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The liverwort flora of Bering Island (north-west Pacific, Russia)

Vadim A. Bakalin

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A checklist of the liverworts of Bering Island (north-west Pacific) is presented. A total of 102 species have been enumerated, including 95 new records for Bering Island and the Commander Archipelago. *Macrodiplophyllum imbricatum* (M.A. Howe) Perss. is a new record for Russia and the Eastern Hemisphere, *Solenostoma gracillimum* (Sm.) R.M. Schust. has been recorded for the second time for Asia and four species are new records for the Russian Far East. An overview of the liverwort flora of Bering Island is presented. Data on occurrence, ecology and reproduction are provided for each species. The flora in geographic sense can be characterized as Arctic/boreal/montane circumpolar with a notable boreal and oceanic tendency.

V. A. Bakalin, Inst. of Biology and Soil Sciences of Far East Division of Russian Academy of Sciences, Vladivostok, pr. 100-letiya Vladivostoka, 159, RU-690022, Russia (v_bak@list.ru).

The Commander Islands, although situated at 55º N latitude, lack trees and even commonly occurring high shrubs such as *Pinus pumila* Pall, which is widespread in northern East Asia. The islands are the western part of the Aleutians and probably constituted a plant migratory route between Asia and America, parallel to Beringia. The fact that the Commander Islands are isolated from the Kamchatka Peninsula and the nearest islands of Aleutians by over 200 km make them well suited for studying the effect of insularity. Earlier information on the hepatics of Bering Island was published in a paper by H.W. Arnell (1917), which reported specimens collected by members of the Swedish "Vega Expedition". The flora of the island was sampled in August 1879. A total of 33 species of bryophytes were discovered, with 11 taxa of liverworts among them. = The aim of this study was to improve on our knowledge of the hepatic flora of these Islands.

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Study area

Bering Island is a part of the Commander Archipelago, the westernmost of the Aleutian Islands (Fig. 1). Bering Island is 96 km long and covers an area of about 1800 km^2. The island was formed from pre-Quaternary sediments and it is covered by thick volcanic strata from the Paleocene and Lower Miocene Epochs. The most recent evidence of volcanism has been estimated to be from the Upper Pliocene-Lower Pleistocene (Luchitsky 1974). A mountain range with peaks as high as 750 m a.s.l. follows the main axis of the island. The area to the south of Nykol'skoye settlement (Fig. 1) is distinguished by river valleys with a number of waterfalls. The waterfalls occur only near the coast and vary in height, from 10 to 200 m. To the north of Nikol'skoye is a depression with a number of low sea terraces. Only a few are intact, while the others have eroded, forming knolls surrounded by a large boggy plain. These knolls have flat tops and range from 120 to 150 m a.s.l. (Fig. 2).

Spore and pollen analyses suggest land uplift at a rate of 2.1–2.2 mm per year. Small islets, ranging from 50–100 m a.s.l., first appeared during the middle of the Pleistocene. During the Upper Pleistocene, mountain valley glaciation was common. The vege-

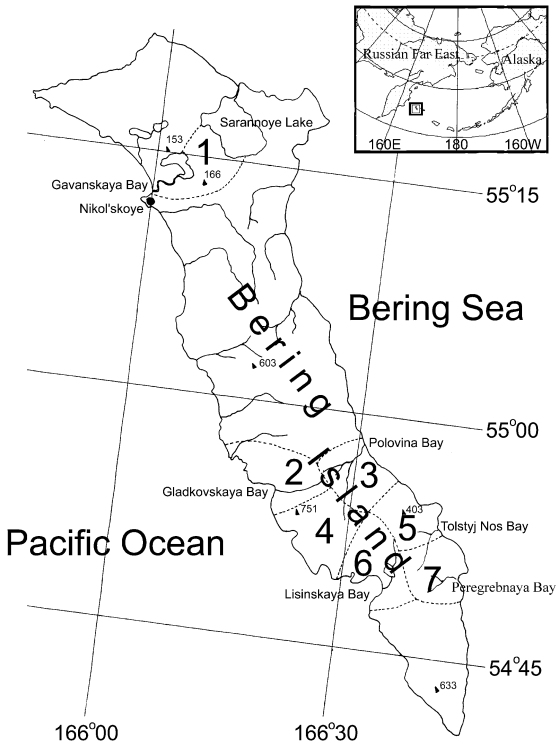

Fig. 1. Bering Island with collecting localities: 1) wide plain 20–40 m a.s.l., with some knolls (Svinyje, Stolovyje Mtns., Gavanskaya Mt.) up to 166 m a.s.l. The plain contains the valleys of the slowly flowing Gavanskaya, Zapornaja and Ivanovskij Zapor Rivers, limited to the northeast by Sarannoye Lake. 2) Gladkovskaya Bay, the Gladkovskaya and Vodopadnaya River valleys, 0–400 m a.s.l. 3) The Polovina River valley, 20–100 m a.s.l. 4) Dikaya and Peresheek Bays as well as Dikaya and Peresheek Rivers, 0–500 m a.s.l. 5) Peredovaya River and Tolstyj Nos Bay 10–400 m a.s.l. 6) Lisinskoye Lake and a complex of rivulets, draining into the lake, 10–250 m a.s.l. 7) Peregrebnaya Bay and Peregrebnaya River and the upper reaches of Peredovaya River 10–450 m a.s.l.

tation of the boggy plain near Nikol'skoye was probably assembled during the second half of the Holocene. We surmise this because sedimentary rocks of the Holocene optimum are absent from the plain (Luchitsky 1974).

The climate of the Commander Archipelago is moderately oceanic with an annual average temperature of +2.1°C, a low annual temperature amplitude (about 15°C) and annual precipitation of about 500 mm. Bering Island lacks forest cover, in spite of being located at the same latitude as Moscow. The main reason is insufficient insolation owing to low summer temperatures (9–10°C), strong winds and constant clouds (Kursanova and Savchenko 1966).

An overview of the collection localities is given in Fig. 1.

List of species

Taxa are arranged alphabetically. Nomenclature follows Konstantinova et al. (1992), incorporating some recent name changes from Konstantinova and Vasiljev (1994), Bakalin (2001, 2003), Bakalin et al. (2001). New taxa for the Kamchatka Region in its broadest sense (Persson 1970), are marked with an asterisk. Authors of names are cited as proposed by Brummit and Powell (1992). Synonyms used in Grolle and Long (2000) have been added where the traditional Russian concept of genera conflicts with the generic concept of West-European and North American scientists (e. g. *Jungermannia* s. l. and *Lophozia* s. l.). Information has been provided on observed reproduction, the collecting site numbers (enclosed in dashes) and habitats and accompanying species. If a species was collected only once, more exact information about the location is reported. Comments have been added on taxonomy and distribution for some species. All voucher specimens are being kept in the bryological herbarium of Polar Alpine Botanical Garden Institute (KPABG).

Aneura pinguis (L.) Dumort. With antheridia. – 1, 2, 7 – In crevices on wet cliffs, on fine-grained soil and on slopes of moss tussocks in sedge-moss mires. Once found together with *Leiocolea heterocolpos*.

Anthelia julacea (L.) Dumort. With antheridia. – 6 – Sedge-moss mire, in hollows between *Juncus*, with *Pleurocladula albescens*, *Cephalozia bicuspidata* and *Marsupella boeckii*.

Anthelia juratzkana (Limpr.) Trevis. – 2, 4, 6, 7 – Miscellaneous communities: areas of fine-grained soil formed by cryogenic processes with *Nardia* and *Solenostoma*; wet nival communities, cliff-crevices on cliffs with species of *Marsupella*, *Gymnomitrion*, as well as *Cladopodiella francisci* and *Nardia breidleri*; on dense hummocks in raised mires with *Gymnocolea inflata*, *Cladopodiella fluitans*, and *Cephalozia bicuspidata*; in dry tundra with *Diplophyllum* and *Macrodiplophyllum*.

