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IMPACT OF PHYSICOCHEMICAL PARAMETERS ON ZOOPLANKTON AND BIOCOENOLOGICAL ANALYZES ON ZOOPLANKTON OF MANDRA RESERVOIR, IN SOUTHEASTERN BULGARIA

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Abstract

The aim of this paper is to present some unpublished data from studies of zooplankton complexes in Mandra Reservoir during the period 2020-2021 at 7 research sites. It analyses whether physicochemical parameters pH, dissolved oxygen and conductivity significantly influence the occurrence of zooplankton in a reservoir. At the time of the investigation, 33 taxa of rotifers, 18 taxa of Cladocera, and 12 taxa of Copepoda were noted, and 4 taxa from Protozoa too. Canonical Correspondence Analysis (CCA) and biocoenological analyses were performed. In conclusion, we can say that in this shallow holopolymictic basin, no strong correlation was found between the grouping of zooplankton and the measured values for pH, dissolved oxygen and electrical conductivity. The dominant analysis reflects the dynamics in the dominant complexes of zooplankton in accordance with the conditions in the ecotonic zones between the Mandra Reservoir and the inflowing rivers.

Key words: *zooplankton, biocoenological analyzes, Mandra Reservoir.*

INTRODUCTION

The results in this paper are a continuation and upgrade of the work and analysis about zooplankton of Mandra Reservoir published by Fikovska et al., 2022. During the period February 2020 - January 2021, 67 zooplankton components were found - 33 taxa of rotifers, 18 taxa of Cladocera, and 12 taxa of Copepoda were noted, and 4 Protozoan taxa too. A complete list of the species found in Reservoir Mandra and their values of pF – frequency of occurrence for the studied period is presented by Fikovska et al., 2022, Table 1.

Ecotone effects in river-reservoir systems, as well as the influence of environmental factors on the dynamics of zooplankton, have been studied for a number of water bodies in Bulgaria, such as Zhrebchevo Reservoir (Naidenow, 1981; Stanachkova et al., 2010; Kozuharov & Stanachkova, 2015), Iskar Reservoir (Stefanova et al., 2015; Kozuharov et al., 2016; Stanachkova et al., 2017; Stefanova et al., 2020), Pchelina Reservoir (Kozuharov et al., 2007; Kozuharov, 2019).

Zooplankton organisms occupy a fundamental position in aquatic food webs because of the fact that they have the role of primary consumers and are an energy link between primary producers such as phytoplankton and higher consumers such as fish (Lampert & Sommer, 1997; Haberman & Haldna, 2014; Zhikharev et al., 2024). They are an important element in the structure and functioning of aquatic ecosystems. In addition, zooplankton can rapidly respond to changes in trophic cascades, such as phyto-plankton blooms, and to the physicochemical conditions of the habitat, changing species richness, increasing or decreasing their number (Naselli-Flores & Rossetti, 2010). These characteristics make them suitable indicators of water quality and changes in trophic conditions (Anas et al., 2013).

To expand the understanding of the relationship between environmental factors and the quantitative development of zooplankton in different trophic conditions, Zhikharev et al. (2024) used several environmental parameters measured at each zooplankton sampling station.

Authors choose the following parameters as the most relevant: specific electrical conductivity of water (EC), pH value (pH), water temperature (WT), content of chlorophyll-pigment in water (Chlorophyll a) and dissolved oxygen (DO) in water (Zhikharev et al., 2024).
This paper also aims to assess the influence of some physicochemical factors of the environment on the distribution of zooplankton in Mandra Reservoir. It is considered that zooplankton biomass is affected by temporal and spatial changes of water quality parameters (Ahmad et al., 2011; Fakioglu et al., 2018; Paturej et al., 2017).

Dissolved oxygen (DO) is an important aquatic parameter whose measurement is vital in the context of culture of any aquatic animal as oxygen plays a crucial role in its life processes (Rajagopa et al., 2010).

MATERIALS AND METHODS

The study was carried out in the coastal reservoir Mandra, which is located in southeastern Bulgaria, at 7 sampling points, which are indicated in Figure 1.

