ECOLOGIA BALKANICA
2021, Vol. 13, Issue 1 June 2021 pp. 93-104

Population Dynamics and Structure of Zooplankton Community of Mandra Reservoir, Bulgaria

Dimitar S. Kozuharov, Eleonora Ts. Fikovska**, *Marieta S. Stanachkova

Sofia University "St. Kliment Ohridski", Faculty of Biology, Department of General and Applied Hydrobiology, 8 Dragan Tzankov Blvd., Sofia, BULGARIA
*Corresponding author: e_fikovska@abv.bg

Abstract. The zooplankton community in Mandra Lake has been almost unstudied since it was turned into reservoir in 1963. Human intervention in the natural water regime of the lake has affected the species diversity of the aquatic system. This study was conducted in March 2017 and December 2018 in the reservoir. A total of 64 zooplankton taxa from the groups Protozoa, Rotifera, Cladocera and Copepoda were identified in the studied samples. The majority of these organisms (37%) belonged to the Rotifera group, with most common species in spring – *Keratella hiemalis* Carlin, 1943 and *Polyarthra major* Burckhardt, 1900. During the investigation period, the most frequent zooplankton components were *Chydorus sphaericus* (O.F. Müller, 1776) and Nauplii and Copepodites of Copepoda. 22 species from class *Branchiopoda* were established. Considerable changes in the quantitative composition of Rotifera at different sampling points and years are indicated by the low values of the Jaccard similarity index. When comparing the two spring seasons (1955 and 2017), the index has a value of less than 9 %. At the same time, the number of species increased 2.5 times.

Key words: zooplankton, Mandra Reservoir, modified coastal lake, human influence, eutrophication processes.

Introduction

Mandra was a natural Black Sea coastal shallow lake until the dam was built in 1963. The average annual fish production of the lake was approximately 170 tons per year (Mihaylova-Neykova, 1961). After the research of Mihaylova-Neykova (1961), no recent data about fish production in the reservoir exists. Nowadays reservoir is used only for recreational fishing. Main threats to the balance of the ecosystem and in particular for the zooplankton is internal loading and nuisance algal blooms with toxin presence, and the situation in industrial region (Stoyneva & Michev, 2007).

The zooplankton community in Mandra Lake has been almost unstudied since it was turned into reservoir. Human intervention in the natural water regime of the lake has affected the species diversity of the aquatic system. It is possible to trace the result of the changes of hydrological parameters after construction of a dam in the main characteristics of the formation and composition of the zooplankton (Naidenow, 1981; 1984). Many authors use zooplankton communities of the lakes as indicator for the ecological state of standing water bodies (Ismail & Adnan, 2016; Krupa et al., 2020).

The zooplankton of the reservoir Mandra was investigated by Pandourski in

1999 - 2000 (Pandourski, 2007). During that period the lowest biomass values were in the locality of the dam, which was determined by the high quality of a relatively small Rotifera species, and the central part of the reservoir was richest due to mass development of *Daphnia cucullata* G.O. Sars, 1862.

The recent data about population dynamics of the zooplankton in fresh and mixohaline lentic water bodies in relation to different environmental factors were given by many authors such as Løvik & Kjellberg (2003), Etilé, et al. (2009), Stanachkova et al. (2017), Su et al. (2019), Picapedra et al. (2020).

The aim of the present investigation was to determine the qualitative structure of the zooplankton complex of Mandra Reservoir in March 2017 and December 2018 in the changed conditions of the water body due to the anthropogenic impact and to compare the results with previous research data.

Material and Methods

This study was conducted in 25 March 2017 and 16 December 2018 in the Mandra Reservoir (Fig. 1). It is situated in Bulgarian coast of the Black Sea at geographic coordinates of 42° 24′ 30″ N, 27° 22′ 19″ E. The data about the area, surface and depth of the reservoir are given on Table 1. It also contains information about the area and maximum depth of the former Mandra Lake (Mihaylova-Neykova, 1961). During the two samplings, 12 quantitative samples were collected at 6 sites by using an Apstein plankton net 55 μm mesh size and via filtering of 100 dm^3 of water through the net. This method of direct filtering a certain amount of water through Apstein plankton net is widely used in the study of shallow holo-polymictic standing water bodies and ecotone river-reservoir zones (Kozuharov et al., 2007; Yakimov et al., 2016). The samples were fixed in 4% formalin. Under laboratory conditions, they were counted using the method of Hensen, modified by Dimoff (1959) and Naidenow (1981).

The biomass of the zooplankton organisms was calculated by using of their standart individual weights according to their average length after Jadin (1956) and Standard Operating Procedure for Zooplankton Analysis (2016).

The location of the sites can be seen on Fig. 1. The places of sampling points in the reservoir were chosen close to the inflowing rivers in the reservoir, to find out eventual influence on the zooplankton of the organic meter what inflow with the water of the rivers. One station is situated close to the dam and one in the central pelagic part of the reservoir as control point.

In the selection of the seasons for the study we have taken into account the climatic features of the region - warm and mild winters and cool summers, as well as the specific characteristics of Mandra Reservoir, which provides cooling water for local industries and after that warm water is returned to the reservoir. When the samplings were collected, the water temperature was also measured with an alcohol thermometer. The average water temperature measured on 25.03.2017 was 9.1℃, and on 16.12.2018 - 10℃.

The shallow polymictic freshwater ecosystems are particularly susceptible to climate changes also (Mooij et al., 2005; 2007; Jeppesen et al., 2014; Haberman & Haldna, 2017). It is well documented that the effect of climate change is more significant in spring and winter (Weyhenmeyer et al., 1999; Nõges, & Nõges, 2014; Haberman & Haldna, 2017).

Cluster analysis was used for comparing similarity of the zooplankton complexes in Mandra Reservoir and in the former Mandra Lake. The comparison was made by seasons - Spring 1955 / Spring 2017 and Winter 1955 / Winter 2018. Jaccard similarity index was used, with the unweighted pair-group average (UPGMA) algorithm. The calculation was made by statistical package PAST version 4.0 (Hammer et al., 2001). The RCC index presents the percent ratio between most common zooplankton groups Rotifera, Cladocera and Copepoda (Kozuharov et al, 2013).

