Arctoa (2024) **33:** *41–49*
doi: 10.15298/arctoa.33.06

MOSS FLORA OF MAGADAN REGION IN THE CONTEXT OF MOSS FLORAS OF THE RUSSIAN FAR EAST

МЕСТО ФЛОРЫ МХОВ МАГАДАНСКОЙ ОБЛАСТИ В РЯДУ БРИОФЛОР РОССИЙСКОГО ДАЛЬНЕГО ВОСТОКА

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Abstract

The list of mosses known for Magadan Region includes 434 species. It is compared to moss floras of other regions in the Russian Far East. It is shown that in the north of the Russian Far East, Magadan Region is characterized by a heightened diversity of mosses along with Kamchatka and Beringian Chukotka; the greatest similarity in the moss flora is observed with these same regions. The compiled summary table of species clearly demonstrates the latitudinal distribution of moss species in the Russian Far East and the distribution by the floristic regions within the Magadan Region. As a result of sorting the summary table of species lists, in the moss flora of Magadan Region three large groups of species differing in their predominant distribution in the Far East were revealed: "cross-cutting", "northern" and "southern". The former account for approximately 40%; the "northern" and "southern" groups have a comparable number of species. More than half of "southern" species in Magadan Region are at the northern limit of their distribution in the Far East. The locations of the "southern species" are concentrated in the Okhotsk District. A list of species that can be found in future is provided.

Резюме

Для Магаданской области в настоящий момент известно 434 вида мхов. Проводится сравнение списка видов области со списками мхов других регионов российского Дальнего Востока. Показано, что на севере Дальнего Востока Магадан выделяется разнообразием мхов наряду с Камчаткой и Берингийской Чукоткой; с этими же регионами имеется наибольшее число общих видов. Составленная сводная таблица видов позволяет выявить особенности широтного распределения видов мхов на Дальнем Востоке и по флористическим районам территории Магаданской области. В результате сортировки сводной таблицы видовых списков во флоре мхов Магаданской области выделены три большие группы видов, различающихся по преимущественному распространению на Дальнем Востоке: "сквозные", "северные" и "южные". На долю первых приходится около 40%, «северная» и «южная» группы сопоставимы по числу видов. Более половины "южных" видов в Магаданской области находятся на северной границе своего распространения на Дальнем Востоке. Местонахождения "южных видов" сосредоточены в Охотском районе. Составлен список видов, нахождение которых в Магаданской области ожидаемо.

KEYWORDS: moss, phytogeography, Far East, distribution patterns, North-East Asia

INTRODUCTION

Magadan Region has a special place among the regions of the Russian Far East. Paleogeographically, the region belongs to Okhotia, which is the southwestern part of the so-called Mega-Beringia (Yurtsev, 1974). It has been repeatedly noted that the flora and vegetation of the region change rapidly from the south-southeast to the north-northwest, reflecting the transition from a mild, wet climate on the Okhotsk Coast to a sharp continental climate in the upper reaches of the Kolyma River (Khokhryakov, 1971, 1985; Yurtsev, 1974; Yurtsev & Khokhryakov, 1975; Berkutenko *et al.*, 2010). Yurtsev (1974) wrote about the exceptional historical role of the region during different climatic periods as an area of floral exchange between the Arctic and the more southern Asian highlands, with both continental and oceanic influences. Yurtsev gave the territory a high rank in floristic zoning, distinguishing it as the North-Okhotsk province of the Boreal Region, pointing out the stable coexistence of oceanic and continental species and their complexes here (Yurtsev, 1974). He emphasized the significant number of species that are common along the Okhotsk coast, in Kamchatka and in the lower reaches of the Amur, which are absent from the flora of the Kolyma Highlands; many of these species are relicts of warmer periods. He considered the narrow coastal strip along the

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Fig. 1 The exploration of the Magadan Region bryophyte flora. Dots are localities cited by Blagodatskikh (1984). Triangles are the points of expeditions organized by Bakalin in 2010–2014 (Pisarenko, Bakalin, 2018). Squares are the collection points of Vilk. Asterisks are the collections of O. A. Mochalova. Abbreviations for the floristic districts are: K – Kolymsky, OK – Okhotstko-Kolymsky, O – Okhotstky, GO – Gizhigsko-Omolonsky; G – Gizhigsky and Om – Omolonsky.

