ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Zooplankton spatial distribution in thermokarst lake of The Lena River Delta (Republic of Sakha (Yakutia)).

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ABSTRACT

This paper presents the study results of zooplankton spatial distribution at the thermokarst lake of the Lena river delta (Republic of Sakha (Yakutia)). The species composition of zooplankton revealed 40 species: 25 species of Rotifera type, 8 species of Cladocera suborder and 7 species of Copepoda subclass. The basic complex of the following species is revealed: rotifers *Conochilus unicornis* (Rousselet, 1892), *Kellicotia longispina* (Kellicot, 1879), *Keratella cochlearis* (Gosse, 1851), crustaceous cladocerans: r. *Bosmina*, copepods: *Maranaebiotus brucei* (Richard, 1898), *Leptodiaptomus angustilobus* (Sars, 1898), *Eudiaptomus graciloides* (Lilljeborg, 1888). The zooplankton number of reservoir was determined by rotifers (69.1% of the total), the average value was 178,2 ± 21,6 thousand individuals/m3. The biomass of zooplankton was represented by major species of copepods (74.4% of the total biomass), the average value is equal to 1184.1 mg/ m3. 2 peaks of zooplankton quantitative indicators are revealed. The differences of the spatial distribution of species are represented within the water area of the reservoir: in the polygonal part of the lake, in the littoral and the pelagic thermokarst part of the reservoir. According to the ecological state of the reservoir evaluation this lake is characterized is a clean and oligosaprobic one. In accordance to zoogeographical, ecological and faunal characteristics the zooplankton is presented mainly by cosmopolitan, eurytopic and littoral species.
Keywords: zooplankton, spatial distribution, thermokarst lake, Arctic.

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ISSN: 0975-8585

INTRODUCTION

The Republic of Sakha (Yakutia) is the unique Russian subject according to its natural conditions. The climate is sharply continental one with almost a universal distribution of permafrost, which makes Yakutia territory is one of the richest river and lake areas of Russia [1, 2]. The climate of this region explains the existence of one of the largest deltas in the world - The Lena river delta. The formation of a unique natural object with numerous islands, channels and lakes is explained by the removal of a huge amount of sediment [3]. But the ecosystems of this region are not studied enough. Hydrobiological studies of the Lena river delta were initiated in 1901. The papers were published on the description of zooplankton qualitative and quantitative characteristics for different parts of the delta [4]. There is the information on the paleoconditions of this region making the part of Russian Arctic [5, 6]. However, literature data on the pelagic fauna of numerous and varied The Lena delta reservoirs is limited. The regular studies of reservoir hydrofauna were started since the organization of the Ust-Lensky Nature Reserve [7].

This paper presents the results of zooplankton spatial distribution study of the thermokarst lake. The water body chosen by us (Fig. 1) is located on Samoylov island (72°22'38"N, 126°29'17"E) in the Lena river delta and it is characterized mainly as thermokarst one [8], but with an increasing polygonal part. The thermokarst part of the reservoir is represented by the depths of 5-6 m. The polygonal part of the lake is characterized by smaller depths (1-3 m) with abundant vegetation. The lake was mineralized weakly (<200 mg/l), pH was close to a neutral value (6,7-7,7); water is referred to bicarbonate-calcium type of the first subtype. The silicon content may increase up to 500 mg Si/l. The highest concentration of phosphates are marked in the thermokarst part of the lake. A considerable decrease of element concentration during the vegetation period is observed. The concentrations of oxidized forms of nitrogen are low ones. This body of water is characterized by the influence of river water during the spring flood on the hydrological regime and a total hydrochemistry of reservoirs [8].

