

Standard Paper

Two new species of the genus *Lecidella* (Lecanoraceae, Ascomycota) from maritime Antarctica, southern South America and North America

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Abstract

Two new species of the genus *Lecidella*, one with a North American-maritime Antarctic distribution and one with a so far exclusively southern South American-maritime Antarctic distribution, are described using molecular and morphological tools. *Lecidella ayazii* is a species growing on soil and also on mosses and has so far been found on the Antarctic Peninsula, as well as in the alpine areas of the La Sal Mountains, Utah, USA and in the Kivalliq Region (Nunavut) in the north of Canada, whereas *L. drakensis* occurs mainly on siliceous rocks, rarely on mosses, and has been recorded on both sides of the Drake Passage in southern Patagonia and the Antarctic Peninsula. Phylogenetic analysis of the nrITS sequence data shows that both species belong in the *L. elaeochroma* clade, each forming a highly supported and distinct group. Furthermore, they also differ in morphological and chemical characters from the species described so far in this clade. In addition, five further accessions were recorded from the maritime Antarctic, which were placed in the cosmopolitan and heterogeneous *L. stigmatea* clade, of which one could be assigned to the bipolar species *L. siplei*.

Keywords: biodiversity; bipolar distribution; crustose lichens; subantarctic subregion; taxonomy

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Introduction

The southern polar regions include not only the Antarctic continent, with less than *c.* 1% surface area suitable for terrestrial vegetation (Peat *et al.* 2007), but also the climatically milder maritime Antarctic Peninsula and the islands in the South Atlantic, as well as the islands in the southern Indian Ocean, the New Zealand shelf islands (Auckland Islands and Campbell Island), Macquarie Island (Lauer *et al.* 1996; Brummitt *et al.* 2001) and the subantarctic subregions along the mountain ranges in southern South America (Morrone 2000).

These milder and often ice-free areas are characterized by the absence of arboreal vegetation and are colonized by specialized and cold-adapted pioneer vegetation, including a high density of mostly rock-dwelling crustose lichens acting as pioneer organisms (Hertel 1984; Ruprecht *et al.* 2020). Lichens, as the dominant elements of Antarctic terrestrial vegetation, are represented by 300–400 species in the continent, according to the BAS (British Antarctic Survey) database, and they have been recorded in many studies during the last hundred years (e.g. Øvstedal &

Smith 2001; Castello 2003; Hertel 2007; Peat *et al.* 2007; Ruprecht *et al.* 2010, 2012; Colesie *et al.* 2014; Halıcı *et al.* 2018, 2021; Wagner *et al.* 2021). An even higher diversity of lichens can be estimated for southern South America (sSA, including Falkland Islands: Fryday *et al.* 2019; Ruprecht *et al.* 2020; Etayo *et al.* 2021; Fryday 2022). However, the biodiversity of lichens in the Antarctic regions is still not fully known. New species are continuing to be described, which has become possible especially through the use of modern techniques such as DNA barcoding (Ruprecht *et al.* 2020; Halıcı *et al.* 2021, 2022; Lagostina *et al.* 2021). These techniques also have the potential to reveal whether species for which only an endemic distribution was previously indicated are in fact bipolar, along continents (South to North America) or even globally distributed. This also applies to a small number of lecideoid lichen species such as *Lecidella siplei* (C. W. Dodge & G. E. Baker) May. Inoue or *Lecidea polypycnidophora* U. Rupr. & Türk which were previously described as endemic to Antarctica (Castello 2003; Ruprecht *et al.* 2010). More recent studies have demonstrated that *Lecidella siplei* has a bipolar distribution and *Lecidea polypycnidophora* an alpine (North American)-southern polar distribution (Ruprecht *et al.* 2012; Hale *et al.* 2019). These unresolved biogeographical connections between Antarctica and Svalbard (Norway; *L. siplei*), as well as montane regions of western North America (*L. polypycnidophora*, *L. andersonii* Filson), show that potential colonization routes seem to exist and that the timing of dispersal events may

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also be highly relevant (e.g. Buschbom 2007; Fernandez-Mendoza & Printzen 2013; Hale *et al.* 2019; Ruprecht *et al.* 2020).

The globally distributed genus *Lecidella* Körb. is represented by c. 50 recognized species and belongs to the family *Lecanoraceae* (Knoph & Leuckert 2004). This is not only clearly supported by molecular data (Zhao *et al.* 2015), but also by the quite similar ascus type. However, the *Lecidella*-type ascus also occurs in the genus *Japewiella* (Printzen 1999). It differs from the *Lecanora*-type ascus by an amyloid tholus and a narrow axial body converging towards the apex (Knoph & Leuckert 2004), in contrast to a thickened and also amyloid tholus at the apex, but with a broad non-amyloid axial mass (Wirth *et al.* 2013). The genus is better distinguished by the extremely lax and rarely capitate paraphyses (Wirth *et al.* 2013). Initially, Hertel & Leuckert (1967) treated *Lecidella* as a subgenus of the genus *Lecidea*, but two years later they elevated it to genus level (Hertel & Leuckert 1969) because of its secondary chemistry, which differs from *Lecidea* by the presence of chlorinated norlichexanthones in many species. This genus is considered taxonomically difficult because of its high variation and/or plasticity in diagnostic characters (Zhao *et al.* 2015). The genus *Lecidella* is currently represented by nine species from the subantarctic region (Knoph & Leuckert 1994; Ruprecht *et al.* 2020; Etayo *et al.* 2021; Fryday 2022) and around six for maritime and continental Antarctica (Castello 2003; Ruprecht *et al.* 2012; Fryday 2022).

Globally distributed genera in lichen-forming fungi repeatedly show disjunct distributions caused, for instance, by vicariance and mid-distance dispersal (Lücking *et al.* 2008), or by transition from the Arctic to Patagonia (sSA) in the Pleistocene, resulting in cryptic speciation (Fernandez-Mendoza & Printzen 2013). Although this is not a common occurrence, Ruprecht *et al.* (2012, 2020) reported a small number of endemic taxa and locally differentiated subgroups for the southern polar regions (southern South America, continental Antarctica) for the genera *Lecidea* and *Lecidella*.

Here we describe two new species of the genus *Lecidella* from maritime Antarctica and southern Patagonia, one with a North American-maritime Antarctic distribution and one with a so far exclusively southern South American-maritime Antarctic distribution, as well as several other maritime Antarctic accessions.

Material and Methods

Site descriptions (Fig. 1)

James Ross Island, located in the North-East Antarctic Peninsula region, has a cold, polar-continental climate (Martin & Peel 1978) because of the Trinity Peninsula Mountains (Antarctic Peninsula) that shield the island from precipitation (Davies *et al.* 2013). Precipitation estimates range from 200 to 500 mm per year (van Lipzig *et al.* 2004) and, therefore, James Ross Island is considered a semi-arid environment.

Horseshoe Island is located in Marguerite Bay within the West Antarctic Peninsula. Gaul Cove is located on the east, while Lystad Bay is on the west coast of the island. The glacier-free regions are mainly composed of plutonic rocks consisting of granite and gabbro, banded gneiss and granitic gneiss belonging to the metamorphic complex. Sediments and moraines are also formed because of glacial movements on the island. The north of the island consists of rocks of a more diverse origin, whereas the mountains in the south are ponderous granites.

