



Standard Paper

Australidea (Malmideaceae, Lecanorales), a new genus of lecideoid lichens, with notes on the genus *Malcolmiella*

Gintaras Kantvilas¹ , Mats Wedin²  and Måns Svensson³

¹Tasmanian Herbarium, Tasmanian Museum and Art Gallery, P.O. Box 5058, UTAS LPO, Sandy Bay, Tasmania 7005, Australia; ²Department of Botany, Swedish Museum of Natural History, P.O. Box 50007, SE10405, Stockholm, Sweden and ³Museum of Evolution, Uppsala University, Norbyvägen 16, SE-75236, Uppsala, Sweden

Abstract

The new genus *Australidea* Kantvilas, Wedin & M. Svensson is described to accommodate *Lecidea canorufescens* Kremp., a widespread lichen in temperate Australasia. It is characterized by a crustose thallus with a green photobiont, reddish brown, biatorine apothecia with an internally hyaline, cupulate proper exciple constructed of branched and anastomosing hyphae, mainly simple paraphyses, 8-spored, *Porpidia*-type asci and simple, hyaline, non-halonate ascospores. A phylogenetic analysis places the new genus in the family Malmideaceae. *Lecidea canorufescens* Kremp., *L. glandulosa* C. Knight, *L. immarginata* R. Br. ex Cromb. and *L. intervertens* Nyl. are lectotypified. These names, plus *L. dacrydii* Müll. Arg. and *L. eucheila* Zahlbr., are all synonyms of *Australidea canorufescens* (Kremp.) Kantvilas, Wedin & M. Svensson comb. nov. Several genera superficially similar to *Australidea*, including *Malcolmiella* Vězda, *Malmidea* Kalb *et al.* and *Myochroidea* Printzen *et al.*, are compared. A comprehensive anatomical and morphological description of the genus *Malcolmiella*, recorded for Tasmania for the first time, is also provided. The new combination *M. interversa* (Nyl.) Kantvilas, Wedin & M. Svensson is introduced and the names *M. cinereovirens* Vězda and *M. cinereovirens* var. *isidiata* Vězda are reduced to synonyms. The systematic position of this genus remains unclear, although phylogenetic analysis suggests its affinities lie with a group of genera that includes *Bryobilimbia* Fryday *et al.*, *Romjularia* Timdal and *Clauzadea* Hafellner & Bellem.

Key words: ascus structure, Australia, biodiversity, corticolous *Lecidea*, lichenized fungi, *Malmidea*, *Myochroidea*

(Accepted 19 May 2021)

Introduction

One of the challenges confronting lichenologists in relatively poorly documented regions such as Australia is to link the many disused species names, mostly described in the 19th century and in an extremely concise way, to modern collections and comprehensive descriptions, and to assign them to currently accepted genera. This particularly applies to names placed in the old Zahlbruckner ‘form’ genera such as *Bacidia*, *Catillaria* and, in particular, *Lecidea*. A reappraisal of these groups has now been underway for several decades, initially based principally on anatomical characters, especially ascus structure (e.g. Hafellner 1984; Timdal 1984; Hertel & Rambold 1987, 1990; Kantvilas & Elix 1994; Printzen 1995, 1999; Rodriguez Flakus 2020), and, more recently, with the added phylogenetic evidence from DNA sequence data (e.g. Printzen & Kantvilas 2004; Printzen *et al.* 2008; Stenroos *et al.* 2009; Kalb *et al.* 2011; Schmull *et al.* 2011; Rodriguez Flakus & Printzen 2014; Spribille *et al.* 2020). Thus, *Lecidea* in the strictest sense is today considered an exclusively saxicolous genus, characterized by, *inter alia*, distinctive 8-spored asci (*Lecidea*-type, after Hafellner (1984)) with simple, hyaline,

non-halonate ascospores (e.g. see Hafellner 1984; Hertel 1984; Fryday & Hertel 2014) and, consequently, the corticolous taxa currently classified in this genus do not belong here. This is also the case for most of the species listed under *Lecidea* in the Australian lichen checklist (McCarthy 2020), whereas for New Zealand, Galloway (2007) explicitly noted that at least 11 of the 26 species of *Lecidea* recognized are misplaced.

The beginnings of the present study lay in the quest to establish the taxonomic affinities for a widespread, frequently collected corticolous Australian species that has gone under the name of *Lecidea immarginata* R. Br. ex Cromb. (Kantvilas & James 1991). This was one of the first lichens to be collected in Australia, by the botanist explorer Robert Brown who accompanied the expedition of the navigator Matthew Flinders in 1801–1803 to circumnavigate the continent of Australia, and who was present in 1804 at the founding of the settlement in Tasmania that was to become Hobart. The species was not formally described until much later, when the British lichenologist Rev. James Crombie reviewed Brown’s collections, by then housed in London’s Natural History Museum (Crombie 1880). Our examination of numerous *Lecidea* taxa based on Australasian types revealed that *L. immarginata* has been described multiple times. Its curious ascus type led to an investigation of several other genera, most notably *Malcolmiella* Vězda (Vězda 1997), *Malmidea* Kalb *et al.* (Kalb *et al.* 2011) and *Myochroidea* Printzen *et al.* (Printzen *et al.* 2008).

Author for correspondence: Gintaras Kantvilas. E-mail: Gintaras.Kantvilas@tmag.tas.gov.au

Cite this article: Kantvilas G, Wedin M and Svensson M (2021) *Australidea* (Malmideaceae, Lecanorales), a new genus of lecideoid lichens, with notes on the genus *Malcolmiella*. *Lichenologist* 53, 395–407. <https://doi.org/10.1017/S0024282921000311>

© The Author(s), 2021. Published by Cambridge University Press on behalf of the British Lichen Society

The genus *Malcolmiella* was introduced for the single species *M. cinereovirens* by Vězda (1997), who described two varieties, differing by the putative presence of isidia. His description was scant and made no particular reference to the peculiar asci of these lichens. The genus was soon taken up by Lücking & Kalb (2000) who added four taxa and noted that the critical features of *Malcolmiella* were the asci having a ring structure, the paraplectenchymatous exciple and the halonate ascospores. Over the following years, *Malcolmiella* was gradually expanded by the addition of further, exclusively tropical taxa (Kalb 2004; Aptroot *et al.* 2007; Cáceres 2007; Lücking 2008; Kalb *et al.* 2009). Interestingly, some of these authors specifically referred back to the particular asci that were present in Vězda's type species from the cool temperate latitudes of New Zealand, even though the taxa they were studying did not possess this character.

At length, Kalb *et al.* (2011) studied these taxa using molecular and anatomical data and found that the tropical species, all essentially those referred to historically as the *Lecidea piperis*-group, were in fact unrelated to *Malcolmiella* and erected the genus *Malmidea* within a new family, the *Malmideaceae*. With respect to anatomy, *Malmidea* differs from *Malcolmiella* by its exciple of radiating, thick hyphae encrusted with hydrophobic granules, a dark pigmented hypothecium, a coherent hymenium with thin, entangled, branched paraphyses, asci with a tholus that lacks any internally differentiated structures, thinly halonate ascospores, sometimes with an apically thickened wall, and a thallus chemistry usually consisting of atranorin and other substances. Molecular data supported *Malmidea* as sister to the *Pilocarpaceae*, whereas *Malcolmiella* was, curiously, placed as sister to the *Teloschistaceae*, even though there were no supporting anatomical similarities between the two (Kalb *et al.* 2011). *Malmidea* is now a generally accepted genus of some 50 species (Breuss & Lücking 2015) whereas *Malcolmiella* is monotypic. McCarthy (2020) records four species of *Malmidea* for Australia, chiefly from tropical latitudes, but it is likely that further species may be lurking amongst Australasian species and herbarium specimens currently classified in *Lecidea*.

Myochroidea was described by Printzen *et al.* (2008) for a group of corticolous, lecideoid lichens with reddish brown, biatorine apothecia and 8-spored, *Micarea*-type asci. All four species are known only from the temperate Northern Hemisphere.

In the present study, these and other superficially similar genera are compared and the new genus *Australidea* is described to accommodate *Lecidea immarginata* under an older name, *L. canorufescens*. A comprehensive anatomical and morphological description of *Malcolmiella* is also provided and this genus is recorded for Tasmania for the first time. Several names based on Australasian types are reduced to synonymy.

Materials and Methods

Morphology and anatomy

The study is based mainly on the first author's collections, housed in the Tasmanian Herbarium (HO), and on reference material in other herbaria as cited, chiefly London's Natural History Museum (BM), the Finnish Museum of Natural History (H), the Museum of Evolution, Uppsala University (UPS), and the Swedish Museum of Natural History (S). Investigations were undertaken on hand-cut sections of thalli and apothecia, using standard

methods, reagents and stains: water, 10% KOH (K), lactophenol cotton blue and Lugol's iodine (I).

Measurements of ascospores are based on 60–100 observations of each taxon and are presented in the format 5th percentile–average–95th percentile, with outlying values in brackets and *n* the number of observations. Routine thin-layer chromatographic analysis (TLC) was undertaken using standard methods, with solvent A as the preferred medium (Orange *et al.* 2010).

Observing and interpreting the structure of the exciple and asci can present technical difficulties. Interpretation is rarely arrived at after a single observation or even several, but may require multiple sections, experimentation with different concentrations of key reagents, and other manipulations. Such complications should not act as a deterrent, especially when, as illustrated in this study, many of the taxa in question are represented entirely by old specimens which do not offer usable DNA and anatomical characters are all that are available.

Comparative herbarium material examined for anatomical studies

Type material studied is cited in the main text. Other specimens studied are listed here:

Biatora subduplex (Nyl.) Printzen. **Austria:** Oetzal, Obergurgl, 2400–2700 m, 1993, A. Vězda & F. Ceni (*A. Vězda: Lich. Rar. Exs.*, 112) (HO).

Biatora vernalis (L.) Fr. **Sweden:** Jämtland, Undersåker, Vällista, 1912, G. O. Malme (*Malme: Lich. Suec. Exs.*, 285a) (UPS).

Japewiella pruinosa (Müll. Arg.) Kantvilas. **Australia:** Tasmania: St Crispins Well, 42°56'S, 147°13'E, 640 m, 1987, G. Kantvilas 69/87 (HO).

