Impact of Environmental Factors of Water on Zooplankton Diversity and Dynamic in Yacoub El Mansour Reservoir, Morocco

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Abstract: The spatio-temporal distribution of crustacean zooplankton in relation to environmental factors was studied in the Yacoub El Mansour reservoir in a semi-arid climate in the province of El Haouz, in Oued N'fis, located at 65 km south of Marrakech (Morocco). The samples are taken during two annual cycles 2012 and 2013. In this study, 6 species of crustacean zooplankton divided into 2 groups: copepods and cladocerans were identified. Daphnia lumholtzi is the most dominant species, accounting for 58.26% of the total zooplankton. The analysis of the results obtained at the studied reservoir shows a low zooplankton specific richness and a great spatial heterogeneity. A canonical correspondence analysis (CCA) was used to estimate the influence of environmental factors on the studied crustacean evolution. Thus, in the studied reservoir lake, hydrodynamics of the ecosystem, trophic relationships and environmental factors are generally responsible for the spatial and temporal distribution of these zooplankton species.

1. INTRODUCTION

The biodiversity of aquatic ecosystems is threatened by hydrological dysfunctions, anthropogenic pollution, habitat fragmentation, overexploitation of some aquatic species, invasive organisms and by climate change (Underwood et al. 2006). Databases on "macroscopic diversity" such as birds, mammals or higher vegetation have been produced. However, data on "microscopic diversity", particularly those of microfauna and algal microflora, are still fragmented, especially in freshwater ecosystems. Moreover, in recently watered reservoirs, the significant amount of organic matter from the flooded immersion could stimulate bacterial production and lead to a high amount of heterotrophic and mixotrophic organisms. This could be a source of crustacean zooplankton's food (Paterson 1997). Zooplankton plays a critical role in aquatic food chains. It is an important source of food for planktivorous fish and invertebrates. Also it intensely grazes algae, bacteria, protozoa and others invertebrates (Balvay 1990). Zooplankton community responds rapidly to environmental change because most species have very short-lived generations. The study of these organisms remains a necessity for developing effective strategies for hydraulic and trophic resources management. In Morocco, few hydrobiological studies have been carried out on the zooplankton in reservoirs lakes sash as: Lalla Takerkoust reservoir (Tifnouti 1993), Hassan I reservoir (Benzekri 1992), El Kansra reservoir (Fqih Berrada et al. 2000), The Mansour Eddahbi reservoir (Sadani 2005) and on the level of Zima and Sedd-El-Messjoun (Saadi 1994, 2002). This study of zooplankton was never carried out in the Yacoub El Mansour reservoir, which prompted us to study the interrelations of crustacean zooplankton with the different physical and chemical parameters of a recently watered reservoir under semi-arid climate.

2. MATERIALS AND METHODS

2.1 Study Area

The Yacoub EL Mansour dam is located in N'fis' river, 65 km south of Marrakesh city. It is about 20 km upstream Lalla Takerkoust dam and 1.5 km north of Wigand village. Thanks to its reserve of 70 million m3, the dam improves the regulation capacity of N'fis' river in Lalla Takerkoust dam. Also it

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decreases water loss downstream. The dam is built using concrete compacted with a ruler. It is 70 m height with a crest length of 233 m. This dam help increase the water volume of N'fis inputs, this volume being 68-85 million cubic meters per year (Fig.1)

