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To study of the lichen biota of Chirpoi Island (Sahkalin Region, Kuril Islands)

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The paper contains data on the finds of 10 species of lichens, first discovered on the hard-to-reach volcanic island of Chirpoi (Kuril Islands). Among them, *Cladonia ochrochlora* and *Cladonia subfurcata* are new species for the Kuril Islands, as well as *Cladonia vulcani* and *Cladonia graciliformis,* listed in the Red Data Book of the Russian Federation and the Red Data Book of the Sakhalin Region. Information on the habitats of the species on Chirpoi Island, as well as on their distribution in the Kurils and neighboring regions is provided. Possible causes of the distribution patterns are discussed.

Keywords: lichens, Russian Far East, Red Data Book of the Russian Federation, distribution, ecology, new finds.

The Kuriles are a chain of 56 volcanic islands between the Kamchatka Peninsula and the island of Hokkaido, separating the Sea of Okhotsk from the Pacific Ocean. The islands form two parallel ridges: the Greater Kuriles and the Small Kuriles.

Chirpoi Island, together with Brat Chirpoev Island, is part of the Chernyye Brat'ya subarchipelago and belongs to the southern group of the Great Kuril Islands (Fig. 1).

It is located between two large islands – Urup (1428 km^2) in the south and Simushir (345 km^2) in the north. The Chernyye Brat'ya islands lie on the shallow eastern seabed of Urup. Administratively, Chirpoi is part of the Kuril urban district of the Sakhalin region, uninhabited. Chirpoi covers an area of 21 km^2, the highest point is Chirpoi Mt. (691 m). The island is volcanic in origin. The central part of the island consists of four volcanoes closely merged at the foot, from north to south: Mt. Chirpoi (691 m) and Mt. Chirpoi II, Chernogo (624 m) and Mt. Snow (395 m), the last two of which are active. A narrow sandy spit connects the narrow, long Lapka Peninsula with the island in its northwestern part. The composition of the rocks that make up the volcanic structures on the islands varies from basalts to andesites. The cones of the Chirpoi and Chirpoi II volcanoes are composed of Middle Pleistocene basalts, andesite-basalts, and andesites. Modern lavas of the Chernogo and Snow volcanoes are repre-

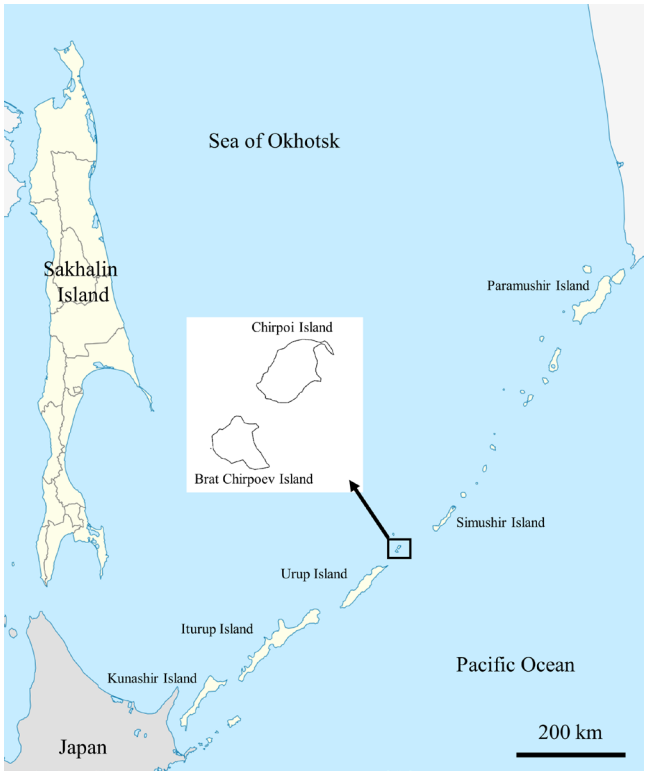

Figure 1. Schematic map showing the location of Chirpoi Island.

