Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(6): 329 – 342 (2023)
www.ejabf.journals.ekb.eg

Comparative Study of Zooplankton Dynamics (Cladocerans and Rotifers) in Relation to Abiotic Parameters in Sidi Mhamed Benali Lake and Sarno Dam (Western Algeria)

Meriem El Batoul Amar*, Sara Bouchera Amar, Youcef Amar

Department of Environmental Sciences, Faculty of Natural and Life Sciences, Djillali Liabes University, Sidi Bel Abbes, Algeria

***Corresponding Author:** meriem.amar@univ-sba.dz

ARTICLE INFO

Article History:
Received: Sept. 29, 2023
Accepted: Nov. 7, 2023
Online: Dec. 5, 2023

Keywords:
Zooplankton,
Cladocerans,
Rotifers,
Sidi Mhamed Benali Lake,
Sarno Dam,
Specific richness,
Dynamics

ABSTRACT

The present work aimed to study the distribution of Cladocera and Rotifera populations in two reservoirs in western Algeria (Sidi Mhamed Benali Lake and Sarno Dam), taking into account two physical parameters: water temperature and pH in the Mediterranean climate. The abundance of zooplankton groups, specifically Cladocerans and Rotifers, exhibited an evolution closely paralleling the environmental characteristics of the ecosystem. Both populations were monthly sampled from January to July 2017 using a plankton net of 64µm mesh size. In total, 35 taxa were recorded, of which 18 species belong to the Cladocera and 17 others are members of the Rotifera. The results of this comparative study showed, on the one hand, heterogeneity in the specific richness of Cladocera and Rotifera on a spatiotemporal scale and a relationship with the physical quality of the water in the two environments on the other hand. Furthermore, Sidi Mhamed Benali Lake appeared to be more diverse and the richest in Cladocera. Overall, the highest taxon richness and abundance were recorded during the rainy season from January to April (35 species) compared with 22 taxa in the dry season. These results were confirmed and clearly demonstrated by the results of the principal component analysis (PCA).

INTRODUCTION

Limnic environments, such as lakes, dams and reservoirs, exhibit a heterogeneous distribution of planktonic organisms both horizontally and vertically **(Thornton *et al.*, 1982; Hart, 1990)**. These organisms play an essential role in the trophic chain, representing an important level in the transfer of energy from primary production to higher trophic links such as fish **(Indresha *et al.*, 2018)**. There has been reports indicating that planktivorous fish change their usual diet, opting to consume substantial quantities of zooplankton (cladocerans and copepods) in the absence or low biomass of macrophytes **(Quirino *et al.*, 2021)**.

Studies show that phytoplankton production in freshwater is closely linked to environmental factors **(Garnier *et al.*, 1995)**. The spatial and temporal variability of biomass and the distribution of plankton in the lake are influenced by the hydrodynamics of the ecosystem, particularly seasonal variations that affect nutrients and temperature **(Côté *et al.*, 2002; Oneyma *et al.*, 2008)**. The distribution of zooplankton organisms is dynamically influced by a variety of environmental factors. The availability of food (algae, bacteria) and predation by fish and invertebrates help to characterize each of the two reservoirs.

Productivity is probably the most important process for regulating zooplankton biomass in lakes on a large scale **(Masson *et al.*, 2004)**. Hydrological factors and temperature linked to the Mediterranean climate are thought to be one of the main causes of the temporal distribution of species **(Pinel-Alloul *et al.*, 1999; Cherbi *et al.*, 2008)**. Water temperature appears to be a significant factor in the abundance of cladocerans, while magnesium content and nitrate are significant factors for rotifers in the samples **(Kar *et al.*, 2018**). Several authors have demonstrated that zooplankton is selected as an indicator of water quality due to its sensitivity to even the slightest changes in environmental conditions, affecting the overall functioning of aquatic ecosystem **(Čeirāns, 2007; Dulic *et al.*, 2009; Munoz-Colmenares *et al.*, 2021)**. Very little previous work has been conducted on the ecology of zooplankton in the waters of Lake SMB. It should be noted that the study relies on the analysis of physical and chemical parameters, the saprobic index, and cladocerans to determine the extent and nature of pollution in Lake Sidi Mhamed Benali **(El Badaoui *et al.*, 2015; Ebrahimi *et al*., 2018)**.

In this context, the present work addressed two sites (Sarno dam and SMB Lake in the wilaya of Sidi Bel Abbes). The objectives included understanding the composition and dynamics of the zooplankton assemblage, particularly cladocerans and rotifers. Additionally, the study involved a a comparative study of the specific richness of the two environments, considering variations in physical parameters resulting from anthropic actions. This research is part of a planned aquaculture project in the target region.

MATERIALS AND METHODS

1. Study area and sampling

The Sidi M'hamed Benali Lake has a surface area of 40 hectares, located 1.7km from the town of Sidi Bel Abbes; its maximum depth is around 12m. It is mainly fed by a canal, with the aim of reducing flood flows from the Mekerra River during the winter. Regarding the Sarno Dam, it often receives wastewater from the nearby village of Dlahim and water from the Tessala watershed.

Zooplankton were monthly sampled over a period from January to July 2017. A total of ten stations were chosen, five stations in Lake SMB and five others in the Sarno Dam (Fig. 1).