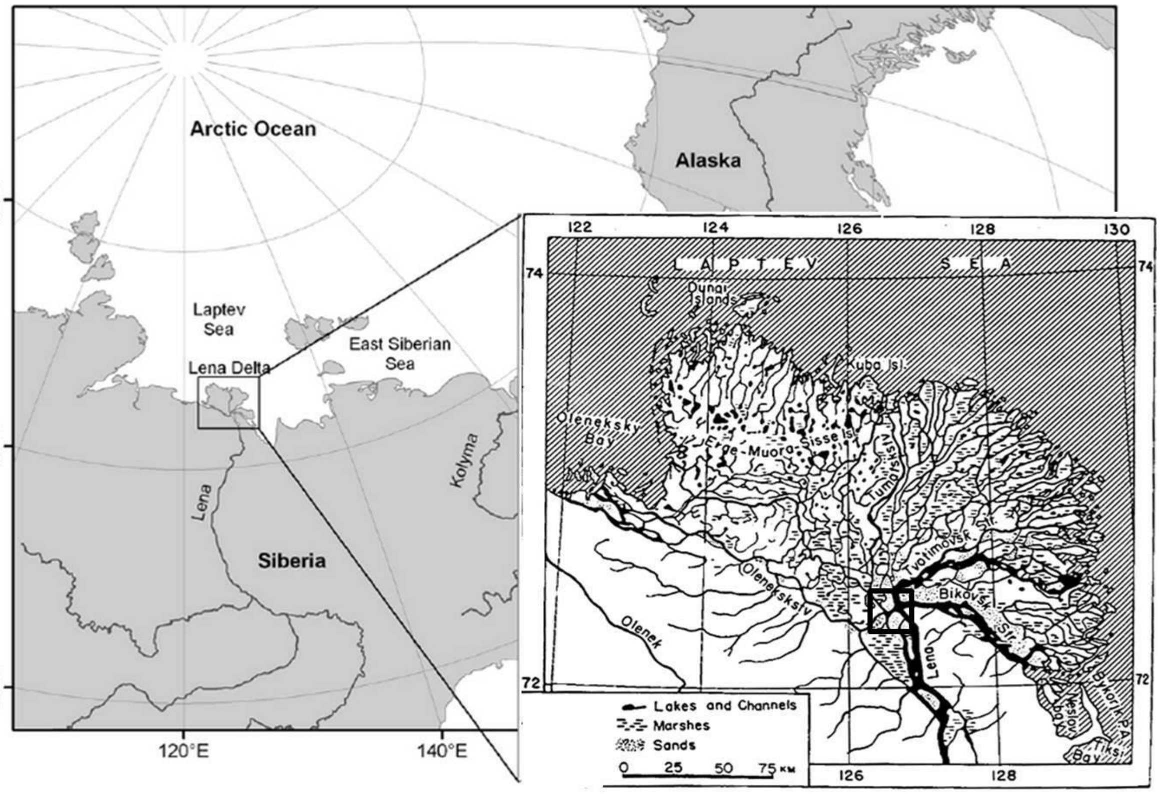

Fig. 1. Map - Research area layout (the location of Samoylov island is indicated by square)

MATERIALS AND METHODS

Zooplankton samples for these studies were collected in the course of the scientific expedition "The Lena 2013" in August 2013. Besides, the author performed the measurements of the reservoir hydrological parameters. 23 samples of zooplankton were collected in total from three permanent stations within 3 days: the polygonal part of the lake, the littoral of the lake thermokarst part and the vertical collection of samples from the deepest part of the reservoir (Figure 2).

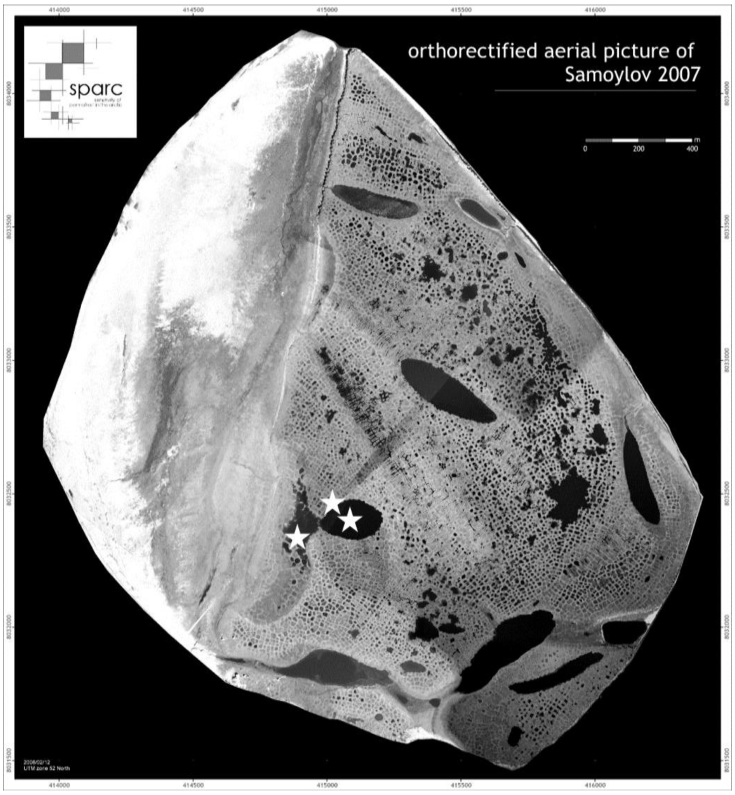

Fig. 2. Researched Ruiba Lake site within Samoylov Island [9] (icons denote sampling sites)

