The Lichenologist **46**(6): 763–782 (2014)
doi:10.1017/S0024282914000395

Charcotiana and *Amundsenia*, two new genera in *Teloschistaceae* (lichenized Ascomycota, subfamily *Xanthorioideae*) hosting two new species from continental Antarctica, and *Austroplaca frigida*, a new name for a continental Antarctic species

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Abstract: Based on a combined three locus analysis two new genera, *Charcotiana* and *Amundsenia,* are proposed in the lichen family *Teloschistaceae*, subfamily *Xanthorioideae*. *Charcotiana* includes the new species *C. antarctica*, which is known only from continental Antarctica. The bipolar genus *Amundsenia* includes the new species *A. austrocontinentalis*, which is also known only from continental Antarctica, and the Arctic species *Caloplaca approximata* which is here combined into the new genus. The two new genera are phylogenetically distinct, but poor in morphological characters; the new species consist mainly of minute apothecia in cracks of rocks located in the climatically harshest regions of the Antarctic. They are somewhat similar to another continental Antarctic species, *Austroplaca frigida,* which is described as a new name based on the illegitimate name *Caloplaca frigida* Søchting. The distribution of the four species is mapped.

Key words: *Amundsenia approximata*, *Amundsenia austrocontinentalis*, bipolar distribution, *Caloplaca approximata*, *Caloplaca frigida*, *Charcotiana antarctica*, ITS, lichens, molecular phylogeny

Accepted for publication 2 June 2014

Introduction

The knowledge of Antarctic *Teloschistaceae* has expanded significantly in recent years (Søchting & Øvstedal 1992, 1998; Olech & Søchting 1993; Søchting & Olech 1995, 2000; Olech 2004; Søchting *et al*. 2004, 2014; Lindblom & Søchting 2008; Søchting & Castello 2012), and numerous new species have been described, all in the genus *Caloplaca*. The highest diversity has been recorded in the maritime Antarctic, and particularly towards the lower latitudes as is the general trend for lichens (Peat *et al*. 2007). However, recent expeditions to continental Antarctica have brought back lichen collections disclosing species that are unknown in the more mesic parts of Antarctica, in spite of those parts having been most intensively explored (Olech 2004; Søchting *et al*. 2004). Two such species, which appear to have so far passed unnoticed also by the Antarctic lichen flora authors (Dodge 1973; Øvstedal & Smith 2001), are described here as new to science. The phylogenetic analysis of three loci has made it possible to establish their taxonomic affiliation in relation to the recently published taxonomy of the *Teloschistaceae* (Arup *et al.* 2013). Based on their position in the molec-

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ular phylogenetic tree of *Teloschistaceae*, we have found it necessary to place them in two new genera, also including the Arctic species known as *Caloplaca approximata* (Lynge) H. Magn.

Material and Methods

The study includes material collected during Antarctic expeditions to continental Antarctica by the Italian Antarctic Research Programme (PNRA) (1988–1996), Australian Antarctic Division (1971–2010) and New Zealand Antarctic Program (2007, 2009). The collections are kept in designated herbaria. Collections formerly in ADT are now lodged in the Tasmanian Herbarium (HO). Distribution data for *Amundsenia* (*Caloplaca*) *approximata* are based on specimens from C, LD, O and UPS.

Morphology and anatomy

Macroscopic descriptions are based on observations made with a Wild Heerbrugg, M5-53204 dissecting microscope. Measurements were made using a mounted Nikon DS-Fi1 camera combined with the software NIS-Elements. For the apothecia, only the thickness of the whole margin and the proper exciple was measured because the distinction of thalline and proper exciple was frequently unclear. Sections were cut by hand or using a Reichert-Jung Cryostat 2800 Frigocut E microtome. Measurements were taken using an Olympus BX60 microscope. All measurements were made on material mounted in water. Ascospores were measured outside the asci, and ascospore size is given as an average with standard deviation; extremes are given in brackets. The thickness of spore septa is measured at the outer wall in accordance with Vondrák *et al.* (2013). The number of measurements is indicated in brackets.

PCR-amplification and alignment

Thirteen new nuclear rDNA sequences of the internal transcribed spacer region (nrITS) and three of the large subunit (nrLSU), together with a further three new sequences of the small subunit of the mitochondrial ribosomal RNA gene (mrSSU), were produced. The PCR amplifications were carried out using direct PCR following Arup (2006). The primers used were ITS1F (Gardes & Bruns 1993) and ITS4 (White *et al.* 1990) for ITS, AL1R (Döring *et al.* 2000), LR5 or LR6 (Vilgalys & Hester 1990) for nrLSU, and mrSSU1 (Zoller *et al.* 1999) and mrSSU7 (Zhou & Stanosz 2001) for mrSSU. The PCR settings followed Ekman (2001) or Arup *et al.* (2013). PCR products were electrophoresed in a 1% agarose gel and visualized using ethidium bromide or GelRed^{TM} (Biotium). Products were cleaned using a Cycle Pure Kit (Qiagen or Five Prime). The primers used for the PCR were also used in the sequencing reaction in combination with LR3 and LR3R (Vilgalys & Hester 1990) for nrLSU; sequencing was carried out by Macrogen Inc., Korea. Sequences were assembled using CLC Main Workbench ver. 4.1.2. Additional sequences were downloaded from GenBank. Voucher information and GenBank accession numbers are provided in Table 1 for both the new and the downloaded sequences.

Two alignments were produced: one combined alignment with 86 species including three loci, nrITS, nrLSU and mrSSU, representing the three subfamilies in *Teloschistaceae*, and another with 39 ITS sequences representing relevant clades of the subfamily *Xanthorioideae* (Arup *et al.* 2013). For the combined analysis, *Physcia aipolia* (Ehrh. ex Humb.) Fürnr. and *Amandinea punctata* (Hoffm.) Coppins & Scheid. were used as outgroups. For the ITS analysis, *Parvoplaca tiroliensis* (Zahlbr.) Arup *et al.* was used as outgroup. Ambiguously aligned regions were removed from all alignments before analyses.

Phylogenetic analyses

The alignments of the three different genes were first analyzed separately to check for incongruence between genes, but no incongruences were found. A conflict was assumed to be significant if two different relationships (one monophyletic and one non-monophyletic) were both supported with posterior probabilities 0·95 or higher (Buckley *et al.* 2002). A suitable model of molecular evolution for each of the loci was selected using the Bayesian Information Criterion (BIC) as implemented in jModeltest ver. 2.1.4 (Guindon & Gascuel 2003; Darriba *et al.* 2012), evaluating only the 24 models available in MrBayes 3.2.0 (Ronquist *et al.* 2012). The GTR+I+G was found to be optimal for both the nrITS and nrLSU data sets for the combined analysis, but HKY+I+G for the mrSSU data set. The ITS alignment was also analyzed separately using the evolutionary model GTR+I+G. Bayesian tree inference was carried out using Markov chain Monte Carlo (MCMC) as implemented in MrBayes 3.2.0. In the combined analysis, the three genes included were treated as separate partitions. Parameters used in the analyses followed those of Arup *et al.* (2013), except for the branch length prior that was set to an exponential with mean 1/10. Three parallel runs of Markov chain Monte Carlo were performed, each with 7 chains, 6 of which were incrementally heated with a temperature of 0·10. Analyses were diagnosed every 100 000 generations and automatically halted when convergence was reached. Convergence was defined as a standard deviation of splits (with frequency ≥0·1) between runs below 0·01. Every 1000th tree was sampled and the first 50% of the runs were removed as burn-in. PAUP* 4.0b10 (Swofford 2002) was used to construct 50% majority-rule consensus trees from the post-burn-in tree samples, and FigTree 1.4 (http://tree.bio.ed.ac.uk/software/figtree/) and Apple Works 6.2.9 (Apple Computers Inc.) to illustrate them.

Secondary chemistry

The secondary metabolite pattern was identified using HPLC and analyzed separately for thallus and apothecia. The relative composition of the secondary compounds was calculated based on absorbance at 270 nm, according to Søchting (1997).

TABLE 1. *Sequences used in any of the two analyses, newly produced in bold and others downloaded from GenBank.*