The two areas in southern Patagonia (Chile, sSA) are located in the Región de Magallanes y de la Antártica Chilena: Laguna Blanca at the volcanic Rock Morro Chico and the western part

of the Torres del Paine National Park. Both areas are dominated by siliceous substrata and are influenced by the unique climate conditions for Patagonia, caused by strong westerly winds from the Pacific Ocean (Silva *et al.* 2009).

The specimens are deposited at the Erciyes University Herbarium Kayseri, Turkey (ERCH), at the herbarium of the University of Salzburg, Austria (SZU) and at the herbarium of Michigan State University (MSC; Table 1).

Morphological analyses

Light microscopic investigations were carried out with a Leica DVM6 digital microscope, a LEITZ Laborlux S and an Olympus BX53 (with an Olympus OM-D, E-M1 mark II camera). Photographic images were made of thallus morphology and anatomical features of asci and ascospores. Cross-sections of apothecia (12 µm thick) were prepared using a Leitz Kryomat 1703 freezing microtome. Measurements of anatomical structures always refer to water mounts, with at least 20 measurements made for all investigated anatomical structures. Spore measurements are given as: (minimum) most frequent (80%) (maximum).

Chemical analyses

Secondary metabolites were identified by thin-layer chromatography (TLC) using solvents A (toluene:1,4-dioxane:glacial acetic acid, 36:9:1) and C (toluene:glacial acetic acid, 20:3) (Huneck *et al.* 1996; Orange 2001). Spot tests were as follows: KOH, 10% (K), nitric acid solution, 35% (N), saturated potassium hypochlorite solution (C) and Lugol's iodine solution, 50% (I). KC: at first K was applied and then C within 10 s.

DNA amplification, sequencing and phylogenetic analyses

Total DNA was extracted from individual thalli using the DNeasy Plant Mini Kit (Qiagen) following manufacturer instructions. The internal transcribed spacer (ITS) regions of the mycobionts' nuclear ribosomal DNA (nrITS) were sequenced and amplified using the primers ITS1F (Gardes & Bruns 1993) and ITS4 (White *et al.* 1990) with standard conditions. PCR products were sent to Eurofins Genomics (Germany) for sequencing.

The sequences were assembled and edited using Geneious Pro v. 6.1.8 (www.geneious.com), aligned with MAFFT v. 7.017 (Katoh *et al.* 2002) and placed in context of the most recently published phylogenies of Ruprecht *et al.* (2020) and Fayyaz *et al.* (2022) based on the concept of Zhao *et al.* (2015). The maximum likelihood analysis (ML) was performed using the IQ-TREE web server (Trifinopoulos *et al.* 2016) with default settings (ultrafast bootstrap analyses (Hoang *et al.* 2017), 1000 BT alignments, 1000 max. iterations, min. correlation coefficient: 0.99, SH-aLRT branch test with 1000 replicates) and presented as a consensus tree. The best-fit model according to BIC, Tne + I + G4, was selected with the implemented model finder (Kalyaanamoorthy *et al.* 2017) of the program IQ-TREE. Bayesian phylogenies were inferred using the Markov chain Monte Carlo (MCMC) procedure as implemented in MrBayes v. 3.2. (Ronquist & Huelsenbeck 2003). The analysis was performed assuming the general time reversible model of nucleotide substitution including estimation of invariant sites and a discrete gamma distribution with six rate categories (GTR + I + Γ; Rodriguez *et al.* 1990). Two runs with 2 million generations each starting with a random tree and employing four

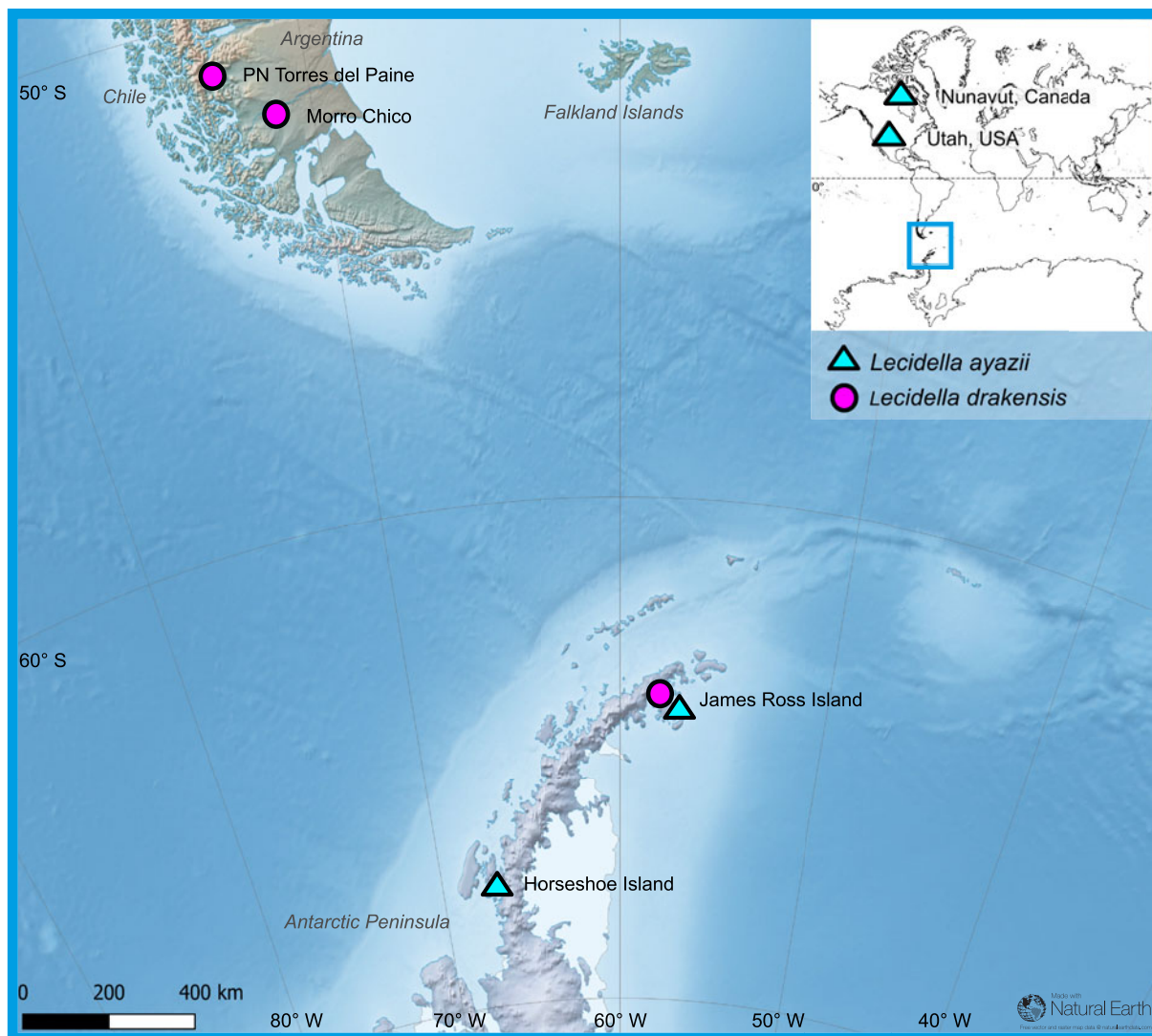


Figure 1. Collection sites of *Lecidella* species in maritime Antarctica, the subantarctic areas of southern South America (Chile), and North America. Turquoise triangles = *Lecidella ayazii*; pink circles = *Lecidella drakensis*. In colour online.

simultaneous chains were executed. Every 1000th tree was saved into a file. Subsequently, the first 25% of trees was deleted as the 'burn-in' of the chain. A consensus topology with posterior probabilities for each clade was calculated from the remaining 1501 trees. The phylogenies were visualized with the program FigTree v. 1.4.3 (Rambaut 2014).

