

# Rare lichens, mosses, liverworts and fungi from the Republic Sakha (Yakutia), Russia

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**Abstract:** The Republic of Sakha (Yakutia) is situated in the north-east of Siberia. The area of Yakutia (3 103 200 km<sup>2</sup>) occupies one-fifth of the Russian Federation's territory. In total 1984 species of vascular plants, 523 of mosses, 199 of liverworts, 703 of lichens, 911 of fungi and 2476 of algae are known in Yakutia. Among them 19 species of vascular plants, 6 of mosses, 8 of liverworts, 2 of lichens, and 2 species of fungi are included in the Red Data Book of the Russian Federation (2008). In this study all currently available information about locations of red-listed mosses, hepatics, lichens, and fungi on the territory of the Sakha Republic, is provided. Diverse climatic and edaphic conditions of Yakutia provide a wide range of ecological niches for the growth of species of different ecological requirements. Most of the rare species included in the Red Data Book of Russian Federation have narrow ecological amplitude. Majority of the species was recorded in mountain ecosystems on rocky outcrops, especially on limestone, at the banks of rivers and streams, and in old-growth boreal forests.

## INTRODUCTION

The flora of Yakutia numbers 1984 species of vascular plants, 523 of mosses, 199 of liverworts, 703 of lichens, 911 of fungi and 2476 of algae (Danilova, 2005; Troeva et al., 2010). The most vulnerable components of biological diversity are the species with narrow ecological specialization, disjunctive distribution, and low potential for self-sustaining populations. Many of them are very sensitive to the anthropogenic impact on ecosystems. For the species rare in nature, or reducing in the number and area, there are targeted measures for conservation. The most important of them includes compilation of Red Data Books. Lists of rare representatives of the kingdoms of plants and fungi, included in the Red Data Book of the Russian Federation (2008) and found on the territory of Yakutia comprise 19 vascular plant, 6 moss, 8 liverwort, 2 lichen, and 2 fungi species. Outside Russia very little is known about biodiversity of the enormously extensive ecosystems of Yakutia. Most botanical works concerning Yakutia have been published in Russia and in Russian. This significantly hampers the distribution of unique and interesting information abroad. The paper contains all the currently available information about the locations of these rare species, which are included in the Red Data Book of the Russian Federation.

## Study area

The Republic of Sakha (Yakutia) is situated in the north-east of Siberia. The area of Yakutia (3 103 200 km<sup>2</sup>) makes up one-fifth of the Russian Federation's territory. The territory stretches for 2000 km north to south, and 2500 km west to east. Over 40% of the region is beyond the Polar Circle. The territory of Yakutia consists of two large geomorphologic areas: the plateau and folded areas. The latter, represented by mountains and high tablelands, covers two thirds of the territory and is largely centered in the north-east, east and south-east of the republic. Tablelands and plateaus are located in Western Yakutia, while the northern and central regions are characterized by vast depressions. Vegetation comprises several natural zones, from the arctic deserts to the middle taiga with the elements of the southern taiga (Troeva et al., 2010).

Arctic vegetation covers 26%, boreal 74% of the territory (Andreev et al., 1987). The tundra zone of Yakutia covers 394.3 thousand km<sup>2</sup>, i.e. about 13% of the territory of the republic. The region includes all the islands of the Arctic Ocean and the zone along the continental coastline of 120–150 km width. The zone is widest at the Lower Alazeya, Indigirka, Yana and Anabar Rivers (up to 300 km), and narrowest (up to 50 km) at the Kolyma River mouth and near the Buor-Khaya Bay. In the northernmost islands

of the Arctic Ocean the vegetation is represented mostly by arctic deserts and semi-deserts, significant areas of which are covered with rocks and gravel. Along the whole coastline of the Arctic coastal meadows with *Puccinellia phryganodes*, *Carex subspathacea* and *Calamagrostis deschampsoides* are found, grading into the typical arctic and subarctic tundra towards the interior. Significant areas in lake depressions, river valleys and deltas are covered by polygonal-ridged tundra landscapes. The Yana-Indigirka Lowland features moss-tussock tundra and bogs. The mountainous part of the tundra zone is occupied by stony deserts characterized by the crustose lichens *Haematomma ventosum*, *Rhizocarpon geographicum*, *Umbilicaria hyperborea* and fragments of higher vascular plant groupings (Troeva et al., 2010).

The total forest area in the territory of the republic is 82.5%. In boreal taiga larch forests prevail (*Larix cajanderi*, *L. gmelinii*, *L. sibirica*, *L. czekanowskii* (*L. sibirica* x *L. gmelinii*)), in total 77.5% of the forested area. Less common are *Pinus sylvestris* (6.5%), and *Picea obovata* (0.24%) forests. In the southwest *Pinus sibirica* (0.25%) and *Abies sibirica* (0.01%) forests appear, in the mountainous areas in the South *Picea ajanensis* forests. The share of deciduous forests (*Betula pendula*, *B. pubescens*, *B. ermanii*, *Populus suaveolens*, *P. tremula*, *Chosenia arbutifolia*, tree species of *Salix*) accounts for about 1.24% of the forested area. Significant areas (4.6%) mainly in mountains are covered with creeping cedar (*Pinus pumila*). The share of other shrubs (mainly *Betula nana* subsp. *exilis*, *B. divaricata*, *B. fruticosa*, *Duschekia fruticosa*, shrubby forms of *Salix*) accounts for 9.6% of the forested area. The northernmost location of larch woodlands in Yakutia is marked at about 72°N latitude. Besides forests, in taiga also shrubberies, wetlands, and coastal aquatic vegetation occur. There are also unique ecosystems that are more characteristic for southern latitudes (steppe, tundra-steppe, etc.) (Timofeev, 2003; Troeva et al., 2010; Isaev, 2011).

The climate parameters vary significantly due to the size of the republic and its complicated relief. In most of the territory of Yakutia, except for its coastline and the highland region in the South, the climate is strongly continental with very low winter and very high summer temperatures, insignificant nebulosity and relatively mild winds, especially in winter. A major

pressure phenomenon is the establishment and growth of the Asian anticyclone system at the very beginning of the winter. The high pressure produces extremely steady air with very low surface temperatures, strong surface inversions and low humidity. Some days, 60 °C below zero can be observed almost all over the territory. Extremely low temperatures have been recorded in the Oymyakon depression and Yana intermountain trough: -71 °C in Oymyakon and -68 °C in Verkhoyansk. Minimal temperatures in the South and South-West may reach from -58 °C to -62 °C, and in Central Yakutia -66 °C. In coastal areas and on islands, the lowest recorded temperatures are -46 °C and -52 °C. Yakutia has no analogues both in minimal temperature values and the duration of the period with extremely low temperatures in the Northern Hemisphere. A distinct feature of the warm period is the quick rise of the average daily temperatures in spring and their quick drop in autumn, July is the warmest month. The highest temperatures in Yakutia between May to August are observed in the central region. The average July temperature in the central, southern, and eastern parts of the republic is +17 to +19 °C, while North of the Viluy River it ranges from +12 to +15 °C. Lowest July temperatures (+2 to +5 °C) are recorded in coastal areas and on the islands. In highland regions, temperature distributions depend on altitude, relief, and other microclimatic peculiarities. In most of the lowlands maximum temperatures may reach +34 to +38 °C, in the coastal areas +29 to +32 °C, and on the islands +18 to +24 °C. Characteristic of the thermal conditions of Yakutia are the significant annual amplitudes. Differences between temperatures of the warmest and coldest months, and differences between absolute minimum and maximum values in the interior, are the world's greatest. Thus, the amplitude of absolute minimum and maximum temperatures reach 99 °C in Tommot to 102 °C in Ust-Moma and 104 °C in Oymyakon. The transition to an average daily air temperature above 10 °C (which means the start of plant growth) occurs in early July in the tundra, in the first decade of June in the West and East, and in late May in the central and south-western regions. The average duration of the period with temperatures above 10 °C is 0–50 days in the tundra, 65–90 days in the West and East, and 90–100 days in Central and South-West Yakutia. Sometimes frost may

occur all summer long. The annual precipitation amounts for most of the territory to 150–250 mm, and to 350–500 mm in the South and South-West. At foothills and highland regions, precipitation amounts to 400–700 mm. Precipitation falls unevenly during the year: 15–20% of the total amount occurs during the cold period (November through March), and 4–5 times more (75–80%) during the warm period (April through October). In most of Yakutia snow cover lasts 225–250 days a year. Depth of snow cover is insignificant (especially in the North) due to the prevalence of anticyclones circulation in winter. Deepest snow cover (40–60 cm) is observed in the Upper Aldan River basin, the Kolyma River valley, and in some highland regions (Troeva et al., 2010).

