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The effect of environmental factors on rotifers abundance in Oubeira Lake (North East of Algeria)

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Abstract

This work aims to study the impact of the variation of physicochemical parameters on the dynamic of the zooplankton community on Lake Oubeira, a wetland of El Kala National Park. Temperature, pH and dissolved oxygen are measured *in situ* using a field's multi parameters; the turbidity of the water is evaluated using a turbid meter, the analysis of the nutrients is carried out by colorimetric method, the chlorophyll a with the method of SCOR-UNESCO, and suspended matter with the differential weighing method, the sampling of zooplankton is achieved by a plankton net.The study reports 43 rotifers belonging to 17 different genera. *Brachionus* and *Keratella* were the most taxon rich genus being represented by 12 and 11 species, respectively. The *Pompholyx camplanata* species represents 4/5 of the density of the rotifers counted in spring; the species *Brachionus diversicornis* and *Keratella tropica* represent more than 2/3 of the density recorded in summer; *Brachionus calyciflorus* and *Keratella tropica* represent more than 4/5 of the density of rotifers in the fall. In winter, there are 39 other species that predominate saving more than 50% of the high density. The results of the Principal component analysis showed that the species *Filinia terminalis, B. bidentata, B. diversicornis, B. calyciflorus*, *Keratella tropica* and *K. cochlearisvarhispida* were correlated positively with the temperature and N-NH4, N-NO3, P-PO4 and Chl-a. The present study shows that the Oubeira Lake had undergone progressive increase in rotifers from 15 (in 1998) to 43 species (in 2016); thus, the community composition of the rotifers indicated that the Oubeira is a highly eutrophic Lake, Furthermore the rotifers is influenced by changes in the physicochemical parameters of water and rhythm of the seasons.

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Introduction

Zooplanktons are microscopic organisms, which do not have the power of locomotion and move at the mercy of the water movements. Rotifers occur almost everywhere and constitute an important group of zooplankton community in aquatic eco-systems of the world.

Rotifers are small pseudo-coelomate animals that inhabit in a wide variety of aquatic habitats .They act as connecting link between primary producers and consumers in aquatic eco-systems (Barbiero *et al.*, 2012). Some rotifers are highly specialized but most are opportunistic feeders since they consume and assimilate different types of food (Wallace *et al.,*2008). Besides, rotifers are used as indicators for pollution (Sladecek, 1983) and eutrophication because of their high reproduction rate and sensitivity to any ecological change in water bodies (Lucinda *et al.,*2004).

Species composition and abundance of rotifers can be influenced by a number of physical, chemical and biological factors, such as temperature (Berzins and Pejler, 1989a), dissolved oxygen (Berzins and Pejler, 1989b), pH (Berzins and Pejler, 1987), quantity and quality of food (Enrique-Garcia *et al.*, 2003), predation and competition (Wickham and Gilbert 1991; Dieguez and Gilbert, 2002). The species composition of rotifers is also greatly influenced by the size of water bodies (Patalas, 1971), their trophic state (Gannon and Stemberger, 1978) and the succession stage .According to Pilière*et al.* (2014), biomonitoring the environmental quality of a given aquatic ecosystem can be judged from its species assemblages, based on knowledge of the environment-biota relationships.

In Algeria, some limnological studies related to plankton have been made on freshwater ecosystems (Samraoui *et al.,* 1998 and Samraoui, 2002; Cherbi *et al.,* 2008; Hamaidi *et al.,* (2008 and 2010) ;Hamaidi-Chergui and Hamaidi, 2013; Hamaidi-Chergui *et al.,* 2013; Sellamand Arab, 2013; Bidi-Akli *et al.,* (2014 and 2017);Boussadia *et al.,* 2015; Errahmani Brahim *et al.,* 2015; Saoudi *et al.,* 2015).

