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Pannaria byssoidea (*Pannariaceae*), a new squamulose species from southern South America

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Abstract. The present contribution is part of an extensive revision of *Pannariaceae* in southern South America *Nothofagus* forests. *Pannaria byssoidea* is described as new to science from this area. The morphology, anatomy and chemistry of collections, including type specimens from Argentina, Chile and New Zealand were studied. The specimens from southern South America differ from those from New Zealand, and are here accommodated in a new species, *P. byssoidea*. The new species differs from *P. implexa* mainly in two characters: spore anatomy and medullary substance. The South American *P. byssoidea* is characterized by an orbicular squamulose thallus, surrounded by a thick byssoid prothallus, ellipsoid to subglobose ascospores, with roughened perispore, and the presence of leprolomin as medullary substance. *Pannaria implexa* is considered endemic to New Zealand, and is characterized by the ellipsoid ascospores, with a halonate perispore, and the presence of pannarin as medullary substance. Both species are illustrated and notes on their taxonomy, distribution and ecology are given.

Keywords. Lichens, endemisms, Patagonia, New Zealand.

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The family *Pannariaceae* has been under revision for the past 30 years (Jørgensen 1978), with more emphasis during the past 15 (Ekman & Jørgensen 2002; Jørgensen 1994, 2001, 2002). The current classification segregates genera mainly by the apical structures of asci, chemistry and thallus anatomy and morphology. New generic classifications were proposed, with new genera described and the circumscription of existing taxa, such as *Degelia, Parmeliella*, *Pannaria* and *Psoroma,* revised (Elvebakk et al. 2010; Jørgensen 2000a, b, 2001, 2004; Passo & Calvelo 2006; Passo et al. 2008). Two of these genera, *Psoroma* and *Pannaria,* have historically been considered closely related since early lichenological studies (Nylander 1859), and some species have alternatively been placed in *Pannaria* (Hue 1902) or *Psoroma* (Zalbruckner 1925). More recently several species, previously considered under *Psoroma* were transferred either to *Pannaria* (Elvebakk & Galloway 2003; Jørgensen 2001; Passo & Calvelo 2006) or to newly described genera (Elvebakk et al. 2010; Passo et al. 2008).

However, there are still some poorly known species in *Psoroma* from the Southern Hemisphere

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with uncertain position. One of these, *Psoroma implexum* Stirt. was considered as endemic to New Zealand (Galloway 1985), until it was reported from southern South America in Chile (Galloway & Quilhot 1998; Quilhot et al. 1989). Galloway (2007) mentioned that in its current circumscription, *Psoroma* is still heterogeneous, with at least three distinct groupings within it, with *Psoroma implexum* representing one of them.

Stirton (1874) described *Psoroma implexum* based on material collected by John Buchanan in the Wellington Province of New Zealand. As shown by Galloway (1985), *Psoroma sphinctrinum* var. *crispellum* Nyl. (Nylander 1869) is an earlier name for this taxon, but without priority at the rank of species. Galloway (op. cit.) further synonymized two other younger specific names with *Psoroma implexum: Pannaria campbelliana* Hue (1906) from Campbell Islands, just south of New Zealand, and *Psoroma spectabile* Zahlbr. (1941) from the North Island of New Zealand. The species was recently transferred to *Pannaria*, as *Pannaria implexa* Passo, Stenroos & Calvelo (Passo et al. 2008). However, during our continued studies on this group of lichens, striking morphological, anatomical and chemical differences were detected among collections from South America, previously identified as *P. implexa*. With the purpose of understanding the species concept and the intraspecific variability, collections from both areas and the type specimens of *P. implexa* and its synonyms were studied. As a result a new species is proposed based on discussion of morphological, anatomical and chemical characters and geographical distribution. The present contribution is part of an extensive revision of *Pannariaceae* in southern South America (Passo 2010).

