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18. Dynamics of zooplankton community in Danube Delta Biosphere Reserve aquatic ecosystems

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Abstract: The present study conducted a qualitative analysis of zooplankton in six lakes over a period of four years (2019-2022). During the period of analysis, the mean numerical abundance for the studied years exhibited variation, with recorded values of 12.69 ind/l in 2019, 10.28 ind/l in 2020, 11.05 ind/l in 2021, and 15.28 ind/l in 2022. Likewise, the mean biomass also showed fluctuation with an average of 0.23 mg ww/l in 2019, 0.33 mg ww/l in 2020, 0.42 mg ww/l in 2021, and 0.31 mg ww/l in 2022. The study identified a total of 135 zooplankton species belonging to three taxonomic groups: Rotifera, Cladocera, and Copepoda. The Rotifera group had the highest number of species with 95, followed by Cladocera with 22 species and Copepoda with 18 species. The results of this study suggest that there is a high diversity of zooplankton in the studied lakes, with some lakes showing greater diversity than others, thus the study also found that Merhei and Uzlina were the lakes with the highest zooplankton diversity, with 85 and 84 identified species, respectively, at the same time Parches and Razim lakes had the lowest number of identified species, with 67 and 44 species, respectively. These findings can provide valuable information for the conservation and management of these aquatic ecosystems.
Keywords: zooplankton, Danube Delta Biosphere Reserve, aquatic communities

INTRODUCTION

Aquatic ecosystems are complex systems, and variations in factors such as water quality, and biological communities can affect the health and functioning of these ecosystems. Understanding these variations is important for managing and preserving aquatic ecosystems. By monitoring these ecosystems, scientists and policymakers can make informed decisions about how to protect and restore these valuable resources. Additionally, understanding these variations can help identify potential threats to the health of aquatic ecosystems and develop strategies to mitigate or prevent these threats. The zooplankton community holds a significant role in the aquatic food chain linking primary producers like phytoplankton and higher-level consumers such as invertebrates and fish, as such, they facilitate the transfer of energy within the food chain (Jeppensen et al., 2011; Lampert and Sommer, 1997; Muñoz-Colmenares et al., 2021). Due to their short generation time, zooplankton is highly sensitive to changes in their habitat, both physical and chemical having a fast reaction.

Danube Delta aquatic ecosystems zooplankton is represented by species belonging mainly to Cladocera, Copepoda, and Rotifera. Cladocerans are important components of aquatic trophic networks. Most species feed on algae, detritus, and bacteria. The feeding mode through filtration allows for the concentration of a very large amount of suspended particles dispersed in the water column. Predatory species feed on other species of zooplankton. Littoral and benthic species consume large amounts of detritus and bacteria. They, in turn, serve as food for predatory copepods and cladocerans, as well as for the larval and juvenile stages of fish species. In littoral habitats, cladocerans are also exposed to a wide variety of benthic predators. High filtration rates allow cladocerans, to be key species in the pelagic zone of lakes. At the end of spring, the large number of cladocerans can control the abundance of algae, leading to a phase of water clarification that ends when cladocerans are consumed by planktivorous fish. Copepods are common in a wide variety of aquatic habitats.

Most species feed on detritus, phytoplankton, other invertebrates, and even fish larvae. Copepods constitute a large part of the biomass of aquatic habitats. They play an essential role in the aquatic food web both as primary and secondary consumers and as a major food source for many aquatic invertebrates and vertebrates.

Rotifers are important constituents of aquatic food webs due to their high reproductive rates and large numerical abundances, as well as their role as a link between bacteria and phytoplankton as secondary consumers. Moreover, their rapid response to changes in environmental factors makes rotifers highly valuable ecological indicators (Jeppensen et al., 2011). The most diverse group of zooplankton comprises organisms that can be found in a wide variety of freshwater habitats, from large lakes to small ponds and temporary pools. Within an aquatic ecosystem, they populate both the plankton and the littoral zones with aquatic vegetation as well as the benthic zone, with a large number of species crawling or attaching to substrates or being sessile. By examining changes in the community structure of zooplankton, including species composition, abundance, and biomass, it is possible to detect the impacts of environmental disturbances on aquatic ecosystems. Variations in zooplankton communities can be influenced by biotic and abiotic factors such as food availability for zooplankton, water temperature, nutrient levels and weather conditions. The study of these parameters can be useful in assessing the state of health of the lacustrine ecosystem and in identifying possible changes caused by anthropogenic factors or natural environmental disturbances.

