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LIVERWORT FLORA OF THE SUNTAR-KHAYATA RESOURCE RESERVE (YAKUTIA, RUSSIA)

ФЛОРА ПЕЧЕНОЧНИКОВ РЕСУРСНОГО РЕЗЕРВАТА «СУНТАР-ХАЯТА» (ЯКУТИЯ, РОССИЯ)

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Abstract

The article considers the liverworts flora of the Resourse Reserve "Suntar-Khayata". This reserve constitutes the central part of the Suntar-Khayata Range which is located in the southern part of the Verkhoyansk Mountains. The annotated list of liverworts includes 95 species. The results of a long-term study from 1998 to 2017 have been summarized. Each species is provided with comments on the presence of reproductive structures, the frequency of occurrence, a description of the main habitats and plant communities where they occur. The study resulted in the finding noteworthy species in the area include *Bucegia romanica, Cryptocolea imbricata, Frullania ignatovii, F. subarctica, Lejeunea alaskana, Mannia triandra, Marsupella sprucei, Radula prolifera, Scapania rufidula, S. sphaerifera*.

Резюме

Обобщены результаты многолетних исследований флоры печеночников, проводившихся с 1998 по 2017 гг. на территории ресурсного заказника «Сунтар-Хаята». Заказник расположен в центральной части хребта Сунтар-Хаята, сам хребет расположен в южной части Верхоянской горной цепи. Аннотированный список печеночников включает 95 видов. Для каждого вида приводятся сведения о наличии репродуктивных структур, частоте встречаемости, описания основных местообитаний и растительных сообществ, где они произрастают. Наибольший интерес представляют находки редких видов *Bucegia romanica, Cryptocolea imbricata, Frullania ignatovii, F. subarctica, Lejeunea alaskana, Mannia triandra, Marsupella sprucei, Radula prolifera, Scapania rufidula, S. sphaerifera*.

KEYWORDS: liverworts, rare species, ecology, Resourse Reserve "Suntar-Khayata", Suntar-Khayata Range, Verkhoyansk Mountains, Russia

Introduction

The Resourse Reserve "Suntar-Khayata" is situated in the central part of the Suntar-Khayata Range in the upper course of the East Khandyga River, a tributary of Aldan, Lena River Basin, near the watershed of the Lena and Indigirka Rivers. The reserve was founded in 1996, covering 6310 sq. km. Its primary purpose is the preservation of biological diversity, which includes a unique flora and various fauna. The Suntar-Khayata Range is located in the southern part of the Verkhoyansk Mountains (Fig. 1). The total area of the park is about 66600 hectares. Liverworts flora studies were conducted in the Suntar-Khayata range since 1998. However, data for the reserve have only been provided in a single publication (Sofronova, 2000). In general, the Suntar-Khayata Range has been previously mentioned in our publications (Sofronova *et al*., 2015a; Sofronova, Potemkin, 2016). However, continuously accumulated data on liverworts flora of the Reserve remained unpublished.

Study area

Suntar-Khayata Range mainly reach 1400 to 2200 m alt., and 2959 m at the maximum in Mus-Khaya Peak, with the valley being 880–1100 m deep in relation to nearby mountains. Permafrost is 700 m thick, due to a very cold climate. The Reserve is only 350–250 km away from Oimyakon, an area with the lowest temperature in the Northern Hemisphere (among lowland regions), –67.7°C. Climate is ultracontinental, with the mean temperature in January –36.2°C, in July +12.6°C. Creeks are numerous, and many of them are interrupted with semi-permanent valley' ice-beds. The vegetation of the forest belt is composed by *Larix cajanderi* Mayr stands that reach 1400 m on southern and western slopes and 1000 m on north- and east-faced ones. Mountain tundra above timber-line is represented by a variety of communities with the dominance of *Dryas octopetala* s.l., *Cassiope tetragona, Cladonia stellaris*, etc. Slopes often have expanded rock fields. Tickets of shrubby *Pinus pumila*

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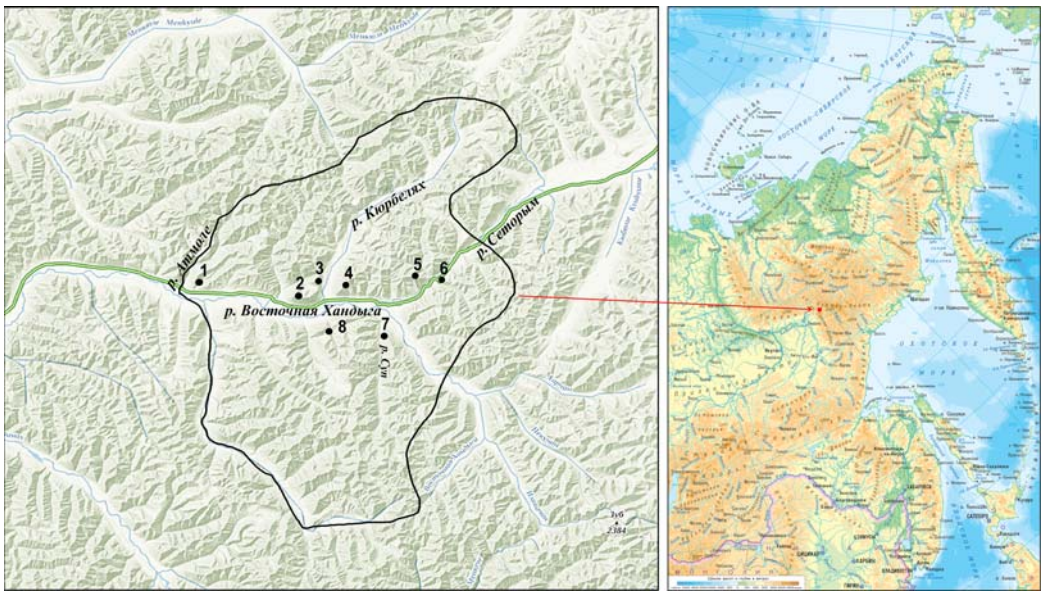