Peculiar vegetation grows on perennially frozen grounds, the so-called permafrost that thaws only up to several meters deep and allows a short growing season. Vegetation grows in very severe and extreme weather conditions. Permafrost is a basic factor greatly influencing the distribution and functioning of ecosystems, and vegetation in particular. The whole territory of Yakutia lies in the zone of perennially frozen soils. The permafrost stratum varies widely in depth within Yakutia. Thus, on above-floodplain terraces, it is as thick as 300–400 m, while in the upper reaches of the Markha River (West Yakutia, south of the Polar Circle) it reaches 1500 m. This is the maximum thickness recorded worldwide. The average annual temperature of perennially frozen grounds at a depth of 15–20 m fluctuates from  $-1^{\circ}$  to  $-2^{\circ}$  °C (SW Yakutia) to  $-10^{\circ}$  to  $-12^{\circ}$  °C (high watersheds in mountains). The continuous permafrost zone alternates with patches of non-frozen grounds, the so-called *talik*. In Southern Yakutia (the Lena-Aldan and the near-Lena plateaus, as well as upper regions of the Yakokit and Seligar River basins), *taliks* occupy up to 50% of the area and are concentrated on dry, flat watersheds, under river beds which do not freeze through in winter, under deep lakes, and near permanent sources of underground water. Firmly frozen, ice-bound strata represent waterproof horizons for precipitation and facilitate to some extent soil wetting by oozing out ground moisture during seasonal periods of thawing (Troeva et al., 2010).

## MATERIALS AND METHODS

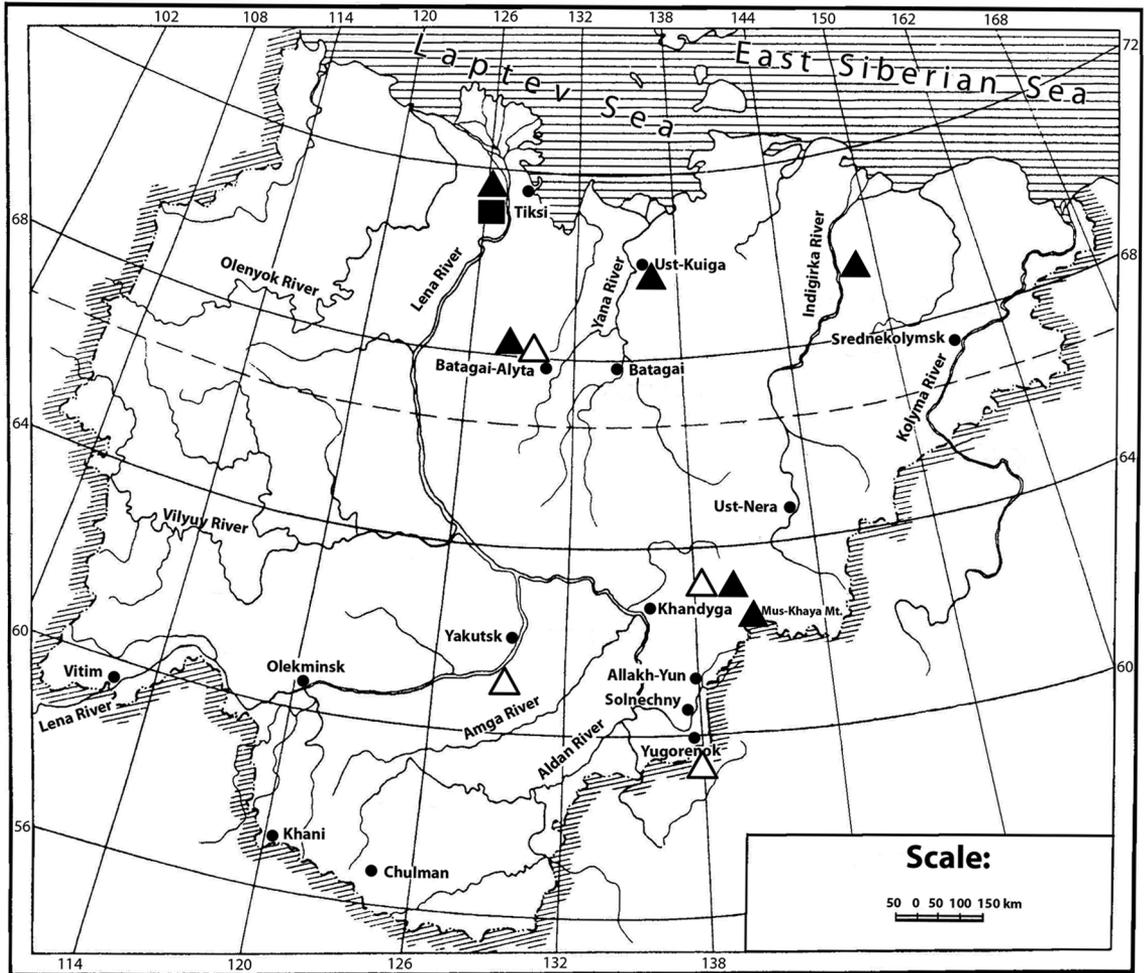
The main part of the material was collected by the authors in 1998–2011. All specimens collected by the authors and E. Ohenoja are deposited in SASY. Nomenclature follows the Red Data Book of the Russian Federation (2008), and for mosses Ignatov et al. (2006), for liverworts Potemkin, Sofronova (2009), for lichens Hawksworth et al. (1995), for fungi Hansen et al. (1992). Data without reference are presented according to the Red Data Book of the Russian Federation (2008). On the maps one point represents a single location, except for *Scapania sphaerifera* where one point unites several localities.

The material was examined using standard microscopic techniques. External morphology was studied with a dissecting LOMO MSP-1, MBS-1, anatomy with LOMO Mikmed-2, Laboval-2, Biolam R-17 light microscope. The material was examined in water and sometimes for lichens and fungi additionally in 5% and 10% KOH (K), P (paraphenylenediamine solution [ $C_6H_4(NH_2)_2$ ]) in an aqueous solution hyposulfite and Melzer's reagent (IKI), Cotton Blue (Ryvar-den, Gilbertson, 1993).