**Athalamia hyalina* (Sommerf.) S. Hatt. – 6 – In crevices on coastal cliffs on the south bank of Golodnaya Bay. Once with *Plagiochila porelloides*.

Barbilophozia hatcheri (A. Evans) Loeske. With gemmae. – 2, 5, 7 – In dry hummocks in grass-dwarf-shrub-peat-moss mires and mirey meadows; in dry coastal crevices; in grass-moss tundra with *Cephaloziella divaricata*, *Sphenolobus minutus*, species of *Lophozia*, *Nardia*, *Diplophyllum*; in fine-grained soil between patches of *Empetrum nigrum* and *Rhododendron camtschaticum* with *Macrodi-*

plophyllum imbricatum and *Ptilidium ciliare*. Along with typical plants, a transitional form of *Barbilophozia lycopodioides* was noted.

Barbilophozia lycopodioides (Wallr.) Loeske – 7 – In pure mats in moss-dwarf shrub tundra on the upper Peredovaya River.

Blasia pusilla L. – 7 – On wet boulders in the waterfall canyon near Tolstyj Nos Bay.

Blepharostoma trichophyllum (L.) Dumort. With gemmae, perianthia, sporogonia – 1, 6, 7 – On wet boulders near streams; in cliff crevices on cliffs; on peaty banks of small lakes, with *Pleurocladula albescens*, *Anthelia juratzkana*, *Tritomaria quinquedentata*, *Scapania irrigua*, *Calypogeia integristipula*, *Cephalozia bicuspidata*, *C. leucantha*, *Lophozia sudetica* and *L. ventricosa*.

Calypogeia integristipula Steph. – 2 – On the peaty banks of ponds formed by cryogenic processes, near Gladkovskaya Bay, with *Moerckia blyttii*, *Odontoschisma elongatum* and *Cephalozia bicuspidata*.

Calypogeia muelleriana (Schiffn.) Müll. Frib. – 2, 5, 6, 7 – Among mosses and hepatics on hummocks in different types of mires, on rocks covered by fine-grained soil, among hepatics in seepage slopes in the subnival belt. Found in miscellaneous combinations with *Blepharostoma trichophyllum*, *Moerckia blyttii*, *Plectocolea subelliptica*, *Pellia neesiana*, *Orthocaulis kunzeanus*, *Lophozia wenzelii*, *L. ventricosa*, *Scapania paludosa* and *S. parvifolia*. Along with typically coloured plants, a dark coloured mod. *fusca* was found.

Calypogeia sphagnicola (Arnell et J. Perss.) Warnst. et Loeske – 2 – On the peaty bank of ponds formed by cryogenic processes in a peat moss-sedge mire near Gladkovskaya Bay, with *Odontoschisma elongatum*, *Gymnocolea inflata*, *Riccardia latifrons*, *Lophozia ventricosa*, *Cephalozia leucantha* and *C. bicuspidata*.

Cephalozia ambigua C. Massal. – 7 – On soil in very moist grass-moss tundra, severely damaged by reindeer in the upper part of Peredovaya River, with *Anthelia juratzkana*, *Lophozia sudetica* and *Moerckia blyttii*.

Cephalozia bicuspidata (L.) Dumort. With perianthia, antheridia, archegonia. – 1, 2, 3, 4, 5, 6, 7 – Occurring in almost all communities, with the exception of xeric alpine gravely barrens; with patches of dwarf shrubs and cold areas of dry fine-grained soil, together with almost all species, but more frequently with *Scapania irrigua*, *Moerckia blyttii*, *Gymnocolea inflata*, *Odontoschisma elongatum*, *Calypogeia sphagnicola* and *Nardia japonica*.

Cephalozia leucantha Spruce. With perianthia, sporogonia – 2 – On hummock slopes in mires, with *Mylia anomala*, *Cephaloziella spinigera*, *Odontoschisma elongatum*, *Riccardia latifrons*, *Gymnocolea inflata* and *Calypogeia sphagnicola*. Found once in a wet crevice near a waterfall, with *Diplophyllum taxifolium* and *Marsupella emarginata*.

Cephalozia lunulifolia (Dumort.) Dumort. – 2 – On the peaty bank of a pond formed by cryogenic processes near Gladkovskaya Bay, with *Cladopodiella fluitans*, *Cephalozia bicuspidata* and *Nardia compressa*.

Cephalozia pleniceps (Austin) Lindb. – 1 – On hummock slopes in sedge-moss mires in the Gavanskaya River valley, with *Cephalozia bicuspidata*, *Lophozia excisa*, *Harpanthus flotovianus* and *Cephaloziella divaricata*.

Cephaloziella divaricata (Sm.) Schiffn. With antheridia, archegonia, perianthia, gemmae – 1, 2, 3 – On hummocks of different types in raised peat moss-dominated mires with hypnaceous mosses, sedges and shrubs; with *Barbilophozia hatcheri*, *Harpanthus flotovianus*, *Scapania hyperborea*, *Cephalozia pleniceps*, *Chiloscyphus polyanthos* and *Pellia neesiana*.

**Cephaloziella elachista* (Jack ex Gott. & Rabenh.) Schiffn. – 5 – Peat moss-sedge-shrub tundra, in *Sphagnum* tufts on the banks of ponds near Tolstyj Nos Bay; with *Cephalozia bicuspidata* and *Lophozia ventricosa*.

Cephaloziella spinigera (Lindb.) Warnst. – 2 – In wet, shady crevices on cliffs near waterfalls at the mouth of the Vodopadnaya River, with *Scapania undulata*, *Marsupella emarginata*, *Diplophyllum taxifolium* and *Cephalozia leucantha*.

Chiloscyphus fragilis (A. Roth) Schiffn. [*C. pallescens*] – 2, 5 – On stream banks in rhododendron-sedge and moss tundra; in shady crevices near streams; with *Jungermannia* spp., *Pellia neesiana* and *Conocephalum conicum*.

Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort. – 5 – On humic banks of rivulets in shrub-moss tundra near Tolstyj Nos Bay, with *Scapania paludicola*, *Pellia neesiana* and *Conocephalum conicum*.

Chiloscyphus polyanthos (L.) Corda With perianthia – 2, 5, 7 – On wet banks along streambeds, subvertical slopes in river valleys , on hummock slopes in sedge-moss mires; with *Conocephalum conicum*, *Lophozia ventricosa* s.l., as well as *Pellia neesiana*, *Hygrobiella laxifolia*, *Plectocolea subelliptica* and *Cephaloziella divaricata*.

Chiloscyphus rivularis (Schrad.) Hazsl. [*C. polyanthos*] – 5 – On humic banks of rivulets in shrub-

moss tundra near Tolstyj Nos Bay, with *Scapania undulata*.

A taxonomic note regarding *Chiloscyphus*: Separating *Chiloscyphus* into four discrete species, as has been done above, is a somewhat ambiguous distinction, due to the occurrence of transitional forms both in the study area and in Northern Asia as a whole. These species may be identified using the key provided below (based mainly on Schljakov, 1981). Maintaining a split in species for *Chiloscyphus* increases the risk of misidentification. Nevertheless, splitting the species may aid in further studies, as it will be far easier to lump these entities together in the future, instead of having to separate the ambiguous citation "*C. polyanthos*" into four species.

