

***Psoroma nivale* (*Pannariaceae*, lichenized ascomycota) a new species from arctic Québec, Canada with dark, elongate squamules and bacilliform ascospores**

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Abstract: The new species *Psoroma nivale* is described from an area of late snow-lie in the Keglo Bay area on the eastern side of Ungava Bay northern Québec, Canada. It is superficially similar to *P. hypnorum* but has a dark, brownish black thallus colour without reddish hues, much-branched, proliferating squamules, thick paraphyses, distinct, but inconspicuous IKI + ascus tube structures, and characteristic elongate, bacilliform, often asymmetrical ascospores. The new species is compared with possibly related taxa and its systematic position discussed. A key to the species of pannarioid lichens reported from arctic areas of North America is also provided.

Key words: identification key, late snow-lie, Nunavik, perispore, taxonomy, variable ascus structure

Introduction

Traditionally, the genus *Psoroma* Ach. ex Michx. was the main genus of the *Pannariaceae*, in which the species typically had a green chlorococcoid alga as the primary photobiont. However, Jørgensen (2001) showed that some of the large foliose austral species with a chlorococcoid photobiont previously included in *Psoroma* were better placed in *Pannaria* Delise ex Bory. He formally transferred three of them to *Pannaria* and this process has been continued by other researchers (Elvebakk & Galloway 2003; Passo & Calvelo 2006). More recently, several segregate genera have been split off from *Psoroma*; the Palearctic species

to *Gibbosporina* Elvebakk, S.G. Hong & P.M. Jørg. (Elvebakk *et al.* 2016) and other Southern Hemisphere groups to *Joergensenia* Passo, S. Stenroos & Calvelo, (Passo *et al.* 2008) as well as *Psorophorus* Elvebakk & S.G. Hong and *Xanthopsoroma* Elvebakk & S.G. Hong (Elvebakk *et al.* 2010).

In this revised circumscription, the genus *Psoroma* is mostly confined to mid to high latitude regions, but also with representatives at high altitudes in tropical countries like Ecuador (Jørgensen & Palice 2010). The genus is most species-rich in the Southern Hemisphere; for example, the most recent lichen checklist for Chile (Galloway & Quilhot 1998) lists 35 taxa, but 13 of these have been removed to other genera and seven are synonyms (see above and Jørgensen 2003), leaving a total of 15. In contrast, only five species have been reported from the Northern Hemisphere (Henssen & Renner 1981; Jørgensen 2000 [2001], 2004; Timdal & Tønsberg 2006; Elvebakk 2012; Elvebakk & Tønsberg 2018) and two of these species are known from only single collections (*P. cinnamomeum* Malme from southern California and *P. spinuliferum* Elvebakk & Tønsberg from coastal Alaska). Molecular investigation of the *Pannariaceae* by Ekman *et al.* (2014) showed that another taxon, *Psoroma tenue* Henssen, was not congeneric with the type species of the genus, *P. hypnorum* (Vahl) Grey, although they were unable to suggest the correct placement for this species because of the lack of resolution in that part of their phylogeny.

Here we describe a further species for the Northern Hemisphere that is known only from an area of late snow-lie in northern Québec, Canada (Fig. 1). We also discuss its systematic position within the *Pannariaceae* and provide a key to pannarioid lichens in arctic areas of North America.

Materials and Methods

Apothecial characteristics were examined by light microscopy on hand-cut sections mounted in water, 10% KOH (K), 50% HNO₃ (N) or Lugol's reagent (0.15% aqueous IKI). Thallus sections were investigated in water and K. The ascus structure was studied in IKI, both without prior treatment and after pretreatment with K. Measurements of ascospores and paraphyses were made in water. Only ascospores liberated from asci were studied. Nomenclature of ascospore structures follows Nordin (1997) and proper ascospores and perispores were measured separately. Sketches of a total of 20 ascospores and the IKI + structures of c. 70 asci were drawn and a selection made to represent the variation observed. Thin layer chromatography followed the methods of Orange *et al.* (2001).

Selected additional collections examined: Austrella arachnoidea P. M. Jørg. **French Southern and Antarctic Lands: Îles Kerguelen:** Île Guillou, 49°28'57"S, 69°49'06"E, 14m, feldfield, 2014, *D. Ertz* 18847 (MSC0242550).

