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A CONTRIBUTION TO THE LIVERWORT FLORA OF ENDYBAL RIVER BASIN (ARKACHAN PLATEAU, VERKHOYANSKY RANGE, YAKUTIA)

МАТЕРИАЛЫ К ФЛОРЕ ПЕЧЕНОЧНИКОВ БАССЕЙНА Р. ЭНДЫБАЛ (АРКАЧАНСКОЕ ПЛАТО, ЦЕНТРАЛЬНОЕ ВЕРХОЯНЬЕ, ЯКУТИЯ)

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Abstract

Liverwort flora of the Arkachan Plateau is studied for the first time. This area is situated in the northern macroslope of the Central Verkhoyanie (Yana River Basin). The annotated list includes 36 species and one variety. 28 species were found for the first time in Central Verkhoyanye. Data on structures associated with reproduction, recorded localities, substrates, habitats, associated species, growth pattern and representative specimens are listed for every species. New data are obtained on the distribution of rare hepatics: *Bucegia romanica, Lejeunea alaskana, Radula prolifera,* and *Frullania subarctica*.

Резюме

Впервые изучена флора печеночников Аркачанского плато, расположенного на северном макросклоне Центрального Верхоянья (бассейн р. Яны). Аннотированный список включает 36 видов и 1 разновидность, из них 28 видов приводятся впервые для флоры печеночников Центрального Верхоянья. В списке для каждого вида указаны выявленные местнахождения, местообитания, субстрат, наличие структур, связанных с размножением, характер произрастания, приводятся сопутствующие виды и репрезентативные образцы. Интерес представляют находки *Bucegia romanica*, *Frullania subarctica, Lejeunea alaskana* и *Radula prolifera*, редко встречающихся на территории республики.

KEYWORDS: liverworts, flora, Endybal River, Yana River Basin, Central Verkhoyanye Range, Verkhoyansk Mountain System, Yakutia.

Introduction

The study area is situated in the Endybal River Basin (Yana River Basin) on the Arkachan Plateau. The plateau occurs on the northern macroslope of Central Verkhoyanye of Verkhoyansk Mountain System (Fig. 1) (Nikolin & Troeva, 2011). The hepatic flora of this territory is poorly explored, because this part of the Verkhoyansk mountain system is nearly inaccessible due to absence of roads. In Central Verkhoyanye Mountains,only 14 liverwort species are currently known; they were found in the Tukulan River Basin (Akimova, 1995). Tukulan River belongs to Aldan River Basin, it flows on southern macroslope of the Central Verkhoyanye. The present work is based on the specimens collected in Endybal River Basin, namely on Sirelende River (by L.I. Kopyrina in 2014) and on Fedor-Yuryage and Sirelende Rivers (by Al. P. Isaev and N.S. Karpov in 2005).

Study area

Landforms of the study area have a middle mountainous relief. The absolute altitudes vary from 1172 to 1450 m with the valleys being 750–900 m deep in relation to nearby mountains. The mountains usually have a gentle slopes and flattened tops (Fig. 2A, B, C) (Desyatkin, 2006). In the study area (Upper Arkachan River) the watershed surfaces with an altitude 1100–1400 m has fragments of relict sediments of Neogene age. Numerous well-rounded boulders and pebbles belonging to the ancient river network were found there on the flat surfaces. The study of spore-pollen complexes of the relict sediments has shown the presence of coniferous-small-leaved forests with an admixture of thermophiles in the early Pliocene (Rusanov *et al.*, 1967; Kropachev, 2008). The bedrocks consist mainly of Carboniferous, Jurassic, Permian and Triassic sediments. They are represented by alternating strata of siltstone, mudstone, sandstone, arenaceous limestones and calcareous siltstones. In the igneous complexes of Carboniferous and Cretaceous age marked antimony, mercury, lead, zinc, nickel, cobalt and other heavy metals (Kropachev, 2006). Meteorological data for the the studied area is presented in Table 1.

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Table 1. Meteorological data from the nearest meteostations (Izyumenko, 1966, 1968).

