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СООБЩЕНИЯ

FLORA OF THE CHIVYRKUYSKIY BAY ISLANDS: MAIN FEATURES AND PATTERNS (ZABAIKALSKIY NATIONAL PARK, RUSSIA)

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The vegetation cover of seven islands in Chivyrkuyskiy Bay (Zabaikalskiy National Park, Northeastern Baikal region) was poorly studied. An understanding of the floristic diversity of the islands is important under conditions of climate change and anthropogenic impact.

The floristic diversity of the islands is relatively high due to a great variety of environmental conditions. 334 vascular plant species from 188 genera and 61 families have been registered among the island flora. Of these, 178 and 18 species were found for the first time for the islands and the Zabaikalskiy National Park respectively. A positive correlation between flora diversity and island size has been identified. It has also been determined that dense nesting colonies of gulls and cormorants have a significant influence on the vegetation of three islands (Belyy Kamen, Pokoynitskiy Kamen, Golyy), causing a lower plant species number. These patterns are similar to those in the flora of islands of the Maloe More Strait at the western coast of Lake Baikal.

In general, the structure of the island flora is typical for Zabaikalskiy National Park flora and generally reflects main features of Baikal Siberian flora. Holarctic and Eurasian species, as well as South Siberian and North Asian plants largely contribute to the flora composition. The island flora is classified in general as boreal semihumid. 13 species (3.5% of the total flora) endemic to the Baikal region are found on the islands. Lokhmatyy Island is the richest in endemics, being inhabited by 9 of them. Remarkably, most of the endemics are montane-steppe plants. Habitats and distribution on the islands were examined for the following rare and endangered species: *Deschampsia turczaninowii* Litv., *Corispermum ulopterum* Fenzl, *Cotoneaster tjuliniae* Pojark. ex Peschkova, *Rhodiola rosea* L., *Papaver popovii* Sipliv., and *Epipactis helleborine* (L.) Crantz. There are no invasive species in the flora, but fairly common ruderals were found and are especially abundant in the ornithogenic plant communities.

To summarize, the structure and composition of the island flora demonstrate its commonality with the floras of both Barguzinskiy Ridge and the Svyatoy Nos Peninsula which surround Chivyrkuyskiy Bay.

Keywords: vascular plants, floristic patterns, endemics, species richness, Lake Baikal, island biogeography, rare species, phytodiversity, national park

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The area of Chivyrkuyskiy Bay is located near the northeastern coast of Lake Baikal and is a part of Zabaikalskiy National Park. Since 2011, Zabaikalskiy National Park, Barguzinskiy State Nature Biosphere Reserve, and Frolikhinskiy Wildlife Sanctuary have been under management of the "Zapovednoe Podlemorye" Federal State Establishment. In terms of physiographic regions, the National Park area belongs to the Baikal-Dzhugdzhurian mountain taiga domain, the Pribaikalskiy mountain taiga province, the Barguzinskiy high mountain district (Sochava, 1979), and to the district named as "Baikal Uplands" which is one of 15 conditionally identified floristic districts in Central Siberia (Malyshev, Peshkova, 1984). Currently, flora of Zabaikalskiy National Park counts 977 species and subspecies revealed in the course of numerous studies conducted by various scientific organizations and researchers (Anenkhonov, Pykhalova, 2010). However, no specific studies of flora on the seven islands in Chivyrkuyskiy Bay have been carried out to

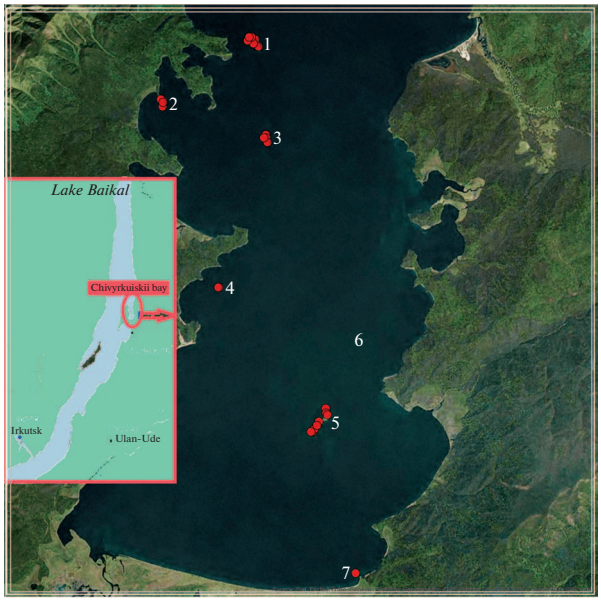

Fig. 1. Location of islands in Chivyrkuyskiy Bay. Islands: 1 – Lokhmatyy; 2 – Elena; 3 – Golyy; 4 – Pokoynitskiy Kamen; 5 – Baklaniy; 6 – Belyy Kamen; 7 – Kovrizhka.

date. Only very limited and sparse data on their plant species can be found in papers of non-botanical subjects (Molozhnikov, 1974; Imetkhenov et al., 1990), or included in general floristic inventories (Popov, Busik, 1966; Boikov et al., 1991; Anenkhonov, Pykhalova, 2010; etc.). All available botanical information and herbarium materials were gathered in the course of visits to the islands by various researchers on their way to other locations. The island flora remained insufficiently studied as a result. According to the previous data compilation made by Anenkhonov and Pykhalova (2010), 115 vascular plant species were registered in the island flora. No doubt, this data was incomplete. In modern conditions when anthropogenic influence is growing and climate change is accelerating, it is important to develop our knowledge of flora as a crucial element of biodiversity: its composition, structure, and spatial distribution. Because island plant communities are naturally isolated and are sufficiently important to the conservation regime, the main goal of our studies was the inventory of flora composition on the Chivyrkuyskiy Bay islands (Bukharova et al., 2019) and the outline of the taxonomic and geographical patterns observed.

STUDY AREA

Chivyrkuyskiy Bay is situated in the central part of the eastern coast of Lake Baikal. It is formed by the southern reaches of the Barguzinskiy mountain range in the east and the Svyatoy Nos Peninsula in the west. The maximum width of the bay is 14 km (from cape Verkhneye Izgolovye to cape Malyy Sukhoy). Its length is almost 30 km. A high mountain ridge of the Svyatoy Nos Peninsula shields the bay from direct winds coming from the main area of Lake Baikal. On the other side, the Barguzinskiy Ridge shields the bay from the east. Consequently, the bay is geographically well isolated, being exposed only to winds and waters from the north. Winds from the south are usually weakened after passing through swampy lowlands on the peninsula isthmus. This creates a rather special local microclimate with lower wind intensity and relatively high temperatures (Boikov et al., 1991). The sum of daily temperatures above 10°C reaches 1200 (90 days) – much higher compared to the main area of the lake. On Bolshoy Ushkaniy Island located among the open waters of Baikal, for example, the sum is 990°C (80 days) (Imetkhenov et al., 1990). Besides this, the bay is relatively shallow (with a maximum depth of 10 meters). This allows its waters to warm up to 24°C, which significantly lowers the cooling effect of water masses on the microclimate of nearby land ecosystems.

