RESEARCH ARTICLE

New data on zooplankton communities of two Bulgarian reservoirs: Konush and Sinyata Reka, Plovdiv Region

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ABSTRACT
Zooplankton communities have several vital functions within lake ecosystems, including the transfer of energy and material from producers to secondary consumers. Their structure is potentially affected by both lake morphology and typology, as well as by anthropogenic changes in lakes. These communities are also sensitive to various substances in the water column, e.g. nutrients and pollutants. Thus, they have often been used as indicators to assess the condition of and changes in lentic environments. Our aim was to present first detailed data about the species composition and structure of zooplankton communities in two understudied Bulgarian reservoirs, the Konush and Sinyata Reka Reservoirs. Twelve samples were collected in spring and summer 2016. The qualitative analysis of the zooplankton revealed the presence of 40 taxa from three main taxonomic groups: Rotifera, Cladocera and Copepoda. From these, the most frequently occurring were the rotifers (53.66%), followed by the cladocerans (24.39%) and the copepods (21.95%). The established high abundance and higher species diversity of rotifers, together with the equal distribution for all zooplankton species in the samples, confirmed the eutrophic status of both reservoirs.

Key words: zooplankton, diversity, eutrophic reservoirs, Ecoregion 7, Bulgaria

Introduction

Zooplankton plays a central role in standing water bodies. It is a characteristic indicator of water quality, eutrophication and pollution levels, on the one hand, and is an essential element of the food chain, on the other (Saksena, 1987). It is important to study the relationship between the trophic structure of lakes and reservoirs and their plankton communities (Rogozin, 2000). The depth of the reservoirs influences the extent of eutrophication. The shallower the water basin is, the less is the relative share of the zooplankton community in its biotic balance (Naidenov, 1987). The filtering capacity of zooplankton may have significant implications for the trophic state of standing water bodies. Therefore, in order to understand the processes in reservoirs, it is necessary to study the composition and structure of their zooplankton assemblages.

Another parameter that could be used to assess the trophic state of natural or manmade lakes is the Secchi depth transparency. It reflects both the seasonal thermal structure and the plankton productivity in reservoirs (Likens, 1975). It is a function of the light absorption characteristics of the water which is impacted by dissolved and particulate matter.

Zooplankton communities in Bulgarian reservoirs have been previously studied by Naidenov (1962, 1964, 1987), Angelov (1968), Kozuharov (1994, 1996), including the study by Grozev (1997) on small lowland reservoirs in the Plovdiv Region. Zooplankton has been found to represent between 40 and 98% of the secondary productivity of reservoirs in Bulgaria; the relative share of zooplankton is the lowest in highly eutrophicated water bodies with high autotrophic production (Naidenov, 1987).

Our aim was to present new data on species composition of zooplankton communities in the Konush and Sinyata Reka Reservoirs, Bulgaria. For the Sinyata Reka Reservoir, there are no hydrobiological data in the available literature and this is the first paper on its zooplankton fauna. The Konush Reservoir is a Protected Natura 2000 wetland and an Important Bird Area. In a recent management plan for the Konush Reservoir, 16 zooplankton taxa have been listed [Management Plan of Protected Area "Konush Reservoir" (BG002015), 2016]. In our study, we supplement and expand these data.

Materials and Methods

Study area

The Konush and Sinyata Reka Reservoirs are located in Ecoregion 7 – East Balkans, as determined on the basis of their biogeographical zoning (Illies, 1978). They are both located in the Plovdiv Region, Aegean Sea Basin (Figure 1).

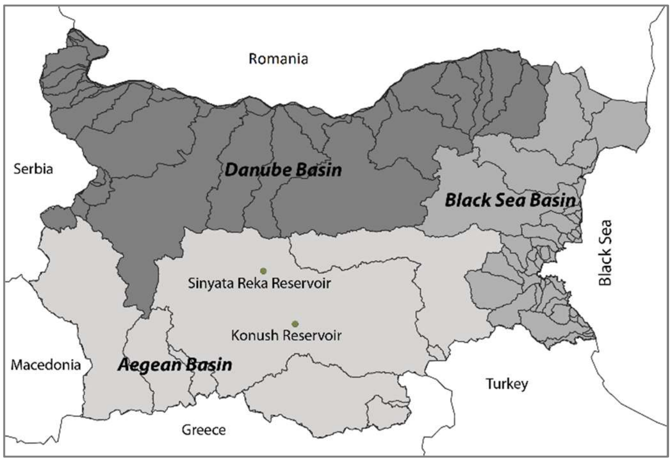


Figure 1. *Map of Bulgaria (1:250 000) with main watersheds (Ecoregion 12: Danube and Black Sea Basins and Ecoregion 7: Aegean Basin) and location of the two studied reservoirs.*