Materials and Methods

The specimens analyzed for the present study include personal collections of the senior author, deposited in BCRU, H and his personal herbarium (herb. Passo). Samples were collected mostly at Nahuel Huapi National Park (north-western Patagonia, Argentina) in a typical evergreen temperate rainforest dominated by *Nothofagus dombeyi*, with two tree strata and usually dense understory. Herbarium specimens analyzed include collections from South America and New Zealand (BRCU, BM, H, MERL, MSC, W, WELT). Type specimens of all species mentioned in this contribution and of their synonyms were also studied. Morphological and anatomical features were studied under dissecting and compound microscopes. Measurements of anatomical structures were made on water-mounted sections. Lactophenol cotton-blue was used for the description of the anatomy. Hymenial characters were studied on slides pre-treated with a KOH solution (10%), afterwards washed with water and followed by Lugol's reagent. Secondary compounds were characterized by thin layer chromatography (TLC), or for select specimens by high performance liquid chromatography (HPLC) following standardized protocols (Feige et al. 1993; Huneck & Yoshimura 1996; White & James 1985).

The Species

Pannaria byssoidea Passo & Calvelo sp. nov. **Fig. 1**

Mycobank #: MB 563471.

Pannariae implexae similis, sed perisporis sporarum verruculosis, et acidum leprolominum continens.

TYPUS: ARGENTINA. RIO NEGRO: Bariloche, Puerto Blest, shore of Río Frías, on *Nothofagus dombeyi*, 6.IV.2006, *Passo 274* (holotype: BCRU 5229; isotype: H).

Description. Thallus squamulose, corticolous, orbicular, 3–8 cm diam., ± closely attached to substratum (**Fig. 1A**). Prothallus conspicuous, dark brown to black, byssoid to occasionally fibrous, 0.1–0.5 mm thick, projecting 3–4 mm beyond thallus margins (**Figs. 1A & B**). Squamules initially rounded and discrete at margins, 0.1 mm diam., becoming incised, and sublobulate towards centre (**Figs. 1B & C**), up to 2 mm diam., ± crowded and confluent; upper surface smooth, shiny to waxy, light green when wet, whitish to pale green when dry, becoming yellowish brown in herbaria, margins frequently lighter (but not "frosted" or pubescent). Thallus section 100–150 µm thick; upper cortex ca. 50 µm, with a thin epicortex of thick-walled, gelatinized hyphae, and a paraplecthenchymatous layer of rounded isodiametric cells; algal layer ca. 30 µm, of globose cells, 12–16 µm, of cf. *Myrmecia*; medulla prosoplentenchymatous, ca. 40 µm; lower cortex