MATERIALS AND METHODS

The Danube Delta has 479 shallow lakes remaining after significant hydro-morphological changes that occurred post-1980's. These lakes are spread across an area of approximately 23,000 hectares, and can be classified into six lake complexes (Oosterberg et al., 2000). The lakes are linked through a vast network of channels, including natural and man-made channels constructed after 1930.

During 2019-2022, we collected zooplankton samples from the most representative six lakes situated within the six aquatic complexes of the Danube Delta Biosphere Reserve namely Furtuna, Uzlina Roșu, Merhei, Parcheș, Razim. The location of zooplankton sampling sites (marked with yellow points) is illustrated in Figure 1. Sampling was conducted in March, July, and October, to cover the annual development cycles of planktonic organisms, as well as the higher and lower water levels and samples were taken from both the coastal and central areas of each lake. An additional expedition was carried out in August 2022 to collect samples from the Furtuna and Roșu lakes. The sampling was done according to Tudor et al. (2015), by filtering 30 liters of water through a 55 µm mesh size plankton net.

The collected material was transferred into plastic containers (100 ml) and fixed with 96% alcohol. The samples were properly labeled, and transported to the laboratory where they were concentrated by slow sedimentation for two weeks in order to optimize their analysis. After that, 30-50 ml of concentrated sample was obtained. The zooplankton organisms were counted in a Sedgewick-R after counting chamber of 1 ml, under the Axio Lab (ZEISS) microscope, the procedure was repeated twice. For the taxonomic identification of zooplankton communities, identification keys and specialized literature were used: Rudescu (1960), Damian - Georgescu (1963), and Negrea (1983).

The identification was carried to the species level and where not possible, up to the genus level. The numerical density expressed as individuals per liter were estimated, according to the formula established by the American Public Health Association (APHA) and described in Clesceri et al. (1989) as follows: Density (ind/L) = (n*v1)/(v2*v), where n represent the number of organisms counted in the sub-sample; v1 – the concentrated volume of sample; v2- the analyzed volume of sub-sample; v – the volume of filtered water. Biomass is calculated in wet weight, using tables adapted from specialized literature. The number of individuals of each species is multiplied by their corresponding mean individual value, and the total biomass is calculated for each taxonomic group and then for the whole sample, expressed as mg per unit of wet volume.

