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Biodiversity of benthic invertebrates in lakes located along aridity gradient (lakes in the south of West Siberia as a case study)

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Introduction

For the past 30 years, in the Inner Asia the average annual air temperature has increased by 1.4 °C, while the average annual precipitation remained almost unchanged [3]. These changes lead to climate aridization caused by increased evaporation and decreased evaporation-precipitation ratio. The lakes are accumulating elements of landscapes, their ecosystems are highly dependent on soil and geochemical climate-induced processes [6]. Benthic invertebrate communities are an important structural component of lake ecosystems; their composition and abundance depend on many environmental factors, including climate. Aridity gradient in various natural zones can serve as an indicator for predicting the impact of climate change on ecosystems of water bodies.

Material and methods

The communities of bottom invertebrates were studied in 2008 -2011 during the complex limnological field trips to lakes of the Ob-Irtysh interfluvium. Altogether 25 lakes were examined. The material was collected and processed using standard hydrobiological methods [5]. A total of 150 quantitative and 40 qualitative samples were collected and analyzed. Dominant species were identified by their occurrence frequency [1].

The studied lakes are located in two natural zones and four sub-zones [7]. Lakes Kulundinskoye, Presnoye and a nameless one are in the dry steppe subzone; lakes Krivoye, Mostovoye, Uglovoye, Maloye Topol'noye, Peschanoye, Khorosheye, Bol'shoye Topol'noye, Krivoye, Khomutinoye, Kaban'ye - in the arid-steppe subzone; Gor'koye, Bol'shoye Ostrovnoye – in the moderately arid-steppe subzone; Mel'nichnoye, Ledoreznoye, Batovoye, Chernakovo, Lena, Verkhneye, Nizhneye, Pryganskoye, Pustynnoye, Bol'shoye - in the southern forest-steppe subzone.

Results and discussion

A total of 127 bottom invertebrate species of eight classes (Nematoda, Oligochaeta, Hirudinae, Bivalvia, Gastropoda, Phylactolemata, Crustacea, Insecta) were met in the lakes under study. The greatest number of the species was from the class Insecta, where Diptera dominated. Also, the

insects Coleoptera, Ephemeroptera, Trichoptera, Odonata, Heteroptera, Collembola, Lepidoptera were found.

According to the classification of surface water quality [3], the studied lakes from the dry sub-zone belong mainly to euhaline (salinity is within 25-140 g/l), from the dry-steppe and moderately arid-steppe subzones to alpha-mesohaline (1.5-18 g/l), from the south forest-steppe subzone to the oligohaline and alpha mesohaline (0.3-2.5 g/l) ones. Maximal species diversity of benthic invertebrates is observed in oligohaline lakes (1-13 species per sample, 5 on average). Minimal species diversity falls on euhaline lakes; here the number of species in the sample does not exceed two. It is evidence of general tendency towards the decrease in species diversity of aquatic organisms with the increase in salinity of inland waters [8].

The change in dominant and subdominant taxa of benthic invertebrates occurs from the southern forest to dry steppe. In the southern forest-steppe zone, dominant and subdominant taxa of benthic invertebrates are represented by Chironomidae, Coleoptera, Odonata, Ephemeroptera, Trichoptera. In arid and moderately sub-arid steppe zones, the dominant taxa declines in number and the composition of benthic invertebrates changes. Here Chironomidae and Ceratopogonidae dominate. In the dry steppe, the dominant taxa are Ephydriidae and Ceratopogonidae.

Change in the heat-moisture balance of the lake catchment strongly influences water mineralization that in turn has a significant impact on the taxonomic composition of aquatic organisms. Generally, salinity is accompanied by decrease in species number [8]. Our research shows that the greatest resistance to high mineralization is characteristic of typical inhabitants of brackish and salt water, namely larvae from the order Diptera: Ephydriidae and Ceratopogonidae (0.55-140 g/l) [4]. Also great ecological plasticity is revealed for larvae Chironomidae and Coleoptera found in the salinity range from 0.384 to 25.4 g/l. Annelida (Oligochaeta and Hirudinae), Lepidoptera, Ephemeroptera, Trichoptera, Heteroptera were identified in lakes with water salinity exceeding 3.3 g/l.