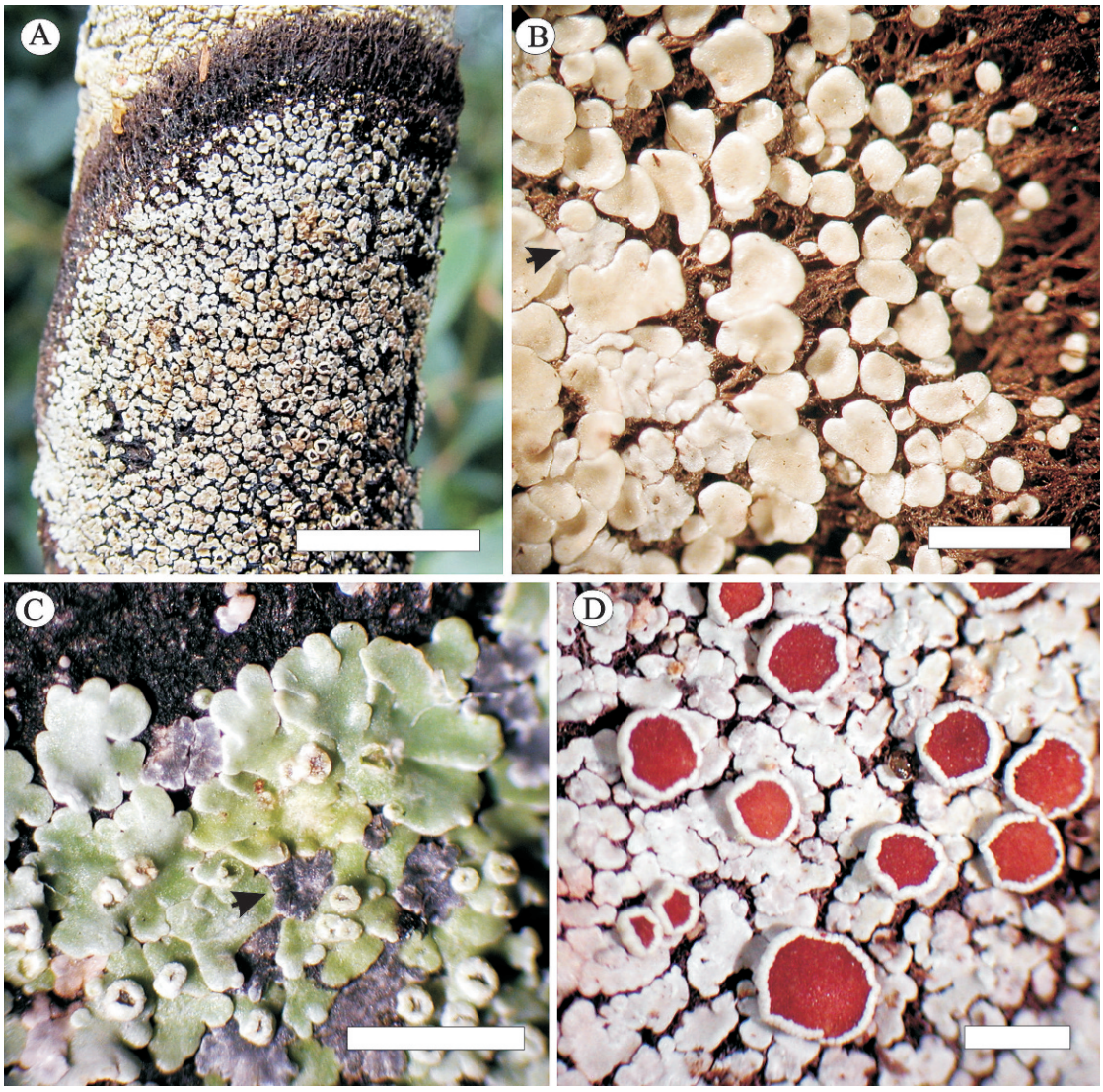


Figure 1. *Pannaria byssoidea* – **A.** Corticolous thallus on *Nothofagus dombeyi*. **B.** Thallus margin, detail of prothallus, young squamules and cephalodia (black arrow), *Passo 273* (herb. Passo). **C.** Fully developed squamules and cephalodia (black arrow), *Passo 83* (herb. Passo). **D.** Detail of apothecia, holotype *Passo 274* (BCRU 5229). Scales: A = 1 cm; B = 1 mm; C = 1.5 mm; D = 3 mm.

absent. Lower surface directly on the propothallus, not visible. Cephalodia frequent, conspicuous, growing directly on the prothallus, up to 2 mm diam., squamulose to placodioid, epruinose, smooth, bluish grey when wet, lighter at edges, concolorous with the thallus when dry (**Figs. 1B & C**). Apothecia numerous, crowded at the centre, circular to contorted by mutual pressure (**Fig. 1D**), 1–3 mm diam., disc plane to concave, often with central depressions or with a squamule of sterile tissue at the center; brown to dark brown; thalline margin prominent, 0.1–0.2 mm thick, obscuring the disc when immature, crenulated; hymenium 100–120 µm, I + blue; ascus subclavate, without internal amyloid structures; ascospores broadly ellipsoid to ovoid, 16.5–20 × 10–12.5 µm, perispore verruculose, 1–2 µm thick. Pycnidia absent.