1. Cells in the mid-leaf 33–45(55) µmin width, rare in small plants 28–30 µm; chloroplasts in leaf cells 1–2.5(3) µm in diameter, oil bodies usually 4–10 per cell … ..... *C. pallescens*
–. Cells in the mid-leaf 20–33 µm in width, chloroplasts in leaf cells 3–4 µm in diameter; oil bodies usually 2–6 per cell 2
2. Leaves broadly lingulate to lingulate-subelliptical, convex, with abaxial margin incurved to ventral side; cells in the mid-leaf 25–35 × (19)21–25(27) µm; habitat in rapidly flowing rivulets .... *C. rivularis*
–. Leaves slantwise-lingulate, orbicular to quadrate-orbicular, almost flat to concave, with flat to undulate margins; cells in the mid-leaf more than 24–25 µm in width; habitat in slow flowing rivulets, stagnant lakes, ponds and moist habitats … 3
3. Leaves flat with undulate margins, longer than wide: length 1.0–1.3 the width; base of ventral margin makes an angle with the stem of about 40–60(80)º; plants frequently with perianths .... *C. polyanthos*
–. Leaves slightly concave, wider than long: length 0.8–1.0 the width; base of ventral margin makes an angle with the stem of about 0–30º; plants almost always sterile … ..... *C. fragilis*

Cladopodiella fluitans (Nees) Buch With perianthia, antheridia – 2, 3, 6 – On hummocks or in the hollows between them in moss-shrub or moss-sedge mires, with *Gymnocolea inflata*, *Cephalozia bicuspidata*, *Marsupella boeckii*, *Riccardia latifrons*, *Odontoschisma elongatum* and *Anthelia juratzkana*. It should be noted that this species is more or less common on Bering Island, although extremely rare or absent in other sectors of northern Asia.

Cladopodiella francisci (Hook.) Jorg. With gemmae – 1, 2 – On fine-grained soil along paths and peaty banks of ponds, with *Cephalozia bicuspidata*, *Pleurocladula albescens*, *Diplophyllum taxifolium*, *Kurzia makinoana* and *Gymnocolea inflata*.

Conocephalum conicum (L.) Dumort. – 5, 7 – On humic and rocky banks of brooks in different kinds of tundra, with *Pellia neesiana*, *Chiloscyphus fragilis* and *C. pallescens*.

Conocephalum japonicum (Thunb.) Grolle – 2, 7 – In crevices on cliffs filled by fine-grained soil on vertical coastal slopes; once found in a crevice near a small waterfall; in pure mats, in wet conditions with *Chiloscyphus polyanthos*.

Diplophyllum albicans (L.) Dumort. With antheridia – 2, 4, 7 – In dry crevices between boulders in barren alpine gravelly substrates with patches of dwarf shrubs, on wet soil in moss-shrub tundra, on hummocks in raised mires, on moist boulders in crevices near small waterfalls; in dry conditions with *Macrodiplophyllum imbricatum*, *Anthelia juratzkana*, *Diplophyllum taxifolium* and *Marsupella brevissima*; in wetter conditions it has also been associated with *Lophozia sudetica*, *L. savicziae*, *L. ventricosa*, *Calypogeia muelleriana*, *Gymnomitrion concinnatum*, *Marsupella boeckii*, *Cephalozia bicuspidate* and *Gymnocolea inflata*.

Diplophyllum taxifolium (Wahlenb.) Dumort. With perianthia, antheridia, gemmae – 2, 4, 5, 7 – On cliffs and in crevices on cliffs with differing moisture regimes, boulders along the streams, fine-grained soil, shrubs and moss tundra, moss-shrub mires. In dry conditions with *Lophozia sudetica*, *Diplophyllum albicans*, *Nardia scalaris*, *N. japonica*, *Macrodiplophyllum imbricatum*, *Blepharostoma trichophyllum* and *Gymnomitrion corallioides*; in wetter places with *Cephalozia bicuspidata*, *C. leucantha*, *Lophozia savicziae*, *L. silvicola*, *L. ventricosa*, *L. sudetica*, *Calypogeia muelleriana*, *C. integristipula*, *Kurzia makinoana*, *Cephaloziella spinigera*, *Marsupella emarginata*, *Riccardia latifrons* and *Odontoschisma elongatum*.

**Eremonotus myriocarpus* (Carrington) Pearson. With perianthia – 7 – On wet boulders in crevices near a minimally terraced waterfall in the upper reaches of the Peredovaya River, with *Marsupella emarginata* and *Cephalozia bicuspidata*.

Gymnocolea inflata (Huds.) Dumort. With perianthia – 2, 3, 5 – In the hollows of peat-hypnaceous-mosses-sedge mires and moss-shrub-sedge tundra, on fine-grained soils in areas formed by cryogenic processes. Most frequently with *Cephalozia bicuspidata*, *Calypogeia sphagnicola*, *Orthocaulis kunzeanus*, *Marsupella boeckei* and *Scapania undulata*, rarer with *Diplophyllum taxifolium*, *Nardia breidleri* and *Cladopodiella fluitans*.

Gymnomitrion apiculatum (Schiffn.) Müll. Frib. – 4 – Alpine gravely barrens with patches of dwarf shrubs, in the crevices between boulders in the Peresheikovskaya River – Dikaya Bay pass; with

Anthelia juratzkana, *Lophozia savicziae*, *Diplophyllum albicans*, *Marsupella brevissima*, *Tritomaria quinquedentata* and *Gymnomitrion concinnatum*.

Gymnomitrion concinnatum (Lightf.) Corda. With perianthia, sporogonia – 4, 7 – On rocks covered by fine-grained soil along streams, in wet crevices on cliffs and on fine-grained soil in alpine barren gravelly soil with patches of dwarf shrubs, with *Anthelia juratzkana*, *Diplophyllum taxifolium*, *D. albicans*, *Lophozia sudetica*, *L. savicziae*, *Marsupella brevissima*, *M. boeckii* and *Tritomaria quinquedentata*.

Gymnomitrion corallioides Nees – 4, 7 – On fine-grained soil near hummocks in crowberry-lichen tundra and on fine-grained soil in dry alpine gravelly barrens with patches of dwarf shrubs; with *Diplophyllum taxifolium*.

**Gymnomitrion pacificum* Grolle – 4 – In the crevices between boulders in dry alpine gravelly barrens with patches of dwarf shrubs in the Peresheikovskaya River – Dikaya Bay Pass; with *Anthelia juratzkana*, *Marsupella brevissima*, *Diplophyllum albicans* and *Gymnomitrion concinnatum*.

Harpanthus flotovianus (Nees) Nees – 1, 2, 7 – On peaty banks of lakes and sluggish rivulets, on hummocks in moss-sedge mires, in wet crevices on cliffs near waterfalls, with species of *Cephalozia*, *Scapania*, as well as *Pleurocladula albescens*, *Blepharostoma trichophyllum*, *Cephaloziella divaricata*, *Mylia anomala* and *Odontoschisma elongatum*.

Hygrobiella laxifolia (Hook.) Spruce. With perianthia, sporogonia, antheridia – 5, 7 – In crevices on wet cliffs near waterfalls, on boulders covered by fine-grained soil along streams, on rocks in canyons near glaciers; with *Plectocolea subelliptica*, *Scapania paludosa*, *S. subalpina*, *Chiloscyphus polyanthos*, *Jungermannia eucordifolia* and *J. exsertifolia*.

Jungermannia atrovirens Dumort. With perianthia, antheridia – 7 – In crevices on wet cliffs near small waterfalls; in pure mats.

Jungermannia borealis Damsh. & Vana. With perianthia, antheridia – 2, 6, 7 – On fine-grained soil in wet cliff crevices along streams, on wet rocks near waterfalls and in wet crevices on coastal cliffs; with *Radula complanata*, *Plectocolea subelliptica*, *Scapania undulata*, *Chiloscyphus polyanthos* and *Plagiochila porelloides*.

Jungermannia eucordifolia Schljakov [*Jungermannia exertifolia* ssp. *cordifolia* (Dumort.) Vana]. With antheridia – 5, 7 – On humic banks of rivulets, wet boulders in shady canyons and along streams and high mires; in pure mats or with *Chiloscyphus fragilis* and *Hygrobiella laxifolia*.