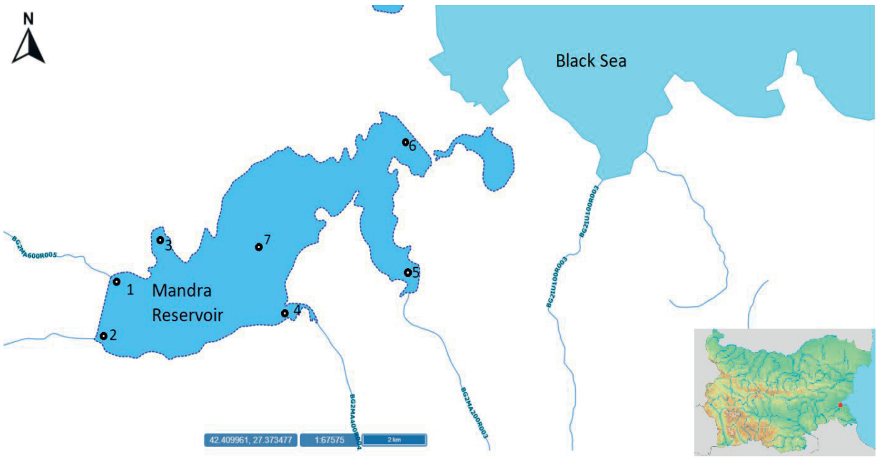

Figure 1. Location of the sampling points in Mandra Reservoir: 1 - mouth of Rusokastrenska River; 2 - mouth of Sredetska River; 3 - northern dike; 4 - mouth of Fakiyska River; 5 - mouth of Izvorska River; 6 – Dam; 7 - central part

The reservoir is a shallow holo-polymictic water body with maximum depth of 7 m, surface of 13000 hectares and maximal volume of 165 000 000 m^3. Most of the sampling points were situated in the ecotone zones between the inflowing rivers and the reservoir. The reason was to find out the eventual influence of the contamination from the inflowing wastes on the reservoir plankton. The methods of collecting the samples, the used equipment, as well as the subsequent processing of the information, are standard to the international hydrobiological practice and were described in detail by Fikovska et al. (2022).
The data on the parameters of the environment is presented in Table 1.
Biocoenological analyzes were then conducted on the basis of several widely used indexes such as frequency of dominance (DF) and order of dominance (DT) after De Vries - (Pielou, 1975; Odum & Barrett, 2005; Kumar & Mina, 2018).
The frequency of dominance, like the frequency of occurrence, is directly proportional to the importance of the given species for the biocoenosis.
The order of dominance is an indicator of the evenness of the distribution of the species in time and space. These indexes were used for analysis of the zooplankton community status, together with structural indexes such as Shannon - Weaver individual diversity, index of domination after Simpson, and evenness index after Pielou (1975) (Fikovska et al., 2022).

Table 1. Values of hydrological parameters measured in Mandra Reservoir during the studied period, pH, dissolved oxygen (DO, mg/l), oxygen saturation (DOS, %) and electrical conductivity (COND, µs)

Date-sampling point	pH	DOS (%)	DO (mg/l)	COND (µs)
Feb 20-S4	8.5	58	6.9	662
Feb 20-S5	8.85	56	6.5	630
Feb 20-S6	9.26	50	6	600
Feb 20-S7	8.73	57	7.12	638
June 20-S1	7.99	102	8.23	1039
June 20-S2	7.48	88	7.2	691
June 20-S3	7.5	86	7.5	560
June 20-S4	7.51	61	5.35	936
June 20-S5	7.94	65	5.65	523
June 20-S6	9.16	115	9.29	508
Sep 20-S1	8.85	99	9	585
Sep 20-S2	8.6	61	5.7	483
Sep 20-S3	8.85	75	6.8	229
Sep 20-S4	9	75	6.8	214
Sep 20-S5	8.9	57	5.2	194
Sep 20-S6	8.89	41	3.7	583
Sep 20-S7	8.8	53	4.8	193
Jan 21-S1	8.69	53	6	494
Jan 21-S2	8.59	50	5.7	671
Jan 21-S3	8.7	61	6.8	535
Jan 21-S4	8.66	61	6.9	625
Jan 21-S5	8.67	59	6.5	639
Jan 21-S6	8.33	52	6	428
Jan 21-S7	8.36	63	7.12	470

RESULTS AND DISCUSSIONS

The analysis of zooplankton in assessing its response to different trophic conditions should start with basic indicators, namely species richness and dominant species (Zhikharev et al., 2024).

