

## Addition to the lichen biota of Franz Josef Land archipelago

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### Abstract

Forty-four new lichen species and one lichenicolous fungus have been identified as a result of studies of the lichen biota of the Franz Josef Land archipelago. *Bryocaulon hyperboreum* was reported for the first time from Russia. *Gyalecta hypoleuca* and *Umbilicaria maculata* were first identified in the Arctic. *Arctocetraria andrejevii*, *Brodoa oroarctica*, *Candelariella borealis*, *Cercidospora stereocaulorum*, *Massalongia carnosus*, *Miriquidica nigroleprosa*, *M. plumbeoatra*, *Myriolecis zosterae* var. *palanderi* and *Polyblastia gothica* are new to the Arkhangelsk Region; and *Arthrorhaphis citrinella*, *Mycoblastus alpinus*, *Racodium rupestre*, *Rhizocarpon ferax*, *Scytinium intermedium*, *Stereocaulon glareosum* are new to the Arctic part of the Arkhangelsk Region. Species new to Arkhangelsk Region, Arctic and Russia are supplied with information on distribution in neighboring regions and world and on differences from closely related species. The checklist of the Franz Josef Land archipelago thus includes 277 species and 6 varieties of lichenized and 43 lichenicolous fungi to date.

**Key words:** Arctic, Arkhangelsk Region, lichenized fungi, new records

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## Introduction

The history of lichenological research on the Franz Josef Land archipelago dates back about 120 years. The most important investigation of the archipelago took place in the period from the 90s of the 19<sup>th</sup> century to the 30s of the 20<sup>th</sup> century by the Jackson-Harmsworth expedition in 1894–1897 (Fischer 1899), Polar expedition Luigi Amadeo of Savoy Duke of Abruzzi in 1899–1900 (Mattiolo and Belli 1903), the Russian "Yermak" expedition in 1901 (Elenkin and Savicz 1912), and "Sedov" expedition in 1929 (Savicz 1932), and Norwegian expedition in 1930 (Lyng 1931). Significant material was collected on 14 islands of the archipelago, which still serves as the basis for a number of taxonomic studies (*e.g.*, Vitikainen 1994, Zhurbenko and Santesson 1996, Halonen *et al.* 2009, Zhurbenko 2009, Kukwa and Zhurbenko 2010) and generalizing checklists (Andreev *et al.* 1996, Kristinsson *et al.* 2010). An insignificant contribution to the study of lichens was made during the geobotanical

study of Alexandrova (1969, 1977, 1981, 1983) on the Alexandra Land Island. New data on the diversity of lichens in the archipelago were obtained thanks to geobotanical research by S. S. Kholod, where he collected lichens on 24 islands, and revisions of the unstudied collections of V. P. Savich (Konoreva *et al.* 2019a). Due to a great distance from the mainland, the archipelago remains one of the poorly studied territories in the Arctic. Strong fragmentation of the territory into small islands (about 192 islands) and the difficulty of moving between the islands, as well as harsh conditions contribute to still insufficient bioecological studies of lichens at the Franz Josef Land as well. Currently, the checklist includes 234 species and 6 varieties of lichenized and 42 lichenicolous fungi (Savicz 1932, Lyng 1931, Andreev *et al.* 1996, Kristinsson *et al.* 2010, Konoreva *et al.* 2019a). This paper is a follow-up study of lichen biodiversity in the Franz Josef Land archipelago.

## Material and Methods

### Study area

The Franz Josef Land archipelago administratively belongs to the Arkhangelsk region and is located in the northern part of the Barents Sea within 79°55'–81°51' N and 44°50'–65°30' E. It includes more than 190 islands with a total area 16 134 km<sup>2</sup>. The surface of most of the islands of the Franz Josef Land archipelago is plateau-like. Average heights range 400–490 m a. s. l., and the highest point of the archipelago reaches 620 m a. s. l. It is located on the Wiener Neustadt Island. Most of the islands are covered with glaciers (about 85% of the area of the archipelago). Only small areas of the coastal plains are ice-

free. Many lakes are located on glacier-free places. The islands are mainly composed of sandstones, siltstones, and limestones overlain by an effusive sequence of horizontal basalt sheets. Permafrost occurs over the entire surface of the islands. The climate of the archipelago is typically arctic. Cold period lasts 8–10 months. In June, the maximum temperature is +1.6°C. January is characterized by a temperature of –24°C. The wind in the archipelago can reach speeds of up to 40 m/s. The average annual rainfall is 400–500 mm (Govorucha 1968, Dzhenyuk 2014).

