ZOOPLANKTON COMMUNITY STRUCTURE IN THE HAMIZ LAKE AND ITS RELATIONSHIPS WITH ENVIRONMENTAL FACTORS

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Abstract. The present study reports ten identified species of zooplankton in an Algerian lake. Seven stations were chosen according to different criteria and eleven physicochemical parameters were estimated to describe the water quality of each station. Qualitative and quantitative samples were collected from the lower horizon to the surface monthly, in October 2006 and from January to March 2007. In January, the highest species richness (S=9) was recorded in the upper lake corresponding to greater diversity (H'=1.41). The maximum density (28101 ind./L) was observed at the most vegetated site. The crustacean community consisted of 5 Cladocerans, 2 Cyclopidae and 1 Calanoida, however, rotifers were scarce. The CCA analysis reveals that most cladocerans seem to be associated with water hardness contrary to rotifers and copepods. The zooplankton structure was dominated in the north by copepods. However, cladocerans showed an inverse pattern from north to south. Taken together, our data indicate that community structure changes over time during our sampling surveys and in the lake, three zooplanktocenoses were identified. Therefore, it seems that environmental factors linked to the Mediterranean climate play a fundamental role in shaping the architecture of the food webs and the distribution of zooplanktocenoses of the Hamiz reservoir.
Keywords: *zooplanktocenoses, density index, bioindicators, water quality, sub-humid region*

Introduction

Hamiz lake, is one of the first dams of the Algerian hydrotechnical infrastructure (Remini, 2017), with a capacity of more than 15 million m^3 (Cheikhlounis et al., 2011), it supplies the population of Algiers with drinking water through the Keddara reservoir. This aquatic ecosystem has been the subject of various researches like parasitology (Ould Rouis et al., 2016) ecology of ichtyofauna (Ould Rouis, 2016) and reproductive biology (Ould Rouis et al., 2012). However, data on diversity and dynamics of zooplankton is still inadequate.

More than 94 water reservoirs were built in Algeria (National Agency of Dams and Transfers) to supply the urban population with drinking water, irrigate agricultural land and develop aquaculture in some dam lakes (Utomo et al., 2019) in order to enrich people's diet with proteins (Lynch et al., 2016). However, fish constitute good indicators of water quality but most fry feed on the three main groups of zooplankton: rotifers, cladocerans and copepods thus, considerably modifying the specific composition of zooplankton. Simultaneously, temperature and oxygen are the most important factors in the regulation of the zooplankton communities, as well as the spatial and temporal scale of lake ecosystems (Itigilova, 2019).

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Zooplankton species are crucial components of aquatic food webs (Yang et al., 2018) and knowledge of these communities can provide useful information on water quality. Indeed, the study of plankton is an integrative measure of water quality (Suthers and Rissik, 2009). Zooplankton inhabit lakes and ponds that functionally are “aquatic islands” in the landscape and both community composition and richness depend on the one hand, on their ability to disperse and their post-dispersal colonization abilities (Hessen et al., 2019) and to use the available resources (nutrient content and concentration) on the other hand (Walz, 1995). This ability to disperse makes them interesting tools to test the hypothesis of dispersion (Battuello et al., 2016). They are important for understanding ecosystem functioning and stability (Msiteli-Shumba et al., 2017). These species are commonly used as bioindicators (Gökçe and Özhan Turhan, 2014) with their short life cycles rapidly responding to changes in environmental conditions (Suikkanen et al., 2007; Suthers and Rissik, 2009) also used as model systems to maintain biological diversity (Aránguiz-Acuña et al., 2018). Moreover, the composition, abundance and dynamics of zooplankton are themselves shaped by the environment and biotic interaction (Wetzel, 2001; Fernández-Rosado and Lucena, 2001) and for this, it seems especially in reservoirs, difficult to isolate the primary causes explaining the variation in abundance (Velho et al., 2001).

In the dam lake Hamiz we investigate, for the first time, the spatial heterogeneity and the distribution of zooplanktonic species in relation to environmental parameters. Our objectives were to identify the most common freshwater zooplankton occurring presently in Hamiz reservoir (hereafter Hamiz) and then determine: (1) whether physicochemical properties influence the occurrence of species and thus characterize zooplankton assemblages in relation to environmental variables (2) zooplankton structure based on the variation in species density over time between groups of sampled stations and (3) the allocation of zooplanktonic communities and define the proportion of space and how consistently one or another species occupies the water area of the reservoir. Based on these results and knowledge of the ecology of these species, we highlight the zooplanktocenoses living in the Hamiz, discuss possible reasons of their organization in response to the temporal dynamics of environmental indicators, taking into account their interrelationships and their roles in the evolution of these species.

Finally, knowledge of the distribution, abundance and dynamics of this important link in the food web will allow us to both understand and contribute to the restoration and protection of our aquatic ecosystems.

Materials and Methods

Sampling area

The study took place in Algeria, from 2006 to 2007 (in October 2006 and from January to March 2007). Hamiz lake is situated under a Mediterranean climate in the sub-humid region where, winters are relatively cool and wet. The drought lasts five months (late May to October) while the rainy period covers the remaining months of the year. The dam reservoir is located in *Mitidja* (36°35′59″N, 3°20′50″E), 158 m above sea level and 35 km east of Algiers.

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Sampling sites

Seven stations (from A to G) were chosen on the lake (*Fig. 1*), according to bottom topography (depths), North/ South exposure, the place where the tributaries/ small rivers flow in as well as vegetation distribution. Station A (exceeding 20 m), is located a few meters from the dike, northeast side. Station B (not exceeding 16 m) is near northwest coast of water reservoir. Going from Ghar Tabarante (north bank), approximately towards the center is station C (up to 20 m). Station D is situated rather towards the southwest where, Oued Arbatache (a little river) throws into the reservoir. On the south shore, stations E and F are located respectively opposite Chabet Djnane M'Sada and Chabet El M'Ghassel. The latter three stations are characterized by a strong presence of emergent plants. Opposite station A is station G, which receives water from a small tributary that crosses Ghabet Tararesse and flows into the lake.

