Study of the zooplankton community as an indicator of the trophic status of reservoirs of the Chelyabinsk Region, Russia

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Abstract. To date very little research has been carried out on zooplankton ecology in artificial reservoirs in Chelyabinsk region. The paper considers the current state of the zooplankton community in six reservoirs of the Chelyabinsk region (Russia). The species composition (32 species) and quantitative characteristics of the zooplankton community of reservoirs in summers of 2016 and 2017 were studied. The species common to all reservoirs belong to widespread Palearctic or cosmopolitan. It is studied the ratio of major groups. The results of the study showed that the share of Cladocera in mesotrophic reservoirs is 2.5 times higher than in eutrophic reservoirs. Unlike Cladocera, the Rotifera group is 10 times more abundant in eutrophic reservoirs compared to mesotrophic ones. Copepoda were common to all bodies of water, as they belong to widespread Palearctic or cosmopolitan. Changes in species diversity were recorded depending on the eutrophication of the reservoir. The increased anthropogenic load influenced the decrease in both the composition and the structure of zooplankton communities in water bodies.

1. Introduction

Currently, it is obvious that uncontrolled human activity leads to extremely negative consequences associated with a decrease in the stability of ecosystems [1]. As a result, in a relatively short period of time (several years or decades) there is a transformation comparable with natural changes covering entire geological epochs [2]. Sufficient detailed and comprehensive information on water bodies is needed to identify anthropogenic changes against the background of natural fluctuations [3]. This is especially true for artificial reservoirs, where higher rates of eutrophication are observed in comparison with natural ecosystems.

One of the most important features of aquatic ecosystems is their trophic status. Zooplankton, as an object of biomonitoring in studies of the ecological state of water bodies, is a potentially powerful tool for assessing this indicator [4]. Due to the change in trophic status, there may be a complete or partial change in the zooplankton community [5]. The question of the relationship of trophic level with different quantitative and qualitative characteristics of zooplankton in natural water bodies in different regions has been studied repeatedly [6]. The possibility of using indicator plankton species for water quality assessment has been sufficiently studied [1,2,6]. The complex study of aquatic ecosystems takes into account the complex nature of interactions between hydrobionts against the background of varying degrees of adaptation to extreme environmental conditions (temperature, level of mineralization, pH, etc.). Despite the inconsistency of ideas about bioindication [7-9] the possibility of
using zooplankton as an indicator in environmental studies is confirmed by many authors [10-12]. However, studies on the ecology of zooplankton species in artificial reservoirs of the Chelyabinsk region are few. There are a few works devoted to the issues of spatial distribution, seasonal changes of abundance and biomass [13].

The aim of the work is to determine the taxonomic structure of zooplankton communities in reservoirs of Chelyabinsk region (Russia) and to reveal the influence of trophic status on its formation in artificial reservoirs.

2. Methods

2.1. Study area

In the Chelyabinsk region there are 377 [14] reservoirs of various sizes, water regime, salinity, etc. [15]. The accumulation of water in the reservoirs is due to the rivers forming them, the melt flow in the spring months and the surface rain runoff. There is a change in the mineralization class and pH level, depending on weather conditions and a number of other reasons during the summer season. During the season fluctuations of mineralization can reach 50‰ [5].

In the course of this work, 6 artificial reservoirs (reservoirs) of the Chelyabinsk Region (Russia) were surveyed: Argazinskoe, Verkhne-Iremelskoe, Verkhneuralskoe, Dolgobrodskoe, Shershnevskoe and Yuzhnouralskoye. These reservoirs are subject to anthropogenic impact of varying degrees, which is reflected in their different trophic status. The main characteristics of these reservoirs [5,6,15,16] are shown in table 1.

| Reservoir name         | Depth (m) | Surface area (km²) | Geographical coordinates | Trophic status               |
|------------------------|-----------|--------------------|--------------------------|------------------------------|
| Argazinskoe            | 18        | 84.4               | 55°22'35"N 60°22'43"E   | Mesotrophic                  |
| Verkhne-Iremelskoe     | 5         | 6.64               | 54°51'16"N 59°52'37"E   | Mesotrophic                  |
| Verkhneuralskoe        | 12        | 72.0               | 53°38'54"N 59°14'40"E   | Eutrophic- mesotrophic       |
| Dolgobrodskoe          | 25        | 35.2               | 55°46'10"N 60°4'23"E    | Mesotrophic- oligotrophic   |
| Shershnevskoe          | 14        | 39.0               | 55°5'43"N 61°17'13"E.   | Eutrophic                    |
| Yuzhnouralskoye        | 11        | 17.2               | 54°29'5"N 61°14'47"E    | Eutrophic                    |

2.2. Sample collection

The collection of source materials was carried out in the following order. In June-July 2016, samples were taken from closer objects: the Verkhneuralskoe reservoir (3 sites), the Yuzhnouralskoye reservoir (3 sites) and the Shershnevskoe reservoir (5 sites). Samples from the remaining reservoirs were collected in June-July 2017: Argazinskoe (4 sites), Verkhne-Iremelskoe (3 sites) and Dolgobrodskoe (2 sites). In 2018, calculations and taxonomic identification of zooplankton species were carried out.