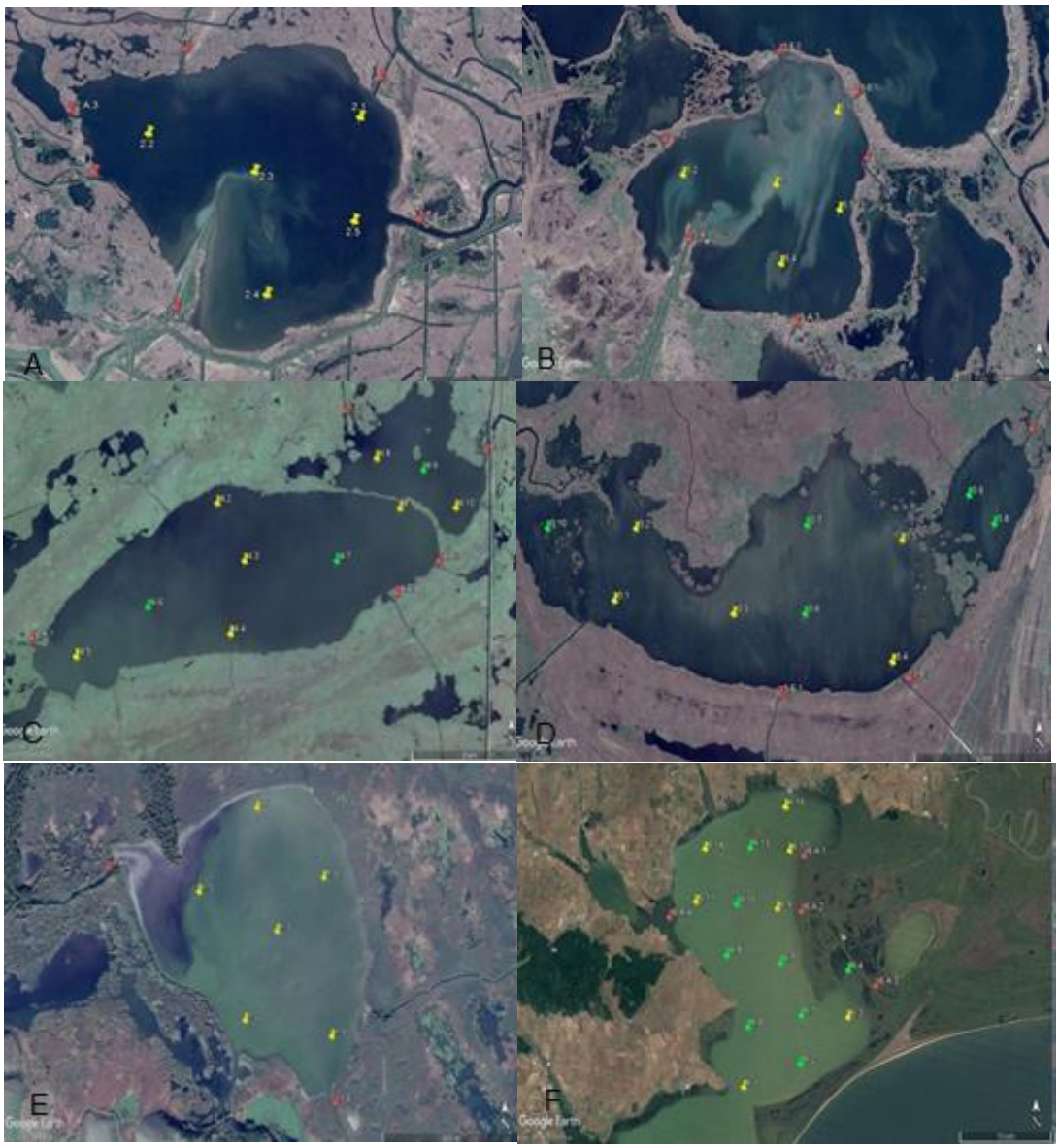

Figure 1. Sampling points locations: A. Furtuna lake; B. Uzlina lake; C. Roșu lake; D. Merhei lake; E. Parcheș lake; F. Razim lake.

RESULTS AND DISCUSSION

Over the study period, the average numerical abundance of zooplankton in analyzed years was 12.69 ind/l in 2019, 10.28 ind/l in 2020, 11.05 ind/l in 2021, and 15.28 ind/l in 2022, while the average biomass was 0.23 mg ww/l in 2019, 0,33 mg ww/l in 2020, 0,42 mg ww/l in 2021 and 0.31 mg ww/l in 2022.

Furtuna

Lake Furtuna, with an area of 977.5 ha and a volume of 9.8 million m³, is a lake with a direct and increased connection to the Danube and with a dense hydrographic network that ensures a good water supply. During the analyzed period, the average numerical abundance of zooplankton in Lake Furtuna varied from values of 4.59 ind/L in 2019, 5.12 ind/L in 2020, and 4.65 ind/L in 2021, with the highest value of numerical abundance recorded in the last year of study at 11.03 ind/L. Regarding the average zooplankton biomass, it showed low values characteristic of the small size of zooplankton species, ranging from 0.05 mg ww/L in 2019, 0.04 mg ww/L in 2020, 0.06 mg ww/L in 2021, and the highest value, as in the case of numerical abundance, was recorded in the last year of study - 0.15 mg ww/L.

According to Figure 2, the distribution of the mean zooplankton numerical abundances by taxonomic groups in Lake Furtuna showed that the highest value of cladocerans, at 14.98 ind/L, was recorded in October 2022. The lowest value, at 0.5 ind/L, was reported in March 2019. Copepod values ranged from 3.21 ind/L in March 2020, the lowest value, to 34.26 ind/L in August 2022, the highest value. For rotifers, the values ranged from 0.52 ind/L in October 2020 to 15.56 ind/L in August 2022.

