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THE COMPOSITION AND STRUCTURE OF THE MICROCRUSTACEAN ZOOPLANKTON OF THE ARTIFICIAL RESERVOIR GRLIŠKO IN EASTERN SERBIA

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ABSTRACT. This paper provides an overview of the qualitative composition and structure of the microcrustacean of the Grliško reservoir based on field research conducted from 11 June 2019 to 9 July 2019. Sampling was carried out every seven days at sub-sites with different macrofauna, using the standard hydrobiological methodology. A total of 18 zooplankton taxa were recorded, belonging to the following groups: Rotifera (1 taxon), Cladocera (12 taxa), and Copepoda (5 taxa). The largest number of taxa was found in June. The total number of taxa was almost the same in the sub-areas with a lot of macro-vegetation and without vegetation but differed in the qualitative composition of zooplankton species, spatially and temporally. Since the main purpose of the Grliško reservoir is to provide water for the population, it is necessary to constantly monitor the zooplankton, as it can be an important indicator of the state of this aquatic ecosystem.

Keywords: Grliško reservoir, zooplankton, community composition, Cladocera, Copepoda

INTRODUCTION

Communities of planktonic invertebrates (zooplankton) are important indicators of the status of natural and artificial aquatic ecosystems. Normally, they present the key trophic link between primary producers and higher trophic levels in the natural systems. As these organisms provide food for other invertebrates and fish, high predation pressure spreads to all levels of the ecosystem. The effects of predation pressure are expressed in various adaptive behaviors of community members, including cyclomorphosis (PAVKOVIĆ-LUČIĆ *et al.*, 2017).

In his study, OSTOJIĆ (2010) mentions that zooplankton research in Serbia has been rather sporadic and unsystematic in the past. In addition to basic research on zooplankton

composition and dynamics, researchers focused on water quality monitoring and aquatic ecosystem restoration. Other important contributions to zooplankton research have been made through the study of zooplankton fauna, their vertical distribution, their importance as fish food, and a biological phenomenon known as cyclomorphosis (OSTOJIĆ, 2010).

So far, studies of microcrustacean in the Grliško reservoir have been carried out as part of the hydrobiological analyses for monitoring the water quality of the artificial lake. However, due to the potential risk of eutrophication, the studies have mainly focused on phytoplankton. The zooplankton community has also been studied, and unlike other artificial lakes, it has been extensively researched before (JANKOVIĆ, 1966; OSTOJIĆ, 2000).

The aim of this work is to investigate the qualitative composition and structure of the microcrustacean zooplankton of Grliško reservoir and thus contribute to the management of the artificial lake and the knowledge of the microcrustacean zooplankton fauna of Serbia.

MATERIALS AND METHODS

Study area

Reservoir Grliško is an artificial reservoir created in 1989 by damming the Grliška River to solve the problem of water supply in the area of the town of Zaječar. It is located 18 km south of Zaječar. Reservior Grliško is one of the smallest shallow reservoirs in Eastern Serbia, with a volume of 11 x 10^9 m^3 and a maximum water depth of 20 m (SIMONOVIĆ *et al*., 2008). Large water level fluctuations are possible during the year, so that the risk of eutrophication is high. Such reservoirs, rich in macrophyte vegetation and detrital deposits on the muddy bottom, are suitable aquatic habitats for research of zooplankton communities (PETKOVIĆ, 1975). During zooplankton sampling, the water level was relatively high (about 193 cm, according to official data from PUK "Vodovod", Zaječar, Water Purification Plant “Kraljevica”).

Sampling and laboratory analyses

Zooplankton sampling was conducted in June-July 2019 at a site with coordinates N: 43º 48' 31"; E: 22º 13' 49" (Fig. 1) at two separate habitats: a habitat with a muddy bottom and a water depth of about 70 cm (subsite 1) and a habitat with a water depth of 60 cm and dense coastal macro-vegetation (subsite 2).

