



Трансформация экосистем Ecosystem Transformation www.ecosysttrans.com

The current state and dynamics of the flora of several small lakes of the Yaroslavl Region, Russia

Eugeny A. Belyakov*, Ekaterina G. Sakharova,
Alexandra S. Sokolova

I.D. Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences, Borok 109, Nekouz District, Yaroslavl Region, 152742 Russia

*eugenybeliakov@yandex.ru

Received: 19.05.2020

Accepted: 14.09.2020

Published online: 13.11.2020

DOI: 10.23859/estr-200519

UDC 581.93, 574.583

ISSN 2619-094X Print

ISSN 2619-0931 Online

Translated by D.M. Martynova

The phytoplankton and vascular aquatic plants have been studied in small lakes Vashutinskoe, Chashnitskoe, Ryumniki, and Zaozer'e, located in the southern part of the Yaroslavl Region, Russia. The taxonomic composition of phytoplankton comprised 137 species of algae belonging to 8 divisions, 18 orders, and 76 genera. The studied water bodies were characterized by high biomass of cyanobacteria. *Aphanizomenon flos-aquae* (L.) Ralfs ex Born et Flah. and the species of the genus *Anabaena* had a significant contribution to the phytoplankton biomass in the lakes Zaozer'e, Chashnitskoe, and Ryumniki, *Limnithrix planctonica* (Wolosz.) Meff. and *Microcystis aeruginosa* (Kütz.) Kütz. in the Lake Vashutinskoe. In terms of phytoplankton biomass, the pelagial and shallow areas of the Lake Vashutinskoe belonged to eutrophic reservoirs, of the Lake Ryumniki, to oligotrophic. The phytoplankton biomass in the pelagial zone of the lakes Chashnitskoe and Zaozer'e indicated the mesotrophic status of these water bodies, in the littoral zone, eutrophic. The study of the phytoplankton of the lakes was carried episodically and was often performed at different periods of the growing season. Therefore, the obtained data did not allow one to assess the direction of the successional changes in the algal flora. The flora of vascular plants of lakes was represented by 118 species belonging to 4 divisions, 5 classes, 22 orders, and 37 families. Thirty-four species were common to all studied water bodies. The differences in the flora of vascular aquatic plants of the studied lakes were associated with differences in their trophic status, the presence of various biotopes, the nature of anthropogenic load, and the degree of eutrophication. During a hundred years of observations, some species have disappeared, but some have appeared, including adventive species (such as *Elodea canadensis* Michx., *Bidens frondosa* L., *Epilobium adenocaulon* Hausskn., *Zizania latifolia* Griseb., and *Juncus tenuis* Willd.). The study of the current state of rare and protected species of vascular plants made it possible to reveal the eventual causes and period of disappearance of some species from the lakes. The taxonomic and ecological structure of phytoplankton and vascular plants of lakes was quite diverse and usual for the water bodies of the European part of Russia.

Keywords: lakes, phytoplankton, vascular plants, flora transformation, anthropogenic influence, rare species, trophic status.

Belyakov, E.A. et al., 2020. The current state and dynamics of the flora of several small lakes of the Yaroslavl Region, Russia. *Ecosystem Transformation* 3 (4), 15–40.

Introduction

Small lakes are still a relatively poorly studied group of the water bodies (Izmailova et al., 2017; Lyashenko et al., 2002). They are most sensitive to climate change and are subject to large anthropogenic pressure (Belyakov and Garin, 2018; Izmailova et al., 2017; Lawniczak-Malińska and Achtenberg, 2018; Lobunicheva et al., 2013; Slukovskii et al., 2018; Strahovenko et al., 2014). The latter affects the species richness of macrophytes, which is closely related to the natural type and status of the water bodies (Mäemets et al., 2010).

The studied lakes Vashutinskoe, Chashnitskoe, Ryumniki, and Zaozer'e are located in the Eastern Borisoglebsk Upland in the East European Plain. In accordance with the classification of the lakes by the depth suggested by S.P. Kitaev (1984), the Lake Vashutinskoe refers to shallow water bodies, while the Chashnitskoe, Ryumniki and Zaozer'e lakes are mid-depth water bodies. The lakes Chashnitskoe, Vashutinskoe, and Zaozer'e belong to the basin of the Klyazminskaya Nerl' River; the Lake Ryumniki is located in the Ryumniko-Osoevskaya Depression, in the watershed area of the rivers flowing southeastwards, to the Klyazminskaya Nerl' River and further to the Klyazma River, and northwards, to the Sara River and further to the Kotorosl' River (Fortunatov and Moskovskii, 1970). The studied lakes are common by their glacial origin and the peculiarities of their location, but differ by the degree of anthropogenic impact, as a result, they have different modern trophic status. In addition, according to the Decree of the Government of the Yaroslavl Region of November 2, 2017 no. 823-p "On approval of the regime of special protection of the territory of natural monuments of regional significance in the Yaroslavl Region" (Postanovlenie..., 2017), the three lakes (Ryumniki, Chashnitskoe, and Vashutinskoe) are included into the list of natural monuments of regional significance, the species of vascular plants, included into the Red Data Book of the Yaroslavl Region (Krasnaya Kniga..., 2015), are found in each lake.

The data on the ecosystem state of these water bodies are scarce. The composition and some quantitative characteristics of their flora are known only from episodic observations carried out in the XX – beginning of the XXI century. The first data on the phytoplankton of lakes were obtained in 1903 (Blokhontsev, 1903a, b). During this period, 17 species of algae were reported for the Lake Ryumniki, 20 species, for the Lake Chashnitskoe, and 13 species, for the Lake

Zaozer'e (Grigor'ev, 1903). Cyanobacteria dominated by biomass in the phytoplankton communities of the lakes. According to the results of studies performed in 1963 (Fortunatov and Moskovskii, 1970), a large number of cells of *Anabaena elliptica* Lemm. was registered in the Lake Ryumniki, *Aphanizomenon flos-aquae* (L.) Ralfs ex Born. et Flah., in the Lake Chashnitskoe, and *Microcystis aeruginosa* (Kütz.) Kütz., in the lakes Zaozer'e and Vashutinskoe. In the 2002, cyanobacteria from the genera *Microcystis*, *Aphanizomenon*, *Oscillatoria*, *Aphanothece*, and *Woronichinia* dominated (Lyashenko et al., 2002).

The first data on the flora of higher aquatic plants in the studied lakes were obtained in 1902 (Flerov, 1903). During this period, in the Lake Zaozer'e, 6 species of aquatic and coastal aquatic plants (*Potamogeton perfoliatus* L., *Alisma plantago-aquatica* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* (L.) Roem. et Schult., *E. palustris* (L.) Roem. et Schult., and *Persicaria amfibia* (L.) Delarbre) were indicated, in the Lake Chashnitskoe, 11 species, and in the Lake Ryumniki, 21 species. Further studies of these water bodies were carried out by A.P. Belavskaya only 60 years later, in 1963 (Fortunatov and Moskovskii, 1970). However, these studies were mainly focused on studying the processes of overgrowing of lakes, not the floristic composition. Apparently, it has been noted that the natural communities of aquatic plants have been greatly changed in the Lake Zaozer'e due to long-term pollution by waste from livestock farms. Significant thickets of the great manna grass *Glyceria maxima* (Hartm.) Holmb. were observed here, in the southwestern part of the lake, there were horsetail-calla floating mats (Fortunatov and Moskovskii, 1970). Later, in 1985, common spike-rush *Eleocharis palustris*, water smartweed *Persicaria amphibia*, and the species of the genus *Carex* were found in addition to the great manna grass (Trusov et al., 1988). Studying the flora of the Lake Chashnitskoe, A.P. Belavskaya reported on 21 species of vascular plants and noted the widespread association of the water horsetail *Equisetum fluviatile* L. and arrowheads *Sagittaria sagittifolia*, in the southern and southeastern parts of the lake, the association of the bottle sedge *Carex rostrata* Stokes and shift-bogbean communities. After 25 years, 22 plant species were indicated in the floristic lists (Trusov et al., 1988). In the Lake Ryumniki, three species were indicated for the first time by A.P. Belavskaya, bulrush *Scirpus radicans* Schkuhr, clasping-leaved pondweed *Potamogeton perfoliatus*, and bottle sedge.

New data on the flora of vascular plants appeared almost a hundred years after the first studies, when the survey of the flora of these lakes was carried out in September 2001 by G.F. Lyashenko (Lyashenko et al., 2002). As a result of these studies, 12 species of vascular plants were identified for the Lake Zaozer'e, 19 species, for the Lake Chashnitskoe, 21 species, for the Lake Ryumniki, and 14 species, for the Lake Vashutinskoe. Considering all the studies performed, the flora of vascular plants of the Lake Zaozer'e was presented by about 20 species, of the Lake Chashnitskoe, by 31 species, of the Lake Ryumniki, 40 species, and for the Lake Vashutinskoe, 34 species in total.

The study aims to assess the current state and nature of changes in phytoplankton and the floristic composition of vascular plants of small lakes Zaozer'e, Ryumniki, Chashnitskoe, and Vashutinskoe located in the Rostov District, the Yaroslavl Region, Russia, for more than 50-year period.

Materials and methods

The studies were carried out in mid-July 2018 at four lakes (Zaozer'e, Ryumniki, Chashnitskoe, and Vashutinskoe) located in the Rostov District of the Yaroslavl Region: (Fig. 1).

The Lake Zaozer'e (other names: Zaozerskoe, Pokrovskoe, Monastyrskoe) is located in a closed depression. The lake is drainless. The area of the water surface is 32 hectares, the maximum depth is 10 m, the average depth, 5 m. During the phytoplankton bloom in the lake, the water transparency reaches 10–30 cm, pH, 9.0–9.2, and the electrical conductivity, 27.2–30.0 μS . The lake has a rounded shape, the shores are gentle. The increased content of alkali metal ions associated with water pollution with organic matter was noted (Fortunatov and Moskovskii, 1970; Grigor'ev, 1903). Regard must be paid to a smaller amount of organic matter having been entered to the lake for a long time, which is primarily due to the closure of livestock farms located along the lake shores. The soils near the coast are sandy, the silt layer over the sandy bottom increases along with the depth increase, the silt has a pungent smell of hydrogen sulfide. The sapropel deposits in the lake are not found (Lyashenko et al., 2002).