Fig. 1. Collecting localities

N	Localities	Altitude, m	Latitude	Longitude
1	Mouth of At-Moole (Atmoole) Creek	700-800	63°07'	138°49'
2	Baran'ya Mountain, right bank of Kyurbelyakh Creek, lower course	850-1500	63°07'	139°01'
3	Treugol'naya Mountain, right bank of Kyurbelyakh Creek, lower course	900-1350	63°07'	139°02'
4	Strelka Mountain, left bank of Kyurbelyakh Creek, lower course	900-1600	63°07'	139°06'
5	Schatskogo Mountain, right bank of Setorym River, middle course	1000-1600	63°09'	139°11'
6	section of road Zayach'ya petlya, left bank of Setorym River	1100	63°07'	139°16'
7	right bank of Soup River, lower course	950-1600	63°04'	139°11'
8	Kamennyy Brook Basin	700-1600	63°05'	139°04'

(Pall.) Regel do not form a belt, as in more southern regions of Siberia, but its individual groups are scattered across all altitudes. A succession of vegetation in river valleys starts with *Chosenia arbutifolia* and then *Populus suaveolens*, which are later replaced by *Larix*. Meadows, bogs, and *Betula nana* and *Salix* spp. shrubs form a mozaic in valleys and foothills. *Betula lanata* (Regel) V.N. Vassil., or stone birch, and *Alnus fruticosa* Rupr. occur along brooks on slopes and in stream canyons (Yurtsev, 1968; Sofronova, 2000; Ivanova *et al*., 2016; ONUFRIEVA, 1987–1990). Bedrocks include Upper Permian and Lower Triassic sandstones (with occasional calcareous layers), aleurolites, argillites, and schists (Sofronova *et al*., 2015b; Ivanova *et al*., 2016).

Species list

The annotated list of liverworts includes 95 species. The nomenclature of follows Söderström *et al*. (2016). The species in the list are arranged in alphabetical order. The list is annotated in the following order: after the species name are given literature references in square brackets. Next the presence of reproductive structures is given in parentheses (and. – androecia; gyn. – gynoecia; per. – perianths or pseudoperianths; spor. – sporophytes; gem. – gemmae). The numbers of localities where the species was recorded, in accordance with Fig. 1, are provided in Arabic numerals in bold. Altitudinal zones: F: forest, SS: subalpine shrub, A: alpine and the floodplain of the river: FR; elevation range (m a.s.l.) in parentheses; substrate and habitat types. The frequency is characterized as: R – rare (2–3 localities), Sp – sporadic (4– 6 localities), Fr – frequent (7–15 localities) and Cm – common (more than 15 localities), in bold. 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. For species collected from 1–2 (3) localities, labels are given in full. All specimens are deposited in the Herbarium of Institute for Biological Problems of Cryolithozone SB RAS, Yakutsk (SASY).

Aneura pinguis (L.) Dumort. [Sofronova, 2000] (and., gyn.) – **1–4, 8** (F, A; 900–1500); on soil, soil covered stones, decaying wood, plants debris, in the water on soil, soil covered stones, decaying wood: rock outcrops, brook bank, *Larix* forests, mires, *Sphagnum* mountain tundra. Fr: FP, M.

Anthelia juratzkana (Limpr.) Trevis. – **2** (F, A; 1100–1400); on soil, in the water on soil, soil covered stones, *Sphagnum*: brook banks. Sp: FP, M.

Apotreubia cf. *nana* (S. Hatt. & Inoue) S. Hatt. & Mizut. [Sofronova, 2005] – **2** (A; 1310); a single shoot among *Anthelia juratzkana, Blepharostoma trichophyllum, Cephalozia bicuspidata, Cryptocolea imbricata, Scapania scandica, Tritomaria heterophylla* and others on constantly moist soil on the moss-*Sphagnum*-covered bank of a mountain brook on the northern slope. 22.VII.1999.

Barbilophozia barbata (Schmidel ex Schreb.) Loeske [Sofronova, 2000] (and., per., spor.) – **1–5, 7, 8** (F, SS, A, FR; 700–1500); on soil, fine earth, soil covered stones, decaying wood,

Fig. 2. Main plant communities and liverwort habitats. A: view of Vostochnaya Khandyga River Valley and the Kamennyy Brook flowing into it, at the headwaters of which there is a large snowfield, place of *Bucegia romanica* growth; B: typical shrub-lichen *Larix* forest that forms the forest altitudinal zone; C: rock outcrops on the mountainside and a small lake formed from both atmospheric precipitation and water flowing from melting permafrost. Place of *Lejeunea alaskana* growth; D: rock fields on mountain slopes, a typical habitat for *Scapania sphaerifera*; E: typical moss-dwarf shrub and lichen mountain tundras that forms the alpine altitudinal zone. Further down the slope is the bank of a brook, green moss and *Sphagnum* covered, place of *Apotreubia* cf. *nana* growth. In the background is Treugol'naya Mt.; F: the top of Treugol'naya Mt., its flat top is place of *Frullania ignatovii* growth; G: *Clevea hyalina* grows in caves in the rocky outcrops at the edge of the Baran'ya Mt; H: typical mountain brook valley where alder communities develop; I: section of road Zayach'ya petlya. Place of *Mannia triandra* growth.

plants debris, bark of trees, sand, in the water on soil: brook and river banks, *Salix* and *Alnus fruticosa* shrubs, *Larix* forests, rock outcrops, screes, mountain tundras, *Betula lanata, Populus suaveolens* and *Chosenia arbutifolia* forests, *Pinus pumila* shrubs and rock-fields. Cm: FP, M, rarely S, L.

B. sudetica (Nees ex Huebener) L. Söderstr., De Roo & Hedd. [Sofronova, 2000] (gem.) – 5 (F; 1200); minor admixture among *Cephalozia bicuspidata, Cephaloziella varians, Scapania crassiretis* on soil covered stones of rock fields. 14.VII.2098.

Biantheridion undulifolium (Nees) Konstant. & Vilnet [Sofronova, 2000] – 4 (F; 900); minor admixture among *Calypogeia sphagnicola, Cephaloziella arctogena, Mylia anomala, Neoorthocaulis binsteadii* on *Sphagnum* of bog. 12.VII.1998.