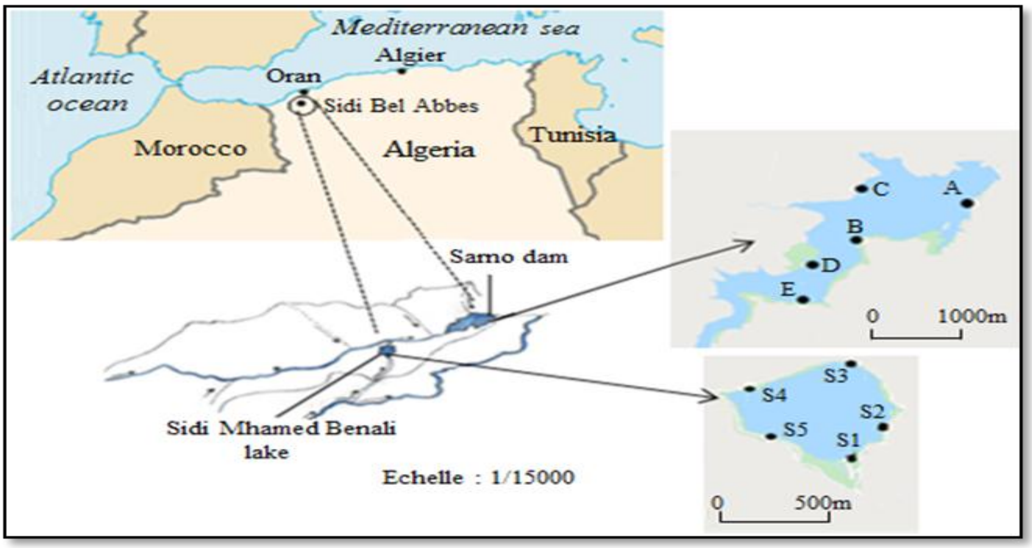


Fig. 1. Geographical situation of the study area and localization of sampling stations

The stations chosen are far enough from each other to be considered sufficiently as representatives of the spatial variability of the ecosystem. The samples were horizontally taken at the surface of the water between -30 and -50cm using a plankton net (with an opening diameter of 30cm and a mesh size of 64µm). For each sampling, the net and the collector were rinsed from the inside with water in order to recover the rest of the species from the station. The filtrate of this water was added to the sample, along with 4% formalin, as part of the experimental procedure. Only Cladocera and Rotifera were sorted, counted and identified using a Zeiss-type optical microscope, and they were identified using keys and determination books of **Pourriot (1980)**, **Amoros (1984)**, **Pourriot and Francez (1986)** and **Ruggiero *et al.* (2004)**.

2. Data analysis

The results obtained from the biological analysis of the two reservoirs were statistically processed to summarize and interpret the results. This process aimed to characterize the state of the water and understand the dynamics of Cladocera & Rotifera, as well as the observed variability between stations. The relationship between zooplankton assemblages and physical factors (T °C and pH) was determined from the correlation matrix for each study sites by means of typological analysis. All tests were carried out using the STATISTICA 6.0 software.

The variables and observations were represented by the months in which the samples were taken and the species, respectively. These variables describe the average monthly abundance with a frequency greater than 30% of all the taxa in each reservoir. The biological data obtained was also used to study the taxonomic richness and calculate the diversity indices (below) that characterize the composition and evolution of the zooplankton (Cladocera and Rotifera) in the two study environments.

The Shannon-Wiener Diversity Index (H') = $-\sum (ni/Nt) \log_2 (ni/Nt)$,

Pielou Index (J) = H'/Hmax

RESULTS

1. Environmental parameters

In the SMB Lake, the average monthly pH fluctuated between 7.8 and 9.05. The minimum value was recorded at stations S_2 and S_4 in January and became very high (pH= 9.10) in July at stations S_3 and S_4. With respect to the Sarno Dam, the average pH varied between 7.60 and 8.93. The minimum value (7.4) appeared at station A, compared to a maximum pH of 9.19 in July at station C. The pH values of the Sarno Dam fluctuated between 7.6 in January and 8.9 in July although there were irregular variations from one month to the next, with an annual average of 7.62± 0.10 (Table 1).

The results obtained through our study showed a variability of these parameters, which allowed us to envisage the state of the water in which the zooplankton live. The highest water temperatures in Lake SMB were recorded in June and July at 27.3 and 28.3°C, respectively. In regards with the Sarno Dam, the water temperature was similar, with a slight increase in pH to 8 and 9.12 (Table 1).

Table 1. Monthly fluctuation of each environmental parameters means measured in SMB Lake and Sarno Dam between Juanuary and July 2017

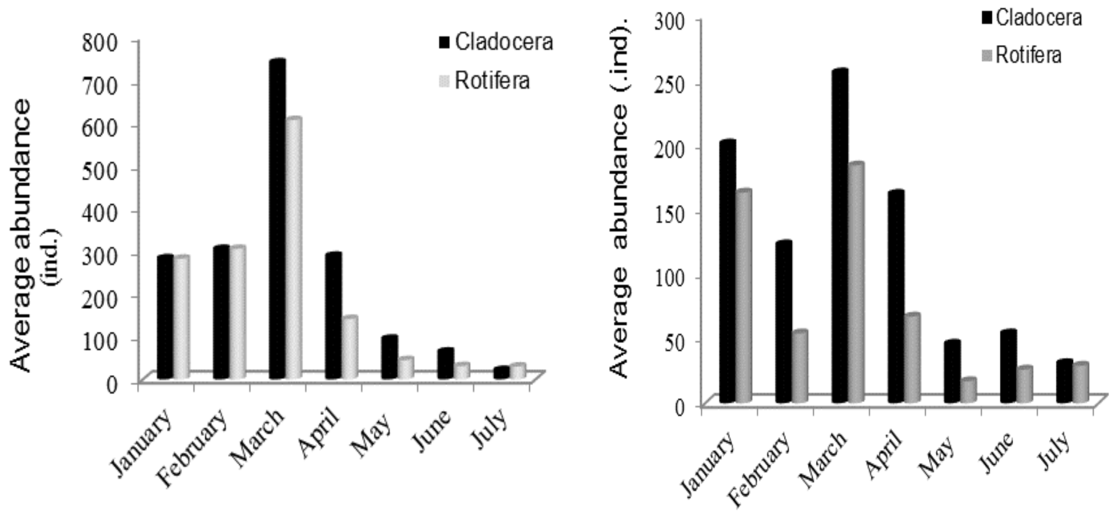
Area		January	February	March	April	May	June	July
SMB Lake	**T °C**	10,1± 0,28	9,2 ± 0,57	15,2 ± 0,19	16,1 ± 0,13	20,2 ± 0,21	27,3 ± 0,46	28,3± 0,45
	pH	7,8± 0,10	8,61± 0,33	8,72 ± 0,24	8,87 ± 0,30	8,77 ± 0,28	8,86 ± 0,26	9,05 ± 0,15
Sarno Dam	**T °C**	10 ± 0,33	9,3 ± 0,27	15,4 ± 0,12	16,3 ± 0,15	20 ± 0,11	27,5 ± 0,34	28,2 ± 0,61
	pH	7,60± 0,14	7,76± 0,12	7,89 ± 0,10	7,99 ± 0,19	8,50 ± 0,25	8,75 ± 0,20	8,93 ± 0,26

The interaction between these parameters in the lake can be explained by high microbial activity in the summer in the bottom sludge. This leads to a reduction in the concentrations of the dissolved oxygen and also an increase in nitrate and phosphate concentrations.