50 liters of water from the polygonal zone and the littoral zone of the thermokarst lake part were filtered through a small Apshtein net (the mesh size makes 100 microns). The sample was taken from the central part of the lake by the vertical pulling of the net from the bottom to the surface of the pond using a boat. The fixation was performed with 4% formalin.

The conventional techniques were used for the hydrobiological sample processing [10, 11]. The reconstructed weight table was used to determine the biomass [12]. In order to assess the level of saprobity Pantle and Bukk saprobity indices in Sladechek's [13] and Zelinka's and Marvan's [14] modifications were used. In order to determine the trophic status of the reservoir the Shannon-Weaver diversity was calculated [15]. Equitability index was used to assess the distribution of species [16]. We used Jaccard common factor in order to carry out the comparative analyzes of samples from different sampling stations [17]. STATISTICA 6.0 software was used for statistical analysis and data processing. The nature of value distribution in the samples was identified using Shapiro-Wilk, Kolmogorov-Smirnov criteria. Kruskal-Wallis test was used in order to check the median equality of several samples [18].

RESULTS

According to hydrological measurements performed in the studied lake during August 2013 the average values (M ± m) of the parameters were the following ones: water temperature + 10.4 ± 0.4 °C, pH value made 7.64 ± 0.04 and conductivity made 98.9 ± 0.1 mcSm/m.

40 species were found in lake zooplankton composition. Among these species there were 25 species of rotifers, 8 species of Cladocera, and 7 species of Copepoda. Rotifers (Rotifera type) were represented by 25 species. The following families were represented most of all: Lecanidae, Brachionidae, Synchaetidae (Fig. 3). *Conochilus unicornis* (Rousselet, 1892), *Kellicotia longispina* (Kellicot, 1879), *Keratella cochlearis* (Gosse, 1851) were represented by 100% of occurrence in the samples was.

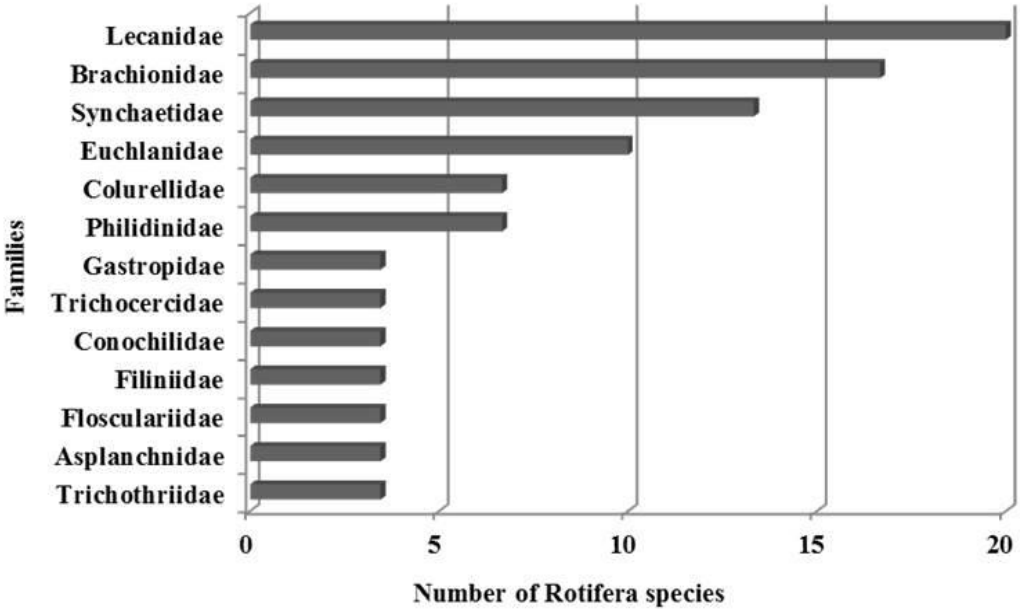

Fig. 3. The representation of Rotifera families in the lake

8 species were revealed among Cladocera suborder. According to the number of species Chydoridae family (5 species) was the leading one. The most common was *Bosmina (E.) longispina* (Leydig, 1860) type of Bosminidae family (the rate of occurrence makes 82,6%).