Ecological studies related to the zooplankton of the freshwater eco-system of Algeria are scarce. Cherbi *et al.,* (2008), studied the distribution of zooplankton community in Mediterranean climate lakes. The study of the rotifers structure and dynamic of Ghrib dam (Algeria) has been made by Sellam and Arab (2013). Zooplankton spatiotemporal variation in Zéralda Game Reserve dam (Algeria) was investigated by Bidi-Akli *et al.,* (2014). ErrahmaniBrahim *et al.,* (2015) investigated the impact of seasonal variations of water physico-chemical parameters on the zooplankton and phytoplankton composition in the Boukourdane reservoir (Tipaza, Algeria).

In the northeast of Algeria, studies related to zooplankton inventory have been made by Samraoui *et al.* (1998) and Samraoui (2002).The first have treated Rotifera, Cladocera, Copepoda, and Ostracodasampled from two costal wetland complexes and the second have treated Branchiopoda (Ctenopoda and Anomopoda) and Copepoda sampled from temporary pools, dunes lacks and shallow lake.

The aim of the present study is to describe the rotifer community of the Oubeira Lake and its seasonal variations by the analysis of rotifer samples and the most significant abiotic parameters.

Materials and methods

Study area and sample collection

The Oubeira Lake is an endorheic natural fresh water lake located in north eastern Algeria (36° 50' 695 Nord – 8° 23' 272), It is the home of El-Kala National Park (PNEK) and has an average altitude of 25m above of the sea level (Fig.1). It is the first largest fresh water lake in Algeria, and has an estimated surface area of 2200 ha and a maximum depth of about 4m. In 1984, the lake was included as a wetland under the Ramsar Convention (Ramsar Convention Official Website, 2007, www.ramsar.org). The Oubeira Lake is an important natural reserve for migratory birds and wildfowl species. This site has a great socio-economic importance in terms of fish production and the use of water for irrigation and peanut cultivation. The native Ichthyofauna of the Oubeira lake is represented by *Barbuscallensis*, *Pseudophoxinuscallensis*, *P.guichenoti*, *P. punicus*and *Gambusiaaffinisaffinis* (Poeciliidae), *Mugilcephalus*, *Liza ramada* (Mugilidae) and eel *Anguilla Anguilla*(MPRH, 2004). The lake is very important for wintering water birds and hosts an interesting aquatic flora including water chestnut (*Trapanatans*), white water lily (*Nupharalba*) and yellow lily (*Nupharluteum*).