The Lake Ryumniki (other names: Ryumnikovskoe, Ryumnikovo). The area of the water surface is 153 hectares, the maximum depth is 10 m, the average depth, 3 m. The water in the lake is weakly mineralized (16–17 mg/L), sulfate class, pH 6.0–6.9. The water transparency is 1.4–1.6 m. In the years of



Fig. 1. Location of the studied lakes in the Rostov District of the Yaroslavl Region, Russia.

mean moisture regime, the lake is drainless; in high-water years, part of the water flows out to the swamps adjacent to the southwestern coast. The thickness of the sapropel layer in the lake basin ranges from 0.5 to 2.0 m; in the southern part, the sapropel is overlain by a layer of peaty silt up to 3-m thick. The coastal areas along the northern coast and partially along the southern coast are sandy. In the southern part of the lake, the shores are steep, formed by loams and boulders, in the southeastern part of the lake, they are low, gentle. In the northeastern part, there is a swampy backwater; the northwestern, western and southwestern coasts are highland moors with birch forests or wet alder groves (Fortunatov and Moskovskii, 1970; Kuzmichev et al., 1990).

The Lake Chashnitskoe (other names: Chashnitsy, Chashnikovo, Chashniche). The area of the water surface is 54 hectares, the maximum depth of the lake is 11 m, the average depth is 4–5 m. The waters of the lake are slightly mineralized (19.0–23.5 m/L) and are characterized by high transparency. The electrical conductivity of the surface water layer ranges from 36.1 to 43.0 μ S, pH, 6.7–7.6. In dry years, the lake has no drainage; in high-water years, the water from the lake flows through the ravine towards the Lake Karash and further, through the Pashma River, into the Klyazminskaya Nerl' River. The shores and most of the littoral zone of the lake are composed by sandy-pebble or sandy soils and, to a lesser extent, by peat. The sediments forming the bottom of the lake are also heterogeneous. Thus, in the eastern part of the lake, sandy-silty deposits are widespread, sometimes with an admixture of pebbles and boulders. Near the western and southern coasts, mainly peaty silts are found, overlapping gray sapropel (thickness from 0.10 to 4.5 m) in some areas. In the central part of the lake, clayey sapropel dominates, while in the southern part, the sapropel stratum is covered by a 2-m layer of peaty silt (Fortunatov and Moskovskii, 1970; Grigor'ev, 1903; Kuzmichev et al., 1990; Lyashenko et al., 2002).

The Lake Vashutinskoe (other names: Vashutino). The area of the water surface is 310 hectares, the maximum depth is 6.5 m, the average depth, 3.5 m. The waters of the lake are characterized by sufficiently high mineralization of 100 m/L. The water transparency ranges from 40–60 cm near the shores to 80 cm in the center of the lake; pH is 6.6–7.9; the electrical conductivity of the surface water layer is 58–59 μ S. The lake is open; the Sutyaga River inflows to the lake from the north-west, the Dubets Brook, from the north; the River Kamenka (a tributary of the Klyazminskaya Nerl' River) outflows from the southeastern part of the lake. The shores of the lake are swampy in the northern and southern parts. The bottom is formed mainly by peaty silts, overlapping sapropel in some areas (Fortunatov and Moskovskii, 1970; Kuzmichev et al., 1990; Lyashenko et al., 2002).

Hydrophysical and hydrochemical characteristics of water (temperature, electrical conductivity, dissolved oxygen) were measured with a multiparameter hand-held portable probe YSI-ProPlus (YSI, USA) in the surface layer (10 cm), the pH was determined using a portable analyzer Combo HI 98129 (Hanna Instruments, Germany), the water transparency was assessed using the Secchi disk.

Integral samples were taken in the pelagial zone and in the shallow waters covered with thickets of higher aquatic vegetation in order to determine the biomass and species composition of algae. The collection and processing of phytoplankton samples was carried out according to standard methods (Metodika..., 1975). Taxa with biomass equal to or exceeding 10% of the total biomass were considered dominants. When analyzing the phytoplankton communities of the lakes, the microalgae biomass and the species richness of phytoplankton were considered. The trophic status of the lakes was determined by the phytoplankton biomass in accordance with the classification by S.P. Kitaev (1984, 2007).

The vegetation cover of the lakes was studied according to the methods generally accepted in hydrobotany (Katanskaya, 1981; Shennikov, 1964; etc.). The material was collected by the route method using a rowing boat and going round the lake along the shore. During the field surveys, the taxonomic composition of the flora of the vascular plants of the lakes was taken into account (Papchenkov, 2001), the depth of plant growth and the nature of the soil were noted. When compiling a plant species list of the lake, materials from our own research were used. The species of vascular plants were determined using the taxonomic keys of local flora (Lisitsyna et al., 2009; Maevskii, 2014). Latin names of taxa were verified in accordance with the summary of P.F. Maevskii (2014), recent taxonomy was also taken into account for a number of taxa. For example, the nomenclature of ferns is given here in accordance to M.M. Christenhusz and M.W. Chase (2014), the nomenclature of the genera *Ranunculus* L. and *Lysimachia* L., by the APG IV system (Byng et al., 2016; Emadzade et al., 2010; Hao et al., 2004). Taxonomic, ecological, and ecobiomorphological analyzes of the flora were performed in accordance with the recommendations of V.G. Papchenkov (2001).

The plant species lists are presented for each lake (Appendices 1 and 2), these species were those observed in the lake area in mid-July 2018.

Results and discussion

The greatest depth and the lowest water transparency during the study period were registered in the Lake Zaozer'e (Table 1). The highest temperature, dissolved oxygen content, and pH were also recorded here, which was apparently associated with a high biomass of cyanobacteria. It should be noted that the

Table 1. Some abiotic characteristics of small lakes in the Rostov District of the Yaroslavl Region in July 2018. P – pelagial zone, OL – overgrown littoral zone, «–» – no data.

Parameter	Lake							
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe	
	P	OL	P	OL	P	OL	P	OL
Sampling depth, m	7	1	9	0.4	3.5	0.9	2.6	1.2
Water transparency, m	1	0.9	0.3	0.1	1.4	down to the bottom	0.6	0.4
Water temperature, °C	21.6	21.8	22.3	23.4	22.2	22.0	21.4	22.1
Dissolved oxygen, mg/L	8.89	8.62	12.40	11.90	8.36	7.83	–	–
Oxygen saturation, %	100	99	139.7	132	96	91	–	–
Total dissolved solids, mg/L	31.9	31.2	29.9	27.3	17.6	17.6	–	–
pH	6.8	6.8	9.0	9.2	6.5	6.9	6.6	7.0

active photosynthesis exactly causes an increase in water pH and an increase in the oxygen concentration in the reservoir during the phytoplankton bloom (Kellar and Paerl, 1980; Paerl and Ustach, 1982). The lowest water transparency was characteristic of the shallowest of the studied lakes, the Lake Vashutinskoe, the highest water transparency in the pelagial and littoral zones was observed in the lakes Ryumniki and Chashnitskoe. The lakes Vashutinskoe, Ryumniki, and Chashnitskoe did not differ significantly in terms of pH and dissolved oxygen content. The lowest mineralization was observed in the Lake Ryumniki, the highest, in the Lake Chashnitskoe.

Algal flora

In total, 137 species of algae belonging to 8 divisions, 18 orders, and 76 genera were identified in the studied lakes of the Rostov District of the Yaroslavl Region. The largest number of species was found in the Lake Vashutinskoe (81 species), followed by the lakes Chashnitskoe and Zaozer'e (69 species each), in the Lake Ryumniki, 65 species were found (Appendix 1). The largest number of species in the pelagial zone was found in the Lake Vashutinskoe (68 species), the lowest, in the Lake Chashnitskoe (50 species). The number of phytoplankton species in the pelagial zone in the lakes Zaozer'e and Ryumniki was 53 and 54 species, respectively. In the shallow waters of the lakes, the number of algal species was lower than that in the deep-water part: 29 species in the Lake Zaozer'e, 37, in the Lake Ryumniki, and 46 species each in the lakes Chashnitskoe and Vashutinskoe.

The lowest phytoplankton biomass in the pelagial zone was recorded in the Lake Ryumniki (0.65 mg/L),

the highest, in the Lake Vashutinskoe (7.13 mg/L) (Fig. 2A). According to the algae biomass, the pelagial zone of the lakes Chashnitskoe and Zaozer'e was characterized by mean values (2.18 mg/L and 3.38 mg/L, respectively). The phytoplankton biomass in the pelagial zone of the lakes turned out to be generally lower than that in the littoral zone overgrown with higher aquatic vegetation (Fig. 2A). The greatest difference was observed in the Lake Zaozer'e, where biomass in the littoral zone was 6 times greater comparing to the pelagial zone, the lowest, in the Lake Ryumniki (1.5 times more in the littoral zone than in the pelagial zone).

Cyanobacteria dominated by biomass in the Lake Chashnitskoe (~50% of the total biomass), followed by green algae (15–25%) (Fig. 2B). Bacillariophyta (14%) and Dinophyta (10%) also prevailed in the pelagial zone of the lake, Chrysophyta (13%), in the littoral zone. In the deep-water part of the Lake Chashnitskoe, the dominating species were *Snowella lacustris* (Chod.) Kom. et Hind. (21%), *Anabaena* sp. (17%), and *Aulacoseira ambigua* (Grun.) Sim. (12%); in shallow waters, these were *Anabaena* sp. (37%), *Dinobryon divergens* Imhof (12%), and the species of the genus *Chlamydomonas* Ehrenb. (10%) (Appendix 1).

In the Lake Zaozer'e, cyanobacteria dominated also (91–99%) in the studied biotopes (Fig. 2B). *Aphanizomenon flos-aquae* prevailed in the pelagial and littoral zones of this water body (84% and 78%, respectively). In shallow waters, *Microcystis aeruginosa* (18%) was a subdominant (Appendix 1).