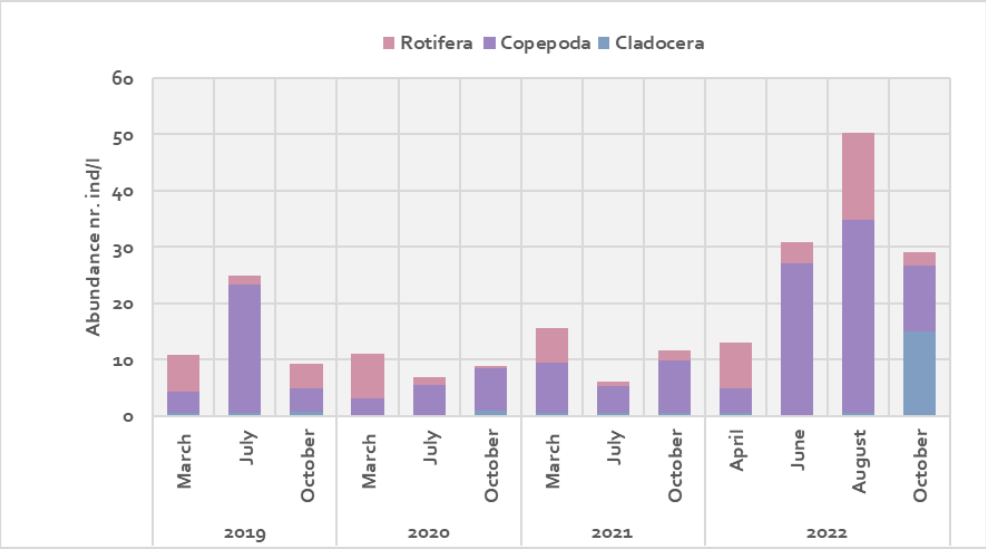

Figure 2. Comparative analysis of average zooplankton numerical abundances in Lake Furtuna

Uzlina Lake

The average numerical abundance of zooplankton in Lake Uzlina was 7.63 ind/l in the first year of study, followed by a decrease in 2020 to 5.78 ind/l and in 2021 to 6.82 ind/l. In the last year, there was a significant increase to 13.11 ind/l. The average biomass of zooplankton in Lake Uzlina was 0.09 mg ww/L and 0.13 mg ww/L in 2021 respectively 2022, with a slightly higher value of 0.11-0.13 mg ww/L in 2019-2020. The distribution of numerical abundances of zooplankton, by taxonomic groups in Lake Uzlina during the 4 years of monitoring, is represented in the figure 3. The data collected from Lake Uzlina indicates that the numerical abundance of cladocerans was the lowest in March 2021 and the highest in October 2020. Copepods, on the other hand, exhibited the lowest value in March 2019, while the highest value was observed in October 2022. As for rotifers, their highest mean numerical abundance values were recorded in July 2022, with a value of 13.41 ind/l, and the lowest value was observed in July 2020 at 2.27 ind/l.

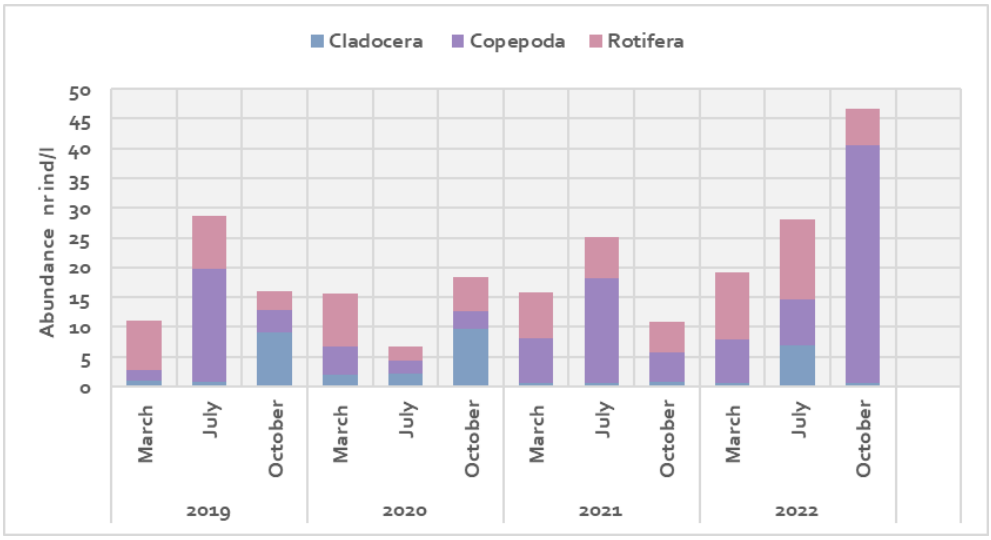

Figure 3. Comparative analysis of average zooplankton numerical abundances in Lake Uzlina between 2019 – 2022