Chemistry. C-, K-, Pd-, leprolomin (major).

Distribution and ecology. *Pannaria byssoidea* is present in southern South America and in the Juan Fernández archipelago. In southern South America, it is an element of the temperate rainforest of western

Patagonia (Argentina and Chile), in particular of the Valdivian rainforest and the subantarctic evergreen *Nothofagus* forests, and is lacking in the deciduous *Nothofagus* forests. It occurs from northern Patagonia to Magallanes and Tierra del Fuego in the South. In Juan Fernández, it was collected in scrub and brush-wood with some *Drimys*. This disjunctive distribution pattern, restricted to Patagonia and Juan Fernández, is not very frequent, as most species shared between the lichen biota of both areas have a wider distribution, e.g. also in New Zealand (Galloway 1991). Within the genera more recently studied from southern South America it was reported for some species of *Pseudocyphellaria* (Galloway 1992), *Pertusaria* (Messuti 2005), and within the *Pannariaceae* for *Joergensenia cephalodina* Passo et al. (Passo et al. 2008), *Degelia symtichia* (Tuck.) P.M. Jørg. (Jørgensen 2004), *Santessoniella polychidioides* (Zahlbr.) Henssen (Henssen 1997), and *Psorophorus pholidotus* (Mont.) Elvebakk (Elvebakk et al. 2010). No species of *Parmeliaceae* s.str. (Adler y Calvelo 2002; Calvelo 1994; Nash et al. 1995) or *Sticta* (Galloway 1994) exhibit such distribution pattern.

Pannaria byssoidea grows in humid forest, in rather open areas, although also found in shaded habitats, where the thalli produce more cephalodia. *Pannaria byssoidea* is a relatively fast growing species, commonly found on young stems and high branches, occasionally overgrowing other lichens.

Distinguishing features. *Pannaria byssoidea* is characterized by the orbicular squamulose thallus, surrounded by a thick byssoid prothallus, the large cephalodia, easily distinguished in the field when wet, and also by the presence of leprolomin in the medulla.

Selected specimens examined. ARGENTINA. PROV. DE NEUQUÉN: Laguna Cántaros, *Passo 81* (Herb. Passo); Lago Queñi, *Passo 253* (BCRU). PROV. RÍO NEGRO: Puerto Blest, *Passo 82* (BCRU4898), *83, 84* (BCRU 4908), *104* (herb. Passo); Río Frías, *Passo 237* (herb. Passo). PROV. DE TIERRA DEL FUEGO: Bahía Buen Suceso, *Imshaug 50087* (MSC 118725). CHILE. V REGIÓN DE VALPARAÍSO: Archipiélago Juan Fernández, *Imshaug 38118b*, (MSC 110848). X REGIÓN DE LOS LAGOS: Antillanca, *Imshaug 42869* (MSC 104546). Chiloé, *Imshaug 43177* (MSC 104020). XII REGIÓN DE MAGALLANES: Bahía Fortescue, *Imshaug 45000*, (MSC 104016); Bahía Última Esperanza, *Redón 11610* (MERL); Fiordo Finlandia, Bahía Kairamo 1929, *Hollermayer* (H).

Pannaria implexa (Stirt.) Passo, Stenroos & Calvelo, Mycological Research 112: 1471 (2008). *Psoroma implexum* Stirt., Transect. New Zealand. Instit. 6: 236 (1874). TYPE: NEW ZEALAND, Wellington, Tinakori Hills, Dec 1871, *J. Buchanan 38* (WELT, lectotype *fide* Galloway, 1985: 476; BM 000764448 isolectotype!).

Psoroma sphinctrinum var. *crispellum* Nyl., Syn. Meth. Lich. 2: 25 (1869). TYPE: NEW ZEALAND, Ruahine forest, *W. Colenso 4705* (BM, lectotype *fide* Galloway, 1985: 476; isotypes at WELT, collection L1120, H-NYL 30768!).

