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RESEARCH ARTICLE

Planktonic crustaceans of the Balkhash-Alakol lake system (South-Eastern Kazakhstan)

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Abstract

Planktonic crustaceans are the basis of the food supply for animals with higher trophic levels and determine the fish productivity of any water body. Large Cladocera play a significant role in the natural purification of the water column. Some Copepods are intermediate hosts of parasites, including those that are dangerous to humans. Given the key role of planktonic invertebrates, their research is essential for effective management of aquatic ecosystems. The Balkhash-Alakol system includes five main lakes (Balkhash, Alakol, Koshkarkol, Sasykkol, and Zhalanashkol), with a pronounced gradient of water mineralization. The study of planktonic crustaceans in the lakes of the Balkhash-Alakol system was carried out between 2002 and 2007. Previous studies addressed zooplankton; however, planktonic crustaceans were not studied separately, making this research necessary. The samples and the processing of the zooplankton samples were performed using standard methods. During the study, 74 planktonic crustaceans were recorded, with the highest species richness in the East Balkhash and Alakol lakes (48–47 species) and the lowest values in Zhalanashkol (9 species). According to the results of the cluster analysis, the species composition of planktonic crustaceans in the lakes surveyed was characterized by a low level of similarity. Ecologically, euryhaline forms predominated throughout. The abundance of planktonic crustaceans ranged from 31,836 to 105,860 individuals/m^3. The dominant species included *Diaphanosoma lacustris*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, *Arctodiaptomus salinus*, and *Ceriodaphnia reticulata*. The results obtained expand our understanding of the formation of the structure of plankton communities under the influence of external factors.

Keywords
Cladocera, Copepoda, mineralization, species composition, species similarity

Introduction

The planktonic Crustacean, represented by Cladocerans and Copepods, is an essential component of the trophic network of any waterbody (Dubovskaya 2009). Large Cladocerans (eg, genera *Daphnia* O.F. Müller, 1785, *Simocephalus* Schoedler, 1858) act as active filter feeders, playing a significant role in improving water quality and serving as food for fish (Bruce et al. 2006; Park, Shin 2007; Jeppesen et al. 2011; Mehner et al. 2016; Korponai et al. 2019; Gerasimova, Sadchikov 2021). Some copepods are intermediate hosts of parasitic infections, including those dangerous to humans (Zamora-Terol et al. 2021).

The main factor influencing the species richness of plankton communities, in addition to temperature, is mineralization (Zavarzin 2021; Anufriieva, Shadrin 2023) and the chemical composition of water (Krupa et al. 2008). With an increase in mineralization from the ultrafresh level to fresh and brackish waters, biological diversity increases, then decreases, and reaches a minimum at an indicator value of approximately 5-8 g/dm^3 (Khlebovich 2013). As a rule, biological communities' species richness is higher in large waterbodies (Dodson 1991; Chertoprud et al. 2022) due to wider biotopic diversity in them compared to small ones.

The Balkhash-Alakol system includes five leading lakes (Balkhash, Alakol, Sasykkol, Koshkarkol and Zhalanashkol) located within the Balkhash-Alakol depression (Fig. 1). The largest of these is Balkhash Lake, with an area of 16,996 km^2 (Abrosov 1973). The Alakol (2,650 km^2), Sasykkol (736,7 km^2), Koshkarkol (120 km^2) and Zhalanashkol (38 km^2) lakes come after it (Filonets 1965). Sasykkol and Koshkarkol are flowing lakes, while the remaining lakes are endorheic. Water mineralization varies widely. The eastern Balkhash, Alakol, and Zhalanashkol with water mineralization ranging from 2.6 to 8.5 g/dm^3 are saline, while the western part of the Balkhash, Sasykkol, and Koshkarkol lakes are fresh (Tarasov 1961; Amirgaliyev et al. 2003; Krupa et al. 2008).

Zooplankton studies of the Balkhash-Alakol lake system have been conducted for a long time (Samonov 1940; Malinovskaya 1959; Loginovskikh 1965; Loginovskikh, Dyusengaliev 1972; Dyusengaliev 1972; Abrosov 1973; Sharipova, Lopareva 1983; Mirabdullaev 1996; Sharapova 1999; Stuge 1999; Amirgaliyev et al. 2003; Stuge et al. 2004; Krupa et al. 2008; Krupa, Sharipova 2009; Krupa et al. 2013). Published articles mainly focus on the species composition and quantitative variables without distinguishing planktonic crustaceans as the community's leading group. This research, which aims to analyze the species richness and quantification of planktonic crustaceans, partially fills this gap.

Figure 1. Location map of the Balkhash-Alakol lake system with zooplankton sample points.

