Freshwater mollusks of the Priplotinny Ples Reach, the Kuibyshev Reservoir (middle Volga River, Russia)

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Abstract. In September 2020, the fauna of mollusks was studied at the Priplotinny Ples Reach of the Kuibyshev Reservoir, the Volga River, Russia. In total, 23 taxa were registered, including four invasive species. Extrapolating of the species richness, taking into account the sampling effort, allowed to assess the estimated species pool according to the Chao 2 algorithm. Bivalve mollusks predominated in the studied area. The mollusks *Dreissena (Pontodreissena) bugensis* and *Dreissena (Dreissena) polymorpha* have been found most frequently at the study sites. Both abundance and biomass varied in wide range, as 391 ± 325 ind. m\(^{-2}\) and 256.693 ± 228.355 g m\(^{-2}\), respectively. The complex of dominant species was mainly represented by alien mollusks. The type of bottom sediment was a significant ecological factor \((p \leq 0.05)\) that determined the distribution of mollusks at the Priplotinny Ples Reach. The water quality of the study area was assessed by bioindication method according to the composition and structure of the mollusk fauna, formed mainly by species of European and European-West Siberian ranges.

1. Introduction
Establishing and maintaining reservoirs lead to significant changes in the environment [1]. This is especially important due to the fact that pristine or weakly disturbed valley territories, which are not affected by anthropogenic flow regulation, are nearly absent on the territory of the Russian Plain. In recent years, dynamically changing climatic conditions are rather unstable and thus have resulted as even greater transformation of the environment in the already disturbed ecosystems [2]. In this regard, the study of reservoirs has now become extremely relevant.

The Kuibyshev Reservoir is the sixth stage of the reservoir cascade of the Volga River; it is the largest reservoir in Europe. It is located in the Middle Volga region and is formed by two large waterways, the Volga River and the Kama River. The Kuibyshev Reservoir has an elongated shape from north to south and stretches from the forest to the forest-steppe and steppe landscape zones [3]. The reservoir has a complex configuration, significantly different from other reservoirs, which is due to the nature of the structure of the river valley, the specificity of the hydrophysical and hydrochemical properties of water masses coming from the Cheboksary and Nizhnekamsk reservoirs located upstream [3, 4].

Zoobenthos is one of the most important elements of the ecosystems of continental water bodies [5]. This is primarily due to the diversity of its taxonomic composition; in particular, the representatives of up to twenty classes and ten types of animals are found in the freshwater zoobenthic communities in temperate climatic zone [6]. Freshwater mollusks are one of the key
groups of macrozoobenthos [7]. Their high importance in both being the food supply for many species of commercial fish and participating in the self-purification of reservoirs and watercourses are undoubted, making them a key study object [8]. At the same time, data on the fauna and abundance of mollusks at particular areas of the Kuibyshev Reservoir are scarce [9-11].

The study aims to analyze the taxonomic composition, structure and distribution of the mollusk fauna of the Priplotinny Ples Reach of the Kuibyshev Reservoir in the autumn period.

2. Materials and Methods

The Priplotinny Ples Reach is the closing extension of the Kuibyshev Reservoir, resembling a lake (figure 1). It has the greatest depth of all reaches of the reservoir (40 m). The water surface area is 397 km², the length, 35 km. The hydrological features of the reach include the presence of maximum water back pressure, temporary reverse currents caused by the operation of hydroelectric power plant (HPP), and steep banks [12]. The Usa River flows into the reservoir at the right bank, forming a large Usinsky Bay.

![Figure 1. Schematic map of sampling stations at the Priplotinny Ples Reach of the Kuibyshev Reservoir](image)

Mollusks were sampled in the second half of September 2020 using an Ekman bottom grab with a capture area of 0.025 m², two samples were taken at each station. The sediments were washed through a sieve (310-μm mesh size) and fixed with a 95% ethanol, replaced by same volume of 70% ethanol a week later [13]. Processing of samples was carried out in the laboratory of the Institute of the Ecology of the Volga Basin of the Russian Academy of Sciences according to generally accepted methods under a stereoscopic microscope MBS-10 [6]. The mollusk species were defined according to a complex of shell and anatomical traits and according to the up-to-date nomenclature [14]. Simultaneously with the mollusk sampling, a number of hydrophysical parameters were determined (depth, water temperature, water transparency, pH, concentration of dissolved oxygen, total mineralization, the type of bottom sediments, and some others).

