

CONTRIBUTION TO THE LIVERWORT FLORA OF FRANZ JOSEF LAND ARCHIPELAGO  
I. LIVERWORTS (MARCHANTIOPHYTA) OF ZIEGLER ISLAND

К ФЛОРЕ ПЕЧЁНОЧНИКОВ АРХИПЕЛАГА ЗЕМЛЯ ФРАНЦА-ИОСИФА  
I. ПЕЧЁНОЧНИКИ (MARCHANTIOPHYTA) ОСТРОВА ЦИГЛЕРА

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Abstract

An annotated list of liverworts of the Ziegler Island (Franz Josef Land) was compiled for the first time based on identification of 30 specimens collected by one of the authors in north-western and southern parts of the island. The list counts 19 species, including *Clevea hyalina* (Sommerf.) Lindb. and *Saccobasis polymorpha* (R.M. Schust.) Schljakov new for archipelago. Previously unpublished GenBank accession numbers for five species (10 samples) are provided. A total of 23 accessions were deposited in GenBank. The morphological features and distribution of a number of species in the archipelago are discussed.

Резюме

Впервые приводится аннотированный список печеночников острова Циглера (Земля Франца Иосифа), составленный на основе идентификации 30 образцов, собранных одним из авторов в северо-западной и южной частях острова. Список включает 19 видов, в том числе новые для архипелага *Clevea hyalina* (Sommerf.) Lindb. и *Saccobasis polymorpha* (R.M. Schust.) Schljakov. Для 5 видов (10 образцов) приводятся номера 23 последовательностей в ГенБанке. Обсуждаются морфологические особенности и распространение на архипелаге ряда видов.

KEYWORDS: morphology, GenBank accession numbers, phytogeography, Arctic, Russia

INTRODUCTION

Franz Josef Land Archipelago is the northern-most land in the European part of the eastern hemisphere. Its northern-most cape is located ca. 970 kilometers from the North Pole. Administratively the archipelago is part of the Arkhangelsk Province (Russia). The liverwort flora of the archipelago has never been studied by experienced bryologists. The most significant works by Anna L. Zhukova (Zhukova, 1972, 1973a,b, and Ladyzhenskaya & Zhukova, 1972) are based on the collections of geobotanists, mainly Vera D. Alexandrova, and lichenologists. In the summary article on the analysis of the liverwort flora of the archipelago Zhukova (1973a) cites 33 species and 15 infraspecific taxa. A partial revision of specimens studied by Zhukova led on one hand to the exclusion of some species, and on the other to the addition of new ones for the archipelago (Konstantinova & Potemkin, 1997). Several papers concerning the liverworts of several islands of the Franz Josef Land have been published recently (Czernyadjeva *et al.*, 2015; Potemkin, 2014). Data on the diversity of liverworts in the archipelago are summarized by Potemkin & Matveyeva (2015). The list includes 39 species. This list is clearly incomplete, which is confirmed by the findings of new

species for the archipelago after studying even the quite small collections discussed below. In addition the knowledge of the distribution and abundance of species in archipelago is extremely limited. Therefore, even incomplete information about the flora of the liverworts of Ziegler island, which still remained a “white spot” in relation to the liverworts flora is, in our opinion, of considerable value.

STUDY AREA

Ziegler island is one of the islands of central group of the Franz Josef Land archipelago called the Zichi Islands (Figs. 1-2). This is a fairly large island, its length from South-East to North-West is 45 kilometers, the area is 448 square kilometers mostly covered by glaciers. The highest point of the island is about 555 meters. Ice-free areas are very restricted and represent peculiar “islands” on capes, coasts of bays and some Nunataks in the center of the island. The soils are bound by permafrost, the thickness of the active layer on the Islands is usually no more than 30 cm. The climate is Maritime Arctic, with relatively mild winters with frequent cyclonic precipitation and snowstorms, and cloudy, cold, wet summers. The average temperature of the warmest month, July, is + 1.2° on the Hooker island and + 0.7° on Rudolf Island;