2. Qualitative and quantitative distribution

A total of 35 taxa (Cladocera and Rotifera) were observed in both reservoirs. The population consists of 18 cladocerans and 17 rotiferans. These taxa are divided into 8 families and 14 genera. The Daphnidae and Brachionidea families are the most diverse. The other families are all monospecific.

Significant variations in the species richness and density of the cladoceran and rotiferan community were observed during this study in each reservoir. It should be noted that the cladoceran and rotiferan populations at the SMB Lake have a higher specific richness than those at the Sarno Dam. Cladocerans were usually present throughout the study, particularly in March, with a maximum of 995 individuals in S1. This number gradually decreased until July. In spring, Cladocera reach their highest abundance, while rotifers are more prevalent in winter, but their numbers decrease in April (Fig. 2).



(a) Sidi Mhamed Benali Lake **(b)** Sarno Dam

Fig. 2. Fluctuations in the average abundance of Cladocera and Rotifera during the study period

The richness is dominated by cladocerans, especially *Daphnia magna*, *Ceriodaphnia reticulata* and *Chydorus latus*. Rotifers are characterized by a high dominance of *Brachionus calyciflorus*, *Keratella quadrata* and *K. cochlearis*. The rest of the taxonomic composition is only incidental, namely *Chydorus piger*, *Chydorus brevicornis*, *Brachionus quadridentatus*, *Lecane luna*, *Filinia* sp., *Streblocerus serricaudatus*, *Daphnia similis*, *Ceriodaphnia pulchella*, *Alona* costata and *Bosmina longirostris.* The Sarno Dam has a total of 9 species, but *Chydorus latus* is the leading cladoceran species (F = 100%). The other 8 species: *Alona rectangula*, *Daphnia magna*, *Brachionus calyciflorus*, *Keratella ticinensis*, *Daphnia similis*, *Bosmina longirostris*, *Keratella quadrata* and *K. cochlearis* appear with frequencies between 57> F> 86% .

Cladocerans are generally reported from January to April. A peak in abundance was observed in March, primarily represented by *Daphnia magna*, *Ceriodaphnia reticulata*, *Daphnia ambigua* and *Macrothrix hirsutcrus*. These species were consistantly present, with a percentage of occurrence of over 85%. Their respective numbers correspond to average abundances of 95, 435, 18 and 40 individuals across all of the lake's stations. In January, *Chydorus brevilabris* appeared in S_1, S_2 and S_4, with an average abundance of 83 individuals. Its numbers gradually declined until May, and it suddenly disappeared from the water of Lake SMB in July.

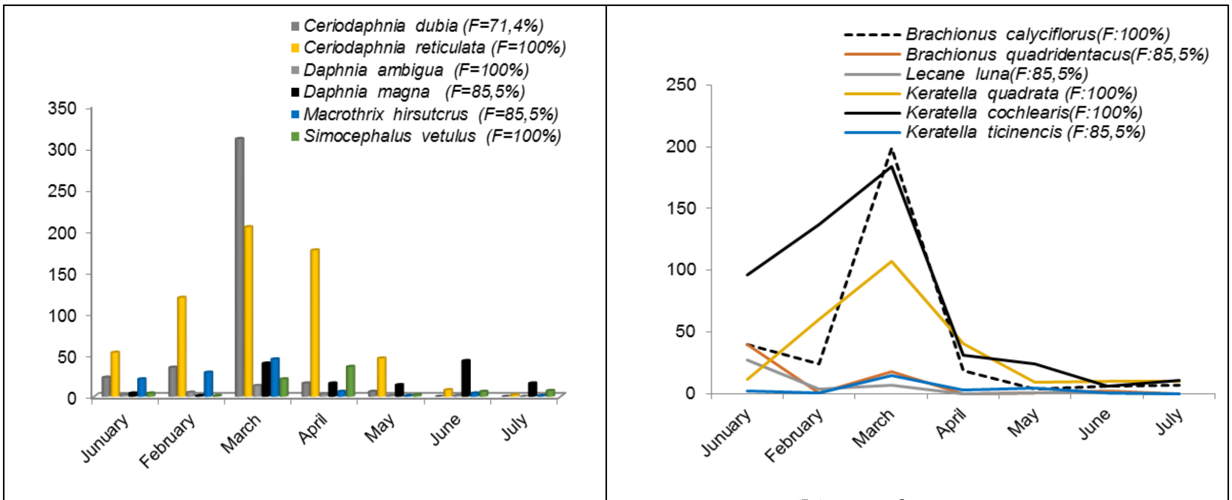
Contrarily, the species *Ceriodaphnia pulchella*, *Streblocerus serracaudatus* and *Daphnia similis* were less represented. For the rotifers *Brachionus clyciflorus*, *B. quadridentatus*, *Keratella quadrata*, *K. cochlearis* and *K. ticinensis*, constant species were reported throughout the study, with average abundances between 18 and 328 in stations S_1

and S_4, respectively. The numbers of this species decreased gradually from April onwards (Table 2).

At the Sarno Dam stations, *Daphnia similis* and *Daphnia longispina* (perennial species) appeared in January, with average abundances of 84 and 68 individuals at all stations. Their numbers decreased gradually from February to July (Figs. 3, 4).