Austrella isidioidea P. M. Jørg. & Fryday **Falkland Islands:** *West Falkland:* Port Howard, Mt. Maria, Lightning Rocks, 51°61'9028"S, 59°60'1849"W, 575 m., over *Andreaea* sp. in recess on exposed, E-facing rocks, 2015, *Fryday* 10918 (MSC0195379).

Fuscopannaria pacifica P.M. Jørg. **USA: Alaska:** Hoonah-Angoon District, Glacier Bay National Park, Bartlett Lake Road, 58.46350°, -135.77520°, mixed woodland, alder twigs, 2012, *Fryday* 9900 (MSC0256265).

Pannaria euphylla (Nyl.) Elvebakk & D.J. Galloway **New Zealand: South Island:** at junction of Craigieburn River and Route 73, mature *Nothofagus* forest in ravine, 1971, *H. A. Imshaug* 48263 (MSC0140775).

Pannaria xanthomelana (Nyl.) Hue **New Zealand: The Auckland Islands:** Adams Island, slope of Magnetic Station, southwest of Camp Cove, Carnley Harbour, *Metrosideros* forest, 1973, *H. A. Imshaug* 57459 (MSC0242519).

Protopannaria hilaris (Zahlbr.) P.M. Jørg. **Chile: Juan Fernandez Islands:** Mas a Tierra, Portezuelo de Villagra, Villagra side of saddle, *Drimys* forest, 550 m, 1965, *H. A. Imshaug* 37627B (MSC0011743); *ibid.*, 1–200 m E of the mountain pass between Quebrada Vaquería and Valle Ingles, 33°37'S, 78°51'W, 400 m, on *Escallonia*, 2006, *Elvebakk* 06:368 (TROM).

Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman **USA: Wyoming:** Big Horn Co., Bighorn National Forest, USFS 28 at North Fork of Crazy Woman Creek, 20.5 mi (33 km) SW of Buffalo, 44°09'33"N, 107°01'23"W, 8690 ft. [2650 m], north facing hillside with spruce [*Picea*] and few fir [*Abies*], 2007, *C.M. Wetmore* 96618 (Lichenes Exsiccati #215) (MSC0108446). **Norway:** *Troms:* Karlsøy, Vanna, Djupvik, on limestone debris, 10 m, 25 June 1994, *Engelskjøn & Aasen* (TROM).

Psoroma angustisectum Zahlbr. **Chile: Juan Fernandez Islands:** Mas Afuera, Los Inocentes, south summit, heath with *Lophosoria*, 1300 m, 1965, *H. A. Imshaug* 37416 A (MSC0162040).

Psoroma buchananii (C. Knight) Nyl. **Chile: Magallanes:** Morro Chico, over bryophytes on a vertical S-facing cliff wall, 52°03'S, 71°24'W, 200 m, 1999, *Elvebakk* 99:1236 (TROM).

Psoroma hypnorum (Vahl) Gray. **USA: Wyoming:** Teton Co., Yellowstone National Park, Elephant Back Ridge, 1.5 miles (2.4 km) west of Fishing Bridge; 44°34'17"N, 110°24'27"W, 8600 ft, on ridge with lodgepole pine (*Pinus contorta*) and some whitebark pine (*Pinus albicaulis*), 1998, *C. M. Wetmore* 81768 (MSC0108449). **Alaska:** Hoonah-Angoon District, Glacier Bay National Park, Willoughby Island, 58.60809°, -136.117358°, terricolous, calcareous shoreline heath, 2011, *Fryday* 9715 (MSC0154284).

Psoroma polychidioides (Zahlbr.) P.M. Jørg. **Falkland Islands:** *West Falkland:* Hill Cove, NE base of French Peaks, UTM 21F TC 8188, 200 ft., stone run, 1968, *H. A. Imshaug* 41019 & *R. C. Harris*. (MSC0136449).

Psoroma tenue var. *tenue* Henssen **Argentina:** *Tierra del Fuego:* Ushuaia, Río Olivia, on rocks by the river, 1940, *Santesson* 971 (S).

Psoroma tenue var. *boreale* Henssen **Norway:** *Troms:* Tromsøya, Telegrafbukta, on mosses between N-facing rocks, 2 m, just above the littoral zone, 2009, *Elvebakk* 09:039 & *S. G. Hong* (TROM).