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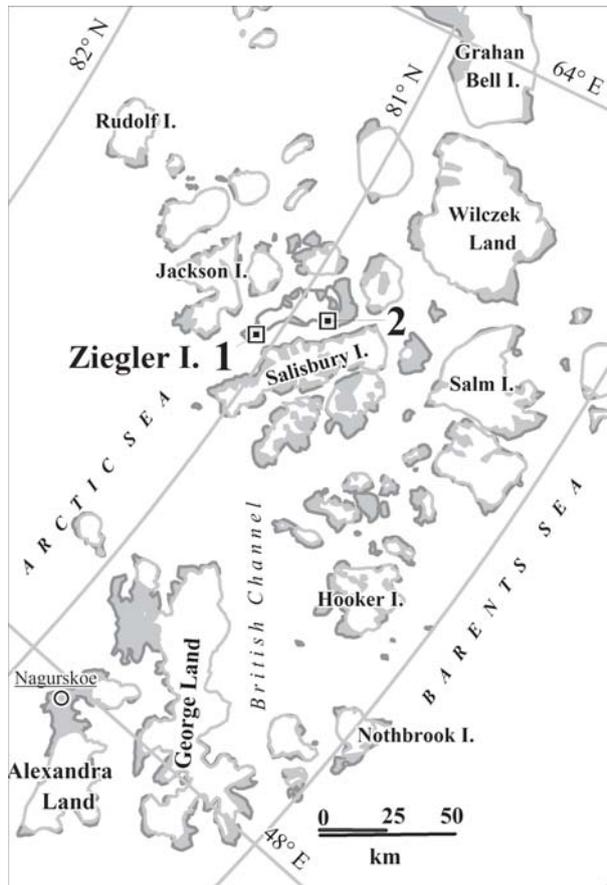


Fig. 1. Map of the Franz-Josef land Archipelago. Collecting localities are indicated: 1 – north-west part of island, 81.06689°N – 56.29464°E; 2 – southern part of island, 80.87465°N – 57.28807°E.

and the average annual air temperature is  $-10.2^{\circ}$  and  $-11.9^{\circ}$ , respectively. It should be emphasized, however, that on the surface of the soil, and in small cracks where liverworts usually grow, temperatures in summer are much higher. The summer months are cloudy and humid with frequent fogs and high humidity, which is favorable for liverworts.

#### MATERIAL AND METHODS

In summer 2019 Anatoliy Savchenko gathered hepatics in the Franz Josef Land Archipelago as part of the Russian Botanical group from Komarov's Botanical Institute (Saint-Petersburg). Due to the difficult ice conditions, transportation difficulties, and the large concentration of polar bears on the islands at this time, the collecting of liverworts on most of the studied islands was limited to 1-2 hours. On Ziegler island he managed to visit two different locations for ca. 1.5 hours each (Figs. 1-2). In total 30 specimens were collected. The coordinates were measured using GPS. The collected specimens were studied in the laboratory of the Polar-Alpine Botanical Garden-Institute (Kirovsk, Murmansk Province) by the senior author. The specimens are deposited in Herbarium of Polar-Alpine Botanical Garden-Institute of the Kola Scientific Center, Russian Academy of Scienc-

es (KPABG). Label data are incorporated in the CRIS – Cryptogamic Russian Information System ([kpabg.ru/cris/?q=node/16](http://kpabg.ru/cris/?q=node/16)).

As has been repeatedly noted, identification of liverworts from the Arctic and, in particular, high-arctic regions presents significant difficulties. Due to the harsh conditions, many species here have a very different appearance compared with more southern areas (Frisvoll & Elvebakk, 1996; Zhukova, 1973a; Schuster, 1988; Schuster & Damsholt, 1974, *etc.*). In addition, species often do not have perianths and sporophytes, and with such a limited collection time, often are represented by a very small number of plants, which also makes it difficult to accurately identify them. Therefore, some of the species identifications are tentative. For some species represented by single plants, we give brief descriptions of some morphological characteristics that support our identification.

We also found it useful to sequence some samples and provide GenBank data for sequenced samples to confirm our identifications. For all sequenced specimens we counted and described oil-bodies in case they were preserved. We believe that the sequenced data from the rarely collected arctic specimens will allow them to be used in the future to solve taxonomic problems, including to assess the degree of isolation of numerous previously described arctic forms. The nucleotide sequences of ITS1-2 nrDNA, *trnL-F*, *trnG-intron* or *rbcL* cpDNA were obtained for ten collected specimens and analyzed in our previous or newly produced corresponding datasets. Totally 23 accessions were deposited in GenBank (Appendix 1). The nucleotide sequences were assembled in BioEdit 7.0.1 (Hall, 1999) and then were included in corresponding previously obtained datasets for the genera *Lophozia*, *Lophoziaopsis*, *Sphenolobus*, *Mesoptychia* to reveal its similarity with other multiple sampled known species. BLAST search (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>) was implemented to determine affinity of *Plagiochila* specimen and ITS1-2 dataset was produced with specimens from Barbulesku *et al.* (2017). The nucleotide sequence variability was estimated as the value of the *p*-distances calculated in Mega 5.1 (Tamura *et al.*, 2011) using the pairwise deletion option for counting gaps.