In the geological past, there was a terrestrial area linking the Svyatoy Nos Peninsula to the Barguzinskiy Ridge where Chivyrkuyskiy Bay lies today. The bay was formed at the beginning of the Quaternary period (Lamakin, 1968), or even later, in the middle of the Holocene (Mats, 1974). Today there are seven islands in the bay: Baklaniy, Lokhmatyy (Bolshoy Kyltygey), Golyy (Malyy Kyltygey), Pokoynitskiy Kamen, Elena, Belyy Kamen, Kovrizhka (Fig. 1). All of them are local rocky outcrops of crystalline basement. They remained above water level after land subsidence (a process that continues as a result of geological processes in the Baikal rift zone). Thus, the islands are remnants of a single large, ancient terrestrial area. We can consider their combined flora as the legacy of spatially continuous vegetation in the past. It should be noted that due to short distances between the islands and the mainland (Table 1), significant influence from the mainland flora on the local flora remains unavoidable despite the separation.

Three of the seven islands (i.e. Lokhmatyy, Elena, Pokoynitskiy Kamen) are close to the western coast (Svyatoy Nos Peninsula), one island (Kovrizhka) is located by the southern coast, one island (Belyy Kamen) is not far from the eastern (mainland) coast, and two islands (Golyy, Baklaniy) are located near the central sublongitudinal "axis" of the bay (Fig. 1).

Brief description of the islands. This description is largely based on our data, but available published information was considered as well.

Lokhmatyy Island is the northernmost of the islands; its steep rocky cliffs plunge directly into the bay or slope down to narrow pebble beaches. Its northwestern, northeastern, and eastern shores are formed by high cliffs, and several separate rocks are found some distance from the main rock mass of the island. The southern and southwestern slopes are rather steep

Table 1. Some characteristics of Chivyrkuyskiy Bay islands

Island	Area, ha*	Minimal distance to a bay shore, m	Birds nesting colony	Number of plant species
Kovrizhka	0.2	160	–	38
Belyy Kamen	0.2	1480	+	1
Pokoynitskiy Kamen	0.8	710	+	43
Elena	2.3	144	–	103
Golyy	8.8	2300	+	128
Lokhmatyy	14.8	746	–	177
Baklaniy	19.2	2170	–	176

and formed by a series of platforms, which give way to cliffs that are lower than those found on the north side. Most of the island's area is covered by deciduous, mixed, dark, and light coniferous forests. These forests developed in the warmer habitats on the southern and southwestern slopes and are dominated by grasses in the herb layer. Forests containing green mosses and dwarf shrubs in the ground layer are found in colder and wetter habitats. Meadow steppes and low grass petrophytic steppe communities (with *Agropyron distichum* (Georgi) Peschkova, *Thalictrum foetidum* L., *Chamaerhodos grandiflora* (Pall. ex Schult.) Bunge, etc.) have developed in the lowest reaches of the southern and southwestern slopes. Sinusia of petrophyte species, e.g. *Alyssum obovatum* (C.A. Mey.) Turcz., *Draba hirta* L. and alpine species such as *Rhodiola rosea* L. inhabit cold and wet northern slopes. The population of the endemic species *Papaver popovii* Sipliv. is strictly confined to these slopes.

Baklaniy Island is the largest in Chivyrkuyskiy Bay. Located in the southeastern part of the bay, it has an irregular shape, elongated from the southwest to the northeast. The northwestern side is formed by cliffs with numerous grottoes. The southeastern half of the island is more gently sloping, but in some places the lower reaches of the slopes descend sharply to pebble-boulder beaches. Small sandy beaches are found in a flat middle of the island's southeastern coast. Most of the island is covered with secondary small-leaved aspen-predominated forest, indicating past forest fires and logging. Intensive logging was carried out here before the establishment of Zabaikalskiy National Park (Tyulina, 1981). Patches of relatively undisturbed larch forests with embedded Scots pine trees remain, however, and occur on the southern slope of the northern part of the island. Steppe communities are small-sized and represented by xeropetrophytic phytocoenoses on the steep southern slope on the southwestern cape, and *Selaginella rupestris* (L.). Spring forms small spots on stony level surfaces scattered along the axial "ridge" of the island. On the flat parts of the southeastern shore, psammophytes and small swampy patches are found.

Golyy Island has the shape of an irregularly curved and thickened comma, with cliffs on the northern and eastern slopes, obliquely descending and even concave western and southwestern slopes. In the past, the upper part of the island was forested; at present, the forest is at the final stages of extinction (apparently due to toxins from cormorant droppings) (Anenkhonov et al., 2020). The birds have created a large breeding colony on the island. On the open parts of slopes, nitrophilic-ruderal plants and their communities are distributed, combined with steppe-like species-poor communities that contain patches of ruderal plants.

Pokoynitskiy Kamen Island has an oval shape. Rocks form its main part, to which a narrow triangular platform (rising only slightly above the waterline) is "attached" in the northwest. Highly productive nitrophilic ruderal meadow plants with a few young birches (*Betula platyphylla* Sukacz.) and poplar (*Populus laurifolia* Ledeb.) trees, as well as willow bushes (*Salix pseudopentanmdra* (B. Flod.) B. Flod.), grow on this platform. Meadow communities have also formed on the slopes, where the last remaining Siberian pines can be found. The upper part of the island is completely devoid of vegetation due to a nesting colony of gulls and cormorants.

Elena Island is in the Onkogonskaya cove. The island has an elongated, curved, and irregular shape. A rocky outcrop forms its southern part and includes the highest point on the island. The northern end of the island is formed by a low platform with pebble and sandy areas adjacent to the main rocky outcrop in the south. Different types of forest cover the island. Communities of shrubs, meadows, and coastal-aquatic plant communities also exist and are confined to the platform and the coastal strip around the rocky part of the island. A dark coniferous forest with Siberian pine and dwarf Siberian pine in the shrub level is noted, as well as a light coniferous forest with larch and Scots pine. Those forest types are combined with small-leaved birch forest communities dominated by grasses (e.g. *Brachypodium pinnatum* (L.) Beauv.) in the herb layer.

Bare, rocky Belyy Kamen Island is almost monolithic. Its steep slopes drop straight down to the bay

and are marked by various protrusions and grottoes. Only two plant specimens were discovered on the island, both presumably related to *Artemisia mongolica* (Besser) Fisch. ex Nakai. They were seen on its eastern and western cliff faces. It was not possible to reach or collect these plants for exact identification.

Kovrizhka Island is the smallest of the group and located in the southeastern "corner" of the bay. It is comprised of a single large rock surrounded by smaller stones and covered in trees and shrub vegetation. Small patches of grass communities are developing at the foot of the rock.