'*Santessoniella*' *arctophila* (Th. Fr.) Henssen **USA:** *Alaska:* Hoonah-Angoon District, Glacier Bay National Park, Muir Point, 58.83415°N, 136.05753°W, 4. m., terricolous/muscicolous, in flat area behind sea-bank, *Plantago* zone, 2012, *Fryday* 10221, *T. Spribille* & *M. Svensson* (MSC); **Norway:** *Troms:* Kåfjord/Gáivuona, 300 m N of the inlet Stuoraluokta of lake Guolasjávri, on calcareous mineral soil on an exposed *Dryas* ridge, 69°22'N, 21°06'E, 840 m, 2011, *Elvebakk* 11:021 (TROM).

Xanthopsoroma contextum (Stirt.) Elvebakk & S.G. Hong **New Zealand:** *The Auckland Islands:* Auckland Island, tussock above Ranui Cove, mosaic of low scrub and tussock, 1972, *H. A. Imshaug* 56192 (MSC0136326).

The Species

***Psoroma nivale* Fryday, Elvebakk, F.L. Anderson & J. Gagnon sp. nov.**

Mycobank No.: MB 831357

Superficially similar to *P. hypnorum*, but differing in having a dark brown to black thallus without reddish hues, more finely-dissected squamules, less prominent internal IKI+ tube structures within the asci, presence of strongly swollen paraphyses, and narrow, elongate and ±bacilliform ascospores (l/b ratio:2.5–3.0), without large, apical perispore extensions.

Type: Canada, Québec, Nunavik, Keglo Bay, 34.1 km east-north-east of Kangiqsualujjuaq, 15.2 km east-south-east of lake Qarliik, 12.8 km south of Baudan river, 8.8 km south-south-east of Lake Angusik, 0.9 km west of an unnamed stream, 58.84867°N, 65.44511°W, 321 m, over *Andreaea rupestris* on low boulder below area of prolonged snow lie, 1 August 2016, *J. Y. Gagnon* 31.1 (QFA: SF16-1315—holotype).

(Figs 2-4)

Thallus composed of small, horizontal to ascending, elongated, dissected and proliferating squamules, much branched with terminal lobes up to 1 mm long; end lobes c. 0.2 mm wide, mostly ±flat but becoming rounded, 0.1–0.2 mm thick; brownish black when

dry becoming sordid yellow in shaded areas; lower surface sordid yellow. *Cortex* blackish brown pigmented, mostly composed of five or more layers of prosoplectenchyma, *cells* c. $10\text{--}15 \times 3 \mu\text{m}$, but cortex of upper surface c. $20 \mu\text{m}$ thick and composed of \pm isodiametric cells (paraplectenchyma) to $10 \mu\text{m}$ across. *Cephalodia* present in basal parts of thalli, common, but black and inconspicuous, pulvinate to irregularly coralloid, $0.2\text{--}1 \text{ mm}$ diam. *Primary photobiont* *Trebouxia*, cells $9\text{--}15 \mu\text{m}$ with thick hyaline wall c. $2 \mu\text{m}$ wide, and finely papillose chloroplasts. *Secondary photobiont* *Nostoc*, individual cells blue-green, $5\text{--}8 \times 3\text{--}7 \mu\text{m}$, ellipsoid to irregularly angular, arranged in glomeruli without visible chain structures.