Materials and methods

Planktonic crustacean studies were conducted in the Balkhash-Alakol lake system between 2002 and 2007. Material was collected according to a station grid, depending on the water surface. In total, 441 samples were collected, including Balkhash – 169, Alakol – 150, Sasykkol – 69, Koshkarkol – 47, and Zhalanashkol – 9 samples. Zooplankton samples were collected using a small Juday plankton net with an input diameter of 12 cm by pulling it from the bottom to the surface. Filtered water was poured into 250 ml plastic containers. Samples were fixed with 40% formalin at a final concentration of 4%. Planktonic crustacean species were identified using guides (Rylov 1948; Manuilova 1964; Krupa et al. 2016). Zooplankton samples were processed using standard methods (Winberg, Lavrentieva 1984) with our modification. The sample was concentrated in a particular volume depending on the abundance of organisms. Usually, each sample was examined at several dilutions (250, 125, 50 ml), each time collecting 3 subsamples using a 1 ml pipette. Finally, the sample, with a volume of 20 to 25 ml, was examined as a whole. The step-by-step processing procedure allows a more accurate account of the species composition and the abundance of age stages. The results obtained were recalculated per 1 m^3. Cluster analysis was performed using Primer 5 software, based on the Bray-Curtis index. Graphs and maps of sampling station locations in each of the lakes were plotted in R software, taking into account their coordinate reference.

Results

In zooplankton, 74 species of planktonic crustaceans were found, including 48 species of Cladocera, 23 species of Cyclopoida, and 3 species of Calanoida (Table 1). *Diaphanosoma lacustris*, *Daphnia galeata*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, and *Arctodiaptomus salinus* had the widest distribution. *Ceriodaphnia reticulata*, *Chydorus sphaericus*, *Alona rectangula*, *Bosmina longirostris*, and *Leptodora kindtii* were registered in the zooplankton of almost all lakes, but within their water areas, they occurred locally, mainly in the coastal zone.

Table 1. Species composition and frequency of occurrence of planktonic crustaceans in the Balkhash-Alakol lake system from 2002 to 2007

Taxon name	Frequency of occurrence, %						
	WB	EB	AK	SK	KK	ZK	Total
Cladocera							
Sida cristallina (O.F. Müller, 1776)	67	100	20	-	13	-	21
Diaphanosoma brachyuran (Liévin, 1848)	-	50	-	-	-	-	3
Diaphanosoma dubium Manuilova, 1964	-	-	10	-	-	-	3
Diaphanosoma lacustris Korinek, 1981	67	100	60	88	100	100	82
Diaphanosoma macrophthalma Mirabdullaev, 1995	33	-	30	-	-	-	12
Diaphanosoma mongolianum Ueno, 1938	-	50	30	13	25	-	21
Diaphanosoma orghidani Negrea, 1982	67	50	-	-	-	-	9
Daphnia pulex Leydig, 1860	33	-	10	-	-	-	6
Daphnia longispina O.F. Müller, 1785	-	50	10	-	-	-	6
Daphnia cucullata Sars, 1862	33	50	-	-	-	-	6
Daphnia galeata Sars, 1863	67	100	80	100	13	-	62
Simocephalus vetulus (O.F. Müller, 1776)	33	50	-	13	-	-	9
Simocephalus mixtus Sars, 1903	-	50	-	-	-	-	3
Moina micrura Kurz, 1875	-	-	30	-	-	-	9
Moina brachiata (Jurine, 1820)	-	-	60	-	-	-	18
Ceriodaphnia quadrangula (O.F. Müller, 1785)	-	50	80	-	13	-	29
Ceriodaphnia reticulata (Jurine, 1820)	33	100	90	-	-	100	44
Ceriodaphnia laticaudata P.E.Müller, 1867	33	100	20	-	-	-	15
Ceriodaphnia pulchella Sars, 1862	-	-	10	-	-	-	3
Ceriodaphnia setosa Matile, 1890	-	-	20	-	-	-	6
Ceriodaphnia dubia Richard, 1894	-	-	20	-	-	-	6
Macrothrix hirsuticornis Norman & Brady, 1867	33	50	20	-	-	33	15
Macrothrix laticornis (Jurine, 1820)	-	50	30	-	-	33	15
Macrothrix spinosa King, 1853	33	50	-	-	-	-	6