## THE SPECIES

### Mosses.

DIDYMODON GIGANTEUS (Funck) Jur. (Fig. 1.) – Northern Yakutia, the lower reaches of the Lena River, Chekanovsky Range, Kumakh-Surt Locality surroundings, on limestone hill between the stones on the bank of a creek ( $71^{\circ}28'N$ ,  $127^{\circ}17'E$ ). 1898, coll. H. Nilson-Ehle (Savich-Lyubitskaya, Smirnova, 1970). – Arctic-alpine species with a disjunctive distribution. In Russia, the only known location of the species is in the lower reaches of the Lena River (Yakutia), collected (coll.) by H. Nilson-Ehle in 1898. During special bryological studies conducted in this area in 2006, the species was not found. Possible suitable habitats for future investigation are also in other mountain regions of Russian Arctic, where there is limestone. Distribution in the world: Europe, Asian part of Russia, Asia and North America.



**Fig. 1.** Distribution of *Encalypta brevipes* (black triangle), *Indusiella thianschanica* (open triangle), *Didymodon giganteus* (black square).

*ENCALYPTA BREVIPES* Schljakov (Fig. 1.) – [1] Northern Yakutia, the lower reaches of the Lena River, Chekanovsky Range, Kumakh-Surt Locality surroundings (~71°28'N, 127°17'E) (Horton, 1983); [2] North-Eastern Yakutia: (a) the lower reaches of the Yana River, Selennyahsky Range, Ust-Kuiga Settlement surroundings, between stones (~69°59'N, 135°35'E). 24.07.1978, coll. N.A. Stepanova (Stepanova, 1986); (b) Orulgan Sis Range, ca. 60 km NW of Batagay Alōta Settlement, Delong River (tributary Tumara River), crevices in rocky outcrops (68°09'N, 129°21'E). 01.08.2011, coll. M.S. Ignatov (Ignatov, Isakova, Ignatova, 2014); (c) the lower reaches of the Indigirka River, ca. 120 km S of Chokurdakh Settlement, Bolshaya Ercha River Mouth, steppe

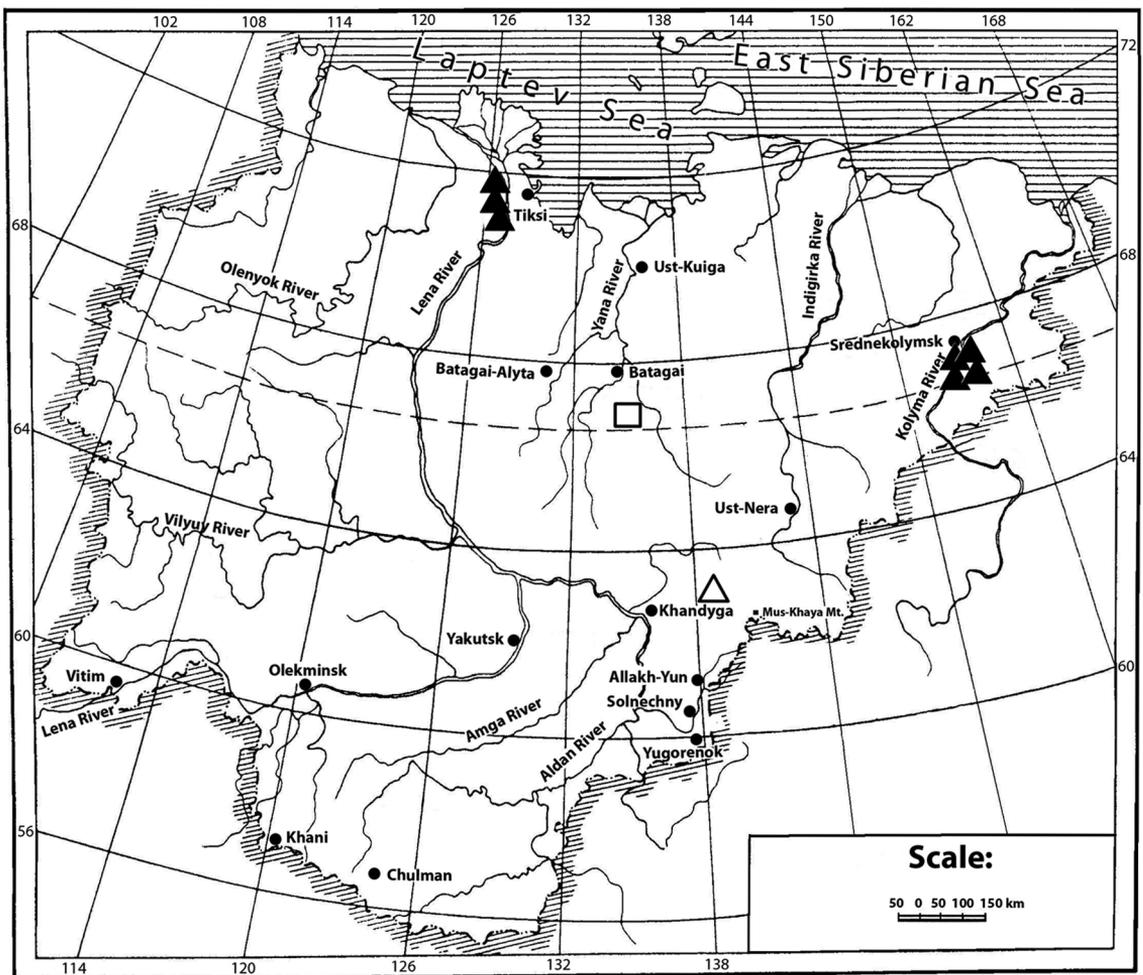
community on SW-facing slope in forest belt, between stones (69°31'N, 147°41'E). 24.07.2005, coll. E.I. Ivanova (Ivanova, Ignatova, 2008); [3] Eastern Yakutia: (a) Oimyakon Highland, ca. 230 km E of Khandōga Settlement, the upper reaches of the Kobyume River, steppe community on slope (63°18'N, 139°52'E). 10.07.2005, coll. N.B. Ermakov (Ivanova, Ignatova, 2008); (b) Suntar-Khayata Range, ca. 278 km E of Khandōga Settlement, Knory Creek (tributary Agayakan River), Mus-Khaya Mt. surroundings, dry stony tundra (62°33'N, 141°04'E). 14.07.2011, coll. E.I. Ivanova (Ignatov et al., 2011). – Rare arctic-alpine species, growing on limestone rocks, in xerophytic communities of plants on rocky and gravelly slopes, and in willow-*Dryas*-herb com-

munities. In Russia known mainly from Siberia and Chukotka, from the European part known only in the Murmansk Province. Distribution in the world: Europe, Greenland, North America and Asian part of Russia.

*HILPERTIA VELENOVSKYI* (Schiffn.) R.H. Zander (Fig. 2.)– North-Eastern Yakutia, Yano-Adychansky Highland, ca. 53 km S of Batagai Settlement, Borulakh River (tributary Adycha River), Tomtor Village surroundings, on soil in steppe community on SE-facing slope (67°09'N, 134°40'E). 30.06.2007, coll. V.G. Isakova (Isakova, Ignatov, Ignatova, 2008). – In Russia also known from the Caucasus and Western Siberia (Altai, Taimyr). Species is included in the Red List of

bryophytes of the Czech Republic (Kučera & Vaňha, 2003). Distribution in the world: Europe, Russia, China, Mongolia and Canada.

*INDUSIELLA THIANSHANICA* Broth. et Müll. Hal. (Fig. 1.) – [1] North-Eastern Yakutia, Orulgan Sis Range, ca. 50 km NW of Batagai-Alöta Settlement, Delong River (tributary Tumara River), crevices in rocky outcrops on S-facing slope in forest belt (68°07'N, 129°32'E). 12.08.2011, coll. M.S. Ignatov (Ignatov, Isakova, Ignatova, 2014); [2] Eastern Yakutia, Suntar-Khayata Range, ca. 175 km NE of Khandöga Settlement, At-Moole River (tributary Vostochnaya Khandöga River), crevices in rocky outcrops (63°07'N, 138°49'E).