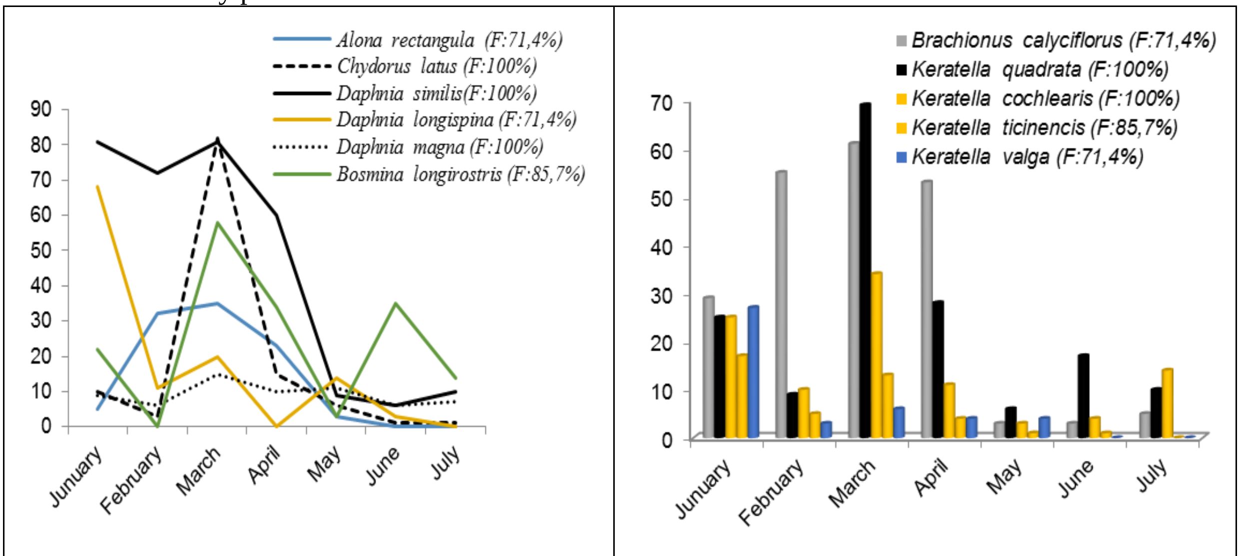
Table 2. List of zooplankton taxa collected in the Lake SMB and Sarno Dam (Western Algeria) during the different months of the study period

Zooplankton species	Sidi Mhamed Benali Lake							F (%)	Sarno Dam							F (%)
	J	F	M	A	M	J	J		J	F	M	A	M	J	J	
Cladocera																
Alona rectangula (Sars, 1862)		+						14,3	+	+	+	+	+			71,4
Alona costata (Sars, 1862)		+	+					28,6								
Bosmina longirostris (O. F. Müller, 1776)			+			+		28,6	+		+	+	+	+	+	85,7
Ceriodaphnia dubia (Richard, 1894)	+	+	+	+	+			71,4								
Ceriodaphnia pulchella (Sars, 1862)	+	+	+	+	+			71,4								
Ceriodaphnia quadrangula (O.F. Müller, 1785)						+		14,3								
Ceriodaphnia reticulata (Jurine, 1820)	+	+	+		+	+	+	85,7								
Chydorus brevilabris (Frey, 1980)	+	+	+		+			57,1								
Chydorus latus (Sars, 1862)								-	+	+	+	+	+	+	+	100
Chydorus piger (Sars, 1862)	+	+	+	+			+	71.4								
Daphnia ambigua (Scourfield, 1947)	+	+	+	+	+	+		85,7								
Daphnia longispina (Müller 1785)		+	+					28,6	+	+			+			42,8
Daphnia magna (Straus, 1820)	+	+	+	+	+	+	+	100		+		+	+	+	+	71,4
Daphnia similis (Claus, 1876)		+					+	28,6	+	+	+	+	+		+	85,7
Macrothrix hirsutcrus (Normand and brad. 1867)	+	+	+	+	+	+	+	100						+		14,3
Moina micrura (Kurz, 1874)							+	14,3								
Simocephalus vetulus (O.F. Müller, 1776)	+	+	+	+	+	+		85,7	+							14,3
Streblocerus serricaudatus (Fischer, 1849)			+	+	+			42,8								
Rotifera																
Asplanchna girodi (De Guerne, 1888)	+	+	+					42,8								
Asplanchna priodonta (Gosse, 1850)		+		+				28,6				+				14,3
Asplanchna sp.		+	+		+			42,8				+				14,3
Brachionus angularis (Gosse, 1851)			+					14,3								-
Brachionus caliciflorus (Pallas, 1766)	+	+	+	+	+	+	+	100			+	+	+	+	+	71,4
Brachionus quadridentatus (Hermann, 1783)	+	+	+		+	+		71,4								
Brachionus sp.				+				14,3								
Epiphanes senta (O.F. Müller, 1773)		+	+		+			42,8								
Filinia sp.	+	+	+		+			57,1								
Keratella quadrata (Gosse, 1851)	+	+	+	+	+	+	+	100	+	+	+	+	+	+	+	100
Keratella cochlearis (O.F. Müller, 1786)	+	+	+	+	+	+	+	100	+	+	+	+	+	+	+	100
Keratella ticinensis (O.F. Müller, 1786)	+	+	+	+	+	+	+	100	+	+	+	+	+	+	+	100
Keratella valga (Ehrenberg, 1834)								-	+	+	+	+	+		+	85,7
Lecane luna (O.F. Muller, 1776)	+	+	+		+	+		71,4				+				14,3
Lepadella sp.						+		14,3								
Polyarthra dolicoptera (Idelson, 1925)	+	+						28,6	+					+	+	42,8
Rotaria neptunia (Ehrenberg, 1832)			+			+		28,6								



(**a**) Cladocera (**b**) Rotifera species

Fig. 3. Evolution of the average abundance of zooplankton main species of SMB Lake during the study period



(a) Cladocera species **(b)** Rotifera species

Fig. 4. Fluctuation in the average abundance of the main species of Cladocera and Rotifera from the Sarno Dam

Although the appearance of *Chydorus latus* (10 individuals) and *Alona rectangula* (5 ind.) in January at stations A, B, D and E reached mean abundances of 62 and 35 individuals, respectively, in March, their average abundance has been steadily declining since April.

