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Zooplankton communities of the Varvara water reservoir

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Abstract. Zooplankton communities play a massive role in biological processes both in salt and fresh water. The majority of zooplankton species belong to primary or secondary consumers, which underscores their importance as primary components of various food chains. On one hand, they are prolific consumers of producer organisms (bacteria, algae, etc.) and, on the other hand, they are a food base for many other groups of zooplankton, including larvae of commercially important fish at early stages of development after switching to exogenous feeding. It is also worth noting that most zooplankton research is performed either on unicellular organisms — mainly ciliates — or on multicellular rotifers or crustaceans. However, it is very clear that a more comprehensive understanding of qualitative and quantitative changes in seasonal successions in plankton communities of freshwater bodies requires complex research into all key animal groups of zooplankton, such as free-living ciliates and other multicellular organisms (Rotatoria, Cladocera, Copepoda).

Keywords: Varvara water reservoir, free-living ciliate, multicellular zooplankton, species composition, quantity, Rotifera, Cladocera, Copepoda.

Сообщества зоопланктона Варваринского водохранилища

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Аннотация. Сообщества зоопланктона играют огромную роль в биологических процессах как в морских, так и в пресноводных водоемах. Большинство животных зоопланктона относятся к консументам первого и второго порядка. Этим объясняется их важность как первичных звеньев пищевых цепей, являющихся активными потребителями организмов продуцентов (бактерии, микроскопические водоросли и др.) и составляющих, в свою очередь, пищевую базу для многих других групп зоопланктеров, включая и личинок ценных промысловых рыб на ранних стадиях их онтогенеза после перехода к экзогенному питанию. Следует отметить, что большинство исследований зоопланктона, как правило, выполнены либо на одноклеточных объектах, в основном инфузориях, либо на многоклеточных — коловратки и ракообразные. В то же время совершенно ясно, что для более полного понимания качественных и количественных изменений в сезонных сукцессиях в планктонных сообществах пресных водоемов необходимо проводить комплексное изучение всех основных животных групп зоопланктеров, таких как свободноживущие инфузории и остальные многоклеточные (Rotatoria, Cladocera, Copepoda).

Ключевые слова: Варваринское водохранилище, свободноживущие инфузории, многоклеточный зоопланктон, видовой состав, количество, коловратки, кладоцеры, веслоногие рачки.

Introduction

The Varvara reservoir is located on Kura, the main river Azerbaijan, 20 km below Azerbaijan's largest reservoir—the Mingachevir reservoir. It is fed by water flowing from the Mingachevir reservoir at a depth of 35 meters, and stretches across the Kura river. The water reservoir consists of upper, middle and lower sections. Its total surface area is 21.4 km^2, with a length of 13 km, maximum width at normal level of 3.4 km, average depth of 8.2 m, maximum depth at dam of 18 m, and shoreline length of 31 km. The reservoir is overgrown with higher aquatic plants, mainly reeds and *Potamogeton,* especially near the shore. The prevailing alga is *Chara sp.*

Information on multicellular zooplankton groups in the Varvara reservoir is available in publications by Akhmedov (1967; 1969; 1971). He mentions 59 species of zooplankton, of which 36 belong to the rotifers, 13 to the cladocerans, and 10 to the copepods (Abbasov et al. 1969; Akhmedov 1971; Akhmedov, Likhodeyeva 1967).

Free-living ciliates of the Varvara reservoir were researched by Alekperov (Alekperov 1979; 1981a; 1981b; 1992; 2012). Overall, 104 planktonic ciliate species were found.

Materials and methods

Samples of multicellular groups of zooplankton were collected in the Varvara reservoir seasonally through 2019–2020. Fig. 1 presents the water reservoir chart and sample points.

Sample collection was conducted in accordance with methods accepted in hydrobiological research. To collect quantitative samples in the pelagic zone, an Apstein net was used, lowered to a depth of 0.5–1.0 meters and stretched over 5 meters in the boat's direction. To collect samples from the coastal area, nets of various sizes were used. All samples were labeled and fixed with a 4% formaldehyde solution. Pelagic zone samples of planktonic ciliates were taken using a Ruthner bathometer, while the samples from the coastal areas were taken simply by scooping water into plastic vials. Part of the samples were examined in vivo in the field, the remaining samples were promptly examined in a laboratory.

For taxonomic identification, impregnation methods of silver nitrate (Chatton, Lwoff 1930) and silver proteinate (Alekperov 1992) were used.

