

A CONTRIBUTION TO THE LIVERWORT FLORA OF THE UPPER COURSE
OF INDIGIRKA RIVER, EAST YAKUTIA

МАТЕРИАЛЫ К ФЛОРЕ ПЕЧЕНОЧНИКОВ ВЕРХНЕГО ТЕЧЕНИЯ Р. ИНДИГИРКА,
ВОСТОЧНАЯ ЯКУТИЯ

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Abstract

The list of liverworts of Upper Course of the Indigirka River was first updated in 1980. An annotated list of liverworts collected and reported here includes 65 species. The data on structures associated with reproduction, localities, substrates, habitats, and growth pattern are also provided. *Marsupella sprucei* is recorded for the first time for Yakutia. In several plant communities, a very small number of liverworts have been collected. Almost all the diversity of species was found to occur along the banks of watercourses, in wet niches of rock-fields and in moist, shaded cracks of rock. On the banks of a small brook, numerous rock outcrops and rock-fields on Tas-Kystabyt Mt. Range, eight rare species were found – *Calycularia laxa*, *Cryptocolea imbricata*, *Marchantia romanica*, *Marsupella boeckii*, *Pseudotritomaria heterophylla*, *Scapania kaurinii*, *S. rufidula*, *S. sphaerifera*. *Asterella saccata* and *Mannia fragrans* are limited here in their distribution only to steppes. Another rare species – *Haplomitrium hookeri* – is found in the moss community on old rut winter road.

Резюме

Приводится аннотированный список печеночников для верхнего течения р. Индигирка, включающий 65 видов. Для каждого вида указано наличие структур, связанных с размножением, выявленные местонахождения, субстрат, местообитания, характер произрастания. *Marsupella sprucei* впервые приводится для флоры печеночников Якутии. В растительных сообществах отмечено очень небольшое число печеночников. Почти все разнообразие видов обнаружено вдоль берегов водотоков, во влажных нишах курумов и трещинах скал. На хребте Тас-Кыстабыт по берегу одного небольшого ручья и среди скальных обнажений и курумах вдоль ручья найдено восемь редких видов: *Calycularia laxa*, *Cryptocolea imbricata*, *Marchantia romanica*, *Marsupella boeckii*, *Pseudotritomaria heterophylla*, *Scapania kaurinii*, *S. rufidula*, *S. sphaerifera*. *Asterella saccata* и *Mannia fragrans* произрастают здесь только в степных сообществах. Еще один редкий вид (*Haplomitrium hookeri*) отмечен в моховом сообществе на колее зимника.

KEYWORDS: flora, liverworts, ecology, Yakutia

INTRODUCTION

The study area is situated in the Upper Course of the Indigirka River and includes areas near the Ust-Nera settlement and the In'yalinsky Range, located on the left bank of the In'yali River. The hepatic flora of the Indigirka River Basin is very poorly explored. The only data on liverworts for the study area was published by Afonina & Duda (1980) for the In'yali Creek area, about 80 km downstream of the Indigirka River from the Ust-Nera settlement. It was based on collections made by O.M. Afonina in the course of a Polar expedition of the Komarov Botanical Institution; this study especially concentrated on tundra-steppe communities occurring on south-facing slopes (Ivanova *et al.*, 2018). This list comprised of 43 liverworts species, mainly from the spurs of the Silyap Range. This present work is based on specimens

collected on the left bank of the In'yali River in 2012 from June 30 to July 7 and in the vicinity of the Ust-Nera settlement in 2015 during July 31 to August 7. The resulting list is obviously not exhaustive; however, it includes a number of interesting new records.

STUDY AREA

The explored territory is located in the upper course of the Indigirka River near the mouth of the Nera and In'yali Rivers. The liverwort specimens were collected in In'yali-Olchan Upland (namely near Ol'chan gold works and in the In'yali River valley, In'yalinsky Range), Mt. Range Tas-Kystabyt (Sarychev), Indigirka River valley up to ca. 10 km upstream Ust-Nera Settlement, and Nera River valley up to ca. 60 km from its mouth (Fig. 1, Table 1).