Apothecia common, lecanorine, sessile with a narrow base, arising from the upper surface of the squamules; initially flat, $0.4\text{--}0.8 \text{ mm}$ diam, but up to 3 mm across with an irregular, often lobed outline and undulating surface when mature, covering much of the surface of the central part of the thallus; *disc* red when young becoming black when mature and turning dark red-brown when wet; *thalline margin* thick, raised, $0.1\text{--}0.15 \text{ mm}$ wide, entire with shallow radial fissures when young, composed of proliferating \pm digiform to coralloid, slightly flattened squamules similar to those of the thallus when mature. *Exciple* $150\text{--}175 \mu\text{m}$ wide, cupular and finely white-tomentose below, algae present, the same as in thallus, hyaline, composed of radiating hyphae $4\text{--}5 \mu\text{m}$ wide, cells $5\text{--}18 \mu\text{m}$ long, *cortical cells* dark brown pigmented (N+ red). *Hymenium* c. $150 \mu\text{m}$ tall, IKI+ strongly blue, *paraphyses* $3\text{--}4 \mu\text{m}$ wide, in mid hymenium, gradually widening to $5\text{--}7 \mu\text{m}$ wide at the apex with a brown pigmented cap that sometimes forms a sheath around the terminal cell, simple, rarely branching above, septate, constricted at the septa, sometimes almost moniliform; *epihymenium* dilute brown. *Hypothecium* c. $50 \mu\text{m}$ deep, hyaline to dilute orange-brown. *Asci* cylindrical c. $100\text{--}120 \times 15\text{--}20 \mu\text{m}$, apical structure variable, usually with an IKI+ blue external cap and one or more IKI+ blue \pm horizontal sheets in the upper tholus, but some asci have only the external cap, whereas others have a weak, but distinct IKI+ blue tube structure; *proper ascospores* hyaline, narrow elongate with rounded ends, mostly bacilliform, or weakly asymmetrical, $17\text{--}21 \times 5.5\text{--}8 \mu\text{m}$ (l/b ratio: c. $2.5\text{--}3.0$), *perispores* of the same shape, regularly low-verrucose, without or with modest pulvinate apical extensions, $18\text{--}22 \times 6\text{--}8.5 \mu\text{m}$, perispore gradually degenerating in K, but swelling to $4\text{--}5 \mu\text{m}$ thick in N.

Conidiomata not observed.

Chemistry. All spot tests negative; no substances detected by TLC.

Distribution and Ecology. *Psoroma nivale* is known only from the type collection where it grew over *Andreaea rupestris* Hedw. on the upper surface of a low acidic boulder associated with glacial till at the lower edge of an area of late snow-lie (slope: 15%; aspect: 70°). Also present on the same boulder were *Cladonia* sp., *Micarea incrassata* Hedl., *Peltigera* sp. and *Rhizocarpon* sp. Other cryptogams recorded from the vicinity are given in Table 1. The surrounding vegetation consisted of a dwarf shrub community dominated by *Salix herbacea* L. with *Carex bigelowii* Torr. ex Schwein. The Keglo Bay site is situated within the Arctic shrub tundra domain (Ministère des Forêts, de la Faune et des Parcs, 2019; Elvebakk *et. al.*, 1999).

Remarks. The perispore of the ascospores of the new species expands dramatically in N, from *c.* 1 µm to 4–5 µm. We could find no mention of this phenomenon in the literature and so were unsure whether it was restricted to our new species or was common to other species of the genus, or even family. Consequently, we tested specimens of several other species of *Psoroma* and other *Pannariaceae* genera from the MSC herbarium (see “*Additional Collections Examined*” above) and discovered that the perispore expanded in N in the studied species of *Psoroma* and *Pannaria*, all with a warted perispore, but not in the smooth-spored *Fuscopannaria pacifica*.

Systematic position. Initially, we thought that our collection might represent an extreme environmental modification of *Psoroma hypnorum*, but we soon dismissed this idea because of the characteristic elongate, ascospores, always without large apical extensions (Fig. 3G, 4), as well as the very thick paraphyses (4–7 µm; Fig. 3E), both of which are very different from those of *P. hypnorum*. The amyloid reaction of the ascus apex was also confusing. The asci of *P. hypnorum* have a well-defined IKI+ blue tube structure (Fig. 4C in Elvebakk *et al.* 2010), whereas the ascus structure of our new species appears variable. Most asci had an IKI+ blue external cap and one or more IKI+ blue ±horizontal sheets in the upper tholus (Fig. 4), whereas weak, but distinct tube structures were also rarely observed (Fig. 3F, 4). This is possibly due to differing degrees of maturity of the asci, with immature asci having only the external cap that later develop the internal horizontal sheets, with the tube-like structure developing only in fully mature asci. A similar process has been documented in the asci of *Xenolecia* Hertel, with immature asci having an internal cap (*Lecidea*-type) that develop a tube structure (*Porpidia*-type) on maturity (Fryday & Thüs 2007).

