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## First data on lichens from Matua Island, Far East of Russia. Families *Physciaceae* and *Caliciaceae*

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**Abstract.** The presented work is based on the study of material collected by F.A. Romanyuk in the surroundings of Sarychev Peak active volcano on Matua Island, middle Kurils in 2017. Two families – *Physciaceae* and *Caliciaceae* – were sorted out from the collection and studied at first. As a result, seven species of the families were found: two species of the genus *Rinodina*, two species of the genus *Physcia*, two species of the genus *Buellia* and the species *Tetramelas chloroleucus*. All found species of the studied families were first identified for Matua Island. Matua Island is the northernmost location point in Eurasia for the species *Rinodina ascociscana*. *Buellia badia* is a new registered species for the Sakhalin Region.

**Keywords:** lichens, active volcano, biodiversity, Kurils, Northeast Asia

## Первые сведения о лишайниках с острова Матуа, Дальний Восток России. Семейства *Physciaceae* и *Caliciaceae*

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**Резюме.** Работа основана на исследовании материала лишайников, собранного Ф.А. Романюком в 2017 г. в окрестностях действующего вулкана Пик Сарычева на о. Матуа, средние Курилы. Образцы лишайников собраны в юго-восточной долиненной части острова, которая периодически подвержена влиянию аэральная пирокластике и слабому воздействию парагазовых эмиссий. Главная особенность современных извержений влк. Пик Сарычева – высокая эксплозивность, при которой выбрасываемый вулканом обломочный материал формирует пирокластические потоки. Кроме активности вулкана в кратере иных ее проявлений в пределах острова не отмечено. После обработки первых двух семейств лишайников *Physciaceae* и *Caliciaceae* из коллекции было выявлено 7 видов: 2 вида из рода *Rinodina*, 2 из рода *Physcia* и 2 из рода *Buellia*, а также вид *Tetramelas chloroleucus*. Все найденные виды лишайников в окрестностях вулкана впервые указываются для о. Матуа. Для *Rinodina ascociscana* о. Матуа является самой северной точкой местонахождения вида в Евразии. *Buellia badia* – новый вид для Сахалинской области.

**Ключевые слова:** лишайники, активный вулкан, биоразнообразие, Северо-Восточная Азия

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## Introduction

Matua Island (N 48°05' E 153°13') relates to the middle Kuril Islands, located in the northeastern part of the Pacific Ocean. The climate of the island is cold similar to the northern Kuril Islands with a high rainfall of 1223 mm/year, a predominance of cloud cover, frequent fogs (up to 205 days per year), constant and strong winds\*. Winter is relatively mild (the average monthly temperature of January is  $-6^{\circ}\text{C}$ ), summer is cold – the average temperature of the warmest month (August) is  $+10.9^{\circ}\text{C}$ . Vegetation is boreal-alpine typical for the middle Kurils [1]. Matua is a volcanic island with an area of 50 km<sup>2</sup>, a length of 11 km and a width of 6.5 km. The southeastern part of the island is a rather flat surface and Sarychev Peak active volcano rises in the northwestern part with a height of 1446 m [2]. Matua Island has a rather complex structure. Young pyroclastic flows and lava largely overlap and mask the older parts of the foundation of the island where tertiary rocks lie. There are two types of lava flows on the island: relatively ancient flows (more than 1000 years) and young flows of modern volcanism (up to several hundred years) [2]. The volcano crater is the center of its historical eruptions ( $1765 \pm 5$ , 1878–1879, 1923, 1928, 1930, 1946, 1954, 1960, 1976, 2009, 2017, 2018, 2020, 2021). All of them were terminal and mostly short-lived (first hours, days). The nature of the activity of Sarychev Peak is mainly explosive and explosive-effusive – from weak eruptions of the Vulcanian type to powerful paroxysms of the Subplinian type. The main feature of modern eruptions of Sarychev Peak volcano is their high explosivity in which the clastic material emitted by the volcano forms pyroclastic flows. The products of Sarychev Peak eruptions are dominated by pyroclastics. The part of lava material is sharply subordinated. Pyroclastic formations are represented by an almost complete set of facies typical of modern explosive eruptions of andesite volcanoes (deposits of pyroclastic flows and waves, ash of the flow cloud) [3].