Meteorological stations and distance from study area	mean annual t°C	mean January t°C	mean July t°C	annual precipitation
Imtandzha (51 km to N, 1375 m alt.)	–11.9	–28.2	9.6	255
Suren-Kuel (70 km to SE, 744 m alt.)	–11.9	–34.6	12.7	337
Segen-Kuel (190 km to SE, 208 m alt.)	–10.1	–39.1	18.1	319

Vegetation of the forest belt is composed by *Larix cajanderi* stands that reach altitude of 1050–1130 m. Tundras with *Dryas punctata*, lichens and dwarf shrubs are widespread in the tundra belt. Shrub communities do not form a belt. Only individual groups of *Betula divaricata* and *Betula exilis*, and rarely of *Pinus pumila* are scattered at 900–1300 m. In flood-valleys grassy larch forests and forests of *Chosenia arbutifolia* occur, as well as shrub communities of *Betula exilis, Salix alaxensis*, *S. lanata* and *S. krylovii*. Meadows of *Leymus interior* and *Chamaenerion latifolium* occur along watercourses in river valleys, and communities of *Dryas grandis* are common on the pebble bars (Andreev *et al*., 1987; Desyatkin, 2006).

LIST OF SPECIES

The paper is based on detailed study of 52 specimens collected by L.I. Kopyrina, N.S. Karpov and A.P. Isaev. The specimens collected by L.I. Kopyrina are marked as "LK", by A.P. Isaev as "AI" and by N.S. Karpov as "NK". The nomenclature follows Potemkin & Sofronova (2009). The list is annotated in the following order: species name, abbreviations of structures connected with reproduction, if present, in parentheses: fem. pl. – female plant, per. – perianthia, spor. – mature sporophytes, gem. – gemmae; collecting sites (according to Fig. 1); substrates, habitats and growth pattern. The following scale was used for determination of the growth pattern: few plants (FP), minute continuous cover (M) – up to 1 sq. cm and small continuous cover (S) – up to 100 sq. cm. Annotations of selected species are accomplished by data on associated species. Every species is annotated by representative specimens. All specimens are deposited in Herbarium of Institute for Biological Problems of Cryolithozone SB RAS, Yakutsk (SASY).

Aneura pinguis (L.) Dumort. (fem. pl.) – 1–3 – on soil in *Larix* forest, sometimes mixed with *Cephalozia bicuspidata*, FP; on soil in moss-lichen tundra among mosses, mixed with *Blepharostoma trichophyllum, Odontoschisma macounii, Radula prolifera, Scapania gymnostomophila*, FP; on soil of rocky outcrops along stream banks, in pure mats or mixed with *Mesoptychia sahlbergii, Radula prolifera, Scapania simmonsii, Tritomaria quinquedentata*, FP, M, S. (## Arc-LK-1, Arc-AI-40).

Barbilophozia barbata (Schmidel ex Schreb.) Loeske – 1 – on soil on the pebbles of the river, FP. (# Arc-AI-23).

Blepharostoma trichophyllum (L.) Dumort. – 1–3 – on soil in *Larix* forest mixed with *Ptilidium ciliare, Scapania simmonsii*, FP; on soil in lichen tundras, in pure mats or mixed with *Aneura pinguis, Cephalozia bicuspidata, Frullania subarctica, Odontoschisma macounii, Ptilidium ciliare, Radula prolifera, Scapania gymnostomophila, Schistochilopsis grandiretis*, *Sphenolobus minutus,* FP, M, S; among *Sphagnum* in tundra, mixed with *Calypogeia muelleriana, Cephalozia bicuspidata, Ptilidium ciliare, Riccardia* sp., *Scapania paludicola*, FP; on soil of rocky outcrops along stream bank mixed with *Odontoschisma macounii, Scapania scandica, Tritomaria quinquedentata,* M. (# Arc-LK-17).

Bucegia romanica Radian – 3 – on soil in niches between the stones of rockfields, FP. (# Arc-AI-52).

Calycularia laxa Lindb. & Arnell – 2 – on soil of rocky outcrops along stream bank, S. (# Arc-AI-34).