At first, the ascus characters of our new species appeared to exclude from consideration not only *P. hypnorum* but also the genus *Psoroma* in general. Because the shape and colour of the thallus squamules of our new species resemble those of a species of *Fuscopannaria* P.M. Jørg. and, also as in some *Fuscopannaria* species, it has apothecia with squamulose margins that are sunken below the squamules, our next thought was that it might be a species of *Fuscopannaria* with a chlorococcoid photobiont. Although the photobiont in *Fuscopannaria* is usually a cyanobacterium, one species, *Fuscopannaria viridescens* P.M. Jørg. & Zhurb., does have a green chlorococcoid photobiont and occurs in the North American Arctic. However, that species has a fawn brown thallus with expanded marginal lobes (Jørgensen & Zhurbenko 2002, Nelson & Wheeler 2013) and because the ascospores of *Fuscopannaria* species have a smooth surface (James & Jørgensen 2009) and their hymenia are IKI + reddish brown, we excluded that genus from consideration for our species.

Based on the amyloid reaction of the ascus structure and the ascospores with a warted perispore, we next considered whether our collection could be accommodated in *Protopannaria* P.M. Jørg. However, all described species of *Protopannaria* have a cyanobacterium as photobiont and comparison with *P. pezizoides* (Weber) P.M. Jørg. & S. Ekman, the type species of the genus, revealed that our species had very little else in common with that genus. *Protopannaria pezizoides* differed in having a completely different thallus structure and apothecial anatomy with an adglutinated epihymenium of thin paraphyses, and asci with very distinct, external IKI + blue apical caps. Some internal sheets were observed, but no tube structures. We also looked at several of the Southern Hemisphere species referred to *Protopannaria*, which differed widely from both *P. pezizoides* and each other. For example, *Protopannaria hilaris* (Zahlbr.) P.M. Jørg., described from the Juan Fernández Islands (Chile) had ascus IKI+ reactions different from those of *P. pezizoides*. The external caps were not so dominant, internal sheet-like structures were well developed, but many cases of true tube structures were also observed. However, unlike our new species, its ascospores were small and short-ellipsoid. *Protopannaria*, as presently understood, includes seven species but it appears to be heterogeneous and definitively in need of further study.

This brought us back to our original opinion, that the new species could only be accommodated in a widely circumscribed *Psoroma* as depicted by Ekman *et al.* (2014; clade 2c). However, as the paraphyses are different and the IKI + tube structures less pronounced compared to those of *P. hypnorum* (the type species) we checked the phylogeny of Ekman *et al.* (2014) for other taxa in their 'clade 2c' that might be congeneric with our species. Among these, *Psorophorus* ssp. and *Psoroma tenue* have well-developed IKI+ apical tube structures,

but no other similarities to our new species, except that *P. tenue* var. *tenue* has similar paraphyses. *Austroparmeliella lacerata* (P.M. Jørg.) P.M. Jørg. is also very different, including having smooth ascospores, and the two *Austrella* species do not have IKI+ blue hymenia, and were recently found to be paraphyletic (Fryday *et al.* 2017). This left us with '*Santessoniella*' *arctophila*, which is not a very useful reference for defining generic positions, as the type species of the genus, *S. polychidioides* (Zahlbr.) Henssen, was recovered within the core *Psoroma* clade by Ekman *et al.* (2014), leaving *S. arctophila* as an orphaned taxon. Our studied material of '*S.*' *arctophila* may be heterogeneous; *Elvebakk* 11:021 has asci with a combination of IKI+ sheets and true tubes, but the smooth ascospores are devoid of visible perispore structures, whereas *Fryday* 10221 and the type collection in UPS have ascospores with a warted perispore.

Within *Psoroma*, our new species is distinguished primarily by its unique ascospore shape (Fig. 3G), a character that is unknown in any previously described species of the genus: ascospores of *Psoroma* species are predominantly ellipsoid, whereas some are ovoid and others weakly or strongly citriform. We have searched for *Psoroma* species with a similar morphology with regard to other characters, particularly in the Southern Hemisphere, where the genus definitively has its evolutionary origin. *Psoroma angustisectum* Zahlbr., a rare species described from the Juan Fernandez Islands and also reported from southern mainland Chile and New Zealand, has long and dissected squamules, but they have the brown melanin colour of *P. hypnorum* and its ascospores have been described as much larger, 25–35(–38) × 10–15 μm (Galloway 2007).