Sampling was conducted using a plankton net (mesh size 250 μm) along the water column. For each sample, the net was cast ten times to achieve a higher concentration of sampled material. In the field, samples were preserved with 70% ethanol. Fixed samples were first examined to separate zoological material from algae and detritus, and then identified using keys (КУТИКОВА, 1984; MARTIN and DAVIS, 2001; DUMONT and NEGREA, 2002; WITTY, 2004; HANEY *et al.*, 2013). Identification was made to the genus and species level, while part of the sample was identified to the family or class (subclass) level. Identification was carried out with a Nikon Eclipse E100 binocular light microscope and photographed with a digital camera installed on the microscope. Observation of larger specimens was done with a Nikon SMZ800N binocular with an integrated Nikon DS -Fi2 camera. A Nikon DS -L3 control unit was used for calibration and scaling.

Official data on physical and chemical parameters of water quality for June and July 2019 from JKP “Vodovod” Zaječar, water treatment plant “Kraljevica” were used (ANONYMOUS, 2018).

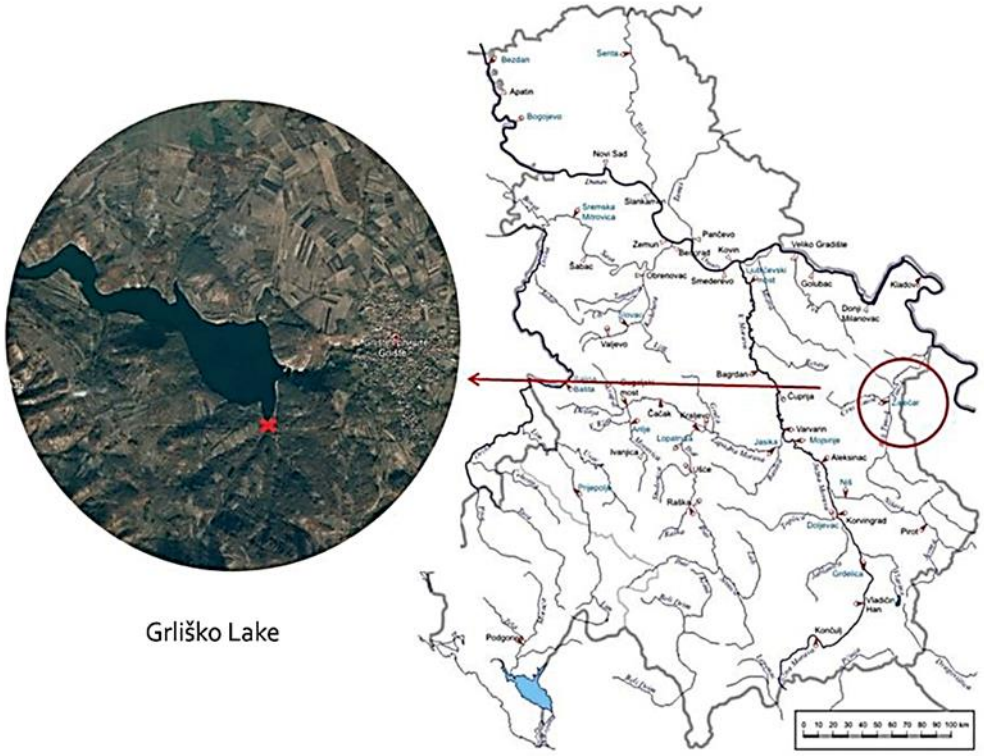

Figure 1. Geographical position of Grliško reservoir in Serbia (in red circle) and the point where the sampling sites were located (marked with x on the map).

RESULTS AND DISCUSSION

The characteristics of the type and quality of water in the study area, i.e., knowledge of its physical and chemical parameters, are important for monitoring aquatic organisms. The values of the basic physical and chemical parameters of the water quality of the Grliško reservoir by the public utility "Vodovod" Zaječar are presented in Tab. 1.

Table 1. Basic physico-chemical water quality parameters in 2019, Grlište reservoir by the public utility "Vodovod" Zaječar (ANONYMOUS, 2018).

