Arctoa (2023) **32**: *216–224*
doi: 10.15298/arctoa.32.19

TO THE KNOWLEDGE OF LIVERWORT DIVERSITY IN BADZHAL RANGE (KHABAROVSK TERRITORY, RUSSIAN FAR EAST)

К ПОЗНАНИЮ РАЗНООБРАЗИЯ ПЕЧЕНОЧНИКОВ БАДЖАЛЬСКОГО ХРЕБТА (ХАБАРОВСКИЙ КРАЙ, РОССИЙСКИЙ ДАЛЬНИЙ ВОСТОК)

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Abstract

Badzhal Range is the southernmost tip of the continuous mountainous landscapes stretching from Northeast Asia along the western coast of the Sea of Okhotsk. Besides, this is the southeast corner where ranges along Sea of Okhotsk contact with the great mountain systems of East Siberia. It is also the northern edge of the transitional zone between East Asian and Circumboreal Floristic Regions. The present study was carried out in the southeast part of the Badzhal Range and revealed 116 liverwort taxa (114 species and 2 varieties). The vast majority of collected taxa belong to boreal, arctic-boreal and arctic-montane floristic elements. The peculiarity of the flora reflects its latitudinal and longitudinal position and is showed by the occurrence of some predominantly East Asian taxa in the northern edges of their distribution. Five species have the northernmost worldwide localities in the range; all are broadly East Asian in distribution: *Acrolejeunea sandvicensis*, *Cheilolejeunea obtusifolia*, *Pedinophyllum truncatum*, *Porella ulophylla* and *Schistochilopsis cornuta*.

Резюме

Баджальский хребет расположен на южной оконечности сплошного горного ландшафта, протянувшегося из Северо-Восточной Азии вдоль западного побережья Охотского моря до 50 градуса северной широты и где этот массив смыкается с горными системами Восточной Сибири. Хребет находится на северной окраине переходной зоны между Восточноазиатской и Циркумбореальной флористическими областями. В результате изучения юго-восточной части Баджальского хребта, выявлено 116 таксонов печеночников (114 видов и 2 разновидности). Подавляющее большинство собранных таксонов относится к бореальным, арктобореальным и арктомонтанным элементам флоры. Своеобразие флоры, отражающее ее широтное и долготное положение, проявляется в наличии некоторых преимущественно восточноазиатских таксонов на северных границах их распространения. Местонахождения пяти видов, широко распространенных в Восточной Азии, являются самыми северными в мире: *Acrolejeunea sandvicensis*, *Cheilolejeunea obtusifolia*, *Pedinophyllum truncatum*, *Porella ulophylla* и *Schistochilopsis cornuta*.

KEYWORDS: liverworts, Badzhal Range, amphi-Pacific Asia, distribution patterns, East Asia

INTRODUCTION

The Badzhal Range stretches for about 170 kilometers from the Northeast to Southwest and has a maximum width about 60 kilometers. It is located in the middle part of the Khabarovsk Territory 400 km westward of Tartar Strait of the Sea of Japan. In the satellite photographs it looks as an mountainous island amongst lowland taiga. It is bordered in the southeast by a wide terrain of the lower course of the Amur River, the northwestern flank borders with the valley of the Amgun River, the southwestern edge – by the plains at the upper reaches of Urmi River, and in the northeast – by the valley of the upper reaches of the Gorin River. In the northwestern margin, across the Amgun River valley (about 30 km in a straight line in the narrowest place), the Badzhal Range has the shortest distance to another mountainous area – the Bureinsky Range. Through the latter, it is connected with the mountain systems of the western coast of the Sea of Okhotsk and further to northeast Asia to the North and the great mountain systems of East Siberia to the West. Another mountain system closest to the Badzhal Range is the Sikhote-Alin, which is 250 kilometers away (along the shortest line) in a southeast direction. Since Badzhal Range is bounded in almost all circumferences by taiga developed on a leveled terrain that situated in lower altitudes (not exceeding 500–700 m a.s.l.), it may be expoected as an isolated ‘enclave’ of the arctic-montane flora, despite mountain tundras are fragmentary there. This ‘enclave’ seems to be weakly connected with other mountain systems, except of the

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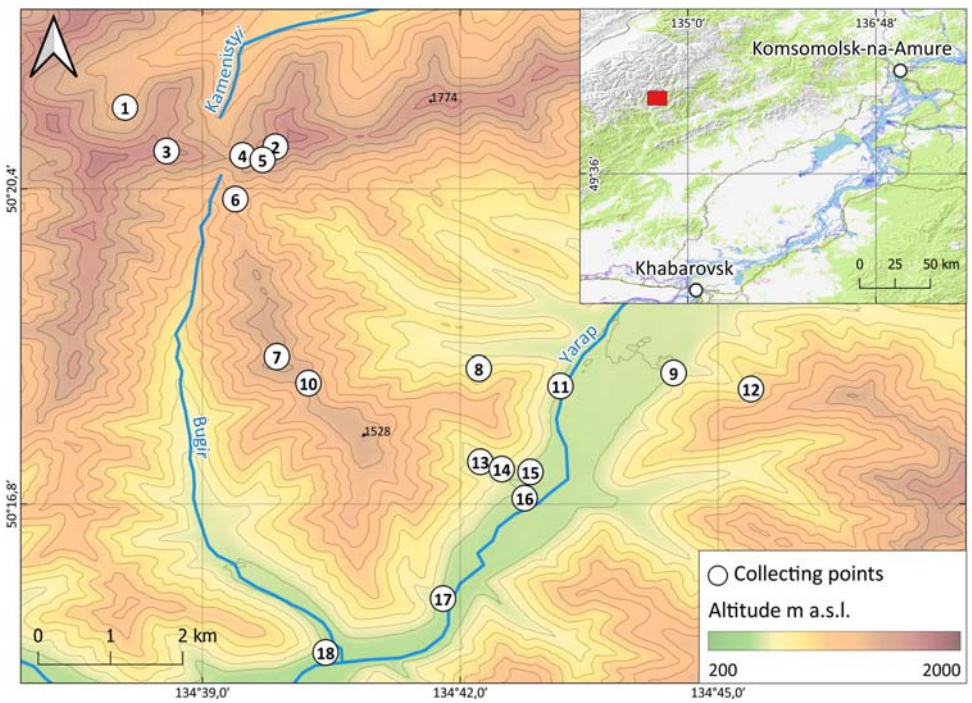

Fig 1. Collecting sites in Badzhal Range (cf. Tabl. 1)

Table 1. Collecting sites in Badzhal Range: Latitide, longitude, altitude and vegetation zone (cf. Fig. 1)