They are small lowland reservoirs (lake type L17) according to the Water Framework Directive (WFD, 2000/60/EC) and the National water bodies typology (Belkinova et al., 2013). Both reservoirs are used for sports fishing and annually stocked with carp fish. They are without fluctuations in water levels, except when the fish is caught. Data on their altitude, longitude and latitude were provided by the East Aegean River Basin in Plovdiv, Bulgaria (Table 1).

Table 1. *Basic parameters and geographic coordinates (WGS 84 map system) of the studied reservoirs.*

Reservoir	Lake area (ha)	Max depth (m)	Latitude N	Longitude E	Altitude (m a.s.l.)
Konush	37.6	5	42.08147	25.03406	237
Sinyata Reka	52.8	6	42.46888	24.70333	309

Sampling and laboratory analysis

The samples were taken from five stations: three in the Konush and two in the Sinyata Reka Reservoirs, in both spring and summer 2016. They were collected with an Apstein qualitative plankton net with mesh size of 40 µm. The zooplankton samples were stored in plastic bottles and fixed with ethanol (70%).

The physical and chemical parameters of the water were measured in situ using standard methods (ISO 5667). Temperature, oxygen and conductivity were measured with WTW portable meters (series 330i). Water transparency was measured using a Secchi disk with a diameter of 0.25 m.

In the laboratory, zooplankton was identified to species level, following Kutikova (1970); Bledzki & Rybak (2016), when possible, and counted estimation of zooplankton abundance was done through sub-sampling (1 – 5 ml) of the well-mixed sample using a Dimov type counting chamber (Dimoff, 1959).

The size of the rotifers was estimated following EPA (2016). Due to the diversity and wide size range of plankton crustaceans, individual lengths were routinely measured under a microscope. The biomass was calculated using specific ratios of length and dry weight for individual zooplankton species (McCauley, 1984). These conversion equations followed the general power equation:

$W = \alpha L^{\beta}$,

or in its logarithmic transformation

$Ln(W) = Ln(\alpha) + \beta Ln(L)$,

where W was dry weight in µg, L was length in mm, β was the slope of the logarithmic relationship and Ln(α) was the intercept.

Zooplankton abundance and wet weight biomass were expressed as $ind.m^{-3}$ and $mg.m^{-3}$, respectively.

Data analysis

We studied the diversity of the two reservoirs based on their taxon list. The selected biodiversity indices included: Shannon (H), dominance (d) and Pielou's evenness (e) indices. They were calculated using Past software (version 3.14). The value of the Shannon index normally varies between 1.5 – 3.5 for ecological data and rarely exceeds 4 (Southwood & Henderson, 2000). The dominance and the evenness indices range is 0 – 1. The dominance index captures the variance of the species abundance distribution (Magurran, 2004). It approaches 0 when all taxa are equally presented and approaches 1 when one taxon dominates the community completely. On the other hand, evenness approaches 1 when all species have similar abundance (Pielou, 1975).

Results

Environmental factors

The measured values of the water parameters (Table 2) were generally outside the range for "referent conditions" for L17 (Regulation N4/2012 and East Aegean River Basin Directorate). Secchi disk transparency was very low which was due to the registered phytoplankton blooms during our sampling.

Table 2. *In-situ parameters of surface waters from the Konush and Sinyata Reka Reservoirs, 2016.*

Water parameter	Konush		Sinyata Reka	
	spring	summer	spring	summer
Temperature (˚C)	22.9	28.0	22.9	24.6
Conductivity (µS)	617	604	370	414
Dissolved oxygen ($mg.dm^{-3}$)	-	13.8	-	3.5
pH	8.58	9.22	9.39	9.68
Secchi depth (m)	0.6	0.6	0.8	0.5