The mollusk communities were analyzed for composition, structure, frequency of occurrence (P, %), and the Bray-Curtis similarity index. The dominant species in terms of abundance and biomass
were defined by the Palia-Kovnatsky index. Canonical Conformity Analysis (CCA) was applied to search for the relationship between environmental factors and the abundance of mollusks [15]. The completeness of the calculated species richness was assessed using the nonparametric Colwell-Mao interpolation methods and the Chao 2 algorithm extrapolation [16]. The widely used Pantle-Buck saprobity index modified by Slădeček was used to assess the water quality [17]. All statistical calculations were performed in the R program (v 3.02) using the packages vegan, mgcv, and tseries.

3. Results and Discussion

Sampling was carried out in different parts of the reservoir at the depth range of 3—32 m, the maximum depths were observed at the channel stations along the right bank. The water transparency was typical for this period and varied from 2.1 to 4.3 m. The pH level practically did not differ at all stations (8.24—8.51). The near-bottom water temperature was 14.8—16.2 °C; at the surface, it was the same (14.7—16.2 °C). The content of dissolved oxygen was 7.71—9.59 mg/L, which was comparable to that in the surface layer (8.1—9.84). Bottom sediments were mainly represented by sandy, sandy-silty, and silty sediments. It was noted that in the near-bottom layers and in the trophogenic area of the Priplotinny Ples Reach, there was no pronounced stratification, which was probably associated with hydrodynamic peculiarities caused by storms (wind speed of 5—10 m/s) and the operation of hydroelectric power plants, leading to significant mixing of water masses.

In total, 23 mollusk taxa were recorded in the fauna of the Priplotinny Ples Reach of the Kuibyshev Reservoir (table). The identified species belonged to 2 classes, 5 orders, 10 families, and 18 genera. Four invasive species of Ponto-Caspian and Ponto-Azov origin were also found. The class Bivalvia was represented by 14 species, Gastropoda, by 9. No differences were found in the species composition in different zones (shallow, 14, deep-water, 17). This was probably due to the influence of the Zhigulevsk HPP, which operating led to low content of organic matter in the bottom sediments in the littoral zone and to poor aquatic vegetation on the flooded areas, as well as to a significant wave impact in the coastal zone [3], which was an unfavorable factor not only for mollusk populations [11, 18], but also for higher aquatic vegetation [19], which, in turn, was important for the habitat of some mollusks.

The frequency of occurrence of mollusk species was different at particular stations of the Priplotinny Ples Reach (table). Only one species, Dreissena (Pontodreissena) bugensis was found in all the samples. Such a trend has been observed in the reservoirs of the Volga River for the last years [20]. Valvata (Cinctina) piscinalis and Dreissena (D.) polymorpha were noted a bit less frequently. The occurrence of mollusk D. (D.) polymorpha in the samples gradually decreases [21-22]. Seven species, recorded each only at one of the studied stations, were R. (P.) balthica, G. (G.) truncatula, P. (P.) planorbis, U. (U.) pictorum, E. (E.) personata, E. (H.) lilljeborgii, E. (C.) nitida, and P. (E.) tenuilineatum.

The species similarity at different stations of the Priplotinny Ples Reach averaged 58 ± 13.5%. The minimum values were observed at the deep-water station in front of the hydroelectric dam, where specific conditions caused by HPP operation significantly affected the mollusk fauna. The maximum species similarity was observed for station no. 10, where a small number of species were found, but they were recorded almost in each sample. No significant differences have been found in the mollusk fauna between the sampling sites (p ≤ 0.05) in terms of taxonomic composition, according to Bray-Curtis similarity index.

