Mosses of the Franz Josef Land Archipelago (Russian Arctic)

Irina V. Czernyadjeva1, Olga M. Afonina1 & Sergei S. Kholod1

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.

INTRODUCTION

Franz Josef Land Archipeligo 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 floristic 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. In 1930, V. P. Savicz participated in the All-Union Arctic Expedition on the icebreaker “Georgy Sedov”. He visited Aaagaard, Alger, Bell, Hooker, McClintoik, Northbrook and Scott-Keltie islands, and made an extensive collection of mosses. Specimens were identified by L.I. Savicz, along with collections of I.I. Prezent in 1932 at Northbrook and Rudolf islands. Thus the list of mosses of the archipelago increased up to 75 species (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

1 – Komarov Botanical Institute Rus. Acad. Sci., Prof. Popova Str. 2, St. Petersburg, 197376, Russia – Ботанический институт им. В. Л. Комарова РАН, 197376 Россия, Санкт-Петербург, ул. Проф. Попова, 2; e-mail: irinamosses@yandex.ru, stereodon@yandex.ru, sergeikholod@yandex.ru
were collected for these relevés have not been preserved and cannot be re-examined. In 1979, I.N. Safronova conducted geobotanical studies on Meibel 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 were 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, Meibel 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. (Govorukh, 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
Mosses of the Franz Josef Land Archipelago

Fig. 1. Collecting localities and collectors of mosses in Franz Josef Land:

1. Alexandra Land Island: 1959 Aleksandrova.
2. Alexandra Land Island, cape Meri Harmsworth, 80°36'N, 44°57'E: 1930 Hanssen; 2012 Kholod.
3. Alexandra Land Island, to south of the polar station «Nagurskaya», 80°47'N, 47°35'E: 2012 Kholod.
4. Alexandra Land Island, Severnaya Bay, 80°46'–80°47'N, 47°43'–47°54'E: 2019 Konoreva, Chesnokov.
5. Alexandra Land Island, Zveroboev Bay, 80°48'N, 48°08'E: 2019 Konoreva, Chesnokov.
6. George Land Island, Stephens Cape: 1930 Hanssen.
7. George Land Island, Forbes Cape: 1930 Hanssen.
8. George Land Island, Nansen Cape, 80°27'N, 47°29'E: 1930 Hanssen; 2012 Kholod.
9. George Land Island, Grey Bay, 80°14'N, 47°36'E: 2012 Kholod.
10. George Land Island, Kalina Cape, 80°14'N, 47°28'E: 2012 Kholod.
11. George Land Island, Krautera Cape, 80°09'N, 47°11'E: 2012 Kholod.
12. George Land Island, northwestern part, 80°51'N, 49°52'E: 2012 Kholod.
13. George Land Island, Armitage Peninsula, Bay of Geographers, 80°48'N, 50°28'E: 2019 Konoreva, Chesnokov.
14. Bell Island, 80°00'N, 49°15'E: 1930 Savich; 2016 Moseev.
15. Meibel Island, –80°01'N, 49°22'E: 1979 Safrochina; 2012 Kholod; 2016 Moseev.
16. Northbrook Island, Flora Cape, 79°57'N, 50°06'E: 1901 Palibin; 1929 Ivanov; 1930 Savich; 1930 Hanssen; 1932 Prezent; 2012 Kholod.
17. Scott-Keltie Island, 80°19'N, 52°40'E: 1930 Savich.
18. Hooker Island: 1929 Ivanov; 1930 Savich; 1991 Odasz; 1979 Safrochina;
19. Hooker Island, Cape Sedova, polar station Tikhaya Bay, –80°20'N, 52°52'E: 1929 Ivanov; 1930 Savich; 2012 Kholod; 2016 Moseev; 2019 Konoreva, Chesnokov.
20. Etheridge Island, 80°04'N, 59°21'E: 2016 Moseev.
21. Li-Smith Island, 80°12'N, 54°21': 2016 Moseev.
22. Nansen Island, 80°29'N, 54°07'E: 2012 Kholod.
23. Brice Island, 80°25'N, 55°10'E: 2012 Kholod.
24. Alger Island: 1930 Savich.