#### ANNOTATED LIST OF SPECIES

The annotated list of liverworts is given in alphabetical order. It includes 19 species, 2 subspecies and 2 varieties. The nomenclature generally follows Hodgets *et al.* (2020). Brief descriptions of each species include some synonyms that are common in some Russian publications (in brackets). After the species name the presence of reproductive structures is given in parentheses (and. – androecia; gyn. – gynoecia; per. – perianths or pseudoperianths; spor. – sporophytes; gem. – gemmae). The collecting sites are listed according to Fig. 1, followed (in brackets) by the number of specimens in herbarium KPABG. Accompanying species are given and at least



Fig. 2. A: North-west part of Ziegler Island, terrace of the glacial moraine with a small glacial lake, locality I; B: North-west part of Ziegler Island, micro-scale polygonal tundra, locality I; C: Southern part of Ziegler Island, the slope with rock fields (screes), locality II; D: Southern part of Ziegler Island, the base of slope with cliffs, locality II.

one reference to herbarium number in the Cryptogamic Russian Information System – CRIS ([kpabg.ru/cris/?q=node/16](http://kpabg.ru/cris/?q=node/16)) is cited. An asterisk before a species name means a new record for the Franz Josef Land Archipelago.

*Anthelia juratzkana* (Limpr.) Trevis. – I (1): in mats with dominance of *Trilophozia quinquedentata* [122752]; II (3): in mats with dominance of *Lophozia polaris* and *Cephaloziella varians* [122752].

*Blepharostoma trichophyllum* (L.) Dumort. subsp. *brevirete* (Bryhn & Kaal.) R.M. Schust. [*Blepharostoma trichophyllum* var. *brevirete* Bryhn & Kaal.] – I (12); II (8). In several collections dominates in mats [122710]. The species occurs in most specimens studied, the most frequent associates are other liverworts widespread in the Arctic: *Cephaloziella varians*, *Odontoschisma macounii*, *Trilophozia quinquedentata*, etc.

*Cephalozia ambigua* C. Massal. – I (1): several shoots in mat with dominance of *Lophozia polaris* and *Cephaloziella varians* [122713].

*Cephaloziella varians* (Gottsche) Steph. [*Cephaloziella alpina* Douin, *Cephaloziella arctica* Bryhn & Douin, *Cephaloziella varians* var. *arctica* (Bryhn & Douin)

Damsh., *Cephaloziella varians* var. *scabra* (S.W. Arnell) Damsh.] – I (29), II (11) [122715]. This species occurs as an admixture to almost all other liverworts or forming mats almost without admixture of other species. It was found exclusively in sterile form. This is different from what Schuster (1980, 1988) writes about the species in Greenland, noting that it is “usually fertile” there. But it is consistent with our experience of working on Svalbard. As stressed by Schuster (1988), “sterile plants (of *Cephaloziella*, N.K.) are aside from *C. aspericaulis*, often hardly surely placeable”. We referred the majority of the specimens of this genus to this species based on shape of leaves and underleaves, characters of insertion, size and shape of cells, brown and purplish-brown pigmentation, as well as glistening appearance.

\**Clevea hyalina* (Sommerf.) Lindb. [*Athalamia hyalina* (Sommerf.) S. Hatt., *Clevea hyalina* var. *suecica* (Lindb.) Lindb., *Athalamia hyalina* var. *suecica* (Lindb.) S. Hatt., *Clevea hyalina* var. *rufescens* (S.W. Arnell) Konstant. nom. inval.] – II (1) One thallus with *Scapania obcordata*, *Mesoptychia heterocolpos*, and *Plagiochila porelloides* [122767]. Thallus bright green in the middle, with dark purplish margins and partly the mid-