In both study areas, cladocerans were recorded as the dominant species in terms of quality and quantity, with the exception of station S3 in January and March. In both sites, the highest values of the Shannon-Wiener index were recorded in February and April (2.82 to 3.18), with a species richness varying between 10 and 25 species in the waters of Lake SMB. Moreover, the lowest values were frequented in the months of May to July in the Sarno Dam with 2.57 to 2.76, corresponding to a species richness between 9 and 13 species (Figs. 5, 6). The same applies to the Pielou regularity index with high values (0.84 to 0.92), indicating a very good distribution of species in the populations observed during the wet season (January to April), compared to 0.79 to 0.81 during the dry season in both reservoirs.

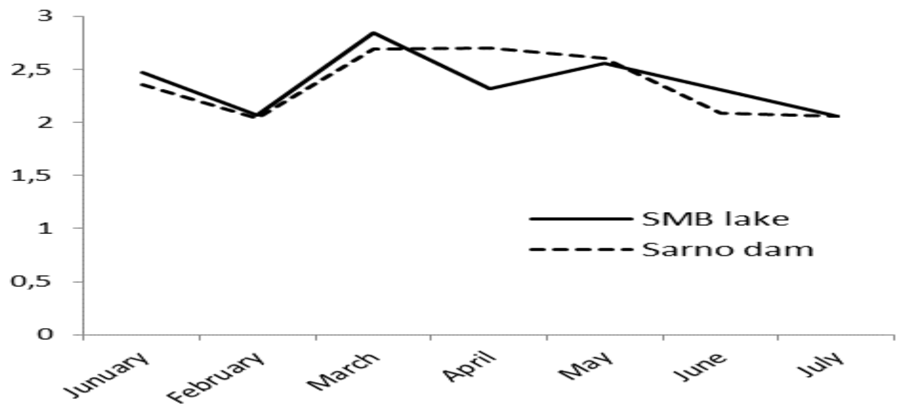


Fig. 5. Graphic representation of Shannon-Wiener diversity during the period of study

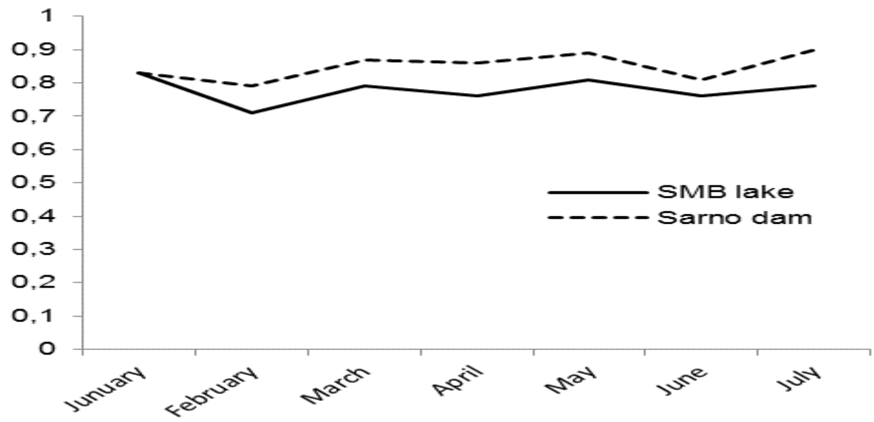


Fig. 6. Graphic representation of the regularity index of the SMB Lake and Sarno Dam during the period of study

Principal component analysis (PCA)

The typological structure identified by the factorial design (F_1, F_2) revealed that two groups were present, each represented by a season. Interpretation of the principal component analysis (PCA) gave the following results: For the SMB Lake, the first two axes (F_1 and F_2) explaining approximately 76.99% of the total inertia, emphasized two sets of variables, each of which designated a period of the year. A dry season (G_3) begins from April to July was characterized by a lower number of species, attributed to the rise in pH and temperature. The wet season represented January (G_1) and March (G_2), and the species richness was high (Fig. 7a).

Principal component analysis (PCA) showed a significant correlation between the months (April, May, June and July) and the rise in temperature and pH. This justified the dry period (G_3) where the number of species was very poorly diversified and presented in low abundance (Fig. 7a).

The result obtained showed that during the wet season the species of G_1 and G_2 seemed more diversified in cladocera and rotifera from a qualitative and quantitative point of view than during the dry season. The G_1 set showed a group of species that were fairly well correlated with each other ($0.48< r< 0.96$). This set formed a high-abundance assemblage during the wet period (January and February), including species of *Chydorus brevicornis*, *Lecane luna*, *Brachionus quadridentatus*, *Ceriodaphnia pulchella*, *Asplanchna girodi* and *Chydorus piger*. Similarly for G_2, it represented the wet season (March) while characterized by other species with a large number of individuals, located in the negative part of the F_2 axis. We observed a high positive correlation ($0.51< r< 0.99$) between effective and a group of species in March consisting of *Keratella cochlearis*, *Macrothrix hirsutcrus*, *Brachionus calyciflorus*, *Daphnia ambigua*, *Ceriodaphnia reticulata*, *Ceriodaphnia dubia*, *Keratella quadrata* and *K. ticinensis*. These results coincide and justify the results obtained in Fig. (7a). In regards with G_3, located in the negative part of the factorial axis F_2, species, such as *Daphnia magna*, *Streblocerus serricaudatus* and *Simocephalus vetulus*, displayed low abundances with adaptation to change in environmental conditions of Lake SMB due to the dry season (Fig. 7b).