N	Lat, N	Longitude, E	Alt, m	Vegetation zone
1	50.35555556	134.635	1370	Crooked forests
2	50.34805556	134.6641667	1760	Mountain tundra
3	50.34722222	134.6430556	1780	Mountain tundra
4	50.34638889	134.6577778	1480	Crooked forest
5	50.34555556	134.6616667	1640	Mountain tundra
6	50.33805556	134.6563889	1310	Crooked forest
7	50.30805556	134.6644444	1570	Mountain tundra
8	50.30583333	134.7036111	770	Forest
9	50.305	134.7413889	605	Forest
10	50.30305556	134.6705556	1460	Mountain tundra
11	50.3025	134.7194444	600	Forest
12	50.30194444	134.7563889	930	Forest
13	50.28805556	134.7038889	850	Forest
14	50.28666667	134.7080556	690	Forest
15	50.28611111	134.7136111	550	Forest
16	50.28111111	134.7125	570	Forest
17	50.26194444	134.6966667	540	Forest
18	50.25166667	134.6738889	585	Forest

Bureinsky Range, and may be the terminal link in the distribution of the amphi-Okhotian and even mega-Beringian taxa in the southern direction. The latter led to our initial interest in the study area. Besides, the largest tin ore deposit in Russia (Kryukov & Shcherbak, 1987) is located at the southwestern end of the range, and it is currently being actively developed. Therefore, the initial inventory not only liverworts, but also mosses and an additional study of the vascular plants taxonomic diversity in the range seems very important for planning various environmental conservation measures in the light peculiar geographic position and human initiated disturbance of the area.

In July–August of 2016, the Botanical Garden-Institute of the Far Eastern Branch of the Russian Academy of Sciences organized and conducted an expedition with the aim of a comprehensive study of the flora and vegetation of the southeastern part of the Badzhal Range. As a result, of the field exploration and succeeded laboratory investigation, the data set on the plant diversity of the range was significantly replenished. Three new-for-science vascular plant taxa were described: *Chrysosplenium krestovii* Barkalov & Koldaeva (Barkalov & Koldaeva, 2017), *Silene badzhalensis* Barkalov et Krestov (Barkalov & Krestov, 2018) and *Calamagrostis burejensis* Prob. et Barkalov (Probatova, 2017). A list of mosses and the description of plant communities in the southeastern part of the range (Pisarenko *et al.*, 2022), as well as a list of vascular plants of the same area (Barkalov *et al.*, 2022) were published before. The present account provides the first information on liverwort diversity in the Badzhal Range although is based on the study of a small area, approximately 20×20 km in its southeastern part. The presented here information possesses preliminary character and is not an exhaustive treatment of liverwort diversity in the range.

Material and Methods

Liverworts were collected at the timespan from July 30 to August 14 of 2016. We tried to visit all types of communities represented in the area and to study all substrates with several repetitions. A total 387 specimens were collected, which were transferred alive to the Laboratory of Cryptogamic Biota of the Botanical Garden-Institute FEB RAS (herbarium acronym VBGI) and then studied by traditional morphological methods using Olympus SZX16 and CX31 microscopes equipped with Olympus digital cameras. For most of the species, oil bodies were photographed. A total 685 identifications within collected specimens were done (because in the vast majority of cases each specimen contains more than

one species). All collections were gathered within 18 sites those are placed in Table 1 in the sequence from the North to the South, and are shown in Fig. 1. In all cases Table 1 provides exact measurements where the coordinates were taken. The same coordinates were used for bioclimatric variables measurements. In the reality the collection was done within the imaginable circle of 100-150 m in radius from the point of coordinates measurements. Meantime it worth to be mentioning the compiled checklist is based entirely on collected specimens. This lead in probable disproportion in the number of known localities for some common species in studied area those were not collected in all localities we visited and studied. The latter may especially concern *Cephalozia bicuspidata*, *Ptilidium ciliare* and *P. pulcherrimum* those likely distributed wider that it may be expected from the compiled checklist.

Nature environments

Considering that in the past few years, the natural conditions in the studied area were reviewed by other authors in freely accessible journals (Pisarenko *et al.*, 2022; Barkalov *et al.*, 2022), we present here only the brief overview. The study area is located within an area of 50.25–50.35°N and 134.63–134.76° E over Badzhal Jurassic (Jurassic–Early Cretaceous) accretionary complex (Zyabev, 2011) with sparse volcanic formations of the Khingan-Okhotsk volcano-plutonic zone (Bortnikov *et al.*, 2019). The landscapes represent a series of small ranges from 540 m a.s.l, in the riverbed and up to 1800 m above sea level having alpine-type appearance: with steep slopes, narrow ridges, fast-moving streams with a significant elevation dropping in their courses, strongly swelling during floods and opening into the middle course of the Yarap River. Visually, the rocks are sedimentary, commonly strongly crumbling, with only at the tops denser rocks of volcanic origin being opened. The geological map (State geological map of the Russian Federation, scale 1:200000 M-53-XV (Yarap River)] 2004. VSEGEI) provides the following information for area under consideration. The study area is located in a zone dominated by Late Cretaceous subvolcanic and extrusive rhyodacites, dacites and rhyolites, vent agglomerate tuffs, ignimbrites, lava breccias, dacites and rhyodacites, sulfidized and silicified rocks, and metasomatites. These rocks erupt at altitudes of more than 600-900 m above sea level. Below, in a narrow strip along the Yarap River bed, ignimbrites, tuffs of rhyolites, dacites and rhyodacites, as well as rhyolites, tuff conglomerates, conglobreccias, tuff sandstones, tuffites, andesites and dacyandesites are developed. In the valley of the stream in the northwest of the studied area there are glacial deposits, boulders, blocks, and rubble. In the floodplain of the Yarap River and large streams, alluvial deposits are developed: pebbles, sands, sandy loams, loams, covering the bottom of the valley up to 10 meters thick. As can be seen, there are no rocks with either a strongly acidic pH of the water extract or a pronounced alkaline reaction. The nearly neutral reaction of water extract is reflected in the absence or relative rarity of both pronounced basiphilous and acidophilous taxa.

Bioclimatic indices were identified using WorldClim (Fick, Hijmans, 2017; WorldClim, 2020–2022), for each collecting site and are provided in Table S1 (Supplementary Material 1). It should be taken into account that the maximum resolution of the WorldClim is confined to 30'. Therefore, the calculated indicators for the sharp peaks of the ridges actually represent the average calculated for the peaks themselves and adjacent slopes, which does not allow us to consider the given data as unconditionally accurate. Thus, the accuracy of temperature indicators to decimals, and precipitation to a millimeter is very conditional.

The climate summary is as following. Mean annual temperatures are negative and varying from –2.7... –3.6°C in lowlands to –5.6... –5.7°C in ridgelines. The mean maximum temperature varying from 24°C in lowland to 19°C in ridgelines. The mean minimal temperatures are very similar along altitudinal gradient and varying near –30°C. The wettest quarter and the warmest quarter are the same; their temperature varies from 15°C in lowlands to 11°C in ridges. The driest and coldest quarter are also the same, with the temperature variations low, and does not depending of elevation. It comprises about –21…–22°C through the altitudinal gradient. The temperature seasonality (standard deviation ×100) is very high, becoming slightly lower in upper elevations and varying from 1516 in lowland to 1349 in the ridges. The annual precipitation varies from 747–767 mm per year in lowlands to 846–884 per year in uppermost elevations. The precipitation in wettest quarter varies from 428–433 mm per quarter in lower elevation to 488–511 mm per quarter near ridgeline. The precipitation of coldest quarter is very low and comprises only 29–35 mm per quarter across elevation range, being obscurely higher in upper elevations. Precipitation seasonality (coefficient of variation) is quite high and varying from 88.6 to 92.9. Therefore, the available data (Table S1) shows gradual changes along altitudinal gradient in temperature and precipitation in vegetation season, strong seasonality and very limited amount of winter precipitation. These data suggest continental climate, probably with some monsoon features and show slight interception of moisture from air masses going from the Pacific Ocean.