Results

DA total of 64 zooplankton taxa from the groups Protozoa, Rotifera, Cladocera and Copepoda were identified in the studied samples. The majority of these organisms - (37%) belonged to the Rotifera group, with the most common species in spring – *K. hiemalis* and *P. major* (Table 2). In winter, the Rotifera abundance was significantly less, and no species from this group were found at sampling point 5. The most common Rotifera in winter were *Asplanchna sieboldi* (Leydig, 1854) and *Asplanchna priodonta* Gosse, 1850.

During winter, the most frequent zooplankton species were *C. sphaericus* and Nauplii and Copepodites of Copepoda. 22 species from class *Branchiopoda* were established. The most frequent were *Bosmina longirostris* (O. F. Müller, 1776), *Bosmina coregoni* Baird, 1857, *Bosmina kessleri* Uljanin, 1874 and *D. cucullata*. Microcrustaceans were represented by a total of 14 species, with greater species richness in winter.

Considerable changes in the Rotifera quantitative composition at different sampling sites and years of sampling were indicated by the low values of the Jaccard similarity index. When comparing the two spring seasons (1955 and 2017), the index has a value less than 9 %. At the same time, the number of species increased 2.5 times. The Jaccard similarity index for the winter was even lower – 2.2 %, and the number of species increased eight times.

Cluster analysis (Fig. 2 and Fig. 3) showed the similarity in species composition between the investigated periods. Four species were common for the spring of 1955 and the spring of 2017. The analysis included 46 taxa and 32 of them were newly registered in Mandra Reservoir. 10 species out of 14 in the past are absent. Only *C. sphaericus* was common for both periods.

Quantitative analysis showed the poorest zooplankton abundance and biomass at site 4, at the mouth of the Fakiyska River, while at the dam a relatively high abundance was observed (Fig. 4 and Fig. 5). In winter the highest zooplankton abundance and maximum biomass were measured at site 3.

Discussion

The reconstruction of costal lake to reservoir and lack of connection with the sea leads to considerable changes of community structure. Increasing number of rotifer species is a major sign to transformed environmental frame. Most of the rotifer species occurs mainly in freshwater habitats while in brackish water their number decline. The obtained results corresponded with the received data published by Stanchkova et al. (2015).

The high number of Rotifera species (34) is typical for advanced eutrophication process of the investigated water body (Hellawell, 1986; Karabin et al., 1997; Protasov, 2002; Kozuharov et al., 2013). Such high number of the rotifers was found in other Bulgarian shallow lakes and ponds (Pehlivanov et al., 2006). Most of the rotifers are from genus *Brachionus, Keratella, Notholca, Testudinella* and *Pompholyx,* wich is common for swamps and heavily loaded by organic meter basins (Hellawell, 1986; Erdoğan & Güher, 2012). The presence of many cladocerans from Chydoridae family also confirms that the studied reservoir is eutrophic water body. Most Chydorid crustaceans and specifically the small-bodied *C. sphaericus,* are typical for the eutrophicated water basins (Smirnov, 1971; Flossner, 1972; Frey, 1987; Dugan, 1992; Hofmann, 1996; Vijverberg & Boersma, 1997; Eyto et al., 2002). Species from genus *Chydorus* are generally found within lakes of higher eutrophication and on/or near the bottom sediments. Some scientists have suggested that these organisms migrate away from the bottom sediments during the night to feed within the general safety of low light (Evans & Stewart, 1977).

Table 1. Information about the area, surface and depth of Mandra Reservoir.

	Mandra Reservoir	the former Mandra Lake
Area	33 км^2	10.8 км^2
Max. length	11.8 km	
Max. width	3.8 km	
Max. depth	7 m	7 m
Surface altitude	2 meters above sea level	
Dam height	12 m	

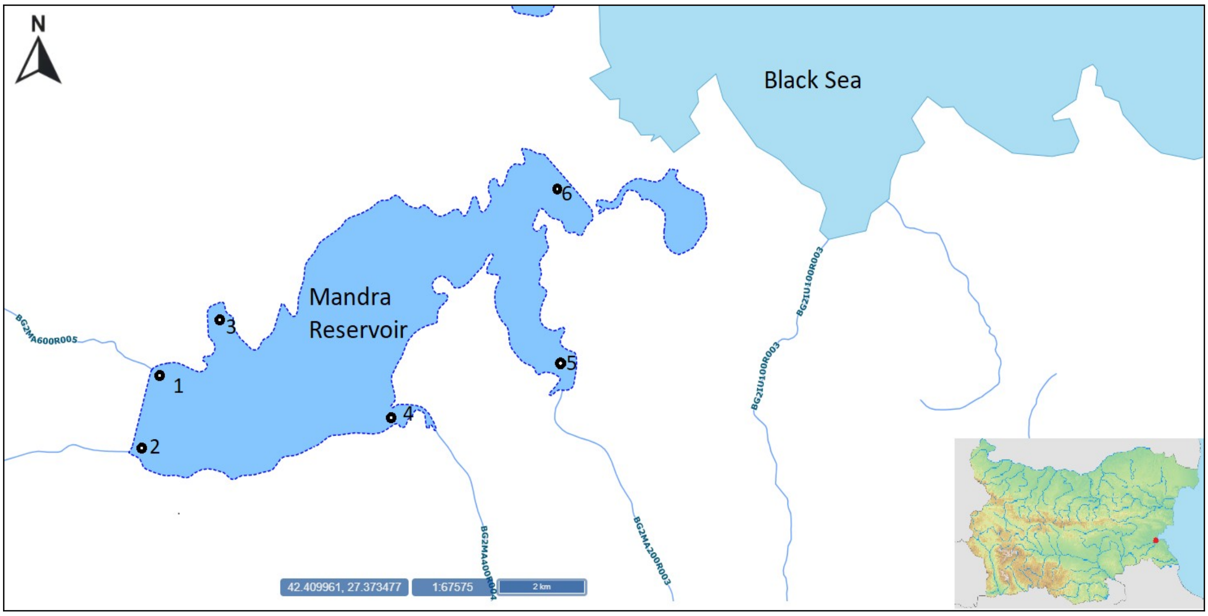

Fig. 1. Location of the worksites in Mandra Reservoir in Southeast Bulgaria.

