

A CONTRIBUTION TO THE LIVERWORT FLORA OF ORULGAN RANGE
(NORTH-EASTERN YAKUTIA)

МАТЕРИАЛЫ К ФЛОРЕ ПЕЧЕНОЧНИКОВ ХРЕБТА ОРУЛГАН
(СЕВЕРО-ВОСТОЧНАЯ ЯКУТИЯ)

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Abstract

An annotated list of liverworts of the northern part of the Orulgan Range is presented. In total, 71 species and 3 varieties of liverworts are recorded in the study area. One genus, *Dichiton*, is recorded for the first time for Yakutia, four taxa are new for Verkhoyansk Range (*Asterella lindenbergiana*, *Mannia fragrans*, *Nardia geoscyphus*, *Riccia sorocarpa* subsp. *arctica*), 15 species (*Athalamia hyalina*, *Eocalypogeia schusteriana*, *Lophozia pellucida*, *L. perssonii*, *L. savicziae*, *Marchantia polymorpha*, *Mesoptychia badensis*, *Orthocaulis hyperboreus*, *Ptilidium pulcherrimum*, *Sauteria alpina*, *Scapania* cf. *curta*, *S. irrigua*, *S. spitsbergensis*, *S. opacifolia*, and *Tritomaria scitula*) are newly found in Orulgan Range. Data on frequency, altitude range, recorded localities, habitats, substrates, growth pattern and structures associated with reproduction are listed for every species. Annotations of selected species are accomplished by data on associated species and additional notes on distribution. Most remarkable are records of rare in Russia and Yakutia *Asterella lindenbergiana*, *Lophozia excisa* var. *elegans*, *Bucegia romanica*, *Eocalypogeia schusteriana*, *Lophozia perssonii*, and *Scapania sphaerifera*. Four latter species are included in the Red Data Book of Russian Federation.

Резюме

Приводится список печеночников северной части хребта Орулган, включающий 71 вид и 3 разновидности. Один род (*Dichiton*) приводится впервые для флоры печеночников Якутии, 4 таксона являются новыми для Верхоянской горной цепи (*Asterella lindenbergiana*, *Mannia fragrans*, *Nardia geoscyphus*, *Riccia sorocarpa* subsp. *arctica*), 15 видов (*Athalamia hyalina*, *Eocalypogeia schusteriana*, *Lophozia pellucida*, *L. perssonii*, *L. savicziae*, *Marchantia polymorpha*, *Mesoptychia badensis*, *Orthocaulis hyperboreus*, *Ptilidium pulcherrimum*, *Sauteria alpina*, *Scapania* cf. *curta*, *S. irrigua*, *S. spitsbergensis*, *S. opacifolia*, *Tritomaria scitula*) для хребта Орулган. В списке для каждого вида указаны встречаемость, высотный диапазон распространения в районе исследования, выявленные местонахождения, местообитания, субстрат, наличие структур, связанных с размножением, и характер произрастания. Для ряда видов приводятся сопутствующие виды, а также комментарии по распространению. Особого внимания заслуживают находки таких редких для флоры печеночников России видов, как *Asterella lindenbergiana*, *Lophozia excisa* var. *elegans*, *Bucegia romanica*, *Eocalypogeia schusteriana*, *Lophozia perssonii*, *Scapania sphaerifera*. Последние четыре вида включены в Красную книгу Российской Федерации.

KEYWORDS: liverworts, flora, Tumara River, Orulgan Range, Sietindensky Range, Verkhoyansk Range, Yakutia

INTRODUCTION

Despite of a progress in recent years, the hepatic flora of Yakutia remains poorly explored, especially that of extremely sparsely populated and almost roadless northern part of the Republic. The Orulgan Range is a part of Verkhoyansk Mountain System, an expanded mountain area east of Lena River, stretched over thousand kilometers. The Orulgan Range, being difficult to access, is particularly weakly explored for hepatic flora. Sofronova (2003) reported 24 species found in geobotanists' collections from Undyulyung River and Sobolokh-Mayan River with

their tributaries, flowing through the western macroslope of the range in its central part, at 66-67°N. Later liverwort flora of the Orulgan Sis Resource Reserve was published (Sofronova & Sofronov, 2012); it included 73 species. The latter area is situated at 67°N. In addition, during July and August 2011 we conducted a field work further to the north, at 68°N; the results of this expedition are provided in the present paper. Moss flora of the area has been published earlier by Ignatov *et al.* (2014), while only two rare hepatics, *Bucegia romanica* and *Lophozia perssonii*, has been published by Sofronova *et al.* (2014).