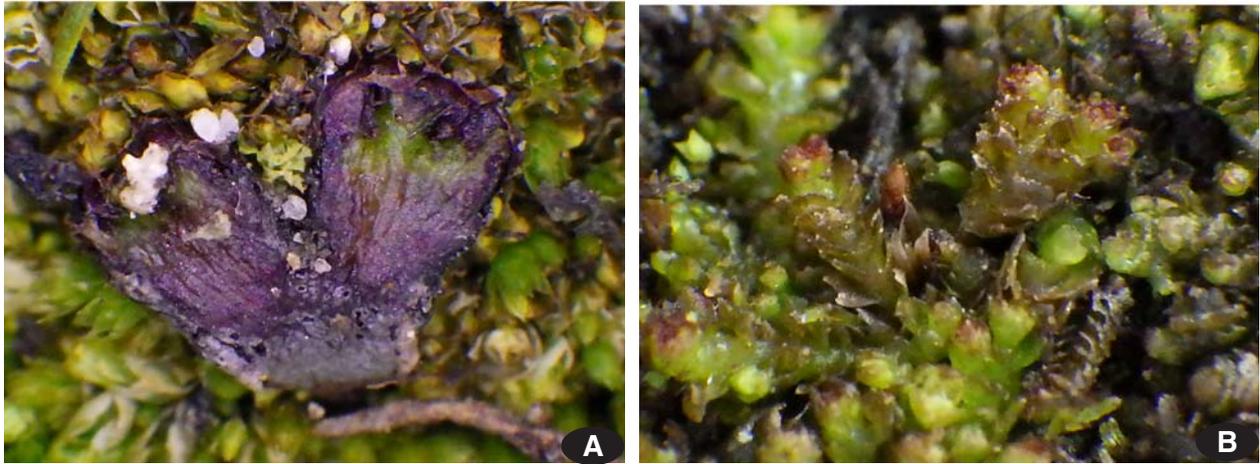


Fig. 3. A: the single collected thallus of *Clevea hyalina* (Sommerf.) Lindb.; B: mat with dominance of *Lophoziopsis polaris* (R.M.Schust.) Konstant. et Vilnet

dle of thallus in older parts, and intensively dark purplish scales, dichotomously branched, with branches ca. 3–3.5 mm wide (Fig. 3A).

*Gymnomitrium concinnatum* (Lightf.) Corda – I (1): dominates in one mat [122728]; II (1) dominates with *Scapania obcordata* in some mats [122754]. Common and often abundant species in the Arctic.

*Gymnomitrium coralloides* Nees (spor.) – I (4): dominates in some mats [122720] or occurs scattered in mats of *Scapania obcordata* or *Trilophozia quinquedentata*. Common and often abundant species in the Arctic.

*Jungermannia* cf. *polaris* Lindb. [*Jungermannia pumila* subsp. *polaris* (Lindb.) R.M. Schust.] – I (1): [122712]. Single shoots in mats with dominance of *Blepharostoma trichophyllum* subsp. *brevirete* and admixture of *Cephaloziella varians*, *Lophoziopsis polaris*, *Scapania* cf. *obcordata*, *Trilophozia quinquedentata*. This species is rather common in the Arctic but usually occurs scattered among other bryophytes. Correct identification of this species in the Arctic is impossible without perianth.

\**Lophozia wenzelii* (Nees) Steph. var. *lapponica* H. Buch & S.W. Arnell (gem.) – I (2): dominates in mats [122733] or occurs as admixture [122735] in mats with dominance of *Trilophozia quinquedentata* and admixture of *Cephaloziella varians*, *Sphenolobus minutus*, *Lophoziopsis polaris* and *Scapania obcordata*.

Plants small, ca. 0.7–0.8 mm wide, cells of leaves different even in one plant, varying from 20 to 25  $\mu\text{m}$  wide, cell walls in some leaves slightly thickened, red-brown in upper part and along margins, trigones mostly small, lumens of cells mostly rounded; leaves in upper part and along the border dark red to purplish red, with admixture of 3-lobed and then 600  $\mu\text{m}$  wide and 500  $\mu\text{m}$  long, 2-lobed leaves subquadrate, 520 $\times$ 500  $\mu\text{m}$ , with sinus descending (0.15–)0.25–0.3 leaf length. Oil-bodies 15–20 per cell, rounded or wide-ellipsoidal, light grey, from ca. 4–5  $\mu\text{m}$  to 3–4 $\times$ 6–7(–8)  $\mu\text{m}$ , rapidly becoming large dark green with many spherules after moistening. Gemmae colorless but some tinged slightly red, partly

rounded triangular, some ellipsoidal (probably not ripe), in mass on upper leaves (hidden in the leaves), very variable: from single, stellate but mostly triangular, rounded, long triangular, with thickened ends to rounded subquadrate, 20–25(–30)  $\mu\text{m}$ , few gemmae very large, almost ellipsoidal, up to 20 $\times$ 45  $\mu\text{m}$ . Based on morphology, we placed these specimens to *Lophozia wenzelii* var. *lapponica*. According to the obtained sequences the specimens differ in 0.5–1.1% by ITS1–2 and 0.2% by *trnL-F* from specimens we previously referred to *Lophozia wenzelii* (Vilnet *et al.*, 2008).