Table 2. Presence (x) of zooplankton taxa during the two investigated periods in Mandra Reservoir compared to zooplankton in 1955 according to Mihaylova-Neykova (1961).

№	Taxa	Spring 1955	Spring 2017	Winter 1955	Winter 2018
	Protozoa				
1	*Arcella catinus* Penard, 1890				x
	ROTIFERA				
2	*Pompholyx complanata* Gosse, 1851		x		x
3	*Testudinella sp.*		x		x
4	*Testudinella truncata* (Gosse,1886)		x		
5	*Filinia longiseta/Triarthra longiseta* (Ehrenberg, 1834)	x			
6	*Monostyla cornuta* (O. F. Müller, 1786)	x			
7	*Euchlanis dilatata* Ehrenberg, 1832		x		
8	*Brachionus sp.*				x
9	*Brachionus angularis* Gosse, 1851	x			
10	*Brachionus mulleri* Ehrenberg, 1833	x			

11	*Brachionus urceolaris* (O. F. Müller, 1773**)**	x			
12	*Brachionus urceus* (Linnaeus, 1758)		x		
13	*Brachionus bakeri* O. F. Müller, 1786			x	
14	*Brachionus pala* Ehrenberg, 1838			x	
15	*Keratella cochlearis* (Gosse, 1851)		x		x
16	*Anuraea quadrata* Müller	x			
17	*Keratella quadrata* (Müller, 1786)		x		x
18	*Keratella hiemalis* Carlin, 1943		x		
19	*Keratella testudo* (Ehrenberg, 1832)				x
20	*Notholca squamula* (Müller, 1786)		x		
21	*Notholca acuminata* (Ehrenberg, 1832)		x		x
22	*Asplanchna sp.*	x			x
23	*Asplanchna sieboldi* (Leydig, 1854)				x
24	*Asplanchna priodonta* Gosse, 1850				x
25	*Trichocerca sp.*				x
26	*Synchaeta sp.*		x		x
27	*Polyarthra sp.*		x		x
28	*Polyarthra remata* Skorikov, 1896		x		
29	*Polyarthra dolichoptera* Idelson, 1925		x		x
30	*Polyarthra minor* Voigt, 1904		x		
31	*Polyarthra major* Burckhardt, 1900		x		
32	*Polyarthra luminosa* Kutikova, 1962		x		
33	*Polyarthra platyptera* Ehrenberg, 1832	x			
	CLADOCERA				
34	*Diaphanosoma lacustris* Korjinek, 1981		x		
35	*Bosmina sp.*		x		
36	*Bosmina longirostris* (O. F. Müller, 1776)		x		x
37	*Bosmina kessleri* Uljanin, 1874				x
38	*Bosmina coregoni* Baird, 1857				x
39	*Bosmina sp. Juv.*				x
40	*Daphnia cucullata* G.O. Sars, 1862		x		x
41	*Daphnia longispina typica* O.F. Müller, 1785		x		
42	*Daphnia pulex* (O.F. Müller, 1785)				x
43	*Daphnia sp. Juv.*				x
44	*Daphnia magna ephippium*				x
45	*Moina dubia* Guerne & Richard, 1892				x
46	*Macrothrix hirsuticornus* Norman et Brady, 1867		x		
47	*Alona affinis* Leydig, 1860				x
48	*Alona guttata* Sars, 1862		x		x
49	*Alona rectangula* Sars, 1861		x		
50	*Alonella nana* (Baird, 1850)				x
51	*Alonella exigua* (Lilljeborg, 1853)				x
52	*Chydorus sp.*		x		

53	*Chydorus sphaericus* (O.F. Müller, 1776)	x	x	x	x
54	*Chydorus ovalis* Kurz, 1875		x		
55	*Chydorus latus* G.O.Sars, 1862				x
	COPEPODA				
56	*Acartia clausi* Giesbrecht, 1889	x			
57	*Calanipeda aque dulcis* Krichagin, 1873	x			
58	*Eudiaptomus gracilis* (Sars, 1862)				x
59	*Eucyclops sp.*		x		
60	*Eucyclops macruroides* (Lilljeborg, 1901)				x
61	*Cyclops strenuus* Fischer, 1851		x		x
62	*Halicyclops neglectus neglectus* Kiefer, 1935				x
63	*Grateriella sp.*		x		
64	*Thermocyclops sp.*				x
65	*Thermocyclops crassus* (Fischer, 1853)				x
66	*Acanthocyclops sp.*		x		
67	*Acanthocyclops americanus* (Marsh, 1893)		x		
68	*Acanthocyclops robustus* (G. O. Sars, 1863)				x
69	*Macrocyclops albidus* (Jurine, 1820)				x
70	*Harpacticoida genus sp.* G. O. Sars, 1903	x		x	
71	*Cyclops sp.*	x	x	x	
72	*Copepodites - Copepoda*	x	x		x
73	*Nauplius*	x	x		x
74	*Gastrotricha g. sp.*				x