Blasia pusilla L. [Sofronova, 2000] – 2, 7 (F, FR; 800–1100); on soil, sand, in the water on soil: brook and river bank, *Salix* shrub, rock outcrops. Sp: FP, M.

Blepharostoma trichophyllum (L.) Dumort. [Sofronova, 2000] (per., spor.) – 2, 3, 5, 8 (F, SS, A, FR; 850–1500); on soil, soil covered stones, fine earth, decaying wood, *Sphagnum*, in the water on soil, soil covered stones: brook banks, *Larix* forests, rock fields, rock outcrops, *Betula* shrubs, mountain tundras, screes, mire. Cm: M, rarely FP or S.

Bucegia romanica Radian (gyn.) – 8 (F; 1250); few thalli on constantly moist soil covered stones of brook banks. 25.VII.1999. 8 (A; 1400); few thalli on constantly moist soil of brook banks. 25.VII.1999. Included in the Red Book of the Russian Federation (Geltman, 2024).

Calycularia laxa Lindb. & Arnell [Sofronova, 2000] (and., per.) – 2, 5, 7, 8 (F, A; 1100–1500); on soil, soil covered stones, fine earth, in the water on soil covered stones: brook banks, rock fields, rock outcrops. Sp: FP.

Calypogeia integristipula Steph. [Sofronova, 2000] – 1–3, 5 (F; 700–1200); on soil, decaying wood, soil covered stones: *Larix* forests, rock fields, rock outcrops, *Betula* shrubs. Fr: M, S, L, FP.

C. muelleriana (Schiffn.) Müll. Frib. [Sofronova, 2000] – 1, 2, 4, 5, 8 (F, SS, A, FR; 800–1500); on soil, *Sphagnum*, decaying wood, bark of trees, in the water on plants debris, soil: *Larix* forests, *Betula* shrubs, bogs, *Sphagnum* mountain tundra, brook bank. Cm: FP, M.

C. sphagnicola (Arnell & J. Perss.) Warnst. & Loeske [Sofronova, 2000] – 3, 4 (F; 900–1000); on *Sphagnum*, plants debris: bogs. Sp: FP, M.

Cephalozia bicuspidata (L.) Dumort. [Sofronova, 2000] (spor.) – 1–5, 8 (F, SS, A, FR; 850–1500); on soil, soil covered stones, *Sphagnum*, decaying wood, fine earth, in the water on soil, soil covered stones, *Sphagnum*, decaying wood, plants debris: *Larix* forests, brook banks, *Betula* shrubs, rock outcrops, bogs, mountain tundras, rock-fields. Cm: usually M or FP, rarely S, L.

Cephaloziella arctogena (R.M. Schust.) Konstant. [Sofronova, 2000]– 4 (F; 900); very small turf up to 1 sq. cm on *Sphagnum* mixed with *Calypogeia sphagnicola, Mylia anomala, Neoorthocaulis binsteadii, Biantheridion undulifolium*. 12.VII.1998.

C. rubella (Nees) Warnst. (spor.) –2 (FR; 800); small turf up to 1 sq. cm on bark of trees bases in Salix shrub. 10.VII.1999. 2 (A; 1450); in bogs on the *Sphagnum* carpet as a small admixture among *Calypogeia muelleriana, Cephalozia bicuspidata, Riccardia chamedryfolia, Schistochilopsis grandiretis*. 29.VII.2015.

C. spinigera (Lindb.) Jørg. [Sofronova, 2000] (per., spor.) – 1, 2 (F; 850–950); on *Sphagnum*, decaying wood, soil: *Larix* forests, rock outcrops. Sp: M.

C. varians (Gottsche) Steph. [Sofronova, 2000] (and., per., spor., gem.) – 2, 3, 7 (F, SS, A, FR; 850–1500); on soil, soil covered stones, fine earth, decaying wood, sand: rock outcrops, *Betula* shrubs, *Larix, Populus suaveolens, Betula lanata, Chosenia arbutifolia* forests, mountain tundras, river bank, rock fields. Cm: M, rarely FP.

Chiloscyphus polyanthos (L.) Corda [Sofronova, 2022] – 2 (F; 900); small turf up to 10 sq. cm on decaying wood in rosehip-*Calamagrostis*-horsetail *Populus suaveolens* forest. 1.VIII.2016.

Clevea hyalina (Sommerf.) Lindb. [Sofronova, 2022] (and., spor.) – 2 (A; 1500); very small turf up to 1 sq. cm on fine earth in caves in the rock outcrops at the edge of the mountain. 29.VII.2015.

Cryptocolea imbricata R. M. Schust. [Sofronova, Potemkin, 2000] (gyn.) – 2 (F; 1200); minor admixture among *Anthelia juratzkana, Blepharostoma trichophyllum, Trilophozia quinquedentata* and others on soil covering stones in the water of brook. 22.VII.1999. 2 (A; 1310); minor admixture among *Aneura pinguis, Anthelia juratzkana, Blepharostoma trichophyllum, Trilophozia quinquedentata* and others on soil in the water of brook. 22.VII.1999.

Diplophyllum sibiricum Vilnet & Bakalin (spor.) – 2, 7 (A; 1400–1500); on soil, fine earth: mountain tundras, rock-fields. Sp: FP, M, S.

D. taxifolium (Wahlenb.) Dumort. [Sofronova, 2000] (per., gem.) – 2, 3, 5 (F, SS; 850–1200); on soil, fine earth, soil covering stones: rock outcrops, rock-fields. Sp: FP, M.

Frullania ignatovii Sofronova, Mamontov & Potemkin [Sofronova, 2000 as *Frullania nisquallensis* Sull.] – 3 (A; 1500); small mat with minor admixture *Cephaloziella varians, Plagiochila porelloides, Trilophozia quinquedentata* on fine earth of lichen mountain tundra. 19.VII.1998.

F. subarctica Vilnet, Borovich. & Bakalin [Sofronova, 2000 as *Frullania nisquallensis*] – 8 (A; 1300); extensive mat more than 1 sq. m on soil covering stones of the stream waterfall. 25.VII.1999.