Fig. 1. Plankton sampling points in the Varvara reservoir

Рис. 1. Точки отбора проб планктона в Варваринском водохранилище

 https://www.doi.org/10.33910/2686-9519-2021-13-3-423-433

The ciliates abundance was calculated by counting living cells in 5 ml of water in a Bogorov chamber with subsequent recalculation per 1 liter. An Olympus CX-41RF binocular microscope was used for quantitative and qualitative analysis of zooplankton. To determine the occurrence of species over the area of the reservoir, the following formula was used:

$$P = \frac{m}{n} \times 100\%$$

where P is the abundance, or frequency of occurrence of the given species, m is number of specimens in sample and n is total number of all species in sample.

Species ranking was done according to the Tischler's scale (Tischler 1955):

Dominant (D)—encountered in 10% to 5% of samples

Subdominant (Sd)— encountered in 5% to 2%

Recedent (R)— encountered in 2% to 1%.

Subrecedent (Sr)— encountered in 1% to 0%.

Results

Free-living planktonic ciliate species composition in the Varvara reservoir is presented in table 1, indicating that the total number of planktonic ciliate species we have observed during our multi-year research in the Varvara reservoir is 44. It also indicates that the diversity of planktonic ciliates species increases consistently from the top (36 species) through the middle (41) and to the lower section, where all 44 species were found. We believe that this is due to the hydrological conditions of each section.

The upper area of the Varvara reservoir is characterised by strong water flow and relatively low water temperature (12–15°C in summer), as water is fed here from the Mingachevir reservoir from a depth of 35 m. Naturally, the rheophilic factor also strongly affects ciliate species diversity not only in plankton, but also inhibiting their development in periphyton, phytocenosis and benthos.

In terms of its ecological conditions, the middle section is closer to the lower one, only differentiated by higher depth and lower number of islands overgrown with higher aquatic plants. When comparing the frequency of ciliate occurrence in the biotopes of periphyton, phytocenosis and benthos, a consistent increase in frequency is also observed in all the three sections of the reservoir. For instance, in periphyton of upper, middle and lower sections 15, 18 and 20 species were observed; with 15, 26 and 27 species in phytocenosis and 12, 16 and 23 species in benthos.

We believe that the differences in planktonic species occurrence in other biotopes of the middle and lower sections are due to the fact that the Varvara reservoir is overgrown with aquatic plants and is shallow in the middle and, especially, the lower section. The availability of aquatic plant life creates a substrate for the attachment of most peritrich ciliates and the shallowness, even with low water heaving, contributes to active water mixing and the transfer of many plankton species to the benthic layers and benthos.

Analysis of planktonic ciliate species occurrence in sections of the Varvara reservoir clearly points to higher species diversity in the middle and lower sections. Dominant species were only identified in the lower section (19 species). The number of subdominant species in the upper section was the lowest (2 species), while in the middle and lower sections it was 14 and 11 species respectively.

Distribution of recedent species showed that their numbers, inversely, changed from 9 in the lower, to 12 in the middle, and 16 in the upper sections. As for subrecedent — also known as random — species, normally identified only by single specimens, interestingly, most of them are observed in the upper section — 22 species, while in the middle and lower sections we only identified 2 and 5 species respectively.

Analysis of ciliate species occurrence in other biotopes shows a clear pattern that is due to several factors. In the relatively cold upper section with a strong flow, in biotopes of extremely weak periphyton and almost absent phytocenosis, only 15 species were found. In the middle and lower sections of the reservoir, with large, warmer shallows and