Vegetation

The study area is located in the mountain-valley Urmiysko-Gorinskiy district of *Abies-Picea* and *Larix* forests, belonging to the Amur-Okhotsk Province of the Eurasian coniferous forest region (Kolesnikov, 1963). The bottoms of the Yarap River valley and large streams are covered by the communities dominating by *Salix* spp. and *Chosenia arbutifolia* (Pall.) A.K. Skvortsov. Above the periodically flooded floodplain, communities with *Picea ajanensis* (Lindl. et Gord.) Fisch. ex Carr. and *Abies nephrolepis* (Trautv. ex Maxim.) Maxim. dominating are

developed. In the both cases, they usually have a dense shrub understory, although sometimes the cover is simply mossy and free of shrubs. *Betula platyphylla* Sukaczev occurs as an admixture in such communities. Above valley's bottoms the slopes of the mountains covered in the vast majority of cases by monodominant *Picea ajanensis* forests. *Abies nephrolepis–Picea ajanensis* dominating forests occurs in the lower part of the slopes only. Decaying wood is inhabited in the forested areas by *Aneura pinguis*, *Liochlaena subulata*, *Mylia taylorii*, *Nowellia curvifolia*, etc. Small-sized communities of *Larix gmelinii* (Rupr.) Kuzen. are developed in swampy areas. *Anastrophyllum michauxii* occasionally occurs on decaying wood of *Larix*. *Larix* is also widely participated in the formation of post-fire forests on drier habitats, where *Picea* and *Abies* occurs as young trees (undergrowth) only. In the upper part of the steep slopes (above 1000 m a.s.l.) *Betula lanata* (Regel) V.N. Vassil. begins to form a noticeable admixture to *Picea ajanensis* stands (up to codominance). *Pinus pumila* (Pall.) Regel begins to dominate in upper parts of the slopes (often found as clumps under the forest canopy in lower altitudes). It is difficult to determine the exact lower boundary for these crooked forests, it is usually about 1300–1500 m a.s.l., but actually strongly vary depending of relief. *Ptilidium pulcherrimum* is the common participant of those communities, often covering branches of *Pinus pumila*. In places where groundwater comes out, small-sized thickets of *Alnus fruticosa* Rupr. are formed. In the uppermost areas, including ridgelines and descending down by wind-faced slopes and the places with late snow melting, there are tundras of various composition, including *Sphagnum*, green moss, moss-lichen and dwarf shrub-moss dominating communities. *Calypogeia muelleriana* and *Schljakovia kunzeana* were collected on side walls of the hummocks. The rock outcrops are common in the upper elevation. They are the habitat for *Scapania microdonta*, *Sphenolobus saxicola*, *Tetralophozia setiformis*, etc. Extended areas on the flattened tops of small ranges are occupied by rock fields, some being apparently, of a post-fire origin. The mountain streams crossing all elevation zones in the studied area. The liverwort inhabitants on rocks, cliffs and humus along streams are sometimes similar in different zones, *Scapania rufidula*, *S. crassiretis*, *Marsupella emarginata* are commonly growing there.

Checklist

The names of taxa in the list are arranged alphabetically, nomenclature follows Söderström et al. (2016), with the exception for: 1) Solenostomataceae, where narrow genus concept was adopted following to Bakalin (2014), 2) acceptance of *Pseudolophozia* distinct from *Barbilophozia* (cf. Konstantinova & Vilnet, 2009), 3) the concept of *Schistochilopsis* according to Bakalin et al. (2020), 4) *Cephalozia otaruensis* described from Hokkaido in North Japan is treated as different from *Cephalozia hamatiloba* described from Yakushima Island of the same country. Each taxon is annotated with: 1) altitudinal range in square brackets, in meters above sea level, if the species was collected in 1–3 elevations, they are listed separately, if the species is collected in 4 and more localities then only diapason is given, sometimes with indication that it is more common in upper or lower elevations, 2) collection locality numbers according to the Table 1 and Fig. 1, 3) description of habitat where the species was collected, 4) selected specimens examined field numbers, by two for each taxon at maximum, if available, 5) the presence of generative structures and vegetative propagules with the following abbreviations: ant. – antheridia, arch. – archegonia, per. – perianthia, spor. – sporangia, gemm. – gemmae.

Acrolejeunea sandvicensis (Gottsche) Steph. – [540, 585], 17, 18. Open mesic cliffs in *Betula-Picea* and *Picea-Abies* dominating forests. Kh-16-22-16, Kh-31-11-16. – per.

Anastrophyllum assimile (Mitt.) Steph. – [1460-1780], 2, 3, 5, 7, 10. Open to partly shaded moist cliffs and their crevices in crooked forests and tundra. Kh-20-3-16, Kh-21-6-16.

A. michauxii (F. Weber) H. Buch – [550-1480], 1, 4, 6, 13, 14, 15. Open to partly shaded moist to mesic decaying wood in *Larix* forests, lying branches of *Pinus pumila* in crooked forests and, rarely, hummock sides in tundra. Kh-22-18-16, Kh-24-11-16. – ant., per., spor.

Aneura pinguis (L.) Dumort. – [550, 1370], 1, 15. Partly shaded moist decaying wood in *Picea-Abies* forests. Kh-14-63-16, Kh-25-7-16. – arch.

Anthelia juratzkana (Limpr.) Trevis. – [1370, 1480, 1780], 1, 4, 3. Moist cliffs and stream banks in crooked forests and gravelly barrens. Kh-18-13-16, Kh-21-9-16. – per., ant.

Apotreubia nana (S. Hatt. et Inoue) S. Hatt. et Mizut. – [550-1640, more common in upper elevations], 5, 7, 10, 12, 15. Partly shade moist decaying wood in humid *Picea-Abies* forests, open mesic cliff crevices and mossy patches on steep slopes in crooked forests and gravelly barrens. Kh-19-17-16, Kh-27-1-16.

Asterella lindenbergiana (Corda) Lindb. – [585], 18. Partly shaded mesic cliff crevices in *Picea-Abies* forest. Kh-31-6-16. – ant., arch.

Barbilophozia barbata (Schreb.) Loeske – [550-1640], 5, 6, 15, 16. Partly shaded mesic bare soil on slopes, cliffs, trunk bases from forest to alpine zones, rarely moist boulders near stream in *Picea* forest. Kh-25-14-16, Kh-14-36-16. – per., spor.