Jungermannia exsertifolia Steph. With antheridia – 5, 7 – On wet boulders in cliff crevices near small waterfalls and on humic stream banks; with *Hygrobiella laxifolia*, *Plectocolea subelliptica*, *Scapania mucronata*, *Pellia neesiana* and *Chiloscyphus fragilis*. Maintaining this taxon as a species separate from *J. eucordifolia* is somewhat open to discussion. Amakawa (1960: 46) distinguishes *J. exertifolia* from *J. eucordifolia* (*J. exsertifolia* subsp. *cordifolia* in l.c.) by "(1) its smaller size, (2) olive-brown colour, (3) imbricate leaves whose dorsal margin is not so strongly incurved and covering stem, and (4) not occurring on acidic substrata". Additionally, undulate leaves are characteristic for *J. eucordifolia*, but never occur in *J. exsertifolia*. The typical forms of both species are easily distinguished even in field, but some forms from the northern reaches of the Russian Far East have an intermediate morphology and the utility of continuing with two taxa needs further study. I follow R.N. Schljakov's (1980) treatment in my account.

Jungermannia pumila With. With perianthia, antheridia, sporogonia – 2, 7 – On wet rocks in canyons with waterfalls and glaciers; in pure mats, more rarely with *Plectocolea subelliptica*.

Kurzia makinoana (Steph.) Grolle. With perianthia – 2 – Peaty banks of ponds formed by cryogenic processes, in peat moss-shrub mires near Gladkovskaya Bay; with *Cephalozia bicuspidata*, *Cladopodiella francisci*, *Diplophyllum taxifolium*, *Pleurocladula albescens*, *Gymnocolea inflata* and *Odontoschisma elongatum*.

Leiocolea heterocolpos (Thed. ex C. Hartman) H. Buch [*Lophozia heterocolpos* (Thed. ex C. Hartman) M. Howe]

– var. *heterocolpos*. With gemmae – 1, 2, 7 – In wet cliff crevices on subvertical slopes, on mossy outgrowths that hang over water (*Bartramia*, etc.), on wet boulders in shady canyons; with *Blepharostoma trichophyllum* and *Plagiochila porelloides*, once with *Aneura pinguis*.

– var. *harpanthoides* (Bryhn et Kaal.) S. W. Arnell. With archegonia – 7 – On wet boulders in canyons with waterfalls, near Tolstyj Nos Bay.

Lophocolea heterophylla (Schrad.) Dumort. With perianthia, antheridia, sporogonia – 6 – On decaying driftwood logs in Golodnaya Bay; with *Lophozia ventricosa* var. *longiflora*, *Cephalozia bicuspidata* and *Scapania irrigua*.

Lophocolea minor Nees. With gemmae – 2, 6 – On mosses on dry coastal vertical cliff slopes and on decaying driftwood logs; with *Plagiochila porelloides*, *Scapania curta* and *Cephalozia bicuspidata*.

Lophozia excisa (Dicks.) Dumort. With antheridia,

Fig. 2. Boggy plain near Nikol'skoye settlement with the Svinyje Knolls and Stolovyje Mts.

archegonia, perianthia, gemmae – 1, 5, 6 – On hummock slopes in sedge-moss mires, in areas of fine-grained soil formed by cryogenic processes in dry heath-rhododendron tundra, on decaying driftwood logs; with *Scapania paludicola*, *S. irrigua*, *Lophozia silvicoloides*, *Cephalozia pleniceps* and *C. bicuspidata*.

Lophozia lacerata N. Kitag. With gemmae, perianthia, sporogonia – 5 – On patches of fine-grained soil in dwarf-shrub tundra among patches of *Empetrum nigrum* and *Rhododendron camtschaticum*, with *Barbilophozia hatcheri*.

Lophozia savicziae Schljakov. With perianthia, antheridia, sporogonia, gemmae – 4, 5, 7 – On spots of fine-grained soil in dwarf-shrub tundra, in crevices between boulders in alpine gravely barrens with patches of dwarf shrubs, in peaty soil in shrub tundra, on rocks covered by fine-grained soil along rivulets; with *Anthelia juratzkana*, *Macrodiplophyllum imbricatum*, *Diplophyllum albicans*, *Gymnomitrion concinnatum*, *G. apiculatum* and *Tritomaria quinquedentata*. *L. savicziae* is a poorly known species outside of Russia due to a misunderstanding of it by foreign bryologists. As I have shown (Bakalin 2000), *L. savicziae* is synonymous with *L. silvicola* var. *grandiretis* H. Buch et S.W. Arnell and consequently with *L. ventricosa* var. *grandiretis* (H. Buch et S.W. Arnell) R.M. Schust et Damsh. In that publication (l.c.) I tried to define the characteristics of– *L. savicziae*, in English, because all previous information about this species was only published in Russian. The species is known from northern Sweden and Norway, western Greenland and northern Russia (Bakalin 2000).

Lophozia schusteriana Schljakov. With gemmae – 7 – On wet rocks covered by fine-grained soil in the upper part of the Peredovaya River; with *Calypogeia muelleriana* and *Plectocolea subelliptica*.

Lophozia silvicola H. Buch. With gemmae – 2, 4, 5 – On hummock in raised mires, on patches of fine-grained soil in moss-shrub tundra and alpine gravelly barrens with clumps of dwarf shrubs; with *Anthelia juratzkana*, *Barbilophozia hatcheri*, *Pleurocladula albescens* and *Nardia* spp. Along with common variants, mod. *pachyderma* and mod. *pachyderma-colorata* were frequently found.

Lophozia silvicoloides N. Kitag. With antheridia, gemmae – 5 – On patches of fine-grained soil among clumps of *Empetrum nigrum* and *Rhodo-*

dendron camtschaticum in dwarf-shrub tundra near Tolstyj Nos Bay; with *Lophozia excisa*.

Lophozia sudetica (Nees ex Huebener) Grolle. With perianthia, sporogonia, gemmae – 2, 6, 7 – On fine-grained soil and among bryophytes in different types of tundra and in alpine gravelly barrens with clumps of dwarf shrubs, in moss hummocks along the brooks, in wet crevices on cliffs and on moss hummocks in mires; in pure mats or with *Anthelia juratzkana*, *Gymnomitrion concinnatum*, *Marsupella emarginata*, *M. boeckei*, *Cephalozia bicuspidata*, *Diplophyllum taxifolium*, etc.

Lophozia ventricosa (Dicks.) Dumort. sensu Grolle and Long 2000, but excluding *L. silvicola.* With gemmae, antheridia

– var. *ventricosa* – 1, 2, 5, 6, 7 – On hummocks in raised mires of different types, on wet boulders along the brooks, among mosses in moss-dwarf shrub tundra, on wet soil near glaciers and on wet spots of fine-grained soil in alpine gravelly barrens with patches of dwarf shrubs and along paths; with *Mylia anomala*, *Odontoschisma elongatum*, *Riccardia latifrons*, *Harpanthus flotovianus*, *Pleurocladula albescens*, *Cephaloziella elachista*, *Scapania hyperborea*, *Cephalozia bicuspidata*, *Orthocaulis kunzeanus*, etc.

*– var. *guttulata* (Lindb. et Arnell) Bakalin – 2 – On the peaty banks of a pond formed by cryogenic processes near Gladkovskaya Bay, with *Cephalozia bicuspidata*, *C. leucantha*, *Diplophyllum taxifolium*, *Odontoschisma elongatum* and *Moerckia blyttii*. It is commonly considered, that ecotype of this taxon is limited by decaying wood. However, the observations showed that sometimes it grows in tundra and raised mires of the different types. The striking features of var. *guttulata* taxon are (1) somewhat narrow leaves, with length about 1.1-1.3(1.4) the width, versus 0.9-1.1 in var. *longiflora* and (2) bulging trigones in the leaf-cells (even almost confluent at leaf margin), (3) ciliate (up 4 cells in length) to sometimes shortly lacinulate perianth mouth. In addition var. *guttulata* sometimes has faintly papillose leaf-cuticle – the feature not found in any other taxa of *Lophozia* s. str. Neither habitat, nor oil-bodies structure and quantity are features separating var. *guttulata* from var. *longiflora*.