Table 1

Free-living planktonic ciliate species composition in the Varvara reservoir

Таблица 1

Видовой состав свободноживущих инфузорий планктона Варваринского водохранилища

№	Species composition	Reservoir areas											
		Upper				Middle				Lower			
		1	2	3	4	1	2	3	4	1	2	3	4
	Class Oligotrichea Butschli, 1887												
	Order Halteriida Jankowski, 2007												
	Fam. Halteriidae Clap. et L., 1858												
1.	*Halteria grandinella* (Müller, 1786)	++		+		+++				++++		+	
2.	*Pelagohalteria viridis* (Fromentel, 1876)	++				++++				++++			
3.	*P. cirrifera (*Kahl, 1932)	++				++	+	+	+	+++	+	+	
	Order Strombidiida Jankowski, 1980												
	Fam. Strombidiidae Fauré-Fremiet, 1970												
4.	*Limnostrombidium viride* (Stein, 1867)	++				+++		++		++++	+	+	+
5.	*Pelagostrombidium. fallax* (Zacharias, 1896)					+++				+++	+	++	
6.	*Strombidium conicoides* (Leegaard, 1915)	+				++++	+	+		+++		+	
	Order Strobilidiida Jankowski, 1980												
	Fam. Strombidinopsidae Small et Lynn, 1985												
7.	*Strobilidium caudatum* (Fromentel, 1876)	++	+	+		++				+++	+		+
8.	*S. conicum* Kahl, 1932	+				+++	+	+		++++		+	+
9.	*Rimostrombidium velox* (Fauré-Fremiet, 1924)	++		+	+	++++				++++	+	++	+
10.	*R. humile* (Penard, 1922)	++				++	+	+		++			+
	Order Tintinnida Kofoid et Campbell, 1929												
	Fam. Codonellidae Kent, 1881												
11.	*Codonella cratera (*Leidy, 1877)	++		+		+++		+		++++	++	+	
12.	*C. relicta* Minkewitch, 1909					++++				++++			
13.	*Tintinnopsis cylindrata* Kofoid et Campbell, 1892	++	+			+++		+	+	+++	+	+	+
	Class Litostomatea Small et Lynn, 1981												
	Order Haptorida Corliss, 1974												
	Fam. Lacrymariidae Fromentel, 1876												
14.	*Lacrymaria olor* (Müller, 1786)	++	+	+	++	++		+	+	+++	+	+	+
15.	*L. lagenula* Kahl, 1927	+			++				+	++			+
16.	*L. clavarioides* Alekperov, 1984				+			+	+	+++			++
17.	*Pelagolacrymaria moserae* Foissner, Berger et Schaumburg, 1999	++	+	+		+++		+	+	+++	+	++	+
	Fam. Didiniidae Poche, 1913												
18.	*Monodinium balbianii* Fabre-Domerque, 1888	++				++++	+			++++			+
19.	*Didinium nasutum* (Müller, 1773)	+		+	+	+++		+		++++		+	+
20.	*D.* chlorelligerum Kahl, 1935	+	+			++		+		++	+		+
	Fam. Trachelidae Ehrenberg, 1838												
21.	*Pelagodileptus trachelioides* (Zacharias, 1894)	+++		+		++++				++++		+	
22.	*Paradileptus elephantinus* (Svec, 1897)	++	+	+		+++		+		++++	+	+	
23.	*P. conicus* Wenrich, 1929	++				++++				++++			
24.	*Trachelius ovum* Ehrenberg, 1831	+				++++		+		++++		+	
25.	*Teutophrys trisulca* (Chatton et de Beauchamp, 1923)	+				+				+		+	
	Order Cyclotrichida Jankowski, 1980												
	Fam. Mesodiniidae Jankowski, 1980												
26.	*Askenasia confunis* Alekperov, 1984	+	+	+	+	++++	+		+	++++		+	
27.	*A. mobilis* Alekperov, 1984	+	+	+		+++	+	+		+++	+	+	
28.	*A. volvox* (Eichwald, 1852)	++			+					+		+	+
29.	*A. stellaris* (Leegard, 1920)	+	+			++		+		+			

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Таблица 1. Окончание
Table 1. Completion

		1	2	3	4	1	2	3	4	1	2	3	4
30.	*Mesodinium acarus* (Claparede et Lachmann, 1859)	+++	+	+	+	++++		+		++++	+	+	
	Fam. Cyclotrichiidae Jankowski, 1980												
31.	*Cyclotrichium cyclokaryon* Meunier, 1910	+				+++				++	+		
32.	*C. gigas* Fauré-Fremiet, 1924	+		+		++				++		+	
33.	*C. inflatum* Alekperov, 1984					+++				+			
	Class Oligohymenophora Puytorac et al., 1974												
	Order Philasterida Small, 1967												
	Fam. Cyclidiidae Ehrenberg, 1838												
34.	*Cyclidium citrullus* Cohn, 1865	+	+	+	+	+++	+	+	+	++	+	+	+
35.	*C. glaucoma* Muller, 1786	+	+		+	++	+	++	+	++	+	+	+
	Fam. Uronematidae Thompson, 1964												
36.	*Uronema marinum* Dujardin, 1841	+				++	+	+	+	+	+		+
37.	*U. nigricans* (Müller, 1786)	+			+	++	+	+	+	++	+	+	+
38.	*U. elegans* (Maupas, 1883)					+	+		++	+++			+
	Order Sessilida Kahl, 1933												
	Fam. Epistylidae Kahl, 1933												
39.	*Epistylis plicatilis* Ehrenberg, 1830	+				++++	+	+		++++	+++		+
40.	*E. coronata* Nusch, 1970	+			++	++	+			++++		++	+
	Fam. Vorticellidae Ehrenberg, 1838												
41.	*Vorticella chlorellata* Stiller, 1940		++			++++	++	++	+	+++	+	++	
42.	*V. microstoma* Ehrenberg, 1830					++	++	+	+	++	+		
43.	*V. alba* Fromentel, 1874	+	++	+		++	+++	++	+	++++			
	Fam. Zoothamniidae Sommer, 1951												
44.	*Zoothamnium arbuscula* Ehrenberg, 1831		++			+++	++	++		++++	+++	+	
	Total:	36	15	15	12	41	18	26	16	44	20	27	19