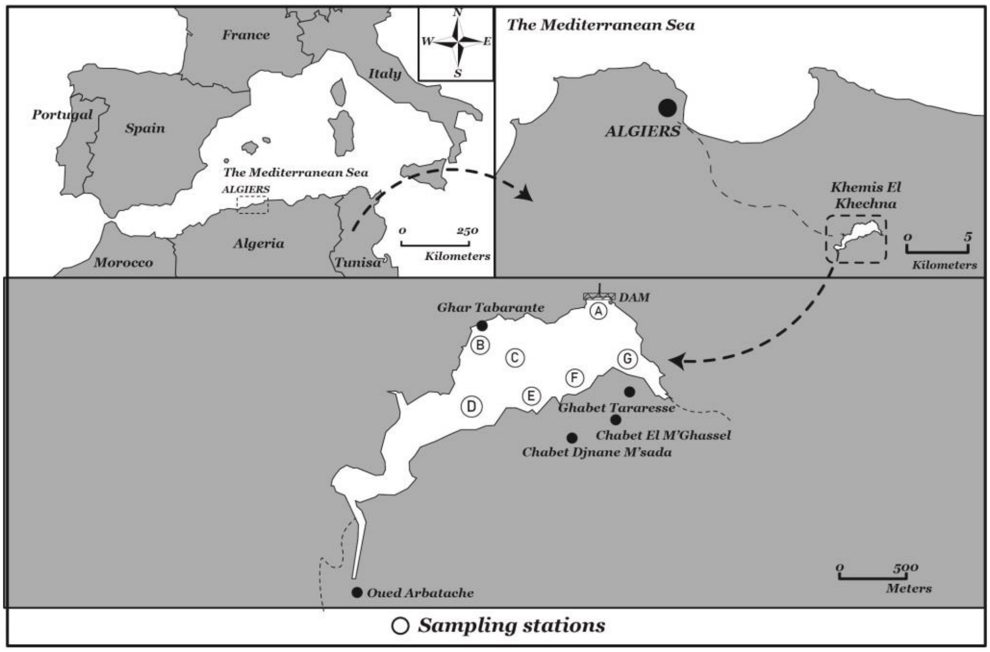

Figure 1. *Sampled stations on the Hamiz (from A to G)*

Water quality estimation

To characterize the quality of the water column at each station, eleven parameters, both physical and chemical, were estimated and measured together with zooplankton sampling. Water temperature, pH and dissolved oxygen (O_2) were assessed by means of the multi-parameter (Multi 340i/ SET WTW) while, transparency was determined using a black and white Secchi disk 20 cm in diameter. The remaining chemical parameters studied (Ca^{2+} - calcium, Mg^{2+} - magnesium ion, PO_4^- - orthophosphate phosphorus, NO_3^- - nitrate nitrogen, NO_2^- - nitrite nitrogen, Cl^- - chloride ion, H_2CO_3 - carbonic acid) were analyzed according to Rodier et al. (2009).

Zooplankton determination

Qualitative zooplankton sampling was determined by a hand net (50 µm mesh size) fired over a distance of about 10 m (horizontal hauls) at the surface (level 0 m).

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However, quantitative sampling was collected via a Ruttner's bathometer (1-liter capacity). We throw it at different depth (vertical hauls) from the lower horizon to surface; at the deep stations A, B and C samples were selected in three points of vertical water column: from surface (0.0 m-1.0 m), in the middle layers (1.5 m-4.5 m) and in the lower layers of water (5.0 m-9.0 m). At shallow-water, E and F stations were sampled from two horizons and the rest stations (D and G) only from surface. On the lake, stations A and B are considered to be located along the northern bank. We assume that station C is in the center and stations D, E, F and G are situated on the south shore (on the opposite side). The selected samples of water were filtered through the planktonic net during sampling then, we use the zooplankton collected by the pill container for calculation and identification of organisms. A total of 60 quantitative and 28 qualitative samples were collected and processed. All these samples were preserved in 90% ethanol. Zooplankton individuals were identified to the species level using a compound microscope (Zeiss) at high power magnifications. Identification keys of Einsle (1993, 1996), Dussart (1967, 1969) and Stella (1982) were used for copepods, while cladocerans were identified following Margaritora (1983), Ould Rouis (1995) for Algerian species and Alonso (1996). For Rotifera, we used Pourriot and Francez (1986).

Quantitative zooplankton abundance is expressed as number of organisms per liter. Each sample was counted on at least half of the total volume. Therefore, to characterize the structure of zooplankton communities and describe diversity, the Shannon-Wiener index (H) (Wolda, 1983) and the species Evenness (E) were calculated according to Pielou (1966).

Finally, to determine which particular species is constantly present at a given station (Bayanov, 1997), we used the density index according to Pidgajko (1978), which specifies the spatial volume and the period when the species are present in the water reservoir, which are then presented in the form of column diagrams. The square root of the biomass of the whole zooplankton population at a specified date was theoretically considered as the maximum possible density. This latter is divided by 4 for the calculation of four intervals of the density. The particular verbal characteristic corresponding to a species with density values within a particular interval: the species in the upper interval were called dominant species, in the next interval sub-dominant species, in the third typical and in the last minor. The communities were therefore called according to the names of the dominant species or, if there were no apparent dominants, after the sub-dominants and typical species.

