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Zooplankton of the coastal areas of reservoirs of the arid zone: effects of level regime and meteorological conditions

Alexander V. Krylov[1]*, Bud Mėndsaĭkhan[2], Chananbaatar Ayushsuren[3], Alexander I. Tsvetkov[1]

[1]*Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences, Borok 109, Nekouz District, Yaroslavl' Oblast, 152742 Russia*

[2]*Institute of Geography and Geoecology, Mongolian Academy of Sciences, Baruun Selbe 15, Ulaanbaatar, 210620 Mongolia*

[3]*The Institute of General and Experimental Biology Mongolian Academy of Sciences, Prospekt Mira 546, Ulaanbaatar, 210351 Mongolia*

**krylov@ibiw.yaroslavl.ru*

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The interannual differences in the zooplankton of the coastal zone of two different types of reservoirs were analyzed, depending on the location along the longitudinal profile of water bodies, the amount of atmospheric precipitation, air temperature, the level and electrical conductivity of the water, and the morphometry of the water areas. The zooplankton of the coastal area of the large Tayshir Reservoir differed markedly along the longitudinal profile of the reservoir. In the upstream zone, the state of the zooplankton was estimated by totalling the effects from changes in water mineralization, in the supply of organic and nutrient substances brought by the river, in the surrounding landscape, and also the effects of the transfer of nutrients from the sediments to the water. In the middle zone, the following effects were taken into account: external intake of substances and diffusion of nutrients from bottom sediments. In the downstream zone these were: an increase in the amount of precipitation and water level that led to a dilution of water with already impoverished zooplankton content.

In the Durgun reservoir, which is short and narrow, the quantity and content of zooplankton in the coastal areas of the upstream and downstream zones were not much different: in the downstream zone the number of species was somewhat higher, as well as the proportion of Cladocera in the total biomass, and the values of Shannon diversity indices calculated for the numbers and the biomass. In general, in the Durgun reservoir, the quantitative characteristics and structure of zooplankton depended on the connection with the feeding eutrophic Har-Us Lake, which was determined by the amount of precipitation. An increase in precipitation led to an increase in the number and biomass of rotifers. An increase in the water level of the reservoir associated with a reduction in the discharge of hydroelectric power stations and a general decrease in the amount of precipitation, when the littoral zone and floods were nearly entirely absent, was correlated with an increase in the numbers and biomass of Copepoda.

Keywords: zooplankton, reservoirs, coastal zone, arid zone, temperature, electrical conductivity, water level, amount of precipitation, air temperature.

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Introduction

Regulation of river flow is one of the most ancient and widespread human-induced transformations of aquatic ecosystems in the world. According to Yu.S. Datsenko (2007), active construction of reservoirs occurred in 1950–1970, but later their construction slowed down in industrially developed states, but increased in developing countries with arid climate. Mongolia is no exception, with the Taishir and Durgunskoye reservoirs constructed there in the first decade of this century (Uglublennyi obzor..., 2011). To construct the Taishir Reservoir in the upper reaches of the Zavkhan River, the largest river in Western Mongolia, a dam 50 m high, 190 m long (N 46°41'39", E 96°39'57") was built. The filling of the channel began in 2007, and station became operational in November 2008. The length of the reservoir is ~35 km, the maximum width is ~6 km (Dulmaa, 2013). The Durgun Reservoir was constructed in the Great Lakes Depression in 2008 by restricting the Chonokharaikh canal connecting the Khar-Us, Dalai and Khar lakes, with a dam 20 m high and 252 m long (N 48°19'33", E 92°48'25") (Uglublennyi obzor..., 2011). The length of the reservoir is ~4 km, the maximum width is ~400 m. The Taishir Reservoir corresponds to the river type of valley reservoirs, while the Durgun Reservoir combines the features of the basin and canyon reservoirs: it is constructed on a channel flowing out of the lake, but its back end level does not extend to the source, it is almost without a shallow littoral zone and is enclosed in a narrow gorge.

The functioning of reservoirs is associated with significant human impact on their ecosystems, as they are usually built in densely populated and intensively developing regions (Datsenko, 2007). The Tayshir and Durgun reservoirs are an exception, they are located in territories that do not have a high population density, and lack significant human impact. This makes them convenient objects for studying the role of a number of natural environmental factors that determine the state of hydrobiocenoses and the ecological state of water bodies of this type. However, irrespective of the degree of human impact on the reservoir catchment area, the reservoirs are fundamentally different from natural reservoirs in having significant and artificially regulated daily, annual and interannual fluctuations in the water level that affect the overall biology of these water bodies. With large fluctuations in the level, a periodically flooded and drained zone is formed in the reservoirs, the water regime of which is capable of changing the biogenic load on the reservoir (Edelshtein et al., 2005; Kuzin and Shtagman, 1972). At the same time, the level patterns and biogenic load depend not only on the mode of operation of hydroelectric power stations and human impact, but also on river and slope flows. Studies of the Tayshir and Durgun reservoirs, with high intensity of seasonal and interannual changes in the level regime and the extended periodically flooded and drained littoral zone, make it possible to isolate the role of one or another factor in the formation of the biological regime of the coastal zone of quasi-natural aquatic ecosystems of arid territories. In addition, reservoirs are complexly organized systems, within comprising several hydrological zones, differing in depth, wind wave and speed regime: shallow (river), intermediate or lake-river and deep-water or lacustrine zones (Berkovich, 2012). Therefore, it is of particular interest to analyze the reaction of communities of different sites of reservoirs of different types to the influence of the same factors.

For a long time zooplankton has been successfully used as an indicator of change in the biological regime of reservoirs (Lazareva, 2010; Luferova, 1963, 1966; Mordukhai-Boltovskoy and Dzyuban, 1966; Riv'er, 1988, 1998), as its structure and functions reflect eutrophication processes (Andronikova, 1996; Lazareva, 2010), which depend on meteorological and hydrological conditions (Datsenko, 2007; Datsenko et al., 2017; Lazareva, 2010).

The purpose of this study is to describe the summer zooplankton of the coastal zone of different reservoirs of the arid zone associated with changes in the water level, the amount of atmospheric precipitation, and air temperature.

Material and methods

Studies of the Taishir Reservoir were carried out in August 2010–2017 in the coastal zone of the upstream, middle and dam zones, whereas the Durgun reservoir was studied in 2013–2015 and 2017 in the coastal zone of the upstream and dam zones (Fig. 1). At each station, from a depth of 0.2 to 0.8 m, 2–3 integral samples were collected using a bucket by filtering 50–100 liters of water through a gauze with a mesh size of 64 μm. The samples were preserved in 4% formalin; cameral processing followed the standard procedure (Mordukhai-Boltovskoy, 1975). In parallel with the sampling, the depth, temperature and electrical conductivity of the water were measured using a portable probe "YSI-85". Data on air temperature and precipitation were received from the meteorological posts of Taishir (N 46,695923°; E 96,672535°) and Durgun (N 48,325346°; E 92,806940°) somons (districts) and data on the level of reservoirs in the period from the beginning of the growing season to the time of collection were received from the power station posts. Statistical analysis included testing the normality of the Kolmogorov–Smirnov distribution, and the significance of the differences was assessed