Рисунок 1. Схема расположения острова Чирпой.

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sented by andesites. On the Lapka Peninsula, basaltic and andesite-basaltic lavas are noted, and the ridge of this peninsula is covered with a layer of dacitic pumice, apparently associated with caldera-forming eruptions (Gorshkov, 1967; Bondarenko, Rashidov, 2003). Eruptions of the Chernogo and Snow volcanoes and their fumarole activity were repeatedly noted in the 18th-20th centuries (Gorshkov, 1967; Bondarenko, Rashidov, 2003). The last eruption of the Snow volcano was recorded in 2017 (Melnikov et al., 2018).

There are two lakes of lagoon origin in the southwestern part of the island, at a distance of ca. 360 m from each other. The first lake (max. length 157 m, width 100 m) is located on the lower sea terrace (ca. 10-12 m above sea level), only 45-100 m from the coast of the Sea of Okhotsk. The lake appears to be brackish-water. The second lake (max. length 95 m, width ca. 40 m) is located 360 m east of the first, on the edge of the lava flow between the Chernogo and Snow volcanoes, at an altitude of ca. 27 m above sea level (Fig. 2). The lake lies on a marine terrace covered by lavas and volcanogenic lahars.

The island's vegetation was formed under the influence of catastrophic natural phenomena – volcanic eruptions, the lava flows of which periodically completely destroyed all vegetation on their way. Vegetation is best represented in the northeastern and western parts of the island, while in the southern part, due to the recent eruption of the Snow volcano, vegetation is extremely sparse. The latest lava flows and ash fields of Mt. Chernogo and Snow volcanoes are practically devoid of vegetation or covered with open moss-lichen communities with separate pioneer herbaceous plants (*Pennellianthus frutescens* (Lamb.) Crosswh., *Gaultheria miqueliana* Takeda, *Carex flavocuspis* Franch. & Sav.). Old and ancient overgrowing lavas are covered with partially or completely closed plant communities dominated by heather shrubs, grasses, and sedges (Fig. 3).

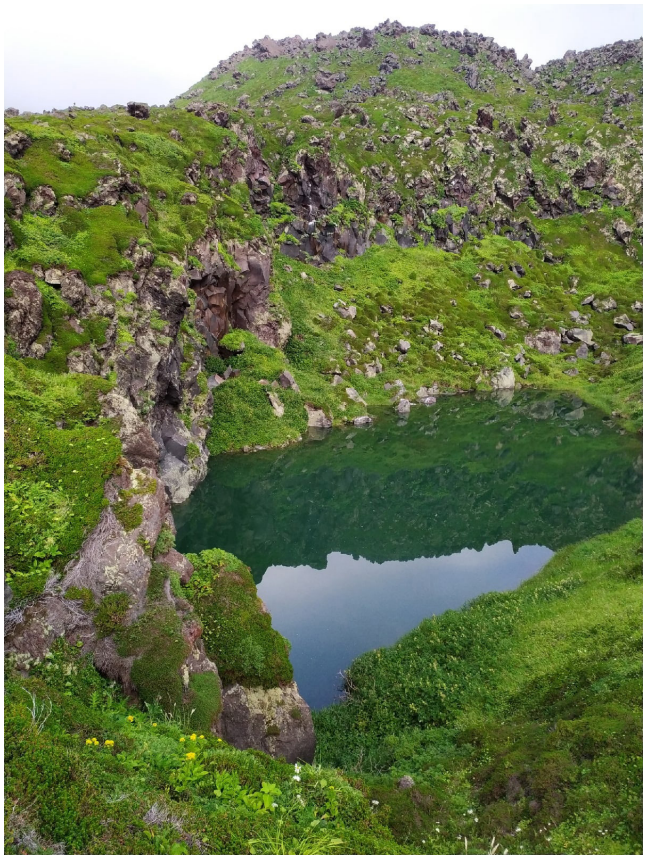

Figure 2. The lake on the edge of the lava flow between the Chernogo and Snow volcanoes. Photo by Elena Glazkova.