Malmidea granifera (Ach.) Kalb *et al.* **Brazil:** Rio de Janeiro: M^o Canos da Carioca, 1892, G. O. Malme 144 (S).

Malmidea leptoloma (Müll. Arg.) Kalb *et al.* **Solomon Islands:** Guadalcanal: Umasani River, 50–150 m, 1965, D. J. Hill 8072 (BM).

Malmidea piperis (Spreng.) Kalb *et al.* **Peru:** Prov. San Martin: Cerro Escalera (c. 20 km NE of Tarapoto, 6°27'S, 76°15'W, 900–1100 m, 1981, R. Santesson & G. Thor P72:29 (S).—**Paraguay:** Concepción: Colonia Risso, 1893, G. O. Malme 1942 (S).—**Australia:** Queensland: Cape Tribulation, 16°05'S, 145°29'E, 1991, W. H. Ewers 8342 (CANB, HO). Northern Territory: Channel Point, 13°07'S, 130°13'E, 10 m, 1991, J. A. Elix 27700, H. T. Lumbsch & H. Streimann (CANB, HO).—**USA:** Louisiana: Burden Research Plantation, Essen Lane, Baton Rouge, 1984, S. Tucker 26667 (HO).

Malmidea psychotrioides (Kalb & Lücking) Kalb *et al.* **Cuba:** Prov. Oriente: Bayate, 1917, E. L. Ekman s. n. (S L6964).

Myochroidea porphyrospoda (Anzi) Printzen *et al.* **Sweden:** Jämtland: Mt Täljstensvalen, 63°15'N, 12°27'E, 750 m, 2005, M. Svensson 549 (HO, UPS).

Myochroidea rufofusca (Anzi) Printzen *et al.* **Sweden:** Torne Lappmark, southern slope of Mt Latnjačorru, 1935, G. E. Du Rietz (HO, UPS).

DNA extraction, amplification and sequencing

Total DNA was extracted using the Plant DNA Mini Kit (Qiagen, Hilden, Germany) following the manufacturer's instructions. The mrSSU rDNA was amplified and sequenced with the primers mrSSU1 and mrSSU3R (Zoller *et al.* 1999). The nuLSU rDNA

was amplified and sequenced using the primers nu-LSU-155-5' (Döring *et al.* 2000) or LRlecF (Schneider *et al.* 2015), or in combination with either LR5 (Vilgalys & Hester 1990) or LRlecR (Schneider *et al.* 2015).

Amplifications were performed with the initial denaturation at 95 °C for 5 min, followed by 35 (mrSSU) or 40 (nuLSU) cycles of 95 °C for 45 s, 57 °C for 45 s, 72 °C for 1 min 45 s, and a final extension at 72 °C for 10 min. PCR products were subsequently purified with Exonuclease I and FastAP Thermosensitive Alkaline Phosphatase (Thermo Scientific™). For mrSSU, sequencing reactions were carried out using the BigDye Terminator Cycle Sequencing Kit (Applied Biosystems, Warrington, Cheshire, UK), and fragments were separated on an ABI 3130xl Genetic Analyzer (Applied Biosystems). For LSU, purified PCR products were sequenced by MacroGen Europe B.V. (Amsterdam, The Netherlands).

Taxon sampling

BLAST searches and preliminary analyses suggested that *Australidea canorufescens* is a member of the *Malmideaceae*. To further assess the phylogenetic position of this species within the family, sequences from representatives of all genera known to belong to *Malmideaceae* were downloaded from GenBank: *Cheiromycina* (Muggia *et al.* 2017), *Crustospathula* (Sodamuk *et al.* 2017; Kistenich *et al.* 2019), *Malmidea* (Kalb *et al.* 2011), *Puttea* (Spribille *et al.* 2020), *Savoronala* (Ertz *et al.* 2013), *Sprucidea* (Cáceres *et al.* 2017) and *Zhurbenkoa* (Flakus *et al.* 2019). For all these genera, mitochondrial SSU was available in GenBank; we also included LSU when that was available (see Table 1). Species of unclear generic affinities (e.g. *Lecidea cyrtidia*, *Psoroma karstenii*, *Toninia thiopora*) that might belong in the *Malmideaceae* (e.g. Ertz *et al.* 2013; Kistenich *et al.* 2019) were not included. The only available LSU sequence of *Puttea margaritella* (GenBank Accession no.: EU940111) was found to blast close to species of *Phacidium* and was therefore not included. As outgroup, we selected representatives from the *Sphaerophorinae*, including the families *Pilocarpaceae*, *Psoraceae*, *Ramalinaceae* and *Sphaerophoraceae*. This decision was based on *Malmideaceae* being sister to *Pilocarpaceae* in the analysis by Kalb *et al.* (2011) and as sister to the *Sphaerophorinae* in fig. 10 of Spribille *et al.* (2020). The recently described genus *Kalbionora* was placed in the *Malmideaceae* by its authors (Sodamuk *et al.* 2017) but, in a subsequent analysis using wider taxon sampling and more loci, a placement of *Kalbionora* within *Malmideaceae* was not supported (Spribille *et al.* 2020). Consequently, we excluded *Kalbionora* from our analyses. Furthermore, we note that the only available mrSSU sequence from *Kalbionora palaetropica* (GenBank Accession no.: KY926784), and which was used in the earlier analyses, blasts with members of the *Chaethyriales*. No sequences for *Myochroidea* were available, nor could recent collections suitable for sequencing be obtained.

Since the earlier analysis of Kalb *et al.* (2011) placed *Malcolmiella* as sister taxon to *Teloschistaceae*, and as our preliminary analyses indicated that it was indeed only distantly related to the *Malmideaceae*, we performed a separate analysis to assess the phylogenetic position of this genus. BLAST searches and preliminary analyses indicated a possible relationship with the *Lecideaceae*, and we thus selected a number of genera from this family in a broad sense. We retained *Teloschistaceae* in the analysis and also included two genera each from the *Peltigerinae* and *Collematinae*, since these are probably more closely related

to *Lecideaceae* than to *Teloschistaceae* (Miadlikowska *et al.* 2014). We selected *Rhizocarpaceae* as outgroup, as this family appears basal to the *Lecanoromycetidae* (Miadlikowska *et al.* 2014), which includes all other genera and families used in the analysis. For the selected genera and species, we downloaded sequences of mrSSU, LSU, ITS, *RPB1* and *RPB2* from GenBank (Table 2).

Sequence alignment, partitioning scheme and phylogenetic analysis

For both the *Malmideaceae* and *Malcolmiella* phylogenies, we estimated separate alignments for mrSSU, LSU and (for the *Malcolmiella* analysis) ITS using PASTA (Mirarab *et al.* 2015), with the mask option activated, MAFFT (algorithm L-INS-i) for alignment, OPAL for the pairwise merging, and FastTree as the tree estimator, with GTR + Γ as the model for molecular evolution. As PASTA is an iterative method that optimizes the alignment under a maximum likelihood (ML) framework, we did no further manual adjustment or filtering of ambiguous regions of the resulting alignments. For *RPB1* and *RPB2*, we estimated the alignment using MAFFT (algorithm E-INS-i; Katoh *et al.* 2019). After aligning the sequences, we identified several non-coding introns in the *RPB1* alignment and removed these before any further analysis was performed.

To check for possible conflicting phylogenetic signals between datasets, we performed a separate ML analysis of each alignment using IQ-TREE (Nguyen *et al.* 2015), assessing branch support with ultrafast bootstrap (Hoang *et al.* 2018), running 2000 replicates. We evaluated models of molecular evolution using the version of ModelFinder (Kalyaanamoorthy *et al.* 2017) implemented in IQ-TREE and chose AICc as the criterion for estimation of model fit. For the *Australidea* analysis, GTR + F + I + G4 (mrSSU) and GTR + F + R3 (LSU) were selected as having the best model fit, whereas for the *Malcolmiella* analysis, the models TIM2 + F + I + G4 (ITS, *RPB1*), TIM2 + F + R3 (LSU), TVM + F + R3 (mrSSU) and TIM3 + F + I + G4 (*RPB2*) were selected. The single marker trees were then compared to locate any supported (> 80% bootstrap), conflicting results. As no such results were detected, in both cases (*Malmideaceae* + *Malcolmiella*) we decided to concatenate the separate datasets into one alignment. The final, concatenated alignments are deposited in TreeBase (TB-ID 28193).

Assessment of the division of the two different concatenated alignments into partitions was undertaken using PartitionFinder 2.1.1. (Lanfear *et al.* 2017), which also allows for simultaneous estimation of models of molecular evolution for the partitions. We restricted the estimation to models implemented in MrBayes 3.2.6. (which was used for subsequent phylogenetic analysis, see below), used AICc for model selection, assumed linked branched lengths, and used the 'greedy' algorithm (Lanfear *et al.* 2012). For the *Malmideaceae* phylogeny, we assessed the division of the concatenated alignment into two partitions, mrSSU and LSU. The analysis recommended keeping two partitions, with GTR + Γ selected as the best model for mrSSU and GTR + Γ + I for LSU. For the *Malcolmiella* phylogeny, we assessed the division of the dataset into 11 partitions: five for mrSSU, LSU, ITS1, 58S and ITS2, and six for three independent codon positions of *RPB1* and *RPB2*, respectively. The analysis recommended merging the 1st codon position of *RPB1* and *RPB2* into one partition. Furthermore, the model selection gave the best models for the partitions as GTR + Γ (ITS2, *RPB2* 2nd codon position, *RPB2*

Table 1. Sequence data used for the phylogenetic study of *Australidea canorufescens*, with GenBank Accession numbers and voucher information. Newly obtained sequences are in bold.