For the fishing of zooplankton, a conical plankton net was used (the diameter of the upper ring is 18 cm, the lower one is 24 cm, and the mesh size is 25 μm). Samples of water samples with zooplankton were collected by filtering thirty liters of surface water through the net [17,18].

Samples were fixed with 5% formalin, adjusted to 100 ml, three successive 1 ml samples were examined under an Altami BIO 2T binocular research microscope (Altami Ltd, Russia, St. Petersburg). The average amount was taken for analysis and the results were expressed as the number of animals per m³. The standard counting method was used to estimate the abundance and biomass of zooplankton [19,20]. Zooplankton taxa were identified with published literature [21-24].

3. Results and discussion

During the study of zooplankton of the reservoirs, 32 species of zooplankton were found: 11 species - representatives of the order Cladocera, class Crustacea; 7 species - representatives of the order Copepoda, class Crustacea; 14 species belong to the type Rotifera. The species composition,
abundance, and relevance of each species to the studied reservoirs are shown in Table 2.

**Table 2.** Species composition and abundance of zooplankton species (sample per cubic meter).

| Species | Reservoirs* |
|---------|-------------|
|         | 1 | 2 | 3 | 4 | 5 | 6 |
| Order Cladocera, class Crustacea | | | | | | |
| Leptodora kindtii (Focke, 1844) | 145 | 248 | 17 | 324 | 0 | 242 |
| Bosmina longirostris (O. F. Müller, 1776) | 324 | 1551 | 297 | 2706 | 345 | 1209 |
| Ceriodaphnia quadrandula (O. F. Müller, 1785) | 303 | 1732 | 321 | 1387 | 152 | 1872 |
| Daphnia cucullata (Sars, 1862) | 4643 | 40645 | 1117 | 43567 | 117 | 11860 |
| Daphnia longispina (O. F. Muller, 1776) | 132 | 2987 | 816 | 1013 | 0 | 51652 |
| Diaphanosoma brachirum (Levin, 1848) | 4972 | 0 | 3889 | 289 | 0 | 958 |
| *Daphnia magna* (Streu, 1820) | 0 | 61 | 32 | 218 | 16 | 126 |
| Polyphemus pediculus (Linnaeus, 1766) | 338 | 87 | 183 | 0 | 338 | 35 |
| Bosmina kessleri (Muller, 1785) | 2718 | 0 | 5038 | 245 | 7229 | 118 |
| Bythotrephes longimanus (Leydig, 1860) | 527 | 51 | 89 | 472 | 17 | 0 |
| *Daphnia pulex* (Leydig, 1860) | 4072 | 362 | 523 | 1128 | 118 | 1186 |
| Order Copepoda, class Crustacea | | | | | | |
| Mesocyclops leuckarti (Claus, 1857) | 0 | 42 | 0 | 392 | 0 | 32 |
| Cyclops vicinus (Uljanin, 1875) | 986 | 1456 | 328 | 1100 | 201 | 744 |
| Cyclops strenuus (Fischer, 1851) | 197 | 124 | 124 | 8 | 134 | 13 |
| Thermocyclops oithonoides (Sars, 1863) | 10432 | 179 | 6543 | 121 | 1987 | 71 |
| Eudiaptomus graciloides (Lilljeborg, 1888) | 2800 | 1525 | 1405 | 2432 | 2405 | 39 |
| Eudiaptomus vulgaris (Schmeil, 1896) | 0 | 28 | 0 | 197 | 24 | 0 |
| Nauplii | 11255 | 16712 | 7370 | 1327 | 1114 | 1081 |
| Type Rotifera Vermes:Rotatoria | | | | | | |
| Keratella cochlearis (Gosse, 1851) | 320 | 146 | 251 | 241 | 19 | 0 |
| Kellicottia longispina (Kellicott, 1879) | 654 | 18 | 637 | 537 | 8 | 0 |
| Notholca labis (Gosse, 1887) | 715 | 14 | 717 | 9 | 0 | 0 |
| Nauplii | 21 | 0 | 27 | 31 | 0 | 20 |
| *Trichocerca stylata* (Gosse, 1851) | | | | | | |
| Keratella licinensis (Callero, 1921) | 0 | 219 | 0 | 221 | 21 | 0 |
| Diplol daviesiae Gosse, 1886 | 0 | 0 | 18 | 249 | 169 | 0 |
| Brachionus diversicornis (Daday, 1883) | 6935 | 709 | 5526 | 703 | 4292 | 419 |
| Euchlanis dilittata (Ehrenberg, 1832) | 569 | 0 | 0 | 719 | 0 | 30 |
| Keratella irregularis (Lauterborn, 1898) | 246 | 320 | 331 | 294 | 21 | 121 |
| Lecane luna (O. F. Muller, 1776) | 19 | 0 | 34 | 74 | 0 | 0 |
| Keratella quadrata (O.F.Muller, 1786) | 4132 | 110 | 9432 | 332 | 1679 | 210 |
| Bipalpus hudsoni (Imhof, 1891) | 321 | 52 | 642 | 87 | 232 | 78 |
| Asplanchna priodonta (Gosse, 1850) | 67 | 7 | 17 | 0 | 14 | 0 |
| Filinia longiseta (Ehrenberg, 1834) | 0 | 0 | 380 | 190 | 0 | 11 |

