Трансформация экосистем
Ecosystem Transformation
www.ecosysttrans.com

Zooplankton of the channel zone 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] I.D. Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences, Borok 109, Nekouz Distrikt, Yaroslavl region, 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*

Received: 25.03.2018
Accepted: 28.06.2018

DOI: 10.23859/estr-180325
УДК [574.583:591]:574.472(517.3)
URL: http://www.ecosysttrans.com/publikatsii/detail_page.php?ID=92

ISSN 2619-094X Print
ISSN 2619-0931 Online

Translated by S.V. Nikolaeva

In the channel areas of the large Tayshir Reservoir valley, zooplankton is unevenly distributed along the longitudinal profile. The number and biomass of communities increases from the upper to lower reaches. In the Durgun Reservoir, which has features of a canyon-type reservoir, the greatest abundance and biomass of zooplankton are recorded in the upper reaches, while the greatest number of species is recorded in the lower reaches. In the Taishir Reservoir, an increase in precipitation and a raised water level have a stimulating effect on the crustaceans in the middle part of the reservoir, the area of the greatest accumulation of substances brought from the catchment area, contributing to the food supply of the invertebrates. In the upper reaches of the reservoir, with increased precipitation, high flowage prevents the development of zooplankton, and in the lower reaches, due to minimal accumulation of organic and biogenic substances and the impossibility of their intensive diffusion from bottom sediments due to maximum depth and width, the communities display the effect of “dilution” (reduced abundance). For interannual changes in the zooplankton of the channel of the upper part of the Durgun reservoir, precipitation fluctuations are of major importance. In the lower reaches of the reservoir, in the deeper areas, the temperature regime and fluctuations of the water level, depending on the work of hydroelectric power plants, are of decisive importance.

Keywords: zooplankton, arid zone, reservoirs, water level, rainfall, channel area, temperature, electrical conductivity, air temperature.

Krylov, A.V., Mėndsaĭkhan, B., Ayushsuren, Ch., Tsvetkov, A.I., 2019. Zooplankton of the channel zone of reservoirs of the arid zone: effects of level regime and meteorological conditions. *Ecosystem Transformation* **2** (1), 3–17.

Introduction

The arid climate, lack of water and energy resources in the territory of Mongolia give special status to water bodies of artificial origin, so studying the transformation of their hydrological, hydrochemical and biological regime under the influence of environmental and anthropogenic factors is a very important task.

Analysis of the zooplankton of the coastal zone of two different types of reservoirs in Mongolia showed (Krylov et al., 2018) that the communities of the large Taishir Reservoir are different along the longitudinal profile of the reservoir, and are also characterized by interannual changes. In the upper reaches of the reservoir, this is determined by an increase in water mineralization, the influx of organic and biogenic substances from the waters of the feeding river and from the surrounding landscape, as well as the diffusion of biogenic substances from bottom sediments. In the middle section of the reservoir, external influx of substances and the diffusion of biogenic oozes from bottom sediments are particularly important. In the lower reaches, an increase in precipitation and water level leads to dilution of the already less mineralized waters with impoverished zooplankton.

In the Durgun Reservoir, which is small and narrow, the differences in zooplankton in the coastal zone of the upper and lower areas are poorly expressed.

In general, in the Durgun Reservoir, the quantitative characteristics and structure of coastal zooplankton are largely determined by the relationship with Khar-Us Lake, the eutrophic feeding lake, which depends on the amount of precipitation: their increase leads to an increase in the number of rotifers. With an increase in the level of water associated with the reduction of hydroelectric station discharges, under conditions of a poorly pronounced littoral zone and the possibility of flooding of land, the number of copepods increases in the composition of zooplankton.

It is known that the water level and the amount of precipitation can alter the nutrient load on the channel sections of reservoirs, transforming the biological regime and ecological state of water bodies (Edelshtein et al., 2005; Kuzin and Shtegman, 1972).

The purpose of this work is to describe the summer zooplankton of the channel areas of reservoirs of different types in the arid zone, with changes in water level, rainfall and air temperature.

Materials and methods

Research on Taishir Reservoir conducted in August 2012–2017, in the channel zone of the upper, middle and near-dam sections, Durgun, in 2012–2015 and 2017. In the channel zone of the upper and near-dam sections (Fig. 1). At each station, 2–3 samples were collected; extending from the bottom to the surface, using a Juday net with a mesh size of 64 μm and an inlet opening of 12 cm; the samples were fixed with 4% formalin; cameral processing was performed according to the standard method (Mordukhai-Boltovskoi, 1975). At the same time as

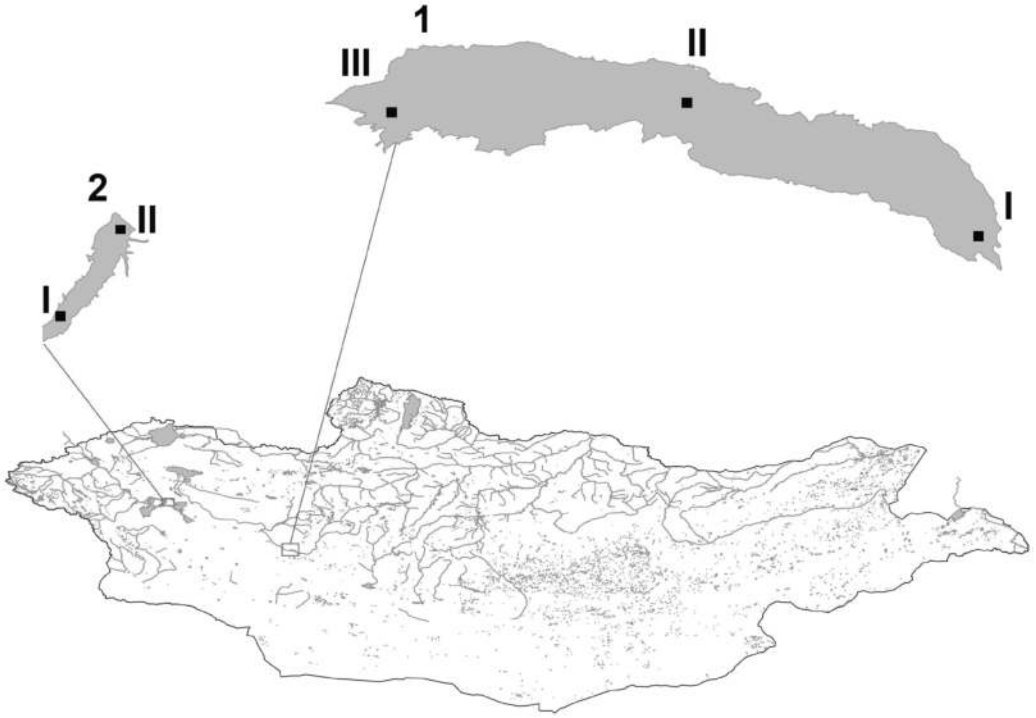

Figure 1. Location of the sampling sites in the Taishir (1) and Durgun (2) reservoirs.

sampling, the depth, temperature, and conductivity of water were measured, information was obtained on the level of the reservoir from the beginning of the growing season to the time of collection, as well as on air temperature and rainfall (according to hydrometeorological posts of the Research and Information Institute for Meteorology, Hydrology and Environment (Mongolia)). Statistical analysis included checking the normality of the distribution using the Kolmogorov – Smirnov criterion, the significance of differences was assessed using single-factor analysis of variance ($p < 0.05$, ANOVA), the Pearson correlation coefficient was determined ($p < 0.05$).

Results

Taishir Reservoir

Information on the amount of precipitation, air temperature and water level was previously published (Krylov et al., 2018).

Both in individual years and on average over the period studied, the highest water temperature was recorded in the middle of the reservoir, which is likely due to the optimal combination of conditions for slowing down the current and minimal wind mixing (Table 1).