12a. Alger Island, 80°22'N, 56°03'E, Camp Ziegler: 1930 Hanssen; 2012 Kholod.
12b. Alger Island, Baldwin expedition winter field camp, 80°21'N, 56°13'E: 2012 Kholod.
12c. Alger Island, cape Podgorny: 2016 Moseev.
13. McCintock Island, Dillon Cape, 80°05'N, 55°48'E: 1930 Savich; 2012 Kholod.
14. Aagaard Island, 80°00'N, 56°20'E: 1930 Savich.
15. Hall Island, Cape Tegetthof, 80°05'N, 58°01'E: 2012 Kholod.
16. Wilczek Island, 79°53'N, 58°52'E: 2012 Kholod.
17. Lamont Island, 79°46'N, 58°40'E: 2012 Kholod.
18. Hochstetter Island, 80°11'N, 60°07'E: 1901 Palibin.
19. Heiss Island, 80°37'N, 58°03'E: 2007 Zaverina; 2016 Moseev.
20. Fersman Island, 80°38'N, 57°57'E: 2012 Kholod.
21. Champ Island, 80°40'N, 56°14'E: 2012 Kholod.
22. Wilczek Land Island, 80°48'N, 60°05'E: 2012 Kholod.
23. Wiener Neustadt Island, 80°51'N, 58°52'E: 2012 Kholod.
24a. Ziegler Island, surroundings of Cape Bryce, the site of an Austrian expedition field camp, 81°04'–81°06'N, 56°14'–56°18'E: 2012 Kholod; 2019 Konoreva, Chesnokov.
24b. Ziegler Island, in the surroundings of Rhodes strait, 80°52'N, 57°17'E: 2019 Konoreva, Chesnokov.
25. Greely Island, 80°56'N, 58°21'E: 2012 Kholod.
26. Kane Island, 81°06'N, 58°31'E: 2012 Kholod; 2016 Moseev.
27. Kuhn Island, 81°07'N, 58°28'E: 2012 Kholod; 81°07'N, 58°19'E: 2019 Konoreva, Chesnokov.
28. Apollonov Island, 81°10'N, 58°08'E: 2012 Kholod.
29. Gage Island, 80°52'N, 60°05'E: 2012 Kholod.
30. La Ronciera Island, 80°58'N, 60°00'E: 2012 Kholod.
31a. Jackson Island, Norway Cape, 81°12'N, 55°33'–55°37'E: 2012 Kholod; 2019 Konoreva, Chesnokov.
31b. Jackson Island, Bystron Cape, 81°20'N, 55°41'E: 2012 Kholod.
32. Hoffmann Island, 81°17'N, 60°25'E: 2012 Kholod.
33a. Rudolf Island, Borok Cape: 1929 Ivanov; 1932 Prezent.
33b. Rudolf Island, near the polar station “Rudolph Island”, 81°48’–81°49’N, 57°55’–58°57’E: 2007 Zaverina; 2012 Kholod.
34. Eva-Liv Island, 81°38’N, 63°00’E: 2012 Kholod.
35. Graham Bell Island: Hanssen, 1930; 80°52’N, 64°17’E: 2007 Zaverina.
the families Poaceae, Juncaceae, Caryophyllaceae, Bras-
sicaceae, Saxifragaceae predominate. The vegetation of
the archipelago is characterized by a high degree of spar-
sity: 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 usu-
ally does not exceed 5–7 species per relevé plot (e.g., Pa-
paver polare, Phippsia algida, Saxifraga cespitosa, S. ni-
vallis, S. oppositifolia, Cerastium regelii ssp. caespitosum,
Stellaria edwardsii). The average height of plants is 12–
15 cm, being taller 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, Sax-
ifraga cespitosa). Under the canopy of dwarf shrubs
mosses and lichens form a shallow carpets. Various po-
lygonal communities with an average coverage of 8–10
% are usually represented on loamy watersheds. Poly-
gons usually have a diameter of 45–60 cm, being sepa-
rated by hollows 15–20 cm wide. The polygons have a
crust of liverworts, and inhabited by such vascular plants
as Papaver polare, Cerastium arcticum, Cochlearia
groenlandica, Stellaria edwardsii. Hollows have dense
patches of lichens (e.g., Flavocetraria nivalis, Pseude-
phebe pubescens, Alectoria nigricans, Cetraria islandi-
da, Hypogymnia subobscura), with overall , the projec-
tive coverage ca. 25%. Communities of the spotted po-
lygonal type are also formed on the tops of loamy
slopes with species such as Papaver polare, Aloepecurus alpi-
nus subsp. borealis, Luzula confusa, Poa abbreviata,
Minuartia rubella. Lichen coverage here is 30–40 % (e.g.,
Stereoaulon alpinum, S. arcticum, Flavocetraria cucul-
lata, Alectoria nigricans, Thamnolia vermicularis).

Peculiar vegetation is formed on high sea terraces lo-
cated below the cliffs-steep, steep rocks with sea birds
nesting on them. A characteristic feature of the vegeta-
tion of such terraces is the exceptionally high projective
coverage of mosses, which in some cases reaches up to
95 %. Here, moss turf is formed with a thickness of 8–12
cm. Most of species here are common in arctic tundra:
Aulacomnium turgidum, Hylomniun sp., Tomen-
typnum involatum, Sanionia uncinita, Bryum sp., asso-
ciating with such vascular plants as Aloepecurus alpinus
subsp. borealis (12-15 %), and also Poa arctica, Ranunc-
culus sulphureus, Cochlearia groenlandica, Stellaria ed-
wardsii, Saxifraga cernua, S. rivularis. The abundance
of lichens is always quite high (up to 55 %) in the mar-
ginal parts of the terraces adjacent to the coastal ledge,
these are Flavocetraria cucullata, Bryocaulon divergens,
Stereoaulon botryosum, Umbilicaria proboscidea,
Sphaerophorus globosus, Cetraria islandica.

On the surface of a number of islands (at an altitude
of 15–20 m above sea level), loamy soils with admixture
of gravel are present. Here, sparse groupings of li-
chens with vascular plants are common (e.g., Poa ab-
breviata, Luzula confusa, Minuartia rubella, Cerasstium
arcticum). Large clusters of Thamnolia vernicularis li-
chen 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 (Gymnomi-
trion sp.). The role of some vascular plants, in particu-
lar, Phippsia algida, Cerastium regelii, Saxifraga hyper-
borea, Cochlearia groenlandica, increases on coastal
plains composed of sand deposits, the total coverage of
which reaches 10%. Mosses and lichens cover the sur-
face of large- and medium-sized blocky basalt ruins with
a glandular crust. Large layers of the scale lichen Por-
pidia 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
(Gymnomitrion sp.). On low sea terraces, large polygons
sometimes develop with abundant lichen vegetation,
with coverage in some areas up to 70-80 % (Alectoria
nigricans, Bryocaulon divergens, Pseudephebe pubes-
cens, Sphaerophorus fragilis, S. globosus, Umbilicaria
arctica, U. decussata). In the valleys that divide poly-
gons, a nival situation occurs, the sign of which is a cer-
tain set of mosses and lichens: (e.g., Andreaea rupesriss,
Racomitrium lanuginosum, Cetrariella delisii ). On nu-
merous taluses that overlap the slopes of the plateau and
individual remains, extremely sparse vegetations is formed
(projective coverage – 1-2 %), where 4-5 species of vas-
cular plants are usually found (e.g., Saxifraga cespito-
sa). In the lower parts of the mobile scree, there is a black-
ening of the slope with a projective vegetation cover of
up to 15-17 %. Alectoria nigricans, Bryocaulon diver-
gens, Luzula confusa and Potentilla hystarcica are com-
mon in the vegetation cover.

COLLECTIONS

The present publication is based on the identification
of mosses collected by S.S. Kholod on 25 islands in Franz
Josef Land Archipelago in 2012. The results of the iden-
tification of moss collections made in 2019 by L.A. Konor-
eva 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 tax-
onomical 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 syn-
onyms that are common in some Russian publications (in
brackets). After the species name the presence of reproduc-
tive 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*, *Flextrichium flexicaule*) community; B: George Land Island, moss (*Hygrohypnella polare*, *Drepanoclados 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 cryophyllum*, *Orthothecium* sp.) community near the seashore; G: Northbrook Island, Flora Cape, stony-gravelly moss (*Bryum cryophyllum*, *Brachythecium turgidum*, *Orthothecium* sp.) community; H: Northbrook Island, Flora Cape, moss (*Warnstorfia sarmentosa*, *Brachythecium turgidum*, *Aulacomnium palustre*) community near snowfields.
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 wormskiioldii (Hornem.) R. Br. (spor.) – Palibin, 1903-1906; Savicz, 1936, 1936; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1, 1c, 7a, 7e, 17, 24a, 33a, 33b. On soil in moss-lichen community; on rocks, boulders, fine earth between boulders.