B. hatcheri (A. Evans) Loeske – [585], 18. Mesic cliff crevice in *Picea-Abies* forest. *Acrolejeunea sandvicensis*. Kh-31-11-16 (the same specimen with *Acrolejeunea sandvicensis*, keeping in the herbarium under the latter).

Bazzania denudata (Torr. ex Gottsche, Lindenb. et Nees) Trevis. – [540, 550], 15, 17. Partly shaded moist stumps and humus on steep slopes in *Picea* and *Betula-Picea* forests. Kh-14-26-16, Kh-16-2-16.

B. parabidentula Bakalin – [1310], 6. Partly shaded moist decaying wood in *Picea* forest. Kh-24-14-16.

B. trilobata (L.) Gray – [540, 570, 1370], 1, 16, 17. Partly shaded moist decaying wood in *Picea* and *Picea-Betula* forest and forest floor in *Pinus pumila* crooked forest. Kh-22-1-16, Kh-25-5-16.

Blepharostoma trichophyllum (L.) Dumort. – [550-1760], 2, 4, 6, 7, 14, 15, 16, 14. Open to partly shaded moist cliff crevices, ledges, boulders, including those near stream, mossy patches and bare humus on steep slopes, decaying wood in all vegetation zones. Kh-24-4-16, Kh-25-11-16. The narrow species concept in *Blepharostoma* (Bakalin et al., 2020b) is

not followed because to distinguish taxa the information on oil bodies is necessary, that was unavailable after the treatment was published (four years has passed).

Calycularia laxa Lindb. et Arnell – [550-1780, more common in upper elevations], 3, 5, 7, 12, 15. Partly shaded moist cliffs, boulders, including those near stream, humificated soil near watercourses in coniferous and crooked forests and slightly above to alpine zone. Kh-19-11-16, Kh-27-2-16. – ant.

Calypogeia integristipula Steph. – [550-1570], 4, 6, 7, 8, 12, 15. Partly shaded moist cliff crevices, sides of hummocks and decaying wood, from coniferous forests to alpine zone. Kh-27-10-16, Kh-28-7-16. – gemm.

C. muelleriana (Schiffn.) Müll. Frib. – [570, 1640], 5, 16. Open moist cliff crevices in alpine zone and partly shaded decaying wood in *Picea-Abies* forest. Kh-23-2-16, Kh-25-2-16 (the same specimen with *Riccardia palmata*, keeping in the herbarium under the latter).

C. suecica (Arnell et J. Perss.) Müll. Frib. – [550, 570, 1310], 6, 15, 16. Partly shaded moist decaying wood in dark coniferous and crooked *Pinus pumila* forest. Kh-24-3a-16, Kh-25-3-16 (the same specimen with *Scapania apiculata*, keeping in the herbarium under the latter).

Cephalozia bicuspidata (L.) Dumort. – [550-1640], 1, 4, 5, 6, 12, 14, 15. Partly shaded to open moist cliffs, boulders, bare humus, including those near streams, rarer decaying wood. Kh-14-38-16, Kh-24-13-16. – per., ant., spor.

C. otaruensis Steph. – [690], 14. Partly shaded moist decaying wood in humid *Larix* forest. Kh-12-14-16.

Cephaloziella divaricata (Sm.) Schiffn. – [540], 17. Partly shaded mesic cliff in *Betula-Picea* forest. Kh-16-12-16.

C. divaricata var. *scabra* (M. Howe) Haynes – [570, 585, 600], 11, 16, 18. Open to partly shaded mesic cliff crevices in riversides in coniferous forest zone. Kh-29-1-16, Kh-31-13-16.

Cheilolejeunea obtusifolia (Steph.) S. Hatt. – [1570, 1640], 5, 7. Moist open cliffs in upper edge of crooked forest zone and lower limit of alpine zone. Kh-17-34-16, Kh-19-13-16.

Chiloscyphus polyanthos (L.) Corda – [570], 16. Partly shaded bottom of temporarily inundated hollow in humid *Picea-Abies* forest. Kh-25-17-16.

Cololejeunea subkodamae Mizut. – [550], 15. Partly shaded mesic cliffs in *Picea* forest along river. *Frullania davurica*, *Metzgeria pubescens*. Kh-14-35-16.

Conocephalum salebrosum Szweyk., Buczk. et Odrzyk. – [550], 15. Moist cliff crevice in *Picea* forest along river. Kh-14-31-16 (the same specimen with *Geocalyx graveolens*, keeping in the herbarium under *Conocephalum salebrosum*).

Crossocalyx hellerianus (Nees ex Lindenb.) Meyl. – [690], 14. Partly shaded moist decaying wood in humid *Larix* forest along stream. Kh-12-12-16.

Diplophyllum sibiricum Bakalin et Vilnet – [550- 770], 8, 15, 16, 18. Partly shaded moist cliffs in dark coniferous forests, mostly in stream valleys. Kh-11-5-16, Kh-28-3-16. – per., ant.

D. taxifolium (Wahlenb.) Dumort. – [550-1780], 2, 3, 5, 7, 13, 15. Open to partly shaded moist cliffs, crevices between boulders, including those near streams from forests and crooked forests to alpine zone. Kh-13-6-16, Kh-20-3-16 (the same specimen with *Gymnomitrion commutatum*, keeping in the herbarium under the latter).

Douinia plicata (Lindb.) Konstant. et Vilnet – [850], 13. Partly shaded mesic decaying stump in *Betula-Picea* forest. Kh-13-3-16 (the same specimen with *Mylia verrucosa*, keeping in the herbarium under *Douinia plicata*).

Frullania appendiculata Steph. – [540], 17. Partly shaded mesic cliff in *Betula-Picea* forest. Kh-16-13-16. – ant.

F. austinii J.J. Atwood, Vilnet, Mamontov et Konstant. – [570], 16. Partly shaded mesic *Betula* trunk in *Picea-Abies* dominating forest. Kh-25-12-16.

F. davurica Hampe – [540-1570 more common in lower elevations], 7, 15, 16, 17, 18. Open to partly shaded moist to mesic and rarely wet cliffs, including those along watercourses, decaying wood and bases of *Populus* trunks, mostly in *Picea* forests, rarely in *Betula-Picea* and crooked forests. Kh-30-3-16, Kh-31-12a-16.

F. koponenii S. Hatt. – [585, 690], 14, 18. Partly shaded mesic trunks of *Abies* and *Betula* in *Larix* and *Picea-Abies* dominating forests. Kh-12-8-16, Kh-31-5-16. – per., ant.

F. muscicola Steph. – [585, 850], 13, 18. Open to partly shaded mesic cliffs and their crevices in *Betula-Picea* and *Picea* dominating forests. Kh-13-7-16, Kh-31-11-16 (the same specimen with *Acrolejeunea sandvicensis*, keeping in the herbarium under the latter).

F. sinensis Steph. – [550], 15. Partly shaded mesic *Picea* branches in *Picea* dominating forest in river valley. Kh-14-54-16.

