., Kaab, A., Westermann, S., Strozzi, T., Wiesmann, A., Duguay, C., Seifert, F.M., Obu, J. & Goler, R. (2016). GlobPermafrost - How Space-Based Earth Observation Supports Understanding of Permafrost, Living Planet Symposium, ADS Bibcode
2016ESASP.740E.332B, 332

Beak, M., Ichii, K., Yamamoto, Y. Wang, R., Zhang, B., Ram C. Sharma, R.C. & Hiyama, T. (2025). Land cover classification for Siberia leveraging diverse global land cover datasets. *Progress in Earth and Planetary Science* 12(3). https://doi.org/10.1186/s40645-024-00672-5

Carrera, A., Pavoni, M., Ruiz-Pereira, S. et al. (2026). First subsurface characterization of periglacial areas in the Yendegaia National Park, Southern Tierra del Fuego Island, Chile. *Cold Regions Science and Technology*, 247. 10.1016/j.coldregions.2026.104919

Černosvitov, L. (1928). Eine neue, an Regenwürmern schmarotzende Enchyträiden-Art. *Zoologischer Anzeiger*, 78, 49–62.

Černosvitov, L. (1934). Zur Kenntnis der Enchytraeiden II. *Zoologischer Anzeiger*, 105, 295–305.

Černosvitov, L. (1937). Notes sur les Oligochaeta (naïdidées et enchytraeidées) de l′Argentine. Anales del Museo Argentino de Ciencias Naturales Bernardino Rivadavia Buenos Aires, 39, 135−157.

Christensen, B., Dózsa-Farkas, K. (2006). Invasion of terrestrial enchytraeids into two postglacial tundras: North-eastern Greenland and the Arctic Archipelago of Canada (Enchytraeidae, Oligochaeta). *Polar Biology* 29, 454–466. https://doi.org/10.1007/s00300-005-0076-3

Christoffersen, M.L. (2009). Species diversity and distributions of microdrile earthworms (Annelida, Clitellata, Enchytraeidae) from South America. *Zootaxa*, 2065, 51–68.

Christoffersen, M.L. (2010). Continental biodiversity of South American oligochaetes: the importance of inventories. Acta Zoológica Mexicana (nueva serie), 26, 35–46.

Contreras, L.F.O. (2025). Análisis de biodiversidad y distribución de musgos (Bryophyta) en ecosistemas subantárticos del sureste del Parque Nacional Yendegaia, Región de Magallanes y Antártica Chilena. Master's thesis (in Spanish), Universidad Austral de Chile. https://www.forestal.uach.cl/manejador/resources/tesina-lucas-oyarzun-contrerascompressed.pdf

Dash, M.C. (1970). A taxonomic study of Enchytraeidae (Oligochaeta) from Rocky Mountain forest soils of the Kananaskis region of Alberta, Canada. *Canadian Journal of Zoology*, 48, 1429–1435. https://doi.org/10.1139/z70-242

Dash, M.C, Cragg, J.B. (1972). Ecology of Enchytraeidae (Oligochaeta) in Canadian Rocky Mountain soils. *Aspen Bibliography.* Paper 5439. https://doi.org/10.1016/S0031-4056(23)02055-3

Degtyarev, M.I., Saifutdinov, R.A., Korobushkin, D.I., Bastrakov, A.I., Danilova, M.A., Davydov, I.D., Gorbunova, A.Yu., Guseva, P.A., Karlik, E.I., Koshchanova, R.E. et al. (2024). Taxonomic diversity and abundance of enchytraeids (Annelida, Clitellata, Enchytraeida) in the Northern Palaearctic. 1. Asian part. *Biodiversity Data Journal*, 12: e114682. https://doi.org/10.3897/BDJ.12.e114682

Dózsa-Farkas, K. (1989). Neue Enchytraeiden-Arten (Oligochaeta) aus Ekuador. *Acta Zoologica Hungarica*, 35, 191–203.

Dózsa-Farkas, K. (2019). *Enchytraeids of Hungary (Annelida, Clitellata, Enchytraeidae).* Pedozoologica Hungarica No. 7. Eötvös Loránd University, Budapest.