A. rupesstris (Hedw.) Schimp. – Rare: 5. Andreea 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.) Schwägr. – Savicz, 1932; 1936; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; 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.

Arctoa anderssonii Wich. (spor.) – Ellis et al., 2019b. Rare: 4, 26, 30. In moss, lichen-moss-lichen open plant community.

Aulacomnium palustre (Hedw.) Schwägr. – Savicz, 1932; 1936; Störmer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 2a, 2b, 2e, 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 et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 1996; Afonina, 2015; Czernyadjeva et al., 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 et 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-moss communities.

B. mildeanum (Schimp.) Schimp. ex Milde – Savicz, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 5, 7. On streem bank.

B. salebrosum (F. Weber & D. Mohr) Schimp. – Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Safronova et al., 2019b. Rare: 28. On loamy-gravelly soil near shore of sea, with Pohlia cruda. Det. Ignatov.

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, 2h, 5, 7a, 10, 12a, 13, 15, 19, 20, 21, 22, 25, 27, 30, 31a. In various grass-moss-lichen, herb-moss-lichen-liverwort, forb-lichen-moss-liverwort, graminoids-lichen-moss, Phippsia-moss, Papaver-lichen-moss communities; in Phippsia-moss-lichen and moss-lichen open plant communities.

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

Bryoerythrophyllum ferruginaescens (Stirt.) Giacom. – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1, 7, 22, 27, 31a. In forb-moss-lichen and Phippsia-moss-lichen communities with Distichium capillaceum, Euryynchiastrum pulchellum, Flexitrichium flexicaule, Sanionia uncinata.

B. recurvirostrum (Hedw.) P.C. Chen – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7, 19, 22. In Salix-lichen-moss, Phippsia-moss-lichen communities with Distichium capillaceum, Myurella tenerrima, Oncophorus wahlenbergii.

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-moss-lichen, moss-lichen-liverwort, Saxifraga-lichen-moss communities and Phippsia-moss-lichen moss-lichen open plant communities; on loamy-gravelly area; with Myurella julacea, Pohlia cruda, Niphophitrichum pashii, Polytrichastra septentrionale etc.
Bryum arcticum (R. Br.) Bruch & Schimp. (spor.) – Savicz, 1936; Abramova et al., 1961; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 1, 3, 4, 5, 7, 14. In Salix-herb-lichen-moss, herb-lichen-moss, forb-lichen communities.

B. argenteum Hedw. – Savicz, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 5, 7, 13, 14. On rocks and gravelly scree.

B. cryophilum Mårtensson – Palibin, 1903-1906; Savicz, 1932, 1936; Størmer, 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, 7, 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, Scorpidium revolvens, Warnstorfia sarmentosa etc.

B. cyclophyllum (Schwägr.) Bruch & Schimp. (gem.) – Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1, 12, 31a, 33a. In Saxifraga-moss, moss-lichen communities with Drepanoclados arcticus, Flexitrichum flexicaule, Polytrichium septentrionale.

*B. cf. elegans Nees – Sporadic: 1b, 4, 20, 26, 30. In Saxifraga-moss, moss-liverwort, forb-moss, herb-moss-lichen communities; Papaver-moss-lichen open plant communities with Flexitrichum flexicaule etc.

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

B. nitidulum Lindb. (spor.) – Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995. Rare: 14.

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

B. pseudostrictum (Hedw.) P. Gaertn., 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-moss-lichen 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, Flexitrichium flexicaule. The genus Buckia was established by Câmara et al. (2018) to accommodate Hypnum vaucheri.

*Buclandiella sudetica (Funck) Bednarek-Ochyra & Ochyra – 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; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7, 10, 20, 31a. In forb-liverwort-moss, moss-lichen and spotty Salix-herb-lichen-moss communities; on bare loamy-gravelly soil; with Distichium capillaceum, Flexitrichium flexicaule.

C. stellatum (Hedw.) C.E.O. Jensen – Savicz, 1932; Abramova et al., 1961; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Sporadic: 1, 1b, 7a, 10, 22, 33b. In Phippsia-moss-lichen, herb-moss, moss-liverwort-moss communities; Phippsia-lichen-moss polygonal open plant community; with Flexitrichium flexicaule, Orthothecium sp.

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; Størmer, 1940; Abramova et al., 1961; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 1a, 2c, 2f, 2g, 4, 5, 7, 13, 14, 17, 18, 32, 34. In Poa arctica-moss-lichen, 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.

Cratoneuron curvispica (Jur.) G. Roth – Savicz, 1932, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 7, 13, 19. On gravelly slope.
Dicranella subulata (Hedw.) Schimp. (spor.) – Czernyadjeva et al., 2015. Rare: 5. In lichen-moss-lichen-moss communities.

*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, 11, 12a, 13, 16, 22, 24a, 26, 30, 31a, 31b. In differently *Poa arctica*-lichen-moss, herb-moss-lichen, forb-lichen-moss-lichen-liverwort, grass-lichen-moss-lichen-polygonal open plant communities; moss-lichen-polygonal open plant communities.

D. groenlandicum Brid. – Czernyadjeva et al., 2019. Rare: 13. In grass-lichen-moss community.

*D. laevidens* R.S. Williams – Afonina, 2015; Czernyadjeva et al., 2015. Frequent: 2f, 4, 5, 7, 7a, 12a, 15, 22, 26. In *Salix polaris*-lichen-moss, Saxifraga-lichen, herb-moss-lichen, grass-lichen-moss communities; *Papaver*-moss-lichen open plant communities; with *Aulacomnium turgidum*, *Sanionia uncinata*, *Stereodon holmenii* etc.

*D. leioneuron* Kindb. – Rare: 7. This species is given on a base of identification of one specimen collected by I.M. Ivanov in 1929 on Hooker Land Island and identified by L.I. Savicz as *D. scoparium* Hedw. var. *integrifolium* Lindb.

D. scoparium Hedw. (D. scoparium var. *integrifolium* Lindb.) – Størmer, 1940. Rare: 5. This species was recorded from Franz Jozef Land also by L.I. Savicz (1932) and Savicz-Ljubitzkaja & Smirnova, (1970) as *D. scoparium* var. *integrifolium* Lindb. However, during the revision the so-named specimens were reidentified as *D. laevidens*; Størmer’s record needs confirmation.