Fuscocephaloziopsis connivens (Dicks.) Váňa & L. Söderstr. [Sofronova, 2000] – 5 (F; 1200); minor admixture among *Scapania scandica, Schistochilopsis incisa, Sphenolobus minutus* on decaying wood on brook bank. 14.VII.1998. 2 (F; 900); small turf up to 1 sq. cm mixed with *Calypogeia muelleriana, Cephalozia bicuspidata, Sphenolobus minutus, Tritomaria exsectiformis* on decaying wood in *Larix* forest. 10.VII.1999.

F. pleniceps (Austin) Váňa & L. Söderstr. [Sofronova, 2000] (spor.) – 2, 3, 5, 8 (F, SS, A; 850–1400); on soil, soil covering stones and on or among *Sphagnum*, in the water on soil covering stones: *Larix* forests, brook banks, mountain tundras, bog, rock outcrops. Fr: M, FP, S.

Gymnomitrion concinnatum (Lightf.) Corda (spor.) – 2 (A; 1500); small turf up to 100 sq. cm on fine earth in cracks of rock outcrops at the edge of the mountain. 29.VII.2015. 2 (A; 1400); small turf up to 100 sq. cm with admixture *Diplophyllum sibiricum, Scapania sphaerifera, Trilophozia quinquedentata* on soil between small stones of dwarf shrub mountain tundra. 2.VIII.2016.

G. corallioides Nees [Sofronova, 2000] – 2 (F; 900); small turf up to 1 sq. cm with an admixture *Scapania sphaerifera, Sphe-*

nolobus minutus on fine earth at the base of a cliff covered with lichens. 11.VII.1998. 2 (F; 850); minor admixture among *Diplophyllum taxifolium* on the soil between rocky outcrops along the river bank. 23.VII.1998.

Isopaches bicrenatus (Schmidel ex Hoffm.) H. Buch (per.: paroecious, gem.) – 2, 7 (F, A; 850–1500); on soil, soil covered stones, fine earth: *Larix* forests, mountain tundras. Sp: M.

Jungermannia borealis Damsh. & Váňa [Sofronova, 2000] (and., per.) – 2, 8 (F, A; 850–1400); on soil, soil covered stones, surfaces of stone: brook banks, rock outcrops. Sp: S, FP.

Lejeunea alaskana (R. M. Schust. & Steere) Inoue & Steere – 2 (F; 900); small turf up to 100 sq. cm on soil among dwarf shrub-moss rocky outcrops near a small lake. 13.VII.1999. 8 (A; 1300); small turf up to 100 sq. cm on soil covered stones along the bank of a brook flowing out of a snowfield. 25.VII.1999.

Lepidozia reptans (L.) Dumort. – 1 (F; 900); minor admixture among *Lophozia longiflora, Plagiochila porelloides, Sphenolobus minutus* on decaying wood on the bank of a brook. 18.VI.1999.

Lophozia longiflora (Nees) Schiffn. [Sofronova, 2000] (and., per., spor., gem.) – 1, 2, 5 (F; 700–1250); on decaying wood, soil, *Sphagnum*, in the water on soil: *Larix* forests, brook and river banks, *Alnus fruticosa* shrubs. Cm: M, FP, rarely S.

L. cf. *savicziae* Schljakov (per., gem.) – 2 (F, A; 1200–1500); on soil, soil covering stones: on the paths through the *Larix* forests, in a niche between the stones of rocky fields, brook banks. Sp: S, FP, M.

L. cf. *silvicola* H. Buch (gem.) – 1 (F; 900); small turf up to 100 sq. cm on soil in niches in rock outcrops. 19.VI.1999.

L. ventricosa (Dicks.) Dumort. s.l. [Sofronova, 2000] – 1, 2, 8 (F, SS, A; 850–1350); on soil, decaying wood, soil covered stones, fine earth, *Sphagnum*, in the water on decaying wood, soil covered stones: rock outcrops, *Betula* and *Alnus fruticosa* shrubs, brook banks, *Larix* forest, rock fields. Fr: M, S, FP.

Lophoziopsis excisa (Dicks.) Konstant. & Vilnet [Sofronova, 2000] (andr., spor., gem.) – 1–3, 5, 7, 8 (F, SS, A, FR; 800–1500); on soil, fine earth, soil covered stones, decaying wood, bark of trees, sand, in the water on soil, soil covered stones: brook banks, mountain tundras, *Salix, Betula* and *Alnus fruticosa* shrubs, *Chosenia arbutifolia, Populus suaveolens, Larix* forests, rock outcrops, rock fields, screes. Cm: FP, M, rarely S.

L. jurensis (Meyl. ex Müll. Frib.) Mamontov & Vilnet [Sofronova, 2000] – 3 (A; 1500); noticeable admixture among *Lophoziopsis excisa, Trilophozia quinquedentata* on soil of forb-lichen mountain tundra. 19.VII.1998.

L. longidens (Lindb.) Konstant. & Vilnet [Sofronova, 2000] (gem.) – 1–4 (F; 700–1100); on soil, fine earth, decaying wood: rock fields, *Larix* forests. Sp: FP, M.

L. polaris (R. M. Schust.) Konstant. & Vilnet [Sofronova, 2000] (and., gem.) – 2 (F; 950); noticeable admixture among *Blepharostoma trichophyllum, Ptilidium ciliare, Scapania crassiretis, S. scandica* on soil in water brook. 11.VII.1998. 8 (A; 1400); noticeable admixture among *Plagiochila porelloides, Scapania praetervisa*, on fine earth between the pebbles of the bank of a brook flowing out of a snowfield. 25.VII.1999.

Mannia cf. *gracilis* (F. Weber) D.B. Schill & D.G. Long (spor.) – 3 (F; 1000); few thalli mixed with scattered thalli of *Mannia triandra, Sauteria alpina* on moist soil covering stones of rocky outcrops in the mountain stream valley. 10.VII.1999.