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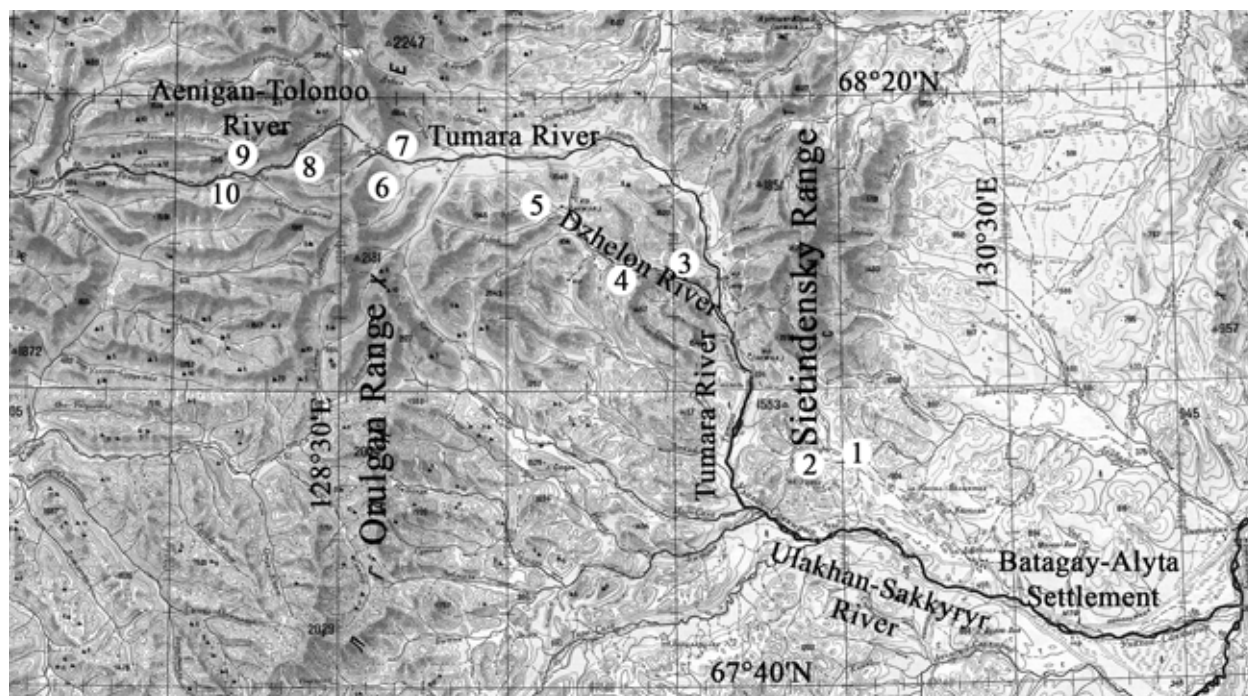


Fig. 1. Collecting localities in Orulgan Range

№	Locality	alt, m	Lat	Long
1	Dyaballakh Creek, middle reaches	660-750	67°55'	130°03'
2	Dyaballakh Creek, upper course	825	67°55'	129°54'
3	Left slope to Dzhelon Creek Valley near confluence with Tumara River	810-1010	68°07'	129°32'
4	Right slope to Dzhelon Creek Valley 10 km from confluence with Tumara River	830	68°08'	129°21'
5	Dzhelon Creek, upper course	1090	68°12'	129°06'
6	Tumara River, upper course, near Kovsh Glacier	1330-1750	68°13'	128°40'
7	Tumara River, upper course	1270-1410	68°16'	128°43'
8	Aenigan-Tolonoo River, upper course	790-900	68°15'	128°22'
9	Aenigan-Tolonoo River, right tributary	620-810	68°15'	128°09'
10	Aenigan-Tolonoo River, near the mouth of the Sahchan-Yuzhny Creek	600-790	68°13'	128°07'

STUDY AREA

The study area is located in the northern part of Orulgan Mountain Range, on the watershed between sources of Aenigan-Tolonoo River, a tributary of Lena River, and Tumara River belonging to the basin of Yana River. Tumara River in its middle and lower reaches demarcates the Orulgan and Sietindensky Ranges (see Fig. 1); two localities in the latter range were also studied and the results are included into the present list.

The Orulgan Range is characterized by distinctly asymmetrical structure. Its formation is associated with Verkhoyansk terrigenous complex cover thrusting to the outskirts of the Siberian Platform as a result of the collision of the Siberian Continent and the lithospheric blocks of the northwestern margin of the Pacific Ocean (Metelkin & Vernikovskiy, 2005). Therefore west- and east-faced macroslopes are contrastingly different. The latter one is gentler and has a hilly relief. Contrary to this, the west-facing slope to the Lena River has deep valleys, with canyons and numerous rock outcrops. Also the amount of precipitation in the study area is unevenly distributed. Wet Arctic air masses increase moisture on the western

slopes of the Orulgan Range (Table 1). According to the data of Dzhardzhan meteorological station located near its west-faced macroslope, precipitation rates reach 308 mm, which is rather high for this area; in comparison, in the vicinities of the Batagay-Alyta Settlement on east-faced macroslope precipitation is only 155 mm per year (Table 1). Additional physiographic facts of the territory were published by Sofronova & Sofronov (2012) and Ignatov *et al.* (2014).

LIVERWORTS IN VEGETATION COVER

Forests are formed mostly by *Larix cajanderi*, and only flood-valley forests on the Lena River macroslope have also stands of *Chosenia arbutifolia*. *Larix* forms a continuous forest at 450 to 800 m alt. in the study area, while above this altitude, up to 900(-1000) m, only small scattered stands occur (Ignatov *et al.*, 2014).

