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Hydrobiological investigations of Kytalyk Wildlife Reserve polygonal ponds (North-Eastern Yakutia)

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Abstract. In the following article there are introduced the first researching results of 27 water bodies of polygonal tundra in Kytalyk Wildlife Reserve in the summer 2011. The evaluation of physic-hydrochemical indexes of water bodies is given. The basic structure-forming characteristics of zooplankton communities are analyzed. The ecological state of the lakes is estimated.

1. Introduction

Researching of plankton communities of polygonal ponds typical for permafrost regions [1] is one important component of the modern state of cryolithozone lakes evaluation. Species composition and level of quantitative development of aquatic invertebrates are the high-sensitive indicators for the water pollution extent and the impact of climate change on northern ecosystems [2, 3]. Changes of the organisms' existence conditions are reflected in the species composition, quantitative indicators, the ratio of individual taxonomic groups, and the structure of the zooplankton organisms' population. Kytalyk resource wildlife reserve which is located in the basin of the river Chroma of the Yano-Indigirka interfluvium (East Siberian Sea coast) was created with the support of the World Wildlife Fund (WWF) with an issue to protect the east population of Siberian Crane, as well as to conserve other rare and economically important animals and plants. Furthermore, the Paleolithic sites of primitive man and repositories of mammoth fauna are located on the territory of natural sanctuary [4, 5] (figure 1). The landscape of the reserve is diverse: arctic tundra and complex mires, larch-tundra woodlands and mountain tundra. Polygonal ponds, which are the habitat for numerous bird species, some of which are in the Red List of IUCN, Russia and the Republic of Sakha (Yakutia) [5], and containing unique tundra plankton communities, play a significant role in the reserve.

The altitude above the sea level of the investigated region varies between 0.4-71 m. The geographic coordinates of the wildlife reserve are 70°30'-72°35' N. and 143°00'-152°30' E. Square footage of the area is 1608,000 hectares [7].

2. Material and methods

Data for the current study was collected in the summer of 2011 in the frames of a joint Russian-German expedition to the lower course of the Indigirka River. The most part of study area is covered with Quaternary permafrost deposits. The landscape consists of a flood plain and terraces of the Berelekh River, its branches and tributaries, a yedoma hills of the Middle and Late Pleistocene ice



complex, alas and thermokarst lakes formed in Lateglacial and Holocene. Flora is represented by tussock-sedge, dwarf shrub, moss tundra. According to meteorological data, the climate is characterized as sharply continental, the average air temperatures in July and January are +9.7 °C and -36.6 °C, respectively. The temperature of the frozen soil is -4 - -6 °C with a permafrost thickness of 200-300 mm [8].

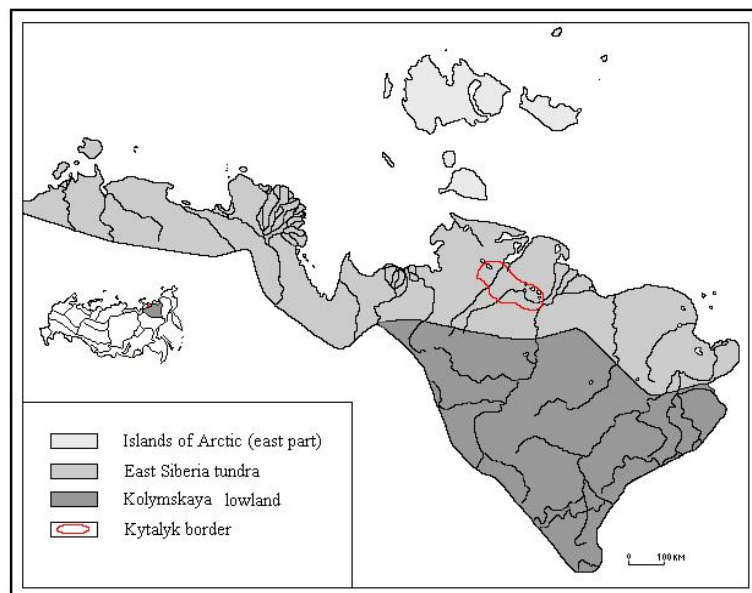


Figure 1. Map for Kytalyk Site in Republic Sakha (Yakutia) [6].