7 species were marked in the subclass Copepoda. The family Cyclopidae was the most represented one. The incidence of *Maranaebiotus brucei* (Richard, 1898) of the order Harpacticoida (73,9%) was the high one. The juvenile stages of copepods development had a 100% representation.

The polygonal part of the lake revealed 41 species of zooplankton. There were 28 species of rotifers; the core set was presented by *C. unichornis*, *K. longispina, K. cochlearis, Notholca caudata* (Carlin, 1943), g. *Euchlanis* species. Cladocera was represented by 8 species. The species of g. *Bosmina* and *Alona* were met more often (Fisher, 1854). Copepods were represented by 4 species. The juvenile forms of crustaceans, as well as *M. brucei* had 100% of occurrence.

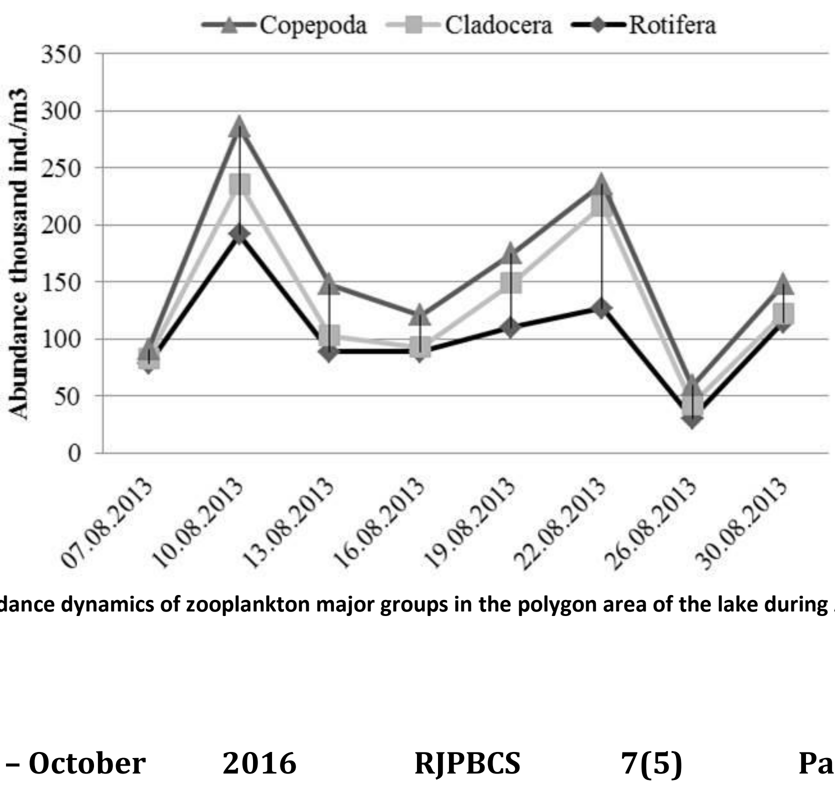

Fig. 4. Abundance dynamics of zooplankton major groups in the polygon area of the lake during August 2013.

The average value of zooplankton abundance in the polygonal part of the lake made 158 ± 26.2 thousand ind./ m^3 (high errors of the median indicate strong differences between sample indices). The abundance was made by rotifers, M ± m 103.9 ± 16.3 thousand ind./ m^3 (Fig. 4), namely *K. longispina*, *K. cochlearis*, as well as *B. (E.) longispina* from Cladocera.

In the polygonal part of the reservoir biomass made 851.6 mg/m3 on the average and was determined by copepod crustaceans, generally by juvenile stages of crustaceans development and by *Acanthocyclops capillatus* to a lesser extent (Sars, 1863) (Fig. 5.).