Note: Biotoped 1 — plankton, 2 — periphyton, 3 — phytocenosis, 4 — benthos. Dominant (D) ++++, Subdominant (Sd) +++, Recedent (R) ++, Subrecedent (Sr) +.

zones overgrown with higher aquatic plant life, species diversity of ciliate plankton societies is considerably higher, consisting of 18 and 26 species in the periphyton and phytocenosis of the middle section respectively, and 20 and 27 species in the same biotopes in the lower section.

Multicellular zooplankton of the Varvara reservoir was researched seasonally throughout 2019–2020. Table 2 presents species composition and occurrence of main multicellular plankton groups by season.

Species composition and seasonal complexes of zooplankton. As seen in fig. 2, the trends in the total numbers of different groups of multicellular zooplankton differ to an extent. For instance, rotifer plankton specimens were least numerous in winter (955 ind./m^3). With the arrival of spring and water temperature increase in the reservoir, the number of rotifers grows steadily to 3 660 ind./m^3, reaching a maximum of 8 227 ind./m^3 in the middle of summer. In autumn, the total numbers of Rotatoria decrease to 2 858 ind./m^3.

In contrast with the rotifers, the total numbers of Cladocera and Copepoda are the highest in spring. For instance, Cladocera reaches a minimum of 1 649 ind./m^3 in winter, while in spring it climbs to the maximum of 16 999 ind./m^3.

In 2019–2020, 39 species and 2 subspecies of multicellular zooplankton were observed in the Varvara reservoir. Of these species, 19 belong to the rotifers, 11 species and 1 subspecies to the water fleas, and 9 species and 1 subspecies to the copepods. All species observed by us are typical for zooplankton of the inner water bodies of Azerbaijan. They are widely encountered both in saline and freshwater bodies.

Table 2

Species composition and occurrence of main multicellular plankton groups by season

Таблица 2

Видовой состав и встречаемость основных групп многоклеточного зоопланктона по сезонам

№	Species	2019–2020			
		Winter	Spring	Summer	Autumn
	Rotatoria				
1.	*Synchaeta pectinata* Ehrenberg, 1832	++++	++++	++++	++++
2.	*Polyarthra vulgaris* Garlin, 1943	++++	++++	++++	++++
3.	*Asplanchna priodonta* Gosse, 1850	++++	++++	++++	++++
4.	*Lecane luna* (Müller, 1776)	++	++++	++	++++
5.	*L. quadridentata* (Ehrenberg, 1832)	–	+	++	+
6.	*L. lunaris* (Ehrenberg, 1832)	–	++	++	+
7.	*Trichotria tetractis* (Ehrenberg, 1830)	–	++	++++	+++
8.	*Lepadella ovalis* (Müller, 1786)	–	+	++	+
9.	*Brachionus quadridentatus* Hermann, 1783	–	++	++	++
10.	*B. bennini* Leislsing, 1924	–	++	++	+
11.	*B. falcatus* Zacharias, 1898	–	++	+++	–
12.	*B. diversicornis* (Daday, 1883)	–	++	+++	–
13.	*B. calyciflorus* Pallas, 1766	++++	++++	++++	++++
14.	*B. angularis* Gosse, 1851	–	+	+	–
15.	*Platyas patulus* (Müller, 1786)	–	++++	+++	++
16.	*Keratella cochlearis* (Gosse, 1851)	++++	++++	++++	++++
17.	*K. quadrata* Müller, 1786	–	+++	++++	++
18.	*Filina longiseta* (Ehrenberg, 1834)	–	+++	++	–
19.	*Hexarthra mira* (Hudson, 1871)	–	+++	++++	–
	Cladocera				
20.	*Daphnia longispina* O. F. Müller, 1785	++++	++++	++++	++++
21.	*D. longispina hyalina* (Leyding, 1860)	++++	++++	++++	++++
22.	*Simocephalus vetulus* (O. F. Müller, 1776)	–	++++	++++	++
23.	*Moina brachiata* (Jurine, 1820)	–	++++	++++	++
24.	*Ceriodaphnia reticulata* Lillejeborg, 1900	–	++++	++++	++
25.	*Scapholeberis mucronata* (O. F. Müller, 1785)	–	++++	++++	++
26.	*Macrothrix hirsuticornis* Northman et Brady, 1867	–	++	++	+
27.	*Graptoleberis testudinaria* (Fisher, 1848)	–	++	++	+
28.	*Chydorus sphaericus* (O. F. Müller, 1785)	++++	++++	++++	++++
29.	*Pleuroxus aduncus* (Jurine, 1820)	–	++	++	+
30.	*Alona affinis* Leydig, 1860	+	+++	++	++
31.	*Bosmina longirostris* (O. F. Müller, 1785)	++++	++++	++++	++++
	Copepoda				
32.	*Arctodioptomus acutulobatus* G. O. Sars, 1903	++++	++++	++++	++++
33.	*Macrocylops fuscus* (Jurine, 1820)	++++	++++	++++	++++
34.	*M. albidus* (Jurine, 1820)	++++	++++	++++	++++
35.	*Eucyclops serrulatus* (Fisher, 1838)	+	++++	++++	+++
36.	*E. macruroides macruroides* (Lillejeborg, 1901)	–	++	+++	++
37.	*Paracyclops fimbriatus fimbriatus* (Fisher, 1853)	+	++	+++	++
38.	*Cyclops vicinus* Uljan, 1875	–	++	+++	++
39.	*Acanthocyclops gigas* (Claus, 1857)	++	+++	+++	+++
40.	*Metacyclops gracilis* (Lilljeborg, 1858)	–	++	+++	+
41.	*Termocyclops dybowskii* (Lande, 1890)	–	++++	+++	++++
	Total:	**17**	**41**	**41**	**36**