Dózsa-Farkas, K., Convey, P. (1997). *Christensenia*, a new terrestrial enchytraeid genus from Antarctica. *Polar Biology,* 17, 482–486. https://doi.org/10.1007/s003000050146

Dózsa-Farkas, K., Convey, P. (1998). Erratum: Polar Biol 17: 482–486. *Polar Biology,* 20, 292. https://doi.org/10.1007/s003000050305

Elvebakk, A., Bjerke, J.W., & Støvern, L.E. (2014). Parmelioid lichens (Parmeliaceae) in southernmost South America. *Phytotaxa*, 173, 1–30. http://dx.doi.org/10.11646/phytotaxa.173.1.1

Esteban, F.D., Tassone, A., Lodolo, E. et al. (2014). Geometría del basamento y espesores sedimentarios del lago Fagnano (Tierra del Fuego). *Andean Geology*, 41, 293–313, 10.5027/andgeoV41n2-a02

Fassl, M., Aakala, T., Östlund, L. (2024). Elevation-dependent tree growth response to climate in a natural Scots pine/downy birch forest in northern Sweden. *Plant-Environment Interactions* 5(2), e10140. https://doi.org/10.1002/pei3.10140.

Faragó, V., Megyes, M., Nagy, B., Hengst, M., Paquis, P., & Borsodi, A. K. (2024). Environmental characterization and impact of climatic fluctuations on the diversity of extremophilic bacterial communities of a high-altitude seasonal meltwater pond on Ojos del Salado (Dry Andes, Chile). *Geomicrobiology Journal*, 41(10), 1008–1017. https://doi.org/10.1080/01490451.2024.2415717

Faragó, V., Borsodi, A. K. & Nagy, B. (2026). The taxonomic diversity of prokaryotic communities from permafrost active layers of the Chilean Andes. *Microorganisms*, 14(3), 613. https://doi.org/10.3390/microorganisms14030613

Gustafson, A., Miller, P. A., Björk, R. G., Olin, S., Smith, B. (2021). Nitrogen restricts future sub-arctic treeline advance in an individual-based dynamic vegetation model. Biogeosciences, 18, 6329–6347, https://doi.org/10.5194/bg-18-6329-2021

Jones, M., Willey, L. (Eds.) (2018). Eastern Alpine Guide: Natural History and Conservation of Mountain Tundra East of the Rockies. University Press of New England.

Moen, J., Cairns, D.M., Lafon, C.W. (2008). Factors structuring the treeline ecotone in Fennoscandia. *Plant Ecology & Diversity*, 1(1), 77–87. https://doi.org/10.1080/17550870802246664

Moreno, P.I., Lambert, F., Hernández, L., Villa-Martínez, R.P. (2023). Environmental evolution of western Tierra del Fuego (~54°S) since ice-free conditions and its zonal/hemispheric implications. Quaternary Science Reviews, 322, 108387. https://doi.org/10.1016/j.quascirev.2023.108387.

Nunez, M. (1983). Estimation of solar radiation received on slopes in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania,* 117, 153–159. DOI: 10.26749/rstpp.117.153.

Nurminen, M. (1967). Ecology of enchytraeids (Oligochaeta) in Finnish coniferous forest soil.
Annales Zoologici Fennici, 4, 147–157.

Nurminen, M. (1973). Enchytraeidae (Oligochaeta) from the vicinity of Montreal, Canada. *Annales Zoologici Fennici*, 10, 399–402.

O'Connor, F.B. (1962). The extraction of Enchytraeidae from soil. In: Murphy, P. W. (ed.) *Progress in Soil Zoology*. London, p. 279–285.

Parker, T.C., Subke, J.A., Wookey, P.A. (2015). Rapid carbon turnover beneath shrub and tree vegetation is associated with low soil carbon stocks at a subarctic treeline. *Global Change Biology* 21, 2070–2081. https://doi.org/10.1111/gcb.12793

Peel, M. C., Finlayson, B. L., & McMahon, T. A. (2007). Updated world map of the Köppen–Geiger climate classification. *Hydrology and Earth System Sciences,* 11, 1633–1644. https://doi.org/10.5194/hess-11-1633-2007

Promis, A., Cruz, G., Reif, A., Gärtner, S. (2008). *Nothofagus betuloides* (Mirb.) Oerst 1871 (Fagales: Nothofagaceae) forests in Southern Patagonia and Tierra del Fuego. Anales del Instituto de la Patagonia. 36 (1). doi:10.4067/S0718-686X2008000100005.

Rivas-Martínez, S., Rivas-Saenz, S. & Penas, A. (2011). Worldwide Bioclimatic Classification System. Global Geobotany, 1, 1–634.

