MOSSES OF THE FRANZ JOSEF LAND ARCHIPELAGO (RUSSIAN ARCTIC)
МХИ АРХИПЕЛАГА ЗЕМЛЯ ФРАНЦА ИОСИФА (РОССИЙСКАЯ АРКТИКА)

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Abstract
Moss flora of the Franz Josef Land Archipelago is studied. The paper was compiled based on examination of recent collections, revision herbarium material and summarizing literature data. An annotated list includes 156 species, 18 of them are new for the archipelago. The interesting records are *Arctoa anderssonii*, *Pohlia beringiensis*, *Schistidium abrupticostatum*, *S. andreaeopsis*.

KEYWORDS: mosses, flora, Arctic, Franz Josef Land Archipelago, rare species

INTRODUCTION
Franz Josef Land Archipelago is the most northern part of Eurasia, being at its northern part less than 1000 km apart from the North Pole. This area is exceedingly difficult to access, and it remains almost uninhabited and poorly explored.

The beginning of bryophyte exploration can be attributed to L.V. Palibin, who participated the expedition on the icebreaker “Ermak” to the Barents Sea in 1901. He published records of 12 moss species, collected mainly at the Flora Cape, Northbrook Island, and also small collections in Hochstetter Island (Palibin, 1903–1906). He also provided a detailed historical overview of floricistic research at the archipelago, with solitary bryophyte records from the Austrian expeditions on the ship “Tegetthoff” (1872–1874), collections of Payer; the English expedition in 1894–1897, collections of H. Fischer; and Italian expedition on the ship “Stella Polare” (1899–1900), collections of Cavalli-Molinelli at Rudolf Island. Altogether 14 moss species were listed by Palibin (1903–1906).

In 1929, I.V. Ivanov during polar expedition on the icebreaker “Georgy Sedov” collected mosses mainly on Hooker Island, and small collections were made also on Northbrook and Rudolf islands. The specimens were identified by L.I. Savicz, who listed 37 moss species and one liverwort. (Savicz, 1936). This list is thoroughly annotated with information about habitats and various notes on some features of individual species in the high Arctic, lists of mosses for each island were also provided. Later, all these data with some additions were included in “Handbook of mosses of Arctic of the USSR” (Abramova et al., 1961) and “Handbook of mosses of the USSR. The mosses acrocarpous.” (Savicz-Ljubitzkaja & Smirnova, 1970).

In 1930, O. Hanssen collected mosses at Alexandra Land, Alger, George Land, Graham Bell, Northbrook islands. These specimens were identified by P. Størmer, who listed 28 species of moss and 2 species of liverworts (Størmer, 1940). Thus, 95 species of mosses were known from the archipelago according to literature at the time.

Some contribution to the study of mosses of the archipelago was made by geobotanists. In 1959, a vegetation study was conducted on Alexandra Land Island by V.D. Aleksandrova. She collected very thoroughly bryophytes and lichens on relevé plots. Collections of mosses and liverworts were identified by A.L. Abramova and R.N. Schljakov, and published in vegetation overview of Alexandra Land Island (Aleksandrova, 1977, 1981) and included also in the monograph “Polar desert vegetation” (Aleksandrova, 1983). Unfortunately, the specimens that

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were collected for these relevés have not been preserved and can not be re-examined. In 1979, I.N. Safronova conducted geobotanical studies on Meibl and Hooker islands. Her moss collection was identified by O.M. Afonina and I.V. Czernyadjeva, and the results have been published in two papers (Safronova, 1986; Czernyadjeva, 1992).

In 1995, the check-list of the mosses of the Russian Arctic was published (Afonina & Czernyadjeva, 1995) and 103 moss species were listed there for Franz Josef Land based on literature data. In 1996, A.M. Odasz published a paper, in which 47 species were reported for Hooker Island (Odasz, 1996). In 2015, the monograph “Plants and fungi of polar deserts of the Northern Hemisphere” was published under the editorship of N.V. Matveeva; in this publication, the section on mosses was prepared by O.M. Afonina (Afonina, 2015). This publication provides a general list of mosses based on all available literature on different polar desert regions, including the Franz Joseph Land Archipelago, and also using the unpublished results of identifying of different collections. Thus, it contains previously unpublished data on the moss flora of Heiss Island, based on specimens collected by D.A. Walker in 2010 and identified by O.M. Afonina. The publications on taxonomy of certain groups of mosses, providing information about the distribution of species in the polar desert zone (Blom, 1996, 1998; Frisvoll, Lewinsky, 1981; Frisvoll, 1983a, b; Czernyadjeva, 2003; Afonina, 2004) were also accounted in this monograph. It also included amendments related to the revision of herbarium specimens, mainly concerning the genera Bryum (V.I. Zolotov) and Schistidium (E.A. Ignatova). As a result, 115 moss species were listed for the archipelago (Afonina, 2015).

In 2012, during the complex expedition of the national park “The Russian Arctic”, extensive collections of liverworts and mosses were performed on the territory of Franz Josef Land by S.S. Kholod. The moss specimens from Northbrook Island was examined by I.V. Czernyadjeva, and check-list including 45 species was published (Czernyadjeva et al., 2015). Additionally, some new findings from this collection have been published in the section “New records ...” (Ellis et al., 2019a, 2019b, 2020; Sofronova et al., 2019a, 2019b; Czernyadjeva et al., 2019). In 2016, D.S. Moseev carried out geobotanical research and collected mosses on Alger, Bell, Etheridge, Eva-Liv, Hooker, Kane, Heiss, Li-Smith, Meibl islands. The mosses were identified by E.Yu. Kuzmina, and the results were published (Moseev et al., 2018, 2019). However, the records on Campylium pratense, Calliergon megalophyllum, C. richardsonii, Climaci-um dendroides, Drepanocladius aduncus, Sciuro-hypnum plumosum, Syntrichia norvegica were erroneous.

**STUDY AREA**

Franz Josef Land is located in the western sector of the Russian Arctic, in the northeast of the Barents Sea. This is an archipelago of 196 islands separated by numerous straits. Its natural features are largely determined by the hydrological and ice conditions of both the straits themselves and the surrounding marine bodies of water. The total area of the archipelago is 16096 km², of which 13690 km² (85.1 %) are glaciers. The archipelago is 375 km from West to East, and 234 km from North to South. Most of the islands of the archipelago are the remnants of an extensive basalt plateau, divided by tectonic faults into separate blocks, experiencing differentiated movements relative to each other with amplitudes of up to 1000 m. Terracing of plateau slopes is extremely characteristic, which was caused by intermittent uplift of the archipelago during the Late Pleistocene and Holocene. The relief of the islands is currently experiencing the influence of nival, permafrost-solifluction, gravitational-al-diluvial and aeolian processes, and extensive modern glaciation is its main physiographic feature.

The thickness and cohesion of the ice cover in the straits separating the islands and the distribution of water masses have a noticeable effect on the landscape conditions of the islands, determining the regime of temperature, precipitation, humidity, and the nature of glaciation. The degree of development of ice sheets is one of the most important landscape-forming factors that determine the natural features of Franz Josef Land. The most significant factor for the formation of the hydrological and ice regime of the straits is the influx of warm Atlantic and Barents Sea waters entering the archipelago from the north-west and the south. The meltwater of glaciers are the main sources for local rivers. Most rivers are characterized by the formation of estuarine spills, the growth of deltas, and a general increase in the length of river systems, which is expressed in lengthening of estuarine sections and the increase of floodplains in the lower reaches. Franz Josef Land has about a thousand freshwater lagoons and glacial lakes. The areas of some of them reach 2 km², and the depths are up to 10 m. (Govorukha, 1968).

Franz Josef Land belongs to the Atlantic-European climatic region of the Arctic and is located in the zone of the marine Arctic climate, whith by intense cyclonic activity, low average annual and summer air temperatures, significant cloud cover, frequent fogs, and high relative humidity. Frequent and strong (up to 40 m/s) winds in combination with temperatures to −52°C make the archipelago one of the most severe areas worldwide. Only two months a year, in July (warmest) and August, have the average month temperature above zero, but both below +2°C, and number of days with the mean temperature above zero is 60 in the southern part of the archipelago, and only 41 in its northern part. The average annual temperature is −12°C (Govorukha, 1968).