M. triandra (Scop.) Grolle (spor.) – 3 (F; 1000); few thalli mixed with scattered thalli of *Mannia* cf. *gracilis, Sauteria alpina* on moist soil covering stones of rocky outcrops in the mountain stream valley. 10.VII.1999. 6 (F; 1100); small mat with minor admixture *Solenostoma obovatum* on moist soil covering stones of rock outcrops in the mountain stream valley. 10.VII.1999. Included in the Red Book of the Russian Federation (Geltman, 2024).

Marchantia polymorpha L. s. str. [Sofronova, 2000] (and., gyn., gem.) – 2 (F, FR; 800–950); on soil, sand, in the water on soil: brook banks, *Salix* shrubs. Sp: FP, S.

Marsupella emarginata (Ehrh.) Dumort. (and.) – 2 (F; 1100); few plants among mat *Solenostoma confertissimum* with admixture *Blepharostoma trichophyllum, Pseudotritomaria heterophylla* and others on soil in water of brook. 24.VII.1999.

M. sprucei (Limpr.) Bernet (spor.) – 2 (A; 1400); few plants among mat *Diplophyllum sibiricum* with admixture *Scapania scandica, Trilophozia quinquedentata* on soil between small stones of dwarf shrub mountain tundra. 2.VIII.2016.

Mesoptychia gillmanii (Austin) L. Söderstr. & Váňa [Sofronova, 2000] – 1 (F; 950); few plants among *Fuscocephaloziopsis pleniceps, Sphenolobus minutus* on plants debris at the base of a tussock of cotton grass in a flooded *Larix* forest. 20.VII.1998.

M. heterocolpos (Thed. ex Hartm.) L. Söderstr. & Váňa [Sofronova, 2000] (gem.) – 1, 2, 5, 8 (F, SS, A, FR; 700–1500); on soil, decaying wood, fine earth, sand: brook banks, *Larix* forests, rock outcrops, rock fields. Fr: M, S, FP.

M. rutheana (Limpr.) L. Söderstr. & Váňa (per.: paroecious) – 2 (F; 1050); minute pure mat (up to 1 sq. cm) among small (up to 100 sq. cm) mat of *Odontoschisma macounii* with admixture few plants of *Scapania simmonsii* on soil of sedge-*Sphagnum* bog. 23.VII.2015.

M. sahlbergii (Lindb. & Arnell) A. Evans [Sofronova, 2000] – 2, 6, 8 (F, A; 850–1300); on soil, soil covering stones, decaying wood, in water on plants debris: *Larix* forests, brook banks, rock outcrops. Fr: S, L, FP, E.

Metzgeria pubescens (Schrank) Raddi [Sofronova, 2000] – 1, 4 (F; 850–950); on fine earth, soil, soil covering stones, decaying wood: rock fields, rock outcrops, brook bank. Sp: FP, S, L.

Mylia anomala (Hook.) Gray [Sofronova, 2000] (gem.) – 1–4 (F; 900–1200); on *Sphagnum*, plants debris: bogs, *Larix* forests. Sp: FP, M.

Neoorthocaulis binsteadii (Kaal.) L. Söderstr., De Roo & Hedd. [Sofronova, 2000] – 1–5 (F, FR; 850–1000); on *Sphagnum*, decaying wood, plants debris: bogs, *Larix* forests, *Betula* shrubs. Fr: FP, M.

Odontoschisma macounii (Austin) Underw. [Sofronova, 2000] (and., per., spor., gem.) – 2, 3 (F, A; 900–1460); on soil, soil covered stones, *Sphagnum*, in the water on decaying wood: *Larix* forests, *Betula* shrubs, bogs, *Betula* dwarf shrubs tundra, rock outcrops. Fr: FP, S, L.

Orthocaulis cavifolius H. Buch & S.W. Arnell [Sofronova, 2000] – 3 (F; 1000); minor admixture among *Fuscocephaloziopsis pleniceps, Scapania scandica, Sphenolobus minutus* in water on soil covered stones of rock outcrops in lichen *Larix* forest. 19.VII.1998.

Plagiochila porelloides (Torr. ex Nees) Lindenb. [Sofronova, 2000] – 1–3, 7, 8 (F, SS, A, FR; 700–1500); on soil, decaying wood, fine earth, soil covered stones, *Sphagnum*, bark of

trees, sand: brook and river banks, *Alnus fruticosa* shrubs, *Larix, Populus suaveolens* forests, mountain tundras, rock outcrops. Cm: FP, M, rarely L.

Preissia quadrata (Scop.) Nees [Sofronova, 2000] (and., spor.) – 1 (FR; 800); few thalli mixed with *Blepharostoma trichophyllum* on soil of river bank. 17.VII.1999. 5 (A; 1700); small mat with minor admixture *Blepharostoma trichophyllum* on soil of forb-shrub mountain tundra. 14.VII.1998. 6 (F; 1100); dominates in mat (up to 1 sq. m) with admixture of *Mesoptychia sahlbergii, Solenostoma obovata, Scapania zemliae* on soil of rock outcrops. 27.VII.2015.

Pseudotritomaria heterophylla (R. M. Schust.) Konstant. & Vilnet [Sofronova, 2000] (gem.) – 2, 5–8 (F, A; 950–1500); on soil, soil covered stones, in the water on soil: brook banks, rock outcrops. Fr: FP, rarely M.

Ptilidium ciliare (L.) Hampe [Sofronova, 2000] – 1–8 (F, SS, A, FR; 850–1600); on soil, fine earth, soil covered stones, plants debris, sand, decaying wood, *Sphagnum*, in the water on soil: *Larix, Populus suaveolens, Chosenia arbutifolia* forests, mountain tundras, *Betula*, *Pinus pumila, Alnus fruticosa* shrubs, screes, rock-fields, rock outcrops, brook and river banks. Cm: FP, rarely M, S.

P. pulcherrimum (Weber) Vain. – 1 (FR; 700); small turf up to 1 sq. cm on the bark of trees in *Populus suaveolens* forest. 15.VI.1999.

Radula complanata (L.) Dumort. [Sofronova, 2000] – 4 (F; 950); noticeable admixture among *Barbilophozia barbata, Ptilidium ciliare* on fine earth between stones of rocky field. 9.VII.1998.

