Further knowledge on the lichen biota of Koryakia (Northern Kamchatka, Russia)

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Abstract. Based on collections of Koryak geobotanical expeditions of the Komarov Botanical Institute, 23 species of lichens and four lichenicolous fungi are reported as new to Koryakia, nine of them are also new to Kamchatka. *Ephebe hispidula*, *Lambiella impavida*, *Rhizocarpon simillimum*, *Rhizoplaca opiniconensis*, and *Vestergrenopsis isidiata* are new to the Russian Far East. Altogether 529 species of lichens and allied fungi are currently known for Koryakia.
Keywords: Koryak Nature Reserve, Beringia, North Pacific.

Новые сведения о лихенобиоте Корякии (Северная Камчатка, Россия)

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Резюме. По материалам Корякской геоботанической экспедиции БИН РАН, выявлено 23 вида лишайников и четыре вида лихенофильных грибов, новых для Корякии, девять из них также являются новыми для Камчатского края. *Ephebe hispidula*, *Lambiella impavida*, *Rhizocarpon simillimum*, *Rhizoplaca opiniconensis* и *Vestergrenopsis isidiata* приводятся впервые для Дальнего Востока. Всего для Корякии известно 529 лишайников и ассоциированных с ними грибов.
Ключевые слова: Корякский заповедник, Берингия, Северная Пацифика.

Koryakia is located in the northern part of the Russian Far East, between Kamchatka and Chukotka. Administratively, the former Koryak Autonomous Okrug is a northern part of the Kamchatka Territory. Due to remoteness and limited transport opportunities, Koryakia has long been “terra incognita” in terms of lichen biota. Lichenological studies in Koryakia were started only in 2016 (see Himelbrant *et al.*, 2019, 2021), and, of course, the region has not yet been sufficiently studied.

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This paper is aimed to expand our knowledge about the lichen diversity of Koryakia. The presented data on species and localities are the outcome of annual geobotanical expeditions under the supervision of the author V. Yu. Neshataeva.

Material and Methods

The paper is based on material collected in 2016–2022 in Olutorsky and Penzhinsky districts of the Kamchatka Territory, former Koryak Autonomous Okrug. The lichens were collected mainly by the authors Neshataeva, K. I. Skvortsov, and V. E. Kirichenko, some specimens were also collected by V. Yu. Neshataev, D. E. Himelbrant, and I. S. Stepanchikova; one specimen was identified from older material stored in the lichen herbarium of St. Petersburg State University (LECB).

The specimens were identified by Himelbrant, Stepanchikova, and E. A. Timofeeva, using classical methods of microscopy. Chromatography was performed according to the standard techniques of high performance thin-layer chromatography using solvent systems A, B, C, and G (Orange *et al.*, 2001).

For the specimen of *Rhizoplaca opiniconensis* DNA sequence was analyzed. DNA was extracted directly from apothecia using the magnetic beads-based kit Phyto-Sorb (Synthol, Russia) following the manufacturer's protocol. PCR amplification and sequencing were performed for two fungal markers: nucITS rDNA with primers ITS1F (Gardes, Bruns, 1993) and ITS4 (White *et al.*, 1990). Amplicon was sequenced at the Research Park of St. Petersburg State University "Center for Molecular and Cell Technologies". A BLASTn search (Altschul *et al.*, 1990; BLAST..., 2023; NCBI..., 2023) was conducted to verify the sequence identity. Newly generated sequence was deposited in NCBI (GenBank); the accession number is provided in the species list.

Altogether more than 1260 specimens of 190 species were identified, of them 27 species represented by 35 specimens collected in 23 sampling locations (Fig. 1) are new to Koryakia and therefore are listed here. The material is deposited in the herbarium of St. Petersburg State University (LECB).

The nomenclature of taxa generally follows recently published checklists for lichens of North America and Scandinavia (Esslinger, 2019; Westberg *et al.*, 2021), as well as the worldwide checklist for lichenicolous fungi (Diederich *et al.*, 2018). All geographical coordinates are given in the coordinate system WGS 84. For the historical collection, coordinates were determined from the topographic map, in this case they are indicated in square brackets.