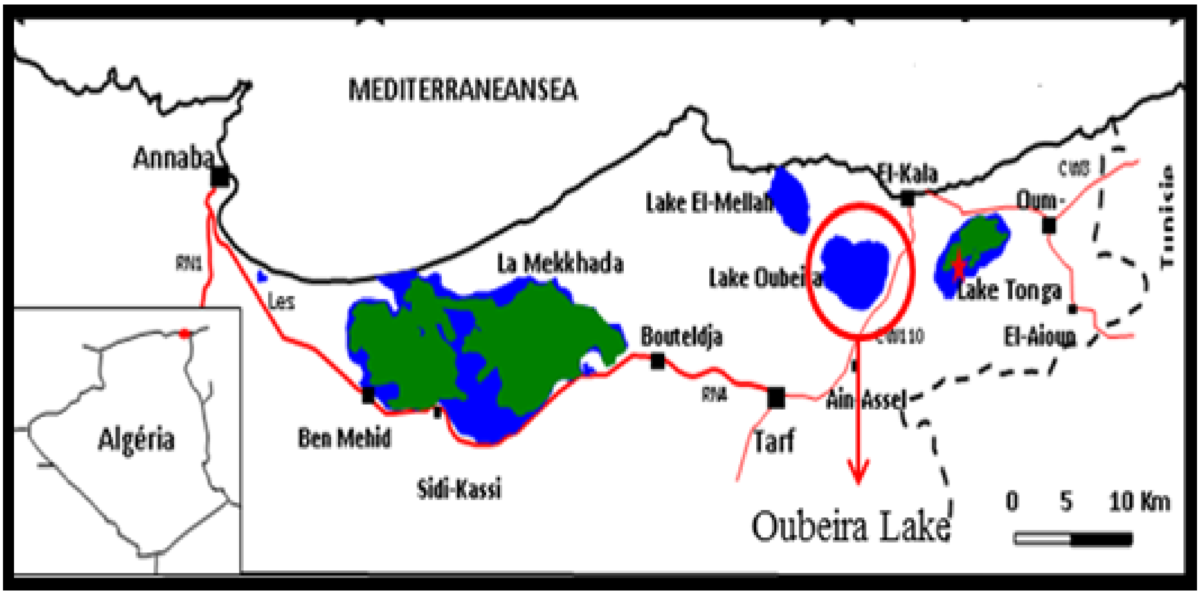

Fig.1. Location of the Oubeira Lake.

Physico-chemical analysis

Water and zooplankton samples were collected monthly during the period April 2015 to March 2016. Physical factors temperature, pH, dissolved oxygen (DO), and conductivity (CON) were measured *in situ* using a multi-parameter probe (Model WTW Multi 340i/SET-82362, Germany).In the laboratory, the turbidity of the water is evaluated using a turbid meter.

Water samples for nutrient determination (P-PO4 -, N-NH4, N-NO3, and N-NO2) were collected superficially, filtered through 0.45-µm Whatman GF/C™ glass microfiber filters (GE Healthcare Ltd., UK) and kept in polypropylene sampling containers at 4°C in darkness and analyzed as soon as possible.

The N-NO3, N-NO2, N-NH4 and P-PO4 concentrations were analyzed according to previous reports ; Bendschneider and Robinson (1952), Mullin and Riley (1955) , Murphy and Riley (1962), Sagi, (1966).

Water samples for chlorophyll-a (Chl-a) determination were filtered through 0.45-µm membrane filters 47 mm in diameter (Whatman GF/CTM™, GE Healthcare Ltd.). Pigments were extracted in 90% acetone and measured by spectrophotometry (SCOR-UNESCO, 1966).

A heat-treated (450°C, 30 min), 0.45 µm pre-weighed glass fiber filter 47 mm in diameter (Whatman GF/CTM™, GE Healthcare Ltd.) was used for filtration of the surface water sample to measure suspended solid matter (MES) concentration. After filtration, the filter was dried at 70°C for 48h. The suspended solid matter concentration was determined from the difference between the weight of the filter before and after filtration.

Plankton identification and enumeration

50 liters of the lake water were filtered using a plankton net of 20 mm mesh size and a mouth diameter of 30 cm. Collected samples were retained in plastic bottles with some lake water, preserved

immediately after collection in 4% neutral formalin. In the laboratory, samples were made up to a standard volume (100 ml). Three milliliters were used for counting all Rotifera under a binocular microscope. Identification of species was made using the identification keys of Ruttner-Kolisko (1974), Koste (1978), Pourriot and Francez (1986), Nogrady, 1993, Segers (1995).

Statistical analysis

The statistical analysis of the data was performed under R (R Development Core Team, 2014 Version 3.1.2) developed by Ross Ihaka (1996). The normality condition of the distributions was checked beforehand by applying the Shapiro-Wilk (not shown). The distributions being usually of asymmetric time, forced us to choose non-parametric alternatives for the statistical analysis. The correlations between the sets of parameters were evaluated by the non-parametric Spearman correlation coefficient (*r*) to analyze the intensity of relations between parameters. The principal component analysis (PCA) was used (package FactoMineR) to directly explain relationships between biotic and abiotic variables

Results and discussion

Analysis of biotic and abiotic parameters

Table 1 shows the values of physico-chemical parameters measured in the water of the Oubeira Lake during the study period. The water temperature varied from 12°C in winter to 29°C in summer and was close to 20°C during the other seasons.