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Fig. 2. A view near Ust-Nera Settlement. A: larch forest and steppes community; B: grass mire; C: *Pinus pumila* community; D: mountain tundra; E: wet rock outcrops; F: bank of small brook on the open slope of Tas-Kystabyt Mt.; G: *Anthelia juratzkana*, *Scapania crassiretis*, *S. kaurinii* and *Tritomaria quinqueidentata* on the bank of brook; H: *Schistochilopsis opacifolia* and *Scapania kaurinii* on the bank of brook.



Fig. 3. A view In'yali River valley. A: larch forest and steppes community; B: *Equisetum* community with *Riccia sorocarpa*; C: mire dominated by *Sanionia uncinata* (ice in the crack of moss); D: *Salix* community; E: *Larix* forest; F: dry rock outcrops, a view of In'yali River valley; G: rock-fields; H: *Mannia fragrans* on rock outcrops.

Table 2. Meteorological data from the nearest meteostations (Izyumenko, 1966, 1968).

Meteostations	t _{ann}	t _{max}	t _{min}	t _{January}	t _{July}	Annual precipitation, mm	Maximal depth of snow cover, cm
Nera	-15.3	34	-68	-48.5	15.5	225	45
Predporozhnaya	-14.6	34	-67	-45.6	15.7	205	37
El'gi	-16.6	–	–	-49.7	14.5	224	–
Oimyakon	-16.6	33	-71	-50.0	14.5	175	43
Agayakan	-16.1	33	-67	-48.4	13.9	220	51

The study area is located in the zone of continuous permafrost, its hydrogeological features affecting vegetation are determined by the water available of the active layer. The latter are formed due to melting of permafrost and the infiltration of precipitation, so the permafrost surface serves as a perforated layer. Additional data on the climate, soils and vegetation of the territory are published by Ivanova *et al.* (2018).

LIVERWORTS IN VEGETATION COVER

This area is relatively xeric, and therefore, liverworts have a very limited distribution in the study area. In the larch forests on soil, liverworts are represented mostly by *Ptilidium ciliare* and *Barbilophozia barbata* which form large patches (up to 1 sq. m). Other hepatics growing on and among *Sphagnum* ssp. in *Sphagnum-Larix* communities and have a minute (up to 1 sq. cm) or small (up to 100 sq. cm) cover; these are *Cephalozia bicuspidata* and *Calypogeia muelleriana*. Shrub communities of *Pinus pumila*, *Betula divaricata*, *Alnus fruticosa*, *Salix* spp. are also quite arid. Only *Isopaches bicrenatus*, *Cephaloziella varians* (up to 1 sq. m) and *Blasia pusilla* (few plants) are recorded. All mires in the study area are extremely arid. There are almost no liverworts, even in *Sphagnum* mires. Only in the grass mires *Lophozia ventricosa* s.l. (up to 1 sq. m) and *Scapania paludicola* (few plants) were found. In the mountainous tundra, only *Gymnomitrium corallioides*, *Isopaches bicrenatus*, *Sphenolobus minutus* and *Tetralophozia setiformis* with a small continuous cover (up to 100 sq. cm) were observed. All other species noted here were represented by few plants. *Asterella saccata*, *Mannia fragrans* and *Riccia sorocarpha* are relatively common in the steppes, though they do not form solid patches. In wet anthropogenic places *Marchantia polymorpha* subsp. *polymorpha* forms continuous cover up to 1 m. On soil in the old rut of winter road, *Haplomitrium hookeri*, *Lophozia excisa*, *Scapania parvifolia*, etc. were found. Liverworts on the banks of brooks and rocky substrates reach a special abundance and diversity (Fig. 2). On soil on brooks and rivers banks in the forest belt *Jungermannia borealis*, *Plagiochila porelloides*, *Solenostoma obovatum*, *Scapania crassiretis*, *S. mucronata*, *S. paludicola* and *S. rufidula* form a minute and small continuous cover. On soil on brooks banks in the tundra belt *Calycularia laxa*, *Cryptocolea imbricata*, *Gymnomitrium concinatum*, *Scapania crassiretis*, *S. irrigua*, *S. kaurinii*, *S. paludicola*, *S. scandica*, etc. grow on soil in large amounts. On the rock-fields in dry niches between the stones *Tetralophozia setiformis*, *Barbilophozia barbata*, *Radula complanata* and *Trilophozia*