– var. *longiflora* (Nees) Macoun – 1, 2, 6, 7 – On wet rocks covered by fine-grained soil and on hummocks in peat-moss-sedge mires, with *Macrodiplophyllum imbricatum*, *Schistochilopsis incisa*, *Pleurocladula albescens*, *Diplophyllum taxifolium*, *Cephalozia bicuspidata*, *Moerckia blyttii*, *Calypogeia muelleriana*, *Blepharostoma trichophyllum*, etc.

Lophozia wenzelii (Nees) Steph. With antheridia, gemmae – 7 – On wet rocks covered by fine-grained soil along the brook in upper part of Peredovaya River valley, with *Calypogeia muelleriana*.

**Macrodiplophyllum imbricatum* (M. Howe) Perss. – 2, 5, 6, 7 – On soil in xero- and xero-mesophytic tundra communities; frequently with *Diplophyllum albicans*, *D. taxifolium*, *Sphenolobus minutus* and *Dicranum* spp., *Dicranella* sp., *Pohlia nutans* (Hedw.) Lindb., *Aulacomnium* sp., etc., and with lichens: species of *Cladonia* and *Nephroma*. Additionally, the species can grow on hummocks in high mires on decaying peat moss; with *Moerckia blyttii*, *Cephalozia bicuspidata*, *Lophozia savicziae*, *Lophozia sudetica*, *Calypogeia muelleriana*, *Schistochilopsis opacifolia* and *Pleurocladula albescens*. This discovery was also treated in Bakalin (2004).

Macrodiplophyllum plicatum (Lindb.) H. Perss. – 2 – On open spaces between hummocks in grass-shrub-peat-moss mire near Gladkovskaya Bay, with *Cephalozia bicuspidata*, *Ptilidium ciliare* and *Lophozia ventricosa* var. *ventricosa*.

**Mannia triandra* (Scop.) Grolle. With sporogonia – 5 – On wet boulders in canyons with waterfalls near Tolstyj Nos Bay.

Marchantia alpestris (Nees) Burgeff. With gemmae – 5, 7 – On subvertical wet cliffs along the sea coast and on humic banks of streams.

Marsupella boeckii (Aust.) Lindb. ex Kaal. With perianthia, antheridia – 2, 6, 7 – On patches of bare peat in raised mires and tundra of different types, on rocky banks of streams and in wet cliff canyons, in pure mats or mixed with *Anthelia juratzkana*, *Cladopodiella fluitans*, *Diplophyllum taxifolium*, *Gymnocolea inflata*, *Nardia* spp., *Scapania* spp., *Lophozia* spp., etc.

Marsupella brevissima (Dumort.) Grolle – 4, 6 – In crevices between boulders in dry alpine gravelly barrens with patches of dwarf shrubs or on wet soil near glaciers. In dry conditions with *Anthelia juratzkana*, *Diplophyllum albicans*, *Gymnomitrion concinnatum*, *G. apiculatum*, *G. pacificum*, *Tritomaria quinquedentata*, etc.; in the moist places it was associated with *Anthelia juratzkana*, *Pleurocladula albescens* and *Nardia breidleri*.

Marsupella emarginata (Ehrh.) Dumort. With perianthia, sporogonia – 2, 7 – On wet boulders in cliff-crevices on cliffs near small waterfalls, on wet rocks near glaciers, with *Cephalozia bicuspidata*, *C. leucantha*, *Eremonotus myriocarpus*, *Lophozia sudetica*, *Anthelia juratzkana*, *Blepharostoma trichophyllum*, *Plectocolea obovata*, etc.

**Moerckia blyttii* (Moerch) Brockm. With antheridia, archegonia – 2, 7 – On bare peaty banks of ponds formed by cryogenic processes in peat moss-shrub mires and on peaty soil in grass-moss tun-

dra, with *Macrodiplophyllum imbricatum*, *Marsupella boeckii*, *Cephalozia ambigua*, *Cladopodiella francisci*, *Schistochilopsis incisa* and *Pleurocladula albescens*.

Mylia anomala (Hook.) Gray. With gemmae – 2 – On hummocks and banks of hollows in grass-shrub-peat moss mires; with *Cephalozia bicuspidata*, *C. leucantha*, *Harpanthus flotovianus*, *Odontoschisma elongatum*, *Orthocaulis kunzeanus*, *Lophozia ventricosa var. ventricosa*, *Orthocaulis kunzeanus*, *Gymnocolea inflata*, *Calypogeia sphagnicola* and *Riccardia latifrons*.

Nardia breidleri (Limpr.) Lindb. – 2, 6 – On wet soil near glaciers, on peat in grass-shrub-peat moss mires; with *Anthelia juratzkana*, *Marsupella brevissima*, *Pleurocladula albescens*, *Nardia compressa*, *Cephalozia bicuspidata*, *Scapania paludicola* and *S. undulata*.

Nardia compressa (Hook.) Gray – 2 – On open spaces between hummocks and on peat in grass-shrub-peat moss mires near Gladkovskaya Bay; with *Marsupella boeckii*, *Gymnocolea inflata*, *Cladopodiella fluitans*, *Scapania paludicola*, *S. undulata*, *Cephalozia bicuspidata* and *C. lunulifolia*.

Nardia geoscyphus (De Not.) Lindb. – 7 – On wet tussocks along lake banks in shrub-moss tundra in the upper part of the Peredovaya River; with *Plectocolea subelliptica* and *Cephalozia bicuspidata*.

Nardia japonica Steph. – 4, 6, 7 – On fine-grained soil in hollows in alpine gravelly barrens with patches of dwarf shrubs, among mosses on wet boulders along streams and on soil in moss-shrub tundra; with *Anthelia juratzkana*, *Pleurocladula albescens*, *Lophozia silvicola*, *L. savicziae*, *L. sudetica*, *Nardia scalaris* and *Marsupella boeckii*.

Nardia scalaris Gray – 1, 4, 5, 6, 7 – On fine-grained soil between tussocks in alpine low-grass meadows, in hollows in alpine gravelly barrens with patches of dwarf shrubs, on soil in moss-shrub tundra and along peaty lake banks; with *Nardia japonica*, *Pleurocladula albescens*, *Diplophyllum taxifolium*, *Cephalozia bicuspidata*, *Moerckia blyttii* and *Lophozia silvicola*.

Obtusifolium obtusum (Lindb.) S. W. Arnell [*Lophozia obtusa* (Lindb.) A. Evans] – 7 – On rocks in canyons with waterfalls or glaciers; with *Plectocolea subelliptica* and *Peltolepis quadrata*.

**Odontoschisma elongatum* (Lindb.) Evans – 2, 3 – On hollows in peat-hypnaceous-mosses, -sedge and grass-dwarf-shrub-moss mires; with *Kurzia sylvatica*, *Cephalozia bicuspidata*, *Cladopodiella fluitans*, *C. francisci*, *Mylia anomala*, *Pleurocladula albescens* and *Gymnocolea inflata*.

Orthocaulis binsteadii (Kaal.) H. Buch [*Barbilophozia binsteadii* (Kaal.) Loeske]. With perianthia, gemmae – 2 – In openings between hummocks in grass-dwarf shrub-peat moss mires near Gladkovskaya Bay; with *Lophozia ventricosa*.

**Orthocaulis floerkei* (F. Weber et D. Mohr) H. Buch [*Barbilophozia floerkei* (F. Weber et D. Mohr) Loeske] – 5 – Among peat mosses in peat moss-sedge-dwarf shrub tundra near Tolstyj Nos Bay; in pure mats.