R. prolifera Arnell – 2 (F; 1400); noticeable admixture among *Anthelia juratzkana, Blepharostoma trichophyllum, Schistochilopsis grandiretis, Trilophozia quinquedentata* and others on soil along the brook bank covered mosses. 8.VII.2011.

Riccardia chamedryfolia (With.) Grolle [Sofronova, 2000] – 2, 3 (F, A; 850–1500); on *Sphagnum*, soil, decaying wood, in the water on soil, plants debris: *Larix* forests, *Betula* shrubs, bog, *Sphagnum* mountain tundra, brook bank. Fr: FP, rarely M.

R. latifrons (Lindb.) Lindb. [Sofronova, 2000] – 1, 2 (F; 950–1400); on soil, among *Sphagnum*, in the water on soil covering stones: brook banks, *Larix* forest. Sp: FP, rarely M.

R. multifida (L.) Gray [Sofronova, 2000] – 3 (F; 1000); few thalli among *Sphagnum* mixed with *Blepharostoma trichophyllum, Mylia anomala, Sphenolobus minutus* and others in *Sphagnum* bog. 19.VII.1998.

Sauteria alpina (Nees) Nees – 3 (F; 1000); few thalli mixed with scattered thalli of *Mannia* cf. *gracilis, M. triandra* on moist soil covering stones of rocky outcrops in the mountain stream valley. 10.VII.1999.

Scapania crassiretis Bryhn [Sofronova, 2000] (per., spor., gem.) – 1–3, 5, 8 (F, SS, A, FR; 700–1500); on soil, soil covered stones, fine earth, decaying wood, sand, *Sphagnum*, in the water on soil, soil covered stones: brook and river banks, rock outcrops, *Larix* forests, rock-fields, *Alnus fruticosa* shrubs, mountain tundra. Cm: M, FP, M, S.

S. cuspiduligera (Nees) Müll. Frib. (gem.) – 8 (F; 700); few plants mixed with *Pseudotritomaria heterophylla, Scapania crassiretis, S. praetervisa, Schljakovianthus quadrilobus* and others on sand of brook bank. 23.VII.1999. 8 (F; 700); few plants mixed with *Scapania praetervisa* on decaying wood on brook bank. 23.VII.1999.

S. degenii Schiffn. & Müll. Frib. [Sofronova, 2000] (gem.) – 5 (F; 1200); small turf up to 100 sq. cm on soil of brook bank. 14.VII.1998.

S. gymnostomophila Kaal. [Sofronova, 2000] (and., gem.) – 1, 6 (F; 900–1100); on soil covered stones, soil: rock outcrops, *Alnus fruticosa* shrubs. R: M, FP.

S. irrigua (Nees) Nees [Sofronova, 2000] (gem.) – 2 (F; 850); small turf up to 1 sq. cm with an admixture *Fuscocephaloziopsis pleniceps, Schljakovia kunzeana* on soil on the paths through the *Larix* forest. 23.VII.1998.

S. microdonta (Mitt.) Müll. Frib. [Sofronova, 2000] (per., gem.) – 2–4, 7 (F, SS, A; 850–1600); on fine earth, soil covered stones: rock-fields, mountain tundra, rock outcrops. Fr: S, L, FP.

S. mucronata H. Buch [Sofronova, 2000] (gem.) – 1, 2 (F, FR; 700–1200); on decaying wood, soil, bark of trees, soil covered stones: rock outcrops, river banks, *Larix* forest, *Alnus fruticosa* shrubs. Sp: FP, rarely S.

S. paludicola Loeske & Müll. Frib. [Sofronova, 2000] (per.) – 2–4, 5 (F, SS, FR; 850–1250); on soil, soil covered stones, fine earth, in water on soil, plants debris: brook and river banks, *Larix* forests, *Betula* shrubs, rock outcrops, bogs. Fr: FP, M, S.

S. praetervisa Meyl. (and., per., spor., gem.) – 2, 8 (F; 700–1200); on soil, soil covered stones, decaying wood: rock outcrops, brook banks. Sp: M, S.

S. rufidula Warnst. (and.) – 7 (F; 1000); few plants on soil on ledges of cliffs. 17.VII.1999.

S. scandica (Arnell & H.Buch) Macvicar (incl. *S. parvifolia* Warnst.) [Sofronova, 2000] (and., per., spor.) – 1–3, 5, 7, 8 (F, SS, A, FR; 850–1500); on soil, soil covered stones, fine earth, decaying wood, *Sphagnum*, in the water on soil, soil covered stones, decaying wood, *Sphagnum*: brook banks, *Larix* forests, rock outcrops, mountain tundras, *Betula, Alnus fruticosa* and *Pinus pumila* shrubs, rock fields, screes. Cm: M, FP.

S. simmonsii Bryhn & Kaal. – 2 (F; 1050); few plants among mat *Odontoschisma macounii* with admixture *Mesoptychia rutheana* on soil of sedge-*Sphagnum* bog. 23.VII.2015.

S. sphaerifera H. Buch & Tuom. [Sofronova, 2000] (gem.) – 2–4, 7 (F, SS, A; 850–1600); on fine earth, decaying wood, soil, soil covered stones: rock fields, rock outcrops, rocky mountain tundra. Fr: FP, M.

S. spitsbergensis (Lindb.) Müll.Frib. – 2 (A; 1500); small mat with minor admixture *Scapania crassiretis* on soil covering stones in a niche between the stones of rocky fields. 2.VIII.2016.

S. zemliae S.W. Arnell (per.) – 6 (F; 1100); few plants mixed with *Mesoptychia sahlbergii, Solenostoma obovata* among *Preissia quadrata* on soil of rock outcrops. 27.VII.2015.

Schistochilopsis grandiretis (Lindb. ex Kaal.) Konstant. [Sofronova, 2000] (spor.) – 2, 3, 8 (F, SS, A; 850–1400); on soil and *Sphagnum*: *Larix* forests, bogs, *Betula* shrubs, brook bank. Fr: FP, rarely M.