Taxon name	Frequency of occurrence, %						
	WB	EB	AK	SK	KK	ZK	Total
Macrothrix daday Daday, 1898	-	-	20	-	-	-	6
Macrothrix triserialis Brady, 1886	-	50	-	-	-	-	3
Ilyocryptus agilis Kurz, 1878	33	-	-	-	13	-	6
Ilyocryptus acutifrons Sars, 1862	67	-	-	-	-	-	6
Camptocercus rectirostris Schoedler, 1862	33	50	10	13	-	-	12
Acroperus harpae (Baird, 1834)	67	50	-	-	-	-	9
Monospilus dispar Sars, 1862	-	50	-	-	-	-	3
Graptoleberis testudinaria (Fischer, 1848)	33	50	30	-	25	-	21
Chydorus sphaericus (O.F. Müller, 1776)	67	100	100	25	13	33	53
Chydorus ovalis Kurz, 1875	-	50	-	-	-	-	3
Pleuroxus aduncus (Jurine, 1820)	-	50	20	13	-	-	12
Pleuroxus uncinatus (Baird, 1850)	-	50	-	-	-	-	3
Pleuroxus trigonellus (O.F.Müller, 1776)	-	100	-	-	-	-	6
Alona costata Sars, 1862	33	100	10	-	13	-	15
Alona guttata Sars, 1862	67	50	10	-	13	-	15
Alona rectangula G.O.Sars, 1862	67	100	90	13	38	-	50
Alonella nana (Baird, 1843)	33	100	-	-	25	-	15
Alonella exigua (Lilljeborg, 1853)	-	-	-	-	13	-	3
Alonella excisa (Fischer, 1854)	-	-	-	13	-	-	3
Bosmina longirostris (O.F.Müller, 1776)	67	50	80	25	13	33	44
Polyphemus pediculus (Linnaeus, 1761)	-	50	10	-	13	-	9
Leptodora kindtii (Focke, 1844)	-	100	10	25	25	-	21
Scapholeberis kingi Sars, 1888	-	-	20	13	-	-	9
Scapholeberis rammneri Dumont & Pensaert, 1983	-	50	-	-	-	-	3
Cyclopoida							
Macrocyclops albidus (Jurine, 1820)	33	100	10	-	-	-	12
Eucyclops serrulatus (Fischer, 1851)	33	100	50	-	13	-	26
Eucyclops denticulatus (Graeter, 1903)	33	100	10	13	-	-	15
Eucyclops speratus (Lilljeborg, 1901)	-	50	-	-	-	-	3
Eucyclops macrurus Sars, 1863	33	50	20	-	-	-	12
Paracyclops affinis Sars, 1863	-	-	-	13	-	-	3
Paracyclops fimbriatus Fischer, 1853	-	50	10	-	-	-	6
Ectocyclops phaleratus Koch, 1838	-	-	10	-	-	-	3
Cyclops vicinus Uljanin, 1875	67	50	90	-	25	-	41
Mesocyclops leuckarti Claus, 1857	67	100	100	100	100	-	88
Mesocyclops pepheiensis Hu, 1943	33	50	-	-	-	-	6

Taxon name	Frequency of occurrence, %						
	WB	EB	AK	SK	KK	ZK	Total
Thermocyclops oithonoides (Sars G.O., 1863)	33	-	-	-	-	-	3
Thermocyclops dybowski Landé, 1890	-	-	-	-	-	33	3
Thermocyclops rylovi (Smirnov, 1928)	-	-	30	-	-	-	9
Thermocyclops crassus (Fischer, 1853)	67	100	80	100	100	-	82
Thermocyclops taihokuensis Harada, 1931	67	-	60	-	-	-	24
Thermocyclops vermifer Lindberg, 1935	-	-	10	-	-	-	3
Diacyclops bicuspidatus (Claus, 1857)	-	-	10	-	-	-	3
Diacyclops bisetosus (Rehberg, 1880)	-	-	10	-	-	-	3
Megacyclops viridis (Jurine, 1820)	-	50	80	-	-	100	35
Acanthocyclops robustus (Sars G.O., 1863)	67	100	20	-	-	-	18
Microcyclops afganicus Lindberg, 1948	33	-	-	-	-	-	3
Microcyclops rubellus (Lilljeborg, 1901)	33	50	-	-	13	-	9
Calanoida							
Eurytemora affinis (Poppe, 1880)	33	-	-	-	-	-	3
Eudiaptomus graciloides (Lilljeborg, 1888)	-	-	-	50	38	-	21
Arctodiaptomus salinus (Daday, 1885)	67	100	100	100	100	100	97
Total	38	48	47	18	23	9	74

Note: WB – West Balkhash, EB – East Balkhash, AK – Alakol, SK – Sasykkol, KK – Kossharkol, ZK – Zhalanashkol.

The Eastern Balkhash and Alakol had the highest species diversity of planktonic crustaceans (Fig. 2). The variable's value was approximately one-third lower in Western Balkhash. A limited number of zooplankton species were found in the Kosharkol and Sasykkol lakes, and the minimum was found in Zhalanashkol.