Table 1. Biotic and abiotic parameters in the Oubeira Lake.

Parameters Seasons	pH	T(°C)	DO mg/l	COND (µs/cm)	TURB (NTU)	Chl-a (µg/l)	$N\text{-}NH_4$ (µmol/l)	$N\text{-}NO_2$ (µmol/l)	$N\text{-}NO_3$ (µmol/l)	$P\text{-}PO_4$ (µmol/l	MES (mg/l)
Spring	8,40 ±0.40	19,32 ± 6.96	8,34 ± 2.99	445,18 ± 67.10	16,21 ±7.82	20,71 ±15.26	3,10 ± 0.37	1,33 ±0.40	4,39 ± 0.10	1,90 ± 0.99	90,39 ± 33.11
Summer	8,63 ±0.30	29,14 ± 2.45	6,39 ± 0.90	486,06 ± 8.26	12,42 ± 5.68	58,09 ±58.39	6,07 ± 3.48	1,33 ± 0.24	5,44 ± 1.13	6,16 ± 7.57	118,15 ± 41.45
Autumn	8,87 ±0.55	21,81 ± 4.52	8,44 ± 1.10	516,27 ± 10.13	11,06 ± 7.56	119,29 ± 4.39	5,53 ± 2.61	1,28 ± 0.30	4,89 ± 0.12	2,12 ± 0 .90	105,06 ± 43.04
Winter	8,77 ±0.11	12,21 ± 0.60	10,24 ± 0.55	541,18 ± 8.91	11,52 ± 1.89	20,39 ±16.84	2,33 ± 0.65	1,09 ± 0.66	3,77 ± 1.18	2,73 ± 0.31	84,24 ± 48.15

The water pH was alkaline and varied from 8.4 (spring) to 8.87 (in autumn). Dissolved oxygen levels were between 6.39 mg/L (in summer) and 10.24 mg/l (in winter); intermediate values were noted in spring and autumn. The conductivity values fluctuated between 445and 541µS/cm; they increased in the order spring > summer> autumn > winter.

The turbidity values of the Oubeira Lake were in their maximum and minimum in spring and winter (16.21 and 11.06 NTU respectively). Suspended solid matter levels were included in the range of 84-118 mg/l. They were low in winter, and exceeded 100 mg/L in summer and autumn. Chlorophyll-a (Chl-a) levels were close to 20µg/L in winter and spring. However, they were three times higher in summer (close to 60µg/l) and six times higher in autumn (close to120 µg/L).

Ammoniacal nitrogen levels were within the interval 2.33-6.07µmol/L. They were high in summer and fall (5.5 and 6µmol/L, respectively) and low in winter and spring (2.3 and 3.1µmol/L, respectively). Nitrate values were low in winter (1.09µmol/L) and stayed close to 1.3µmol/L during the other seasons.

The nitrite values were between 3.7 and 5.4µmol/L and they decreased in the order summer > autumn > spring > winter. Ortho-phosphate levels fluctuated between 1.90 µm/ in spring and 6.16µm/L in summer, and reached 2.12 and 2.73 µm/L in fall and winter, respectively.

Table 2. Rotifers collected in the Oubeira Lake.