In general, in the reservoir in 2012 and 2013, the water temperature was significantly higher than

Table 1. Temperature and electrical conductivity of water in the studied channels of the Taishir reservoir. I – the upper reaches of the reservoir, II – the middle reaches of the reservoir, III – the lower reaches of the reservoir, IV – total for the reservoir.

Zone	Year	Temperature, ºC	Electrical conductivity, µS/cm
I	2012	17.8	153.8
	2013	20.3	130.0
	2014	16.1	155.0
	2015	16.5	140.0
	2016	18.2	196.0
	2017	17.6	150.0
	M ± *SD*	17.8 ± 1.5	154.1 ± 22.6
	Cv	14.7	8.4
II	2012	22.9	202.9
	2013	20.5	221.0
	2014	17.9	215.0
	2015	18.6	265.0
	2016	18.0	212.0
	2017	17.8	200.0
	M ± *SD*	19.3 ± 2.0	219.3 ± 23.7
	Cv	10.8	10.6
III	2012	19.7	220.0
	2013	19.3	229.0
	2014	17.2	233.0
	2015	17.5	270.0
	2016	17.9	212.0
	2017	18.2	240.0
	M ± *SD*	18.3 ± 1.0	234.0 ± 20.2
	Cv	8.6	5.5
IV	2012	20.1 ± 2.6	192.2 ± 34.4
	2013	20.0 ± 0.6	193.3 ± 55.0
	2014	17.1 ± 0.9	201.0 ± 40.8
	2015	17.5 ± 1.1	225.0 ± 73.7
	2016	18.0 ± 0.2	206.7 ± 9.2
	2017	17.9 ± 0.3	196.7 ± 45.1

in 2014 (*p* = 0.010 and 0.012, respectively), 2015 (*p* = 0.023 and 0.028) and 2017 (*p* = 0.043 and 0.050). The water conductivity increased along the longitudinal profile of the reservoir (Table 1), and in the upper course it was statistically significantly less than the average (*p* = 0.0001) and lower (*p* = 0.00002) sections. No significant year-to-year differences were recorded, although the minimum values were found in 2012 and 2013, and the maximum, in 2015. The number of species of zooplankters in the sample in 2012–2013 was less in the upper reaches, but later the difference was not so significant and for the period of study no significant differences between the sites were found (Table 2). However, in the lower reaches of the reservoir, the number of Copepoda species was higher than in the upper (*p* = 0.001) and middle (*p* = 0.013) sites.

The maximum number of species of Rotifera and Cladocera as a whole for the channel sections of the reservoir was recorded in 2014, the values differed significantly from those of 2012 (*p* = 0.012 and 0.049, respectively). In addition, in 2014, the maximum number of invertebrate species in the sample was recorded, which was significantly higher than in 2012 (*p* = 0.008), 2013 (*p* = 0.035) and 2015 (*p* = 0.043). The highest abundance of zooplankton was observed in the lower part of the reservoir and was on average 3.4 times higher than in other areas, although the differences were not significant (Table 3). At the same time, in the lower reaches relative to the upper and middle sections, the number of Copepoda is significantly higher (respectively, *p* = 0.012, 0.013). The maximum density of Rotifera in the reservoir was recorded in 2014, and it significantly exceeded the values of 2012 (*p* = 0.038), 2013 (*p* = 0.047), 2015 (*p* = 0.041) and 2016 (*p* = 0.049). Due to this, the year 2014 was characterized by the largest number of zooplankton, which was more than in 2012 (*p* = 0.037)

Table 2. The number of species of zooplankton in the channel areas of the Taishir reservoir during the study period. I – the upper reaches of the reservoir, II – the middle reaches of the reservoir, III – the lower reaches of the reservoir, IV – total for the reservoir.

Zone	Year	Rotifera	Copepoda	Cladocera	Total
I	2012	3	0	0	3
	2013	4	0	1	5
	2014	9	3	6	18
	2015	6	0	3	9
	2016	8	0	2	10
	2017	5	4	7	16
	M ± SD	5.8 ± 2.3	1.2 ± 1.8	3.2 ± 2.8	10.2 ± 5.9
	Cv	39.7	157.3	88.0	58.2
II	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	6	3	2	11
	M ± SD	6.5 ± 2.0	2.2 ± 1.5	3.7 ± 1.6	12.3 ± 2.3
	Cv	30.4	67.9	44.5	18.3
III	2012	4	4	2	10
	2013	5	6	3	14
	2014	9	4	2	15
	2015	2	4	1	7
	2016	4	5	4	13
	2017	6	4	2	12
	M ± SD	5.0 ± 2.4	4.5 ± 0.8	2.3 ± 1.0	11.8 ± 2.9
	Cv	47.3	18.6	44.3	24.7
IV	2012	3.7 ± 0.6	2.7 ± 2.3	1.3 ± 1.2	7.7 ± 4.0
	2013	5.0 ± 1.0	2.3 ± 3.2	2.3 ± 1.2	9.7 ± 4.5
	2014	8.3 ± 1.2	3.0 ± 1.0	4.7 ± 2.3	16.0 ± 1.7
	2015	6.0 ± 4.0	1.3 ± 2.3	2.7 ± 1.5	10.0 ± 3.6
	2016	6.0 ± 2.0	2.7 ± 2.5	3.7 ± 1.5	12.3 ± 2.1
	2017	5.7 ± 0.6	3.7 ± 0.6	3.7 ± 2.9	13.0 ± 2.6

Table 3. Abundance and biomass of zooplankters in the channel areas of the Taishir Reservoir in the study area. I – the upper reaches of the reservoir, II – the middle reaches of the reservoir, III – the lower reaches of the reservoir, IV – total for the reservoir. Rot – Rotifera, Cop – Copepoda, Clad – Cladocera.