In general, the climate of Chivyrkuyskiy Bay is rather cold. This is caused by the cooling effect of Lake Baikal's waters. However, microclimatic conditions are not homogeneous and depend on elevation above water level, the position of a site on an island, and slope aspect. They vary dramatically in different parts of the islands. Typically, the northern side of an island has steep, almost vertical, shaded slopes. Prevailing winds and waves from the north (and the main area of the lake beyond the bay) bring moisture and also cause a decrease in air temperature. Shading of the northern slopes also plays a significant role and is accompanied by increased humidity. The southern slopes of the islands are less steep, warmer, and drier, due to their exposure to the sun (Molozhnikov, 1974). This leads to the existence of discrepant vegetation types in different parts of the islands (except Belyy Kamen Island, which is almost completely devoid of vegetation). The steepness of slopes reinforces these differences. On the larger islands (Baklaniy, Lokhmatyy, and Elena) most of the slopes are covered with various types of forests. Light coniferous and small-leaved trees predominate: mostly larch, very rarely pine (Elena Island), aspen, and birch. Dark coniferous forest with Siberian pine and sparse Siberian fir trees do occur on the wetter northwestern slopes. On smaller islands, only separate trees or small groups of trees can be found instead of well-developed forest communities.

MATERIALS AND METHODS

Detailed surveys of the vegetation on the Chivyrkuyskiy Bay islands were carried out in the summer of 2018. The route method was applied to study the island flora. Vascular plant species were identified and herbarium specimens were collected along the routes. The routes have covered all the accessible areas of the islands. Sites with cliffs plunging directly into the bay were not surveyed due to their inaccessibility in the absence of rock climbing equipment and limited time. For this reason, petrophytic vegetation was examined only on boulders or pebble-covered ground on accessible coastal cliffs. Besides, surveys were carried out from tip to tip along two "diameter" lines intersecting at the highest point of each island (where accessible). An attempt was also made to include all the main types of plant communities. Secondary ornithogenic phytocoenoses, puddles, small wetlands, rocky cliffs, fine-grained rocky outcrops, ravines, and combs were of particular interest. In some places, standard relevés were conducted to describe vegetation, and 33 relevés have been collected in total. This data allows for an understanding of the habitat distribution of species. Belyy Kamen Island was examined remotely (using a 12 × 50 "Navigator" binocular) from a small vessel because it was impossible to land due to the cliffs surrounding the entire island. Waves allowed us to come no closer than 5 m from its cliffs.

Plants were identified by referring to Flora of Siberia (1988–2003) and the Handbook for Plant Species of Buryatia (2001). The standard Excel 2003 and Statistica 10 software packages were used for statistical data processing and a graphical representation of the results. The coefficient of determination (R^2), as well as the Spearman correlation coefficient, were applied to determine the relationship between the number of vascular plant species and factors like island area, remoteness from the mainland, and ornithogenic factors. Mapping methods and the ArcGIS Pro 1.3 software package were employed to measure the area of islands and their distance from the mainland. The collected herbarium specimens (about 300 in total) are stored in the Herbarium of the Institute of General and Experimental Biology SB RAS, Ulan-Ude (*UUH*). The nomenclature of plant names is given according to the *Flora of Siberia* (1988–2003). When inventorying the composition of the Chivyrkuyskiy Bay islands' flora, previously published data devoted to the whole flora of Zabaikalskiy National Park was also included (Anenkhonov, Pykhalova, 2010).

RESULTS AND ANALYSIS

Species pool patterns in the island flora. As a result of the studies, 334 vascular plant species and subspecies have been registered on the Chivyrkuyskiy Bay islands. Among these, 219 species were registered for the first time based on our research. 115 species were known previously and 77 were confirmed in the course of our studies, while 38 species are included based on previously published data only. All of these species belong to 188 genera and 61 families, accounting for 32.0%, 50.2%, and 63.4% of corresponding taxa numbers in the total Zabaikalskiy National Park flora. Taking into account the fact that the area of the islands is only 0.01% of the total National Park area, the islands' floristic diversity is relatively high. It is well known that species diversity is determined by the heterogeneity of a territory (Malyshev, 1969), and this pattern is also true for the islands studied due to a wide range of habitats.

The number of plant species varies dramatically among the islands and depends on several factors: physiographic (island size and elevation, heterogeneity of habitats, distance from the mainland, etc.), biological (evolutionary time), anthropogenic influences (MacArthur, Wilson, 1967; Ivanov, 2016; et al.) and so

on. The interplay between these factors complicates understanding of the exact role played by each of them. Major differences in the species pools between the islands of Chivyrkuyskiy Bay are observed: from 1 species (Belyy Kamen Island) to 177 species (Lokhmatyy Island) (Table 1).

As a rule, the number of species correlates to an island's area and the same occurred on the islands of Chivyrkuyskiy Bay (there is a significant ratio of the R^2, Fig. 2). However, the influence of the different factors mentioned above is best illustrated by the fact that the number of species on the largest island (Baklaniy) is almost the same as on the significantly smaller Lokhmatyy Island, the second-largest but the richest in flora (Table 1) due to its diversity of habitats and plant communities. Baklaniy Island is almost three times farther from the mainland than Lokhmatyy (Table 1). However, a possible correlation between the number of species and distance to the mainland looks doubtful and needs further investigation, while a correlation with habitat heterogeneity seems to be more probable. Similarly, the strong species-area relationship has been revealed on the islands and peninsulas of the Maloe More Strait at the western coast of Lake Baikal (Chepinoga et al., 2012). The R^2 of the species-area relationship on the islands of both Chivyrkuyskiy Bay and the Maloe More Strait is the same (~0.88) supporting the similarity. However, smaller islands of Chivyrkuyskiy Bay (Kovrizhka, Pokoynitskiy Kamen) and the Maloe More Strait (Modoto, Borga-Dagan, Sarminskaya Kosa, Khunuk, Tojnak, Malyi Tojnak) tend to be more similar in the species-area relationship. Larger islands are different in patterns of species richness, to wit, those of Chivyrkuyskiy Bay have higher species richness concerning comparable islands of the Maloe More Strait.

Undoubtedly, the ornithogenic factor has a significant effect on the vegetation of three islands, namely Belyy Kamen, Pokoynitskiy Kamen, and Golyy. A negative correlation was found there: the presence of bird colonies contributes to a decrease in the number of plant species. The statistical significance of this correlation (–0.43) is low, however. At the same time, the two-fold decrease in overall species richness on the islands in the Maloe More Strait populated by large gull colonies has been found (Chepinoga et al., 2012). Both findings reflect a general pattern of the ornitogenic impact on the species richness on islands. However, the strength of the impact is different depending on the balance between the birds' population density and the island size. There are no the same balances between islands of the Maloe More Strait and Chivyrkuyskiy Bay. For this reason patterns in species richness on islands occupied by bird-nesting colonies are dissimilar.