Sampling locations

Standard sample areas. Olutorsky District: 1 — Koryak State Reserve, N shore of Lavrova Bay, 60°24′25.5″N, 167°02′41.0″E, ca. 100 m a. s. l., wet rocks, VIII 2019, *Kirichenko Lavrova-1*; 2 — *ibid.*, S of Druzhny, 60°23′47.7″N, 167°04′53.2″E, ca. 50 m a. s. l., wet rocks, VIII 2019, *Kirichenko Lavrova-2*; 3 — ca. 4.5 km N to Tilichiki, S slope of the hill Prodolgovataya, 60°28′18.8″N, 166°03′38.5″E, 418 m a. s. l., lichen tundra with dwarf shrubs, 24 VIII 2018, *Himelbrant, Stepanchikova Tilichiki-a26*; 4 — W of Khailino, Vetvey Range, Ledyanoy mine, 60°57′21.0″N, 166°03′16.2″E, 153 m a. s. l., gravel tundra with *Diapensia obovata* (F. Schmidt) Nakai on slope, 19 VIII 2020, *Neshataeva, Skvortsov 2018*; 5 — *ibid.*, 60°59′57.2″N, 166°07′24.9″E, 153 m a. s. l., rocky outcrop, VIII 2020, *Kirichenko 892*;

6 — N of the Pylgovayam River, Ivtygin Ridge, Dolinnaya Mt., SE slope, 61°03′33″N, 167°56′33″E, 604 m a. s. l., nival mountain tundra with *Dryas octopetala* L., 26 VIII 2021, *Skvortsov 21100*; 7 — upper course of the Vyvenka River, N slope of Maingykakyjne Ridge, large scree near the top, 61°24′46″N, 168°03′50″E, 708 m a. s. l., mountain tundra with lichens and dwarf shrubs, 30 VII 2021, *Skvortsov s. n.*; 8 — *ibid.*, close to the mouth of the Vakhavnitvayam River, ca. 87 km NE of Khailino, spurs of the Vetvey Ridge, 61°27′49.9″N, 168°04′43.7″E, ca. 700 m a. s. l., rocks, VII 2021, *Kirichenko 1*; 9 — Vetvey Ridge, Evyoinenelkhan Pass, N macroslope, NE slope of a small valley, 61°28′57″N, 167°16′49″E, 594 m a. s. l., plant community under the rock, 12 VIII 2021, *Skvortsov s. n.*; 10 — *ibid.*, 61°29′24″N, 167°14′58″E, 465 m a. s. l., mountain tundra with lichens and dwarf shrubs, 12 VIII 2021, *Skvortsov 2160*; 11 — *ibid.*, between Nutovayam and Evyoinvayam rivers, 61°29′59.9″N, 167°14′55.8″E, 293 m a. s. l., mountain tundra with lichens and dwarf shrubs, 12 VIII 2021, *Skvortsov GPS220*; 12 — *ibid.*, 61°30′00.0″N, 167°14′54.3″E, 290 m a. s. l., permafrost patches between *Pinus pumila* (Pallas) Regel thickets with lichens, on bear path, 11 VIII 2021, *Neshataeva*, *Skvortsov*, *V. Yu. Neshataev*, *Kirichenko s. n.*; 13 — *ibid.*, 61°30′31″N, 167°13′06″E, 652 m a. s. l., mountain tundra with lichens and dwarf shrubs, 13 VIII 2021, *Skvortsov 2176*; 14 — *ibid.*, 61°30′34″N, 167°12′56″E, 686 m a. s. l., rubble area on the ridge, 13 VIII 2021, *Skvortsov s. n.*; 15 — *ibid.*, 61°30′36.2″N, 167°12′51.2″E, ca. 680 m a. s. l., rocky outcrop, VIII 2021, *Kirichenko 4*; **Penzhinsky District:** 16 — upper stream of Kuiboveem River, [63°50′N, 166°17′E], on soil, 9 VIII 1935, *Nikitenko s. n.*; 17 — Koryak Nature Reserve, Parapol′sky Dol segment, E of Talovskoe Lake, top of the hill in a hill range, 61°18′16.9″N, 164°45′55.0″E, 197 m a. s. l., open rocky outcrops, 10 VIII 2016, *Himelbrant Tal-05-2016*; 18 — ca. 70 km to Kamenskoe, Belaya River, 62°18′27.6″N, 166°43′51.7″E, 51 m a. s. l., dwarf shrub tundra with *Pinus pumila* and *Betula exilis* Sukaczev, 16 VII 2018, *Neshataeva 1811*; 19 — ca. 70 km of Kamenskoe, Belaya River, 62°18′29.1″N, 166°43′52.3″E, 52 m a. s. l., swamp with *Eriophorum vaginatum* L. and *Carex* spp. on permafrost, 16 VII 2018, *Neshataeva 1812*; 20 — *ibid.*, 62°21′15.2″N, 166°32′46.7″E, ca. 350 m a. s. l., butte, 14 VII 2018, *Kirichenko s. n.*; 21 — vicinity of Kamenskoe, right bank of the Penzhina River, 62°26′12.6″N, 166°08′43.3″E, 34 m a. s. l., *Pinus pumila* community with dwarf shrubs, 7 VIII 2018, *Neshataeva 1842*; 22 — *ibid.*, ca. 10 km NW of Kamenskoe, 62°31′03.8″N, 166°02′35.7″E, ca. 400 m a. s. l., rocky outcrop, VIII 2019, *Kirichenko 4*; 23 — vicinity of Manily, Kamennaya Palatka Hill, 62°34′17.0″N, 165°24′53.4″E, ca. 400 m a. s. l., large butte surrounded by stony tundra, 4 VII 2018, *Kirichenko s. n.*