The species richness at the Priplotinny Ples Reach was compared between 2020 and the previous years (2011—2016). In 2020, the material was collected one-time at 21 stations, but in 2011—2016, 50 samples were obtained at three stations. For all studied data, the dependence curves of the average expected accumulation of species on the increase in the number of sampling efforts were built (figure 2). Cumulate curves, summarizing the stations studied in 2011—2016 and in 2020, may be described by the log-equations with correlation coefficients of 0.96 and 0.99, respectively. In 2011—2016, 13 species of mollusks were found [9, 11], in 2020, there were 23 taxa. In both curves, the fastest increase
in the expected number of species was observed at the beginning of the curve. With an increase of the sampling effort, the number of new species gradually decreased, and the cumulative curve had a flatter form. However, the horizontal asymptote was not revealed, which allowed us to argue that there was still a chance to find unregistered species with further sampling in the reservoir. At the same time, according to the curve, the number of such species for 2011—2016 was small (3 species), in contrast to 2020, when there was a double chance to find new species (7 species).

Table. Taxonomic composition of mollusks of the Priplotinny Ples Reach of the Kuibyshev Reservoir

| Species                                      | Key    | Areal | Frequency of occurrence (%) |
|----------------------------------------------|--------|-------|----------------------------|
| Gastropoda                                   |        |       |                            |
| Family Acroloxidae                           |        |       |                            |
| Acroloxus (Acroloxus) lacustris (Linnaeus, 1758) | GAcLa  | E-WS  | 14.3                       |
| Family Lymnaeidae                            |        |       |                            |
| Radix (Peregriana) balthica (Linnaeus, 1758) | GRaBa  | P     | 4.8                        |
| Galba (Galba) truncatula (O.F. Müller, 1774) | GGaTr  | G     | 4.8                        |
| Family Planorbidae                           |        |       |                            |
| Gyraulus (Gyraulus) albus (O.F. Müller, 1774) | GGyAl  | E-WS  | 28.6                       |
| Planorbis (Planorbis) planorbis (Linnaeus, 1758) | GPLPl  | E-WS  | 4.8                        |
| Family Lithoglyphidae                        |        |       |                            |
| Lithoglyphus naticoides (C. Pfeiffer, 1828) | GLiNa  | E     | 57.1                       |
| Family Valvatidae                            |        |       |                            |
| Valvata (Cincinna) piscinalis O.F. Müller, 1774 | GVaPi  | E-WS  | 85.7                       |
| V. (Valvata) cristata O.F. Müller, 1774      | GVaC   | E-WS  | 9.5                        |
| Family Viviparidae                           |        |       |                            |
| Viviparus (Viviparus) viviparus (Linnaeus, 1758) | GViVi  | E     | 9.5                        |
| Bivalvia                                     |        |       |                            |
| Unio (Unio) pictorum (Linnaeus, 1758)        | BUnPi  | E     | 4.8                        |
| Family Cardiidae                             |        |       |                            |
| Adacna (Monodacna) colorata (Eichwald, 1829) | BAdCo  | E     | 19.1                       |
| Family Dreissenidae                          |        |       |                            |
| Dreissena (Dreissena) polymorpha (Pallas, 1771) | BDrPo  | G     | 85.7                       |
| D. (Pontodreissena) bugensis (Andrusov, 1897) | BDrBu  | G     | 100                        |
| Family Sphaeridae                            |        |       |                            |
| Euglea (Euglea) casertana (Poli, 1791)       | BEuCa  | G     | 42.9                       |
| E. (E.) personata (Malm, 1855)               | BEuPe  | E     | 4.8                        |
| Euglea (Pseudoeupera) subtruncata (Malm, 1855) | BEuPSu | G     | 19.1                       |
| Euglea (Henslowiana) henslowana (Leach in Sheppard, 1823) | BEuHe  | E     | 19.1                       |
| E. (H.) lilljeborgii (Clessen in Esmark et Hoyer, 1886) | BEuLi  | G     | 4.8                        |
| E. (H.) supina (A. Schmidt, 1850)            | BEuHSu | E     | 9.5                        |
| Euglea (Cingulipisidium) nitida (Jenyns, 1832) | BEuNi  | G     | 4.8                        |
| Pisidium (Pisidium) amnicum (O.F. Müller, 1774) | BPlAm  | P     | 38.1                       |
| Pisidium (Neopisidium) moitessierianum Paladilhe, 1866 | BPlMo  | E     | 33.3                       |
| Pisidium (Europisidium) tenuilineatum Stelfox, 1918 | BPlTe  | P     | 4.8                        |
| Total: 23                                    |        |       | 23                         |