Taxonomic structure of zooplankton

We recorded 40 zooplankton taxa: 27 taxa from the Konush and 29 from the Sinyata Reka Reservoirs (Table 3). The most frequently occurring were the rotifers (53.66%), followed by the cladocerans (24.39%) and the copepods (21.95%). In addition, we recorded high abundance and higher species composition richness of rotifers in the zooplankton of these eutrophic reservoirs. Dominant in terms of species abundance were *Brachionus diversicornis* (Daday, 1883), *Keratella tecta* (Gosse, 1851), *K. cochlearis* (Gosse, 1851), *Fillinia longiseta* (Ehrenberg, 1834), *Moina micrura* Kurz, 1874, *Bosmina longirostris* (Muller, 1785) and *Thermocyclops crassus* (Fischer, 1853). We identified 23 taxa of the phylum Rotifera, nine taxa of the superorder Cladocera, seven taxa of the order Cyclopoida and one species of the order Calanoida for both reservoirs. With the highest abundance were the rotifers.

Seasonal dynamics of zooplankton

Abundance

The highest absolute sample abundance was recorded in

Table 3. *List of zooplankton taxa, recorded from the Konush and Sinyata Reka Reservoirs for both seasons; sp – spring, su – summer, 0 – not found.*

Taxon	Konush	Sinyata Reka
Rotifera		
Brachionus diversicornis (Daday, 1883)	sp/su	sp/su
Brachionus angularis Gosse, 1851	sp	su
Brachionus caliciflorus Pallas, 1766	sp/su	sp
Brachionus caliciflorus amphiceres (Ehrenberg, 1838)	0	sp/su
Brachionus furficula Wierzejski, 1891	sp/su	su
Keratella tecta (Gosse, 1851)	sp/su	sp/su
Keratella cochlearis (Gosse, 1851)	sp/su	sp/su
Keratella irregularis (Lauterborn, 1898)	sp/su	0
Keratella quadrata (Muller, 1786)	sp	sp
Kellicottia longispina (Kellicott, 1879)	0	sp
Lepadella sp.	0	sp
Trichocerca pusilla (Jennings, 1903)	sp/su	0
Trichocerca similis (Wierzejski, 1893)	0	sp
Asplanchna herricki Guerne, 1888	sp/su	sp/su
Asplanchnopus sp.	sp	0
Polyarthra dolichoptera Idelson, 1925	sp/su	0
Polyarthra longiremis Carlin, 1943	0	su
Polyarthra major Burckhadt, 1900	0	sp
Synchaeta sp.	sp	sp
Fillinia longiseta (Ehrenberg, 1834)	sp/su	sp/su
Tetmaslix opoliensis Gosse, 1851	0	su
Anuraeopsis fissa Gosse, 1851	sp/su	0
Haringey euroda Gosse, 1851	0	sp
Cladocera		
Daphnia obtusa Kurz, 1875	sp	0
Daphnia galeata Sars, 1864	sp	sp
Diaphanosoma sp. (cf. *mongolianum*)	sp	0
Moina micrura Kurz, 1874	sp/su	sp/su
Macrotrix sp.	su	0
Chydorus schaericus (Muller, 1776)	0	su
Alonella sp.	sp	sp
Bosmina longirostris (Muller, 1785)	sp	sp/su
Polyphemus sp.	sp	0
Cyclopoida		
Cyclops vicinus Ulyanin, 1875	sp/su	0
Mesocyclops sp.	su	0
Thermocyclops crassus (Fischer, 1853)	sp/su	sp/su
Megacyclops gigas (Claus, 1857)	0	sp
Acanthocyclops robustus (Sars, 1863)	0	sp/su
Ectocyclops phaleratus (Koch, 1838)	0	sp
Eucyclops serrulatus (Fisher, 1851)	0	sp
Calanoida		
Eudiaptomus gracilis (Sars, 1863)	sp	0

spring in the Sinyata Reka Reservoir (at the site near the dam: 8532ind.m^{-3}), while the maximum average abundance was recorded for spring in the Sinyata Reka Reservoir (7745 ind.m^{-3}), followed by summer for the Konush Reservoir (277 ind.m^{-3}). The lowest was the average abundance in the Sinyata Reka Reservoir in spring (18 ind.m^{-3}). Rotifera had the highest relative abundance followed by Cladocera and Copepoda as based on the 12 samples for the studied seasons of the two reservoirs (Figures 2a and 2b). There was one exception in the summer in the Sinyata Reka Reservoir, when the copepods had a larger percentage (17.3%) than Cladocera (8.3%) but their absolute values were close (45 ind.m^3 copepods and 22 ind.m^3 cladocerans, respectively).