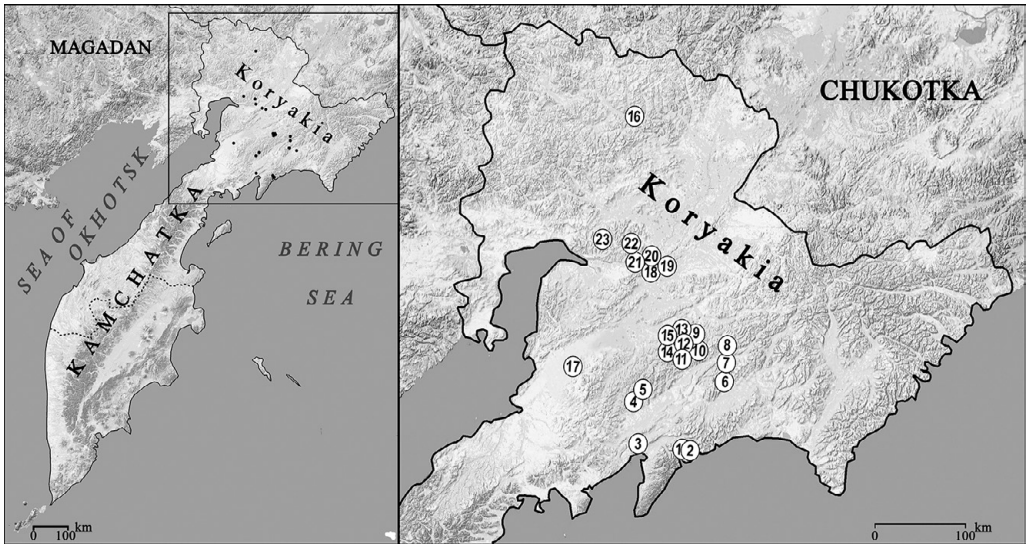

Fig. 1. Map of the study area. Sampling locations are marked by numbers.

Results and Discussion

An annotated list of species is presented in alphabetical order. The species reported for the first time for the Kamchatka Territory are marked with **!**, lichenicolous fungi and lichens with **#**, and species protected by regional Red Data Book (Krasnaya..., 2018) — with **ᴿ**. Each species is accompanied with the list of localities and substrates. Lichen substances are given for HPTLC-analyzed specimens. The information on presence in the neighboring regions is provided for all species. Abbreviations of the neighboring regions are following: Ala — Alaska, Chu — Chukotka Autonomous Area, Kam — Kamchatka Territory (including Commander Islands), Mag — Magadan Region, Yak — Republic of Sakha (Yakutia). References are given after each abbreviation (in brackets), one for each region. For the species unknown in Kam, Chu, Mag, and Yak, the nearest localities in Russia are cited. For the species new to the Russian Far East the most important identification characters are listed.

Amygdalaria pelobotryon (Wahlenb.) Norman — on rock and gravel; 10, 12. — Kam (Himelbrant *et al*., 2014), Mag (Kotlov, 1995), Ala (Thomson, Ahti, 1994).