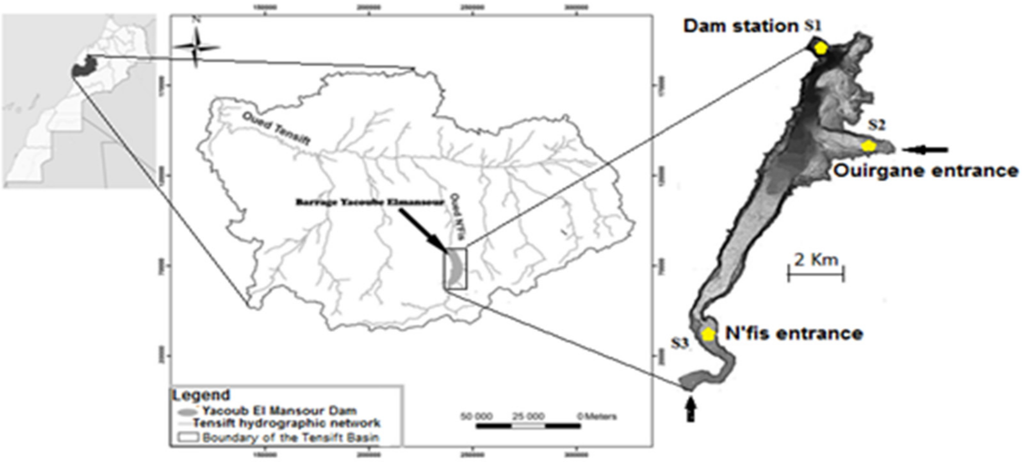

Figure 1: Geographical location on the Yacoub El Mansour dam at the Tensift El Haouz basin (Morocco.

2.2 Sampling

The measurement spots are distributed among several stations in the same area and on several depths in each station. In our study we analyzed two axes of variation: the spatial axis and the temporal axis, during two annual cycles from January 2012 to December 2013. With a monthly sampling interval, in autumn and winter and fortnightly in summer and spring. The different sampling stations are as follow:

- ✓ A dam station (S1): located at the bridge. At this station, samples were taken at different depths: Surface area, -1, -2.5, -5, -10, -15, -19.5m, 1m of the bottom and the bottom (Fig.1).
- ✓ Littoral stations: (S2) located at the entrance of the Ouirgane River and (S3) located at the entrance of the N'fis River (Fig.1).

The water samples at the dam station (S1) were taken using a closed bottle of the Van Dorn type with a 2L capacity, while those from the littoral stations were taken directly from the surface, with a 2L volume sampler as well. The zooplankton were collected using a plankton net of 50 cm in diameter and 50 µm in mesh, collected in jars and fixed with 5% formalin. Because of their low numbers, the zooplankton species studied are counted on all samples in a Dolfus tank. The count is done under a binocular magnifying glass and species determination is made using the determination keys (Dussart 1969) for the Copepods and (Amoros 1984) for the Cladocerans.

2.3 Statistical Analysis

We determined the importance of the various correlations between the zooplankton and physico-chemical variables by the canonical correspondence analysis CCA (Ter Braak, 1986), using XLSTAT software.

3. RESULTS

Six zooplankton species were identified during the period of our study: 4 for Cladocerans and 2 for Copepods. The seasonal variations of the density (ind/L) of these zooplankton species at the different stations studied are represented in Figure 2.

The variation in zooplankton density shows a spatio-temporal fluctuation. The biannual cycle is marked by a maximum number of species in early autumn of the first year (2012) and in spring during the second year (2013). At the level of the Yacoub El Mansour reservoir, the low specific richness affects all the groups and more particularly that of the copepods, which are found throughout the sampling period but with a low abundance of 17.88% compared to the total zooplankton. This group is represented by *Tropocyclops prasinus* (Fischer, 1860) species, with 5.70% (considering the percentage represented by each species in relation to the total number of individuals), which appear to be more numerous in 2013 with a maximum number of individuals (78 ind/L) in April and less present in 2012 (Fig.3).