The vegetation of the Franz Josef Land Archipelago belongs to the northern subzone of the polar desert zone. To date, only 57 species and varieties of vascular plants are known from its islands, among which the species of
Fig.1. Collecting localities and collectors of mosses in Franz Josef Land:

1c. Alexandra Land Island, Severnaya Bay, 80°46'–80°47', 47°43'–47°54'E: 2019 Konoreva, Chesnokov.
1d. Alexandra Land Island, Zveroboev Bay, 80°48'N, 48°08'E: 2019 Konoreva, Chesnokov.

2a. George Land Island, Stephens Cape: 1930 Hanssen.
2b. George Land Island, Forbes Cape: 1930 Hanssen.
2c. George Land Island, Nansen Cape, 80°27', 47°29'E: 2012 Kholod.
2e. George Land Island, Kalina Cape, 80°14', 47°28'E: 2012 Kholod.
2f. George Land Island, Krauter Cape, 80°09', 47°11'E: 2012 Kholod.
2g. George Land Island, northwestern part, 80°51', 49°52'E: 2012 Kholod.
2h. George Land Island, Armitage Peninsula, Bay of Geographers, 80°48', 50°28'E: 2019 Konoreva, Chesnokov.
7a. Hooker Island, Cape Sedova, polar station Tikhaya Bay, ~80°20', 52°52'E: 1929 Ivanov; 1930 Savich; 2012 Kholod; 2016 Moseev; 2019 Konoreva, Chesnokov.

15. Hall Island, Cape Tegetthof, 80°05', 58°01'E: 2012 Kholod.
22. Wilczek Land Island, 80°48', 60°05'E: 2012 Kholod.
24a. Ziegler Island, surroundings of Cape Bryce, the site of an Austrian expedition field camp, 81°04'–81°06', 56°14'–56°18'E: 2012 Kholod; 2019 Konoreva, Chesnokov.
24b. Ziegler Island, in the surroundings of Rhodes strait, 80°52', 57°17'E: 2019 Konoreva, Chesnokov.
29. Gage Island, 80°52', 60°05'E: 2012 Kholod.
30. La Ronciere Island, 80°58', 60°00'E: 2012 Kholod.
33a. Rudolf Island, Borok Cape: 1929 Ivanov; 1932 Prezent.
34. Eva-Liv Island, 81°38', 63°06'E: 2012 Kholod.
the families Poaceae, Juncaceae, Caryophyllaceae, Brassicaceae, Saxifragaceae predominate. The vegetation of the archipelago is characterized by a high degree of sparsity: extremely sparse groups with a projective cover of 2–4 % are occured on sea terraces of different levels, on the slopes of hills, in areas recently released from under the glacier. The species composition of vascular plants usually does not exceed 5–7 species per relevé plot (e.g., Papaver polare, Phippsia algida, Saxifraga cespitosa, S. nivalis, S. oppositifolia, Cerastium regelii ssp. caespitosum, Stellaria edwardsii). The average height of plants is 12–15 cm, being taller only in grasslands, up to 20–25 (−30) cm. A number of species grow in a cushion-shaped form (e.g., Cerastium regelii ssp. caespitosum, C. arcticum, Saxifraga cespitosa). Under the canopy of dward shrunds mosses and lichens form a shallow carpets. Various polygonal communities with an average coverage of 8–10 % are usually represented on loamy watersheds. Polygons usually have a diameter of 45–60 cm, being separated by holows 15–20 cm wide. The polygons have a crust of liverworts, and inhabited by such vascular plants as Poa abbreviata, Luzula confusa, Minuartia rubella, Cerastium arcticum). Large clusters of Thamnolia vernicularis lichen are common here. In areas of snow accumulation in the vast coastal plains, a unique vegetation is occured, the basis of which is the crust of liverworts (Gymnomitron sp.). The role of some vascular plants, in particular, Phippsia algida, Cerastium regelii, Saxifraga hyperborea, Cochlearia groenlandica, increases on coastal plains composed of sand deposits, the total coverage of which reaches 10 %. Mosses and lichens cover the surface of large- and medium-sized blocky basalt ruins with a glandular crust. Large layers of the scale lichen Poria melinodes are formed on the surface of basalt blocks. In the clefts between the blocks, the moss Rhacomitrium lanuginosum with an admixture of Oncophorus sp. is common, while the black crust is composed of liverworts (Gymnomitron sp.). On low sea terraces, large polygons sometimes develop with abundant lichen vegetation, with coverage in some areas up to 70–80 % (Aleatoria nigricans, Bryocalyson divergens, Pseudophebe pubescens, Phaerophorus fragilis, S. globosus, Umbilaricia arctica, U. decussata). In the valleys that divide polygons, a nival situation occurs, the sign of which is a certain set of mosses and lichens: (e.g., Andreaea rupestris, Rhacomitrium lanuginosum, Cryptoporia delisei). On numerous taluses that overlap the slopes of the plateau and individual remains, extremely sparse vegetation is formed (projective coverage – 1–2 %), where 4–5 species of vascular plants are usually found (e.g., Saxifraga cespitosa). In the lower parts of the mobile scree, there is a blackening of the slope with a projective vegetation cover of up to 15–17 %. Aleatoria nigricans, Bryocalyson divergens, Luzula confusa and Potentilla hyperbactica are common in the vegetation cover.

**COLLECTIONS**

The present publication is based on the identification of mosses collected by S.S. Kohlod on 25 islands in Franz Josef Land Archipelago in 2012. The results of the identification of moss collections made in 2019 by I.A. Konorova and S.V. Chesnokov on Alexandra Land, George Land, Hooker, Ziegler, Kuhn and Jackson islands are included, as well as the small collection of Zaverin from Heiss, Rudolf, Graham Bell islands made in 2007. In total, over 1800 moss specimens were studied. The old collections of mosses from the archipelago, stored in the LE, were also revised, taking into account the latest taxonomic updates. All literature sources were considered. The species of genus Schistidium are given according to revision of herbarium materials (LE) by E.A. Ignatova.

**LIST OF SPECIES**

The annotated list of mosses is given in alphabetical order, it includes 157 species. The nomenclature generally follows Ignatov *et al.* (2006) with some updates from recent literature. Annotation of each species includes some synonyms that are common in some Russian publications (in brackets). After the species name the presence of reproductive structure is given in parentheses (spor. – sporophytes;
Fig. 2: Franz Josef Land vegetation types (photos of Kholod). A: Nansen Island, polygonal *Phippsia algida*-moss (*Campylium stellatum, Distichium capillaceum, Flexirichium flexicaule*) community; B: George Land Island, moss (*Hygrohypnella polare, Drepanocladus arcticus, Sanionia uncinata*) community on a high sea terrace; C: George Land Island, *Saxifraga rivularis*-moss (*Aplodon wormskioldii, Aulacomnium palustre, Warnstorfia sarmentosa*) community; D: George Land Island; E: Meibel Island; F: George Land Island, moss (*Bryum cryophilum, Orthothecium sp.*) community near the seashore; G: Northbrook Island, Flora Cape, stony-gravelly moss (*Bryum cryophilum, Brachythecium turgidum, Orthothecium sp.*) community; H: Northbrook Island, Flora Cape, moss (*Warnstorfia sarmentosa, Brachythecium turgidum, Aulacomnium palustre*) community near snowfields.
gem. – gemmae); then literature cited are given, frequency of occurrence, localities, habitats, often accompanying species. The localities are listed according to Fig. 1; localities confirmed by the herbarium specimens are boldfaced, while literature records are given in italics. Species new to the Franz Josef Land Archipelago are marked with asterisk (*). All specimens are deposited in LE.

*Amblystegium serpens* (Hedw.) Schimp. – Rare: 5.