Parameters	June		July	
	Water surface	3 m water depth	Water surface	3 m water depth
Temperature (˚C)	26,9	19,1	28	24,2
pH	8,46	8,12	8,42	8,31
CO_2 (mg/L)	0,0	3,0	0	0
O_2 (mg/L)	9,42	4,74	8,74	8,57
BPK5 (mg/L)	1,42	0,43	1,89	2,08
$KMNO_4$ (mg/L)	15,39	18,21	12,73	14,64
Total hardness ˚dH	10,92	12,04	/	/
Turbidity (NTU)	6,12	6,14	5,15	6,35
Conductivity (µs/cm)	309	346	287	327
NO_3 (mg/L)	0,479	1,083	0,271	0,000
NO_2 (mg/L)	0,005	0,046	0,004	0,007
NH_4 (mg/L)	0,229	0,297	0,142	0,182
Total PO_4 (mg/L)	0,058	0,073	0,108	0,107

The total number of zooplankton taxa detected in the Grliško reservoir was 18, of which 5 were identified at the species level (Tab.2). Six taxa were identified at the genus level, four at the family level, one at the suborder level, and two at the order level.

Table 2. List of identified zooplankton taxa.

	June 2019		July 2019	
Taxa	**Subsite 1**	**Subsite 2**	**Subsite 1**	**Subsite 2**
Phylum Rotifera Cuvier, 1817				
Filinia sp.	+			
Phylum Arthropoda				
Subordo Cladocera Latreille, 1829	+	+	+	+
Bosmina longirostris (O.F. Müller, 1785)	+			
Familia Chydoridae Stebbing, 1902	+		+	+
Alona sp.	+		+	
Alona quadrangularis (O.F. Müller, 1785)			+	
Chydorus sp.			+	
Familia Daphniidae Straus, 1820	+	+		+
Scapholeberis sp.		+		+
Scapholeberis mucronata O. F. Müller, 1776	+	+		
Daphnia sp.	+	+		
Daphnia cucullata Sars, 1862	+	+		
Simocephalus sp.		+		+
Subclassis Copepoda Milne-Edwards, 1840				
Ordo Calanoida Sars, 1903		+		
Familia Diaptomidae Baird, 1850		+		
Eudiaptomus gracilis Sars, 1863		+		
Ordo Cyclopoida Burmeister, 1834	+	+		+
Familia Cyclopidae Rafinesque, 1815	+			

The sampled crustacean taxa mainly belong to the groups Cladocera and Copepoda (Figure 2).

Most crustacean taxa belong to the Cladocera group (12 taxa - 66.67% of the total number of taxa). In the subsite without vegetation (subsite 1) 10 taxa (76.92% of the total number of taxa) were found, while in the subsite with vegetation (subsite 2) 8 taxa were found (66.67% of the total number of taxa). The reason for the results obtained is the use of plankton nets, which are not suitable for collecting microcrustaceans such as rotifers and small planktonic arthropods. Microcrustacean zooplankton composition is highly dependent on local abiotic factors, including hydrology and water nutrition, pH, and biotic factors, especially the presence of aquatic vegetation and the extent of predation (SCHÖLL and KISS, 2008). Physico-chemical water quality parameters are important for characterizing the ecological status, i.e., the potential

of the reservoir. The water temperature was fairly constant throughout the study. Turbidity ranged from 5.15 to 6.35 NTU, at or slightly above the limit of the maximum allowable value (5 NTU). The total organic matter content is determined by the consumption of $KMNO_4$ required for oxidation (oxidizability). Due to the presence of organic material, this value is just above 10 mg O_2/L. From this parameter, it can be concluded that the water of the Grliško reservoir belonged to the third quality class at the time of sampling (ANONYMOUS, 2012). According to the measured pH value, the water in the reservoir is slightly alkaline. The pH and calcium content of the water may affect the occurrence of groups with well-developed shells and, in particular, their competitive advantage over other species. This can affect the population dynamics and productivity of zooplankton communities (HESSEN *et al.*, 1995). Conductivity was within acceptable limits and the results obtained showed that there was no increase in ionized forms of inorganic substances in the water samples (CHAPMAN and KIMSTACH, 1996).

