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A revision of the lichen genus *Protopannaria* (Pannariaceae, Peltigerales, lichenized Ascomycota) in the Russian Far East with a new record to Russia

A. K. Ezhkin[1]*, L. S. Yakovchenko[2]

[1] *Institute of Marine Geology and Geophysics FEB RAS, Nauki St., 1B, Yuzhno-Sakhalinsk, 693022, Russian Federation.*

E-mail: ezhkin@yandex.ru; ORCID iD: https://orcid.org/0000-0002-2242-2250

[2] *Federal Scientific Center of East Asian Terrestrial Biodiversity FEB RAS, 100-let Vladivostoka Ave., 159, Vladivostok, 690022, Russian Federation.*

E-mail: lidiyakovchenko@mail.ru; ORCID iD: https://orcid.org/0000-0002-4342-7771

**Corresponding author*

Keywords: biogeography, boreal zone, cool-temperate distribution, corticolous lichens, disjunctions, Far East of Russia, rare species.

Summary. During the revision of the lichen genus *Protopannaria* in the Russian Far East an epiphyte lichen species new to Russia is reported. *Protopannaria corticola* previously known only from Sichuan Province of China (Himalayas) was found in montane coniferous and riparian deciduous forests on bark of conifer and deciduous trees in the northern and middle Sakhalin and the north-eastern Sikhote-Alin Mountain Range in the Khabarovsk Territory. The record of the species in the Russian Far East shows a rather major disjunction (ca. 4600 km) of the species area. Detailed original descriptions and distinctive features with illustrations for two representatives of the genus – *Protopannaria corticola* и *P. pezizoides* – are presented. One specimen of *Fuscopannaria poeltii* reported for Sakhalin earlier was reidentified as *Protopannaria corticola*, so the species was excluded from the lichen species list of Sakhalin and Russia.

Ревизия рода лишайников *Protopannaria* (Pannariaceae, Peltigerales) на российском Дальнем Востоке

А. К. Ежкин[1], Л. С. Яковченко[2]

[1] *Институт морской геологии и геофизики ДВО РАН, ул. Науки, д. 1Б, г. Южно-Сахалинск, 693022, Россия*

[2] *ФНЦ Биоразнообразия наземной биоты Восточной Азии ДВО РАН, пр. 100-лет Владивостока, д. 159, г. Владивосток, 690022, Россия*

Ключевые слова: бореальная зона, Дальний восток России, дизъюнктивные виды, распространение в умеренном климате, редкие виды, эпифитные лишайники.

Аннотация. Представлены результаты ревизии рода *Protopannaria* на российском Дальнем Востоке. Согласно полученным данным, род насчитывает на изученной территории два вида, один из которых – *Protopannaria corticola* – приводится для России впервые. На РДВ *P. corticola* был найден в горных хвойных и долинных листопадных лесах на коре хвойных и лиственных деревьев в северной и средней части острова Сахалин и в северо-восточной части горного хребта Сихотэ-Алинь в Хабаровском крае. Новые местонахождения вида, ранее известного только из провинции Китая Сычуань (Гималаи), показывают значительную (около 4600 км) дизъюнкцию в его распространении. В статье приведены подробные оригинальные описания и иллюстрации обоих выявленных в России представителей рода – *Protopannaria corticola* и *P. pezizoides*, а также даны их

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отличительные признаки. Поскольку один образец *P. corticola* был ранее неверно определен как *Fuscopannaria poeltii*, данный вид ошибочно приводился для Сахалина и России, поэтому он исключается нами из списка лишайников России.

Introduction

Protopannaria (Gyeln.) P. M. Jørg. et S. Ekman (Pannariaceae Tuck.) was introduced to accommodate crustose-squamulose species without secondary chemistry with lecanorine apothecia, amyloid hymenium and asci lacking internal amyloid structures (Jørgensen, 2000). Phylogenetic studies (Ekman, Jørgensen, 2002; Spribille, Muggia, 2013; Ekman et al., 2014) have shown an independent generic status of *Protopannaria*. The genus is small, of 7 species worldwide growing on mosses, debris or turf, or occasionally found on bark of trees in damp habitats. In Russia only one species of the genus is known – *Protopannaria pezizoides* (Weber) P. M. Jørg. et S. Ekman, which is widely distributed mostly in Arctic and mountain regions southward (Andreev et al., 1996; Urbanavichus, 2011).