Roșu Lake

Lake Roșu is the most representative freshwater lake of the maritime delta, with an area of 1,445 ha, a water volume of 21.7 mil. cm and an average depth of 3 m. (Moldoveanu et al., 2015). The comparative analysis of data regarding the average zooplanktonic numerical abundance in Lake Roșu shows that it had a value of 13.95 ind/l in the first year of study, 13.63 ind/l in 2020, 9.89 ind/l in 2021, and 14.54 in the last year of study in 2022. As for the average zooplanktonic biomass, it recorded values ranging from 0.26 mg ww/L in 2022 to 0.76 in 2020. The distribution of numerical abundances of zooplankton, by taxonomic groups in Lake Roșu during the 4 years of monitoring, is graphically represented in figure 4. According to the data, the highest value of cladocerans in Roșu lake was observed in October 2019, with a value of 27.45 ind/L, while the lowest value was recorded in March 2021 at 0.62 ind/L. Copepods, on the other hand, exhibited the lowest value in October 2021 and the highest value in August 2022. The numerical abundance of rotifers was the lowest in July 2022, and the highest value was observed in August 2022.

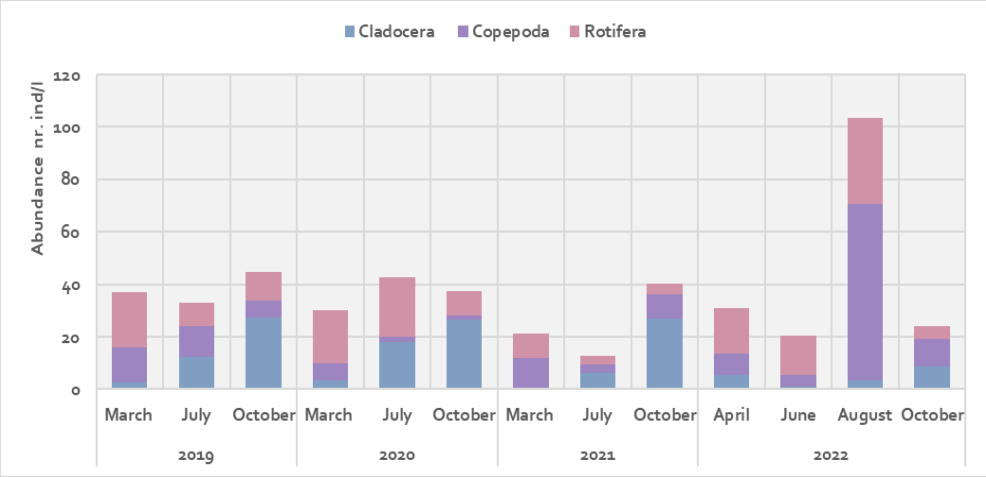

Figure 4. Comparative analysis of average zooplankton numerical abundances in Lake Roșu, 2019 – 2022

Merhei Lake

The long distance to the Danube River led to a reduced circulation of water in the lake. Characterized by a small depth, the perimeter of Lake Merhei has a high degree of sinuosity, thus having a higher value of the ratio between the length of the shoreline and the total area, a significant detail in the dynamics of zooplankton diversity. The comparative analysis of the data on the average numerical abundance of zooplankton in Lake Merhei shows us that it had the highest value in the last year of the study - 24.06 ind/l, these were followed by values of 15.25 ind/l in 2019, 13.07 ind/l in 2020 and 11.65 ind/l in 2021. Regarding the average zooplankton biomass, it recorded values in the range of 0.16 mg ww/L in 2021, 0.26 mg ww/L in 2019, 0.28 mg ww/L in 2020 and 0.36 mg ww/L in 2022. The distribution of numerical abundances of zooplankton, by taxonomic groups in Lake Merhei during the 4 years of monitoring, is represented in figure 5. In terms of cladoceran abundance, the lowest value was recorded in July 2021 at 0.71 ind/L, while the highest value was observed in July 2022 at 22.45 ind/L. For copepods, the smallest value was recorded in October 2020 at 5.07 ind/L, whereas the highest value was recorded in March 2021 at 15.85 ind/L. The lowest value of rotifers was observed in July 2021 at 4.34 ind/L, while the highest value was recorded in March 2019 at 43.95 ind/L.