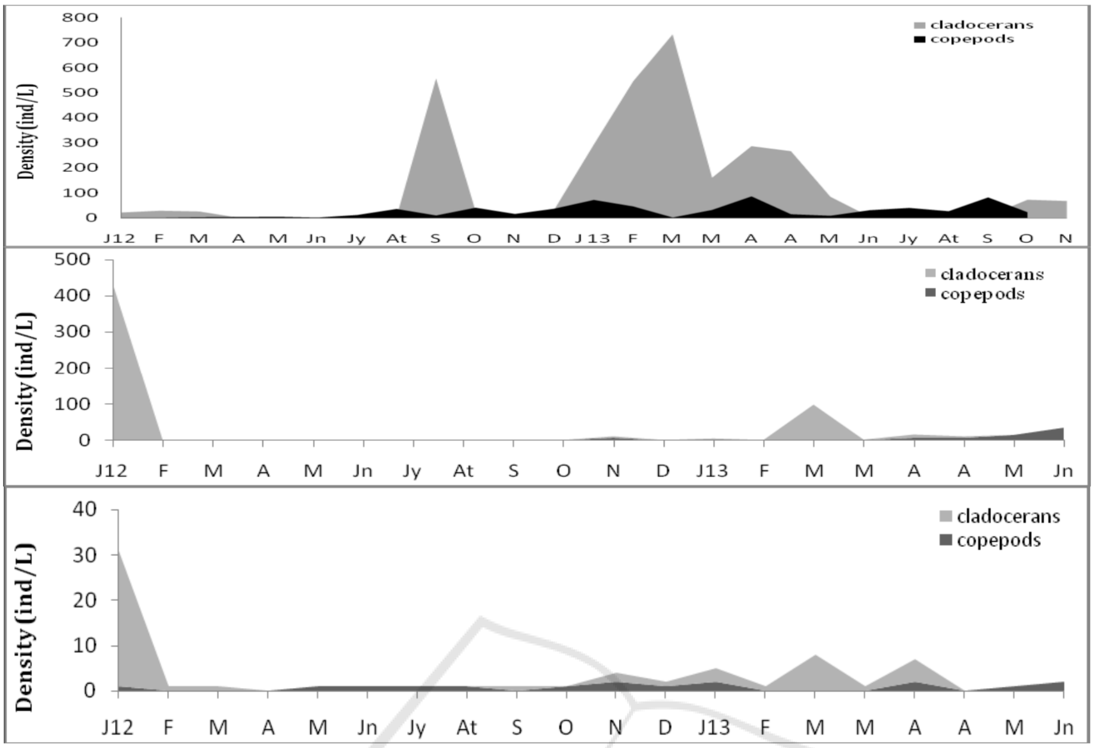

Figure 2: Temporal variations of zooplankton density at the dam station S1 (a) and at the two littoral stations S2 (b) and S3 (c).

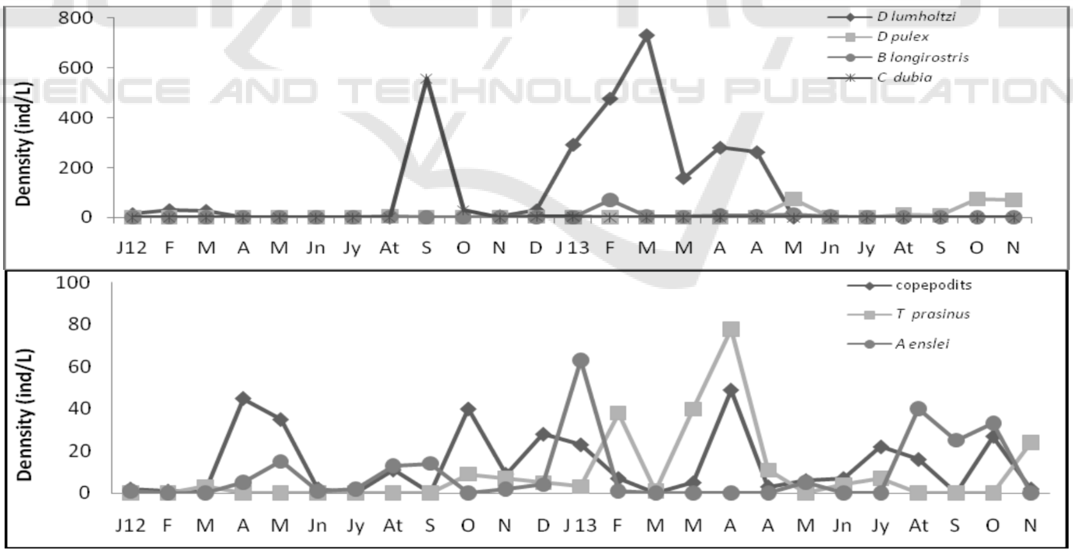

Figure 3: Temporal variation of the different species of cladocerans density (a) and copepods density (b) at the dam station (S1).