In the larch forests with bryophyte layer formed mostly by *Hylocomium splendens* var. *obtusifolium*, *Dicranum elongatum*, *Sphagnum* spp., and *Tomentypnum nitens*, liverworts are represented mostly by *Ptilidium ciliare* which forms large patches (up to 1 sq. m) or extensive continuous carpets (more than 1 sq. m). Other hepatics

Table 1. Meteorological data from the nearest to Orulgan Range meteorological stations (Izyumenko, 1966, 1968).

Locality of meteorostation, with distance from study area and elevation	t°C	t°C	t°C	snow	precipitation
	annual	Jan	July	average/max	annual
Dzhardzhan (185 km to W, 45 m alt.), foothill of W slope of Orulgan Range	-12.1	-39.3	14.7	70/120	308
Batagay-Alyta (95 km to E, 489 m alt.), foothill of E slope of Orulgan Range	-14.9	-40.4	12.2	32/53	155
Imtanzha (250 km to S, 1375 m alt.), ridge of Orulgan Range	-11.9	-28.2	9.6	–	255

growing on soil among *Dicranum* ssp., *Bryum* ssp., *Pleurozium schreberi*, etc. have a minute cover (up to 1 sq. cm); these are *Sphenobolus minutus*, *Schistochilopsis grandiretis* and *Cephalozia bicuspidata*; in addition, *Blepharostoma trichophyllum*, *Cephaloziella varians*, *Scapania scandica*, *Tritomaria quinqueidentata*, etc. comprise only few scattered plants among mosses. *Orthocaulis binsteadii* has a small cover (up to 100 sq. cm) on and among *Sphagnum* ssp., and *Calypogeia muelleriana* grows as few shoots in *Sphagnum* carpet. In these forests, liverworts frequently grow on soil in niches and hollows. *Lophozia polaris* and *Sphenobolus minutus* form a small pure patches; *Cephalozia bicuspidata*, *Scapania scandica* and *Schistochilopsis grandiretis* are even more scarce, and *Sphenobolus saxicola* and *Tritomaria scitula* are usually represented by few plants only. On rotten wood, *Cephalozia bicuspidata*, *Lophozia excisa*, *Scapania scandica*, and *Sphenobolus minutus* are common, while *Tritomaria exsectiformis* was found only once. Liverworts are rare in *Larix* forests with continuous lichen cover. Sometimes *Sphenobolus saxicola* forms an extensive patches on soil, while *Ptilidium ciliare*, *Tetralophozia setiformis* and *Sphenobolus minutus* are found in niches. In *Chosenia* stands, *Lophozia excisa* and *Ptilidium pulcherrimum* grow on rotten wood.

Shrub communities of *Betula nana*, *Duschekia fruticosa* (= *Alnus crispa* subsp. *fruticosa*) and *Salix* spp. (*Salix bebbiana*, *S. boganidensis*, *S. schwerinii*) often occupy the wettest habitats in the study area. In such communities *Mesoptychia sahlbergii*, *Ptilidium ciliare*, *Cephalozia bicuspidata* and *Tritomaria quinqueidentata* grow on soil in large amount. Small and minute cover is characteristic for *Plagiochila porelloides*, *Blepharostoma trichophyllum*, *Marchantia polymorpha*, *Sphenobolus minutus*, *Orthocaulis kunzeanus*, *Scapania irrigua*, and *Lophozia excisa* var. *elegans*. In *Pinus pumila* communities occurring exclusively on the macroslope to Lena River, only *Ptilidium ciliare* grows on soil in large amount, while other liverworts are restricted to the niches in soil.

Within the study area, an extensive territory is covered by mires with dominance of *Carex aquatilis* subsp. *stans* and *Eriophorum polystachion*, where only *Scorpidium scorpioides* is common (Ignatov et al., 2014). In such mires liverworts were not found. They grow in bogs dominated by a mixture of *Aulacomnium* spp., *Dicranum* spp. and *Tomentypnum nitens*. In such bogs they form a minute pure mats or grow as few plants among mosses. Most frequent are *Sphenobolus minutus*, *Cephaloziella* ssp., *Ptilidium ciliare*, *Barbilophozia barbata*.

In wet tundra dominated by a mixture of mosses, i.e., *Aulacomnium turgidum*, *Brachythecium* spp., *Bryum* spp., *Dicranum elongatum*, *Hylocomium splendens* var. *obtusifolium*, *Sanionia uncinata*, etc. (Ignatov et al., 2014), *Ptilidium ciliare* occasionally prevails (coverage up to 70%). In these tundras, *Schistochilopsis* spp., *Radula prolifera*, *Barbilophozia* spp., *Sauteria alpina*, *Odontoschisma macounii*, *Blepharostoma trichophyllum*, *Scapania brevicaulis*, *Aneura pinguis*, and *Scapania crassiretis* form large or small continuous mats, while others liverworts were recorded as few plants only. In lichen and shrub tundras, liverworts are less common; they occur among *Dicranum* spp., *Racomitrium lanuginosum*, *Stereocaulon* sp. or small thallus lichens. Small and minute continuous mats are characteristic for *Gymnomitrium coralloides*, *Tetralophozia setiformis*, *Radula prolifera*, and *Sphenobolus minutus* only. Some other liverworts grow among them as a small admixture.