Most *Psoroma* species share the reddish-brown hues of *P. hypnorum*, or may even be cinnamon-coloured, like *P. tenue* var. *boreale*. However, the species matching the colour of *P. nivale* most closely, may be the panaustral species *P. buchananii*. It has a dark, blackish brown melanin colour, which can take on a more mustard-yellow colour, as in the holotype of *P. nivale*, probably in shaded parts of the thallus. However, the squamules of *P. buchananii* are much less branched, it has conspicuous black pycnidia, and the ascospores are short-ellipsoid to subglobose with rather scattered, wide gibbae, instead of regularly set verrucae.

We conclude that there are no known species from the Southern Hemisphere resembling *P. nivale* in a combination of melanin colours and anatomical and macroscopic characters. The new species will be included among extensive phylogenetic studies that are needed, both to challenge the present paraphyletic position of *Psoroma* shown both by Ekman *et al.* (2014) and Park *et al.* (2018), and to define its nearest neighbouring genera. It is also our hope that

the present paper can stimulate further searches in the field for this species, so far only known from its holotype specimen.

Key to species of *Pannariaceae* and similar families (*Koerberiaceae*, *Massalongiaceae*, *Vahliellaceae*) reported from arctic regions of North America.

Geographically, the Arctic is that area of the Earth north of the Arctic Circle but, biologically, this is of little relevance because it makes no allowance for altitude or continental position – the other main drivers of climatic conditions and the resulting vegetation. Elvebakk (1999) proposed a bioclimatic delimitation of the ‘Arctic’ based on the presence of arctic vegetation that corresponds to that area north of the tree-line. This has been refined by the CAVM Team (Walker *et al.* 2005) who have produced detailed maps of Arctic vegetation. The dominant vegetation of the Keglo Bay area is low shrub tundra, which is characteristic of the ‘Low Arctic’.

- 1 Primary photobiont a green chlorococcoid alga 2
 - Primary photobiont a cyanobacterium 6

- 2(1) Thallus placodioid, fawn brown with wide radiating marginal lobes
 - **Fuscopannaria viridescens**
 - Thallus composed of small squamules without a well-defined margin 3

- 3(2) Apothecia lacking a thalline margin
 - **Vahliella globigera** (Fryday & P.M. Jørg.) P.M. Jørg.
 - Apothecia with a well-developed thalline margin 4

- 4(3) Squamules elongate, much-branched, dark brownish-black, ascospores bacilliform
 - **Psoroma nivale**
 - Squamules rounded to granular, not branched, green to chestnut-brown, ascospores wide ellipsoid to citriform5

- 5(4) Thallus of greenish-brown to brown squamules; apothecial margin squamulose.
 - Thallus lacking lichen substances **Psoroma hypnorum**

	Thallus of reddish-brown, small and glossy granules; apothecial margin granular, Thallus containing porphyritic acid methyl ester and pannaric acid	Psoroma tenue var. boreale
6(1)	Thallus with soredia, sorediose isidia, isidia or coralloid granules	7
	Thallus lacking soredia, sorediose isidia and isidia, usually fertile	11
7(6)	Thallus with true isidia or coralloid granules	8
	Thallus with soralia or sorediose isidia (gymnidia).....	10
8(7)	Squamules on a blue-black hypothallus, on rocks or trees; ascospores simple	
	.....	Parmeliella triptophylla (Ach.) Müll. Arg.
	Hypothallus absent	9
9(8)	Thallus of flat squamules, not adpressed to the surface; usually among bryophytes on rocks or on the ground; ascospores 1-septate	
	.....	Massalongia carnosa (Dicks.) Körb.
	Thallus of narrow radiating lobes, directly on rock; ascospores simple	
	.....	Tingiopsidium isidiatum (Degel.) Hafellner & T. Sprib.
10(7)	Thallus with enlarged, radiating marginal lobes	
	.....	Fuscopannaria ahlneri (P.M. Jørg.) P.M. Jørg.
	Thallus lacking enlarged, radiating marginal lobes	Pannaria conoplea (Ach.) Bory
11(6)	Thallus composed of brown, ascending, frosted lobes, apothecia rare	
	.....	Fuscopannaria praetermissa (Nyl.) P.M. Jørg.
	Thallus otherwise; apothecia usually present	12
12(11)	Thallus subfruticose, composed of ascending greenish black lobes; apothecia greenish-black	Leciophysma finmarkicum Th. Fr.
	Thallus crustose, squamulose or of radiating lobes	13
13(12)	Thallus ±crustose, in small patches, apothecia lacking a thalline margin	14
	Thallus squamulose or of radiating lobes, apothecia with a thalline margin	15