During the treatment of herbarium from the Sakhalin Region and the Khabarovsk Territory we discovered a peculiar Pannariaceae growing on bark of conifer and deciduous trees in montane coniferous and riparian deciduous forests. The taxon was identified as *Protopannaria corticola* P. M. Jørg which was described from Sichuan Province of China (Himalayas) by Jørgensen (2007) and so far was known only from the locus classicus. The findings of the species in the Russian Far East shows a rather major disjunction (ca. 4600 km) of the species distribution area.

Material and methods

Ten specimens of *Protopannaria corticola* were collected in 2011–2018 in North and Middle Sakhalin by the first author and North-Eastern Sikhote-Alin Mountain Range in the Khabarovsk Territory by the second author. Sixteen specimens of *Protopannaria pezizoides*, collected from the Far East of Russia – Sakhalin, Kuriles and Kamchatka Peninsula by several authors in different years, were treated for comparison with a new record – *P. corticola*. The specimens were examined using a stereomicroscope (MBS-10) and compound microscope (LOMO Mikmed 3) by standard microscopic techniques (Stepanchikova, Gagarina, 2014) and identification keys (Jørgensen, 2000, 2007). Anatomical examination was undertaken using hand cut sections mounted in water with following reagents: 10 % KOH (K) and Lugols solution (I). Spot tests were made with K, sodium hypochlorite solution (C) and 1,4-p-phenylendiamine (P), and I. Examined specimens are deposited in the herbaria of Institute of Marine Geology and Geophysics (SAK), Federal Scientific Center of East Asian Terrestrial Biodiversity (VLA) and Botanical Garden-Institute FEB RAS (VBGI). The duplicate of the specimen *Protopannaria corticola* VBGI 177902 is deposited in ALTB.

The results

Protopannaria corticola P. M. Jørg. (Fig. 1, 2): "Russia, Sakhalin Region, Sakhalin Island, Noglikskiy District, Nogliki vicinity, 51°49'14.4"N, 142°56'36.17"E, 83 m, old-growth coniferous forest, on bark of old *Betula ermanii*. 12 X 2012. Leg. A. K. Ezhkin" (SAK 1273); ibid., "…on bark of fallen *Picea jezoensis*. 12 X 2012. Leg. A. K. Ezhkin" (SAK 2517); ibid., "…Tymovskiy District, Tym' and Belaya River valley, 50°36'52.34"N, 142°50'41.58"E, 204 m, low-disturbed riparian forest, on bark of *Populus suaveolens*. 25 VI 2018. Leg. A. K. Ezhkin" (SAK 2518); "Khabarovsk Territory, Ulchskiy District, 40 km western from De-Kastri Village, North-Eastern Sikhote-Alin Mountain Range, western slope of Ploskaya Mt., Yay River Valley, between Zvonkiy and Glubokiy Streams, 51°25'01.9"N, 140°14'13.5"E, 450 m, old-growth coniferous forest, on bark of *Picea jezoensis*. 05 VIII 2011. Leg. L. S. Yakovchenko" (VBGI 177897–177903).

Description of studied specimens: Thallus squamulose, 2–3 cm diam., greenish or brownish grey with white-pruinose margins, 120–130 m thick with a cellular upper cortex, 20–30 μm wide; 50–100 μm thick photobiont layer with *Nostoc* in clusters, individual cells 4–6(7) μm diam; no lower cortex, the medulla merging into the blackish rhizohyphae. Apothecia numerous, 0.5–1.5(2) mm broad with prominent, crenulate, white-rimmed thalline margin and orange-brown, flat disc with reduced proper exciple. Hymenium up to 200 μm high, I+ blue, asci clavate 50–90 × 10–15(20) μm, without internal amyloid apical structures, 8-spored. Ascospores colourless, simple, broadly ellipsoid, (13)17–19(22) × (5.5)7.5–8(11) μm including perispore.

Chemistry: cortex and medulla K–, C–, P–.

Habitat and distribution: The species grows on trees and shrubs – *Rhododendron* sp. and *Salix* sp.

in montane forest in the Himalayas at altitude 2980–3150 m. In the Russian Far East the species occurs in boreal zone in coniferous and riparian forests on bark of *Picea* (Siebold et Zucc.) Carrière, *Betula ermanii* Cham., and *Populus suaveolens* Fisch. *Protopannaria corticola* is a rare species in the region and prefers old-growth and low-disturbed forests at altitude up to 450 m.