Zone	Year	Abundance, thousand specimen/m^3				Biomass, g/m^3			
		Rot	Cop	Clad	Total	Rot	Cop	Clad	Total
I	2012	0.2	0.0	0.0	0.2	0.0003	0.0000	0.0000	0.0003
	2013	0.4	0.0	0.0	0.4	0.0009	0.0000	0.0023	0.0032
	2014	42.2	8.8	13.1	64.0	0.0770	0.1534	1.5121	1.7425
	2015	0.7	0.0	0.1	0.8	0.0012	0.0001	0.0008	0.0021
	2016	0.4	0.3	0.5	1.1	0.0005	0.0006	0.0028	0.0039
	2017	6.5	8.1	4.2	18.8	0.0335	0.0523	0.0824	0.1682
	M ± *SD*	8.4 ± 16.7	2.9 ± 4.3	3.0 ± 5.2	14.2 ± 25.4	0.019 ± 0.031	0.034 ± 0.062	0.267 ± 0.611	0.320 ± 0.700
	Cv	199.9	150.9	174.7	179.1	166.0	179.9	229.1	218.7
II	2012	2.3	1.2	3.6	7.0	0.0025	0.0197	0.2309	0.2530
	2013	1.6	3.3	2.5	7.4	0.0041	0.0080	0.0211	0.0331
	2014	2.4	0.3	0.9	3.7	0.0145	0.0032	0.0691	0.0867
	2015	6.2	2.4	0.2	8.7	0.0037	0.0040	0.0050	0.0126
	2016	1.0	4.4	20.0	25.3	0.0019	0.2331	0.9372	1.1722
	2017	28.6	6.1	3.0	37.7	0.1706	0.0296	0.4824	0.6825
	M ± *SD*	7.0 ± 10.7	2.9 ± 2.1	5.0 ± 7.4	15.0 ± 13.5	0.033 ± 0.068	0.050 ± 0.090	0.291 ± 0.364	0.373 ± 0.464
	Cv	153.4	72.2	148.3	90.3	205.7	182.5	125.0	124.3
III	2012	3.2	8.0	6.3	17.5	0.0012	0.3251	0.8271	1.1533
	2013	11.1	13.6	5.5	30.1	0.1103	0.1638	1.3693	1.6434
	2014	114.8	8.8	5.7	129.3	0.5804	0.1148	1.0010	1.6962
	2015	1.5	16.6	7.4	25.5	0.0004	0.4208	1.8881	2.3093
	2016	13.2	4.6	3.3	21.1	0.0238	0.1474	0.5630	0.7342
	2017	70.2	4.6	0.3	75.1	0.6815	0.1394	0.1091	0.9301
	M ± *SD*	35.7 ± 46.5	9.4 ± 4.8	4.8 ± 2.6	49.8 ± 44.3	0.233 ± 0.313	0.219 ± 0.124	0.960 ± 0.621	1.411 ± 0.583
	Cv	130.3	51.7	53.8	89.0	134.2	56.9	64.7	41.3
IV	2012	1.9 ± 1.6	3.1 ± 4.3	3.3 ± 3.2	8.2 ± 8.7	0.0013 ± 0.0011	0.1149 ± 0.1823	0.3526 ± 0.4268	0.4689 ± 0.6061
	2013	4.3 ± 5.9	5.6 ± 7.1	2.7 ± 2.7	12.6 ± 15.5	0.0384 ± 0.0623	0.0573 ± 0.0924	0.4642 ± 0.7839	0.5599 ± 0.9384
	2014	53.1 ± 57.0	6.0 ± 4.9	6.6 ± 6.1	65.7 ± 62.9	0.2239 ± 0.3103	0.0904 ± 0.0780	0.8607 ± 0.7317	1.1751 ± 0.9429
	2015	2.8 ± 3.0	6.3 ± 8.9	2.6 ± 4.2	11.7 ± 12.6	0.0018 ± 0.0017	0.1416 ± 0.2418	0.6313 ± 1.0884	0.7747 ± 1.3291
	2016	4.8 ± 7.2	3.1 ± 2.5	7.9 ± 10.6	15.9 ± 12.9	0.0087 ± 0.0131	0.1270 ± 0.1176	0.5010 ± 0.4702	0.6368 ± 0.5902
	2017	35.1 ± 32.4	6.3 ± 1.8	2.5 ± 2.0	43.8 ± 28.7	0.2952 ± 0.3415	0.0737 ± 0.0580	0.2246 ± 0.2236	0.5936 ± 0.3887

and 2015 (p = 0.048). The maximum coefficients of variation in the total number and individual taxonomic groups of zooplankters were characteristic of the upper part of the reservoir, and the minimum, was recorded for the lower part.

Rotifers dominated in the zooplankton, their largest proportion was observed in the upper reaches of the reservoir (67.6% vs. 45.1% on average and 51% in the lower reaches samples). The proportion of copepods increased along the longitudinal profile of the reservoir from 14.9% in the upper reaches to 31.7% in the lower reaches of the reservoir, and the maximum proportion of cladocerans was found in the middle reaches of the reservoir (33.1%); whereas in in the upper and lower reaches, it was 17.5 and 17.3%, respectively.

The upper reaches of the reservoir were dominated by *Euchlanis dilatata* Ehrenberg (2012–2015), *E. meneta* Myers (2012, 2013), *Kellicottia longispina* (Kellicott.) (2014), *Brachionus quadridentatus* Ehrenberg (2015), nauplia of Cyclopoida (2016, 2017), copepodites of Cyclopoida (2017), *Bosmina* (*B.*) *longirostris* (O.F. Müller) (2016), *Daphnia* (*D.* (*D.*) *galeata* G.O. Sars, *D.* (*D.*) *hyalina* Leydig, *D.* (*D.*) *galeata*×*D.* (*D.*) *hyalina*) (2014, 2016), and *Alona rectangula* Sars (2017).

The middle reaches were dominated by *Conochilus hippocrepis* (Schrank) (2012), *Asplanchna brightwelli* Gosse (2013, 2014, 2017), *Kellicottia longispina* (2014, 2016), *Keratella cochlearis* (Gosse) (2015, 2016), *K. quadrata* (Müller) (2017), *Filinia longiseta* (Ehrenberg) (2017), nauplii of Cyclopoida (2015, 2017), *Eudiaptomus graciloides* Lilljeborg (2015), *Acanthodiaptomus denticornis* Wierzejski (2012, 2016), and *Daphnia* (2013, 2014, 2016).

The lower reaches were dominated by *Kellicottia longispina* (2014, 2016), *Conochilus hippocrepis* (2012, 2014), *Asplanchna brightwelli* (2013, 2014, 2017), *A. priodonta* Gosse (2017), *Keratella cochlearis* (2016), *K. quadrata* (2017), *Filinia longiseta* (2016), nauplii of Cyclopoida (2012–2015), copepodites of Calanoida (2015), *Eudiaptomus graciloides* (2015), *Acanthodiaptomus denticornis* (2012), and *Cyclops strenuus* Fischer (2012).

No significant differences in the values of the Shannon index calculated for abundance were found along the longitudinal profile of the reservoir or in the interannual aspect (Table 4).

Zooplankton of the dam area (Table 3) differed in maximum biomass, which was significantly higher than in the upper reaches (p = 0.005) and middle reaches (p = 0.008) owing to Copepoda (p = 0.004 and 0.007, respectively). In the lower reaches, the biomass of Cladocera statistically significantly exceeded only the values in the upper reaches (p = 0.043). The largest biomass of rotifers in the reservoir was recorded in 2017 and 2014, Copepoda in 2015, Cladocera and total biomass in 2014, although there were no significant interannual differences. Minimal variation of the total biomass and biomass of crustaceans was observed near the dam, and the maximum was recorded in the upper and middle parts of the reservoir.

Cladocerans formed the basis of zooplankton biomass, from 52.7% in the upper reaches to 70.7% in the middle reaches. The proportion of copepods varied from 10.4% in the upper reaches to 16.4% near the dam, rotifers ranged from 17.3% and 17.5% in the upper and lower reaches to 33.1% in the middle reaches, although all differences were not confirmed. There were also no significant differences in the proportion of taxonomic groups in different years, although the largest relative biomass of Rotifera was noted in 2012 and 2017 (33.7 and 39.4%), the smallest in 2016 (5.0%), Copepoda in 2015, 2016, respectively (18.4, 18.5%) and 2014 (6.4%), Cladocera in 2013, 2014 (72.5, 75.1%) and 2017 (43.8%).

The following taxa dominated by biomass in the upper reaches: *Euchlanis dilatata* (2012, 2013, 2015), *E. meneta* (2012), *Brachionus quadridentatus* (2015), *Asplanchna brightwelli* (2017), *Alona affinis* (Leydig) (2013, 2015, 2017), *A. rectangula* (2017), and *Daphnia* (2014, 2016).

The following taxa dominated by biomass in the middle reaches: *Asplanchna brightwelli* (2013, 2014, 2017), *Eudiaptomus graciloides* (2015), *Acanthodiaptomus denticornis* (2012), and *Daphnia* (2012–2017).

The following taxa dominated by biomass in the middle reaches: *Asplanchna brightwelli* (2014, 2017), *Acanthodiaptomus denticornis* (2012, 2016, 2017), *Eudiaptomus graciloides* (2015), and *Daphnia* (2012–2016).

On average, over the study period, the smallest value of the Shannon index calculated for biomass was recorded in the lower reaches of the reservoir, but no significant differences were found with the upper and middle reaches (Table 4). The minimum mean ratio of the number of cladocerans and copepods and the maximum ratio of the biomass of crustaceans and rotifers were found near the dam, but the differences between the sites were not statistically significant (Table 4).