Sea of Okhotsk to be a "marginal area" of Northeast Asia and a "transition zone" to more southern regions. Voroshilov (1982) was even more definitive: the coast of the Okhotsk Sea is referred to as the Far East, while the northern territories of the Magadan Region, together with the Lena-Kolyma area of the Khabarovsk Territory and the Dauryan area of the Amur region, are considered to be Eastern Siberia. At the same time, he pointed out that the floristic division of the Far East calls for specific research (Voroshilov, 1982).

The focus of the cited works is on vascular plants. With regard to mosses, Magadan at that time was a poorly studied area (a brief review of the history of research is in Afonina *et al.,* 2022). However, at the start of bryological studies, L.S. Blagodatskikh, the first bryologist of Magadan, highlighted the excessive proportion of "southern species" and noted that further bryofloristic studies are promising. The results of her long-term work are summarized in the monograph "Mosses of the Kolyma Upland" (Blagodatskikh, 1984), which contains a list of 234 species. There was then a 30-year pause in bryological research. In 2010-2014, the work was intensified again thanks to V.A.Bakalin. Due to the new material and recent revisions of the Blagodatskikh collection by various authors, the combined list has been raised by almost half to 365 species (Pisarenko & Bakalin, 2018). In 2019, E.F. Kuznetsova (Vilk) joined the research team in the Magadan Region. Soon after, the list of species expanded to 420 (Blagodatskikh *et al.,* 2019; Kuznetsova & Afonina, 2019; Afonina, 2019; Vilk & Afonina, 2020; Sofronova *et al.,* 2020; Afonina & Vilk, 2021; Vilk & Afonina, 2021; Ellis *et al.,* 2021).

It's still too soon to conclude that the moss flora in the region has been fully explored. Only the western part of the area has been more or less investigated (Fig. 1), as the underdeveloped road network makes it difficult to explore the eastern part within the boundaries of the Kolymsky, Okhotsk-Kolymsk and Okhotsky floristic districts (Khokhriakov, 1985; Berkutenko *et al.,* 2010). However, the number of species of the "bryoflora of the Western part of the Magadan province" is comparable to that of nearby regions (Afonina *et al.,* 2022). The list has not been analyzed yet. Moss species on average have a wider areas than vascular plant species. Therefore, it is interesting to trace the distribution of mosses in Magadan Region in the full latitudinal amplitude of the Far East in its broad interpretation, from the south of Primorsky Krai to Chukotka (Kharkevich *et al.,* 1985). An additional basis for this analysis is provided by a phenomenon known as "fascination of zonality", which states that the vegetation cover zonality in Northern Eurasia changes as it moves inland from the coast and the changes are not random (Gerasimov, 1933). Accordingly, the vegetation zoning in the Far East can be considered independently of the territories adjacent to the west.

We realize that the regions of the "Moss Flora of Rus-

sia" (http://arctoa.ru/en/Flora-en/regions-en.php) are mainly defined by administrative boundaries. However, for the sparsely populated Far East as well as Siberia, the administrative division of territories largely inherited the lifestyle of the indigenous people, which in turn reflected the differences in natural conditions. In addition, the large administrative units of Siberia and the Far East were subdivided in the "Moss Flora of Russia" based on biogeographic boundaries. Thus, the border between the East Asian and Circumboreal Regions of the Holarctic Kingdom (Takhtajan, 1986) approximately coincides with the border between Amur Province and Yakutia. And along the line the large Khabarovsk Territory is subdivided into the middle and northern parts ("Khm" / "Khn" in "Moss Flora of Russia"); the border between the central and southern parts of the Khabarovsk Territory ("Khm" / "Khs") corresponds to the floral zoning of the region (Schlothauer *et al.*, 2001). The division of Chukotka into the Beringian ("Chb"), southern ("Chs"), western ("Chw") and continental ("Chc") parts is argued by Yurtsev (Yurtsev *et al*., 1978; Yurtsev, 1994). Similarly, Kamchatka ("Kam"), Komandory ("Kom"), and Koryakia ("Kks" / "Kkn") also have a place in the floral zoning scheme (Kharkevich *et al*., 1985); the Primorsky Territory there nearly corresponds to the Ussuri district.