Rota, E., Healy, B. & Erséus, C. (1998). Biogeography and taxonomy of terrestrial Enchytraeidae (Oligochaeta) in Northern Sweden, with comparative remarks on the genus Henlea. *Zoologischer Anzeiger* 237, 155–169.

Römbke, J., Collado, R. & Schmelz, R.M. (2005). Oligochaetes (Clitellata) of the Mata Atlântica (Parana, Brazil): first results of the SOLOBIOMA project. *Proceedings of the Estonian Academy of Sciences, Biology, Ecology*, 54, 302–309.

Ruiz-Pereira, S., Pavoni, M., Contreras, M., Ivan, L., Boros, G., Carrera, A. et al. (2026). Integrated geomorphological–geophysical characterization of periglacial processes and frozen ground distribution in the easternmost edge of the Darwin range, Tierra del Fuego (54° S). Earth Surface Processes and Landforms, 51(4), e70290. https://doi.org/10.1002/esp.70290

Saifutdinov, R.A., Degtyarev, M.I., Korobushkin, D.I., Artemieva, S.M., Byzov, P.S., Danilova, M.A., Ditts, A.A., Ermokhina, K.A., Garibian, P.G., Gorbunova, A.Yu., et al. (2025). Taxonomic diversity and abundance of enchytraeids (Annelida, Clitellata, Enchytraeida) in the Northern Palaearctic. 2. European Russia. *Biodiversity Data Journal* 13, Article e144992. https://doi.org/10.3897/BDJ.13.e144992

Sarricolea, P., Herrera-Ossandon, M. & Meseguer-Ruiz, Ó. (2017) Climatic regionalisation of continental Chile. *Journal of Maps*, 13, 66–73. https://doi.org/10.1080/17445647.2016.1259592

Schmelz, R.M. (2003). *Taxonomy of Fridericia (Oligochaeta, Enchytraeidae). Revision of species with morphological and biochemical methods*. Abhandlungen des Naturwissenschaftlichen Vereins in Hamburg.

Schmelz, R.M., Collado, R. & Römbke J. (2011). Mata Atlântica enchytraeids (Enchytraeidae, Oligochaeta): A new genus, *Xetadrilus* gen. nov., with three new species, and four new species of *Guaranidrilus* Černosvitov. *Zootaxa*, 2838: 1–29

Schmelz, R.M., Niva, C.C., Römbke, J., Collado, R. (2013). Diversity of terrestrial Enchytraeidae (Oligochaeta) in Latin America: Current knowledge and future research potential. *Applied Soil Ecology*, 69, 13–20. https://doi.org/10.1016/j.apsoil.2012.12.012.

Soto-Rogel, P., Aravena, J. C., Villalba, R., Bringas, C., Meier, W. J.-H., Gonzalez-Reyes, Á., & Grießinger, J. (2022). Two *Nothofagus* species in southernmost South America record divergent climate signals. *Forests*, 13(5), 794. https://doi.org/10.3390/f13050794

Temme, F., Sommer, C., Schaefer, M., Jaña, R., Arigony-Neto, J., Gonzalez, I., Izagirre, E., Giesecke, R., Tetzner, D., Fürst, J.J. (2025). Climate's firm grip on glacier ablation in the Cordillera Darwin Icefield, Tierra del Fuego. *Nature Communications* 16 (1), 2677. doi: 10.1038/s41467-025-57698-6.

Tian, Y.Q., Davies-Colley, R.J., Gong, P., & Thorrold, B.W. (2001). Estimating solar radiation on slopes of arbitrary aspect. *Agricultural and Forest Meteorology,* 109 (1), 67–74. DOI: 10.1016/S0168-1923(01)00245-3.

Ude, H. (1896) Enchytraeiden. In Naturhistorisches Museum in Hamburg, *Ergebnisse der Hamburger Magalhaensischen Sammelreise 1892/93, III. Band, Bryozoen und Würmer* (pp. 1–43 + 1 plate). L. Friederichsen & Co., Hamburg.

Online References

Meteostat. (n.d.). *The weather's record keeper*. https://meteostat.net (Retrieved October, 2026)

Tompkins Conservation. (2013, December 12). *Yendegaia National Park created!* Tompkins Conservation News. https://www.tompkinsconservation.org/news/2013/12/12/yendegaia-national-park-created/