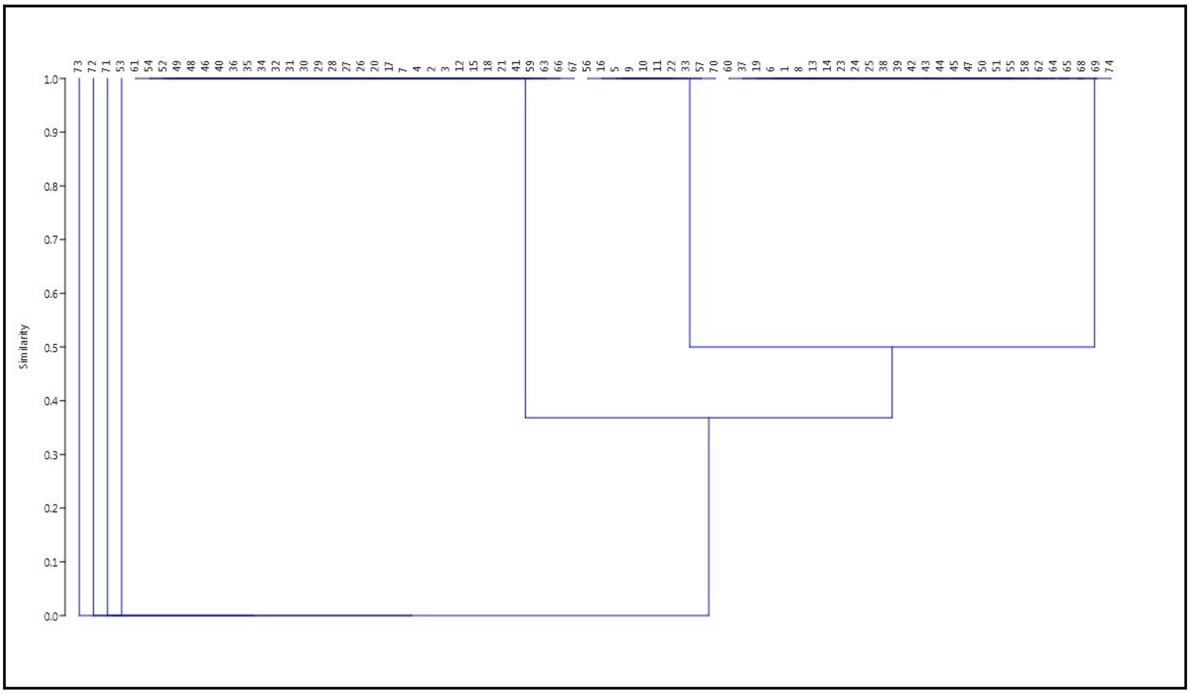

Fig. 2. Cluster analysis (Jaccard similarity index) - Spring. Corr. coph.: 0.9174. Numbers correspond to the zooplankton taxa sequence number in Table 1.

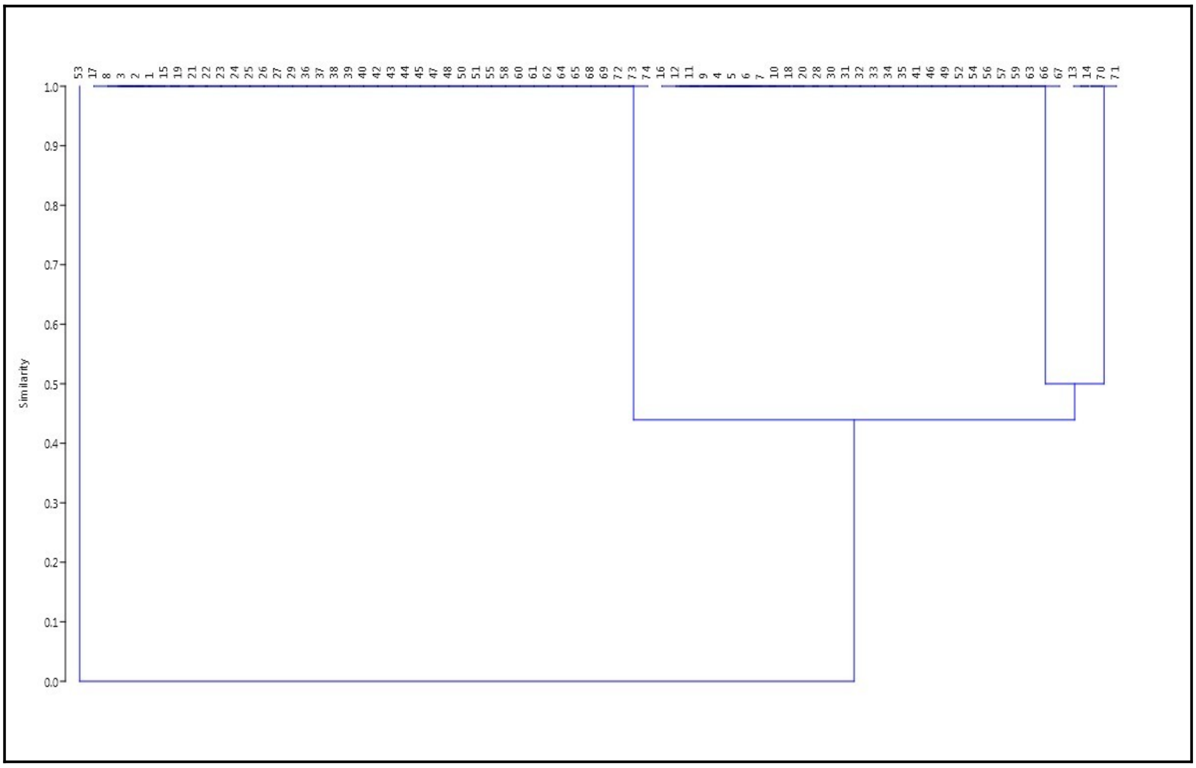

Fig. 3. Cluster analysis (Jaccard similarity index) - Winter. Corr. coph.: 0.9329. Numbers correspond to the zooplankton taxa sequence number in Table 1.

Halicyclops neglectus neglectus Kiefer, 1935 is brackish zooplankter that inhabits coastal parts of seas or reservoirs that are now or in the recent past connected with the sea, and *Acartia clausi* Giesbrecht, 1889 a typical marine species (Boxshall, 2001; Webber et al., 2010). Their presence indicate that in the past the former Mandra Lake was connected to the Black Sea.