The naturalness of the units being considered is supported by the results of our previous analysis of the distribution of moss diversity within a network of 5x5-degree latitude/longitude cells (Pisarenko & Bakalin, 2017). There are only a few significant discrepancies in the positions of the boundaries between administrative and floral divisions; that is so for Sakhalin, the Kuril Islands, the north of the Khabarovsk Territory and Magadan Region (Kharkevich *et al*., 1985). In floristic zoning, both Sakhalin and the Kuril Islands are divided into northern and southern parts. However, this is not significant for our purposes since in both cases the flora in the north is simply much poorer than in the south. The north of the Khabarovsk Territory and Magadan Region, in terms of floristic zoning are divided into the Okhotsk and continental parts (Kharkevich *et al*., 1985); the former is the least-studied region of the Far East and the available data are insufficient for meaningful analysis; and Magadan Region is the focus of this article.

Study Area

A detailed description of the natural conditions in Magadan Region is given in English in recent articles summarizing data on the flora of mosses (Pisarenko & Bakalin, 2017) and liverworts (Bakalin *et al*., 2023). The most important features are the following.

Most of the territory is within the Yano-Kolyma fold system (Shilo, 1970). The basis of the relief is the uplands. The mountains are mainly of the "Goletz" type, with a flat tops and gentle slopes; they are deeply dissected by valleys with altitudes 400–1000 m. Mountain ranges with alpine-type landforms up to 2000–2300 m high rise above the uplands. The rocks in the mountains are diverse, including shales, sandstones, limestones, basalts, porphyrites, gabbros, and granitoids. Most of the area is covered with Quaternary sediments (Petukhov & Shpikerman, 2016).

The glaciation in Northeast Asia developed simultaneously with the marine transgression and the expansion of cyclonic activity, and it was generally asynchronous to the glaciations in Europe and North America (Galanin, 2012). During the marine transgression, the coastline was located about 100 km or more to the south; the southern tip of Magadan Province was a purely continental region. Magadan was never covered by shield glaciers. The Last Glaciation had a network or mountain-valley character and reached its maximum about 35–30 thousand years ago (MIS 3). It had formed under conditions of a moderate humid and cool (subarctic) climate; further cooling led to the desiccation of the climate and the degradation of glaciation (Galanin, 2012). Permafrost is ubiquitous, with a thickness of up to 500 m; thawed grounds occur only along the coast of the Okhotsk Sea and in the valleys of large rivers (Kalabin, 1960). During summer, the permafrost waterproof layer is located at a depth of 40–70 cm. The average amount of precipitation decreases as one moves away from the Okhotsk Sea coast, from 600 mm per year to less than 300 mm in the interior lands (Kovel', 1990). Accordingly, the average annual temperature drops from –2 to –3°C to –11 to –13°C in the continental districts. However, summer on the coast not only has more precipitation, but also is much colder than in inland areas.

The mountainous terrain of the area causes the vertical zonation of vegetation (Ogureeva *et al.*, 1999; Berkutenko *et al.*, 2010). Open larch forests (*Larix cajanderi* Mayr) dominate in the lower belt. Floodplains of large rivers are occupied by *Populus–Chosenia* forest with a mixture of tall willows. Crooked birch forests (*Betula lanata* (Regel) V.N. Vassil.) occur on slopes along the northern coast of the Okhotsk Sea. *Pinus pumila* (Pall.) Regel. is widespread; it forms dense, impenetrable thickets above the tree line. *Duschekia fruticosa* (Rupr.) Pouzar also forms extensive thickets, more often along the seashore and along watercourses. Mountain tundra and stone fields occupy mountain slopes and flattened tops at altitudes above 400–450 m near the coast and over 1100–1200 m in the interior.

Materials and Methods

The species lists of the Far East regions are arranged in the summary table (Supplementary materials available at https://kmkjournals.com/upload/PDF/Arctoa/33/Arctoa_33_Pisarenko_SM.xlsx). Recent checklists of the southern and northern parts (Cherdantseva *et al.*, 2018; Afonina *et al.*, 2022) serve as a basis for the table, which has been updated with the most recent data (Fedosov & Shkurko, 2022a, b; Ishchenko *et al.*, 2022; Maksimov *et al.*, 2022; Pisarenko *et al.*, 2022; Ignatova *et al.*, 2023;