Рисунок 2. Озеро на краю лавового потока между вулканами Чёрного и Сноу. Фото Елены Глазковой.

Figure 3. Old overgrowing lavas on Chirpoi are habitats of lichens. Photo by Elena Glazkova.

Рисунок 3. Старые зарастающие лавовые потоки – места обитания многих видов лишайников. Фото Елены Глазковой.

Such tundra-like shrub communities (heaths), dominated by *Empetrum nigrum* subsp. *sibiricum* (V.N. Vassil.) Kuvaev are widespread on exposed, well-drained slopes. Along with *Empetrum nigrum* subsp. *sibiricum,* it is abundant *Vaccinium vitis-idaea* L. *Arcterica nana* (Maxim.) Makino, *Arctous alpina* (L.) Nied., *Cassiope lycopodioides* (Pall.) D. Don, *Diapensia lapponica* var. *obovata* F. Schmidt, *Rhododendron aureum* Georgi, *Rh. diversipilosum* (Nakai) Harmaja, *Luzula kjellmaniana* Miyabe & Kudô, *Avenella flexuosa* (L.) Drejer, *Oxytropis retusa* Matsum., etc. are often found. The participation of mosses and lichens in these communities is also significant. In some places there are willow shrub communities with *Salix nakamurana* Koidz., *S. nakamurana* subsp. *kurilensis* (Koidz.) H. Ohashi, *S. reinii* Franch. & Sav., etc.

The richest and most diverse in floristic composition on the island of Chirpoi are meadows. Small

patches of tall herbaceous meadow with *Cirsium kamtschaticum* Ledeb. ex DC., *Geranium erianthum* DC., *Aconitum maximum* Pall. ex DC., *Parasenecio auriculata* (DC.) J.R. Grant, *Rumex lapponicus* (Hiitonen) Czernov, etc. are marked on wind-sheltered depressions and low wet slopes. *Trollius riederianus* Schipcz., *Lagotis glauca* Gaertn., *Arnica unalaschcensis* Less., *Geum pentapetalum* (L.) Makino, *Solidago multiradiata* subsp. *paramuschirensis* (Barkalov) Vorosch., *Trifolium lupinaster* L., etc. can be found on the slopes of volcanoes in subalpine meadows.

Rich in herbs communities with *Achillea ptarmica* subsp. *macrocephala* (Rupr.) Heimerl, *Pleurospermum uralense* Hoffm., *Oxytropis retusa, Anaphalis margaritaceae* L., etc. were mentioned on marine terraces.

Reed grass (with *Calamagrostis langsdorffii* (Link) Trin.) and American dunegrass (with *Leymus mollis* (Trin.) Pilg.) communities are found on the slopes of volcanoes and marine terraces at the foot of volcanoes. *Hedysarum nonnae* Roskov acts sometimes as a codominant in *Leymus*-communities. Rocky vegetation is represented by communities with the participation of *Arctanthemum arcticum* (L.) Tzvelev, *Stellaria ruscifolia* Pall. ex Schltdl., *Campanula lasiocarpa* Cham., *Cassiope lycopodioides* (Pall.) D. Don, *Rhodiola rosea* L., etc. In the northeastern part of the island in Peschanaya Bay, plant communities of sandy beaches are developed with *Ixeris repens* (L.) A. Gray, *Leymus mollis, Mertensia maritime* (L.) Gray, and *Carex macrocephala* Willd. ex Spreng.