Data analysis

A hierarchical clustering using Euclidean distances between species was performed to check whether the sampled stations and the collected species are close together. To estimate similarity between stations, Steinhaus coefficient (Legendre and Legendre, 2012) was carried out then, a Chi-square test of homogeneity was conducted to compare zooplankton structure between northern and southern station groups. The variation of species abundance among the station groups was highlighted by using box-whisker plots model. The relationship between water quality and zooplankton species was determined by canonical correspondence analysis (CCA) using XLSTAT software (version 2018). Statistical analysis was performed with the Statistica 7.0 software.

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Results

Environmental factors

During the study period, the dam waters were alkaline and well oxygenated with dissolved oxygen levels averaging between 4.0 mg/L and 6.0 mg/L, with a highest mean value recorded at station A. The average water temperature is approximately the same at all stations. Phosphate values are less than 0.1 mg/L. The hardness of the water is medium, well represented by the values of calcium and magnesium ions. It appears that the calcium contents are higher than those of the magnesium ions.

The maximum average value for chlorides is less than 40.0 mg/L. The levels of bicarbonates evolve almost similarly in the waters of Hamiz, minimum and maximum values were recorded respectively at stations C and D (*Table 1*).

Table 1. *Physicochemical parameters of water at each station*

		Stations						
Parameters	**Variables**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Depth (m)		9.1-14.5	2.4-8.0	4.0-9.0	0.8-2.0	1.8-6.5	2.5-5.0	1.0-3.0
Water Temperature (°C)	Mean	17.0	17.8	17.3	17.6	18.2	17.8	17.6
	SD	4.0	4.8	4.8	5.2	5.1	5.0	4.5
Transparency (m)	Mean	1.1	1.2	1.3	0.9	1.2	1.3	0.7
	SD	0.7	1.0	1.0	0.7	1.0	1.0	0.2
pH	Mean	8.1	8.0	8.2	8.1	8.0	8.1	7.9
	SD	0.1	0.1	0.1	0.2	0.2	0.3	0.3
O_2 (mg/L)	Mean	6.0	4.7	4.2	4.0	4.3	4.4	4.4
	SD	1.1	2.1	2.0	2.1	1.7	1.9	1.9
Ca^{++} (mg/L)	Mean	65.9	66.9	65.5	64.7	64.4	64.6	64.2
	SD	31.2	30.8	30.6	29.9	29.5	29.7	29.8
Mg^{++} (mg/L)	Mean	35.6	35.3	35.9	44.2	39.8	38.9	42.1
	SD	13.8	14.0	14.7	18.7	16.8	17.0	17.6
PO_4^- (mg/L)	Mean	0.02	0.05	0.07	0.08	0.08	0.09	0.09
	SD	0.03	0.05	0.04	0.00	0.00	0.01	0.01
NO_3^- (mg/L)	Mean	2.0	2.1	2.2	2.4	2.3	2.4	2.5
	SD	0.9	1.0	0.5	0.3	0.3	0.4	0.4
NO_2^- (mg/L)	Mean	0.02	0.03	0.03	0.05	0.04	0.04	0.06
	SD	0.03	0.03	0.02	0.02	0.02	0.02	0.04
Cl^- (mg/L)	Mean	23.6	23.4	28.0	38.8	39.9	39.1	38.9
	SD	10.6	10.2	12.7	1.8	2.1	2.2	1.9
H_2CO_3 (mg/L)	Mean	227.2	226.3	224.7	261.2	256.6	245.4	257.7
	SD	11.4	13.7	19.5	32.5	35.5	17.8	19.2

Zooplankton community structure and diversity

Ten species (10) of zooplanktonic fauna were collected from the lake (*Table 2*). These species belong to three main groups (cladocera, copepoda and rotifera).

Shannon-Wiener diversity index during the sampling period varied monthly from 0.43 to 1.41 (*Table 3*). The highest value of species richness (S) was recorded in January (9) corresponding to the highest diversity (H=1.41) in the dam. February and March have the same richness (S=7). The Pielou's evenness was not so different between months however, the minimum value (0.18) was observed in October.

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Table 2. *Zooplankton species occurring in Hamiz*

Zooplankton groups/ species	Code
Cladocera	
Ceriodaphnia reticulata (Jurine, 1820)	Cla1
Daphnia magna (Straus, 1820)	Cla2
Daphnia longispina (O.F. Müller, 1785)	Cla3
Daphnia similis (Claus, 1876)	Cla4
Daphnia hyalina (Leydig, 1860)	Cla5
Copepoda	
Copidodiaptomus numidicus (Gurney, 1909)	Cop1
Cyclops abyssorum (O.G. Sars, 1863)	Cop2
Acanthocyclops americanus (Marsh, 1893)	Cop3
Rotifera	
Keratella quadrata (O.F. Müller, 1786)	Rot1
Filinia longiseta (Ehrenberg, 1834)	Rot2

Table 3. *Species diversity and evenness of zooplankton in Hamiz*

Indices	October 06	January 07	February 07	March 07
Total number of species (S)	5	9	7	7
Total number of Individuals	2400	5512	90631	15315
Shannon-Wiener Index (H)	0.43	1.41	1.28	1.14
Pielou's Evenness Index (E)	0.18	0.44	0.46	0.41

The zooplankton community fluctuates from a station to another; in fact, it appears that station D has a higher total density (28101 ind./l) than all other stations: A (15477), B (14834), C (3658), E (1292), F (26820) and G (23672). In addition, we noticed that the zooplankton species were more developed in the vegetated sites than in unvegetated areas in the reservoir.