- 14(13) Thallus olivaceous, apothecia dark brown, ascospores smooth
 **Leciophysma furfurascens** (Nyl.) Gyeln.
 Thallus brown; apothecia red-brown, ascospores with a warted perispore
 "**Santessoniella**" **arctophila***
- 15(13) Apothecia red-brown **Protopannaria pezizoides**
 Apothecia black 16
- 16(15) Thallus of narrow, fawn-brown radiating lobes
 **Tingiopsidium elaeinum** (Wahlenb.) Hafellner & T. Sprib.
 Thallus squamulose or subfruticose 17
- 17(16) Thallus grey-white, placodioid to squamulose on a black hypothallus
 **Pannaria hookeri** (Borrer) Nyl.
 Thallus forming small, greenish-brown cushions
 **Vahliella hookerioides** (P.M. Jørg.) P.M. Jørg.

*The type species of *Santessoniella* has been shown to belong in *Psoroma*.

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REFERENCES

- Ekman, S., Wedin, M., Lindblom, L. & Jørgensen, P. M. (2014) Extended phylogeny and a revised generic classification of the *Pannariaceae* (*Peltigerales*, Ascomycota). *Lichenologist* **46**: 627–656.
- Elvebakk, A. (1999) Bioclimatic delimitation and subdivision of the Arctic. In: *The species concept in the High North - A Panarctic Flora Initiative* (I. Nordal & V. Y. Razzhivin (eds.): *Det Norske Videnskaps-Akademi I. Matematisk-Naturvidenskapelig Klasse, Skrifta Ny Serie* **38**: 81–112.

- Elvebakk, A. (2012) An overlooked *Psoroma* in Denmark and southern parts of Sweden. *Graphis Scripta* **24**: 45–48.
- Elvebakk, A. & Galloway, D. J. (2003) Notes on the heterogeneous genus *Psoroma* s. lat. in New Zealand. *Australasian Lichenology* **53**: 4–9.
- Elvebakk, A. & Tønsberg, T. (2018) *Psoroma spinuliferum* (Pannariaceae), a new corticolous lichen species from Alaska with two different types of cephalodia. *Bryologist* **121**: 166–173.
- Elvebakk, A., Elven, R. & Razzhivin, V.Y. (1999) Delimitation, zonal and sectorial subdivision of the Arctic. In: *The species concept in the High North - A Panarctic Flora Initiative* (I. Nordal & V. Y. Razzhivin (eds.): *Det Norske Videnskaps-Akademi I. Matematisk-Naturvidenskapelig Klasse, Skrifta Ny Serie* **38**: 375–386.
- Elvebakk, A., Robertson, E. H., Park, C. H. & Hong, S.G. (2010) *Psorophorus* and *Xanthosporoma*, two new genera for yellow-green, corticolous and squamulose lichen species, previously in *Psoroma*. *Lichenologist* **42**: 563–585.
- Elvebakk, A., Hong, S.G., Park, C. H., Robertson, E. H., & Jørgensen, P. M. (2016) *Gibbosporina*, a new genus for foliose and tripartite, Palaeotropic *Pannariaceae* species previously assigned to *Psoroma*. *Lichenologist* **48**: 13–52.
- Fryday, A. M. & Thüs, H. (2017) The genus *Xenolecia* (*Lecideaceae* s. lat., *Lecanoromycetidae inc. sed.*), including a second species in the genus from Campbell Island, New Zealand. *Lichenologist* **49**: 365–372.
- Fryday, A. M., Ertz, D. & Jørgensen, P. M. (2017) Insights into the genus *Austrella* (*Pannariaceae*, *Peltigerales*), including a new species from the Falkland Islands. *Lichenologist* **49**: 57–65.
- Galloway, D. J. (2007) *Flora of New Zealand Lichens. Revised Second Edition Including Lichen-Forming and Lichenicolous Fungi. Volumes 1 and 2*. Lincoln, New Zealand: Manaaki Whenua Press.
- Galloway, D. J. & Quilhot, W. (1998) Checklist of Chilean lichen-forming and lichenicolous fungi [Lista patron de los liquenes y hongos liquenicolas de Chile]. *Gayana Botanica* **55**: 111–185.
- Henssen, A. & Renner, B. (1981) Studies in the lichen genus *Psoroma* I. *Psoroma tenue* and *Psoroma cinnamomeum*. *Mycotaxon* **13**: 433–449.
- James, P. W. & Jørgensen, P. M. (2009) *Fuscopannaria* P.M. Jørg. (1994). In: *The Lichens of Great Britain and Ireland* (C. W. Smith, A. Aptroot, B. J. Coppins, A. Fletcher, O. L. Gilbert, P. W. James & P. A. Wolseley, eds): 411–413. London: British Lichen Society.