The most significant biogeographic and floristic boundary within the Kuril Archipelago, the boundary between the Circumboreal and East Asian regions, runs north of Chirpoi along the deep-water Bussol Strait according to modern schemes of biogeographic and floristic zoning (Pietsch et al., 2003; Bogatov et al., 2009). The Kuril Islands north of this strait belong to the Okhotsk-Kamchatka province of the Circumboreal region (the Euro-Siberian subregion of the Palearctic); south of the strait – to the East Asian region (Palearchearctic subregion of the Palearctic). The Chernye Brat'ya, together with the Urup and Broughton Islands, are singled out as an independent Urup district, belonging to the Sakhalin-Hokkaido province in both of the above schemes. This area is a transitional zone characterized by a sharp depletion of species diversity and the main overlap of the ranges of East Asian and boreal species (Bogatov et al., 2009).

Chirpoi Island belongs to extremely inaccessible areas, and prior to our studies, information on the lichen biota of the island was practically absent. Only one species of lichens was known from Chirpoi, *Ramalina almquistii* Vain. (Joneson et al., 2004).

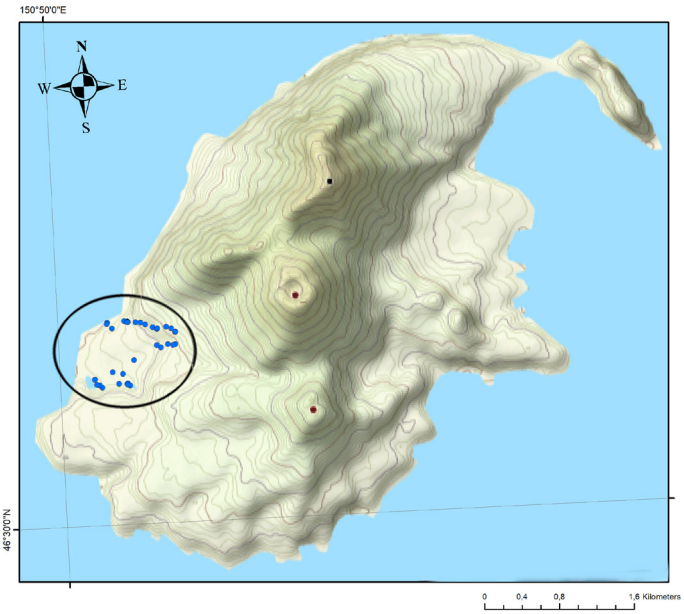

Figure 4. Location of the study area on Chirpoi Island.
Рисунок 4. Район проведения работ на о-ве Чирпой.

Materials and methods

Chirpoi Island was surveyed by the first author using the route method on August 24-25, 2021 and August 20, 2022, as part of the expedition "Eastern Bastion – Kuril Ridge" organized by the Russian Geographical Society and the Expedition Center of the Ministry of Defense of the Russian Federation. Samples of lichens were collected during floristic studies in 2022 in the western part of the island (Fig. 4). They were subsequently identified in the Laboratory of Lichenology and Bryology of the BIN RAS by the second and third authors. The laboratory study was carried out according to the standard technique (Smith et al., 2009; Stepanchikova, Gagarina, 2014) using a binocular stereoscopic microscope MSP 1 var. 2, transmitted light microscope Zeiss Primo Star, a standard set of chemical reagents for carrying out color spots reactions for identification of certain groups of lichen substances in thalli.

Lichen specimens are stored in the lichenological herbarium of the BIN RAS (LE).

Results and discussion

In total, 10 species of lichens belonging to the genera *Baeomyces* and *Cladonia* were identified in the laboratory during the study of 33 specimens. Two lichens could only be identified to the level of the genus, because the material is poorly developed.

All species of lichens are mentioned for Chirpoi Island for the first time. *Cladonia ochrochlora* Flörke

Figure 5. *Cladonia vulcani* Savicz on Chirpoi Island. Photo by Elena Glazkova.

Рисунок 5. *Cladonia vulcani* Savicz on Chirpoi Island. Photo by Elena Glazkova.

and *C. subfurcata* (Nyl.) Arnold are reported for the first time for the Kuril Islands. Among the identified species, *C. vulcani* Savicz (Fig. 5) and *C. graciliformis* Zahlbr. are listed in the Red Data Book of the Russian Federation (Bardunov, Novikov, 2008) and the Red Data Book of the Sakhalin Region (Eremin, Taran, 2019). These are new localities of these species in Russia.

