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The lichen genus *Psoromidium* (*Pannariaceae*) re-evaluated, with nomenclatural notes on *Degeliella* and *Psoromaria*

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Abstract: Molecular studies have shown that *Psoromidium* is well separated from *Psoromaria* and *Degeliella*, when including the type species only. The latter generic name is illegitimate and the correct name for the other species sometimes included in *Psoromidium* is shown to be *Psoromaria versicolor* (Müll. Arg.) P. M. Jørg. & H. L. Andersen, comb. nov. It is the type species of the genus *Psoromaria* Nyl. ex Hue. The inclusion of *Degeliella rosulata* in *Psoromaria* is unresolved, according to the molecular evidence. However, its characters (except the photobiont) match those of *Psoromaria*, rather than those of the other species with which it groups. So for nomenclature reasons it is transferred to this genus, as *Psoromaria rosulata* (P. M. Jørg. & D. J. Galloway) P. M. Jørg. & H. L. Andersen comb. nov.

Key words: austral biogeography, molecular phylogeny, nomenclature

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Introduction

In the recent revised generic classification of the *Pannariaceae*, Ekman *et al.* (2014) provisionally accepted the genus *Psoromidium*, but noted that further studies were necessary. Since then we have managed to acquire fresh material, making it possible to investigate the position of the type species using molecular studies, which has not yet been done in any other such studies (e.g. Spribille & Muggia 2013). Morphological and anatomical characters alone are not distinct enough to secure a clear perspective on the taxonomy of this genus and other *Psoroma*-like taxa that lack a thalline apothecial margin. Several names have been proposed and the treatments of these taxa have varied considerably through the years. For example, Müller (1894) treated them in *Phyllopsora*, a view also held by Zahlbruckner (1905) who placed them in the *Phyllopsoraceae* and subsequently in the *Lecideaceae* (Zahlbruckner 1926). Dodge (1971) redescribed the type species of *Psoromidium* as *Coccocarpia fineranii* (Arvidsson 1983). More recently, Galloway & James (1985) treated *Psoromidium*, a genus originally described with only one species by Stirton (1877), in detail, accepting two species: *P. aleuroides* (Stirt.) D. J. Galloway & P. James and *P. versicolor* (Hook. f. & Taylor) D. J. Galloway & P. James, the former being the type species. Jørgensen (2004), however, regarded these as belonging in two different genera and transferred the latter to the new genus *Degeliella*. *Psoromidium versicolor* had originally been included in the genus *Psoromaria* Nyl. ex Hue under its synonym *P. subdescendens* (Nyl.) Hue, the species which Clements & Shear (1931) chose as the lectotype of that genus.

In this paper we intend, as far as possible, to resolve these taxonomic and nomenclatural problems.

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Material and Methods

Fresh material of *Psoromidium aleuroides* was kindly submitted to us by G. Kantvilas, collected from Tasmania [Mt. Young, 7 June 2008, *G. Kantvilas* 219/08 (HO)].

Herbarium material relating to the mentioned species was studied by standard microscopic and TLC methods (Jørgensen 1978). The chemically and microscopically studied material is found in the following herbaria: BG, BM, G, H, HO, S, UPS, and listed in Ekman *et al.* (2014).

Total DNA was extracted using DNeasy Plant Mini Kit (Qiagen). The mrSSU region of the mtDNA was amplified using the primers mrSSU1 and mrSSU3R (Zoller *et al.* 1999). The PCR reactions were performed with 1× GeneAmp® 10× PCR Buffer II (Applied Biosystems), 2·5 µM $MgCl_2$ (Applied Biosystems), 20 µM dNTPs (Promega), 0·7 µM of each primer, 1·5 U AmpliTaq® DNA Polymerase (Applied Biosystems), 5·0 µl of genomic DNA extract and distilled water to a total volume of 50 µl. Thermal cycling parameters were: initial denaturation for 4 min at 94 °C, followed by 40 cycle reactions (denaturation at 94 °C for 1 min, annealing with a 56–50 °C touchdown procedure decreasing 1° per cycle for 30 s each, polymerization at 72 °C in 1 min 45 s), and a final elongation for 10 min at 72 °C.