Species	Voucher/source	mrSSU	LSU
<i>Australidea canorufescens</i> 1	Tasmania, <i>Kantvilas</i> 106/10 (HO)	MZ068032	MZ068028
<i>A. canorufescens</i> 2	Tasmania, <i>Kantvilas</i> 310/93 (HO)	MZ068033	MZ068029
<i>Bilimbia sabuletorum</i>	<i>Björk</i> 11302 (UBC), <i>Miadlikowska et al.</i> (2014)	KJ766361	KJ766534
<i>Byssoloma leucoblepharum</i>	Portugal, <i>Ekman</i> 3502 (BG), <i>Andersen & Ekman</i> (2005)	AY567778	AY756317
<i>Cheiromycina flabelliformis</i>	Czech Republic, <i>Palice</i> 18257 (PRA), <i>Muggia et al.</i> (2017)	MF431799	MF431804
<i>C. petri</i>	Czech Republic, <i>Palice</i> 17855 (PRA), <i>Muggia et al.</i> (2017)	MF431800	MF431805
<i>C. reimeri</i>	Poland, <i>Kukwa</i> 17681 (hb. Kukwa), <i>Muggia et al.</i> (2017)	MF431802	MF431806
<i>Crustospathula cartilaginea</i>	Papua New Guinea, <i>Aptroot</i> 36411 (B), <i>Kistenich et al.</i> (2019)	MG925869	N/A
<i>Fellhanera subtilis</i>	Germany, <i>Tønsberg</i> 28199 (BG), <i>Andersen & Ekman</i> (2005)	AY567786	AY756321
<i>Lecania fuscella</i>	Sweden, <i>Ekman</i> L1351 (LD), <i>Kistenich et al.</i> (2019)	MG925877	MG926075
<i>Malmidea attenboroughii</i>	Bolivia, <i>Kukwa</i> 19645 (UGDA), <i>Guzow-Krzeminska et al.</i> (2019)	MK542860	N/A
<i>M. aurigera</i>	Thailand, <i>Kalb</i> 36858 (hb. Kalb), <i>Kalb et al.</i> (2011)	HM447600	N/A
<i>M. bakeri</i>	Thailand, <i>Kalb</i> 36830 (hb. Kalb), <i>Kalb et al.</i> (2011)	HM447608	N/A
<i>M. chrysostigma</i>	Thailand(?), <i>Kalb</i> 37093 (hb. Kalb), <i>Kalb et al.</i> (2011)	HM447607	N/A
<i>M. coralliformis</i>	Thailand, <i>Kalb</i> 37082 (hb. Kalb), <i>Kalb et al.</i> (2011)	HM447597	N/A
<i>M. floridensis</i>	USA, <i>May</i> 3088 (hb. May), <i>Schmull et al.</i> (2011)	HQ660565	HQ660540
<i>M. inflata</i>	Thailand, <i>Kalb</i> 37060 (hb. Kalb), <i>Kalb et al.</i> (2011)	HM447611	N/A
<i>M. piperis</i>	<i>Lücking</i> 25504 (hb. F s.n.), <i>Kalb et al.</i> (2011)	HM447623	N/A
<i>M. rhodopis</i>	<i>Lücking</i> 25539 (hb. F s.n.), <i>Kalb et al.</i> (2011)	HM447624	N/A
<i>Mycobilimbia carnealbida</i>	Finland, <i>Haikonen</i> 23317 (H), <i>Miadlikowska et al.</i> (2014)	KJ766438	KJ766599
<i>Neophyllis melacarpa</i>	Australia, <i>Kantvilas & Wolseley</i> 9/1/1997 (BM), <i>Wiklund & Wedin</i> (2003)	AY340511	AY340556
<i>Protoblastenia calva</i>	AFTOL-ID 992, <i>Miadlikowska et al.</i> (2006)	DQ986904	JQ301601
<i>Psora decipiens</i>	Spain, <i>Burgaz</i> s. n. 2004 (H), <i>Miadlikowska et al.</i> (2014)	KJ766474	KJ766640
<i>Puttea margaritella</i>	Finland, <i>Lesonen</i> 98 (TUR), <i>Stenroos et al.</i> (2009)	FJ006731	N/A
<i>Savoronala madagascariensis</i> 1	Madagascar, <i>Sérusiaux</i> DNA537 (LG), <i>Ertz et al.</i> (2013)	KC020144	KC020142
<i>S. madagascariensis</i> 2	Madagascar, <i>Sérusiaux</i> DNA538 (LG), <i>Ertz et al.</i> (2013)	KC020145	KC020143
<i>Sphaerophorus globosus</i>	Norway, <i>Spribille</i> 41201 & <i>Holien</i> (GZU), <i>Spribille et al.</i> (2020)	MN508300	MN460232
<i>Spruceia gymnopiperis</i>	Brazil, <i>Caceres</i> 28322 (ISE), <i>Caceres et al.</i> (2017)	MF093876	MF093874
<i>S. rubropencillata</i>	Brazil, <i>Caceres</i> 28211 (ISE), <i>Caceres et al.</i> (2017)	MF093877	MF093875
<i>Zhurbenkoa epicladonia</i> 1	Bolivia, <i>Flakus</i> 25212 (KRAM), <i>Flakus et al.</i> (2019)	MK491331	MK491328
<i>Z. epicladonia</i> 2	Bolivia, <i>Flakus</i> 25624 (KRAM), <i>Flakus et al.</i> (2019)	MK491332	N/A
<i>Z. latispora</i>	Bolivia, <i>Flakus</i> 25452 (KRAM), <i>Flakus et al.</i> (2019)	MK491333	MK491330

3rd position), GTR + Γ + I (mrSSU, LSU, *RPB1* 2nd codon position, *RPB1* + *RPB2* 1st codon positions combined), SYM + Γ (*RPB1* 2nd codon position) and K80 + Γ (ITS1).

We performed phylogenetic analyses on the concatenated, partitioned alignments using MrBayes 3.2.6. (Ronquist *et al.* 2012). We used flat Dirichlet priors for the substitution rates and state frequencies, and a uniform prior for invariant sites. We ran four Markov chain Monte Carlo (MCMC) chains, three incrementally heated (by a factor of 0.1) and one cold. The sample frequency was set to every 100th generation. The analysis was halted when convergence was reached, which was defined as an average standard deviation of split frequencies below 0.01. The fraction of trees discarded as burn-in was set to 25%. In addition to

the Bayesian analysis, we also performed ML analyses of the concatenated alignments with IQTree, using the same partitioning scheme and models of molecular evolution as for the Bayesian analysis. We used edge-proportional partition models and assessed branch support by running 1000 non-parametric bootstrap replicates.

Results

The results of the molecular analysis of *Malmideaceae* (Fig. 1) show strong support for a placement of *Lecidea canorufescens* in this family, where the species is sister to the genus *Malmidea* (the type genus of the family). In addition to the phylogenetic

Table 2. Sequence data used for the phylogenetic study of *Malcolmiella interspersa*, with GenBank Accession numbers and voucher information. Newly obtained sequences are in bold.

Species	Voucher/source	mrSSU	LSU	ITS	RPB1	RPB2
Collematinae						
<i>Coccocarpia erythroxyli</i>	AFTOL-ID 333, Miadlikowska <i>et al.</i> (2006)	DQ912294	DQ883800	HQ650691	DQ883743	DQ883756
<i>Collema nigrescens</i>	Sweden, Wedin 7046 (UPS), Wedin <i>et al.</i> (2009)	GQ259020	JX992875	N/A	GQ259049	N/A
Lecideaceae s. lat.						
<i>Bellemeria diamarta</i>	Sweden, Wedin 6822 (UPS), Ekman <i>et al.</i> (2008)	AY756398	AY756336	N/A	AY756406	N/A
<i>Bryobilimbia australis</i>	Chile, Pérez-Ortega 1419 (FR), Fryday <i>et al.</i> (2014)	KF683100	KF683106	KF683092	KF683112	N/A
<i>Clauzadea monticola</i>	USA, Fryday 9703 (MSC), Fryday <i>et al.</i> (2014)	KF683097	KF692710	KF683090	N/A	KF683110
<i>Farnoldia jurana</i>	Austria, Türk 39660 (hb. Türk), Ruprecht <i>et al.</i> (2010)	GU074511	N/A	EU263920	MK684889	N/A
<i>Lecidea auriculata</i>	USA, Lay 07-0075 (hb. Lay), Schmull <i>et al.</i> (2011)	HQ660561	HQ660536	HQ650658	HQ660552	HQ660525
<i>L. berengeriana</i>	Sweden, Arup L00015 (hb. Arup), Schmull <i>et al.</i> (2011)	HQ660562	HQ660537	HQ650659	N/A	HQ660526
<i>L. fuscoatra</i>	Sweden, Wedin 6860 (UPS), Ekman <i>et al.</i> (2008)	AY756401	AY756339	N/A	AY756408	N/A
<i>Lecidoma demissum</i>	AFTOL-ID 1376, Miadlikowska <i>et al.</i> (2006)	DQ986881	DQ986759	HQ650630	KJ766867	DQ992445
<i>Porpidia speirea</i>	AFTOL-ID 1050, Miadlikowska <i>et al.</i> (2006)	DQ986865	DQ986758	HQ650631	DQ986829	DQ992444
<i>Romjulularia lurida</i>	Spain, Pérez-Ortega 1372 (FR), Fryday <i>et al.</i> (2014)	KF683098	KF683107	KF683091	KJ766891	KJ766982
Malcolmiella						
<i>Malcolmiella interspersa</i> 1	Tasmania, Kantvilas 312/93 (HO)	MZ068030	MZ068027	N/A	N/A	N/A
<i>M. interspersa</i> 2	Tasmania, Kantvilas 154/93 (HO)	MZ068031	N/A	N/A	N/A	N/A
Peltigerinae						
<i>Lobaria pulmonaria</i>	USA, Widhelm <i>et al.</i> (2018)	MG754091	MG063078	MG367435	MG754080	N/A
<i>Peltigera hydrophila</i>	AFTOL-ID 1838, Miadlikowska <i>et al.</i> (2006)	DQ986809	DQ986796	HQ650648	DQ986854	DQ992425
<i>Vahliella leucophaea</i>	Sweden, Wedin 8131 (S), Wedin <i>et al.</i> (2011)	HQ268598	N/A	N/A	HQ268597	N/A
Rhizocarpaceae						
<i>Rhizocarpon oederi</i>	USA, Spribille 36629 (MSC), Spribille <i>et al.</i> (2020)	MN508296	MN460228	MN483144	N/A	N/A
<i>R. sphaerosporum</i>	Spain, Lumbsch s. n. (F), Wedin <i>et al.</i> (2005)	AY853340	AY853390	N/A	DQ870991	N/A
<i>R. suomiense</i>	Norway, Holtan-Hartwig & Timdal 4917 (O), Ihlen & Ekman (2002)	AF483181	N/A	AF483613	N/A	N/A
Teloschistaceae						
<i>Rusavskia elegans</i>	USA, Gaya <i>et al.</i> 2007-07-22 (DUKE), Gaya <i>et al.</i> (2012)	JQ301529	JQ301588	N/A	JQ301733	JQ301783
<i>Xanthomendoza oregana</i>	Sweden, Gaya <i>et al.</i> 2006-08-09 (BCN), Gaya <i>et al.</i> (2012)	JQ301525	JQ301583	JQ301689	JQ301730	JQ301778
<i>Xanthoria parietina</i>	Sweden, Gaya <i>et al.</i> 2006-08-11 (BCN), Gaya <i>et al.</i> (2012)	JQ301530	JQ301589	JQ301691	JQ301734	JQ301784

results, *L. canorufescens* also differs from *Malmidea* and other genera of *Malmideaceae* in anatomical and morphological respects, and we thus describe the new genus *Australidea* to accommodate it.