D. spadiceum J.E. Zetterst. – Czernyadjeva et al., 2019. Rare: 2e, 4, 12a. In Saxifraga-lichen-moss, herb-moss-lichen communities.

*Didymodon icmadophilus* (Schimp. ex Müll. Hal.) R.H. Zander – Rare: 7. In spotty forb-lichen community; with *Distichium inclinatum*.

*D. vinealis* (Brud.) R.H. Zander – Rare: 7. In *Salix polaris*-herb-lichen-moss community; with *Distichium capillaceum*, *Flexitrichum flexicaule*. Earlyly for Hooker Island *D. rigidulus* 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; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Common: 1, 1b, 2c, 2e, 4, 5, 6, 7, 7a, 10, 11, 12a, 13, 15, 16, 19, 20, 21, 22, 23, 24a, 26, 27, 29, 30, 31a, 33a. In different Saxifraga-moss-lichen-liverwort, *Salix polaris*-herb-lichen-moss, *Papaver*-lichen-moss, *Phippsia*-lichen-moss, herb-lichen-moss-lichen-moss communities; forb-moss and *Phippsia*-lichen-moss polygonal open plant communities.

D. hagenii Ryan ex H. Philib. – Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995. Rare: 7. On a rocky southern slope.

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

Drepanoclados arcticus (Williams) Hedénäs – Savicz, 1936; Størmer, 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-liverwort, lichen-moss-liverwort polygonal, forb-liverworts, *Phippsia*-lichen-moss, lichen-moss communities; *Phippsia*-lichen-moss-liverwort and polygonal herb-moss-lichen open plant communities.

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

Encalypta alpina Sm. (spor.) – Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 1, 7, 10, 19, 21. In forb-liverworts and herb-liverwort-lichen communities; with *Distichium capillaceum*.

E. rhaptocarpa Schwägr. (spor.) – Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 7, 7a, 13, 24a, 26, 31a. In forb-moss-lichen-liverwort; on fine earth between stones.

E. trachymitra Ripart (spor.) – Savicz, 1932, 1936; Størmer, 1940; Abramova et al., 1961; Afonina & Czernyadjeva, 1995. Rare: 5, 7, 13. On fine earth between stones; on gravelly slope; with *Orthothecium strictum*, *Syntrichia ruralis*.

Eurynchiastrum pulchallum (Hedw.) Ignatov & Huttunen – Savicz, 1936; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 7, 7a, 13, 24a, 26, 31a. In forb-lichen-moss-liverworts, herb-moss-lichen, moss-lichen communities; *Papaver*-moss-lichen open plant community; with *Distichium capillaceum*, *Pohlia cruda*, *Sanionia uncinata*, *Roaddia revoluta*, *Timmia austriaca*.

Flexitrichum flexicaule (Schwägr.) Ignatov & Fedosev [Didymichum flexicaule (Schwägr.) Hampe] – Savicz,
Mosses of the Franz Josef Land Archipelago

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: 1, 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, *Phippsia*-lichen-moss, forb-lichem-moss-lichen, grass-lichen-lichen, herb-moss-lichen communities; moss-lichen polygonal and lichen-moss-lichen-moss identical plant communities.

*F. gracile* (Mitt.) Ignatov & Fedosov [Ditrichum gracile (Mitt.) Kuntze] – Czernyadjeva et al., 2019. Sporadic: 1c, 4, 10, 11, 16, 22, 31a. In *Phippsia*-lichen-moss, herb-lichen-lichen, lichen-moss lichen-lichen communities; for open plant community with *Pohlia cruda, Sanioniauncinata, Syntrichia ruralis, Tomentypnum involutum* etc.

*Hennerdiella heimii* (Hedw.) R.H. Zander var. arctica (Lindb.) R.H. Zander (spor.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 5, 7, 7a. In 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, 6, 7, 11, 12, 13, 14, 16, 22, 27. In different *Phippsia*-lichen-liverwort polygonal, grass-lichen-lichen, lichen-lichen, forb-lichen-lichen communities; *Saxifraga*-moss and moss-lichen polygonal open plant communities.

*Hygrohypnum luridum* (Hedw.) Jenn. – Afonina, 2015. Rare: 4, 7. In *Salix*-lichen-lichen-moss and gravelly herb-lichen-lichen communities.

*Hylocomium splendens* Schimp. – 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. Frequent: 1, 2e, 2f, 4, 5, 7, 7a, 10, 11, 12, 15, 22, 24a, 26, 27, 31a, 33a. In different *Poa arctica*-lichen-moss, *Phippsia*-moss-lichen, *Saxifraga*-moss-lichen, grass-lichen-lichen, herb-lichen-lichen communities; herb-moss-lichen open plant communities.

*Hymenoloma crisptula* (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*-moss-lichen, forb-lichen, lichen-lichen communities; moss-lichen polygonal open plant communities.

*Hypnum cupressiforme* Hedw. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 2f, 7. In *Saxifraga*-moss open plant community with *Sanioniauncinata.*

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

*Kiaeria glacialis* (Brrgr.) I. Hagen – Rare: 1a, 1c. In lichen polygonal open plant community; on rocks.

*K. starkei* (F. Weber & D. Mohr) I. Hagen – Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1. The species is given for the archipelago according to V.D. Aleksandrova (1983).

*Leptobryum pyriforme* (Hedw.) Wilson – Rare: 5. On gravelly scree; with *Tayloria acumana, Tortula leucasoma.*

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

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

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

*Meesia triquetra* (Jolycl.) Ĺngstr. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Moseev et al., 2019. Rare: 4, 7, 12c, 24b. In *Salix* polaris-lichen communities.

*Mnium blyttii* Bruch & Schimp. – Aleksandrova, 1983; Afonina, 2015. Rare: 1. The species is given for the archipelago according to V.D. Aleksandrova (1983).

*M. cf. lycopodioides* Schwägr. – Rare: 30. In *Salix* polaris-lichen-moss community 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: 4, 5, 7, 7a, 10, 13, 19, 23, 27, 30, 31a. In Papaver-lichen-moss, forb-lichen-moss, herb-lichen-lichen-liverwort, grass-moss communities; *Phippsia*-lichen-moss polygonal, herb-moss-lichen and forb open plant communities; with *Bartramia ithyphylla, Dictichiumcapillaceum, Flexitrichum flexicaule, Orhtothecium chryseum, Pohlia cruda, Timmia australica.*

*M. tenerrima* (Brid.) Lindb. – Savicz, 1936; Abramova et al., 1961; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Moseev et al., 2019.
Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1b, 2h, 7, 7a, 21, 30, 31a, 33b. In forb-moss-lichen, forb-liverworts, moss-lichen communities; with Distichium capillaceum, Flexitrichium flexicaule, Orhtothecium sp., Pohlia cruda, Roaddia revoluta, Timmia austriaca.