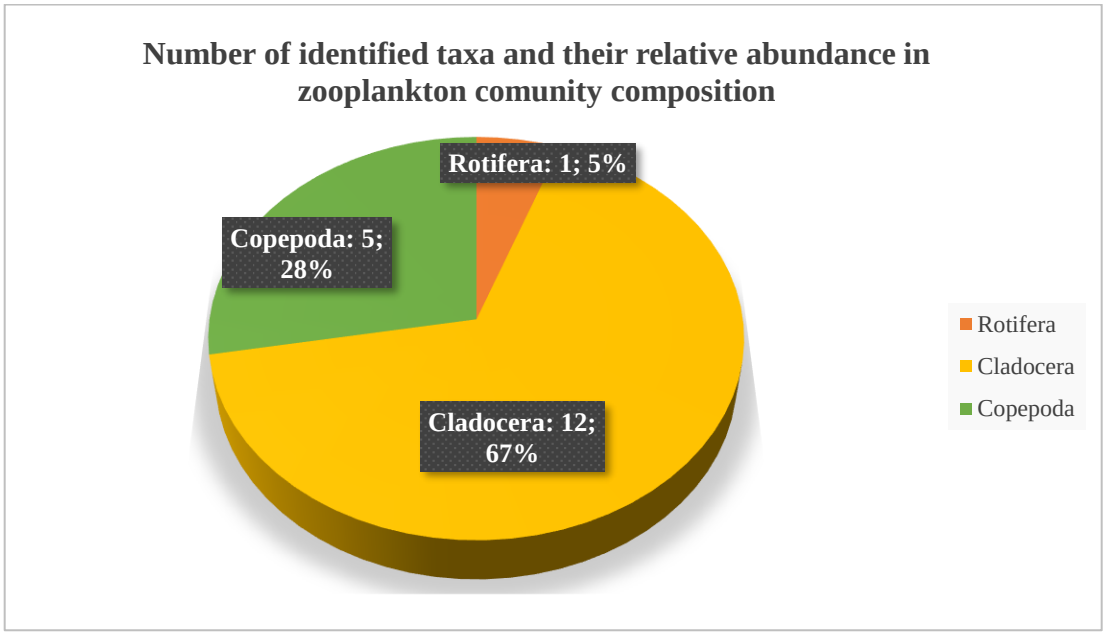

Figure 2. Structure of zooplankton community.

Important factors affecting the community of planktonic crustaceans in Grliško reservoir include water temperature, nutrients, sediment, presence of predators (*Carassius gibelio, Alburnus alburnus, Abramis brama, Rutilus rutilus)* (SIMIĆ *et al.*, 2018) and macrophytes. The most numerous taxa in this study were Cladocera, including six genera: *Bosmina*, *Alona*, *Chydorus*, *Scapholeberis*, *Daphnia*, and *Simocephalus* (Table 2). The species *Bosmina longirostris* O.F. Müller, 1785 is common in all types of fresh and brackish water around the world (DANG *et al.*, 2015), regardless of the nutrient status or pH of the water (DUMONT and NEGREA, 2002; ADAMCZUK, 2015). Changes in Cladocera community composition and relative abundance are often associated with fluctuations in water level. Fish feed primarily on large zooplankton - Cladocera - and affect plankton communities, which can increase the relative abundance of other zooplankton species. For example, DAVIDSON *et al.* (2007) found that a decrease in the abundance of "larger" taxa, particularly the family Daphniidae, led to an increase in the abundance of "smaller" species of the family Bosminidae.

Cladoceran species are usually predominant in temperate lakes (FORRÓ *et al.*, 2008), and members of this taxon are considered to be one of the most important factors influencing the evolution of the lake ecosystem (DAVIDSON *et al.*, 2007). Among the taxa that dominated in lakes is the genus *Alona*. Some species can survive in lakes with different depths and nutrient situations and feed on detritus, even under extreme conditions (FLÖSSNER, 2000). Some of the

Chydorus species, such as *C. sphaericus* (O. F. Müller, 1776) are also tolerant (FLÖSSNER, 2000). Cladocera zooplankton is not particularly sensitive to pH, but the range of 6.5 to 8.5 is best for most species (PETROV *et al.*, 2008). Cladoceras are very sensitive to changes in diet influenced by water temperature, especially in summer when the temperature is an important factor determining the composition and relative abundance of plankton communities. The microcrustacean community, Cladoceran and Copepoda species (*Cyclops sp*. and *Diaptomus sp.*) had high production in the Ćelije reservoir during the summer months (ŽIVIĆ *et al.*, 2008). Further, in this respect, parthenogenesis in these taxa responds to seasonal fluctuations. The response, with a rapid transition to sexual reproduction and the production of dormant eggs, occurs when temperature conditions become unfavorable (BRENDOCK and DE MEESTER, 2003).