Besides the volcano activity in the crater, no other impacts on the environment within the island were noted. As a result, a volcanic activity influence on the ecosystem components, including lichen cover appears occasionally during eruptive

events: destruction by lava and pyroclastic flows, burying by lahar deposits, suppression by vapor-gas emissions and ashfalls [1]. This paper presents lichen material collected in the southeastern valley part of the island, which is periodically exposed to aerial pyroclastics and the weak effect of vapor-gas emissions.

Earlier only one lichen species – *Ramalina scoparia* Vain. was registered for Matua Island [4]. In this study we represent lichen species of two families – *Physciaceae* and *Caliciaceae* – sorted out from the big collection of lichens made from Matua Island. Totally 7 species were identified from the mentioned families. Two species of the genus *Rinodina*, two species of the genus *Physcia*, two species of the genus *Buellia* and *Tetramelas chloroleucus*. *Buellia badia* is new registered species for the Sakhalin Region. The collection was housed in the herbarium of the Institute of Marine Geology and Geophysics of the Far Eastern Branch of RAS (SAK), and Federal Scientific Center of East Asian Terrestrial Biodiversity of the Far Eastern Branch of RAS (VLA).

## Material and Methods

Herbarium specimens were collected by the third author Fedor A. Romanyuk in 2017 from Matua Island (Fig. 1). Voucher specimens are de-

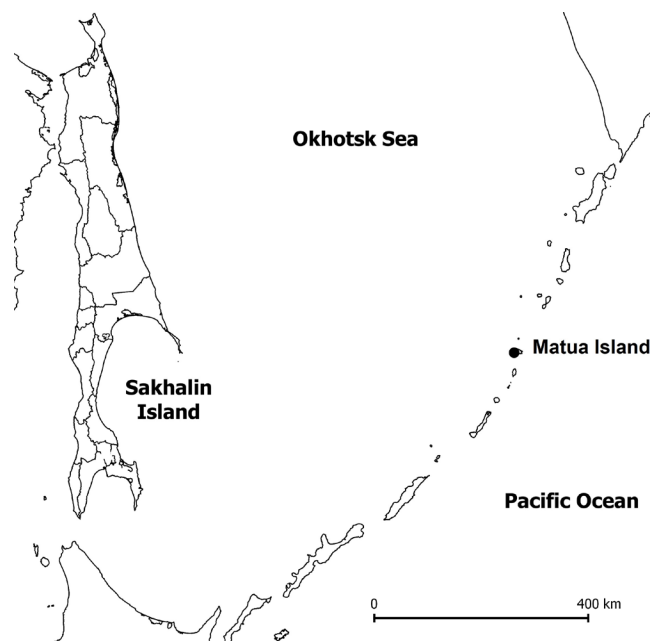


Fig. 1. Map of the study area. Matua Island.

\* [USSR Climate Handbook. Issue 34. Sakhalin region]. 1990. Leningrad, 351 p. (In Russ.)

posited in the herbaria SAK and VLA. Morphological and anatomical characters were analyzed by standard light microscopical techniques. Full label data of examined specimens are provided for every species. A few publications have been used to identify the samples [5–9].