Cladocerans *Diaphanosoma lacustris*, *Daphnia galeata*, *Chydorus sphaericus*, *Alona rectangula*, *Bosmina longirostris*, copepods *Mesocyclops leuckarti*, *Thermocyclops crassus*, and *Arctodiaptomus salinus* were widespread in all lakes. Cladocerans *Sida cristallina*, *Diaphanosoma mongolianum*, *Simocephalus vetulus*, *Ceriodaphnia quadrangula*, *C. reticulata*, *Macrothrix hirsuticornis*, *M. laticornis*, *Graptoleberis testudinaria*, *Pleuroxus aduncus*, *Alona costata*, *A. guttata*, *Alonella nana*, *Polyphemus pediculus*, *Leptodora kindtii*, copepods *Macrocyclops albidus*, *Eucyclops serrulatus*, *E. denticulatus*, *E. macrurus*, *Cyclops vicinus*, *Megacyclops viridis*, *Acanthocyclops robustus* and *Microcyclops rubellus* were comparatively common. Of the total species of planktonic crustaceans, 29 (40%) were found only in one of the lakes within the Balkhash-Alakol system.

Regarding mineralization, euryhaline forms were predominant, representing 39.1% to 55.6% of the entire species list. Regarding habitat preference, planktonic forms constituted between 25.0% and 38.9%, while littoral forms accounted for 11.0% and 29.2%.

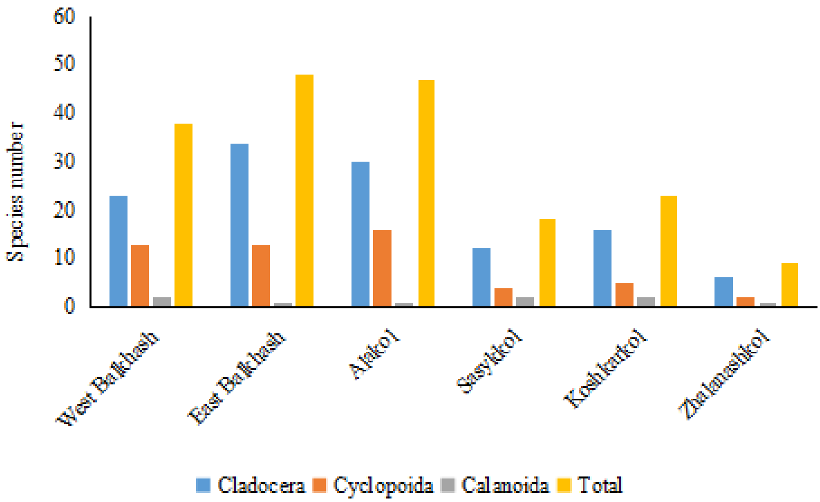

Figure 2. Number of species of planktonic crustaceans in the Balkhash-Alakol Lakes from 2002 to 2007.

The results of the cluster analysis indicated that the lakes surveyed are divided into four distinct groups according to the species composition of planktonic crustaceans (Fig. 3). The first cluster covered the entire water body of Balkhash Lake, despite the notable differences in water mineralization between its western freshwater section and the eastern saline part. The key species characteristic of this group include the cladocerans *Diaphanosoma orghidani*, *Daphnia cucullata*, *Macrothrix spinosa*, *Acroperus harpae*, and copepod *Mesocyclops pehpeiensis*.

Zhalanashkol Lake formed a distinct cluster, demonstrating a low level of similarity to other lake communities. The characteristic species was *Thermocyclops dybowski*. In Alakol Lake, which represents the third cluster, zooplankton includes cladocerans *Diaphanosoma dubium*, *Moina micrura*, *M. brachiata*, *Ceriodaphnia pulchella*, *C. setosa*, *C. dubia*, and *Macrothrix daday*. Additionally, cyclopids such as *Ectocyclops phaleratus*, *Thermocyclops rylovi*, *T. vermifer*, *Diacyclops bicuspidatus*, and *D. bisetosus* were identified. The fourth cluster covers the freshwater Sasykkol and Kossharkol Lakes, with the characteristic species of *Eudiaptomus graciloides*.

Common species in all lakes except Zhalanashkol were *Diaphanosoma lacustris*, *Daphnia galeata*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, and *Arctodiaptomus salinus*. In the Zhalanashkol Lake, *Daphnia galeata* and *Mesocyclops leuckarti* were absent, but *Ceriodaphnia reticulata* and *Megacyclops viridis* were widespread.

The abundance of planktonic crustaceans varied by orders of magnitude (Table 2). The highest values were recorded in the freshwater Zhalanashkol, Sasykkol and Koshkarkol lakes, and the lowest values were observed in the mineralized Balkhash and Alakol lakes.