Zooplankton assemblages in relation to environmental factors

On the lake, we noted that zooplankton assemblages are strongly related to the physicochemical nature of water (*Fig. 2*). Indeed, environmental factors such as water hardness (calcium and magnesium), dissolved oxygen and nitrates are strongly associated with the first two axes. CCA analysis reveals that the first two axes provide 83.91% of the total information on zooplankton species assemblages with environmental parameters. The first axis accounts for 64.41%. It discriminates between zooplankton species associated with hard and well oxygenate waters on the right of the axis and on the left; rotifers seem to be insensitive to the physicochemical nature of the lake waters. The second canonical axis, explaining 19.50% of the variance, shows mainly species that prefer nutrient-rich waters. The species-environment correlations were 0.849 for axis 1 and 0.871 for axis 2. Thus, the zooplankton distribution seems to be highly related to water quality. In fact, some species such as Daphnids (*Ceriodaphnia reticulata*, *Daphnia similis* and *Daphnia longispina*) and the Copepod (*Copidodiaptomus numidicus*) were all strongly and positively influenced by calcium, magnesium, bicarbonates and dissolved oxygen in water. Others such as, *Cyclops abyssorum* and *Daphnia magna* are sensitive to phosphates, chlorine and nitrates ions but do not appear to be influenced by water hardness. Furthermore, most of cladocerans seem to be associated to water's hardness contrary to rotifers and copepods.

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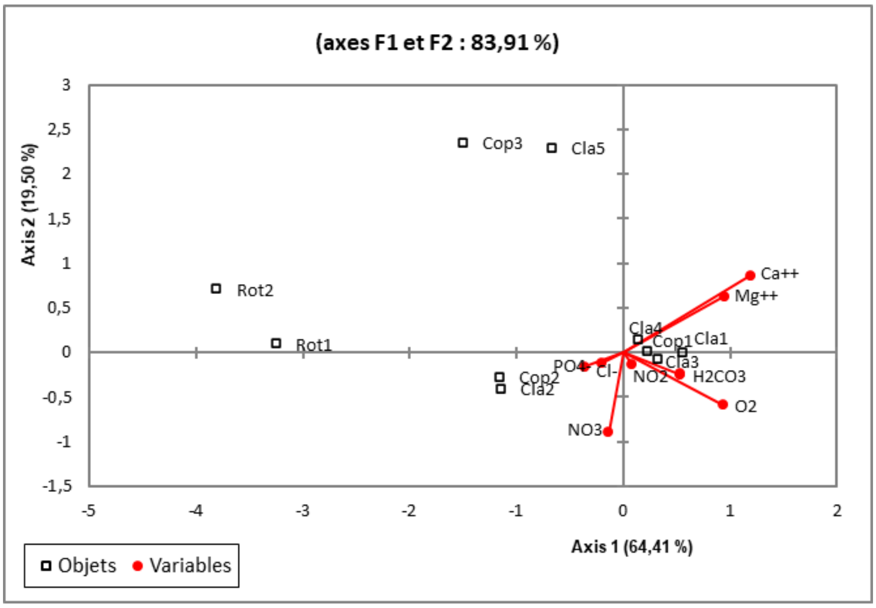

Figure 2. *CCA according to zooplankton assemblages (10 species, codes as in Table1) and environmental parameters (8) on the lake during the study period*

Similarity between stations

Based on the abundance of zooplankton species, the CLUSTER analysis divides the sampling stations into three groups (*Fig. 3*). At the first cutoff value 4000: two clusters each contains two sites A-B; C-E (northern stations; the center station and the one closest to it) and the third one formed squarely by the southern stations (G-F-D). This is in accordance with the locations of the stations. Taking into account the presence/absence of species, two main groups of stations reappear (*Table 4*); similarity between C-E stations is greater than 50% however between the other stations, similarity exceeds 56% and can exceed 90% as it is the case for stations F and D.

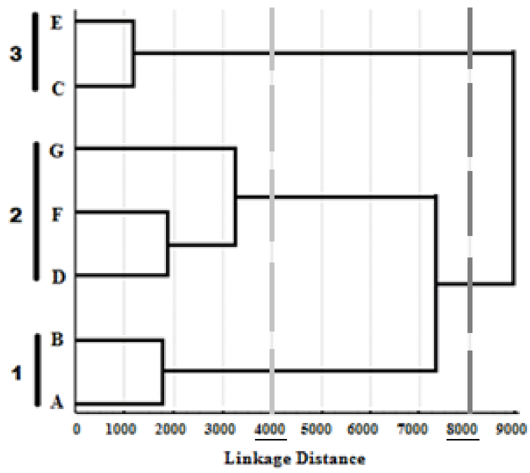

Figure 3. *Dendrogram showing the clustering of the sampling stations based on the abundance of zooplankton species*

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Table 4. *Similarity matrix of sampling stations based on Steinhaus coefficient*

E							
C	**0.522**						
G	0.104	0.232					
F	0.092	0.203	**0.842**				
D	0.088	0.228	**0.872**	**0.926**			
B	0.158	0.292	**0.715**	**0.565**	**0.595**		
A	0.153	0.371	**0.765**	**0.601**	**0.663**	**0.890**	
	E	C	G	F	D	B	A

In addition, the Chi-square test of homogeneity showed a significant difference ($p < 0.05$) among groups of stations taken in pairs and this difference is highly significant (*p-value* < 0.00001) between northern group and southern one. The probable reason that could explain this difference is the variation in species abundance (*Fig. 4*). Quantitatively, the southern stations enjoy maximum abundance and qualitatively, they host an important diversity (H=1.33; S=10 and E=0.4). In the Hamiz, copepods were the dominant group in determining total zooplankton abundance and contributed with 91.74% in the north, 86.48% in the center and 80.78% in the south. However, cladocerans show increasing proportions from north to south (8.19%, 12.83% and 19.06%) and rotifers are extremely rare in the lake.