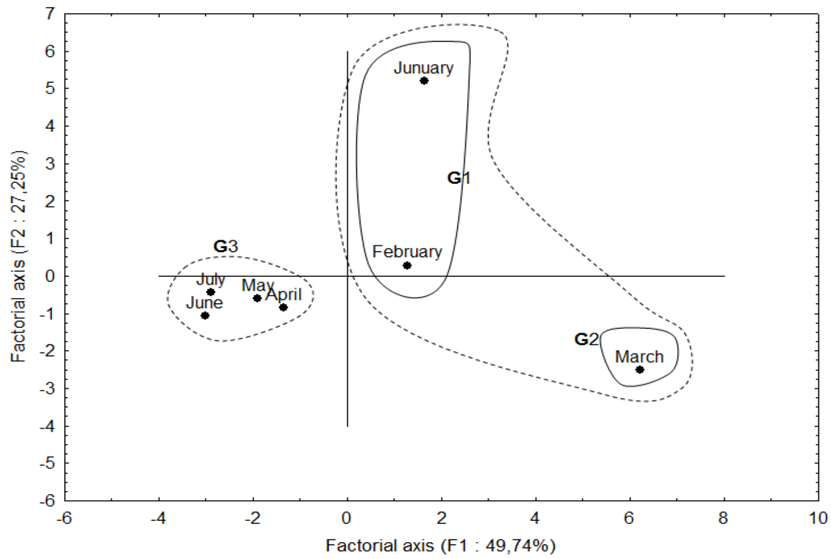


Fig. 7a. Result of the factorial plane of the principal component analysis indicating the Mediterranean climate of Lake Sidi Mhamed Benali during the period from January to July 2017

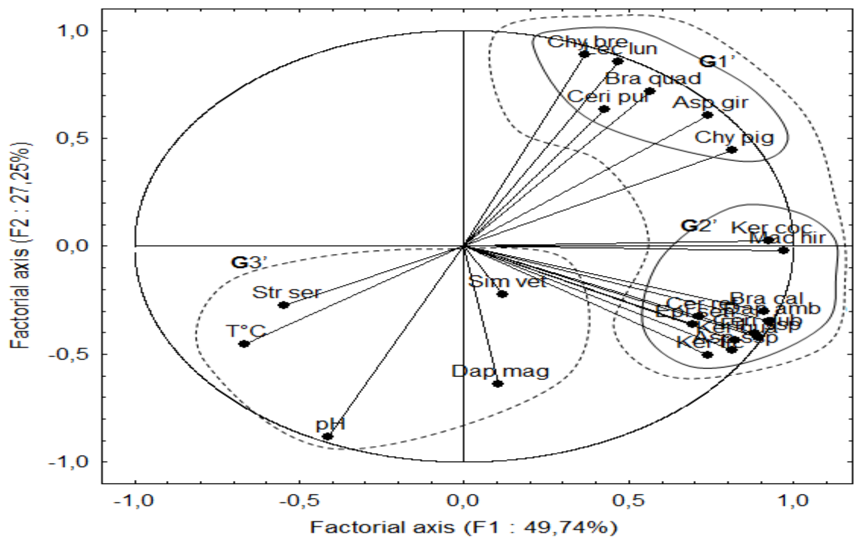


Fig. 7b. Factorial plane of the principal component analysis showing the assemblages of cladocerans and rotifers from Lake Sidi Mhamed Benali during the period from January to July 2017

At the Sarno Dam, axis F_1 and F_2 focused on the distribution of Cladocera and Rotifera. The results, based on the relative abundance of species, are similar to those recorded for Lake SMB. The correlation circle for factorial plans F_1 and F_2 showed that months were correlated with both factorial axes. It appeared in the positive factorial plane F_1 and F_2, a set of G_a included January and February corresponding to the wet season (Fig. 8a). For G_b, March also designated the wet season and formed with G_a a season similar to the result shown in Fig. (7a). Opposite to the G_a and G_b groups, the G_c set corresponded to the dry season (April, May, June and July). This set was located in the negative part of the F_1 and F_2 factorial axis.

The typological structure identified by the factorial plan (F_1, F_2) showed the characterization of three different (G_a, G_b and G_c) groups according to their specific composition and the correlation between the species. The study of the correlation revealed that the species of the G_a set presented significant abundances and varied in the positive of the F_1 and F_2 axis, with strong correlations between them (Fig. 8b).

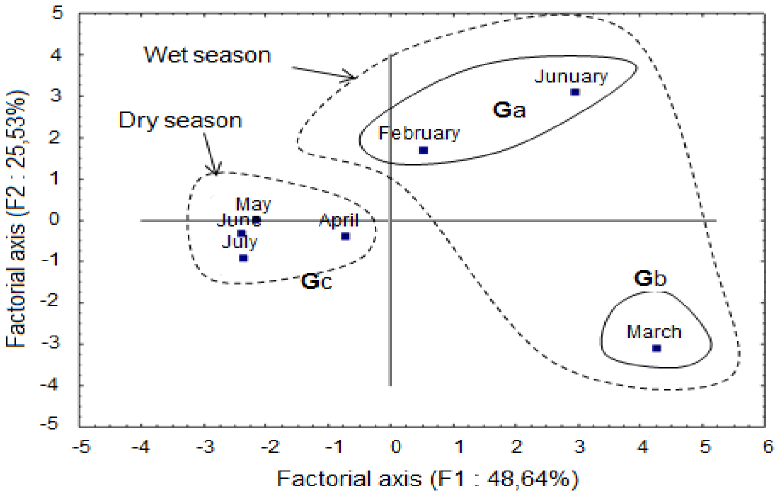


Fig. 8a. Factorial axis of the principal component analysis indicating the Mediterranean climate in the Sarno Dam from January to July 2017