To analyze the effect of the heat-atmospheric moisture ratio in the catchment area on the species diversity of benthic invertebrates, the average annual precipitation-evaporation ratios ($R_{p/e}$) obtained from the nearest weather stations located directly in the catchment area (for flowing water reservoirs it is upstream the river) or in the same latitude were used (Baevo: Mostovoye, Chernakovo, Lena; Blagoveshenka, Uglovskoe; Kulundinskoye, Presnoye, nameless; Volchiha: Uglovoye; Kamen'-na-Obi: Pustynnoye,

Bol'shoje; Mamontovo: Gor'koye, Bol'shoje Ostrovnoye, Krivoye (Kasmala), Batovoye, Mel'nichnoye, Ledoreznoye; Slavgorod: Krivoye (Burla), Khomutinoye, Peschanoye, Khorosheye, Bol'shoje Topol'noye; Habary: Kaban'ye, Maloye Topol'noye, Verkhneye, Nizhneye) [9].

The analysis shows strong correlation between the moisture content and the total number of zoobenthos species (Nt) of the lakes with $R_{p/e}$ and the average value of the Shannon index (H). The Spearman's correlation between $R_{p/e}$ and H equals $r=0.93$ ($p=0.03$). We found the correlation between $R_{p/e}$ and Nt unreliable ($p>0.05$). However, the accuracy of the approximation of the obtained power and exponential functions ($R^2>0.5$) indicates that they adequately describe the in-situ data of H and Nt with higher reliability of H (low line) (see Fig.1). Similar trends were previously described, but not confirmed by statistical methods [4].

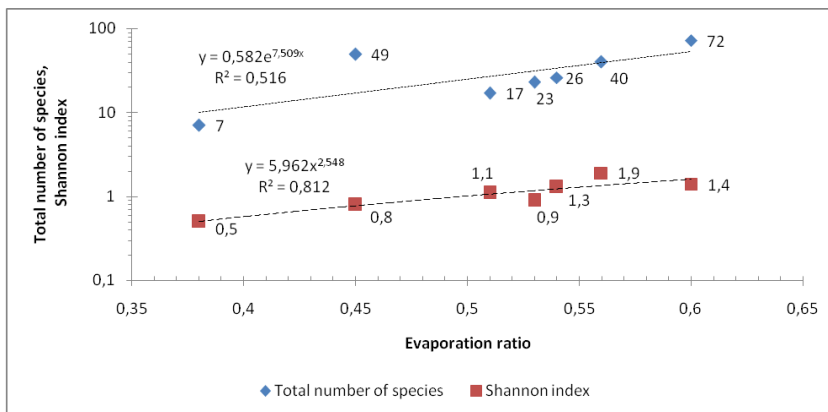


Fig. 1. Total number of species and mean species diversity (Shannon index) in lakes, the catchments of which are located in areas with different precipitation-evaporation ratio

Conclusion

1. A total of 127 bottom invertebrate species of eight classes were recorded in the lakes studied. Species diversity is maximal in oligohaline lakes of forest-steppe zone, the minimal - in euhaline lakes of dry steppe.

2. Dominant and sub-dominant taxa of zoobenthos, i.e. Thrichoptera, Ephemeroptera, Coleoptera, Odonata, Chironomidae are typical for the lakes of the south-steppe subzone, while for the moderately arid and arid-steppe these are Chironomidae and Ceratopogonidae. In the lakes of the dry steppe sub-zone Chironomidae are replaced by Ephydriidae.

3. From the southern forest to dry steppe, the change in dominant taxa and the decrease in species diversity of benthic invertebrates are observed. Diminution of the evaporation-precipitation ratio in the catchment is accompanied by decrease in species diversity of zoobenthos (Shannon index) including total number of species.

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