Note: Occurrence of species: noted in 25% of samples (+), in 50% (++), in 75% (+++), 100% of samples (++++)

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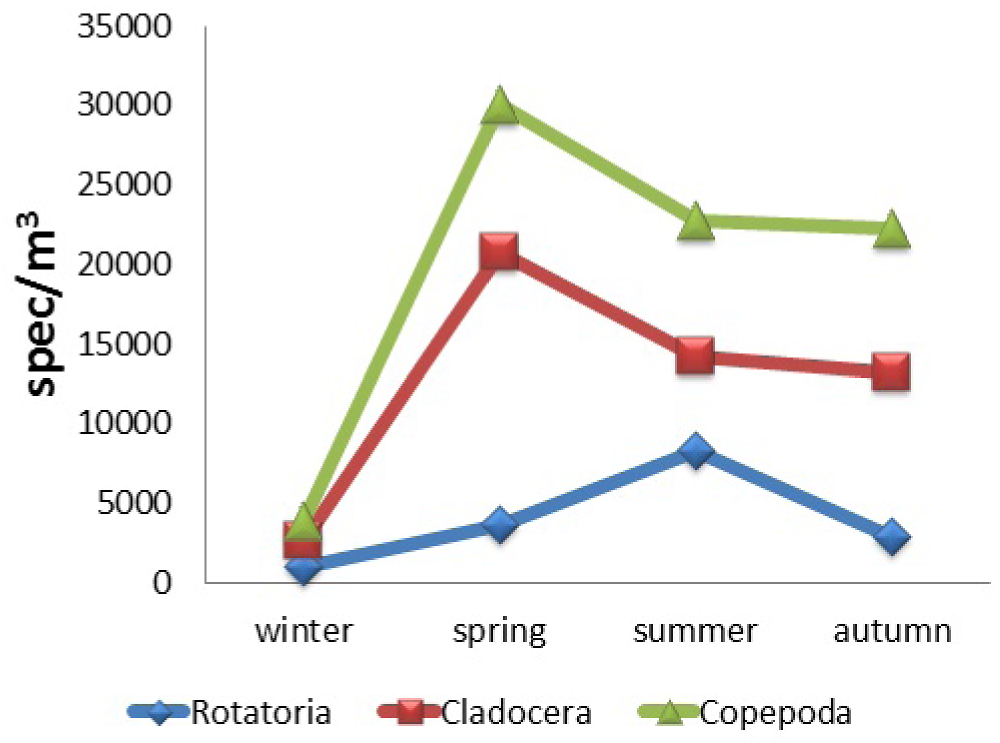

Fig. 2. Seasonal differences in the total numbers of different groups of multicellular zooplankton in the Varvara reservoir

Рис. 2. Сезонные количественные различия групп многоклеточного зоопланктона Варваринского водохранилища

In terms of distribution, the species of multicellular zooplankton observed in the reservoir may be divided into the following ecological groups by their preferences:

(a) Ubiquitous species, widespread not only in plankton, encountered all year round. This group includes 17 species and subspecies (41.4% of total), for example: *S. pectinata, P. vulgaris, A. priodonta, L. luna, B. calyciflorus, K. cochlearis, D. longispina, D. hyalina, Ch. sphaericus, A. affinis, B. longirostris, Arct. acutulobatus, M. fuscus, M. albidus, E. serrulatus, P. f. fimbriatus, A. gigas.*

(b) True plankton species, including, along with ubiquitous species, *S. pectinata, P. vulgaris, A. priodonta, L. luna, B. calyciflorus, K. cochlearis, K. quadrata, F. longiseta, D. longispina, D. longispina hyalina, B. longirostris, A. acutulobatus, A. gigas,* belong also *L. lunaris, B. angularis, K. quadrata, F. longiseta, M. brachiata* encountered mainly in pelagic waters in open regions of the Varvara reservoir.

(c) Species inhabiting aquatic phytocenosis (living amongst plants), such as *L. quadridentata, B. quadridentatus, B. falcatus, B. diversicornis, P. patulus, C. reticulata, S. vetulus, M. hirsuticornis, G. testudinaria, Ch. sphaericus, P. aduncus, M. albidus, M. fuscus, M. aduncus, E. serrulatus, E. macruroides, M. gracilis, M. dybowski* preferring regions overgrown with aquatic plants in well-lit coastal waters where microalgae and ciliates are always present in large numbers, acting as food items for many multicellular zooplankton species of different taxonomic groups.

It is known that the species composition of zooplankton in water reservoirs constantly changes depending on time of year. The formation of seasonal complexes of zooplankton depends on the biological features of the species, but also on the water temperature, availability of food sources and many other factors. These complexes of zooplankton differ from each other by leading species. There is a clear pattern of the lowest number of species being observed in the cold months of the year and the highest in the warm ones. From winter to summer, a linear growth in species quantity and population density of zooplankton is observed.

As already noted, of all the zooplankton species observed in the Varvara reservoir, 18 ubiquitous species are encountered throughout the whole year. In April, these zooplankton species join the former in the Varvara reservoir: *L. lunaris, K. quadrata, P. patulus, Hexatra mira, M. brachiata, C. reticulata, C. vicinus* and *M. dybowski.* Aside from specimens of these species, nauplii of early stages are encountered, belonging to suborders of the colonoids and cyclopoids. Along with the ubiquitous species, they make up the spring complex of zooplankton. As the water temperature rises to 18–22°C, there is a linear increase in the total numbers of observed species, and heat-loving species appear, such as: *B. falcatus, B. diversicornis, F. longiseta, S. vetulus, S. mucronata, M. hirsuticornis, G. testudinaria, P. aduncus, M. gracilis* which drive the high population density of zooplankton in spring and make up most of the total numbers. Thus the spring complex of zooplankton forms in May.

In the summer period, water temperature in the middle and lower sections of the reservoir grows to 25–32°C, and the number of heat-loving species is naturally the highest. Among these, numerically significant ones include *B. falcatus, B. diversicornis, F. longiseta, S. vetulus, S. mucronata, M. brachiata, C. vicinus, M. grasilis* and *M. dybowskii* reaching maximum numbers in their development.

The autumn zooplankton complex is comprised of 36 species. In this period, water temperature falls to 15–20°C. Heat-loving species such as *B. falcatus* and *B. diversicornis* fall out of plankton communities, and the numerically dominant species of this period are *S. pectinata, P. vulgaris, A. priodonta, L. luna, B. calyciflorus, K. quadrata, D. longispina, D. l. hyalina, M. brachiata, C. reticulata, Ch. sphaericus, B. longirostris, A. acutulobatus, M. fuscus, M. albidus.*

Thus, throughout the year the Varvara reservoir sees a consecutive alternation of multicellular zooplankton species, each associated with different seasons and dominating in the specific conditions optimal for them.

Seasonal succession in ciliate communities of zooplankton. Multi-year data on seasonal changes in the quantity of planktonic ciliates of the Varvarian reservoir can be portrayed as a double-peaked curve, with two maximums in spring and autumn, and two minimums in winter, and, less markedly, in summer (figure 3).

As seen in fig. 3, there is a steady increase in the amount of planktonic ciliates from winter to spring. For instance, if in winter the total number of ciliates was 1 200 ind./l, in March it would have already reached 2 100 ind./l, and in April and May would reach its maximum of 10 000 ind./l. In June, the total quantity of planktonic ciliates would drop to 8 000 ind./l, and in July and August to 6 500 ind./l.