S. incisa (Schrad.) Konstant. [Sofronova, 2000] (spor., gem.) – 2, 3, 5 (F, FR; 850–1300); on soil, decaying wood, soil covered stones, *Sphagnum*, in the water on soil, decaying wood, soil covered stones: brook and river banks, rock outcrops, *Larix* forest, *Alnus fruticosa* shrubs. Cm: S, M, FP.

S. opacifolia (Culm. ex Meyl.) Konstant. – 2 (F; 1200); small admixture among *Anthelia juratzkana, Blepharostoma trichophyllum, Trilophozia quinquedentata* and others on soil covering stones in the water of brook. 24.VII.1999. 2 (F; 1400); small admixture among *Anthelia juratzkana, Blepharostoma trichophyllum, Schistochilopsis grandiretis, Trilophozia quinquedentata* and others on soil along the brook bank covered mosses. 8.VII.2011.

Schljakovia kunzeana (Huebener) Konstant. & Vilnet [Sofronova, 2000] – 2–4 (F; 850–900); on soil, decaying wood, fine earth: *Betula* shrubs, *Larix* forests, rock-field. Fr: FP.

Schljakovianthus quadrilobus (Lindb.) Konstant. & Vilnet – 8 (F; 700); few plants mixed with *Pseudotritomaria heterophylla, Scapania crassiretis, S. cuspiduligera, S. praetervisa* and others on sand of brook bank. 23.VII.1999.

Solenostoma confertissimum (Nees) Schljakov – 2 (F; 1100); small mat on soil in water of brook. 24.VII.1999.

S. hyalinum (Lyell) Mitt. [Sofronova, 2000] (and., per.) – 2 (FR; 800); small turf with admixture of *Blasia pusilla* on soil along the river bank covered mosses. 11.VII.1998. 7 (F; 1000); small turf with admixture of *Cephaloziella varians* on soil on ledges of cliffs. 17.VII.1999.

S. obovatum (Nees) C. Massal. [Sofronova, 2000] (per.: paroecious) – 2, 6 (F; 850–1100); on soil, soil covering stones, in the water on soil: rock outcrops, brook bank. Sp: FP, M.

Sphenolobus minutus (Schreb. ex D. Crantz) Berggr. [Sofronova, 2000] (and., per., spor., gem.) – 1–8 (F, SS, A, FR; 700–1500); on soil, soil covered stones, decaying wood, fine earth, plants debris, *Sphagnum*, bark of trees, in the water on soil, soil covered stones: *Larix* forests, brook and river banks, rock outcrops, rock-fields, *Betula* shrubs, mountain tundras, bogs, *Alnus fruticosa* shrubs. Cm: M, FP, rarely S.

S. saxicola (Schrad.) Steph. [Sofronova, 2000] – 2, 3, 5, 7, 8 (F, SS, A; 900–1600); on fine earth, soil, soil covering stones: rock-fields, rock outcrops, mountain tundras, *Pinus pumila* shrubs, *Larix* forests. Cm: FP, M, S.

Tetralophozia setiformis (Ehrh.) Schljakov [Sofronova, 2000] – 2–4, 7, 8 (F, SS, A; 850–1600); on fine earth, soil covered stones, soil: rock fields, mountain tundras, rock outcrops, *Pinus pumila* shrubs. Cm: S, L, M, FP.

Tritomaria exsecta (Schmidel) Schiffn. ex Loeske (gem.) – 2 (F; 900); few plants mixed with *Blepharostoma trichophyllum, Odontoschisma macounii, Trilophozia quinquedentata* and others on soil between the stones of rocky outcrops. 13.VII.1999.

T. exsectiformis (Breidl.) Schiffn. ex Loeske [Sofronova, 2000] (and., per., gem.) – 1, 2 (F, FR; 700–900); on decaying wood, bark of trees, soil: *Larix* forests, *Alnus fruticosa* shrubs, brook bank, rock outcrops. Fr: M, FP.

Trilophozia quinquedentata (Huds.) Bakalin [Sofronova, 2000] (and., per., spor.) – 1–5, 8 (F, SS, A, FR; 800–1500); on fine earth, soil, soil covered stones, decaying wood, *Sphagnum*, sand, in the water on soil, soil covered stones, decaying wood: rock outcrops, rock-fields, brook banks, mountain tundras, screes, *Larix* forests, *Betula*, *Salix, Pinus pumila, Alnus fruticosa* shrubs. Cm: FP, M, rarely S.

DISCUSSION

In total, 95 species of liverworts were recorded in the study area. This diversity is rather high, although the area is quite xeric, including cryoaridity. It is comparable with the local liverworts flora of Upper Kyubyume River of eastern macroslope of the Suntar-Khayata Range (65 species, Sofronova & Potemkin, 2016), Momsky Nature Park (85 species, Sofronova, 2019), Orulgan Sis Reserve (73 species, Sofronova & Sofronov, 2012). The diversity of the recorded liverworts is even slightly higher, which is probably due to many years of research. Most of the specimens were collected in 1998 and 1999. In subsequent years, more attention was paid to specific habitats such as cliffs, brook banks, poplar forests, bogs, etc.

It should be noted that almost all the variety of species, like in other studied mountainous regions of Yakutia, is concentrated along the banks of watercourses (51 species, of these, 13 species were found only here), in moist, shaded cracks of rock and in wet niches of rock-fields (53 species, of these, 12 species were found only here).

In total, 39 species were identified in various types of forests: *Larix cajanderi, Chosenia arbutifolia, Populus suaveolens, Betula lanata*. Relatively large variety of liverworts has been discovered in *Larix* forests (37 species). However, only two species were found only here (*Mesoptychia gilmannii* and *Scapania irrigua*). This is due both to the wide distribution of these communities and to their great variety. Other types of forest communities are much less common. Only two poplar forests were studied, however, of the eight species recorded here, two (*Chiloscyphus polyanthos* and *Ptilidium pulcherrimum*) have been found only in such habitats.