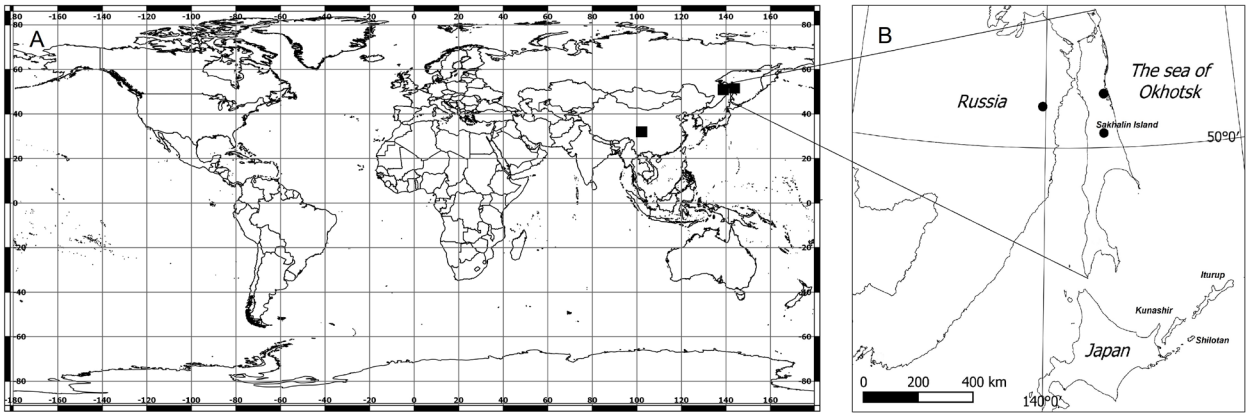

Fig. 1. Distribution of *Protopannaria corticola* in the World (A) and the Russian Far East (B).