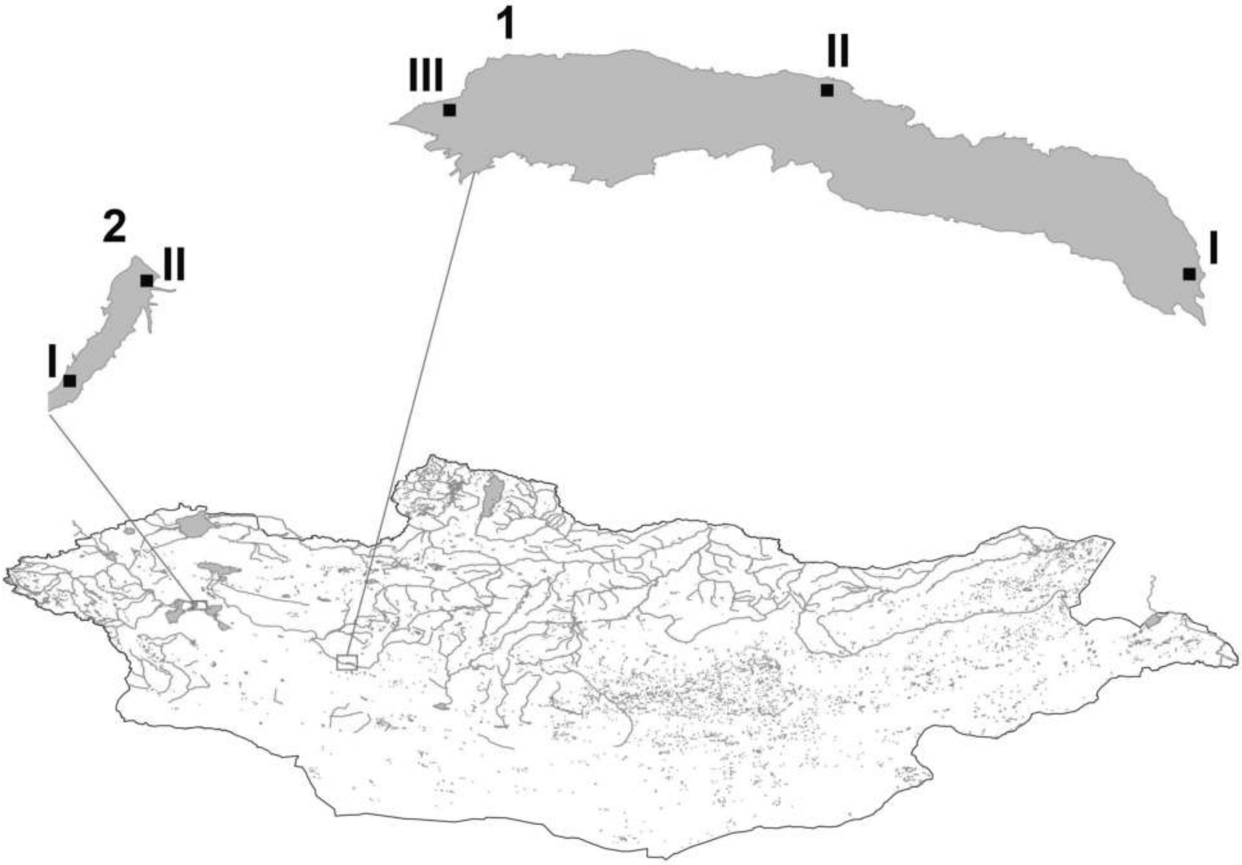

Figure 1. Location of the sampling sites in the Taishir (1) and Durgun (2) reservoirs.

using a single-factor analysis of variance ($p<0.05$, ANOVA); the Pearson correlation coefficient ($p<0.05$) was estimated.

Results

Taishir Reservoir

The period studied differed in the amount of atmospheric precipitation: the maximum values were recorded in 2011, 2015 and 2016, the minimum was in 2017 (Table 1). During the study period, an increase in the average air temperature was recorded, from April (the beginning of the season of positive temperatures) to August (Table 1). The highest average for May–August and August water levels was recorded in 2016, the lowest – in 2010 (Table 1). The maximum increase in water level in the interannual aspect was observed in 2011 and 2016, and maximum decrease in 2012, 2015 and 2017. Every year from May to August, the water level of the reservoir increased, except in 2017 when it decreased slightly.

The lowest water temperature was recorded, as a rule, in the upper part of the reservoir (except in 2017), and the highest in the middle zone (except for 2017), although no significant differences between the sites were observed during the period under study (Table 2). In general, the highest temperatures were recorded in the reservoir in 2011–2013, in 2014 it was significantly lower relative to the data in 2012 (p=0.032) and 2013 (0.026), in 2015 – relative to data in 2011 (p=0.031), 2012 (0.016), 2013 (0.013), in 2016 – relative to the data in 2011 (p=0.039), 2012 (0.021), 2013 (0.017), and in 2017 – relative to the data in 2011 (p=0.003) as well as in 2012 and 2013 (0.001).

The lowest interannual variations in water temperature were typical of the downstream zone of the reservoir, and the highest were observed in the upstream zone. The minimum water conductivity was recorded in the upstream zone of the reservoir (Table 2), and the differences with the middle and downstream zones were significant (p=0.002 and 0.0005, respectively). The smallest difference in the electrical conductivity of water between reservoir sections was noted in 2016, the largest average value for the reservoir was registered in 2015 and it is significantly higher than in 2010 (p=0.045).

The number of species of zooplankton in the sample varied from 6 to 15; the assemblage was dominated by rotifers (on the average 61–69% of the species composition) (Table 3). On the longitudinal profile of the reservoir, no significant differences in the number of species were observed during the

Parameter		Year							
		2010	2011	2012	2013	2014	2015	2016	2017
Precipitation, mm	Total January–August	95.1	136.8	80.3	87.4	107.3	133.4	126.9	69.4
	Total April–July	60.1	99.3	46.9	73.6	84.8	78.4	103.4	35.3
	Total April–August	87.8	119.4	79.1	81.1	99.4	121.9	119.2	64.2
The average monthly temperature, ºC	April	0.0	5.8	2.8	4.5	5.2	4.7	5.2	6.7
	May	10.4	9.9	12.5	12.7	10.2	10.8	9.1	13.8
	June	18.3	17.5	18.9	17.3	16.9	16.5	17.6	20.2
	July	20.1	18.8	18.6	18.2	21.3	20.5	21.0	22.4
	August	15.2	17.2	16.1	17.1	16.2	18.1	18.0	17.2
	Mean April–August	12.8	13.8	13.8	13.9	13.9	14.1	14.2	16.0
Level, m	May	1683.9	1694.1	1697.4	1697.6	1699.4	1697.7	1699.1	1700.8
	June	1687.5	1696.0	1698.6	1698.3	1700.2	1697.6	1703.2	1701.3
	July	1691.0	1700.0	1698.4	1698.8	1701.1	1698.0	1704.6	1701.1
	August	1693.3	1701.6	1699.0	1699.7	1701.3	1699.0	1704.5	1700.7
	Mean May–August	1688.9	1697.9	1698.3	1698.6	1700.5	1698.1	1702.9	1701.0
	Difference between May and August	9.4	7.5	1.6	2.1	1.8	1.3	5.3	−0.2
	Mean difference May–August	3.1	2.5	0.5	0.7	0.6	0.4	1.8	−0.1
	Mean difference from the previous year	4.0	8.3	−2.6	0.7	1.6	−2.3	5.5	−3.8

Table 1. The amount of precipitation, air temperature (data of the meteorological station of Taishir Somon) and the level of the Taishir Reservoir (data from the Taishir Power Station).

study period, although the number of Rotifera species decreased from the upstream to the downstream zone and that of Copepoda increased. The number of species of Cladocera was highest in the zooplankton of the middle zone, while the total abundance of Cladocera was the highest in the upstream and middle zones. The greatest interannual variation in the number of species of rotifers was observed in the downstream zone, the lowest in the middle zone and those of the crustaceans was observed in the upstream and downstream zones, respectively. In general, the reservoir showed significant interannual differences in the number of Copepoda species in 2012 and 2015 (p=0.043), Cladocera in 2010, 2011 and 2014 (p=0.013), as well as in 2016, 2010 and 2011 (p=0.021).