Andreaea papillosa Lindb. (spor.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1c, 7a, 7c, 17, 24a, 33a, 33b. On soil in moss-lichen community; on rocks, boulders, fine earth between boulders.

A. rupestris Hedw. (spor.) – Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Moseev et al., 2019. Rare: 4, 7, 33a. On fine earth between boulders.

Aplodon wormskioldii (Hornem.) R. Br. (spor.) – Palibin, 1903-1906; Savicz, 1936; Störmer, 1940; Abramova at al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 2f, 4, 5, 6, 7, 24b, 33a, 33b. In Papaver polare open plant community, grass-moss, Saxifraga-moss, Salix polaris-moss-lichen communities.


Aulacomnium palustre (Hedw.) Schwägr. – Savicz, 1932, 1936; Störmer, 1940; Abramova at al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 2a, 2b, 2e, 2f, 4, 5, 6, 7, 12a, 13, 15, 24b. In grass-lichen-moss, Saxifraga-moss, herb-lichen, Salix polaris-lichen-moss communities; with Straminergon stramineum, Warnstorfia sarmentosa etc.

A. turgidum (Wahlenb.) Schwägr. – Palibin, 1903-1906; Savicz, 1932, 1936; Störmer, 1940; Abramova at al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 2a, 2b, 2c, 2e, 2f, 3, 4, 5, 6, 7, 7a, 10, 11, 12, 12a, 13, 15, 18, 23, 24a, 25, 26, 27, 30, 31a, 31b, 32, 33a, 33b, 34. In various grass-moss-lichen, herb-lichen-moss-lichen-liverwort, forb-lichen-moss-lichen-liverwort, graminoids-lichen-moss communities and moss-lichen polygonal open plant communities.

Bartramia ithyphylla Brid. (spor.) – Savicz, 1932, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019.

Common: 1, 1b, 2e, 4, 5, 6, 7, 10, 12a, 15, 16, 19, 20, 22, 23, 24a, 26, 27, 31b. In forb-lichen-moss-lichen, herb-lichen-lichen, moss-lichen-liverwort, Saxifraga-lichen-moss communities and Phippsia-lichen-moss polygonal open plant communities; on loamy-gravelly area; with Myurella julacea, Pohlia cruda, Niphotrichium panthii, Polystichum septentrionale etc.

*Blindia acuta* (Hedw.) Bruch & Schimp. – Sofronova et al., 2019a. Rare: 1b, 12b, 15. In moss-lichen-liverwort, moss-lichen and lichen communities.

*Blindiadelphus polaris* (Bergr.) Fedosov & Ignatov (Seligeria polaris Bergr.) – Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1, 7. The genus *Blindiadelphus* was segregated from Seligeria on the basis of morphological and molecular evidence (Fedosov et al. 2017). The species is given for the archipelago according to A.M. Odasz (1996).

Brachythecium cirrosum (Schwägr.) Schimp. – Savicz, 1932, 1936; Störmer, 1940; Abramova at al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Moseev et al., 2019. Sporadic: 1, 4, 5, 7, 12a, 12c, 13, 19. In stony forb-lichen and damp herb-lichen communities.


*B. turgidum* (Hartm.) Kindb. – Palibin, 1903-1906; Störmer, 1940; Abramova et al., 1961; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1b, 1c, 2a, 2b, 2c, 2f, 4, 5, 7, 7a, 10, 12a, 13, 15, 19, 20, 21, 22, 25, 27, 30, 31a. In various grass-moss-lichen, herb-lichen-moss-liverwort, forb-lichen-moss-liverwort, graminoids-lichen-moss, Phippsia-moss, Papaver-moss-lichen-moss communities; in Phippsia-moss-lichen and moss-lichen polygonal open plant communities.

*B. udum* I. Hagen – Afonina, 2015; Czernyadjeva et al., 2015. Rare: 5. In Saxifraga-moss communities; with Bryum sp., Syntrichia ruralis.


Bryum arcticum (R. Br.) Bruch & Schimp. (spor.) – Savicz, 1936; Abramova et al., 1961; Aleksandrova, 1983; Czernyadjeva, 1995; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 1, 2c, 4, 5, 6, 7a, 12a, 12c, 13, 18, 26, 31a. In Saxifraga-moss, moss-lichen, moss-liverwort, forb-moss-liverwort, herb-lichen communities.


B. luteum Märtensson – Palibin, 1903-1906; Savicz, 1932, 1936; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Frequent: 1, 2e, 4, 5, 6, 7a, 12a, 12c, 13, 18, 26, 31a. In damp grass-moss, forb-moss, Saxifraga-lichen-moss, moss-lichen communities, on shore of stream with Orthothecium sp., Philonotis fontana, P. tomentella, Scopodium revolvens, Warnstorfia sarmentosa etc.

B. neodamense Itzigs. – Aleksandrova, 1983; Afonina, 2015. Rare: 1, 24a, 27. In damp moss-lichen polygonal communities with Hygrohypnella polare, Scopodium revolvens, Warnstorfia sarmentosa etc.

B. pallescens Scheich. ex Schwägr. – Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1. In moss-lichen community.

B. pseudotriquetrum (Hedw.) P. Gaerth., B. Mey. & Scherb. – Palibin, 1903-1906; Abramova et al., 1961; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Rare: 1, 2c, 5, 19. In Saxifraga-moss, grass-moss communities; herb-lichen-moss open plant community.

B. rutilans Brid. (gem.) – Savicz, 1932, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 1, 1b, 1c, 2e, 2f, 2g, 5, 6, 7, 11, 12, 12b, 19, 22, 24a, 24b, 25, 31a, 31b, 33a, 33b. In different Phippsia-lichen-liverwort-polygonal, Salix polaris-moss-lichen, grass-moss, herb-moss, moss-lichen, moss-liverwort communities; Saxifraga-moss open plant community; on fine earth between boulders near shore of sea; with Ceratodon heterophyllus, Hygrohypnella polare, Pohlia cruda, Santionia uncinata etc.

B. teres Lindb. – Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Rare: 1, 5, 13. In herb-liverwort-moss, lichen-moss-liverwort and Phippsia-lichen-moss communities.

Buckia vaucheri (Lesq.) D. Rios, M.T. Gallego & J. Guerra [Stereodon vaucheri (Lesq.) Lindb. & Broth.] – Rare: 7a, 15. In moss-herb and lichen-moss-liverwort communities; with Drepanoclados arcticus, Flexitrichum flexicaule. The genus Buckia was established by Câmara et al. (2018) to accommodate Hypnum vaucheri.

Butchlandiella sudetica (Funck) Bednarek-Ochry & Ochrya – Rare: 31a. On bare soil by shore of sea.

Calliergon cordifolium (Hedw.) Kindb. – Rare: 4. In grass-moss community.

C. giganteum (Schimp.) Kindb.– Savicz, 1936; Abramova et al., 1961; Afonina, 2015; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7, 10, 20, 31a. In forb-liverwort-lichen, moss-lichen and spotty Salix-herb-lichen-moss communities; on bare loamy-gravelly soil; with Distichium capillaceum, Flexitrichum flexicaule.


Ceratodon heterophyllus Kindb. – Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 2, 5, 7, 12, 12b, 13, 19, 22, 24a, 33b, 35. In Phippsia-moss, moss-lichen communities; with Bryum rutilans, Pohlia cruda, Polytrichastrum septentrionale.

C. purpureus (Hedw.) Brid. (spor.) – Palibin, 1903-1906; Savicz, 1936; Störmer, 1940; Abramova et al., 1961; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 10, 22, 33b. In Poa arctica-lichen-moss, Phippsia-moss-liverwort, herb-moss communities; Saxifraga-moss open plant communities; on bare soil among boulders; with Ceratodon heterophyllus, Syntrichia ruralis etc.

Cinclidium arcticum (Bruch & Schimp.) Schimp. – Odasz, 1996; Afonina, 2015. Rare: 7. The species is given for the archipelago according to A.M. Odasz (1996).