Cladonia stricta (Nyl.) Nyl. — on soil; 6. Thallus contains atranorin and fumarprotocetraric acid. — Kam (Himelbrant *et al*., 2014), Chu (Andreev *et al*., 1996), Mag (Kotlov, 1995), Yak (Andreev *et al*., 1996), Ala (Spribille *et al*., 2010).

#Corticifraga fuckelii (Rehm) D. Hawksw. et R. Sant. — on thallus of *Peltigera* sp. on soil; 19. — Kam (Himelbrant *et al*., 2014), Yak (Zhurbenko *et al*., 2005), Ala (Spribille *et al*., 2010).

#Diploschistes muscorum (Scop.) R. Sant. — on thallus of *Cladonia* sp. on soil; 21. — Kam (Himelbrant *et al*., 2014), Chu (Andreev *et al*., 1996), Yak (Poryadina, 2005), Ala (McCune *et al*., 2009).

Diplotomma alboatrum (Hoffm.) Flot. — on thallus of *Rusavskia elegans* (Link) S. Y. Kondr. et Kärnefelt on rock; 5. — Kam (Nylander, 1887), Chu, Yak (Andreev *et al*., 1996), Ala (Geiser *et al*., 1998).

!Ephebe hispidula (Ach.) Horw. — on wet rocks; 1, 2. Ala (McCune *et al*., 2009). New to the Russian Far East. The nearest known locality in Russia is in the Irkutsk Region (Lishtva, 2022). The species is characterized by filamentous thallus to 3 cm in diam. with numerous spine-like branchlets (Nordic..., 2007).

Fuscidea mollis (Wahlenb.) V. Wirth et Vězda — on rocks; 15, 20. — Kam (Nylander, 1887), Chu (Andreev *et al*., 1996), Mag (Kotlov, 1995), Yak (Poryadina, 2005), Ala (Fryday, 2008).

!Ionaspis lacustris (With.) Lutzoni — on rock; 9. — Chu (Andreev *et al*., 1996), Yak (Poryadina, 2005), Ala (Spribille *et al*., 2010).

!Lambiella impavida (Th. Fr.) M. Westb. et Resl — on rock; 23. — Ala (Hertel, Andreev, 2003). New to the Russian Far East. The nearest known locality in Russia is in the Novaya Zemlya Archipelago (Andreev *et al*., 1996). The species is characterized by free-living dark, usually glossy thallus, black apothecia usually without central "button", and relatively small spores up to 12 μm long (Foucard, 2001; McCune, 2017).

Lecidea paupercula Th. Fr. — on rock; 23. Thallus contains stictic acid. — Kam (Nylander, 1887), Chu (Andreev *et al*., 1996), Ala (Hertel, Andreev, 2003).

L. tessellata Flörke — on rock; 23. — Kam (Hertel, Andreev, 2003), Chu (Andreev *et al*., 1996), Mag (Kotlov, 1995), Yak (Andreev *et al*., 1996), Ala (Hertel, Andreev, 2003).

!Leciophysma finmarkicum Th. Fr. — on soil over rock; 5. — Chu (Andreev *et al*., 1996), Yak (Poryadina, 2005), Ala (Spribille *et al*., 2010).

[R]Lobaria pseudopulmonaria Gyeln. — on soil; 4. — Kam (Himelbrant *et al*., 2008), Ala (Thomson, Ahti, 1994).

[R]Masonhalea richardsonii (Hook.) Kärnefelt — on soil; 11, 12, 16. — Kam (Himelbrant, Neshataev, 2012), Chu (Andreev *et al*., 1996), Mag (Kotlov, 1995), Yak (Andreev *et al*., 1996), Ala (McCune *et al*., 2009).

!Massalongia carnosa (Dicks.) Körb. — on soil; 9. — Mag (Zhurbenko, 2003), Yak (University..., 2023), Ala (McCune *et al*., 2009).

Peltigera britannica (Gyeln.) Holtan-Hartw. et Tønsb. — on soil; 18. — Kam (Urbanavichus, Urbanavichene, 2004, although without specifying the data source), Ala (Spribille *et al*., 2010).

#Phacopsis huuskonenii Räsänen — on thalli of *Bryoria nitidula* (Th. Fr.) Brodo et D. Hawksw. on soil; 14, 15. — Kam (Zhurbenko *et al*., 2012); Ala (Spribille *et al*., 2010).