Results

Phylogenetic analyses

The final data matrix of this phylogeny contains 61 sequences of the ITS marker with a length of 538 characters, and was rooted with species of the genera *Carbonea* (Hertel) Hertel and *Lecanora* Ach. The phylogeny (Fig. 2) is divided into four main clades: *L. stigmatea* (Ach.) Hertel & Leuckert, *L. enteroleucella* (Nyl.) Hertel, *L. elaeochroma* (Ach.) M. Choisy (Zhao *et al.* 2015) and *Lecidella* sp. nov. (Ruprecht *et al.* 2020). Five accessions from the maritime Antarctic were located in the very heterogeneous clade of *L. stigmatea*. One of these accessions (JR_0.303) can be assigned to *L. siplei*. Both new species described here are part of the *L. elaeochroma* clade and form two strongly supported

distinct clades. The terricolous species *Lecidella ayazii* sp. nov., which occurs in maritime Antarctica, as well as in the alpine areas of the La Sal Mountains, Utah, USA and the Kivalliq Region, Nunavut in the north of Canada, is sister to accessions of *L. elaeochroma*, *L. effugiens* (Nilson) Knoph & Hertel and *L. elaeochromoides* (Nyl.) Knoph & Hertel. *Lecidella drakensis* sp. nov., restricted to southern Patagonia (sSA) and maritime Antarctica, is sister to a heterogeneous group consisting of accessions assigned to *L. wulfenii* (Hepp) Körb, *L. elaeochroma*, *L. euphorea* (Flörke) Hertel and *L. flavosorediata* (Vědza) Hertel & Leuckert. *Lecidella meiococca* (Nyl.) Leuckert & Hertel is basal to this highly supported group.

Taxonomy

Lecidella ayazii Halıcı & U. Rupr. sp. nov.

Mycobank No.: MB 851244

Differing from *L. wulfenii* by having a golden brown instead of a reddish or orange-brown hypothecium, growing on mosses over a siliceous instead of calcareous substratum and by a different

Table 1. Voucher information and GenBank Accession numbers of the investigated specimens of the genus *Lecidella* collected in the subantarctic areas of southern South America (Chile), maritime Antarctica and northern Canada.

Voucher-ID	Accession-number	Species name	Country	Region	Area	Coordinates	Alt. (m a.s.l.)	Collector	Collection date	Herbarium
Fryday_11820	OR648670	<i>L. ayazii</i> sp. nov.	Canada	Nunavut, Kivalliq Region	Rankin Inlet, Iqalugaarjuup Nunanga Territorial Park	62°52'49.2"N 92°08'48.8"W	9	Fryday, A. M. McMullin, R. T. Allen, J. Sokoloff, P.	2023-07-10	MSC
Fryday_11935	OR648671	<i>L. ayazii</i> sp. nov.	Canada	Nunavut, Kivalliq Region	Rankin Inlet, Iqalugaarjuup Nunanga Territorial Park	62°53'24.1"N 92°09'24.1"W	27	Fryday, A. M. McMullin, R. T. Allen, J. Sokoloff, P.	2023-07-16	MSC
HS 0.009	OQ534852	<i>L. ayazii</i> sp. nov.	Antarctica	Antarctic Peninsula	Horseshoe Island	67°48'30"S 67°17'39"W	5	Halici, M. G.	2022-02-17	ERCH
JR 0.062	OQ534850	<i>L. ayazii</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°49'80"S 57°54'11"W	260	Halici, M. G.	2017-01-27	ERCH
JR 0.258	OQ534855	<i>L. ayazii</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°48'42.0"S 57°50'5.4"W	345	Halici, M. G.	2017-01-23	ERCH
JR 0.323	OQ534851	<i>L. ayazii</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°49'46.2"S 57°54'21.6"W	292	Halici, M. G.	2017-01-27	ERCH
JR 0.340	OQ534853	<i>L. ayazii</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°48'24.9"S 57°50'27.6"W	142	Halici, M. G.	2017-01-24	ERCH
UR00086	MK620140	<i>L. drakensis</i> sp. nov.	Chile	Región de Magallanes y de la Antártica Chilena, Laguna Blanca	Morro Chico	52°3'31"S 71°25'11"W	440	Ruprecht, U.	2015-02-10	SZU
UR00120	MK620158	<i>L. drakensis</i> sp. nov.	Chile	Región de Magallanes y de la Antártica Chilena, Laguna Blanca	Torres del Paine National Park	51°7'26"S 73°8'33"W	239	Ruprecht, U.	2018-02-12	SZU
JR 0.082	OQ534854	<i>L. drakensis</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°48'24.9"S 57°50'27.6"W	142	Halici, M. G.	2017-01-24	ERCH
JR 0.115	OQ534857	<i>L. drakensis</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°52'39.0"S 57°46'51.6"W	2	Halici, M. G.	2017-02-03	ERCH
JR 0.397	OQ534856	<i>L. drakensis</i> sp. nov.	Antarctica	Antarctic Peninsula	James Ross Island	63°49'46.2"S 57°54'21.6"W	292	Halici, M. G.	2017-01-27	ERCH
JR 0.303	OQ557118	<i>L. siplei</i> (C. W. Dodge & G. E. Baker) May. Inoue	Antarctica	Antarctic Peninsula	James Ross Island	63°49'46.2"S 57°54'21.6"W	292	Halici, M. G.	2017-01-27	ERCH
JR 0.130	OQ557090	<i>L. stigmattea</i> (Ach.) Hertel & Leuckert	Antarctica	Antarctic Peninsula	James Ross Island	63°48'24.9"S 57°50'27.6"W	142	Halici, M. G.	2017-01-24	ERCH
JR 0.213	OQ557089	<i>L. stigmattea</i> (Ach.) Hertel & Leuckert	Antarctica	Antarctic Peninsula	James Ross Island	63°48'42.0"S 57°50'5.4"W	345	Halici, M. G.	2017-01-25	ERCH
JR 0.337	OQ557119	<i>L. stigmattea</i> (Ach.) Hertel & Leuckert	Antarctica	Antarctic Peninsula	James Ross Island	63°48'38.1"S 57°51'36"W	92	Halici, M. G.	2017-01-26	ERCH
JR 0.367	OQ557737	<i>L. stigmattea</i> (Ach.) Hertel & Leuckert	Antarctica	Antarctic Peninsula	James Ross Island	63°48'24.9"S 57°50'27.6"W	142	Halici, M. G.	2017-01-24	ERCH