Conostomum tetragonum (Hedw.) Lindb. – Sofronova et al., 2019a. Rare: 12b. In moss-liverwort community.

Dicranella subulata (Hedw.) Schimp. (spor.) – Czernyadjeva et al., 2015. Rare: 5. In lichen-moss-lichen community.

*Dicranum acutifolium* (Lindb. & Arnell) C.E.O. Jensen – Sporadic: 4, 6, 7, 11, 12a, 24a, 26, 30, 31a. In Saxifraga-lichen, herb-moss-lichen, moss-lichen communities; Papaver-moss-lichen open plant communities; with Aulacomnium turgidum, Sanionia uncinata, Tomentypnum involutum etc.

D. elongatum Schleich. ex Schwägr. – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 1c, 2f, 4, 5, 7, 11a, 12, 13, 16, 22, 24a, 26, 30, 31a, 31b. In differently Poa arctica-lichen-moss, herb-moss-lichen, ror-lichen-moss-lichen-lower plant communities; grass-lichen, moss-lichen open plant communities; with Aulacomnium turgidum, Sanionia uncinata, Tomentypnum involutum etc.

D. frondosa (Hedw.) Kindb. – Rare: 7. In moss-lichen-lichen community; with Distichium capillaceum, Pohlia cruda, Sanionia uncinata, Tomentypnum involutum etc.

*D. inclinatum* (Hedw.) Bruch & Schimp. (spor.) – Rare: 7. In spotty forb-lichen community; with Didymodon icnadophillus.

Drepanocladius arcticus (Williams) Hedenäs – Savicz, 1936; Stormer, 1940; Abramova et al., 1961; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1, 2c, 2d, 2e, 2f, 2g, 3, 4, 5, 6, 7, 7a, 12b, 19, 21, 22, 23, 25, 26, 27, 30, 31a. In various herb-lichen-moss-lichen-lower plant communities, moss-lower-lichen-moss-lower plant communities; with Phippsia-lichen-moss-lower and polygonal herb-lichen-lichen open plant communities.

D. polygamus (Schimp.) Hedenäs – Afonina & Czernyadjeva, 1995; Moseev et al., 2018, 2019. Rare: 4, 7, 30. In grass-moss and herb-lichen-lower plant communities; with Sanionia uncinata, Stereodon holmenii etc.

D. spadiceum (Hedw.) E. J. Zetterst. – Rare: 7. In moss-lower-lichen-moss-lower plant communities; with Aulacomnium turgidum, Sanionia uncinata, Tomentypnum involutum etc.

D. vinealis (Brid.) R.H. Zander – Rare: 7. In spotty forb-lichen community; with Distichium inclinatum.


*D. vinealis* (Brid.) R.H. Zander – Rare: 7. In Saxifraga-lichen-moss community; with Distichium capillaceum, Flexitrichum flexicaule. Earlyl for Hooker Island D. rigidus was recorded (Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015), but later the specimen was reidentified as *D. vinealis* by J. Kučera.

Distichium capillaceum (Hedw.) Bruch & Schimp. (spor.) – Palibin, 1903-1906; Savicz, 1932; Savicz, 1936; Abramova et. al., 1961; Aleksandrova, 1983; Safranova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 1b, 2c, 2e, 4, 5, 6, 7a, 10, 11, 12a, 13, 15, 16, 19, 20, 21, 22, 23, 24a, 26, 27, 29, 30, 31a, 33a. In different Saxifraga-moss-lower, Salix polaris-herb-lichen-moss, Papaver-lichen-moss, Phippsia-lichen-moss, herb-lichen-moss-lower communities; forb-moss and Phippsia-lichen-moss polygonal open plant communities.


*D. inclinatum* (Hedw.) R.H. Zander – Rare: 7. In spotty forb-lichen community; with Didymodon icnadophillus.

Drepanocladius arcticus (Williams) Hedenäs – Savicz, 1936; Stormer, 1940; Abramova et al., 1961; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1, 2c, 2d, 2e, 2f, 2g, 3, 4, 5, 6, 7, 7a, 12b, 19, 21, 22, 23, 25, 26, 27, 30, 31a. In various herb-lichen-moss-lichen-lower plant communities, moss-lower-lichen-lower-moss-lower plant communities; with Phippsia-lichen-moss-lower and polygonal herb-lichen-lichen open plant communities.
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1932, 1936; Størmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1b, 1c, 2c, 2e, 2g, 4, 5, 6, 7, 9a, 10, 12a, 12c, 13, 14, 16, 19, 20, 21, 22, 23, 24a, 27, 30, 31a, 32, 33a, 33b, 34. In different Saxifraga-moss-lichen communities, *Phytopia*-lichen-moss, forb-lichen-moss-lichen, forb-lichen-moss-lichen, lichen-sooty moss communities; moss-lichen polygonal and lichen-moss-lichen communities.


*Hygrohypnella polare* (Lindb.) Ignatov & Ignatova – Savicz, 1932, 1936; Størmer, 1940; Abramova et al., 1961; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Frequent: 1, 1a, 1b, 2c, 2e, 2f, 2g, 3, 4, 6, 7, 11, 12, 13, 14, 16, 22, 27. In different *Phytopia*-lichen-lichen communities, *Phytopia*-lichen-moss, *Salix arctica*-lichen-moss, moss-lichen communities; with *Timmia austriaca*, *Timmia uncinata*, *Tomentypnum involutum* etc. *Hygrohypnum luridum* (Hedw.) Jenn. – Afonina, 2015. Rare: 4, 7. In Salix-lichen communities, moss-lichen communities.


*Hymenoloma crispula* (Hedw.) Ochyra (spor.) – Savicz, 1932, 1936; Størmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Moseev et al., 2019. Common: 1a, 1b, 2c, 2g, 4, 5, 6, 7, 7a, 8, 11, 16, 17, 20, 22, 24a, 25, 26, 27, 31b, 32, 33b, 34. In *Saxifraga*-lichen-moss-lichen communities, moss-lichen communities; moss-lichen open plant communities.

*Hypnum cupressiforme* Hedw. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 2f, 7. In *Saxifraga*-moss-lichen communities with *Sanionia uncinata*.

*Isopterygiella pulchella* (Hedw.) Ignatov & Ignatova [*Isopterygiopsis pulchella* (Hedw.) Z. Ivats.]. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1b, 2e, 4, 7, 23, 24a, 30, 31a, 33b. In forb-moss-lichen, herb-lichen-moss-lichen communities; with *Bartramia ithyphylla*, *Dicranum spadiceum*, *Flexitrichum flexicaule*, *Pohlia cruda*, *Sanionia uncinata*, *Timmia austriaca* etc.

*Kiæeria glacialis* (Berrgr.) J. Hagen – Rare: 1a, 1c. In lichen polygonal open plant community; on rocks.


*Leptosyncha pyriforme* (Hedw.) Wilson – Rare: 5. On gravelly slope; with *Tayloria acuminata*, *Tortula leucolelostra*.

*Leptodictyum riparium* (Hedw.) Warnst. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7. In lichen-herb community with *Distichium capillaceum*.

*Lesnikska pylea* (Brid.) F. Lara, Garilleti & Gofﬁnet [*Orthotrichium pylea* (Brid.) (spor.)] – Savicz, 1936; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 7. On gravelly scree on slope; on rocks near waterfall.

*Loeskytnum badium* (C.C. Hartm.) Paul. – Czernyadjeva et al., 2019. Rare: 24a, 24b, 33b. In *Salix polaris*-moss-lichen communities; on fine earth between boulders; with *Bryum sp.*, *Scorpidium revolvens*, *Warnstoria sarmentosa*.


*M. cf. lycopodioides* Schwägr. – Rare: 30. In *Salix polaris*-lichen communities; with *Flexitrichum flexicaule*, *Pohlia cruda*.