Similarly to mosses (Ignatov et al., 2014), liverworts growing on wet cliffy faces on eastern macroslope to the Yana River, indicate rather complex rock composition. They are represented by to a mixture of acidophilous species (*Lophozia jurensis*, *Gymnomitrium concinnatum*, *Scapania sphaerifera*, *Sphenobolus saxicola*, *Tetralophozia setiformis*, etc.) and calciphilous ones (*Scapania gymnostomophila*, *Asterella lindenberiana*, *Scapania simmonsii*, etc.). The Lena River (west-facing) macroslope is somewhat different (and likely more calcareous); some calciphilous liverworts, e.g., *Athalamia hyalina*, *Bucegia romanica*, *Eocalypogeia schusteriana*, *Lophozia perssonii*, *Mannia pilosa*, *Mesoptychia badensis*, *M. heterocolpos*, and *Tritomaria scitula* were found only there.

Two taxa, *Mannia fragrans* s. str. and *Riccia sorocarpa* subsp. *arctica*, were found on soil in grass community on the shale and tundra-steppe slope, they are . The latter taxon was also collected on soil on the old road rut. On the pebble of a brook in the grass community, *Marchantia alpestris* was found.

On soil on brooks banks *Blepharostoma trichophyllum*, *Mesoptychia sahlbergii*, *Preissia quadrata*, *Orthocaulis hyperboreus*, *Cephalozia bicuspidata*, *Plagiochila porelloides*, *Scapania cuspiduligera*, *S. brevicaulis*, *Dichiton* sp. and *Lophozia polaris* form a minute and small continuous cover. Other species were found as few shoots only.

ANNOTATED LIST OF SPECIES

The nomenclature follows Potemkin & Sofronova (2009) and Cailliau et al. (2013). The list is annotated in the following order: species name, abbreviations of struc-

tures connected with reproduction, if present, in parentheses: gyn. – unfertilized gynoecia, andr. – androecia; per. – perianthia, spor. – mature sporophytes, gem. – gemmae; elevation range in brackets (m alt.); collecting sites (1-10, cf. fig. 1); substrate, habitats and growth pattern. The following scale was used for determination of growth pattern: few plants (FP), minute continuous cover (M) – up to 1 sq. cm, small continuous cover (S) – up to 100 sq. cm, large (L) – up to 1 sq. m and extensive continuous cover (E) – more than 1 sq. m. Annotations of selected species are accomplished by data on associated species and additional notes on distribution and ecology. All specimens are deposited in Herbarium of Institute for Biological Problems of Cryolithozone SB RAS, Yakutsk (SASY).

