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*Article*

## **Floristic diversity of Volga Reach islands of the Rybinsk Reservoir**

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**Abstract.** Floristic diversity, i.e. vascular plants, fungi, lichens, liverworts and mosses of five islands (some of which are protected areas) situated in the middle part of the Volga Reach of the Rybinsk Reservoir has been studied. For vascular plants, ecological groups and life forms have been identified. The island of Shumorovsky is distinguished by the largest number of species, while Koprinsky – by the least one. According to the Jacquard coefficient, the similarity between the islands is less than 50% that is explained by the difference in the present ecotopes. Mesophytes, xeromesophytes and hygrophytes dominate in ecological groups of the floral composition of different islands. The analysis of life forms is evidence of the predominance of herbaceous plants (65.9% of the total flora).

**Keywords:** flora composition, generic coefficient, ecological groups, life forms

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*Научная статья*

# Флористическое разнообразие островов Волжского плёса Рыбинского водохранилища

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**Аннотация.** Проведено исследование растительного мира (сосудистые растения, грибы, лишайники, печеночники и мхи) на пяти островах средней части Волжского плеса Рыбинского водохранилища, часть из которых является особо охраняемой природной территорией. Для сосудистых растений определены экологические категории и жизненные формы. Остров Шуморовский выделяется наибольшим числом видов, а Копринский – наименьшим. Сходство между островами по коэффициенту Жаккара менее 50%, что объясняется различием имеющихся на них экотопов. Выявлено, что среди экологических групп флоры преобладают mesophytes, хегомесофиты и нугрофиты. Анализ жизненных форм продемонстрировал преобладание травянистой растительности (65.9% от общего числа видов).

**Ключевые слова:** состав флоры, родовой коэффициент, экологические группы, жизненные формы

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## Introduction

The Rybinsk Reservoir was formed in the late 1930s – early 1940s in the area of the Mologa-Sheksna interfluvium. As a result of its basin filling, islands, representing the highest floodplain and terrace geomorphological structures of the valley landscape, appeared. Some of them (in particular, Shumarovsky Island) are currently classified as specially protected natural territories. They serve as a reserve for the gene pool of the flora and fauna of the former Volga River valley, acting as a generator of biological production (Fatkulina, 2000). An island may be a convenient model for studying an ecosystem – with clear boundaries, fixed area, and simplified biotic connections. The water regime of the reservoir, which, unlike an unregulated river, possesses not only seasonal but also weekly and daily dynamics, is responsible for a high variability of the boundaries of the island area, as well as the sites of flooding and waterlogging of a soil cover. This, in turn, determines the evolutionary rate and direction of the entire island ecosystem (Ivanov et al., 2007; Ryazanov and Kulagina, 2019).

When assessing the state of natural systems, botanical criteria carry the most weight since vegetation, being the leading component of the ecosystem, acts as an indicator of a soil cover, a habitat, and a food source for animals. As for the island flora, it is formed by a random flow of migrants, species diversity depends on the area of the island and its landscape diversity. Besides, the species composition changes over time because of migration and extinction of species (Ivanov, 2016).

Since the formation of the Rybinsk Reservoir, the islands have been actively involved in recreational activities. This is associated with the need for rehabilitation of island ecosystems, based on assessing their natural significance, in particular, the flora analysis. It is believed that the simplest indicators (the number of species of individual groups, the ratio of different groups of species) can serve as indicators of the state of the overall biological diversity of the territory and have a prognostic value (Belonovskaya, 1997). The purpose of our work was to study the floristic composition of Volga Reach islands in the Rybinsk Reservoir to monitor its dynamics in the course of further development.