F. subarctica Vilnet, Borovich. et Bakalin – [1460, 1570, 1640], 5, 7, 10. Mesic to moist cliffs and other rock outcrops in upper edge of crooked forests. Kh-15-10-16, Kh-23-14-16.

Fuscocephaloziopsis leucantha (Spruce) Váňa et L. Söderstr. – [550, 570], 15, 16. Partly shaded moist decaying wood in *Picea* and *Picea-Abies* forests. Kh-14-66-16, Kh-25-8-16. – per., spor.

F. lunulifolia (Dumort.) Váňa et L. Söderstr. – [550-1370], 1, 6, 8, 12, 14, 15, 16. Partly shaded moist decaying wood in dark coniferous forests. Kh-27-6-16, Kh-28-6-16. – per., spor.

Geocalyx graveolens (Schrad.) Nees – [550, 570, 585], 15, 16, 18. Partly shaded moist decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-25-4-16, Kh-31-16-16 (the same specimen with *Conocephalum salebrosum*, keeping in the herbarium under the latter).

Gymnomitrion commutatum (Limpr.) Schiffn. – [1460-1760], 2, 5, 7, 10. Open moist to mesic cliffs and their crevices in upper edge of crooked forests zone and through alpine zone. Kh-20-3-16 (the same specimen with *Diplophyllum taxifolium*, keeping in the herbarium under *Gymnomitrion commutatum*), Kh-23-1-16 (the same specimen with *Herbertus arcticus*, keeping in the herbarium under the latter). – arch.

Herbertus arcticus (Inoue et Steere) Schljakov – [1570, 1640], 5, 7. Moist open cliffs in upper edge of crooked forest zone and lower limit of alpine zone. Kh-17-14-16, Kh-23-1-16 (the same specimen with *Gymnomitrion commutatum*, keeping in the herbarium under *Herbertus arcticus*).

H. dicranus (Taylor ex Gottsche, Lindenb. et Nees) Trevis. – [540-1640, more common in upper elevations], 5, 6, 10, 17. Partly shaded to open mesic cliffs, rarely tree trunk bases in *Picea-Abies*, *Betula-Picea* forests, and crooked forests. Kh-19-2-16, Kh-24-3-16.

Jungermannia pumila With. – [690, 1640], 5, 14. Open to partly shaded moist to wet cliffs, mostly along streams. Kh-12-4-16, Kh-23-8-16.

Lejeunea alaskana (R.M. Schust. et Steere) Inoue et Steere – [1570, 1640], 5, 7. Open to partly shaded moist cliffs in upper extreme of crooked forest zone and lower part of alpine zone. Kh-19-1-16, Kh-23-11-16.

Lepidozia reptans (L.) Dumort. – [550-1370], 1, 6, 13, 14, 15. Partly shaded moist decaying wood, rarely cliffs in *Picea* and *Picea-Abies* dominating forests. Kh-12-17-16 (the same specimen with *Mylia verrucosa*, keeping in the herbarium under the latter), Kh-25-10-16.

Lepidozia subtransversa Steph. – [550, 605, 1310], 6, 9, 15. Partly shaded moist boulders near streams, humus along streamside and decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-24-6-16, Kh-26-4-16.

Liochlaena subulata (A. Evans) Schljakov – [550, 585], 15, 18. Partly shaded moist decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-14-58-16, Kh-31-15-16. – gemm., per.

Lophocolea heterophylla (Schrad.) Dumort. – [690], 14. Partly shaded moist decaying wood in *Larix* forest. Kh-12-13-16.

L. minor Nees – [540, 550], 15, 17. Partly shaded moist *Populus* trunk base and clayish soil near stream in *Picea* and *Picea-Abies* dominating forests. Kh-14-22-16, Kh-16-5-16. – gemm., per.

Lophozia ascendens (Warnst.) R.M. Schust. – [690], 14. Open decaying wood in humid *Larix* forest. Kh-12-18-16. – gemm.

L. guttulata (Lindb. et Arnell) A. Evans – [930], 12. Partly shaded moist cliffs in *Picea-Abies* dominating forest. Kh-27-4-16.

L. lantratoviae Bakalin – [550-1480, more common in upper elevations], 1, 4, 6, 15. Open to partly shaded moist humus and boulders near streams, rarely decaying wood, in *Picea* dominating forests and alpine tundra. Kh-22-6-16, Kh-24-8a-16. – gemm.

L. longiflora (Nees) Schiffn. – [1570, 1780], 3, 7. Open to partly shaded moist cliff crevices in upper part of crooked forests and middle of alpine zone. Kh-17-20-16, Kh-21-3-16. – per., ant., spor., gemm.

L. silvicola H. Buch – [850, 930, 1570], 7, 12, 13. Partly shaded moist decaying wood, cliff crevices and bare soil on steep slope in *Picea* dominating forests and crooked forest. Kh-17-6-16, Kh-27-5-16 (the same specimen with *Riccardia palmata*, keeping in the herbarium under *Lophozia silvicola*). – per., ant.

L. silvicoloides N. Kitag. – [570, 1480], 4, 16. Partly shaded moist humus near presumable wind hole opening in *Picea-Abies* dominating forest and open sides of mossy hummocks in lowered tundra. Kh-18-23-16, Kh-25-21-16. – gemm.

L. ventricosa (Dicks.) Dumort. – [850, 1370], 1, 13. Open moist humus on slope to stream and moist hollows in the swamps. Kh-13-2-16, Kh-22-12-16 (the same specimen with *Solenostoma hyalinum*, keeping in herbarium under the latter). – gemm.

Lophoziopsis excisa (Dicks.) Konstant. et Vilnet – [540, 1460], 10, 17. Mostly open cliff crevices and humus covering boulders in gravelly barrens in subalpine zone and *Betula-Picea* forests. Kh-15-22-16 (the same specimen with *Lophoziopsis longidens*, keeping in the herbarium under *Lophoziopsis excisa*), Kh-16-6-16. – per., ant.

L. longidens (Lindb.) Konstant. et Vilnet – [540, 1460], 10, 17. Open to partly shaded mesic cliffs and their crevices in *Betula-Picea* dominating forest and gravelly barrens in crooked forest zone. Kh-15-22-16 (the same specimen with *Lophoziopsis excisa*, keeping in the herbarium under the latter), Kh-16-18-16. – gemm.

L. polaris (R.M. Schust.) Konstant. et Vilnet – [570], 16. Partly shaded moist humus near presumable wind hole opening in *Picea-Abies* dominating forest. Kh-25-19-16. – gemm.

Mannia sibirica (Müll. Frib.) Frye et L. Clark – [540, 570], 16, 17. Partly shaded mesic cliff crevices and soil on steep slope in *Picea-Abies* and *Betula-Picea* dominating forests. Kh-11-3-16, Kh-16-21-16.

Marchantia polymorpha L. subsp. *polymorpha* – [570], 16. Partly shaded moist bottom of temporarily inundated hollow in *Picea-Abies* forest. Kh-25-18-16.

M. polymorpha subsp. *ruderalis* Bischl. et Boissel.-Dub. – [585], 18. Partly shaded mesic cliff crevice in *Picea-Abies* dominating forest. Kh-31-8-16.