Biomass

The zooplankton biomass in the Konush Reservoir was higher in summer (2.252 mg.m^{-3}, Figure 3a), while in the Sinyata Reka Reservoir, it was higher during the spring (5.117 mg.m^{-3}, Figure 3b). In both reservoirs, the major part of the total biomass was due to the rotifers (with one exception), which also had high abundance.

Structural indices of zooplankton

The values of the Shannon index were very close in both reservoirs during the two seasons (Table 4). This was probably due to the very similar species composition. The evenness index had relatively high values, while the dominance index was low. This was determined by the similar abundance of most zooplankton species and the lack of highly dominant ones for all groups in the Sinyata Reka Reservoir and for the rotifers in the Konush Reservoir.

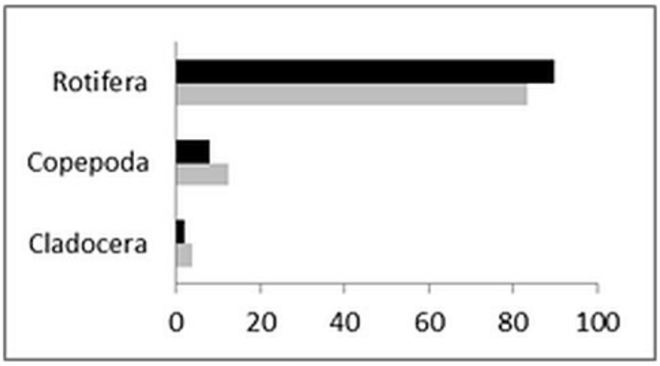
Discussion

Species composition

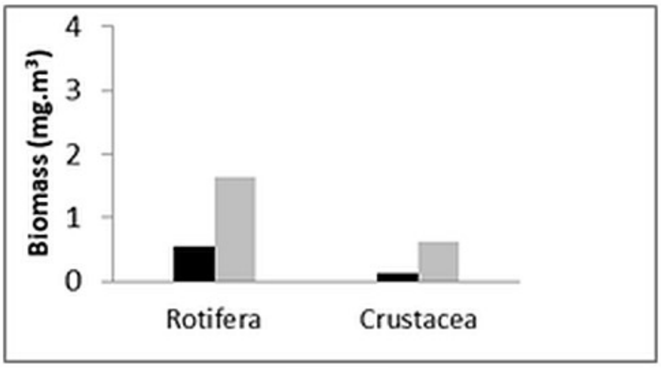
We found a total of 27 taxa in the Konush and 29 in the Sinyata Reka Reservoirs. The most taxon-rich was the group of the rotifers. It was dominant in terms of abundance and biomass for both reservoirs and seasons (except for spring in

Table 4. *Structural parameters of zooplankton community from the Konush and Sinyata Reka Reservoirs during 2016: Shannon index (H); dominance (d); evenness (e).*

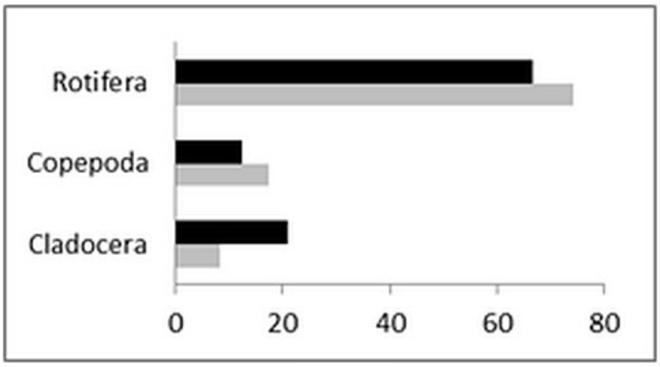
Reservoir	Season	H	d	e
Konush	Spring	2.30	0.09	0.65
	Summer	2.21	0.10	0.76
Sinyata Reka	Spring	2.15	0.10	0.56
	Summer	2.23	0.11	0.78