Myarella julacea (Schwägr.) Schimp.– Savicz, 1932, 1936; Abramova et al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Moseev et al., 2019. Rare: 1a, 2c, 4, 6, 7, 10, 13, 19, 23, 27, 30, 31a. In *Papaver*-lichen communities; with *Bartramia ithyphylla*, *Distichicum capillaceum*, *Flexitrichum flexicaule*, *Orthotrichium chryseon*, *Pohlia cruda*, *Timmia austriaca* etc.

*M. tenerima* (Brld.) Lindb. – Savicz, 1936; Abramova et al., 1961; Aleksandrova, 1983; Safronova, 1986;
Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1b, 2h, 7, 7a, 21, 30, 31a, 33b. In forb-moss-lichen, forb-lichen, moss-lichen communities; with Distichium capillaceum, Flexitrichum flexicaule, Orthothecium sp., Pohlia cruda, Roaldia revoluta, Timmia austriaca.


*N. ericoides* (Brid.) Bednarek-Ochyra & Ochyra – Savicz, 1936; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1b, 1c, 2g, 4, 6, 7, 15, 25, 27. In moss-lichen polygonal, herb-lichen-moss, grass-lichen-moss, moss-lichen-liverwort communities; for lichen open plant communities; with Aulacomnium turgidum, Flexitrichum flexicaule, Orthothecium sp.

*N. panschii* (Müll. Hal.) – Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1a, 1b, 1c, 2g, 7, 15, 19, 21, 22, 23, 24a, 26, 27. In forb-moss-lichen, herb-lichen-liverwort, gravelly moss-lichen, moss-lichen open polygonal communities; with Flexitrichum flexicaule, Sanionia uncinata.

*Oncophorus demetrii* (Renauld & Cardot) Hedenäs – Rare: 12a, 15, 27. In Saxifraga-lichen-moss, Salix polaris-lichen-moss, Phippsia-lichen-moss, moss communities; with Distichium capillaceum, Flexitrichum flexicaule. *O. demetrii* was recognised as a species by Hedenäs (2018).


*O. virens* (Hedw.) Brid. – Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 1, 5, 6, 7, 12, 12a, 19. In Saxifraga-lichen-moss communities; with Distichium capillaceum.

*O. wahlenbergii* Brid. [O. compactus (Bruch et Schimp.) De Not.] – Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1c, 1d, 2h, 6, 12, 22, 24a, 24b, 31a, 31b. In Phippsia-moss-lichen, forb-lichen-moss-liverwort, gravelly lichen, moss-lichen communities; with Distichium capillaceum, Flexitrichum flexicaule, Pohlia cruda etc.

*Orthothecium chryseon* (Schwägr.) Schimp. – Savicz, 1932, 1936; Abramova et al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1, 1b, 2c, 4, 5, 6, 7a, 8, 10, 11, 12a, 12c, 15, 16, 19, 21, 22, 23, 25, 26, 31a, 33b, 34. In different Saxifraga-lichen-moss, Phippsia-lichen-moss, forb-moss-lichen, forb-lichen-liverwort, herb-lichen-moss-liverwort, moss-lichen communities; Phippsia-lichen-moss polygonal and forb-lichen open plant communities.

*O. remotifolium* Ignatov & Ignatova – Rare: 6, 7. Moss community on the terrace with Myurella julacea, Pohlia cruda, Sanionia uncinata etc. Det. E.A. Ignatova. This species and the next are given according to Ignatov et al., 2020.

*O. retroflexum* Ignatov & Ignatova – Sporadic: 2e, 2g, 4, 6, 7, 7f, 24b, 27, 31a, 33. In moss and moss-lichen communities; Papaver polare open plant communities; swampy moss-lichen communities with Salix polaris.

*O. strictum* Lorentz – Savicz, 1932, 1936; Abramova et al., 1961; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1b, 2c, 2g, 7a, 13, 16, 19, 20, 22, 30, 33a. In Papaver-lichen-moss, Phippsia-moss-lichen, forb-moss-lichen communities; herb-moss-lichen open plant communities; on fine earth between stones.

*Orthotrichium pellucidum* Lindb. – Odasz, 1996; Afonina, 2015. Rare: 7. The species is given for the archipelago according to A.M. Odasz (1996).

*Philonotis fontana* (Hedw.) Brid. – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 2e, 2g, 4, 5, 7, 7a, 31a. In grass-moss, herb-moss, moss communities; with Bryum cryophilum, Flexitrichum flexicaule, Orthothecium sp.


*Plagiomnium curvatulum* (Lindb.) Schljakov – Rare: 1c. In gravelly moss-lichen community; with Bryum sp., Drepanoclados arcticus.

*P. ellipticum* (Brid.) T.J. Kop. – Palibin, 1903-1906; Savicz, 1936; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015;
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Savicz, 1936; Abramova communities; with 13.

Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare:

In moss-lichen-moss, herb-lichen-moss communities; with Distichium capillaceum, Drepaznocladus arcticus, Flexitrichium flexicaule, Orthothecium sp.
Pogonatum dentatum (Brd.) Brd. – Sofronova et al., 2019b. Rare: 1a. In moss-lichen community.

Pohlia andrewsii A.J. Shaw (gem.) – Sofronova et al., 2019a. Rare: 2e, 2f, 12b. In lichen-liverwort and Phippsia-moss communities; Saxifraga-moss open plant community; with Ceratodon purpureus, Pohlia drummondii, Pspilium caviolium, Sanionia uncinata, P. drummondii, Phippsia dii, Psilopilum cavifolium, Sanionia uncinata.
P. beringiensis A.J. Shaw (gem.) – Ellis et al., 2019a. Rare: 1b, 30, 31b. In lichen-moss-liverwort polygonal, moss-liverwort and moss communities; with Alacom- nium turgidum, Bryum rutilans, Pohlia cruda.
P. cruda (Hedw.) Lindb. (spor.) – Palibin, 1903-1906; Savicz, 1932, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Savronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1, 1a, 1b, 2c, 2d, 2e, 2f, 2g, 3, 4, 5, 6, 7, 7a, 9, 10, 11, 12a, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24a, 26, 27, 28, 30, 31a, 31b, 32, 33a, 33b, 34. In different Phippsia-lichen-liverwort polygonal, Salix polaris-lichen-liverwort, Poa arctica-lichen-moss, Phippsia-lichen-moss, forb-liverworts, forb-lichen-moss, herb-lichen-moss-liverwort, moss-liverwort, moss-liverwort-moss, lichen-moss communities; moss-liverwort polygonal, Saxifraga-moss, Papaver polare moss and forb-lichen open plant communities.
P. crudoides (Sull. & Lesq.) Broth. – Sofronova et al., 2019b. Rare: 31b. In moss-liverwort-moss polgyo- nal community; with Timmia austriaca.
P. drummondii (Müll. Hal.) A.L. Andrews (gem.) – Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 1, 2d, 2e, 2f, 2g, 4, 5, 7, 9, 11, 12a, 12b, 15, 16, 19, 22, 24a, 31a, 33b. In Phippsia-moss, lichen-liverwort, moss-lichen, moss-grass, herb-lichen communities; Saxifraga-moss and moss-lichen-moss open plant communities; with Bartramia ithyphylla, Bryum sp., Flexitrichium flexicaule, Pohlia cruda, Pspilium caviolium, Sanionia uncinata etc.
P. nutans (Hedw.) Lindb. (spor.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 1, 1b, 2d, 2f, 4, 5, 6, 7, 11, 12a, 13, 16, 20, 24a, 26b, 28, 31a. In Salix polaris-lichen-moss, lichen-moss-liverwort polygonal, forb- lichen-moss-liverwort, herb-moss, moss-lichen communities; with Dicranum elongatum, D. laevidens. Pohlia cruda, Stereodon holmenii.
P. obtusifolia (Vill. ex Brd.) L.F. Koch – Savicz, 1932; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1b, 2c, 7, 11, 12, 33b. In moss communities; on fine earth between boulders; with Polytrichastrum fragile.
Polytrichastrum alpinum (Hedw.) G.L. Sm. – Savicz, 1932, 1936; Stormer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 1, 2b, 2c, 2e, 4, 5, 6, 7, 7a, 10, 11, 12a, 13, 15, 16, 19, 20, 24b, 25, 31a, 31b, 33a. In different Salix polaris-moss-lichen, herb-moss-lichen, grass-moss, moss-liverwort, lichen-liverwort communities; Phippsia-lichen-moss polygonal open plant communities.
P. fragile (Bryhyn) Schljajkov – Savicz, 1932, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 1, 1b, 1c, 2e, 2d, 2e, 2g, 5, 6, 7, 12a, 12b, 13, 14, 16, 17, 19, 22, 24a, 26, 28. In Phippsia-lichen-moss, forb-lichen, grass-liverwort, herb-moss, moss-liverwort, gravelly moss-lichen communities; moss-liverwort polygonal and forb-lichen open plant communities.
P. septentrionale (Brd.) E.I. Ivanova, N.E. Bell & Ignatov – Czernyadjeva et al., 2015. – Common: 1b, 2c, 2e, 2f, 2g, 4, 5, 7, 12b, 14, 16, 22, 23, 24a, 25, 26, 27, 31b, 32. In Phippsia-lichen-liverwort polygonal, P. arctica-lichen-moss, Phippsia-moss, herb-lichen-moss-liverwort, forb- lichen-moss-liverwort, grass-moss, moss-lichen communities; herb-moss-lichen, moss-lichen polygonal and forb-lichen open plant communities.
The species is given for the archipelago according to A.M. Odasz (1996).