We found no records of this species in any previous publications on liverworts of Franz Josef Land except for the summary list in Potemkin & Matveyeva (2015). So we do not know any data on distribution of the species in the archipelago. Based on our knowledge on liverworts of Nordaustlandet, we suppose that *Lophozia wenzelii* var. *lapponica* occurs at least sporadically in the archipelago.

*Lophoziopsis polaris* (R.M. Schust.) Konstant. et Vilnet (gem.) – I (20), II (4): one of the commonest species in the collecting sites. Occurs as dominant [122723, Fig. 3B] but usually mixed with other liverworts.

We referred all specimens with abundant purple red gemmae, relatively large cells and more or less obliquely inserted leaves to this species (Fig. 3B). The species is quite common and very variable both in the Arctic and on Ziegler Island. We attributed various extreme forms to this species with a high degree of doubt. Initially, some of these forms were identified as *Lophoziopsis* cf. *rubrigemma* on the basis of relatively large leaf cells and gemmae, the size of which, however, varied greatly even in a single plant. All the studied specimens did not provide nucleotide variability in *trnL-F* sequences, and varied up to 0.2% in ITS1–2. The difference from populations from Svalbard is quite low: 0–0.4 in ITS1–2, 0–0.7 in *trnL-F* (Konstantinova *et al.*, 2020). At this stage, we have assigned all such specimens to *Lophoziopsis polaris*. However, in the future, it is necessary to conduct a

more thorough study on the basis of a large number of samples and study of the type material.

*Lophozia polaris* (as *Lophozia alpestris* (Schleich.) Evans subsp. *polaris* R.M. Schust.) was earlier recorded from Hooker Island (2 specimens) and Scott-Kelti Island (one specimen) (Zhukova, 1973a).

*Mesoptychia heterocolpos* (Thed. ex Hartm.) L. Söderstr. & Vána var. *harpanthoides* (Bryhn & Kaal.) L. Söderstr. & Vána [*Lophozia heterocolpos* Thed. ex C. Hartm.) M. Howe var. *harpanthoides* (Bryhn & Kaal.) R.M. Schust.; *Leiocolea heterocolpos* (Thed. ex Hartm.) H. Buch var. *harpanthoides* (Bryhn & Kaal.) S. Arnell] – I (2); II(3)[122729]. – In most specimens occurs as single shoots mainly with *Blepharostoma trichophyllum* subsp. *brevirete*, *Cephaloziella varians*, and *Odontoschisma macounii*. Based on the absence of gemmae and concave leaves, we referred the collected specimens to var. *harpanthoides*, but the taxonomic status of this variety should be clarified.

Compared to previously sequenced specimens of *Mesoptychia heterocolpos*, the differences of the studied specimens are 0–0.6% in *trnL-F* and 0–1.0% in *trnG-intron* (Bakalin *et al.*, 2015; Konstantinova *et al.*, 2020).

*M. heterocolpos* var. *harpanthoides* has previously been recorded once in Franz Josef Land (Hooker Island, Zhukova, 1973a). For sure the species is more widespread in archipelago than is now known.

*Odontoschisma macounii* (Austin) Underw. – I(2); II (9). Prevails in mats with other liverworts [122750, 122758, 122759] or occurs scattered in mats of liverworts widespread in the arctic and archipelago, but as well in few specimens with dominance of facultative calciphytes *Schljakovianthus quadrilobus* and *Mesoptychia heterocolpos* var. *harpanthoides*. The species has previously been recorded for Hooker Island (Zhukova, 1973a: 2 records).

*Plagiochila porelloides* (Torr. ex Nees) Lindenb. – II (2). On edge of mat with dominance of *Scapania obcordata* and *Mesoptychia heterocolpos* and a single thallus of *Clevea hyalina* [122767] and scattered in mats with dominance of *Blepharostoma trichophyllum* subsp. *brevirete* and *Cephaloziella varians* [122757]. Plants are very small, just up to 1.5 mm wide in the upper, widest part, but with appearance quite characteristic for the species: with relatively large leaves alternating with several very small; leaves subquadrate, with dorsal part shortly decurrent; underleaves very small; cells of leaves ca. 20 µm wide and 25 µm long, with small trigones. Apart from the very small size, the collected specimens do not differ from those collected in the Murmansk Province and other regions of Russia. The ITS1-2 sequence variation of the studied specimen [122757] is 0–0.7% with 19 representatives of *P. porelloides* from Germany, Switzerland, France, Portugal, Italy, Greece, United Kingdom, Canada and USA, and 0.1–0.3% with *P. satoi* from Japan (Barbulesku *et al.*, 2017) and China (our unpub-

lished data) as calculated in Mega 5.0 (Tamura *et al.*, 2011). The variability in *rbcL* of the mentioned specimens is 0–0.4%. Thus, the studied arctic extreme morph fits well into the framework of intraspecific variability of the widespread typical variety of *P. porelloides* characterized by low variability of studied loci over large areas.