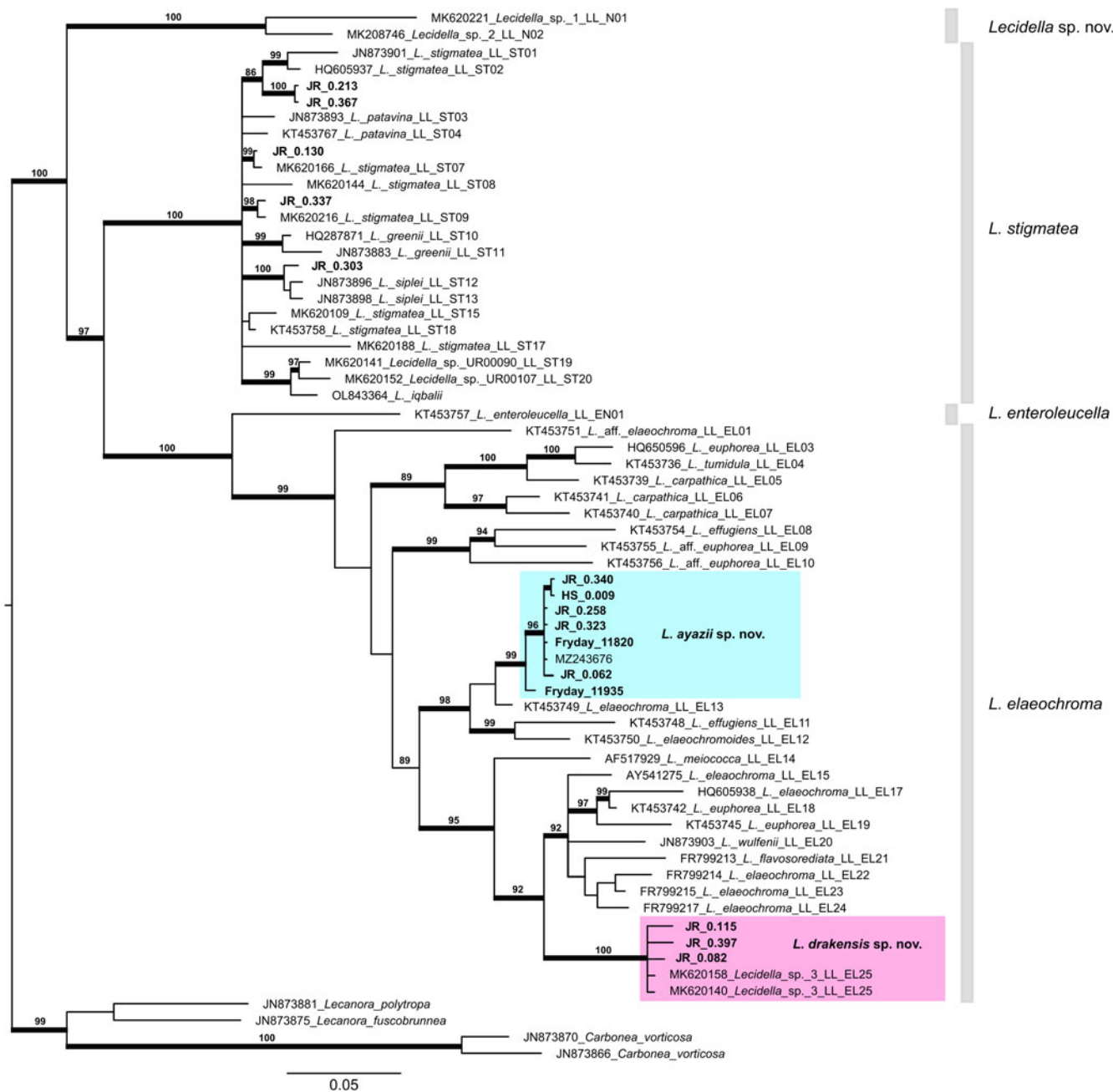


Figure 2. Phylogenetic analysis of ITS sequences of the genus *Lecidella* with the newly described species *L. ayazii* (turquoise) and *L. drakensis* (pink), and five other accessions (bold) integrated in the species concepts of Zhao *et al.* (2015) and Ruprecht *et al.* (2020). Maximum likelihood (ML) bootstrap values ≤ 95 were directly mapped on the Bayesian tree with posterior probability values ≤ 0.95 (branches in bold). Branch tips are labelled with voucher ID/Accession number_species_OTU. In colour online.

chemistry, and from *L. effugiens* and *L. elaeochromoides* by growing on mosses instead of on rocks, and by having smaller apothecia and a different chemistry. It also differs from *L. elaeochroma* by growing on mosses instead of on bark and by having an interspersed hymenium.

Type: Antarctic Peninsula, James Ross Island, Berry Hill Mesa, 63°48'42.0"S, 57°50'5.4"W, 345 m a.s.l., 23 January 2017, M. G. Halıcı, (ERCH—holotype; ERCH—isolates). GenBank Accession no.: OQ534855.

(Fig. 3)

Thallus crustose, granulose to rimose, up to 0.2 mm thick. *Areoles* distinct, almost squamule-like, irregular. *Surface* rough, pruinose. *Colour* greyish to chalky white.

Apothecia lecideine, black, abundant and evenly distributed, sessile, constricted at the base, up to 0.8 mm. *Disc* dull, black, epruinose, slightly convex, distinct margin. *Margin* thin, not raised, \pm level with the disc, smooth. *Exciple* in section up to 50 μ m thick, blue-green to blackish, I–, dark green (black) margin. *Epihymenium* dark green to bluish green, up to 20 μ m, K–, N+ red (Cinereorufa-green). *Hymenium* hyaline, interspersed with oil droplets, up to 100 μ m. *Subhymenium* light brown, up to