		GenBank Accession Number		
Species	Country, collector, collector no., herbarium	nrITS	nrLSU	mrSSU
Amandinea punctata	Unknown	AF250780	AY340536	AY143399
Amundsenia austrocontinentalis 1	Antarctica, Upper Garwood, *A. de los Ríos*, MAF-Lich 18173	JX036068		**KJ789975**
A. austrocontinentalis 2	Antarctica, Miers Valley, *A. de los Ríos*, MAF-Lich 18174	JX036036		
A. austrocontinentalis 3	Antarctica, McMurdo Dry Valleys, *Seppelt* 27537, HO	**KJ789961**		
A. austrocontinentalis 4	Antarctica, Miers Valley, *Seppelt* 21966, HO	**KJ789962**		
A. approximata 1	Greenland, *Søchting* 10490, C	**KJ789963**		
A. approximata 2	Sweden, *Arup* L02084, LD	**KJ789964**		
A. approximata 3	Norway, *Arup* L08179, LD	**KJ789965**	**KJ789972**	**KJ789974**
Athallia cerinelloides	Sweden, *Arup* L06208, LD (ITS); Sweden, *Arup* L07202, LD (LSU, SSU)	KC179339	KC179147	KC179477
A. holocarpa	Sweden, *Arup* L04019, LD	J346540	KC179148	KC179478
A. pyracea	Sweden, *Arup* L04039, LD	J346553	KC179149	KC179479
A. scopularis	Iceland, *Søchting* 7521, C	KC179340	KC179150	KC179480
Austroplaca ambitiosa	UK, Falkland Isl., *Lewis Smith* 11027, AAS (ITS, LSU)	KC179081	KC179151	
	Chile, *Søchting* 11271, C (SSU)			KC179481
A. cirrochrooides	Chile, *Søchting* 11300, C	KC179082	KC179152	KC179482
A. darbishirei	Antarctica, Antarctic Peninsula, *Søchting* 11401, C	KC179083	KC179153	KC179483
A. erecta	New Zealand, 26 iii 2000, *Eagle*, C	KC179084		
A. frigida 1	Antarctica, Dry Valleys, Garwood Valley, *J. Raggio*, MAF-Lich 18904	JX036061		
A. frigida 2	Antarctica, Dry Valleys, Garwood Valley, *J. Raggio*, MAF-Lich 18890	JX036062		
A. frigida 3	Antarctica, Dry Valleys, Garwood Valley plateau, *J. Raggio*, MAF-Lich 18902-2	JX036127		
A. hookeri	Antarctica, South Shetland Isl., *Søchting* 7611, C	KC179085	KC179154	KC179484
A. lucens	France, Kerguelen Isl., *Søchting* 9417, C	KC179087	KC179155	KC179485
A. millegrana	Chile, *Søchting* 11330, C (ITS); *Søchting* 10176, C (LSU)	KC179088	KC179156	
	Chile, *Søchting* 10350, C			KC179486
A. soropelta	Iceland, *Frödén* 650, LD (ITS); Iceland, *Søchting* 7536, C (LSU, SSU)	KC179089	KC179157	KC179487
Calogaya arnoldii	Sweden, *Arup* L06205, LD (ITS); Sweden, *Søchting* 10610, C (LSU)	KC179342	KC179165	–
C. arnoldii s.lat	Denmark, *Søchting* 7472, C	KC179343	KC179166	KC179497
C. decipiens	Denmark, 1995, *Søchting*, C	KC179344	KC179167	
	Sweden, *Arup* L06187, LD			KC179498
C. cerina	Norway, Svalbard, *Elvebakk* 03:084, TROM	KC179425	KC179168	KC179499
Cerothallia luteoalba	Sweden, *Frödén* 1869, LD	KC179099	KC179177	KC179511
C. subluteoalba	Australia, VIC, *Kondratyuk* 20433, LD isotype	KC179100	–	KC179512
C. yorkensis	Australia, VIC, *Kärnefelt* 996101, LD	KC179101	KC179178	KC179513
Charcotiana antarctica 1	Antarctica, Victoria Land, *Bersan* A815, TSB	**KJ789966**		**KJ789976**
C. antarctica 2	Antarctica, Victoria Land, *Bersan* A833, TSB	**KJ789967**		

TABLE 1. *Continued*

Species	Country, collector, collector no., herbarium	GenBank Accession Number		
		nrITS	nrLSU	mrSSU
Charcotiana antarctica 3	Antarctica, Northern Victoria Land, *Seppelt* 25454, HO	**KJ789968**		
C. antarctica 4	Antarctica, Northern Victoria Land, *Seppelt* 25292, HO	**KJ789969**		
C. antarctica 5	Antarctica, Southern Victoria Land, *Smykla*, KRAM-L-63612	**KJ789970**	**KJ789973**	
C. antarctica 6	Antarctica, Northern Victoria Land, *Seppelt* 25038, HO	**KJ789971**		
Dufourea alexanderbaii	South Africa, *Feuerer & Thell* 60487b, LD holotype	KC179350	KC179179	KC179514
D. angustata	Australia, NSW, *Kondratyuk* 20483, CANB holotype	KC179351	KC179180	
	Australia, NSW, *Kärnefelt* 20045001 & *Kondratyuk*, LD			KC179515
D. bonae-spei	South Africa, *Feuerer & Thell* 60485ab, LD	KC179353		
	South Africa, *Feuerer & Thell* 60493a, LD		KC179181	KC179516
D. dissectula	South Africa, *Feuerer & Thell* 604796, LD holotype	KC179355	KC179182	KC179517
D. flammea	South Africa, *Feuerer & Thell* 60488a, HBG	KC179357	KC179183	KC179518
D. karrooensis	South Africa, *Wetschnig W. & U.*, GZU 133-8p	KC179358		
	South Africa, 10 ix 2010, *Fröberg* s. n., LD		KC179184	KC179519
D. ligulata	Australia, TAS, *Frödén* 1234, LD	KC179359	KC179185	KC179520
Flavoplaca citrina	Sweden, *Arup* L03013, LD	DQ173224	KC179186	KC179521
F. marina	UK, England, *Arup* L92106, LD (ITS); Sweden, *Arup* L04057, LD (LSU, SSU)	AF353946	KC179187	KC179522
F. microthallina	Sweden, *Søchting* 7480, C	KC179368	KC179188	KC179523
F. oasis	Sweden, *Arup* L03017, LD	FJ346546	KC179189	KC179524
Gondwania cribrosa	Australia, TAS, *Søchting* 11581, C	KC179102	KC179192	KC179526
G. regalis	Antarctica, Antarctic Peninsula, *Søchting* 11416, C	KC179103		
	Antarctica, Antarctic Peninsula, *Søchting* 11427, C		KC179193	KC179527
Gyalolechia flavorubescens	Estonia, *Søchting* 10127, C	KC179439	KC179197	KC179531
Josefpoeltia parva	Argentina, *Frödén* 1671, LD	KC179296	KC179204	KC179539
Leproplaca xantholyta	Austria, *Arup* L97278, LD (ITS); Spain, *Søchting* 9675, C (LSU, SSU)	KC179451	KC179208	KC179542
Orientophila subscopularis	Japan, *Frisch* Jp99, LD holotype	KC179375	–	KC179546
Pachypeltis castellana	Denmark, Greenland, *Søchting* 10500, C (ITS)	KC179105		
	Greenland, *Søchting* 10470, C (SSU)		–	KC179547
P. invadens	Norway, Svalbard, *Elvebakk* 03:109, TROM	KC179108	KC179212	KC179548
P. sp.	China, *Abbas & Mahamat* 500113, XJUG	KC179110	KC179214	KC179550
Parvoplaca sp.	Sweden, *Arup* L10208, LD	KC179113	KC179215	KC179551
P. suspiciosa	Russia, *Hermansson* 16839, private hb.	KC179115		
	Sweden, *Hermansson* 18005, private hb.			**KJ810561**
P. tiroliensis	Sweden, *Arup* L02364, LD (ITS); Sweden, *Frödén* 1945, LD (LSU, SSU)	KC179116	KC179216	KC179552
Physcia aipolia	Unknown (ITS, SSU); *Wedin* 6145, BM (LSU)	AF250803	AY300857	AY143406

TABLE 1. *Continued*

Species	Country, collector, collector no., herbarium	GenBank Accession Number		
		nrITS	nrLSU	mrSSU
Polycauliona candelaria	Iceland, *Søchting* 7488, C	KC179379	KC179217	KC179553
P. coralloides	Mexico, *Søchting* 9887, C	KC179380	KC179218	KC179554
P. ignea	Mexico, *Moberg* 10402, UPS (ITS); Mexico, *Søchting* 9879, C (LSU, SSU)	KC179382	KC179219	KC179555
P. luteominia	USA, California, *Wetmore* 73797, LD	KC179387		
	USA, California, *Søchting* 11219, C		KC179220	KC179556
P. phlogina	Sweden, *Göransson* L02055, LD	DQ173235	KC179221	KC179557
P. polycarpa	USA, Minnesota, *Wetmore* 80511, LD	KC179389		
	Denmark, 3 v 1995 *Fredtoft*, C (LSU); Denmark, *Søchting* 10507, C (SSU)		KC179222	KC179558
P. rosei	USA, California, *Arup* L89165, LD (ITS)	KC179390		
	USA, California, *Søchting* 11225, C (LSU, SSU)		KC179223	KC179559
P. stellata	USA, California, *Arup* L09154, LD	KC179400	KC179229	KC179566
P. tenax	USA, California, *Westberg* 949, LD	KC179401	KC179230	KC179567
P. tenuiloba	Mexico, *Nash* 40170, LD	KC179402	KC179231	KC179568
P. thamnodes	Mexico, *Søchting* 9878, C	KC179403	KC179232	KC179569
P. verruculifera	Sweden, *Arup* L06209, LD (ITS); Iceland, *Søchting* 7522, C (LSU, SSU)	KC179404	KC179233	KC179570
Pyrenodesmia variabilis	Austria, *Arup* s. n., LD (ITS); Sweden, *Arup* L03134, LD (LSU, SSU)	AF353963	KC179234	KC179572
Rufoplaca tristiuscula	Norway, *Arup* L08171, LD	KC179460	KC179237	KC179575
Rusavskia elegans	Iceland, *Søchting* 7530, C	KC179406		
	Russia, *Zhurbenko* 96376, C		KC179238	KC179576
R. sorediata	Norway, *Lindblom* 1229, BG (ITS); Iceland, *Søchting* 7538, C (LSU, SSU)	AY453647	KC179239	KC179577
Schackletonia hertelii	Chile, *Søchting* 10349, C	KC179118		KC179579
	Antarctica, South Shetland Isl., *Søchting* 7932, C		KC179240	
S. sauronii	Antarctica, South Shetland Isl., *Søchting* 7654, C	KC179120	KC179241	KC179580
Sirenophila eos	Australia, NSW, *Kärnefelt* 20044702, LD	KC179300	KC179246	KC179585
Solitaria chrysophthalma	Sweden, *Arup* L03101, LD	KC179408	KC179251	KC179590
Squamulea galactophylla	USA, Kansas, *Morse* 10997, LD	KC179122		
S. kiamae	Australia, NSW, *Kondratyuk* 20480, LD isotype	KC179123		
S. squamosa	USA, Arizona, *Kärnefelt* AM960105, LD	KC179125	KC179252	KC179591
S. subsoluta	Austria, *Arup* L97072, LD	AF353954	KC179253	KC179592
Teloschistes flavicans	Chile, *Frödén* 1624, LD	KC179317	KC179255	KC179594
Variospora velana	Italy, *Arup* L07194, LD (ITS); Italy, *Arup* L07123, LD (LSU, SSU)	KC179476	KC179265	KC179605
Villophora isidioclada	Chile, *Søchting* 10185, C	KC179325	KC179266	KC179606
Wetmoreana texana	Mexico, *Søchting* 9925, C	KC179337	KC179273	KC179612
Xanthocarpia crenulatella	Austria, *Søchting* 9359, C	KC179126	KC179274	KC179613
X. epigaea	Spain, *Etayo* 21453, C (ITS, LSU); Germany, 2006, *Huneck*, C (SSU)	KC179127	KC179275	KC179614
X. marmorata	Italy, *Arup* L07030, LD	KC179131	KC179276	KC179615