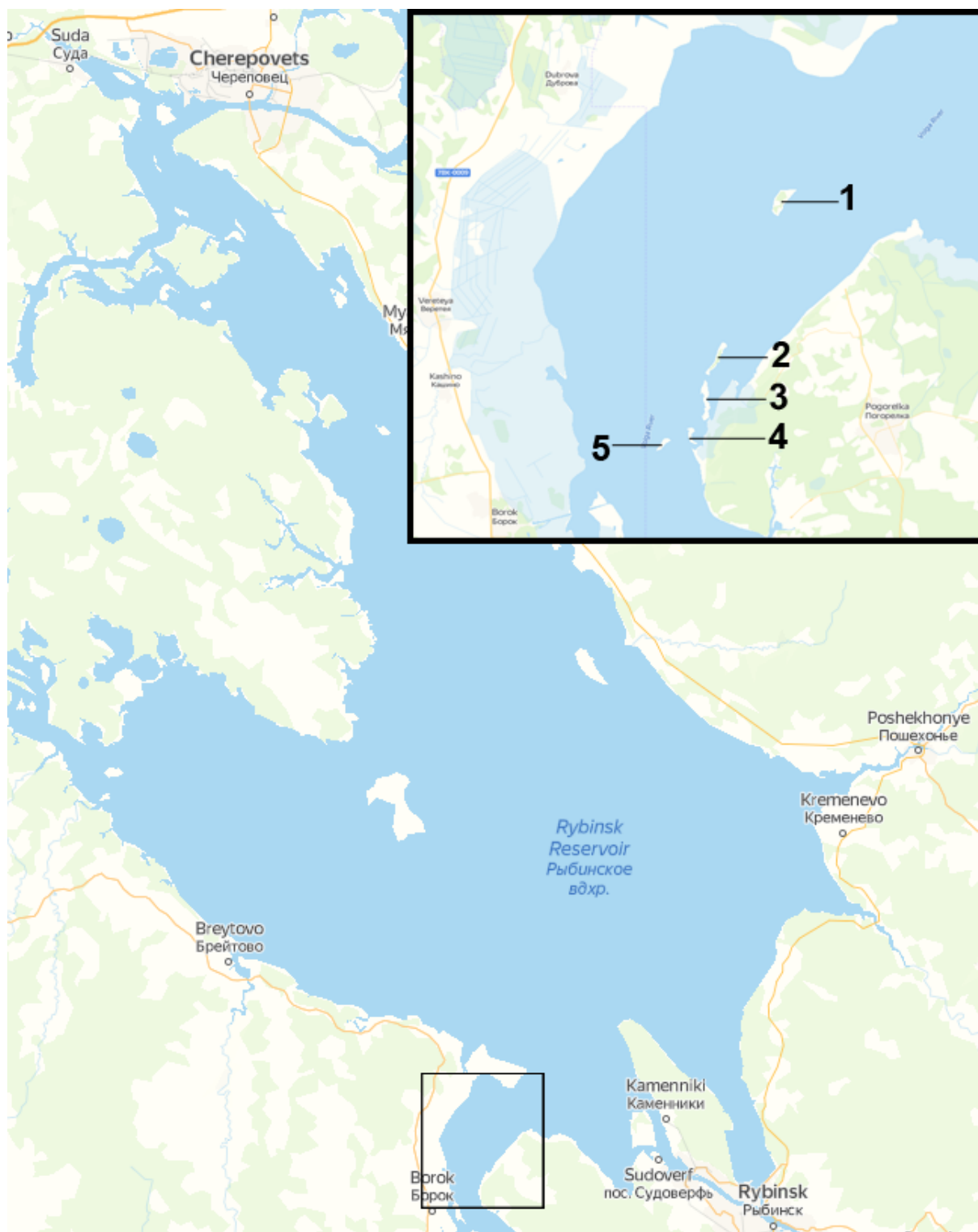
## Materials and methods

Using the route survey method in 2018–2020, the flora of five large islands (Shumarovsky, Koprinsky, as well as the northern, central, and southern Tryasye) of the Volga River floodplain in the Rybinsk Reservoir was studied (Fig. 1). A floristic list was compiled and, in addition to vascular plants, it included mosses, liverworts, bracket fungi, lichens, and myxomycetes that broadens the understanding of the distribution of representatives of these groups in the Yaroslavl region (Bolshakov et al., 2022; Novozhilov, 1993 et al.). The species affiliation of herbarium specimens was determined using the “Flora of the temperate zone of the European part of Russia” (Maevsky, 2014) and the “Flora of water bodies of the Volga river basin” (Lisitsyna et al., 2009). The structure of the studied flora was given according to APG IV with minor modifications proposed for the flora of the Yaroslavl region (Byng et al., 2016; Garin, 2016). The analysis of the flora was conducted according to the classic scheme (Garin, 2004; Krylova, 2003); taxonomic and ecological analysis of the flora, characterization of latitudinal and longitudinal elements were performed in accordance with the recommendations of V.G. Papchenkov (2001), life forms of vascular plants were presented according to the classification of C. Raunkiaer (Raunkiaer, 1937).

To assess the diversity of ecological conditions, the generic coefficient was determined, i.e. the ratio of the number of genera to the number of species (Alyokhin, 1944). The following ecological groups of plants were identified: hydrophytes (floating and submerged forms), hydrohygrophytes (aero-aquatic), hygrophytes (moisture-loving species/water-resistant plants), hygromesophytes (plants developing in conditions of temporary excess moisture, in particular, on wet and flooded shores), mesophytes (plants living under average moisture conditions and able to withstand short-term drought), xeromesophytes (plants of ecotopes with temporary moisture deficit), mesohygrophytes (plants intermediate in moisture preference between hygrophytes and mesophytes) and mesoxerophytes (plants of dry habitats). Absolute similarity measures were defined from the number of common species, while the relative similarity ones – by the Jaccard coefficient:

$$K = N_{A+B} / (N_A + N_B - N_{A+B}) \cdot 100\%,$$

where  $N_{A+B}$  is the number of common species,  $N_A$  is the number of species in flora A, and,  $N_B$  is the number of species in flora B.



**Fig. 1.** Map of the location of the study islands in the Volga Reach of the Rybinsk Reservoir.

### **Island characteristics**

The approximate size of the northern Tryasye island is 1.0×0.15 km (over a significant length, the width of the island is 0.03–0.08 km), central Tryasye – 0.5×0.03–0.08 km, southern Tryasye – 0.5×0.07 km, Koprinsky – 0.3×0.08 km, Shumarovsky – 0.95×0.4 km (Fig. 1). It is worth noting that due to the highly fluctuating water level of the Rybinsk Reservoir across different seasons and years, the linear dimensions and area of islands can change, up to the northern and southern Tryasye merging through a sandy spit. The main ecotopes are high dry shores, shallows and shoals, wet and flooded shores, sandy spits, and depressions on gentle sections of the coast. Drawing on the study of other islands (in particular, Seredysh and Shalyga in the Saratov Reservoir), it is known that islands are subject to periodic inundation during high water and submersion in the low water period. They also undergo active geodynamic processes, where alluvial, sod-podzolic, and gray forest soils prevail. Here, natural channel processes occur (erosion, transport, re-sedimentation of alluvium), including desiccation and falling of old-growth trees forming windthrows (Lebedeva et al. 2007).

### **Research results and discussion**

All identified vascular plants belong to two phylums: Polypodiophyta (2, 1, 2, 2, and 5 species for islands of n. Tryasye, c. Tryasye, s. Tryasye, Koprinsky and Shumarovsky, respectively) and Spermatophyta (118, 84, 106, 73, 139 species) (Table 1).

In the flora of the northern Tryasye island, 120 species from 38 families and 88 genera were identified. The leading families were Asteraceae (21 species / 17.5% of the vascular plant flora list), Poaceae and Salicaceae (10 species each / 8.3%), Rosaceae (8 / 6.6%), and Polygonaceae (6 / 5%). These families accounted for 45.8% of the entire flora. The generic coefficient was 73.3%.

In the flora of the central Tryasye island, 85 species from 27 families and 61 genera were discovered. The leading families were Asteraceae (13 / 15.3%), Salicaceae (9 / 10.1%), Rosaceae (8 / 9.4%), Poaceae and Ericaceae (7 species each / 8.2%), Cyperaceae (6 / 7.1%), totaling 28.6% of the entire flora. The generic coefficient was 71.8%.

In the flora of the southern Tryasye island, 107 species from 39 families and 68 genera were noted. The leading families were Asteraceae (15 / 13.9%), Salicaceae (10 / 9.3%), Poaceae (9 / 8.3%), Rosaceae (6 / 5.5%), together comprising 37% of the entire flora. The generic coefficient was 73.1%.

The flora of Koprinsky island was represented by 75 species from 31 families and 59 genera. The leading families were Poaceae (13 / 17.3%), Asteraceae (11 / 14.7%), Salicaceae (8 / 10.7%), Rosaceae (5 / 6.7%), totaling 49.4% of the entire flora. The generic coefficient was 78.7%.

In the flora of Shumarovsky island, 143 species from 44 families and 99 genera were identified. The leading families were Poaceae (18 / 12.5%), Asteraceae (15 / 10.4%), Salicaceae and Rosaceae (10 each / 6.9%), Caryophyllaceae (7 / 4.9%), Cyperaceae and Polygonaceae (6 each / 4.2%), totaling 43.1% of the entire flora. The generic coefficient made up 70.1%.

In the flora of all islands, the dominant families are Asteraceae, Poaceae, Salicaceae, and Rosaceae. The first two are universally present in the first triad of the family-species spectrum of the Holarctic kingdom; the described flora has an arcto-boreal-East Eurasian character (Khokhryakov, 2000). A large number of genera and families with few species (31/22) indicates the complexity of the florogenesis process and the significant role of the related migration (Tolmachev, 1974).