The study of modern polygonal reservoirs in certain key areas, covering different development stages, can serve as an informative natural model, making possible to trace the character and impact depth of the main ecological factors on the biota. Herewith the structural elements of the polygons provide a wide range of hydrological conditions from the water habitats (at the center of the polygons) to xeromorphic conditions (above the ridges). Selection of polygonal ponds and lakes for hydrological research was determined by the factor of formation and development stage, i.e. we chose the water reservoirs with a strongly marked polygonal shape, lakes, which are formed in result of confluence of two or more small lakes of the neighboring polygons or polygonal lakes in the overgrowing stage. During of the research for the first time samples of water and samples of zooplankton from 27 different water bodies of polygonal tundra were collected. Also, physical and hydrochemical studies of selected reservoirs were done, during which such indicators like water depth, temperature of water and air, pH, specific electrical conductivity of water, content of ions NH_4^+ and NO_3^- , phosphates, dissolved oxygen in water were determined. Sampling of zooplankton was conducted in the littoral part of water reservoirs with the help of a small conical network of Apstein (inlet diameter 25cm, size of the mesh is 100 μm). Fixation of organisms was done with 4% formaldehyde solution. In total during the research 36 samples of zooplankton were selected.

Main aims of current research of zooplankton communities were the following: analysis of zooplankton communities' species composition, comparison the qualitative characteristics of zooplankton communities in the water reservoirs, analysis of the zoogeographic structure of zooplankton, eco-faunistic description of dominant zooplankton species, analysis of morphological, hydrochemical and hydrobiological features of the researched lakes, evaluation of water quality. To achieve these aims we calculated the following indexes and indicators: Pantle-Buck's saprobic index in modification of Sládeček [9], based on regard of complex of physiological properties of the organism, conditioning its' ability to live in water with one or another content of organic substances; index of saprobity by Zelinka and Marvan, taking into account the saprobic valency of each indicator

species [10]. Statistical processing of data was done using the package of the program of the integrated system STATISTICA 6.0. A non-normal distribution of values in the samples was determined using the Shapiro-Wilk's criterion and the Kolmogorov-Smirnov's criterion with Lilliefors's correction. The Spearman correlation analysis was made in the Nonparametric distribution module of Rotifera species depending on the physical and hydrochemical parameters of the water reservoirs, taking into account the correlation coefficient at significance level $p \leq 0.05$.

3. Results and discussion

According to the results of the water samples, the studied polygonal ponds are distinguished by low mineralization (to $100 \text{ mg} \cdot \text{l}^{-1}$), the pH values change from acidic to neutral, the average values were 6.3 ± 0.08 (table 1), content of biogenic and organic substances were low. The studied water reservoirs of the polygonal tundra are small, the depth of the polygonal ponds ranges from 0.2 to 2.0 m, with an average depth of 45.1 cm, often overgrown. In most reservoirs, little or moderately decomposed plant detritus with a small amount of sandy silt was found. The average air temperature for the period of research was $+11.9^\circ\text{C}$, the water temperature - $+11.5^\circ\text{C}$. The average value of electrical conductivity was $35.2 \mu\text{S} \cdot \text{cm}^{-1}$ that indicates a low degree of water mineralization of the studied reservoirs. Content of the dissolved oxygen in the reservoirs is sufficient; the average value was $8.7 \text{ mg} \cdot \text{l}^{-1}$.

Table 1. Results of physical and hydrochemical analysis of water polygonal ponds.