**Fig. 2.** Distribution of *Hilpertia velenovskiyi* (open square), *Mielichhoferia macrocarpa* (open triangle), *Myrinia rotundifolia* (black triangle).

22.07.2003, coll. E.I Ivanova, V.I Zolotov (Ivanova, Ignatova, 2008); [3] Central Yakutia, the middle reaches of the Lena River, ca. 160 km SW of Yakutsk City, Labōya River Mouth, crevices in rocky outcrops (61°06'N, 127°22'E). 17.08.2000, coll. M.S. Ignatov (Krivoshapkin, Ignatov, Ignatova, 2001); [4] South-Eastern Yakutia, Udoma-Maya Upland, the middle reaches of the Udoma River, ca. 11 km E of Yugorenok Village, crevices in rocky outcrops on S-facing slope in forest belt (59°45'N, 137°53'E). 07.09.2000, 09.07.2000, coll. E.I. Ivanova (Ignatov et al., 2001). – Species usually grows in warm and xerophytic places on calcium-containing rocks. In Russia also known from the Caucasus (Dagestan) and Siberia (Altai, Tuva and Buryatia Republics, Krasnoyarsk Territory, Irkutsk Province). Distribution in the world: Russia, Mongolia, China, Tajikistan, Africa (Chad), North America (Alaska).

MIELICHOFERIA MACROCARPA (Hook. ex Drumm.) Bruch et Schimp. ex Jaeg. et Sauerb. (Fig. 2.) – Eastern Yakutia, Suntar-Khayata Range, ca. 175 km NE of Khandōga Settlement, At-Moole River (tributary Vostochnaya Khandōga River), crevices in rocky outcrops on the bank of the creek (63°07'N, 138°49'E). 22.07.2003, coll. V.I Zolotov (Ivanova, Ignatova, 2008). – In Russia known only one other location in the Republic of Buryatia (Siberia). Distribution in the world: Asian part of Russia, North America and Greenland.

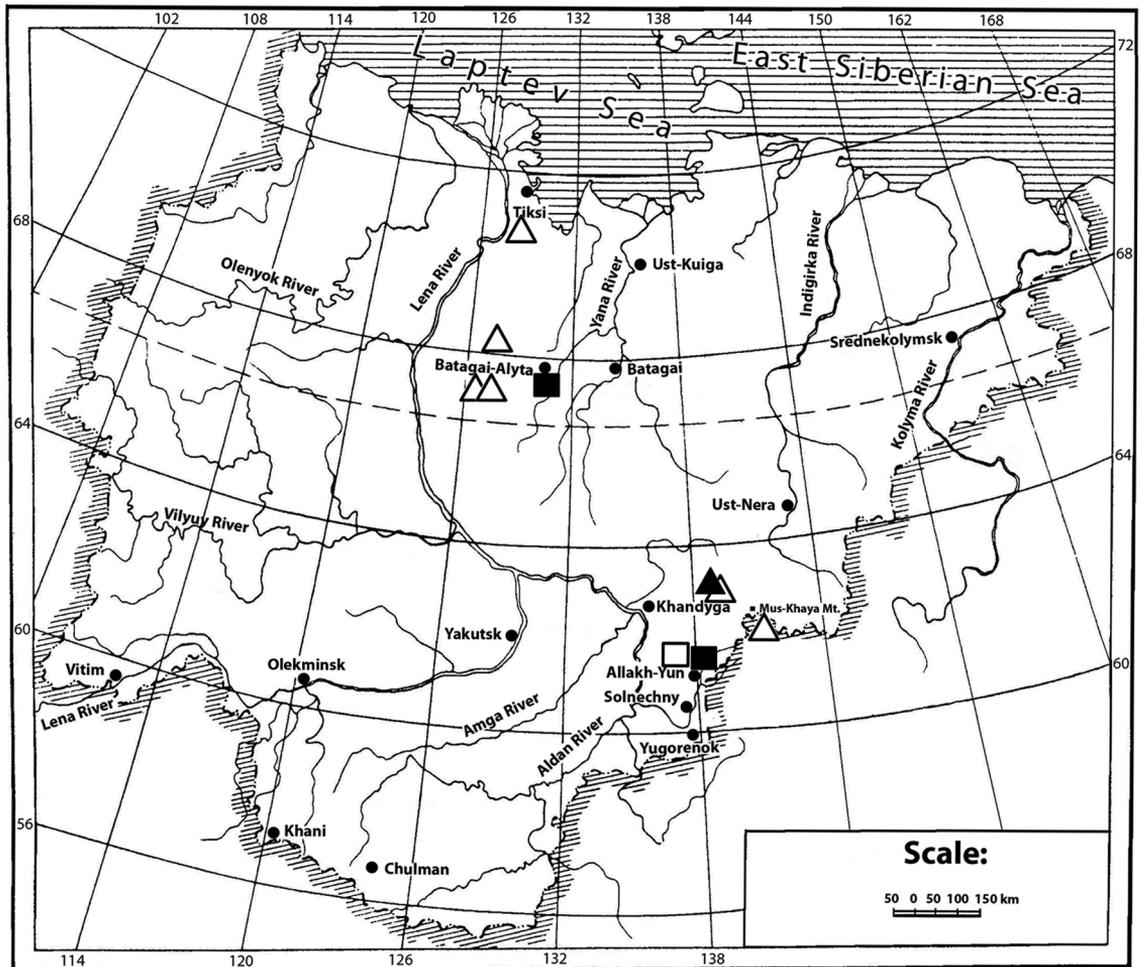
MYRINIA ROTUNDIFOLIA (Arnell) Broth. (Fig. 2.) – [1] Northern Yakutia, the lower reaches of the Lena River, Chekanovsky Range: (a) Kumakh-Surt Locality surroundings (~71°28'N, 127°17'E) (locus classicus); (b) Krestyakh Locality surroundings (~71°04'N, 127°27'E); (c) Bulkur Locality surroundings (~70°53'N, 127°06'E). 1898, coll. H. Nilson-Ehle (Arnell, 1913); [2] North-Eastern Yakutia, the middle reaches of the Kolōma River, ca. 15 km NE of Srednekolymsk Settlement: (a) Lobuya Locality surroundings, crevices in rocky outcrops (67°29'N, 154°01'E) (Egorova et al., 1991); (b) Krasnyi Kamen Locality surroundings, foot of rocky bank (67°02'N, 153°03'E). 16.08.2003, coll. M. Ohenoja; (c) Manzhelek Locality surroundings, humus-mixed silty soil on rock outcrops on NW-facing slope (67°37'N, 155°10'E). 13.08.2003, coll. E. Ohenoja; (d) Manzhelek Locality surroundings, in the niches between the stones in rock outcrops (67°11'N,

153°41'E). 15.08.2003, coll. M. Ohenoja (Ivanova, Sofronova, 2013). – Endemic to the north of Eastern Siberia, known from Taymyr. The species grows on lime-rocks and silted pebbles on the banks of rivers in carbonate rocks areas.

### Liverworts.

APOTREUBIA cf. HORTONIAE R.M. Schust. et Konstant. (Fig. 3.) – Eastern Yakutia, Suntar-Khayata Range, ca. 187 km NEE of Khandōga Settlement, Kyurbelyakh River (tributary Vostochnaya Khandōga River), on wet stream bank among the *Sphagnum* moss on N-facing slope in tundra belt (63°07'N, 139°02'E). 22.07.1999, coll. E.V. Sofronova (Sofronova, 2005 as *Apotreubia* sp.). – In the world known from 4 localities: Russia (Taimyr, Yakutia), North America (Alaska) and Kanada (British Columbia).