Orthocaulis kunzeanus (Huebener) H. Buch [*Barbilophozia kunzeana* (Huebener) Müll. Frib. – 1, 2 – Peaty banks of small lakes and ponds, between hummocks in grass-shrub-peat moss mires, on fine-grained soil in paths; with *Harpanthus flotovianus*, *Lophozia ventricosa*, *Mylia anomala*, *Calypogeia sphagnicola*, *Gymnocolea inflata*, *Cephalozia leucantha*, *C. bicuspidata*, *Scapania hyperborea* and *S. kaurinii*.

Pellia neesiana (Gottsche) Limpr. With antheridia, archegonia – 1, 5, 6, 7 – On humic and rocky banks of brooks and on slopes of hummocks in moss-sedge mires, with *Chiloscyphus polyanthos*, *C. fragilis*, *Cephalozia bicuspidata*, *Lophozia ventricosa*, *Calypogeia muelleriana*, *Conocephalum conicum* and *Jungermannia exsertifolia*.

Peltolepis quadrata (Saut.) Müll. Frib. With archegonia, sporogonia – 7 – On rocks in canyons with glaciers in the upper part of the Peredovaya River valley; with *Obtusifolium obtusum*.

Plagiochila porelloides (Torrey ex Nees) Lindenb. – 1, 2, 5, 6, 7 – In -crevices on cliffs of vertical slopes of differing moisture regimes, more rare on humic and rocky banks of streams; with *Radula complanata*, *Tritomaria quinquedentata*, *Barbilophozia hatcheri* and *Leiocolea heterocolpos*, etc. Along with the typical expression of the species, some populations were found with distinct underleaves ranging from 7 to 10 cells in length (mod. *amphigastriata*) and some with clearly bilobate leaves (mod. *bilobata*).

Plectocolea obovata (Nees) Lindb. [*Jungermannia obovata* Nees] – 5 – On peaty banks of a small lake in *Rhododendron aureum* - sedge tundra, near Tolstyj Nos Bay; with *Scapania undulata*.

Plectocolea subelliptica (Lindb. ex Kaal.) Evans [*Jungermannia subelliptica* (Lindb. ex Kaal.) Levier]. With perianthia, antheridia – 2, 5, 7 – Along rocky banks of rivulets and on wet rocks; with *Schistochilopsis opacifolia*, *Pleurocladula albescens*, *Diplophyllum taxifolium*, *Lophozia sudetica*, *Blepharostoma trichophyllum*, *Anthelia juratzkana*, *Jungermannia borealis* and *Hygrobiella laxifolia*.

Pleurocladula albescens (Hook.) Grolle. – 2, 4, 6, 7 – On patches of fine-grained soil of differing moisture regimes, on peaty, rocky and fine-grained soil along rivers and streams, in different types of tun-

Fig. 3. Dikaya Bay and the Dikaya River valley (the photograph is taken from about 400 m a.s.l.).

dra, on hummocks in raised mires, on rocks, with the majority of species, but more frequently with *Anthelia juratzkana*, *Diplophyllum taxifolium*, *Cephalozia bicuspidata*, *Nardia japonica* and *N. scalaris*.

*– var. *islandica* (Nees) Grolle – 6 – On wet soil near glaciers at Lisinskoye Lake, with *Anthelia juratzkana*, *Nardia breidleri* and *Marsupella brevissima*.

Preissia quadrata (Scop.) Nees – 7 – On wet boulders in crevices on cliffs near small waterfall and streams; with *Schistochilopsis opacifolia*.

Ptilidium californicum (Austin) J. Pearson – 2 – In place between hummocks in a grass-dwarf shrub-peat moss mire near Gladkovskaya Bay; with *Cephaloziella divaricata* and *Barbilophozia hatcheri*.

Ptilidium ciliare (L.) Hampe – 2, 5 – Between hummocks in grass-dwarf shrub-peat moss mires and on humic banks of rivulets; with *Barbilophozia hatcheri*, *Macrodiplophyllum plicatum*, *Cephalozia bicuspidata*, *Lophozia ventricosa* and *Orthocaulis kunzeanus*.

Radula complanata (L.) Dumort. With perianthia, antheridia, sporogonia – 2, 7 – In crevices on coastal cliffs ; with *Plagiochila porelloides*, *Tritomaria quinquedentata* and *Jungermannia borealis*.

Riccardia latifrons (Lindb.) Lindb. – 2 – On bare peat and on places between hummocks in grass-dwarf shrub-peat moss mires near Gladkovskaya Bay; with *Cephalozia leucantha*, *Odontoschisma elongatum*, *Diplophyllum taxifolium*, *Cladopodiella francisci*, *Gymnocolea inflata*, *Mylia anomala* and *Calypogeia sphagnicola*.

Scapania curta (Mart.) Dumort. With gemmae – 6, 7 – On wet boulders in canyons and on decaying driftwoods logs in Golodnaya Bay; with *Anthelia juratzkana*, *Lophocolea minor* and *Cephalozia bicuspidata*.

Scapania hyperborea Jorg. – 1, 5 – On slopes of hummocks in sedge-moss mires, on the sides of paths in sedge mires, on banks of ponds in peat moss-sedge-shrub tundra; with *Harpanthus flotovianus*, *Gymnocolea inflata*, *Cephaloziella divaricata* and *Orthocaulis kunzeanus*, etc. A mod. *leptoderma* was also found along with the typical form of the species and its bulging trigones in leaf cells.

Scapania irrigua (Nees) Nees – 1, 6, 7 – On decaying driftwood logs in Golodnaya Bay, on banks of small lakes in different types of tundra; with *Chiloscyphus polyanthos*, *Lophozia excisa*, *Harpanthus flotovianus*, *Blepharostoma trichophyllum*, *Pleurocladula albescens* and *Nardia scalaris*.

**Scapania kaurinii* Ryan – 5 – Among peat mosses

on the banks of ponds in peat moss-sedge-shrub tundra near Tolstyj Nos Bay; with *Gymnocolea inflata*, *Cephalozia bicuspidata* and *Orthocaulis kunzeanus*.

**Scapania mucronata* H. Buch – 5 – On wet boulders in crevices on cliffs near a small terraced waterfall near Tolstyj Nos Bay; with *Jungermannia exsertifolia*, *Hygrobiella laxifolia* and *Plectocolea subelliptica*.

**Scapania obscura* (Arnell et C. E. O. Jensen) Schiffn. – 5 – Peaty banks of lakes near Tolstyj Nos Bay, in *Rhododendron aureum* – sedge tundra; in pure mats.

Scapania paludicola Loeske et Müll. Frib. – 1, 2, 5, 7 – In sedge-moss mires, on humic and rocky banks of rivulets, with *Lophozia excisa*, *Nardia japonica*, *N. compressa*, *N. breidleri*, *Chiloscyphus pallescens*, *Cephaloziella divaricata*, *Pellia neesiana*, *Marsupella boeckii*, etc.

Scapania paludosa (Müll. Frib.) Müll. Frib. With antheridia – 2, 3, 5, 6, 7 – One of the most common species of the genus. In shady crevices on cliffs, on the banks of ponds, lakes and rivulets, on hollows of springy mires; in pure mats or with *Harpanthus flotovianus*, *Marsupella emarginata*, *Chiloscyphus polyanthos*, *Plectocolea subelliptica*, *Hygrobiella laxifolia*, etc.

Scapania parvifolia Warnst. [*S. scandica* (Arnell et H. Buch) Macvicar, pro parte] – 6 – On wet boulders along the stream in Lisinskaya Bay – Peregrebnaya Bay pass; in pure mats.

Scapania subalpina (Nees ex Lindenb.) Dumort. With perianthia – 5 – On wet slopes near rivulets and on peaty banks of lakes. In pure mats, less often with *Hygrobiella laxifolia* and *Plectocolea subelliptica*.