The ratio of the dominant algae divisions was different in the pelagial and littoral zones of the Lake Ryumniki (Fig. 2B). In the deep-water part of the lake,

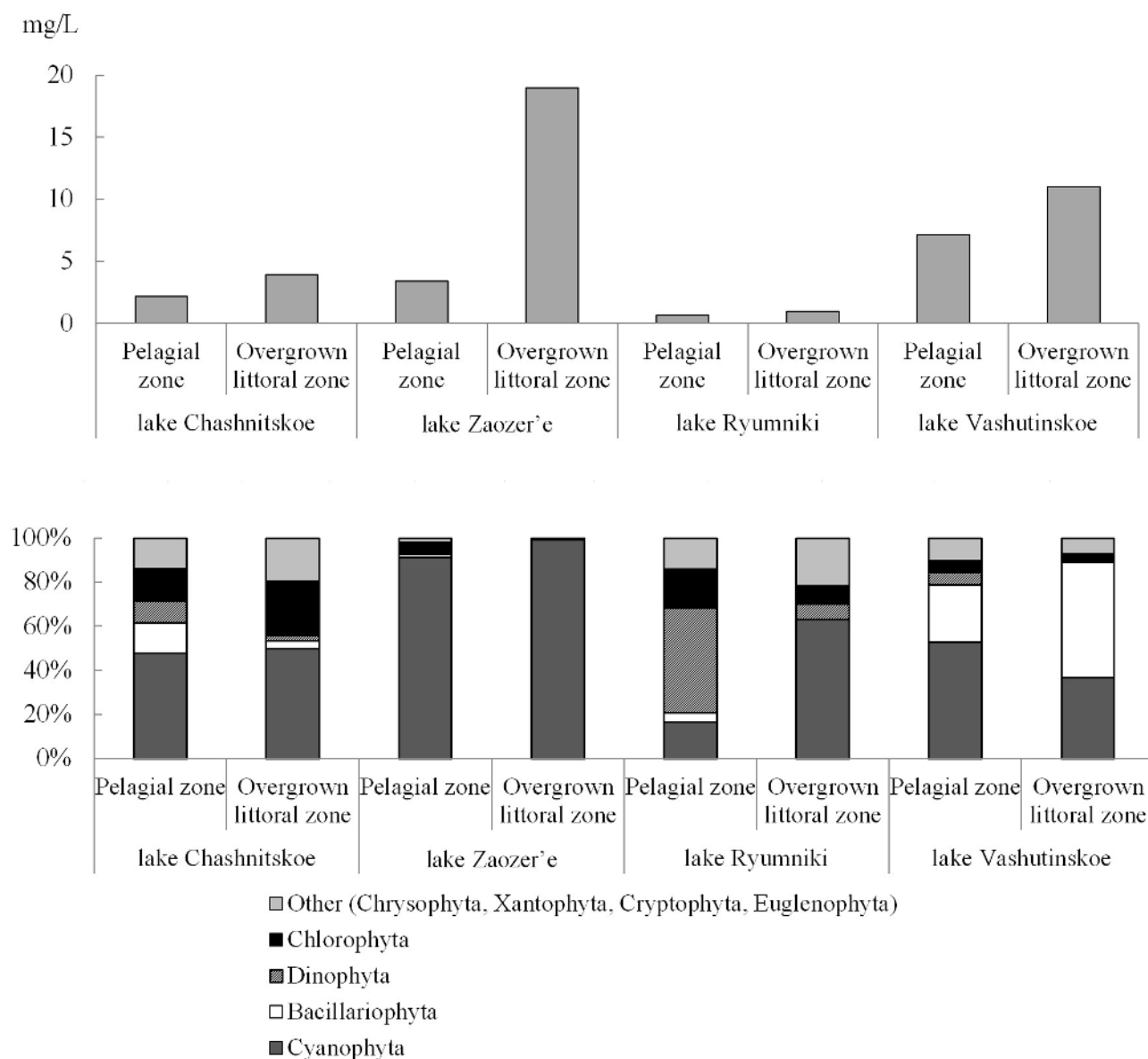


Fig. 2. Phytoplankton biomass (A) and the share of different groups of planktonic algae in regard to the total biomass (B) in different parts of the studied lakes of the Rostov District of the Yaroslavl Region, Russia, in July 2018.

the biomass was dominated by Dynophyta (48%), Chlorophyta (17%), and Cyanobacteria (16%), while in shallow water, Cyanobacteria (63%) and Cryptophyta (19%) prevailed. *Ceratium hirundinella* (O.F. Müll.) Schrank dominated by biomass (43%) in the pelagial zone, in the littoral zone, these were *Aphanizomenon flos-aquae* (34%), *Anabaena* sp. (25%), and *Cryptomonas marssonii* Skuja (17%) (Appendix 1).

In the Lake Vashutinskoe, the dominant algae divisions were cyanobacteria (53% in the pelagial and 37% in the littoral zones) and diatoms (26% and 52%, respectively) (Fig. 2B). *Limnothrix planctonica* (Wolosz.) Meff. (30%), *Aulacoseira ambigua* (19%), and *Microcystis aeruginosa* (13%) prevailed in the deep-water area, *Aulacoseira ambigua* (51%) and *Limnothrix planctonica* (26%), in shallow waters.

Based on the phytoplankton biomass data obtained for the pelagial zone, the Lake Vashutinskoe belongs to the eutrophic water bodies, the lakes Chashnitskoe and Lake Zaozer'e, to mesotrophic, and the Lake Ryumniki, to oligotrophic (Kitaev, 1984, 2007). Shallow areas of the reservoir are characterized by a higher phytoplankton biomass than deep-water ones; according to the trophicity scale, the lakes Chashnitskoe, Zaozer'e, and Vashutinskoe are classified as eutrophic reservoirs. Shallow waters of the Lake Ryumniki have an oligotrophic status. It should be noted that the coastal areas are characterized by higher enrichment with biogenic elements, which probably contributes to the active development of phytoplankton in these zones (Korneva, 1983; Solov'eva and Korneva,

2006). The lowest species richness of phytoplankton has been noted in the shallow waters, which also confirms the advantage of cyanobacteria (whose biomass is higher in the littoral zone than in the pelagial zone) in high rates of nutrient consumption, so they are responsible for the light limitation for other phytoplankton species (Paerl and Huisman, 2009). The study of the processes occurring in the shallow waters is especially important in regard to their role in the ecosystem of the entire water body. It is known that the eutrophication processes beginning in the littoral areas are then observed in the deep-water zones of the reservoir (Sakharova and Korneva, 2018).

The study of the phytoplankton of these lakes was very episodic, the sampling was carried out only in September (Fortunatov and Moskovskii, 1970; Lyashenko et al., 2002); therefore, the available data do not allow us to conclude on the vector of successional changes in the algal community. The predominance of cyanobacteria in all lakes was noted both in our studies and earlier (Fortunatov and Moskovskii, 1970; Grigor'ev, 1903; Lyashenko et al., 2002). Decreasing role of *Aphanizomenon flos-aquae* and species of the genus *Anabaena* was reported earlier (Lyashenko et al., 2002), but these algae made a significant contribution to biomass (up to 80%) during our studies. As it was observed in September 2001 (Lyashenko et al., 2002), during our studies, phytoplankton of the Lake Vashutinskoe was similar in composition of the dominant complex (genera *Microcystis* and *Limnothrix*) with other shallow eutrophic lakes, for example, the Lake Nero (Babanazarova et al., 2011).

Vascular plants

Currently, the flora of vascular plants of all studied lakes includes 118 species belonging to 4 divisions, 5 classes, 22 orders, and 37 families. A full list of vascular plants is presented in Appendix 2.

The Lake Zaozer'e was characterized by the poorest species richness (50 species; Table 2). This was caused by the anthropogenic disturbance of its vegetation cover, associated with the income of the organic-rich wastewater from two livestock farms, which were previously located on the shores of the lake (Fortunatov and Moskovskii, 1970). It should be noted that the farms have not been operating for a long time; however, the lake still "blooms" strongly in the summer months, and so the water transparency drops sharply and thus inhibits the development of submerged aquatic plants. The oligotrophic Lake Ryumniki was characterized by the richest species composition (82 species; Table 2); apparently, this was due to a significant number of different biotopes (both natural and anthropogenically disturbed).

Cyperaceae Juss and Poaceae Barnhart were the dominant families of the flora of all studied lakes (Table 3). Their share in the total composition of the flora reached 22.0% in the Lake Zaozer'e, about 24.0%, in the Lake Chashnitskoe, 23.1%, in Lake Ryumniki, and 27.3% in the Lake Vashutinskoe. Redard must be paid to a significant share of grasses in the flora of the studied lakes, which can serve as an indicator of an increase of the anthropogenic load (Teteryuk, 2012). In the Lake Ryumniki, Ranunculaceae Juss may also be included into the list of dominant families. The floras of the lakes Chashnitskoe, Ryumniki, and Vashutinskoe were characterized by a pronounced distinctness along with the common leading genera *Carex* L., *Persicaria* (L.) Mill., and *Potamogeton* L. (Table 3). Thus, *Juncus* L. and *Sparganium* L. were the leading genera in the Lake Chashnitskoe, in addition to the genera listed above, *Salix* L. and *Ranunculus* L., in the Lake Ryumniki, and *Calamagrostis* Adans, in the Lake Vashutinskoe.

When considering ecological and coenotic structure, hygrophytes were the leading group of

Table 2. The taxonomic structure of the flora of small lakes in the Rostov District of the Yaroslavl Region in July 2018.

Number of taxonomic groups	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
Species	71	50	82	76
Genera	51	37	59	56
Families	30	24	37	31
Orders	21	16	23	23
Classes	4	4	5	3
Divisions	2	2	3	2

Table 3. Contribution of the dominant families and genera of vascular plants to the species richness of the flora of small lakes in the Rostov District of the Yaroslavl Region in July 2018.

Lake	Family	Contribution to the species richness, %	Genus	Contribution to the species richness, %
Chashnitskoe	Cyperaceae	12.6	<i>Carex</i>	5.6
	Poaceae	11.3		
	Araceae, Lamiaceae, Polygonaceae, Typhaceae	5.6 each	<i>Juncus, Persicaria, Potamogeton, Sparganium</i>	4.2 each
Zaozer'e	Cyperaceae	12.0		
	Poaceae	10.0		
	Typhaceae	8.0	<i>Sparganium, Carex, Galium</i>	6.0 each
	Araceae, Lamiaceae, Rubiaceae	6.0 each		
Ryumniki	Poaceae	13.4	<i>Carex</i>	6.1
	Cyperaceae	9.7	<i>Salix, Ranunculus</i>	5.0 each
	Ranunculaceae	6.1		
	Araceae, Lamiaceae, Salicaceae	5.0 each	<i>Potamogeton, Persicaria</i>	3.6 each
Vashutinskoe	Poaceae	14.3	<i>Carex</i>	7.8
	Cyperaceae	13.0	<i>Calamagrostis, Potamogeton, Persicaria</i>	~ 4.0 each
	Araceae, Lamiaceae, Polygonaceae	5.2 each		

the flora of each of the studied lakes: 44.0% in the Lake Zaozer'e, 39.4% in the Lake Chashnitskoe, 39.0% in the Lake Ryumniki, and 36.8% in the Lake Vashutinskoe. The second place belonged to hygrophytes (24.0% each in the lakes Zaozer'e and Chashnitskoe, 25.0% in the Lake Vashutinskoe), followed by hydrophytes (14.0%, in the Lake Zaozer'e, 17.0% in the Lake Chashnitskoe, and 19.7% in the Lake Vashutinskoe). It should be noted that in the Lake Ryumniki, in contrast to the other lakes, hydrophytes (22.0%) dominated over hygrophytes (20.7%). The share of helophytes, as usual, was much lower: 16.0% in the Lake Zaozer'e, 15.6% in the Lake Chashnitskoe, 12.0% in the Lake Vashutinskoe, and 7.4% in the Lake Ryumniki. Mesophytes were either absent (the Lake Zaozer'e), or are present by no more than one or two species (2.4% in the Lake Ryumniki, 1.4% in the Lake Chashnitskoe, and 1.3% in the Lake Vashutinskoe).