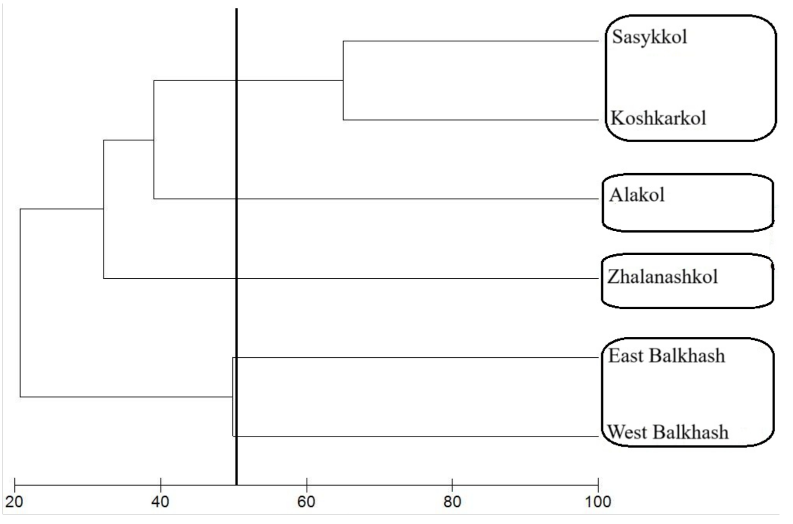

Figure 3. Dendrogram of the similarity of planktonic crustaceans in the Balkhash-Alakol lake system from 2002 to 2007.

Table 2. Mean annual abundance of planktonic crustaceans in the Balkhash-Alakol lake system

Lake	Years	Abundance, ind. $10^3/m^3$			
		Cladocera	Cyclopoida	Calanoida	Total
Balkhash	2003–2004	12.1±2.8	15.1±1.6	19.7±2.2	46.8±4.8
Alakol	2002–2007	2.8±0.7	7.5±1.7	7.5 ± 2.3	17.8 ± 3.3
Sasykkol	2002, 2004–2007	41.5±17.8	23.1±5.5	25.0±8.3	89.6±30.4
Koshkarkol	2003–2007	23.8±11.4	28.8±13.4	20.6±6.1	73.2±29.1
Zhalanashkol	2005–2007	60.2±19.4	12.1±9.0	33.4±21.0	105.9±41.0

The interannual dynamics of planktonic crustaceans in the Sasykkol, Koshkarkol, and Alakol lakes were synchronous (Fig. 4), with Pearson's correlation coefficient values of 0.828–0.925, $p<0.05$. In all lakes, the outbreak of plankton crustaceans was recorded in 2005, against the backdrop of rising water levels. In Zhalanashkol Lake, where the observations were conducted for only three years, a high community abundance (average 173.6 thousand ind./m^3) was also observed in 2005. In 2006, the values decreased almost six times (31.8 thousand ind./m^3), subsequently rising to 112.1 thousand ind./m^3 in 2007. From 2003 to 2004, the abundance of planktonic crustaceans in the Western Balkhash increased on average from 36.2 to 59.3 and in the Eastern Balkhash from 44.0 to 47.6 thousand ind./m^3.

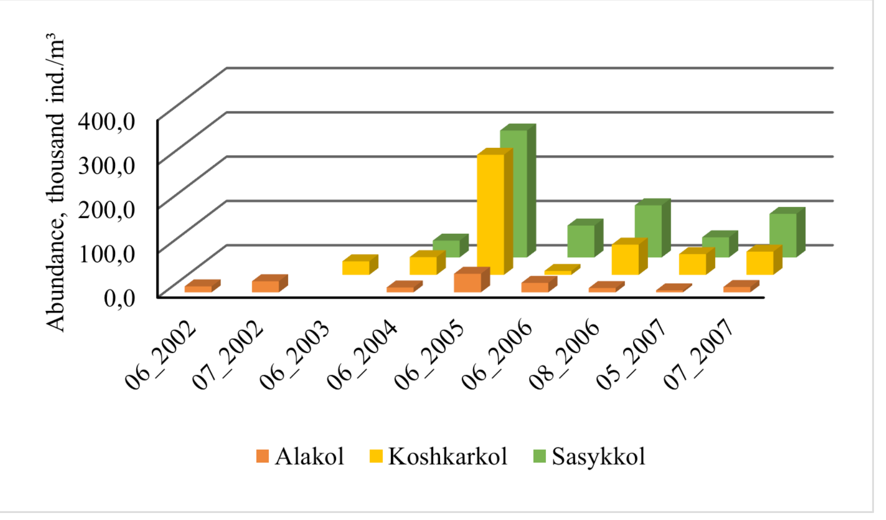

Figure 4. Interannual dynamics of planktonic crustacean abundance in Sasykkol, Koshkarkol, and Alakol lakes.

During the examined period, cladocerans were the dominant group in terms of abundance in Zhalanashkol and Sasykkol lakes. On the contrary, cyclops or calanoids prevailed in the communities of the other lakes. The composition of the dominant complexes remained relatively constant and usually included 2 to 4 species (Table 3). The share of dominant species did not exceed 44.0% of the total abundance of crustaceans.