Patterns in flora composition. Angiosperms constitute the main body of the flora, accounting for 315 species (94.3% of the total species number). Dicots prevail among these, with 231 species (69.2% of the total number of angiosperms), monocots comprise 84 species (25.1%), which generally corresponds to the proportions in the broader flora of Zabaikalskiy National Park (Anenkhonov, Pykhalova, 2010). The list of top multispecies families is also similar to the National Park flora one (Table 2), and the Zabaikalskiy National Park flora is, in turn, a good representation of the entire Baikal region (Osipov, 1999).

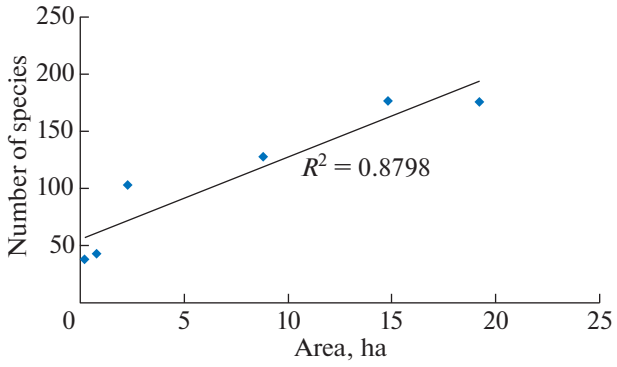

Fig. 2. Correlation between the vascular species number and island area (the data on Belyy Kamen Island were excluded).

It is worth noting that some changes in family ranks do occur and are caused by a small size of the islands as well as the incompleteness of their habitats as compared to the environmental diversity of the entire region. About half of all families are monogeneric (33 of 61), and 25 are represented by a single species.

Asteraceae and Poaceae are predominant in the island flora and this is a typical feature for any boreal flora (Tolmachyov, 1974; Khokhryakov, 2000). Both families have the same rank as in the National Park flora. The Rosaceae family is ranked third, which is a bit higher compared to the National Park flora, and is due to the lower ranking of the Cyperaceae family. The most probable reason for a reduced presence of the latter is that the islands are poor in wetlands, which are the main habitat for species of this family. The majority of the Cyperaceae species belong to the *Carex* genus, while species of other genera comprise less than 20% of the entire family in the island flora. Apart from these two predominant families, Ranunculaceae keeps its rank and almost claims the same share as in the National Park flora. The Brassicaeae family has an increased rank because of a more sufficient reduction in Caryophyllaceae and Fabaceae in some genera and the presence of ruderal nitrophilous species inhabiting ornitogenic plant communities. The absence of high mountains and a deficit of habitats sufficiently disturbed by humans are possible reasons for the slight lowering of Caryophyllaceae in the rankings. The rank of Fabaceae is also lower but still in the top ten since its species pool includes the sylvan and meadow plant

Table 2. The spectrum of multispecies families in the flora of Chivyrkuyskiy Bay islands and Zabaikalskiy National Park (ZNP) flora

№	Family	Islands' flora			ZNP flora	
		Number of species in the islands' flora	% from total islands' flora	Rank in the islands' flora	% from total number of species in the ZNP flora	Rank in the ZNP flora
1	Poaceae	46	13.8	1	10.7	1
2	Asteraceae	41	12.3	2	9.8	2
3	Rosaceae	22	6.6	3	5.4	4
4	Cyperaceae	20	6.0	4	8.6	3
5	Ranunculaceae	14	4.2	5–6	4.7	5
6	Brassicaceae	14	4.2	5–6	3.5	8
7	Caryophyllaceae	12	3.8	7	4.1	6
8	Fabaceae	10	3.0	8–12	4.0	7
9	Polygonaceae	10	3.0	8–12	2.9	10–11
10	Apiaceae	10	3.0	8–12	2.4	12
	Total of 10 families	199	60.1		55.7	
11	Ericaceae	10	3.0	8–12	2.1	13
12	Lamiaceae	10	3.0	8–12	2.0	14
13	Scrophulariaceae	9	2.7	13–14	2.9	10–11
14	Boraginaceae	9	2.7	13–14	1.6	16
15	Salicaceae	6	1.8	15–16	3.2	9
16	Chenopodiaceae	6	1.8	15–16	1.1	21

species of *Vicia* and *Lathyrus*. This is not representative of Baikal Siberian flora as a whole, where plants belonging to *Oxytropis* and *Astragalus* are typical for steppe vegetation and numerous (Malyshev, Peshkova, 1984). Salicaeae and Scrophulariaceae have dropped out of the top-ten families due to the absence of alpine and riverine landscapes on the islands. Another group of families (namely Apiaceae, Ericaceae, and Lamiaceae) has intruded instead (Table 2).

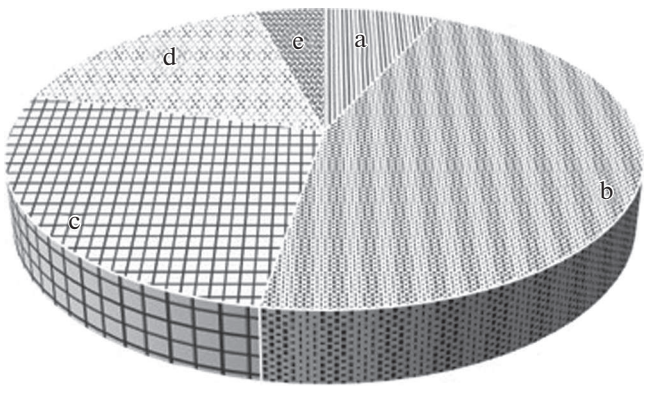

Fig. 3. The manifestation of latitudinal-and-altitudinal patterns in the flora of Chivyrkuyskiy Bay islands.
a – Alpine and Montane floristic complex; b – Sylvan floristic complex; c – Steppe floristic complex; d – Azonal floristic complex; e – Anthropophytes.

There are just a few multispecies genera on the islands: *Carex* (17 species), *Poa* (12), and *Artemisia* (9). These genera are typically rich in species in boreal and deeply inner-continental regions (Yurtsev, 1968).

An analysis of geographical patterns in the flora was carried out using L.I. Malyshev's and G.A. Peshkova's methodology (1984). The resulting sets of florogenetic groups (zonal sets on the one hand and chorological groups on the other) have been ordered and compared to each other. The largest set in the island flora is the Sylvan floristic complex (Fig. 3).

Within this complex, the largest number of species occurs in the light coniferous sylvan group (e.g. *Rhododendron dauricum* L., *Lathyrus humilis* (Ser.) Spreng., *Pedicularis labradorica* Wirsing, etc.). The groups of preboreal (e.g. *Hesperis sibirica* L., *Fragaria vesca* L., etc.) and dark coniferous sylvan species (e.g. *Ledum palustre* L., *Linnaea borealis* L., etc.) are substantially less numerous. This is caused by the prevalence of light coniferous groups in the taiga on the islands as well as throughout the whole Northern Baikal region (except for some parts of the western slopes of the Barguzinskiy Ridge).