The flora of small lakes was traditionally dominated by herbaceous plants; their contribution to the species richness of each particular lake ranged as 90.2–96.0%. Perennials and annual / biennial plants formed the basis of the vegetation cover of lakes (89.4–94.7%). This group also included polycarpous and sporulating species (*Isoetes echinospora* Durieu,

Equisetum fluviatile, and *Thelypteris palustris* Schott). Annuals made up to 5.3–7.8%. It is interesting that in the Lake Ryumniki annual plants were represented not by 3–4 species (as in other lakes), but by 8 species (9.7% of the lake flora).

The rare and protected species of the Yaroslavl Region (Krasnaya Kniga..., 2015) were represented by *Nuphar pumila* (Timm) DC. in the Lake Vashutinskoe and *Isoetes echinospora* in the Lake Ryumniki. *Sparganium gramineum* Georgi was recorded in all studied water bodies.

Thirty-four plant species were found in all the studied water bodies, of which 4 were hydrophytes: *Elodea canadensis* Michx., *Lemna minor* L., *Spirodela polyrrhiza* (L.) Schleid., *Sparganium gramineum*; six species were helophytes (*Equisetum fluviatile* L., *Alisma plantago-aquatica*, *Sagittaria sagittifolia*, *Glyceria maxima*, *Phragmites australis* (Cav.) Trin. ex Steud., and *Typha latifolia* L.), and two species were hydrohelophytes (*Eleocharis acicularis* and *E. palustris*).

Since 1950s, *I. echinospora*, *Elatine hydropiper* L., and *E. triandra* Schkuhr. have disappeared from the flora of the Lake Chashnitskoe; in the Lake Zaozer'e, these are *Persicaria amphibia*, and *Potamogeton*

perfoliatus; in the Lake Rymniki – *Elatine callitrichoides* (W. Hyl.) Kauffm., *Nuphar pumila*, *Carex elongata* L., *Sparganium natans* L., and *Potamogeton lucens* L.; in the Lake Vashutinskoe – *I. echinospora*, *Potamogeton berchtoldii* Fieb., *P. natans* L., *Caulinia flexilis* Willd., *Zizania palustris* L., *Carex caespitosa* L., *Ranunculus trichophyllum* Chaix, *R. reptans* L., *Elatine hydropiper*, *Callitriche hermaphroditica* L., and *Galium trifidum* L.

The disappearance of *Isoetes echinospora* from the flora of the lakes Chashnitskoe and Vashutinskoe could have occurred during the period from 1965–1972 to 1985; apparently, it is associated with an increase in the trophic status of these water bodies (Fortunatov and Moskovskii, 1970; Lyashenko et al., 2002). Currently, this species has survived only in the oligotrophic Lake Rymniki, where the state of its population can be considered satisfactory. *I. echinospora* grows here along the southern and southeastern coasts at the depths from 0.15 to 1.0 m; the sediments are sandy, less often sandy with thin deposit of spring floods. It is found as single specimens and does not form clusters or thickets. It should be noted that the data on the growth of *I. lacustris* L. in the Yaroslavl Region, given earlier for the lakes Rymniki, Vashutinskoe, and Chashnitskoe, are erroneous (Garin, 2015).

Sparganium × longifolium Turcz. ex Ledeb., which is a hybrid between the boreal-montane Eurasian species *Sparganium gramineum*, preferring ultra-fresh water bodies with a nearly neutral pH, and *S. emersum* Rehm., a plurizonal Holarctic species with a wide ecological amplitude (Belyakov et al., 2017), registered during our studies in the lakes Chashnitskoe and Zaozer'e, is an indicator of an increase in the degree of trophicity as a result of vigorous economic activity (Fortunatov and Moskovskii, 1970; Lyashenko et al., 2002).

Active water blooming (transparency of 10 cm and less) in the summer in the Lake Zaozer'e was apparently a consequence of the extremely low number of submerged hydrophytes found here. Thus, the *Potamogeton perfoliatus* and *Persicaria amphibia* previously noted here were not found in the lake in 2001 (Lyashenko et al., 2002), although in the early summer period, when the water in the lake is still clear, *Elatine hydropiper*, *Potamogeton crispus* L., and *Ceratophyllum demersum* L. are found here. It should be noted that the last two species are the indicators of the eutrophication of the reservoir. In addition, both parental species of bur-reed and their hybrid co-grow on this lake. The alternating groups of *Sparganium gramineum* and *S. × longifolium* are located in a narrow strip along the northern and northwestern shores of the lake, while *S. emersum* is distributed exclusively along the southern coast. In the future, this situation may lead to the loss of *S. gramineum* from the flora of the lake.

Due to eutrophication and active overgrowth of the north-eastern shore of the Lake Vashutinskoe, *Nuphar pumila* (Timm) DC are endangered, as well as a single small clump of *Sparganium gramineum* (no more than 1 m in diameter); in addition, the appearance of *Stratiotes aloides* L., an indicator species of eutrophication, in this lake raises concerns. Absence of *Chara strigosa* A. Br. in 2018, a relict species listed in the Red Data Book of the Yaroslavl Region (2015), is another indicator of the eutrophication processes in the Lake Vashutinskoe. *Chara strigosa* is a stenothermal cold-water freshwater, predominantly light-loving plant that is considered an indicator of oligotrophic waters (Langangen and Mjelde, 2010; Romanov et al., 2014). For the first time, this species was noted in the Lake Vashutinskoe in 1972, and the last time it was found here in 2017 in the form of a few and strongly suppressed shoots.

The saturation of the flora of lakes with adventive species is extremely low. *Elodea canadensis*, *Bidens frondosa* L., and *Epilobium adenocaulon* Hausskn were noted in all studied lakes. *Zizania latifolia* Griseb. and *Juncus tenuis* Willd. were also registered in the lake Vashutinskoe. The high adaptive potential of these plants allows them to colonize quickly and hold successfully their niches in phytocenoses. It should be noted that *E. canadensis*, apparently, could appear in the studied lakes not earlier than in the 1980s and currently does not form significant thickets in the water bodies. Cultivation of the Far Eastern perennial *Zizania latifolia* and the Canadian annual plant *Z. palustris* in the Lake Vashutinskoe was associated with the presence of a hunting farm on its shore, which is still functioning. Apparently, these species were planted along the Lake Vashutinskoe as early as in 1960s and 1970s in order to increase the food supply and improve the habitat conditions for semiaquatic animals (Lisitsyna et al., 2009; Maltseva and Bobrov, 2017). Two more North American invasive species, *Epilobium adenocaulon* and *Bidens frondosa*, are now widely distributed in all areas of the middle zone of the European part of Russia (Lisitsyna et al., 2009; Maevskii, 2014).

Conclusions

In the studied water bodies, 137 species of algae belonging to 8 divisions, 18 orders, and 76 genera were identified. The algoflora of the Lake Vashutinskoe is the richest (81 species), followed by the lakes Chashnitskoe and Zaozer'e (69 species each), 65 species inhabit the Lake Rymniki. Despite the fact that phytoplankton of the studied water bodies is known only from episodic observations, cyanobacteria predominate in the lakes. A significant contribution to the biomass of *Aphanizomenon flos-aquae* and species of the genus *Anabaena* was noted in the lakes Zaozer'e, Chashnitskoe, and Rymniki, in the Lake Vashutinskoe, they were *Limnithrix planctonica* and *Microcystis aeruginosa*. According to the phytoplankton biomass of

the pelagial zone, the Lake Vashutinskoe is classified as eutrophic water body, the lakes Chashnitskoe and Zaozer'e, as mesotrophic, and the Lake Ryumniki, as oligotrophic. By trophicity, shallow waters of the lakes Chashnitskoe, Zaozer'e, and Vashutinskoe belong to the eutrophic water bodies, while the littoral zone of the Lake Ryumniki has an oligotrophic status. The irregular nature of the observations carried out in different years and periods of the growing season does not allow us to conclude on the vector of the successional changes in the algal flora.

The total list of vascular plants of the studied lakes includes 118 species belonging to 4 divisions, 5 classes, 22 orders, and 37 families; 34 species are common for all studied lakes. The Lake Ryumniki is the richest by the species composition, the Lake Zaozer'e, the poorest. In general, the differences in the taxonomic composition of the flora of certain lakes are associated with both the diversity of biotopes and the different level of conservation of the vegetation cover, as well as with the degree of eutrophication of a particular water body. The low species richness of the flora of the Lake Zaozer'e is mainly due to the monotonous nature of the coastline and the active blooming of water in summer. In accordance with the ecological-coenotic characteristics of the flora of the lakes, the group of hygrophytes is traditionally the largest in number of species, followed by hygrohelophytes, and then hydrophytes. In the oligotrophic Lake Ryumniki, the representatives of the ecological group of hydrophytes prevail over hygrohelophytes. The prevalence of herbaceous plants found in the studied lakes is natural and characteristic of aquatic flora. After 1950s, two species have disappeared from the Lake Zaozer'e, three species, from the Lake Chashnitskoe, five species, from the Lake Ryumniki, and eleven species, from the Lake Vashutinskoe. For example, *I. echinospora* was not found after 1965 in the Lake Chashnitskoe and after 1972 in the Lake Vashutinskoe. *Caulinia flexilis* was not found in the Lake Vashutinskoe since 1972. *Potamogeton crispus*, *Sparganium × longifolium*, *Ceratophyllum demersum*, *Elodea canadensis*, *Stratiotes aloides* and some other species are among the main indicators of eutrophic waters observed in the studied lakes. The saturation of the flora of lakes with adventive species is low: only two adventive species was registered in the Lake Chashnitskoe over the entire period of research, five species, in the Lake Ryumniki, and ten species, in the Lake Vashutinskoe.

Acknowledgments

The work was carried out within the framework of the State Tasks nos. AAAA-A18-118012690096-1 and AAAA-A18-118012690099-2. Special thanks go to I.P. Samakov, the Head of the Pereslavl hunting farm, V.S. Gal'tsov, chief hunting expert, and other employees of the hunting farm for invaluable support during the studies on the Lake Vashutinskoe.