### Data collection

The material was collected in 2019 by Liudmila A. Konoreva (LK), Sergey V. Chesnokov (SC) on Alexandra Land, George Land, Ziegler, Kuhn, Jackson and Hooker islands (Fig. 1). The collection of material was carried out by the route method, mainly in coastal areas, which are typical of rocky outcrops, rubble and/or moss-lichen tundras, wetlands and polar deserts (Fig. 2). The area and time of study of lichens on each of the islands was limited by weather conditions and the proximity of the polar bear. In total, about 1000 specimens of mainly terricolous and saxicolous lichens were collected. Additionally, lichens growing on mosses and plant debris were collected. We analyzed morphology and anatomy of the lichens using a binocular stereoscopic microscope MBS-10 (JSC LZOS, Russia), transmitted light microscope Zeiss Primo Star (Zeiss, Germa-

ny) and chemical tests (Smith et al. 2009). The presence or absence of olivetoric and physodic acids in the genus *Briocaulon* was checked using thin layer chromatography with solvent system A (Orange et al. 2001). The voucher specimens are deposited at the herbarium of the Komarov Botanical Institute RAS (LE), the Altai State University (ALTB) and the Institute of Experimental Botany V. F. Kuprevich National Academy of Sciences of Belarus (MSK-L).

In the species list, the nomenclature of taxa generally follows Westberg et al. (2021). For each species the substrates and localities of collection are specified. Species new to the Arkhangelsk Region, Arctic and Russia are supplemented with information on distribution in neighboring regions and world and the differences from closely related species.

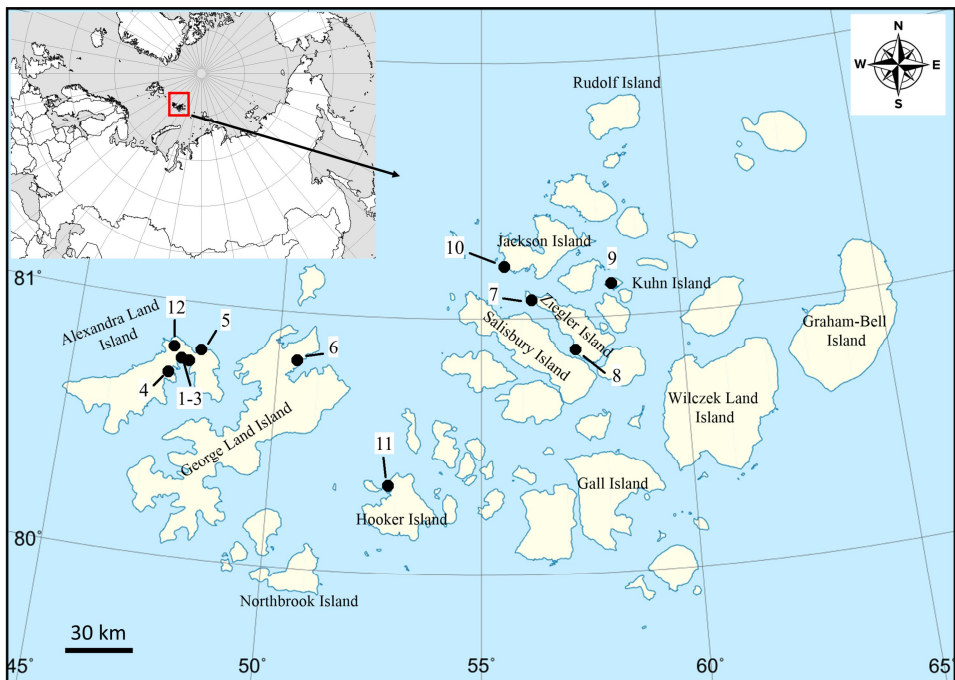
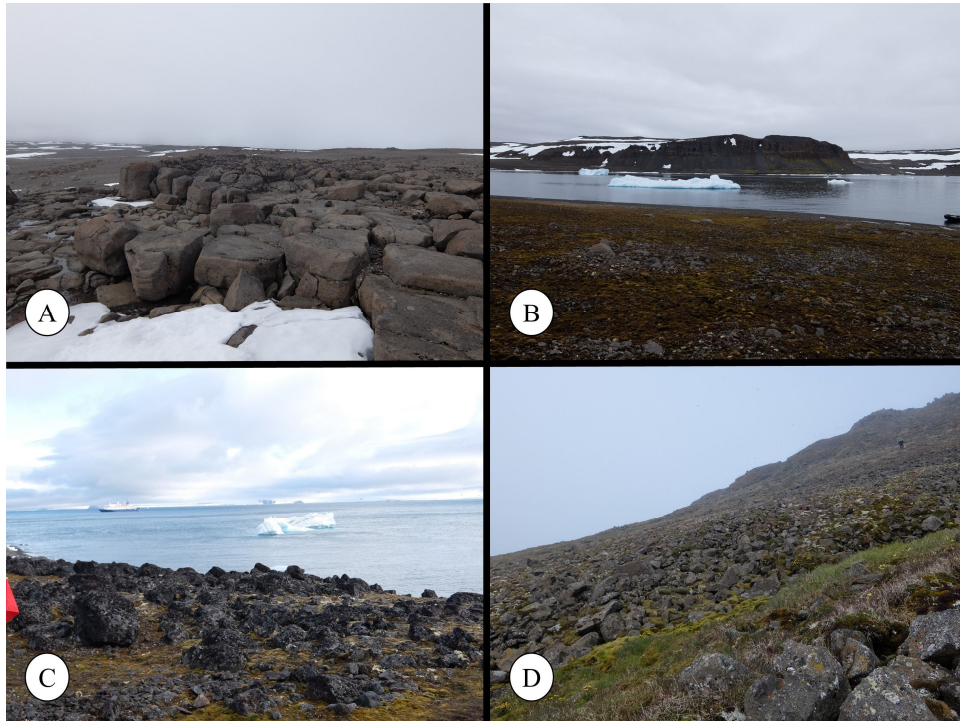