- Aneura pinguis* (L.) Dumort. (gyn.) – [600-1270 m]. 2, 7, 10. On soil and among *Sphagnum*: *Larix* forest, *Betula* shrubs, wet tundra, brook bank. FP, S.
- Asterella lindenberghiana* (Corda ex Nees) Arnell (spor.) – [670-800 m]. 1, 9. On soil between rocks: rock outcrops. FP. In Yakutia, the species was found only on the Orulgan Range and neighboring Yansky Plateau (Andrejeva, 2009). Fig. 2.
- A. saccata* (Wahlenb.) A. Evans (spor.) – [1370 m]. 7. On soil: wet tundra; associated with *Lophozia polaris*. FP.
- Athalamia hyalina* (Sommerf.) S. Hatt. (spor.) – [830-900 m]. 8, 10. On stones covered with soil: rock outcrops. FP.
- Barbilophozia barbata* (Schmidel ex Schreb.) Loeske (andr.) – [670-1380 m]. 1, 5, 7, 8. On soil, in cracks of boulders: *Pinus pumila* shrubs, moss bogs, wet tundra, stone field. FP, S.
- B. hatcheri* (A. Evans) Loeske (gem.) – [1340-1380 m]. 6, 7. On soil, on stones covered with soil, in cracks of boulders filled with soil: wet tundra, rock outcrops. FP, S.
- Blasia pusilla* L. (gem.) – [830 m]. 4. On soil: *Salix* shrubs. FP.
- Blepharostoma trichophyllum* (L.) Dumort. (spor.) – [820-1470 m]. 2, 5-8, 10. On soil, rotten wood, stones covered with soil: *Larix* forests, *Salix* shrubs, wet and lichen tundra, rock outcrops, stone fields, brook banks. FP, M, S.
- Bucegia romanica* Radian (spor.) – [900 m]. 10. On stones covered with soil: rock outcrops; associated with *Blepharostoma trichophyllum*, *Eocalypogeia schusteriana*, *Mesoptychia sahlbergii*. FP. Rare species in Russia, in Yakutia previously known from the Verkhojansk Mountain System: Tuora-Sis and Suntar-Khayata Ranges (Sofronova et al., 2014). Fig. 2.
- Calypogeia muelleriana* (Schiffn.) Müll. Frib. – [600-780 m]. 9, 10. On soil, on and among *Sphagnum*: *Larix* forest, *Betula* and *Duschekia* shrubs. FP, M.
- Cephalozia bicuspidata* (L.) Dumort. (spor.) – [620-830 m]. 2, 9, 10. On soil and rotten wood: *Larix* forests, *Duschekia* shrubs, bank of dry brook. M, S, L.
- C. pleniceps* (Austin) Lindb. – [600 m]. 10. On and among *Sphagnum*: *Betula* shrubs. FP.
- Cephaloziella elachista* (J.B. Jack ex Gottsche & Rabenh.) Schiffn. – [600 m]. 10. On *Sphagnum*: *Betula* shrubs. FP.
- C. polystratosa* (R.M. Schust. et Damsh.) Konstant. – [820 m]. 3. On soil among *Aulacomnium turgidum*: grass bog. FP.
- C. rubella* (Nees) Warnst. (per.: paroicous) – [820 m]. 3. On soil: *Betula* shrubs. FP.
- C. varians* (Gottsche) Steph. (spor.) – [600-1430 m]. 1, 2, 6, 9, 10. On soil and rotten wood: *Larix* forests, moss bogs, rock outcrops, bank of dry brook. FP, M.
- Dichiton* sp. (per.) – [820 m]. 2. On soil: bank of dry brook; associated with *Cephaloziella varians*. M. The genus is found for the first time in Asian part of Russia (Potemkin & Sofronova, 2009). The specimen superficially differs from the widespread *Dichiton integerrimus*, but as the specimen is scanty, its identification is problematic.
- Eocalypogeia schusteriana* (S. Hatt. et Mizut.) R.M. Schust. – [900 m]. 10. On stones covered with soil: rock outcrops; associated with *Blepharostoma trichophyllum*, *Bucegia romanica*, *Mesoptychia sahlbergii*. FP. Rare species in Siberia, in Yakutia previously found in southern part of the Verkhojansk Mountain System (Sofronova, 2011). Fig. 2.
- Gymnomitrium concinnatum* (Lightf.) Corda (andr.) – [1340 m]. 6. On stones covered with soil: rock outcrops. FP.
- G. corallioides* Nees – [1090-1730 m]. 5-7. On soil, stones covered with soil, in cracks of boulders filled with soil: shrubs and lichen tundra, rock outcrops, stone field. M, S, L.
- Jungermannia polaris* Lindb. (spor.) – [770-1470 m]. 6, 8, 10. On soil, stones covered with soil: rock outcrops. FP, M, S.
- Lophozia excisa* (Dicks.) Dumort. var. *excisa* (spor., gem.) – [600-1740 m]. 1, 2, 6, 8, 10. On soil, rotten wood: *Larix* and *Chosenia* forests, *Duschekia* shrubs, shrub tundra, rock outcrops, brook bank. FP, M.
- var. *elegans* R.M. Schust. (gem.) – [830 m]. 4. On soil: *Salix* shrubs; associated with *Blasia pusilla*. M (Fig. 3).
- L. jurensis* Meyl. ex Müll. Frib. (gem.) – [1340 m]. 6. On stones covered with soil: rock outcrops. M.
- L. longidens* (Lindb.) Macoun (gem.) – [900 m]. 8. On soil: *Pinus pumila* shrubs. M.
- L. pellucida* R.M. Schust. (gem.) – [600-820 m]. 2, 10. On soil and on *Sphagnum*: *Salix* and *Betula* shrubs. FP.
- L. perssonii* H. Buch et S.W. Arnell (gem.) – [850-900 m]. 8, 10. On soil, stones covered with soil: rock outcrops; associated with *Jungermannia polaris*. M, S.
- L. polaris* (R.M. Schust.) R.M. Schust. et Damsh. (gem.) – [780-1380 m]. 2, 6-8, 10. On soil, rotten wood, stones covered with soil, in cracks of boulders filled with soil: *Larix* forests, *Salix* and *Duschekia* shrubs, wet tundra, rock outcrops, bank of dry brook. FP, M, S.
- L. savicziae* Schljakov (gem.) – [790-1340 m]. 2, 6, 8. On soil, stones covered with soil: *Larix* forests, rock outcrops. FP, M.
- L. ventricosa* (Dicks.) Dumort. var. *longiflora* (Nees) Macoun sensu Schuster 1969 – [820 m]. 3. On soil: *Betula* shrubs. FP.
- Mannia fragrans* (Balbis) Frye et L. Clark s.str. – [670-700 m]. 1. On soil: grass community on shale, on tundra-steppe slopes. M.
- M. pilosa* (Hornem.) Frye et L. Clark (spor.) – [700-850 m]. 8, 9. On soil: rock outcrops; associated with *Jungermannia polaris*. M, S.
- Marchantia alpestris* (Nees) Burgeff (gem.) – [600 m]. 9. On soil: grass community on pebble. S.
- M. polymorpha* L. (gem.) – [820 m]. 2. On soil: *Salix* shrubs. S.
- Mesoptychia badensis* (Gottsche ex Rabenh.) L. Söderstr. et Váňa (per., andr.) – [770-900 m]. 10. On soil, stones covered with soil: rock outcrops. M.
- M. gillmanii* (Austin) L. Söderstr. et Váňa (per.: paroicous) – [820 m]. 2. On soil: *Salix* shrubs. S.
- M. heterocolpos* (Thed. ex Hartm.) L. Söderstr. et Váňa (per., andr.) – [840 m]. 8. On stones covered with soil: rock outcrops. S.
- M. sahlbergii* (Lindb. et Arnell) A. Evans – [600-1010 m]. 2-4, 8, 10. On soil, stones covered with soil and on *Sphagnum*:

- Betula* and *Salix* shrubs, rock outcrops, brook bank. FP, M, S, L.
- Nardia geoscyphus* (De Not.) Lindb. – [1470 m]. 6. On soil: rock outcrops; associated with *Gymnomitrium corallioides*. FP. The genus was found from Verkhoyansk Mountain System for the first time only recently by Potemkin & Sofronova (2009). Fig. 3.
- Odontoschisma macounii* (Austin) Underw. – [780-1270 m]. 7, 10. On soil: wet tundra, *Duschekia* shrubs. FP, L.
- Orthocaulis binsteadii* (Kaal.) H. Buch (spor.) – [600-820 m]. 2, 3, 10. On soil, on and among *Sphagnum*: *Larix* forest, *Betula* shrubs. FP, M, S.
- O. hyperboreus* (R.M. Schust.) Konstant. – [1300-1410 m]. 7. On soil: wet tundra, bank of dry brook. FP, L.
- O. kunzeanus* (Huebener) H. Buch – [660-820 m]. 1, 2. On soil: *Betula* and *Salix* shrubs, brook bank. FP, M.
- Plagiochila arctica* Bryhn et Kaal. – [670-1370 m]. 1, 6, 8. On soil, stones covered with soil: rock outcrops. FP, M.
- P. porelloides* (Torrey ex Nees) Lindenb. – [660-1430 m]. 1, 2, 5-7, 10. On soil: *Betula*, *Duschekia* and *Salix* shrubs, wet tundra, rock outcrops, stone field, bank of dry brook. FP, M, S.
- Preissia quadrata* (Scop.) Nees (spor.) – [840-1410 m]. 3, 7, 8. On soil, stones covered with soil: wet tundra, rock outcrops, brook banks. M, S.
- Ptilidium ciliare* (L.) Hampe – [600-1370 m]. 1-3, 6-10. On soil, stones covered with soil: *Larix* forests, *Betula*, *Duschekia* and *Pinus pumila* shrubs, moss bogs, wet and lichen tundra, rock outcrops, bank of dry brook. FP, S, L, E.
- P. pulcherrimum* (Weber) Vain. – [610 m]. 10. On rotten wood: *Chosenia* stands. FP.
- Radula prolifera* Arnell – [1360-1370 m]. 6. On soil, stones covered with soil: wet and lichen tundra, rock outcrops. M, S, L.
- Riccardia* cf. *palmata* (Hedw.) Carruth. (gem.) – [600 m]. 10. On *Sphagnum*: *Betula* shrubs. M.
- Riccia sorocarpa* Bisch. subsp. *arctica* R.M. Schust. (spor.) – [660-700 m]. 1. On soil: on old road, grass community on shale, tundra-steppe slopes. FP, M. Fig. 3.
- Sauteria alpina* (Nees) Nees (spor.) – [1410 m]. 7. On soil: wet tundra. L.
- Scapania brevicaulis* Taylor [incl. *S. degenii* phenotype m] (gem.) – [820-1380 m]. 2, 7. On soil, in cracks of boulders filled with soil: wet tundra, brook banks. FP, S.
- S. crassiretis* Bryhn (gem.) – [1340-1360 m]. 6. On soil, stones covered with soil: wet tundra, rock outcrops. S.
- S. cf. curta* (Mart.) Dumort. (gem.) – [1470 m]. 6. On soil: rock outcrops. M.
- S. cuspiduligera* (Nees) Müll. Frib. (gem.) – [1300-1430 m]. 6, 7. On soil: rock outcrops, bank of dry brook. M, S. The species is very common in the study area. All samples listed previously as *S. zemliae* (Sofronova & Sofronov, 2012) belong *S. cuspiduligera*.
- S. gymnostomophila* Kaal. (gem.) – [670-1470 m]. 1, 5-8, 10. On soil, stones covered with soil: wet tundra, rock outcrops, stone field, *Duschekia* shrubs. FP, M.
- S. hyperborea* Jørg. (per., gem.) – [1340-1430 m]. 6. On soil, stones covered with soil: rock outcrops. FP, S.
- S. irrigua* (Nees) Nees (andr., gem.) – [820 m]. 2. On soil: *Salix* shrubs. S.
- S. paludicola* Loeske et Müll. Frib. – [660-670 m]. 1. On soil: *Betula* shrubs, moss bogs. FP.
- S. scandica* (Arnell & H. Buch) Macvicar (gem.) – [820-830 m]. 2. On soil, rotten wood: *Larix* forests. FP, M.
- S. simmonsii* Bryhn et Kaal. – [1360-1370 m]. 6. On soil, stones covered with soil: wet tundra, rock outcrops. FP.
- S. sphaerifera* H. Buch et Tuom. (gem.) – [1340 m]. 6. On stones covered with soil: rock outcrops. FP.
- S. spitsbergensis* Müll. Frib. – [1340 m]. 6. On stones covered with soil: rock outcrops. M.
- S. zemliae* S.W. Arnell (per., gem.) – [830-1370 m]. 6, 8. On stones covered with soil: rock outcrops; associated with *Lophozia polaris*, and *Tritomaria heterophylla*. FP, S. The species is quite rare in the study area.
- Schistochilopsis grandiretis* (Lindb. ex Kaal.) Konstant. (gem.) – [620-1270 m]. 2, 7, 9, 10. On soil: *Larix* forests, *Duschekia* shrubs, wet tundra. FP, M, S.
- S. opacifolia* (Culm. ex Meyl.) Konstant. (gem.) – [1360 m]. 6. On soil: wet tundra. L.
- Sphenobolus minutus* (Schreb.) Berggr. (spor., gem.) – [620-1740 m]. 1-3, 5, 6, 8-10. On soil, rotten wood, stones covered with soil: *Larix* forests, *Betula* and *Duschekia* shrubs, moss bogs, shrubs, wet and lichen tundra, rock outcrops, stone field. FP, M, S.
- S. saxicola* (Schrad.) Steph. – [620-1340 m]. 6, 8, 10. On soil, stones covered with soil: *Larix* forests, *Pinus pumila* shrubs, rock outcrops. FP, S, L.
- Tetralophozia setiformis* (Ehrh.) Schljakov – [620-1740 m]. 5, 6, 10. On soil, stones covered with soil: shrub tundra, rock outcrops, stone field, *Larix* forest. S, L.
- Tritomaria exsectiformis* (Breidl.) Loeske (gem.) – [620 m]. 9. On rotten wood: *Larix* forest. FP.
- T. heterophylla* R.M. Schust. (per., andr., gem.) – [670-1430 m]. 1, 6. On soil, stones covered with soil: rock outcrops. FP, S.
- T. quinquentata* (Huds.) H. Buch (spor.) – [600-1740 m]. 1, 2, 5-8, 10. On soil, stones covered with soil, on and among *Sphagnum*: *Larix* forests, *Betula*, *Duschekia* and *Salix* shrubs, lichen, shrub and wet tundra, rock outcrops, stone field, brook bank. FP, M, S, L.
- T. scitula* (Taylor) Jørg. (gem.) – [790 m]. 8. On soil: *Larix* forest, associated with *Lophozia polaris*. FP. The species is rare in the Verkhoyansk Mountain System. Previously it has been recorded only in its southern part (Sofronova, 2011; Sofronova & Sofronov, 2010).