In autumn, with the dropping water temperature, the total number of planktonic ciliates increases again, reaching first 7 000 ind./l, and in October forming the second — although smaller than the spring one — peak of 8 300 ind./l.

It should be noted that the seasonal succession in ciliate plankton communities is explained by constant rotation of different species complexes.

(a) Ubiquitous group, forming the core of the ciliate communities. These include such genera as *Halteria, Strombidium, Strobilidium, Limnostrombidium, Askenasia, Mesodinium,* and *Cyclidium*. These ciliates are present in plankton communities practically throughout the year. However, their total quantity grows significantly in spring and autumn, accounting for the spring and autumn peaks of total numbers along with ciliates of other groups.

(b) Stenobiont group, present in plankton for a short time in spring and autumn. Most of the observed species belong here, only appearing in planktonic ciliate communities for a short time and accounting for spring and autumn peaks of total numbers. These ciliates develop during temperature parameters optimal for them (12–12°C) and when bacte-

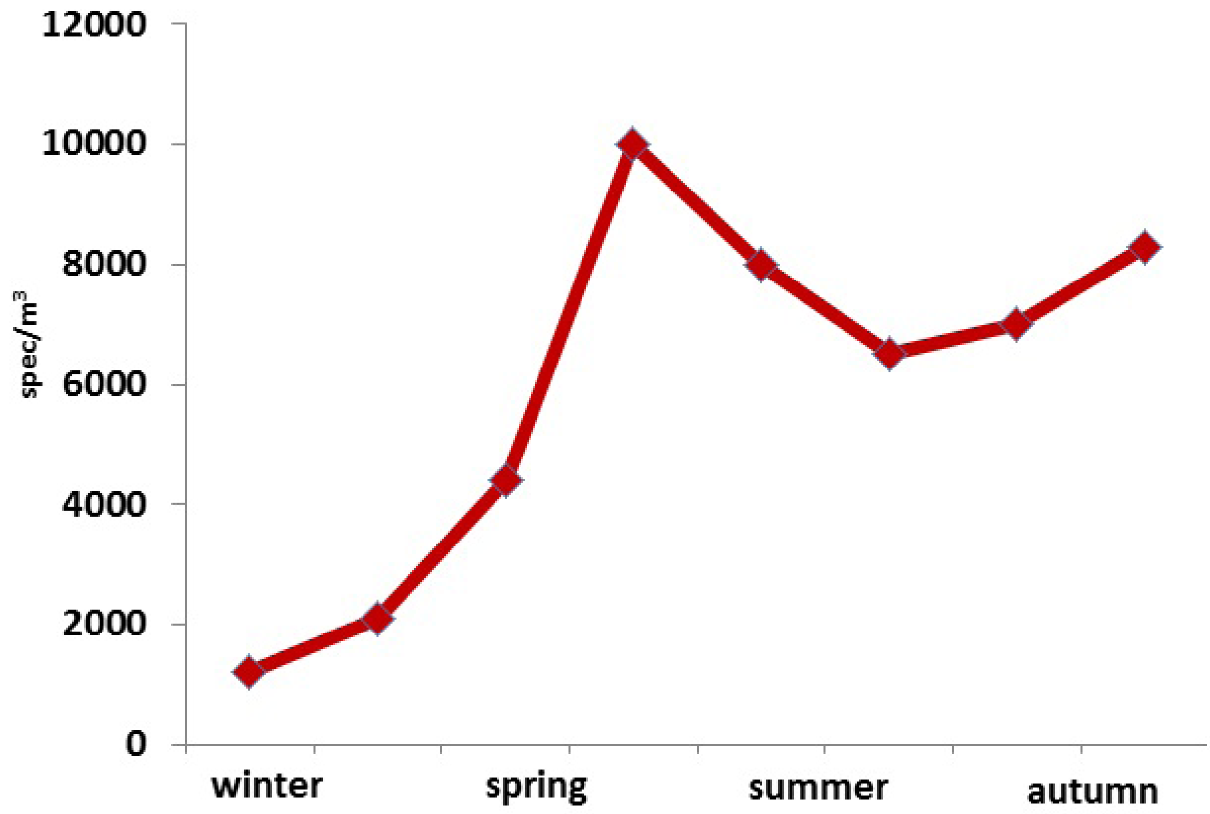

Fig. 3. Seasonal dynamics of total quantity of planktonic ciliates in the Varvara reservoir

Рис. 3. Сезонная динамика общего количества инфузорий планктона Варваринского водохранилища

ria and microalgae are abundant in the water, serving as their food sources.