Table 1. *Continued*

Species	Country, collector, collector no., herbarium	GenBank Accession Number		
		nrITS	nrLSU	mrSSU
Xanthocarpia ochracea	France, 1998, *Roux*, C (ITS); Italy, *Arup* L07009, LD (LSU);	KC179132	KC179277	
	Italy, *Arup* L07124, LD (SSU)			KC179616
Xanthopeltis rupicola	Chile, *Frödén* 1654, LD	KC179146	KC179286	KC179626
Xanthoria calcicola	Sweden, *Arup* L97372, LD	AF353944		
	Spain, *Søchting* 9627, C		KC179287	KC179627
X. parietina	Denmark, 2002, *Søchting* s. n., C	KC179411		KC179629
	Denmark, *Søchting* 7157, C		KC179289	
Xanthomendoza borealis	Greenland, *Søchting* 10499, C	KC179133		
	Russia, *Zhurbenko* 94411, UPS		KC179278	KC179617
X. fallax	Austria, *Arup* L97529, LD (ITS); USA, Wisconsin, *Søchting* 9566, C (LSU)	AF353955	KC179279	
	USA, Michigan, *Søchting* 9566, C (SSU)			KC179618
X. hasseana	USA, Arizona, *Søchting* 7014, C	KC179136	KC179280	KC179619
X. mendozae	Chile, *Søchting* 10209, C	KC179138	KC179281	KC179620
X. novozelandica	New Zealand, *Kärnefelt* 999003, LD	KC179140	–	KC179621
X. poeltii	Sweden, *Kondratyuk* 2, LD holotype	KC179142		KC179622
	Denmark, *Søchting* 7473, C		KC179282	
X. trachyphylla	USA, North Dakota, *Wetmore* 80270, LD	KC179143	KC179283	KC179623
X. ulophyllodes	Russia, 2006, *Kuznetsova*, H (ITS); USA, Wisconsin, *Søchting* 9571 (LSU, SSU)	KC179144	KC179284	KC179624
X. weberi	USA, North Carolina, *Søchting* 7241, C	KC179145	KC179285	KC179625

Results and Discussion

Molecular analyses

The combined analysis of the nrITS, nrLSU and mrSSU data set included 41 terminal species and a total of 2030 positions. A 50% majority-rule consensus tree is presented in Figure 1. The tree splits into three main clades corresponding to the three subfamilies proposed by Arup *et al.* (2013). *Xanthorioideae* and *Teloschistoideae* are well supported here, in concordance with Arup *et al.* (2013), but *Caloplacoideae* has lower support (PP = 0·84) in this rather limited analysis. All the new sequences are clearly nested within *Xanthorioideae*, with the new genus *Charcotiana* on a separate branch in the middle of the subfamily. For practical reasons, the analyses presented here include fewer taxa than those presented in Arup *et al.* (2013) and the support for the backbone structure of the tree is therefore lower for many nodes. However, even in analyses with three genes and a more extensive species sampling, the placement of *Charcotiana* is the same and we have been unable to accommodate it within any of the already defined genera in the subfamily. The other new genus, *Amundsenia*, appears as the sister clade of *Squamulea* with high support (Fig. 1).

The analysis of only ITS data included 39 sequences and a total of 544 positions. A 50% majority-rule consensus tree is presented in Figure 2. In this analysis, the genus *Amundsenia* is weakly supported, whereas the support is strong in the combined three gene analyses with a strong posterior probability (PP = 1). The two species of the genus show some infra-specific variation, one variable position in *A. austrocontinentalis* and six variable positions in *A. approximata* with up to 5 differences between specimens, but they clearly appear as monophyletic with full support. The variation is slightly greater in *Charcotiana antarctica*, with eight variable positions with up to five differences between specimens. *Caloplaca frigida* Søchting is well nested within the genus *Austroplaca*, with the two sorediate species *A. darbishirei* and *A. soropelta* as its closest relatives.

Secondary chemistry

Only chemosyndrome A of Søchting (1997) was shown to occur in the two new species.

This chemosyndrome is dominated by parietin, but in addition has small proportions of emodin, teloschistin, parietinic acid and fallacinal. It is the most frequent chemosyndrome in the subfamily *Xanthorioideae*.

Taxonomy

Charcotiana Søchting, Garrido-Benavent & Arup gen. nov.

MycoBank No.: MB 808600

Type: *Charcotiana antarctica* Søchting, Garrido-Benavent, Pérez-Ortega, Seppelt & Castello

Thallus saxicolous, crustose, areolate, orange.

Apothecia sparse or abundant, zeorine with orange disc. *Spores* polardiblastic.

Secondary chemistry. Apothecia and thalli contain parietin (dominant) and small proportions of teloschistin, fallacinal, parietinic acid and emodin. Chemosyndrome A of Søchting (1997).

Etymology. The genus is named after the significant French polar explorer and scientist Jean-Baptiste Charcot (1867–1936).

Distribution. *Charcotiana* is known only from continental Antarctica.

Notes. So far, *C. antarctica* is the only species included in the genus. *Charcotiana* is defined primarily on molecular phylogenetic characters and is similar to several other crustose genera in the subfamily with regard to main morphology, anatomy and chemistry. However, it has a strong tendency to develop stipitate apothecia, a feature that is rare in most genera. Such apothecia occur, for example, in *Austroplaca*, *Calogaya* and *Gondwania*, but the species in those genera normally produce distinct lobes or are subfruticose. Stipitate apothecia also occur in *Gyalolechia stipitata* (Wetmore) Søchting *et al.* in subfamily *Caloplacoideae*, but this genus is