Fig. 1. Location of sampling sites on Franz Josef Land archipelago [1].



**Fig. 2.** Coastal communities of the Franz Josef Land archipelago. A – large boulders on the shore on Alexandra Land Island, B – moss-lichen tundra on George Land Island, C – moss-lichen community near rocks on Jackson Island, D – moss-lichen slope with stones under seashore colony of birds on Hooker Island.

### **List of the studied locations on Franz Josef Land archipelago:**

1. Alexandra Land Island, Severnaya Bay, vicinity of the Omega Base, 80°46'44.4"N, 47°43'07.5"E, alt. 30 m, polar desert with depressions occupied by mosses, 11 VII 2019.
2. ibidem, 80°46'36.4"N, 47°48'00.9"E, alt. 15 m, rubble-moss-lichen community on the shore, 13 VII 2019.
3. ibidem, 80°46'36.1"N, 47°48'35.0"E, alt. 14 m, large boulders on the shore, 14 VII 2019.
4. ibidem, Ostrovnaya Bay, opposite Dvoynoy Cape, 80°43'17.7"N, 47°24'58.4"E, alt. 20 m, stone rubble-lichen tundra, 15 VII 2019.
5. ibidem, Zveroboyev Bay, 80°48'30.0"N, 48°07'30.6"E, alt. 5 m, stone rubble-lichen tundra on sea shore, 17 VII 2019.
6. George Land Island, Armitidzh Peninsula, Geografov Bay, 80°48'14.3"N, 50°28'25.6"E, alt. 5 m, moss-lichen tundra, 23 VII 2019.
7. Ziegler Island, vicinity of Bryce Cape, site of the former Austrian camp, 81°04'01.0"N, 56°17'39.0"E, alt. 9 m, polygonal tundra, gravelly areas with moss-lichen cover, 25 VII 2019.