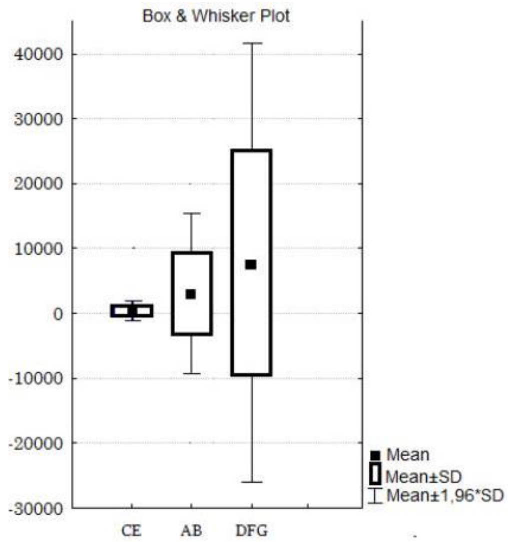

Figure 4. *Box and Whisker Plot of the abundance species variation in the station groups*

Dynamics of the Hamiz zooplanktocenoses

Horizontal structure (Table 5; Fig. 5)

From October to January, the zooplankton population was represented by the dominant species *Cyclops abyssorum*. The lowest abundance was found in October (5 species only), then it increased significantly in January up to 9 species. It should be noted that the highest abundance of species could be observed in the Hamiz especially

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in January. In February *C. abyssorum* loses its leading position, transferring to typical species category and making place for the thermophilic *Copidodiaptomus numidicus*. In this period, the typical species includes also *Daphnia longispina*. Neither *Filinia longiseta* nor *Acanthocyclops americanus* were detected during February. In March *C. numidicus* community was retained in the whole water reservoir. In addition, *D. longispina* was included in the typical species. *C. abyssorum* was excluded from the typical species, replaced with *Acanthocyclops americanus* and *Filinia longiseta* was not detected at all.

Table 5. *Dynamics of zooplankton communities in Hamiz (2006-2007)*

Months / **Depth (m)**		**October**	**January**	**February**	**March**
Horizontal structure (0.0)		*Cyclops abyssorum*		*Copidodiaptomus numidicus*	
Vertical structure	0.0-1.0	*Cyclops abyssorum*		*Copidodiaptomus numidicus*	
	1.5-4.5	*Cyclops abyssorum*	*C. abyssorum – C. numidicus*		
	5.0-9.0	*C. numidicus – C. abyssorum*	*C. abyssorum*	*C. numidicus*	*C. abyssorum - C. numidicus*

Vertical structure (Table 5; Fig. 5)

In October, *C. abyssorum* was distributed along the whole water column. If in the upper horizons *C. abyssorum* apparently dominated in the community then in the depths (5.0-9.0 m), this species was equally represented along with *C. numidicus* (taking into account that the common density of the organisms is less by an order than the density in the upper horizons and lessening the abundance of species from five to two species). In January, the zooplankton organisms were distributed in the water thickness more evenly and with rather high density. The abundance of the species was as usual noticeably lower in the near bottom horizons where only *C. abyssorum*, *C. numidicus* and *Ceriodaphnia reticulata* were available. Here *C. abyssorum* is very strong with its dominant position. In the surface layer of the water, this species also outnumbers the rest of the species and the cenosis of middle horizons can be determined as *C. abyssorum - C. numidicus* communities, as the second species is considered as subdominant. The significant restructuring (change of the dominants) took place from January till February. Indeed, *C. numidicus* community occupies all the horizons in February. The ex-dominant *C. abyssorum* is transferred to the typical species, where *D. longispina* makes appearance as well as *C. reticulata* in the lower layers of the water. In March *C. numidicus* retained its dominant position in the whole water column. *C. abyssorum*, was subdominant in the lower horizon only, and it could not be detected in the middle layers of the water and sometimes could be detected near the surface.

Temporal structure

When considering variations in community structure over time, the density index gives us the possibility to define the zooplankton communities typical for each station (*Fig. 6*) and we can therefore, identify four zooplankton communities in the Hamiz (*Table 6*).