Out of 216 species of vascular plants, 32 are common on all islands:

1) trees and shrubs: *Amelanchier spicata*, *Betula pendula* and *B. pubescens*, *Pinus sylvestris*, *Populus tremula*, *Salix acutifolia*, *S. cinerea*, *S. euxina*, *S. myrsinifolia*, and *S. triandra*, *Sambucus racemosa*, *Sorbus aucuparia*;

2) herbaceous plants and shrubs: *Agrostis capillaris*, *Artemisia campestris*, *Calamagrostis epigejos*, *Calystegia sepium*, *Carex acuta*, *Epilobium angustifolium*, *Equisetum arvense*, *Erigeron canadensis*, *Hieracium umbellatum*, *Linaria vulgaris*, *Persicaria amphibia*, *Phragmites australis*, *Rumex acetosella* and *R. maritimus*, *Solanum dulcamara*, *Tanacetum vulgare*, *Taraxacum officinale*, *Tussilago farfara*, *Vaccinium myrtillus*, *V. vitis-idaea*.

**Table 1.** Taxonomic composition of the flora of the study islands. I – northern Tryasye, II – central Tryasye, III – southern Tryasye, IV – Koprinsky, V – Shumarovsky island; «+» – presence; «–» – absence of species.

Species	Ecological group	Island				
		I	II	III	IV	V
<b>Phylum Polypodiophyta</b>						
<b>Class Equisetopsida</b>						
Family Equisetaceae Michx.						
<i>Equisetum arvense</i> L.	mesophyte	+	+	+	+	+
<i>E. pratense</i> Ehrh.	mesophyte	–	–	–	–	+
Family Athyriaceae Alst.						
<i>Athyrium filix-femina</i> (L.) Roth	hygromesophyte	–	–	–	–	+
Family Dryopteridaceae Ching						
<i>Dryopteris carthusiana</i> (Vill.) H.P. Fuchs	mesophyte	+	–	+	+	+
<i>D. filix-mas</i> (L.) Schott	mesophyte	–	–	–	–	+
<b>Phylum Spermatophyta</b>						
<b>Class Pinopsida</b>						
Family Pinaceae Spreng. ex F. Rudolphi						
<i>Picea abies</i> (L.) Karst.	mesophyte	+	+	–	–	+
<i>Pinus sylvestris</i> L.	mesophyte	+	+	+	+	+
Family Cupressaceae Gray						
<i>Juniperus communis</i> L.	mesophyte	+	+	–	+	–
<b>Phylum Magnoliopsida</b>						
Family Acoraceae Martinov						
<i>Acorus calamus</i> L.	hydrohygrophyte	–	–	+	–	–
Family Araceae Juss. (incl. Lemnaceae S.F. Gray)						
<i>Lemna minor</i> L.	hydrophyte	–	–	+	+	+
<i>L. trisulca</i> L.	hydrophyte	–	–	–	–	+
<i>Spirodela polyrrhiza</i> (L.) Schleid.	hydrophyte	–	–	+	–	+
Family Alismataceae Vent.						
<i>Alisma plantago-aquatica</i> L.	hygrophyte	+	+	+	–	+
<i>Sagittaria sagittifolia</i> L.	hygrophyte	–	–	+	–	–
Family Hydrocharitaceae Juss.						
<i>Hydrocharis morsus-ranae</i> L.	hydrophyte	–	–	+	–	+
Family Potamogetonaceae Bercht. et J. Presl						
<i>Potamogeton gramineus</i> L.	hydrophyte	–	–	–	–	+
<i>P. lucens</i> L.	hydrophyte	–	–	+	–	–
<i>P. natans</i> L.	hydrophyte	–	–	–	–	+
<i>P. perfoliatus</i> L.	hydrophyte	+	+	+	–	–
Family Orchidaceae Juss.						
<i>Platanthera bifolia</i> (L.) Rich.	mesophyte	–	–	–	–	+
Family Iridaceae Juss.						
<i>Iris pseudacorus</i> L.	hygrophyte	+	–	–	–	+
Family Asparagaceae Juss.						
<i>Convallaria majalis</i> L.	mesophyte	+	+	+	–	+

Species	Ecological group	Island				
		I	II	III	IV	V
<i>Maianthemum bifolium</i> (L.) Schmidt	mesophyte	–	+	+	+	+
Family Typhaceae Juss.						
<i>Sparganium emersum</i> Rehm.	hydrohygrophyte	–	–	+	–	–
<i>Typha latifolia</i> L.	hydrohygrophyte	–	–	–	+	–
Family Juncaceae Juss.						
<i>Juncus articulatus</i> L.	hygromesophyte	+	+	–	–	–
<i>J. bufonius</i> L.	hygrophyte	–	–	+	–	–
<i>J. filiformis</i> L.	hygromesophyte	–	–	–	–	+
<i>Luzula pilosa</i> (L.) Willd.	mesophyte	–	–	+	–	–
Family Cyperaceae Juss.						
<i>Carex acuta</i> L.	hygrophyte	+	+	+	+	+
<i>C. ericetorum</i> Poll.	xeromesophyte	+	–	–	–	+
<i>C. hirta</i> L.	mesophyte	–	+	–	–	–
<i>C. leporina</i> L.	hygromesophyte	–	–	–	–	+
<i>C. nigra</i> (L.) Reichard	hygrophyte	–	–	–	–	+
<i>C. rostrata</i> Stokes	hygrophyte	–	+	–	–	–
<i>C. vesicaria</i> L.	hygrophyte	–	+	+	+	+
<i>Eleocharis acicularis</i> (L.) Roem. et Schult.	hygrophyte	–	+	+	–	+
<i>E. palustris</i> (L.) Roem. et Schult.	hygrophyte	+	–	+	–	–
<i>Schoenoplectus lacustris</i> (L.) Palla	hydrohygrophyte	+	+	+	–	–
Family Poaceae Barnhart						
<i>Agrostis capillaris</i> L.	mesophyte	+	+	+	+	+
<i>A. gigantea</i> Roth	hygromesophyte	–	–	–	+	–
<i>A. stolonifera</i> L.	hygrophyte	+	+	+	–	+
<i>Anthoxanthum odoratum</i> L.	mesophyte	–	–	–	–	+
<i>Bromopsis inermis</i> (Leyss.) Holub	xeromesophyte	–	–	–	–	+
<i>Calamagrostis epigeios</i> (L.) Roth	hygrophyte	+	+	+	+	+
<i>C. canescens</i> (Weber) Roth	xeromesophyte	–	–	–	–	+
<i>Dactylis glomerata</i> L.	mesophyte	–	–	–	–	+
<i>Elytrigia repens</i> (L.) Nevski	mesophyte	–	+	+	+	+
<i>Festuca gigantea</i> (L.) Vill.	mesophyte	–	–	–	–	+
<i>F. ovina</i> L.	xeromesophyte	+	–	+	+	+
<i>F. rubra</i> L.	xeromesophyte	+	–	–	+	+
<i>Glyceria maxima</i> (Hartm.) Holmb.	hydrohygrophyte	–	–	–	+	+
<i>Hierochloa odorata</i> (L.) P. Beauv.	mesophyte	–	–	–	+	+
<i>Koeleria glauca</i> (Spreng.) DC.	ксерофит	–	–	–	+	–
<i>Milium effusum</i> L.	mesophyte	–	–	–	–	+
<i>Nardus stricta</i> L.	hygromesophyte	–	+	–	+	–
<i>Phalaris arundinacea</i> L.	mesohygrophyte	–	–	+	+	+
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	hygrophyte	+	+	+	+	+
<i>Poa annua</i> L.	mesophyte	+	–	–	–	–