The greatest average value of the trophic coefficient (Mäemets, 1980) was recorded in the upper reaches of the reservoir, and downstream along the longitudinal profile its values decreased, in the middle reaches and near the dam they were significantly lower (p = 0.023 and 0.001, respectively) (Table 4).

During the study period, the upper and middle reaches of the reservoir were characterized by the trophic coefficient as eutrophic, the lower mesotrophic. The maximum trophic index for the entire reservoir was noted in 2014, the minimum in 2012, but in general, the interannual differences

Table 4. Shannon indices calculated for abundance (H_N) and biomass (H_B), ratios of cladocerans and copepods (N_{Clad}/N_{Cop}), biomasses of crustaceans and rotifers (B_{Crust}/B_{Rot}), trophic coefficient (*E*) and mean individual mass of zooplankters (*w*) of the channel areas of the Taishir Reservoir. I – the upper reaches of the reservoir, II – the middle reaches of the reservoir, III – the lower reaches of the reservoir, IV – total for the reservoir.

Zone	Year	H_N, bit/spec.	H_B, bit/g	N_{Clad}/N_{Cop}	B_{Crust}/B_{Rot}	*E*	*w*, g/specimen
I	2012	1.25	0.89	–	–	–	0.0017
	2013	1.92	1.21	1.00	2.52	4.0	0.0081
	2014	2.91	1.09	1.49	21.63	5.0	0.0272
	2015	2.32	2.13	5.00	0.76	4.0	0.0025
	2016	2.86	1.76	1.77	7.55	3.0	0.0035
	2017	3.48	3.07	0.52	4.02	1.4	0.0090
	M ± *SD*	2.46 ± 0.80	1.69 ± 0.82	1.96 ± 1.77	6.1 ± 8.1	3.5 ± 1.4	0.0087 ± 0.0096
	Cv	32.5	48.3	90.4	132.8	39.6	110.5
II	2012	2.19	0.72	3.04	101.22	1.0	0.0361
	2013	2.46	2.04	0.76	7.17	1.0	0.0045
	2014	2.90	1.17	3.08	4.99	1.5	0.0238
	2015	2.98	2.97	0.06	2.40	3.0	0.0014
	2016	2.35	1.63	4.57	606.74	0.5	0.0463
	2017	2.81	1.35	0.49	3.00	3.6	0.0181
	M ± *SD*	2.62 ± 0.33	1.65 ± 0.79	2.00 ± 1.81	120.9 ± 241.1	1.8 ± 1.2	0.0217 ± 0.0175
	Cv	12.5	47.7	90.6	199.4	70.4	80.7
III	2012	2.91	1.48	0.79	989.42	0.7	0.0659
	2013	2.75	1.09	0.40	13.90	0.6	0.0546
	2014	2.49	1.19	0.65	1.92	1.7	0.0131
	2015	2.55	0.89	0.45	5662.19	0.2	0.0905
	2016	3.07	1.32	0.72	29.88	0.4	0.0348
	2017	2.20	1.78	0.07	0.36	1.5	0.0124
	M ± *SD*	2.66 ± 0.31	1.29 ± 0.31	0.51 ± 0.26	1116.3 ± 2261.1	0.8 ± 0.6	0.0452 ± 0.0309
	Cv	11.8	24.3	51.4	202.6	74.5	68.4
IV	2012	2.12 ± 0.83	1.03 ± 0.40	1.91 ± 1.59	363.5 ± 544.4	0.8 ± 0.2	0.035 ± 0.032
	2013	2.38 ± 0.42	1.45 ± 0.51	0.72 ± 0.30	7.9 ± 5.7	1.9 ± 1.9	0.022 ± 0.028
	2014	2.77 ± 0.24	1.15 ± 0.05	1.74 ± 1.24	9.5 ± 10.6	2.7 ± 2.0	0.021 ± 0.007
	2015	2.62 ± 0.34	2.00 ± 1.05	1.84 ± 2.75	1888.5 ± 3268.2	2.4 ± 2.0	0.031 ± 0.051
	2016	2.76 ± 0.37	1.57 ± 0.23	2.35 ± 1.99	214.7 ± 339.7	1.3 ± 1.5	0.028 ± 0.022
	2017	2.83 ± 0.64	2.07 ± 0.89	0.36 ± 0.25	2.5 ± 1.9	2.2 ± 1.3	0.013 ± 0.005

were not significant. Downward along the longitudinal profile of the reservoir, the average individual mass of zooplankters increased, and the differences between the upper and lower sections were statistically significant ($p = 0.009$).

Durgun reservoir

Information on the amount of precipitation, air temperature and water level were presented earlier (Krylov et al., 2018). The water temperature increased from sites in the upper to the lower reaches, but there were no significant differences between them (Table 5). On the whole, the minimum water temperature in the reservoir was found in 2017, it was significantly lower than in 2012 ($p = 0.004$), 2014 ($p = 0.007$) and 2015 ($p = 0.033$). The maximum temperature recorded in 2012 and 2014 was statistically significantly higher than in 2013 ($p = 0.016$ and 0.033, respectively). Sites in the upper and lower reaches did not differ in the electric conductivity of water, although, significant inter-annual changes were recorded (Table 5).

For instance, from 2012 to 2014 an increase in water conductivity was observed ($p_{2012–2013} = 0.00007$, $p_{2012–2014} = 0.00003$), however, it subsequently significantly declined ($p_{2012–2015} = 0.0012$, $p_{2012–2017} = 0.036$, $p_{2013–2015} = 0.000008$, $p_{2013–2017} = 0.0002$, $p_{2014–2015} = 0.000005$, $p_{2014–2017} = 0.00009$, $p_{2015–2017} = 0.0002$). By the number of species of zooplankters in the sample in different parts of the reservoir, no significant changes were observed; only in 2017 in the lower reaches there were more Rotifera species (Table 6), but their number also increased in sites of the upper reaches. As a result, in 2017, the number of invertebrate species in zooplankton of the reservoir was significantly higher than in 2012 ($p = 0.009$), 2013 ($p = 0.004$), 2014 ($p = 0.016$) and 2015 ($p = 0.022$). In the same year, the maximum number of species of cladoceran species was recorded, significantly exceeding the values in 2015 ($p = 0.030$). The lowest number of Copepoda species was found in 2015 and it is significantly lower than in 2012 ($p = 0.035$) and 2013 ($p = 0.020$). The abundance of zooplankton in the upper reaches was on average 3.7 times higher, as well as the abundance of rotifers (in 4.1 times), copepods (in 3.3 times), and cladocerans (in 4.3 times) (Table 7). However, in the period from 2012 to 2015, the difference in the number of zooplankton in the upper and lower reaches was reduced (from 5 times to dominance in the lower section), but in 2017 it was again observed to increase up to 11.2 times. No significant interannual differences in the numbers of zooplankton and its individual taxonomic groups were found. The largest density variation coefficients are recorded in the upper reaches of the reservoir. Copepoda accounted for 47.9% in the upper section and 54% in the lower section; Rotifera comprised 34.5% and 30.2%, Cladocera 17.6% and 15.8%, respectively. In general, for the reservoir, the maximum proportion of Rotifera was found in 2015 (55.9%) and 2017 (44.6%), and it was significantly more than in 2013 ($p = 0.010$ and 0.027, respectively). In addition, in 2015 and 2017 the minimum proportion of Copepoda (29.5 and 32.9%, respectively) was recorded, and it was significantly less than in 2012

Table 5. Temperature and electrical conductivity of water in the studied channel areas of the Durgun Reservoir. I – the upper reaches of the reservoir, II – the lower reaches of the reservoir, III – total for the reservoir.