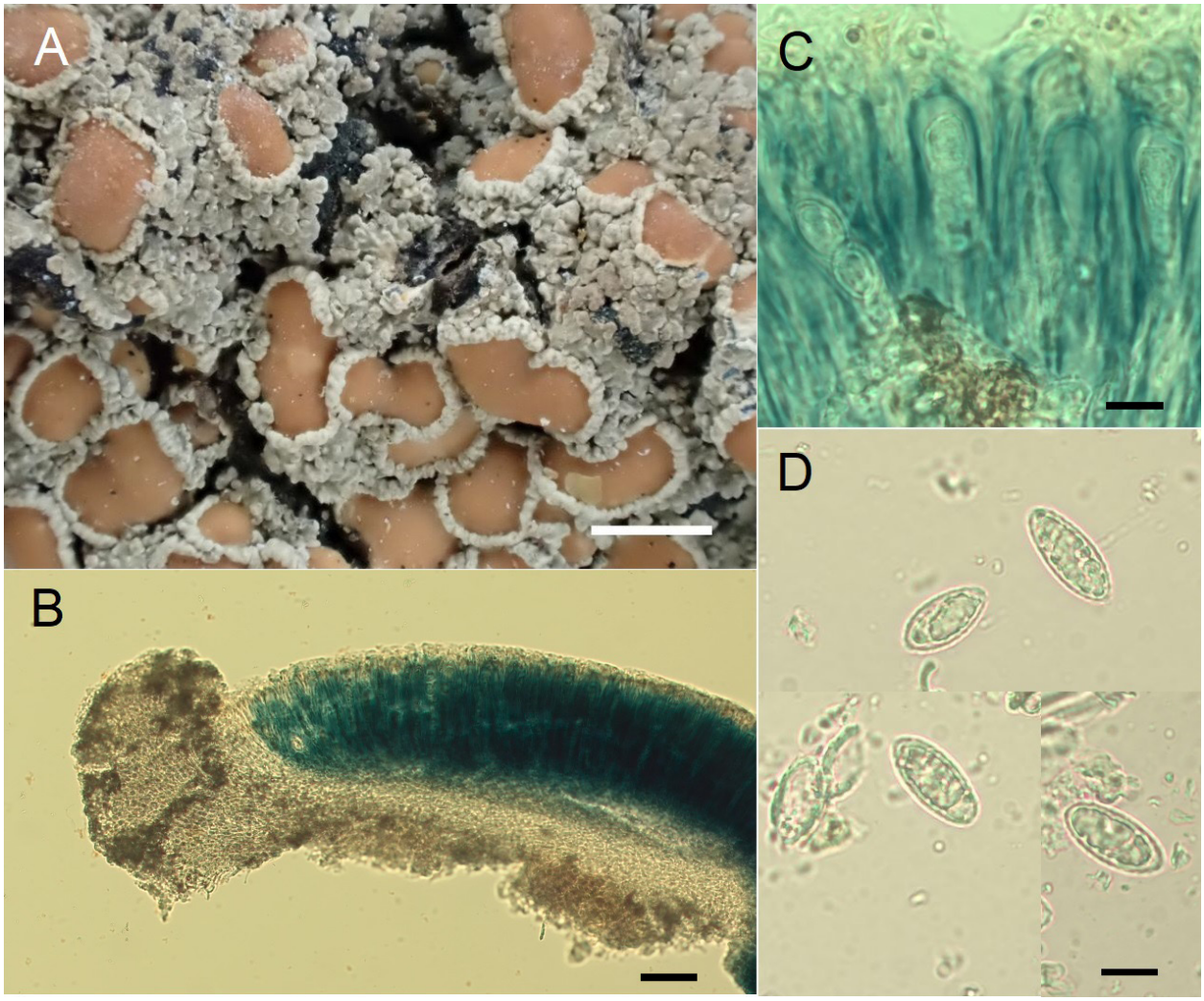

Fig. 2. *Protopannaria corticola* (VBGI 177902): A – Thallus with apothecia; B – Apothecium section and blue reaction of hymenium with I; C – Asci without internal amyloid apical structures in I; D – Ascospores. Scale bars: A = 1 mm, B = 50 µm, C and D = 10 µm.

Notes: The species reminds a northern, terricolous species – *Protopannaria pezizoides* (Weber) P. M. Jørg. et Ekman by the same orange-brown apothecia, but the last one is clearly differed by its less developed thallus, larger ascospores, (18)20–28(30) × (8)9–11(13) μm and apothecia, lack of pruinose on margins and different habitat – grows on soil, plant debris and moss (Jørgensen, 2000, 2007; Smith et al., 2009; Stenroos et al., 2016). The studied specimens are in general corresponded to the protologue (Jørgensen, 2007), however we have found larger size of ascospores (12–15 × 7–10 μm in the protologue), smaller size of asci (100–130 × 10–15 μm in protologue) and thinner size of thallus with thicker upper cortex (200–300 μm thick with a cellular upper cortex, 40–50 μm wide in the protologue).

Protopannaria pezizoides (Weber) P. M Jørg. et S. Ekman (Fig. 3): "Russia, Sakhalin Region, Shikotan Island, The Krai Sveta Cape, 43°50'28.9"N, 146°54'35.49"E, 59 m, seaside meadow, on soil on old military bunker. 19 IV 2017. Leg. A. K. Ezhkin" (SAK 1268); ibid., "…Paramushir Island, The Utesnaya Bay, 50°36'15.67"N, 156°09'27.72"E, 57 m, seaside, on soil among rocks. 03 X 2017. Leg. A. K. Ezhkin" (SAK 1269); ibid., "…The Ozernyi Cape, 50°35'24.22"N, 156°09'40.96"E, 57 m, seaside meadow, on soil among rocks. 03 X 2017. Leg. A. K. Ezhkin" (SAK 1270); ibid., "…Sakhalin Island, Smirnykhovskiy district, Mt. Vaida vicinity, Vitnitsa River valley, coniferous forest, on moss. 13 VII 2018. Leg. V. V. Kaganov" (SAK 2001); ibid., "…Sakhalin Island, Smirnykhovskiy district, Poronayskiy district, Beluha River valley, 50°10'10.61"N, 143°22'16.3"E, 293 m, mixed forest, on soil on forest trail. 2018 VIII 2020. Leg. A. K. Ezhkin" (SAK 719); "Kamchatka Peninsula, Elisovskiy district, Valaginskyi Ridge, Mt. Pereval, 1781 m, on soil among rocks. 25 VI 1984. Leg. A. G. Mikulin" (VLA 840625-18,2); ibid., "…Tihon'kaya Bay, 20 m, on soil among rocks. 29 VI 1981. Leg. A. G. Mikulin" (VLA 840-629-121); ibid., "…Kronotskoye Lake, 390 m, larch woodland, on soil among rocks. 22 VI 1984. Leg. A. G. Mikulin" (VLA 840622-16-15); ibid., "…Krasheninnikova Bay, 375 m, heath tundra, on moss on soil. 30 VI 1984. Leg. A. G. Mikulin" (VLA 840630-21-11); ibid., "…Geizernaya River valley, 380 m, on soil among rocks. 08 VIII 1979. Leg. A. G. Mikulin" (VLA 790808-XIII-I); ibid., "…Pyataya River, 20 m, birch forest, on mossy tree trunk. 26 VII 1982. Leg. A. G. Mikulin" (VLA 820726-91); ibid., "…Mt. Poputnaya, 1656 m, on soil. 9 VIII 1985. Leg. A. G. Mikulin" (VLA 850809-13a/2); ibid., "…Chazhma River valley, 20 m, on soil. 7 VII 1981. Leg. A. G. Mikulin" (VLA 810707-255); ibid., "…Chazhma Cape, 40 m, seaside, on soil among rocks. 23 VI 1981. Leg. A. G. Mikulin" (VLA 810623-32); ibid., "…Pamyatnik Cape, seaside, 5 m, on soil among rocks. 25 VIII 1979. Leg. A. G. Mikulin" (VLA 790825-I-в); ibid., "…Tyushevka River and Volch'ya River valley, 120 m, coastal cliffs, on soil among rocks. 14 IX 1981. Leg. A. G. Mikulin" (VLA 810914-948).