Polytrichum hyperborea R. Br. – Czernyadjeva et al., 2015; Afonina, 2015. Rare: 1b, 5. In lichen-moss-liverwort and moss communities.


P. juniperinum Hedw. – Czernyadjeva et al., 2015; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 2e, 5. In herb-moss community.

P. piliferum Hedw. – Savicz, 1936; Størmer, 1940; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1a, 4, 7, 14, 31b. In moss-liverwort-lichen polygonal community with Dicranum elongatum.


P. turgescens (T. Jensen) Loeske – Savicz, 1936; Størmer, 1940; Abramova et. al., 1961; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Common: 1a, 1b, 2a, 2c, 2g, 5, 6, 7, 12a, 10, 17, 26, 27. In forb-liverwort-lichen, herb-moss-lichen, gravelly lichen, grass-moss, moss-lichen communities; forbb-lichen open plant community; on lake shore; with Drepanocladus arcticus, Flexitrichum flexicaule, Scorpioides revolvens etc.


Racomitrium lanuginosum (Hedw.) Brid. – Palibin, 1903-1906; Savicz, 1932, 1936; Abramova et. al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 1a, 1b, 2c, 2e, 4, 5, 6, 7a, 12, 16, 17, 18, 20, 21, 22, 24a, 26, 31a, 31b, 33a, 33b, 34. In Phippsia-lichen-moss, Poa arctica-lichen-moss, herb-moss-lichen, forb-liverwort, lichen-liverwort, moss-lichen communities; Papaver polare and lichen polygonal open plant communities.

Rhizomnium pseudopunctatum (Bruch & Schimp.) T.J. Kop. – Czernyadjeva et al., 2015. Rare: 4, 5. In grass-moss communities; with Brachythecium turgidum, Plagiomnium ellipticum.

Roaldia revoluta (Mitt.) P.E.A.S. Câmara & Carv.-Silva (Stereodon revolutus Mitt.) – Savicz, 1932, 1936; Abramova et. al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 1a, 1b, 2a, 2g, 4, 5, 6, 7a, 10, 13, 14, 16, 19, 20, 21, 22, 23, 24a, 25, 26, 28, 29, 30, 31a. In Saxifraga-lichen-moss, forb-moss-liverwort, lichen-moss-liverwort, moss-lichen-moss-moss, moss-lichen-liverwort, moss-moss-lichen and lichen open plant communities. The genus Roaldia was established to accommodate Hyphnum revolutum s.lat. (Câmara et al. 2018).

Saelania glaucescens (Hedw.) Broth. – Sofronova et al., 2019a. Rare: 20, 23, 27. In Phippsia-lichen-moss, moss-lichen polygonal, herb-lichen-moss-liverwort communities; on fine earth between boulders; with Bartramia ithyphylla, Isopterygiella pulchella.

*Sanionia nivalis* Hedenäs – Sporadic: 1a, 1c, 1d, 11, 25, 27, 31b, 33b. In gravelly moss-lichen, moss-lichen-moss open plant communities; with Hygrohypnella polaris, Pohlia cruda, Pseudocalliergon turgescens, Warnstorfia sarmentosa.

S. orthothecioides (Lindb.) Loeske – Palibin, 1903-1906; Savicz, 1932, 1936; Størmer, 1940; Abramova et. al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 3, 5, 6, 7a, 13. In Papaver-lichen-moss, moss-lichen-liverwort communities; with Roaldia revoluta, Syntrichia ruraria.

S. uncinata (Hedw.) Loeske – Palibin, 1903-1906; Savicz, 1932, 1936; Størmer, 1940; Abramova et. al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Moseev et. al., 2019. Common: 1, 1a, 1b, 2a, 2c, 2d, 2e, 2f, 2g, 3, 4, 5, 6, 7, 7a, 8, 10, 12a, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24a, 25, 26, 27, 29, 31a, 33a, 33b, 34. In various Poa arctica-lichen-moss, Saxifraga-lichen-moss, Phippsia-lichen-moss-liverwort, moss-lichen-liverwort, forb-moss-liverwort, grass-liverwort, moss-lichen-moss-moss, moss-liverwort, moss-lichen-moss open plant communities.

**S. andreaeopsis** (Müll. Hal.) Laz. – Rare: 24b. In *Salix polaris-moss-lichen community; with Distichium capillaceum, Pseudocalliergon brevifolium*.


*S. frigidum* H.H.Blom (spor.) – Afonina, 2015. Rare: 1c, 2b, 7, 13, 15. In gravelly moss-lichen, moss-lichen-liverwort and moss-lichen communities; with *Bryum* sp., *Polytrichastrum alpinum*.

*S. grandirete* H.H. Blom (spor.) – Sofronova et al., 2019b. Rare: 1a, 2g, 15, 27. In herb-moss-lichen and grass-moss-lichen communities; for-*lich-in lichen open plant community; with Or**

*Orthothecium sp.*. Pseudocalliergon turgescens, Sanionia uncinata. *S. holmenianum* Steree & Brassard – Rare: 27. In moss-lichen polygonal community.


*S. plathyphyllum* (Mitt.) H. Perss (spor.) – Rare: 7. On rocks.

*S. rugo-hypnum glacieale* (Schimp.) Ignatov & Huttunen – Odasz, 1996; Afonina, 2015. Rare: 1c, 5, 7. In grass-moss and moss communities; with *Brachythecium turgidum, Drepanocladus arcticus, Sanionia uncinata*. *S. rugossidium* cossonii (Schimp.) Hedenäs – Moseev et al., 2018, 2019. Sporadic: 1c, 7a, 10, 12c, 21, 33b. In for-*lich-lich moss, herb-moss, gravelly moss-lichen, moss-lichen communities; with Phippsia-lichen-moss polygonal open plant community; with *Brachythecium turgidum, Flexitrichum flexicaule, Orthothecium sp.*

*S. revolvens* (Sw.) Rubers – Savicz, 1932, 1936; Abramova et al., 1961; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Sporadic: 1a, 4, 5, 6, 7, 7a, 12c, 24b, 26, 27. In *Salix polaris-moss-lichen, Phippsia-lichen-moss, grass-lichen moss, herb-moss communities; with Flexitrichum flexicaule, Orthothecium sp.*, Pseudocalliergon brevifolium.

*Splachnum vasculosum* Hedw. – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 13. On grevelly slope; with *Philonotis tomentella*.

*Stegonia latifolia* (Schwägr.) Venturi ex Broth. (spor.) – Abramova et al., 1961; Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7. On southern grevelly slope.

*Stereodon callichroum* (Brud.) Braithw. – Odasz, 1996; Afonina, 2015. Rare: 7. The species is given for the archipelago according to A.M. Odasz (1996).