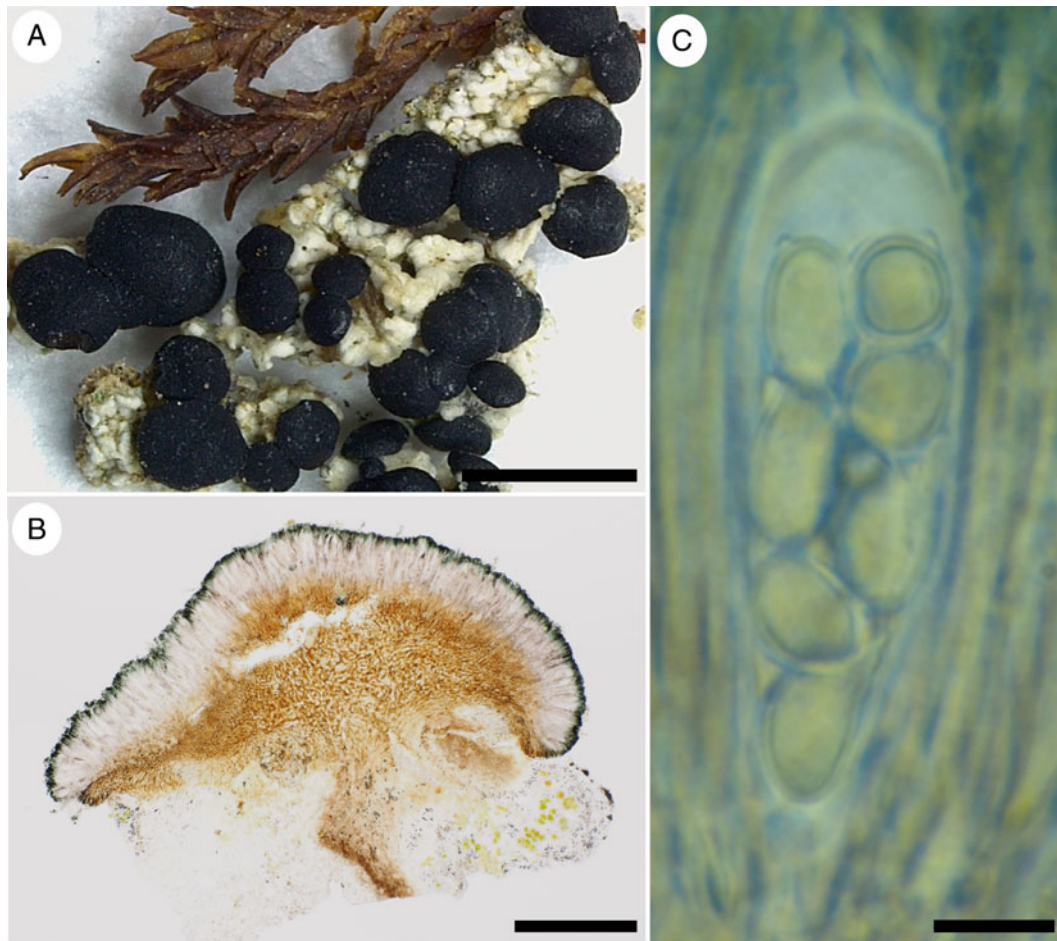


Figure 3. Diagnostic characters of *Lecidella ayazii*. A, typical thallus and apothecia. B, cross-section of apothecium. C, *Lecidella*-type ascus and ascospores. Scales: A = 1 mm; B = 100 μ m; C = 10 μ m. In colour online.

10 μ m. *Hypothecium* golden brown, interspersed with crystals. *Paraphyses* hyaline, simple, slightly agglutinated, flexuous, vertical, partially interspersed. *Apical cell* slightly thickened up to 5.0 μ m, dark green. *Asci* *Lecidella*-type, slightly clavate with dark amyloid tholus, eight unicellular spores, up to 40–50 μ m. *Ascospores* simple, hyaline, broadly ellipsoid, (9–)10(–12) \times (5–)6–7(–8) μ m, l/w: 10.2/5.8 μ m.

Conidiomata not observed.

Chemistry. Atranorin, thuringione and lichenxanthone by TLC. Spot test: thallus K+ yellow, C–, KC–.

Etymology. Named in honour of Çağan Ayaz Halıcı, dear son of the last author, who was born during his father's Antarctic expedition to James Ross Island in 2017.

Distribution and habitat. *Lecidella ayazii* is currently known from James Ross Island, located in the NE part of the Antarctic Peninsula, and Horseshoe Island in the SW; where it occurs on soil or sometimes on mosses from 5 to 345 m a.s.l., especially in humid habitats such as near streams. It is also known from the La Sal Mountains, Utah, USA and the Kivalliq Region, Nunavut, Canada, growing on mosses over siliceous substrata (Fig. 1).

Notes. *Lecidella ayazii* forms a distinct and highly supported clade of five accessions from maritime Antarctica as well as one

accession from alpine areas of the La Sal Mountains, Utah, USA and two accessions from the Kivalliq Region, Nunavut in the north of Canada; it is placed in the *L. elaeochroma* clade (Zhao *et al.* 2015). According to Øvstedal & Smith (2001), one of two muscicolous species of *Lecidella* known from Antarctica is *L. wulfenii*, which is also part of the *L. elaeochroma* clade, but the latter species has a different chemistry, an orange-brown (McCune 2017) or reddish brown hypothecium and occurs over calcareous substrata (Knoph & Leuckert 2004; Wirth *et al.* 2013), in contrast to the newly described species which occurs over siliceous substrata. Furthermore, *L. ayazii* and *L. wulfenii* are phylogenetically placed in distinct clades and are not closely related. The second Antarctic species growing on mosses is *L. siplei*, which belongs to the *L. stigmathea* clade and is therefore clearly distinct from *L. ayazii*. Morphologically it differs with an often dark-pigmented (grey) thallus and a different chemistry (Ruprecht *et al.* 2012; Zhao *et al.* 2015). Two other phylogenetically related species, *L. effugiens* and *L. elaeochromoides*, grow on rocks, have a different chemistry and larger apothecia (Knoph & Mies 1995). The most closely related species is *L. elaeochroma* which shares a partially similar chemistry (atranorin, thuringione), but does not have an interspersed hymenium and typically grows only on bark (Wirth *et al.* 2013).

Additional specimens examined. **Antarctica:** Antarctic Peninsula: Horseshoe Island, 5 m a.s.l., 67°48'30"S, 67°17'39"W,

M. G. Halıcı HS 0.009 (OQ534852; ERCH); James Ross Island, 260 m a.s.l., 63°49'80"S, 57°54'11"W, *M. G. Halıcı* JR 0.062 (OQ534850, ERCH); *ibid.*, 292 m a.s.l., 63°49'46.2"S, 57°54'21.6"W, *M. G. Halıcı* JR 0.323 (OQ534851, ERCH); *ibid.*, 142 m a.s.l., 63°48'24.9"S, 57°50'27.6"W, *M. G. Halıcı* JR 0.340 (OQ534853; ERCH).—**Canada:** Nunavut, Kivalliq Region, 9 m a.s.l., 62°52'49.2"N, 92°08'48.8"W, Fryday, A. M., McMullin, R. T., Allen, J., Sokoloff, P. Fryday_11820 (OR648670, MSU); *ibid.*, 27 m a.s.l., 62°53'24.1"N, 92°09'24.1"W, Fryday, A. M., McMullin, R. T., Allen, J., Sokoloff, P. Fryday_11935 (OR648671, MSU) (Table 1).

Lecidella drakensis U. Rupr. & Halıcı sp. nov.

MycoBank No.: MB 851245

Differing from *L. elaeochroma* by having much smaller apothecia, from *L. flavosorediata* by the absence of soralia, from *L. wulfenii* by having more oblong ascospores, from *L. euphorea* by having a dark green to bluish green epihymenium, and from *L. meiococca* by having a thinner thallus. All the above-mentioned species also differ from *L. drakensis* in their chemistry.

Type: Chile, Región de Magallanes y de la Antártica Chilena, Patagonia chilena, Torres del Paine National Park, eastern slope of Co. Ferrer, 51°7'26"S, 73°8'33"W, on siliceous rock, 239 m a.s.l., 12 February 2018, U. Ruprecht (SZU—holotype; SZU, ERCH—iso-types). GenBank Accession no.: MK620158. Paratype (TLC): Antarctic Peninsula, James Ross Island. GenBank Accession no.: OQ534854 (Table 1).

(Fig. 4)

Thallus crustose, granulose to rimose, well developed, up to 0.2 mm thick. *Areoles* indistinct, irregular. *Surface* rough, pruinose. *Colour* whitish to beige.