BUCEGIA ROMANICA Radian (Fig. 3.) – [1] Northern Yakutia, Tuora-Sis Range, ca. 77 km SSW of Tiksi Settlement, Sietachan Creek (tributary Lena River), between stones on N-facing slope (71°05'N, 127°30'E). 03.07.1956, coll. A.E. Katenin & V.V. Petrovsky (Schljakov, 1973). [2] North-Eastern Yakutia, Orulgan Sis Range: (a) ca. 97 km SW of Batagay-Alōta Settlement, Khobol River (tributary Bōtantay River), in cracks of rock outcrops on a mountain top in tundra belt (67°08'N, 128°59'E). 22.06.2006; (b) ca. 122 km SW of Batagay-Alōta Settlement, Sulda Tekeekit River (tributary Undulung River), in cracks of rock outcrops on N-facing slope in tundra belt (67°04'N, 128°15'E). 30.06.2006 (Sofronova, Sofronov, 2012); (c) ca. 102 km NW of Batagay-Alōta Settlement, Enigan Toloono River (tributary Menkere River), on rock outcrops between shale on E-facing slope in tundra belt near the top of the mountain (68°13'N, 128°07'E). 07.08.2011 (Ivanova, Sofronova, 2013). [3] Eastern Yakutia, Suntar-Khayata Range: (a) ca. 187 km NEE of Khandōga Settlement, Kamenny Creek (tributary Vostochnaya Khandōga River), on wet stream bank under snowfields among the rubble on N-facing slope in tundra belt (63°04'N, 139°05'E). 25.07.1999 (Sofronova, 2001). All coll. E.V. Sofronova. (b) ca. 278 km E of Khandōga Settlement, Knory Creek (tributary Agayakan River), Mus-Khaya Mt. surroundings, near the creek in tundra belt (~62°28'N, 140°56'E). 15.07.2011, coll. M.S. Ignatov. – In Russia also known from Chukotka.



**Fig. 3.** Distribution of *Apotreubia cf. hortoniae* (black triangle), *Bucegia romanica* (open triangle), *Eocalypogeia schusteriana* (open square), *Fossombronia alaskana* (black square).

Species are included in the Red List of hornworts and liverworts of Romania (Ștefănuț, 2008). Distribution in the world: Europe, Asian part of Russia, Alaska and Western Canada.

*EOCALYPOGEIA SCHUSTERIANA* (S. Hatt. et Mizut.) R.M. Schust. (Fig. 3.) – Eastern Yakutia, Sette-Daban Range, ca. 4 km SW of Allakh-Yun Village, Sellyakh Creek (tributary Allakh-Yun River), in wet cracks of rock outcrops on N-facing slope in forest belt (61°06'N, 137°58'E). 30.08.2000, coll. E.V. Sofronova (Sofronova, 2005). – In Russia at the western border of the distribution area. Species is characterized by narrow ecological amplitude: grows in the tundra and rock communities on substrates

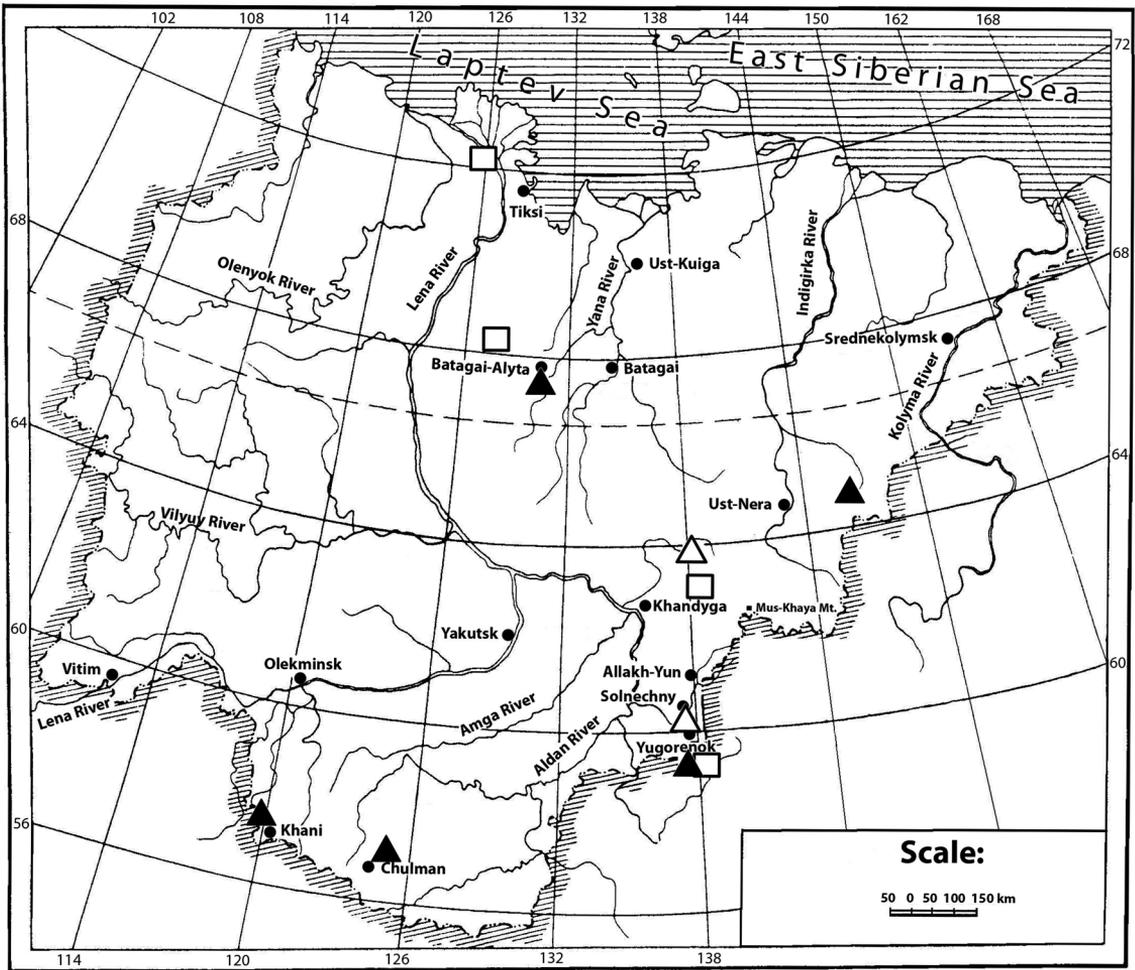
containing calcium. In Russia known from one location in Siberia (Amur Province) and from two locations in Chukotka. Distribution in the world: Asian part of Russia, Alaska, Canada and Greenland.

*FOSSOMBRONIA ALASKANA* Steere et Inoue (Fig. 3.) – [1] North-Eastern Yakutia, the lower reaches of the Ulakhan-Sakkörör River, ca. 3.5 km SE of Batagai Alöta Settlement, on soil of the old road in *Larix* forest (67°45'N, 130°27'E). 15.08.2011, coll. M.S. Ignatov, V.G. Isakova, E.V. Sofronova (Sofronova, 2011). [2] Eastern Yakutia, Sette-Daban Range, near the Allakh-Yun Village, on soil of the old road in *Larix* forest (61°08'N, 138°03'E). 23.08.2000, coll. E.V. Sofronova

(Sofronova, 2010). – Species is characterized by narrow ecological amplitude: grows on wet soil containing calcium. In Russia it is also known from the Yamal-Nenets Autonomous District (Siberia) and Anadyr River Basin (Chukotka). Distribution in the world: Asian part of Russia, Alaska and Western Greenland.