Marsupella boeckii (Austin) Lindb. ex Kaal. – [1370, 1480, 1780], 1, 3, 4. Open moist boulders and humus near streams and moist cliffs in ridgeline, in alpine and crooked forest zones. Kh-21-10-16, Kh-22-7-16. – per.

M. emarginata (Ehrh.) Dumort. – [540-1780], 3, 4, 5, 7, 8, 9, 10, 12, 13, 15, 17. Open to partly shaded moist to wet cliffs and boulders, including those near streams, though all vegetation zones. Kh-27-8-16, Kh-30-1-1. – per., ant.

Metacalypogeia cordifolia (Stephani) Inoue – [550, 570], 15, 16. Partly shaded moist cliffs in *Picea* and *Picea-Abies* dominating forests. Kh-14-40-16, Kh-25-16-16.

Metzgeria pubescens (Schrank) Raddi – [550, 690, 1640], 5, 14, 15. Partly shaded mesic cliffs in forests and tundra-like communities, also mesic tree trunk base in *Picea* forest. Kh-14-2-16, Kh-23-10-16 (the same specimen with *Porella vernicosa*, keeping in the herbarium under the latter). – ant., arch., spor.

Mylia taylorii (Hook.) Gray – [550-1780], 1, 3, 4, 6, 7, 10, 12, 13, 14, 15. Partly shaded moist decaying wood in forest and crooked forest zones, open mesic to moist cliff crevices in upper half of crooked forest and alpine zones. Kh-13-15-16, Kh-14-6-16. – ant., per., spor.

M. verrucosa Lindb. – [550-1310 more common in lower elevations], 6, 12, 13, 14, 15, 16. Partly shaded to open moist decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-12-17-16 (the same specimen with *Lepidozia reptans*, keeping in the herbarium under *Mylia verrucosa*), Kh-13-3-16 (the same specimen with *Douinia plicata*, keeping in the herbarium under the latter). – ant., per., spor.

Nardia geoscyphus (De Not.) Lindb. – [1370], 1. Open moist humus near stream in crooked forest zone. Kh-22-3-16.

N. insecta Lindb. – [1460], 10. Open mesic soil on slope in crooked forest zone. Kh-15-15-16. – per., ant.

Neoorthocaulis attenuatus (Mart.) L. Söderstr., De Roo et Hedd – [1370], 1. Partly shaded mesic *Pinus pumila* branch in crooked forest zone. Kh-22-16-16. – gemm.

Nowellia curvifolia (Dicks.) Mitt. – [550-1310 more common in lower elevations], 6, 14, 15, 16. Partly shaded to open decaying wood in *Picea*, *Picea-Abies* and *Larix* dominating forests. Kh-24-12-16, Kh-25-9-16. – per.

Pedinophyllum truncatum (Steph.) Inoue – [550], 15. Partly shaded mesic tree trunk base in *Picea-Abies* dominating forest. Kh-14-3-16.

Pellia neesiana (Gottsche) Limpr. – [550, 1370], 1, 15. Partly shaded moist humus, including that near stream in *Picea* dominating forest and crooked forest zone. Kh-14-27-16, Kh-22-9-16.

Plagiochila ovalifolia Mitt. – [550-1310, more common in lower elevations], 6, 12, 16, 15. Open to partly shaded moist to mesic humus, fine soil, including those near streams, partly shaded moist *Populus* trunk base. Kh-24-5-16, Kh-27-9-16. – ant., per.

P. porelloides (Torr. ex Nees) Lindenb. – [540, 570], 16, 17. Partly shaded moist cliffs and decaying wood. Kh-16-23-16, Kh-25-20-16. – ant.

Pleurocladula albescens (Hook.) Grolle – [1370, 1480], 1, 4. Open moist boulders and humus near streams in crooked forest and alpine zones. Kh-18-10-16, Kh-22-15-16.

Porella ulophylla (Steph.) Hatt. – [540], 17. Partly shaded mesic cliff in *Betula-Picea* forest. Kh-16-8-16.

P. vernicosa Lindb. – [540-1640, more common in lower elevations], 5, 16, 17, 18. Open to partly shaded mesic cliffs in *Abies-Picea* and *Betula-Picea* dominating forests, once on

mesic cliff in alpine zone. Kh-23-10-16 (the same specimen with *Metzgeria pubescens*, keeping in the herbarium under *Porella vernicosa*), Kh-31-14-16. – per.

Protochilopsis grandiretis (Lindb. ex Kaal.) A.V. Troitsky, Bakalin et Fedosov – [1480], 4. Open sides of mossy hummocks in mountain tundra. Kh-18-19-16. – gemm.

Pseudolophozia sudetica (Nees ex Huebener) Konstant. et Vilnet – [540-1780, more common in upper elevtions], 3, 4, 5, 17. Partly shaded moist cliffs in upper half of crooked forest and through alpine zones. Kh-17-21-16, Kh-23-6-16. – gemm.

Ptilidium ciliare (L.) Hampe – [690, 1570, 1640], 5, 7, 14. Open cliff, moist mossy patches on cliff ledges, slopes in moist tundras, *Larix* trunk base in forest zone. Kh-17-1-16, Kh-19-16-16.

P. pulcherrimum (Weber) Vain. – [540-1370], 1, 4, 14, 16, 17. Open to partly shaded mesic branches of *Pinus pumila* and trunks of *Picea* in *Picea-Abies* dominating forests and crooked forest zone. Kh-22-20-16, Kh-25-1-16. – per.

Radula complanata (L.) Dumort. – [550, 690, 1310], 6, 14, 15. Partly shaded mesic *Picea* trunks and branches in *Picea* and *Larix* dominating forests. Kh-14-53-16, Kh-24-1-16. – per., ant.

R. obtusiloba Steph. – [550, 585, 1640], 5, 15, 18. Partly shaded moist cliffs in *Picea* and *Picea-Abies* dominating forests. Kh-14-47-16, Kh-31-3-16.

R. prolifera Arnell – [1640, 1760], 2, 5. Open moist cliffs and their crevices in alpine zone. Kh-20-5-16, Kh-23-4-16 (the same specimen with *Sphenolobopsis pearsonii*, keeping in the herbarium under the latter).

Reboulia hemisphaerica subsp. *orientalis* R.M. Schust. – [540], 17. Open mesic cliff crevice in *Picea-Betula* dominating forest. Kh-16-19-16. – ant., arch.

Riccardia palmata (Hedw.) Carruth. – [550-930], 12, 15, 16, 18. Partly shaded moist decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-25-2-16 (the same specimen with *Calypogeia muelleriana*, keeping in the herbarium under *Riccardia palmata*), Kh-27-5-16 (the same specimen with *Lophozia silvicola*, keeping in the herbarium under the latter).

Scapania apiculata Spruce – [550-1310, more common in lower elevations], 6, 14, 15, 16. Open to partly shaded moist decaying wood in *Picea*, *Picea-Abies* and *Larix* dominating forests. Kh-14-61-16, Kh-25-3-16 (the same specimen with *Calypogeia suecica*, keeping in the herbarium under *Scapania apiculata*). – per., ant., gemm.