(c) Heat-loving group, only growing in numbers in summer. Foremost of these are the members of *Oligotricha,* being mainly bacteriophages, such as members of the genera Pelagohalteria, Rimostrombidium, and the representatives of *Peritricha,* such as *Epistylis plicatilis* and *E.coronata,* often attaching not only to the algal thalli, but also the bodies of plankton crustaceans (*Daphnia sp*., *Bosmina sp*., etc.).

Thus, in communities of both multicellular and ciliate plankton of the Varvara reservoir, a seasonal succession is observed, represented by a constant rotation of dominant species.

According to our observations, this is due to two factors:

1. Temperature factor. With the spring increase in temperature and solar insolation, strong development of both bacterial cells and phytoplankton organisms begins in the plankton, first and foremost coccoid and diatom algae.

2. Trophic factor. These organisms and dead organic matter, serving as food for many zooplankton filter feeders, act as an abundant food source for primary and secondary consumer organisms, to which both ciliates and small multicellular zooplankton organisms belong.

Relationships between communities of ciliates and groups of multicellular zooplankton. As we have already noted, to understand general patterns of development and function of communities of freshwater zooplankton, it is crucial to research and compare qualitative and quantitative characteristics of its main groups as a single whole. In this vein, our observations have shown the clear seasonal correlation between the trends in quantities of ciliate and specific multicellular zooplankton life in the Varvara reservoir.

For instance, our observations have confirmed the active role of rotifers in the feeding of many ciliates, especially oligotrichs. These true planktonic ciliates, as is known, are active bacteriophages and play an important role in biological self-cleaning of freshwater bodies, consuming bacterial cells in massive numbers. We have also noted a maximum density of rotifers and early stages of copepods during their thermal optimum in the summer (20–24°C).

It should also be noted that maximum quantities of rotifers and copepods correlate to the development of many ciliate bacteriophages, especially members of the genera *Halteria, Strombidium, Rimostrombidium, Codonella,* etc. Maximum quantities of rotifers and copepods was observed 15–25 days after the arrival of a high quantity of ciliate plankton. There have already been reports indicating that nauplii of dominant cyclopoid copepods have a significant effect on overall numbers of nanoplankton, including free-living ciliates, and thus present an important trophic link in classical food nets in aquatic ecosystems.

It is also interesting that the increase of copepod density happens in experimental conditions even in habitats with unoptimal temperatures of 12–19°C which is another indication of the trophic factor playing a dominant role in their development.

In early spring, with water temperatures of 10–12°C, the ciliate plankton of the pelagic waters of the Varvara reservoir—especially its upper sector—is dominated by large predators such as members of genera *Paradileptus* and *Trachelius*. These ciliates do not only utilize small species of other ciliates *(Cyclidium, Uronema)* as food, but also consume rotifers.

In summer, peritrich ciliate plankton develops in large numbers, such as members of genera *Epistylis, Vorticella,* and *Zoothamnium.* Notably, many species of peritrich ciliates become ectocommensals of multicellular zooplankton organisms, attaching to rotifers, copepods, and cladocerans, sometimes covering their surface very tightly. This commensalism allows the attached organisms to increase their feeding capabilities significantly, as movement at large speeds on the surface of multicellular organisms increases their filtration of bacterial cells and microalgae.

Conclusion

1. Research of zooplankton communities in the Varvara reservoir revealed 44 species of ciliate plankton, and that of multicellular zooplankton revealed 19 species of Rotatoria, 12 species of Cladocera and 10 species of Copepoda.

2. Seasonal changes in numbers of reservoir zooplankton communities differ. In the ciliate plankton community, there were two growth peaks in spring and autumn. In multicellular zooplankton, there is only one quantity peak of Rotifera in summer, and one quantity peak of Cladocera and Copepoda in winter. A correlation between the quantity of ciliate communities and multicellular plankton was observed. The peak of total numbers of Cladocera and Copepoda was observed 15–25 days after the total peak of the main groups of ciliates.

3. Seasonal succession of species composition of zooplankton is due to the rotation of species with seasonal changes. In communities of planktonic ciliates, there are three distinct groups: ubiquitous species, present in plankton throughout the whole year, stenobionts, accounting for spring-autumn quantity peaks, and heat-loving species, only present in plankton in summer. In the community of multicellular zooplankton, we identify the group of ubiquitous species, group of true plankton species and phytocenosis inhabitant group, which prefers to live amongst aquatic plants.

4. Maximum density of rotifers and nauplii of copepods correlate with maximum quantity growth of many ciliate bacteriophages. Maximum quantity of rotifers and copepods was observed 15–25 days after a high quantity of ciliate plankton was registered, which in our view can be explained by tight trophic connections between the two.

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