Family	Species
Asplanchnidae H.M.,1926	*Asplanchna priodonta Gosse, 1850*
Brachionidae Ehrenberg, 1838	*Anuraeopsis fissa* Gosse, 1851 *Brachionus angularis* Gosse, 1851 *Brachionus calyciflorus* Pallas, 1766 *Brachionus diversicornis*Daday, 1883 *Brachiouus bidentatabidentata* Anderson, 1889 *Brachionus urceolarisurceolaris* Müller, 1773 *Brachionus quadridentatusquadridentatus* Hermann, 1783 *Brachionus leydigivarrotundus* Rousselet, 1896 *Brachionus polyacanthus* Ehrenberg, 1838 *Brachionus quadridentatusvarancylognathus* Schemarda, 185 *Brachionusmurus f angustus* Koste, 1896 *Brachionusbidentata f crassispineus* Anderson, 1889 *Brachionus sp.* *Keratella cochlearis cochlearis* Gosse, 1851 *Keratella tecta* Gosse, 1851 *Keratella quadrataquadrata* Muller, 1786 *Keratella tropica* Apstein, 1907 *Keratella cochlearisvarhispida* Lauterborn, 1900 *Keratella irregularis* Lauterborn, 1898 *Keratella lenzi* Hauer, 1953 *Keretella ticiensis* Callerion, 1834 *Keretella valga* Ehrenberg, 1834 *Keratella cholearisvartecta* Gosse, 1851 *Keratella sp.*
Notommatidae Hudson et Gosse, 1886	*Cephalodellain tuta* Myers, 1924
ProalidaeHarring& Myers, 1924	*Proales sp.*
Euchlanidae Ehrenberg, 1838	*Euchlanis dilatata dilatata* Ehrenberg, 1832
LecanidaeRemane, 1933	*Lecane bulla bulla* Gosse, 1851 *Lecane luna* Müller, 1776
GastropodidaeHarring, 1913	*Ascomorphaec audis Perty, 1850*
TrichotriidaeHarring, 1913	*Trichotria tetractis* Stenroos, 1898
MytilinidaeBartos, 1959	*Mytilinilina bicarinata Perty, 1850* *Lopochlaris salpina* Ehrenberg, 1834 *Polyarthra dolichoptera* Idelson, 1925
TrichocercidaeRemane, 1933	*Trichocerca collaris* Rousselet, 1896
TestudinellidaeHarring, 1913	*Pompholyx camplanata* Gosse, 1851 *Pompholyx sulcatta* Hudson, 1885 *Testudinella incisa* Ternetz, 1892 *Testudinella parvaparva* Ternetz, 1892
FilinidaeBartos, 1959	*Filinia longesta* Ehrenberg, 1834 *Filinia opoliensis* Zacharias, 1898 *Filinia terminalis* Plate, 1886

Distribution of Rotifera

The study of the zooplankton fauna of the water of the OubeiraLake had permitted the identification of forty-three (43) species of rotifers (Table2). These species were affiliated to 12 families whose most represented are the familiesof Brachionidae (24 species), Testudinellidae (04 species), Filinidae and Mytilinidae (03 species, each).

In the water of the Oubeira Lake, more than 53% of the identified species were related to the genus *Brachionus* (12) and *Keratella* (11). The species of *Filinia* (3), *Testudinella* (2), *Lecane* (2) and *Pompholyx* (2) represented more than 20%.

Seasonal distribution of the rotifers

The largest number of species of rotifers was found in summer (25 species) and autumn (12 species). During winter and spring, the number of species was seven and four, respectively.

The rotifers were strongly present in summer where they recorded more than 64% of the overall density. Their proportions were close to 14%, 11% and 10% in fall, winter and spring, respectively (Table 3).

Proportions of the dominant genus

Brachionus and *Keratella* genera predominate with respectively 39% and 37% of overall density.

Table 3. Species diversity and density of Rotifera in Oubeiralake.

Season	Spring	Summer	Autumn	Winter
No. Of species	4	25	12	7
ind/L	26 282	164 010	35 385	28 256
Rates	10.34%	64.58%	13.93%	11.12%

The genus *Pompholyx* and *Filinia* represented 10 and 5 percent, respectively. The other collected genus represented just 9 percent of the whole density (Fig.2).