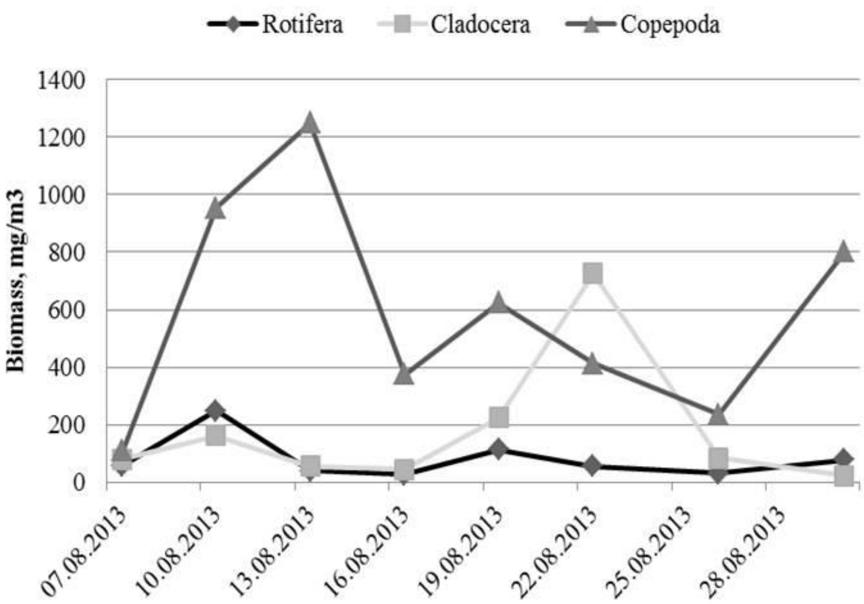

Fig. 5. Biomass Dynamics of zooplankton major groups in the polygonal part of the lake during August 2013

40 zooplankton species, including 27 species of rotifers were revealed in the littoral of the lake thermokarst part. The main complex belongs to the same species as in the polygonal part of the lake. Among 8 revealed species of Cladocera B*. (E.) longispina* was dominated by the occurrence. *M. brucei* and the juvenile stages of crustaceans dominated among 5 copepods.

In the lake littoral the abundance made 162.5 ± 35.5 thousand ind./m^3 on the average and was determined by rotifers (M ± m = 119.3 ± 25.1 thousand ind./m^3), primarily by *K. longispina* and *K. cochlearis* (Fig. 6).

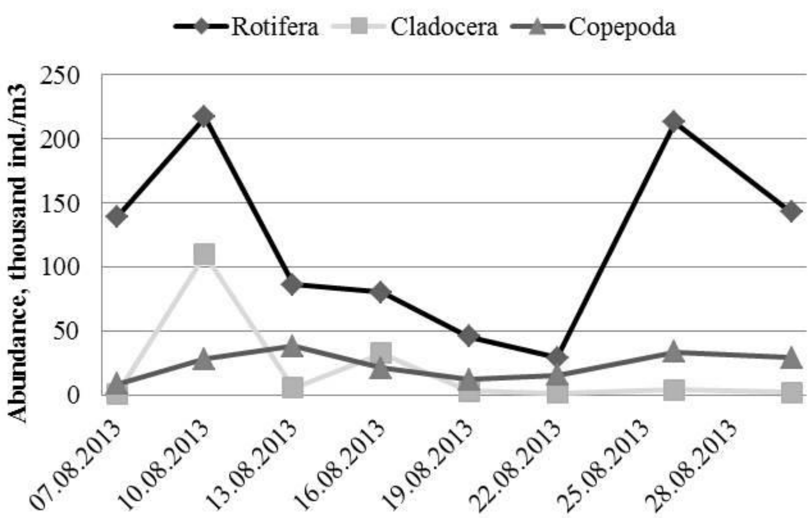

Fig. 6. Abundance changes in zooplankton major groups of in the littoral part of the lake during August 2013

In the littoral of the reservoir the biomass was presented by copepods (569.4 mg/m3), especially by *M. brucei* and copepodit stages; the average value of biomass made 813.4 mg/m^3 (Fig. 7).

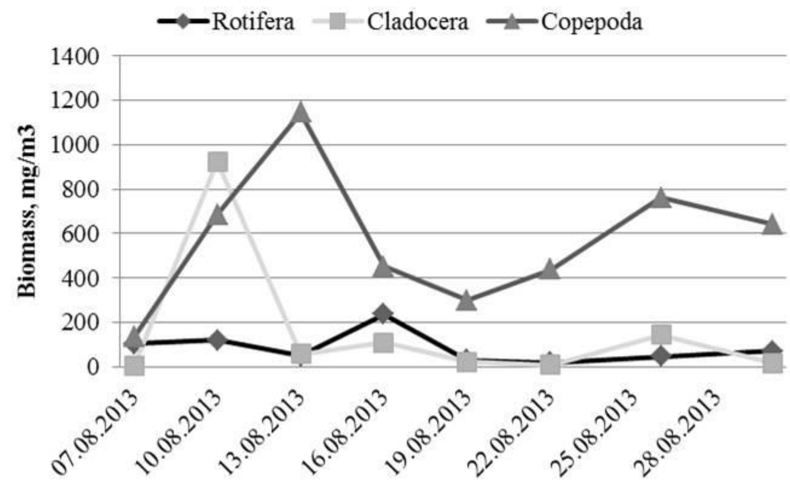

Fig. 7. The dynamics of zooplankton major group biomass in the littoral of the lake during August 2013