PCR product was cleaned according to the manufacturer's instructions using Exo-Sap-IT (GE Healthcare). Direct sequencing of PCR product was done in both directions. Sequencing reactions were carried out using BigDye Terminator Cycle Sequencing kit (Applied biosystems), and run on an ABI Prism 3700 DNA analyzer (Applied Biosystems) at the DNA Sequencing Laboratory at the University of Bergen, Norway.

The mrSSU sequence of *Psoromidium aleuroides* was edited, assembled and aligned using Geneious® version 8.0.4 (http://www.geneious.com, Kearse *et al.* 2012), together with 36 mrSSU sequences downloaded from GenBank (Table 1), based on the study of Ekman *et al.* (2014). One sequence from each species of Clade 1 in Ekman *et al.* (2014) was included, and sequences of the type species were included from Clade 2. As in Ekman *et al.* (2014), *Vahliella leucophaea* was chosen as outgroup. Ambiguously aligned sites were removed from the alignment manually.

TABLE 1. *List of sequences downloaded from GenBank for use in this study. The new species names are based on Ekman* et al. *(2014) and this study.*

Previous names used in GenBank	New species names	GenBank Acc. No.
Austrella arachnoidea		KC608054
Degelia atlantica	*Pectenia atlantica*	KC608055
D. cyanoloma	*Pectenia cyanoloma*	AY340491
D. duplomarginata		KC608058
D. durietzii		KC608059
D. gayana		AY652619
D. plumbea	*Pectenia plumbea*	KC608060
Degeliella rosulata	*Psoromaria rosulata*	KC608063
D. versicolor	*Psoromaria versicolor*	KC608064
Erioderma pedicellatum		KC608065
E. verruculosum		DQ972990
Fuscoderma applanatum		KC608066
Fuscopannaria leucosticta		DQ900630
F. sampaiana	*Nevesia sampaiana*	KC608076
Joergensenia cephalodina		EU885329
Leciophysma finmarkicum		GQ259027
Leioderma erythrocarpum		KC608078
L. pycnophorum		GQ259031
Pannaria rubiginosa		AY340513
Parmeliella appalachensis		KC608090
P. incrassata	*Nebularia incrassata*	KC608091
P. lacerata	*Austroparmeliella lacerata*	KC608092
P. miradorensis		KC608094
P. nigrocincta		KC608095
P. pannosa		KC608096
P. stylophora	*Lepidocollema stylophora*	KC608097
P. triptophylla		KC608098
Physma byrsaeum		GQ259039
Protopannaria pezizoides		AY340519
Psoroma hypnorum		KC608100
Psorophorus pholidotus		EU885336
Ramalodium succulentum		GQ259043
Siphulastrum squamosum		KC608107
Staurolemma omphalarioides		GQ259044
Vahliella leucophaea		AY652621
Xanthopsoroma contextum		EU885335

MrModeltest 2.3 (Nylander 2004) was used to find the most appropriate substitution model for the Bayesian phylogenetic analysis that was performed with MrBayes v3.2.1 (Ronquist *et al.* 2012). The analysis was performed with the GTR+I+G model. Two parallel MCMC runs were performed, each with four parallel chains, three heated and one 'cold', with the temperature set to 0·10 °C. The analysis was run until the average standard deviation of split frequencies was below 0·01, as a measure of convergence, resulting in 1 100 000 generations, and sampling every 200th generation. Relative burn-in was set to 25%. The resulting majority-rule consensus tree with posterior probabilities was made using FigTree v1.4 (Rambaut 2006).

Results

The mrSSU sequence of *Psoromidium aleuroides* is deposited in GenBank with accession number KP279291. The resulting alignment contained 37 sequences and 700 bps, whereas 410 were constant.

The resulting majority-rule consensus tree from Bayesian inference (Fig.1) with strong support includes *P. aleuroides* in Clade 1 using the numeration from Ekman *et al.* (2014).This tree shows that *Psoromidium* is a separate genus when regarded as unispecific, but the support for this branch is low, suggesting that the internal position of *Psoromidium* within Clade 1 is uncertain. The other species that sometimes has been included in this genus, *Degeliella versicolor (Psoromaria versicolor*), appears in a complex, unresolved group containing *Degeliella rosulata*, the type of the genus *Degeliella.*

Discussion and Conclusions

The status and circumscription of *Psoromidium* has been discussed in detail by Galloway & James (1985) and needs no further comment, except that we restricted it to the type species (*Psoromidium aleuroides*). A full description of the type species (Fig. 2A) can be found in Galloway & James (*op. cit.*).