*Plagiochila arctica* Bryhn & Kaal. and *P. porelloides* (Torr. ex Nees) Lindenb. var. *subarctica* (Jørg.) Lammes have previously been recorded for Franz Josef Land (Zhukova, 1973a; Konstantinova & Potemkin, 1997). It is evident that taxonomy of the arctic forms of this species need to be studied more carefully based on an expanded set of specimens.

\**Saccobasis polymorpha* (R.M. Schust.) Schljakov – II. (1) [122768]. Single shoots in mats with dominance of *Scapania obcordata* and *Cephaloziella varians* and admixture of *Sphenolobus minutus*, *Trilophozia quinque-dentata*, *Schljakovianthus quadrilobus*, *Blepharostoma trichophyllum* subsp. *brevirete*, and *Lophozia polaris*. Only one plant was found. It is very small, just 450–500 µm wide, with 2-lobed and 3-lobed leaves. Leaves have quite characteristic shape and distinct coarse trigones; gemmae are numerous on upper leaves, ellipsoidal, 2-celled, green to slightly brownish-colored, the largest gemmae 12–13×17–20 µm. This species has not been previously recorded for Franz Josef Land, but is not rare in Svalbard, including Nordaustlandet.

*Scapania obcordata* (Berggr.) S.W. Arnell (per., gem.) – I (15), II (8) [122719]. This species occurs with 16 of 19 species recorded from the island. It dominates in mats but often occurs scattered or just as single stems. Almost always it was collected with gemmae, but perianth was found in only one specimen. This is one of the most common species in the arctic. We agree with Schuster (1974: 281) that “the limits of this species are still problematic”. We referred to this species all plants of small *Scapania* with not keeled or slightly keeled leaves, colorless, green or light red two-celled ovoid gemmae, and slightly mammillate cells below the gemmiparous region. The species was not recorded for Franz Josef Land by Zhukova (1973a), but reported as rare by Konstantinova & Potemkin (1997). Single records of this species have recently been cited for Northbrook Island (Czernyadjeva *et al.*, 2015). For sure the species is common in archipelago but is overlooked or misidentified.

*Schljakovianthus quadrilobus* (Lindb.) Konstant. & Vilnet [*Barbilophozia quadriloba* (Lindb.) Loeske, *Lophozia quadriloba* (Lindb.) A. Evans, *Lophozia quadriloba* var. *glareosa* (Jørg.) Jørg.] – II (3) [122751]. In the collected specimens this species occurs as single shoots among other liverworts, in mats with dominance of *Scapania obcordata*. It is a common and extremely variable species in the Arctic, abundant in areas with basic rocks.

*Sphenolobus minutus* (Schreb.) Berggr. [*Anastrophyllum minutum* (Schreb.) R.M. Schust., *Anastrophyllum*



Fig. 4. Arctic appearance of *Trilophozia quinquedentata* (Huds.) Bakalin.

*minutum* var. *weberi* (Mart.) Kartt.] (Per.). – I (8), II(5) [122718]. It dominates in some mats or is mixed with other liverworts, more often with *Cephaloziella varians*, *Scapania obcordata*, and *Trilophozia quinquedentata*; a total of 11 species have been recorded with it. Plants are very small, just 0.4–0.8 mm wide and 3–4 mm long, often with red-colored upper parts of the upper leaves. The differentiation of the tested *Sphenobolus minutus* (Appendix 1) from previously published data (Vilnet *et al.*, 2010, Feldberg *et al.*, 2010) is 0.3–0.7% in ITS1-2 and 0–0.7% in *trnL-F*, which fits within the framework of intraspecific variability. The species is common in the Arctic, including polar deserts.

*Trilophozia setiformis* (Ehrh.) Schljakov – I (1) [122738]: scattered in mats with dominance of *Sphenobolus minutus* and *Trilophozia quinquedentata*. The species has previously been recorded as single specimens for Hooker and Rudolf islands (Zhukova, 1973a, b).