	Min	M	Max	M \pm m
Depth (cm)	15.00	45.08	150.00	45.08 \pm 4.08
Tair ($^\circ\text{C}$)	5.50	11.96	25.00	11.96 \pm 1.05
Twater ($^\circ\text{C}$)	5.50	11.50	23.50	11.50 \pm 0.90
Conductivity ($\mu\text{S} \cdot \text{m}^{-1}$)	19.00	35.20	153.00	35.20 \pm 5.14
Mineralization ($\text{mg} \cdot \text{l}^{-1}$)	12.35	22.85	99.45	22.85 \pm 3.34
pH	5.50	6.30	7.10	6.30 \pm 0.08
NH_4^+ ($\text{mg} \cdot \text{l}^{-1}$)	0.002	0.03	0.13	0.03 \pm 0.01
NO_3^- ($\text{mg} \cdot \text{l}^{-1}$)	0.04	0.41	0.79	0.41 \pm 0.04
PO_4^{3-} ($\text{mg} \cdot \text{l}^{-1}$)	-0.01	0.03	0.29	0.03 \pm 0.01
Dissolved oxygen ($\text{mg} \cdot \text{l}^{-1}$)	5.40	8.68	11.80	8.68 \pm 0.31
Alkalinity ($\text{mmol} \cdot \text{l}^{-1}$)	0.20	0.51	1.60	0.51 \pm 0.06
Acidity ($\text{mmol} \cdot \text{l}^{-1}$)	0.40	0.42	0.60	0.42 \pm 0.01
Water hardness ($^\circ\text{dH}$)	1.50	3.97	7.50	3.97 \pm 0.28

In zooplankton of water bodies of the wildlife reserve there were determined 71 species, belonging to 26 families. The main part of the list of species was presented by Rotifera (70.4%), crustaceans accounted for 19.7% and 9.9% of the copepods (Copepoda, type Arthropoda, Crustacea) and cladocerans (Cladocera, class Branchiopoda, Crustacea) respectively.

Among Rotifera we found 50 species from 17 families. The most widely represented families were Brachionidae (8 species) and Trichocercidae (7 species), as well as Testudinellidae, Notommatidae, Lecanidae and Euchlanidae (4 species in each). Cosmopolitan and eurytropic *Rotaria rotatoria* (Pallas, 1766) dominated in the samples and was found in 91.7% of all samples. The cosmopolitan *Trichothiria tetractis* (Ehrenberg, 1830) (occurrence frequency 80.6%) and *Lecane crenata* (Harring, 1913) (75%) became subdominants in our samples.

The copepods numbered 14 species, including 7 species of Cyclopoida, 5 species of Copepoda and 2 species of the family Camptocamptidae (order Harpacticoida). Order Cyclopoida was represented by 4 species of the subfamily Cyclopinae, 3 species of the subfamily Eucyclopinae, among which there were both cosmopolitan species and species specific to northern regions. Among order Copepoda 4 species of the family Diaptomidae, having mainly Palearctic area distribution, and *Hetercope appendiculata* (Sars, 1863) of the family Temoridae, were recognized. Copepodite development stages of the copepods were recorded in 91.7% of all samples, in 75% of the samples nauplius stages were registered.

Cladocera were represented in the zooplankton community by 7 species belonging to 5 families. By two of these species were attributed to the families Bosminidae and Chydoridae, each of the families Daphniidae, Polyphemidae and Euricercidae had one representative in the community. *Chydorus cf sphaericus* had a frequency index 91.7%, Holarctic *Daphnia pulex* (Leydig, 1860) - 77.8%, cosmopolitan *Alona guttata* (Sars, 1862) - 66.7%.

The species diversity of zooplankton in polygonal ponds varied in wide range. The lowest diversity of zooplankton was observed in water bodies marked KYT-15, KYT-16, KYT-18 and KYT-20, 5-6 representatives of zooplankton were recorded that may be explained by the small size of water bodies. Within communities of these small lakes, Rotifera and Cladocera were found in almost equal quantities and only one Copepoda species per lake, except for the reservoir marked KYT-8, where Copepoda species were not found.

The following lakes were characterized by relatively rich species diversity: KYT-2 - 22 species, KYT-7 - 19 species, KYT-8 and KYT-25 - 17 zooplankton species. Within the community of these reservoirs, only Rotifera (14-16 species) were among dominants, Cladocera were represented by 3-4 species. Copepoda were absent, except for a reservoir KYT-2, in which two representatives of copepods were identified.