Niphotrichum canescens (Hedw.) Bednarek-Ochya & Ochya – Savicz, 1932; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Sporadic: 1, 1b, 4, 7, 11, 22, 23, 30, 32, 33b. In Phippsia-lichen-liverwort, herb-lichen-moss-liverwort polygonal, moss-lichen, herb-moss-lichen communities; on fine earth between boulders; with Hymenoloma crispulum, Flexitrichium flexicaule, Orhtothecium sp.

N. canescens subsp. latifolium (C.E.O. Jensen) Bednarek-Ochya & Ochya – Afonina, 2015. Rare: 4, 7, 33a.

N. ericoides (Brid.) Bednarek-Ochya & Ochya – 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-brief open plant communities; with Aulacornium turgidum, Flexitrichium flexicaule, Orhtothecium sp.

N. panschii (Müll. Hal.) Bednarek-Ochya & Ochya – Afonina, 2015. Sporadic: 2a, 1b, 1c, 7, 7a, 15, 19, 21, 22, 23, 24a, 26, 27. In forb-moss-lichen, herb-lichen-liverwort, gravelly moss-lichen, communities; moss-lichen polygonal open plant communities; with Flexitrichium flexicaule, Sanionia uncinata. *Oncophorus demetrii* (Renauld & Cardot) Hedenäs (2018).

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

*O. integerimus* Hedenäs – Sporadic: 4, 7a, 10, 23, 31a. In herb-lichen-moss-liverwort, grass-moss, moss-lichen communities; Phippsia-lichen-moss polygonal open plant community; Drepanoclados arcticus, Orhtothecium sp., Scorporidium revolutum, Warnstorphi sermentosa. O. integerimus was recognised at species level by Hedenäs (2017).

*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-lichen 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: 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, Flexitrichium 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. In different Saxifraga-lichen-moss, Phippsia-lichen-moss, forb-moss-lichen, forb-liverwort, herb-lichen-moss-liverwort, moss-lichen communities; Phippsia-lichen-moss polygonal and forb-liver 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-lichen-moss, forb-moss-lichen communities; herb-moss-lichen open plant communities; on fine earth between stones.

Orhtothecium 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, Flexitrichium flexicaule, Orhtothecium sp.

P. tomentella Molendo – Savicz, 1932, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015. Sporadic: 1, 2e, 2f, 4, 5, 7, 11, 13. In forb-moss-lichen, herb-moss-lichen, forb-liverwort, liverwort-moss communities; Saxifraga-moss and forb-liver open plant communities.

*Plagiomnium curvatulum* (Lindb.) Schljakov – Rare: 1c. In gravelly moss-lichen community; with Bryum sp., Drepanoclados arcticus.
Czernyadjeva et al., 2015. Sporadic: 1, 2e, 2f, 4, 5, 12a, 13. In Saxifraga-lichen-moss, herb-moss, grass-moss communities; with Brachythecium turgidum, Rhizomnium pseudopunctatum, Sanionia uncinata.

Plagiothecium berggrenianum Frisvoll – Czernyadjeva et al., 2015. Rare: 5. In grass-moss community; with Dicranum laevidens, Pohlia nutans, Sanionia uncinata. P. pseudopunctatum, Sanionia uncinata.

Platydictya jungermannioides (Brid.) H.A. Crum – Savicz, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare: 7, 12a, 13. In Saxifraga-lichen-moss and gravelly herb-lichen-moss communities; with Distichium capillaceum, Drepanoclados arcticus, Flexitrichum flexicaule, Orthothecium sp.

Pogonatum dentatum (Brid.) Brid. – Sofronova et al., 2019b. Rare: 1a. In moss-lichen community.

P. urnigerum (Hedw.) P. Beauv [P. urnigerum var. subintegriofolium (Arnell & C.E.O. Jensen) H.A. Möller] – Savicz, 1936; Aleksandrova, 1983; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 1, 1c, 3, 11, 19, 34. In herb-moss-lichen and lichen communities; on rocks.

Pohlia andrewsi A.J. Shaw (gem.) – Sofronova et al., 2019a. Rare: 2e, 2f, 12b. In lichen-liverwort and Phisippa-moss communities; Saxifraga-moss open plant community; with Ceratodon purpureus, Pohlia drummondii, Psilopilum cavifolium, Sanionia uncinata.

P. beringiensis A.J. Shaw (gem.) – Ellis et al., 2019a. Rare: 1b, 30, 31b. In lichen-liverwort-moss polygonal, moss-liverwort and moss communities; with Allacomnium 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; Sarfónova, 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 Phisippa-lichen-liverwort polygonal, Salix polaris-lichen-moss, Poa arctica-lichen-moss, Phisippa-lichen-moss, forb-liverworts, forb-lichen-moss, herb-lichen-moss-liverwort, grass-moss, liverwort-moss, lichen-moss-liverwort communities; moss-lichen-moss, Saxifraga-moss, Papaver polare-moss and forb-lichen open plant communities.

P. crudaoides (Sull. & Lesq.) Broth. – Sofronova et al., 2019b. Rare: 31b. In moss-liverwort-moss polygonal community; with Timmia austria.

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, 4, 5, 7, 9, 11, 12a, 12b, 15, 16, 19, 22, 24a, 31a, 33b. In Phisippa-moss, lichen-liverwort, moss-lichen, grass-moss, herb-lichen communities; Saxifraga-moss and moss-lichen-moss open plant communities; with Bartramia ithyphylla, Bryum sp., Flexitrichum flexicaule, Pohlia cruda, Psilopilum cavifolium, 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, 26, 28, 31a. In Salix polaris-lichen-moss, lichen-moss-liverwort polygonal, forb-lichen-moss-liverwort, herb-moss, moss-lichen-moss communities; with Dicranum elongatum, D. laevidens, Pohlia cruda, Stereodon holmenii.

P. obtusifolia (Vill. ex Brid.) L.F. Koch – Savicz, 1932; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Afonina & Czernyadjeva, 1995; Afonina, 2015. Sporadic: 1b, 2c, 7, 11, 12b, 33b. In moss communities; on fine earth between boulders; with Polytrichastrum fragile.