*Trilophozia quinquedentata* (Huds.) Bakalin [*Tritomaria quinquedentata* (Huds.) H. Buch], *Tritomaria quinquedentata* f. *gracilis* (C.E.O. Jensen) R.M. Schust.] – I (19); II (9) [122721]. This species occurs with almost all liverworts recorded in the island, and more often with other common species: *Blepharostoma trichophyllum* var. *brevirete*, *Cephaloziella varians*, *Lophoziaopsis polaris*, *Odontoschisma macounii*, *etc.*

Plants often have quite unusual appearance: leaves are partly destroyed, often strongly concave, stem wide and somewhat flattened (Fig. 4). They were probably referred to *Tritomaria scitula* by Zhukova (1972, 1973 a, b, *etc.*) based on the unusual appearance of plants, despite the absence of gemmae, while *Trilophozia quinquedentata* was not cited by this author (*l.c.*) for the archipelago.

#### DISCUSSION

The liverworts of Ziegler Island have never been studied before. As with many islands in the archipelago, the gathering opportunities were limited to one day. It was possible, however, to make collections in two remote parts of the island (Fig. 1). At each point, collections were

limited to no more than 1.5 hours. Naturally, it is unrealistically to explore all the habitats in such a limited time. As a result it is impossible to judge the diversity, occurrence and abundance of species based on the incomplete collections at hand. However, the data obtained significantly expands our understanding of the distribution and abundance of certain species of liverworts on Franz Josef Land and suggests that this flora is significantly underexplored and is actually much richer than what is currently known.

In spite of the limited collections gathered on the island, the list of species counts 19 species which is about half of the liverworts of the entire archipelago. It is more than what is known for other studied islands of the archipelago except for Hooker Island where collecting has been carried out repeatedly. Two species are recorded for the first time for the archipelago. One of these (*Clevea hyalina*) is recorded for the first time for the Russian part of the polar deserts. Only one thallus was collected. Since the sample is sterile, it was difficult to determine which of the two arctic species of the family Cleveaceae with purple pigmentation (*Clevea hyalina* or *Peltolepis quadrata*) it belongs to. We eventually referred it to *Clevea hyalina* on the basis of ventral scales projecting beyond margin and apex of thallus, and based on our experience of collecting similar dark and almost black-purple fertile plants of this species in the Nordaustlandet (Svalbard archipelago), where it occurs in fertile condition and its identification was not in doubt.

The second species not previously recorded for the archipelago is *Saccobasis polymorpha*. This taxon was not cited for the arctic desert zone by Potemkin & Matveyeva (2015). However, *Saccobasis polita* (as *Jungermannia polita* Nees) was cited for Nordkap, Svalbard by Berggren (1875), and this record most likely represents *Saccobasis polymorpha*. Just as in the case of *Clevea hyalina*, only one plant was found. However, there is no doubt about the identification, given the appearance of the plant: the peculiar shape of three- and two-lobed leaves, a characteristic very large nodular thickness of cell walls, as well as the characteristic ellipsoid gemmae.

Another species, *Odontoschisma macounii*, is not listed for Franz Josef Land by Potemkin & Matveyeva (2015), although it was previously recorded by Zhukova (1973a) for Hooker island. The species was found on Ziegler Island in about a third of the studied specimens, and in some of them it apparently dominates. For the polar deserts of Russia, this species is only indicated for the island of Bolshevik, while it is widely distributed in the Canadian provinces (Potemkin & Matveyeva, 2015; Damsholt, 2002). *Odontoschisma macounii* is rather common in Nordaustlandet (Svalbard), where we have repeatedly found it in all the studied regions, except the north coast of Murchison Fjorden. It is most likely not rare in polar deserts of Russia, but is overlooked due to its small size

and restriction to small cracks in bare soil – habitats that do not attract attention of botanists collecting in polar deserts.

One of the interesting findings is *Plagiochila porelloides*. *Plagiochila arctica* was previously recorded for Hooker island (Zhukova, 1973a), where this species was recorded 11 times; *Plagiochila porelloides* fo. *subarctica* was also listed (Zhukova, l.c.). As we discussed above, the specimens collected by us on Ziegler Island do not differ from plants of *Plagiochila porelloides* from more southern regions apart for the very small size.

The majority of the species found on Ziegler Island are widespread and abundant in the Arctic. However, in the studied collection, many of them (*Anthelia juratzkana*, *Cephalozia ambigua*, *Gymnomitrium concinnatum*, *Gymnomitrium corallioides*, *Jungermannia* cf. *polaris*, *Mesoptychia heterocolpos*, *Schljakovianthus quadrilobus*, and *Tetralophozia setiformis*) are represented by one or two specimens, which may be due solely to incomplete collections. The most commonly present species in most of the studied samples and often predominating are *Blepharostoma trichophyllum* subsp. *brevirete*, *Cephalozia varians*, *Scapania obcordata* and *Trilophozia quinquedentata*. These species are found everywhere in the Arctic and on Ziegler island as well. Some species that previously were known from single finds in the archipelago were collected several (*Mesoptychia heterocolpos*) or even many times (*Lophoziaopsis polaris*, *Odontoschisma macounii*, *Scapania obcordata* and *Trilophozia quinquedentata*) on Ziegler Island. Apart from species widespread in Arctic, this group includes species confined to some specific conditions, particularly species restricted mainly to basic rocks, e.g. *Lophoziaopsis polaris*, *Mesoptychia heterocolpos* and *Odontoschisma macounii*. These species are widespread in the Arctic, but they rarely form large mats, occurring scattered among other liverworts or as small mats where they predominate.