## Results

### The species

#### *Buellia disciformis* (Fr.) Mudd

The species is characterized by crustose thallus, rimose or areolate, slightly verrucose, superficial or sometimes immersed, thin, pale or yellowish grey, often delimited by a black prothallus. Apothecia 0.3–1.3 mm diam., lecideine type, superficial, flat or rarely convex, black. Hymenium to 100  $\mu\text{m}$ , containing numerous oil droplets. Spores *Callispora*-type, 8 in asci, 1-septate, occasionally with two additional false septa, narrowly ellipsoid, sometimes slightly curved; (12)17–26(30)  $\times$  (6.5)7–10(13)  $\mu\text{m}$ . Thallus K+ pale yellow, C–, PD+ pale yellow. The species grows commonly on deciduous and coniferous trees, very often in mixed forests. *B. disciformis* is widely distributed in the Northern Hemisphere mostly in boreal and temperate vegetation zones [10]. *B. disciformis* can be confused with *Tetramelas chloroleucus* but the latter has a positive reaction with C+ orange, *Buellia*-type spores, and absence of oil droplets in the hymenium.

Specimens examined: Matua Island, near takeoff strip, alder forests (*Duschekia fruticosa* (Rupr.) Pouzar), on bark of *D. fruticosa*, alt. 66 m, 48°03'15,25" N, 153°15'11,52" E. 12.06.2017. F.A. Romanyuk. No. 2113 (SAK); *ibid.*, Ainu Bay, sea meadow, on deadwood, alt. 10 m, 48°02'27,61" N, 153°13'41,28" E. 14.06.2017. F.A. Romanyuk. No. 2114 (SAK).

*B. disciformis* was found for the first time in alder forests of Matua Island on soil, deadwood and rock. The species is widely distributed in Russia [11] including Far East – Khabarovskiy, Primorskiy and Sakhalin Regions [12].

#### *Buellia badia* (Fr.) A. Massal.

The species is characterized by crustose thallus, bullate, subsquamulose becoming distinctly squamulose, without prothallus; usually deep chocolate to grey-brown, with thin epine-

cral layer of dead cells. Apothecia 0.3–0.8 mm diam., lecideine type, black, soon sessile on thallus surface. Hymenium to 100  $\mu\text{m}$ , without oil droplets. Spores *Buellia*-type, 8 in asci, 1-septate, (10)12–15(20)  $\times$  6–9  $\mu\text{m}$ . Thallus K–, C–, PD–. The species grows on siliceous rock, roof tiles, on other lichens. The species is registered in Europe, Northern Africa, North America, Asia, Australia, New Zealand. [10, 13]. The species is close to *Dimelaena californica* but distinguished for the presence of norstictic acid in *D. californica*. Asci of both *B. badia* and *D. californica* are different from the typical *Bacidia*-type ascus that is usually observed in *Buellia*. Marbach [14] and Kalb [15] included *B. badia* in the monotypic genus *Monerolechia*, arguing that its ascus structure is significantly different from *Buellia*.

Specimens examined: Matua Island, Ainu Bay, sea meadow, on rock, alt. 10 m, 48°02'27,61" N, 153°13'41,28" E. 14.06.2017. F.A. Romanyuk. No. 2117 (SAK).

*B. badia* was found in sea meadow of Matua Island on rock. The species is widely distributed in Russia [11] including Arctic and Northern Far East. The species is noted in the Sakhalin Region for the first time.

#### *Physcia caesia* (Hoffm.) F  rnrr.

The species is characterized by orbicular to irregular thallus to 7 cm diam., grey – bluish grey, white-dotted, lower surface grey – dark brown with dark rhizines, soralia numerous to 2 mm diam., blue-grey, usually laminal, often capitate and crater-like or rarely marginal and lip-shaped, in older parts soralia often cover the whole upper surface. Apothecia rare, disc to 2 mm, black, grey-pruinose. Ascospores 17–25  $\times$  6–11  $\mu\text{m}$ . Cortex and medulla K+ yellow, PD–. The species grows commonly on calcareous and nitrogen-rich rocks surfaces, including tops of walls, concrete roofs, bird's perching rocks by the sea and lakes, rarely on wood and bases of trees. The species is widely distributed within the arctic, boreal and temperate vegetation zones [10, 13, 16]. *P. caesia* resembles *P. subalbinea* but the species has soralia on top of the lobes and the latter has lip-shaped soralia at lobe tips. The species close to *P. dubia* but the latter is distinguished by a K– medulla, terminal lip-shaped soralia, has narrower and more fragile lobes.