The abundance of zooplankton varied from 0.32 to 87 thousand specimens/m^3 (Table 4). The highest density was more often observed in the upstream and middle zones, although in general during the period of study no significant differences in the longitudinal profile were observed. The zooplankton and rotifers increased in abundance from the upstream to the downstream zones, while the abundance of Cladocera decreased. The maximum variation in the Rotifera abundance was in the downstream zone of the reservoir, and the minimum in the upstream zone, of Copepoda in the upstream and downstream, respectively, of Cladocera in the middle and downstream zones, and the maximum variance of the total abundance was in the downstream and middle zones. In general, the density of Copepoda in the reservoir in 2016 was significantly higher than in 2010 (p=0.043), 2011 (p=0.015) and 2014 (p=0.021). In addition, in 2016 Cladocera density was significantly higher than in 2010 (p=0.002), 2011 (0.002), 2012

Zone	Year	Temperature, ºC	Electrical conductivity, μS/cm
I	2010	16.8	110.0
	2011	19.2	101.0
	2012	20.1	148.0
	2013	21.6	141.0
	2014	16.8	165.0
	2015	17.1	140.0
	2016	18.3	190.0
	2017	16.0	155.0
	M±SD	18.2±1.9	143.8±28.6
	Cv	10.6	19.9
II	2010	20.4	137.0
	2011	21.1	154.0
	2012	22.4	211.5
	2013	21.5	221.0
	2014	19.2	265.0
	2015	18.8	272.0
	2016	18.8	198.0
	2017	16.2	210.0
	M±SD	19.8±2.0	208.6±47.2
	Cv	9.9	22.6
III	2010	19.6	180.0
	2011	21.0	194.0
	2012	19.8	200.0
	2013	19.5	239.0
	2014	19.1	235.0
	2015	18.1	266.0
	2016	17.3	195.0
	2017	18.1	250.0
	M±SD	19.1±1.2	219.9±31.4
	Cv	6.2	14.3
IV	2010	18.9±1.9	142.3±35.3
	2011	20.4±1.1	149.7±46.7
	2012	20.8±1.4	186.5±33.8
	2013	20.9±1.2	200.3±52.2
	2014	18.4±1.4	221.7±51.3
	2015	18.0±0.9	226.0±74.5
	2016	18.1±0.8	194.3±4.0
	2017	16.8±1.2	205.0±47.7

Table 2. Temperature and electrical conductivity of water in the investigated sections of the Taishir Reservoir (during the study period). Note: I – the upstream zone of the reservoir, II – the middle zone of the reservoir, III – the downstream zone of the reservoir, IV – total for the reservoir.

(0.005), 2013 (0.009), 2014 (0.011), 2015 (0.002) and 2017 (0.003).

No significant differences in the Shannon index, calculated for abundance, were not found between the reservoir zones, but it tended to decrease from the upstream to downstream zones (Table 5). The highest interannual variation of values was found in the downstream zone, while the lowest was recorded in the middle zone. In total, during the study period, there was an increase in the index, with small declines in 2015 and 2017.

The dominant organisms in the upstream zone

Zone	Year	Rotifera	Copepoda	Cladocera	Total
I	2010	10	0	0	10
	2011	5	0	1	7
	2012	9	1	1	11
	2013	9	2	4	15
	2014	7	1	6	14
	2015	11	0	0	11
	2016	6	4	5	15
	2017	5	2	3	10
	M±SD	7.8±2.3	1.3±1.4	2.5±2.3	11.6±2.8
	Cv	29.9	111.1	93.2	24.3
II	2010	6	0	0	6
	2011	7	2	1	10
	2012	4	4	2	10
	2013	6	1	3	10
	2014	7	2	6	15
	2015	10	0	4	14
	2016	6	3	5	14
	2017	8	2	4	14
	M±SD	6.8±1.8	1.8±1.4	3.1±2.0	11.6±3.1
	Cv	26.0	79.4	65.0	26.8
III	2010	8	3	2	13
	2011	8	1	0	9
	2012	2	5	2	9
	2013	5	4	2	11
	2014	7	3	1	10
	2015	4	2	2	8
	2016	8	0	2	10
	2017	11	3	1	15
	M±SD	6.6±2.8	2.6±1.6	1.5±0.8	10.6±2.3
	Cv	42.6	60.9	50.4	21.9
IV	2010	8.0±2.0	1.0±1.7	0.7±1.2	9.7±3.5
	2011	6.7±1.5	1.0±1.0	0.7±0.6	8.7±1.5
	2012	5.0±3.6	3.3±2.1	1.7±0.6	10.0±1.0
	2013	6.7±2.1	2.3±1.5	3.0±1.0	12.0±2.6
	2014	7.0±0.0	2.0±1.0	4.3±2.9	13.0±2.6
	2015	8.3±3.8	0.7±1.2	2.0±2.0	11.0±3.0
	2016	6.7±1.2	2.3±2.1	4.0±1.7	13.0±2.6
	2017	8.0±3.0	2.3±0.6	2.7±1.5	13.0±2.6

Table 3. Number of zooplankton species in the Taishir Reservoir during the study period.
Note: I – the upstream zone of the reservoir, II – the middle zone of the reservoir, III – the downstream zone of the reservoir, IV – total for the reservoir.

of the reservoir include *Euchlanis dilatata* Ehrenberg (2010–2016), *E. deflexa* Gosse (2010), *E. meneta* Myers (2011), *Trichotria pocillum* Müller (2011), *Brachionus calyciflorus* Pallas (2010, 2016), *B. quadridentatus* Ehrenberg (2012, 2016), *Lecane luna* (Müller) (2012), *L. mira* Murray (2010), *Kellicottia longispina* (Kellicott.) (2014, 2017), *Keratella quadrata* (Müller) (2017), *Asplanchna brightwelli* Gosse (2017), *Filinia longiseta* (Ehrenberg) (2017), nauplii (2012, 2013) and copepodites (2017) of Cyclopoida, *Eucyclops serrulatus* (Fischer) (2012), *Cyclops abyssorum* (G.O. Sars) (2016), *Chydorus sphaericus* (O.F. Müller) (2013), *Daphnia (D. (D.) galeata* G.O. Sars, *D. (D.) hyalina* Leydig., *D. (D.) galeata×D. (D.) hyalina* (2014), *Alona affinis* (Leydig) (2014), *Bosmina (Bosmina) longirostris* (O.F. Müller) (2016).

The middle zone was dominated by *Euchlanis meneta* (2013), *Brachionus quadridentatus* (2010), *Filinia longiseta* (2012, 2015), *Polyarthra vulgaris* Carlin (2010), *Kellicottia longispina* (2014), *Keratella cochlearis* (Gosse) (2015), *Asplanchna brightwelli* (2014, 2017), nauplii of Cyclopoida (2012, 2013, 2015, 2017), copepodites of Cyclopoida (2013), *Bosmina (B.) longirostris* (2013, 2016), *Daphnia* (2012, 2014), and *Leptodora kindtii* (Focke) (2016).

The samples from the downstream zone were dominated by *Polyarthra vulgaris* (2010), *Kellicottia longispina* (2011, 2014), *Conochilus hippocrepis* (Schrank) (2014), *C. unicornis* Rousselet (2011), *Keratella cochlearis* (2013), *Asplanchna brightwelli* (2017), *Filinia longiseta* (2017), nauplii of Cyclopoida (2011–2016), copepodites of Cyclopoida (2015), *Chydorus sphaericus* (2013), *Bosmina (B.) longirostris* (2016), and *Daphnia* (2012).

The biomass of zooplankton varied from 0.001 to 1.17 g/m^3 (Table 4). As a rule, in most cases, its maximum value was typical for the middle part of the reservoir, but for the whole period between the upstream and middle zones the differences in biomass were insignificant. The minimum biomass (4.5 times lower on the average) was noted in the dam zone. Along the longitudinal profile of the reservoir the biomass of rotifers tended to increase and that of crustaceans to decrease. Rotifera biomass in 2017 significantly exceeded the values recorded in previous years (p=0.004 (2010), 0.001 (2011, 2012), 0.002 (2013–2015, 2017)). In 2016, the total biomass of zooplankton was the greatest (p=0.005 (2010, 2015), 0.004 (2011), 0.011 (2012), 0.006 (2013), 0.013 (2017)), Copepoda (p=0.004 (2010, 2013–2015, 2017), 0.003 (2011), 0.005 (2012)) and Cladocera (p=0.015 (2010, 2017), 0.014 (2011, 2015), 0.038 (2012), 0.017 (2013)). The largest interannual variation of the biomass of zooplankton, Copepoda and Cladocera was recorded in the middle and upstream zones, the lowest variation was recorded in the downstream zone, and Rotifera in the downstream and upstream, respectively.

According to the value of the Shannon index, calculated for the biomass, there were no significant differences between coastal zones along the longitudinal profile of the reservoir, although the downstream zone showed a trend towards its increase (Table 5). The minimum interannual variation of the index was observed in the downstream zone, and the maximum in the upstream and middle zones. The highest average for the reservoir is the value of the index in 2013, the lowest was recorded in 2017, the differences between them being significant (p=0.048).