Zone	Year	Temperature, ºC	Electrical conductivity, μS/cm
I	2012	22.3	186.6
	2013	18.2	225.0
	2014	21.2	230.0
	2015	19.6	171.0
	2017	17.2	199.0
	M ± SD	19.7 ± 2.1	202.3 ± 25.1
	Cv	10.6	12.4
II	2012	23.5	194.7
	2013	19.8	227.0
	2014	23.2	234.0
	2015	21.6	172.0
	2017	17.6	199.0
	M ± SD	21.1 ± 2.5	205.3 ± 25.3
	Cv	11.7	12.3
III	2012	22.9 ± 0.8	190.7 ± 5.7
	2013	19.0 ± 1.1	226.0 ± 1.4
	2014	22.2 ± 1.4	232.0 ± 2.8
	2015	20.6 ± 1.4	171.5 ± 0.7
	2017	17.4 ± 0.3	199.0 ± 0.0

Table 6. The number of zooplankton species in the channel areas of the Durgun Reservoir during the study period. I – the upper reaches of the reservoir, II – the lower reaches of the reservoir, III – total for the reservoir.

Zone	Year	Rotifera	Copepoda	Cladocera	Total
I	2012	5	2	6	13
	2013	6	4	8	18
	2014	8	2	5	15
	2015	7	0	4	11
	2017	12	3	8	23
	M ± *SD*	7.6 ± 2.7	2.2 ± 1.5	6.2 ± 1.8	16.0 ± 4.7
	Cv	35.6	67.4	28.9	29.3
II	2012	8	5	8	21
	2013	4	4	7	15
	2014	7	2	6	15
	2015	9	1	6	16
	2017	16	2	8	26
	M ± *SD*	8.8 ± 4.4	2.8 ± 1.6	7.0 ± 1.0	18.6 ± 4.8
	Cv	50.4	58.7	14.3	26.0
III	2012	6.5 ± 2.1	3.5 ± 2.1	7.0 ± 1.4	17.0 ± 5.7
	2013	5.0 ± 1.4	4.0 ± 0.0	7.5 ± 0.7	16.5 ± 2.1
	2014	7.5 ± 0.7	2.0 ± 0.0	5.5 ± 0.7	15.0 ± 0.0
	2015	8.0 ± 1.4	0.5 ± 0.7	5.0 ± 1.4	13.5 ± 3.5
	2017	14.0 ± 2.8	2.5 ± 0.7	8.0 ± 0.0	24.5 ± 2.1

(62.2%, p = 0.047) and 2013 (71.1%, *p* = 0.021), and in 2017 (32.9%) less than in 2013 (*p* = 0.028). No significant difference in the proportion of Cladocera was found, but their maximum proportion was registered in 2013 and 2017 (23.3 and 22.4%), while in the rest of the time it was 11.4–14.5%.

The upper reaches were dominated by *Filinia longiseta* (2014), *Polyarthra vulgaris* Carlin (2015), *Keratella cochlearis* (2015), *Trichocerca longiseta* (Schrank) (2015), *T. pusilla* (Gosse) (2017), juvenile Cyclopoida (2013–2015, 2017), *Ceriodaphnia reticulata* (Jurine) (2013, 2017), and *Chydorus sphaericus* (O.F. Müller) (2017).

The upper reaches were dominated by *Brachionus angularis* Gosse (2012, 2014), *Trichocerca pusilla* (Gosse) (2017), juvenile Cyclopoida (2012–2015, 2017), *Ceriodaphnia reticulata* (2013), *Filinia longiseta* (2015), and *Trichocerca longiseta* (Schrank) (2015).

No significant differences in the values of the Shannon index calculated for the abundance were found in different areas; the maximum value was recorded in 2015 and it was significantly higher than in 2017 (*p* = 0.031) (Table 8).

The zooplankton biomass in the upper reaches of the reservoir was on average 2.7 times higher than in the lower reaches; the biomass of rotifers was 3.7 times higher, the copepods 2.6 times higher, and cladocerans 2.7 times higher (Table 7). In addition, in the period from 2012 to 2015, there was a decrease in the difference, moreover, in 2013 and 2015. The biomass of zooplankton in the dam area was dominated by copepods. The largest variation of the total biomass and biomass of taxonomic groups was recorded in the upper reaches of the reservoir. The biomass was dominated by cladocerans, their maximum proportion was found in 2014 (72.7%), the minimum in 2012 (49.6%). The proportion of copepods in the total biomass in 2012 and 2013, was the highest, 48.7 and 42.1%; subsequently it was 23.5–26.5%.

The maximum proportion of rotifers was recorded in 2015 (10.4%), and it was more than in 2012 (*p* = 0.011), 2013 (*p* = 0.006) and 2014 (*p* = 0.030), and the proportion of rotifers in 2017 (7.8%) also significantly exceeded the values in 2012 (*p* = 0.038) and 2013 (*p* = 0.020).

The upper reaches were dominated by juvenile Cyclopoida (2013, 2017), *Ceriodaphnia reticulata* (2013, 2015, 2017), *Daphnia* (2014), *Bosmina (B.) longirostris* (2015, 2017), and *Chydorus sphaericus* (2017).

The lower reaches were dominated by juvenile Cyclopoida (2012–2015, 2017), *Eudiaptomus graciloides* (2012, 2014, 2015), *Diaphanosoma brachyurum* Liévin (2012, 2014), *Ceriodaphnia reticulata* (2012, 2013, 2015, 2017), *Bosmina* (*B.*) *longirostris* (2012, 2013), *Daphnia* (2013, 2014), *Campocercus uncinatus* Smirnov (2015).

In the value of the Shannon index calculated for the biomass, zooplankton of the lower reaches prevailed, although the differences between the plots were not confirmed (Table 8). In general, the smallest value in the reservoir was recorded in 2017, and it was significantly less than in 2012 (*p* = 0.006), 2013 (*p* = 0.005), 2014 (*p* = 0.038) and 2015 (*p* = 0.017).

The ratio of the number of cladocerans and copepods near the dam was lower than in the upper

Table 7. Abundance and biomass of zooplankters of the Durgun reservoir during the study period. I – the upper reaches of the reservoir, II – the lower reaches of the reservoir, III – total for the reservoir. Rot – Rotifera, Cop – Copepoda, Clad – Cladocera.

Zone	Year	Abundance, thousand specimens/m^3				Biomass, g/m^3			
		Rot	Cop	Clad	Total	Rot	Cop	Clad	Total
I	2012	29.3	64.6	4.9	98.8	0.012	0.299	0.213	0.524
	2013	2.3	20.2	6.7	29.2	0.001	0.082	0.093	0.176
	2014	14.5	23.7	4.2	42.5	0.013	0.067	0.242	0.321
	2015	11.3	1.8	3.2	16.3	0.005	0.002	0.034	0.041
	2017	42.9	52.2	42.4	137.5	0.033	0.182	0.475	0.690
	M ± *SD*	20.0 ± 16.0	32.5 ± 25.5	12.3 ± 16.9	64.8 ± 51.4	0.013 ± 0.013	0.126 ± 0.116	0.211 ± 0.170	0.350 ± 0.261
	Cv	80.0	78.3	137.5	79.2	97.6	91.7	80.7	74.5
II	2012	4.4	11.6	3.7	19.6	0.002	0.093	0.134	0.229
	2013	0.6	14.2	4.6	19.4	0.001	0.075	0.124	0.200
	2014	4.8	11.9	2.5	19.2	0.004	0.032	0.086	0.123
	2015	7.5	8.5	1.7	17.8	0.006	0.032	0.030	0.067
	2017	7.1	3.4	1.7	12.2	0.004	0.007	0.022	0.033
	M ± *SD*	4.9 ± 2.7	9.9 ± 4.1	2.8 ± 1.3	17.6 ± 3.1	0.003 ± 0.002	0.048 ± 0.035	0.079 ± 0.052	0.130 ± 0.084
	Cv	56.3	41.8	45.3	17.6	53.8	73.2	65.7	64.4
III	2012	16.8 ± 17.6	38.1 ± 37.5	4.3 ± 0.9	59.2 ± 56.0	0.007 ± 0.007	0.196 ± 0.146	0.173 ± 0.056	0.377 ± 0.208
	2013	1.5 ± 1.2	17.2 ± 4.3	5.6 ± 1.5	24.3 ± 6.9	0.001 ± 0.000	0.079 ± 0.005	0.108 ± 0.022	0.188 ± 0.017
	2014	9.6 ± 6.9	17.8 ± 8.3	3.4 ± 1.3	30.8 ± 16.5	0.009 ± 0.006	0.049 ± 0.024	0.164 ± 0.110	0.222 ± 0.141
	2015	9.4 ± 2.7	5.2 ± 4.8	2.4 ± 1.1	17.0 ± 1.0	0.005 ± 0.001	0.017 ± 0.021	0.032 ± 0.003	0.054 ± 0.018
	2017	25.0 ± 25.3	27.8 ± 34.5	22.0 ± 28.7	74.9 ± 88.6	0.019 ± 0.021	0.095 ± 0.124	0.248 ± 0.320	0.362 ± 0.465