Table 3. Composition of dominant species of planktonic crustaceans in the Balkhash-Alakol lake system from 2002 to 2007

Lake	Dominant species	Abundance, %	Lake	Dominant species	Abundance, %
Alakol	*Mesocyclops leuckarti*	26.1	Zhalanashkol	*Ceriodaphnia reticulata*	40.9
	Arctodiaptomus salinus	42.0		*Megacyclops viridis*	11.5
West Balkhash	*Diaphanosoma lacustris*	23.4		*Arctodiaptomus salinus*	31.6
	Mesocyclops leuckarti	19.8	Koshkarkol	*Diaphanosoma lacustris*	29.9
	Thermocyclops crassus	13.0		*Mesocyclops leuckarti*	15.0
	Arctodiaptomus salinus	40.1		*Thermocyclops crassus*	23.7

Lake	Dominant species	Abundance, %	Lake	Dominant species	Abundance, %
East Balkhash	*Diaphanosoma lacustris*	19.5		*Arctodiaptomus salinus*	26.6
	Mesocyclops leuckarti	17.4	Sasykkol	*Diaphanosoma lacustris*	2.3
	Thermocyclops crassus	10.8		*Mesocyclops leuckarti*	26.1
	Arctodiaptomus salinus	44.0		*Arctodiaptomus salinus*	42.0

Discussion

During our research, 74 species of planktonic crustaceans were identified in the Balkhash-Alakol lake system, which is 19 species more than was previously known (Samonov 1940; Malinovskaya 1959; Loginovskikh 1965; Loginovskikh, Dyusengaliev 1972; Dyusengaliev 1972; Abrosov 1973; Sharipova, Lopareva 1983; Mirabdullaeav 1996; Sharapova 1999; Stuge 1999; Amirgaliyev et al. 2003; Stuge et al. 2004). The mineralized lakes Balkhash (57 in total) and Alakol (47) were characterized by the greatest species richness of the communities. This is due to their large area and the diversity of external conditions (Dodson 1991; Zavarzin 2021), including hydrochemical variables, and the removal of planktonic crustaceans with river runoff (Sharapova 1999).

Comparison with data from the literature (Stuge 1999; Stuge et al. 2004) showed that over the past decades the background species complex remained constant and included *Diaphanosoma lacustris*, *Arctodiaptomus salinus*, *Thermocyclops crassus*, and *Mesocyclops leuckarti*. The appearance of the cladoceran *Daphnia magna*, uncharacteristic for the waterbodies of the system (Sharipova, Lopareva 1983), in the late 1980s was associated with a high level of pollution in the lakes and an unfavorable hydrological regime (Stuge et al. 2004). During the same period, *Eudiaptomus graciloides*, previously common in freshwater lakes, disappeared from zooplankton. During our studies, it was again recorded in the Sasykkol and Koshkarkol Lakes, which may be associated with improved environmental conditions.

According to the results of the lake cluster analysis, the surveyed formed four clusters according to the species composition of planktonic crustaceans. The main factor in the differences in species composition is mineralization of the water, which varies on average from 0.4 to 0.6 g / dm^3 in Sasykol and Koshkarkol to 4.6 to 7.8 g / dm^3 in Alakol and the eastern Balkhash (Krupa 2012). Variability in hydrochemical conditions is also observed within the lakes' water areas, from 1.2 to 2.2 g / dm^3 in the zones of influence of river runoff to 5.9 g/dm^3 in the eastern part of Balkhash and 9.2 g/dm^3 in the deep water zone of Alakol. Despite the difference in hydrochemical conditions, the species composition of planktonic crustaceans in the West and East Balkhash is characterized by a high level of similarity. This is due to the high proportion of euryhaline species in the community and desalinated zones in the eastern mineralized part of the lake.

Freshwater lakes were characterized by a higher abundance of planktonic crustaceans (on average 73.2 to 104.9 thousand individuals/m^3) than mineralized ones (17.8 to 45.8 thousand individuals/m^3). In addition to trophic conditions and mineralization, one of the reasons for the differences identified in the abundance of planktonic crustaceans is the chemical composition of the water. The water in the Alkakol and Balkhash lakes contains a large amount of alkali metal ions (Krupa et al. 2008; 2010), which is unfavorable for most species of aquatic organisms.

The synchronous dynamics of planktonic crustaceans in three interconnected lakes (Alakol, Sasykkol, and Koshkarkol), with a maximum in 2005, reflected the influence of natural and climatic factors, in particular, interannual fluctuations in the water level. The maximum abundance of planktonic crustaceans in Zhalanashkol, isolated from other lakes in the system, was also observed in the high-water year 2005. This indicated that the influx of nutrient compounds into lakes with surface runoff was greater than what was accumulated in the lakes. This pattern was previously shown for several water bodies in Kazakhstan, where wastewater is not discharged directly (Krupa 2012). In Lake Balkhash, which is polluted by municipal and industrial wastewater discharges, as well as the influx of polluted runoff from the Ili River, the relationship between the long-term dynamics of the abundance of zooplankton (without isolating planktonic crustaceans) and the level of water was weakly expressed (Krupa, Sharipova 2009; Krupa et al. 2013).