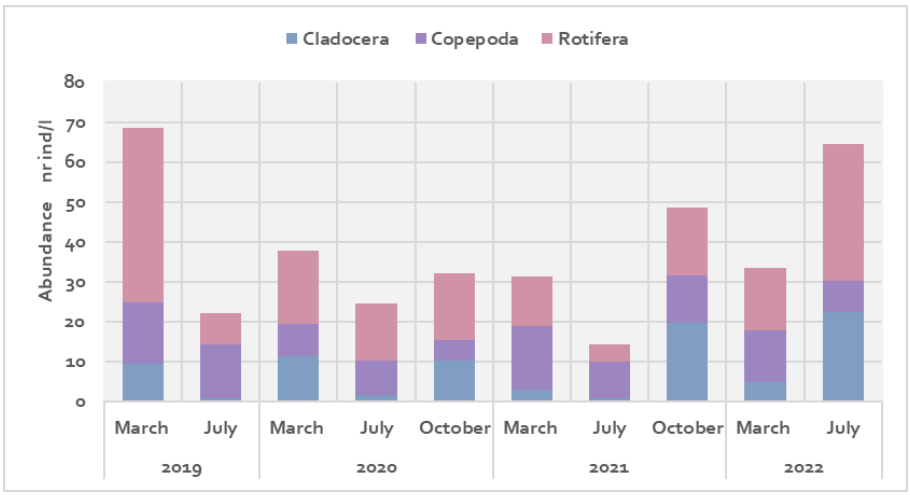

Figure 5. Comparative analysis of average abundances in Lake Merhei, 2019 – 2022

Parches Lake

The numerical abundance of zooplankton recorded a maximum value in the third year of the study (18.17 ind/l), followed by lower values in previous years (15.94 ind/l in 2019, 14.47 ind/l in 2020, 14.89 ind/l in 2022). As for the average zooplankton biomass, it recorded values falling within a relatively tight range (0.19 mg ww/L in 2020, 0.20 mg ww/L in 2022, 0.22 mg ww/L in 2021, and 0.32 mg ww/ L in 2019), with a maximum value in 2019. The distribution of numerical abundances of zooplankton, by taxonomic groups in Parcheș Lake during the 4 years, is represented in Figure 6 In 2019, the numerical abundance of cladocerans exhibited the highest value in March, recording 19.06 ind/L, and the lowest value in July at 0.5 ind/L. Copepods showed the highest value in October 2022 at 27.00 ind/L and the lowest value in July 2021 at 2.97 ind/L. As far as rotifers, the lowest value was observed in October 2022 at 2.35 ind/L, whereas the highest value was recorded in March 2021 at 38.44 ind/L.

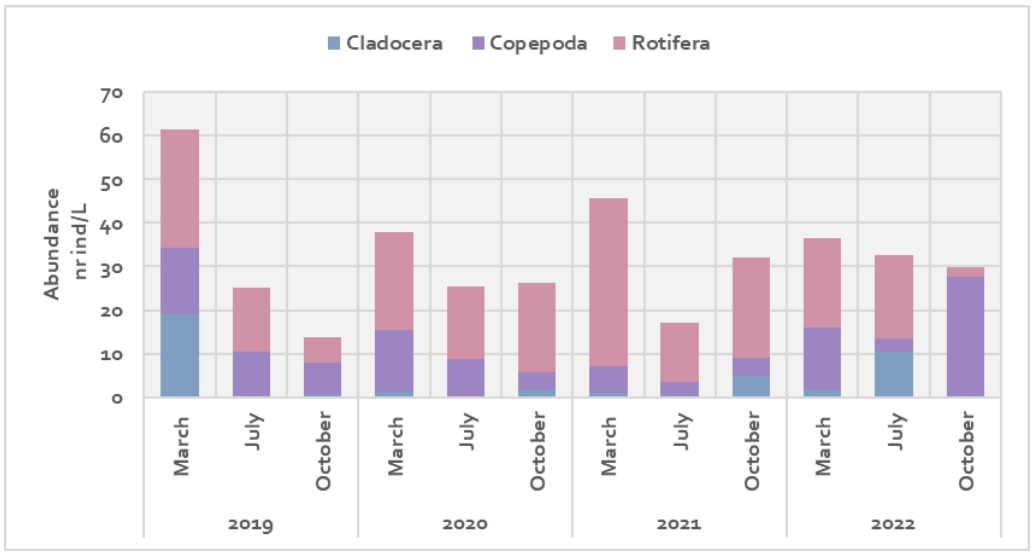

Figure 6. Comparative analysis of average zooplankton numerical abundances in Lake Parcheș, 2019 – 2022