The Steppe complex contains far fewer species than the Sylvan one: less than 1/3 of the total number of species in the flora (Fig. 3). The species of the forest-steppe group (e.g. *Carex pediformis* C.A. Mey., *Galium boreale* L., *Phlomoides tuberosa* L., etc.) are the most numerous in the Steppe complex; such a pattern is

Table 3. Cross-spectrum of chorological and latitudinal-and-altitudinal groups in the flora of Chivyrkuyskiy Bay islands

LAG	Chorological groups													Total %
	CP	EuA	EuS	PA	NA	SS	En	CA	MD	NEA	Okh	EA	AA	
Alpine and Montane floristic complex														
Al	–	–	–	–	2	2	–	–	–	–	–	–	–	4/1.2
AlT	3	1	–	–	–	–	–	–	–	1	–	–	–	5/1.5
Mn	–	1	–	–	2	5	–	–	–	1	–	–	1	10/3.0
HMn	4	1	–	–	–	–	–	–	–	–	–	1	–	6/1.8
Subtotal	7	3	–	–	4	7	–	–	–	2	–	1	1	25/7.5
Sylvan floristic complex														
DCS	8	1	3	–	3	2	–	–	–	–	–	–	3	20/6.0
LCS	24	27	8	7	15	11	3	–	3	1	3	2	6	110/32.9
PB	–	4	6	–	2	–	–	1	1	–	1	2	–	17/5.1
Subtotal	32	32	17	7	20	13	3	1	4	1	4	4	9	147/44.0
Steppe floristic complex														
FSt	7	19	4	1	2	5	1	1	2	–	–	–	–	42/12.6
MnSt	2	7	–	3	4	9	3	1	–	–	–	–	1	30/9.0
St	1	2	1	1	3	3	2	2	–	–	–	3	–	18/5.4
DsSt	–	–	–	–	–	–	2	–	–	–	–	–	–	2/0.6
Subtotal	10	28	5	5	9	17	8	4	2	–	–	3	1	92/27.5
Azonal floristic complex														
Md	13	5	2	–	1	–	1	–	–	–	–	4	1	27/8.1
Cs	2	–	–	–	1	1	1	–	–	–	–	1	–	6/1.8
WL	11	4	1	–	1	1	–	–	–	–	–	2	–	20/5.9
Aq	2	1	–	–	–	–	–	–	–	–	–	–	–	3/0.9
Subtotal	28	10	3	–	3	2	2	–	–	–	–	7	1	56/16.8
APh	8	6	–	–	–	–	–	–	–	–	–	–	–	14/4.2
Total, %	85/25.4	79/23.6	25/7.5	12/3.5	36/10.8	39/11.7	13/3.9	5/1.5	6/1.8	3/0.9	4/1.2	15/4.5	12/3.6	334/100

Note. LAG – latitudinal-and-altitudinal groups; Al – Alpine; AlT – Alpine Tundra; Mn – Montane; HMn – Hypoarctic-Montane; DCS – Dark Coniferous Sylvan; LCS – Light Coniferous Sylvan; PB – Preboreal; FSt – Forest-Steppe; MnSt – Montane-Steppe; St – Steppe; DsSt – Desert-Steppe; Md – Meadow; Cs – Coastal; WL – Wetland; Aq – Aquatic; APh – Anthropophytes. Chorological groups: see Fig. 4.

typical for taiga areas where steppe vegetation does not occupy significant areas and is strictly confined to steep southern slopes. Xeromesophytes belong to this group in the study area; forest edges and open semidry forest stands are among the typical habitats for them. One-third of the Steppe complex is composed of a group of montane-steppe species (e.g. *Allium strictum* Schrad., *Veronica incana* L., *Youngia tenuifolia* (Willd.) Babc. & Stebbins, etc.). The species of this group are characterized by a well-balanced water regime and a combination of both xeromorphic and mesomorphic traits in the leaf anatomical structure which give them advantages in harsh conditions (Popova, 2005). There are just a few plant species of the typical steppe group (e.g. *Agropyron cristatum* (L.) Gaertn., *Thymus baicalensis* Serg., etc.) because steppe communities have developed on relatively small sites on the islands.

An Azonal complex of species makes up a sixth of the flora. It contains meadow (e.g. *Persicaria lapathifolia* (L.) Delarbre, *Scutellaria galericulata* L., *Veronica longifolia* L., etc.) and wetland species (e.g. *Menyanthes trifoliata* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Rorippa palustris* (L.) Bess., etc.) in roughly equal measure (Table 3). Plants of both groups grow in lowland sites on the Baikal coast, in the splash zone, and where the groundwater table is close to the surface.

A small portion of species belongs to the Alpine and Montane complex. Species of the montane group (e.g. *Bergenia crassifolia* (L.) Fritsch, *Aconitum rubi-*

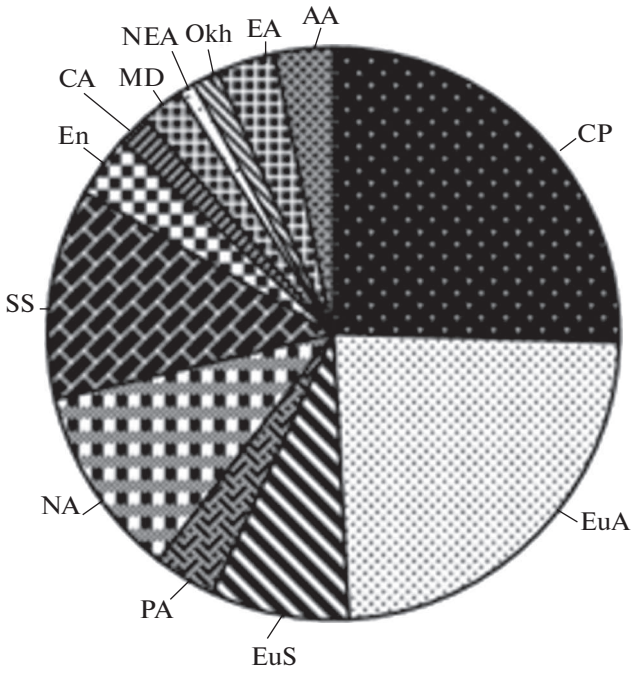

Fig. 4. Patterns of species geographical distribution in the flora of Chivyrkuyskiy Bay islands.

Chorological groups: CP – Circumpolar; AA – American-Asian; EuA – Eurasian; EuS – European-Siberian; PA – Pan-Asian; NA – North Asian; EA – East Asian; SS – South Siberian; MD – Manchurian-Daurian; NEA – North-East Asian; CA – Central Asian; En – Endemic; Okh – Okhotsk.

cundum Fisch., etc.) as well as of the hyparctomontane one (e.g. *Draba hirta* L., *Woodsia ilvensis* (L.) R. Br., etc.) are typical for mountain vegetation.