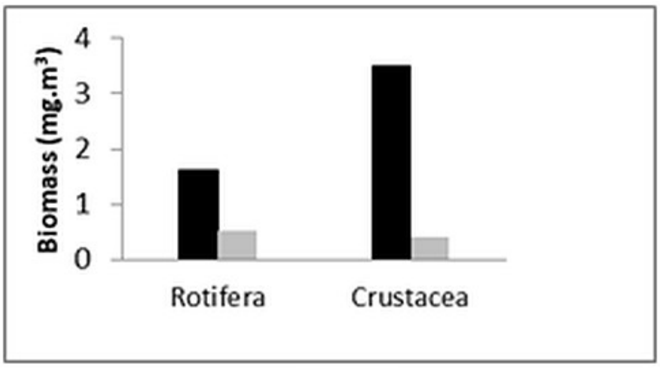
2a)



3a)



2b)



3b)

Figure 2. *Relative abundance of the zooplankton (%) in spring (black) and summer (grey) 2016:* ***a)*** *from the Konush Reservoir;* ***b)*** *from the Sinyata Reka Reservoir.*

Figure 3. *Biomass (mg.m^{-3}) of the zooplankton during spring (black) and summer (grey) 2016;* ***a)*** *from the Konush Reservoir;* ***b)*** *from the Sinyata Reka Reservoir.*

the Sinyata Reka Reservoir). We recorded the highest density and biomass in August for the Konush Reservoir, and in June for the Sinyata Reka Reservoir. According to Naidenov (1987), the maximum abundance of zooplankton, in small lowland Bulgarian reservoirs, is in spring and summer (May – July period). The shallow reservoirs over time get clogged. In addition, reservoirs whose depth is equal or close to the euphothic zone have high zooplankton production (Naidenov, 1987). The productive layer of sediments, from which the biogenic elements are extracted, is growing and is reducing the water purity as zooplankton production rapidly increases (Naidenov, 1964).

Zooplankton bioindicators

Some of the recorded rotifers, such as *Brachionus angularis* and *Filinia longiseta*, are characteristic of lakes with heavy pollution and eutrophication (Saksena, 1987). Others, like *Brachionus calyciflorus*, *Brachionus furficula* and *Keratella* spp., are typical inhabitants of mesotrophic waters (Kutikova, 1970). According to Sladecek (1983), most of the species in the genus *Brachionus* are connected to eutrophic waters.

Dominant taxa

Dominant species from Crustacea were *Moina micrura*, *Bosmina longirostris* and *Thermocyclops crassus*. This result coincides with the findings of Grozev (1997), who observed that the cladocerans *B. longirostris* and *M. micrura* dominated in the middle of the vegetation period – June, July and August. These cladocerans, together with *Thermocyclops crassus* are characteristic of eutrophic water bodies. The last cyclopoid is known to occur in large and small, natural and artificial mesotrophic and eutrophic lakes and reservoirs (Rylov, 1948; Kiefer, 1978) and occurs across Eurasia, Asia and Australia (Ueda & Reid, 2003). In Bulgaria, *Thermocyclops crassus* has been previously found in the epilimnion of lowland reservoirs, during the hottest months of the year (Naidenov, 1962).

Another cyclopoid, *Acanthocyclops robustus,* is common and occurring in high numbers in the summer in the lakes, all over the country (Naidenov, 1962). In our study, the species was found only in the Sinyata Reka Reservoir, where it had the highest abundance (395 ind.m^{-3}) of Copepoda.

Community structure

The comparison of the taxonomic composition between the two reservoirs showed a great similarity, especially in the groups of Rotifera and Cladocera, as expressed by the close values of the calculated structural indices. This might be due to the similar conditions of the reservoirs: geographic location, hydromorphology, lake typology and the similar level of eutrophication.

Conclusions

The deteriorated oxygen regime, along with the values of the other hydrochemical parameters; the low Secchi dick transparency and the registered phytoplankton blooms suggest that the two studied reservoirs are enriched with nutrients. Moreover, the specific zooplankton taxonomic structure, the dominant role of Rotifera and the values of the used structural parameters confirm that the Sinyata Reka and Konush Reservoirs are highly eutrophied (see also Kozuharov, 1996). The trophic state of the studied reservoirs might be additionally affected by fish farming in the reservoirs and other human activities in the region (mainly agriculture and presence of settlements), which could trigger further changes in the zooplankton communities and in the whole ecosystem. If the sources of pollution are not restricted, the eutrophication of the two reservoirs will increase in the future.

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