The species richness of the Cladocera group in the Grliško reservoir could also be related to the increasing eutrophication in summer. According to the studies conducted under the Fisheries Management Programme "Timok" (2017-2026) (SIMIĆ *et al.*, 2018), the water of Grliško was classified as moderately eutrophic. The eutrophication of the lake is indicated in our study by the presence of *Daphnia cucullata* Sars, 1862, one of the typical species of the lake. OSTOJIĆ (2000) emphasized that the presence of a large number of *D. cucullata* is also characteristic of the Grošnica reservoir in summer. Other authors noted that the species *D. cucullata* has displaced *D. longispina* O. F. Müller, 1785 in other reservoirs due to eutrophication (see in OSTOJIĆ, 2000, 2002a). A similar situation was found in the Ćelije reservoir near the town of Kruševac in central Serbia (ŽIVIĆ *et al.*, 2010), which is within the range's characteristic of meso- and eutrophic freshwater ecosystems. The predominant macrozooplankton population of Lake Ćelije was Cladocera (Bosminidae) and Copepoda (Cyclopoidae), with a significant share of *Daphnia* sp., *Bosmina* sp., and *Cyclops* sp. in the total abundance of the zooplankton (ŽIVIĆ *et al.*, 2008). In such ecosystems, temperature is the main factor influencing macrozooplankton dynamics (JOHANNSSON and O'GORMAN, 1996; ŽIVIĆ *et al.*, 2010).

The Copepoda taxa recorded belong to the families Diaptomidae and Cyclopidae. The only recorded representative of the family Diaptomidae is *Eudiaptomus gracilis* Sars, 1863. Copepod representatives were found in a small number of taxa, mainly in the vegetated parts of the reservoir, as those habitats are endowed with more oxygen, more food (phytoplankton), and better protection (with more shelter and spawning sites).

The research of zooplankton fauna in Serbian inland waters has a history of 20 years old (KALAFATIĆ, 1995a,b,c), and the results obtained by OSTOJIĆ *et al.* (2012) contribute to a better understanding of freshwater zooplankton diversity and distribution.

In this study, we summarized information available mainly for Cladocera and Copepod taxa. On the other hand, data on genera and families of rotifers are missing in the present study, which is somewhat unexpected considering that rotifers are the dominant taxa in the zooplankton of many Serbian inland waters. In the Grošnica and Gruža reservoirs, for example, they accounted for more than 50% of the taxa found (OSTOJIĆ, 2002b; 2008). The unexpectedly low number of rotifers in the Grliško reservoir may be due to the gaps in sampling procedures. Much species information may be due to the escape of smaller species through the net mesh during sampling. Although the distribution of small organisms (such as the many planktonic taxa) can be unpredictable in both freshwater and marine environments (SOININEN *et al.* 2013), further study of the fauna of the Grliško reservoir is needed, particularly for rotifers and other neglected planktonic species.

CONCLUSION

Since the Grliško is a reservoir with the main purpose to supply water for the city of Zaječar and the surrounding area, there is a need for continuous monitoring of the stability of

its ecosystem to ensure good water quality for the population. Zooplankton monitoring is extremely important because any gradual or sudden decline in zooplankton dominance can be a direct or indirect indicator of seasonal changes, as well as changes in the water level, which can lead to a disturbance in the balance of this ecosystem over time.

It is supposed to be that the actual diversity of microcrustacean taxa in the Grliško reservoir is higher compared to the present data, and further research at several sub-habitats is needed. Group Cladocera was represented by the largest number of taxa (12), and it probably mostly affects the relative abundance of other zooplankton species in the lake. Also, moderate eutrophication of the lake was confirmed by the presence of one of the most characteristic cladoceran bioindicator species, *Daphnia cucullata*. Those observed trends indicate the possible direction of further research in the Grliško reservoir.

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