Scapania undulata (L.) Dumort. With gemmae – 2, 3, 5, 7 – On hollows in raised mires of different types, in shady crevices on cliffs, on banks of rivulets, rivers and lakes, in pure mats or associated with *Chiloscyphus rivularis*, *Jungermannia borealis*, *Plectocolea subelliptica*, *Gymnocolea inflata*, *Marsupella boeckii*, *Nardia compressa*, etc.

Schistochilopsis incisa (Schrad.) Konstantinova [*Lophozia incisa* (Schrad.) Dumort.]. With gemmae, perianthia, antheridia – 7 – On wet boulders in shady crevices on cliffs near small waterfalls; with *Macrodiplophyllum imbricatum*, *Diplophyllum taxifolium*, *Lophozia sudetica*, *L. ventricosa*, *Pleurocladula albescens* and *Moerckia blyttii*.

Schistochilopsis opacifolia (Culm. ex Meyl.) Konstantinova [*Lophozia opacifolia* Culm. ex Meyl.]. With archegonia, gemmae – 6, 7 – On wet soil near glaciers and on wet boulders in crevices on cliffs near rivulets and rivers; with *Preissia quadrata*, *Plectocolea subelliptica*, *Pleurocladula albescens*, *Diplophyllum taxifolium* and *Lophozia sudetica*.

**Solenostoma gracillimum* (Sm.) R.M. Schust. [*Jungermannia gracillima* Sm.]. With archegonia – 6 – On bare soil in hollows among *Juncus* sp. in rush-moss-sedge mires near Lisinskaya Bay; in pure mats.

Solenostoma sphaerocarpum (Hook.) Steph. [*Jungermannia sphaerocarpa* Hook.] – 2, 5 – On peaty banks of lakes, on fine-grained soil in wet crevices and along streams; in pure mats or with *Anthelia juratzkana* and *Cephalozia bicuspidata*.

Sphenolobus minutus (Schreb.) Berggr. [*Anastrophyllum minutum* (Schreb.) R. M. Schust.]. With antheridia, perianthia – 1, 2, 6 – On fine-grained soil in crevices on cliffs of differing moisture regimes, on bare soil in tundra, between boulders in alpine gravelly barrens with patches of dwarf shrubs; in pure mats or with *Barbilophozia hatcheri*, *Plectocolea subelliptica*, *Lophozia silvicola* and *Macrodiplophyllum imbricatum*.

Tritomaria quinquedentata (Huds.) H. Buch – 4, 7 – On the hollows in alpine gravelly barrens with patches of dwarf shrubs and in crevices on cliffs along rivulets; with *Lophozia savicziae*, *Marsupella brevissima*, *Anthelia juratzkana*, *Gymnomitrion concinnatum*, *Gymnomitrion apiculatum*, *Diplophyllum albicans* in dry conditions and with *Plectocolea subelliptica*, *Harpanthus flotovianus* and *Blepharostoma trichophyllum* in moist habitats.

*) new taxa for the Kamchatka Region

Comments on the species list

Identification of the collections revealed 102 species. Considering the small size of the island and that all types of habitats were studied, I assume that the number of known species will not increase more than 10% as a result of future investigations. *Macrodiplophyllum imbricatum* is a new record for Russia and the Eastern Hemisphere as a whole. *Solenostoma gracillimum* has been recorded for the second time for Asia (previously found in Taiwan: Piippo 1990).

Two species were found for the first time in the Russian Far East; these are *Cephaloziella elachista*, with its locality the most eastern in Eastern Hemisphere, and *Moerckia blyttii*. Five species were collected for the second time in the Russian Far East. *Cladopodiella francisci* has only been recorded from the Kamchatka Peninsula in an earlier report (Konstantinova et al. 1992). *Gymnomitrion pacificum* has only been recorded from the Chukotka Peninsula in

Table 1. Grouping of 102 species of hepatics from the Bering Island, by their floristic element and geographic distribution. The treatment of each floristic element and geographic distribution follows Konstantinova (2000).

Geographic distribution	Floristic element							
	Arctic	Arcto-montane	Montane	Arctoboreo-montane	Boreal	Temperate	Cosmo-politan	Total
circumpolar	1	16	4	28	13		3	65
subcircumpolar		5	4	1				10
amphioceanic		1	7	2	1	1		12
Pacific			5					5
Eurasian-West American		1						1
Disjunctive		4	2					6
Unclear area	2	1						3
Total:	3	27	22	32	14	1	3	102

an earlier report. In addition to its occurrence in Russia, this rare species has been found in Japan and the northern part of North America (Kitagawa 1963, Schuster 1974). *Kurzia makinoana* has earlier been recorded from the Kamchatka Peninsula (Konstantinova et. al. 1992). Although this represents its second discovery in Russia, the species appears to be more or less common in coastal peat moss mires in the Pacific regions of eastern and northern Asia. *Scapania kaurinii* has previously been found in the Chukotka Peninsula (Afonina and Duda 1993). *Nardia breidleri* has previously been recorded from the Kamchatka Peninsula (Czernyadjeva and Potemkin 2003); this taxon does not seem to be rare in the Russian Far East and in Russia as a whole, but may have been overlooked due to its minute size.

Lophozia lacerata was also collected; but this species has previously been treated as a Japan-Taiwan endemic (Kitagawa 1965). Recently it was recorded from the Chukotka Autonomous Region (Konstantinova and Kuzmina, 2001) and the Kamchatka Peninsula (Czernyadjeva and Potemkin, 2003). I have also seen previously unpublished specimens from Sakhalin Island (Sakhalin: Korsakoff, anno 1908, leg. Urban Faurie, KYO, identified by N. Kitagawa). The record of this species in Bering Island is the fourth such in Russia. It is highly probable that *L. lacerata* is not a rare species in Eastern Russia.

Three species were reported by Arnell (1917) but were not found in this study. *Calypogeia trichomanis* auct. is synonymous with *C. azurea* Stotler et Crotz in the modern definition of the species (Grolle and Long 2000), but during Arnell's time, this species was treated extremely broadly. All samples with this name from northern Asia thus refer to other species, mainly to *Calypogeia muelleriana* (Schljakov 1979). I did not find *C. azurea* and it has not been included on the list of the island's hepatics. Also not found was *Jamesoniella autumnalis*, which is also missing from the nearest island of the Aleutian chain (Attu Island, Schofield, pers. comm.). It is most likely that it Arnell's record refers to another species, possibly to *Plectocolea subelliptica*. Finally, the specimen named by Arnell as *Marchantia polymorpha* is most likely *M. alpestris*. The latter species was found in some sites on the island, whereas *M. polymorpha* was not recorded. The likely reason that Arnell identified *M. polymorpha,* was that he didn't treat *M. alpestris* on the species level but rather included it with *M. polymorpha*.

An overview of Bering Island flora with special attention to the liverworts

Most of Bering Island is covered with tundra vegetation; however, there are differences in the local florulas apparently correlated with the moisture content of the substrates. At higher elevations, the tundra is drier, largely as a result of the better drainage conditions. The dry lichen tundra in Bering Island has been to a large degree destroyed by reindeer, introduced to the island at the end of 19th century. Lichen cover provides a habitat for some hepatics, but such cover occurs only in the northern part of the island, near the Nikolskoye Settlement.

A.N. Ivanov (2003) has divided the geosystems in three groups: plain, mountain and coastal. The plain geosystems occur in the northern part of Bering Island in the lowland from Nikol'skoye settlement to Sarannoye Lake (Fig. 1, 2). The lower regions of the plains are usually covered by crowberries, willows, sedges and sedge-cotton grass tundra communities on peaty ground, and less often by sedge-peat moss mires. The drainage of the substrates increases on the knolls, and stony and hummocky crowberry tundra develops here. Hummocky tundra is very com-

Fig. 4. The Dikaya River – Peresheek River pass (the photograph is taken from about 350 m a.s.l.).

mon on Bering Island. This landscape was formed under the joint influences of cryogenic and biogenic processes, and the plant cover exceeds 90% in these communities. Stony tundra has less plant cover (40–60%), with dwarf shrubs (crowberry and bearberry) and lichen communities with some forbs. Similar communities are observed in the low-mountain geosystems. The hepatic component of these communities is discussed below.