Psoromidium is easily separated from *Psoromaria* on the basis of the amyloid hymenial reaction and the asci with an amyloid apical ring-structure. *Psoromidium aleuroides* is also a more distinctly squamulose species (Fig. 2A), whereas the species of *Psoromaria* (including *Degeliella*) are closely adpressed, subcrustose rosettes (Fig. 2B & C). *Psoromidium* is a species centred around the region of the Tasman Sea, whereas *Psoromaria* has a wider, more subantarctic distribution (Fig. 3), perhaps suggesting a different evolutionary history. The situation concerning *Degeliella* is less clear and quite complex, and is discussed below.

Though there is no molecular evidence for the acceptance of *Psoromaria*, we are, however, sure that the generic name *Psoromaria* needs to be reintroduced for nomenclatural reasons, for *Psoromaria versicolor* (Fig. 2B, described in detail by Galloway & James 1985), and *P. rosulata*. When Jørgensen (2004) described the genus *Degeliella* with the blue-green *D. rosulata* (Fig. 2C) as the type species, he also included *Psoromaria versicolor* within it, unaware that Clements & Shear (1931) had selected this species under its synonym *P. subdescendens* (Nyl.) Hue as the lectotype of that genus. It follows that *Degeliella* is a superfluous, illegitimate name for *Psoromaria*, a genus which Nylander (1888) only suggested by pointing out that two species in *Psoroma* differed so much from the others that they perhaps were better placed in a genus of their own, and for which he proposed the name *Psoromaria*. The first formally correct description and acceptance of the genus was published by Hue (1891). It was lectotypified by Clements & Shear (1931) by *Psoromaria subdescendens*, but when Galloway & James (1985) revised *Psoromidium* (to which they referred this species) they found an older name (Hooker & Taylor 1844) for it, *Lecanora versicolor* Hook. f. & Taylor, which they transferred to *Psoromidium*. However, they had overlooked that this older name was illegitimate since it is a younger homonym of the completely different *Lecanora versicolor* (Pers.) Ach. (Acharius 1814). Müller (1888) nevertheless took up this epithet in a new position, basing it on Hooker's material, when describing *Psoroma versicolor*, which is a legitimate name; Nylander's name *Psoroma subdescendens* had just been published a few months previously, and this would therefore be the correct one to apply to the species. Müller's name, however, has been conserved over Nylander's after a