Razim Lake

Based on the comparative analysis of data on the average numerical abundances of zooplankton in Lake Razim during the analyzed period, the highest values were observed in the first and last year of the study, with values of 13.99 ind/L and 12.26 ind/L, respectively. The lowest value was recorded in 2020 at 4.41 ind/L, while the value for 2021 was 7.71 ind/L. The average zooplankton biomass ranged between 0.11 mg ww/L to 0.60 mg ww/L. Figure 7 illustrates the distribution of average zooplankton abundances by taxonomic groups in Lake Razim over four years. In terms of the numerical abundance

of cladocerans in Lake Razim, the lowest value was observed in July 2022 at 0.54 ind/L, whereas the highest value was recorded in October 2022 at 33.26 ind/L. On the other hand, copepods exhibited the lowest value in October 2021 at 2.83 ind/L and the highest value in March 2019 at 18.83 ind/L. For rotifers, the smallest values were observed in July 2020 at 1.12 ind/L, while the highest value was observed in July 2022 at 19.42 ind/L, with 2019 showing a value of 4.16 ind/L.

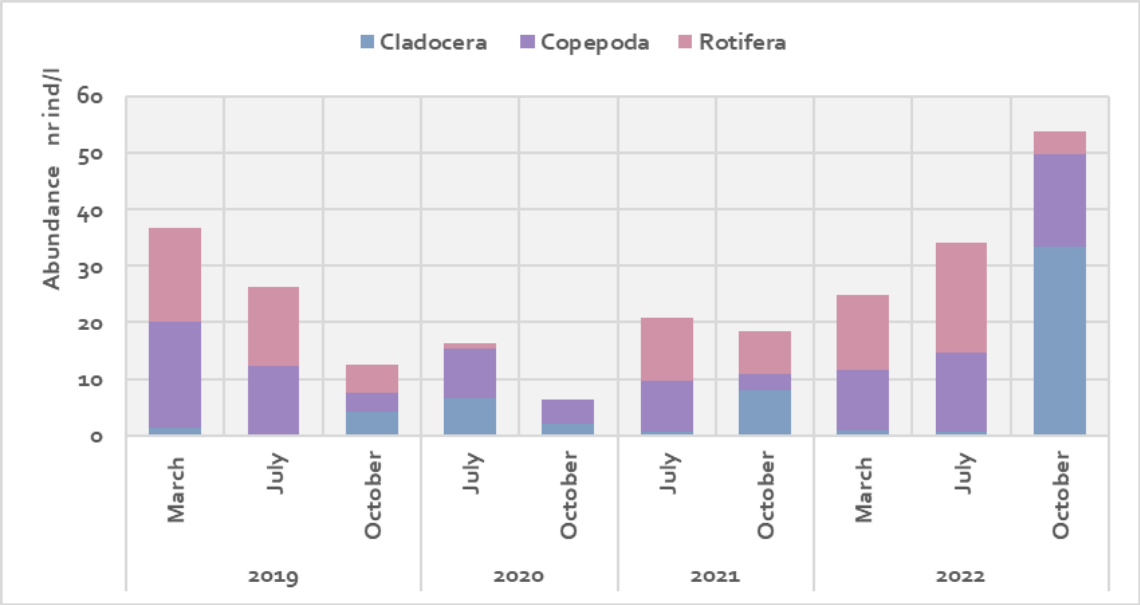

Figure 7. Comparative analysis of average zooplankton numerical abundances in Lake Razim between 2019 – 2022

During the period 2019-2022, after studies conducted on the six lakes, the qualitative analysis of zooplankton indicated the existence of three taxonomic groups, Rotifera (95 species), Cladocera (22 species), and Copepoda (18 species), comprising a total of 135 species.

Merhei and Uzlina lakes were found to have the most diverse zooplankton fauna, with 85 and 84 species respectively, while Rosu and Furtuna lakes followed with 74 and 71 species respectively. In contrast, Parcheș Lake was found to have the smallest number of species, with 67 identified, while Razim Lake had only 44 species.