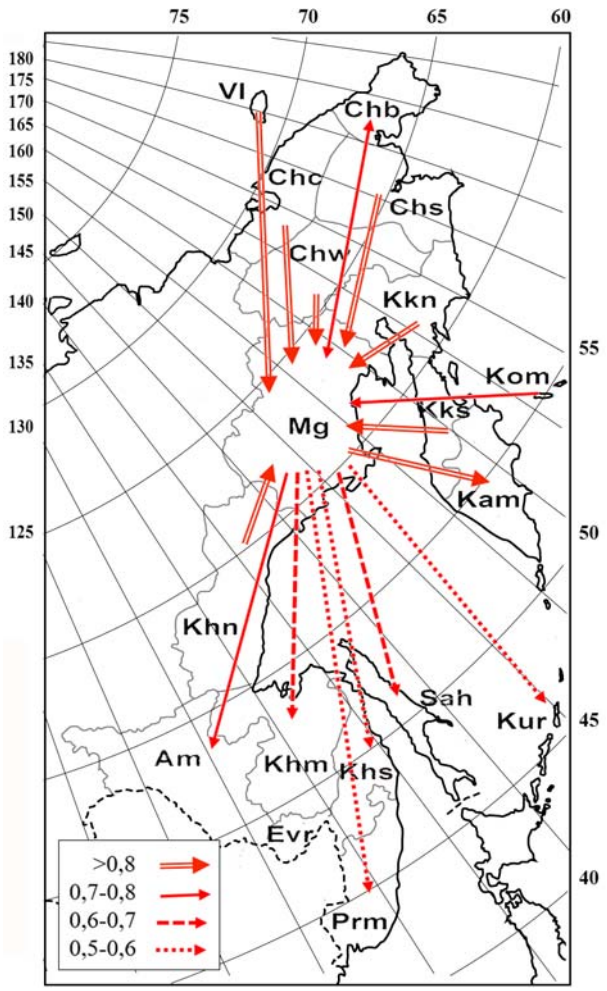

Fig. 2. Similarity of Magadan bryoflora with other regions of the Far East in the prevailing measures of inclusion. The arrows illustrate the prevailing direction and the size of the measures of inclusion (Yurtsev & Semkin 1980). Borders and abbreviation of the regions are given according to Ignatov & al.(2017): VI – Wrangel Island, Chw – Chukotka, western part, Chc – Chukotka, continental part, Chs – Chukotka, southern part, Chb – Chukotka, Beringian part, Mg – Magadan Region, Kkn – Koryakia, northern part, Khn – Khabarovsk Territory, northern part, Kks – Koryakia, southern part, Kam – Kamchatka, Kom – Commander Islands; Am – Amur Province, Evr – Evreiskaya [Jewish] Autonomous Province; Khm – Khabarovsk Territory, middle part, Khs – Khabarovsk Territory, southern part; Kur – Kuril Islands [Sakhalin Province]; Prm – Primorye Territory; Sah – Sakhalin Province (excluding Kuril Islands).

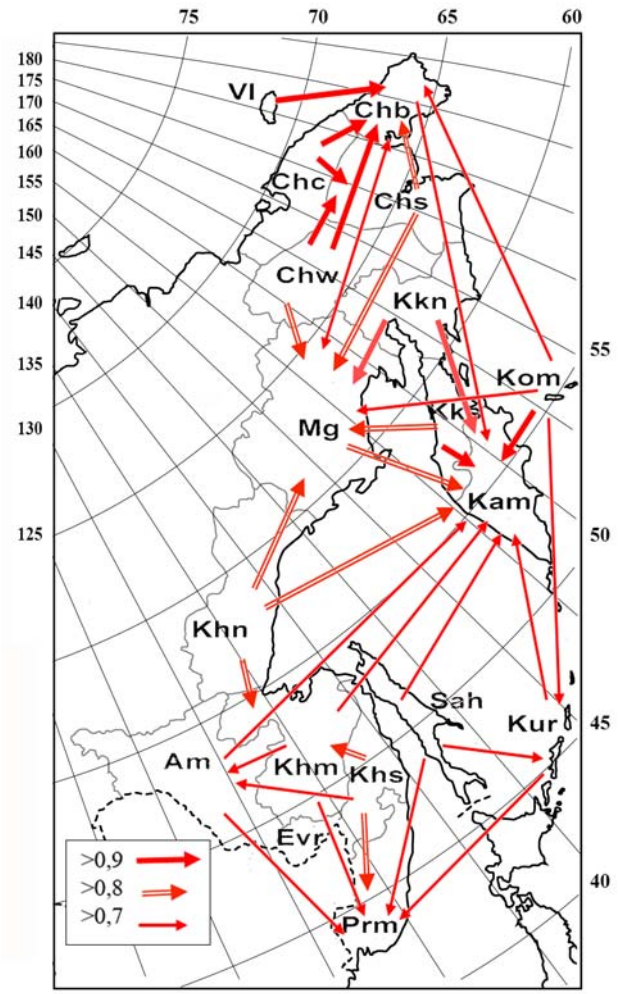

Fig. 3. Similarity of the Far East regional bryofloras in the prevailing measures of inclusion. The arrows show the predominant direction and the magnitude of the inclusion measures (Yurtsev & Semkin 1980). Abbreviations of the regions are given under Fig.2.