Description of studied specimens: Thallus squamulose, 2–4 cm diam., usually brown without pruinose, blue-grey in shaded habitats, often forming compact mats on substrate, 200 μm thick with a cellular upper cortex, (20)30–50 μm wide; 60–140(160) μm thick photobiont layer with *Nostoc* in clusters, individual cells 4–5 μm diam.; no lower cortex. Apothecia numerous, 0.5–2.5(3) mm broad with prominent crenulate margin and bright orange-brown, flat disc. Hymenium up to 190 μm high, I+ blue, asci clavate to subcylindrical 100–120 × 13–16 μm, without internal amyloid apical structures, 8-spored. Ascospores colourless, simple, broadly ellipsoid, (18)20–28(30) × (8)9–11(13) μm including perispore.

Chemistry: cortex and medulla K–, C–, P–.

Habitat and distribution: The species grows on bare soil, over dump mosses on basses of trees, walls and rocks, on decaying wood and plant debris, prefers northern territories and mountains (Jørgensen, 2000, 2007; Smith et al., 2009; Stenroos et al., 2016).

Notes: The studied specimens are in general corresponded to the protologue (Jørgensen, 1978), however we have found wider range of the size of ascospores (25–30 × 9–12 μm including perispore in the protologue), larger size of apothecia (to 2 mm in the protologue), thicker photobiont layer (60–90 μm in the protologue) and hymenium (up to 150 μm in the protologue).

Discussion

After the revision of the genus *Protopannaria* collected from the Russian Far East we reported a species new to Russia – *P. corticola*, which occurs in boreal zone on Sakhalin and Sikhote-Alin Mountain Range. In the area of investigation, the species prefers cool moist old-growth montane coniferous forests and grows on bark of old coniferous trees and birch. Only one finding of the species was reported in riparian forest where the species occurs on bark of poplar. The most extended localities of *Protopannaria corticola* is ca. 4600 km. Obviously, this species has a much wider cool temperate distribution and its disjunction hardly real since it certainly has

been overlooked in the interjacent area and with a high probability can be found in other mountainous regions within East Asia. *Protopannaria corticola* seems to be a rare lichen as it is absent in managed and young forests. So, the species can be used as an indicator of low-disturbed coniferous forests in the region. It resembles another representative of the genus – widespread *Protopannaria pezizoides*, which grows on soil, moss and plant debris mostly in northern territories and mountains. *Protopannaria corticola* differs from *P. pezizoides* by lesser sizes of spores and ecology – the species grows only on tree bark. Earlier, one specimen of *Protopannaria corticola* (SAK 1273) was misidentified and reported as *Fuscopannaria poeltii* (P. M. Jørg.) P. M. Jørg. for Sakhalin (Ezhkin, Jørgensen, 2018), so the species is excluded here from the lichen species list of Sakhalin and Russia. *Fuscoppanaria* species differs from other Pannariaceae lichens by hemiamyloid hymenium, first reacting blue-green, then rapidly turning red-brown, and the asci have amyloid apical structures, most often a ring-structure or tube. *Protopannaria* species have amyloid hymenium I+ blue only around the asci lacking internal amyloid structures (Jørgensen, 2000).