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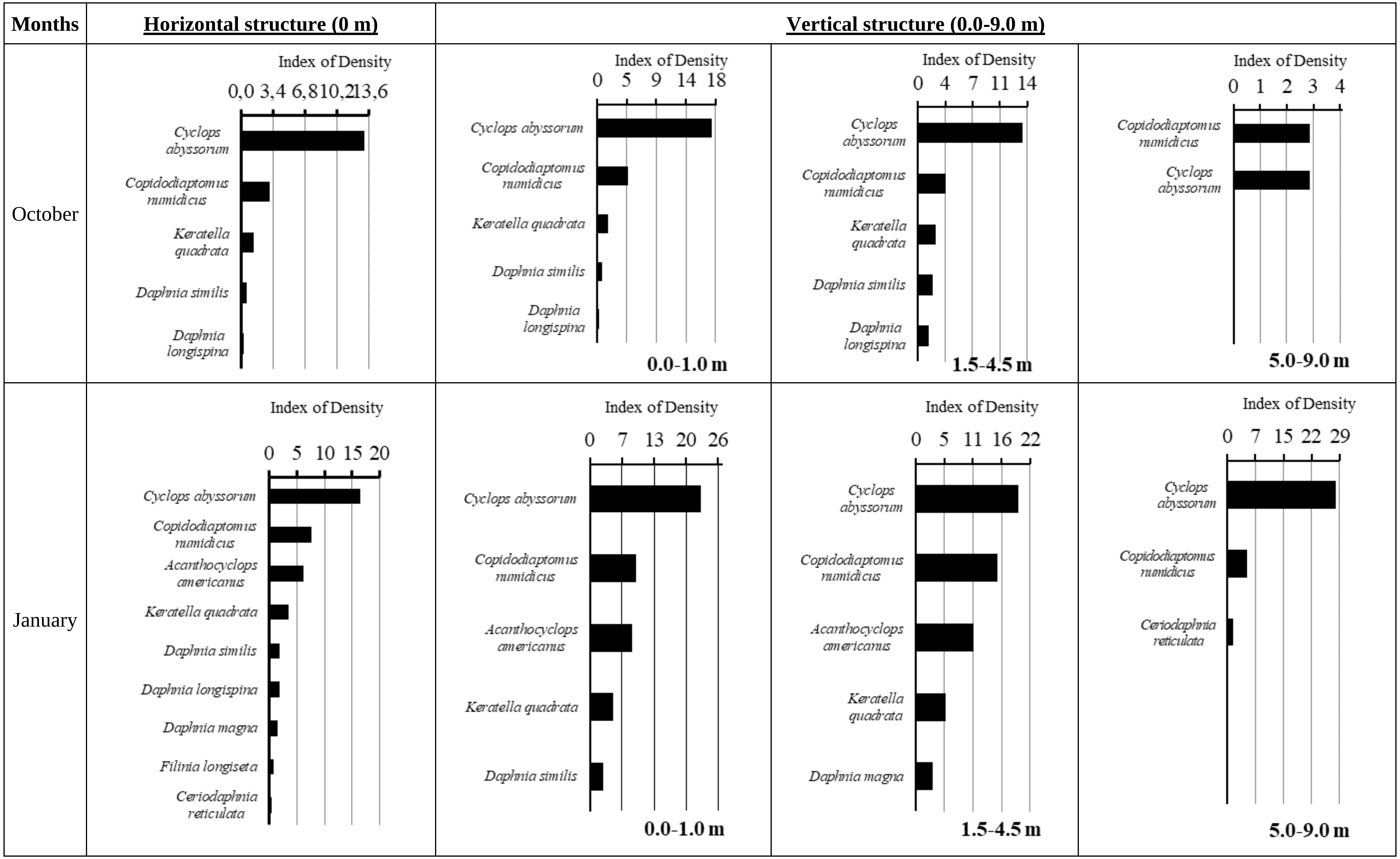

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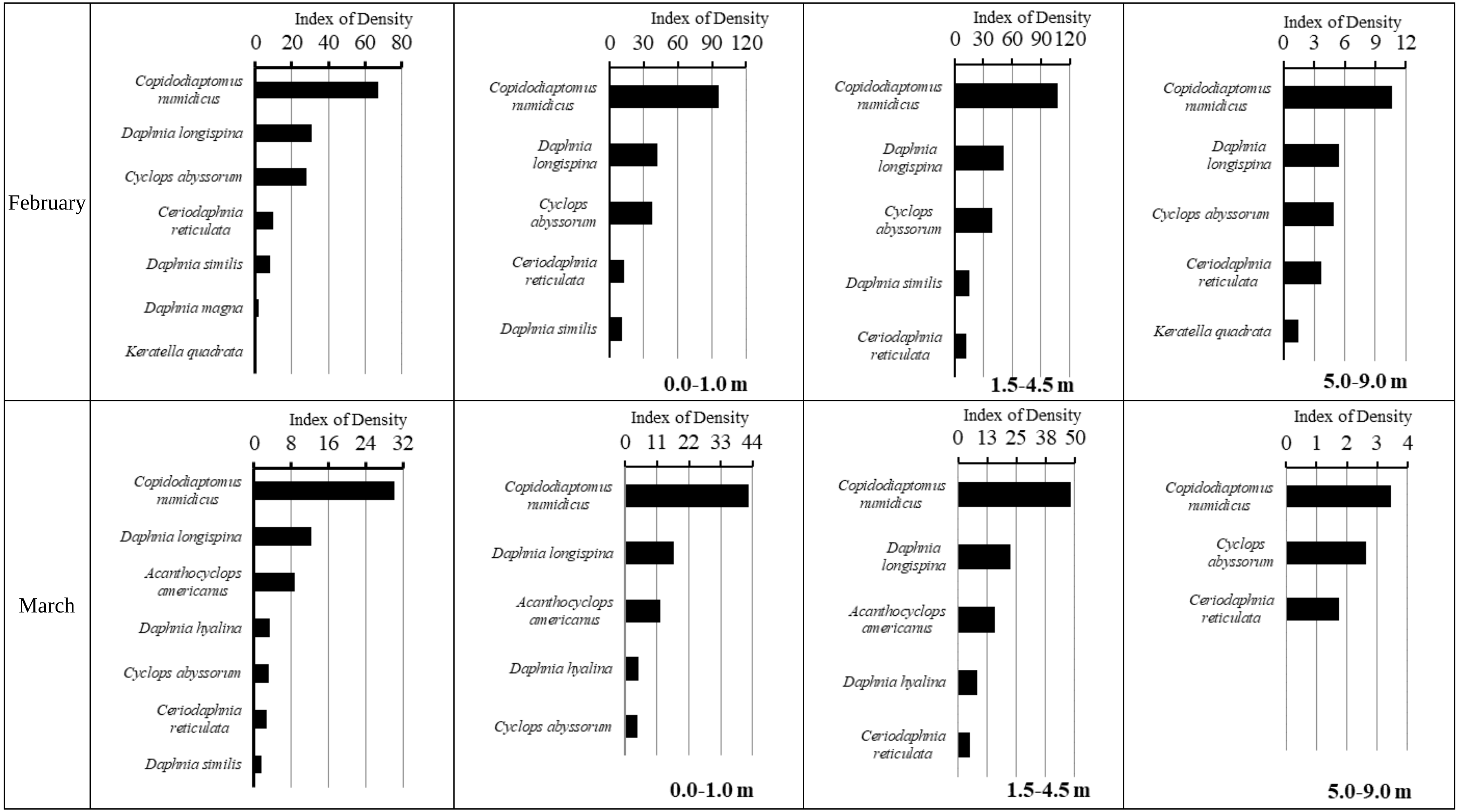