The analysis of the phylogenetic position of *Malcolmiella* (Fig. 2) shows that this genus is only distantly related to *Teloschistaceae*, where it had appeared as sister in earlier work (Kalb *et al.* 2011). The results indicate affinities with a group of

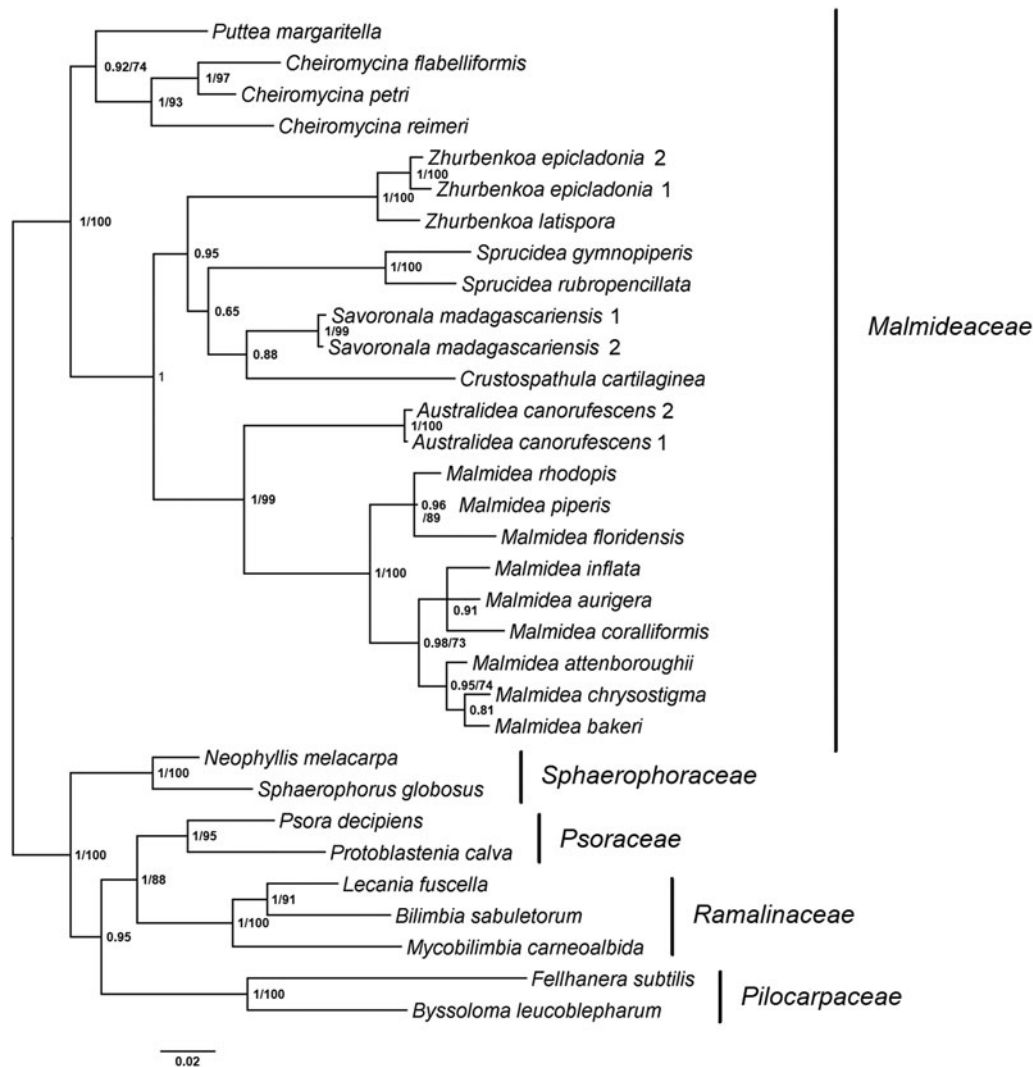


Fig. 1. Majority-rule consensus tree based on a Bayesian MCMC analysis of mrSSU and LSU, showing the phylogenetic position of *Australidea* in the *Malmideaceae*. Branch support is given as posterior probability (PP)/bootstrap support (BS). Bootstrap support values are from a corresponding maximum likelihood analysis. Only BS values > 70% are shown. GenBank Accession numbers and voucher information are given in Table 1.

genera (*Bryobilimbia*, *Clauzadea*, *Romjularia* and the *Lecidea berengeriana*-group) that is usually assigned to *Lecideaceae*. While our analysis does not offer any unequivocal conclusions regarding the phylogenetic position of this group (including *Malcolmiella*), the results clearly indicate that it, as well as the genus *Lecidoma*, do not belong in the *Lecideaceae*.

Taxonomy

Australidea Kantvilas, Wedin & M. Svensson gen. nov.

Mycobank No.: MB 839472

Thallus crustaceus, corticolus, algas virides unicellulares continens. Apothecia biatorina, excipulo proprio cupulato interne incolorato, ex hyphis ramosis anastomosantibusque constructo. Paraphyses plerumque simplices. Asci octospori typo *Porpidiae* pertinentes, ascosporis simplicibus hyalinis non-halonatis ovatis vel ellipsoideis.

Typus generis: *Australidea canorufescens* (Kremp.) Kantvilas, Wedin & M. Svensson.

Thallus crustose. *Photobiont* a unicellular green alga with globose cells 6–15 µm diam.

Ascomata apothecia, biatorine, basally constricted; proper exciple in section cupulate, hyaline within, not inspersed, composed of a loose reticulum of branched and anastomosing hyphae in a gel matrix. *Hypothecium* hyaline. *Hymenium* intensely KI+ blue, rather coherent in water and K. *Paraphyses* simple or, very occasionally, sparsely branched, not capitate. *Asci* clavate, 8-spored; tholus amyloid, with a darker-staining ring structure with parallel or diverging sides; ocular chamber not developed. *Ascospores* simple, hyaline, non-halonate, ovate to ellipsoid.

Pycnidia not found.

Chemistry. No substances detectable by TLC.

Etymology. The generic name is derived from ‘austral’, meaning ‘southern’ in geographical distribution, and ‘*Lecidea*’, the traditional placeholder genus for many crustose lichens with simple ascospores.

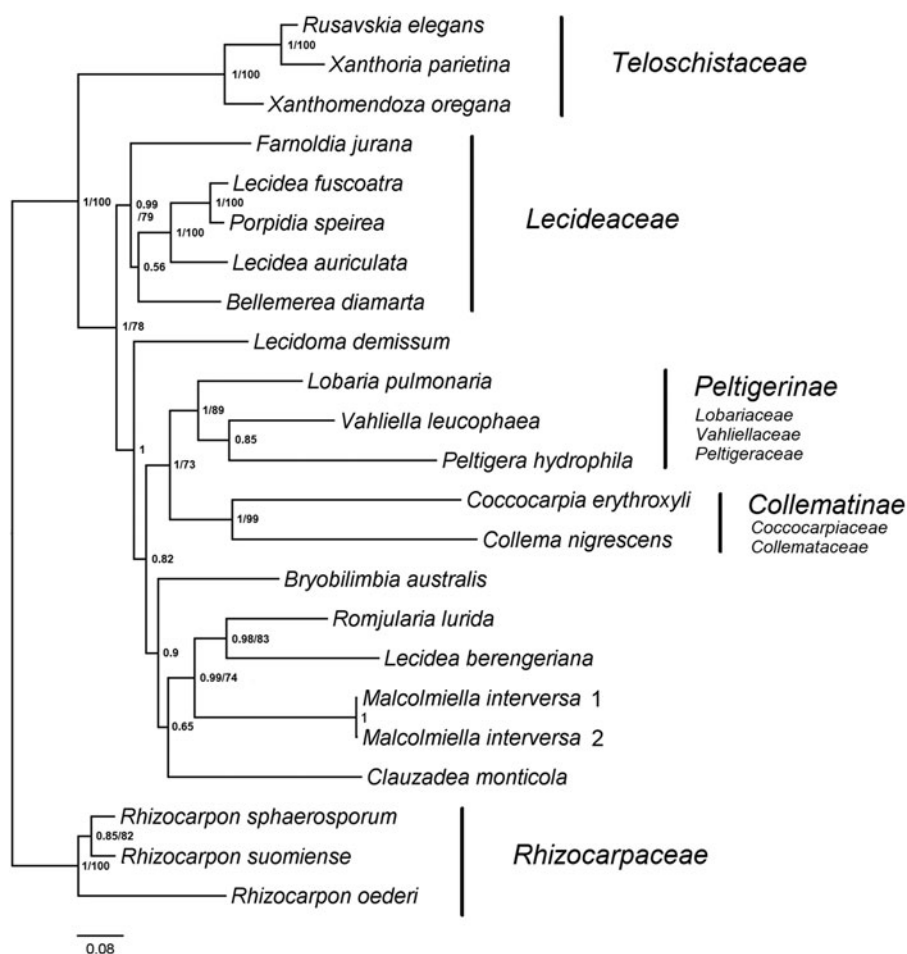


Fig. 2. Majority-rule consensus tree based on a Bayesian MCMC analysis of mrSSU, LSU, ITS, *RPB1* and *RPB2*, showing the phylogenetic position of *Malcolmiella*. Branch support is given as posterior probability (PP)/bootstrap support (BS). Bootstrap support values are from a corresponding maximum likelihood analysis. Only BS values > 70% are shown. GenBank Accession numbers and voucher information are given in Table 2.