quinquedentata develop a continuous population up to 100 sq. cm or 1 sq. m and *Scapania sphaerifera*, *Lophozia excisa*, and *L. longidens* up to 1 cm. Also on the rock-fields in places of late snow melting occur *Marsupella emarginata*, *Scapania curta* and *S. spitsbergensis* forming a continuous patches up to 10 cm, while *Jungermannia borealis*, *Lophozia excisa*, *Sphenolobus minutus* and *Trilophozia quinquedentata* up to 1 cm. On scree, among small stones, small (up to 10 cm) and minute (up to 1 cm) cover is characteristic for *Sphenolobus saxicola*, *Lophozia excisa*, and *Cephaloziella varians*. High species diversity is noted on wet cliff habitats. *Marsupella emarginata* forms extensive continuous carpets (more than 1 sq. m), *Marchantia romanica* – large patches (up to 1 sq. m), *Anthelia juratzkana*, *Cephalozia bicuspidata*, *Diplophyllum taxifolium*, *Gymnomitrium corallioides*, *Lophozia excisa*, etc. have smaller cover, and *Barbilophozia sudetica*, *Marsupella boeckii*, *Pseudotritomaria heterophylla*, etc. – minute (up to 1 cm) cover. *Mannia fragrans* and *Frullania inflata* were found only on dry cliffs.

SPECIES LIST

In the present list liverwort taxa are arranged alphabetically. The list is annotated in the following order: species name, abbreviations of structures connected with reproduction, if present, in parentheses: m. pl. – male plant, f. pl. – female plant, 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. All specimens are deposited in the Herbarium of Institute for Biological Problems of Cryolithozone SB RAS, Yakutsk (SASY).

- Aneura pinguis* (L.) Dumort. – [1200 m]. 5. On soil: brook bank. FP.
- Anthelia juratzkana* (Limpr.) Trevis. (spor.) – [1200–1600 m]. 5. On soil, stones covered with soil: tundra, rock outcrops, brook banks. FP, M, S.
- Asterella saccata* (Wahlenb.) A. Evans – [550–620 m]. 1, 7. On soil: steppes. FP, L.
- Barbilophozia barbata* (Schmidel ex Schreb.) Loeske – [300–1050 m]. 3, 8, 10. On soil, stones covered with soil: *Larix* forests, rock-fields. FP, S, L.
- B. sudetica* (Nees ex Huebener) L. Söderstr., De Roo et Hedd. (andr., gem.) – [1200–1600 m]. 5. On soil, stones covered with soil: rock outcrops, rock-fields, brook banks. FP, M.