Species	Ecological group	Island				
		I	II	III	IV	V
<i>P. compressa</i> L.	xeromesophyte	+	–	+	–	–
<i>P. palustris</i> L.	mesohygrophyte	+	+	–	–	+
<i>P. pratensis</i> L.	mesophyte	+	–	+	+	+
	Family Papaveraceae Juss.					
<i>Chelidonium majus</i> L.	mesophyte	–	+	–	–	–
	Family Ranunculaceae Juss.					
<i>Ranunculus circinatus</i> Sibth.	hydrophyte	–	–	+	–	–
<i>R. repens</i> L.	mesohygrophyte	–	–	–	–	+
<i>R. reptans</i> L.	hygrophyte	–	+	–	–	+
<i>R. sceleratus</i> L.	hygrophyte	–	–	+	–	+
<i>Thalictrum flavum</i> L.	mesohygrophyte	–	–	+	–	–
	Family Grossulariaceae DC.					
<i>Ribes nigrum</i> L.	mesohygrophyte	+	–	–	–	–
<i>R. rubrum</i> L.	mesophyte	–	–	+	–	–
<i>R. uva-crispa</i> L.	mesophyte	+	–	–	–	–
	Family Crassulaceae J. St-Hil.					
<i>Sedum acre</i> L.	xeromesophyte	–	–	+	–	+
<i>S. purpureum</i> L.	xeromesophyte	–	–	–	–	+
	Family Fabaceae Lindl.					
<i>Vicia cracca</i> L.	mesophyte	–	–	–	–	+
<i>V. sepium</i> L.	mesophyte	+	–	–	–	–
	Family Rosaceae Juss.					
<i>Amelanchier alnifolia</i> (Nutt.) Nutt. ex M. Roem.	mesophyte	–	+	+	+	–
<i>A. spicata</i> (Lam.) K. Koch	mesophyte	+	+	+	+	+
<i>Fragaria vesca</i> L.	mesophyte	+	+	+	–	+
<i>Malus sylvestris</i> Mill.	mesophyte	+	+	–	+	+
<i>Padus avium</i> Mill.	hygromesophyte	+	–	+	–	+
<i>Potentilla intermedia</i> L.	mesophyte	–	+	–	–	–
<i>P. norvegica</i> L.	mesophyte	+	+	+	–	–
<i>Rosa acicularis</i> Lindl.	mesophyte	–	–	–	–	+
<i>R. majalis</i> Herrm.	xeromesophyte	–	–	–	–	+
<i>R. rugosa</i> Thunb.	xeromesophyte	+	–	–	–	+
<i>Rubus idaeus</i> L.	mesophyte	+	+	–	+	+
<i>R. saxatilis</i> L.	mesophyte	–	–	–	–	+
<i>Sorbus aucuparia</i> L.	mesophyte	+	+	+	+	+
	Family Rhamnaceae Juss.					
<i>Frangula alnus</i> Mill.	mesohygrophyte	+	–	+	+	+
	Family Urticaceae Juss.					
<i>Urtica dioica</i> L.	hygromesophyte	–	–	–	+	+
	Family Betulaceae Gray					
<i>Alnus glutinosa</i> (L.) Gaertn.	mesohygrophyte	–	–	–	–	+

Species	Ecological group	Island				
		I	II	III	IV	V
<i>Betula pendula</i> Roth	mesophyte	+	+	+	+	+
<i>B. pubescens</i> Ehrh.	hygromesophyte	+	+	+	+	+
Family Hypericaceae Juss.						
<i>Hypericum perforatum</i> L.	xeromesophyte	+	–	–	–	–
Family Violaceae Batsch						
<i>Viola arvensis</i> Murray	mesophyte	+	–	–	–	+
<i>V. canina</i> L.	mesophyte	+	–	–	–	+
<i>V. rupestris</i> F.W. Schmidt	xeromesophyte	–	–	–	–	+
Family Salicaceae Mirb.						
<i>Populus × berolinensis</i> K. Koch	mesophyte	+	+	+	–	–
<i>Populus × sibirica</i> G.V. Krylov et G.V. Grig. ex A.K. Skvortsov	mesophyte	+	+	–	–	+
<i>P. longifolia</i> Fisch.	mesophyte	–	–	+	–	–
<i>P. tremula</i> L.	hygromesophyte	+	+	+	+	+
<i>Salix acutifolia</i> Willd.	mesophyte	+	+	+	+	+
<i>S. alba</i> L.	hygromesophyte	–	–	–	+	+
<i>S. caprea</i> L.	mesophyte	–	+	–	+	+
<i>S. cinerea</i> L.	hygrophyte	+	+	+	+	+
<i>S. fragilis</i> L.	hygromesophyte	+	+	+	+	+
<i>S. gmelinii</i> Pall.	hygromesophyte	+	–	–	–	+
<i>S. myrsinifolia</i> Salisb.	hygromesophyte	+	+	+	+	+
<i>S. × rubens</i> Schrank	hygromesophyte	–	–	+	–	–
<i>S. triandra</i> L.	hygromesophyte	+	+	+	+	+
<i>S. viminalis</i> L.	hygrophyte	+	–	+	–	–
Family Lythraceae J. St.-Hil.						
<i>Lythrum salicaria</i> L.	hygrophyte	–	–	–	–	+
Family Onagraceae Juss.						
<i>Epilobium adenocaulon</i> Hausskn.	hygromesophyte	+	–	–	–	–
<i>E. angustifolium</i> L.	mesophyte	+	+	+	+	+
<i>Oenothera biennis</i> L.	mesoxerophyte	–	+	–	–	–
<i>O. rubricaulis</i> Kleb.	mesoxerophyte	+	+	+	+	–
Family Sapindaceae Juss.						
<i>Acer negundo</i> L.	mesoxerophyte	–	–	–	+	–
Family Malvaceae Juss.						
<i>Tilia cordata</i> Mill.	mesophyte	+	–	–	–	+
Family Brassicaceae Burnett						
<i>Berteroa incana</i> (L.) DC.	xeromesophyte	–	–	–	–	+
<i>Capsella bursa-pastoris</i> (L.) Medikus	mesophyte	+	–	+	–	–
<i>Cardamine dentata</i> Schult.	hygrophyte	–	–	–	–	+
<i>Draba nemorosa</i> L.	mesophyte	+	–	–	–	–
<i>Erysimum cheiranthoides</i> L.	xeromesophyte	–	–	–	–	+