Figure 5. *Zooplanktocenoses at different depths on Hamiz*

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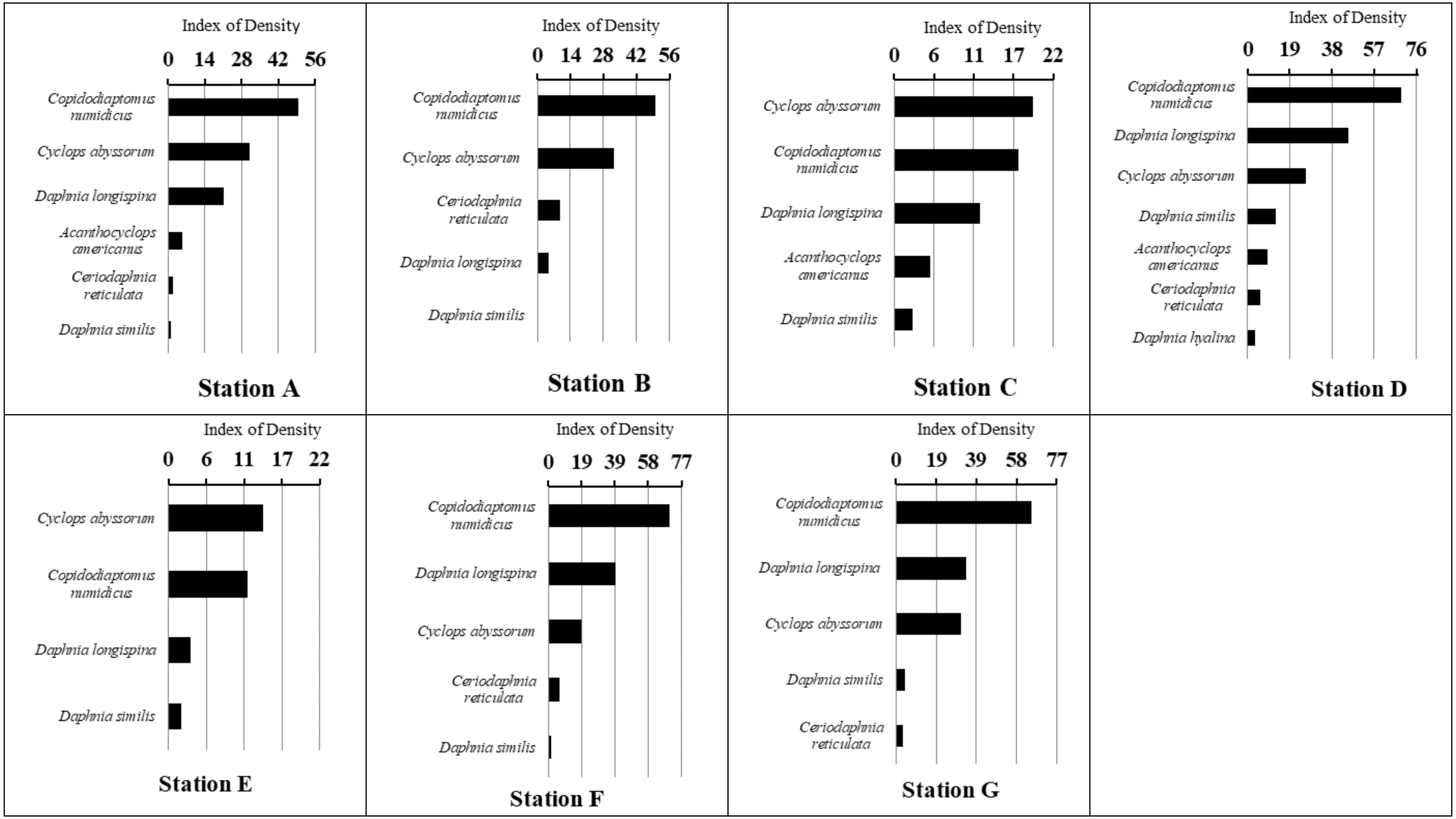

Figure 6. *Zooplanktocenoses at each station*

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Table 6. *Zooplankton communities in Hamiz (2006-2007)*

Zooplankton communities at different stations			
C. numidicus – C. abyssorum	*C. abyssorum – C. numidicus*	*C. numidicus – D. longispina*	*C. numidicus*
A-B	C-E	D	F-G

1. The zooplankton community where the only species *C. numidicus*, dominates for most of the year. It is the typical community of stations F and G, located along the south-west bank of the water reservoir.
2. The very close to this community is the zooplankton community *C. numidicus - C. abyssorum*, which is typical of stations A and B, which are located near the dam (North-West) and near the north-east bank of the water reservoir.
3. The community *C. numidicus - D. longispina*, which is typical of station D. This community is also related to the first two communities.
4. The *C. abyssorum - C. numidicus* community is typical of stations C and E, which are located next to each other.