P. proligera (Kindb.) Lindb. & Broth. (gem.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 2e, 5, 12a, 25. In lichen-liverwort, herb-lichen, grass-moss communities; with Drepanoclados arcticus, Polytrichastrum alpinum.

P. wahlenbergii (F. Weber & D. Mohr) A.L. Andrews – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 4. In moss community on shore of stream; with Sanionia uncinata.

Polytrichastrum alpinum (Hedw.) G.L. Sm. – Savicz, 1932, 1936; Stormer, 1940; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Aleksandrova, 1983; Sarfónova, 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, 12, 12a, 13, 15, 16, 19, 20, 24b, 25, 31a, 31b, 33a. In different Salix polaris-moss-lichen, herb-moss-lichen, grass-moss, moss-liverwort communities; Pohlia cruda, lichen-liverwort, lichen-liverwort communities; Phisippa-moss-lichen-moss polygonal open plant communities.

P. fragile (Bryhn) Schljakov – 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 Phisippa-moss-lichen, forb-lichen, grass-moss, herb-moss, moss-lichen-moss-liverwort, gravelly moss-lichen communities; moss-lichen polygonal and forb-lichen open plant communities.

P. septentrionale (Brid.) 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 Phisippa-moss-lichen-liverwort polygonal, Poa arctica-lichen-moss, Phisippa-moss, herb-lichen-moss-liverwort, forb-lichen-moss-liverwort, grass-moss, moss-lichen communities; herb-lichen-moss, moss-lichen-polygonal and forb-lichen open plant communities.
In moss-lichen-liverwort and moss-lichen communities; with Salix polaris, Papaver polare and lichen polygonal open plant communities. *Rhzomnium pseudopunctatum* (Bruch & Schimp.) T.J. Kop. – Czernyadjeva et al., 2015. Rare: 4, 5. In grass-moss communities; with Brachythecium turgitum, 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. Rare: 20, 23, 27. In *Phippsia*-lichen-moss, moss-lichen polygonal, herb-lichen-moss-lichen communities; on fine earth between boulders; with *Bartramia thyphylla*, *Isopterygiella pulchella*.

*Saelania glaucescens* (Hedw.) Broth. – Sofronova et al., 2019a. Rare: 20, 23, 27. In *Phippsia*-lichen-moss, moss-lichen polygonal, herb-lichen-moss-lichen communities; on fine rock. Det. *Saxifraga* licheni-moss, moss-lichen polygonal open plant communities; on fine earth between boulders; with *Hygrohypnella polaris*, *Pohlia cruda*, *Pseudocalliergon turgescens*, *Warnstorfia sarmentosa*.

*S. orthothecioides* (Lindb.) Loeske – Palibin, 1903-1906; Savicz, 1932, 1936; Störmer, 1940; Abramova et al., 1961; Safronova, 1986; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; 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*-moss-lichen, *Poa arctica*-lichen-moss, herb-moss-lichen, forb-lichen-moss-lichen, forbb-lichen-liverwort, moss-lichen communities; *Papaver polare* and lichen polygonal open plant communities.

*S. uncinata* (Hedw.) Loeske – Palibin, 1903-1906; Savicz, 1932, 1936; Störmer, 1940; 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, 2c, 2e, 4, 5, 6, 7a, 12, 16, 17, 18, 20, 21, 22, 24a, 26, 31a, 31b, 33a, 33b, 34. In *Phippsia*-moss-lichen, *Poa arctica*-lichen-moss, herb-moss-lichen, forb-lichen-moss-lichen, forb-lichen-liverwort, moss-lichen communities; *Papaver polare* and lichen polygonal open plant communities.
**S. andreaeopsis** (Müll. Hal.) Laz. – Rare: 24b. In *Salix polaris*-moss-lichen community; with *Distichium capillaceum*, *Pseudocalliergon brevifolium*.

*S. flexipile* (Lindb. ex Broth.) G. Roth – Afonina, 2015. Rare: 7, 13. On rocks.

*S. frigidum* H.H. Blom (spor.) – Afonina, 2015. Rare: 1c, 2h, 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-lichen-moss communities; with *Orthothecium sp.*, *Pseudocalliergon turgescens*, *Sanionia uncinata*. Rare:

*S. holmenianum* Steere & Brassard – Rare: 27. In moss-lichen polygonal community.

*S. papillosum* Cm. (spor.) – Afonina, 2015. Sporadic: 5, 7, 25, 31a. In moss-fern-moss and moss-lichen communities; with *Pohlia cruda*, *Sanionia uncinata*. Det. E.A. Ignatova.

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

*S. turgidum*, *Drepanocladus arcticus*, *Sanionia uncinata* grass-moss and moss communities; with *Sporadic: 2b, 2d, 2f, 4, 7, 11, 13, 31a*. In herb-moss and grass-moss communities; with *Aulacomnium palustre*, *Sanionia uncinata*.

*S. capillaceum* (Schwägr.) Venturi ex Broth. (spor.) – Afonina, 2015. Rare: 4, 5. In gravelly moss-lichen-moss-liverwort, moss-liverwort and moss-lichen communities; with *A. pavar*., *Tetraplodon mnioides*, *Brachythecium turgidum*, *Flexitrichum flexicaule*, *Orthothecium sp.*.

*S. revolvens* (Sw.) Rubers – Savicz, 1932, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Rare: 1c, 7a, 10, 12c, 21, 33b. In forb-lichen-moss, herb-moss, gravelly moss-lichen, moss-lichen communities; *Phippsia*-lichen-moss polygonal open plant community; with *Brachythecium turgidum*, *Flexitrichum flexicaule*, *Orthothecium sp.*.

*S. solirosum* (Sw.) Rub. – Savicz, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 13. On grevelle 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 grevelle slope.

*Tetraplodon mnioides* (Hedw.) Bruch & Schimp. (spor.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 5, 13. On slope on fine earth.

*Timmia austriaica* 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, 35. In differently *Salix polaris*-lichen-moss, *Phippsia*-lichen-liverwort, *Saxifraga*-moss-lichen-moss, moss-lichen-moss polygonal, grammoids-lichen-moss, forb-lichen-moss, herb-lichen-moss, herb-moss-lichen-liverwort communities; *Papaver*-lichen-moss and herb-lichen open plant communities; on bare loamy-gravelly soil.

*T. bavarica* Hessl. – Rare: 29. In forb-lichen open plant community; with *Roodalia revoluta*.