Apothecia lecideine, mainly scattered, globular and sometimes merged, black, sessile, constricted at the base, up to 0.7 mm. *Disc* dull, black, pruinose, slightly convex when older and large, prominent and slightly rough margin. *Exciple* in section up to 80 µm thick, hyaline, I–, radiate hyphae, dark green (to black) margin, extending as a dark brown and wider margin along the base. *Epihymenium* dark green to bluish green, up to 10 µm, K–, N+ red. *Hymenium* hyaline, up to 70 µm, amyloid. *Subhymenium* light brown, 10 µm, I–. *Hypothecium* golden brown, interspersed with crystals, I–. *Paraphyses* hyaline, simple, flexuous, vertical, slightly agglutinated, 1–2 µm diam. *Apical cell* slightly thickened up to 4.0 µm, dark green. *Asci* *Lecidella*-type, slightly clavate with dark amyloid tholus, eight unicellular spores, 40–45 µm. *Ascospores* simple, hyaline, broadly ellipsoid, I–, (8–)10–11(–12) × (4–)5–6(–7) µm, l/w: 10.6/5.7 µm.

Conidiomata not observed.

Chemistry. Atranorin and thuringione by TLC. Spot test: K+ light yellow, C–, KC–.

Etymology. The term *drakensis* was chosen because the collected specimens occurred north (Chile, Región de Magallanes y de la Antártica Chilena) and south (maritime Antarctica) of the Drake Passage.

Distribution and habitat. Two specimens of *Lecidella drakensis* were found in the subantarctic areas of southern Patagonia

(sSA, Morro Chico and Torres del Paine National Park) solely on siliceous rock and the other three in maritime Antarctica (James Ross Island) on siliceous rock and once on mosses. This species is currently recorded only from these areas.

Notes. The collections of *L. drakensis* form a distinct and highly supported clade containing accessions from southern Patagonia and maritime Antarctica, which is placed in the *L. elaeochroma* clade (Zhao *et al.* 2015). The species is clearly distinguished morphologically by the following characteristics: very small apothecia in contrast to *L. elaeochroma* (Wirth *et al.* 2013); lacking soralia and a different chemistry to *L. flavosorediata* (Wirth *et al.* 2013); more oblong spores and a different chemistry to *L. wulfenii* (Wirth *et al.* 2013); a dark green instead of violet-brown epihymenium and a different chemistry to *L. euphorea* (Zhao *et al.* 2015); a thinner thallus and also a different chemistry to *L. meiococca* (Knoph & Leuckert 1994). Neither species described here is related to the Southern Hemispheric, not yet molecularly confirmed species *L. sublaticida* (C. Knight) Hertel. This species is distinguished by its different chemistry (arthothelin, isoarthothelin) and reddish brown hymenium (Knoph & Leuckert 1994). Kappen (1985) mentioned a '*L. antarctica*', which has not been formally described, that forms a greyish pulvinate crust on rock, from northern Victoria Land (H. Hertel, personal communication) and is clearly morphologically different from *L. ayazii* and *L. drakensis*.

Additional specimens examined. **Antarctica:** Antarctic Peninsula: James Ross Island, 142 m a.s.l., 63°48'24.9"S, 57°50'27.6"W, *M. G. Halıcı* JR 0.082 (OQ534854; ERCH); *ibid.*, 2 m a.s.l., 63°52'39.0"S, 57°46'51.6"W, *M. G. Halıcı* JR 0.115 (OQ534857; ERCH); *ibid.*, 292 m a.s.l., 63°49'46.2"S, 57°54'21.6"W, *M. G. Halıcı* JR 0.397 (OQ534856; ERCH) (Table 1).—**Chile:** Región de Magallanes y de la Antártica Chilena: Laguna Blanca, 440 m a.s.l., 52°3'31"S, 71°25'11"W, U. Ruprecht UR00086 (MK620140; SZU).

Discussion

Various lichen species are exclusively found in the Southern Hemisphere. They are often part of globally distributed genera but form well-distinguished groups located only in the southern polar areas. Two prominent examples are the common species *Lecidea cancriformis* C. W. Dodge & G. E. Baker and *Usnea aurantiacoatra* (Jacq.) Bory (Ruprecht *et al.* 2020; Lagostina *et al.* 2021). Both species are distributed not only in the subantarctic areas of southern South America but also in the maritime and/or continental Antarctic. Other species such as *Usnea antarctica* Du Rietz are even more restricted to southern polar areas and occur only in the maritime Antarctic (Lagostina *et al.* 2021). Conversely, species such as *Lecidea polypycnidophora* (Hale *et al.* 2019) and *Lecidea andersonii* (Hertel 2007; Ruprecht *et al.* 2010; Hale *et al.* 2019) have an alpine and/or bipolar distribution which suggests that there are migration routes especially along the American continent (Garrido-Benavent & Pérez-Ortega 2017; Hale *et al.* 2019). The two newly described species, *L. ayazii* and *L. drakensis*, are part of the cosmopolitan genus *Lecidella*. They are both located in the *L. elaeochroma* clade, to which mostly Northern Hemisphere species have been assigned until now, and form clearly distinguished groups.

Lecidella ayazii, which was found by the last author only in the maritime Antarctic, was also found to cluster with a collection from alpine areas of the La Sal Mountains, Utah, USA (Leavitt