Dudov *et al.*, 2022; Yatsenko *et al.*, 2023). The nomenclature is improved, where possible, according to the "Moss flora of Russia" (Ignatov *et al.*, 2017, 2018, 2020, 2022), and the data on the distribution of species provided there is also taken into account.

For Magadan Region, the table also shows the distribution of species among three floristic districts (Kolymsky, Okhotstko-Kolymsky and Okhotstky). The distribution of species revealed in Magadan Region by floristic districts is illustrated by an Euler-Venn diagram (Fig. 6).

The composition of the bryofloras in the Far Eastern regions is compared in several ways. Cluster analysis and detrended correspondence analysis (DCA) were carried out using Past ver. 2.17c (Hammer *et al.*, 2001).

A matrix of inclusion measures is calculated by IBIS (Zverev, 2007), as:

$$K(A;B) = \frac{n(A \cap B)}{n(A)}; K(B;A) = \frac{n(A \cap B)}{n(B)}$$

This method is considered to be the most appropriate for comparing floras that differ in size (Yurtsev, 1968; Semkin & Komarova, 1977).

The summary table has been arranged so that species with similar distributions in the Far East regions are grouped together.

RESULTS

A total of 1024 species are currently known for the Russian Far East (Table 1, Supplementary materials). Of these, only 28 species are widely distributed and noted in each region under consideration. 151 species are found only in its northern part and 289 species are only found

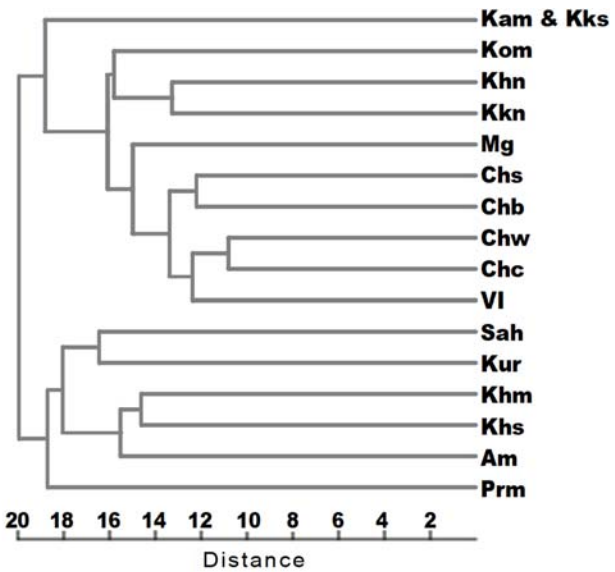

Fig. 4. Dendrogram of similarity of moss lists of the Far East regions (Pired group (UPGMA), Euclidean distance). Abbreviations of the regions are given under Fig. 2.

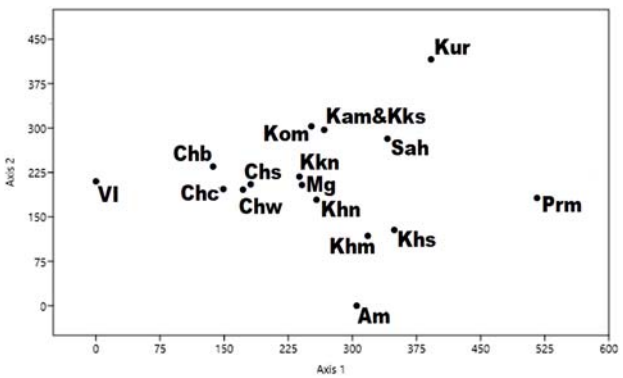

Fig. 5. DCA ordination diagram of moss lists of the Far East regions.

in the southern. In addition, 180 species were recorded for no more than one of the considered regions. Among the regions, the lowest number of taxa has been recorded for Evr (154), Kks (151), Kkn (180), and Khn (219). This is obviously not due to a lack of diversity, but rather due to insufficient investigation.