reaches, the highest values were recorded in 2015 and 2017, the lowest in 2012 and 2014 (Table 8).

The ratio of the biomass of crustaceans and rotifers in the upper and lower reaches did not change significantly; however, in general, year-to-year fluctuations were recorded in the reservoir (Table 8). The largest value was recorded in 2013 and it was significantly higher than in 2012 (p = 0.0005), 2014 (p = 0.0001), 2015 (p = 0.00009) and 2017 (p = 0.0001) years, in 2015 and 2017 B_{Crust}/B_{Rot} was lower than in 2012 (p = 0.017 and 0.024, respectively).

The trophic coefficient has characterized the eutrophogenic conditions in the reservoir in all years (Table 8). Its higher value was recorded in 2015 and 2017.

Average individual mass of zooplankters in 2012, 2013 and 2015, was higher in the dam area of the reservoir, in 2014 and 2017, in the upper reaches (Table 8). A total trend to its decline was recorded for the reservoir over the entire research time.

Discussion

As mentioned above, in the Taishir Reservoir, the water level in August (p = 0.60), the difference in May and August of the current year (r = 0.71), the average difference between the months between May and August (r = 0.71) and the difference in the current and previous years (r = 0.94) were associated with precipitation (Krylov et al., 2018).

However, unlike the seashore, channel areas of the reservoir, between indicators of changes in the water level, showed no correlation with its electrical conductivity either for the entire reservoir or for its middle and lower reaches separately. Only in the upper reaches of the reservoir did the study reveal the coefficient of average correlation for May – August and the August water levels and its electrical conductivity (r = 0.83 and 0.89, respectively). Apparently, sites in the upper reaches, which are the first to receive the river waters carrying substances from the catchment area, characterized by smaller depths and width, as well as a larger land area flooded with increasing water levels, accumulate salt ions, which contribute to an increase in electric conductivity. In the middle and lower reaches, which are distinguished by large volumes of water, depth and width, and to which the intact water of the river does not reach, an increase in the water level did not change its electrical conductivity.

A negative correlation was found in the Durgun Reservoir between the water level and the amount of precipitation in January – August, April – July and April – August (for the level in April – August r = −0.79, –0.92, –0.95, for the level in August – respectively r = −0.97, −0.99, −0.99), which, as we pointed out earlier (Krylov et al., 2018), is associated with an increase in discharge of the hydroelectric power station. At the same time, the electrical conductivity of water (r = −0.66, 0.88, respectively) was associated with a change in the average difference in the water level during May – August and the average difference in water level (r = −0.66, 0.88, respectively), which explains its decrease in 2015 and 2017. A similar relationship between the difference in levels in May and August and the electric conductivity of water was found at the top (r = 0.91) and the lower reaches (r = 0.97) of the reservoir.

A series of correlation coefficients has been obtained between the quantitative characteristics of zooplankton in the Taishir Reservoir channel sections and the studied environmental factors that indicate the important role of the amount of atmospheric precipitation and the associated water level, which could indirectly determine the state of the plankton invertebrates.

Thus, the number and biomass of rotifers (r = 0.53 and 0.60), the number of zooplankton (r = 0.54), the number of Rotifera species (r = 0.48) and the total number of species (r = 0.59) correlated with the amount of atmospheric precipitation.

The results of the analysis of long-term observations at the Mozhaisk Reservoir (Datsenko et al., 2017), which showed a positive relationship between precipitation and phytoplankton biomass, suggest that the main cause of an increase in the number of suspension-feeders in zooplankton can be the enrichment of their feeding base due to an increase in algae, resulting from an increased supply of biogenic and organic substances from the catchment area.

In addition, the specific number of zooplankton species, as well as rotifers and cladocerans was associated with the water level in August (r = 0.49, 0.48, 0.58, respectively). Apparently, with an increase in water supply and the water level, species brought by the river from floodplains enter the channel zone of the reservoir, the influence of the communities of the littoral zone increases, while the improvement of the feeding base creates the conditions for an increase in abundance of rare species. Similar results were obtained at the Rybinsk Reservoir (Lazareva, 2010).

As the surface runoff increases, inorganic electrolytes (Na^+, K^+, Ca^{2+}, Mg^{2+} cations and Cl^-, SO_4^{2-}, and HCO_3^- anions) also enter the water, changing the electric conductivity of the water and playing an important role in the life of hydrobionts. Apparently, this explains the positive correlation between the abundance and biomass of Copepoda (r = 0.51 and 0.53), biomass of zooplankton and Cladocera (r = 0.49 and 0.54) with the electric conductivity of water. In the Durgun Reservoir, the interannual changes in the range of zooplankton indices were also determined by the amount of precipitation, the level of the regime and the air temperature.

Thus, the number of rotifer species increased when the average air temperature rose in April – August (r = 0.83) and decreased while the difference in water level increased from May to August (r = −0.66). The number of species Copepoda and Cladocera was reduced with a decrease in precipitation in January –

Table 8. Shannon index calculated for abundance (H_N) and biomass (H_B), ratios of abundance of cladocerans and copepods (N_{Clad}/N_{Cop}), biomasses of crustaceans and rotifers (B_{Crust}/B_{Rot}), trophic coefficient (*E*) (Myaemets, 1980) and mean individual mass of zooplankter (*w*) of the Durgun Reservoir. I – the upper reaches of the reservoir, II – the lower reaches of the reservoir, III – total for the reservoir.