DISCUSSION

In total, 71 species and three varieties of liverworts were recorded in the study area. One genus (*Dichiton*) was found for the first time in Yakutia, four taxa are new for the Verkhoyansk Mountain System (*Asterella lindenbergiana*, *Mannia fragrans*, *Nardia geoscyphus*, *Riccia sorocarpa* subsp. *arctica*), and 15 species (*Athalamia hyalina*, *Eocalypogeia schusteriana*, *Lophozia pellucida*, *L. perssonii*, *L. savicziae*, *Marchantia polymorpha*, *Mesoptychia badensis*, *Orthocaulis hyperboreus*, *Ptilidium pulcherrimum*, *Sauteria alpina*, *Scapania* cf. *curta*, *S. irrigua*, *S. spitsbergensis*, *S. opacifolia*, and *Tritomaria scitula*) are newly recorded for Orulgan Range.

On the east-facing macroslope of Orulgan Range 55 species and three varieties were recorded, while on its west-facing macroslope 41 species were found. Twenty five species are common for western and eastern macroslopes, most of them are widespread in the Verkhoyansk Range: *Aneura pinguis*, *Barbilophozia barbata*,

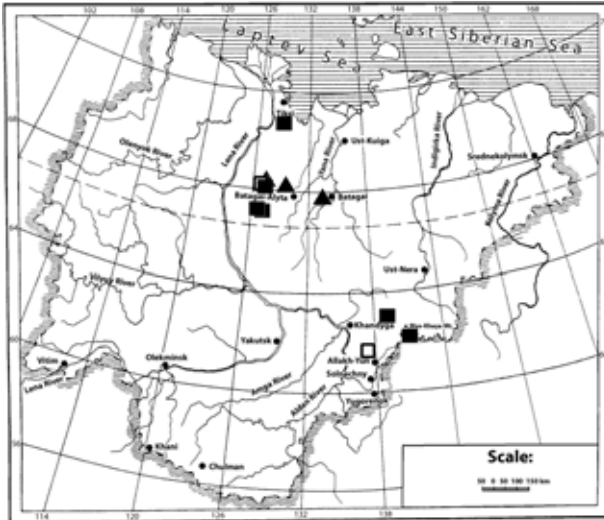


Fig. 2. Distribution in Yakutia of *Asterella lindenberghiana* (triangles), *Bucegia romanica* (black squares) and *Eocalypogeia schusteriana* (open square). From Sofronova et al. (2014) with additions of the author.