For the entire study period, Nauplii and Copepodites of Copepoda with the highest frequency of occurrence are with pF = 97.22, while the values for adult copepods do not exceed 50%. In general, the larval stages of Copepoda – Nauplii and Copepodites numerically outnumber the adult Copepodites (Fikovska et al., 2022). A possible reason is the better survival of juvenile forms under unfavorable conditions, which is observed in some other species (Fakioglu et al., 2018).

Permanent representatives of the zooplankton complexes can also be considered *Keratella cochlearis* with pF = 100%, *Bosmina coregoni* with pF = 83%. Both *Pompholyx complanata* and *Chydorus sphaericus* have the same pF = 79%. With the present publication, we have set out to complement the dominant community analysis and to compare it with previous ones.

When calculating dominance frequency (DF) and dominance order (DT) of the zooplankton elements we prefer to use their abundance, rather than their biomass. The reason is that the numerical value is more representative and is used more often in this type of research (Kozuharov et al., 2009).

The dynamic conditions of the environment, as well as the ecotone effects and the processes taking place in the ecotone zones are the reason for the frequent dynamic changes of species composition and in the zooplankton dominant complexes. In Mandra reservoir, for the entire period of study, the frequency of dominance varied between 21 and 42% (Table 2). Examined by sampling sessions/seasons, DF reaches 100% in the coldest months - January and February, when only 1 species is present in the dominant complexes. During the study period the reservoir doesn't freeze in winter – the lowest registered temperature was 4.5ºC. In the other seasons, the dominant complex includes two or three components, on which the dynamics of the zooplankton complexes in the Mandra reservoir and the replacement of some dominants with others can be traced. A typical example is the dominant complex in September 2020 (Table 2). The perennial dominant zooplankton element was Nauplii of Copepoda. The established dominant zooplankton organisms are typical for the eutrophic and hypertrophic water bodies. This result confirms these from the use of the RCC index which presents correlation between three main taxonomic groups in the zooplankton – Rotifera, Cladocera and Copepoda (Kozuharov et al., 2013). Both types of analysis show the advanced process of eutrophication, which is illustrated by high abundance of Rotifera species – *Polyarthra vulgaris, Keratella cochlearis* and partly *Pompholix complanata.* The high numbered presence of Cladocera Chydoridae species *Ch. sphaericus* is also a demonstration of this eutrophication process.

Table 2. Frequency of dominance (DF) and order of dominance (DT) of zooplankton in Mandra reservoir by seasons and for the whole study period (2020-2021), values are in %

Date	Taxa	DF	DT
Feb. 2020	Nauplii	100	100
Jun. 2020	Nauplii	50	50
	Polyarthra vulgaris	33	50
	Chydorus sphaericus	17	25
Sep. 2020	Nauplii	43	43
	Polyarthra vulgaris	43	43
	Keratella cochlearis	14	14
Jan. 2021	*Keratella cochlearis*	100	100
For the whole period	Nauplii	42	42
	Keratella cochlearis	33	33
	Polyarthra vulgaris	21	25

Dominance order indicates whether a dominant is local or not, whether it dominates throughout the study period or only for a particular season. The order of dominance has high values for species that occur rarely, but when they do occur, they dominate the other species.

The DT value was between 25 and 42% for the entire period, with the three components of the dominant complex showing close values. This illustrates unstable dominant complexes. Stable communities cannot practically exist in the ecotone zone between the reservoir and the inflowing rivers because of the frequently changing conditions there.