- Blasia pusilla* L. – [550–650 m]. 9, 10. On soil: horsetail, moss shrub post-ice community. FP.
- Blepharostoma trichophyllum* (L.) Dumort. – [1050 m]. 10. On stones covered with soil: rock-fields. FP.
- Calycularia laxa* Lindb. et Arnell (spor.) – [1400 m]. 5. On soil: tundra, brook banks. FP, S.
- Calypogeia muelleriana* (Schiffn.) Müll.Frib. – [500–850 m]. 3, 6. On soil, on and among *Sphagnum: Larix* forest, rock outcrops. FP, S.
- Cephalozia bicuspidata* (L.) Dumort. (spor.) – [500–1400 m]. 3, 5, 6, 10. On soil, on and among *Sphagnum*, stones covered with soil: *Larix* forests, tundra, rock outcrops, rock-fields, brook and river bank, moss community on disturbed soil. FP, M, S, L.
- Cephaloziella polystratosa* (R.M. Schust. et Damsh.) Konstant. (spor.) – [850 m]. 3. On rotten wood: brook bank. M.
- C. varians* (Gottsche) Steph. (spor., gem.) – [550–1600 m]. 3, 5, 6, 10. On soil, stones covered with soil: *Salix* shrubs, moss community on old rut winter roads, rock-fields, rock outcrops, screes, brook banks. FP, M.
- Cryptocolea imbricata* R.M. Schust. – [1400 m]. 5. On soil: brook banks. FP, S.
- Diplophyllum taxifolium* (Wahlenb.) Dumort. (gem.) – [1200–1550 m]. 5. On soil, stones covered with soil: tundra, rock outcrops, brook banks. FP, M, S.
- Frullania inflata* Gottsche – [550 m]. 8. On stones covered with soil: rock outcrops in steppe. M.
- Fuscocephaloziopsis pleniceps* (Austin) Váňa et L. Söderstr. – [500 m]. 8. On soil: brook bank. FP.
- Gymnomitrium concinatum* (Lightf.) Corda (spor.) – [1200–1550 m]. 5. On soil, stones covered with soil: tundra, rock outcrops, brook banks. FP, S, L.
- G. corallioides* Nees – [1350–1600 m]. 5. On soil, stones covered with soil: lichen tundra, rock outcrops. S.
- Haplomitrium hookeri* (Lydell ex Sm.) Nees – [650 m]. 10. On soil: moss community on old rut winter road. FP.
- Isopaches bicrenatus* (Schmidel ex Hoffm.) H. Buch (spor., gem.) – [500–1350 m]. 3, 5, 6, 10. On soil: *Larix* forest, *Pinus pumila* shrubs, lichen tundra, brook bank. FP, M.
- Jungermannia borealis* Damsh. et Váňa (andr.) – [850–1050 m]. 3, 10. On soil, stones covered with soil: brook bank, rock-fields. M.
- Lophocolea minor* Nees – [800 m]. 10. On rotten wood: brook bank. FP.
- Lophozia* cf. *savicziae* Schljakov (spor., gem.) – [500–1400 m]. 5, 6, 10. On soil, stones covered with soil: rock-fields, rock outcrops, brook banks. M, S.
- L.* cf. *silvicola* H. Buch (gem.) – [500 m]. 6. On soil: *Larix* forest. FP.
- L.* cf. *ventricosa* (Dicks.) Dumort. s.l. (gem.) – [500–850 m]. 3, 6. On soil, on and among *Sphagnum: Larix* forest, grass mire. FP, S.
- L.* cf. *wenzelii* (Nees) Steph. (gem.) – [1300 m]. 5. On stones covered with soil: rock outcrops. FP.
- Lophoziopsis excisa* (Dicks.) Konstant. et Vilnet (spor., gem.) – [700–1600 m]. 3, 5, 6, 10. On soil, stones covered with soil, rotten wood: lichen tundra, moss community on disturbed soil, rock-fields, rock outcrops, screes, brook bank. FP, M, S.
- L. jurensis* (Meyl. ex Müll. Frib.) Mamontov et Vilnet (gem.) – [500 m]. 8. On soil: rock-fields. M.
- L. longidens* (Lindb.) Konstant. et Vilnet (andr., gem.) – [850 m]. 10. On stones covered with soil: rock-fields. M.
- L. polaris* (R.M. Schust.) Konstant. et Vilnet (gem.) – [1200–1400 m]. 5. On soil: brook banks. FP.
- Mannia fragrans* (Balb.) Frye et L. Clark (spor.) – [550–700 m]. 7, 8, 10. On soil, stones covered with soil: steppes, rock outcrops. FP, L.
- Marchantia polymorpha* L. subsp. *polymorpha* (m., f. pl.) – [770 m]. 4. On soil: brook bank. L.
- M. polymorpha* L. subsp. *ruderalis* Bischl. et Boissel.-Dub. (gem.) – [550 m]. 9. On soil: horsetail community. FP.
- M. romanica* (Radian) D.G. Long, Crand.-Stotl., L.L. Forrest et J.C. Villarreal – [1600 m]. 5. On soil: brook bank. L.
- Marsupella boeckii* (Austin) Lindb. ex Kaal. (andr., per.) – [1300 m]. 5. On stones covered with soil: rock outcrops. M.
- M. emarginata* (Ehrh.) Dumort. (spor.) – [1050–1600 m]. 5, 10. On soil, stones covered with soil: rock outcrops, rock-fields, brook bank. M, S, E.
- M. sprucei* (Limpr.) Bernet (spor.) – [1400 m]. 5. On soil: tundra. FP.
- Mesoptychia rutheana* (Limpr.) L. Söderstr. et Váňa – [800 m]. 10. On soil: brook bank. FP.
- Neorthocaulis binsteadii* (Kaal.) L. Söderstr., De Roo et Hedd. – [850 m]. 3. On and among *Sphagnum: Larix* forest. FP.
- Plagiochila porelloides* (Torr. ex Nees) Lindenb. – [300–1050 m]. 8, 10. On soil, stones covered with soil: rock-fields, brook banks. FP, S.
- Pseudotritomaria heterophylla* (R.M. Schust.) Konstant. et Vilnet (gem.) – [1100–1200 m]. 2, 5. On soil, stones covered with soil: rock outcrops, brook bank. M.
- Ptilidium ciliare* (L.) Hampe – [300–1050 m]. 3, 8, 10. On soil, stones covered with soil, rotten wood: *Larix* forests, rock-fields, brook banks. FP, S, L.
- Radula complanata* (L.) Dumort. (spor.) – [850 m]. 10. On stones covered with soil: rock-fields. S.
- Riccardia chamedryfolia* (With.) Grolle – [1200 m]. 5. On soil: brook bank. FP.
- Riccia sorocarpa* Bisch. – [550–620 m]. 1, 7, 9. On soil: steppes, horsetail. FP.
- Scapania crassiretis* Bryhn (gem.) – [550–1400 m]. 2, 5, 6. On soil, stones covered with soil: tundra, rock outcrops, brook and river banks. FP, S.
- S. curta* (Mart.) Dumort. (andr., per., immature spor., gem.) – [300 m]. 8. On stones covered with soil: rock-fields. S.
- S. hyperborea* Jørg. – [1050 m]. 10. On stones covered with soil: rock-fields. FP.
- S. irrigua* (Nees) Nees (gem.) – [1200 m]. 5. On soil: brook bank. S.
- S. kaurinii* Ryan (spor.) – [1300–1400 m]. 5. On soil, stones covered with soil: rock outcrops, brook banks. FP, S.
- S. microdonta* (Mitt.) Müll. Frib. – [1050–1300 m]. 5, 10. On stones covered with soil: rock-fields. FP.
- S. mucronata* H. Buch (andr., gem.) – [300 m]. 8. On soil: brook bank. M.
- S. obcordata* (Berggr.) S.W. Arnell (gem.) – [800 m]. 10. On soil: brook bank. M.
- S. paludicola* Loeske et Müll. Frib. (andr.) – [500–1200 m]. 3, 5, 6, 8. On soil: grass mire, brook and river banks. FP, S.
- S. parvifolia* Warnst. (andr., per., gem.) – [500–850 m]. 3, 6. On soil: moss communities on disturbed soil, *Larix* forest, rock outcrops. FP, M.
- S. rufidula* Warnst. – [500–1400 m]. 5, 7. On soil: brook and river bank. FP, M.
- S. scandica* (Arnell et H. Buch) Macvicar (andr., gem.) – [1200 m]. 5. On soil: brook bank. S.