aabbreviations: G – Holarctic; P – Palearctic; E – European; E-WS –European-West Siberian

bAlien species
The extrapolation of data on species richness for different years of the study made it possible to calculate a prognostic pool of species richness according to the Chao 2 algorithm (figure 2). In both cases, presumable total species richness exceeded the values of the rarefaction curves: 81% in 2011—2016, 76% in 2020. It should be noted that a forecast based on the data obtained in 2011—2016 was smaller than according to the cumulative curve for 2020.

Therefore, it should be noted that a high sampling effort does not always make it possible to describe the maximum species richness of the study area [23]. Collecting material in various biotopes of the study area will be more productive in assessing the fauna.

![Figure 2. Curves of rarefaction and extrapolation of the species richness of the mollusk fauna of the Priplotinny Ples Reach in different study years](image)

The abundance and biomass of mollusks at the Priplotinny Ples Reach varied within wide ranges, 66—716 ind. m⁻² and 28.338—485.048 g m⁻², respectively (figure 3). Bivalve mollusks (70%) dominated over gastropods (30%) by abundance and biomass. At all stations, invasive species contributed the most. The highest values were registered at station no. 13, nearby Togliatti city, the lowest, at station no. 8. Low values were noted at the mouth of the Usa River, where the dissolved oxygen concentration in the near-bottom layer was close to zero throughout the summer period. The lack of oxygen in the water at this station during the growing season of mollusks led to low abundance and biomass at the end of the low-water season.

The differences in the quantitative indicators of mollusks in the deep-water zone from those in the shallow-water zone were rather ambiguous. For example, 2,338 specimens (total biomass of 1,997.044 g) were recorded at the coastal stations; in the channel, there were 2,675 specimens with a biomass of 1,588,999 g. This can be explained by the dominance of bivalves, preferring deeper parts of water bodies [7]. However, the values of the abundance and biomass in these biotopes were nearly similar, since pronounced variability across stations in the reservoir zones did not allow to distinguish clear margins of certain areas, where the indicators differed by an order of magnitude.

Regard must be paid to very low mollusk abundance in 2020 (three times lower than during the previous years [1]), but the biomass was nearly the same. This was probably due to either a lesser abundance of juveniles, recorded previously in huge numbers, or a change in the mollusk population structure.
Biodiversity indicators varied significantly in the parts of the reach in terms of abundance (1.012 ± 0.651 bit ind.\(^{-1}\)) and biomass (0.652 ± 0.413 bit g\(^{-1}\)). At the same time, the evenness was rather low at all stations both in terms of abundance (0.473 ± 0.204) and biomass (0.290 ± 0.124). The maximum index was noted in the channel (station no. B7) located at the mouth of the Priplotinny Ples Reach, due to the significant predominance of three species of mollusks from the genera *Dreissena* and *Valvata*. On the contrary, the minimum diversity was revealed closer to the reservoir dam (station no. 14), same taxa dominated by abundance there.

We used the value of the species diversity index to assess the trophicity of the study area. According to our calculations, it varied from mesotrophic to eutrophic, with the largest number of biogenic substances in the area of the HPP dam.

The complex of dominant species (in terms of abundance and biomass) was represented by four species (figure 4). *D. (P.) bugensis* played a major role at all the studied stations of the reach. The share of this species both in the mollusk communities and in the entire macrozoobenthos has significantly increased over the past decade [20]. The role of another invader from the genus *Dreissena* has changed slightly in recent years; so nowadays it has the same share as aboriginal dominants, which have recently decreased their biomass and abundance [24]. The complex of dominant species included the indigenous gastropod mollusk *V. (C.) piscinalis*. This widespread species often has significant quantitative indicators due to its ability to develop in a wide range of conditions [25].