S. carinthiaca J.B. Jack ex Lindb. – [550, 570, 930], 12, 15, 16. Partly shaded moist decaying wood in *Picea* and *Picea-Abies* dominating forests. Kh-14-59-16, Kh-25-11-16. – per., gemm.

S. crassiretis Bryhn – [550-1640], 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 18. Open to partly shaded moist to wet, rarely submerged cliffs, mostly those near streams, moist mossy hummock near presumable wind hole opening, in all vegetation zones. Kh-12-5-16, Kh-28-2-16. – per., gemm.

S. irrigua (Nees) Nees – [540-1480, more common in lower elevations], 1, 4, 10, 17. Open moist boulders and humus along streams in upper extremes of crooked forest zone and tundras. Kh-22-5-16, Kh-30-2-16 (the same specimen with *Scapania rufidula*, keeping in the herbarium under the latter).

S. microdonta (Mitt.) Müll. Frib. – [850-1780], 2, 3, 5, 7, 10, 13. Open mesic to moist crevices in gravelly barrens and cliffs in *Betula-Picea* forest, crooked forests and alpine zone. Kh-13-13-16, Kh-19-9-16.

S. mucronata H. Buch – [585, 600, 770], 8, 11, 18. Open moist to mesic cliffs near streams and other watercourses in *Picea* and *Picea-Abies* forests. Kh-28-4-16, Kh-29-2-16. – per., gemm.

S. paludosa (Müll. Frib.) Müll. Frib. – [1370], 1. Open moist hollow in the swamp in crooked forest zone. Kh-22-11-16.

S. parvifolia Warnst. – [850-1640], 4, 5, 7, 10, 12, 13. Open to partly shaded moist cliffs and boulders, including those near streams in upper half of coniferous forest zone, crooked forests and lower part of alpine zone. Kh-13-5-16, Kh-19-15-16. – per.

S. rufidula Warnst. – [540-1480, more common in lower elevations], 4, 9, 13, 14, 15, 17. Open wet cliffs near stream in various types of coniferous forests, once in alpine zone. Kh-26-1-16, Kh-30-2-16 (the same specimen with *Scapania irrigua*, keeping in the herbarium under *S. rufidula*). – ant., per., gemm.

S. scandica (Arnell et H. Buch) Macvicar – [550], 15. Partly shaded moist cliffs in *Picea* forest. Kh-14-46-16.

S. sphaerifera H. Buch et Tuom. – [600, 850], 13, 17. Open mesic cliffs and crevices between stones in gravelly barrens in forest zone. Kh-13-11-16, Kh-16-15-16. – gemm.

Schistochilopsis cornuta (Steph.) Konstant. – [770], 8. Partly shaded moist decaying wood in *Picea-Abies* dominating forest. Kh-28-5-16. – gemm.

S. incisa (Schrad.) Konstant. – [550-1570], 6, 7, 10, 12, 13, 15. Partly shaded moist cliffs and decaying wood in various types of forests and crooked forests. Kh-13-8-16, Kh-14-30-16. – per., gemm.

Schljakovia kunzeana (Huebener) Konstant. et Vilnet – [1370], 1. Open moist hollow in the swamp in crooked forest zone. Kh-22-14-16.

Schljakovianthus quadrilobus (Lindb.) Konstant. et Vilnet – [1640], 5. Partly shaded moist cliffs in alpine zone. Kh-23-7-16.

Solenostoma hyalinum (Lyell) Mitt. – [585, 1370], 1, 18. Open moist humus and boulders along streams and moist hollow in the swamp in *Picea* dominating forests and crooked forest zone. Kh-22-12-16 (the same specimen with *Lophozia ventricosa*, keeping in the herbarium under *Solenostoma hyalinum*), Kh-31-1-16. – arch., per.

S. obscurum (A. Evans) R.M. Schust. – [550-1370], 1, 6, 15, 18. Open to partly shaded moist to wet boulders along streams, decaying wood covering with soil near stream. Kh-24-8-16, Kh-31-18-16. – per., ant.

S. pseudopyriflorum Bakalin et Vilnet – [550, 1570], 7, 15. Partly shaded moist cliffs in *Picea* dominating forest and upper part of crooked forest zone. Kh-14-39-16, Kh-17-15-16.

S. subellipticum Lindb. ex Heeg) R.M. Schust. – [540, 1480], 4, 17. Moist boulders near streams and ponds in *Betula-Picea* dominating forest and mountain tundra on steep slope. Kh-16-4-16, Kh-18-9-16.

Sphenolobopsis pearsonii (Spruce) R.M. Schust. – [1460, 1570, 1640] 5, 7, 10. Open to partly shaded moist to mesic cliff crevices in upper extreme of crooked forests and lower half of alpine zone. Kh-17-36-16, Kh-23-4-16 (the same specimen with *Radula prolifera*, keeping in the herbarium under *Sphenolobopsis pearsonii*).

Sphenolobus minutus (Schreb.) Berggr. – [540-1780], 1, 3, 4, 5, 7, 10, 12, 14, 15, 17. Open to partly shaded mesic to moist cliffs and gravelly barrens crevices from forest to alpine zones. Kh-21-2-16, Kh-23-3-16. – per.

S. saxicola (Schrad.) Steph. – [850-1760], 2, 4, 5, 7, 10, 13. Open mesic cliffs and gravelly barrens crevices, from upper half of forest zone (but not within forests) to crooked forests and alpine zone. Kh-15-19-16, Kh-20-1-16. – per.

Syzygiella autumnalis (DC.) K. Feldberg, Váňa, Hentschel et Heinrichs – [550-1310], 6, 8, 14, 15, 16. Open to partly shaded mesic to moist decaying wood in *Picea*, *Larix* and *Picea-Abies* dominating forests. Kh-12-11-16, Kh-28-8-16. – ant., arch., per., spor.

Targionia hypophylla L. – [540, 570, 585], 16, 17, 18. Open to partly shaded mesic cliff crevices in *Picea-Abies* and *Betula-Picea* dominating forests. Kh-16-20-16, Kh-31-10-16. – spor.

Tetralophozia setiformis (Ehrh.) Schljakov – [1460, 1760, 1780], 2, 3, 10. Open mesic crevices in the cliffs and gravelly barrens in alpine zone. Kh-20-6-16, Kh-21-1-16.

Trilophozia quinquedentata (Huds.) Bakalin – [540-1780], 1, 2, 3, 4, 5, 6, 7, 10, 12, 13, 14, 15, 16, 17. Open to partly shaded moist cliffs and boulders including those near streams, from forest to alpine zones. Kh-14-43-16, Kh-19-5-16. – per.

Tritomaria exsecta (Schmidel ex Schrad.) Schiffn. ex Loeske – [550-1640], 5, 6, 7, 8, 12, 13, 14, 15, 16, 18. Partly shaded moist, rarely mesic decaying wood, *Picea* trunk bases, humus on slopes and near streams, crevices in cliffs and gravelly barrens, from various forests to crooked forests and lower half of alpine zone. Kh-11-1-16, Kh-28-1-16. – gemm.