Conclusions

The planktonic crustaceans of the Balkhash-Alakol lake system were represented by 74 species, of which 48 are Cladocera, 23 are Cyclopoida and 3 are Calanoida. *Diaphanosoma lacustris*, *Daphnia galeata*, *Chydorus sphaericus*, *Alona rectangula*, *Bosmina longirostris*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, and *Arctodiaptomus salinus* are the most common. The highest number of planktonic crustacean species was recorded in the mineralized lakes Balkhash and Alakol, while the total abundance was higher in the freshwater lakes. The differences in the species composition and quantitative variables of planktonic crustaceans were determined by several primary factors: the area of the lakes, the diversity of biotopes, the mineralization, and the chemical composition of the water. The results obtained contribute to understanding the structure of the plankton communities under the influence of external factors.

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References

Anufriieva EV, Shadrin NV (2023) Salinity as a Factor Limiting the Potential Taxonomic Richness of Crustaceans in Ecosystems of Hypersaline Reservoirs around the World. Inland Water Biology 16: 892–898. https://doi.org/10.31857/S0320965223050030

Abrosov VN (1973) Lake Balkhash. Nauka, Leniningrad, 180 pp. [In Russian]

Amirgaliyev NA, Lopareva TY, Gogol LA, Kaganatova SC (2003) Hydrochemical regime of the lakes of the Alakol basin. Hydrometeorology and Ecology 4: 102–114. [In Russian]

Bruce LC, Hamilton DP, Imberger J, Gal G, Gophen M, Zohary T, Hambright KD (2006) A numerical simulation of the role of zooplankton in C, N and P cycling in Lake Kinneret, Israel. Ecological Modelling 193(3–4): 412–436. https://doi.org/10.1016/j.ecolmodel.2005.09.008

Chertoprud ES, Novichkova AA, Novikov AA, Fefilova EB, Vorobjeva LV, Pechenkin DS, Glubokov AI (2022) Assemblages of meiobenthic and planktonic microcrustaceans (Cladocera and Copepoda) from small water bodies of mountain Subarctic (Putorana Plateau, Middle Siberia). Diversity 14(6): 492. https://doi.org/10.3390/d14060492

Dubovskaya OP (2009) Non-predatory mortality of planktonic crustaceans: possible causes (literature review). Journal of General Biology 2: 168–192. [In Russian]

Dodson S (1991) Species richness of crustacean zooplankton in European lakes of different sizes. SIL Proceedings 24(2): 1223–1229. https://doi.org/10.1080/03680770.1989.11898949

Dyusengaliev T (1972) Zoogeographical and ecological characteristics of zooplankton in the Alakol lakes. Biological Foundations of Fishery Management of Water Bodies of Central Asia and Kazakhstan. Fergana, Tashkent, 82–83. [In Russian]

Filonets PP (1965) Morphometry of Alakol lakes. Questions of Geography of Kazakhstan 12: 79–87. [In Russian]

Gerasimova TN, Sadchikov AP (2021) Fighting cyanobacterial blooms in an experimental ecosystem: The role of filtering zooplankton. Materials on the flora and fauna of the Republic of Bashkortostan 30: 33–40. [In Russian]

Jeppesen E, Nõges P, Davidson TA, Haberman J, Nõges T, Blank K, Lauridsen TL, Søndergaard M, Sayer C, Laugaste R, Johansson LS, Bjerring R, Amsinck SL (2011) Zooplankton as Indicators in Lakes: A Scientific-Based Plea for Including Zooplankton in the Ecological Quality Assessment of Lakes According to the European Water Framework Directive (WFD). Hydrobiologia 676: 279–297. https://doi.org/10.1007/s10750-011-0831-0

Korponai J, Braun M, Forró L, Gyulai I, Kövér C, Nédli J, Urák I, Buczkó K (2019) Taxonomic, functional and phylogenetic diversity: how subfossil cladocerans mirror contemporary community for ecosystem functioning: a comparative study in two oxbows. Limnetica 38(1): 431–456. https://doi.org/10.23818/limn.38.25

Khlebovich VV (2013) Critical salinity–homeostasis–sustainable development. Proceedings of the Zoological Institute RAS 317(3): 3–6.

Krupa EG, Stuge TS, Lopareva TY, Shaukharbaeva DS (2008) Distribution of Planktonic Crustaceans in Lake Balkhash in Relation to Environmental Factors. Inland Water Biology 1(2): 150–157. https://doi.org/10.1134/S1995082908020077

Krupa EG, Sharipova KZ (2009) Multi-year dynamics of quantitative variables of zooplankton of Lake Balkhash. Research, Results 4:15–18.