HAPLOMITRIUM HOOKERI (Sm.) Nees (Fig. 4) – [1] North-Eastern Yakutia: (a) the lower reaches of the Ulakhan-Sakkörör River, ca. 3.5 km SE of Batagay Alöta Settlement, on soil of sedge marshes along the shore of the lake (67°45'N, 130°27'E). 26.07.2011 (Sofronova, 2011); (b) Ulakhan-Chistay Range, ca. 150 km NEE of Ust-Nera Settlement, Artök River (tributary

Nera River), on wet stream bank in tundra belt (64°28'N, 146°15'E). 27.07.2003 (Sofronova, 2005). [2] South-Eastern Yakutia, Udoma-Maya Upland, the middle reaches of the Udoma River, ca. 11 km E of Yugorenok Village, on river bank in *Populus* forest (59°45'N, 137°53'E). 08.09.2000 (Sofronova, 2001). [3] Southern Yakutia: (a) Aldan Upland, ca. 27 km NEE of Chulman Settlement, Timpton River (tributary Aldan River), rock outcrops on river bank on N-facing slope in forest belt (56°58'N, 125°17'E). 02.07.2007 (Sofronova, 2008). All coll. E.V. Sofronova; (b) Udokan Range, ca. 315 km NW of Nerungri Town, Oldongdo River (tributary Khani River), on roadside (57°04'N, 119°35'E). 2000, coll. V.A. Bakalin (Bakalin, 2004). – In



**Fig. 4.** Distribution of *Haplomitrium hookeri* (black triangle), *Isopaches decolorans* (open triangle), *Lophozia perssonii* (open square).

Russia also known from Murmansk, Leningrad and Kemerovo Provinces, the Republic of Komi, Krasnoyarsk Territory. Species is included in the Red Data Book of European Bryophytes (1995), Red Data Book of East Fennoscandia (1998), Red List of bryophytes of the Czech Republic (Kučera & Vána, 2003) and Red List of hornworts and liverworts of Romania (Ștefănuț, 2008). Distribution in the world: Greenland, Europe, Russia, Japan, Nepal, North America.

ISOPACHES DECOLORANS (Limpr.) H. Buch (Fig. 4.) – [1] North-Eastern Yakutia, Suntar-Khayata Range, ca. 175 km NE of Khandōga Settlement, near the mouth Duganda River (tributary Tompo River), on stone of a creek in tundra belt (~63°51'N, 137°44'E). 29.07.1956, coll. I.D. Kil'dyushevsky (Ladyzhenskaya, Zhukova, 1971). [2] South-Eastern Yakutia, Udoma-Maya Upland, the middle reaches of the Allakh-Yun River, ca. 6 km SEE of Solnechny Settlement, between gravel in *Duschekia fruticosa* shrubs on plateau of mountain (60°17'N, 137°39'E). 07.09.1999, coll. E.V. Sofronova (Sofronova, 2001 as *Lophozia decolorans*). – In Russia also known from the Murmansk Province and the Yamal-Nenets Autonomous District. Distribution in the world: Europe, Russia, Nepal, Canada, Equatorial Africa.

LOPHOZIA PERSSONII H. Buch et S.W. Arnell (Fig. 4.) – [1] Northern Yakutia, Lena River Delta, left bank of Olenekskaya Duct, abandoned Chay-Tumus Village (72°20'N, 125°45'E). 1979, coll. V.R. Filin (Konstantinova, Filin, 1998). [2] North-Eastern Yakutia, Orulgan Sis Range, ca. 102 km NW of Batagay-Alōta Settlement, Enigan Toloono River (tributary Menkere River), on rock outcrops between shale on E-facing slope in tundra belt near the top of the mountain (68°13'N, 128°07'E). 07.08.2011 (Ivanova, Sofronova, 2013). [3] Eastern Yakutia, Sette-Daban Range, ca. 140 km NEE of Khandōga Settlement, Neprohodimy Creek (tributary Vostochnaya Khandōga River), on soil in dwarf-shrub mountain tundra (63°09'N, 138°06'E). 09.08.2001 (Sofronova, 2005). [4] South-Eastern Yakutia, Udoma-Maya Upland, the middle reaches of the Udoma River, ca. 11 km E of Yugorenok Village, on soil of the old road in *Larix* forest (59°45'N, 137°53'E). 07.09.2000 (Sofronova, 2001). All coll. E.V. Sofronova. – The species has narrow ecological amplitude, it grows only on limestone outcrops.

In Russia also known from Arkhangelsk and Moscow Provinces, Karelia, Komi and Altai Republics, Nenets Autonomous Province. Species is included in the Red Data Book of East Fennoscandia (1998) and List of bryophytes under State protection in Estonia (Vellak, Ingerpuu, 2012). Distribution in the world: Greenland (doubtful location), Europe, Russia and Alaska.

SCAPANIA SPHAERIFERA H. Buch et Tuom. (Fig. 5.) – [1] North-Eastern Yakutia: (a) Orulgan Sis Range: ca. 100 km SW of Batagay-Alōta Settlement, Khobol River Basin (tributary Bōtantay River), in the niches between the stones in rock outcrops in forest and tundra belt (67°04'–67°05'N, 128°48'–129°03'E). June, July 2006, all coll. E.V. Sofronova (Sofronova, Sofronov, 2012); ca. 145 km NEE of Zhigansk Settlement, Sobolokh-Mayan River (tributary Lena River), stone scree in *Pinus pumila* (dwarf pine) community on SW-facing slope (~67°05'N, 126°28'E). 23.08.1991, coll. S.N. Kirillina; ca. 165 km SEE of Zhigansk Settlement, Undyulyung River (tributary Lena River), in the niches between the stones in rock outcrops on N-facing slope in forest belt (~66°13'N, 126°59'E). 12.07.1990, coll. E.V. Sofronova; (b) Western Verkhoynie Range, ca. 190 km NW of Khandōga Settlement, Tukulan River Basin (tributary Aldan River), in the niches between the stones in rock outcrops in forest belt (~63°51'–64°01'N, 132°40'–133°11'E). September 1990, coll. S.N. Kirillina & E.V. Sofronova (Sofronova, Potemkin, 2000); (c) Ulakhan-Chistay Range, ca. 165 km NEE of Ust'-Nera Settlement, Gyrbynya River (tributary Moma River), in the niches between the stones in rock outcrops on E-facing slope in forest belt (64°38'N, 146°39'E). 27.07.2003, coll. E.V. Sofronova (Sofronova, 2005); [2] Eastern Yakutia: (a) Skalisty Range, ca. 165 km NE of Khandōga Settlement, Chukomnan River (tributary Menkyule River), between the stones in rock outcrops (~63°29'N, 138°14'E). (Schljakov, 1981 as *Scapania verrucosa*); (b) Suntar-Khayata Range, ca. 187 km NEE of Khandōga Settlement, Vostochnaya Khandōga River Basin, between the stones in rock outcrops in forest and tundra belt (63°05'–63°08'N, 139°02'–139°10'E). 1998, 1999 (Sofronova, 2003); [3] Southern Yakutia: (a) Tokinsky Stanovik Range, ca. 300 km SE of Chulman Settlement, Algama River Basin (tributary Gonam River), in the niches between the stones in rock outcrops on W-facing slope in forest belt