Discussion

In total 116 taxa are recorded, including 114 species and 2 varieties. This number of records is exceeding the number of species known for the vast majority of the sectors 5 × 5 degrees (latitude/longitude correspondingly) in the Russian Far East, thus for much larger areas (Bakalin, 2013, fig. 3 in l.c.). However, a few of the richest local floras of the Russian Far East leave Badzhal Range flora behind. The leader among such floras are the Southern Kurils, whose liverwort flora reaches 242 taxa (Bakalin *et al.*, 2022a). Other local floras exceed studied area in the number of species in lesser extent: Bystrinsky Nature Park – 144 taxa (Klimova, 2015), South Kamchatka Nature Park – 132 taxa (Bakalin *et al.*, 2022b). Only for four species exceed the number of known taxa in the flora of the Ayan surroundings on the coast of the Sea of Okhotsk (Bakalin *et al.*, 2021). However, in fairness, it must be said that such a comparison is not entirely appropriate, since the floras listed above: 1) have been studied much better (except for Ayan, whose knowledge is just very similar), 2) their area sizes are still larger, than the studied flora of the Badzhal Range, and 3) all of them are located in a climate that is significantly more humid and mild than in the studied area. Thus, among the local floras of the Russian Far East, the studied area looks quite taxonomically rich. Since the studied flora is located in the northern edge of the contact of East Asian and circumboreal floras, and the relief in the studied area is mountainous, the taxonomic list is composed by various elements, which are discussed below.

Not numerous, but providing the 'peculiarity' to the studied flora are East Asian (sometimes even broadly East Asian – Southeast Asian and Asian tropical) taxa. The bright examples of that group are *Acrolejeunea sandvicensis*, *Cheilolejeunea obtusifolia*, *Pedinophyllum truncatum*, *Porella ulophylla*, *Schistochilopsis cornuta*. Here they were found in the northernmost known localities of the species distribution in the World. Other temperate and boreal-temperate East Asian *Bazzania parabidentula*, *Cololejeunea subkodamae*, *Frullania davurica*, *F. koponenii*, *F. sinensis*, *Metacalypogeia cordifolia*, *Mylia verrucosa*, *Plagiochila ovalifolia*, *Porella vernicosa* *Radula obtusiloba*, *Solenostoma pseudopyriflorum*, also show mostly East Asian distribution pattern. Highly disjunct and rare, generally amphi-oceanic *Sphenolobopsis pearsonii* has here the northernmost known locality in Asia. More broadly distributed (although the most abundant in Sino-Himalaya) *Anastrophyllum assimile* is rare mountain element in the flora.

The position of Badzhal Range in taiga zone led to abundance of circumboreal taxa, including predominantly epixylous *Anastrophyllum michauxii*, *Crossocalyx hellerianus*, *Fuscocephaloziopsis leucantha*, *Geocalyx graveolens*, *Lepidozia reptans*, *Lophozia ascendens*, *L. guttulata*, *Neoorthocaulis attenuatus*, *Riccardia palmata*, *Scapania apiculata*, *S. carinthiaca*, *Schistochilopsis incisa*, *Tritomaria exsecta*.

Circumpolar taxa whose distribution cover more than one vegetation zone (mostly from subarctic to boreal) with the tendency to be distributed in mountainous areas like *Barbilophozia barbata*, *Cephaloziella divaricata*, *Diplophyllum taxifolium*, *Jungermannia pumila*, *Lophozia longiflora*, *L. silvicola*, *L. ventricosa*, *Lophoziopsis longidens*, *Mylia taylorii*, *Nardia geoscyphus*, *N. insecta*, *Pellia neesiana*, *Scapania irrigua*, *S. mucronata*, *S. parvifolia*, *S. scandica*, *Schljakovia kunzeana*, *Schljakovianthus quadrilobus*, *Solenostoma hyalinum*, *S. subellipticum*, *Sphenolobus minutus*, *Trilophozia quinquedentata* follows from the mountainous relief of the studied area. The presence of landscapes above the timberline predicts occurrence of arctic-montane taxa. That group includes *Anthelia juratzkana*, *Gymnomitrion commutatum*, *Herbertus arcticus*, *Lophoziopsis polaris* (unlike to others found in low elevation only, although near tentative wind hole opening), *Marsupella boeckii*, *Pleurocladula albescens*, *Protochilopsis grandiretis*, *Pseudolophozia sudetica*, *Scapania crassiretis*, *S. paludosa*, *Sphenolobus saxicola*, *Tetralophozia setiformis*.

Broadly distributed (Holarctic to subcosmopolitan) *Aneura pinguis*, *Chiloscyphus polyanthos*, *Lophocolea heterophylla*, *L. minor*, *Lophoziopsis excisa*, *Marchantia polymorpha*, *Metzgeria pubescens*, *Reboulia hemisphaerica*, *Targionia hypophylla* and *Cephalozia bicuspidata* seems to be inevitable in the floras situated in the southern taiga in Asia.

Some unusual associations of the taxa are observed in studied area. For instance, mostly tropical-subtropical Asian *Acrolejeunea sandvicensis* was gathered in the same patch together with arctic-boreal montane *Barbilophozia hatcheri* and *B. barbata*. The even more unforeseen is the association of temperate *Cheilolejeunea obtusifolia* collected in studied area above timberline only (alpine occurrences were not known for the taxon before) growing together with arctic-montane *Frullania subarctica.*

Summarizing, Badzhal Range may be recognized as valuable phytogeographic northern outpost for the distribution of more southern East Asian taxa. Five species of liverworts observed in the studied area have there the northernmost known localities. Before the study was conduct-

ed, we expected the occurrence of some 'northern' taxa in Badzhal Range in the southernmost localities known in the World or in Pacific Asia. However, instead we sound a number of more 'southern' taxa having northern outpost in their distribution in Badzhal Range and none of taxa having southern limit of distribution in Badzhal. The occurrence of highly disjunctive *Apotreubia* and *Sphenolobopsis* in Badzhal Range may show the value of the studied area as the phytogeographic refugium and may confirm the necessity of future nature conservation actions in the area. Since liverworts in Badzhal Range were studied only in one small-sized area we suggest the obtained data on occurrence of 116 taxa in the range are quite far from the number of taxa that would be revealed in the course of purposeful exploration of the whole range.

ACKNOWLEDGEMENTS

The work is within the framework of the institutional research project "Cryptogamic Biota of Pacific Asia" (no22040800088-5) carried out in the Botanical Garden-Institute of the Russian Academy of Sciences. V.A. Bakalin is deeply indebted to Dr. Pavel Krestov (VBGI), Dr. Vladimir Fedosov (MW), Dr. Olga Pisarenko (NSK) and other colleagues who helped in the liverwort collecting in the studied area and shared the duties of the field expedition living in the course of the present investigation.

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Received 4 September *Accepted 9 November 2023*