Pannaria campbelliana Hue, Nouv. Arch. Mus. Hist. Nat. 4(8): 271 (1906). TYPE: NEW ZEALAND. Campbell Island, 1874, *M. Filhol* (H-NYL 30769, lectotype! *fide* Galloway, 1985: 476).

Psoroma spectabile Zahlbr., Denkschr. Akad. Wiss. Wien Math.-naturwiss Kl. 104: 278 (1941). TYPE: NEW ZEALAND, Otago, Flagstaff Hill, on *Dacrydium cupressinum*, *J.S. Thomsom ZA 145,* 1933 (W, holotype!).

Description. Thallus squamulous, corticolous or muscicolous, orbicular to irregularly spreading, 4–10 mm diam., on a black, fibrous conspicuous prothallus, projecting 4–5 mm beyond thallus margins (**Figs. 2A & B**). Squamules 0.5–1.5 (−3) mm diam., flat and closely attached to substratum; initially circular and discrete, becoming crenulate, incised to sublobulate, with margins slightly crisped and often imbricate at thallus center (**Fig. 2B & C**). Upper surface smooth, mat to waxy in young squamules, light green, yellow-brown in storage, paler at edges, pubescent or white frosted. Thallus section 175–225 µm thick, upper cortex ca. 50 µm, with a necrotic epicortex of thick-walled, gelatinized hyphae, and a paraplectenchymatous layer; algal layer ca. 35 µm, of globose cells, 12–17 µm, of cf. *Myrmecia*; medulla prosoplentenchymatous, up to 130 µm. Lower surface directly on the prothallus, not visible, without lower cortex. Cephalodia squamulose, wrinkled to cerebroid, growing directly on the prothallus or on the squamules, grey to bluish, difficult to distinguish in old specimens (**Fig. 2C**). Apothecia frequent, circular to contorted by mutual