In the upstream zone the following taxa were dominant in their biomass: *Euchlanis dilatata* (2011–2015), *E. meneta* (2011), *Brachionus calyciflorus* (2010), *Asplanchna girodi* Guerne (2010), *Asplanchna brightwelli* (2017), *Cyclops abyssorum* (2016), *Eucyclops serrulatus* (2012), *Chydorus sphaericus* (2013), and *Daphnia* (2014, 2015).

The middle zone was dominated by *Brachionus quadridentatus* (2010), *Asplanchna brightwelli* (2014, 2015, 2017), nauplii of Cyclopoida (2013, 2015), copepodites of Cyclopoida (2013), *Cyclops abyssorum* (2016), *Bosmina (B.) longirostris* (2013), *Daphnia* (2012, 2014, 2015), and *Leptodora kindtii* (2016).

The downstream zone was dominated by *Polyarthra vulgaris* (2010), *Asplanchna brightwelli* (2011, 2017), nauplii of Cyclopoida (2013), copepodites of Cyclopoida (2015), *Acanthodiaptomus denticornis* Wierzejski (2014), *Cyclops strenuus* (Fischer) (2011), *Eudiaptomus graciloides* Lilljeborg (2015), *Chydorus sphaericus* (2013), *Bosmina (B.) longirostris* (2016), and *Daphnia* (2012, 2015).

The longitudinal profile of the reservoir showed a tendency to decrease the ratio of the number of Cladocera and Copepoda crustaceans, although the differences were not significant (Table 5). The largest interannual variations of the parameter were characteristic of the upstream zone of the reservoir, and the lowest for the middle zone. The minimum N_{Clad}/N_{Cop} values were registered in 2010 and 2015, the maximum was recorded in 2014 and it was significantly higher than in 2010 (p=0.018), 2011 (p=0.028), 2012 (p=0.045), 2013 (p=0.035), 2015 (p=0.017), and 2017 (p=0.019) yrs.

There were no significant differences in the ratio of the biomass of crustaceans and rotifers along the longitudinal profile of the reservoir, although there was a noticeable increase from the upstream to the downstream of the reservoir (Table 5). In addition, along the longitudinal profile of the reservoir, the coefficient of variation of its values increased. The minimum values were registered in 2017 and 2010, the maximum values in 2012.

Based on the trophic index (Myaemets, 1980),

Zone	Year	Number, thousand specimens/m³				Biomass, g/m³			
		Rot	Cop	Clad	Total	Rot	Cop	Clad	Total
I	2010	0.3	0.0	0.0	0.3	0.001	0.000	0.000	0.001
	2011	1.9	0.0	0.0	1.9	0.003	0.000	0.000	0.003
	2012	0.6	0.3	0.0	0.9	0.001	0.002	0.000	0.003
	2013	7.6	2.5	3.1	13.2	0.016	0.013	0.023	0.051
	2014	4.1	0.4	5.5	10.0	0.006	0.009	0.697	0.711
	2015	3.4	0.1	0.0	3.5	0.007	0.000	0.000	0.007
	2016	10.2	7.4	12.8	30.4	0.017	0.469	0.543	1.028
	2017	3.8	1.0	0.1	4.9	0.019	0.004	0.001	0.024
	M±SD	4.0±3.4	1.5±2.5	2.7±4.5	8.1±10.0	0.009±0.008	0.062±0.164	0.158±0.288	0.229±0.405
	Cv	85.9	172.6	169.5	123.6	86.0	265.4	182.4	177.1
II	2010	4.3	0.0	0.0	4.3	0.016	0.000	0.000	0.016
	2011	1.9	0.9	1.1	3.9	0.005	0.002	0.009	0.016
	2012	2.3	1.2	3.6	7.0	0.002	0.020	0.231	0.253
	2013	1.6	3.3	2.5	7.4	0.004	0.008	0.021	0.033
	2014	2.4	0.3	0.9	3.7	0.014	0.003	0.069	0.087
	2015	6.2	2.4	0.2	8.7	0.004	0.004	0.005	0.013
	2016	1.0	4.4	20.0	25.3	0.002	0.233	0.937	1.172
	2017	13.0	3.6	0.8	17.4	0.097	0.012	0.013	0.122
	M±SD	4.1±4.0	2.0±1.6	3.6±6.7	9.7±7.7	0.018±0.032	0.035±0.080	0.161±0.323	0.214±0.396
	Cv	97.9	81.1	185.2	79.4	179.6	226.9	200.9	184.9

Zone	Year	Number, thousand specimens/m³				Biomass, g/m³			
		Rot	Cop	Clad	Total	Rot	Cop	Clad	Total
III	2010	83.4	3.2	0.4	87.0	0.034	0.011	0.025	0.070
	2011	0.4	0.1	0.0	0.4	0.000	0.001	0.000	0.001
	2012	0.1	2.0	0.5	2.5	0.000	0.016	0.045	0.061
	2013	1.0	1.9	0.9	3.7	0.001	0.007	0.006	0.015
	2014	6.1	1.0	0.5	7.7	0.003	0.008	0.004	0.015
	2015	0.2	2.1	0.1	2.4	0.000	0.012	0.004	0.015
	2016	0.4	0.3	0.5	1.1	0.000	0.001	0.003	0.004
	2017	20.1	0.8	0.0	20.9	0.196	0.010	0.002	0.208
	M±SD	13.9±28.9	1.4±1.1	0.3±0.3	15.7±29.5	0.029±0.068	0.008±0.005	0.011±0.016	0.049±0.069
	Cv	207.1	74.9	83.4	188.2	232.5	64.5	142.2	142.5
IV	2010	29.3±46.9	1.1±1.8	0.1±0.2	30.5±48.9	0.017±0.017	0.004±0.006	0.008±0.014	0.029±0.036
	2011	1.4±0.9	0.3±0.5	0.4±0.6	2.1±1.7	0.003±0.002	0.001±0.001	0.003±0.005	0.007±0.008
	2012	1.0±1.1	1.2±0.9	1.4±1.9	3.5±3.1	0.001±0.001	0.013±0.010	0.092±0.122	0.106±0.131
	2013	3.4±3.7	2.5±0.7	2.1±1.2	8.1±4.8	0.007±0.008	0.009±0.003	0.017±0.009	0.033±0.018
	2014	4.2±1.9	0.6±0.4	2.3±2.8	7.1±3.2	0.008±0.006	0.007±0.003	0.256±0.383	0.271±0.383
	2015	3.2±3.0	1.5±1.2	0.1±0.1	4.8±3.4	0.004±0.004	0.005±0.006	0.003±0.003	0.012±0.004
	2016	3.9±5.5	4.0±3.6	11.1±9.9	18.9±15.6	0.006±0.009	0.234±0.234	0.494±0.469	0.735±0.637
	2017	12.3±8.2	1.8±1.5	0.3±0.4	14.4±8.4	0.104±0.088	0.009±0.005	0.006±0.007	0.118±0.092

Table 4. Number and biomass of zooplankters of the Taishir Reservoir during the research period.
Note: I – the upstream zone of the reservoir, II – the middle zone of the reservoir, III – the downstream zone of the reservoir, IV – total for the reservoir.
Rot – Rotifera, Cop – Copepoda, Clad – Cladocera.

all the studied sites were annually characterized as eutrophic, but in 2012 and 2013, in the downstream zone, the species composition of the zooplankton characterized mesotrophic conditions, and in 2016 and 2017 hypertrophic conditions were recorded. Hypertrophic conditions were observed in 2011–2013 and 2017 in the upstream zone, and in 2012, 2013 and 2015 in the middle zone (Table 5). In general, the reservoir trophic index in 2010, 2013 and 2014 corresponded to the values typical of eutrophic waters