References

- Babanazarova, O.V., Sidelev, S.I., Aleksandrina, E.M., Sakharova, E.G., Kurmayer, R., 2011. Phytoplankton structure and microcystine concentration in the highly eutrophic Nero Lake. *Water Resources* 2, 229–236. <https://doi.org/10.1134/S0097807811020023>
- Belyakov, E.A., Garin, E.V., 2018. Long-term dynamics of flora of karst lakes: Changes and current state. *Biosystems Diversity* 26 (2), 160–169. <https://doi.org/10.15421/011825>
- Belyakov, E.A., Shcherbakov, A.V., Lapirov, A.G., Shilov, M.P., 2017. Morfologiya i ekologicheskie osobennosti *Sparganium × longifolium* (Typhaceae) v centre evropeiskoy chasti Rossii [Morphology and ecological characteristics of *Sparganium × longifolium* (Typhaceae) in the central part of the European Russia]. *Biosystems Diversity* 25 (2), 154–161. doi:10.15421/011723. (In Russian).
- Blokhontsev, E.N., 1903a. O fitoplanktone nekotorykh ozer Rostovskogo uezda Yaroslavskoi gubernii i dvukh ozer Vladimirskoi gubernii [About phytoplankton of some lakes of the Rostov Uezd (parish) of the Yaroslavl Guberniya (government) and two lakes of the Vladimir Guberniya]. *Trudy Saratovskogo obshchestva estestvoispytatelej i lyubitelej prirody [Proceedings of the Saratov Society of Naturalists and Nature Enthusiasts]* 4 (2), 253–269. (In Russian).
- Blokhontsev, E.N., 1903b. Fitoplankton Rostovskikh ozer [Phytoplankton of the lakes Rostovskie]. *Zemlevedenie [Earth Sciences]* 10 (4), 47–54. (In Russian).
- Byng, J.W., Chase, M.W., Christenhusz, M.J.M., Fay, M.F., Judd, W.S. et al., 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181 (1), 1–20. <https://doi.org/10.1111/boj.12385>
- Christenhusz, M.M., Chase, M.W., 2014. Trends and concepts in fern classification. *Annals of Botany* 113 (4), 571–594. <https://doi.org/10.1093/aob/mct299>
- Emadzade, K., Lehnebach, C., Lockhart, P., Hörandl, E., 2010. A molecular phylogeny, morphology and classification of genera of Ranunculaceae (Ranunculaceae). *Taxon* 59 (3), 809–828. <https://doi.org/10.2307/25677670>
- Flerov, A.F., 1903. Botaniko-geograficheskie ocherki. III. Rostovskii krai [Botanical and geographical

- essays. III. Rostov Region]. *Zemlevedenie [Earth Sciences]* **10** (2–3), 193–218. (In Russian).
- Fortunatov, M.A., Moskovskii, B.D., 1970. Oзера Yaroslavskoi oblasti: Kadaistrovoe opisanie i kratkie limnologicheskie kharakteristiki [Lakes of the Yaroslavl Region: Cadastral description and brief limnological characteristics]. In: Fortunatov, M.A. (ed.), *Oзера Yaroslavskoi oblasti i perspektivy ikh khozyaistvennogo ispol'zovaniya [Lakes of the Yaroslavl Region and prospects for their economic use]*. Yaroslavl State Pedagogical University, Yaroslavl, USSR, 3–177. (In Russian).
- Garin, E.V., 2015. Sosudistye sporovye rasteniya flory Yaroslavskoi oblasti [Vascular cryptogames of the flora of the Yaroslavl Region]. In: Lapirov, A.G. (ed.), *Horizons of Hydrobotany. Trudy IBVV RAN. Vyp. 71 (74) [Transactions of the I.D. Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences. Issue 71 (74)]*. Fili-gran', Yaroslavl', Russia, 48–59. (In Russian).
- Grigor'ev, S., 1903. Oзера Rostovskogo uезда [Lakes of the Rostov Uezd]. *Zemlevedenie [Earth Sciences]* **10** (2–3), 163–192. (In Russian).
- Hao, G., Yuan, Y.-M., Hu, C.-M., Ge, X.-J., Zhao, N.-X., 2004. Molecular phylogeny of *Lysimachia* (Myrsinaceae) based on chloroplast trnL – F and nuclear ribosomal ITS sequences. *Molecular Phylogenetics and Evolution* **31**, 323–339. [https://doi.org/10.1016/S1055-7903\(03\)00286-0](https://doi.org/10.1016/S1055-7903(03)00286-0)
- Izmailova, A.V., Rumyantsev, V.A., Drabkova, V.G., 2017. Limnologicheskaya izuchennost evropeiskoy chasti Rossii v svete problem antropogennoi modifikatsii ozernykh ekosistem [Limnological study of the European part of Russia in regard to the issue of anthropogenic modification of lake ecosystems]. *Izvestiya Russkogo geograficheskogo obshchestva [Bulletin of the Russian Geographical Society]* **149** (6), 1–13. (In Russian).
- Katanskaya, V.M., 1981. Vysshaya vodnaya rastitel'nost' kontinental'nykh vodoemov SSSR. Metody izucheniya [Higher aquatic vegetation of the continental water bodies of the USSR. Study methods]. Nauka, Leningrad, USSR, 187 p. (In Russian).
- Kellar, P.E., Paerl, H.W., 1980. Physiological adaptations in response to environmental stress during an *N₂-fixing Anabaena* bloom. *Applied and Environmental Microbiology* **40**, 587–595.
- Kitaev, S.P., 1984. Ekologicheskie osnovy bioproduktivnosti ozer razlichnykh prirodnykh zon [Ecological basis of bioproductivity of lakes of various natural zones]. Nauka, Moscow, USSR, 208 p. (In Russian).
- Kitaev, S.P., 2007. Osnovy limnologii dlya gidrobiologov i ikhtiologov [Fundamentals of Limnology for Hydrobiologists and Ichthyologists]. Karelian Scientific Center, Russian Academy of Sciences, Petrozavodsk, Russia, 395 p. (In Russian)
- Korneva, L.G., 1983. Planktonnye algotsenozy pribrezhiya Rybinskogo vodokhranilishcha [Plankton algocoenoses of the coastal areas of the Rybinsk Reservoir]. In: Monakov, A.V., *Presnovodnye gidrobionty i ikh biologiya [Freshwater aquatic organisms and their biology]*. Nauka, Leningrad, Russia, 38–51. (In Russian).
- Krasnaya kniga Yaroslavskoy oblasti [Red Data book of the Yaroslavl Region], 2015. Akademiya-76, Yaroslavl, Russia, 472 p. (In Russian).
- Kuz'michev, A.I., Ekzertsev, V.A., Lisitsyna, L.I., Dovbnya, I.V., Trusov, B.A. et al., 1990. Flora i rastitel'nost' ozer Yaroslavskoi oblasti [Flora and vegetation of the lakes in the Yaroslavl Region]. In: Ekzertsev, V.A. (ed.), *Flora i produktivnost' pelagicheskikh i litoral'nykh fitotsenozov vodoemov basseina Volgi [Flora and productivity of pelagic and littoral phyto-cenoses of the water bodies of the Volga River basin]*. Nauka, Leningrad, USSR, 272 p. (In Russian).
- Langangen, A., Mjelde, M., 2010. Handlingsplan for kalksjøer – Faktaark for viktige arter av kransalger og tjønnaks. Miljøvernavdelingen, Fylkesmannen i Oppland, Lillehammer, Norway, 39 p.
- Lawniczak-Malińska, A.E., Achtenberg, K., 2018. On the use of macrophytes to maintain functionality of overgrown lowland lakes. *Ecological Engineering* **113**, 52–60. <https://doi.org/10.1016/j.eco-leng.2018.02.003>
- Lisitsyna, L.I., Papchenkov, V.G., Artemenko, V.I., 2009. Flora vodoemov Volzhskogo basseina. Opredelitel' sosudistyykh rastenii [Flora of the water bodies of the Volga River basin. Taxonomic keys for vascular plants]. KMK, Moscow, Russia, 219 p. (In Russian).
- Lobunicheva, E.V., Borisov, M.Ya., Filonenko, I.V., Filippov, D.A., 2013. Otsenka ekologicheskogo sostoyaniya malyykh vodoemov. Uchebnoe posobie [Environmental assessment of small water bodies. A tutorial]. State Research Institute on Lake and River Fisheries (FGBNU GosNIORKh), Vologda, Russia, 218 p. (In Russian).
- Lyashenko, G.F., Lazareva, V.I., Lyashenko, O.A., 2002. Dinamika vysshei vodnoi rastitel'nosti i plank-