*S. hamulosum* (Schimp.) Lindb. – Rare: 12a. In Saxifraga-lichen-moss community; with *Bartramia utphylla, Bryum sp.*, *Distichium capillaceum, Flexitrichum flexicaule*.


*Straminegron stramineum* (Dicks. ex Brid.) Hedenäs – Savicz, 1936; Störmer, 1940; Abramova et al., 1961; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Sporadic: 2b, 2d, 4, 7, 11, 13, 31a. In herb-moss and grass-moss communities; with *Aulacomnium palustre, Sanionia uncinata*.


*Timmia austriaca* Hedw. – Savicz, 1932; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Common: 1b, 2e, 2f, 4, 5, 6, 7, 7a, 10, 11, 12a, 15, 16, 20, 21, 22, 23, 24a, 26, 28, 29, 30, 31a, 31b, 33b.


*T. bavarica* Hessl. – Rare: 29. In forb-lichen open plant community; with *Roadalia revoluta*. *T. norvegica* J.E. Zetterst. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Rare: 4, 5, 7. In spotty *Salix-lichen-moss, herb-moss, gravelly herb-moss moss and gravelly moss communities; with *Bryum* sp., *Distichium capillaceum, Flexitrichum flexicaule, Orthothecium sp.*, *Pohlia drummondii*. *Tomentypnum involutum* (Limpr.) Hedenäs & Ignatov [Tomentypnum nitens (Hedw.) Loeske var. involutum]
Catosciptum nigrum (Hedw.) Brid. – The record of this species from archipelago in Moss Flora of Russia (Ignatov & Ignatova, 2017) is erroneous.

Climacium dendroides (Hedw.) F. Weber & D. Mohr – This species was erroneously reported for Maybell Island (Moseev et al., 2018, 2019). The specimen was re-indentified as Drepanoclados arcticus by Czernyadjeva.

Dicranum angustum Lindb. – Previously, this species was reported from archipelago as common (Czernyadjeva, 1992; Odasz, 1996; Afonina & Czernyadjeva, 1995); later the materials were reidentified by Afonina as D. laevidens according to Nyholm (1986).

Dicranum flexicaule Brid. (D. congestum auct. non Brid.) – Previously Dicranum congestum was reported for archipelago (Savicz, 1932, 1936; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995). Later it was synonymized with D. flexicaule and under this name was recorded for archipelago (Afonina, 2015). These specimens were later reidentified as D. acutifolium by Afonina.

Didymodon rigidulus Hedw. – This species was erroneously reported for Hooker Island (Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015), the specimen was reidentified as D. vinealis by J. Kučera.

Drepanoclados aduncus (Hedw.) Warnst. – This species was erroneously reported for Heiss Island (Moseev et al., 2018, 2019), the specimen was reidentified as Sanionia uncinata by Czernyadjeva.

Ochyraea alpestris (Hedw.) Ignatov & Ignatova – The record of this species from Hooker and Meibel Islands (Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995) was based on erroneously identified specimens. They were reidentified as Hygrohypnum luridum by Czernyadjeva.

Orthothecium complanatum Kindb. – The record of this species from Hooker Island (Czernyadjeva, 1992) is erroneous. The specimens were reidentified as O. strictum by Afonina.

Plagiothecium affine (Blandow ex Funck) T.J. Kop. – The record of this species from archipelago (Afonina & Czernyadjeva, 1995) belongs to P. ellipticum.

Pohlia filamentosa (Schimp.) Mårtensson – This species was erroneously recorded from Hooker Island (Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015). The specimens were reidentified as P. drummondii by Czernyadjeva.


Schistidium apocarpum (Hedw.) Bruch & Schimp. – According Ignatova & Blom (2017), this species does not occur in Franz Josef Land Archipelago; all so-named specimens were reidentified as S. plathypyllum, S. flexipile, S. frigidum, and S. abraticostatum by E.A. Ignatova.
Schistidium confertum (Funck) Bruch & Schimp. – The record of this species on McClintock Island (Savicz, 1936; Savicev-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995) is erroneous. The specimens were reidentified as S. frigidum by E.A. Ignatova.

Schistidium gracile (Röhl.) Limpr. – The record of this species on Hooker and Northbrook islands (Savicz, 1932, 1936; Alexandrova, 1983) is erroneous. The specimens were reidentified as S. papillosum by E.A. Ignatova.

Schistidium pulchrum H.H. Blom – This species was reported for McClintock Island (Afonina, 2015), later the specimen was reidentified as S. frigidum by E.A. Ignatova.

Schistidium rivulare (Brid.) Podp. – The record of this species on Hooker Island is erroneous (Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995). The specimens were reidentified as Schistidium abrupticostatum by E.A. Ignatova.

Schistidium strictum (Turner) Loeske ex Mårtensson – This species was recorded from the archipelago by Savicz-Ljubitzkaja & Smirnova (1970), Aleksandrova (1983), and Odasz (1996). However, according to Ignatova & Blom (2017), it does not occur in Russia.

Sciuro-hypnum plamosum (Hedw.) Ignatov & Huttunen – The record of this species on Hooker Island (Moseev et al., 2018, 2019) is erroneous. The specimen was reidentified as Sanionia uncinata by Czernyadjeva.

Syntrichia norvegica F. Weber – The record of this species on Hayes Island (Moseev et al., 2018, 2019) is erroneous. The specimen was reidentified as S. ruralis by Afonina.

Warnstorfia tundrae (Arnell) Loeske – This species was recorded for Hooker Island by Savicz (1936) as Drepanoclados exannulatus (Bruch et al.) Warnst. var. tundrae (Arnell) Dietz., and subsequently it was reported for archipelago as Warnstorfia exannulata by Afonina & Czernyadjeva (1995); however, later the specimen was reidentified as W. pseudostreuminea.

**DISCUSSION**

Mosses (comprising 270 species and 8 intraspecific taxa) in the polar desert zone are the richest group of plants in terms of the species number (Afonina, 2015). The diversity of mosses in this region exceeds the diversity of vascular plants by more than two times. This ratio is one of the characteristic features of the polar desert zone (Matveeva, 2015).

At the present time the list of mosses of Franz Josef Land Archipelago, based on identification of recent collections, revision of herbarium materials and literature data, includes 156 species and one variety; 18 species are listed for archipelago for the first time, and 6 species are included based on literature records. The moss species diversity of the archipelago is thus nearly three times more than that of vascular plants (57 taxa) (Safronova et al., 2020).

The largest number of species was recorded for Hooker (101 species), Alexandra Land (73), Northbrook (62), Meibel (58), George Land (53), Alger (46), Jackson (44) islands. Less than 40 species were collected on the remaining islands, and less than 10 species were listed for 9 islands (Table 1). This difference in species richness between the islands was attributed primarily to the duration of collection trips, as visits to some islands were short and mostly random.

The families Polytrichaceae (13 species), Grimmiaceae (13), and Pottiaceae (8) dominate the moss flora of the archipelago, which is due to the wide distribution of stony-gravelly substrates on the islands. The genera Bryum (11 species), Pohlia (9), Schistidium (8) and Dicranum (7) are fairly well represented in the flora, whereas the genera Sphagnum and Grimmia were not recorded. The absence of species of the genus Sphagnum was expected because in polar deserts they are very rare. Species of the genus Grimmia also were not collected on archipelago, apparently due to overlooking during botanical exploration, as these species prefer rocky substrates. It should be noted that species of the genus Cinclidium are weakly represented in the archipelago. In tundra zone, they are usually common and often constitute an important component of moss cover. However, in the archipelago only Cinclidium arcticum was reported from Hooker Island by A.M. Odaz (1996).

The moss flora in the archipelago is dominated by arctic-montane species (49) and arctic species (24), whereas holarctic polyzonal (22), omniholarctic polyzonal (21), bipolar (22), and cosmopolitan (4) species are less abundant. The geographical distribution was not established for nine species.