Whereas *Acanthocyclops einslei* (MirabdulLayev & defay, 2004) species (5.56%) reaches its maximum density in January 2013, with 63 ind/l. Concerning the copepodite stages, they are present almost throughout the study period and present 48.37% of the copepods and 8.65% of the whole crustacean zooplankton (Fig.3). Generally the settlement is dominated by the Cladocerans (82.11%). The maximum peak of their density is reached in September and March respectively for the year 2012 and 2013. Whereas during the first sampling campaigns, the density of the settlement is very low or null and the individuals are replaced by resting eggs in S1 station. At the dam station (S1), the seasonal succession of the different species of this group (Fig. 3) presented an annual cycle characterized by the dominance of the species *Daphnia lumholtzi* (Sars, 1885) (58.26%), which is a perennial species in this lake and has a maximum development in spring (729 ind/L). It is followed by *Ceriodaphnia dubia* (Richard, 1894) with an abundance of 14.97%. This species reaches its maximum (557 ind/L) in September, while the two species *Daphnia pulex* (Leydig, 1860) and *Bosmina longirostris* (O.F. Muller, 1785) have a low abundance of 6.04% and 2.84%, respectively; *Daphnia pulex* density increases towards the end of spring and autumn with a maximum of 73 ind/L. Whereas *Bosmina longirostris* shows a maximum peak in February with 71 ind/L. At the two littoral stations S1 and S2 (Fig. 4) the species *Daphnia lumholtzi* is most present also with a maximum in January 2012 of 430 ind/L at S2 and 30 ind/L at S3 . The influence of eleven physical and chemical parameters (temperature, pH, conductivity, dissolved oxygen, total phosphorus, orthophosphates, nitrites, nitrates, ammonium and chlorophyll a) on the different zooplanktonic species studied, at the Yacoub El Mansour reservoir, was assessed using Canonical Correspondence Analysis (CCA). The first two axes of the CCA represent 45.12% and 30.78% of the total inertia. The first factor axis (F1) has been strongly associated with *C.dubia* (C.b) species, conductivity (Cond) , dissolved oxygen (Do) and nitrate (NO_3), while the second factor axis (F2) is strongly related to *D.pulex* (D.p) species, filling volume (Fv) and Chlorophyll a (chl a). It is also noted that, dissolved oxygen is negatively correlated with temperature (Tem) and positively correlated with NO_3, total phosphorus (Pt) and orthophosphates (PO_4) .The species such as *Daphnia lumholtzi* and *Bosmina longirostris* were associated with high value of dissolved oxygen, total phosphorus (Pt) and orthophosphates (PO_4), during the months of February – April 2012, whereas species such as *Daphnia pulex*, *Acanthocyclops einslei* and *Tropocyclops prasinus* were associated with high values for pH, nitrates and chl a. while, *Ceriodaphnia dubia* species is associated with highest volume of filling (Fv) and nitrites (NO_2). In CCA ordination diagram, *Ceriodaphnia dubia*, a cladoceran species, occupies an aberrant position due to its occurrence only in September 2012 when a substantial increase in NO_2 levels was evident (Fig. 5).

4. DISCUSSION

The abundance and specific zooplankton richness in the Yacoub El Mansour reservoir are low compared to those found in other Moroccan dams; 8 crustaceans zooplankton at the Lalla Takerkoust reservoir (Tifnouti 1993) and 12 at the Hassan I reservoir (Benzekri 1992). Indeed, the Yacoub El Mansour reservoir was recently put into water. Also, the period of study coincides with a period of frequent draining especially during the year 2012. This generates a short retention time in the reservoir (Benzha 2005). The impact of draining on the zooplankton populations was underlined by many authors (Axelson 1961, Rodhe 1964, Pechlaner 1964). Brook and Woodward (1956) found that high rates of water turnover can involve quantitative and qualitative variations of the plankton in the lakes. In general, the low abundance of Cladocerans and Copepods is associated with environmental conditions, caused by, the hydrodynamics of the reservoir, such as the low water volume, short residence time and morphometry (Isumbisho 2006). Predation by planktivorous fish and the poor availability of food sources, may also lead to a reduction in the specific richness of the reservoir (Achembach and Lampert 1997). According to an earlier study on phytoplankton at Yacoub El Mansour reservoir (Hammou 2014), the phytoplankton population inventoried in the Yacoub El Mansour reservoir is not very diversified, and quantitatively only a few species play a decisive role in this lake. This may also explain the low specific richness of zooplankton communities at the reservoir. It was found that at the Yacoub El Mansour reservoir, the arid climate favored the existence of two periods of abundance during the year: an autumn-spring period favorable to the development of zooplankton and a winter-summer period, characterized by a significant decline of the number of species, their densities and their distributions. During the rainy season, water supplies from the reservoir upstream and precipitation tend to cause small mixtures of water bodies, nutrients are then available in the mass of oxygenated water and are very rapidly assimilated by the invertebrates which could lead to the development of zooplankton. In addition, some fish take advantage of exogenous inputs during the rainy season. Whereas in the dry season some fish consume endogenous material (mainly micro-crustaceans) and consequently cause a decrease in the abundance of the zooplankton population (Horeau et *al.* 1998). Muylaert (2003) also corroborated the conclusion, that zooplankton biomass generally reaches its peak during rainfall in reservoirs. In spring, physical factors (nutrient input, photoperiod and temperature increase) increase the primary production (phytoplankton). Which increase zooplankton density (Tifnouti 1993).