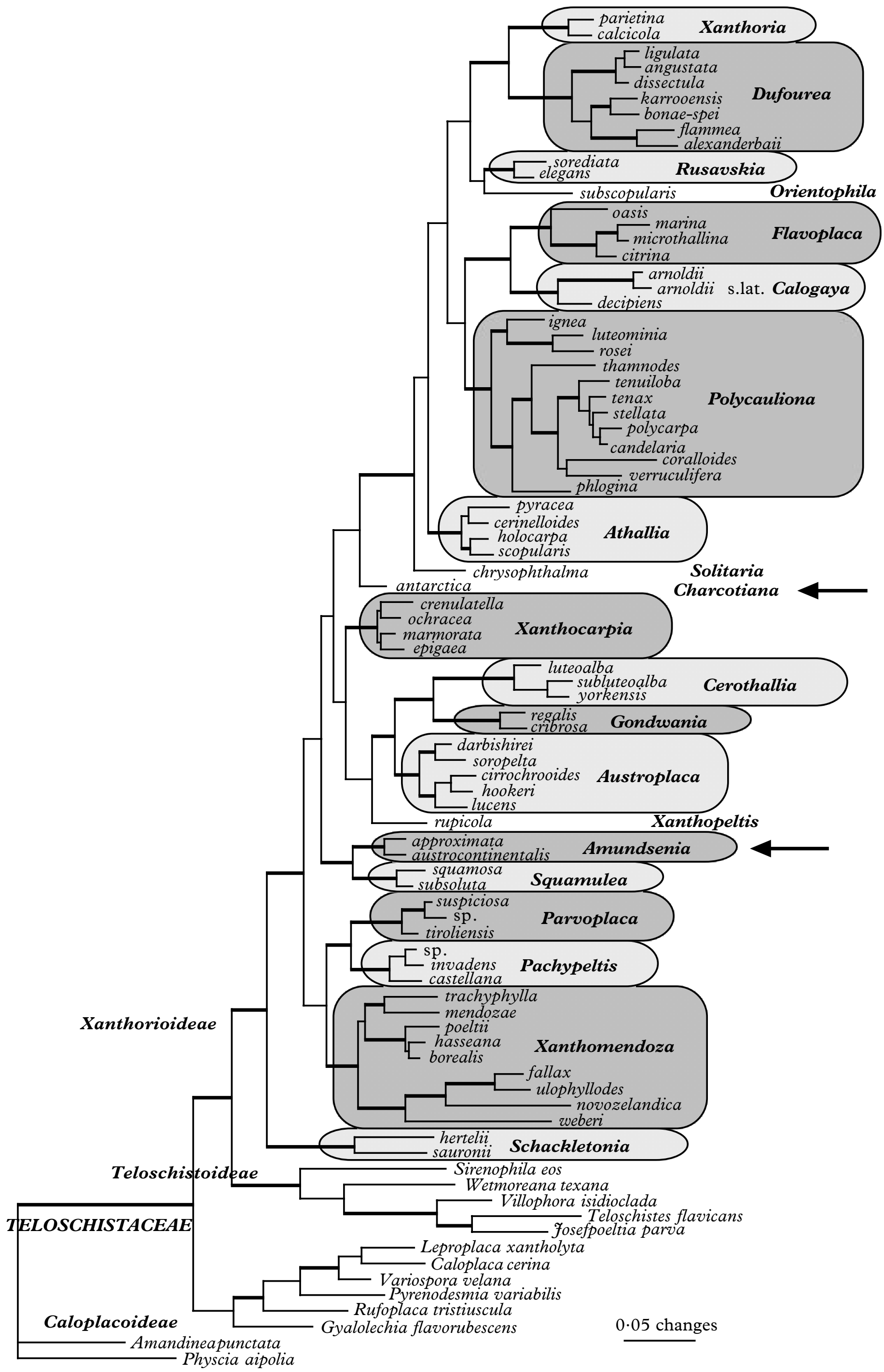

FIG. 1. 50% majority-rule consensus tree of nrITS, nrLSU and mrSSU data using Bayesian MCMC. Nodes with posterior probabilities ≥0·95 are shown in bold.

https://doi.org/10.1017/S0024282914000395 Published online by Cambridge University Press

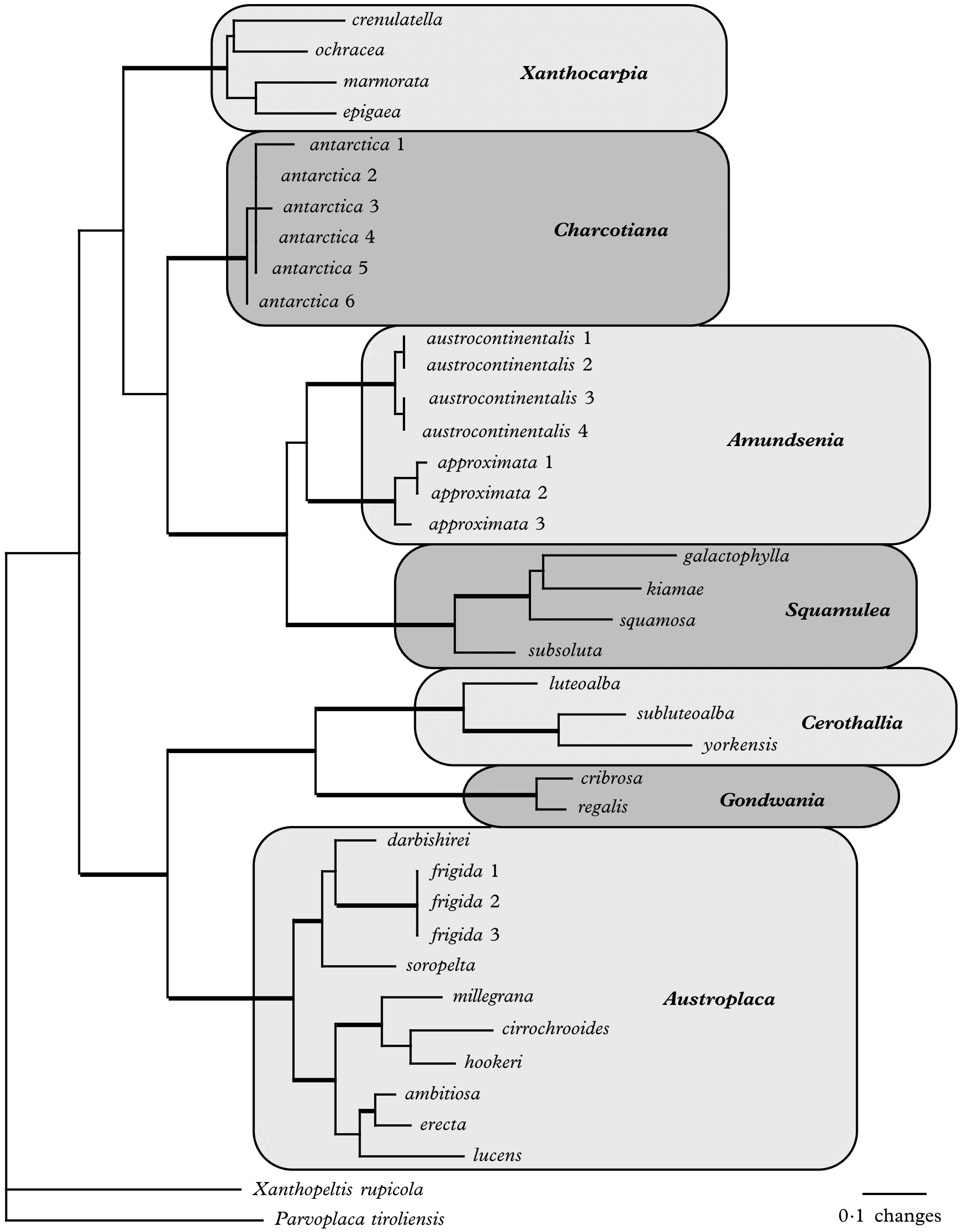

FIG. 2. 50% majority-rule consensus tree of nrITS data using Bayesian MCMC. Nodes with posterior probabilities ≥0·95 are shown in bold.

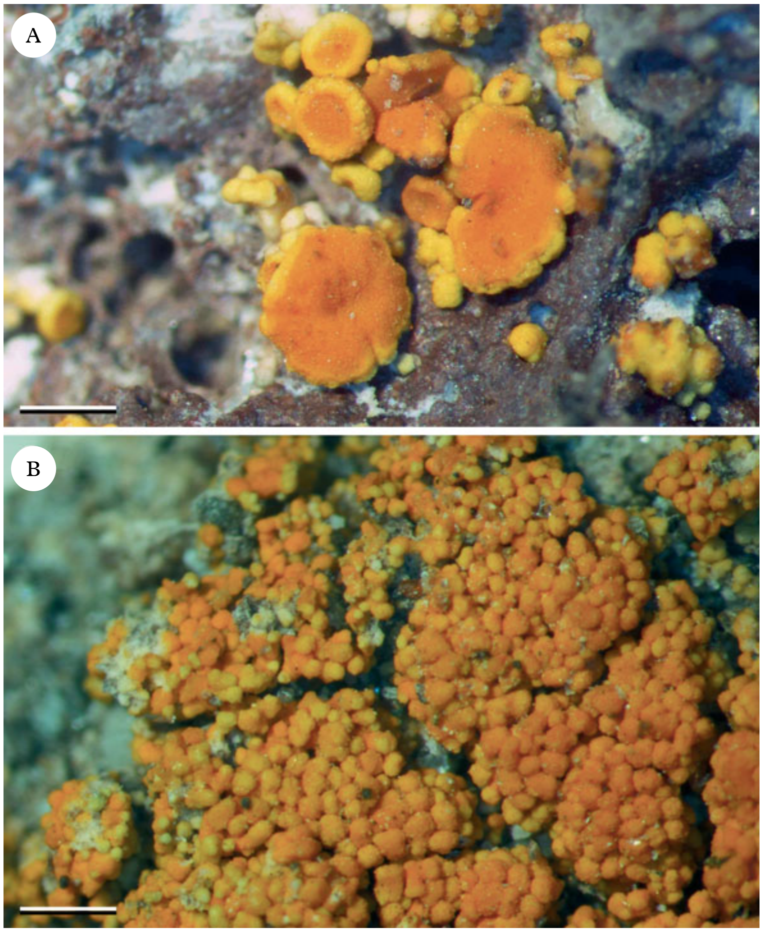

FIG. 3. *Charcotiana antarctica,* habitus. A, holotype; B, sterile, granular thallus on sandy soil (TSB A580). Scales A & B = 0·5 mm. In colour online.

characterized by a fragilin dominated chemistry (Arup *et al.* 2013).

Charcotiana antarctica Søchting, Garrido-Benavent, Pérez-Ortega, Seppelt & Castello sp. nov.

MycoBank No.: MB 808602

Thallus crustose, orange, bullate to areolate with minutely lobate margins, most often distinctly stipitate, particularly when fertile. Apothecia crowded, often stipitate and irregular, with excluded margin. Spores polardiblastic, 12·0 × 6·5 µm; septum *c.* 3·5 µm.

Type: Antarctica, Northern Victoria Land, Daniell Peninsula, Cape Phillips, 73°05′S, 169°35′E, on volcanic rock, 7 January 1996, *F. Bersan* (TSB A833—holotype; MA-Lich 18175, C—isotypes).

(Fig. 3)

Thallus crustose, saxicolous, up to 3 cm wide, consisting of scattered areoles. Prothallus absent. Areoles small, initially isolated and bullate, eventually coalescing, forming larger irregular-shaped areoles that are minutely lobate at margins, pale to deep orange, 0·1–3·0 mm wide ($n = 40$) and 0·1–0·6 mm ($n = 34$) thick (Fig. 3A). A large proportion of the specimens studied have a ramified structure with finger-like protrusions that continue branching, thus giving an overall coralloid appearance (Fig 3B). Yellowish white dead tissue abundant in some samples, especially in old or abraded areoles. *Thallus cortex* paraplectenchymatous with cell lumina 2·5–4·5 µm wide ($n = 12$). *Photobiont* trebouxioid.