Species	Ecological group	Island				
		I	II	III	IV	V
<i>Rorippa amphibia</i> (L.) Bess.	hygrophyte	+	–	+	+	+
<i>R. palustris</i> (L.) Bess.	hygrophyte	+	–	+	–	+
Family Polygonaceae Juss.						
<i>Fallopia convolvulus</i> (L.) Á. Löve	mesophyte	+	–	–	–	–
<i>Persicaria amphibia</i> (L.) Delarbre	hydrophyte	+	+	+	+	+
<i>P. lapathifolia</i> (L.) S.F. Gray	hygrophyte	–	+	–	–	+
<i>Polygonum aviculare</i> L. s.l.	mesophyte	+	–	–	–	+
<i>Rumex acetosella</i> L.	mesophyte	+	+	+	+	+
<i>R. maritimus</i> L.	hygrophyte	+	+	+	+	+
<i>R. thyrsoflorus</i> Fingerh.	xeromesophyte	+	–	–	–	+
Family Caryophyllaceae Juss.						
<i>Moehringia trinervia</i> (L.) Clairv.	mesophyte	+	–	–	–	+
<i>Sagina procumbens</i> L.	hygrophyte	–	+	–	–	–
<i>Scleranthus perennis</i> L.	mesoxerophyte	–	–	–	–	+
<i>Silene nutans</i> L.	mesophyte	+	+	–	+	+
<i>S. pratensis</i> (Rafn) Godr.	mesophyte	+	–	–	–	+
<i>Stellaria aquatica</i> (L.) Scop.	hygrophyte	–	–	+	–	+
<i>S. graminea</i> L.	mesophyte	+	–	–	+	+
<i>S. palustris</i> Ehrh. ex Retz.	hygrophyte	–	–	–	–	+
Family Amaranthaceae Juss.						
<i>Chenopodium album</i> L.	mesophyte	+	+	+	–	–
<i>Oxybasis rubra</i> (L.) S. Fuentes, Uotila et Borsch	mesophyte	–	+	+	–	–
Family Primulaceae Batsch ex Borkh.						
<i>Lysimachia europaea</i> (L.) U. Manns et Anderb.	mesophyte	+	+	–	–	+
<i>L. nummularia</i> L.	hygromesophyte	–	–	+	–	+
<i>L. thyrsoflora</i> L.	hydrohygrophyte	–	+	+	+	+
<i>L. vulgaris</i> L.	hygrophyte	+	+	–	+	+
Family Ericaceae Juss.						
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	xeromesophyte	+	+	+	+	–
<i>Calluna vulgaris</i> (L.) Hill	xeromesophyte	+	–	–	–	+
<i>Orthilia secunda</i> (L.) House	mesophyte	+	+	–	–	+
<i>Pyrola minor</i> L.	mesophyte	–	+	–	–	–
<i>P. rotundifolia</i> L.	mesophyte	–	+	–	–	+
<i>Vaccinium myrtillus</i> L.	mesophyte	+	+	+	+	+
<i>V. uliginosum</i> L.	hygrophyte	–	+	+	–	–
<i>V. vitis-idaea</i> L.	mesophyte	+	+	+	+	+
Family Rubiaceae Juss.						
<i>Galium mollugo</i> L.	mesophyte	+	+	–	–	+
<i>G. palustre</i> L.	hygrophyte	+	–	+	+	+
<i>G. trifidum</i> L.	hygrophyte	+	–	+	–	–

Species	Ecological group	Island				
		I	II	III	IV	V
<i>G. verum</i> L.	mesoxerophyte	–	–	–	–	+
	Family Boraginaceae Juss.					
<i>Myosotis stricta</i> Link ex Roem. et Schult.	mesoxerophyte	–	–	–	+	–
	Family Convolvulaceae Juss.					
<i>Calystegia sepium</i> (L.) R. Br.	mesohygrophyte	+	+	+	+	+
<i>Convolvulus arvensis</i> L.	mesophyte	–	–	–	–	+
	Family Solanaceae Juss.					
<i>Solanum dulcamara</i> L.	mesohygrophyte	+	+	+	+	+
<i>S. lycopersicum</i> L.	mesophyte	+	–	+	–	–
	Family Plantaginaceae Juss.					
<i>Callitriche palustris</i> L.	hydrophyte	–	–	+	–	–
<i>Linaria vulgaris</i> Mill.	mesophyte	+	+	+	+	+
<i>Plantago major</i> L.	mesophyte	+	–	–	–	–
<i>Veronica anagallis-aquatica</i> L.	hydrohygrophyte	–	–	–	+	–
<i>V. beccabunga</i> L.	hydrohygrophyte	–	–	+	–	–
<i>V. chamaedrys</i> L.	mesophyte	+	+	+	–	–
<i>V. officinalis</i> L.	mesophyte	+	–	+	–	+
	Family Scrophulariaceae Juss.					
<i>Limosella aquatica</i> L.	hygrophyte	–	–	+	–	+
	Family Lentibulariaceae Rich.					
<i>Utricularia vulgaris</i> L.	hydrophyte	–	–	+	–	–
	Family Lamiaceae Martinov					
<i>Lycopus europaeus</i> L.	hygrophyte	+	–	+	–	+
<i>Mentha arvensis</i> L.	hygromesophyte	+	–	+	–	–
<i>Scutellaria galericulata</i> L.	hygrophyte	+	+	+	–	+
<i>Stachys palustris</i> L.	hygrophyte	+	–	+	+	+
	Family Orobanchaceae Vent.					
<i>Melampyrum pratense</i> L.	mesophyte	+	+	+	+	–
	Family Campanulaceae Juss.					
<i>Campanula rotundifolia</i> L.	mesophyte	+	–	+	–	+
	Family Asteraceae Bercht. et J. Presl					
<i>Achillea collina</i> (Becker ex Wirtg.) Heimerl	xeromesophyte	+	–	–	+	–
<i>A. millefolium</i> L.	mesophyte	+	+	–	–	+
<i>A. salicifolia</i> Bess.	mesohygrophyte	+	+	+	+	–
<i>Artemisia campestris</i> L.	mesoxerophyte	+	+	+	+	+
<i>A. vulgaris</i> L.	xeromesophyte	+	+	+	+	–
<i>Bidens cernua</i> L.	hygrophyte	–	–	+	–	–
<i>B. frondosa</i> L.	hygrophyte	+	+	+	+	–
<i>B. radiata</i> Thuill.	hygrophyte	+	–	+	–	+
<i>Centaurea jacea</i> L.	mesophyte	–	–	–	–	+
<i>Cirsium arvense</i> (L.) Scop.	xeromesophyte	+	+	+	–	+