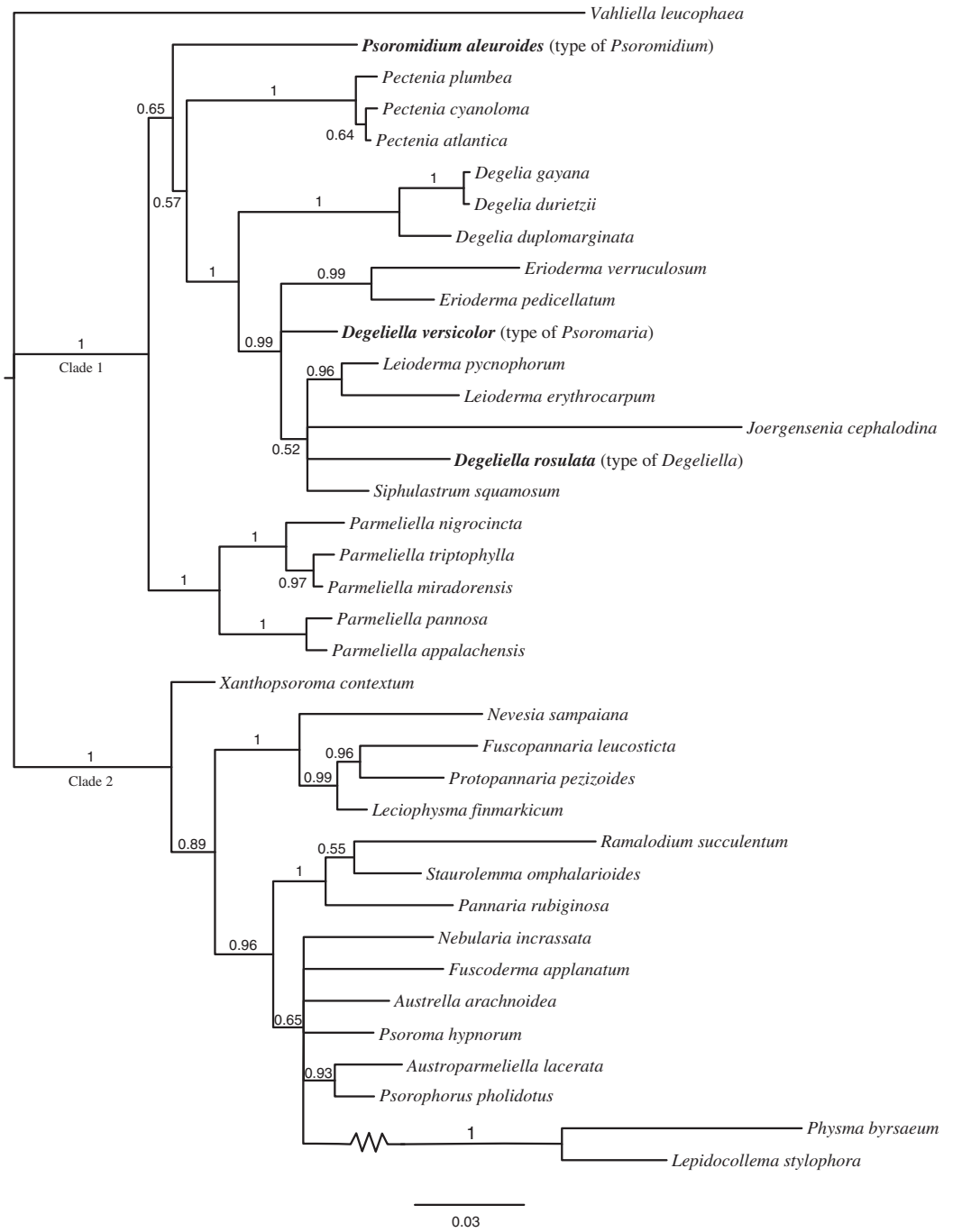

FIG. 1. Majority-rule consensus tree from the Bayesian MCMC analysis, with all compatible groups and branch lengths. Branches values are posterior probabilities. *Psoromidium aleuroides*, *Degeliella versicolor* and *Degeliella rosulata* are given in bold, and *Vahliella leucophaea* is outgroup. The annotation of Clades 1 and 2 is taken from Ekman *et al.* (2014).

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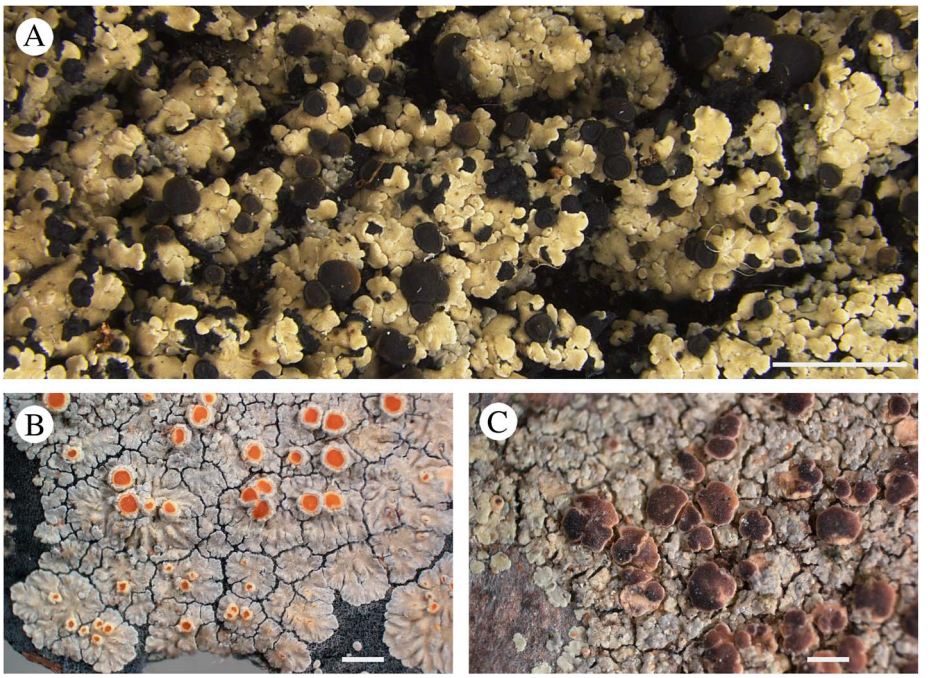