Apothecia lecanorine to mostly zeorine, mainly one per areole, numerous, rather crowded, regular to deformed by compression, sessile, often stipitate on top of finger-like protrusions of the thallus, in which case they are slightly constricted at the base, 0·2–1·2 mm diam. ($n = 26$) (Fig. 3A). *Disc* flat to somewhat convex in mature apothecia, deep orange to dark orange-brown when old, sometimes bright, epruinose. Apothecial margin particularly in very young apothecia rather thick, (60–)95 ± 16(–120) µm ($n = 24$). *Thalline exciple* rarely persistent, more often excluded early but still visible below the proper exciple of older apothecia, mainly pale orange. *Proper exciple* distinct, thin, often difficult to observe in deformed mature apothecia, (20–)43 ± 11(–70) µm thick ($n = 45$), concolorous with the disc. Proper exciple tissue prosoplectenchymatous, fan-shaped, consisting of non-isodiametric cells with lumina 4·5–6·0 µm long ($n = 7$) and *c.* 2 µm wide ($n = 4$). *Hypothecium* hyaline, consisting of densely interwoven hyphae. *Hymenium* hyaline, (51–)58 ± 6(–66) µm high ($n = 8$). *Epithecium* with dark orange, medium coarse epipsamma. *Paraphyses* (1·6–)2·3 ± 0·4(–3·9) µm thick ($n = 64$), simple to apically sparingly branched, septate, cylindrical with attenuate apex to moniliform and apically gradually slightly inflated, with (2·9–)5·2 ± 0·9(–7·0) µm thick ($n = 49$) apical cells. *Asci* clavate, with 8 spores, (39·5–)48·0 ± 6·0(–61·0) µm ($n = 18$) long and (13·5–)16·0 ± 2·5(–21·0) µm ($n = 16$) wide. *Ascospores* polardiblastic, ellipsoid, rarely subcylindrical with rounded ends, (8·5–)12·0 ± 1·5(–16·0) × (5·0–)6·5 ± 0·7(–8·0) µm ($n = 90$); length/breadth ratio (1·3–)1·9 ± 0·3(–2·9); ascospore septa (2·4–)3·6 ± 0·7(–5·7) µm thick; ratio of ascospore length/septum width (2·0–)3·4 ± 0·5(–4·6).

Conidiomata not seen.

Chemistry. Thallus and apothecia K+ purple. Chemosyndrome A of Søchting (1997).

Etymology. The name reflects the distribution of this species, so far known only from continental Antarctica and nearby islands.

Ecology and distribution. Based on the known localities, the species can grow on acid rocks, sand and dead mosses. *Charcotiana antarctica* grows in a wide spectrum of microhabitats including large stones, scoria debris, pebbles, rubble or gravel, silt, vulcanites, charnockite and coarse-grained granite. It is commonly found growing in small crevices of rocks where it may be able to retain a more humid environment. It is known from coastal sites at 25 m a.s.l. to high mountain ranges at 1457 m a.s.l, but most of the samples were collected 215–652 m a.s.l. Accompanying species are, for example, *Buellia frigida* Darb., *Lecanora mons-nivis* Darb., *Lecanora physciella* (Darb.) Hertel, *Lecidea cancriformis* C. W. Dodge & G. E. Baker, *Pleopsidium chlorophanum* (Wahlenb.) Zopf, *Umbilicaria decussata* (Vill.) Zahlbr. and *Rusavskia elegans* (Link) S. Y. Kondr. & Kärnefelt. The moss *Syntrichia sarconeurum* Ochyra & R. H. Zander was also seen accompanying them. *Charcotiana antarctica* is so far known from continental Antarctica, including several islands close to the continent margin (Coulman, Ross and Windmill Islands) (Fig. 7A). According to the number of extant collections, *C. antarctica* is expected to be a common but often neglected species in continental Antarctica. It has, however, never been recorded from maritime Antarctica or the Subantarctic Islands.

Notes. Specimens growing on sandy soil and mosses (ADT 25057, ADT 25393, ADT 25233, ADT 25051) develop a continuous, granular thallus, up to 10 mm wide, consisting of strongly aggregated, sometimes slightly fused, bullate (granule-like) areoles, (80·0–)157·0 ± 49·5(–260·0) µm wide ($n = 20$). They can be somewhat more greenish yellow when growing in the shade. Old areoles may become black. Moreover, these thalli are strongly coralloid (Fig. 3B) and usually sterile; apothecia from epigaeic specimens were seen only in ADT 25051.

Additional material studied. **Antarctica:** *Northern Victoria Land*: Cape Hallett region, Football Saddle, 652 m, 72°30′20·1″S, 169°42′42·7″E, 2004, *R. D. Seppelt* (ADT 25067, ADT 25040, ADT 25051, ADT 25038, ADT 25057, ADT 25454); 72°31′S, 169°45′E, 1996, *F. Bersan* (TSB A829); NW end of Cape Hallett summit, 373·6 m, 72°19′20·9″S, 170°15′ 20·8″E, 2004, *R.*

D. Seppelt (ADT 25292, ADT 25286); Cape Christie, 523·8 m, 72°17′41·2″S, 169°55′39·9″E, 2004, *R. D. Seppelt* (ADT 25388); 448·8 m, 72°18′10·4″S, 169°58′53·9″E, 2004, *R. D. Seppelt* (ADT 25393); Red Castle Ridge: 323 m, 72°26′50·9″S, 169°56′44·7″E, 2004, *R. D. Seppelt* (ADT 25233); 342 m, 72°26′53·5″S, 169°56′51·0″E, 2004, *R. D. Seppelt* (ADT 25223); Daniell Peninsula, Cape Phillips, 73°05′S, 169°35′E, 1994, *R. Bargagli* (TSB A922, TSB A580); Wood Bay, Mt. Melbourne, Edmonson Point, 74°21′S, 165°06′E, 1995, *F. Bersan* (TSB A815); Deep Freeze Range, Boomerang Glacier, 74°33′S, 163°54′E, 1991, *S. Sedmak* (TSB A885); Coulman Island, 73°19′S, 169°45′E, 1989, *P. Modenesi* (TSB A353). *Southern Victoria Land*: Ross Island, Cape Crozier, 182 m, 77°31·801′S, 169°17·458′E, 2007, *L. G. Sancho* (MAF-Lich 18885, MAF-Lich 18885-2, MAF-Lich 18886, MAF-Lich 18886-2, MAF-Lich 18888, MAF-Lich 18889, MAF-Lich 18891, MAF-Lich 18891-2, MAF-Lich 18894, MAF-Lich 18895, MAF-Lich 18898, MAF-Lich 18903, MAF-Lich 18891, MAF-Lich 18903-2, MAF-Lich 18905); 158 m, 77°31·877′S, 169°16·652′E, 2007, *L. G. Sancho* (MAF-Lich 18900); 212 m, 77°31·682′S, 169°17·345′E, 2007, *L. G. Sancho* (MAF-Lich 18882, MAF-Lich 18883, MAF-Lich 18884, MAF-Lich 18887, MAF-Lich 18887-2, MAF-Lich 18892, MAF-Lich 18893, MAF-Lich 18896, MAF-Lich 18897, MAF-Lich 18882 MAF-Lich 18897-2, MAF-Lich 18897-3, MAF-Lich 18897-4, MAF-Lich 18899); Cape Crozier, 77°27′S, 169°14′E, 2010, *J. Smykla* (KRAM-L-63612 as *Caloplaca erecta*); Tripp Bay, Cape Ross, 76°45′S, 163°00′E, 1994, *R. Bargagli* (TSB A684); Dry Valleys, Miers Valley, 480 m, 78°05′47·1″S, 163°41′33·6″E, 2000, *R. D. Seppelt* (ADT 21960). *Windmill Islands*: Ford Island, central, 66°24′S, 110°32′E, 1983, *R. D. Seppelt* (ADT 14247); Holl Island, central part of the island, 66°25′S, 110°25′E, 1989, *R. D. Seppelt* (ADT 19258). *Ingrid Christensen Coast*: Vestfold Hills, gully on south side of Trajer Valley, 68°36′00·0″S, 78°27′30·0″E, 1979, *R. D. Seppelt* (ADT 8755); east end of Lake Druzhby, 25 m, 68°34′25·0″S, 78°24′00·0″E, 1979, *R. D. Seppelt* (ADT 8278).

Amundsenia Søchting, Garrido-Benavent, Arup & Frödén gen. nov.

MycoBank No.: MB 808601

Type: *Amundsenia austrocontinentalis* Garrido-Benavent, Søchting, Pérez-Ortega & Seppelt

Thallus saxicolous, crustose, orange.

Apothecia sparse, dispersed, orange. *Spores* polardiblastic, small, with short spore septum.

Secondary chemistry. Apothecia and thalli contain parietin (dominant) and small proportions of teloschistin, fallacinal, parietinic acid and emodin. Chemosyndrome A of Søchting (1997).

Etymology. The genus is named after the successful Norwegian polar explorer Roald Amundsen (1872–1928), who was the first man to reach the South Pole.

Distribution. *Amundsenia* is so far known only from the Arctic and subarctic, and from continental Antarctica.

Notes. As seen from Fig. 1, the genus *Amundsenia* is a monophyletic clade that belongs in the subfamily *Xanthorioideae*. Its sister group, the genus *Squamulea,* has a different proper exciple consisting of paraplectenchymatous tissue, usually a squamulose to lobate thallus and it occurs in subtropical to temperate regions. Therefore we have chosen not to merge the two sister groups. Currently two species are accepted in *Amundsenia*.