Calypogeia muelleriana (Schiffn.) Müll. Frib. – 1, 3 – among *Sphagnum* in *Larix* forest, M; among *Sphagnum* in tundra, mixed with *Mylia anomala, Orthocaulis binsteadii*, FP. (# Arc-LK-4).

Cephalozia bicuspidata (L.) Dumort. (spor.) – 1–3 – on soil in *Larix* forests mixed with *Aneura pinguis, Ptilidium ciliare, Tritomaria quinquedentata*, FP, M; on soil in lichen tundra, mixed with *Blepharostoma trichophyllum, Ptilidium ciliare, Schistochilopsis grandiretis*, *Sphenolobus minutus,* M; among *Sphagnum* in tundra mixed with *Blepharostoma trichophyllum, Calypogeia muelleriana, Ptilidium ciliare, Riccardia* sp., *Scapania paludicola*, FP. (# Arc-LK-20).

C. pleniceps (Austin) Lindb. – 1 – among *Sphagnum* in *Larix* forest, mixed with *Calypogeia muelleriana, Schistochilopsis grandiretis*, FP. (# Arc-LK-3).

Cephaloziella rubella (Nees) Warnst. – 1 – on rotten wood in *Larix* forest, FP. (# Arc-LK-22).

C. varians (Gottsche) Steph. – 2 – on soil on rocky outcrops along stream bank, mixed with *Diplophyllum taxifolium, Marsupella emarginata, Scapania crassiretis, Sphenolobus minutus*, FP. (# Arc-AI-37).

Diplophyllum taxifolium (Wahlenb.) Dumort. – 2 – on soil of rocky outcrops along stream bank, mixed with *Cephaloziella varians, Marsupella emarginata, Scapania crassiretis, Sphenolobus minutus*, FP. (# Arc-AI-42).

Frullania subarctica Vilnet, Borovich. & Bakalin – 1 – on soil in lichen tundra, mixed with *Blepharostoma trichophyllum, Lejeunea alaskana, Odontoschisma macounii, Ptilidium ciliare, Scapania gymnostomophila, Schistochilopsis grandiretis*, FP, M, S. (## Arc-LK-11, 12).

Lejeunea alaskana (R.M.Schust. & Steere) Inoue & Steere – 1, 3 – on soil in *Larix* forest, mixed with *Odontoschisma macounii, Scapania simmonsii*, FP, M; on soil in lichen tundra mixed with *Frullania subarctica, Ptilidium ciliare,* FP. (# Arc-AI-48).

Lophozia pellucida R.M. Schust. (gem.) – 2 – on soil of rocky outcrops along stream bank mixed with *Aneura pinguis, Mesoptychia sahlbergii, Radula prolifera, Scapania simmonsii,* FP. (# Arc-LK-26).

L. polaris (R.M. Schust.) R.M. Schust. & Damsh. (gem.) – 2 – on soil in lichen tundra, mixed with *Sphenolobus minutus,* FP; on soil of rocky outcrops along stream bank mixed with *Aneura pinguis, Mesoptychia sahlbergii, Radula prolifera, Scapania simmonsii,* FP. (# Arc-LK-26, 30).