In order to assess the influence of abiotic and biotic factors, determining the distribution of freshwater mollusks in the Pryplotinny Reach, a canonical conformity analysis (CCA) was carried out. In total, the influence of 14 environmental factors was assessed. A significant relationship between shellfish abundance axis and environmental variables has been found (figure 5).

The direction of the vectors varied greatly, which indicated a significant relationship between the gradients of environmental factors. The unequal length of the vectors indicated a different degree of influence of these factors. The type of sediment had the greatest effect on the mollusk abundance and biomass. In addition, this factor turned out to be the only statistically significant (\(p \leq 0.05\)) when applying the Monte Carlo simulation. The most abundant taxa and invading species were located in the center of the diagram, which indicated the minimal influence of the assessed environmental factors on their distribution in the Priplotinny Ples Reach.
Figure 4. Dominance of mollusk species by abundance (a) and biomass (b) in the Priplotinny Ples Reach of the Kuibyshev Reservoir

The Pantle-Buck saprobity index, modified by Sládeček, evidenced that the studied section of the reservoir might be generally characterized by β-mesosaprobic conditions. At the same time, the saprobity coefficient at all stations was approximately the same with an average value of 2.025 ± 0.146. The maximum saprobity index was at the mouth of the Priplotinny Ples Reach, the minimum, at the deep-water station along the right bank. It should be noted that the data obtained cannot be compared with our results from previous years of research, since too few species were recorded in the samples previously.

Figure 5. CCA ordination of the relationship between environmental factors and the mollusk parameters at the stations of the Priplotinny Ples Reach. The species keys are given in the table. Vectors: T – water temperature, O2 – dissolved oxygen concentration, H – depth, S – water transparency, pH – pH value, G – type of sediment.
According to the scheme of zoogeographic zoning suggested by Ya.I. Starobogatov [26], the Priplotinny Ples Reach of the Kuibyshev Reservoir is located in the Middle Volga Province of the European-Central Asian Sub-region of the Palaearctic Region. The mollusks inhabiting the reservoir belong to Holarctic, Palaeartic, European-West Siberian, and European ranges (table). European and European-West Siberian species make together up 62%, and European species dominate (38%). The Holarctic species, characterized by the widest ranges, comprise 30%. The Palaearctic species represent only 14% of mollusk species in the reservoir. In general, the zoogeographic composition of the aquatic fauna is preconditioned by general dispersal of species at the beginning of the Holocene [27], when the latitudinal links between the basins in this region have allowed species from different provinces to penetrate to the region [28].

4. Conclusion

The mollusk fauna of the Priplotinny Ples Reach of the Kuibyshev Reservoir was analyzed in the autumn period. In total, 23 taxa of freshwater mollusks were found, the representatives of class Bivalvia predominated. The alien mollusk Dreissena (Pontodreissena) bugensis was the most common species. Predictive assessment of the diversity pool revealed incompleteness of the registered species richness. Analysis of the sampling effort and the registered taxonomic diversity testified that the collection of material in different biotopes of similar areas would be more productive for assessing the biodiversity rather than multiple sampling at the same stations. Mollusk abundance and biomass varied greatly, but bivalves dominated at all stations. The lowest abundance and biomass were recorded at the station located in the mouth of the Usa River, which was associated with low concentration of dissolved oxygen during the entire low-water period. At most stations, representatives of the alien fauna of the Ponto-Azov and Ponto-Caspian origin dominated. The type of sediment was a significant environmental factor determining the distribution of mollusks in the study area. In general, the studied area of the reservoir may be attributed to the β-mesosaprobic zone. The fauna of the reservoir, located in the Middle Volga Province of the European-Central Asian Sub-Region, is formed by species of European and European-West Siberian ranges.

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