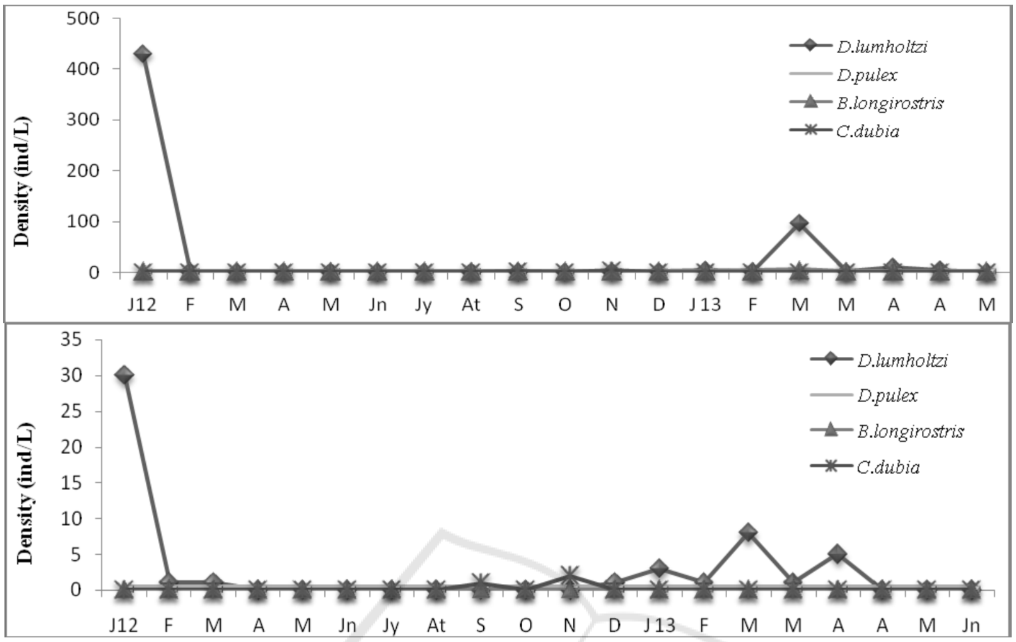

Figure 4: Temporal variation of the different species of cladocerans density at the littoral stations S2 (a) and S3 (b).