Anthropophytes (e.g. *Chenopodium album* L., *Lappula squarrosa* (Retz.) Dumort., etc.) represent the smallest group in the flora (Table 3). Since the islands were included in the strict protection zone of Zabaikalskiy National Park, the human impact has been very restricted. Anthropophytes either have been long existing on the islands as a legacy of more intensive anthropogenic influence in the pre-national park period, or are associated with the ornithogenic factor and, in these case, confined to the islands populated by bird colonies. On those islands, anthropophytes are closely linked to bird nesting colonies that enrich the soil with a high amount of nitrogen, phosphorus, and other chemical elements. Under these conditions, indigenous plant communities degrade, even to the extinction. At the same time, ruderal plants, whose seeds are carried by wind and waves, gain a competitive advantage. Some of them form continuous thickets in well-fertilized areas. Despite this, the share of anthropophyte species in the island flora remains rather small (Table 3).

Considering the patterns in the geographical distribution of species (Fig. 4), it should be noted that most of them have a very wide distribution area: Circumpolar (*Diphasiastrum complanatum* (L.) Holub, *Vaccinium vitis-idaea* L., *Linnaea borealis* L., etc.), and Eurasian (*Atragene sibirica* L., *Dianthus superbus* L., etc.). Together they contain almost half of the totality of species represented in the island flora. The next set of multispecies groups reflects the geographical position of the area and is represented by chorological groups of South Siberian (*Astragalus suffruticosus* DC., *Thesium repens* Ledeb., etc.) and North Asian (*Rubus matsumuranus* H. Levl. ex Vaniot, *Gentianopsis barbata* (Froel.) Ma, etc.) distribution, as well as showing European-Siberian (*Ribes nigrum* L., *Lathyrus pratensis* L., etc.) floristic connections. Other chorological groups possess shares of less than 5%. Nevertheless, the group of plants endemic to the Baikal region can be assessed as being rather numerous, and its share here is comparable to that seen in the broader National Park flora (Anenkhonov, Pykhalova, 2010). Plant species confined to the Lake Baikal shoreline (*Deschampsia turczaninowii* Litv., *Papaver popovii* Sipliv., *Corispermum ulopterum* Fenzl, etc.) are especially unique among the group of endemics.

The groups of easterly areas (Manchurian-Daurian, Okhotsk, East Asian, Central Asian, North-East Asian, American-Asian) all together comprise 13.5% of the total island flora. Some plants of these groups play a significant role in the formation of plant communities, such as, for example, the North-East Asian shrub (prostrate tree) *Pinus pumila* (Pall.) Regel, which forms sparse undergrowth in forests on three islands (Baklaniy, Lokhmatyy, Elena).

A cross-analysis of chorological and zonal groups (Table 3) shows that the flora is geographically heterogeneous. The share of species with a wide range (Circumpolar, Eurasian, European-Siberian) is lowest in the Alpine and Montane floristic complex, while highest in the Azonal one. In the Sylvan floristic complex, the species with a wide range are especially numerous, although this complex is the most heterogeneous in the flora. An abundance of North-Asian species is intrinsic to the light-coniferous sylvan group and it causes a relatively high quantity of those species in the entire Sylvan complex. As expected, a lack of northerly groups (North-East Asian, Okhotsk) and a low share for the Circumpolar group are observed in the Steppe complex. Instead, the highest share is occupied by the South Siberian and Endemic groups and this is a typical feature of the complex (Peshkova, 2001). This remarkable endemism has developed due to the unique conditions in lakeside psammophytic-steppe communities formed under the influence of the lake (Vika, Namzalov, 2013). Within the Azonal floristic complex, widely distributed species prevail as usual. Anthropophyte species belong to two types of distribution: Circumpolar and Eurasian. In general, the proportions of chorological and zonal groups correspond to geographical patterns in the National Park flora.

Rare and endangered species. Six endangered species (*Deschampsia turczaninowii* Litv., *Corispermum ulopterum* Fenzl, *Cotoneaster tjuliniae* Pojark. ex Peschkova, *Rhodiola rosea* L., *Papaver popovii* Sipliv., *Epipactis helleborine* (L.) Crantz) from the island flora are listed in the *Red Data Book of the Republic of Buryatia* (Krasnaya ..., 2013). Most of them are endemics. The rarest species is *Papaver popovii*, which has a small population on Lokhmatyy Island and has also been found on Olkhon Island (Krasnaya ..., 2013). The population on Lokhmatyy Island has been described as stable (Bukharova, Burdukovskiy, 2016). Another endemic of the Baikal shoreline, *Deschampsia turczaninowii* grows in sandy and pebble supralittoral zones and has been listed in the *Red Data Book of Russia* (Krasnaya ..., 2008). Despite its naturally low abundance, the population of this species is quite stable in those habitats (Bukharova, 2013). It is able to regenerate extensively with seeds, which allows it to recover successfully its population when it is damaged, for instance, by storm waves (Bukharova, 2014). *Corispermum ulopterum* is another endemic species. It inhabits narrow strips of sandy deposits in the upper part of the supralittoral zone. This annual plant has adapted to survive thanks to morphological features of its seeds and high seed productivity (Bukharova, Burdukovskiy, 2016). *Cotoneaster tjuliniae* is a rare species, endemic on the northern coast of Lake Baikal. It has been registered on Lokhmatyy Island where it is confined to sun-exposed habitats at forest edges. We found *Rhodiola rosea*, a species listed in the *Red Data Book of Russia* (Krasnaya ..., 2008), on the north-facing cliffs of Lokhmatyy Island. Environmental conditions there (especially moisture and temperature) are similar to its typical habitats, i.e. alpine meadows on stream banks and lakeshores (Moskvin, Moskvina, 1991). Such habitats are quite common in the Barguzinskiy Ridge nearby (Siplivinskiy, 1967; Bukharova, 2010).

CONCLUSION

The flora of the seven islands in Chivyrkuyskiy Bay is represented by 334 species of vascular plants from 188 genera and 61 families. This can be described as a high level of species diversity and is explained by the great variety of environmental conditions present. There is a positive correlation between species pool richness and island area.

The taxonomic patterns of the island flora are typical of Zabaikalskiy National Park flora, and, for the most part, reflect the main features of Baikal Siberian flora as a whole. Holarctic and Eurasian species together account for the majority of species in the island flora. Plants related to both South Siberian and North Asian types of ranges are the most numerous representatives of Asian plants. In general, the composition and structure of the island flora indicate that it was once physically connected to flora on the Barguzinskiy Ridge and the Svyatoy Nos Peninsula, and remains closely related to them. 13 endemic plant species were registered on the islands. All of them are endemics of the Baikal region, but not of the islands themselves. Lokhmatyy Island is inhabited by 9 plant endemics, which makes it the richest in terms of unique species among the Chivyrkuyskiy Bay islands. The anthropophyte group is presented by the same species as in the broader National Park flora. Anthropophytes have been registered on all of the islands. However, they are especially common and abundant on the islands occupied by bird nesting colonies.