Magadan Region is second among the regions in the north of the Russian Far East when it comes to moss diversity, behind only Kamchatka. Magadan Region and Kamchatka share 365 species in common; that is the maximum value in the intersection matrix of the species lists (Supplementary materials, Table 2). The number of species that are common to Magadan Region and Beringian Chukotka is 323, and that are common to Magadan Region and Western Chukotka is 318.

The calculated indexes of the similarity between regional bryofloras (Supplementary materials, Table 3) are more evident when applied to the map. The main measures of inclusion for Magadan moss flora compared to other regions are shown in Fig. 2. On the scheme, Magadan Region seems to be a spot of change in the inclusion vector: inclusion into Magadan's bryoflora prevails for the northern bryoflora (75–90 % vs. 31–74%); while the reverse is true for the southern ones (44–65% vs. 56–84%). This is quite natural, because the regions of the southern Far East have a greater number of moss species compared to Magadan Region.

For the Magadan bryoflora, the maximum inclusion measure is into the Kamchatka one, 84%.

On the scheme of the main measures of inclusion of each region (Fig. 3), Kamchatka appears to be a link between the bryofloras of the northern and southern regions. With the exception of Kamchatka, there is a low similarity between the bryofloras of the regions of the southern and northern parts of the Russian Far East; the measures of mutual inclusion are less than 0.7.

At the current level of knowledge in the north of the Far East, Magadan looks like one of the centers of diversity along with Kamchatka and Beringian Chukotka; bryoflora of other nothern regions are included in them by 72–98%. In the south, the highest values of inclusion measures are common to Primorje bryoflora: others are included in it by 70–98% (Supplementary materials, Table 3; Fig. 3).

Borders and abbreviation of the regions are provided according to Ignatov *et al*. (2017); they are given under Fig. 2.

It should be noted that the maximum values of measures of inclusion (Table 3) primarily reflect the current state of knowledge. So, Evr-bryoflora is 99% included in Prm-bryoflora, but only 154 moss species are known for Evr; this does not reflect the reality, and the region has not been taken into account in subsequent calculations. Only 151 species are known for Kks-bryoflora, it is 99% included in Kam-bryoflora; and due to its territorial proximity, further they are considered together.

Cluster analysis reveals a clear separation between the bryoflora of the northern and southern regions of the Far East (Fig. 4). At the next level (~distance 19) within the north and south clusters the richest bryofloras secede, Kam and Prm respectively. In the northern cluster, at the following levels, there are associations between maritime bryofloras (Kom, Khn and Kkn) and extremely northern ones (Chs, Chb, Chw, Chc, and VI) with Mg-bryoflora taking an intermediate position between them.

Indirect ordination by DCA showed the main differentiation of bryofloras along axis-1, and to a lesser extent along axis-2 (Fig. 5). The eigenvalues for the axes were 0.3375 and 0.1489 respectively, while the eigenvalue for axis-3 was only 0.09. Axis-2 is correlated with the oceanic/continental conditions of the territory, while axis-1 can be interpreted as a factor of heat supply, which correlates with the latitude position of the regions. The limits of the positions along the axis are marked by VI and Prm, which corresponds to the geographic locations

of the regions. In the scheme, Mg is located in the center of the coordinate plane.

The position between the oceanic and continental regions on the DCA-diagram is determined by the heterogeneity of the Magadan bryoflora. The three floristic districts of Magadan – oceanic (Okhotstky), continental (Kolymsky) and transitional (Okhotstko-Kolymsky) – have different lists of mosses; it is illustrated by the Euler-Venn diagram (Fig. 6). This difference deserves special attention, even considering that none of the floristic districts can be considered fully explored. Only 114 species are common to all three districts. Out of the species recorded in the Okhotsky district, 89 species (32%) have not yet been found in the Kolymsky one. Conversely, of the species found in the Kolymsky district, 119 species 39%) were not recorded in the Okhotsky one.