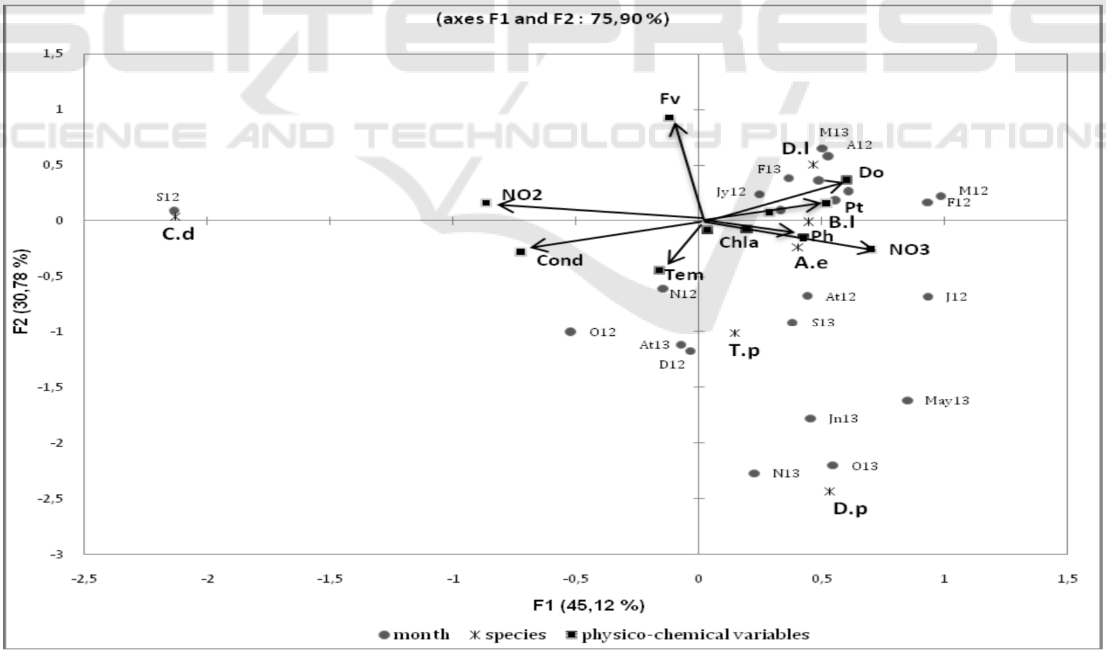

Figure 5: CCA ordination diagram with zooplankton species and environmental variables in Yacoub El Mansour reservoir. The zooplankton species shown are: Daphnia lumholtzi (D.l), Ceriodaphnia dubia (C.d), Daphnia pulex (D.p), Bosmina longirostris (B.l). The environmental variables are: filling volume (Fv), total phosphorus (Pt), Orthophosphates (PO4), nitrites (NO2), nitrates (NO3), ammonium (NH4), chlorophyll a (Chl), dissolved oxygen (Do), conductivity (Cond), Temperature (Temp) and pH. The Months are :January 2012 or 2013 (J12 or 13), February (F), March (M), April (A), June (Jn), July(Jy), August (At), September (S), October (O), November (N), December (D).

Positive correlations between pH and conductivity with some zooplanktonic species (Fig. 5) show that alkaline pH and high conductivity also promote the growth of some zooplankton in the dam reservoir. This is in agreement with the conclusions of Byars (1960), Hujare (2005) and Mustapha (2009). At the dam station (S1), the density of the zooplankton species is higher compared to the two littoral stations S2 and S3, due to their relative stability and slower flow velocity. Similar results were found by Tifnouti (1993), at the Lalla Takerkoust reservoir. In the summer according to the PEG model (Plankton Ecology Group), small Cladocerans are replaced by larger Cladocerans and adults Copepods (Sommer et al. 1986, Lair and Ayadi 1989, Tifnouti 1993). In the Yacoub El Mansour reservoir, during the summer, there was an absence of most crustacean zooplankton and a presence of a few individuals of Copepods and Cladocerans, mainly the species *B.longirostris*, a species of small size, which continues its development by parthenogenesis until late spring. The population passes through a sexual reproduction around June, which ensures the appearance of a new generation next winter. This type of development is similar to that observed by Tifnouti (1993), at the level of Lalla Takerkoust reservoir. At the Yacoub El Mansour reservoir this species reaches its maximum density in February, which is in agreement with the results of Vijverberg (1980). Which, considers that the development of the species in question is adapted to the low temperatures of the environment. The study of the vertical distribution of zooplankton shows that the zooplankton is concentrated over the first 10 meters. The depletion of zooplankton, particularly at young stages, in depth from -15 m, may be related to the high suspended mater (Tifnouti 1993), or to low availability of food. Juvenile stages preferentially stay in warmer and more nutritious surface waters (Hutchinson 1967, Kerfoot 1980).

5. CONCLUSION

In conclusion, zooplankton settlement in the Yacoub El Mansour oligotrophic lake (Chakir and Saadi 2016), set in 2008 is characterized, by a very low number of individuals per liter and a low specific richness (4 Cladocerans and 2 Copepods). The spatial and temporal variations of the various zooplankton species follow a distribution pattern strongly influenced by conditions. Which fluctuate according to the season: water level, temperature, pH, conductivity, dissolved oxygen, suspended matter, total phosphorus, orthophosphates, nitrites, nitrates, ammonium, and Chlorophyll *a*. Moreover, the floods of the wet season favor the appearance of sporadic species. Among all the factors studied, the fluctuations in water level and temperature associated with the semi-arid climate of the region, presenting a period of great drought, would be tow of the main causes of the temporal distribution of the species in the Yacoub El Mansour reservoir. This study should be completed taking into account the other components of the trophic chain, in particular Protozoa, Rotiferes, Phytoplankton and fish, in order to integrate the "crustacean zooplankton" component into the conceptual models that describe the effect of the manipulations of trophic chains on water quality. Generally, successive drainings should be taken into account in the management of the tanks where fish farming is required.

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