* Designations of reservoirs: 1 - Shershnevskoe; 2 - Verkhne-Iremelskoe; 3 - Verkhneuralskoe; 4 - Dolgobrodskoe; 5 - Yuzhnouralskoe; 6 - Argazinskoe.

The table 2 shows that the species composition of materials collected from different reservoirs varies slightly, and in general, varies from 23 to 30 species. The greatest number of species (30) was found in the mesotrophic-oligotrophic Dolgobrodskoe reservoir, including: 10 – Cladocera and 7 Copepoda, and 13 Rotifera. The lowest (23 species) - in mesotrophic Argazinskoe and eutrophic Yuzhnouralskoy reservoirs, including 8–10 species of Cladocera, 6 species of Copepoda and 7 to 9 species of Rotifera.

The species composition of hydrobionts of the studied reservoirs is generally characteristic of this type of water bodies in the southern Urals. The mass presence of the genus *Cyclops* in the middle of summer in the shallow and most heated Verkhne-Iremelskoe reservoir is unusual. Representatives of
this genus, as a rule, are dicyclic and most numerous in spring and late autumn. Among the groups of zooplankton, the largest number of species of the order Cladocera is noted in the Verkhneuralskoe reservoir (11 species), Copepoda – in the Verkhne-Iremelskoe and Dolgobrodskoe reservoirs (6 species), type Rotifera – in Dolgobrodskoe reservoir (13 species). And only 37.5% (12 species) are found everywhere.

It should be noted that, despite the slight differences in the species composition of the studied reservoirs, the development of zooplankton, estimated in terms of abundance, approximately corresponds to their trophic status. For eutrophic reservoirs the average number of zooplankton is significantly lower (124.3 thousand sample per cubic meter) than in reservoirs of lower trophic capacity (202.1 thousand sample per cubic meter).

The results of the study showed that in mesotrophic reservoirs, where the entire thickness is saturated with oxygen, the share of Cladocera is 82.3% (figure 1(a)). They are considered to be sensitive to oxygen content [13]. The situation is fundamentally different in eutrophic reservoirs, where the share of Cladocera is reduced to 30.9% (figure 1(b)).

![Figure 1. Ratio of the main groups of zooplankton in reservoirs of various trophicity: (a) mesotrophic reservoirs (Argazinskoe, Dolgobrodskoe, Verkhne-Iremelskoe); (b) eutrophic reservoirs (Shershnevskoe, Verkhneuralskoe, Yuzhnouralskoe); 1 – Cladocera; 2 – Copepoda; 3 – Rotifera.](image)

Unlike Cladocera, the Rotifera group in midsummer is not the dominant group of zooplankton in the epilimnion [13]. However, there is a clear predominance in abundance in eutrophic reservoirs (30.9%) as compared with mesotrophic reservoirs (3.05%). This can be attributed solely to anthropogenic pollution. The share of Copepoda in the total number of zooplankton in mesotrophic reservoirs was 13.7%, and in eutrophic reservoirs – 38.06% (figure 1).

It should be noted that, regardless of the trophic status of the reservoir, the same components form the basis of the copepodal complex: T. oithonoides, C. vicinus, E. graciloides, copepodites of cyclopids of junior stages, as well as nauplii. Apparently, they are little sensitive to anthropogenic pollution.

4. Conclusions

Thus, the analysis of the abundance and biomass of zooplankton of artificially created reservoirs of the Chelyabinsk region (Russia) showed that the biodiversity of zooplankton depends on the trophicity of the reservoir. There are no species with pronounced stenothermy in the composition of the zooplankton of the studied reservoirs. The results of the study showed that in eutrophic reservoirs the total number of representatives of the studied zooplankton groups is less than twice as compared to mesotrophic reservoirs. The percentages of the Cladocera, Copepoda and Rotifera groups in eutrophic
reservoirs are approximately the same. In mesotrophic reservoirs, representatives of the *Cladocera* group significantly predominate (2.5 times more). Representatives of the *Rotifera* group are 10 times more in eutrophic reservoirs than in mesotrophic ones. These are signs that indicate some degradation of biocenoses. The increase in anthropogenic load seems to have affected the reduction of both the composition and structure of zooplankton communities in water bodies.

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