- tona v malykh ozerakh basseina Verkhnei Volgi [Dynamics of higher aquatic vegetation and plankton in small lakes of the upper Volga River basin]. In: Papchenkov, V.G. (ed.), *Dinamika raznoobraziya gidrobiontov vo vnutrennikh vodoemakh Rossii* [Dynamics of diversity of aquatic organisms in the inland waters of Russia]. Yaroslavl State Technical University, Yaroslavl, Russia, 34–57. (In Russian).
- Maevskii, P.F., 2014. Flora srednei polosy evropeiskoi chasti Rossii [Flora of the temperate climatic zone of the European part of Russia]. 11th edition. KMK, Moscow, Russia, 635 p. (In Russian).
- Mal'tseva, S.Y., Bobrov, A.A., 2017. Alien species of vascular plants in the Rybinsk Reservoir (Upper Volga, Russia). *Russian Journal of Biological Invasions* 8 (4), 321–326. <https://doi.org/10.1134/S2075111717040063>
- Mäemets, H., Palmik, K., Haldna, M., Sudnitsyna, D., Melnik, M., 2010. Eutrophication and macrophyte species richness in the large shallow North-European Lake Peipsi. *Aquatic Botany* 92 (4), 273–280. <https://doi.org/10.1016/j.aquabot.2010.01.008>
- Metodika izucheniya biogeotsenozov vnutrennikh vodoemov [Method of Analysis of Biogeocenoses of Inland Water Bodies], 1975. Mordukhai-Boltovskoy, F.D. (ed.), Nauka, Moscow, USSR, 240 p. (In Russian).
- Paerl, H.W., Huisman, J., 2009. Climate change: a catalyst for global expansion of harmful cyanobacterial blooms. *Environmental Microbiology Reports* 1 (1), 27–37. <https://doi.org/10.1111/j.1758-2229.2008.00004.x>
- Paerl, H.W., Ustach, J.F., 1982. Blue-green algal scums: an explanation for their occurrence during freshwater blooms. *Limnology and Oceanography* 27, 212–217.
- Papchenkov, V.G., 2001. Rastitelnyi pokrov vodoemov i vodotokov Srednego Povolzh'ya [Vegetation cover of the water bodies and watercourses of the middle Volga River region]. International Academy of Business and New Technologies, Yaroslavl, Russia, 214 p. (In Russian).
- Postanovlenie pravitel'stva Yaroslavskoi oblasti ot 2 noyabrya 2017 goda N 823-p "Ob utverzhdenii rezhima osoboy okhrany territorii pamyatnikov prirody regionalnogo znacheniya Yaroslavskoi oblasti" [Decree of the Government of the Yaroslavl Region of November 2, 2017, no. 823-p "On approval of the special protection regime for the territory of nature monuments of regional significance of the Yaroslavl Region"]. (In Russian).
- Romanov, R.E., Chemeris, E.V., Vishnyakov, V.S., Chepinoga, V.V., Azovskii, M.G., Kuklin, A.P., Timofeeva, V.V., 2014. *Chara strigosa* (Streptophyta: Charales) v Rossii [Chara strigosa (Streptophyta: Charales) in Russia]. *Botanicheskiy Zhurnal* [Botanical Journal] 99 (10), 1148–1161. (In Russian). <https://doi.org/10.1134/S1234567814100097>
- Sakharova, E.G., Korneva, L.G., 2018. Phytoplankton in the littoral and pelagial zones of the rybinsk reservoir in years with different temperature and water-level regimes. *Inland Water Biology* 1, 6–12. <https://doi.org/10.1134/S1995082918010157>
- Shennikov, A.P., 1964. Vvedenie v geobotaniku [Introduction to geobotany]. Leningrad State University, Leningrad, USSR, 447 p. (In Russian).
- Slukovskii, Z.I., Shelekhova, T.S., Syroezhko, E.V., 2018. Otklik diatomovoy flory malogo ozera na vozdeistviye tyazhelykh metallov v usloviyakh urbanizirovannoi sredy Respubliki Karelii [A response of diatoms from the small lake on heavy metals effect in an urban environment, Republic of Karelia]. *Vestnik Sankt-Peterburgskogo universiteta. Nauki o Zemle. [Vestnik of Saint Petersburg University. Earth Sciences]* 63 (1), 103–123. (In Russian). <https://www.doi.org/10.21638/11701/spbu07.2018.106>
- Solov'eva, V.V., Korneva, L.G., 2006. Struktura i dinamika fitoplanktona melkovodii i pelagiali Volzhskogo plesa Rybinskogo vodokhranilishcha [Structure and dynamics of phytoplankton of shallow waters and pelagic zone of the Volga Reach of the Rybinsk Reservoir]. *Biologiya vnutrennikh vod [Inland Water Biology]* 4, 34–41. (In Russian).
- Strakhovenko, V.D., Kabannik, V.G., Malikova, I.N., 2014. Geochemical features of the ecosystem of the Lake Kolyvanskoe (Altai Krai) and the effect of the technogenic impact. *Lithology and Mineral Resources* 3, 213–227.
- Teteryuk, B.Y., 2012. Flora i rastitelnost' drevnikh ozer evropeiskogo Severo-Vostoka Rossii [Flora and vegetation of ancient lakes of the European north-east part of Russia]. Nauka, Saint-Petersburg, Russia, 237 p. (In Russian).
- Trusov, B.A., Lapirov, A.G., Lyashenko, G.F., 1988. O zarastanii nekotorykh ozer Yaroslavskoi oblasti [About the overgrowth of some lakes in the Yaroslavl Region]. *Biologiya vnutrennikh vod [Inland Water Biology]* 78, 17–21. (In Russian).

SUPPLEMENTARY MATERIALS

Appendix 1

Taxonomic composition of phytoplankton of small lakes of the Rostov District of the Yaroslavl Region in July 2018. 1 – presence of the taxon, 0 – absence. P – pelagial zone, OL – overgrown littoral zone

Taxon	Lake									
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe			
	P	OL	P	OL	P	OL	P	OL	P	OL
DIVISION CYANOBACTERIA										
Order Chroococcales										
<i>Aphanocapsa holsatica</i> (Lemmermann) Cronberg et Komárek	1	1	1	0	1	1	1	1	1	1
<i>A. incerta</i> (Lemmermann) Cronberg et Komárek	0	0	1	0	1	0	1	0	1	0
<i>Aphanothece clathrata</i> W. et G.S. West f. <i>Clathrata</i>	0	0	0	0	0	1	0	1	0	0
<i>A. clathrata</i> f. <i>brevis</i> (Bachmann) Elenkin	1	1	0	1	1	1	1	1	1	1
<i>Chroococcus limneticus</i> Lemmermann	1	1	1	1	1	1	1	1	1	1
<i>Merismopedia marssonii</i> Lemmermann	0	0	0	0	0	0	1	0	1	1
<i>M. tenuissima</i> Lemmermann	0	0	0	0	1	1	0	1	0	0
<i>Microcystis aeruginosa</i> (Kützinger) Kützinger	1	1	1	1	1	1	1	1	1	1
<i>M. flos-aquae</i> (Wittrock) Kirchner	0	0	0	1	0	0	0	0	0	0
<i>M. pulverea</i> (H.C. Wood) Forti	1	0	0	0	0	0	1	0	1	0
<i>M. smithii</i> Komárek et Anagnostidis	0	1	0	1	0	0	0	0	0	0
<i>M. wesenbergii</i> (Komárek) Komárek	1	1	1	1	0	0	0	0	0	0
<i>Snowella lacustris</i> (Chodat) Komárek et Hindák	1	1	0	0	0	0	1	0	1	1
Order Nostocales										
<i>Anabaena flos-aquae</i> Brébisson ex Bornet et Flauhault	0	1	1	0	0	0	0	0	0	0
<i>A. scheremetievi</i> Elenkin	0	0	0	0	0	0	1	0	1	0
<i>Anabaena</i> sp.	1	1	1	1	1	1	0	1	0	1
<i>Aphanizomenon flos-aquae</i> (Linnaeus) Ralfs ex Bornet et Flauhault	1	0	1	1	1	1	0	1	0	0
<i>A. klebahnii</i> Elenkin ex Pechar	0	0	0	0	0	0	1	0	1	1

Taxon	Lake									
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe			
	P	OL	P	OL	P	OL	P	OL	P	OL
Order Oscillatoriales										
<i>Limnothrix planctonica</i> (Woloszyńska) Meffert	0	0	1	0	0	0	1	0	1	1
<i>L. redekeii</i> Van Goor	0	0	0	0	0	0	1	0	1	1
<i>Lyngbya limnetica</i> Lemmermann	0	1	0	0	0	0	1	0	1	1
<i>Oscillatoria</i> sp.	1	0	0	0	0	0	0	0	0	0
<i>Planktothrix agardhii</i> Gomont	0	0	0	0	0	0	1	0	1	0
<i>Pseudonabaena limnetica</i> Lemmermann	1	0	1	1	0	0	1	0	1	1
DIVISION CHRYSOPHYTA										
Order Chromulinales										
<i>Chromulina</i> sp.	0	0	0	0	1	0	1	0	1	0
<i>Chrysococcus rufescens</i> G.A. Klebs	1	1	1	0	1	1	1	1	1	1
<i>Chrysococcus</i> sp.	0	0	0	1	0	0	0	0	0	0
<i>Dinobryon bavaricum</i> Imhof	0	0	0	0	0	0	1	0	1	1
<i>D. divergens</i> Imhof	1	1	0	0	0	0	0	0	0	0
Order Synurales										
<i>Mallomonas</i> sp.	0	0	0	0	0	0	0	0	1	1
<i>Synura</i> sp.	1	1	0	0	1	0	1	0	1	0
DIVISION BACILLARIOPHYTA										
Order Thalassiosirales										
<i>Cyclotella comta</i> Kützing	0	0	0	1	0	0	0	0	0	0
<i>C. meneghiniana</i> Kützing	0	1	0	0	0	0	0	0	0	1
<i>Cyclotella</i> sp.	1	0	1	0	1	0	1	0	1	0
<i>Stephanodiscus invisitatus</i> Hohn et Helleman	0	0	0	0	0	0	1	0	1	0
Order Melosirales										
<i>Aulacoseira ambigua</i> (Grunow) Simonsen	1	1	0	0	1	0	1	0	1	1

Taxon	Lake									
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe			
	P	OL	P	OL	P	OL	P	OL	P	OL
Order Araphales										
<i>Asterionella formosa</i> Hassal	0	0	1	0	1	0	1	0	1	0
<i>Diatoma tenuis</i> Agardh	0	0	0	0	0	0	1	0	1	0
<i>Flagilaria capucina</i> Desmazières	1	0	0	0	1	0	0	0	0	1
<i>F. crotonensis</i> Kitton	0	1	0	0	0	0	1	0	1	0
<i>Tabellaria fenestrata</i> (Lyngbye) Kützing	1	0	0	0	0	0	0	0	0	0
<i>Ulnaria acus</i> (Kützing) M. Aboal	0	1	0	0	0	0	1	0	1	1
<i>U. ulna</i> (Nitzsch) P. Compère	0	0	0	0	0	0	1	0	1	1
Order Raphales										
<i>Achnanthes</i> sp.	0	0	0	0	1	0	0	0	0	0
<i>Amphora</i> sp.	0	1	1	0	0	0	0	0	0	0
<i>Cymbella</i> sp.	0	0	0	0	0	0	1	0	1	0
<i>Navicula</i> sp.	0	0	1	0	1	0	1	0	1	0
<i>Nitzschia acicularis</i> (Kützing) W. Smith	1	0	1	0	0	0	1	0	1	0
<i>N. palea</i> (Kützing) W. Smith	0	0	1	0	0	0	1	0	1	1
<i>Nitzschia</i> sp.	0	0	0	0	0	1	0	0	0	0
DIVISION XANTHOPHYTA										
Order Heterococcales										
<i>Goniocloris fallax</i> Fott	0	0	0	0	0	0	0	0	0	1
<i>G. parvula</i> Pascher	0	0	0	0	0	1	0	0	0	0
<i>Ophiocytium capitatum</i> Wolle	0	1	0	0	0	0	0	0	0	0
<i>Tetraedriella spinigera</i> Skuja	1	0	0	0	0	0	1	0	1	0
DIVISION CRYPTOPHYTA										
Order Cryptomonadales										
<i>Chroomonas acuta</i> Utermöhl	1	1	0	1	1	1	1	1	1	1