Species	Ecological group	Island				
		I	II	III	IV	V
<i>C. vulgare</i> (Savi) Ten.	mesophyte	+	–	–	–	–
<i>Conyza canadensis</i> (L.) Cronquist	mesophyte	+	+	+	+	+
<i>Crepis tectorum</i> L.	mesophyte	–	–	–	–	+
<i>Erigeron acris</i> L.	xeromesophyte	–	+	–	–	+
<i>Gnaphalium uliginosum</i> L.	hygromesophyte	–	–	+	–	–
<i>Hieracium umbellatum</i> L.	xeromesophyte	+	+	+	+	+
<i>Inula britannica</i> L.	hygromesophyte	+	–	–	–	–
<i>Matricaria discoidea</i> DC.	mesophyte	+	–	–	–	–
<i>Pilosella officinarum</i> F.W. Schultz et Sch. Bip.	mesoxerophyte	+	–	–	–	+
<i>Scorzoneroides autumnalis</i> (L.) Moench	mesophyte	+	–	–	–	–
<i>Senecio viscosus</i> L.	xeromesophyte	+	–	–	–	–
<i>Solidago virgaurea</i> L.	mesophyte	+	–	–	–	+
<i>Sonchus arvensis</i> L.	xeromesophyte	+	+	+	–	+
<i>Tanacetum vulgare</i> L.	xeromesophyte	+	+	+	+	+
<i>Taraxacum officinale</i> F.H. Wigg.	mesophyte	+	+	+	+	+
<i>Tussilago farfara</i> L.	mesophyte	+	+	+	+	+
Family Adoxaceae E. Mey.						
<i>Sambucus racemosa</i> L.	xeromesophyte	+	+	+	+	+
<i>Viburnum opulus</i> L.	mesophyte	–	–	–	–	+
Family Caprifoliaceae Juss.						
<i>Lonicera xylosteum</i> L.	mesophyte	+	–	–	–	–
<i>Valeriana officinalis</i> L.	hygromesophyte	–	–	–	–	+
Family Apiaceae Lindl.						
<i>Aegopodium podagraria</i> L.	hygromesophyte	+	–	–	–	–
<i>Angelica sylvestris</i> L.	mesohygrophyte	–	–	+	–	–
<i>Anthriscus sylvestris</i> (L.) Hoffm.	mesophyte	+	–	–	+	–
<i>Cicuta virosa</i> L.	hygrophyte	+	–	–	–	+
<i>Oenanthe aquatica</i> (L.) Poir.	hydrohygrophyte	+	–	+	+	+
<i>Pimpinella saxifraga</i> L.	xeromesophyte	–	–	–	–	+
<i>Sium latifolium</i> L.	hydrohygrophyte	–	–	–	–	+
<b>Total</b>		<b>120</b>	<b>85</b>	<b>107</b>	<b>75</b>	<b>143</b>

The generic coefficient, inversely proportional to the diversity of ecological conditions, is approximately the same on all islands and indicates a small difference in habitats on the studied islands (Alyokhin, 1944).

Based on the species composition data, a matrix of absolute and relative similarity measures was constructed (Table 2). According to the Jaccard coefficient, the similarity between the islands is less than 50%, with the lowest value observed between Shumarovsky with Koprinsky and central Tryasye islands. This is due to the difference in ecotopes: on Shumarovsky island, we observe a much greater variety of habitats – from sandy beaches and an internal shallow lake to high sandy shores with terrestrial vegetation, wet shrub thickets, and pine forests on sands. At the same time, habitats on Koprinsky and central Tryasye islands are more uniform. For instance, a sandy shore here quickly turns to a pine forest with small sections of mixed forest and coastal willow thickets.

The greatest number of common species was found between Shumarovsky island and the southern and northern Tryasye islands. These are the representatives of most families: Asteraceae (10 species), Poaceae and Salicaceae (6 each), Rosaceae (4), Polygonaceae (3), Lamiaceae, Plantaginaceae, Ericaceae, Brassicaceae, and Betulaceae (2 each), Solanaceae, Convolvulaceae, Rubiaceae, Onagraceae, Cyperaceae, Asparagaceae, Alismataceae, Pinaceae, Equisetaceae, Apiaceae, and Adoxaceae (1 each). The first four are the representatives of the most frequently encountered families in the flora of the studied island.

The diagram of ecological groups of the floristic composition of the islands demonstrates that mesophytes predominate on all islands, with a significant number of xeromesophytes noted on northern Tryasye and Shumarovsky islands and hygrophytes - on all islands, except for Koprinsky (Fig. 2). This indicates a greater diversity of habitats for the development of hydrophilous plants/moisture-loving species/water-resistant plants and enduring temporary moisture deficit plants on Shumarovsky and northern Tryasye islands.

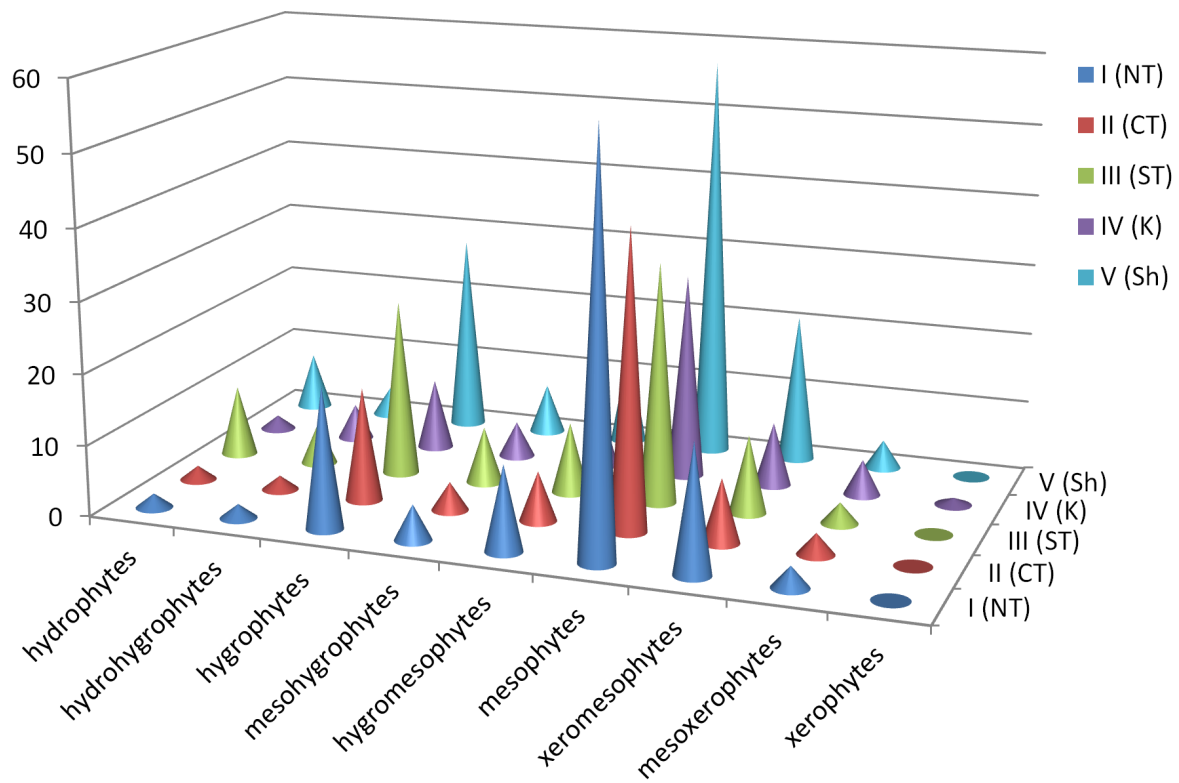
The analysis of life forms (Fig. 3) shows the predominance of hemicryptophytes in the flora of the study islands (39.5%); they are especially numerous on northern Tryasye (42.5%). Phanerophytes are in the second place in terms of species richness – 19.1%, with Koprinsky island accounting for 28.0% of the flora list. Herbaceous plants make up 65.9% of the flora of the studied islands and are found in all ecotopes. Aquatic plants are few (4.7%) and are detected in shallow waters, flooded shores, and along the water's edge.