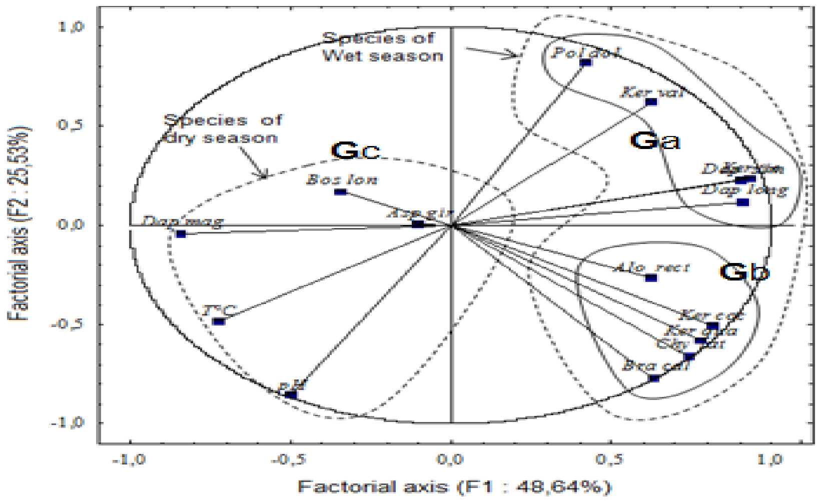


Fig. 8b. Factorial axis of the principal component analysis on the populations of cladocerans and rotifers in the Sarno Dam from January to July 2017

The examination of the correlation matrix between species revealed that G_a was made up of species that were well correlated with each other ($0.61 < r < 0.97$). These species were: *Polyarthra dolicoptera*, *Keratella valga*, *Keratella ticinensis*, *Daphnia similis* and *Daphnia longispina*. In regards with the G_b group, it was characterized by other species with strong correlations between them ($0.90 < r < 0.98$), such as *Chydorus latus*, *Keratella quadrata*, *Keratella cochlearis*, except for *Alona rectangula*, which showed a weak correlation.

DISCUSSION

Analysis of the populations in the two reservoirs allowed us to describe the specific composition and distribution of the two groups of zooplankton (Cladocera and Rotifera), which appeared to be spatially different in the two reservoirs. Zooplankton communities generally changed in response to the quality of water **(Cherbi, 1984)**.

The variations in the abundance of cladoceran, copepod and rotifer zooplanktons could be used to understand the mechanisms that sustained the food webs of the aquatic community of the freshwater bodies **(Kar *et al.*, 2018)**.

The SMB Lake has a species richness which colonised by a characteristic set of species, represented in particular by *Ceriodaphnia dubia*, *Ceriodaphnia pulchella*, *Chydorus piger*, *Daphnia ambigua*, *Macrothrix hirsutcrus*, *Simocephalus vetulus*, *Asplanchna girodi*, *Brachionus quadridentatus*, *Epiphanes senta* & *Lecane luna*, with a frequency higher than 71.4%. These species were absent at Sarno Dam. On the other hand, the Sarno Dam was home to a number of different species, including *Alona rectangula*, *Chydorus latus*, *Daphnia similis* and *Keratella valga*, with frequencies ranging from 71.4 to 100%. These species were considered frequent species in North Africa **(Samraoui *et al.*, 1998)** and the western Mediterranean **(Garcia-Chicote *et al.*, 2019)**. Additionally, *Daphnia magna*, *Brachionus caliciflorus*, *Keratella quadrata*, *K. cochlearis* and *K. ticinensis* were the common species, with their frequency varying between 71.4 and 100%.

The Sarno Dam was characterized by the presence of *Alona rectangula*, *Chydorus latus*, *Daphnia similis* and *Keratella valga*, species that were absent from Lake SMB. According to studies done by **Dirican *et al.* (2009)** and **Munoz-Colmenares *et al.* (2021)**, the presence of *Asplanchna girodi*, *Keratella cochlearis*, *Bosmina longirostris and Keratella quadrata* have been reported as indicator species for hypereutrophic environments although they were recorded in our samples from SMB Lake and Sarno Dam. The species *Brachionus*, *Keratella* and *Lecane* recorded in our study were recognized as indicators of eutrophic environments **(Santos *et al*., 2019)**.

It should be noted that the number of cladocerans in particular was reduced during the winter period in both reservoirs. The environmental conditions of the two reservoirs were not the origin of this variability observed during the study in terms of specific richness, however it was clearly interesting from the point of view of the variability of abundance, diversity and regularity of the communities **(Makarewicz *et al.*, 1995)**. According to **Gadzinowska (2013)**, the dynamics of rotifers were more sensitive to limnological parameters than those of

Cladocera. It was observed in the two reservoirs (SMB Lake and the Sarno Dam). For species variation, the difference between the two reservoirs can be attributed to the distinct type of habitat despite their close proximity. The presence of *Daphnia magna* in winter in all stations was noted just before the appearance of juveniles, which were fearsome predators of zooplankton. The numbers of cladocerans in particular, *Daphnia magna* and *Daphnia longispina*, gradually decreased until July. The analysis of the main components focused on 20 and 12 species corresponding to the SMB Lake and the Sarno Dam, respectively, taking temperature and pH into account.

CONCLUSION

The comparative study of the two reservoirs revealed a difference between the two environments, particularly related to the pH and the Mediterranean climate of Algeria characterized by a period of significant drought. It was one of the main causes of the temporal distribution of species in the two reservoirs. Additionally, this distinction between the two environments in terms of species richness indicated a certain degradation of the limnic ecosystem due to human activity in nearby villages.

According to the biological study of species structure and statistical analysis, the main conclusion that can be drawn was that specific richness and density of zooplankton appeared more important due to the impact of pollution on the qualitative and quantitative composition of zooplankton in the waters of Lake SMB and the Sarno Dam. The functioning of the ecosystem and the dynamics of Cladocera and Rotifera was similar in both environments according to the climatic regime of the Sidi Bel Abbes region.

The results of the indicator species eutrophic environments in this research suggest that the water of Lake Sidi Mhamed Benali and the Sarno Dam will require protection, management and restocking of zooplankton to meet sustainable aquaculture in the region under study.

REFERENCES

Amoros, C. (1984). Crustacés cladocères. Bull. Mens. Soc. Linn. Lyon, **3**: 72–107.

Čeirāns, A. (2007). Zooplankton indicators of trophy in Latvian lakes. Acta Univers. Latvien., **723** : 61– 69.

Cherbi, M. (1984). Contribution à l'étude du peuplement zooplanctonique des lacs de barrage en Algérie. Verh. Int. Ver. Limnol., **22**: 1579–1583.