Zone	Year	H_N, bit/specimen	H_B, bit/g	N_{Clad}/N_{Cop}	B_{Crust}/B_{Rot}		w, g/specimen
I	2010	3.12	2.01	—	0.00	—	0.0031
	2011	1.49	1.15	0.50	0.03	5.0	0.0018
	2012	3.18	1.97	0.08	2.26	13.5	0.0027
	2013	3.05	2.76	1.23	2.21	4.5	0.0039
	2014	3.17	0.36	14.67	126.62	1.9	0.0711
	2015	1.40	0.87	0.00	0.02	—	0.0021
	2016	3.22	2.14	1.73	60.23	1.3	0.0339
	2017	2.71	1.50	0.10	0.25	5.0	0.0049
	M±SD	2.67±0.77	1.60±0.78	2.29±5.04	23.95±46.42	5.2±4.4	0.015±0.025
	Cv	28.9	48.6	204.7	193.8	83.7	161.7
II	2010	1.99	0.77	—	0.00	—	0.0036
	2011	1.98	1.54	1.17	2.51	4.0	0.0042
	2012	2.19	0.72	3.04	101.22	5.0	0.0361
	2013	2.46	2.04	0.76	7.17	4.5	0.0045
	2014	2.90	1.17	3.08	4.99	4.0	0.0238
	2015	2.98	2.97	0.06	2.40	12.5	0.0014
	2016	2.35	1.63	4.57	606.74	1.5	0.0463
	2017	2.85	1.67	0.23	0.27	4.0	0.0071
	M±SD	2.46±0.41	1.56±0.73	1.61±1.72	90.66±211.36	5.1±3.5	0.016±0.017
	Cv	16.5	46.6	93.5	233.1	68.2	109.0
III	2010	0.60	2.02	0.12	1.06	1.6	0.0008
	2011	3.14	1.92	0.00	1.99	4.0	0.0030
	2012	1.90	1.60	0.24	3061.25	0.3	0.0243
	2013	2.45	2.84	0.46	10.02	0.8	0.0042
	2014	2.22	2.63	0.49	4.51	2.6	0.0019
	2015	2.01	2.39	0.05	298.79	2.0	0.0064
	2016	2.86	1.76	1.77	7.55	10.7	0.0035
	2017	1.50	0.71	0.03	0.06	11.0	0.0100
	M±SD	2.08±0.80	1.98±0.67	0.39±0.59	423.15±1070.93	4.1±4.3	0.007±0.008
	Cv	38.2	33.9	148.8	253.1	104.0	112.9
IV	2010	1.90±1.26	1.60±0.72	0.04±0.07	0.35±0.61	1.60±0.00	0.002±0.0015
	2011	2.20±0.84	1.54±0.38	0.56±0.59	1.51±1.31	4.33±0.58	0.003±0.0012
	2012	2.42±0.67	1.43±0.64	1.12±1.67	1054.91±1738.24	6.26±6.70	0.021±0.0169
	2013	2.65±0.34	2.55±0.44	0.82±0.39	6.47±3.95	3.28±2.12	0.004±0.0003
	2014	2.76±0.49	1.39±1.15	6.08±7.55	45.38±70.36	2.85±1.05	0.032±0.0354
	2015	2.13±0.80	2.08±1.08	0.04±0.03	100.41±171.81	7.25±7.42	0.003±0.0027
	2016	2.81±0.44	1.84±0.27	2.69±1.63	224.84±331.78	4.50±5.34	0.028±0.0220
	2017	2.35±0.74	1.29±0.52	0.12±0.10	0.19±0.11	6.67±3.79	0.007±0.0025

Table 5. The Shannon indexes calculated for numbers (H_N) and biomass (H_B), ratios of the number of cladoceran and copepod crustaceans (N_{Clad}/N_{Cop}), biomass of crustaceans and rotifers (B_{Crust}/B_{Rot}), eutrophication index (E) and mean individual weight of zooplankters (w) of the Taishir Reservoir.

Note: I – the upstream zone of the reservoir, II – the middle zone of the reservoir, III – the downstream zone of the reservoir, IV – total for the reservoir.

in 2011, 2012 and 2015–2017 of the hypertrophic conditions. In general, for all the years, the species composition of zooplankton indicated hypertrophic conditions, and a tendency was observed to decrease the coefficient along the longitudinal profile of the reservoir. The minimal coefficient of variation is noted in the middle zone, and the maximum in the downstream zone.

The average individual mass of zooplankton organisms along the longitudinal profile of the reservoir did not differ significantly, but its lowest values were recorded in the lower part (Table 5). In the period 2010–2012, in general for the reservoir, the mass increased, and decreased in 2013, 2015 and 2017. In 2014, the individual mass of organisms was significantly higher than in 2010 (p=0.036), 2011 (p=0.039), 2013 (p=0.046) and 2015 (p=0.041). The greatest coefficient of variation of this indicator was noted in the upstream zones.

Durgun Reservoir

The highest atmospheric precipitation was recorded in 2015 (2.3 times the average recorded in other years) (Table 6). In the period under study, it was found that the maximum air temperatures were recorded in July 2015 and 2017 (Table 6). The highest average air temperature for April–August was registered in 2017, and the lowest in 2014.

The maximum water level in the reservoir was observed in May or August (except in 2012 – in July), although the difference between these months did not exceed 0.1 m on average, the average monthly changes were on average 0.05 m, and interannual 0.12 m (Table 6). The water temperature in the upper part of the reservoir in 2013–2015 was lower than in the downstream zone, while in 2017 it did not differ (Table 7). In general for the reservoir, the maximum water temperature was observed in 2014, the minimal temperature was observed in 2017, and it significantly differed from the values of 2014 (*p*=0.014) and 2015 (*p*=0.029). The electrical conductivity of water along the longitudinal profile was practically unchanged (Table 7), however, significant annual differences were recorded: in 2013, relative to 2014 data (*p*=0.013), 2015 (0.000001), 2017 (0.00002) in 2014, relative to the data for 2015

Parameter		Year				
		2012	2013	2014	2015	2017
Precipitation, mm	Total January–August	36.5	37.7	42.6	68.3	31.2
	Total April–July	27.6	20.0	21.0	48.6	20.0
	Total April–August	35.9	26.2	30.1	65.1	30.9
Temperature, ºC	April	6.5	7.1	7.3	7.7	9.8
	May	13.7	13.9	11.5	15.3	17.1
	June	22.3	18.8	19.4	18.7	23.3
	July	23.2	22.2	22.8	24.4	24.9
	August	18.2	20.0	19.2	21.0	19.5
	Mean April–August	16.8	16.4	16.0	17.4	18.9
Level, m	May	1159.1	1159.2	1159.4	1159.0	1159.1
	June	1159.0	1159.1	1159.1	1158.9	1159.0
	July	1159.6	1159.1	1159.1	1158.8	1159.1
	August	1158.9	1159.2	1159.1	1159.0	1159.2
	Mean for May–August	1159.1	1159.2	1159.2	1158.9	1159.1
	Difference between May and August	0.19	0.07	0.24	0.09	−0.09
	Mean difference between May and August	−0.06	−0.02	−0.08	−0.13	0.03
	Mean difference with the previous year	−0.08	0.01	0.01	−0.25	−0.28

Table 6. The amount of precipitation, air temperature (data from the Durgun Somon meteorological station) and the level of the Durgun Reservoir (data of the Durgun Power Station).

(*p*=0.000001) and 2017 (0.00001) in 2015 against the data for 2017 (*p*=0.00002).

The number of species of zooplankton in the sample ranged from 11 to 30, and usually, the total number of zooplankton was larger in the dam portion, although the differences were not significant (Table 8). The lowest coefficients of variation in the total number of species and all taxonomic groups of zooplankton were recorded in the downstream zone of the reservoir. In total, the highest number of Copepoda species was detected in 2013 and it significantly differed from the values in 2014 (*p*=0.007), 2015 (*p*=0.007) and 2017 (*p*=0.016). In 2013, there were also the largest number of Cladocera species and the total number of species, and the differences were significant relative to the data for 2014 (*p*=0.011 and 0.011, respectively) and 2015 (*p*=0.009 and 0.026, respectively).