*T. norvegica* J.E. Zetterstr. – Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Afonina, 2015; Czernyadjeva et al., 2015. Rare: 4, 5, 7. In spotty *Salix*-herb-lichen-moss, herb-moss, gravelly herb-lichen moss and gravelly moss communities; with *Bryum* sp., *Distichium capillaceum*, *Flexitrichum flexicaule*, *Orthothecium sp.*, *Pohlia drunnondii*.

*Tomentypnum involutum* (Limpr.) Hedenäs – Afonina & Ignatov [Tomentypnum nitens (Hedw.) Loeske var. involutum]
2015; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015. Rare:

Numerous indications of this species (Savicz, 1932, 1936; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019), according to the last treatment (Heidenäs et al., 2020), refer to Tomenypnum involutum.

Tortula leucostoma (R. Br.) Hook. (spor.) – Savicz, 1936; Abramova et al., 1961; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 5. On fine earth and gravelly of slopes; with Leptobryum pyriforme, Pohlia proliger, Tayloria acuminata.

T. mucronifolia var. aristata Müll. Hal. ex Warnst. (spor.) – Savicz, 1936; Abramova et al., 1961; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995; Afonina, 2015. Rare: 6, 7, 14, 22. On rocky slope; on border along edge of puddle; with Distichium capillaceum, Orthothecium strictum; in forb-moss-lichen community; with Roaldia revoluta.

*Warnstorfia pseudostraminea* (Müll. Hal.) Tuom. & T.J. Kop. – Rare: 7. With Aulacomnium turgidum.

W. sarmentosa (Wahlenb.) Hedenäs – Savicz, 1936; Störmer, 1940; Aleksandrova, 1983; Czernyadjeva, 1992; Afonina & Czernyadjeva, 1995; Odasz, 1996; Afonina, 2015; Czernyadjeva et al., 2015; Moseev et al., 2019. Frequent: J, 1a, 1b, 2c, 2d, 2f, 2g, 3, 4, 5, 6, 7a, 11, 15, 26, 31a, 31b, 33b. In Saxifraga-moss, lichen-moss- liverwort, grass-moss, herb-moss, moss-lichen communities; *Papaver polare* open plant communities; with Aulacomnium palustre, Bryum cryophilum, Orthothecium sp., etc.

EXCLUDED TAXA

Calliergon megalophyllum Mikut. – This species was erroneously reported for Hooker and Alger islands (Moseev et al., 2018, 2019). The specimens were reidentified as Calliergon giganteum by Czernyadjeva.

Calliergon richardsonii (Mitt.) Kindb. – This species was erroneously reported for Meibel Island (Moseev et al., 2018, 2019). The specimens were reidentified as Calliergon cordifolium by M.S. Ignatov.

Campyladelphus chrysophyllus (Brud.) R.S. Chopra – The records of this species for archipelago (Afonina & Czernyadjeva, 1995) are erroneous.

Campylidium protensum (Brud.) Kindb. – This species was erroneously reported for Kane Island (Moseev et al., 2018, 2019). The specimens belong to Drepanoclados arcticus.

Catosciopum nigritum (Hedw.) Brud. – The record of this species for 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 reidentified 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 Brd. (D. congestum auct. non Brd.) – 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. Kucera.

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.

Ochryea 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.

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

Pohlia filum (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.

Sanionia georgicauncinata (Müll. Hal.) Ochrya & Hedenäs – So-named specimens from Hooker Island (Afonina, 2015) belong to Sanionia nivalis.

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. plathyphyllum, S. flexipile, S. frigidum, and S. abrupticostatum by E.A. Ignatova.
Schistidium confertum (Funck) Bruch & Schimp. – The record of this species on McClintock Island (Savicz, 1936; Savicz-Ljubitzkaja & Smirnova, 1970; Afonina & Czernyadjeva, 1995) is erroneous. The specimens were reidentified as S. frigidum by E.A. Ignatova.

Schistidium gracile (Röhrl.) Limpr. – The record of this species on Hooker and Northbrook islands (Savicz, 1932, 1936; Aleksandrova, 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 plumosum (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 Drepanoocladius examnulatus (Bruch et al.) Warnst. var. tundrae (Arnell) Dietz, and subsequently it was reported for archipelago as Warnstorfia examnulata by Afonina & Czernyadjeva (1995); however, later the specimen was reidentified as W. pseudostreumineae.

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), Meibell (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), Grimmia-ceae (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 geobotanical 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 ithyphyllica, Brachythecium turgidum, Dicranum elongatum, Distichium capillaceum, Drepanocladius arcticus, Flexitrichum flexicaule, Hymenoloma crispsula, Orthothecium chryseon, Pohlia cruda, Polytrichastrum septentrionale, Pseudocalliergon brevifolium, Racomitrium lanuginosum, Roaldia revoluta, Sanionia uncinata, Syntrichia ruralis, Timmia austriaca, Tomentypnum involutum. An important components of the moss communities are Aulacomnium palustre, Bryum rutiles, Dicranum laevidens, Hygrohypnella polare, Hylococum splendens, Polytrichastrum alpinum, and P. fragile. Myurella julacea, Pohlia drunmonndii 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, Pseudocalliergon tyraceous, Warnstorfiar sarmentosa. Andreaea papillosa, Ceratodon purpureus, Encalypta rhipocarpa, and Niphophrichum canescens are frequent on spots of bare soil.
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): *Camptosorus bambergeri*, *Distichium inclinatum*, *Drepanoclados sendtneri*, *Encalypta rhahtoparca*, *Loeskynnum badium*, *Meisia triquetra*, *Platydictya jungermannioides*, *Suelingia glaucescens*, *Scorpidium cossinii*, *Streodon holmenii*, *Tetraplodon mnioioides*, and *Timmia bavarica*.

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 collecting 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 Nenets Autonomous Area: Bolshezemelskaya tundra and Vaygach Island (Afonina, 2006). Records of *P. beringiensis* for the Murmansk and Amur regions, Khabarovsk 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 Ellesmere 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).

A comparison of the moss flora of within the Barents Province (Nordaustlandet of Svalbard, Franz Josef Land, and Severn Island of Novaya Zemlya) revealed that 93 species are common for Franz Josef Land and Novaya Zemlya Archipelago.
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]

|       | FJL | NZ  | Sv  |
|-------|-----|-----|-----|
| FJL [157] | 0.325 | 0.32 |
| NZ [135]  | [93]  | [81]  | [81]  |

\[Csc=2c/(a+b), \text{where } a \text{ — is the number of species in flora one, } b \text{ — is the number of species to another flora, } c \text{ — is the number of shared species}\]

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-Chekanovsky’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. Brachylococcum trachypodium, Dicranum bonjeanii, Pleurozium schreberi, Warnstorfia exannulata, and W. fluitans in these territories. In addition, two species of the genus Sphagnum and the boreal species Cladoniun dendroides and Plagiobothrum 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 andreanum, 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 take into account that some taxonomic changes that are currently taking place in connection with molecular phylogenetic studies.