Specimens examined: Matua Island, Yurlova Cape, sea meadow, on soil, alt. 20 m, 48°02'36,70" N, 153°16'05,19" E. 27.06.2017. F.A. Romanyuk. No. 2108 (SAK); *ibid.*, on deadwood. F.A. Romanyuk. No. 2109 (SAK); *ibid.*, Ainu Bay, sea meadow, on deadwood, alt. 10 m, 48°02'27,61" N, 153°13'41,28" E. 14.06.2017. F.A. Romanyuk. No. 2110 (SAK); *ibid.*, on rock. F.A. Romanyuk. No. 2111 (SAK).

*P. caesia* was found in sea meadow of Matua Island on soil, deadwood and rock. The species is widely distributed in Russia [11] including Far East – Khabarovskiy, Primorskiy and Sakhalin Regions [12, 17].

### *Physcia dubia* (Hoffm.) Lettau

The species is characterized by orbicular or irregular thallus to 5 cm diam., loosely adnate, grey-white to darkish grey, usually nonpruinose, with sorediate lobes often ascending and usually radiating, soralia terminal, lip-shaped, whitish to dark grey. Lower surface grey – dark brown with dark rhizines. Matua material is sterile. Cortex K+ yellow (atranorin), medulla K–, PD–. This species usually grows on various types of non-calcareous rocks, concrete surfaces and even on asphalt, roofs, bird-perch stones; dust-impregnated bark and wood in parks and roadsides. The species is widely distributed in boreal and temperate areas of the Northern Hemisphere. It is also known from the southern cold temperate part of South America [12, 13, 16]. *P. dubia* is close to *P. tenella* but lacks the marginal cilia of that species. *P. dubia* also resembles *P. caesia* but distinguished from the species with lip-shaped soralia and the K– medulla.

Specimens examined: Matua Island, Dvoynaya Bay, sea meadow, on rock, alt. 20 m, 48°04'39,07" N, 153°15'45,64" E. 13.06.2017. F.A. Romanyuk. No. 2112 (SAK).

*P. dubia* was found in sea meadow of Matua Island on rock. The species is widely distributed in Russia [11] including Far East – Khabarovskiy, Primorskiy and Sakhalin Regions [11, 12, 18].

### *Rinodina ascociscana* (Tuck.) Tuck.

The species is characterized by large *Physcia*-type spores (22.5)30.0–32.0(39.5) × (10.5)13.5–14.5(17.0) μm of Type A development, ochraceous to brownish, glossy thallus and thalline margin of apothecia often radially cracked. This

species usually grows on bark of coniferous and deciduous trees in mixed and deciduous forests in the south of the Russian Far East, Korea and Japan [9, 19, 20]. *Rinodina ascociscana* can be confused with *R. turfacea* (Wahlenb.) Körb. and differs in its ochraceous to brownish, glossy thallus lacking sphaerophorin and thalline margin of apothecia often radially cracked [7].

Specimens examined: Matua Island, Yurlova Cape, sea meadow, on plant debris and mosses in log, alt. 20 m, 48°02'36,70" N, 153°16'05,19" E. 27.06.2017. F.A. Romanyuk. (VLA).

*R. ascociscana* was found in sea meadow of Matua Island on plant debris and mosses on log. It is the northernmost point where this species is found in Eurasia. In Russia, *R. ascociscana* was recently found in Primorye Territory, Kuril Islands and Sakhalin Island [9, 19, 20]. It was found on Honshu Island in Japan, on Jeju Island in Korea and in eastern North America [7, 9, 21].