Probably these species have the ability to survive in the modified water body with almost fresh water and permanent phytoplankton blooms that are characterized for Mandra reservoir.

The big differences in the RCC index of the different stations showed the influence of the flowing rivers and the nutrients they carry (Kozuharov et al., 2007). There are specific conditions in the ecotone zones, which lead to mass development of one zooplankton group or the complete absence of another, which is clearly visible at site 1 in the spring and at site 4 during the two studied seasons.

The maximum of zooplankton abundance and biomass measured at station 3 in the winter is probably due to the discharge of hot water from nearby businesses.

The wind effects could also be an explanation for the spatial distribution of zooplankton communities, as they are important factors in shallow water bodies. The effects of wind waves on the zooplankton was studied by many authors and they suggest that there might be a direct connection between the wind and the spatial distribution of the lighter Rotifera, or through implications in trophic interactions (Jenkins & Underwood, 1998; Blukacz et al., 2009; Zhou & Qin, 2018).

Probably the lower values of the total abundance and the biomass of the zooplankton in the littoral of the reservoir at sampling point 4 is also due to the press of young fishes (Fig. 4, 5). Higher fish predation of the young fishes shapes the general structure and dynamics of Cladoceran communities in the littoral of the shallow lakes (Meerhof et al., 2007).

Most of them, such as these from genus *Brachionus, Keratella, Notholca, Testudinella* and

Pompholyx, are common for swamps and heavily loaded by organic meter basins (Hellawell, 1986; Erdoğan & Güher, 2012; Guher, 2012). The increasing of the number of Rotifera species and their abundance (Fig. 4) indicates advancing of the eutrophication process in the shallow standing water bodies (Wallace et al., 2006; Guher et al., 2011; Kozuharov et al, 2013).

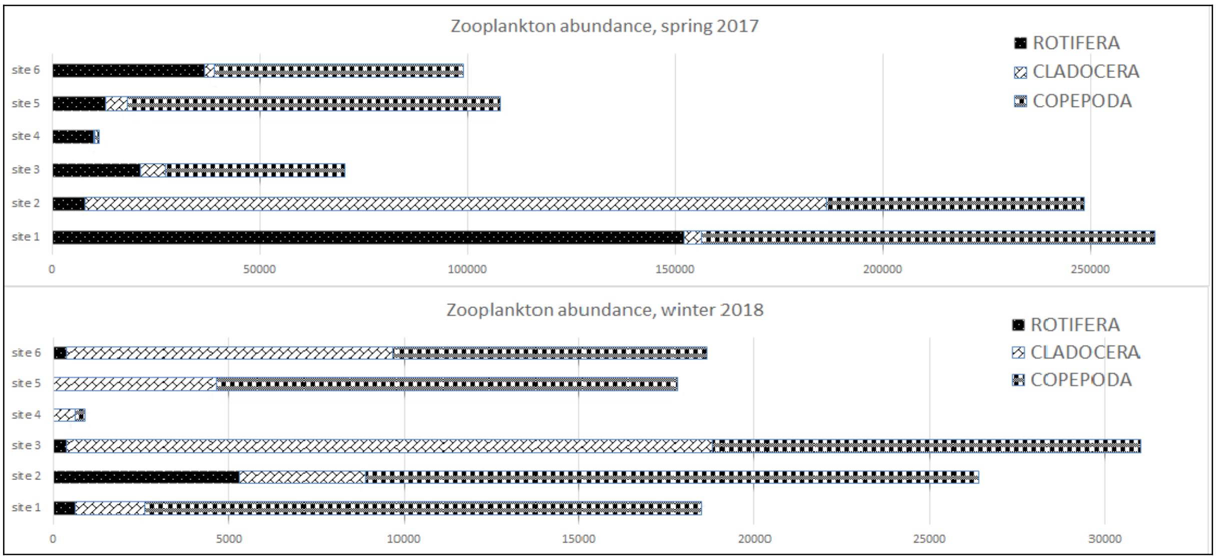

Fig. 4. Zooplankton abundance measured in spring 2017 and winter 2018.