Cherbi, M.; Lek-Ang, S. and **Arab, A. (2008).** Distribution du zooplancton dans les lacs à climat méditerranéenDistribution of zooplankton community in Mediterranean-climate lakes. Ecology, **331**(9): 692–702.

Côté, R.; Bussières, D. and **Desgagnés, P. (2002).** Spatio-temporal distribution of phytoplankton and zooplankton in lake Saint-Jean (Quebec), a hydroelectric reservoir. J. of Wat. Sc., **15**(3): 597–614.

Dirican, S.; Haldun, M. and **Suleyman, C. (2009).** Some physic-chemical characteristics and rotifers of Camligoze Dam Lake, Susehri, Sivas, Turkey Asian J. Anim. Vet. Adv., **8**(4): 715–719 .

Dulic, Z.; Poleksic, V.; Raskovic, B.; Laki, N.; Markovic, Z.; Zivic, I. and **Stankovic, M. (2009).** Assessment of the water quality of aquatic resources using biological methods. Desalin. and Wat., **11**: 264–274.

Ebrahimi, D.E.; Shahraki, M.; Farhadian, O. and **Keivany, Y. (2018).** Seasonal variations of plankton structure as bioindicators in Zayandehrud Dam Lake, Iran Limnol. Rev., 18(4): 157–165.

El Badaoui, N.; Amar, Y.; Joaqum-Justo, C.; Djahed, B.; Ammar, H.; Benosman, R. and **Thomé, J.P. (2015).** Assessment of pollution in Sidi M'Hamed Benali Lake (Algeria) based on bioindicators and physicochemical parameters. Iran. J. Eng. Envir., **6(**4): 308–315.

Gadzinowska, J. (2013). lankton communities in oxbow lakes of the River Vistula (Oświęcim Basin) with bottom sediments heterogeneously contaminated with heavy metals. Limnol. Rev., **13**(2): 93–104.

Garcıa-Chicote, J.; Armengol, X. and **Rojo, C. (2019).** Zooplankton species as indicators of trophic state in reservoirs from Mediterranean river basins. Inland Waters, **9**(1): 113–123.

Garnier, J.; Billen, G. and **Coste, M. (1995).** Seasonal succession of diatoms and Chlorophyceae in the drainage of the Seine River : Observations and modeling. Limnol. Ooeanogr., **40**: 750–765.

Hart, R.C. (1990). Zooplankton distribution in relation to turbidity and related environmental gradients in a large subtropical réservoir: patterns and implications. Freshwat. Biology, **24**: 241–263.

Indresha, G.N.; Parida, S.P.K. and **Patra, A. (2018).** Seasonal variations of zooplankton and their correlation with physico-chemical parameters of Kanjialake, Nandankanan Zoo, Bhubaneswar. Life Sc., 22–34.

Kar, S.; Das, P.; Das, U.; Bimola, M.; Kar, D. and **Aditya, G. (2018).** Correspondence of zooplankton assemblage and water quality in wetlands of Cachar, Assam, India: Implications for environmental management. Limnol. Rev., **18**(1): 9–19.

Makarewicz, J.C.; Bertram, P.; Lewis, T. and **Brown, J.R. (1995).** A decade of predatory control of zooplankton species composition of Lake Michigan. Great Lakes Res., **21**: 620–640.

Masson, S.; Pinel-Alloul, B. and **Dutilleul, P. (2004).** Spatial heterogeneity of zooplankton biomass and size structure in southern Québec lakes: variation among lakes and within lake among epi-, meta- and hypolimnion strata. J. Plank. Res., **26**(12): 1441–1458.

Munoz-Colmenares, M.E.; Soria, J.M. and **Vicente, E. (2021).** Can zooplankton speciesbe used as indicators of trophic status and ecological potential of reservoirs. Aquat. Ecol., **55**: 1143–1156.

Quirino, B.A.; Teixeira; M.F.; Deosti, S.; Bonecker, C.C.; Paz-Cardozo, A.L.; Yasuko, Y.K.; Aleixo; M.H.F. and **Fugi, R. (2021).** Interactions between a planktivorous fish and planktonic microcrustaceans mediated by the biomass of aquatic macrophytes. J. Plank. Res., **43**(1): 46–60.

Onyema, I.C. and **Ojo, A.A. (2008).** The zooplankton and phytoplankton biomass in a tropical creek, in relation to water quality indices. Life Sc. Jour., **5**(4): 75–82.

Pinel-Alloul, B.; Guay, C.; Angeli, N.; Legendre, P.; Dutilleul, P.; Balvay, G.; Gerdeaux, D. and **Guillard, J. (1999).** Large-scale spatial heterogeneity of macrozooplankton in Lake of Geneva. Can. J. Fish. Aquat., **56**: 1437–1451.

Pourriot, R. and **Francez, A.J. (1986).** Introduction pratique a la systematique des organismes des eaux continentales françaises. Bull. Mens. Soc. Linn. Lyon, **55**(5): 148–176.

Pourriot, R. (1980). In Flore et faune aquatiques de l'Afrique sahelo-soudanienne Societe Linneenne de Lyon, 53e année, no 3 et 4.

Ruggiero, A.; Solimini, A.G. and **Carchin, G. (2004).** Limnological aspect of an Apennine shallow lake. Int. J. Limnol., **40**(2): 89–99.

Samraoui, B.; Segers, H.; Maas, S.; Baribwegure, D. and **Dumont, H.J. (1998).** Rotifera Cladocera, Copepoda and Ostracoda from coastal wetlands in Northeast Algeria. Hydrobiologia, **386**: 183–193.

Santos, P.; Fernandes, C. and **Baumgartner, G. (2019).** Structure and ecological aspects of zooplankton (Testate amoebae, Rotifera, Cladocera and Copepoda) in highland streams in southern Brazil. Acta Limnol. Brasili., **31**: e5.

Thornton, K.W.; Kennedy, R.H.; Morgan, A.D. and **Saul, G.E. (1982).** Réservoir water quality sampling design. Water Res. Bull., **18**: 471-480.