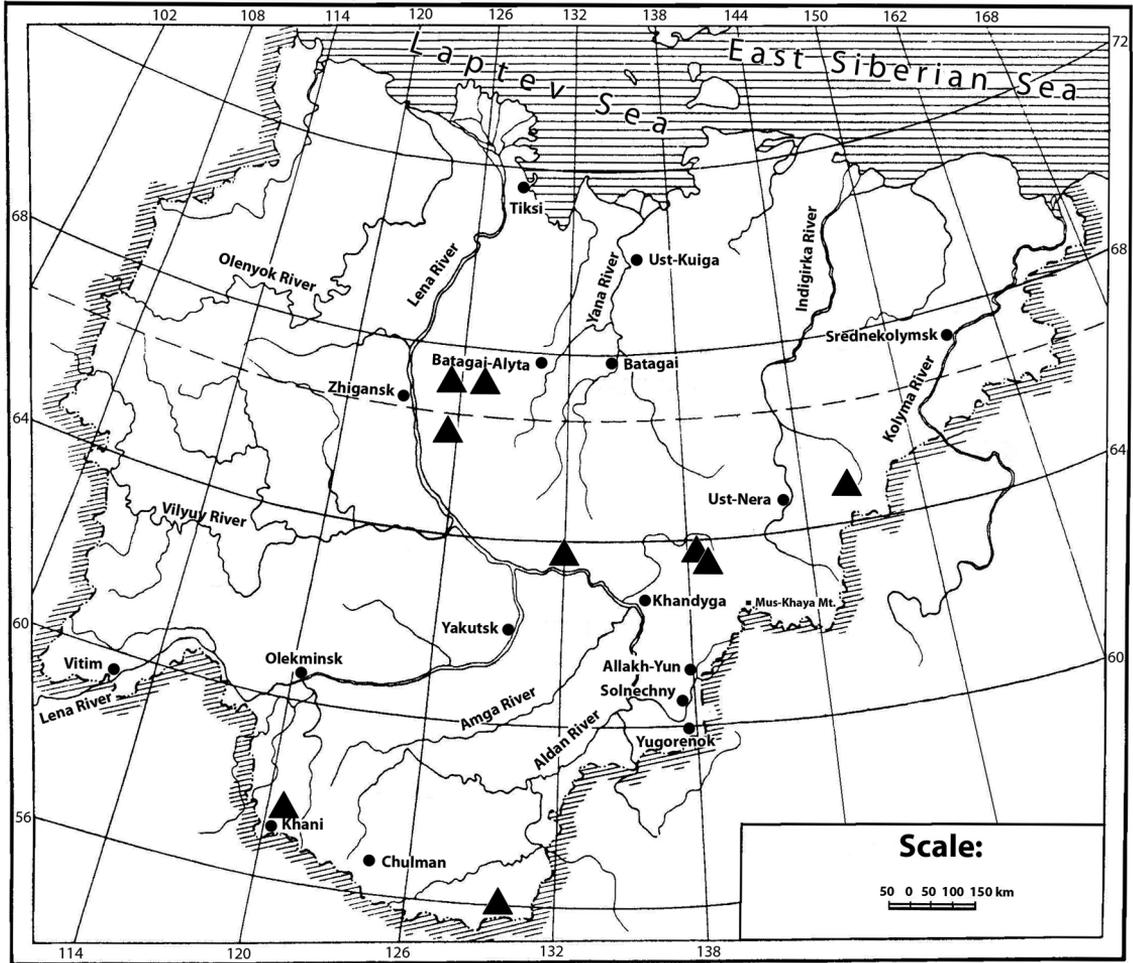


Fig. 5. Distribution of *Scapania sphaerifera* (black triangle).

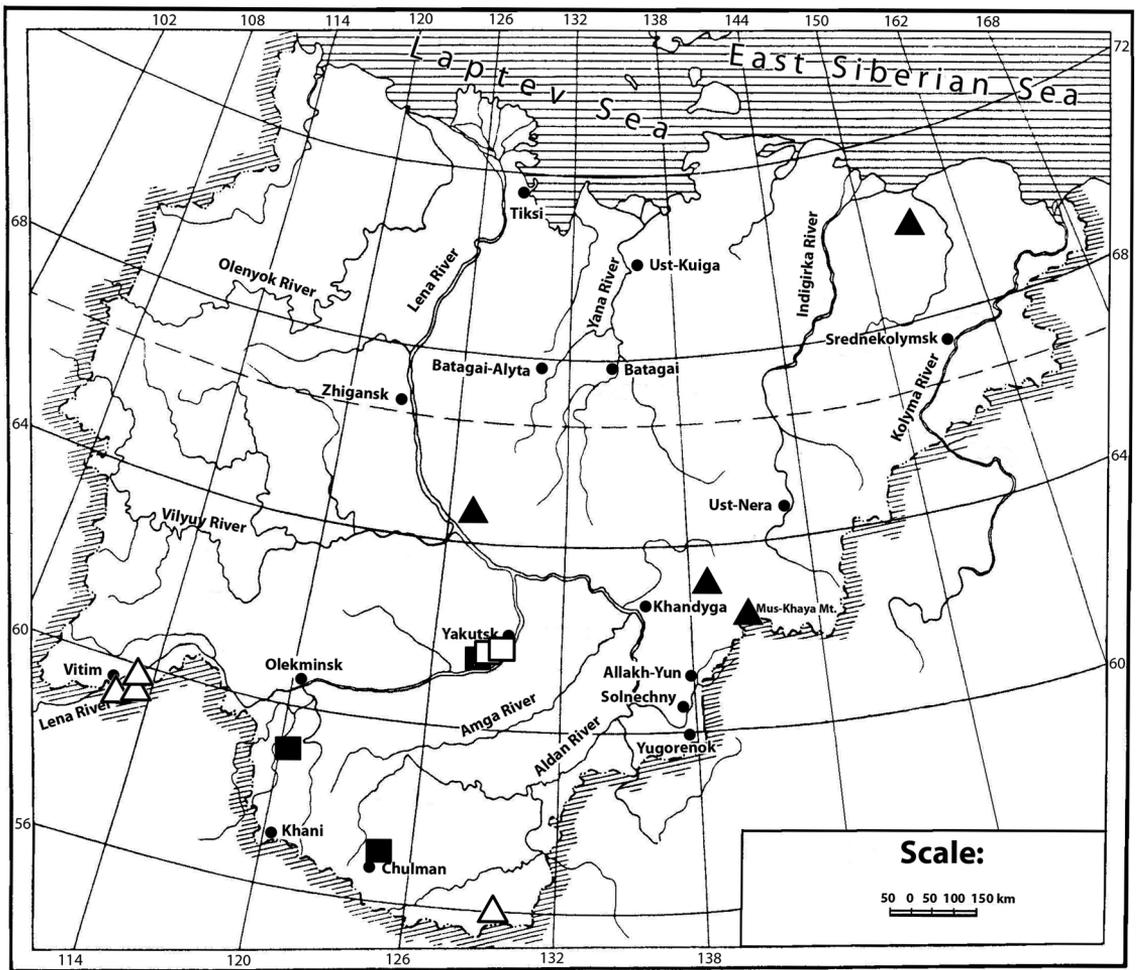
(~55°46'N, 129°26'E). 09.07.2000 (Sofronova, 2013); (b) Udokan Range, ca. 270 km NWW of Chulman Settlement, At-Bastaakh River Basin (tributary Khani River), in the niches between the stones in rock outcrops on N-facing slope in tundra belt (57°14'N, 120°28'E). 13.07.2002 (Sofronova, 2005). All coll. E.V. Sofronova. – Endemic species of Russia. Grows mainly in the forest belt of mountains, on the rocks or between the stones (mainly acidic rocks). The species was described from the Murmansk region and it is the only collection from Europe. In Siberia it has been found in the Republic of Altai, Tuva, Buryatia, in Krasnoyarsk Territory and Irkutsk Province.