The geographical analysis (Table 3) reveals a significant dominance of plurizonal species (63.3% of the total list) in the flora of the studied islands; the significance of boreal and boreal-nemoral species is also considerable (10.7% and 16.3%, respectively). Regionally, the main part of the flora list is distributed between Euro-Asian, Euro-Siberian, and Holarctic species (37.2%, 14.9%, and 29.8%, respectively).

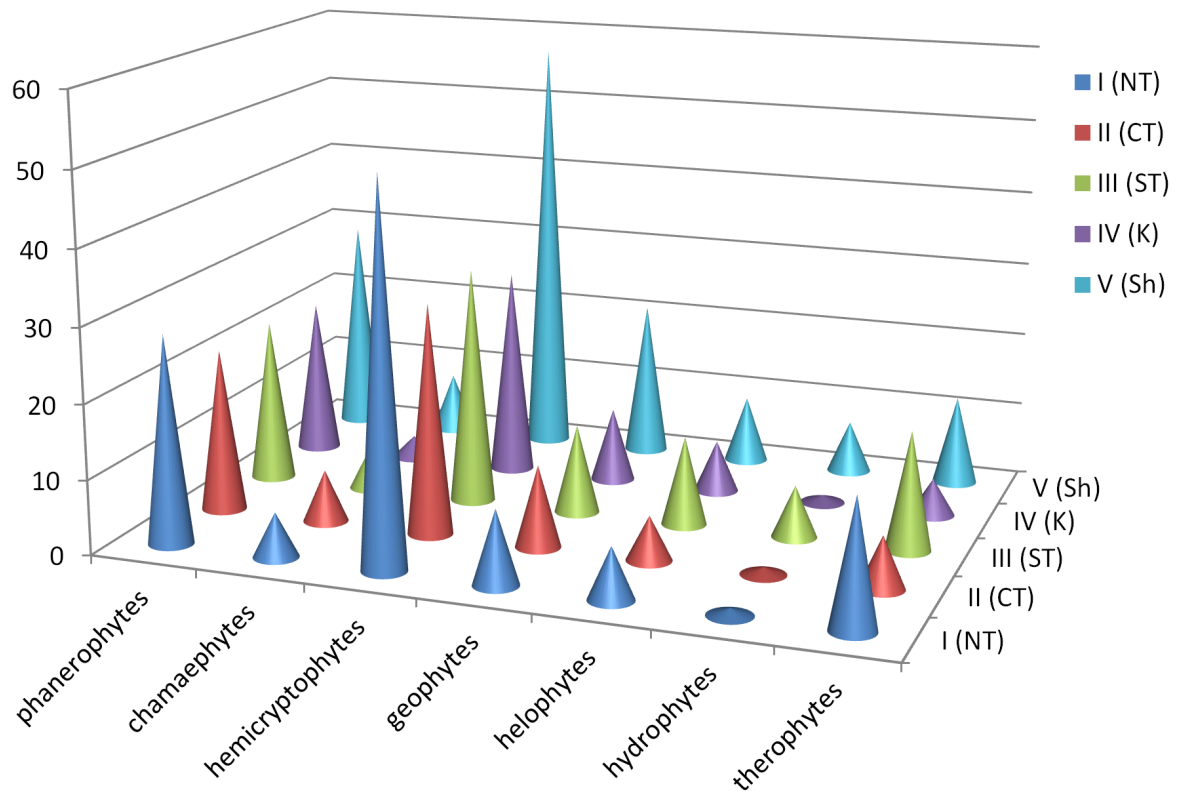
Along with vascular plants, we have recorded other representatives of the plant kingdom, including fungi (Table 4). A total of 5 widely spread in the Northern Hemisphere species were noted on all islands:

**Table 2.** Similarity measures of the floras of the study islands. Diagonally (in bold) – the number of species. Absolute similarity measures are provided under the diagonal, relative similarity measures – above the diagonal (in italics).

Island	Northern Tryasye	Central Tryasye	Southern Tryasye	Koprinsky	Shumarovsky
Northern Tryasye	<b>120</b>	<i>45%</i>	<i>47%</i>	<i>40%</i>	<i>45%</i>
Central Tryasye	61	<b>85</b>	<i>44%</i>	<i>45%</i>	<i>36%</i>
Southern Tryasye	71	51	<b>107</b>	<i>42%</i>	<i>38%</i>
Koprinsky	55	48	53	<b>75</b>	<i>36%</i>
Shumarovsky	76	59	67	56	<b>143</b>



**Fig. 2.** Distribution of ecological groups on the study islands.



**Fig. 3.** Distribution of life forms on the study islands. Designations as in Fig. 1.

2 lichens (*Cetraria islandica* and *Hypogymnia physodes*), moss *Pleurozium schreberi*, and 2 fungi *Amanita muscaria* and *Russula* sp. The presence of *Cetraria islandica* is indicative of air purity on the studied sites. *Lycopodon perlatum*, *Parmelia sulcata*, *Xanthoria parietina*, *Hylocomium splendens*, and *Orthotrichum speciosum* were also frequently encountered.

## Conclusions

In the middle part of the Volga River floodplain of the Rybinsk Reservoir, we have studied the flora of five islands and found 215 species from 135 genera and 53 families. The greatest number of species was noted on Shumarovsky island, the least – on the Koprinsky one. The generic coefficient, inversely proportional to the diversity of ecological conditions and showing a small difference in habitats, was approximately the same on all islands. According to the Jaccard coefficient, the similarity between the islands made up less than 50% that is due to the difference in ecotopes present here. Representatives of the ecological group of mesophytes, as well as xeromesophytes (on northern Tryasye and Shumarovsky islands) and hygrophytes (throughout, except for Koprinsky island) prevailed on all studied islands. The analysis of life forms revealed the predominance of herbaceous plants (65.9% of the entire flora). In addition to vascular plants, representatives of the kingdom of fungi, lichens, liverworts, and mosses were also found.

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**Table 3.** Zonal-regional distribution of the flora.