Eighteen species are widely distributed and found on most islands, where they constitute an important component of the vegetation in polar deserts: Aulacomnium turgidum, Bartramia ithyphylla, Brachythecium turgidum, Dicranum elongatum, Distichium capillaceum, Drepandrus arcticus, Flexitrichum flexicaule, Hymenoloma crispula, Orthothecium chryseon, Pohlia cruda, Polytrichastrum septentrionale, Pseudocallicegon brevifoliatum, Racomitrium lanuginosum, Roaldia revoluta, Sanionia uncinata, Syntrichia ruralis, Timmia austriaca, Tomentypnum involutum. An important components of the moss communities are Aulacomnium palustre, Bryum rutilans, Dicranum laevidens, Hygrohypnella polare, Hylocomium splendens, Polytrichastrum alpinum, and P. fragile. Myurella julacea, Pohlia drummondii and P. nutans are common, although they grow in small amount and usually in mixed tufts. Typical species of waterlogged habitats are Bryum cryophilum, Philonotis fontana, P. tomentella, Pseudocallicegon turgescens, Warnstrofia sarmentosa. Andreaea papillosa, Ceratodon puepureus, Encalypta rhaptocarpa, and Niphotrichum canescens are frequent on spots of bare soil.
Table 1. The number of moss species on the islands of Franz Josef Land Archipelago

<table>
<thead>
<tr>
<th>Island [number in Fig 1]</th>
<th>N species</th>
<th>Island [number in Fig 1]</th>
<th>N species</th>
<th>Island [number in Fig 1]</th>
<th>N species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandra Land [1]</td>
<td>73</td>
<td>Kane [26]</td>
<td>27</td>
<td>Eva-Liv [34]</td>
<td>10</td>
</tr>
</tbody>
</table>

Fifty eight percent of all species of the archipelago are rare. Of those, 12 species are included in “A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts” (Hodgetts et al., 2019): Campylium bambergeri, Distichium inclinatum, Drepanocladus sendtneri, Encalypta rhaptocarpa, Loeskiypnum badium, Meisia triquetra, Platydicyta jungermannioides, Saelania glaucescens, Scorpidium cossionii, Stereodon holmenii, Tetraplodon mniooides, and Timmia bavaria.

The following species can be noted as the most rare and interesting in moss flora of archipelago.

Arctoa anderssonii has a mostly arctic distribution. In European part of Russian Arctic it is recorded for the first time. In Asian Russia it is known from the Chelyuskin Cape on the Taimyr Peninsula, Bolshevik Island in the Severnaya Zemlya Archipelago, and in the mountain regions of the central part of the Kamchatka Peninsula (Czernyadjeva, 2012; Afonina, 2015). Outside Russia, it is known from Iceland, the Faroe Islands, Jan Mayen Island, Svalbard in Norway, Sweden, Greenland, Canadian Arctic Archipelago, Yukon and Alaska ( Schofield et al., 2004; Hallingbäck et al., 2006; Newmaster, 2007).

Pohlia beringiensis is an arctic-montane species with main distribution in North America and Asia. The finding of this species in the Franz Josef Land Archipelago is the northernmost. It was recently identified in collections from the Prince Oscar Land, Svalbard (Belkina & Likhachev, 2013). In Asian Russia P. beringiensis is known from Arctic and Subarctic zones of Yamal and Taimyr Peninsulas, Anabar Plateau, Severnaya Zemlya Archipelago, Yakutia, Magadan Province, Commander Islands, Chukotka, Wrangel Island, and mountain regions of South Siberia (Altai, Kodar Range in Zabaikalsky Territory) (Afonina et al., 2017; Czernyadjeva, 2018; Fedosov et al., 2011). In European Russia it was recorded twice in the Ningens Autonomous Area: Bolshezemelskaya tundra and Vaygach Island (Afonina, 2006). Records of P. beringiensis for the Murmansk and Amur regions, Khabarovsky and Primorsky Territories in the «Moss Flora of Russia» (Czernyadjeva, 2018) are erroneous.

Schistidium abrupticostatum is distributed mostly in the Arctic and Subarctic. It is known from Svalbard, Sweden, Norway, arctic regions of North America; in Russia it was found on the Novaya Zemlya Archipelago, Taimyr Peninsula, Anabar Plateau, Severnaya Zemlya Archipelago, lower reaches of the Lena and Kolyma Rivers (Ignatova & Blom, 2017).

Schistidium andreaeopsis is an arctic species; its findings in archipelago are the most northern. It occurs in the Arctic and Subarctic of Asian Russia (Taimyr Peninsula, October Revolution and Bolshevik Islands of the Severnaya Zemlya Archipelago, Wrangel Island and Chukotka); it is known from a few localities in Yakutia, and from the Novaya Zemlya Archipelago in European Russia. In North America S. andreaeopsis is recorded from Canadian Arctic Archipelago: Prince Patrick and Ellef Ringnes Islands (Afonina et al. 2005; Afonina 2015; Ignatova & Blom, 2017).

Schistidium grandirete is an arctic species. In the High Arctic it is known from Chelyuskin Cape (Taymyr Peninsula), Bolshevik and October Revolution Islands (Severnaya Zemlya Archipelago), Amund Ringnes and Ellensere Islands (Canadian Arctic Archipelago), Peary Land (Greenland) (Afonina, 2015), Svalbard and North of Scandinavia (Ignatova & Blom, 2017).

As a result of our study, a relatively high moss diversity was revealed in the archipelago. Its moss flora, 156 species, comprises 57.7 % of the total number of species (270) known in the polar desert zone (Afonina, 2015). For comparison, 149 species of mosses were recorded from Nordaustlandet, an island in the archipelago of Svalbard (Frisvoll, Elvebakk, 1996; Belkina, Likhachev, 2013), 135 species in the northern extremity of the Novaya Zemlya Archipelago (Fedosov et al., 2019), 165 species in the Severnaya Zemlya Archipelago (Afonina, 2015), and 186 species in the Canadian Arctic Archipelago (Afonina, 2015).
Table 2. The similarity of moss floras in the polar desert zone in Franz Josef Land (FJL), Novaya Zemlya (NZ) and Svalbard (Sv) by Sørensen-Czekanowski Index, Csc; [the numbers of species for areas and number of species in common are given in brackets]

<table>
<thead>
<tr>
<th></th>
<th>FJL</th>
<th>NZ</th>
<th>Sv</th>
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<tr>
<td>Csc=2c/(a+b), where a — is the number of species in flora one, b — is the number of species to another flora, c — is the number of shared species</td>
<td>0.325</td>
<td>0.328</td>
<td>0.32</td>
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Zemlya, 96 species for Franz Josef Land and Svalbard, and 96 species for Novaya Zemlya and Svalbard; 68 species are distributed in all three regions. The pairwise comparison of the flora using Sørensen-Czekanowski’s Index of similarity (Csc) revealed the same degree of similarity between the three floras (Table 2).

The more southern position of Novaya Zemlya and the influence of the Gulf Stream on Svalbard determined the presence of some boreal species, i.e. Brachydecaxstrum trachypodium, Dicranum bonjeanii, Pleurozium schreberi, Warnstorfiella exannulata, and W. fluviatilis in these territories. In addition, two species of the genus Sphagnum and the boreal species Climacium dendroides and Plagiothecium denticulatum were recorded on Svalbard. All these species are absent in the more northern Franz Josef Land. In contrast, a number of rare arctic species, such as Arctoa anderssonii, Schistidium andreeseae, and S. grandirete, have been collected only on Franz Josef Land. Also the arctic species Drepanoclados arcticus, which has not yet been documented in the polar deserts of Novaya Zemlya and Svalbard, is widespread and often abundant in Franz Josef Land.

It can be assumed that the revealed species richness of mosses on Franz Josef Land Archipelago is rather complete. However, the new species findings are possible; in addition, it should be taken into account that some taxonomic changes that are currently taking place in connection with molecular phylogenetic studies.

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LITERATURE CITED

Mosses of the Franz Josef Land Archipelago


