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The modern state of zooplankton in Altai high mountain lakes

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ABSTRACT. Mountain lakes, especially those located at an altitude of 2000-3000 m above sea level, can be model objects for studying global climate changes, as their ecosystems are particularly sensitive to external impacts. The assessment of quantitative and qualitative changes in the hydrobiological communities of the high mountain lakes of Altai, in particular zooplankton, is important in predicting the development of lake ecosystems under different climate change scenarios. 19 lakes were studied in the Kara-Kudur, Saryachik and Chibit systems and Ukok Plateau in 2000 and 2017-2018. It was revealed that during this period in Altai there was a tendency towards air temperature increase in winter and transition seasons. There were structural changes of zooplankton community in the lakes of Kara-Kudur, Saryachik and Chibit systems. However, zooplankton is now dominated by species, which are indicators of organic matter accumulation in the upper layers of bottom sediments. In lakes of the Ukok Plateau during the past 20 years, there was also an increase in the number and biomass of zooplankton, the emergence of phytophilic and nectobenthic species, which may indicate an increase in trophic status of lakes.

Keywords: Mountain lakes, Altai, zooplankton, climate changes

1. Introduction

With the global climate change recorded by many researchers and the increasing need for water resources, studies assessing transformations in lake ecosystems under the influence of changing external impacts become relevant. Mountain lakes, especially those located at an altitude of 2000-3000 m above sea level, are not subjected to anthropogenic effects because these lakes are hardly accessible for people. And these lakes can be model objects for studying environmental changes, as their ecosystems are particularly sensitive to external impacts. The assessment of quantitative and qualitative changes in the hydrobiological communities of the high mountain lakes of Altai, in particular zooplankton, is important in predicting the development of lake ecosystems under different climate change scenarios.

2. Material and methods

In 2000 and 2017-2018, 19 lakes were studied in the territory of Kara-Kudur, Saryachik and Chibit systems and Ukok Plateau in the territory of the Republic of Altai. Here, lakes are located above 2000 m above sea level in the zone of high-mountain taiga and steppe-tundra. Methodological approaches based on data regarding climate changes over the past 50 years were applied (Izmeneniye klimata..., 2011). It was revealed that during this period in Altai there was a tendency towards air temperature increase in winter and transition seasons. The works were carried out during the season of maximum water warming: the end of July - the beginning of August 2000 and 2017. Zooplankton samples were taken by standard methods (Burmistrova and Ermolaeva, 2013).

3. Results

During the summer periods of 1975-1978, 49 species of zooplankton were found in the lakes of the Kara-Kudur, Saryachik and Chibit systems with the dominance of Rotifera (22 species) (Osipova, 1981; 1984). In 2000, we found 29 species dominated by Cladocera (13 species), in 2017-2019 – 76 species. Among them, there were 23 species of Rotifera, 7 species of Cladocera and 11 species of Copepoda that were not found in 2000. In 2000, *Bosmina longirosris, Ceriodaphnia quadrangula, C. affinis, Polyphemus pediculus,* and *Megacyclops viridis* dominated (Burmistrova and Ermolaeva, 2013). In 2017–2019, the

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dominant species in most lakes were *Keratella cochlearis, K. quadrata, Polyarthra dolychoptera, B. longirosris, Ceriodaphnia quadrangula, Chydorus sphaericus,* and *Mesocyclops leuckarti*. The number of zooplankton did not change significantly from 1975 to 2000 (58.5 thousand ind./^{m3} i^{n} 1975 and 47.5 ± 6.8 thousand ind./^{m3} in 2000), whereas in 2017–2018, the average number of zooplankton in these lakes was 90.7 thousand ind./^{m}3. The average biomass of zooplankton in 1975 was 0.3 g/^{m}3, in 2000 – 1.7 ± 0.4 g/^{m}3, in 2017-2018 – 1.9 ± 1.2 g/^{m}3. Therefore, the number and biomass of zooplankton have increased, especially since 2000.

In the lakes of the Ukok Plateau, 37 species of zooplankton were identified in 2000: Rotifera – 18, Cladocera – 9 and Copepoda – 10. Rotifera and juvenile stages of the Copepoda dominated in most lakes in numbers, and Cladocera – in biomass. Typically, the basis of the community included *Kellicottia longispina, Polyarthra minor, Daphnia longispina, Bosmina longispina,* and *Acanthodiaptomus denticornis*. The average number was 5.8 ± 6.3 thousand ind./m^3; biomass – 0.43 ± 0.93 g/m^3. In 2017, in these lakes, we detected 21 species of Rotifera, 13 species of Cladocera and 17 species of Copepoda. Among them, 19 species were not previously found in the Ukok Plateau lakes. For the first time, *Daphnia tenebrosa* Sars and *Hemidiaptomus tarnogradskii* Rylov were specified on the territory of Mountain Altai. The average numbers were 84.8 ± 63.8 thousand ind./m^3; biomass – 0.78 ± 0.53 g/m^3. *Keratella cochlearis, K. quadrata, P. dolychoptera, D. longispina, Ch. sphaericus,* and *B. longirostris* were dominant. In almost all lakes, we detected nectobenthic *Paracyclops fimbriatus,* which was described for the first time in this area.

4. Discussion and conclusions

One of the reasons for the structural changes of zooplankton in the lakes of Kara-Kudur, Saryachik and Chibit systems may be the decline of the fish press. According to N.N. Maneeva (1991), it was associated with an increase in a load of planktonic acclimatizing fish in 1982-1984. In subsequent years, the practice of artificial burying of the lake was suspended. However, since 2010, the program "Development of fisheries complex of the Republic of Altai" has been resumed, and most water bodies of this group are used to grow fish for sports fishing. However, zooplankton is now dominated in biomass by crustaceans, and the number of phytophilic species and nectobenthic species, which are indicators of organic matter accumulation in the upper layers of bottom sediments, has increased.

In terms of climate change indication, the lakes of the Ukok Plateau are more indicative. There is a protected area, and the anthropogenic factor is excluded. There also has been an increase in the number and biomass of zooplankton, the emergence of phytophilic and nectobentic species as well as the active reproduction of fine filter feeders, which may indicate an increase in trophic status of lakes.

Statistical analysis confirmed that in highland lakes, the water temperature was the determining factor in zooplankton development. At the same time, the increase in water temperature caused a positive response in rotifers and branching crustaceans, whereas the share of copepods in the total number and biomass of zooplankton and their species diversity significantly decreased.

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