FIG. 2. A, *Psoromidium aleuroides* from Tasmania: a distinctly squamulose species. Photograph: Katrine Kongshavn. B, *Psoromaria rosulata*; C, *Psoromaria versicolor* from the type specimens. These species have closely adpressed, subcrustose rosettes. Photographs: Jan Berge. Scales = 5mm. In colour online.

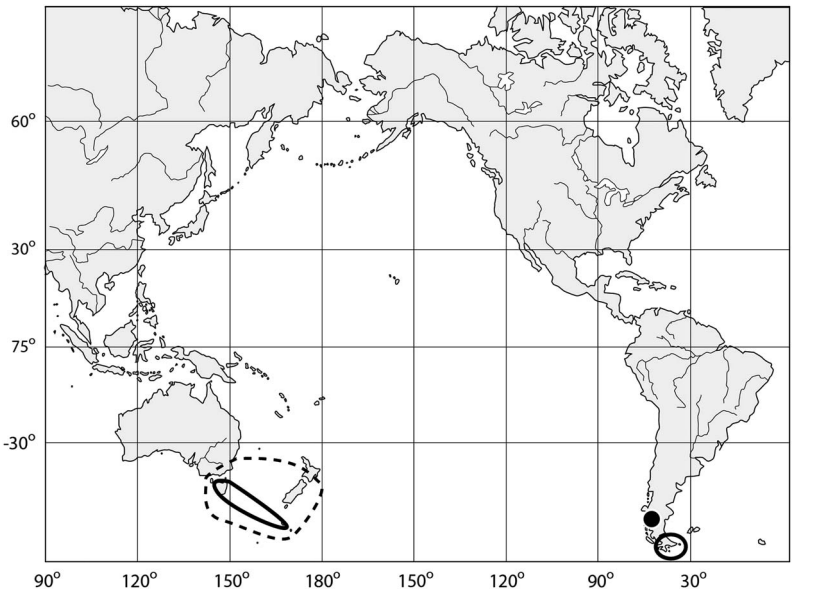

FIG. 3. Distribution of the genera *Psoromidium* (broken line) and *Psoromaria* (continuous line and dot).

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proposal by Fryday & Coppins (2009), so its correct name is as follows:

Psoromaria versicolor (Müll. Arg.) P. M. Jørg. & H. L. Andersen comb. nov.

MycoBank No.: MB812691

Psoroma versicolor Müll. Arg., *Flora* **71:** 534 (1888).

According to the facts above *Degeliella rosulata* needs the following nomenclatural adjustment:

Psoromaria rosulata (P. M. Jørg. & D. J. Galloway) P. M. Jørg. & H. L. Andersen comb nov.

MycoBank No.: MB812693

Degelia rosulata P. M. Jørg. & D. J. Galloway, *Flora of Australia* **54:** 314 (1992).

However, there are still taxonomic problems in this group. The inclusion of *Degeliella rosulata* in *Psoromaria* is unresolved based on the molecular phylogeny. Nevertheless, the two species share the same characters of a non-amyloid hymenium and asci that lack amyloid apical structures. These features separate both species from *Siphulastrum* Müll. Arg., which has a hemiamyloid hymenium and apical ascal ring-structure, as well as containing argopsin (Pd + orange) in the thallus, while that of *Psoromidium* is totally negative. We believe that the matter is best solved by adding more taxa and more genes to the molecular analysis.

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