The pelagic zone of the lake has 24 species in total, including 14 species of rotifers. The main types were the same as described above, except for g. *Euchlanis* species. G. *Lecane* and g. *Rotatoria* species were also not met here. 4 types were met among Cladocera: g. *Bosmina, Holopedium gibberum* (Zadach, 1855) types were leading ones. 100% of occurrence was presented by *Leptodiaptomus angustilobus* (Sars, 1898), *Eudiaptomus graciloides* (Lilljeborg, 1888) and juvenileforms among 6 species of copepods.

In the pelagic zone of the lake an average value of zooplankton abundance made 219.2 ± 15,1 thousand ind./m^3 during the period of studies. In quantitative terms rotifers were the leading ones (M ± m = 149.6 ± 34,7 thousand ind./m^3, in particular *C. unicornis*) (Fig. 8).

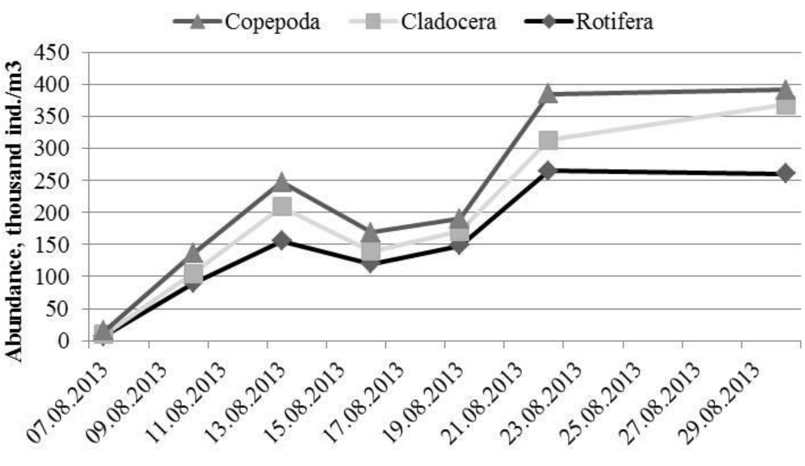

Fig. 8. Abundance Dynamics of zooplankton major groups in the pelagic zone of the lake during August 2013

In the samples from the pelagic part of the lake biomass made 988.4 mg/m^3 on the average, which was determined essentially only by Copepoda representatives: 1562.5 mg/m^3 on the average (Fig. 9.). *E. graciloides* became an absolute dominant by biomass, *L. angustilobus* and B*. (E.) longispina* crustaceans may be considered as a subdominant group.

18 species of zooplankton organisms were met in one sample of the studied lake on the average, among which rotifers prevail (123.1 ± 14.7 thousand ind./m^3) according to the number of species and abundance. Cladocerans and copepods (28 ± 7 thousand ind./m^3 and 27.1 ± 3.2 thousand ind./m^3 respectively) were represented in equal proportions. rotifer *C. unicornis* was the dominant species according to the

representation in the samples. One may regard *K. longispina* and *K. cochlearis* rotifers as the subdominants according to abundance. The abundance values made 178,2 ± 21,6 thousand ind./m^3 on the average. Maximum quantitative indicators were recorded in the pelagic zone.