Taxon	Lake											
	Chashnitskoe			Zaozer'e			Ryumniki			Vashutinskoe		
	P	OL	P	P	OL	P	P	OL	P	P	OL	P
<i>Chroomonas</i> sp.	0	1	0	0	1	0	0	1	1	1	0	0
<i>Cryptomonas marssonii</i> Skuja	1	1	0	0	1	1	1	1	1	1	1	1
<i>C. ovata</i> Ehrenberg	1	1	0	0	1	1	1	1	1	1	1	1
<i>C. curvata</i> Ehrenberg	1	1	1	1	0	0	1	1	1	1	1	1
<i>Cryptomonas</i> sp.	1	0	0	0	0	0	0	0	1	1	1	1
<i>Rhodomonas lens</i> Pascher	0	1	1	1	0	1	0	0	1	1	0	0
DIVISION DINOPHYTA												
Order Peridinales												
<i>Ceratium hirundinella</i> (O.F. Müller) Schrank	0	0	0	0	0	1	0	0	1	1	0	0
<i>Gymnodinium</i> sp.	1	0	1	0	0	0	0	0	1	1	0	0
<i>Peridiniopsis kevei</i> Grigorsky et Vasas	1	0	0	0	0	0	0	0	0	0	0	0
<i>Perediniopsis</i> sp.	0	1	0	0	0	1	1	1	1	0	0	0
DIVISION CHLOROPHYTA												
Order Chlamydomonadales												
<i>Chlamydomonas monadina</i> Stein	1	1	0	0	0	1	0	0	0	0	0	0
<i>Chlamydomonas</i> spp.	1	1	1	1	1	1	1	1	1	1	1	1
Order Chlorococcales												
<i>Ankistrodesmus bibrainus</i> (Reinsch) Korschikov	1	1	1	1	0	1	1	1	1	1	0	0
<i>A. falcatus</i> (Corda) Ralfs	0	0	1	0	0	0	1	1	0	0	1	1
<i>A. fusiformis</i> Corda	0	0	0	0	0	1	0	0	1	1	0	0
<i>Ankya viridis</i> (Massjuk) Tzarenko	0	0	1	1	1	0	0	0	0	0	0	0
<i>Closteriopsis acicularis</i> (G.M. Smith) Belcher et Swale	0	1	0	0	0	1	1	1	1	1	1	1
<i>Coelastrum microporum</i> Nägeli	0	1	0	0	0	0	0	0	0	0	0	0
<i>Coenococcus planctonicus</i> Korschikov	0	0	0	0	0	0	0	1	1	0	0	0
<i>Crucigenia tetrapedia</i> (Kirschner) W. et G.S. West	1	0	0	0	0	1	1	1	1	0	0	0

Taxon	Lake											
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe					
	P	OL	P	OL	P	OL	P	OL	P	OL	P	OL
<i>Crucigeniella apiculata</i> (Lemmermann) Komárek	0	0	0	1	0	0	1	0	1	0	1	0
<i>C. rectangularis</i> (Nägeli) Komárek	0	0	0	0	1	0	0	0	0	0	0	0
<i>Dictyosphaerium chlorelloides</i> (Naumann) Komárek et Perman	0	0	1	0	0	0	0	0	0	0	0	0
<i>D. pulchellum</i> Wood	1	1	1	0	0	1	1	0	1	1	0	0
<i>D. tetrachotomum</i> Printz	1	1	0	0	1	1	0	1	0	1	0	1
<i>Didymocystis planctonica</i> Korshikov	1	1	1	0	0	0	1	0	1	1	1	1
<i>Golenkinia radiata</i> Chodat	0	0	0	0	0	0	0	0	1	0	1	0
<i>Golenkiniopsis parvula</i> (Woronichin) Korshikov	0	0	0	0	0	0	0	0	0	0	0	1
<i>Kirchneriella contorta</i> (Schmidle) Bohlin var. <i>elegans</i> (Playfair) Komárek	0	0	0	0	1	1	0	1	0	0	0	0
<i>K. irregularis</i> (G.S. Smith) Korschikov	0	0	0	0	0	0	0	0	1	0	0	0
<i>K. obesa</i> (W. West) Schmidle	0	0	1	0	0	0	0	0	0	0	0	0
<i>Lagerheimia ciliata</i> (Lagerheim) Chodat	1	0	0	0	0	0	0	0	0	0	0	0
<i>L. genevensis</i> (Chodat) Chodat	0	0	1	0	0	0	0	0	0	0	0	0
<i>L. subsalsa</i> Lemmermann	0	0	0	0	0	0	0	0	0	0	0	1
<i>Monoraphidium arcuatum</i> (Korschikov) Hindák	1	0	1	0	0	0	0	0	1	1	1	1
<i>M. contortum</i> (Thuret) Komárkova-Legnerová	0	0	1	1	1	0	1	1	1	0	1	1
<i>M. komarkovae</i> Nygaard	1	1	0	0	1	1	0	1	0	0	0	0
<i>M. minutum</i> (Nägeli) Komárkova-Legnerová	0	0	1	0	0	0	0	0	0	0	0	0
<i>M. tortile</i> (W. et G.S. West) Komárkova-Legnerová	1	1	0	0	1	1	0	1	0	0	0	0
<i>Oocytis borgei</i> Snow	0	1	0	0	1	0	0	1	0	0	0	0
<i>O. elliptica</i> West	0	0	0	0	0	0	0	1	0	0	0	0
<i>O. lacustris</i> Chodat	1	1	0	0	1	1	0	1	1	0	0	0
<i>Oocytis</i> sp.	0	0	1	0	1	0	1	1	0	1	1	1
<i>Pediastrum boryanum</i> (Turpin) Meneghini var. <i>boryanum</i>	0	0	1	1	0	0	1	0	0	0	0	0
<i>P. duplex</i> Meyen	0	0	0	1	0	0	1	0	0	1	1	0

Taxon	Lake											
	Chashnitskoe			Zaozer'e			Ryumniki			Vashutinskoe		
	P	OL	P	P	OL	P	P	OL	P	P	OL	OL
<i>P. tetras</i> (Ehrenberg) Ralfs	0	1	1	1	1	1	1	0	0	0	0	0
<i>Scenedesmus arcuatus</i> Meyen	0	0	1	1	1	1	1	0	1	0	0	0
<i>S. bicaudatus</i> Dedussenko	0	0	1	1	0	1	1	0	0	0	0	0
<i>S. denticulatus</i> Lagerheim var. <i>linearis</i> Hansgird	0	0	1	1	0	0	0	0	0	0	0	0
<i>S. ellipticus</i> (W. et G.S. West) Chodat	1	1	1	1	0	1	1	1	0	0	0	0
<i>S. gutwinski</i> Chodat	0	0	1	1	0	0	0	0	0	0	1	1
<i>S. incrassatus</i> Bohlin	1	0	1	1	0	0	0	0	0	0	0	0
<i>S. magnus</i> Meyen	0	1	0	1	1	0	0	0	0	0	1	1
<i>S. obliquus</i> (Turpin) Kützing	0	1	0	1	1	1	1	1	0	0	0	0
<i>S. opoliensis</i> P. Richter var. <i>carinatus</i> (Lemmermann) Chodat	0	0	1	1	0	0	0	0	0	0	0	0
<i>S. parvus</i> (G.M. Smith) Bourrelly et Manguin	0	0	1	1	0	0	0	0	0	0	0	0
<i>S. quadricauda</i> (Turpin) Brébisson	1	0	1	1	1	1	1	0	0	0	1	1
<i>S. sempervirens</i> Chodat	0	0	1	1	0	0	0	0	1	0	0	0
<i>Schroederia robusta</i> Koršchikov	0	0	1	1	1	0	0	0	0	0	0	0
<i>Spermatozopsis exsultans</i> Korshikov	0	0	1	1	0	0	0	0	0	0	0	0
<i>Sphaerocystis planctonica</i> (Koršchikov) Bourrelly	1	0	0	0	0	0	0	1	0	0	0	0
<i>Tetradron caudatum</i> (Corda) Hansgird	1	0	0	0	0	0	0	0	1	1	1	1
<i>T. minimum</i> (A. Braun) Hansgird	0	1	1	1	0	1	1	0	1	1	1	1
<i>Tetrastrum triangulare</i> (Chodat) Komárek	1	0	1	1	0	1	1	1	1	1	0	0
<i>Treubaria triappendiculata</i> Bernard	0	0	1	1	0	1	1	0	0	0	0	0
<i>Westella botryoides</i> (W. West) De-Wildeman	1	0	0	0	0	0	0	0	1	1	0	0
Order Ulotrichales												
<i>Elakatothrix genevensis</i> (Reverdin) Hindák	0	0	0	0	0	1	1	0	0	0	0	0
<i>Koliella longiseta</i> (Vischer) Hindák	0	0	1	0	0	1	1	1	1	1	0	0
<i>Ulothrix subtilissima</i> Rabenhorst	0	0	0	0	0	1	1	0	0	0	0	0

Taxon	Lake											
	Chashnitskoe		Zaozer'e		Ryumniki		Vashutinskoe					
	P	OL	P	OL	P	OL	P	OL	P	OL	P	OL
Order Oedogoniales												
<i>Oedogonium</i> sp.	0	0	0	0	0	0	1	0				
Order Desmidiaceae												
<i>Cosmarium bioculatum</i> Brébisson	1	1	0	0	0	0	1	0	0	0		
<i>C. impressulum</i> Elfving	0	0	0	1	0	0	0	0	0	0		
<i>C. meneghinii</i> Bréb. ex Ralfs	0	1	0	0	0	0	0	0	0	0		
<i>Cosmarium</i> sp.	0	0	0	1	1	0	1	0	1	0		
<i>Staurostrum</i> sp.	1	0	1	0	0	0	1	0	1	1		
<i>Staurodesmus</i> sp.	0	0	0	0	1	0	0	0	0	0		
DIVISION EUGLENOPHYTA												
Order Euglenales												
<i>Cryptoglena australis</i> Playfair	0	0	0	0	0	0	0	0	0	0	1	
<i>C. pigra</i> Ehrenberg	1	0	0	0	0	0	0	0	0	0	0	
<i>Euglena</i> sp.	1	1	1	0	1	1	1	1	1	1	0	
<i>Lepocinclis ovum</i> (Ehrenberg) Lemmermann	0	0	0	0	0	0	0	0	1	0		
<i>Trachelomonas cylindrica</i> Ehrenberg	0	0	0	0	0	0	0	0	1	1		
<i>T. volvocina</i> Ehrenberg	0	0	1	0	1	0	1	0	1	1		
TOTAL	50	46	53	29	54	37	68	46				

Appendix 2

Taxonomic composition of the vascular plants of small lakes of the Rostov District of the Yaroslavl Region in July 2018. 1 – presence of the taxon, 0 – absence.