ACKNOWLEDGEMENTS

The authors are very grateful to E.A. Ignatova, M.S. Ignatov, D.Ya. Tubanova, J. Kučera for help in determining complex specimens. The work of I.V. Czernyadjeva and O.M. Afonina was supported by Russian Foundation for Basic Research (grants # 18-05-60093) and it was carried out within the framework of the institutional research project (no. AAAA-A19-119020690077-4) of the Komarov Botanical Institute of the Russian Academy of Sciences; the work of S.S. Khodol was carried out within the framework of the institutional research project (no. AAAA-A18-118031690042-9) of the Komarov Botanical Institute of the Russian Academy of Sciences.

LITERATURE CITED

[ABRAMOVA, A.L., L.I. SAVICZ-LJUBITZKAJA & Z.N. SMIRNOVA] АБРАМОВА, А.Л., Л.И. САВИЧ-ЛЮБИЦКАЯ, З.Н. СМИРНОВА. 1961. Определитель лиственниковых хвоев Арктики СССР. – [Handbook of mosses of Arctic of the USSR] М.-Л., Изд. АН СССР: 1–76.

[AFONINA, O.M.] АФОНИНА О.М. 2004. Виды Нептуния секции Hymalosella (Muscic, Hypnaceae) в России. – [The Hymnium sect. Hymalosella (Muscic, Hypnaceae) in Russia] Arctoa 13: 9–28. https://doi.org/10.15298/arctoa.13.03

[AFONINA, O.M.] АФОНИНА О.М. 2006. Pohlia beringensis A.I. Shaw. – В кн.: Красная Книга Ненецкого Ненецкого автономного округа. [In: Red Book of Nenets Autonomous district] Нарьян-Мар [Нарьян-Мар]: 121.

[AFONINA, O.M.] АФОНИНА О.М. 2015. Mхи – [Mosses] В кн.: Растения и грибы полярных пустынь Северного полушария [In: Plants and fungi of the polar deserts of the Northern Hemisphere]. СПб. [Saint Petersburg]: 75–116.

AFONINA, O.M. & I.V. CZERNYADJEVA. 1995. Mosses of the Russian Arctic: check-list and bibliography. – Arctoa 5: 99–142. https://doi.org/10.15298/arctoa.05.07

AFONINA, O.M., M.K. RAYNOLDS & D.A. WALKER. 2005. On the moss flora of Mould Bay (Prince Patrick Island, Canadian Arctic Archipelago). – Arctoa 14: 115–142. https://doi.org/10.15298/arctoa.14.09

AFONINA, O.M., I.V. CZERNYADJEVA, E.A. IGNATOVA & YU.S MAMONTOV] АФОНИНА О.М., Е.А. ИГНАТОВА & Ю.С. МАМОНТОВ. 2017. Mхи Забайкальского края. – [Mosses of Zabaikalsky Territory] СПб. [Saint Petersburg]: 310 pp.

ALEKSANDROVA, V.D. & ALEKSANDROVA, V.D. 1977. Структура растительных группировок полярной пустыни о. Александры (Земля Франца-Иосифа). – [The structure of plant groups of the polar desert of Alexandria Island (Franz Josef Land)] В кн.: Проблемы экологии, геоботаники, ботанической географии и флористики [In: Problemy ekologii, geobotaniki, botanicheskoy geografii i floristik]. [L.]. [Leningrad]: 26–36.

ALEKSANDROVA, V.D. 2017. О открывы натурализующиеся полярной пустыни о. Александры (Земля Франца-Иосифа) и их классификация. – [Open plant communities of the polar desert of the Alexander Land Island (Franz Josef Land)] В кн.: Проблемы экологии, геоботаники, ботанической географии и флористики [In: Problemy ekologii, geobotaniki, botanicheskoy geografii i floristik]. [L.]. [Leningrad]: 26–36.

ALEKSANDROVA, V.D. 1981. Открытые растительные группировки полярной пустыни о. Александры (Земля Франца-Иосифа) и их классификация. – [Open plant communities of the polar desert of the Alexander Land Island (Franz Josef Land) in the classification] Ботанический журнал [Botanicheskiy Zhurnal] 66(5): 636–649.

ALEKSANDROVA, V.D. 1983. Растительность полярных пустынь СССР. – [Vegetation of polar deserts of the USSR]. [L.]. [Leningrad]: 142 p.

BELKINA, O.A. & A.YU. LIKHACHEV. 2013. Mosses of the Prince Oscar Land (Nordaustlandet, Svalbard). – Arctoa 22: 27–34. https://doi.org/10.15298/arctoa.13.17

BLOM, H.H. 1996. A revision of the Schistidium apocarpum complex in Norway and Sweden. – Bryophytorum bibliotheca 49: 1–333.

BLOM, H.H. 1998. Schistidium Bruch et Schimp. in B.S.G. – In: Nyholm E. Illustrated flora of Nordic mosses. Fasc. 4. Copenhagen; Lund: 249–405.

CÁMARA, P.E.A.S., M. CARVALHO-SILVA, D.K. HENRIQUES, J. GUERRA, M. T. GALLEGOS, D.R. POVEDA, M. STECH. 2018. Pyralisaceae Schimp. (Bryophyta) revised. – Journal of Bryology 40: 251–264. https://doi.org/10.1080/03736687.2018.1472850

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 1992. К бриофлоре архипелага Земля Франца-Иосифа. – [On the bryoflora of Franz Josef Land Archipelago] Новости систематики наших растений [Novosti Sistematiki Nazhikh Rastenij] 28: 156–161.

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 2003. Rod Hygrohypnum (Amblystegiaceae, Musci) в России. – [The genus Hygrohypnum (Amblystegiaceae, Musci) in Russia] Arctoa 12: 23–58. https://doi.org/10.15298/arctoa.12.03

[CZERNYADJEVA, I.V.] ЧЕРНЯДЬЕВА И.В. 2012. Mхи полуострова Камчатка. – [Mosses of Kamchatka Peninsula] СПб. [Saint Petersburg]: 459 pp.

121 Mosses of the Franz Josef Land Archipelago