For each species in the list, the location, habitats, sample collection point number, as well as distribution in the Sakhalin Region and in the world according to the literature data are indicated. The nomenclature of lichens mainly follows Ahti, Stenroos (2013), Ohmura, Kashiwadani (2018), Westberg et al. (2021).

New species for the Kuril Islands

Cladonia ochrochlora Flörke

In the Russian Far East, it is known from Kamchatka Peninsula (Himelbrant et al., 2014), Primorsky Krai and the Amur Region (Tchabanenko, 2002), as well as Sakhalin Island (Skirina et al., 2021). The species is widely distributed in the world, more often in regions with an oceanic climate (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′57″N, 150°50′37″E, 34 m a.s.l., at the foot of the Chernogo volcano, ca. 600 m east of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3884 (LE L-25187).

Cladonia subfurcata (Nyl.) Arnold

In the Sakhalin Region the species recorded on Sakhalin Island (Tchabanenko, 2002). In the world it is found in Eurasia and North America, mainly in arctic-boreal regions, in the mountains (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°31′1″N, 150°50′51″E, 65 m a.s.l., between the Chernogo and Snow volcanoes, ca. 840 m east of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3882 (LE L-25182); *ibid.*, 46°30′51″N, 150°50′17″E, 10 m a.s.l., ca. 163 m east of the shore of the Sea of Okhotsk, at the foot of the Snow volcano, near the eastern shore of the coastal lake, on soil, 20 VIII 2022. E.A. Glazkova 3894 (LE L-25186); *ibid.*, 46°30′49″N, 150°50′29″E, 27 m a.s.l., ca. 483 m east of the coast of the Sea of Okhotsk, ca. 106 m west of the northern tip of the lake, on a marine terrace at the foot of the Snow volcano, on soil, 20 VIII 2022, E.A. Glazkova 3890 (LE L-25190); *ibid.*, 46°30′57″N, 150°50′37″E, 34 m a.s.l., at the foot of the Chernogo volcano, ca. 600 m east of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3884 (LE L-25192).

New species for Chirpoi Island

Baeomyces rufus (Hudson) Rebent.

In the Sakhalin Region it was found on Sakhalin (Tchabanenko, 2002) and Shikotan (Chesnokov, Konoreva, 2022) islands. In Russia, it is distributed from arctic to temperate regions. Cosmopolite, found predominantly in temperate and boreal regions (Smith et al., 2009).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′49″N, 150°50′29″E, 27 m a.s.l., ca. 483 m east of the coast

of the Sea of Okhotsk, ca. 106 m west of the northern end of the lake, on a marine terrace at the foot of Snow volcano, on soil, 20 VIII 2022, E.A. Glazkova 3890 (LE L-25196).

Cladonia coccifera (L.) Willd.

In the Sakhalin Region recorded on Sakhalin (Tchabanenko, 2002), Shikotan (Chesnokov, Konoreva, 2022) and Paramushir (Satô, 1936) islands. In Russia, it is distributed from arctic to temperate regions. In the world widespread in arctic-boreal regions and in the mountains (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′51″N, 150°50′17″E, 10 m a.s.l, ca. 163 m east of the coast of the Sea of Okhotsk, at the foot of the Snow volcano, near the eastern shore of the coastal lake, on soil, 20 VIII 2022, E.A. Glazkova 3894 (LE L-25184).

Cladonia coniocraea (Flörke) Spreng.