The lake with the marking KYT-1 was notable for a maximal high diversity - 39 species in the community, which could be most likely explained with the presence of a large number of samples (10 samples), selected during monitoring from this reservoir, in contrast to other lakes of wildlife reserve, in each of them the samples were selected just once. In the zooplankton species community KYT-1 rotifers were dominated - 71.8% of all species. Cladocera and Copepoda accounted for 17.9% and 10.3% respectively. Species *Trichocerca cylindrica* (Imhof, 1891), *L. crenata* Rotifera, *Ch. cf sphaericus*, *Al. guttata* Cladocera, as well as immature development stages of Copepoda species had 100% occurrence in the samples of this water reservoir. There were not revealed changes in the zooplankton species composition during the monitoring.

According to the Pantle-Buck's index of saprobity in the Sladechek modification, most of the studied reservoirs refer to the β -mesosaprobic zone, 2.03 ± 0.4 . Some water bodies belong to the oligosaprobic zone. The index value for the lake with the KYT-1 marking was 1.6 that also indicates the belonging to the β -mesosaprobic zone.

According to the index of saprobity, calculated by the method of Zelinka and Marvan, oligosaprobic reservoirs with a deviation to the β -mesosaprobic zone predominate in the investigated region. The value of this index for the KYT-1 water reservoir also indicates an oligosaprobic zone with a deviation into the β -mesosaprobic zone.

In consonance with zoogeographical zonation, the main amount of species of limnetic fauna was composed of organisms, which have a cosmopolitan distribution (68% of the total species composition). Such species like *R. rotatoria*, *Ch. cf sphaericus*, which are massive for most of the studied reservoirs, have a worldwide distribution, but among the often-recognized species in the samples there were also cold-water species, which have a limited northern distribution area. Thus, *D. pulex* is characterized as a Holarctic species, preferring temporary and small permanent water bodies. The proportion of species with the Holarctic and Palearctic distribution area accounted for 17% and 15% of the total species composition, respectively.

By biotopic preference the eurytopic organisms are dominated (36 species), other groups: littoral, planktonic and benthic - are presented in lower amounts.

According to the analysis, there is a statistical significance between such parameters as species number of Rotifera and the content of NH_4^+ in lake water ($p = 0.02$). Therefore, the influence of the ammonium index in water on the distribution of species of rotifers in water bodies was identified.

In the studied water reservoirs of polygonal tundra, the indexes of species diversity and of zooplankton communities' abundance were high enough that is specific for tundra zone generally [11, 12]. Complex of dominant species is typical for small polygonal water bodies of Northern lakes ecosystems. Comparison of species composition of the tundra lakes' zooplankton, given in the literature for this region, namely for north-western part of Sakha Republic (Yakutia), and also in our results for Kytalyk wildlife reserve, showed the zonal similarity of zooplankton indicators [1]. Its composition and distribution within the water area of the researched reservoirs were driven by the physico-morphological features of the latter, namely, the shallow depths and development of coastal vegetation.

4. Conclusion

The water bodies of the polygonal tundra of the Kytalyk resource wildlife reserve were studied for the first time in the region of the lower course of the Indigirka River, physical and hydrochemical water indicators of lakes and zooplankton communities were analyzed. The water reservoirs are mostly overgrown and are characterized by small size and relatively small depths, the presence of plant detritus in the decomposition stage, low mineralization and low values of organic and biogenic substances, sufficient oxygen solution in the water and pH values close to neutral. A relatively rich species diversity of the zooplankton community with a predominance of Rotifera species was estimated. The species *Rotaria rotatoria* (Pallas, 1766), *Chydorus* cf. *sphaericus*, *Trichothiria tetractis* (Ehrenberg, 1830), *Daphnia pulex* (Leydig, 1860) and *Alona guttata* (Sars, 1862) belong to the structure-forming complex of zooplankton. By the taxonomic composition, a rotatory-cladocera complex is developed in the researched lakes. Species, which have a cosmopolitan distribution area by zoogeographic characteristics, and organisms, eurytopic by the biotope preferences, are dominated in the community. The influence of ammonium content on the number and distribution of Rotifera species in water bodies was recognized. Due to the results of the calculated indexes, on the basis of data of the zooplankton community, the studied water reservoirs of the polygonal tundra can be characterized as pure and moderately polluted, with low values of saprobity.

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