Mountain geosystems are developed on most of the island, and are represented by mountain tundra. This zone includes two high-altitude belts: (1) middle mountain snow-bed habitats (including alpine gravelly barrens with patches of dwarf shrubs) and (2) low mountain heaths. Communities in the low mountain belt are rather diverse. The largest areas have level surfaces. Thickets of low bushes (*Salix*, *Juniperus sibirica* Burgsd., *Sorbus sombucifolia* (Cham. et Schlecht.) M.Roem.) and middle-sized herb meadows are developed here. Along rivers, the valleys are covered by willow thickets, occasionally reaching up to 3 m in height (the tallest vegetation in the Commander Archipelago). Above the riverbed, the landscape aspect changes to a mosaic of high herbs, sedge-shorthear and forb meadows, small sedge mires and fragments of osier beds. The number of species near the riverbed is not high. Species of *Chiloscyphus*, *Plectocolea*, *Scapania*, as well as *Conocephalum conicum* and *Marchantia alpestris* are common here.

Sometimes high oligotrophic or mesotrophic sedge-moss bogs are developed in broad valleys. Species diversity is higher in peat moss dominated bogs compared to sedge and *Juncus* dominated mires. In the sedge and *Juncus* dominated mires, *Cephalozia bicuspidata* and *Gymnocolea inflata* are relatively common, whereas *Chiloscyphus polyanthos* and *Harpanthus flotovianus* are rare. In the peat moss dominated bogs, additional hepatics can be found, i.e. other *Cephalozia* spp., as well as *Scapania* spp., *Calypogeia* spp., *Aneura pinguis* and *Pellia neesiana*. Of particular interest are those mires formed by the percolation of "spring" water at the base of steep slopes. The specific diversity of these sites is high, and includes *Cladopodiella fluitans*, *Gymnocolea inflata*, *Jungermannia eucordifolia*, *Nardia compressa*, *Orthocaulis binsteadii*, *Mylia anomala*, *Cephalozia* spp. and *Cephaloziella* spp. On open peat, *Moerckia blyttii* and *Kurzia makinoana* appear.

With higher elevation, the vegetation assumes a more xerophytic character. Hummocky heath tundra can be found, sometimes with *Rhododendron camtschaticum* Pall., *R. aureum* Georgi, *Arctous alpinus*

(L.) Niedenzu and a number of lichens. The number of hepatic species is low in these more or less arid conditions, with *Sphenolobus minutus*, *Diplophyllum taxifolium* and *D. albicans* usually present. Sometimes *Macrodiplophyllum imbricatum* occurs in mats or on top of peat moss hummocks. At higher elevation, spots of bare ground of cryogenic origin are frequent. These substrates are occupied by species of *Anthelia*, *Nardia* and *Solenostoma*, and less often *Cladopodiella francisci*.

The middle mountain belt has a rather monotonous structure. The smoothed water-eroded surface of ranges and slopes near mountains tops at heights of more than 300 m a.s.l. are almost free of vegetation. Sparse clumps of shrubs (sometimes with saxifrages and sagebrushes) are observed as fragments only on scree (Fig. 3, 4). Snowfields sometimes persist throughout the summer in depressions on slopes. Snowfield communities near glaciers are absent or extremely poorly developed, because of the xeromorphic conditions resulting from extreme drainage of the substrates. The substrates dry rapidly, even near glaciers. *Marsupella brevissima*, *Gymnocolea inflata*, *Cephalozia bicuspidata*, *Nardia breidleri* have been observed here. The remaining territory is occupied of yellowish-ochre fine- or medium-grained sedimentary rocks that are almost vegetation free. On the surface of the largest patches of soil, reaching 5–6 cm in diameter, *Marsupella brevissima* and *Gymnomitrion pacificum* can be observed, as can various lichens.

Small streams arising from glaciers of different sizes provide a more or less continuous moisture supply and represent the most interesting sites with respect to liverwort flora. Species of *Lophozia*, *Schistochilopsis* and *Plectocolea* grow along streams, on rocky substrates, as well as on subvertical, constantly humid cliff slopes (a phenomenon that is infrequently found on the island). Most common in these communities are *Jungermannia* spp. frequently forming almost pure mats, covering tens of square meters.

The dry, vertical or subvertical slopes are formed by densely compressed sedimentary rocks and represent a special group of habitats. Usually these slopes occur on the coast and reach up to 200 m in height. The species of these rather xeromorphic conditions are *Mannia triandra*, *Peltolepis quadrata* and *Conocephalum japonicum*.

The coastal geosystems are rather unique, as a result of the slight salinity and constant enrichment provided by algae (mainly species of *Fucus* L. and *Laminaria* L.). Liverworts usually are absent in these systems.

A striking feature of the island's flora is the relative absence of woody substrates. The stems of the willows are too slender for the growth of epiphytic species and decompose rapidly. In addition, they are sparsely shaded by foliage. Driftwood brought by the sea can be found almost everywhere on the shore and is used by the indigenous inhabitants as firewood. Such logs are uniformly free of vegetation, because they are splashed with salt water during storms and dry rapidly. However, at one locality (6), driftwood was found rather far from the water, at a locality with snow cover for almost the entire summer. *Lophocolea heterophylla* was found on these logs, which remained more or less damp and away from the salt spray.

Concluding remarks

Konstantinova (1998:12, translated from Russian) wrote: "the predominant liverwort families have a surprising uniformity throughout the Arctic and Hemiarctic. The most dominant family is invariably Lophoziaceae, followed by Scapaniaceae, including more than 40% of the number of species. The third in all floras is Jungermanniaceae. These three dominating families include more than 50% of the species of the floras in all areas". Approximately the same situation is found on Bering Island. The leading families are as follows: Lophoziaceae – 20 species, Jungermanniaceae – 16, Scapaniaceae – 15. Next in dominance are Gymnomitriaceae – 8 and Cephaloziaceae – 8. The relatively few *Scapania* species may be explained both as an effect of insularity and by the insufficient humidity for the growth of *Scapania* species.

More significant differences are observed when comparing the coverage of some species in the Bering Island communities and adjacent continental sites on the Kamchatka Peninsula. Some species have a high coverage in the island's communities (e.g. *Jungermannia eucordifolia* and *Macrodiplophyllum imbricatum*), but are absent or rare in Kamchatka. On the other hand, *Ptilidium ciliare* is a common species in Kamchatka as well as in other regions of northern Eurasia, but is rare and occurs in small quantities on Bering Island.

Most of the species found in Bering Island are more or less common hepatics in northern Eurasia. Many of them (82 species or 80%) have arctoboreomontane, montane and arctomontane distribution (Table 1; treatment of geographic elements and types of areas follow Konstantinova, 2000). The arctic elements of the flora are represented by: *Lophozia savicziae*, *L. schusteriana* and *Scapania hyperborea*. The Temperate and Boreal elements are represented by e.g: *Ptilidium californicum*, *Chiloscyphus* spp., *Conocephalum conicum*, *Cladopodiella fluitans*, *Lophoc-*

olea spp. The majority of species have a circumpolar distribution (62 species or 63%). In addition a number of taxa with a Pacific or Oceanic distribution are present such as: *Gymnomitrion pacificum*, *Macrodiplophyllum* spp., *Lophozia silvicoloides*, *L. lacerata*. As a consequence, the Bering Island flora of liverworts may be characterized in a geographic sense as Arctoboreomontane circumpolar, with a notable boreal and oceanic tendency.

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