Remarks. The combination of the particular ascus type, with its intensely amyloid ring structure within the tholus, the anatomy of the exciple, the mostly simple, non-capitate paraphyses, and the relatively large, simple, non-halonate ascospores with a distinct wall of \pm uniform thickness characterizes this genus and distinguishes it from other genera of *Lecidea* s. lat. It is the ascus in particular that best distinguishes *Australidea* from superficially similar genera with reddish brown, biatorine apothecia and relatively large ascospores, notably *Japewiella* and *Myochroidea*. The ascus is reminiscent of the *Porpidia*-type (Hafellner 1984), which is known only from a complex of genera that are either exclusively saxicolous (e.g. *Porpidia*), terricolous or overgrow epiphytic bryophytes (e.g. *Bryobilimbia*). Many of the species in these genera also have intensely dark-pigmented apothecia and, at times, septate ascospores, and are clearly not closely related to the new genus. A comparison of the salient features of selected superficially similar genera is summarized in Table 3; asci are compared in Fig. 4.

***Australidea canorufescens* (Kremp.) Kantvilas, Wedin & M. Svensson comb. nov.**

MycoBank No.: MB 839489

Lecidea canorufescens Kremp., *Verhandl. Zool.-Bot. Ges. Wien* **26**, 454 (1876); type: New Zealand, *sine loco* [probably Wellington], Charles Knight (M 24801!—lectotype, designated here, MBT10001035; M 24800!, M 24803!—isolectotypes).

Lecidea immarginata R. Br. ex Cromb., *J. Linn. Soc., Bot.* **17**, 400 (1880); type: [Australia, New South Wales] amongst mosses on the bark of trees, bank of Grose River, R. Brown 513 (BM!—lectotype, designated here, MBT10001036; H-NYL 20464!—isolectotype).

Lecidea glandulosa C. Knight, *Trans. N. Z. Inst.* **12**, 376 (1880); type: New Zealand, *sine loco* [probably Wellington], Charles Knight (BM!—lectotype, designated here, MBT10001037; H-NYL, UPS!—isolectotypes).

Lecidea intervertens Nyl., *Lich. Nov. Zel.*, 79 (1888); type: New Zealand, *sine loco* [probably Wellington], 1882, Charles Knight (BM!—lectotype, designated here, MBT10001038; H-NYL, UPS!—isolectotypes) (same specimens as for *L. glandulosa*, above).

Lecidea dacrydii Müll. Arg., *Hedwigia* **32**, 127 (1893); type: New Zealand, *Colenso* b349 (BM!—holotype).

Lecidea eucheila Zahlbr., *Denkschr. Akad. Wiss. Wien Math.-Naturwiss. Kl.* **104**, 309 (1941); type: New Zealand, Otago, Mt Cargill, Dunedin, on bark of *Dacrydium cupressinum*, J. S. Thomson 543 (W—holotype; OTA, CHR!—isotypes).

(Figs 3A & 4A)

Thallus crustose, pale grey, at first smooth and rimose, soon becoming very uneven, scurfy and abraded, at times almost patchily sorediate, 25–100 μ m thick, ecorticate, undelimited although sometimes with a dark grey prothallus at the leading edge; photobiont a unicellular green alga, mostly aggregated in clumps, with individual cells 6–10(–15) μ m diam.

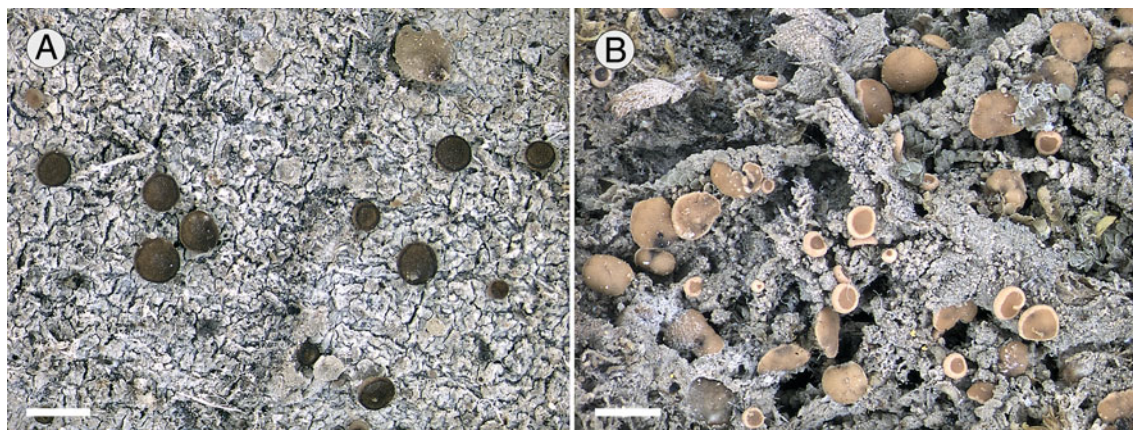


Fig. 3. A, habit of *Australidea canorufescens*. B, habit of *Malcolmiella interspersa*. Scales = 1 mm. In colour online.

Table 3. Comparison of salient features of some superficially similar crustose lichen genera with biatorine apothecia.

	Thallus chemistry	Hypothecium	Excipulum	Paraphyses	Asci	Ascospores
<i>Australidea</i>	nil	hyaline	cupulate, usually persistent but excluded when old, composed of a network of thin hyphae in a gelatinous matrix	mainly simple, non-capitate	tholus with an intensely amyloid ring (approximating the <i>Porpidia</i> -type)	simple, non-halonate
<i>Biatora</i>	nil, \pm depsides, depsidones or xanthonones	hyaline to pale yellow, brown or various shades of bluish	annular, soon reflexed and \pm excluded, composed of radiating, branched hyphae with broad lumina	simple to sparingly branched, not or weakly capitate	<i>Biatora</i> -type: tholus amyloid, penetrated entirely by a conical, weakly amyloid masse axiale with a darker amyloid border	simple or transversely septate, non-halonate
<i>Japewiella</i>	atranorin, xanthonones and depsides (all \pm)	hyaline to pale yellow	cupulate, usually persistent, composed of radiating, branched and anastomosing hyphae in a gelatinous matrix	simple to sparingly branched, sometimes slightly capitate, occasionally with oil vacuoles	<i>Lecidella</i> -type: tholus amyloid, with a \pm barrel-shaped, weakly amyloid masse axiale with a rounded apex	simple, non-halonate
<i>Malcolmiella</i>	nil	hyaline to pale yellow-brown	cupulate, persistent, paraplectenchymatous	simple, capitate	tholus with an intensely amyloid plug with parallel or diverging flanks, pierced by a narrow channel	simple, halonate
<i>Malmidea</i>	atranorin plus other compounds	dark brown	cupulate, persistent, composed of radiating, thick hyphae encrusted with crystals	entangled, branched, non-capitate	lacking internal structures in the tholus	simple, thinly halonate
<i>Myochroidea</i>	fatty acids, lobaric acid, xanthonones (all \pm)	hyaline to pale reddish brown	annular, persistent, composed of a network of gelatinized thin hyphae	sparingly branched and anastomosed, sometimes slightly capitate	approximating the <i>Micareia</i> -type: tholus amyloid, penetrated by a narrow channel with darker staining flanks	simple, non-halonate

Apothecia scattered, biatorine, to 1 mm diam., basally constricted; disc pale brown to reddish brown to brown, frequently a little mottled, rarely flesh-coloured or whitish and \pm translucent when very young or overmature, epruinose, plane when well developed but becoming convex and immarginate when old;

proper exciple concolorous with, paler or darker than the disc, usually persistent and excluded only in the oldest, most convex apothecia, in section cupulate, usually dilutely reddish brown at the outer, upper edge, hyaline within, 50–120 μ m thick laterally, to 125–250 μ m thick at the base, composed of a rather loose