- S. sphaerifera* H. Buch et Tuom. (gem.) – [1050–1300 m]. 5, 10. On stones covered with soil: rock-fields. FP, M.
- S. spitsbergensis* (Lindb.) Müll. Frib. (spor., gem.) – [1050–1550 m]. 5, 10. On stones covered with soil: rock outcrops, rock-fields. FP, S.
- Schistochilopsis opacifolia* (Culm. ex Meyl.) Konstant. (spor., gem.) – [1200–1400 m]. 5. On soil: brook banks. FP.
- Schljakovia kunzeana* (Huebener) Konstant. et Vilnet – [550 m]. 8. On soil: brook bank. FP.
- Solenostoma obovatum* (Nees) C. Massal. (per.: paroicous) – [550 m]. 6. On soil: river bank. M.
- Sphenobolus minutus* (Schreb. ex D. Crantz) Berggr. – [500–1400 m]. 3, 5, 8, 10. On soil, stones covered with soil: tundra, rock-fields. FP, M.
- S. saxicola* (Schrad.) Steph. – [900–1550 m]. 3, 5, 10. On soil, stones covered with soil: rock outcrops, rock-fields, scree, brook bank. FP, S.
- Tetralophozia setiformis* (Ehrh.) Schljakov – [900–1600 m]. 3, 5, 10. On soil, stones covered with soil: rock-fields, rock outcrops, lichen tundra. FP, M, S, L.
- Trilophozia quinqueidentata* (Huds.) Bakalin – [500–1600 m]. 2, 5, 8, 10. On soil, stones covered with soil: rock-fields, rock outcrops, brook banks. FP, M, S.