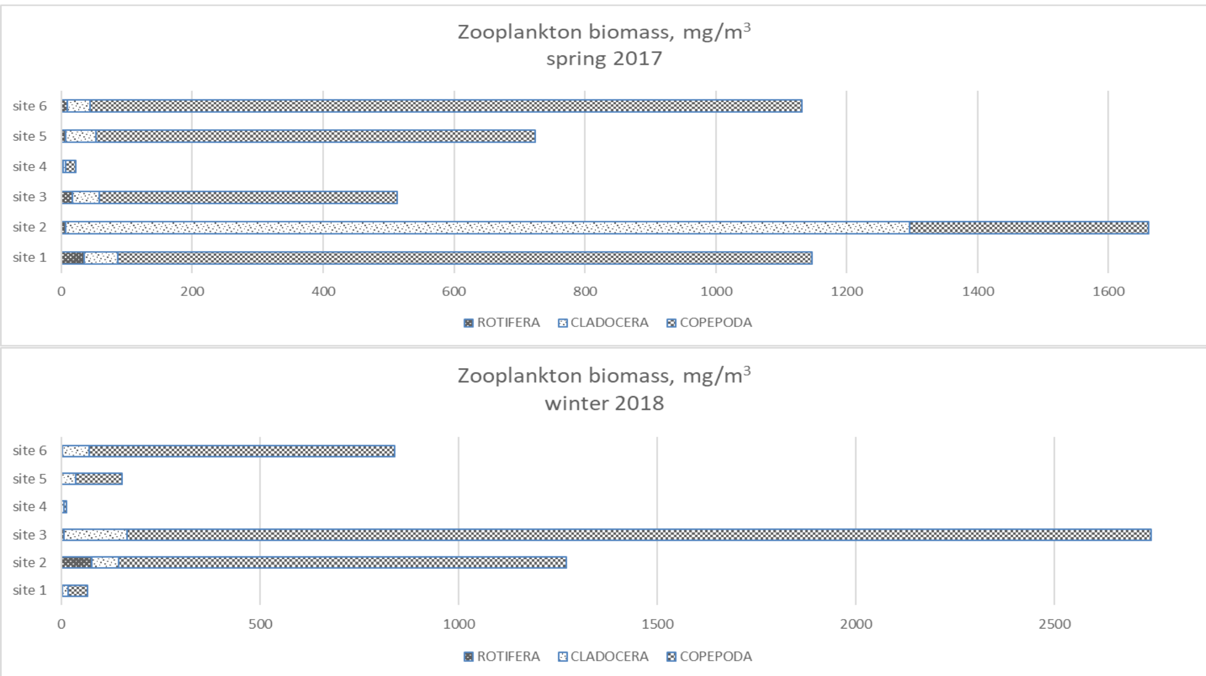

Fig. 5. Zooplankton biomass measured in the studied periods.

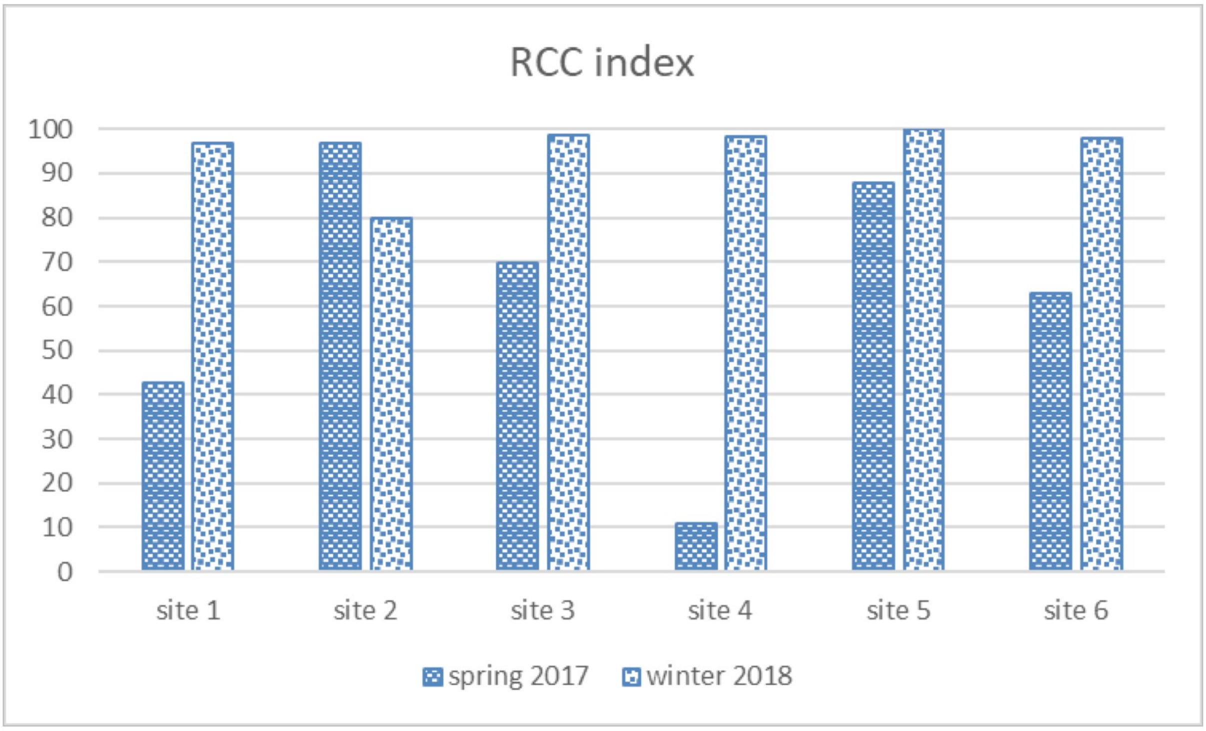

Fig. 6. Values of RCC index in the studied periods.

Conclusions

The obtained results concerning the zooplankton community in today's Mandra reservoir show a significant change in the composition of zooplankton compared to the communities in the former coastal lake Mandra. In addition, the results indicate the effects of eutrophication and provide a basis for further studies in this direction.

The increasing of the richness of the rotifers and their abundance, compared to the previous data, showed that zooplankton of the water body is now typical for the shallow holo-polymictic water bodies studied. Probably the modification from the shallow lake to the reservoir with bigger surface area give possibility to some newly found pelagic organisms to inhabit the water body. Such typical elements are Rotifera *A. priodonta, A. sieboldi, Polyarthra dolichoptera* Idelson, 1925 and Copepoda *Eudiaptomus gracilis* (Sars, 1862). The values of the used RCC index (Fig. 6) indicated that conditions in the reservoir are close to these in the other costal swamps and lakes in the region.

References

Blukacz, E., Shuter, B. & Sprules, W. (2009). Towards understanding the relationship between wind conditions and plankton patchiness. *Limnology and Oceanography, 54*. doi: 10.4319/lo.2009.54.5.1530.

Boxshall, G. (2001). Copepoda (excl. Harpacticoida). In Costello, M.J. et al. (Ed.) (2001). *European register of marine species: a check-list of the marine species in Europe and a bibliography of guides to their identification. Collection Patrimoines Naturels, 50*, 252-268.

Dimoff I. (1959). Improved quantitative method for the counting of plankton. *Comptes rendus De l' Academie Bulgare des Sciences, 12*(5), 2-3. (In Russian, French summary).

Duigan, C. (1992). The ecology and distribution of the littoral freshwater Chydoridae Branchiopoda, Anomopoda of Ireland, with taxonomic comments on some species. *Hydrobiologia, 241*, 1–70.

Erdoğan, S. & Güher, H. (2012). The Rotifera fauna of Turcish Thrace (Edrine, Tekirdag, Kirklareli). *Journal of FisheriesSciences.com, 6*(2), 132–149. doi: 10.3153/jfscom.2012017.