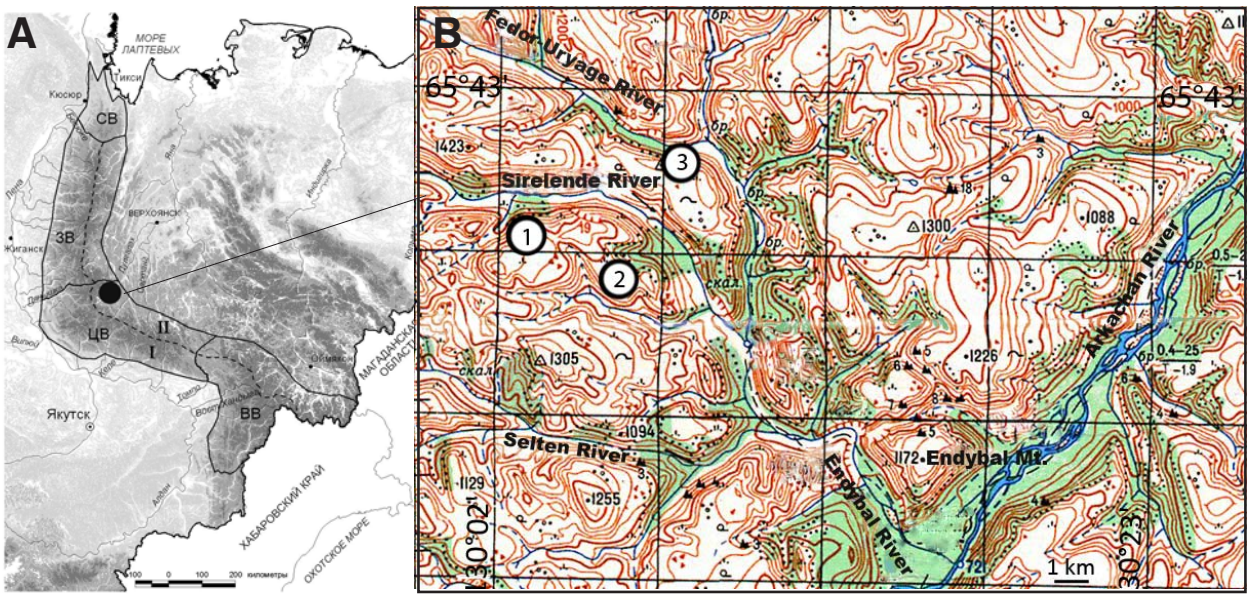

Fig. 1A. Botanical zonation of the Verkhoyansk Mountain System (Nikolin & Troeva, 2011): CB – North Verkhoyanye, 3B – West Verkhoyanye, ЦВ – Central Verkhoyanye, BB – Eastern Verkhoyanye. I – peaked ridge region, II – flat-top region. Collecting localities: 1: Middle course of Sirelende River, near the site Vertical'nyi (65°40'–65°41' N – 130°03'–130°05'E); 2: Middle course of Sirelende River, interfluve of Borisovskyi and Porphyrovyi Streams (65°40'–65°41' N – 130°05'–130°06' E; 3: Middle course of Fedor-Uryage River, near the confluence of the Mangazeyka River (65°42' N – 130°09' E).

L. ventricosa (Dicks.) Dumort. var. *ventricosa* (gem.) – 1 – on rotten wood in *Larix* forest, mixed with *Sphenolobus minutus*, FP. (# Arc-LK-21).

L. ventricosa var. *longiflora* (Nees) Macoun sensu Schuster 1969, Schljakov 1980 (per.) – 2 – among *Sphagnum* along stream bank, FP. (# Arc-AI-44).

Marsupella emarginata (Ehrh.) Dumort. s. l. – 2 – on soil of rocky outcrops along stream bank, mixed with *Cephaloziella varians, Diplophyllum taxifolium, Scapania crassiretis, Sphenolobus minutus*, S. (# Arc-AI-37).

Marchantia polymorpha L. (= *Marchantia aquatica* (Nees) Burgeff) – 1 – on soil of creek bank, FP. (# Arc-LK-5).

Mesoptychia sahlbergii (Lindb. & Arnell) A. Evans – 2 – on soil of rocky outcrops along stream banks, in pure mats or mixed with *Aneura pinguis, Radula prolifera, Scapania simmonsii, Tritomaria quinquedentata*, FP, S; on soil of creek bank, FP. (# Arc-AI-38).

Mylia anomala (Hook.) Gray – 3 – among *Sphagnum* in tundra, mixed with *Calypogeia muelleriana, Orthocaulis binsteadii*, FP. (# Arc-NK-45).

Odontoschisma macounii (Austin) Underw. (spor.) – 1–3 – on soil in *Larix* forest, mixed with *Lejeunea alaskana, Scapania simmonsii*, FP; on soil in lichen tundra, mixed with *Aneura pinguis, Blepharostoma trichophyllum, Frullania subarctica, Radula prolifera, Scapania gymnostomophila, Schistochilopsis grandiretis*, FP, M; on soil of rocky outcrops along stream bank, mixed with *Blepharostoma trichophyllum, Scapania scandica, Tritomaria quinquedentata,* FP. (# Arc-LK-10).