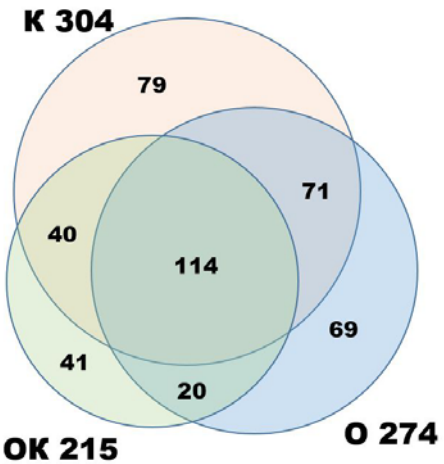

Fig. 6. Euler-Venn diagram of intersection of moss lists of 3 floristic districts of Magadan (see Fig.1): Okhotstky (O), Kolymsky (K) and Okhotstko-Kolymsky (OK). The numbers indicate: total number of species for each district (outside the circle); specific for the district; common for every two districts, common for all three districts.

Discussion

To understand the reasons behind the mentioned features, we examined the distribution of Magadan mosses across the Russian Far East (Table 1, Supplementary materials).

The total set of species can be divided into three main groups: "northern", "southern", "cross-cutting" distribution. It should be noted that this division is somewhat arbitrary and, in many cases, may be disputed with respect to individual species. Accurate calculations of the exact number of species for each group is not necessary here.

We would like to emphasize that the division is based on current data on the distribution of species in the Far East. That is, in other longitude sectors, the latitudinal distribution of species might be different. Additionally, data for a particular species may not be complete and will likely change as a result of further surveys; the table draws attention to a potential finds for regions. For example, *Grimmia anodon* is known from the Far East only from the northern regions, including VI, Chc, Chw, and Chb, and one location in the central part of Mg. But in Central Siberia, this species is distributed in the north to the northern part of Taimyr (~ N74°) and in the south it is found throughout the Republic of Tyva (~ N50°). In Western Siberia, the species is only found in the south. It is quite common in the southeastern and central Altai, reported for Mountain Shoria and Salair foothills, but not further north. One of the reasons for this, of course, is the absence of rocks further north in Western Siberia – so, there are no suitable substrates for petrophytic species. However, the species also has not been found in the Northern, Sub-Polar or Polar Urals, and Dyachenko have classified it as a "southern-oriented" species (Dyachenko & Dyachenko, 2016). It is therefore relevant to compare the behavior of species across different longitude sectors in order to identify the cases and causes of the discrepancies.

"Cross-cutting" species group – the distribution of the species does not seem to have a clear preference for either southern or northern latitudes; they account for about 40% of the Magadan moss flora (rows 143–320 in Table 1, Supplementary materials). More than half of them are registered in all or most of the regions under review; the absence of a record for a particular area is most likely due to an oversight (Supplementary materials, Table 1, rows 143–245; examples: *Calliergonella lindbergii, Ceratodon purpureus, Eurhynchiastrum pulchellum, Funaria hygrometrica, Hylocomium splendens, Niphotrichum canescens, Polytrichum juniperinum, Pseudobryum cinclidioides, Rhytidium rugosum, Sanionia uncinata*). Some of the species are missing on Vrangel Island, and this may indicate their northern limit (rows 226–248; examples: *Amblystegium serpens, Aquilonium plicatulum, Climacium dendroides, Pleurozium schreberi, Polytrichum commune, Ptilium crista-castrensis, Pylaisia polyantha, Sphagnum angustifolium*). Less frequent and widespread species can be distinguished as another block in this group; in some regions their absence may be due to random factors (rows 249–309; *Fissidens adianthoides, Orthotrichum anomalum, Pterigynandrum filiforme*). A small group of species are found in many regions in the middle part of the latitudinal range of the Far East and are absent from extreme latitudes in both the north and south (rows 310–320; examples: *Grimmia mollis, Platyhypnum alpestre, Platyhypnum cochleariifolium, Bryoxiphium norvegicum, Tortella alpicola*).

"Northern" species group – these are species that are more commonly found in the northern part of the Far East. The group includes approximately 30% of the Magadan moss flora; it is more heterogeneous than the ones discussed above. For several species, the localities in Magadan Region are the southernmost in the Far East (rows 1–11; *Bryum longisetum, B. rutilans, Distichium hagenii, Drepanocladus brevifolius, Grimmia anodon, Leptoterigynandrum austroalpinum, Orthotrichum pellu-*