Zone	Year	H_N, bit/spec.	H_B, bit/g	N_{Clad}/N_{Cop}	B_{Crust}/B_{Rot}	*E*	*w*, g/specimen
I	2012	2.29	2.93	0.1	41.7	1.1	0.0053
	2013	2.73	3.05	0.3	204.0	1.5	0.0060
	2014	2.67	2.26	0.2	23.9	3.4	0.0076
	2015	3.16	2.20	1.8	7.3	7.0	0.0025
	2017	2.07	1.36	0.8	19.6	1.8	0.0050
	M ± *SD*	2.58 ± 0.42	2.36 ± 0.68	0.64 ± 0.71	59.3 ± 81.8	3.0 ± 2.4	0.0053 ± 0.0018
	Cv	16.4	28.6	110.7	138.0	81.4	34.7
II	2012	3.19	3.14	0.3	93.4	1.3	0.0117
	2013	2.62	3.11	0.3	198.3	1.1	0.0103
	2014	2.62	2.59	0.2	27.8	2.2	0.0064
	2015	3.01	3.13	0.2	10.4	3.2	0.0038
	2017	2.31	1.65	0.5	8.1	5.6	0.0027
	M ± *SD*	2.75 ± 0.35	2.72 ± 0.65	0.31 ± 0.12	67.6 ± 80.8	2.7 ± 1.8	0.0070 ± 0.0040
	Cv	12.7	23.7	39.7	119.6	68.1	56.7
III	2012	2.74 ± 0.64	3.04 ± 0.14	0.19 ± 0.17	67.5 ± 36.6	1.2 ± 0.2	0.0085 ± 0.0045
	2013	2.68 ± 0.08	3.08 ± 0.04	0.33 ± 0.003	201.2 ± 4.1	1.3 ± 0.3	0.0082 ± 0.0030
	2014	2.65 ± 0.03	2.43 ± 0.23	0.19 ± 0.019	25.9 ± 2.7	2.8 ± 0.9	0.0070 ± 0.0008
	2015	3.09 ± 0.10	2.67 ± 0.66	0.99 ± 1.13	8.9 ± 2.2	5.1 ± 2.7	0.0031 ± 0.0009
	2017	2.19 ± 0.17	1.50 ± 0.20	0.66 ± 0.22	13.9 ± 8.1	3.7 ± 2.7	0.0039 ± 0.0016

August (respectively *r* = −0.69 and −0.72) and April – August (*r* = −0.70 and −0.72) and with the associated water level for April – August (*r* = 0.69 and 0.80). The specific number of types of zooplankters depended on the mean April – August air temperature (*r* = 0.66) and the difference in water level in May – August (*r* = 0.78).

The abundance and biomass of the entire zooplankton and individual taxonomic groups did not correlate with the studied environmental factors. Apparently, the interannual differences largely depended on the state of the food supply and influx of nutrients from the upper reaches.

However, fluctuations in the mean April – August water levels and precipitation changed the proportion of Rotifera in the total zooplankton abundance (respectively *r* = −0.73 and 0.66) and biomass (*r* = −0.83 and 0.68). In contrast, the proportion of Copepoda in the total abundance, with an increase in the water level, rose (*r* = 0.75), but decreased when the mean air temperature in April – August increased (*r* = −0.69). In addition, when the water level increased in the period from May to August, and the amount of precipitation decreased, the value of the Shannon index calculated for the abundance (*r* = −0.75 and 0.68, respectively) decreased, while the index calculated by biomass increased as the mean April – August air temperature (*r* = −0.72) decreased.

It should also be noted that when the average water level for April – August decreased as compared with the previous year and the difference between them increased, the number of Rotifera species (*r* = −0.71), their share in the total number and biomass (*r* = −0.75 and −0.80) decreased, but the proportion of Copepoda increased (*r* = 0.80).

Reservoirs are intricately organized mosaic systems, in which several hydrological zones are distinguished, differing in depth, wind-wave exposure and water speed: shallow (river), intermediate, or lacustrine-river, and deep-water, or lacustrine (Berkovich, 2012). In this regard, a special interest is the analysis of the reaction of communities of different sections of reservoirs to the influence of the same factors. In the Taishir Reservoir area, the number of Cladocera species (*r* = 0.85), the proportion of Rotifera in the total abundance (*r* = −0.86), Copepoda in the total number and biomass (*r* = 0.88 and 0.89), the value of the Shannon index calculated for the abundance (*r* = 0.97) were associated with rainfall during April – August.

In the middle part of the reservoir, the level of play played a large role. The increase in August level, the difference between the level in May and August, as well as the mean monthly difference in the level from May to August, was due to an increase in the number of Cladocera (*r* = 0.88, 0.87 and 0.87, respectively) and the Copepoda biomass (*r* = 0.90, 0.88 and 0.88).

The total biomass of zooplankton (*r* = 0.87) and the biomass of Cladocera (*r* = 0.86), whose proportion in the total population increased depending on the difference in water level in May and August (*r* = 0.86), correlated with the monthly (May – August) water level.

Previously, we pointed out that in the harshly continental climate of Mongolia, characterized by significant interseasonal and daily temperature fluctuations, the data on air temperature during the growing season, rather than the water temperature at sampling times, are useful.

In the middle area of the reservoir, with an increase in the mean monthly (from April to August) air temperature, the number and biomass of rotifers increased (*r* = 0.98 and 0.97), as well as the number of zooplankton (*r* = 0.88).

In the lower reaches of the reservoir, the characteristics of zooplankton were also related to the water level, but their number was limited. In particular, as the water level increased in May – August, the numbers and biomass of Copepoda (*r* = −0.79 and −0.70) and Cladocera (*r* = −0.69 and −0.70) decreased.

Consequently, a change in the amount of atmospheric precipitation and the level of water, the maximum of which was observed in 2016, caused mixed changes in the quantitative characteristics of zooplankton in the channel zone along the longitudinal profile of the Taishir Reservoir.

The correlations were most pronounced in the middle section of the reservoir, where the additional intake of organic and biogenic substances from the catchment area had a stimulating effect on plankton species.

Apparently, this is connected with the improvement of the zooplankton feeding basis due to the accumulation of minerals from the catchment area and the diffusion of biogenic substances from bottom sediments, which contributed to the development of phytoplankton.

The effect of phytoplankton stimulation of the reservoir with an increase in precipitation is described for the Mozhaisk Reservoir (Datsenko et al., 2017; Edelstein et al., 2017). However, as the researchers of the Mozhaisk Reservoir pointed out, the effect of the surface inflow on planktonic waters is most pronounced in the upper reaches of the reservoir.

In our case, in the sites in the upper reaches, only the number of species changed, as well as the ratio of taxonomic groups, which we associate with its high flow rate due to an increase in the discharge of the river that provided the water flow over the top of the dam.

As a result, the stimulation zone shifted to the middle section, where the substances accumulated by the peak were accumulated to the greatest extent.

In the lower reaches, which have a greater depth and volume of water mass, as well as a narrow strip of littoral zone, the quantitative characteristics of zooplankton with increasing rainfall and water level decreased. The reason for this was the smaller accumulation of organic and biogenic substances from the catchment area and the impossibility of their intensive diffusion from bottom sediments, which did not contribute to the enrichment of the invertebrate feeding base. The effect of “diluting” zooplankton with large volumes of water was previously observed in the reservoirs of the Volga (Dzyuban, 1959; Monakov, 1958). On the surface of the Durgun Reservoir, the characteristics of zooplankton were related to the level of the regime, the amount of precipitation and the electrical conductivity of the water. Thus, the number of species of copepods decreased with an increase in precipitation ($r = -0.91$), and cladocerans and the total specific number of species increased with a decrease in the monthly water level between April and August ($r = -0.94$ and -0.96).

The proportion of rotifers, in total numbers and biomass, increased with an increase in precipitation ($r = 0.93$), the proportion of copepods in total numbers increased with an increase in water level ($r = 0.96$), and cladocerans with a decrease in electrical conductivity ($r = -0.99$).

In addition, an increase in precipitation led to an increase in the Shannon index calculated by abundance ($r = 0.88$). In the lower reaches of the reservoir, the temperature regime was of great importance: when the average air temperature increased from April to August, the number of rotifers increased ($r = 0.93$), the abundance of zooplankton ($r = -0.94$) and the copepods ($r = -0.95$) decreased, as well as the proportion of Copepoda in total abundance ($r = -0.94$).

In addition, as the level of water decreased over April – August compared to the previous year and the difference between them increased, the number of copepod species ($r = 0.90$) and their proportions in the total population ($r = 0.91$), and biomass ($r = -0.91$) increased, the proportion of Rotifera in the total abundance ($r = -0.90$) and biomass ($r = -0.91$) decreased.