Amundsenia approximata (Lynge) Søchting, Arup & Frödén comb. nov.

MycoBank No.: MB 808603

Caloplaca vitellinula f. *approximata* Lynge, *Lich. N. Zemlya*: 222 (1928).—*Caloplaca approximata* (Lynge) H. Magn., *Ark. Bot.* **33A** (1)**:** 130 (1946); type: Russia, Novaya Zemlya, Mashigin Fjord, Langs en bæk på N-siden af Blaafjell Basin, 1 August 1921, *Lynge* (O-L-1206—lectotype, selected here).

(Fig. 4A)

For a description of *A. approximata* see Hansen *et al*. (1987).

Distribution. *Amundsenia approximata* is widely distributed in the Arctic region, as shown in Figure 5. It was previously recorded from Antarctica based on a collection from McMurdo, Ross Island, in continental Antarctica (Søchting & Øvstedal 1992), where the other species of the genus, *A. austrocontinentalis*, is fairly common. With the present knowledge, we assume that the specimen was actually *A. austrocontinentalis*. A further record from Signy Island, South Orkney Islands (RILS 1056, BAS) cited by Øvstedal & Smith (2001) proved to be an erroneous identification. Accordingly, *A. approximata* is not considered to occur in Antarctica.

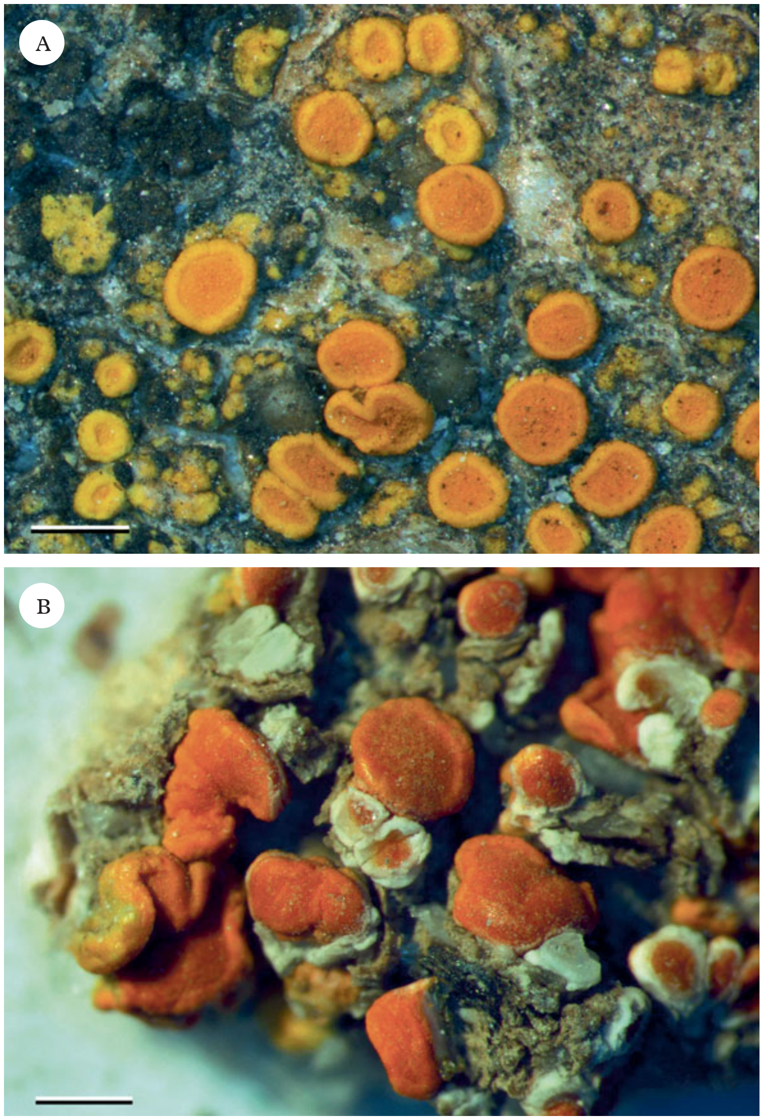

FIG. 4. *Amundsenia* sp. habitus. A, *A. approximata* (*U. Søchting* 4471); B, *A. austrocontinentalis* (MAF-Lich 18901). Scales: A & B = 0·5 mm. In colour online.

Notes. The distinction of *Caloplaca cacuminum* Poelt from *A. approximata* is not clear. *Caloplaca cacuminum* was described from the Alps in 1953, and was later reported from Greenland (Hansen *et al.* 1987). Molecular studies are needed to establish if the two species can be merged.

Selected material studied. **Greenland:** Disko Island, Qeqertarsuaq/Godhavn, 69·271°N, 53·503°W, 1982, *Poelt & Ullrich* (GZU); S-Greenland, Narsaq Community, Narsarssuaq, Sutuluaqqap Quappaa Kua, 61°9·3′N, 45°24·0′W, 2005, *Søchting* 10490 (C); Umanak, Marmorilik, 71·322°N, 51·374°W, 1983, *Poelt & Ullrich* (GZU).—**Iceland:** N-Múlasysla, NW of Mödrudalur, Vegaskard, 65°26′30″N, 15°58′W, 1997,

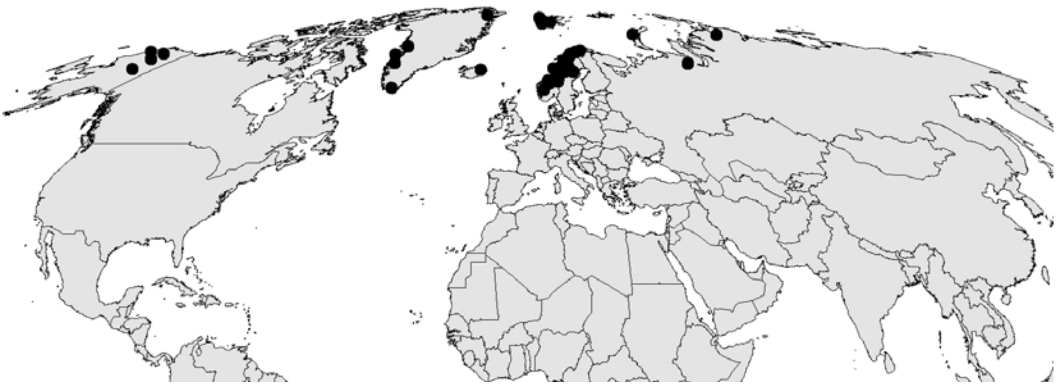

FIG. 5. *Amundsenia approximata*, distribution.

Søchting 7529 (C).—**Norway:** *Finnmark*: Alta county, Vassbotndalen, UTM: EC 6964, 1983, *Søchting* 4471 (C). *Hordaland*: Ulvik kommune, Finse, Mt. St. Finsenuten, UTM: 32W 041606 672088., 2002, *Arup* L02346 (UPS). *Nordland*: Vega Island, Valla, 65·666°N, 11·929°E, 1972, *Degelius* (UPS). *Oppland*: Dovre, Grimsdal at Verkensætri, UTM: NP 2881, 1985, *Søchting* 5321 (C); Dovre, Tverrâi, N of Grimsdalshytta, UTM: NP 3385, 1985, *Søchting* 5443 (C). *Sør-Trøndelag*: Oppdal, Alpine Station, UTM: NQ 1457, 1983, *Sivertsen* (C). *Troms*: S of Skibotndalen, between Luhcajávri and Stuoraoaivi, 69°15′N, 20°24′E, 2003, *Søchting* 10080 (C).—**Svalbard:** Albert I Land, Mitrahalvøya, Erlingvatnet, UTM: VJ 26 01, 1989, *Søchting* 6039 (C); Nordenskjöld Land, Reindalen N of Sørhytta, UTM: WG 2058, 1989, *Søchting* 5530 (C); Oscar II Land, Brøggerhalvøya, Kiærstranda, UTM: VH2464, 1989, *Søchting* 6117 (C); Sabine Land, Sassendalen at Fredheim, 78°21′23″N, 16°57′42″E, 1986, *Søchting* 5855 (C).—**Russia:** *Central Siberia*: Taimyr Peninsula, Byrranga Mts, in the vicinity of northern extremity of Levinson-Lessing Lake, 74°33'N, 98°34'E, 1994, *Zhurbenko* 94474 (C); Jamalo-Nenetskij, Raiis Massive, Alpine meadow W of 134 km railway post, 67°N, 65°35′E, 1993, *Søchting* 6693 (C).—**Sweden:** *Härjedalen*: Ulvberget, *Arup* L02239 (LD); Tännäs, 6 km SE of Mt. Skarsen, 1988, *Santesson* 32467 (UPS). *Jämtland*: Undersåker par., Mt. Välliste, 8 km WSW of Undersåker, UTM: RT90: 702049 136637, 2002, *Arup* L02084 (LD); Åre, Stalltjärnstugan, 63·475°N, 12·559°E, 1952, *Sundell* (UPS). *Norrbotten*: Lule Lappmark, Jokkmokk par., Padjelanta National Park, foot of Allak *c.* 3·5 km SSW of the peak Allaktjåhkkå, UTM: RT90: 7479814 1535934, *Arup* L04213 (LD); Torne Lappmark, Abisko, Abiskojåkk, 68·308°N, 18·661°E, 1919, *Magnusson* 2683b (UPS). *Västerbotten*: Åsele Lappmark, Vilhelmina parish, *c.* 20 km ESE of Saxnäs, UTM: WN 356021, 1991, *Søchting* 6294 (C).—**USA:** *Alaska*: Denali Park at access road, 65°33′N, 148°53′W, 1996, *Søchting* 7454 (C).