The abundance of zooplankton during the study period ranged from 10.5 to 30.5 thousand specimens/m^3 (Table 9). Every year the difference between the density of organisms in the upstream and downstream zones of the reservoir was insignificant (1.6 times on average). The minimal abundance of zooplankton was recorded in 2017, whereas the maximum was recorded in 2013, although the differences were not significant. There were also no differences in the coefficients of variation in the total abundance of zooplankton in the upstream and downstream zones. The maximum number of rotifers recorded in 2015 was significantly higher than in 2013 (*p*=0.005), 2014 (*p*=0.0006) and 2017 (*p*=0.0007), in addition, significant differences were observed between the values recorded in 2013 and 2014 (*p*=0.012) as well as in 2013 and 2017 (*p*=0.017). The coefficient of variation in the number of rotifers was higher in the dam zone of the reservoir. The largest number of copepods was found in 2014 and it was significantly higher than in 2013 (*p*=0.027), 2015 (*p*=0.007) and 2017 (*p*=0.010). No significant interannual differences in the abundance of Cladocera were detected, but their minimum number was recorded in 2015, while the maximum was recorded in 2013. The smallest coefficient of variation in the density of Copepoda and Cladocera was recorded in the downstream zone of the reservoir.

By the value of the Shannon index, calculated for the abundances (numbers), there were no significant differences between the reservoir sites and in different years, but most often the values were higher in the downstream zone, and the maximum values were recorded in 2015 and 2017 (Table 10).

In terms of numbers, the upstream zone was dominated by *Lecane (□onostyla) quadridentata* (Ehrenberg) (2013), *Brachionus angularis* Gosse (2014, 2015), *Polyarthra vulgaris* (2015), *Trichocerca longiseta* (Schrank) (2015), juvenile Cyclopoida (2013, 2014, 2017), *Bosmina (B.) longirostris* (2013, 2014).

The downstream zone was dominated by Trichocerca pusilla (Lauterborn) (2013), Keratella

Zone	Year	Temperature, ºC	Electrical conductivity, µS/cm
I	2013	18.5	227.0
	2014	21.5	230.0
	2015	20	171.0
	2017	17.4	199.4
	M±SD	19.4±1.8	206.9±27.6
	Cv	0.08	10.9
II	2013	20	226.0
	2014	22.9	233.0
	2015	22.6	172.0
	2017	17.4	199.5
	M±SD	20.7±2.6	207.6±27.8
	Cv	0.08	10.9
III	2013	19.3±1.1	226.5±0.7
	2014	22.2±1.0	231.5±2.1
	2015	21.3±1.8	171.5±0.7
	2017	17.4±0.0	199.5±0.1

Table 7. Temperature and electrical conductivity of water in the studied sections of the Durgun Reservoir (during the study period). Note: I – the upstream zone of the reservoir, II – the downstream zone of the reservoir, III – total for the reservoir.

Zone	Year	Rotifera	Copepoda	Cladocera	Total
I	2013	12	3	13	28
	2014	7	0	4	11
	2015	10	0	1	11
	2017	16	0	6	22
	M±SD	11.3±3.8	0.8±1.5	6.0±5.1	18.0±8.4
	Cv	33.6	200.0	85.0	46.9
II	2013	17	2	11	30
	2014	11	0	3	14
	2015	16	0	5	21
	2017	12	1	9	22
	M±SD	14.0±2.9	0.8±1.0	7.0±3.7	21.8±6.6
	Cv	21.0	127.7	52.2	30.1
III	2013	14.5±3.5	2.5±0.7	12.0±1.4	29.0±1.4
	2014	9.0±2.8	0.0±0.0	3.5±0.7	12.5±2.1
	2015	13.0±4.2	0.0±0.0	3.0±2.8	16.0±7.1
	2017	14.0±2.8	0.5±0.7	7.5±2.1	22.0±0.0

Table 8. Number of species of zooplankton in the Durgun Reservoir during the study period.
Note: I – the upstream zone of the reservoir, II – the downstream zone of the reservoir, III – total for the reservoir.

cochlearis (2014), Testudinella patina (Herm.) (2015), Ploesoma truncatum (Levander) (2015), juvenile Cyclopoida (2013, 2014, 2017), Bosmina (B.) longirostris (2013), and Acroperus harpae (Baird) (2017).

The biomass of zooplankton varied from 0.01 to 0.46 g/m^3; there were no significant differences between the upstream and downstream zones, but there was a trend for the total biomass to decline due to Cladocera in the downstream zone of the reservoir (Table 9). There were practically no differences in the coefficients of variation of rotifer biomass during the study period in the upper and lower reaches of the reservoir, but the smallest variation in the biomass of crustaceans and the total biomass of zooplankton was characteristic of the communities of the dam area. In general, the maximum biomass of Rotifera was recorded in the reservoir in 2015 and 2017, and the minimum in 2014, but no significant differences were found. The lowest biomass of Copepoda was recorded in 2015 and significantly differed from the values of 2013 (p=0.026) and 2017 (p=0.031). The maximum total biomass and maximum Cladocera biomass was recorded in 2013, while the minimum was in 2015, but the interannual differences were not significant.

Downstream, along the longitudinal profile, the Shannon index calculated for the biomass increased, but no significant differences were found (Table 10). In general for the reservoir, significant differences were found between the species diversity of zooplankton in 2015 and 2017 (p=0.041).

In terms of biomass the upstream zone was dominated by *Bosmina (B.) longirostris* (2013, 2014, 2017), *Campocercus uncinatus* Smirnov (2013), *Pleuroxus truncatus* (Müller) (2013), *Scapholeberis mucronata* (O.F. Müller) (2013), *Daphnia* (2014), *Eurycercus (Eurycercus) lammelatus* (O.F. Müller) (2014), *Ceriodaphnia affinis* Lilljeborg (2017), nauplii of Cyclopoida (2015), *Alonella nana* (Baird) (2015), *Brachionus angularis* (2015), *Polyarthra vulgaris* (2015), and *Asplanchna brightwelli* (2017).

The downstream zone was dominated by *Lecane (Monostyla) crenata* (Harring) (2015), juvenile Cyclopoida (2014), *Campocercus uncinatus* (2013), *Ceriodaphnia reticulata* (Jurine) (2013, 2014), *Bosmina (B.) longirostris* (2013, 2014), and *Acroperus harpae* (2013, 2017).

N_{Clad}/N_{Cop} and B_{Crust}/B_{Rot} values in 2013 and 2014 in the lower reaches decreased, in 2015 and 2017, on the contrary, they increased, and on average during the study period they were less abundant in the dam area (Table 10). Zooplankton of the upper part of the reservoir was characterized by higher coefficients of variation N_{Clad}/N_{Cop} and B_{Crust}/B_{Rot}. There were no significant interannual differences of these values; the highest values of the former coefficient were observed in 2013 and 2017,

Zone	Year	Number, thousand specimen/m³				Biomass, g/m³			
		Rot	Cop	Clad	Total	Rot	Cop	Clad	Total
I	2013	11.6	4.6	14.3	30.5	0.013	0.024	0.206	0.243
	2014	5.1	10.1	8.4	23.6	0.002	0.013	0.084	0.099
	2015	16.5	1.0	0.3	17.8	0.007	0.001	0.002	0.010
	2017	5.1	3.2	2.5	10.7	0.014	0.005	0.021	0.040
	M±SD	9.6±5.5	4.7±3.9	6.3±6.3	20.7±8.4	0.009±0.005	0.011±0.010	0.078±0.092	0.098±0.103
	Cv	57.8	82.3	99.5	40.8	59.9	93.6	117.7	105.1
II	2013	9.0	3.9	3.1	16.0	0.006	0.015	0.050	0.071
	2014	4.1	7.4	1.3	12.8	0.005	0.009	0.010	0.025
	2015	19.0	3.3	3.3	25.5	0.018	0.009	0.035	0.062
	2017	5.2	2.3	3.0	10.5	0.010	0.007	0.051	0.068
	M±SD	9.3±6.8	4.2±2.2	2.6±0.9	16.2±6.6	0.010±0.006	0.010±0.004	0.036±0.019	0.056±0.021
	Cv	72.6	52.7	35.3	40.9	61.8	36.3	52.1	38.1
III	2013	10.3±1.8	4.3±0.5	8.7±7.9	23.3±10.3	0.009±0.005	0.020±0.006	0.128±0.110	0.157±0.121
	2014	4.6±0.7	8.8±1.9	4.8±5.0	18.2±7.7	0.004±0.002	0.011±0.002	0.047±0.053	0.062±0.053
	2015	17.8±1.8	2.1±1.6	1.8±2.1	21.6±5.5	0.013±0.008	0.005±0.005	0.018±0.024	0.036±0.037
	2017	5.2±0.1	2.7±0.6	2.7±0.4	10.6±0.2	0.012±0.003	0.006±0.001	0.036±0.021	0.054±0.019

Table 9. Number and biomass of zooplankters of the Durgun Reservoir during the study period.
Note: I – the upstream zone of the reservoir, II – the downstream zone of the reservoir, III – total for the reservoir.
Rot – Rotifera, Cop – Copepoda, Clad – Cladocera.