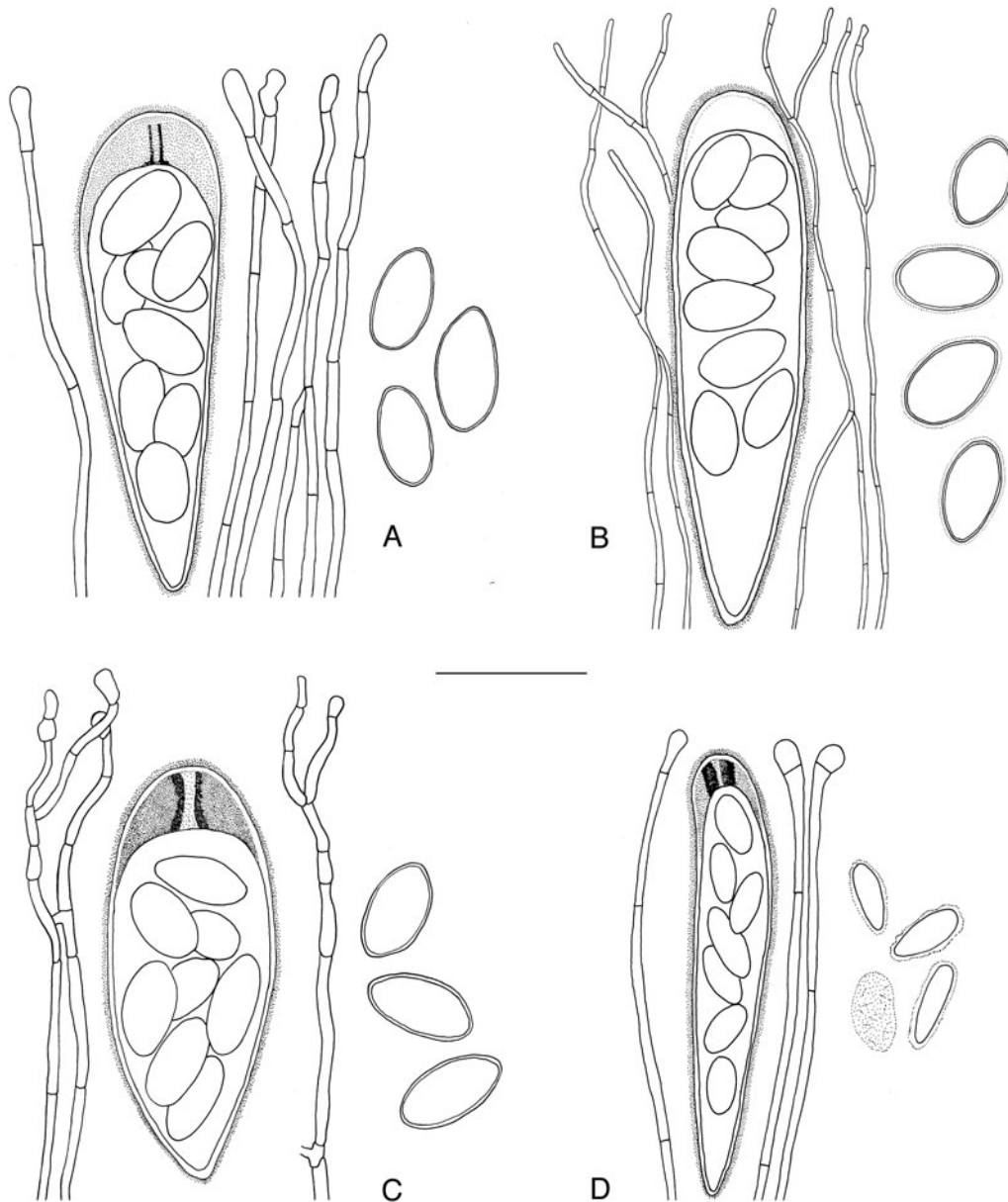


Fig. 4. Comparison of asci (with amyloid parts stippled), paraphyses and ascospores of species of superficially similar corticolous, lecideoid crustose genera. A, *Australidea canorufescens*. B, *Malmidea piperis*. C, *Myochroidea porphyrospoda*. D, *Malcolmiella interversa*. Scale = 20 μm .

reticulum of branched and anastomosing hyphae in a gel matrix; excipular hyphae not interspersed and lacking encrusting crystals, 1–1.5 μm wide where unpigmented, up to 3.5–5 μm wide where pigmented but with the terminal cells not markedly enlarged. *Hypothecium* hyaline, not interspersed, 25–100 μm wide, becoming massive and poorly differentiated from the exciple in old, very convex apothecia. *Hymenium* 60–100 μm thick, not interspersed, intensely KI+ blue, rather coherent in water and K, mostly hyaline but dilutely reddish brown (as in the exciple) in the uppermost part; pigment \pm unchanged or becoming a little duller in K. *Paraphyses* simple or, very occasionally, sparsely branched, 1.5–2.5 μm thick where unpigmented, in the upper part sometimes internally dilutely reddish brown and gradually expanding to 3–5.5 μm wide but not capitate. *Asci* clavate, 8-spored, 50–70 \times 15–22 μm ; tholus prominent in the early stages, becoming compressed as the ascospores develop, amyloid, with a short,

markedly darker-staining ring structure with parallel or diverging flanks; ocular chamber not developed. *Ascospores* hyaline, non-halonate, ovate to ellipsoid, (10–)12–14.5–17(–18) \times (6–)7–8.4–10(–11) μm ($n = 120$); wall not ornamented, uniformly *c.* 1 μm thick.

Pycnidia not found.

Chemistry. Thallus and apothecia containing no substances detectable by TLC.

Remarks. The distinctiveness of this taxon is illustrated to a large extent by the multiple times it has caught the attention of lichenologists in the past and been described. Five synonyms are listed above, but there could well be additional ones amongst the as-yet-uninvestigated names of crustose lichens described from Australasia in the 19th century. However, the synonyms given

by, for example, Galloway (1985, 2007) should be approached with extreme caution since study of the relevant type specimens revealed that several different, albeit superficially similar, species are involved. The Tasmanian record of *Malmidea leptoloma* (Müll. Arg.) Kalb & Lumbsch is also based on old herbarium specimens of *Australidea canorufescens*, dating from a time when the name *Lecidea leptoloma* was widely misapplied to several corticolous lecideoid species; it should be deleted from the Tasmanian census.

The most similar species to *Australidea canorufescens* is what has been described from New Zealand as *Lecidea fuscoincerta* Stirt. (holotype in BM examined). The generic affinities of this lichen are yet to be clarified and must await the collection of fresh material suitable for DNA extraction and amplification. Its brown, biatorine apothecia, scurfy grey thallus, mostly simple paraphyses and ascospores (13–17 × 7–9 µm) are essentially identical to those of *A. canorufescens* but the asci are different, having a well-developed, weakly amyloid tholus that lacks a ring or any other internal differentiation (cf. the *Malmidea*-type; Fig. 4B). Furthermore, its exciple is comprised of densely agglomerated prosoplectenchymatous hyphae. So similar is this taxon to *A. canorufescens* that repeated anatomical observations were required to confirm that these differences were consistent. *Lecidea conisalea* C. Knight (type specimens in BM and H-NYL studied), also described from New Zealand, appears to be the same species as *L. fuscoincerta*.

Although *Malcolmiella interspersa* is based on a specimen which was synonymized with *Australidea canorufescens* (Galloway 1985), these two species are unlikely to be confused, even in the field. Similarly, there are several additional crustose lichens in Australasia with brown, biatorine apothecia, for example *Japewiella pruinosula* (Müll. Arg.) Kantvilas and species of *Bacidia*, but all are readily distinguished by their asci and ascospores (Table 3).

Distribution and ecology. Based on herbarium material, *Australidea canorufescens* occurs in south-eastern Australia, Tasmania and New Zealand. Only in Tasmania has there been an opportunity to study its ecology in greater detail. There it occurs on smooth bark in deep shade in the understorey of wet forests. It appears to be exclusively confined to callidendrous rainforests (terminology after Jarman *et al.* (1994)) where *Atherosperma moschatum* is either the dominant or subdominant canopy species, or to old-growth wet eucalypt forests where it colonizes the bark of *Pomaderris apetala*, an understorey tree typically very richly colonized by cryptogamic epiphytes.

Specimens examined. **Australia: Tasmania:** Wellard Rivulet, 42° 56'S, 147°52'E, 1899, W. A. Weymouth (HO); Guy Fawkes Rivulet, 42°54'S, 147°17'E, 150 m, 1906, W. A. Weymouth 806 (HO); Styx Road, 370 m, 1981, G. Kantvilas 1034/81 (BM, HO); Weldborough, 640 m, 1981, G. Kantvilas 1129/81 (BM, HO); near Lyons River, 340 m, 1982, G. Kantvilas 23/82 (BM, HO); *ibid.*, 280 m, 1982, G. Kantvilas 24/82 (BM, HO); south-eastern slope of MacGregor Peak, 42°59'S, 147°57'E, c. 400 m, 1989, G. Kantvilas 361/89 (HO); Bun Hill, Forestier Peninsula, 42°58'S, 147°56'E, 320 m, 1989, G. Kantvilas 370/89 (HO); Sumac Road, Spur 2, 41°08'S, 145°02'E, 170 m, 1993, G. Kantvilas 310/93 (HO); W of Tahune Bridge, 43°06'S, 146°41'E, 2002, G. Kantvilas 257/02 (HO); Sandspit River, 42°43'S, 147°51'E, 170 m, 2010, G. Kantvilas 106/10 (HO); W of Wielangta Hill, 42° 40'S, 147°50'E, 500 m, 2017, G. Kantvilas 102/17 (HO); W of Tahune Bridge, 43°06'S, 146°41'E, 90 m, 2010, G. Kantvilas

241/10 (HO); Sandspit River, Wielangta Forest Walk, 42°42'S, 147°50'E, 200 m, 2017, G. Kantvilas 328/17 & J. Jarman (HO, UPS); Dip Falls, beside car park, 41°02'S, 145°22'E, 210 m, 2019, G. Kantvilas 100/19 (HO, S); Lyell Hwy, c. 2 km beyond Wayatinah turn-off, 42°22'S, 146°30'E, 400 m, 2020, G. Kantvilas 323/20 (HO). **Victoria:** Tarra Bulga NP, Cyathea Falls, 38°26'47"S, 146°32'19"E, 250 m, 2008, G. Kantvilas 95/08 & J. Elix (HO). **New South Wales:** c. 1 km W of Mt Banda, 31°10'S, 152°25'E, 1050 m, 1988, G. Kantvilas 625/88 (HO, NSW).

***Malcolmiella interspersa* (Nyl.) Kantvilas, Wedin & M. Svensson comb. nov.**

Mycobank No.: MB 839490

Lecidea interspersa Nyl., *Lich. Nov. Zel.*, 79 (1888); type: New Zealand, *sine loco* [probably Wellington], 1867, Charles Knight 87a (H-NYL 20457!), lectotype, selected by Galloway (1985) [ICN Art. 9.10)].

Malcolmiella cinereovirens Vězda, A. Vězda: *Lich. Rar. Exs.*, 265 (1997); type: Nova Zelandia [New Zealand], South Island, Nelson, Hackett River, ad confluentem rivulorum Hackett et Miner, 170 m alt., corticola, 25 March 1996, W. Malcolm 2757 (CHR—holotype; HO!, UPS L-89238!—isotypes).

Malcolmiella cinereovirens var. *isidiata* Vězda, A. Vězda: *Lich. Rar. Exs.*, 266 (1997); type: Australia, ACT, Blundells Creek Road, 30 km ad occidentem Canberra, 800 m alt., secus rivulum in pluvisilva, ad corticem arborum, 5 September 1995, K. & A. Kalb (HO!, UPS L-89239!—isotypes).

(Figs 3B & 4D)

Thallus crustose, pale grey to grey-green, to c. 0.3 mm thick, very scurfy, granular to ±tomentose, undelimited but sometimes with a pale grey, ±byssoid leading edge, ecorticate, sometimes beset with minute, globular, isidioid structures 30–100 µm diam. **Photobiont** a unicellular green alga with globose to subglobose cells, 7–12 × 5–12 µm, occurring in clusters 16–40 µm wide of up to c. 10 cells wrapped in a gelatinous sheath.