Amundsenia austrocontinentalis Garrido-Benavent, Søchting, Pérez-Ortega & Seppelt sp. nov.

MycoBank No.: MB 808604

Thallus crustose, composed of flat areoles that are irregular to minutely lobate at the margins, deep yellow to pale orange. Apothecia sessile, with flat, matt discs, usually with orange pruina. Apothecium margin very thick in young apothecia. Spores polardiblastic, 11·0 × 5·5 µm; septum *c.* 3 µm.

Type: Antarctica, Ingrid Christensen Coast, Vestfold Hills, Mule Peninsula, west of Clear Lake, 8 m, 68°39′00·0″S, 077°57′20·0″E, on small stones in a glacial till, 2 February 1979, *R. D. Seppelt* (ADT 8895—holotype; C—isotype).

(Fig. 4B)

Thallus crustose, saxicolous, areolate, up to 3 cm wide. *Prothallus* absent. *Areoles* 0·2–0·8 mm wide ($n = 26$) and 0·1–0·3 mm high ($n = 25$), flat, with irregular to sometimes minutely lobate margins, deep yellow to pale orange, becoming whitish when abraded or dead. *Thallus cortex* paraplectenchymatous with cell lumina 2·2–3·5 µm wide ($n = 20$). *Photobiont* trebouxioid.

Apothecia lecanorine to zeorine when mature, usually one per areole, scarce to numerous, rather dispersed but occasionally aggregated, regular to deformed by compression, sessile, 0·2–1·5 mm wide ($n = 61$). *Disc* mainly flat, rarely slightly concave when well developed, and sometimes somewhat convex when mature, mostly pale orange, matt, usually with orange pruina. *Apothecial margin* initially very thick, but eventually often excluded and hidden below the disc, (50–) 117 ± 35(–220) µm thick ($n = 38$). *Thalline exciple* often persistent, but may also be excluded early, deep greenish yellow to pale orange. *Proper exciple* distinct, thick even in mature apothecia, (30–)61 ± 14(–90) µm ($n = 56$), concolorous with the disc or slightly paler. Proper exciple tissue prosoplectenchymatous consisting of non-isodiametric cells with lumina 3·8–7·5 µm long and 1–2 µm wide ($n = 15$). *Hypothecium* hyaline, consisting of densely interwoven hyphae. *Hymenium* hyaline, (43·0–)58·0 ± 7·5(–76·0) µm high ($n = 43$). *Epithecium* with dark orange medium coarse epipsamma. *Paraphyses* (1·7–)2·4 ± 0·4(–3·1) µm thick ($n = 63$), septate, simple to sparingly branched at the top, mostly moniliform, apically gradually slightly inflated or rarely with an attenuated cap, (3·1–)4·7 ± 0·7(–6·2) µm thick ($n = 120$) apical cells. *Asci* clavate, with 8 spores, (41·5–)46·5 ± 4·0(–54·0) µm long and (12·0–)12·5 ± 1·0(–14·5) µm wide ($n = 10$). *Ascospores* polardiblastic ellipsoid, rarely subcylindrical with rounded ends, (8–)11 ± 1·0 (–13·5) × (4·0–)5·5 ± 0·5(–6·5) µm ($n = 86$); length/breadth ratio (1–)2 ± 0·2(–2·6); ascospore septa (2·0–)2·9 ± 0·3(–3·5) µm thick; ratio of ascospore length/septum width (3·0–)3·8 ± 0·4(–5·0).

Conidiomata not seen.

Chemistry. Thallus and apothecia K+ purple. Chemosyndrome A of Søchting (1997).

Etymology. The name *austrocontinentalis* is based on the currently known distribution of the new species, which has been found in continental Antarctica.

Ecology and distribution. *Amundsenia austrocontinentalis* is frequently found growing on granite rocks but some specimens have been found on stone flakes in moraine debris, rock fragments amongst dolerite blocks in felsenmeer or on scoria rubble in scree. This species commonly grows in small crevices of large granitic rocks in more or less exposed areas. It is known from the supralitoral level in coastal sites (8 m a.s.l.) to mountains, 320–750 m a.s.l. Accompanying species: *Austroplaca darbishirei* (C. W. Dodge & G. E. Baker) Søchting *et al.*, *Lecanora* spp., *Lecidea cancriformis*, *Muellerella pygmaea* (Körb.) D. Hawksw. and *Rhizoplaca melanophthalma* (DC.) Leuckert. The species is so far known only from continental Antarctica, in the Vestfold Hills (Ingrid Christensen Coast) and Southern Victoria Land (Fig. 7B). It may be locally abundant, for example in McMurdo Dry Valleys.

Notes. There are three samples (ADT 21115, ADT 20302, ADT 19147) whose spore morphology and septum differ from the other specimens analyzed, and that better resemble those of *Amundsenia approximata*, especially in the shorter septa, (2·1–)2·5 ± 0·2(–2·9) µm, ratio of ascospore length/septum width (4·3–)5·5 ± 0·8(–8·3) ($n = 26$). However, the spore size of these peculiar specimens is far greater compared with the latter species: (11·0–)13·5 ± 1·5(–17·5) × (5·5–)6·5 ± 0·5(–8·0) µm, length/breadth ratio (1·5–)2·1 ± 0·3(–2·8) ($n = 26$), whereas *A. approximata* has mean values of 11·0 ± 1·5 × 4·0 ± 0·5 µm ($n = 10$). Accordingly, we have decided not to use any quantitative data of the three samples mentioned above when computing the different measurements for *A. austrocontinentalis*. Moreover, the apothecia of the sample ADT 21115 are clearly stipitate as in *Charcotiana antarctica*, with a protrusion (stipe) 0·10–0·25 mm tall and overall height between 0·3–0·7 mm ($n = 7$). Morphology, colour, chemistry and other microscopic features are the same as in the other *A. austrocontinentalis* samples. At present, ITS sequences are not available for these three specimens; therefore, we cannot corroborate the novelty of a putative new species either.

Even though *C. antarctica* and *A. austrocontinentalis* are molecularly well delimited and normally also macroscopically distinct, they may occasionally be difficult to separate (Table 2). *Charcotiana antarctica* can be distinguished by its deeper orange thallus, with scattered, bullate areoles that usually form protrusions, which can develop into somewhat branched-coralloid structures, deep

TABLE 2. *Morphological and anatomical comparison between* Charcotiana antarctica *and* Amundsenia austrocontinentalis.

	Areole width (mm)	Areole height (mm)	Thallus with ± coralloid protrusions	Thallus colour	Apothecium diam. (mm)	Apothecial margin (µm)	Proper margin (µm)	Disc colour	Disc pruinose
C. antarctica	0·1–3·0 (*n* = 40)	0·1–0·6 (*n* = 34)	Often	Pale to mostly deep orange	0·2–1·2 (*n* = 26)	(60–)95 ± 16(–120) (*n* = 24)	(20–)43 ± 11(–70) (*n* = 45)	Deep orange to dark orange-brown when old	Never
A. austrocontinentalis	0·2–0·8 (*n* = 26)	0·1–0·3 (*n* = 25)	Never	Deep yellow to pale orange	0·2–1·5 (*n* = 61)	(50–)117 ± 35(–220) (*n* = 38)	(30–)61 ± 14(–90) (*n* = 56)	Mostly pale orange	Usually

	Paraphyse apical cell width (µm)	Spore length × width (µm)	Spore length/ breadth ratio	Spore septum width (µm)	Ratio of ascospore length / septum width
C. antarctica	(2·9–)5·2 ± 0·9(–7·0) (*n* = 49)	(8·5–)12·0 ± 1·5(–16·0) × (5–)6·5 ± 0·5(–8) (*n* = 90)	(1·3–)1·9 ± 0·3(–2·9)	(2·4–)3·6 ± 0·7(–5·7)	(2·0–)3·4 ± 0·5(–4·6)
A. austrocontinentalis	(3·1–)4·7 ± 0·7(–6·2) (*n* = 120)	(8–)11 ± 1·0(–13·5) × (4·0–)5·5 ± 0·5(–6·5) (*n* = 86)	(1–)2 ± 0·2(–2·6)	(2·0–)2·9 ± 0·3(–3·5)	(3·0–)3·8 ± 0·4(–5·0)

FIG. 6. *Austroplaca frigida,* habitus (MAF-Lich 18902-2). Scale = 0·5 mm. In colour online

orange, epruinose discs, and stipitate apothecia with thin apothecial margins. The latter feature should be used with caution because both species are quite variable, even within the same sample, and show overlapping value ranges. Additionally, the thallus of *A. austrocontinentalis* is commonly paler, with flat areoles, with flat, matt discs covered by orange pruina, and with thicker apothecial and proper margins. Microscopically, it can be difficult to separate the two species due to the overlapping ranges, but *C. antarctica* tends to have longer spores with thicker septa compared to those of *A. austrocontinentalis*.

Both *C. antarctica* and *A. austrocontinentalis* tend to reduce their interface with the rock substratum by the formation of microstipitate areoles and apothecia. This is a characteristic of many other Antarctic lichens, including *Austroplaca frigida* (see below), and is even more pronounced where the thallus becomes microfruticose with all photosynthetically active parts elevated from the rock, as seen in *Caloplaca scolecomarginata* and *Huea coralligera* (Ott & Sancho 1993; Søchting & Olech 2000); this separation from the rock may improve temperature conditions in the photosynthetic and reproductive parts of the lichen and was previously noted, particularly in eutrophicated sites, by Lamb (1968), Jacobsen & Kappen (1988) and Olech (1990).