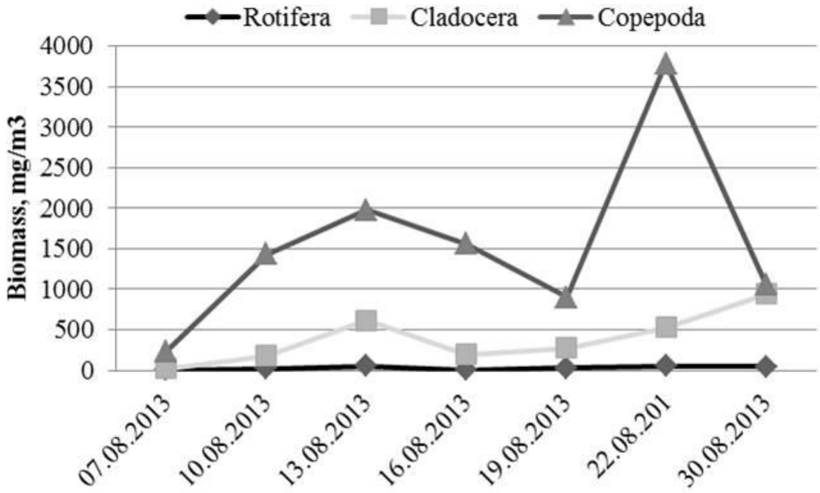

Fig. 9. Dynamics of zooplankton major group biomass in the pelagic zone of the lake during August 2013

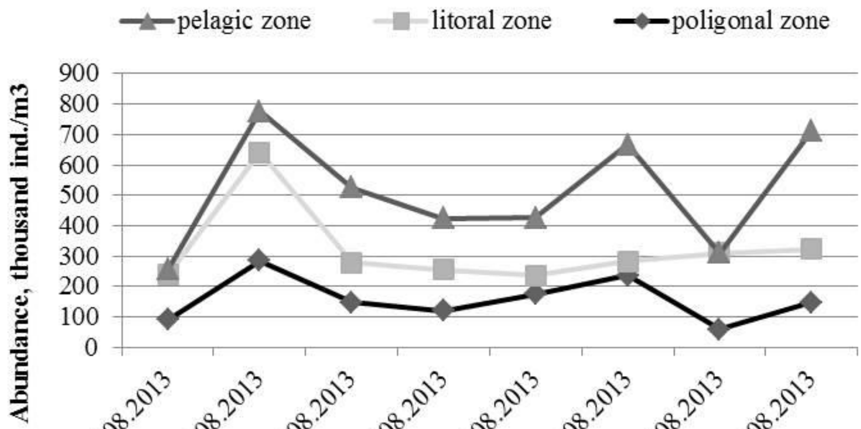

Fig. 10. Zooplankton abundance dynamics according to lake stations during August 2013

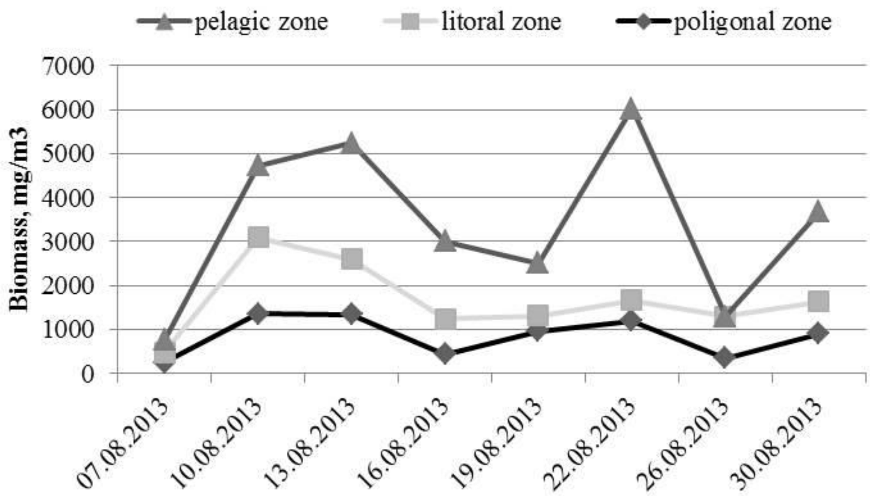

Fig. 11. Dynamics of zooplankton biomass at stations in the lake for August 2013

The average value of biomass in the lake made 1184.1 mg/m3, which was determined essentially only by the representatives of copepods, M ± m = 880.6 mg/m3. Large species of copepods *E. graciloides* and *L. angustilobus* were abundant according to quantitative indicators. 2 peaks of zooplankton abundance and biomass are observed at the beginning and at the end of the study (Fig. 10, 11.).

Faunistic composition of studied reservoir zooplankton was represented mainly by cosmopolites (51% of zooplankton total species diversity). The species that are typical of the Palearctic (27%) and the Holarctic (21.6%) were represented weakly. Eurytopic and littoral species were predominant ones in comarison with planktonic ones.