As a result of our studies, we conclude that the island flora is stable and relatively undisturbed by human activity. Nevertheless, it is necessary to establish the monitoring of these habitats to keep them pristine and preserve their natural state.

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REFERENCES

Anenkhonov O.A., Bukharova E.V., Ananin A.A. 2020. Current state of vegetation cover in the islands of Chivyrkuy Bay (Lake Baikal) under the influence of semiaquatic bird colonies. – Nature of Inner Asia. 2 (15): 7–23 (In Russ.). https://doi.org/10.18101/2542-0623-2020-2-7-23

Anenkhonov O.A., Pykhalova T.D. 2010. Konspekt flory sosudistykh rastenii Zabaikal'skogo natsional'nogo parka [The check-list of vascular plants flora of Zabaikalskyi National Park]. Ulan-Ude. 228 p. (In Russ.).

Boikov T.G., Anenkhonov O.A., Pykhalova T.D., Kharitonov Yu.D., Sekulich I.R., Danilova O.V., Berkovich M.B. 1991. Flora Zabaikal'skogo prirodnogo natsional'nogo parka [Flora of Zabaikalskiy natural national park]. Ulan-Ude. 138 p. (In Russ.).

Bukharova Ye.V. 2010. *Rhodiola rosea* L. v Barguzinskom zapovednike [*Rhodiola rosea* L. in Barguzinskiy Nature Reserve]. – In: Problemy izucheniya rastitel'nogo pokrova Sibiri: Materialy IV Mezhdunarodnoi konferentsii, posvyashchennoi 125-letiyu Gerbariya im. P.N. Krylova Tomskogo gosudarstvennogo universiteta i 160-letiyu so dnya rozhdeniya P.N. Krylova (Tomsk, 1–3d November 2010). Tomsk. P. 165–167 (In Russ.).

Bukharova Ye.V. 2013. *Deschampsia turczaninowii* Litv. v Barguzinskom zapovednike [*Deschampsia turczaninowii* Litv. in Barguzinskiy Nature Reserve]. – In: Rol' i zadachi osobo okhranyayemykh prirodnykh territorii v sovremennoi Rossii: sb. mater. vserossiiskoi nauch.-praktich. konf. Yoshkar-Ola. P. 78–81 (In Russ.).

Bukharova Ye.V. 2014. Semennaya produktivnost' *Deschampsia turczaninowii* Litv. v Barguzinskom zapovednike [Seed productivity of *Deschampsia turczaninowii*

Litv. in Barguzinskiy Nature Reserve]. – In: Aktual'nyye voprosy v nauchnoi rabote i obrazovatel'noi deyatel'nosti: sb. nauch. tr. po mat-lam Mezhdunar. nauch.-prakt. konf. Chast' 11. Tambov. P. 16–18 (In Russ.).

Bukharova Ye.V., Anenkhonov O.A., Badmaeva N.K., Pykhalova T.D., Burdukovskiy A.I., Luzhkova N.M. 2019. Annotirovannyi spisok flory ostrovov Chivyrkuiskogo zaliva (Zabaikalskii natsional'nyi park) [The annotated list of flora of Chivyrkuyskii bay islands (Zabaikalsky National Park)]. – In: Prirodnye kompleksy Severo-Vostochnogo Pribaikal'ya: trudy Barguzinskogo gosudarstvennogo prirodnogo biosfernogo zapovednika. Ulan-Ude. 11. P. 154–182 (In Russ.). https://doi.org/10/31554/978-5-7925-0575-9-11-2019-154-182

Bukharova Ye.V., Burdukovskiy A.I. 2016. Redkiye vidy rastenii vo flore Zabaikal'skogo natsional'nogo parka. – Vestnik Buryatskogo gosudarstvennogo universiteta. 2–3: 121–128. (In Russ.).

Chepinoga V.V., Zverev V.E., Zvereva E.L., Kozlov M.V. 2012. Vascular plants on the islands and peninsulas of Maloe More (Lake Baikal): patterns of diversity and species turnover. – Boreal Environment Research. 17: 219–236.

Flora Sibiri. V 14 tomakh [Flora of Siberia. 14 Volumes]. 1987–2003. Novosibirsk (In Russ.).

Imetkhenov A.B., Boikov T.G., Tsybzhitov Ts.Kh., Yumov B.O., Matveichuk S.A. 1990. Priroda Zabaikal'skogo natsional'nogo parka [Nature of Zabaikalsky National Park]. 192 p. (In Russ.).

Ivanov A.N. 2016. Ostrovnaya biogeografiya i ostrovnoye landshaftovedeniye: istoriya formirovaniya predstavlenii i osnovnyye etapy razvitiya [Island biogeography and island landscape ecology: history of preception formation and main stages of development]. – Voprosy istorii yestestvoznaniya i tekhniki. 37 (4): 684–701 (In Russ.).

Khokhryakov A.P. 2000.Taksonomicheskiye spektry i ikh rol' v sravnitel'noi floristike [Taxonomic spectra and their role in comparative floristics]. – Bot. Zhurn. 85 (5): 1–11 (In Russ.).

Krasnaya kniga Respubliki Buryatiya: Redkiye i nakhodyashchiyesya pod ugrozoy ischeznoveniya vidy zhivotnykh, rastenii i gribov. [Red Book of Republic of Buryatia: rare and endangered animals, plants, and fungi]. 2013. Ulan-Ude. 688 p. (In Russ.).

Krasnaya kniga Rossiiskoy Federatsii (rasteniya i griby) [Red Book of the Russian Federation (plants and fungi)]. 2008. Moscow. 855 p. (In Russ.).

Lamakin V.V. 1968. Neotektonika Baikal'skoi vpadiny [Neotectonics of the Baikal rift]. Moscow. 247 p. (In Russ.).

MacArthur R.H., Wilson E.O. 1967. The Theory of Island Biogeography. Princeton. 293 p.

Malyshev L.I. 1969. Zavisimost' floristicheskogo bogatstva ot vneshnikh uslovii i istoricheskikh faktorov [Dependence of floristic richness from exterior conditions and historical factors]. – Bot. Zhurn. 54 (8): 1137–1147 (In Russ.).

Malyshev L.I., Peshkova G.A. 1984. Osobennosti i genezis flory Sibiri (Predbaikal'ye i Zabaikal'ye) [Features and genesis of flora in Siberia (Lake Baikal Region)]. Novosibirsk. 265 p. (In Russ.).

Mats V.D. 1974. Baikal'skiye terrasy nizkogo kompleksa [Baikal terraces of low complex]. – In: Priroda Baikala. Leningrad. P. 31–57 (In Russ.).

Molozhnikov V.N. 1974. Chivyrkuiskoye semiostrov'ye i poluostrov Svyatoi Nos (sostoyaniye ekosistem i voprosy okhrany ikh zhivotnykh komponentov) [Archipelago of seven islands in Chuvyrkuyskii Bay and Svyatoi Nos Peninsula (conditions of ecosystems and issues of wildlife protection)]. – In: Priroda Baikala. Leningrad. P. 257–271 (In Russ.).