Additional material studied. **Antarctica:** *Ingrid Christensen Coast*: Vestfold Hills, 500 m South of Pauk Lake, 25 m, 68°34′40·0″S, 78°28′30·0″E, 1979, *R. D. Seppelt* (ADT 9015). *Southern Victoria Land*: Ross Island, Scott Base Area, 150 m NW seismic station, 77°51′S, 166°45′E, 1997, *R. D. Seppelt* (ADT 20302); Kar Plateau, south eastern end, 76°56′S, 162°20′E, 1992, *R. D. Seppelt* (ADT 19147); McMurdo Dry Valleys, Garwood Valley, 78°02·046′S, 163°56·237′E, 1999, *R. D. Seppelt* (ADT 21115); 360 m, 78°1′36·4″S, 163°51′36·4″E, 2009, *J. Raggio* (MAF-Lich 18901)); Upper Garwood, 688 m, 78°02·173′S, 163°50·191′E, 2009, *A. de los Rios* (MAF-Lich 18171); 671 m, 78°03·454′S, 163°48·531′E, 2009, *A. de los Rios* (MAF-Lich 18173); Upper Garwood/Upper Miers Valleys area, *c.* 1 km ESE of Shangri-La Camp, 750 m, 78°03′28·4″S, 163°46′10·0″E, 2009, *R. D. Seppelt* (ADT 27534); *c.* 1·5 km ENE of Shangri-La Camp, 750 m, 78°03′29·6″S, 163°49′17·8″E , 2009, *R. D. Seppelt* (ADT 27537); Miers Valley, 320 m, 78°05′50·6″S, 163°43′07·3″E, 2000, *R. D. Seppelt* (ADT 21966); between both glaciers, close to a stream, 171 m, 78°06·012′S, 163°48·603′E, 2009, *A. de los Rios* (MAF-Lich 18174); plateau, 521 m, 78°06·825′S, 163°51·225′E, 2009, *A. de los Rios* (MAF-Lich 18172).

https://doi.org/10.1017/S0024282914000395 Published online by Cambridge University Press

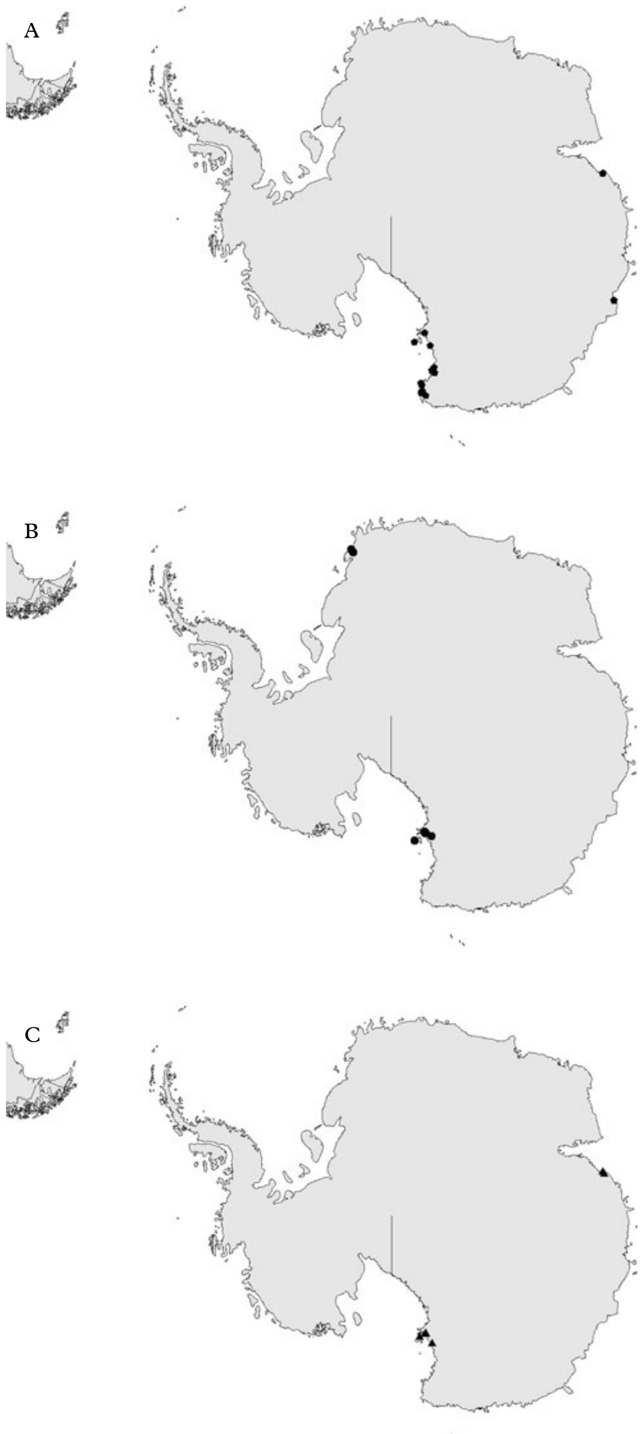

FIG. 7. Distributions. A, *Charcotiana antarctica*; B, *Amundsenia austrocontinentalis*; C, *Austroplaca frigida*.

https://doi.org/10.1017/S0024282914000395 Published online by Cambridge University Press

Austroplaca frigida Søchting & Garrido-Benavent nom. nov.

MycoBank No.: MB 808605

Caloplaca frigida Søchting in Søchting & Olech. *Bibl. Lichenol.* **75:** 24 (2000), *nom. illeg.*, *non Caloplaca frigida* (Paulson) Zahlbr. (1930)

Type: Antarctic Continent, Dronning Maud Land, Vestfjella, the nunatak Basen, January 1992, *Thor* 10559 (S—holotype; C, CRA—isotypes).

(Fig. 6)

This is another characteristic saxicolous lichen from continental Antarctica (Fig. 9). It was described in Søchting & Olech (2000) as *Caloplaca frigida* by Søchting, who overlooked that the combination *Caloplaca frigida* (Paulson) Zahlbruckner had been made in 1930 in *Cat. Lich. Univers.* **7:** 139 based on the basionym *Placodium frigidum* Paulson 1925.

The molecular analysis based on ITS sequences has shown *Caloplaca frigida* Søchting to belong in *Austroplaca* (Fig. 2), and to be closely related to two Antarctic species, *A. soropelta* and *A. darbishirei*, which have well-developed orange-yellow thalli producing soredia (Søchting & Castello 2012). *Austroplaca frigida* is often reduced to scattered apothecia; it may be confused with the above species, but has a narrower spore septum (1·5–2·0 µm).

Austroplaca frigida may be an overlooked species in continental Antarctica. It has so far not been collected outside continental Antarctica (Fig. 7C).

Selected material studied. **Antarctica:** *Southern Victoria Land*: Kar Plateau south east end, 76°56′S, 162°20′E, 1992, *R. D. Seppelt* (ADT 19175); Garwood Valley, 78°2·046′S, 163°56·237′E, 1999, *R. D. Seppelt* (ADT 21118); 78°02·103′S, 163°56·380′E, 1999, *R. D. Seppelt* (ADT 21126); 78°02·046′S, 163°56·237′E, 1999, *R. D. Seppelt* (ADT 21117); 78°02·103′S, 163°56·380′E, 1999, *R. D. Seppelt* (ADT 21125); 78°02·103′S, 163°56·380′E, 1999, *R. D. Seppelt* (ADT 21123); 78°02·890′S, 165°42·290′E, 2009, *Sancho & Seppelt* (MAF); McMurdo Dry Valleys, Upper Garwood Valley area, *c.* 1 km W of Shangri-La camp, 78°02′53·5″S, 163°42′17·5″E, 2009, *R. D. Seppelt* (ADT 27513); 340 m, 78°01′38·4″S, 163°50′20″E, 2009, *J. Raggio* (MAF-Lich 18890, MAF-Lich 18890-2, MAF-Lich 18904); plateau, 78°01′38·4″S, 163°30′20″E, 2009, *J. Raggio* (MAF-Lich 18902, MAF-Lich 18902-2). *Windmill Islands*: Ford Island, central, 66°24′25″S, 110°30′50″E, 1983, *R. D. Seppelt* (ADT14232).

Lisbeth Knudsen is thanked for skilled assistance in the molecular and HPLC laboratories and Bjørn Hermansen for production of the distribution maps. Helen Peat, British Antarctic Survey, Cambridge, is thanked for the loan of specimens and Teuvo Ahti, Helsinki, for nomenclatural advice. This work was made possible due to a Carlsberg Foundation grant (2008_01_0645) to the first author and a SYNTHESYS scholarship to the second author (DK-TAF-3064), which is financed by the European Community Research Infrastructure Action (Project http://www.synthesys.info/). The project was also supported by the Spanish Economy and Competitiveness Ministry grants CTM2012-38222-C02-01/02 and FPU AP2012-3556. We are also grateful to the New Zealand Antarctic Program and the University of Waikato Antarctic Research Program, and to the Italian Antarctic Research Programme (PNRA) and the National Antarctic Museum (MNA). The New Zealand Foundation for Research, Science and Technology (FRST), the University of Waikato Vice Chancellor's Fund, and the Department of Biological Sciences, University of Waikato also provided financial support.

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