Orthocaulis binsteadii (Kaal.) H. Buch – 1, 3 – among *Sphagnum* in *Larix* forest, M; among *Sphagnum* in tundra, mixed with *Calypogeia muelleriana, Mylia anomala*, M. (# Arc-LK-2).

Plagiochila porelloides (Torrey ex Nees) Lindenb. – 3 – on soil in niches between the stones of rockfields, FP. (# Arc-AI-51).

Ptilidium ciliare (L.) Hampe – 1–3 – on soil in *Larix* forest, sometimes mixed with *Blepharostoma trichopyllum, Scapania simmonsii*, FP; on soil in lichen tundras mixed with *Blepharostoma trichophyllum, Cephalozia bicuspidata, Frullania subarctica, Lejeunea alaskana*, *Schistochilopsis grandiretis*, *Sphenolobus minutus,* FP; among *Sphagnum* in tundra mixed with *Blepharostoma trichophyllum, Calypogeia muelleriana, Cephalozia bicuspidata, Riccardia* sp., *Scapania paludicola*, FP; on soil of creek bank, FP. (# Arc-LK-7).

Radula prolifera Arnell (per.) – 1, 2 – on soil in lichen tundra, mixed with *Aneura pinguis, Blepharostoma trichophyllum, Odontoschisma macounii, Scapania gymnostomophila*, FP; on soil of rocky outcrops along stream bank, mixed with *Aneura pinguis, Mesoptychia sahlbergii, Scapania simmonsii,* FP. (## Arc-LK-8, 14).

Riccardia sp. – 3 – among *Sphagnum* in tundra, mixed with *Blepharostoma trichophyllum, Calypogeia muelleriana, Cephalozia bicuspidata, Ptilidium ciliare, Scapania paludicola*, FP. (# Arc-NK-46).

Scapania crassiretis Bryhn (gem.) – 2 – on soil of rocky outcrops along stream banks, in pure mats or mixed with *Cephaloziella varians, Diplophyllum taxifolium, Marsupella emarginata, Sphenolobus minutus*, FP, S. (# Arc-AI-39).

S. gymnostomophila Kaal. (gem.) – 1, 2 – on soil in lichen tundra, mixed with *Aneura pinguis, Blepharostoma trichophyllum, Frullania subarctica, Odontoschisma macounii, Radula prolifera*, FP; on soil of rocky outcrops along stream bank, FP; on soil of creek bank, FP. (# Arc-LK-11).

S. paludicola Loeske & Müll. Frib. – 3 – among *Sphagnum* in tundra mixed with *Blepharostoma trichophyllum, Calypogeia muelleriana, Cephalozia bicuspidata, Ptilidium ciliare, Riccardia* sp., FP. (# Arc-NK-46).

S. praetervisa Meyl. (gem., per.) – 2 – on soil in lichen tundra, mixed with *Sphenolobus minutus,* FP. (# Arc-LK-28).

S. scandica (Arnell & H. Buch) Macvicar (gem.) – 2 – on soil of rocky outcrops along stream bank, mixed with *Blepharos-*

Fig. 2. Environments of the Arkachan Plateau. A – Plato, general view; B – lichen tundra; C – scattered *Larix* trees on mountain top; D – slopes with *Larix* forest, *Betula nana* shrub and lichen tundra; E – fragments of *Betula nana* shrubs (red) and *Larix* stands on slopes to Sirelende Creek Valley; F – rocky slope to Sirelende Creek; G – floodplain larch forest.

toma trichophyllum, Odontoschisma macounii, Tritomaria quinquedentata, FP. (# Arc-LK-27).

S. simmonsii Bryhn & Kaal. – 2, 3 – on soil in *Larix* forest, mixed with *Blepharostoma trichophyllum, Lejeunea alaskana, Odontoschisma macounii, Ptilidium ciliare*, FP, S; on soil of rocky outcrops along stream bank, mixed with *Aneura pinguis, Mesoptychia sahlbergii, Radula prolifera,* FP. (# Arc-AI-47).