Moskvin P.V., Moskvina E.V. 1991. Biologicheskiye osnovy okhrany rodioly rozovoy v Pribaikal'ye [Biological background for Rhodiola rosea protection in Baikal region]. – In: Ratsional'noye ispol'zovaniye i okhrana rastitel'nykh resursov Tsentral'noy Sibiri. Irkutsk. P. 85–92 (In Russ.).

Opredelitel' rastenii Buryatii [Handbook for identification of plants of Buryatia]. 2001. Ulan-Ude. 672 p. (In Russ.).

Osipov K.I. 1999. Flora Baikal'skoy Sibiri i yeyo kolichestvennyi sostav [Flora of Lake Baikal Siberia and its quantitative composition]. – In: Raznoobraziye rastitel'nogo pokrova Baikal'skogo regiona: Materialy mezhdunar. nauch. konf. Ulan-Ude. P. 24–26 (In Russ.).

Peshkova G.A. 2001. Florogeneticheskii analiz stepnoi flory gor Yuzhnoi Sibiri [Florogenetic analysis of steppe flora of mountains in South Siberia]. Novosibirsk. 192 p. (In Russ.).

Popov M.G., Busik V.V. 1966. Konspekt flory poberezhii ozera Baikal [Flora Synopsis of the Lake Baikal coastal area]. Moscow–Leningrad. 215 p. (In Russ.).

Popova O.A. 2005. Bioraznoobraziye i osobennosti adaptogeneza rannetsvetushchikh rastenii Baikal'skoy Sibiri (Vostochnoye Zabaikal'ye) [Biodiversity and features of adaptation genesis of early blooming plants in Lake Baikal Siberia (Eastern Zabaikalye)]. Chita. 225 p. (In Russ.).

Siplivinskiy V.N. 1967. Ocherk vysokogornoy rastitel'nosti Barguzinskogo khrebta [Outline of the highland vegetation of the Barguzinskiy Ridge]. – In: Trudy Barguzinskogo gosudarstvennogo zapovednika. Issue 6. Moscow. P. 64–130.

Sochava V.B. 1979. Rastitel'nyy pokrov na tematicheskikh kartakh [Vegetation cover on thematic maps]. Novosibirsk. 190 p. (In Russ.).

Tolmachyov A.I. 1974. Vvedeniye v geografiyu rasteniy [Introduction to the plant geography]. Leningrad. 244 p. (In Russ.).

Tyulina L.N. 1981. Rastitel'nost' yuzhnoi chasti Barguzinskogo khrebta [Vegetation of the southern part of Barguzinskiy ridge]. Novosibirsk. 85 p. (In Russ.).

Vika S., Namzalov B.B., Rakhmonov O., Snytko V.A., Shchipek T. 2013. Psammostepi vostochnogo poberezh'ya ozera Baikal: osobennosti floristicheskogo i fitotsenoticheskogo raznoobraziya [Psammosteppe vegetation of eastern shore of Lake Baikal: features of floristic and phytocoenotic diversity]. – Rastitel'nyy mir Aziatskoi Rossii. 2 (12): 99–108 (In Russ.).

Yurtsev B.A. 1968. Flora Suntar-Khayata. Problemy istorii vysokogornykh landshaftov Severo-Vostoka Sibiri [Flora of Suntar-Khayata Ridge. The problems of the history of highland landscapes of the Northeastern Siberia]. Leningrad. 235 p. (In Russ.).

ОСНОВНЫЕ ЧЕРТЫ И ОСОБЕННОСТИ ФЛОРЫ ОСТРОВОВ ЧИВЫРКУЙСКОГО ЗАЛИВА (ЗАБАЙКАЛЬСКИЙ НАЦИОНАЛЬНЫЙ ПАРК, ВОСТОЧНАЯ СИБИРЬ)

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Чивыркуйский залив находится на северо-восточном побережье оз. Байкал и является частью территории Забайкальского национального парка (ЗНП). В пределах акватории залива находится семь островов (Чивыркуйское семиостровье): Бакланий, Лохматый, (Большой Кылтыгей), Голый (Малый Кылтыгей), Покойницкий Камень, Елена, Белый Камень, Коврижка. Растительный покров островов залива был слабо изучен. Выявление флористического разнообразия островов важно в условиях климатических изменений и антропогенного влияния. Для исследования островной флоры был использован маршрутный метод. Для выявления зависимости числа видов сосудистых растений от площади островов, удаленности от материкового берега и орнитогенного фактора использовались коэффициент детерминации и коэффициент корреляции Спирмена, для определения размеров островов, их удаленности от материка, применялись картографические методы и инструменты пакета программ ArcGIS Pro 1.3.

Видовое разнообразие флоры островов Чивыркуйского залива довольно высокое и обусловлено пестротой экологических условий. Оно представлено 334 видами сосудистых растений, относящихся к 188 родам и 61 семейству. Из них впервые указаны 178 видов для островов Чивыркуйского семиостровья и 18 видов для территории ЗНП. Флористическое богатство островов положительно коррелирует с их площадью. На растительный покров островов, населенных колониями монгольской чайки и большого баклана (Белый камень, Покойницкий камень, Голый), значительное влияние оказывает орнитогенный фактор. Наблюдается обратная корреляция этого фактора с видовым богатством, следовательно, он вносит вклад в снижение числа видов растений, произрастающих на островах.

Таксономическая структура флоры островов в целом типична для флоры ЗНП, а также, в основных чертах, отражает общие черты флоры Байкальской Сибири. Географический анализ показал, что основу флоры островов составляют виды, широко распространенные в Голарктике и Евразии. Из азиатских растений наибольшее участие в составе флоры принимают виды с южно-сибирским и североазиатским типами ареалов. На островах довольно высокий уровень эндемизма (3.5%). Основное количество эндемиков (9 из 13) отмечено на о-ве Лохматый. Это преимущественно горностепные растения. Впервые для островов Чивыркуйского залива выявлены и уточнены местообитания редких видов: *Deschampsia turczaninowii* Litv., *Corispermum ulopterum* Fenzl, *Cotoneaster tjuliniae* Pojark. ex Peschkova, *Rhodiola rosea* L., *Papaver popovii* Sipliv., *Epipactis helleborine* (L.) Crantz. В составе флоры нет инвазионных видов, но присутствуют антропофиты (в основном в орнитогенных ценозах), зарегистрированные также и во флоре ЗНП в целом.

Состав и структура флоры островов позволяют считать ее почти полностью преемственно и неразрывно связанной с флорами окружающих Чивыркуйский залив Баргузинского хребта и полуострова Святой Нос. В целом анализ характеризует флору островов как бореальную полугумидную, а флористическое богатство обусловлено, в первую очередь, биотопическим разнообразием.

Ключевые слова: сосудистые растения, структура флоры, видовое богатство, озеро Байкал, национальный парк, островная биогеография, редкие виды, фиторазнообразие, эндемики

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