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
DIVISION LYCOPODIOPHYTA				
Class Lycopodiopsida				
FAMILY ISOETACEAE RCHB.				
<i>Isoetes echinospora</i> Durieu	0	0	1	0
DIVISION EQUISETOPHYTA				
Class Equisetopsida				
FAMILY EQUISETACEAE Michx. ex DC.				
<i>Equisetum fluviatile</i> L.	1	1	1	1
DIVISION PTERIDOPHYTA				
Class Polypodiopsida				
FAMILY TELYPTERIDACEAE Pic. Serm.				
<i>Thelypteris palustris</i> Schott	1	1	1	1
DIVISION SPERMATOPHYTA				
Class Magnoliopsida				
FAMILY NYMPHAEACEAE Salisb.				
<i>Nuphar lutea</i> (L.) Smith	1	0	1	1
<i>N. pumila</i> (Timm) DC.	0	0	0	1
<i>Nymphaea candida</i> J. Presl	1	0	0	1
FAMILY POTAMOGETONACEAE Rchb.				
<i>Potamogeton berchtoldii</i> Fieb.	0	0	1	0
<i>P. compressus</i> L.	1	0	0	1
<i>P. crispus</i> L.	0	1	0	0
<i>P. gramineus</i> L.	0	0	0	1

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
<i>P. natans</i> L.	1	0	1	0
<i>P. perfoliatus</i> L.	1	0	1	1
FAMILY HYDROCHARITACEAE Juss.				
<i>Elodea canadensis</i> Michx.	1	1	1	1
<i>Hydrocharis morsus-ranae</i> L.	0	1	1	1
<i>Stratiotes aloides</i> L.	0	0	0	1
FAMILY ALISMATACEAE Vent.				
<i>Alisma plantago-aquatica</i> L.	1	1	1	1
<i>Sagittaria sagittifolia</i> L.	1	1	1	1
FAMILY ARACEAE Juss.				
<i>Calla palustris</i> L.	1	1	1	1
<i>Lemna minor</i> L.	1	1	1	1
<i>L. trisulca</i> L.	1	0	1	1
<i>Spirodela polyrrhiza</i> (L.) Schleid.	1	1	1	1
FAMILY IRIDACEAE Juss.				
<i>Iris pseudacorus</i> L.	1	0	1	1
FAMILY POACEAE Barnhart				
<i>Agrostis stolonifera</i> L.	1	1	1	1
<i>Calamagrostis canescens</i> (Web.) Roth	1	1	0	1
<i>C. epigeios</i> (L.) Roth	0	0	0	1
<i>C. neglecta</i> (Ehrh.) Gaertn., B. Mey. et Schreb.	0	0	1	1
<i>C. purpurea</i> (Trin.) Trin.	1	0	1	0
<i>Festuca pratensis</i> Huds.	0	0	1	0
<i>Glyceria fluitans</i> (L.) R. Br.	1	1	1	1
<i>G. maxima</i> (C. Hartm.) Holmb.	1	1	1	1
<i>Leersia oryzoides</i> (L.) Sw.	0	0	0	1

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
<i>Molinia caerulea</i> (L.) Moench	0	0	1	0
<i>Phalaroides arundinacea</i> (L.) Rauschert	1	1	1	1
<i>Phleum pratense</i> L.	1	0	0	0
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	1	0	1	1
<i>Poa annua</i> L.	0	0	1	0
<i>P. pratensis</i> L.	0	0	1	0
<i>Scolochloa festuacea</i> (Willd.) Link	0	0	0	1
<i>Zizania latifolia</i> (Griseb.) Stapf	0	0	0	1
FAMILY JUNCACEAE Juss.				
<i>Juncus conglomeratus</i> L.	0	1	0	0
<i>J. articulatus</i> L.	1	0	0	0
<i>J. effusus</i> L.	1	0	1	1
<i>J. filiformis</i> L.	1	0	0	0
<i>J. compressus</i> Jacq.	0	0	1	0
<i>J. tenuis</i> Willd.	0	0	0	1
FAMILY TYPHACEAE Juss.				
<i>Sparganium emersum</i> Rehm.	1	1	0	1
<i>S. gramineum</i> Georgi	1	1	1	1
<i>S. × longifolium</i> Turcz. ex Ledeb.	1	1	0	0
<i>Typha latifolia</i> L.	1	1	1	1
FAMILY CYPERACEAE Juss.				
<i>Carex acuta</i> L.	1	1	1	1
<i>C. canescens</i> L.	0	1	0	1
<i>C. echinata</i> Murray	0	0	1	0
<i>C. hirta</i> L.	0	1	1	1
<i>C. lasiocarpa</i> Ehrh.	0	0	0	1

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
<i>C. leporina</i> L.	1	0	0	0
<i>C. pseudocyperus</i> L.	1	0	0	0
<i>C. rostrata</i> Stokes	1	1	1	1
<i>C. vesicaria</i> L.	0	0	1	1
<i>Eleocharis acicularis</i> (L.) Roem. et Schult.	1	1	1	1
<i>E. palustris</i> (L.) Roem. et Schult.	1	1	1	1
<i>Schoenoplectus lacustris</i> (L.) Palla	1	0	0	1
<i>Scirpus radicans</i> Schkuhr	1	0	1	1
<i>S. sylvaticus</i> L.	1	0	0	0
FAMILY CERATOPHYLLACEAE S.F. Gray				
<i>Ceratophyllum demersum</i> L.	0	1	1	1
FAMILY RANUNCULACEAE Adans.				
<i>Caltha palustris</i> L.	1	1	1	1
<i>Ranunculus lingua</i> L.	0	0	0	1
<i>R. repens</i> L.	0	0	1	0
<i>R. reptans</i> L.	1	0	1	0
<i>R. sceleratus</i> L.	0	1	1	0
<i>R. trichophyllum</i> Chaix ex Vill.	0	0	1	0
FAMILY GROSSULARIACEAE DC.				
<i>Ribes nigrum</i> L.	0	0	1	0
FAMILY HALORAGACEAE R.Br.				
<i>Myriophyllum verticillatum</i> L.	1	0	1	1
FAMILY ROSACEAE Juss.				
<i>Comarum palustre</i> L.	1	1	1	1
<i>Filipendula ulmaria</i> (L.) Maxim.	0	0	0	1
<i>Potentilla anserina</i> L.	1	0	1	0

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
FAMILY BETULACEAE S.F. Gray				
<i>Alnus glutinosa</i> (L.) Gaerth.	1	1	1	1
FAMILY SALICACEAE Juss.				
<i>Salix cinerea</i> L.	1	1	1	1
<i>S. × fragilis</i> L.	0	0	1	0
<i>S. pentandra</i> L.	1	1	1	0
<i>S. triandra</i> L.	0	0	1	1
FAMILY ELATINACEAE Dumort.				
<i>Elatine hydropiper</i> L.	0	1	1	0
<i>E. triandra</i> Schkuhr	0	0	1	0
FAMILY ONAGRACEAE Juss.				
<i>Epilobium adenocaulon</i> Hausskn.	1	1	1	1
<i>Epilobium palustre</i> L.	0	1	1	1
<i>Epilobium parviflorum</i> Schreb.	1	0	0	0
FAMILY LYTHRACEAE J.St.-Hil.				
<i>Lythrum salicaria</i> L.	0	1	1	1
FAMILY BRASSICACEAE Burnett				
<i>Cardamine amara</i> L.	1	0	0	0
<i>Rorippa amphibia</i> (L.) Bess.	0	0	0	1
<i>R. palustris</i> (L.) Bess.	0	0	1	0
FAMILY POLYGONACEAE Juss.				
<i>Persicaria amphibia</i> (L.) Delarb.	1	0	1	1
<i>P. hydropiper</i> (L.) Delarb.	1	0	0	1
<i>P. lapathifolia</i> (L.) S.F. Gray	1	0	1	1
<i>Rumex aquaticus</i> L.	1	0	1	1

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
FAMILY CARYOPHYLLACEAE Juss.				
<i>Stellaria aquatica</i> (L.) Scop.	0	0	1	0
<i>S. palustris</i> Ehrh. ex Retz.	1	0	1	1
FAMILY PRIMULACEAE Vent.				
<i>Lysimachia thyrsiflora</i> L.	1	1	1	1
<i>L. vulgaris</i> L.	1	1	1	1
FAMILY RUBIACEAE Juss.				
<i>Galium palustre</i> L.	1	1	1	1
<i>G. rivale</i> (Sibth. et Sm.) Griseb.	0	1	0	0
<i>G. trifidum</i> L.	0	1	1	0
FAMILY BORAGINACEAE Juss.				
<i>Myosotis cespitosa</i> Schultz	0	0	0	1
<i>M. palustris</i> (L.) Nathh.	1	0	1	0
FAMILY SOLANACEAE Juss.				
<i>Solanum dulcamara</i> L.	1	1	1	1
FAMILY LENTIBULARIACEAE Rich.				
<i>Utricularia vulgaris</i> L.	1	0	1	0
FAMILY LAMIACEAE Lindl.				
<i>Lycopus europaeus</i> L.	1	1	1	1
<i>Mentha arvensis</i> L.	1	0	1	1
<i>Scutellaria galericulata</i> L.	1	1	1	1
<i>Stachys palustris</i> L.	1	1	1	1
FAMILY PLANTAGINACEAE Juss.				
<i>Callitriche palustris</i> L.	0	0	1	0
FAMILY SCROPHULARIACEAE Juss.				
<i>Scrophularia nodosa</i> L.	0	0	1	0

Taxon	Lake			
	Chashnitskoe	Zaozer'e	Ryumniki	Vashutinskoe
FAMILY ASTERACEAE Dumort.				
<i>Achillea ptarmica</i> L.	0	0	0	1
<i>Bidens cernua</i> L.	1	1	0	0
<i>B. frondosa</i> L.	1	1	1	1
FAMILY MENYANTHACEAE Dum.				
<i>Menyanthes trifoliata</i> L.	1	0	1	1
FAMILY APIACEAE Lindl.				
<i>Cicuta virosa</i> L.	1	1	1	1
<i>Oenanthe aquatica</i> (L.) Poir.	1	0	0	0
<i>Sium latifolium</i> L.	0	0	1	0
<i>Thyselium palustre</i> (L.) Raf.	1	1	1	1
TOTAL	71	50	82	76