According to the index of species diversity the explored lake belonged to the pure waters, M±m = 3.1±0.1. the Pantle-Buck saprobity index make 1 ± 0.03 on the aqverage, which referred the lake water to oligosaprobic ones. According to the Zelinka and Marvan saprobity index the lake was an oligosaprobic one with a deviation in β-mesosaprobic zone.

In order to compare the similarity of zooplankton species at individual lake stations Jaccard index was used. Thus, at the comparison of zooplankton between stations the average index value made 0.12, i.e. the species composition of the zooplankton in different parts of the reservoir was weakly similar. During the comparison of zooplankton species diversity from the polygonal and littoral parts of the lake thermokarst part the Jaccard index made 0.35 on the average, which indicates a great similarity of species.

According to the statistical analysis of the difference between the total abundance and the total biomass of zooplankton species by stations, as well as the differences between the numbers and the biomass according to zooplankton groups were not statistically significant ($p>0.05$). The reliable differences were found in the values of the Shannon-Weaver index, calculated according to the abundance of zooplankton (Kruskel-Wallis criterion values $H = 6.77$, the number of freedom degrees makes $df = 2$, $N = 23$, the significance level makes $p = 0.033$).

DISCUSSION

So, 40 species of zooplankton were found in the studied reservoir of Samoylov island. All lake stations demonstratde the predominance of rotifers in species diversity and in abundance. But the studied station communities were differed by the spatial distribution of species. So, *K. longispina* and *K. cochlearis* dominated by abundance in the littoral zone of the lake; in the pelagic zone the abundance was conditioned by *C. unicornis*, i.e. this species prefers an open part of the reservoir. Rotifers were presented as the largest part of zooplankton abundance - 123.1 thousand ind./m3, which is normal for arctic lakes [19, 20], the values of Cladocera and Copepods were much lower.

The distribution of copepods had also spatial difference: *A. capillatus*, the juvenile stages of development, and *M. brucei* dominated in the polygonal part of the lake. Such Copepoda species as *E. graciloides* and *L. angustilobus* dominated in the pelagic zone of the lake. I.e. we may say that the last two named species are the pelagic forms and *A. capillatus* and *M. brucei* species are mostly littoral ones [21], [22].

The average value of zooplankton biomass in the lake made 1184 mg/m3, where copepods make 880.6 mg/m3. The values of abundance and biomass in the lake and in a polygon reservoir are within standards for different types of Arctic waters [19].

Two peaks of zooplankton were traced during the lake studies: at the beginning and at the end of the study the values were increased and the decline of quantitative indicators takes place in the middle of the study. Such a dynamics of the zooplankton lake may be explained by food relations, temperature mode and by theconsumption from other animals.

For polygonal part, as well as for the littoral zone of the lake thermokarst part the predominance of representatives from *Lecanidae* and *Chydoridae* families was noted, which were basically the coastal species.

The differences obtained by us in the distribution of organisms and their relationship in the Arctic reservoirs were similar to the results of the Arctic tundra reservoirs studies of the same latitudes, but to the west - within Finnish Lapland [23]. So, M. Rautio [23] noted a wide distribution of *Chydoridae* family from

Cladocera and *E. graciloides* from *Calanoida* in the studied reservoirs. Rautio also noted a large influence of vegetation development on the distribution of zooplankton.

CONCLUSIONS

According to lake zooplankton study results one may note the spatial differentiation of species within the waters of the reservoir and their quantitative indicators according to the stations. So, the littoral zone of the reservoir was dominated mainly by the species which prefer to dwell among the coastal vegetation, keep the bottom lifestyle in rapidly-heated areas with a large number of nutrients (g. *Lecane, Euchlanis, Alonella, Ch. Sphaericus, M. brucei*). They cause a rich composition of species. The pelagic part of the lake was characterized by the development of large species of copepods, which prefer the open areas of the reservoir and capable of migration (*E. graciloides, L. angustilobus*). I.e. lake coastal zone was dominated by eurytopic and littoral species. Plankton and eurytopic species were presented mainly in the pelagic zone.

ACKNOWLEDGEMENT

The work was performed at the expense of subsidies within the framework of Kazan (Volga) Federal University state support in order to improve its competitiveness among the world leading scientific and educational centers, as well as at the expense of the RFBR grant (№№15-05-04442 A 14- 05-00787 A).

The authors would like to thank the hydrologists of Arctic and Antarctic Research Institute in St. Petersburg for their assistance in the field of the Lena River delta study.

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