	Geographical range type	Number of species	Proportion of total species, %
Zonal distribution	arctoboreal	1	0.5
	hypoarctic-boreal	3	1.4
	boreal	23	10.7
	boreal-nemoral	35	16.3
	nemoral	3	1.4
	nemoral-forest-steppe	1	0.5
	forest-steppe	13	6.0
Regional distribution	plurizonal	136	63.3
	west european	4	1.9
	european	10	4.7
	eurosiberian	32	14.9
	eurasian	80	37.2
	north american	10	4.7
	holarctic	64	29.8
	hemicosmopolitan	15	7.0

**Table 4.** Fungi, lichens, liverworts, and mosses of the study islands (see Table 1 for symbols).

Taxonomic groups	Species	Island				
		I	II	III	IV	V
Myxogastria	<i>Myxomycetes</i> sp.	–	+	–	–	
	<i>Leocarpus fragilis</i>	–	–	–	–	+
Lichenized and non-tinder mushrooms	<i>Amanita citrina</i>	+	–	–	+	–
	<i>A. muscaria</i>	+	+	+	+	+
	<i>A. pantherina</i>	+	–	–	–	–
	<i>A. porphyria</i>	+	–	–	–	–
	<i>A. rubescens</i>	–	–	+	–	+
	<i>Boletus edulis</i>	+	–	+	+	–
	<i>Calycina citrina</i>	–	–	–	–	+
	<i>Cantharellus cibarius</i>	+	–	–	–	+
	<i>Crepidotus mollis</i>	–	+	–	–	–
	<i>Hydnum repandum</i>	–	–	–	+	–
	<i>Infundibulicybe gibba</i>	+	–	–	–	–
	<i>Lactarius pubescens</i>	+	–	–	–	+
	<i>L. rufus</i>	+	+	–	–	+
	<i>L. torminosus</i>	–	+	–	–	–
	<i>L. turpis</i>	–	+	–	–	+
	<i>Leccinum scabrum</i>	–	+	–	–	–
	<i>Leotiomyces</i>	–	+	–	–	–
	<i>Lycoperdon excipuliforme</i>	–	–	+	–	–
	<i>L. perlatum</i>	+	+	+	–	+
	<i>Mycena</i> sp.	–	–	–	–	+
	<i>Paxillus involutus</i>	–	+	–	–	–
	<i>Phaeoclavulina</i> sp.	+	–	–	–	–
	<i>Pluteus cervinus</i>	–	+	+	–	–
	<i>Ramaria stricta</i>	–	–	–	–	+
	<i>Russula</i> sp.	+	+	+	+	+
	<i>Suillus bovinus</i>	+	–	–	+	–
	<i>S. luteus</i>	+	+	+	–	–
	Lichen	<i>Cetraria islandica</i>	+	+	+	+
<i>Cladonia arbuscula</i>		–	+	–	–	+
<i>C. gracilis</i> ssp. <i>turbinata</i>		–	+	–	–	–
<i>C. rangiferina</i>		–	+	–	–	+
<i>Evernia mesomorpha</i>		–	+	+	–	–
<i>E. prunastri</i>		–	–	–	–	+
<i>Hypogymnia physodes</i>		+	+	+	+	+

Taxonomic groups	Species	Island				
		I	II	III	IV	V
Lichen	<i>Melanohalea olivacea</i>	+	+	+	–	–
	<i>Parmelia sulcata</i>	+	+	–	+	+
	<i>Peltigera canina</i> × <i>P. membranacea</i>	–	–	–	–	+
	<i>P. degenii</i>	–	–	–	–	+
	<i>P. extenuata</i>	–	+	–	–	–
	<i>P. malacea</i>	–	–	–	+	–
	<i>P. neopolydactyla</i>	–	–	–	–	+
	<i>P. polydactylon</i>	–	–	–	–	+
	<i>P. praetextata</i>	–	+	–	–	+
	<i>Physcia adscendens</i>	+	+	–	–	+
	<i>P. aipolia</i>	–	–	–	–	+
	<i>P. stellaris</i>	–	+	–	–	–
	<i>Vulpicida pinastri</i>	–	–	–	–	+
	<i>Xanthoria parietina</i>	+	+	+	–	+
	<i>X. polycarpa</i>	–	–	+	–	–
Polypore	<i>Bjerkandera adusta</i>	+	–	–	–	–
	<i>B. fumosa</i>	–	–	–	–	+
	<i>Coltricia perennis</i>	+	–	–	–	–
	<i>Crucibulum laeve</i>	+	+	–	–	+
	<i>Daedaleopsis confragosa</i>	+	–	–	–	–
	<i>Fomitopsis betulina</i>	–	–	–	–	+
	<i>F. pinicola</i>	–	–	–	–	+
	<i>Ganoderma applanatum</i>	–	+	–	–	–
	<i>Gloeoporus dichrous</i>	–	+	–	–	–
	<i>Peniophora rufa</i>	–	–	–	–	+
	<i>Phellinus igniarius</i>	+	+	–	–	–
	<i>Trametes betulina</i>	+	–	–	–	–
	<i>T. ochracea</i>	–	–	+	–	–
<i>T. suaveolens</i>	–	+	–	–	–	
Marchantiophyta	<i>Lophocolea heterophylla</i>	+	–	–	–	–
	<i>Ptilidium pulcherrimum</i>	–	–	–	+	+
	<i>Radula complanata</i>	–	–	–	–	+
	<i>Riccia fluitans</i>	–	–	+	–	+
	<i>Ricciocarpos natans</i>	–	–	+	–	–

Taxonomic groups	Species	Island				
		I	II	III	IV	V
Bryopsida	<i>Aulacomnium palustre</i>	–	–	+	–	+
	<i>Brachythecium</i> sp.	+	+	–	–	–
	<i>Bryum pseudotriquetrum</i>	+	–	–	–	–
	<i>Ceratodon purpureus</i>	+	–	+	–	+
	<i>Cirriphyllum piliferum</i>	+	+	+	–	–
	<i>Climacium dendroides</i>	+	+	+	–	+
	<i>Dicranum polysetum</i>	+	–	+	+	+
	<i>D. scoparium</i>	–	–	+	+	–
	<i>Didymodon fallax</i>	+	–	–	–	+
	<i>Drepanocladus aduncus</i>	–	–	+	–	–
	<i>Fontinalis antipyretica</i>	–	–	+	–	–
	<i>Hylocomiadelphus triquetrus</i>	–	–	+	–	+
	<i>Hylocomium splendens</i>	+	+	+	–	+
	<i>Orthotrichum speciosum</i>	+	+	+	–	+
	<i>Plagiomnium cuspidatum</i>	–	–	–	–	+
	<i>P. undulatum</i>	–	+	–	–	–
	<i>Plagiothecium laetum</i>	–	–	–	–	+
	<i>Pleurozium schreberi</i>	+	+	+	+	+
	<i>Polytrichum commune</i>	–	–	+	–	+
	<i>P. juniperinum</i>	–	+	+	+	–
	<i>P. piliferum</i>	–	–	–	–	+
	<i>Ptilium crista-castrensis</i>	–	–	–	–	+
	<i>Pylaisia polyantha</i>	–	+	+	–	–
	<i>Sanionia uncinata</i>	–	–	–	–	+
	<i>Sciuro-hypnum oedipodium</i>	–	–	–	–	+
	<i>Stereodon pallescens</i>	+	–	+	–	+
	<i>Syntrichia ruralis</i>	+	–	–	–	+
	<i>Thuidium delicatulum</i>	–	–	+	–	–
	<i>Warnstorfia fluitans</i>	–	–	–	–	+

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