Unlike the other studied aquatic ecosystems Merhei is a lake with reduced connectivity, and this is reflected in its ecological conditions. The large distance from the arms of the Danube leads to reduced water circulation in the lake. The perimeter of the lake has a high degree of sinuosity, resulting in a higher value of the ratio between the length of the shoreline and the total surface area, which is a significant detail for the diversity of zooplankton (Zinevici et al., 2010). The spatio-temporal dynamics of the total number of zooplankton species in the lakes of the RBDD, in the period 2019 – 2022, is graphically represented in Figure 8.

Chydorus sphaericus, Bosmina longirostris, Bosmina coregoni, Diaphanosoma brachiurum, *Acanthocyclops sp., Cyclops vicinus, Eucyclops serrulatus, Megacyclops viridis, Macrocyclops albidus, Anuraeopsis fissa, Ascomorpha ovalis, Asplanchna priodonta, Brachionus angularis, Brachionus calyciflorus, Brachionus diversicornis, Brachionus forficula, Brachionus leydigi, Colurella uncinata, Euchlanis dilatata, Filinia longiseta, Keratella cochlearis, Keratella quadrata, Keratella serrulata, Lecane bulla, Lecane luna, Notholca acuminata, Polyarthra vulgaris, Pompholyx sulcata, Testudinella patina, Trichocerca cylindrica, Trichocerca longiseta.* represent some of the most common and frequently encountered species in the studied lakes during 2019-2022.

Their constant presence may be due to their adaptability to environmental variations or to pressures at the level of the zooplankton community. These species can have an important role in structuring zooplankton communities and can be used as indicators of the health status of aquatic ecosystems.

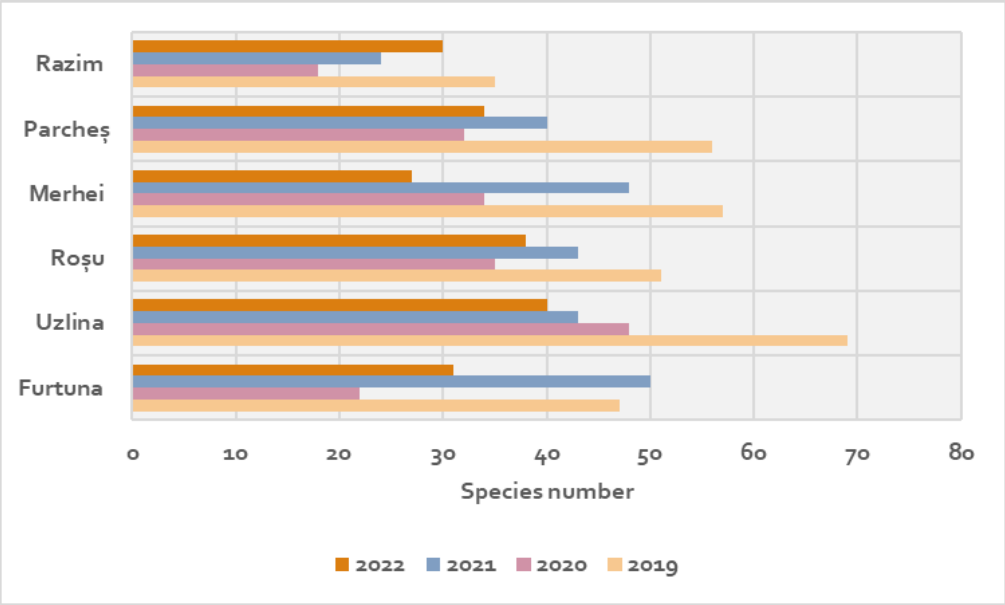

Figure 8. The total number of zooplankton species in the lakes of the RBDD, 2019 – 2022

CONCLUSIONS

Qualitative analysis of zooplankton in the six lakes studied during the period 2019-2022 revealed the presence of a total of 135 species belonging to three taxonomic groups: Rotifera (95 species), Cladocera (22 species), and Copepoda (18 species).

During the analyzed period, the lakes with more diverse zooplankton fauna were Merhei, with 85 species, and Uzlina, with 84 species, followed by Rosu, with 74 species, and Futuna, with 71 species. The lakes with the lowest number of species were Parches, with 67 identified species, and Razim, with 44 species.

The analysis of numerical densities highlighted two seasonal peaks in the spring and summer months, which can be attributed to the seasonal dynamics of zooplankton, which reaches their maximum development. Given the numerical dominance of small-sized species, the zooplankton biomass in the studied ecosystems is characterized by low values, closely following the variation of numerical densities.

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