Zone	Year	H_N, bit/specimen	H_B, bit/g	N_{Clad}/N_{Cop}	B_{Crust}/B_{Rot}	□	w, g/specimen
I	2013	3.29	2.63	3.09	18.17	1.9	0.0079
	2014	2.53	2.06	0.83	42.48	8.8	0.0042
	2015	2.44	2.85	0.25	0.40	20.0	0.0006
	2017	2.83	1.86	0.77	1.81	4.4	0.0037
	M±SD	2.77±0.38	2.35±0.46	1.23±1.26	15.71±19.58	8.8±8.0	0.0041±0.0030
	Cv	13.9	19.8	102.3	124.6	91.2	73.2
II	2013	3.16	3.26	0.79	10.92	9.2	0.0044
	2014	2.84	2.81	0.17	3.79	8.3	0.0019
	2015	3.83	3.26	1.00	2.36	12.8	0.0024
	2017	3.50	2.00	1.29	5.83	2.4	0.0064
	M±SD	3.33±0.43	2.83±0.59	0.81±0.48	5.72±3.74	8.2±4.3	0.0038±0.0020
	Cv	12.8	20.9	58.5	65.4	52.9	54.4
III	2013	3.23±0.10	2.95±0.44	1.94±1.62	14.54±5.13	5.52±5.13	0.006±0.002
	2014	2.69±0.22	2.43±0.53	0.50±0.47	23.13±27.36	8.50±0.35	0.003±0.001
	2015	3.13±0.99	3.05±0.29	0.63±0.53	1.38±1.39	16.40±5.09	0.001±0.001
	2017	3.16±0.48	1.93±0.10	1.03±0.37	3.82±2.85	3.42±1.45	0.005±0.002

Table 10. The Shannon indices calculated for numbers (H_N) and biomass (H_B), ratios of the number of cladoceran and copepod crustaceans (N_{Clad}/N_{Cop}), the biomass of crustaceans and rotifers (B_{Crust}/B_{Rot}), the eutrophication index (E) mass of zooplankters (w) of the Durgun Reservoir.
Note: I – the upstream zone of the reservoir, II – the downstream zone of the reservoir, III – total for the reservoir.

whereas the highest values of the latter were recorded in 2014.

The trophic index in the dam area was lower than in the headwaters, although on both sites it corresponded either to eutrophic or hypertrophic conditions (Table 10). The zooplankton of the upper section showed the largest variation in the trophic index. The maximum value for the reservoir was in 2015 and it was significantly higher than in 2013 (*p*=0.042) and 2017 (*p*=0.024), when its values were the lowest.

The average individual mass of zooplankton in most cases (except for 2015) and on average during the study period, was less in the lower part of the reservoir, where a lower coefficient of its variation was also noted (Table 10). There are no significant spatial and interannual differences in the values of the average individual mass.

Discussion

The study periods were characterized by different meteorological conditions, which could influence the fluctuations in the levels of reservoirs. Indeed, the correlation coefficients have been revealed, indicating that the water level in August in the Taishir reservoir was related to the amount of precipitation from April to July (*r*=0.60), as well as the level difference in May and August of the current year (*r*=0.71), the mean level difference between the months in the period from May to August (*r*=0.71), as well as the difference in levels in the current and previous years (*r*=0.94). In general, the water conductivity (*r*=−0.52) correlated with the difference in the water level in May and August, as well as in the value of its average monthly fluctuations. Similar negative coefficients were obtained separately for the mean (*r*=−0.82) and lower (*r*=−0.82) sections of the reservoir, but in the upper reaches it was positive (*r*=0.74). We assume that the upstream zone, which first receives the river waters carrying the substances from the catchment area, is characterized by shallower depths, is larger than the land area flooded by the increasing water level, and with the increase in the amount of precipitation, there is an accumulation of salt ions, which contribute to an increase in the electrical conductivity of the water. However, in the middle and downstream sections with initially higher values of electrical conductivity, the dilution effect was mainly observed, with increasing water levels.

In the Durgun Reservoir, a negative correlation was found between the water level and the amount of precipitation in January–August, April–July and April–August, on the contrary, (for the level in the period April–August: *r*=−0.79, −0.92, −0.95, respectively in August: *r*=−0.97, −0.99, −0.99). Apparently, this is due to an increase in the discharge through the power station units, the intensification of which depends on the filling of the reservoir and which, in turn, has a significant effect on the water level of a small reservoir. The increase in the electrical conductivity of water is associated with the water level in April–August (*r*=0.99), August (*r*=0.83) and the level difference with the previous year (*r*=0.87). In the upstream and downstream zones of the reservoir, the electrical conductivity of the water was associated with the average water level in April–August (*r*=0.99, 0.98, respectively).

The zooplankton of the coastal area of the Taishir Reservoir was characterized by noticeable interannual variations in quantitative indices. Analysis of correlation relationships showed that when the average for May–August level increased, the total abundance and biomass of zooplankton increased (*r*=0.42 and 0.54, respectively), the number and biomass of Copepoda (*r*=0.43 and 0.49) and Cladocera (*r*=0.57 and 0.46), the specific number of species of zooplankton (*r*=0.54) and Cladocera (*r*=0.64). Consequently, the level regime, which in the reservoir correlated with the amount of precipitation, was one of the factors determining the quantitative representation of planktonic invertebrates. In the course of a study of the plankton of the channel plains of the Mozhaisk Reservoir, it was also shown that the maximum abundance of primary producers was most connected with the flood size and the receipt of biogenic substances from the catchment area (Datsenko et al., 2017). The results of the study of the zooplankton of the Rybinsk Reservoir demonstrated an increase in the number of species in the sample and maxima of zooplankton biomass with the largest volume of water inflow (Lazareva, 2010).

In the upstream zone of the reservoir, with an increase in the average for May–August water level, changes in zooplankton were observed, characteristic of the coastal waters as a whole: the zooplankton abundance and biomass (*r*=0.83 and 0.86, respectively), Rotifera (*r*=0.83 and 0.74), Copepoda (*r*=0.93 and 0.90) and Cladocera (*r*=0.89 and 0.79); however, the share of Rotifera in total (*r*=−0.86) and biomass (*r*=−0.76) decreased, but the share of Copepoda increased (*r*=0.86) and Cladocera in the total abundance and biomass (*r*=0.89 and 0.79) increased as well. Mongolia is a country with a sharply continental climate, with significant inter-seasonal and diurnal temperature differences. Hence, the temperature of the water at the time of sampling does not provide sufficient information about the environmental conditions; analysis of air temperature during the vegetation period would be more useful. With an increase in the average monthly air temperature in the upstream zone of the reservoir, the abundance and biomass of zooplankton (*r*=0.74 and 0.71) and rotifers (*r*=0.74 and 0.95) increased.

In the middle zone of the reservoir, the direction of the zooplankton changes with increasing water level was similar: the abundance and biomass of copepods (*r*=0.79, 0.82) and Cladocera (*r*=0.81, 0.77), the total biomass of zooplankton (*r*=0.79) increased, and with an increase in the mean air temperature from April to August, an increase in the total abundance of zooplankton (*r*=0.76).

In the downstream zone of the reservoir, the direction of changes in the zooplankton was different. In particular, when the water level rose from May to August and in August, the total abundance of invertebrates (*r*=−0.85, −0.82), rotifers (*r*=−0.84, −0.82) and copepods (*r*=−0.78, −0.91), as well as biomass of zooplankton (*r*=−0.84), Copepoda (*r*=−0.86) and Cladocera (*r*=−0.76) decreased.