8. *ibidem*, in the area of the Rods Strait, 80°52'28.4"N, 57°17'17.6"E, alt. 3 m, in the area of seashore colony of birds, swampy moss-lichen tundra with *Salix polaris*, 25 VII 2019.
9. Kuhn Island, 81°06'47.2"N, 58°19'13.1"E, alt. 2 m, finely polygonal moss-lichen tundra on the shore, 26 VII 2019.
10. Jackson Island, Cape Norvegia, 81°12'04.1"N, 55°33'27.6"E, alt. 7 m, moss-lichen community near rocks, 27 VII 2019.
11. Hooker Island, Sedov Cape, Tikhaya Bay polar station, 80°20'18.7"N, 52°47'27.6"E, alt. 10 m, moss-lichen slope with stones under seashore colony of birds, 29 VII 2019.
12. Alexandra Land Island, vicinity of the Nagurskaya Base, 80°49'12.8"N, 47°27'11.7"E, alt. 10 m, anthropogenically disturbed tundra, 6 VIII 2019.

## Results and Discussion

In total, we have identified 44 species of lichenized and one lichenicolous fungi new to the Franz Josef Land archipelago (*see* the below List of species). Most of the identified species are widespread in the Arctic and are known in neighboring regions – Novaya Zemlya, Svalbard, Murmansk region. *Bryocaulon hyperboreum* is new to Russia, and *Gyalecta hypoleuca* and *Umbilicaria maculata* – new to Arctic. Nine species (*Arctocetraria andrejevii*, *Brodoa oroarctica*, *Candelariella borealis*, *Cercidospora stereocaulorum*, *Massalongia carnosus*, *Miriquidica nigroleprosa*, *M. plumbeoatra*, *Myriolecis zosteræ* var. *palanderi*, and *Polyblastia gothica*) are new to the Arkhangelsk Region; and six species (*Arthrorhaphis citrinella*, *Mycoblastus alpinus*, *Racodium rupestre*, *Rhizocarpon ferax*, *Scytinium intermedium*, and *Stereocaulon glareosum*) are new to the Arctic part of the Arkhangelsk Region.

Thus, the checklist includes 277 species and 6 varieties of lichenized and 43 lichenicolous fungi.

In the species list the following symbols and abbreviations are used:

“+” – lichenicolous fungus;

“#” – new to the Arctic part of the Arkhangelsk Region;

“\*” – new to Arkhangelsk Region;

“\*\*\*” – new to Arctic;

“!” – new to Russia.

## The list of species

*Adelolecia kolaensis* (Nyl.) Hertel & Rambold – on siliceous stones, 1, 2, 7, 11, LE.

*Amundsenia approximata* (Lyng) Søchting et al. – on small grave, 1, 6, LE.

\**Arctocetraria andrejevii* (Oxner) Kärnefelt & A. Thell – on soil among mosses, 6, 7, LE. – The species is widespread in northern Asia (Kristinsson et al. 2010), but rare in North-West European Russia. Distribution in neighboring regions: Nenets Autonomous Area (Kulyugina 2013), Republic of Komi (Pystina 2019) and Norway (Westberg et al. 2021). Morphologically it is similar to *Cetraria islandica* Ach. but distinguished by punctate rare whitish pseudocyphellae and sparse and short marginal projections (Thell and Kärnefelt 2011).

#*Arthrorhaphis citrinella* (Ach.) Poelt – on soil among stones, 3, LE.

*Athallia holocarpa* (Hoffm.) Arup et al. – on siliceous stone, 11, LE.

*Biatora subduplex* (Nyl.) Räsänen ex Printzen – on soil and plant debris, 6, 9, LE.

\**Brodoa oroarctica* (Krog) Goward – on siliceous stones, 1, 7, 10, 11, LE. – Distribution in neighboring regions: Svalbard (Øvstedal *et al.* 2009), Murmansk Region (Urbanavichus *et al.* 2008), Yamalo-Nenets Autonomous Area (Zhurbenko 1999) and Severnaya Zemlya (Kristinsson *et al.* 2010). It is characterized by loosely attached thallus with irregularly spreading by torulose lobes and the presence of physodic acid (C+ and KC+ red) and traces of protocetraric acid (Pd+ orange near the lobe tips) (Thell and Westberg 2011).

!*Bryocaulon hyperboreum* Øvstedal (Fig. 3) – on soil, 10, 11, LE L17585. – It was described from Svalbard and was known from the Svalbard and Greenland until now (Øvstedal *et al.* 2009). The studied samples do not contain substances determined by TLC. *Bryocaulon hyperboreum* is very similar to *B. divergens* (Ach.) Kärnefelt, but the latter is distinguished by the presence of olivetoric acid, distinct, conspicuous pseudocyphellae, and a large angle between branches at the top of the thallus (*B. divergens* –  $78 \pm 5^\circ$ ; *B. hyperboreum* –  $65 \pm 7^\circ$ ) (Øvstedal *et al.* 2009).