### *Rinodina turfacea* (Wahlenb.) Körb.

*Rinodina turfacea* is characterized by brownish-grey thallus, large apothecia with concave or plane disc, persistent thalline margin containing crystals of sphaerophorin, *Physcia*-type spores (22.0)27.5–29.5(35.0) × (10.5)12.5–13.5(15.5) μm of Type A development [7]. *R. turfacea* can be confused with *R. cinereovirens* Vain. But *R. cinereovirens* differs by more broadly ellipsoid spores with more bluntly rounded apices. Furthermore, *R. cinereovirens* inhabits bark and wood, in contrast to *R. turfacea* which typically grows on decaying ground vegetation, less often on wood in oroarctic environments in North America [9].

Specimens examined: Matua Island, Yurlova Cape, sea meadow, on plant debris, alt. 34 m, 48°04'14,29" N, 153°15'52,32" E. 11.06.2017. F.A. Romanyuk. (VLA); *ibid.*, Ainu Bay, sea meadow, on deadwood, alt. 10 m, 48°02'27,61" N, 153°13'41,28" E. 14.06.2017. F.A. Romanyuk. (VLA).

*Rinodina turfacea* was found in sea meadow of Matua Island on deadwood and plant debris. It is mainly northern circumpolar species restricted to the Arctic and Subarctic territories in Eurasia from Scandinavia to Kamchatka Peninsula with southernmost locations in the Mongolian and Chinese parts of the Altai [9, 12, 20, 22–29]. In North America, it is common in the Arctic, southward to

the Rocky Mountains in Montana and Wyoming, also in the state of Colorado [7].

### *Tetramelas chloroleucus* (Körb.) A. Nordin

The species is characterized by crustose thallus, granular areolate, moderately thickened, ±continuous or becoming dispersed; prothallus: absent, usually dark grey to pale grey, fresh material is often greenish. Apothecia 0.3–0.8 mm diam., lecideine type, black, soon sessile on thallus surface. Hymenium to 100 µm, with sparse oil droplets. Spores *Callispora*-type, 8 in asci, 1-septate, (10)16–21(23) × 6–9(11) µm. Thallus K+ yellow, C+ orange or C–, PD–. The species grows on coniferous and deciduous trees in montane and subalpine forests. The species is widely distributed throughout North America, Europe and Asia [13]. The species is close to *Buellia erubescens*. Both species have comparatively narrow spores of the *Callispora*-type but *B. erubescens* has broadly ellipsoid spores and normally K+ red reaction (crystals) with thallus.

Specimens examined: Matua Island, near takeoff strip, alder forests (*D. fruticosa*), on bark of *D. fruticosa*, alt. 66 m, 48°03'15,25" N, 153°15'11,52" E. 12.06.2017. F.A. Romanyuk. No. 2115, 2116 (SAK).

*Tetramelas chloroleucus* was found in alder forests of Matua Island on bark of *D. fruticosa*. The species is widely distributed in Asian part of Russia including south of Far East [11].

## Conclusion

The revealed species of the families Physciaceae and Caliciaceae collected on Sarychev Peak volcano and in its surroundings mostly belong to widespread and common species in the region. No rare or threatened species was found among sorted lichens of the investigated families. All studied lichens can be considered as pioneer species which inhabit occasionally rejuvenated substrates which periodically exposed to eruptive events: destruction by lava and pyroclastic flows, burying by lahar deposits, suppression by vapor-gas emissions and ash falls. The main substrates of the collected lichens were deadwood, soil, rocks and bark of *Duschekia fruticosa* widespread on the island. The effect of vapor-gas emissions is rather weak on lichen cover in the place – the southeastern valley

part of Matua Island. The main damage source on lichens in surroundings of Sarychev Peak active volcano is exposure by aerial pyroclastics from activity of the crater. No other impacts on the environment within the island were noted.

It is worth noting that volcano islands of the Middle Kurils are still poorly studied. *Buellia badia* which is new species for Sakhalin Island is good example of the evidence of unexplored territory and a reason to continue investigation.

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