#### Lichens.

ASAHINEA SCHOLANDERI (Llano) C. Culb. et W. Culb. (Fig. 6.) – [1] Northern Yakutia, the lower reaches of the Alazeya River, ca. 260 km N of Srednekolymsk Settlement, Taas Khargō Locality, on stones in rock outcrops (69°44'N, 154°53'E). 25.08.2008 (Poryadina, 2010); [2] North-Eastern Yakutia, Orulgan Sis Range, ca. 270 km S of Zhigansk Settlement, Lyapiske River (tributary Lena River), on stones in rock outcrops in tundra belt (64°40'N, 126°26'E). 15.07.2002 (Poryadina, 2003 a,b); [3] Eastern Yakutia, Suntar-Khayata Range: (a) ca. 187 km NEE of Khandyga Settlement, Kyurbelyakh River (tributary Vostochnaya

Khandōga River), on stones in rock outcrops on NE-facing slope in tundra belt (63°06'–63°07'N, 139°03'E). 1996 (Poryadina, 1998, 2001) and 2011; (b) ca. 278 km E of Khandōga Settlement, Knory Creek (tributary Agayakan River), Mus-Khaya Mt. surroundings, on stones in rock outcrops on N-facing slope in tundra belt (62°33'N, 141°03'E). 15.07.2011. All coll. L.N. Poryadina. – In Russia also known from Siberia (Republic of Buryatia, Trans-Baikal and Krasnoyarsk Territory, Khanty-Mansi Autonomous District) and the Far East (Sakhalin Province, Primorsky and Khabarovsk Territory and Chukotka). Distribution in the world: Asian part of Russia, Mongolia, China, Japan, Canada, USA (Alaska).

LOBARIA PULMONARIA (L.) Hoffm. (Fig. 6.) – [1] South-Western Yakutia: (a) ca. 65 km SWW of Vitim Settlement, Kudalakh River (tributary Pilka River), fir (*Abies sibirica*) forest with *Vaccinium myrtillus* and mosses, on the trunks of fir (59°43'N, 113°35'E). 24.06.04 (Poryadina, 2006); (b) ca. 35 km S of Vitim Settlement, Talaya River (tributary Vitim River), the fir-birch forest, on the trunks of fir, cedar, spruce (59°08'N, 112°40'E). 09.06.04 (Poryadina, 2006); ca. 35 km S of Vitim Settlement, Talaya River, spruce forest with fir and cedar, on the trunks of fir, cedar, spruce (59°08'N, 112°41'E). 12.06.04 (Poryadina, 2006). All coll. L.N. Poryadina; [2] Southern Yakutia, Tokinsky Stanovik Range,



**Fig. 6.** Distribution of *Asahinea scholanderi* (black triangle), *Lobaria pulmonaria* (open triangle), *Polyporus umbellatus* (black square), *Polyporus rhizophilus* (open square).

ca. 310 km SE of Chulman Settlement, Algama River Basin (tributary Gonam River), on stones in rock outcrops on S-facing slope in forest belt (~55°58'N, 129°35'E). 18.07.2000, coll. E.V. Sofronova (Poryadina, 2007, Ivanov, 2010). – In Russia also known from European part, Siberia and Far East. Species is included in the Red Data Books of Britain and Ireland (Church et al., 1996), Red Data Book of Latvia (Piterāns & Vimba, 1996), Red Data Book of Belarus (<http://redbook.minpriroda.gov.by>), Red Data Book of Ukraine (<http://redbook-ua.org>). Distribution in the world: Europe, Asia, tropical Africa, North America, Australia.

### Fungi

POLYPORUS UMBELLATUS (Pers.: Fr.) Fr. (Fig. 6.) – [1] Central Yakutia, ca. 2 km W of Bulgunnyakhtakh Village, the larch forest with *Vaccinium vitis-idaea* and mosses (61°18'N, 128°37'E). 04.09.1998 (Red Data Book RS(Ya), 2000); [2] South-Western Yakutia, ca. 120 km S of Olekminsk Settlement, valley of the Toko River, the mixed forest (the larch, the fir-tree, the birch) (~59°20'N, 120°01'E). 24.07.1994 (Red Data Book RS(Ya), 2000); [3] Southern Yakutia, ca. 20 km NE of Chulman Settlement, the left coast of the Chulmakan River, the larch forest with *Vaccinium vitis-idaea* and mosses (56°59'N, 125°03'E). 26.07.2010 (Mikhaljova, 2013). All coll. L.G. Mikhaleva. In Yakutia it grows at the basis of trunks and stumps of larch, less often birch (Red Data Book RS(Ya), 2000; Mikhaljova, 2013). – In Russia also known from European part, Siberia and Far East. Species is included in the Red List of fungi of Bulgaria (Gyosheva et al., 2006). Distribution in the world: Europe, Asia, North America.

POLYPORUS RHIZOPHILUS (Pat.) Sacc. (Fig. 6.) – [1] Central Yakutia: (a) ca. 1 km N of Vladimirovka Village, stipa-steppe on S-facing slope (61°55'N, 129°32'E). 22.07.1999; (b) ca. 1 km S of Old Tabaga Village, stipa-steppe on the southern slope (61°48'N, 129°37'E). 01.09.2006. All coll. L.G. Mikhaleva. All specimens grow on the root mat of *Stipa krylovii* (Mikhaljova, 2013). – Included in the list of taxa of plants and fungi, which need special attention to their status in the environment and monitoring. In Russia also known from Voronezh and Volgograd Province, Krasnodar Territory ([\[chive/fun\\\_map/polrhi.htm\]\(http://www.binran.ru/resources/ar-chive/fun\_map/polrhi.htm\)\). Distribution in the world: Europe, northern Africa and Asia, South America \(Łuszczzyński & Łuszczzyńska, 2010\).](http://www.binran.ru/resources/ar-</a></p>
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### DISCUSSION

The Red Data Book of the Russian Federation (2008) comprises six species of mosses, eight species of liverworts, two species of lichens, and two species of fungi, including two species (*Myrinia rotundifolia*, *Scapania sphaerifera*) endemic to Russia, found in Sakha Republic. Majority of the species are distributed in the Arctic and in the mountains of Siberia and have narrow ecological amplitude. Several species, namely *Didymodon giganteus*, *Encalypta brevipes*, *Hilpertia velenovskyi*, *Indusiella thianschanica*, *Myrinia rotundifolia*, *Bucegia romanica*, *Eocalypogeia schusteriana*, *Fossombronina alaskana* and *Lophozia perssonii* grow on calcareous rocks or soils, often in xerophytic conditions. *Mielichhoferia macrocarpa* is probably confined to the rocks with high concentration of heavy metals. *Asahinea scholanderi* is common in the tundra belt of the mountains and is often found on the territory of the Republic. *Isopaches decolorans* usually inhabits late snow areas. *Polyporus rhizophilus* grows on the steppe species *Stipa krylovii*, the distribution of the latter is limited with steppe habitats. *Lobaria pulmonaria* prefers old-growth forests with abundant moisture and deep shade. Diverse climatic and edaphic conditions of Yakutia provide a wide range of ecological niches for the growth of species of different ecological requirements. Some species included in Red Data Book of Russian Federation (2008) have in other administrative-territorial units of Russia only one locality, whereas in Yakutia they occur more frequently, usually in 3–4 or more locations. Such species are *Indusiella thianschanica*, *Myrinia rotundifolia*, *Bucegia romanica*, *Lophozia perssonii* and *Scapania sphaerifera*. Most of the rare species were recorded in mountain ecosystems on rocky outcrops, especially limestone, the banks of rivers and streams, and old-growth boreal forests.

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