The results of the study of the Taishir reservoir showed that changes in the zooplankton of the coastal zone in the upstream, middle and downstream zone with increasing water level due to the increase in the amount of precipitation had different directions. From our point of view, this is explained by changes in the mineralization of water and the amount of substances accumulated in the reservoir and brought from the catchment area. This is evidenced by the fact that changes in zooplankton in the upper part of the reservoir were associated not only with the level but also with the electrical conductivity of water (total biomass (*r*=0.76), density and biomass Copepoda (*r*=0.81 and 0.83) and Cladocera (*r*=0.85 and 0.73), the share of Rotifera in the total number (*r*=−0.88) and biomass (*r*=−0.83), the share of Copepoda in the total number (*r*=0.74) and Cladocera in the total abundance and biomass (*r*=0.80 and 0.73)), however in the middle and lower sections of the reservoir, there are no significant correlation coefficients with these environmental characteristics. We attribute this to the fact that in the upper reaches, where the low-mineralized waters of the Zavkhan River increased in water level, and the area of the flooded land increased, the mineralization increased to values more optimal for zooplankton. This, along with the accumulation of substances brought by the river from the catchment area, contributed to an increase in the quantitative representation of communities. In the middle and downstream zones, atmospheric precipitation, on the contrary, caused a decrease in mineralization, but its values did not fall below the values recorded in the upstream zone. However, changes in the quantitative indicators of zooplankton in the middle and lower regions also differed: in the former they increased, and in the latter decreased. Consequently, in this case, a significant role was played not by mineralization, but by other factors, in particular, introduced and accumulated organic and biogenic substances, as well as the average depth and width of the reservoir, the prominence of the littoral zone and the distance from the feeding river.

When studying the phytoplankton of the

Mozhaisk Reservoir, it was shown that the internal load as a result of diffusion of nutrients from bottom sediments is significant only in the upstream, shallow zone of the reservoir, with more frequent mixing of bottom layers saturated with biogenes (Datsenko et al., 2017). In the Taishir reservoir, the upstream and middle zones are also shallow, have a more pronounced and extended littoral zone, and, most likely, accumulate organic and biogenic substances brought by the Zavkhan River during highstands, spring high water and pluvial floods.

At the same time, in the downstream part of the reservoir, which is characterized by maximum depth and width, a narrow band of the littoral zone, in which organic and biogenic substances accumulate to a lesser extent, partly because the waters of the Zavkhan River do not reach it even during high water, no stimulating effect of high water was recorded on quantitative development of zooplankton.

An analysis of the correlation links of the zooplankton in the Durgun Reservoir showed that when the amount of precipitation increased in the period January–August, April–July and April–August, the number of rotifers increased (r=0.85, 0.84 and 0.85, respectively), their share in the total population (r=0.72, 0.84 and 0.84) and biomass (r=0.64, 0.76 and 0.74), which is obviously associated with an increase in water flow in the Chono-Haraikh channel, which carries water from eutrophic Khar-Us Lake, whose zooplankton is characterized by a high abundance of rotifers (Krylov and Mendsajhen, 2012). In addition, as the electrical conductivity of water increased, the number of copepod crustaceans (r=0.74) increased and their share in the total number (r=0.71), which is likely due to the water dilution effect and a decrease in the trophic status of the incoming with the waters of the channel of Chono-Harayh eutrophic waters of Khar-Us Lake. This is also supported by the situation in the upper part of the reservoir, where the percentage of rotifers in the total population decreased with increasing conductivity (r=−0.96), but the proportion of Cladocera in the total population (r=0.96) and biomass (r=0.99) increased. Similarly, in the lower reaches of the reservoir, with an increase in electrical conductivity and an increase in the amount of precipitation in April–July, the biomass of Rotifera (r=−0.98 and 0.95, respectively), changed.

Very important is the issue of changes in the quality of the environment during fluctuation of the water levels, and the amount of precipitation. Using the example of the Mozhaisk Reservoir it was shown that the maximum amount of blue-green algae, which indicates the deterioration of the ecological state, was mostly due to the size of floods and the intake of biogenic substances from the catchment area and the duration of highstands (Datsenko et al., 2017). However, for the Rybinsk Reservoir, it has been established that eutrophication processes increase with reduced water inflow and slowdown in water exchange, and with an increase of the water flow, the de-eutrophication increases (Lazareva, 2010, Lazareva et al., 2001). It is obvious that changes in the state of communities of hydrobionts and the quality of the environment with increasing water availability are determined by a number of factors, among which an important role is played by both the morphometric characteristics and the stage of succession of the ecosystem. Apparently, in shallow but wide reservoirs that are characterized by accumulation of organic and nutrient substances, biogenes from the bottom layers enter the cycle when the level decreases. In deeper and narrow reservoirs, diffuse exchange with bottom layers is difficult, so external influx from the catchment area plays a leading role. It has been shown by Krupa (2012) from studying the reservoirs of Kazakhstan, that the presence of a negative or positive relationship between the water level and the quantitative characteristics of zooplankton is explained by the ratio of biogenic elements accumulated in the reservoir and coming from the catchment area: if the amount of nutrients accumulated in the reservoir is less than that coming from the catchment area, a direct relationship is observed between the level and quantitative characteristics of the zooplankton, and if abundant biogens are accumulated in the reservoir, the influx of water from the catchment area leads to dilution.

The analysis of correlation relationships showed that with an increase in the average May–August water level in the Taishir reservoir as a whole, as well as in its upper and middle sections in the coastal area, the abundance and biomass of zooplankton increased, which is evidence of an increased trophic index. Simultaneously, a number of indicator criteria for the structure of zooplankton (Andronikova, 1996) characterized an improvement in environmental conditions: an increase in the proportion of copepods in total number and biomass, an increase in B_{Crust}/B_{Rot} (r=0.43 in the reservoir, r=0.76 in the upper section and r=0.78 in the middle section) and the average individual mass of organisms (r=0.57, 0.79 and 0.76, respectively). In addition, in the composition of the dominant species, with an increase in the water level and an increase in the amount of precipitation, no indicators of eutrophic waters were recorded. Apparently, the formation of the zooplankton of the reservoir has not yet been completed. This is due to its filling with the clean waters of a mountain river, as well as the fact that the flooded areas of the land were characterized by impoverished soil and vegetation cover, so there was not a sharp or even a temporary increase in the trophic index. On the contrary, there is a slow and gradual accumulation of organic and biogenic substances, the increase in their concentration in years with a high level and the amount of precipitation indirectly stimulates the quantitative development of zooplankton due to copepods and Cladocera that are not indicators of high trophic levels or contamination.

In the Durgun reservoir, there were also no significant changes in the parameters of zooplankton, indicating a change in the quality of the environment. A raised trophic index in 2015 was associated with an increase in the species composition of rotifers entering the basin from Khar-Us Lake, with an increase in the amount of precipitation.

Conclusions

The zooplankton of the coastal area of the Tayshir reservoir had noticeable differences in the longitudinal profile of the reservoir, and was also characterized by interannual changes associated with the amount of atmospheric precipitation, air temperature, water level and mineralization, and the morphometry of the studied sites. In the upstream zone of the reservoir, the effects of increasing the mineralization of water and decomposition of organics of flooded areas, the supply of organic and nutrient substances with the waters of the river and from the surrounding landscape, as well as the diffusion of nutrients from the bottom sediments were totalled. In the middle zone the effects of the two latter factors were summed up, whereas in the downstream zone the increase in precipitation and water level led only to dilution of already impoverished waters. Such a situation was previously described by Monakova (1958) and Dzyuban (1959) for the reservoirs of the Volga cascade, in which zooplankton were impoverished by large volumes of water.

In the Durgun Reservoir, which is not very long, the differences in zooplankton in the coastal areas of the upper and lower sections were poorly expressed. However, the downstream zone, showed a trend to an increased number of species, a higher proportion of Cladocera in the total biomass, as well as higher Shannon indices calculated for quantity and biomass. In general, in the Durgun reservoir, the quantitative characteristics and structure of the zooplankton community largely depended on the connection with the feeding eutrophic Khar-Us Lake. This connection was determined by the amount of atmospheric precipitation, an increase of which led to an increase in the abundance of rotifers. It is also necessary to note the role of the water level, increase of which, apparently, was to a great extent due to the reduction of discharges of hydroelectric power plants. In conditions where the littoral zone is almost absent, the flooding of land areas is linked to increasing volume of zooplankton; the number of copepods increased.

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