**Fig. 3.** New species to Russia – *Bryocaulon hyperboreum* Øvstedal. Scale bar = 2 mm.

\**Candelariella borealis* M. Westb. (Fig. 4A) – on soil, 7, LE. – Distribution in neighboring regions: Svalbard (Konoreva *et al.* 2019b, Konoreva and Chesnokov 2021), and Taymyr Peninsula (Kristinsson *et al.* 2010). It is closely related to *C. placodizans* (Nyl.) H. Magn. from which it differs in the larger and darker yellow thallus with a smooth surface (Westberg 2007).

*Catapyrenium daedaleum* (Kremp.) Stein – on soil, 10, LE.

- \*+*Cercidospora stereocaulorum* (Arnold) Hafellner – on phyllocladia of *Stereocaulon* sp., 6, LE. – Distribution in neighboring regions: Svalbard, Murmansk Region, Nenets Autonomous Area, Yamalo-Nenets Autonomous Area, Severnaya Zemlya (Zhurbenko 2010).
- \*\**Gyalecta hypoleuca* (Ach.) Zahlbr. – on sandstone underside, 7, LE. – Rare species. Known mainly from Europe and the Republic of Adygea (Urbanavichus and Urbanavichene 2014, Gagarina 2015). Here we report the species for the second time for Russia, constituting a considerable northern range extension for the species. *Gyalecta hypoleuca* is characterized by a thin (up to 0.4 mm thick), entire, fissured or areolated thallus, developed thallus margin and ascospores 3-9-septate (Gagarina 2015).
- Hymenelia arctica* (Lynge) Lutzoni – on siliceous stone, 9, LE.
- Hypogymnia austerodes* (Nyl.) Räsänen – on siliceous stone, 10, LE.
- Hypogymnia subobscura* (Vain.) Poelt – on soil, 10, LE.
- Lecidea plana* (J. Lahm) Nyl. – on siliceous stone, 6, LE.
- Lecidella wulfenii* (Hepp) Körb. – on plant debris, 11, LE.
- Leciophysma finmarkicum* Th. Fr. – on soil, 6, 10, LE.
- Leptogium saturninum* (Dicks.) Nyl. – on siliceous stone, 10, LE.
- Lobaria linita* (Ach.) Rabenh. (Fig. 4B) – on soil, 8, LE.
- \**Massalongia carnosia* (Dicks.) Körb. – on mossy stone, 10, LE. – Distribution in neighboring regions: Svalbard (Øvstedal et al. 2009), Murmansk Region (Urbanavichus et al. 2008). Morphologically, the species is very similar to members of the Pannariaceae, especially to *Fuscopannaria praetermissa* (Nyl.) P. M. Jørg., but is distinguished by thallus, with smooth, often glossy upper surface, preference for mossy, moist, acidic rocks and soils and the absence of lichen substances (Jørgensen 2007).
- Miriquidica griseoatra* (Flot.) Hertel & Rambold – on siliceous stone, 6, LE.
- \**Miriquidica nigroleprosa* (Vain.) Hertel & Rambold – on siliceous stone, 7, LE. – Distribution in neighboring regions: Svalbard (Øvstedal et al. 2009), Murmansk Region (Urbanavichus et al. 2008), Polar Ural (Kristinsson et al. 2010). The species is characterized by a dark gray thallus, consisting of shiny convex areoles with dark blue-grey soralia on the upper surface (Smith et al. 2009).
- \**Miriquidica plumbeoatra* (Vain.) A. J. Schwab & Rambold – on siliceous stone, 11, LE. – Distribution in neighboring regions: Murmansk Region (Urbanavichus et al. 2008). The species differs from other species of the genus in dark gray thallus with rusty spots, immersed or slightly sessile apothecia with a thin true exciple and the absence of lichen substances (Andreev 2003).
- #*Mycoblastus alpinus* (Fr.) Th. Fr. ex Hellb. – on mosses, 11, LE.
- \**Myriolecis zosteræ* var. *palanderi* (Vain.) Śliwa et al. – on plant debris, sandstone, siliceous stones, 10, 11, LE. – Distribution in neighboring regions: Svalbard (Konoreva and Chesnokov 2022). *Myriolecis zosteræ* var. *palanderi* differs from the *M. zosteræ* var. *zosteræ* (Ach.) Śliwa et al. by the moderately to heavily pruinose apothecial disc which is also predominantly dark coloured (Śliwa 2007).
- Nephroma expallidum* (Nyl.) Nyl. – among mosses, 7, 8, LE.
- Ochrolechia grimmiae* Lynge – on mosses, 7, LE.
- Orphniospora moriopsis* (A. Massal.) D. Hawksw. – on siliceous stone, 7, LE.
- Physcia tenella* (Scop.) DC. – on siliceous stones, 10, MSK-L.
- Placopsis gelida* (L.) Linds. (Fig. 4C) – on small siliceous stone, 7, 12, LE.
- Placynthium asperellum* (Ach.) Trevis. – on sandstones, 4, 5, LE.