Krupa EG, Amirgaliyev NA, Lopareva TY, Isaeva AK, Bimanbayeva BB (2010) Zooplankton of Alakol Lake and Its Distribution Depending on Water Mineralization and Chemical Composition. Bulletin of KazNU, Biological Series 1: 96–101. [In Russian]

Krupa EG (2012) Zooplankton of Limnic and Lotic Ecosystems of Kazakhstan: Structure and Formation Patterns. Palmarium Academic Publishing, Germany, 346 pp. [In Russian]

Krupa EG, Coy VN, Lopaverova TA, Ponomaryova LP, Anuryeva AN, Sadirbayeva NN, Alysbekova SZ, Isbekov KB (2013) Many years of dynamic hydrobiobionts of the Lake Balkhash and its connection with environmental factors. Vestnik Astrakan State Technical University, Fisheries Series 2: 85–96. [In Russian]

Krupa EG, Dobrokhotova OV, Stuge TS (2016) The Calanoida (Crustacea, Copepoda) fauna of Kazakhstan and adjacent territories. EtalonPrint, Almaty, 208 pp. [In Russian]

Loginovskikh EV (1965) The food base of the Alakol lakes and its use by fish. Alakol Basin and Its Lakes 12: 223–235. [In Russian]

Loginovskikh EV, Dyusengaliev T (1972) Quantitative characteristics of zooplankton in the Alakol lakes. Fishery Resources of Water Bodies of Kazakhstan and Their Use 7: 89–94. [In Russian]

Mehner T, Keeling C, Emmrich M, Holmgren K, Argillier Ch, Volta P, Winfield IJ, Brucet S (2016) Effects of fish predation on density and size spectra of prey fish communities in lakes. Canadian Journal of Fisheries and Aquatic Sciences 4: 506–518. https://doi.org/10.1139/cjfas-2015-0034

Malinovskaya AS (1959) The food base of the Alakol lakes and its use by fish. Collection of works on ichthyology and hydrobiology. Second edition. The Publishing House of the Kazakh SSR, Alma-Ata, 116–144. [In Russian]

Mirabdullaev IM (1996) The genus *Mesocyclops* (Crustacea: Copepoda) in Uzbekistan (Central Asia). International Review of Hydrobiology 81(1): 93–100. https://doi.org/10.1002/iroh.19960810111

Manuilova EF (1964) Branchiopod Crustaceans (Cladocera) of the USSR Fauna. Nauka, Moscow, 326 pp. [In Russian]

Park KS, Shin HW (2007) Studies on phyto-and-zooplankton composition and its relation to fish productivity in a west coast fish pond ecosystem. Journal of Environmental Biology 28(2): 415–422.

Rylov VM (1948) Cyclopoida of freshwaters. Fauna of the USSR. Crustaceans. Vol. 3(3). Publishing House of the Academy of Sciences of the USSR, Moscow, 348 pp. [In Russian]

Samonov AM (1940) Benthos of the Alakol Lakes. Collections of the Kazakh Research Institute of Fisheries (KazNIIRKH). [In Russian]

Sharipova KZ, Lopareva TY (1983) Quantitative development of zooplankton in the Alakol lakes and factors determining it. Biological Foundations of Fishery Management of Water Bodies of Kazakhstan and Central Asia. Conference Abstracts, Tashkent: 145–146. [In Russian]

Sharapova LI (1999) The state of the planktonic fauna in the Alakol lake system at the end of the 1990s. Problems of Conservation and Sustainable Use of Biodiversity of Animal World of Kazakhstan. Proceedings of the International Scientific Conference, Almaty, 159–160. [In Russian]

Stuge TS (1999) On the zooplankton of the Alakol lakes. Problems of Conservation and Sustainable Use of Biodiversity of Animal World of Kazakhstan. Proceedings of the International Scientific Conference, Almaty, 146–147. [In Russian]

Stuge TS, Krupa EG, Smirnova DA (2004) Zooplankton of the Alakol-Sasykkol lake system. Proceedings of the Alakol Reserve, Almaty, 119–137. [In Russian]

Tarasov MN (1961) Hydrochemistry of Lake Balkhash. Publishing House of the Academy of Sciences of the USSR, Moscow, 224 pp. [In Russian]

Winberg GG, Lavrentieva GM (1984) Zooplankton and its production. Methodical recommendations for collecting and processing materials during hydrobiological research in freshwater bodies. Zoological Institute, Leniningrad, 1–34. [In Russian]

Zamora-Terol S, Novotny A, Winder M (2021) Molecular evidence of host-parasite interactions between zooplankton and Syndiniales. Aquatic Ecology 55: 125–134. https://doi.org/10.1007/s10452-020-09816-3

Zavarzin DS (2021) Freshwater and brackish water planktonic copepods (Crustacea: Copepoda) of Sakhalin Island (Far East Asia). Recent advances in freshwater crustacean biodiversity and conservation 22: 255–306. https://doi.org/10.1201/9781003139560-9