- Jørgensen, P. M. (2000) Survey of the lichen family Pannariaceae on the American continent, north of Mexico. *Bryologist* **103**: 670–704.
- Jørgensen, P. M. (2001) New species and records of the lichen family Pannariaceae from Australia. *Bibliotheca Lichenologica* **78**: 109–139.
- Jørgensen, P. M. (2003) Conspectus familiae *Pannariaceae* (Ascomycetes lichenosae). *Ilicifolia* **4**: 1–79.
- Jørgensen, P. M. (2004) *Psoroma tenue* var. *boreale*, an overlooked, widespread, arctic-alpine lichen. *Graphis Scripta* **15**: 60–64.
- Jørgensen, P.M. & Palice, Z. (2010) Additions to the lichen family *Pannariaceae* in Ecuador. *Nordic Journal of Botany* **28**: 623–628.
- Jørgensen, P. M. & Zhurbenko, M. (2002) Two new, remarkable, arctic species in the lichen genus *Fuscopannaria* (Pannariaceae, lichenized Ascomycetes). *Bryologist* **105**(3): 465–469.
- Ministère des Forêts, de la Faune et des Parcs (2019) <https://mffp.gouv.qc.ca/forets/inventaire/inventaire-zones-carte.jsp>. Accessed 20 May 2019.
- Nelson, P. R. & Wheeler, T. (2013) Cephalodia found on *Fuscopannaria viridescens*. *Lichenologist* **45**: 694–696.
- Nordin, A. (1997) Ascospore structures in *Physciaceae*: an ultrastructural study. *Symbolae Botanicae Upsalienses* **32**(1): 195–208.
- Orange, A., James, P. W. & White, F. J. (2001) *Microchemical Methods for the Identification of Lichens*. London: British Lichen Society.
- Park, C. H., Hong, S. G. & Elvebakk, A. (2018) *Psoroma antarcticum*, a new lichen species from the Antarctic and neighbouring areas. *Polar Biology* **41**: 1083–1090.
- Passo, A. & Calvelo, S. (2006) New reports and combinations in the family *Pannariaceae* (Lecanorales, lichenized Ascomycota). *Lichenologist* **38**: 549–555.
- Passo, A., Stenroos, S. & Calvelo, S. (2008) *Joergensenia*, a new genus to accommodate *Psoroma cephalodinum* (lichenized Ascomycota). *Mycological Research* **112**: 1465–1474.
- Timdal, E. & Tønsberg, T. (2006) *Psoroma paleaceum* comb. nov. the only hairy *Psoroma* in northern Europe. *Graphis Scripta* **18**: 54–57.
- Walker, D. A., Raynolds, M. K., Daniëls, F. J. A., Einarsson, E., Elvebakk, A., Gould, W. A., Katenin, A. E., Kholod, S. S., Markon, C. J., Melnikov, E. S., *et al.* (2005) The Circumpolar Arctic Vegetation Map. *Journal of Vegetation Science*, **16**:267–282.

Figure captions

FIG. 1: Map showing the location of Keglo Bay, from where the new species was collected.

FIG. 2: *Psoroma nivale* (holotype). A, habitat. *Psoroma nivale* occurred on a low boulder just below the centre of the snow patch; B, habit; C, thallus with apothecia. Scale = 2 cm.

FIG. 3: *Psoroma nivale* (holotype). A, immature apothecium; B, mature apothecia; C, lower cortex; D, section through mature apothecium; E, paraphyses; F, ascus in IKI; G, ascospore in water; H, ascospores in 70% nitric acid. Scales: A = 0.5 mm; B = 2.0 mm; C, F–H = 10 μm ; D = 100 μm ; E = 5 μm .

FIG. 4. Ascospores, asci and paraphyses of *Psoroma nivale*. Scale = 10 μm .