In the Sakhalin region recorded on the islands of Sakhalin, Kunashir (Tchabanenko, 2002; Bogacheva et al., 2018), Iturup (Chesnokov, Konoreva, 2021), Shikotan (Chesnokov, Konoreva, 2022) and Paramushir (Tchabanenko, 2002). Widely distributed throughout the world from arctic to desert regions and in mountains (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′49″N, 150°50′29″E, 27 m a.s.l., ca. 483 m east of the coast of the Sea of Okhotsk, ca. 106 m west of the northern end of the lake, on a marine terrace at the foot of Snow volcano, on soil, 20 VIII 2022, E.A. Glazkova 3890 (LE L-25195).

Cladonia crispata (Ach.) Flot.

In the Sakhalin Region recorded on the islands of Sakhalin, Paramushir (Tchabanenko, 2002) and Iturup (Tolpysheva, Varlygina, 2021). Globally distributed from arctic to temperate regions (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°31′6″N, 150°50′58″E, 119 m a.s.l., the lower part of the slope of the Chernogo volcano, ca. 593 m southeast of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3878 (LE L-25181); *ibid.,* 46°30′57″N, 150°50′37″E, 34 m a.s.l., the foot of the Chernogo volcano, ca. 600 m east of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3884 (LE L-25188); *ibid.*, 46°30′49″N, 150°50′29″E, 27 m a.s.l., ca. 483 m east of the coast of the Sea of Okhotsk, ca. 106 m west of the northern tip of the lake, on a marine terrace at the foot of the Snow volcano, on soil, 20 VIII 2022, E.A. Glazkova 3890 (LE L-25189).

Cladonia graciliformis Zahlbr.

In the Sakhalin Region recorded on Kunashir, Iturup (Tchabanenko, 2002; Eremin, Taran, 2019), and Paramushir (Eremin, Taran, 2019) islands; also recorded in Kamchatka Peninsula (Bardunov, Novikov, 2008). In the world it is found in Asia and North America in places associated with the activity of volcanoes. Listed in the Red Data Book of the Sakhalin Region (Eremin, Taran, 2019) (2 category) and Red Data Book of Russian Federation (Bardunov, Novikov, 2008) with category 2 a - decreasing in population, species of specific habitats.

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°31′6″N, 150°50′58″E, 119 m a.s.l., the lower part of the slope of the Chernogo volcano, ca. 593 m southeast of the coast of the Sea of Okhotsk, on soil,20 VIII 2022, E.A. Glazkova 3878 (LE L-25197).

Cladonia pyxidata (L.) Hoffm.

In the Sakhalin Region recorded on the islands of Sakhalin and Kunashir (Tchabanenko, 2002). Widespread in the world in arctic-boreal regions, and in the mountains (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′51″N, 150°50′17″E, 10 m a.s.l., ca. 163 m east of the coast of the Sea of Okhotsk, at the foot of the Snow volcano, near the eastern shore of the coastal lake, on soil, 20 VIII 2022, E.A. Glazkova 3894 (LE L-25183, L-25193); *ibid.,* 46°30′49″N, 150°50′18″E, 10 m a.s.l., ca. 215 m east of the coast of the Sea of Okhotsk, at the foot of the Snow volcano, near the SE shore of the coastal lake, on soil, 20 VIII 2022, E.A. Glazkova 3893 (LE L-25194).

Cladonia* cf. *stricta (Nyl.) Nyl.

In the Sakhalin region recorded on the islands of Kunashir (Tchabanenko, 2002) and Shikotan (Chesnokov, Konoreva, 2022). Worldwide found in Eurasia and North America (Ahti, Stenroos, 2013).

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°30′51″N, 150°50′17″E, 10 m a.s.l., ca. 163 m east of the shore of the Sea of Okhotsk, at the foot of the Snow volcano, near the eastern shore of the coastal lake, on soil, 20 VIII 2022, E.A. Glazkova 3894 (LE L-25185).