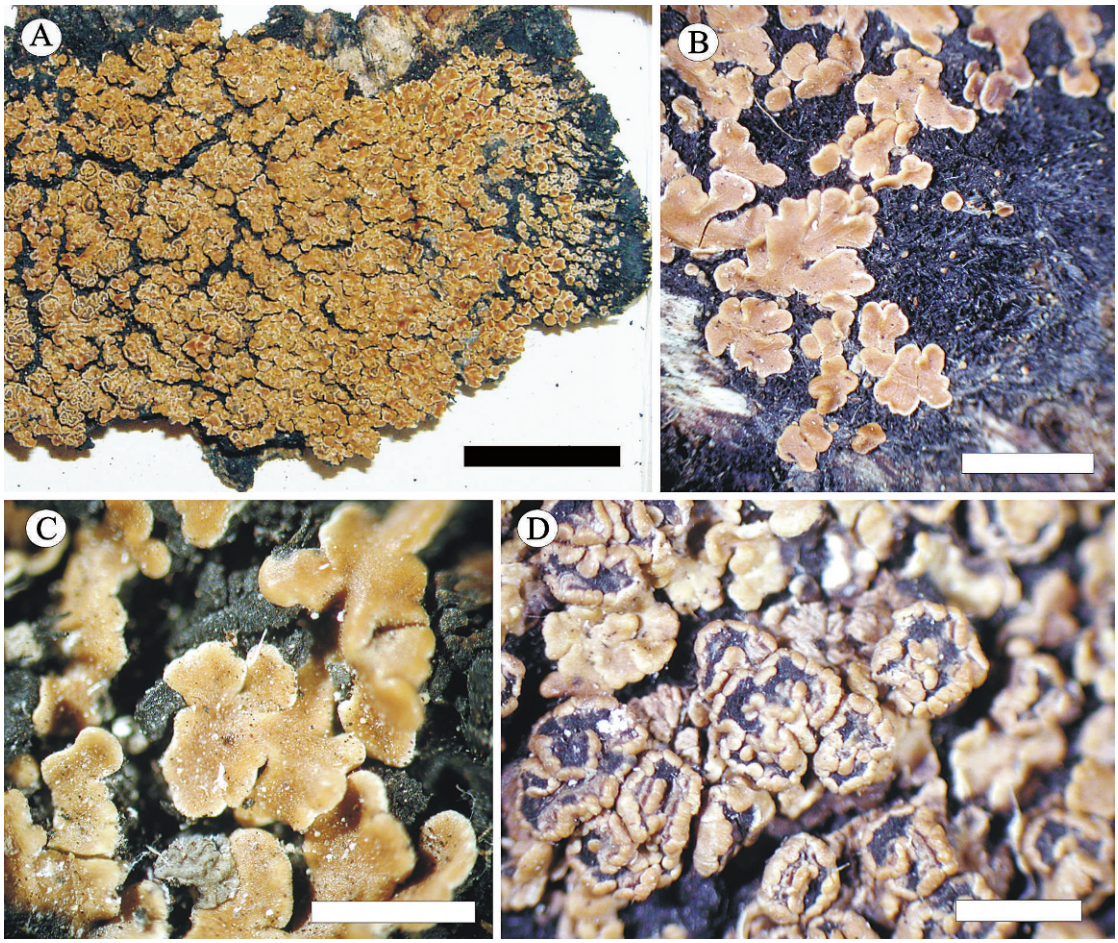


Figure 2. *Pannaria implexa* – **A.** General view of the thallus, lectotype (BM). **B.** Detail of prothallus and squamules, *Imshaug 56234* (MSC 146206). **C.** Detail of squamules and cephalodia, *Imshaug 4467* (MSC 104946). **D.** Mature apothecia, *Imshaug 56540* (MSC 146215). Scales: A = 1 cm; B = 1 mm; C = 1.5 mm; D = 2 mm).

pressure, up to 2 mm diam., disc dark brown, flat to slightly concave, often with concentric ridges or squamules at the center (**Fig. 2D**); margin thick, crenulated, obscuring the disc when immature; hymenium I+ blue, ascus without internal amyloid structures, ascospores ellipsoid to subglobose, 20–22 × 12.5 µm, perispore halonated, with a long apiculus, up to 7 µm, at each apex.

Chemistry. medulla C-, K-, Pd+ orange, pannarin.

Distribution and ecology. *Pannaria implexa* (as *Psoroma implexum*) was for over century considered endemic to New Zealand (Galloway 1985), until it was reported from Chile (Galloway & Quilhot 1998; Quilhot et al. 1989), and thus treated as an austral element (Galloway 2007), occurring in New Zealand, the subantarctic islands and southern South America. With the segregation of the South American *P. byssoidea*, *P. implexa* must be considered again as endemic to New Zealand and the subantarctic islands. Galloway (1985) mentions that it grows on bark of trees and shrubs, in damp habitats, also overgrowing mosses.

Distinguishing features. *Pannaria implexa* is characterized by the squamulose thallus, with black distinctly fibrous prothallus, the thick incised squamules (when mature), with margins distinctly white-pubescent or "frosted", the ascospores with halonated perispore and with a long apiculus at the apices, and the presence of pannarin in the medulla.

Comments. The type material of *P. sphinctrinum* var. *crispellum* at H is fragmentary but we have seen

images of the isotype at WELT (http://collections.tepapa.govt.nz/Taxon.aspx?irn=37167). This material is not typical *Pannaria implexa.* Since, the lectotype was not available at the time of the study, no conclusion could be made for this synonym, but it is likely that it represents *P. caliginosum* Stirt., a similar species with thinner, more adpressed squamules and a less distinct prothalus, as seen in these specimens. On the other hand, the types of *Pannaria campbelliana* and *Psoroma spectabile,* are in good agreement with the features of *P. implexa* type.