Apothecia biatorine, scattered, basally constricted, generally neatly discoid, 0.25–1 mm wide; disc mostly plane and becoming slightly convex only in the oldest apothecia, pinkish orange, orange to orange-brown, epruinose; proper exciple thin, smooth, pale cream or pale brownish and mostly persistent and becoming inconspicuous only in the most convex apothecia, in section cupulate, hyaline or pale brownish at the edges, 30–60 µm thick, paraplectenchymatous, composed of roundish to irregularly rhomboid cells 6–15 × 3.5–10 µm. **Hypothecium** pale yellow-brown or hyaline, 60–80 µm thick. **Hymenium** 55–70 µm, hyaline entirely, or pale orange-brown in the uppermost part, not interspersed, lax in water and KOH. **Paraphyses** mostly simple, 1.5–2 µm wide, sparsely septate, with apices distinctly capitate, unpigmented, to 3–5 µm wide. **Asci** 53–65 × 8–11 µm, 8-spored; tholus amyloid, distinctly thickened at least when young, later becoming compressed by developing ascospores, with an intensely amyloid 'plug' with parallel or diverging flanks, pierced by a narrow, weakly amyloid channel; ocular chamber not developed. **Ascospores** ellipsoid, occasionally with slightly attenuated apices, hyaline, halonate, simple but occasionally with the contents divided and appearing pseudoseptate, (9–)10–12.6–15(–16) × (4–)5–5.4–6.5(–7) µm ($n = 60$); halo c. 1 µm wide, uneven and appearing ornamented.

Pycnidia immersed, very rare (located only by chance); conidia filiform, curved or sigmoid, 16–20 × 1 µm.

Chemistry. Thallus and apothecia containing no substances detectable by TLC.

Remarks. The genus *Malcolmiella* contains a single species and is easily recognized by the combination of biatorine apothecia, distinctive asci (Fig. 4D) and the halonate, ornamented, simple ascospores. The structure of the asci is not inconsistent with that seen in representatives of the genera grouped with *Malcolmiella* in our phylogeny. With its orange apothecia and corticolous habit, *M. interversa* is perhaps most similar to species of *Coenogonium*, but that genus differs by containing *Trentepohlia* as the photobiont and by having *Gyalecta*-type asci with 1-septate ascospores. In contrast, the genera to which *Malcolmiella* is related (see below) generally have dark-coloured apothecia, occasionally septate ascospores, and occur principally on soil, rock or bryophytes.

Our analysis clearly indicates that *Malcolmiella* belongs to a group of genera usually assigned to *Lecideaceae* (e.g. Fryday & Hertel 2014; Fryday *et al.* 2014; Wijayawardene *et al.* 2018). However, in earlier phylogenies spanning a broad range of the *Lecanoromycetes*, the affinities of this group remain unresolved. In these analyses, representatives of this group (*Lecidea berengeriana* and *Romjularia lurida*) have ended up on unsupported sister branches to the *Collematinae* and *Peltigerinae* (Schmull *et al.* 2011; Miadlikowska *et al.* 2014), or on a likewise unsupported sister branch to the *Teloschistales* (*Bryobilimbia* spp. and *Lecidoma demissum*; Schmull *et al.* 2011). The phylogenetic placement of this group in *Lecanoromycetidae* is unresolved in our analysis but the results indicate that it is not close to the *Lecideaceae* (Fig. 2).


Two specimens of *Lecidea interversa*, Charles Knight 87a and 88, are housed in the Nylander Herbarium in H, with the former lectotypified by Galloway (1985). Galloway (loc. cit.) synonymized it and several other names with *Lecidea canorufescens*, but that species and at least some of its synonyms belong in *Australidea*.

Vězda (1997) described two varieties of *Malcolmiella cinereo-virens*, his var. *isidiata* being distinguished by the presence of minute, globose, isidia-like structures scattered on the upper surface. Incipient development of such structures is evident in at least parts of all the specimens examined and they are deemed to have no taxonomic significance. Their anatomy is rather curious. Superficially they resemble apothecial initials but they are very easily detached and contain no apothecial tissue. In section, they are seen to be packages of photobiont and mycobiont cells, wrapped in a fungal sheath c. 5 µm thick from which protrude tapered hyphal spines, 5–6 µm at the base and up to 20 µm long. These presumably anchor the 'isidia' to the upper surface of the thallus.

Distribution and ecology. In the original description of *Malcolmiella*, Vězda (1997) states that it occurs on bark, leaves and rock, and records it from South Island, New Zealand, and the ACT, mainland Australia. *Malcolmiella* is reported here from Tasmania for the first time. It has been collected in *Nothofagus cunninghamii*-dominated cool temperate rainforest and in moist *Melaleuca ericifolia* swamp woodland, in both cases as an epiphyte in deep shade where few other lichens were present. It appears to be genuinely rare.

Specimens examined. **New Zealand:** South Island: Nelson, Brook Waterfalls, 160 m alt., 1997, W. Malcolm & A. Vězda (A. Vězda: *Lich. Rar. Exs.*, 302) (HO).—**Australia:** Tasmania: Denium Hill, at end of Robbins Island Track, 40°45'S, 144°53'E, 5 m alt., 1993, G. Kantvilas 154/93 & J. A. Elix (HO); Sumac Road, Spur 2, south of Arthur River, 41°08'S, 145°02'E, 170 m alt., 1993, G. Kantvilas 312/93 (HO, PRA).

Acknowledgements. For skilful laboratory work, we thank the staff at the Department of Bioinformatics and Genetics at the Swedish Museum of Natural History, in particular Bodil Cronholm. Funding was gratefully received from the Swedish Research Council (VR), grant 2016-03589 to MW. Research by MS on the taxonomy of lecideoid lichens is financially supported by the Swedish Taxonomy Initiative (grant no. 2016-206 4.3). For their hospitality and provision of working space, GK acknowledges with thanks the herbarium staff of the Swedish Museum of Natural History (during a visit in 2017) and the Finnish Museum of Natural History (2016, 2018). We thank Jean Jarman for the photographs and preparing the line drawings for publication.

Author ORCIDs.  Gintaras Kantvilas, 0000-0002-3788-4562; Mats Wedin, 0000-0002-8295-5198.

References

- Andersen HL and Ekman S (2005) Disintegration of the *Micareaeae* (lichenized *Ascomycota*): a molecular phylogeny based on mitochondrial rDNA sequences. *Mycological Research* **109**, 21–30.
- Aptroot A, Saipunkaew W, Sipman HJM, Sparrius LB and Wolseley PA (2007) New lichens from Thailand, mainly microlichens from Chiang Mai. *Fungal Diversity* **24**, 75–134.
- Breuss O and Lücking R (2015) Three new lichen species from Nicaragua, with keys to the known species of *Eugeniella* and *Malmidea*. *Lichenologist* **47**, 9–20.
- Cáceres ME (2007) The corticolous crustose and microfoliose lichens of northeastern Brazil. *Libri Botanici* **22**, 1–168.
- Cáceres MES, Aptroot A, Mendonça CO, Santos LA and Lücking R (2017) *Sprucidea*, a further new genus of rain forest lichens in the family *Malmideaceae* (*Ascomycota*). *Bryologist* **120**, 202–211.
- Crombie JM (1880) Enumeration of Australian lichens in Herb. Robert Brown (Brit. Mus.), with descriptions of new species. *Journal of the Linnean Society, Botany* **17**, 390–401.
- Döring H, Grube M, Clerc P and Wedin M (2000) Mycobiont-specific PCR primers for the nuclear ITS and LSU rDNA from lichenized ascomycetes. *Lichenologist* **32**, 200–204.
- Ekman S, Andersen HL and Wedin M (2008) The limitations of ancestral state reconstruction and the evolution of the ascus in the *Lecanorales*. *Systematic Biology* **57**, 141–156.
- Ertz D, Fischer E, Killmann D, Razafindrahaja T and Sérusiaux E (2013) *Savoronala*, a new genus of *Malmideaceae* (*Lecanorales*) from Madagascar with stipes producing sporodochia. *Mycological Progress* **12**, 645–656.
- Flakus A, Etayo J, Pérez-Ortega S, Kukwa M, Palice Z and Rodríguez Flakus P (2019) A new genus, *Zhurbenkoa*, and a novel nutritional mode revealed in the family *Malmideaceae* (*Lecanoromycetes*, *Ascomycota*). *Mycologia* **111**, 593–611.
- Fryday AM and Hertel H (2014) A contribution to the family *Lecideaceae* s. lat. (*Lecanoromycetidae* inc. sed., lichenized *Ascomycota*) in the southern subpolar region; including eight new species and some revised generic circumscriptions. *Lichenologist* **46**, 389–412.
- Fryday AM, Printzen C and Ekman S (2014) *Bryobilimbia*, a new generic name for *Lecidea hypnorum* and closely related species. *Lichenologist* **46**, 25–37.
- Galloway DJ (1985) *Flora of New Zealand Lichens*. Wellington: Government Printer.
- Galloway DJ (2007) *Flora of New Zealand Lichens. Revised Second Edition. Volume 1*. Lincoln, New Zealand: Manaaki Whenua Press.
- Gaya E, Högnabba F, Holguin A, Molnar K, Fernández-Brime S, Stenroos S, Arup U, Söchting U, van den Boom P, Lücking R, *et al.* (2012) Implementing a cumulative supermatrix approach for a comprehensive phylogenetic study of the *Teloschistales* (*Pezizomycotina*, *Ascomycota*). *Molecular Phylogenetics and Evolution* **63**, 374–387.