Of the shrub communities, the largest areas are occupied by thickets of *Pinus pumila* dwarf. This forms a subalpine zone, poorly defined in the studied area. Six common species were found here (*Barbilophozia barbata, Ptilidium ciliare, Scapania parvifolia, Sphenolobus saxicola, Tetralophozia setiformis, Trilophozia quinquedentata*). Liverworts are quite diverse in dwarf birch (19) and dwarf alder (15) shrub communities. One species (*Neoorthocaulis attenuatus*) was found only in dwarf birch.

Mountain tundra also occupies significant areas and forms the mountain tundra belt. Despite a significant number of mountain tundras studied, relatively few species have been found (28 species). Of these, three species (*Frullania ignatovii, Lophoziopsis jurensis* and *Marsupella sprucei*) were found only here. The high number of species were found on the only one examined *Sphagnum* mountain tundra. However, of the nine species recorded here, seven (*Aneura pinguis, Calypogeia muelleriana, Cephalozia bicuspidata, Cephaloziella rubella, Odontoschisma macounii, Riccardia chamedryfolia* and *Schistochilopsis grandiretis*) have been found only in such habitat.

Liverworts are quite diverse and specific in the bogs, although they have a very limited distribution in the study area. 17 species were recorded here, including *Biantheridion undulifolium, Calypogeia sphagnicola, Cephaloziella arctogena, Mesoptychia rutheana*, *Riccardia multifida* and *Scapania simmonsii*, found in this type only.

The species composition of the flora of the studied region is quite characteristic for the mountain area, with most of the recorded species being widespread arctic montane or arctoboreomontane species. The most common in the studied area are widespread species: *Barbilophozia barbata, Blepharostoma trichophyllum, Cephalozia bicuspidata, Lophoziopsis excisa, Plagiochila porelloides, Ptilidium ciliare, Scapania crassiretis, S. parvifolia, Sphenolobus minutus, S. saxicola, Tetralophozia setiformis* and *Trilophozia quinquedentata*.

The Suntar-Khayata Range has an alpine-type relief, which is why nival habitats are poorly developed. Due to this some species are much rarer, for example *Anthelia juratzkana, Marsupella* spp., *Schistochilopsis opacifolia*. Also extremely rare are boreal species such as *Lepidozia reptans, Lophoziopsis longidens, Ptilidium pulcherrimum, Tritomaria exsectiformis*.

Calcium was probably present in the soil, which added calcifilous species in studied flora: *Bucegia romanica, Clevea hyalina, Cryptocolea imbricata, Mannia triandra, Mesoptychia rutheana, Odontoschisma macounii, Scapania gymnostomophila, S. simmonsii* and others.

The most interesting rare species records in Yakutia.

Eight species included in the Red Data Book of the Russian Federation (Geltman, 2024) and the Republic of Sakha (Yakutia) (Danilova, 2017) have been identified: *Apotreubia* cf. *nana, Biantheridion undulufolium, Bucegia romanica, Cryptocolea imbricata, Frullania ignatovii, Lejeunea alaskana, Mannia triandra, Scapania sphaerifera*.

Also in 1999, *Apotreubia* cf. *nana* was found on Mount Baranya, which remains the only known Yakutian locality of this relic genus of the basalmost hepatics, and known in Russia so far of the few locations (Geltman, 2024). Subsequently, in 2000, 2001, 2011, 2015-2018, attempts were made to rediscover the species, which were unsuccessful. By 2015, this habitat had become overgrown with *Radula prolifera, Mesoptychia rutheana* as small turfs, which had not previously been observed here, interspersed with *Odontoschisma macounii* and *Scapania simmonsii*.

Frullania ignatovii is a species from Mus-Khaya Mountain that has only recently been described (Suntar-Khayata Range) (Sofronova *et al*., 2013). The species was previously found in the study area and published as *F. muscicola* (Sofronova, 2011a). The remarkable records near the *Frullania ignatovii* place of growth include *Frullania subarctica, Lejeunea alaskana, Radula prolifera*. *Lejeunea alaskana*, a species described from Alaska, was found in Russia in Magadan Province (Bakalin *et al*., 2012). Also, this species was previously found in the Suntar-Khayata Range, listed as *Lejeunea cavifolia* (Sofronova, 2003). These species, which commonly grow together with *Lejeunea alaskana*, may be cautiously considered preglacial relics and believed to occur in regions that presumably escaped Pleistocene glaciation (Bakalin *et al*., 2012).

Marsupella sprucei is a very small arctic-montane species. It is very rarely found in the mountainous areas of the republic (Sofronova *et al*., 2015, Sofronova, 2018, Sofronova, 2019). Erroneously cited by Konstantinova *et al*. (2024) as the first record for the liverwort flora of Yakutia.

Cryptocolea imbricata is a species occurring sporadically in the mountainous areas of northeastern Yakutia (Sofronova & Potemkin, 2000, 2016 a,b, Sofronova, 2011b, 2018, 2019). The species is likely demanding of its growing conditions and does not tolerate prolonged desiccation by sun and/or cold. All habitats (substrates) in Yakutia were located in areas with constant moisture. For example, near the study area, in the Kobyume River floodplain, bogs were widespread, where this species was common.

It is also worth noting that *Pseudotritomaria heterophylla*, which Konstantinova *et al*. (2024) classifies as rare in Yakutia, is common throughout the Republic. It grows in a wide variety of habitats across the entire vertical profile, preferring disturbed soil and forming mats up to 100 square centimeters in size.

The second location of *Chiloscyphus polyanthos* is for the Verkhoyansk and Chersky Mountain Systems. Previously, the species was recorded only for the Yudoma-Mayskiy Upland, located further south, in the middle reaches of the Yudoma River near the village of Yugoronok (Sofronova, 2011b). Interestingly, in the mountains of the northeast of the republic, representatives of the genus *Chiloscyphus* have been recorded only in the Yudoma-Mayskiy Upland. However, along the left bank of the Lena River, species of the genus are widespread and can be found even in the tundra zone (Egorova *et al*., 1991). Overall, the species is common in Russia, widespread from arctic tundra to the steppe zone, growing on a variety of substrates (Potemkin & Sofronova, 2009).

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