One of the characteristic features of the arctic local liverwort floras is that in almost every studied flora, there are species known exclusively or almost exclusively for this territory and absent from others. As well as in the Svalbard liverworts (Konstantinova & Savchenko, 2012, 2018) in Franz Josef Land the flora of each newly studied territory adds to the list of species of the entire archipelago. A similar pattern is observed for the flora of vascular plants in the archipelago (Safronova *et al.*, 2020). In addition to the nature of the underlying rocks and geomorphological features, it is explained by the length of time that has passed since the territories were cleared from the glaciers, and the ways of migration of diaspores to this territory plays a major role in the Arctic.

#### CONCLUSION

Taking into account the findings of new species for the archipelago and the addition of *Odontoschisma macounii*, omitted in the work of Potemkin and Matveeva (2015), the list of Franz Josef Land liverworts includes

42 species. This is significantly less than what is known for the Nordaustlandet (Svalbard) located in the same sector of the Arctic, for which 63 species were cited (Konstantinova & Savchenko, 2015). Of course, the Nordaustlandet is located somewhat further south; however, such a significant difference in the richness of the flora is most likely due to the fact that its territory is much better studied.

The obtained results once again indicate an extremely superficial and incomplete knowledge of both the diversity, distribution and ecology of liverworts in high arctic regions. Unusual appearance of plants in the Arctic, small and incomplete samples, often without gametangia and sporophytes lead to questionable identifications of species and erroneous reports. For a more or less objective assessment of the diversity of the arctic liverworts flora, it is necessary to study arctic forms and varieties based on an integrative approach. It is necessary to understand which of the unusual arctic forms of liverworts are separate genetically distinct taxa, and which are just dwarf forms of widespread species. It is important both for widespread and very variable arctic species, e.g. *Tritomaria quinquedentata* and *Schljakovianthus quadrilobus* with its numerous arctic extremes and poorly known taxa described from arctic regions, e.g. *Lophoziaopsis polaris*, *Scapania obcordata*, *S. zemliae*, *Saccobasis polymorpha*, etc. Sequencing of samples of some of these species showed that despite their small size and sometimes extremely unusual appearance at least some forms do not differ in the studied loci from plants of these species from more southern latitudes.

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## Appendix 1. The list of taxa, specimens vouchers and GenBank accession numbers.

Taxon	Specimen-Voucher	GenBank accession number			
		ITS1-2 nrDNA	trnL-F cpDNA	trnG-intron cpDNA	rbcL cpDNA
<i>Sphenolobus minutus</i>	CA-19-29	MT422255	MT431399		
<i>Plagiochila porelloides</i>	CA 19-30-2f [КРАВГ122757]	MT422256	MT431400		MT437762
<i>Lophozia polaris</i>	CA 19-29-12 [КРАВГ 122739]	MT422257	MT431401		
<i>Lophozia polaris</i>	CA 19-30-1c КРАВГ(H): 122747	MT422258	MT431402		
<i>Lophozia polaris</i>	CA 19-29-13a КРАВГ(H): 122740	MT422259	MT431403		
<i>Lophozia polaris</i>	CA19-29-2b КРАВГ(H): 122713	MT422260	MT431404		

Taxon	Specimen-Voucher	GenBank accession number			
		ITS1-2 nrDNA	<i>trnL-F</i> cpDNA	<i>trnG</i> -intron cpDNA	<i>rbcL</i> cpDNA
<i>Lophoziaopsis polaris</i>	CA19-29-6c KPABG(H): 122724	MT422261	MT431405		
<i>Lophozia wenzelii</i> var. <i>lapponica</i>	CA19-29-10a-1 KPABG(H): 122733	MT422262	MT431406		
<i>Lophozia wenzelii</i>	CA19-29-10a-1-2 KPABG(H): 122733	MT422263 MT431408	MT431407 MT431398		
<i>Mesoptychia heterocolpos</i> var. <i>harpanthoides</i>	CA-19-29-8c KPABG(H): 122729		MT431408	MT431398	