Etilé, N., Kouassi, A., Aka, M., Pagano, M., N'douba, V. & Joël Kouassi, N'guessan. (2009) Spatio-temporal variations of the zooplankton abundance and composition in a West African tropical coastal lagoon (Grand-Lahou, Côte d'Ivoire). *Hydrobiologia, 624*, 171-189. doi: 10.1007/s10750-008-9691-7.

Evans, M. & Stewart, J. (1977). Epibenthic and benthic microcrustaceans (copepods, cladocerans, ostracods) from a nearshore area in southeastern Lake Michigan. *Limnology and Oceanography, 22*(6), 1059-1066. doi: 10.4319/lo.1977.22.6.1059.

Eyto, E., Irvine, K. & Free, G. (2002). The use of Members of the Family Chydoridae (Anomopoda, Branchiopoda) as an indicator of Lake Ecological quality in Ireland, *Biology & Environment Proceedings of the Royal Irish Academy*, 81-91.

Flossner, D. (1972). Kiemen und Blattfufier, Branchiopoda Fischlause, Branchiura. *VEB Gustav Fischer Verlag*, Jena 1–501.

Frey, D. (1987). The taxonomy and biogeography of the Cladocera. Hydrobiologia, 145, 5–17. doi: 10.1007/BF02530260.

Güher, H., Erdoğan, S., Kırgız, T. & Çamur-Elipek, B. (2011). The Dynamics of Zooplankton in National Park of Lake Gala (Edirne-Turkey). *Acta zoologica bulgarica, 63*(2), 157-168.

Güher, H., (2012). The Investigation of Zooplanktonic Organisms (Rotifera, Copepoda, Cladocera) of Meric River (Turkey). *Journal of Animal and Veterinary Advances*, *11* (24): 4673-4677.

Haberman, J. & Haldna, M. (2017). How are spring zooplankton and autumn zooplankton influenced by water temperature in a polymictic lake?. *Proceedings of the Estonian Academy of Sciences,* 66, 264-278. doi: 10.3176/proc.2017.3.03.

Hammer, O., Harper, D. & Ryan, P. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, *4*(1), 4-9. Retrieved from palaeo-electronica.org.

Hellawell, J. (Ed.). (1986). *Biological Indicators of Freshwater Pollution and Environmental Management.* London, UK: Elsevier Applied Science Publishers. Doi: 10.1007/978-94-009-4315-5.

Hofmann, W. (1996). Empirical relationships between cladoceran fauna and trophic state in thirteen northern German lakes: analysis of surficial sediments. *Hydrobiologia, 318*, 195–210.

Ismail, A. & Adnan, A. (2016). Zooplankton Composition and Abundance as Indicators of Eutrophication in Two Small Man-made Lakes. *Tropical life sciences research*, *27*(1), 31–38. doi: 10.21315/tlsr2016.27.3.5.

Jadin, V., (1956). Live in the fresh waters of USSR. *Edittorial of Academy of Sciense of USSR. 1*(4). (In Russian).

Jenkins, D. & Underwood, M. (1998) Zooplankton may not disperse readily in wind, rain, or waterfowl. *Hydrobiologia,* 387**,** 15–21. doi: 10.1023/A:1017080029317.

Jeppesen, E., Meerhoff, M., Davidson, T. A., Trolle, D., Søndergaard, M., Lauridsen, T. L., Beklioglu, M., Brucet, S., Volta, P., Gonzalez-Bergonzoni, I. & Nielsen, A. (2014). Climate change impacts on lakes: an integrated ecological perspective based on a multi-faceted approach, with special focus on shallow lakes. *Journal of Limnology*, 73, 88–111. doi: 10.4081/jlimnol.2014.844.

Karabin, A., Ejsmont-Karabin, J. & Kornatowska, R. (1997). Eutrophication processes in a shallow, macrophyte-dominated lake – factors influencing zooplankton structure and density in Lake Łuknajno (Poland**).**

Hydrobiologia, 342, 401–409. doi: 10.1023/A:1017003810282.

Kozuharov, D., Evtimova, V. & Zaharieva, D. (2007). Long-term changes of zooplankton and dynamics of eutrophication in the polluted system of Strouma River - Pchelina Reservoir (South-western Bulgaria). *Acta Zoologica Bulgarica, 59*, 191-202.

Kozuharov, D., Stanachkova, M., Janev, P. & Stanachkov, S. (2013). Introduction of RCC index for stand water bodies. *Comptesrendus de l'Academie Bulgare des Sciences*, *66*(11), 1563-1570.

Krupa, E., Romanova, S., Berkinbaev, G., Yakovleva, N. & Sadvakasov, E. (2020). Zooplankton as Indicator of the Ecological State of Protected Aquatic Ecosystems (Lake Borovoe, Burabay National Nature Park, Northern Kazakhstan) *Water*, *12*(9), 2580. doi: 10.3390/w12092580.

Løvik, J. & Kjellberg, G. (2003). Long-term changes of the crustacean zooplankton community in Lake Mjøsa, the largest lake in Norway. *Journal of Limnology, 62* (2): 143-150. doi: 10.4081/jlimnol.2003.143.

Meerhoff, M., Teixeira De Mello, F., Clemente, J., Jensen, E., Lauridsen, T. & Jeppesen, E. (2007). Effects of habitat complexity on community structure and predator avoidance behaviour of littoral zooplankton in temperate versus subtropical shallow lakes. *Fresh water Biology, 52*(6), 1009-1021. doi: 10.1111/j.1365-2427.2007.01748.x.

Mihailova-Neikova, M. (1961). Hydrobiological research of the Mandra Lake with regard to its importance as a fishing ground. *Annuaire de l'Universitè de Sofia, Facultè de Biologie, Gèologie et Gèographie*, *53*(1), 57-122. (In Bulgarian).