Cladonia vulcani Savicz

In the Sakhalin region it was found on Kunashir, Iturup and Paramushir islands (Eremin, Taran, 2019). In Russia, the species was also found in Kamchatka Peninsula (Bardunov, Novikov, 2008). The global range of *Cladonia vulcani* is limited to East Asia (Russia, Japan, Korea, Taiwan, Papua New Guinea) and the

island of Iceland (Ahti, Stenroos, 2013). It listed in the Red Data Book of the Sakhalin Region (Eremin, Taran, 2019) (2 category) and Russian Federation (Bardunov, Novikov, 2008) with category 2a – decreasing in population, species of specific habitats.

Specimens examined: Sakhalin Region, Kuril District, western part of Chirpoi Island, 46°31′8″N, 150°50′49″E, 97 m a.s.l., slope at the foot of the Chernogo volcano, ca. 414 m southeast of the coast of the Sea of Okhotsk, on soil, 20 VIII 2022, E.A. Glazkova 3874 (LE L-25191).

Most of the species identified at Chirpoi have extensive distribution areas in the world. Only two species, *Cladonia graciliformis* and *C. vulcani*, are limited in distribution to East Asia and North America. Both of these species have a narrow ecological amplitude and are confined exclusively to specific habitats associated with the activity of volcanoes.

Six identified species (*Baeomyces rufus, Cladonia crispata, C. ochrochlora, C. pyxidata, C.* cf. *stricta, C. subfurcata*) were known from the southern Kuril Islands and (or) Sakhalin. Four species (*Cladonia coccifera, C. coniocraea, C. graciliformis, C. vulcani*) are found not only on the southern Kuril Islands, but are also given for Paramushir, which belongs to the group of the Northern Kuriles. In addition, three of the above-mentioned species, *C. graciliformis, C. ochrochlora* and *C. vulcani,* are also found in Kamchatka Peninsula. Noteworthy is the fact that none of the lichen species found on Chirpoi was found on the Middle Kuriles. On the one hand, this fact may be due to the poor knowledge of the lichen biota of the Middle Kuriles in comparison with the large inhabited islands of the Southern (Iturup, Kunashir, Shikotan) and Northern (Paramushir) groups of the Kuril Islands. On the other hand, it is possible that this feature is explained by the existence in the Pleistocene during the maximum regression of the sea of temporary land bridges between the South Kuriles and Hokkaido, on the one hand, and Paramushir and Kamchatka, on the other hand, which contributed to the migration of species from both southern and northern mainland territories. A similar pattern, when a species is known from the southern and northern Kuriles, but absent from the Middle Kuriles – was pointed out for both vascular plants (Takahashi et al., 1997) and animals (Velizhanin, 1970). Chirpoi and Simushir located 65 km north of it, the southernmost in the Middle Kurils group, are separated by the Bussol Strait, the deepest channel in the Kuril Islands, ca. 2000 m deep, therefore they could scarcely have been connected in the last ice age by land bridges (Takahashi et al., 1997), which prevented the migration of species from the south to the Middle Kuriles. Perhaps this is the reason for the absence in the Middle Kuriles of a number of lichen species found both on Chirpoi and on some of the more southern Kuril Islands.

Thus, Chirpoi Island turned out to be very interesting and promising for lichenological and botanical-geographical research. The data obtained indicate the need for further detailed studies of the lichen biota of the island and the geographical features of the distribution of lichen species on the Kuril Islands.

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К изучению лихенобиоты острова Чирпой (Курильские острова, Сахалинская область)

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Статья содержит данные о находках 10 видов лишайников, впервые обнаруженных на труднодоступном вулканическом острове Чирпой (Курильские острова). Среди них *Cladonia ochrochlora* и *Cladonia subfurcata* – новые виды для Курильских островов, а также *Cladonia vulcani* и *Cladonia graciliformis,* занесенные в Красную книгу Российской Федерации и Красную книгу Сахалинской области. Приведена информация о местообитаниях видов на острове Чирпой, обсуждается их распространение на Курилах и в соседних регионах.

Ключевые слова: лишайники, Дальний Восток России, Красная книга РФ, распространение, экология, новые находки.

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