Selected Specimens examined. NEW ZEALAND. NORTH ISLAND: Greymouth, *Helms 51* (H-NYL 30767). *Sine loco,* 1867, *Knight 99* (H-NYL 30766); *sine loco,* 1880, *Knight s.n.* (N-NYL 2516, 2517, 2518; 2519, 2522); CAMPBELL ISLAND: Northwest Beach, *Imshaug 46650* (BRCU 03054); Northwest of Beeman Station, *Imshaug 47191* (BRCU03077); Mt. Honey, *Imshaug 47411* (BRCU 03098); North of Beeman Station, *Harris 4349* (BRCU 03111); St. Col Peak, *Imshaug 45931* (MSC 104935); Tucker Cove Station, *Imshaug 4467* (MSC 104946); Lyall Ridge, *Imshaug 5661* (MSC). AUCKLAND ISLANDS: Ranui Cove, *Imshaug 56234* (MSC 146206); Carnley Harbour, *Imshaug 56905* (MSC 146136).

Discussion

Pannaria byssoidea is here described as a new species from southern South American forests and it is segregated from *Pannaria implexa*, a morphologically similar species. Morphological, anatomical and chemical analysis of *P. implexa* specimens from New Zealand, including the type specimens of the species and of its synonyms, revealed important differences between them and the southern South American collections, initially identified as *P. implexa*. The main differences between the collections from these two distant geographical areas correspond to two independent characters: ascospore anatomy and profile of secondary compounds.

Although the shape of the ascospore is rather constant in *Pannariaceae*, with most species having either oblong to ellipsoid or globose to subglobose ascospores, the ascospore wall ornamentation and thickness varies (Jørgensen 1978). The perispore may be smooth and rather thin, as in some *Parmeliella* species, or with different ornamentations, as reported for many *Pannaria* and *Psoroma* species. The minutely verrucose perispore seen in *Pannaria byssoidea* is also known from *Pannaria pallida* (Nyl.) Hue (Passo et al. 2004), and several additional tripartite *Pannaria* species. Contrary, the halonate perispore, a thick gelatinous irregular perispore, as found in *P. implexa,* is less common in the *Pannariaceae*. The same perispore was reported for *Pannaria athroophylla* (Stirt.) A. Elvebakk & D.J. Galloway (Galloway 1985 as *Psoroma athroophyllum*), and confirmed by the authors in collections from South America. A similar perispore was observed in the species *Pannaria isabellina* (Vain.) Elvebakk & Bjerke, and characterized as gibbose (Elvebakk & Bjerke 2005). We have seen ascospores with halonate perispores also in *Pannaria patagonica* (Malme) A. Elvebakk & D.J. Galloway, *Psoroma pholidotoides* (Nyl.) Trevisan and *Psoroma melanizum* Zahlbr. Ascopores may further vary in the apical extensions of the perispore, varying from a single terminal wart at each end, to round or skewed apiculus, to long flagella-like apiculus, the last one common on halonate perispore. *Pannaria byssoidea* has ellipsoid to ovoid ascospores, with verruculose periospore, and no apiculus, whereas *P. implexa* has ellipsoid to subglobose ascospores, halonate perispore with a long apiculus at each end.

With regard to the chemistry of the medulla, all collections from New Zealand have pannarin, while those from Patagonia have leprolomin. Both substances are common in the genus *Pannaria*, but rarely co-occur in the same species. Leprolomin is so far only known from *Pannaria* species.

Pannaria byssoidea is assigned to the genus *Pannaria* as it exhibits two characteristic traits: the absence of amyloid apical structure in the ascus and the presence of leprolomin. Moreover, this assignation is also supported by molecular data, since the sequences cited by Passo et al. (2008) as *P. implexa*, grouped within the *Pannaria* clade corresponding to a collection from Patagonia, now assigned to *P. byssoidea.*

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