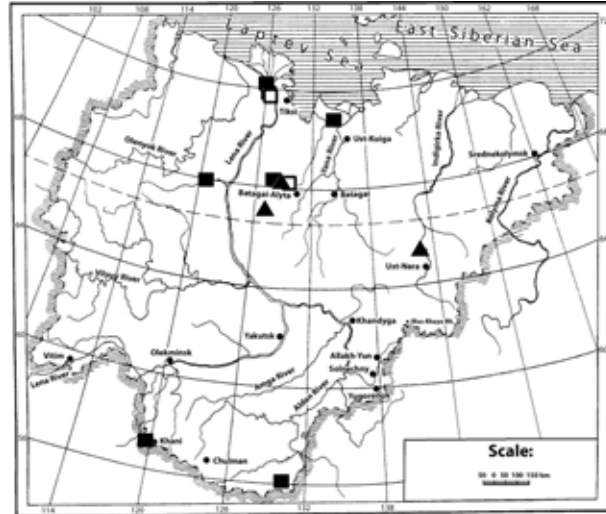


Fig. 3. Distribution in Yakutia of *Lophozia excisa* var. *elegans* (triangles), *Nardia geoscyphus* (black squares) and *Riccia sorocarpa* subsp. *arctica* (open squares). From Potemkin & Sofronova (2009) with additions of the author.

Blepharostoma trichophyllum, *Cephalozia bicuspidata*, *Lophozia excisa* s.str., *Mesoptychia sahlbergii*, *Orthocaulis binsteadii*, *Plagiochila porelloides*, *Preissia quadrata*, *Ptilidium ciliare*, *Schistochilopsis grandiretis*, *Sphenobolus minutus*, *S. saxicola*, *Tetralophozia setiformis*, *T. quinquedentata*, etc. Among species rare in Yakutia, *Asterella lindenberghiana* and *Scapania zemliae* may be noted.

There are 30 species and three varieties recorded only on the east-facing macroslope of the Range; among them, 17 taxa belong to the arctic-montane and arctic elements, as defined by Konstantinova (2000): *Gymnomitrium concinatum*, *G. corallioides*, *Radula prolifera*, *Sauteria alpina*, *Scapania crassiretis*, *S. simmonsii*, *S. spitsbergensis*, *Tritomaria heterophylla*, etc. Arctic-boreal-montane element is represented by ten taxa (e.g., *Barbilophozia hatcheri*, *Orthocaulis kunzeanus*, *Plagiochila porelloides*, *Scapania irrigua*, and *S. paludicola*). Mountain element includes three species (*Asterella saccata*, *Mannia fragrans* and *Scapania sphaerifera*). Cosmopolitan, boreal and arctic-boreal-montane elements are represented by single species, respectively: *Blasia pusilla*, *Cephaloziella rubella* and *Marchantia polymorpha*. Thus, most liverworts on this macroslope belong to Arctic-mountain and arctic elements, which is natural due to severe climatic conditions (Table 1) and the fact that collecting localities 5-7 (Fig. 1) have mostly tundra vegetation, while most other ones are characterized by rather open *Larix* forest. The harsh climate of the Yana River side, exposed to winds from the second “Cold Pole” of the Northern Hemisphere, which is the city of Verkhoyansk with absolute minimum of -68°C , prevents spreading from the west-facing side of the Orulgan such widely distributed species as *Calypogeia muelleriana*, *Cephaloziella rubella*, *Lophozia longidens*, *Ptilidium pulcherrimum*, *Riccardia* cf. *palmata*, and *Tritomaria exsectiformis*, or restricts the occurrence of such species on the east-facing macroslope.

Blasia pusilla, *Cephaloziella rubella*, *Lophozia longidens*, *Ptilidium pulcherrimum*, *Riccardia* cf. *palmata*, and *Tritomaria exsectiformis*, or restricts the occurrence of such species on the east-facing macroslope.

There are 16 species recorded only on the west-facing macroslope, with only seven species belonging to the arctic-mountain and arctic elements (*Athalamia hyalina*, *Bucegia romanica*, *Eocalypogeia schusteriana*, *Lophozia perssonii*, *Mannia pilosa*, *Marchantia alpestris*, and *Tritomaria scitula*). They occur on rocks, because tundra vegetation is totally absent on the cliffy upper part of slope in the study area. Among others, there are representatives of the arctic-boreal-montane element (*Calypogeia muelleriana*, *Cephalozia pleniceps*, *Lophozia longidens*, and *Mesoptychia heterocolpos*), Boreal element *Cephaloziella elachista*, *Ptilidium pulcherrimum*, *Riccardia* cf. *palmata*, and *Tritomaria exsectiformis*, and Mountain element (*Mesoptychia badensis*). Rocks on the west-facing macroslope comprise schists, being more calcareous, judged from moss and liverwort composition. Rock composition probably explains the difference in Arctic and arctic-montane species, as most of them are epilithic. The difference in boreal species composition depends more likely on the climatic conditions, providing an abundance and diversity on rotten wood and on *Sphagnum*.

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