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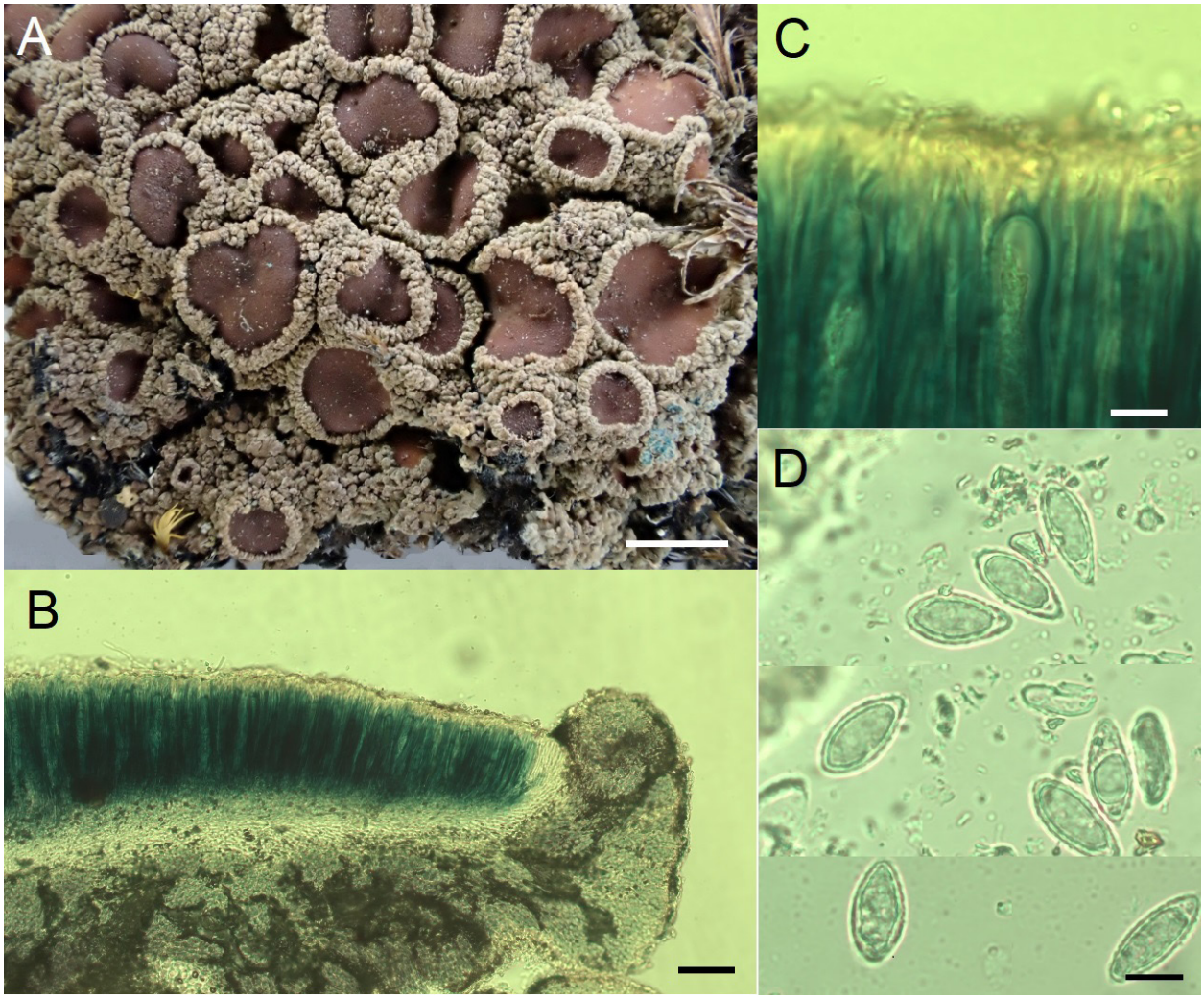

Fig. 3. *Protopannaria pezizoides* (VLA 810707-255): A – Thallus with apothecia; B – Apothecium section and blue reaction of hymenium with I; C – Asci without internal amyloid apical structures in I; D – Ascospores. Scale bars: A = 2 mm, B = 50 μm, C and D = 10 μm.

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