DISCUSSION

In total, 65 species and 1 subspecies of liverworts were recorded in the study area. *Marsupella sprucei* is recorded for the first time for Yakutia. This diversity is rather high, although the area is quite xeric. It is comparable with the local liverworts flora of Upper Kyubyume River (65 species, Sofronova & Potemkin, 2016), Algama River (69 species, Sofronova, 2013), Orulgan Sis Reserve (73 species, Sofronova & Sofronov, 2012). At the same time, it should be noted that almost all the diversity of species was found along the banks of watercourses, in wet niches of rock-fields and in moist, shaded cracks of rock. Calcium was probably present in the soil, which added seven calciphilous species in studied flora: *Asterella saccata*, *Cryptocolea imbricata*, *Frullania inflata*, *Mannia fragrans*, *Marchantia romanica*, *Mesoptychia rutheana*, *Pseudotritomaria heterophylla*. In plant communities, a very small number of liverworts have been collected. Only 9 species were found in larch forests: *Barbilophozia barbata*, *Calypogeia muelleriana*, *Cephalozia bicuspidata*, *Isopaches bicrenatus*, *Lophozia ventricosa*, *Ptilidium ciliare*, *Scapania parvifolia*, *Lophozia silvicola*, and *Neoorthocaulis binsteadii*. Of these, only the last two species were collected only here. In the mountain tundra, 12 liverworts are noted: *Anthelia juratzkana*, *Calycularia laxa*, *Cephalozia bicuspidata*, *Diplophyllum taxifolium*, *Gymnomitrium concinnatum*, *G. corallioides*, *Isopaches bicrenatus*, *Lophozia excisa*, *Scapania crassiretis*, *Sphenobolus minutus*, *Tetralophozia setiformis*, *Marsupella sprucei*, and only the last species was collected only here. *Asterella saccata* and *Mannia fragrans* are limited in its distribution only to steppes in the study area. Most of the species, including the rare ones, were collected on open slope of Tas-Kys-

tabyt Mt. (Fig. 1) on banks of small brook, numerous rock outcrops and rock-fields: *Calycularia laxa*, *Cryptocolea imbricata*, *Marchantia romanica*, *Marsupella boeckii*, *Pseudotritomaria heterophylla*, *Scapania kaurinii*, *S. rufidula*, and *S. sphaerifera* (Fig. 2). Another rare species – *Haplomitrium hookeri* – was found in the moss community on an old rut of a winter road.

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