Mooij, W., Hülsmann, S., De Senerpont Domis, L., Nolet, B.A., Bodelier, P.L.E., Boers, P.C.M., Pires, L.M.D., Gons, H.J., Ibelings, B.W., Noordhuis, R., Portielje, R., Wolfstein K. & Lammens, E.H.R.R. (2005). The impact of climate change on lakes in the Netherlands: a review. *Aquatic Ecology*, 39, 381–400. doi: 10.1007/s10452-005-9008-0.

Mooij, W., Janse, J., De Senerpont Domis, L., Hülsmann, S. & Ibelings, B. (2007). Predicting the effect of climate change on temperate shallow lakes with the ecosystem model PCLake. *Hydrobiologia*, 584, 443–454. doi: 10.1007/s10750-007-0600-2.

Naidenow, W. (1981). Changes of the structure in the fresh waters biocoenosis as integrative index for the anthropogenic influence. *Hydrobiology*, *15*: 3-8. (In Bulgarian).

Naidenow, W. (1984). *Composition and ecology of the zooplankton of the Danube River and the inland water basins in Bulgaria*. Author's summary of Doctor of Science Thesis, Sofia, Bulgarian Academy of Sciences, Inst. of Zoology: 1-45. (In Bulgarian).

Nõges, P. & Nõges, T. (2014). Weak trends in ice phenology of Estonian large lakes despite significant warming trends. *Hydrobiologia*, 731, 5–18. doi: 10.1007/s10750-013-1572-z.

Pandourski, I. (2007) Zooplankton of Non-Lotic Bulgarian Wetlands. In Michev, T. & Stoyneva, M. (Eds). *Inventory of BulgarianWetlands and their Biodiversity. Part 1: Non-Lotic Wetlands.* (166-187). Sofia, Bulgaria: Publ. House Svetlostrouy.

Pehlivanov, L., Tzafkova, V. & Vasilev, V. (2006). Development of the zooplankton community in the Srebarna Lake (North-Eastern Bulgaria) along the process of ecosystem rehabilitation rehabilitation. In *Proceedings 36th International Conference of IAD, Austrian Committee Danube Research / IAD Vienna*, (pp. 280-284).

Picapedra, P., Fernandes, C., Taborda, J., Baumgartner, G. & Sanches P. (2020). A long-term study on zooplankton in two contrasting cascade reservoirs (Igua cu River, Brazil): effects of interannual, seasonal, and environmental factors. *Peer J*, 1-31. doi: 10.7717/peerj.8979.

Protasov, A. (2002). Biodiversity and its estimation. Conceptual Diversicology. Kiev, Ukraine: *National Academi of Sciences*. 106 p. (In Russian, English summary).

Ravara, O. (1996). Zooplankton and trophic state relationships in temperate lakes. *Memorie dell'Istituto Italliano di Idrobiologia*. *54*, 195-212.

Smirnov, N. (1971). Chydoridae of the world fauna. Fauna SSSR. *Rakoobraznie, 1* (2), 1 –531. (In Russian).

Stanachkova, M., Kozuharov, D. & Nenova, E. (2015). The Rotifers of Vaya Lake. *Annuire de l`Universite de Sofia St. Kl. Ohridski". Faculte de Biologie*, *100*(4), 314-319.

Stanachkova, M., Stefanova, M., Kozuharov, D., Raikova-Petrova, G. & Fikovska, E. (2017). Community structure of zooplankton as key factor for self-purification capacity of Iiskar reservoir. *Ecological Engineering and Environment Protection*, *9,* 39-46.

Stoyneva, M. & Michev, T. (comp.). (2007). Yazovir Mandra. In Michev, T. & Stoyneva, M. (Eds). *Inventory of BulgarianWetlands and their Biodiversity. Part 1: Non-Lotic Wetlands.* IBW0003, Sofia, Bulgaria: Publ. House Svetlostrouy.

Su, M., Andersen, T., Burch, M., Jia, Z., An, W., Yu, J. & Yang, N. (2019). Succession and interaction of surface and subsurface cyanobacterial blooms in oligotrophic/mesotrophic reservoirs: a case study in Miyun Reservoir. *Science of the Total Environment, 649*, 1553-1562. doi: 10.1016/j.scitotenv.2018.08.307.

Vijverberg, J. & Boersma, M. (1997). Long-term dynamics of small-bodied and large-bodied cladocerans during the eutrophication of a shallow reservoir, with special attention for *Chydorus sphaericus*. *Hydrobiologia*. *360*. 233-242. doi: 10.1023/A:1003148600983.

Wallace R., Snell, T., Ricci, C. & Nogrady, R. (2006). *Rotifera: Volume 1: Biology, Ecology and Systematics.* Leiden, The Netherlands: Backhuys Publishers and Ghent, Belgium: Kenobi Productions.

Webber, W., Fenwick, G. Bradford-Grieve, J. et al. (2010). Phylum Arthropoda Subphylum Crustacea: shrimps, crabs, lobsters, barnacles, slaters, and kin. in: *Gordon, D.P. (Ed.) (2010). New Zealand inventory of biodiversity: 2. Kingdom Animalia: Chaetognatha, Ecdysozoa, Ichnofossils*. 98-232.

Weyhenmeyer, G., Blenckner, T. & Pettersson, K. (1999). Changes of the plankton spring outburst related to the North Atlantic Oscillation. *Limnology and Oceanography*, 44, 1788–1792. doi: 10.4319/lo.1999.44.7.1788.

Yakimov, B., Shurganova, G., Cherepennikov, V., Kudrin, I. & Il'in, M. (2016). Methods for comparative assessment of the results of cluster analysis of hydrobiocenoses structure (by the example of zooplankton communities of the Linda River, Nizhny Novgorod region). *Inland Water Biology*. *9*(2). 200-208. doi: 10.1134/S1995082916020164.

Standard Operating Procedure for Zooplankton Analysis. (2016). LG 403 Revision 07, July 2016 1-20. www.epa.gov.

Received: 25.01.2021
Accepted: 25.05.2021