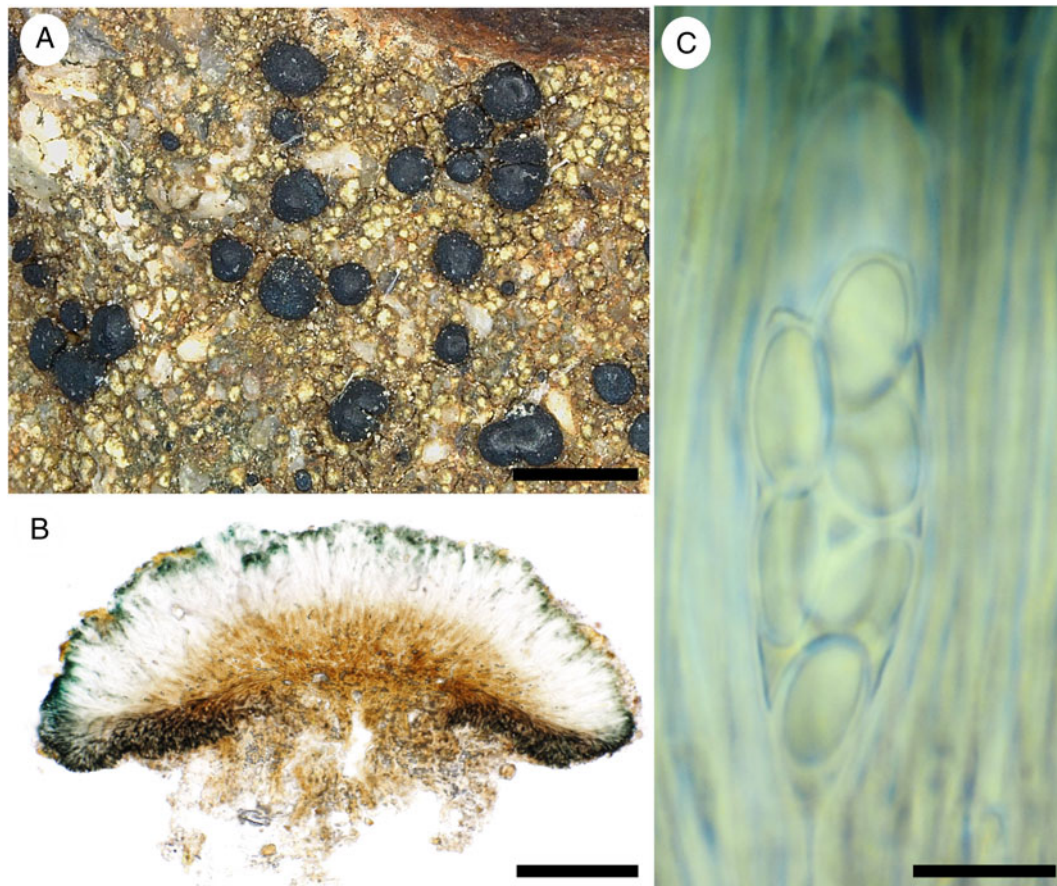



Figure 4. Diagnostic characters of *Lecidella drakensis*. A, typical thallus and apothecia. B, cross-section of apothecium. C, *Lecidella*-type ascus and ascospores. Scales: A = 1 mm; B = 100 μ m; C = 10 μ m. In colour online.

et al. 2021) and the Kivalliq Region, Nunavut, in the north of Canada (this study). The specimen from the La Sal Mountains was determined as *Lecidella wulfenii* because of its growth on moss, which is one of the most important traits for assigning this species. Unfortunately, there is another published sequence of *L. wulfenii* determined by Roman Türk (Ruprecht *et al.* 2012) which is not related and which is located in another clade (Fig. 2). This specimen was found on moss over calcareous rock, which is another important distinguishing characteristic (Wirth *et al.* 2013), in contrast to the specimens from the La Sal Mountains (Utah, USA) and the Kivalliq Region (Nunavut, northern Canada), where it can be assumed that the substratum is siliceous. The specimen of *L. ayazii* from the maritime Antarctic was also growing only over siliceous substrata. *Lecidella wulfenii* was described as *Lichen muscorum* by Wulfen (Jacquin 1790), but because that name is illegitimate, Hepp (1853) introduced the replacement name *Biatora wulfenii* Hepp, which was transferred to *Lecidella* by Körber (1861). Since Wulfen's species was described from Austria and the Türk collection mentioned above is also from Austria, we have no doubt that the epithet 'wulfenii' should be applied to the European species.

Thus far, *Lecidella drakensis* shows a similar pattern to that of *Usnea aurantiacoatra* (Lagostina *et al.* 2021). It occurs in southern South America as well as in maritime Antarctica. However, five other accessions were also recorded from the maritime Antarctic belonging to the cosmopolitan *L. stigmatea* clade, including one assigned to the bipolar species *L. siplei*.

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References

- Brummitt RK, Pando F, Hollis S and Brummitt N (2001) *World Geographical Scheme for Recording Plant Distributions*. Hunt Institute for Botanical Documentation, Carnegie Mellon University, Pittsburgh [WWW resource] URL <http://rs.tdvwg.org/wgsrpd/doc/data/>