cidum, Pohlia schimperi, Schistidium frahmianum, Scouleria rschewinii, Tortula laureri). Further in the table 1 (Supplementary materials), the species are arranged according to the extent of their southern distribution: to Commander Islands (rows 12–16), Kamchatka (rows 17–33), Kuril Islands (rows 34–40), Sakhalin (rows 41–46). The main part of the species of this group can be also found in the southern regions of the Far East, but exclusively or mainly in the mountains; so-called Arctic-Alpine species (rows 47–145; examples: *Aulacomnium acuminatum, Bryum cryophilum, Catoscopium nigritum, Cinclidium arcticum, C. subrotundum, Distichium inclinatum, Drepanocladus trifarius, Hamatocaulis lapponicus, Orthothecium chryseon*). If we only consider the graphical representation of the table, for some species the assignment to this group is not obvious. There are no clear boundaries with the group "Cross-cutting". Ideally, it is important to consider the species occurrence in different regions. We drew on our own experience by considering in the northern (Arctic-Alpine) group such species as *Aulacomnium turgidum, Bartramia ithyphylla, Dicranum elongatum, D. spadiceum, Grimmia reflexidens, Meesia triquetra, M. uliginosa, Paludella squarrosa, Racomitrium lanuginosum, Straminergon stramineum, Tetraplodon mnioides*. It should be noted that, in most cases, the absence of a particular species in a southern region of the Far East does not necessarily mark the southern boundary of its area. In the Primorsky Territory as well as in the Amur Region and in the southern part of the Khabarovsk Territory, there are very few mountainous formations with peaks that rise above the tree line.

Below the "Cross-cutting" block in the table (Supplementary materials, Table 1), the species are sorted according to the reduction in their northern limits.

"Southern" species are those that are more common and widespread in the southern part of the Far East. They account for about 25% of the moss flora of Magadan Region. Just over half of them are found sporadically in Chukotka (row 321–362; examples: *Aquilonium adscendens, Campylophyllopsis sommerfeltii, Dicranodontium denudatum, Fontinalis perfida, Grimmia pilifera, Hylocomiastrum pyrenaicum, Iwatsukiella leucotricha, Myurella sibirica,*). For the remaining 77 species, Magadan marks the northernmost point of distribution in the Russian Far East (seven of them are also found in northern Koryakia: *Bartramiopsis lescurii, Brachythecium rivulare, Chionoloma tenuirostre, Dicranum angustum, Rhizomnium nudum, Schistidium liliputanum, Sphagnum palustre*). It is not a coincidence that almost all the "southern" species found in Magadan Region are rare or known from single localities (Supplementary materials, Table 1, occurrence-column). And naturally, most of them are found only in the Okhotsk region. The most interesting are *Amphidium asiaticum, Dicranum setifolium, Dicranum pacificum, Grimmia pilifera, Leptopterigynandrum austroalpinum,* and *Schistidium frahmianum* (Kuznetsova & Afonina, 2019; Vilk & Afonina, 2020, 2021).

The summary table outlines the species that are expected to be found in the Magadan area. These species are known both south and north of Magadan Region, and some of them are quite widespread (rows 435–496: *Andreaea alpestris, Arctoa starkei, Brachythecium tauriscorum, Bryum elegans, B. lonchocaulon, B. neodamense, Dicranum brevifolium, Mnium spinosum, Oligotrichum hercynicum, Rhytidiadelphus squarrosus, Sphagnum majus, Stereodon hamulosus,* and others). The list of expected species could be supplemented with species known for the areas of Yakutia adjacent to the Magadan Region (Ignatov *et al.,* 2001; Ignatova *et al.,* 2011, 2018, 2020): *Andreaeobryum macrosporum, Barbula jacutica, Blindiadelphus subimmersus, Bryum bicolor, B. sibiricum, Encalypta vulgaris, Fissidens arcticus, Grimmia poecilostoma, G. teretinervis, Hilpertia velenovskyi, Hymenostylium xerophilum, Indusiella thianschanica, Jaffueliobryum latifolium, Orthothecium sibiricum, Physcomitrella patens, Platydictya acuminata, Pseudocrossidium obtusulum, Sanionia nivalis, Schistidium relictum, Tortella densa.*

ACKNOWLEDGEMENTS

Pisarenko is grateful to V.A.Bakalin for the opportunity to participate in his expedition. We are grateful O.M. Afonina for identification of complex taxa of mosses collected by Blagodatskikh and Vilk. Samples of Pisarenko are in biocollection USU 440537; the work is supported by RSF № 23-14-00043. The study of Vilk was carried out within the planned theme of the laboratory of botany of the Institute of Biological Problems of the North FEB RAS № 123032000015-3.

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Recieved 19 April 2024 *Accepted 25 July 2024*

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