Schistochilopsis grandiretis (Lindb. ex Kaal.) Konstant. (gem.) – 1, 2 – among *Sphagnum* in *Larix* forest, mixed with *Calypogeia muelleriana, Cephalozia pleniceps*, FP; on soil in lichen tundra, mixed with *Blepharostoma trichophyllum, Cephalozia bicuspidata, Frullania subarctica, Odontoschisma macounii, Ptilidium ciliare, Sphenolobus minutus,* FP. (# Arc-LK-3).

S. incisa (Schrad.) Konstant. – 2 – on soil of rocky outcrops along stream bank, FP. (# Arc-AI-43).

Sphenolobus minutus (Schreb.) Berggr. (spor.) – 1, 2 – on soil, rotten wood in *Larix* forest, mixed with *Lophozia ventricosa, Tritomaria quinquedentata*, FP, M; on soil in lichen tundra, mixed with *Blepharostoma trichophyllum, Cephalozia bicuspidata, Lophozia polaris, Ptilidium ciliare, Scapania praetervisa, Schistochilopsis grandiretis,* FP, S; on soil of rocky outcrops along stream bank, mixed with *Cephaloziella varians, Diplophyllum taxifolium, Marsupella emarginata, Scapania crassiretis,* FP. (# Arc-LK-28).

Tritomaria quinquedentata (Huds.) H. Buch (gem., per.) – 1, 2 – on soil in *Larix* forest, mixed with *Cephalozia bicuspidata, Ptilidium ciliare, Sphenolobus minutus*, FP, M; on soil in lichen tundra, with *Ptilidium ciliare*, FP; on soil of rocky outcrops along stream banks, sometimes mixed with *Aneura pinguis, Blepharostoma trichophyllum, Mesoptychia sahlbergii, Odontoschisma macounii, Scapania scandica,* FP. (# Arc-LK-31).

DISCUSSION

In total, 36 species and one variety of liverworts were recorded in the study area, 28 species and a variety are new for the hepatic flora of Central Verkhoyanye. First data on liverworts of Central Verkhoyanye were provided for the Tukulan River Basin (Akimova, 1995). Eight species occur both in Endybal River Basin (north-facing macroslope) and Tukulan River Basin (south-facing macroslope): *Barbilophozia barbata, Blepharostoma trichophyllum, Cephalozia bicuspidata, Lophozia ventricosa* s.str.*, Mesoptychia sahlbergii, Ptilidium ciliare, Sphenolobus minutus, Tritomaria quinquedentata*. Another six species (*Lepidozia reptans, Lophozia longidens, Scapania mucronata, Sphenolobus saxicola, Tetralophozia setiformis,* and *Tritomaria exsectiformis*) were recorded only on the south-facing macroslope of the range.

New localities of *Bucegia romanica* are of a certain interest. In Verkhoyansk Range *Bucegia romanica* usually occurs in tundra belt, above 1200 m a.s.l. (Sofronova *et al*., 2015). In the study area this species was found in the forest belt (about 1000 m a.s.l.) in niches between rocks of rock fields. In other areas of Yakutia we collected it on rock outcrops or on creek banks.

Among the most remarkable records are *Frullania subarctica, Lejeunea alaskana,* and *Radula prolifera*. *Lejeunea alaskana*, a species described from Alaska, was only recently recognized in Russia in Magadan Province (Bakalin *et al.*, 2012) and subsequently found in Republic of Buryatia (Potemkin *et al.*, 2015). It was also collected in the Suntar-Khayata Range, but misidentified and listed as *Lejeunea cavifolia* (Sofronova, 2003). *Frullania subarctica* and *Radula prolifera* were collected near the localities of *Lejeunea alaskana* in the study area. These species commonly grow together with *Lejeunea alaskana* and may tentatively be regarded as preglacial relics and occurring in regions that presumably escaped Pleistocene glaciation (Bakalin *et al*., 2012).

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