Nauplii and Copepodites of Copepoda are zooplankton components but they are not taxa. They are also included in the dominant complex, but to the extent that they cannot be determined, they are reported separately as quantitative components of the plankton important for self-purification processes in the basin and as an important trophic resource for fish.

A CCA analysis was performed to show the correlation between zooplankton distribution and measured values for pH, dissolved oxygen (DO), oxygen saturation (DOS) and electrical conductivity. Species that were numerically dominant for the period between February 2020 and January 2021 are included in the analysis.

The CCA (Figure 2) shows that the first axis, which represents a total variance of 82.1 %, has a positive correlation with pH, and a negative correlation with dissolved oxygen, oxygen saturation and electrical conductivity. Axis 2 showed 17.4% variance and was positively related to DO, DOS and conductivity and negatively related to pH.

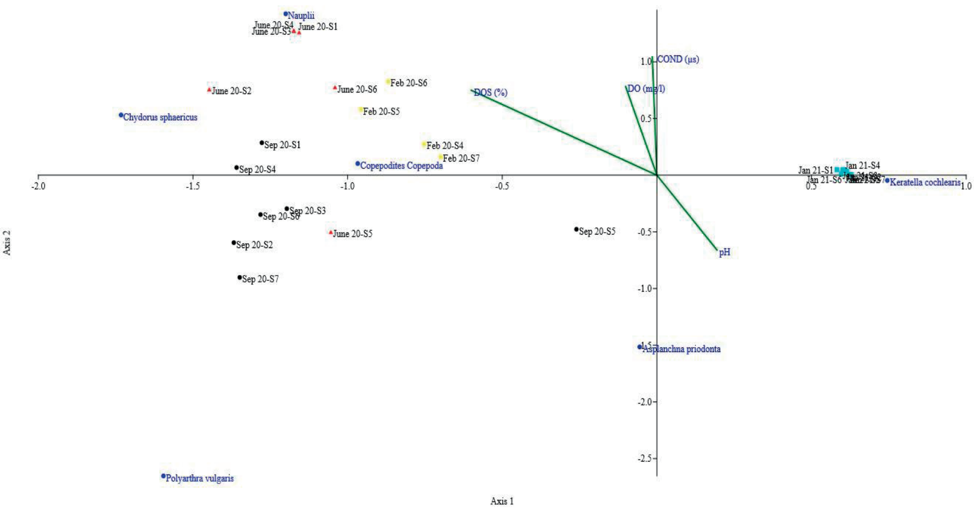

Figure 2. Canonical correspondence analysis (CCA) triplot for the ecological correlations between dominant zooplankton taxa in Mandra Reservoir and pH, dissolved oxygen (DO, mg/l), oxygen saturation (DOS, %) and electrical conductivity (COND, µs) of water measured in the period February 2020 - January 2021 (S1, S2, S3, S4, S5, S6, S7 - sampling points)

These results indicate an equal distribution of dissolved oxygen in the water body because of its mixing regime, and that this factor is not a determinant of the distribution of zooplankton communities in Mandra Reservoir. This is due to the small depth of the reservoir and its comparatively high surface area, frequent mixing, as a result of which good aeration of the water is ensured and dissolved oxygen is not a limiting factor.

CONCLUSIONS

In the study presented here, no distinct trends of zooplankton grouping depending on a given environmental parameter were observed. This can be explained by the specific conditions in the eutrophic Mandra Reservoir and the presence of eurybiont species that have a high tolerance to changes in the environment. A typical example species is *K. cochlearis.*

Our study also proves that shallow water bodies exhibit deviations from some regularities described by the authors. This is due to the specific conditions, especially in the coastal lakes, subjected to multiple mixings caused by the blowing of permanent comparatively strong winds, higher average temperatures even in winter, thanks to the milder climate and other factors. If you compare obtained results with these from Iskar Reservoir - the biggest reservoir in Bulgaria (Stefanova et al., 2020), the dominant complexes and whole species composition of Mandra reservoir are poorer. This tendency is typical for the Bulgarian eutrophic reservoirs and coastal lakes which are eutrophic too (Kozuharov, 2019).

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