Consequently, for the zooplankton of the main plots of the Durgun Reservoir, the amount of atmospheric precipitation, which determines the connection with Lake Khar-Us, the eutrophic feeding lake, level regime, depending on the intensity of power station operation, and the temperature regime, were the most important factors.

Evidently, these factors determined the quantitative development and structures of the zooplankton in 2015 and 2017, which were characterized by the maximum air temperature, the difference between the levels in May and August, as well as the decrease in the mean water level for April – August, compared to the previous year and an increase in the difference between them (Krylov et al., 2018).

In addition, in 2015, the maximum amount of precipitation was recorded, and 2017 followed the 2016 season, when studies on the reservoir were not carried out, but which was characterized by anomalously large amount of precipitation (117.5 mm for the period from April to August, whereas in other years it ranged from 20 to 48.6 mm). Because of this, in these years, zooplankton was distinguished by a significant number of invertebrate species, the maximum proportion of Rotifera and the minimum proportion of Copepoda in total numbers and biomass.

No significant changes in the quality of the environment were observed in the Taishir Reservoir. These are determined by the structural indicators of zooplankton (in this case levelness, the ratio of the number of cladocerans and copepods, the biomass of crustaceans and rotifers, the trophic coefficient and the average individual mass of organisms) and composition of the dominant species, with increasing precipitation and water levels. Evidently, the zooplankton of the channel zone of the reservoir had not yet been fully formed, since the reservoir was filled by the impoverished waters of a mountain river, which flooded land areas with thin soils and vegetation. At present, there is still a gradual accumulation of organic and biogenic substances, an increase in the concentration of which in years with a high level and amount of precipitation indirectly stimulates an increase in the density and biomass of crustaceans, which are indicators of high trophic level or pollution.

In the Durgun Reservoir, changes in the indicative indicators of zooplankton were largely determined by the connection with the eutrophic Khar-Us Lake, which increased with an increase in the amount of atmospheric precipitation, which, also determined the intensity of the work of the hydroelectric power station and, as a consequence, a decrease in the water level.

Therefore observations in 2015 and 2017 showed the greatest decline in the quality of the environment, as evidenced by the increase in the abundance of Cladocera and Copepoda, the trophic level, and a decrease in the ratio of the biomass of crustaceans and rotifers.

Conclusions

The results showed that the zooplankton of the channel areas of the large Taishir valley reservoir is characterized by a non-uniform distribution over the longitudinal profile of the reservoir, an increase in the number of individuals in and biomass of communities from the upper reaches to lower reaches.

The Durgun Reservoir, which has features of a canyon-type reservoir, is characterized by a small length and width, as well as by lake nutrition, the largest number of individuals and biomass is recorded at the upper reaches of the reservoir, the largest number of species, in the lower reaches. The role of atmospheric precipitation, and the level of water and air temperature in the interannual changes in the zooplankton of the channel areas of different reservoirs in the arid zone was studied.

In the Taishir Reservoir, a significant increase in precipitation and water levels stimulated the crustaceans in the middle part of the reservoir, where nutrients from the catchment area were accumulated to a greater extent, which contributed to the enrichment of the feeding basis of zooplankters. In the upper part of the water body, with increased precipitation, high flow rates opposed the development of zooplankton, and in the lower reaches, the quantitative characteristics of the community were reduced due to minimal accumulation of organic and biogenic substances and the impossibility of their intensive diffusion from bottom sediments due to maximum depth and width. The effect of "diluting" zooplankton with large volumes of water has been previously described for the Volga reservoirs (Dzyuban, 1959; Monakov, 1958).

The interannual changes in the zooplankton of the channel area of the upper reaches of the Durgun Reservoir are largely dependent on fluctuations in the amount of precipitation, leading to an increase in the connection with Khar-Us Lake, the eutrophic feeding lake, as well as a decrease in the level of water as a result of the intensification of the work of hydroelectric power stations. In the lower reaches of the reservoir, which is distinguished by great depths, temperature regime had a determining value, as well as fluctuations in water level, depending on the work of the hydroelectric power station.

Acknowledgments

The collection of the first material was carried out in the framework of the work program of the Joint Russian-Mongolian Integrated Biological Expedition of the Russian Academy of Sciences and the Academy of Sciences of Mongolia, its processing and analysis were carried out in the framework of the state assignment of the Russian Federal Agency for Scientific Organizations of Russia (No. g/r AAAA-A18-118012690106-7).

References

Berkovich, K.M., 2012. Ruslovye processy na rekah v sfere vliyaniya vodohranilishch [Riverbed processes in rivers influenced by reservoirs]. MSU, Moscow, Russia, 163 p. (In Russian).

Datsenko, Yu.S., Puklakov, V.V., Edelstein, K.K., 2017. Analiz vliyaniya abioticheskih faktorov na razvitie fitoplanktona v maloprotochnom stratificirovannom vodohranilishche [Analysis the influence of abiotic factors on phytoplankton growth in f low-flow stranified storage reservoir]. *Trudy Karel'skogo nauchnogo centra RAN [Proceedings of the Karelian research center of Russian academy of sciences]* **10**, 73–85. https://doi.org/10.17076/lim611. (In Russian).

Dzyuban, N.A., 1959. O formirovanii zooplanktona vodohranilisch [On the formation of zooplankton in reservoirs]. *Trudyi VI soveschaniya po problemam biologii vnutrennih vod [Transactions of the VI conference on the biology of inland waters]*. AN USSR, Moskow–Leningrad, 597–602. (In Russian).

Edelshtein, K.K., Grechushnikova, M.G., Krasnova, A.E., 2005. Intraannual and interannual variations of water storage in the Mozhaisk reservoir. *Russian Meteorology and Hydrology* **5**, 38–45.

Edelshtein, K.K., Puklakov, V.V., Datsenko, Yu.S., 2017. Ehksperimental'no-teoreticheskie osnovy diagnoza i prognoza cveteniya v vodohranilishchah-istochnikah municipal'nogo vodosnabzheniya [Experimental-theoretical basis of diagnosis and prediction of bloom in reservoirs-sources of municipal water supply]. *Voda Magazine [Water Magazine]* **4** (116), 34–40. (In Russian).

Krylov, A.V., Mendsaikhan, B., Ayushsuren, Ch., Cvetkov, A.I., 2018. Zooplankton of the coastal areas of reservoirs of the arid zones: effects of level regime and meteorological conditions. *Ecosystem transfomation* **1** (1), 5–23.

Kuzin, B.S., Shtegman, B.K. (eds.), 1972. Rybinskoe vodohranilishche i ego zhizn' [Rybinsk reservoir and its life]. Nauka, Leningrad, USSR, 364 p.

Lazareva, V.I., 2010. Struktura i dinamika zooplanktona Rybinskogo vodohranilishcha [Structure and dynamics of the Rybinskoe reservoir's zooplankton]. KMK, Moscow, Russia, 183 p. (In Russian).

Monakov, A.V., 1958. Zooplankton volzhskogo ustevogo uchastka Ryibinskogo vodohranilischa za period 1947–1954 gg. [Zooplankton of the Volga estuary area of the Rybinsk reservoir over the period 1947–1954]. *Trudyi Biologicheskoy stantsii "Borok" [Transactions of the Biological station "Borok"]* **3**, 214–225. (In Russian).

Morduhay-Boltovskoy, F.D. (ed.), 1975. Metodika izucheniya biogeotsenozov vnutrennikh vodoemov [Method to Study Biogeocenoses of Inland Water Bodies]. Nauka, Moscow, Russia, 240 p. (In Russian).

Myaemets, A.Kh., 1980. Changes in zooplankton. In: Kolan-Diks, I.S., Stravinskaya, E.A. (eds.), *Antropogennoe vozdeistvie na malye ozera [Anthropogenic Influence on the Small Lakes]*. Nauka, Leningrad, USSR, 54–64. (In Russian).