- Guzov-Krzemińska B, Flakus A, Kosecka M, Jabłońska A, Rodriguez-Flakus P and Kukwa M (2019) New species and records of lichens from Bolivia. *Phytotaxa* **397**, 257–279.
- Hafellner J (1984) Studien in Richtung einer natürlicheren Gliederung der Sammelfamilien *Lecanoraceae* und *Lecideaceae*. *Beiheft zur Nova Hedwigia* **79**, 241–371.
- Hertel H (1984) Über saxicole, lecideide Flechten der Subantarktis. *Beiheft zur Nova Hedwigia* **79**, 399–500.
- Hertel H and Rambold G (1987) *Mirioidica* genus novum Lecanoracearum (*Ascomycetes* lichenisati). *Mitteilungen der Botanischen Staatssammlung München* **23**, 377–392.
- Hertel H and Rambold G (1990) Zur Kenntnis der Flechtenfamilie *Rimulariaceae* (*Lecanorales*). *Bibliotheca Lichenologica* **38**, 145–189.
- Hoang DT, Chernomor O, von Haeseler A, Minh BQ and Vinh LS (2018) UFBoot2: improving the ultrafast bootstrap approximation. *Molecular Biology and Evolution* **35**, 518–522.
- Ihlen P and Ekman S (2002) Outline of phylogeny and character evolution in *Rhizocarpon* (*Rhizocarpaceae*, lichenized *Ascomycota*) based on nuclear ITS and mitochondrial rDNA sequences. *Biological Journal of the Linnean Society* **77**, 535–546.
- Jarman SJ, Kantvilas G and Brown MJ (1994) Phytosociological studies in Tasmanian cool temperate rainforest. *Phytocoenologia* **22**, 355–390.
- Kalb K (2004) New or otherwise interesting lichens II. *Bibliotheca Lichenologica* **88**, 301–329.
- Kalb K, Buaruang K, Papong K and Boonpragob K (2009) New or otherwise interesting lichens from the tropics, including the lichen genus *Ramboldia* in Thailand. *Mycotaxon* **110**, 109–123.
- Kalb K, Rivas Plata E, Lücking R and Lumbsch HT (2011) The phylogenetic position of *Malmidea*, a new genus for the *Lecidea piperis*- and *Lecanora granifera*-groups (*Lecanorales*, *Malmideaceae*), inferred from nuclear and mitochondrial ribosomal DNA sequences, with special reference to Thai species. *Bibliotheca Lichenologica* **106**, 143–168.
- Kalyaanamoorthy S, Minh BQ, Wong TKF, von Haeseler A and Jermini LS (2017) ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* **14**, 587–589.
- Kantvilas G and Elix JA (1994) *Ramboldia*, a new genus in the lichen family *Lecanoraceae*. *Bryologist* **97**, 296–304.
- Kantvilas G and James PW (1991) Records of crustose lichens from Tasmanian rainforest. *Mycotaxon* **41**, 271–286.
- Katoh K, Rozewicki J and Yamada KD (2019) MAFFT online service: multiple sequence alignment, interactive sequence choice and visualization. *Briefings in Bioinformatics* **20**, 1160–1166.
- Kistenich S, Tindal E, Bendiksby M and Ekman S (2019) Molecular systematics and character evolution in the lichen family *Ramalinaceae* (*Ascomycota*: *Lecanorales*). *Taxon* **67**, 871–904.
- Lanfear R, Calcott B, Ho SY and Guindon S (2012) PartitionFinder: combined selection of partitioning schemes and substitution models for phylogenetic analyses. *Molecular Biology and Evolution* **29**, 1695–1701.
- Lanfear R, Frandsen PB, Wright AM, Senfeld T and Calcott B (2017) PartitionFinder 2: new methods for selecting partitioned models of evolution for molecular and morphological phylogenetic analyses. *Molecular Biology and Evolution* **34**, 772–773.
- Lücking R (2008) Foliicolous lichenized fungi. *Flora Neotropica Monograph* **103**, 1–866.
- Lücking R and Kalb K (2000) Foliikole Flechten aus Brasilien (vornehmlich Amazonien), inklusive einer Checkliste und Bemerkungen zu *Coenogonium* und *Dimerella* (*Gyalectaceae*). *Botanische Jahrbücher für Systematik, Pflanzengesichte und Pflanzengeographie* **122**, 1–61.
- McCarthy PM (2020) *Checklist of the Lichens of Australia and its Island Territories*. Australian Biological Resources Study, Canberra. Version 1 March 2020. [WWW resource] URL <http://www.anbg.gov.au/abrs/lichen-list/introduction.html>.
- Miadlikowska J, Kauff F, Hofstetter V, Fraker E, Grube M, Hafellner J, Reeb V, Hodkinson BP, Kukwa M, Lücking R, *et al.* (2006) New insights into classification and evolution of the *Lecanoromycetes* (*Pezizomycotina*, *Ascomycota*) from phylogenetic analyses of three ribosomal RNA- and two protein-coding genes. *Mycologia* **98**, 1088–1103.
- Miadlikowska J, Kauff F, Högnabba F, Oliver JC, Molnár K, Fraker E, Gaya E, Hafellner J, Hofstetter V, Gueidan C, *et al.* (2014) A multigene phylogenetic synthesis for the class *Lecanoromycetes* (*Ascomycota*): 1307 fungi representing 1139 infrageneric taxa, 317 genera and 66 families. *Molecular Phylogenetics and Evolution* **79**, 132–168.
- Mirarab S, Nguyen N, Guo S, Wang L-S, Kim J and Warnow T (2015) PASTA: ultra-large multiple sequence alignment for nucleotide and amino-acid sequences. *Journal of Computational Biology* **22**, 377–386.
- Muggia L, Mancinelli R, Tønsberg T, Jablonska A, Kukwa M and Palice Z (2017) Molecular analyses uncover the phylogenetic placement of the lichenized hyphomycetous genus *Cheiromycina*. *Mycologia* **109**, 588–600.
- Nguyen L-T, Schmidt HA, von Haeseler A and Minh BQ (2015) IQ-TREE: a fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. *Molecular Biology and Evolution* **32**, 268–274.
- Orange A, James PW and White FJ (2010) *Microchemical Methods for the Identification of Lichens*, 2nd Edn. London: British Lichen Society.
- Printzen C (1995) Die Flechtengattung *Biatora* in Europa. *Bibliotheca Lichenologica* **60**, 1–275.
- Printzen C (1999) *Japewiella* gen. nov., a new lichen genus and a new species from Mexico. *Bryologist* **102**, 714–719.
- Printzen C and Kantvilas G (2004) *Hertelidea*, genus novum Stereocaulacearum (*Ascomycetes* lichenisati). *Bibliotheca Lichenologica* **88**, 539–553.
- Printzen C, Spribille T and Tønsberg T (2008) *Myochroidea*, a new genus of corticolous, crustose lichens to accommodate the *Lecidea leprosula* group. *Lichenologist* **40**, 195–207.
- Rodriguez Flakus P (2020) Non-saxicolous lecideoid lichens in southern South America. *Phytotaxa* **476**, 1–73.
- Rodriguez Flakus P and Printzen C (2014) *Palicella*, a new genus of lichenized fungi and its phylogenetic position in *Lecanoraceae*. *Lichenologist* **46**, 535–552.
- Ronquist F, Teslenko M, Mark P, Ayres DL, Höhna S, Larget B, Liu L and Huelsenbeck J (2012) MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* **61**, 539–542.
- Ruprecht U, Lumbsch HT, Brunauer G, Green TGA and Türk R (2010) Diversity of *Lecidea* (*Lecideaceae*, *Ascomycota*) revealed by molecular data and morphological characters. *Antarctic Science* **22**, 727–741.
- Schmull M, Miadlikowska J, Pelzer M, Stocker-Wörgötter E, Hofstetter V, Fraker E, Hodkinson BP, Reeb V, Kukwa M, Lumbsch HT, *et al.* (2011) Phylogenetic affiliations of members of the heterogeneous lichen-forming fungi of the genus *Lecidea sensu* Zahlbruckner (*Lecanoromycetes*, *Ascomycota*). *Mycologia* **103**, 983–1003.
- Schneider K, Resl P, Westberg M and Spribille T (2015) A new, highly effective primer pair to exclude algae when amplifying nuclear large ribosomal subunit (LSU) DNA from lichens. *Lichenologist* **47**, 269–275.
- Sodamuk M, Boonpragob K, Mongkolsuk P, Tehler A, Leavitt SD and Lumbsch HT (2017) *Kalbionora palaeotropica*, a new genus and species from coastal forests in Southeast Asia and Australia (*Malmideaceae*, *Ascomycota*). *MycKeys* **22**, 15–25.
- Spribille T, Fryday AM, Pérez-Ortega S, Svensson M, Tønsberg T, Ekman S, Holien H, Resl P, Schneider K, Stabentheiner E, *et al.* (2020) Lichens and associated fungi from Glacier Bay National Park, Alaska. *Lichenologist* **52**, 61–181.
- Stenroos S, Huhtinen S, Lesonen A, Palice Z and Printzen C (2009) *Puttea*, gen. nov., erected for the enigmatic lichen *Lecidea margaritella*. *Bryologist* **112**, 544–557.
- Tindal E (1984) The genus *Hypocenomyce* (*Lecanorales*, *Lecideaceae*), with special emphasis on Norwegian and Swedish species. *Nordic Journal of Botany* **4**, 83–108.
- Vězda A (1997) *Lichenes Rariores Exsiccati*. Fasc. 27 (nos 261–270). Brno: Privately published.
- Vilgalys R and Hester M (1990) Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. *Journal of Bacteriology* **172**, 4238–4246.
- Wedin M, Wiklund E, Crewe A, Döring H, Ekman S, Nyberg A, Schmitt I and Lumbsch HT (2005) Phylogenetic relationships among *Lecanoromycetes*

- (Ascomycota) as revealed by analyses of mtSSU and nLSU rDNA sequence data. *Mycological Research* **109**, 159–172.
- Wedin M, Wiklund E, Jørgensen PM and Ekman S** (2009) Slippery when wet: phylogeny and character evolution in the gelatinous cyanobacterial lichens (*Peltigerales*, *Ascomycetes*). *Molecular Phylogenetics and Evolution* **53**, 862–871.
- Wedin M, Jørgensen PM and Ekman S** (2011) *Vahliellaceae*, a new family of cyanobacterial lichens (*Peltigerales*, *Ascomycetes*). *Lichenologist* **43**, 67–72.
- Widhelm TJ, Bertolotti FR, Asztalos MJ, Mercado-Díaz JA, Huang J-P, Moncada B, Lücking R, Magain N, Sérusiaux E, Goffinet B, et al.** (2018) Oligocene origin and drivers of diversification in the genus *Sticta* (*Lobariaceae*, *Ascomycota*). *Molecular Phylogenetics and Evolution* **126**, 58–73.
- Wijayawardene NN, Hyde KD, Lumbsch HT, Liu JK, Maharachchikumbura SSN, Ekanayaka AH, Tian Q and Phookamsak R** (2018) Outline of *Ascomycota*: 2017. *Fungal Diversity* **88**, 167–263.
- Wiklund E and Wedin M** (2003) The phylogenetic relationships of the cyanobacterial lichens in the *Lecanorales* suborder *Peltigerineae*. *Cladistics* **19**, 419–431.
- Zoller S, Scheidegger C and Sperisen C** (1999) PCR primers for the amplification of mitochondrial small subunit ribosomal DNA of lichen-forming ascomycetes. *Lichenologist* **31**, 511–516.