Pilophorus robustus Th. Fr. — on rock; 3. — Kam (Mikulin, 1987, 1988); Chu (Andreev *et al*., 1996), Mag (Kotlov, 1995), Yak (Andreev *et al*., 1996), Ala (McCune *et al*., 2009).

#Pronectria erythrinella (Nyl.) Lowen — on thallus of *Peltigera elisabethae* Gyeln. on soil; 21. Kam (Zhurbenko *et al*., 2012), Yak (Zhurbenko, 2009b), Ala (Zhurbenko, Laursen, 2003).

Rhizocarpon cinereovirens (Müll. Arg.) Vain. — on rocks; 15, 20. Thallus contains stictic acid. — Kam (Mikulin, 1988), Mag (Kotlov, 1995), Yak (Andreev *et al*., 1996), Ala (McCune *et al*., 2009).

!R. simillimum (Anzi) Lettau — on rock; 23. New to the Russian Far East. The nearest locality is known in Taimyr area, Severnaya Zemlya (Andreev *et al*., 1996). The species is characterized by grey thallus with I+ blue medulla, and 2-celled dark spores <17 μm long (Foucard, 2001; McCune, 2017).

!Rhizoplaca opiniconensis (Brodo) Leavitt et al. — on rocks; 17 (GenBank accession number: OR475583). Thalli contain usnic acid, cf. isousnic acid, pannarin, fatty acid and xanthone. New to the Russian Far East. The nearest known locality in Russia is in Altai (Szczepańska *et al*., 2020). The species is related to *R. subdiscrepans* (Nyl.) R. Sant. known from the southern part of Russian Far East (e. g., Kuznetsova *et al*., 2022), from which it differs by epruinose apothecia, weakly developed marginal lobes, shape of conidia (not observed in our material), and more orange tinge of thallus (McCune, 2017; Szczepańska *et al*., 2020). Our material generally corresponds to the description, but it contains a fatty acid and cf. isousnic acid, unlike other specimens of the species (see Szczepańska *et al*., 2020).

Rimularia limborina Nyl. — on rocks; 8, 23. — Kam (Nylander, 1887), Ala (Spribille *et al*., 2020).

!#Sclerococcum deminutum (Th. Fr.) Ertz et Diederich — on thallus of *Lopadium coralloideum* (Nyl.) Lynge on primary soil on rocks; 17. — Chu, Yak, Ala (Zhurbenko, 2009a).

Solorina bispora Nyl. — on soil; 7. — Kam (Himelbrant *et al*., 2014), Chu (Andreev *et al*., 1996), Mag (Zheludeva, 2017), Yak (Andreev *et al*., 1996), Ala (Spribille *et al*., 2020).

Umbilicaria polaris (Schol.) Zahlbr. — on rock; 22. — Kam, Yak (Davydov, 2017).

!Vestergrenopsis isidiata (Degel.) E. Dahl — on wet rock; 2. — Ala (Spribille *et al*., 2010). New to the Russian Far East. The nearest known locality in Russia is in the Republic of Buryatia (Makryi, 1999). The species is characterized by rosette-like thallus consisting of radiate lobes with somewhat striate upper surface and laminal isidia (Nordic..., 2007).

Altogether 23 species of lichens and four lichenicolous fungi are new to Koryakia, 9 of them are also new to Kamchatka. Five species are new to the Russian Far East, namely *Ephebe hispidula*, *Lambiella impavida*, *Rhizocarpon simillimum*, *Rhizoplaca opiniconensis*, and *Vestergrenopsis isidiata*.

Taking into account this paper and earlier studies (Himelbrant *et al*., 2018, 2021), 529 species of lichens and allied fungi are currently known from Koryakia. Saxicolous lichens represent most of the species new for Koryakia. This group is most difficult to collect and identify. So, it is little studied in many regions. At the same time, this is one of the most diverse ecological groups in Koryakia: in the current regional list, saxicolous lichens are represented by 211 species (39.9% of the revealed lichen biota). We expect more saxicolous species to occur in Koryakia and Kamchatka in general.

Undoubtedly, the lichen diversity of Koryakia has not been sufficiently studied, and in the future, we expect new finds from different parts of this large and remote northern region. Almost unstudied are the northwestern part of the region, near the Magadan Region border, and its northeastern part, close to Chukotka. However, coastal part of Koryakia, which in general is better studied now, seems to be an area of high biodiversity, and it has a great potential of new lichenological discoveries.

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