- Buschbom J** (2007) Migration between continents: geographical structure and long-distance gene flow in *Porpidia flavicunda* (lichen-forming *Ascomycota*). *Molecular Ecology* **16**, 1835–1846.
- Castello M** (2003) Lichens of the Terra Nova Bay area, northern Victoria Land (continental Antarctica). *Studia Geobotanica* **22**, 3–54.
- Colesie C, Green TGA, Türk R, Hogg ID, Sancho LG and Büdel B** (2014) Terrestrial biodiversity along the Ross Sea coastline, Antarctica: lack of a latitudinal gradient and potential limits of bioclimatic modeling. *Polar Biology* **37**, 1197–1208.
- Davies BJ, Glasser NF, Carrivick JL, Hambrey MJ, Smellie JL and Nývlt D** (2013) Landscape evolution and ice-sheet behaviour in a semi-arid polar environment: James Ross Island, NE Antarctic Peninsula. *Geological Society, London, Special Publications* **381**, 353–395.
- Etayo J, Sancho LG, Gómez-Bolea A, Söchting U, Aguirre F and Rozzi R** (2021) Catálogo de líquenes (y algunos hongos relacionados) de la isla Navarino, Reserva de la Biosfera Cabo de Hornos, Chile. *Anales del Instituto de la Patagonia* **2021**, 49.
- Fayyaz I, Afshan NS, Niazi AR, Khalid AN and Ruprecht U** (2022) A new species of *Lecidella* (*Lecanorales*, *Ascomycota*) from Azad Jammu and Kashmir, Pakistan. *Acta Botanica Brasiliica* **36**, 0324.
- Fernandez-Mendoza F and Printzen C** (2013) Pleistocene expansion of the bipolar lichen *Cetraria aculeata* into the Southern Hemisphere. *Molecular Ecology* **22**, 1961–1983.
- Fryday A** (2022) *Research Checklists: Southern Subpolar Region*. Consortium of North American Lichen Herbaria (CNALH). [WWW resource] URL <https://lichenportal.org/portal/projects>.
- Fryday AM, Orange A, Ahti T, Øvstedal DO and Crabtree DE** (2019) An annotated checklist of lichen-forming and lichenicolous fungi reported from the Falkland Islands (Islas Malvinas). *Glalia* **8**, 1–100.
- Gardes M and Bruns TD** (1993) ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. *Molecular Ecology* **2**, 113–118.
- Garrido-Benavent I and Pérez-Ortega S** (2017) Past, present, and future research in bipolar lichen-forming fungi and their photobionts. *American Journal of Botany* **104**, 1660–1674.
- Hale E, Fisher ML, Keuler R, Smith B and Leavitt SD** (2019) A biogeographic connection between Antarctica and montane regions of western North America highlights the need for further study of lecideoid lichens. *Bryologist* **122**, 315–324.
- Halıcı MG, Bartak M and Güllü M** (2018) Identification of some lichenised fungi from James Ross Island (Antarctic Peninsula) using nrITS markers. *New Zealand Journal of Botany* **56**, 276–290.
- Halıcı MG, Kahraman M, Kistenich S and Timal E** (2021) *Toniniopsis bartakii* – a new species of lichenised fungus from James Ross Island (Antarctic Peninsula). *Turkish Journal of Botany* **45**, 216–223.
- Halıcı MG, Güllü M, Yiğit MK and Bartak M** (2022) Three new records of lichenised fungi for Antarctica. *Polar Record* **58**, e22.
- Hepp P** (1853) *Die Flechten Europas*. Zürich.
- Hertel H** (1984) Über saxicole, lecideoide Flechten der Subantarktiks. *Beiheft zur Nova Hedwigia* **79**, 399–499.
- Hertel H** (2007) Notes on and records of Southern Hemisphere lecideoid lichens. *Bibliotheca Lichenologica* **95**, 267–296.
- Hertel H and Leuckert C** (1967) Über Flechtenstoffe und Systematik einiger Arten der Gattung *Lecidea*. *Nova Hedwigia* **14**, 291–300.
- Hertel H and Leuckert C** (1969) Über Flechtenstoffe und Systematik einiger Arten der Gattungen *Lecidea*, *Placopsis* und *Trapelia* mit C+ rot reagierendem Thallus. *Willdenowia* **5**, 369–383.
- Hoang DT, Chernomor O, von Haeseler A, Minh BQ and Vinh LS** (2017) UFBoot2: improving the ultrafast bootstrap approximation. *Molecular Biology and Evolution* **35**, 518–522.
- Huneck S, Yoshimura I, Huneck S and Yoshimura I** (1996) *Identification of Lichen Substances*. Berlin, Heidelberg: Springer.
- Jacquin NJ** (1790) *Collectanea ad Botanicam, Chemiam et Historiam Naturalem Spectantia, cum tab. aen.* Wien: Wappler.
- Kalyaanamoorthy S, Minh BQ, Wong TKF, von Haeseler A and Jermin LS** (2017) ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* **14**, 587–589.
- Kappen L** (1985) Vegetation and ecology of ice-free areas of northern Victoria Land, Antarctica. 1. The lichen vegetation of Birthday Ridge and an inland mountain. *Polar Biology* **4**, 213–225.
- Katoh K, Misawa K, Kuma K and Miyata T** (2002) MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. *Nucleic Acids Research* **30**, 3059–3066.
- Knoph JG and Leuckert C** (1994) Chemotaxonomic studies in the saxicolous species of the lichen genus *Lecidella* (*Lecanorales*, *Lecanoraceae*) in America. *Nova Hedwigia* **59**, 455–508.
- Knoph JG and Leuckert C** (2004) *Lecidella*. In Nash TH, III, Ryan BD, Diederich P, Gries C and Bungartz F (eds), *Lichen Flora of the Greater Sonoran Desert Region, Vol. 2*. Tempe, Arizona: Lichens Unlimited, Arizona State University, pp. 309–320.
- Knoph JG and Mies B** (1995) Beiträge zur Flechtenflora der Kapverdischen Inseln III. Die saxicolen Arten der Gattung *Lecidella*. *Bibliotheca Lichenologica* **57**, 297–305.
- Körber GW** (1861) *Parerga Lichenologica*. Breslau: E. Trewendt.
- Lagostina E, Andreev M, Dal Grande F, Grewe F, Lorenz A, Lumbsch HT, Rozzi R, Ruprecht U, Sancho LG, Söchting U, et al.** (2021) Effects of dispersal strategy and migration history on genetic diversity and population structure of Antarctic lichens. *Journal of Biogeography* **48**, 1635–1653.
- Lauer W, Rafiqpoor MD and Frankenberg P** (1996) Die Klimate der Erde: Eine Klassifikation auf ökophysiologischer Grundlage der realen Vegetation (Climates of the Earth: a classification on the base of eco-physiological characteristics of the real vegetation). *Erdkunde* **50**, 275–300.
- Leavitt SD, Hollinger J, Summerhays S, Munger I, Allen J and Smith B** (2021) Alpine lichen diversity in an isolated sky island in the Colorado Plateau, USA – insight from an integrative biodiversity inventory. *Ecology and Evolution* **11**, 11090–11101.
- Lücking R, Papong K, Thammathaworn A and Boonpragob K** (2008) Historical biogeography and phenotype-phylogeny of *Chroodiscus* (lichenized *Ascomycota*: *Ostropales*: *Graphidaceae*). *Journal of Biogeography* **35**, 2311–2327.
- Martin PJ and Peel DA** (1978) The spatial distribution of 10 m temperatures in the Antarctic Peninsula. *Journal of Glaciology* **20**, 311–317.
- McCune B** (2017) *Microlichens of the Pacific Northwest*. Corvallis, Oregon: Wild Blueberry Media.
- Morrone JJ** (2000) Biogeographic delimitation of the Subantarctic subregion and its provinces. *Revista del Museo Argentina de Ciencias Naturales n.s.* **2**, 1–15.
- Orange A** (2001) *Lepraria atlantica*, a new species from the British Isles. *Lichenologist* **33**, 461–465.
- Øvstedal DO and Smith RIL** (2001) *Lichens of Antarctica and South Georgia*. Cambridge: Cambridge University Press.
- Peat HJ, Clarke A and Convey P** (2007) Diversity and biogeography of the Antarctic flora. *Journal of Biogeography* **34**, 132–146.
- Printzen C** (1999) *Japewiella* gen. nov., a new lichen genus and a new species from Mexico. *Bryologist* **102**, 714–719.
- Rambaut A** (2014) *FigTree version 1.4.3*. [WWW resource] URL <http://tree.bio.ed.ac.uk/software/figtree/>.
- Rodriguez F, Oliver JL, Marin A and Medina JR** (1990) The general stochastic-model of nucleotide substitution. *Journal of Theoretical Biology* **142**, 485–501.
- Ronquist F and Huelsenbeck JP** (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* **19**, 1572–1574.
- Ruprecht U, Lumbsch HT, Brunauer G, Green TGA and Türk R** (2010) Diversity of *Lecidea* (*Lecideaceae*, *Ascomycota*) species revealed by molecular data and morphological characters. *Antarctic Science* **22**, 727–741.
- Ruprecht U, Lumbsch HT, Brunauer G, Green TGA and Türk R** (2012) Insights into the diversity of *Lecanoraceae* (*Lecanorales*, *Ascomycota*) in continental Antarctica (Ross Sea region). *Nova Hedwigia* **94**, 287–306.
- Ruprecht U, Fernández-Mendoza F, Türk R and Fryday AM** (2020) High levels of endemism and local differentiation in the fungal and algal symbionts of saxicolous lecideoid lichens along a latitudinal gradient in southern South America. *Lichenologist* **52**, 287–303.
- Silva N, Rojas N and Fedele A** (2009) Water masses in the Humboldt Current System: properties, distribution, and the nitrate deficit as a chemical water

- mass tracer for Equatorial Subsurface Water off Chile. *Deep Sea Research Part II: Topical Studies in Oceanography* **56**, 1004–1020.
- Trifinopoulos J, Nguyen LT, von Haeseler A and Minh BQ** (2016) W-IQ-TREE: a fast online phylogenetic tool for maximum likelihood analysis. *Nucleic Acids Research* **44**, W232–W235.
- van Lipzig NPM, King JC, Lachlan-Cope TA and van den Broeke MR** (2004) Precipitation, sublimation, and snow drift in the Antarctic Peninsula region from a regional atmospheric model. *Journal of Geophysical Research: Atmospheres* **109**, D24106.
- Wagner M, Brunauer G, Bathke AC, Cary SC, Fuchs R, Sancho LG, Türk R and Ruprecht U** (2021) Macroclimatic conditions as main drivers for symbiotic association patterns in lecideoid lichens along the Transantarctic Mountains, Ross Sea region, Antarctica. *Scientific Reports* **11**, 23460.
- White TJ, Bruns TD, Lee SB and Taylor JW** (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In Innis MA, Gelfand DH, Sninsky JJ and White TJ (eds), *PCR Protocols: a Guide to Methods and Applications*. New York: Academic Press, pp. 315–322.
- Wirth V, Hauck M and Schultz M** (2013) *Die Flechten Deutschlands*. Stuttgart (Hohenheim): Ulmer.
- Zhao X, Zhang LL, Zhao ZT, Wang WC, Leavitt SD and Lumbsch HT** (2015) A molecular phylogeny of the lichen genus *Lecidella* focusing on species from mainland China. *PLoS ONE* **10**, e0139405.