*Polyblastia bryophila* Lönnr. – on soil, 6, LE.

\**Polyblastia gothica* Th. Fr. – on soil, 8, LE. – Distribution in neighboring regions: Svalbard (Øvstedal *et al.* 2009), Murmansk Region (Urbanavichus and Fadeeva 2013), Severnaya Zemlya (Zhurbenko and Matveeva 2006). *Polyblastia gothica* is similar to *Agonimia gelatinosa* (Ach.) M. Brand & Diederich by dark subgelatinous thallus, but is distinguished by slightly immersed perithecia (*Polyblastia gothica* – one-quarter to one-half, *Agonimia gelatinosa* – one-half to fully immersed) and smaller ascospores (*Polyblastia gothica* –  $15\text{--}28 \times 7\text{--}15 \mu\text{m}$ , *Agonimia gelatinosa* –  $25\text{--}75 \times 12\text{--}30 \mu\text{m}$ ) (Øvstedal *et al.* 2009, Smith *et al.* 2009).

*Protomicarea alpestris* (Sommerf.) McCune – on soil, 11, LE.

#*Racodium rupestre* Pers. – on soil, 11, LE.

*Rhexophiale rhexoblephara* (Nyl.) Hellb. (Fig. 4D) – on soil, 11, LE.

*Rhizocarpon eupetraeoides* (Nyl.) Blomb. & Forssell – on siliceous stone, 11, LE.

#*Rhizocarpon ferax* H. Magn. – on siliceous stone, 7, LE.

*Scytinium imbricatum* (P. M. Jørg.) Otálora *et al.* – on soil, 6, LE.

#*Scytinium intermedium* (Arnold) Otálora *et al.* – on soil, 10, LE.

*Sporastatia polyspora* (Nyl.) Grumann – on siliceous stone, 7, LE.

*Sporodictyon schaeererianum* A. Massal. – on soil, 10, LE.

#*Stereocaulon glareosum* (Savicz) H. Magn. – on soil, 10, 11, LE.



**Fig. 4.** New species for the Franz Josef Land archipelago: A – *Candelariella borealis* M. Westb., B – *Lobaria linita* (Ach.) Rabenh., C – *Placopsis gelida* (L.) Linds., D – *Rhexophiale rhexoblephara* (Nyl.) Hellb.



\*\**Umbilicaria maculata* Krzew. et al. (Fig. 5) – on siliceous stones, 1, 2, ALTB. – Rare species. *Umbilicaria maculata* was recently described from Europe (Krzewicka et al. 2009). It is known from Russia from the Altai Territory, the Republic of Altai and Kabardino-Balkaria (Davydov et al. 2019). It is characterized by having a monophyllous, flattened, maculate thallus adhering to the substratum, with sparse or lacking cilia, and sessile omphalodisc apothecia with crenulated margin (Krzewicka et al. 2009).



**Fig. 5.** Upper surface of *Umbilicaria maculata* Krzew. et al. with maculae and apothecia. Scale bar = 5 mm.

### EXCLUDED TAXA

*Alectoria nigricans* var. *tschuctschorum* Vain. - This species was published by Savicz (1932) from Hooker Island (Sedov Cape). However, during the revision of *Alectoria* Ach. in the LE the specimen was redefined by I. S. Stepanchikova and D. E. Himelbrant as *Bryocaulon hyperboreum*.

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