Discussion

The Hamiz ecosystem is not only a real biotope that hosts different links in the food webs, especially zooplankton, but also continues to play a vital role by supplying the population with drinking water despite its structure, which was built more than a hundred years ago. Our survey on this lake confirms the presence of ten species belonging mostly to cladocerans and copepods while rotifers, were represented by only two species. Copepods were the major component of zooplankton throughout the reservoir followed by cladocerans. Rotifers are ubiquitous, occurring in almost all types of freshwater habitats (Tasevska et al., 2019) and they constitute with the two last groups most of the zooplankton. In Hamiz, they are very rare mainly represented by *K. quadrata*, which is found occasionally but not recorded near the dam wall where, planktivorous fish are abundant (Ould Rouis et al., 2016) thus modifying the zooplanktonic community structure. These latter are formed mainly by Copepoda and Cladocera since the Rotifera group does not appear well in the lake while their total abundance is a more sensitive indicator of the trophic state of the lake than the composition of the species (Liang et al., 2019). During our study period, the water temperature was almost the same between stations. This ecological factor is very important for several biological compartments, including zooplankton. Indeed, when temperature increases, zooplankton metabolic activity rates change and they can also swim faster (Simoncelli et al., 2019). The oxygenation of the water is sufficient and the pH values recorded characterize alkaline waters, which are common in most of the freshwater ecosystems including lakes, ponds, rivers and streams (Ishaq and Khan, 2013). Moreover, the geology (Cooper et al., 2004) and soil type (Shirazi et al., 2001) of the mountainous massif bordering the Mitidja plain, where the Hamiz basin is located presents schisto-sandstone and marno-calcareous terrains, (Durozoy, 1952; Cheikhlounis et al., 2011). Therefore, the waters that cross these soils have a high concentration of carbonate and a high pH (Angelier, 2000). Phosphate contents are low may be, because of the assimilation of mineral phosphorus dissolved by aquatic plants

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and then rapidly recycled (Simoneau et al., 2004). In addition to the above given factors, calcium and magnesium ions describing the hardness of the water may arise from the subsurface ground waters having higher hardness (Sharma et al., 2016). In Hamiz, variations in environmental parameters are mainly related to precipitation and temperature as well as the geological nature of the soil. Runoff from the watershed and agricultural activity around the lake are also major contributors to changes in nutrient levels, which also provide a picture of water quality (Rossetti et al., 2004). The CCA analysis shows significantly, strong correlations between species influenced par calcium-magnesium ions and others that prefer nutrient-rich waters. Cladocerans were the richest group represented by a single family where, *D. longispina*, *D. similis* and *Ceriodaphnia reticulata* were the most abundant species. It seems that the environmental conditions of the lake suit them. Indeed, the water quality of the Hamiz is generally acceptable. *D. longispina* prefers waters with low mineralization and is very sensitive to magnesium (Gonçalves et al., 2007), while *D. similis* tolerates a wide range of fluctuations of physicochemical parameters of the water. Therefore, the zooplankton community and its distribution in the water column are strongly linked to water quality. Copepods are predominant in the continental waters of Algeria, but some species are regional (Hamaidi et al., 2010). Furthermore, the specific composition of an ecosystem at a regional scale is more likely to be due to local environmental conditions (García-Chicote et al., 2019). However, *C. numidicus* is widely distributed in the western Mediterranean regions (Samraoui et al., 1998), is endemic to North Africa (Mouelhi et al., 2000) and in the Hamiz, this copepod colonized the reservoir from February and now, it becomes the most abundant species. In addition, the distribution of this Calanoida is probably associated with the supply of nutrients, in late winter and spring, by the wadi Arbatache that feeds this lake. Knowing that *C. numidicus* is herbivorous, it was considered to be a potential competitor of cladocerans species (Geraldes and Boavida, 2004). Moreover, the presence of this invasive species, associated with the trophic status of the lake, could be the reason for the rarity of rotifers, because biotic factors are important in shaping the structure of this group (Dumont, 1977). During our survey, the only species recorded are thus *Keratella quadrata* and *Filinia longiseta* without forgetting that the whole genus Keratella is considered eurytopic and cosmopolitan (Segers and De Smet, 2008). The waters of the Arbatache wadi and the small tributary which cross the "Tararesse forest" and then flow into the lake, enrich the latter with nutrient inputs from human activities in the watershed, providing favorable conditions for the development of aquatic plants. In these shallow sites, macrophytes offer food supplies as well as refuge for zooplankton species from pelagial predators (Špoljar et al., 2012). Indeed, it seems that certain areas of the lake usually host the same species, which suggests that the configuration of the food webs in Hamiz is shaped by the orientation of the basin from the northeast to the southwest on the one hand and the depth, which increases as one moves northwards, on the other hand. To these factors are added the macrophytes that are developing well on the southern bank. These differences in both physical and chemical conditions and in the characteristics of the northern and southern shores of the reservoir can lead to different zooplanktocenoses, whose existence and evolution in a given space and time can be an indicator of the fertility of the water and reflect the environmental conditions prevailing in the lake.

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Conclusion

Heterogeneity of physico-chemistry of the water and topography of the basin's reservoir are the main factors that draw and regulate the distribution of the zooplankton communities of the Hamiz. Our results demonstrated, for the first time, that this oligo-mesotrophic lake, has a low zooplankton diversity compensated by a high abundance of species especially copepods, which form the majority of the zooplankton population. The information provided by our findings on the distribution of zoobiocenoses in relation to abiotic factors, may be essential for monitoring and understanding the functioning of lake ecosystems. Additionally, they lead us to predict that the morphology and the exposure of the lake play a fundamental role in shaping the architecture of the food webs and the distribution of these communities not only in the superficial layers but also in the deep layers of the lake. Finally, we recommend to do more investigations considering the characteristics of the studied water mass, the abundance of zooplankton populations while completing the obtained results by a thorough knowledge of phytoplankton species, first link of the food chain.

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