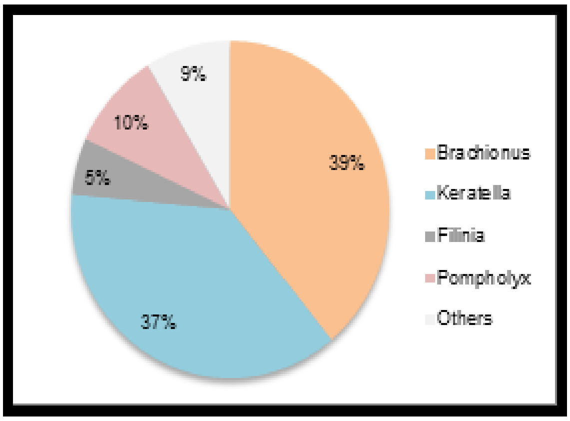

Fig.2. Proportion of dominant genera in the Oubeira Lake rotifers community.

Proportions of the dominant species

The species *Brachionus diversicornis*, *Keratella tropica*and *Pompholyx camplanata* represented 27%, 21% and 8% of whole density, respectively; With *Brachionus calyciflorus* (6%), *K. cochlearis varhispida* (6%) and *Filiniaterminalis* (3%) the six species dominated the rotifers in the Oubeira Lake community representing more than 2/3 of the total density (Fig.3).

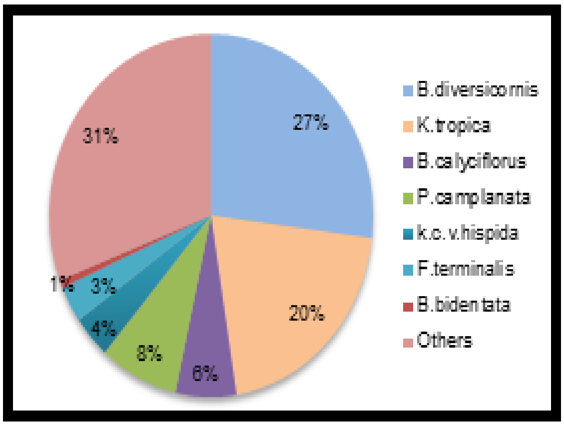

Fig.3. Proportion of species of rotifers inhabiting in the Oubeira Lake.

Seasonal distribution of the dominant species

It is clear that the composition of the community of rotifers of the Oubeira Lake varied from one season to the next and seemed, in most cases, be dominated by one or two species (Fig.4). *Pompholyx camplanata* represented 4/5 of the density of the rotifers counted in spring. *Brachionus diversicornis* (55%) and *Keratella tropica* (12%) represented more than 2/3 of the density recorded in summer. More than 4/5 of the density of rotifers recorded in autumn were represented by *Brachionus calyciflorus* (close to 70%) and to a lesser extent by *Keratella tropica*(15%).

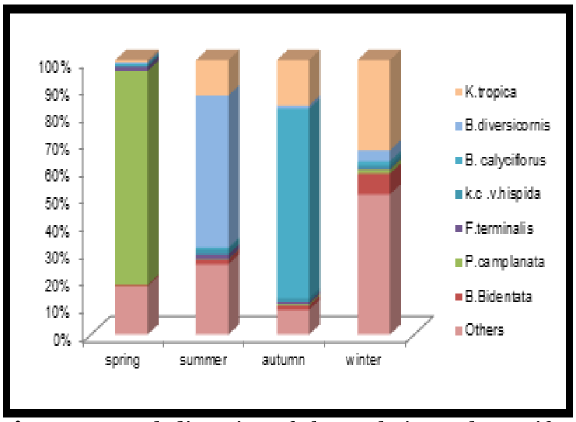

Fig.4. Seasonal diversity of the Oubeira Lake rotifer community.

In winter, the 39 other identified species represented more than 50% of the whole density; However, *Keratella tropica* and *Brachionus bidentata* species represented 33 and 7% seasonal density, respectively.

Seasonal dynamics of Brachionus species

The species *Brachionus diversicornis* showed densities ranging from 20 ind/L to 9971 ind/L respectively, in spring and summer. The average densities recorded in winter and autumn are close to 64.6 ind/L and 61.3 ind/L, respectively (Fig.5).

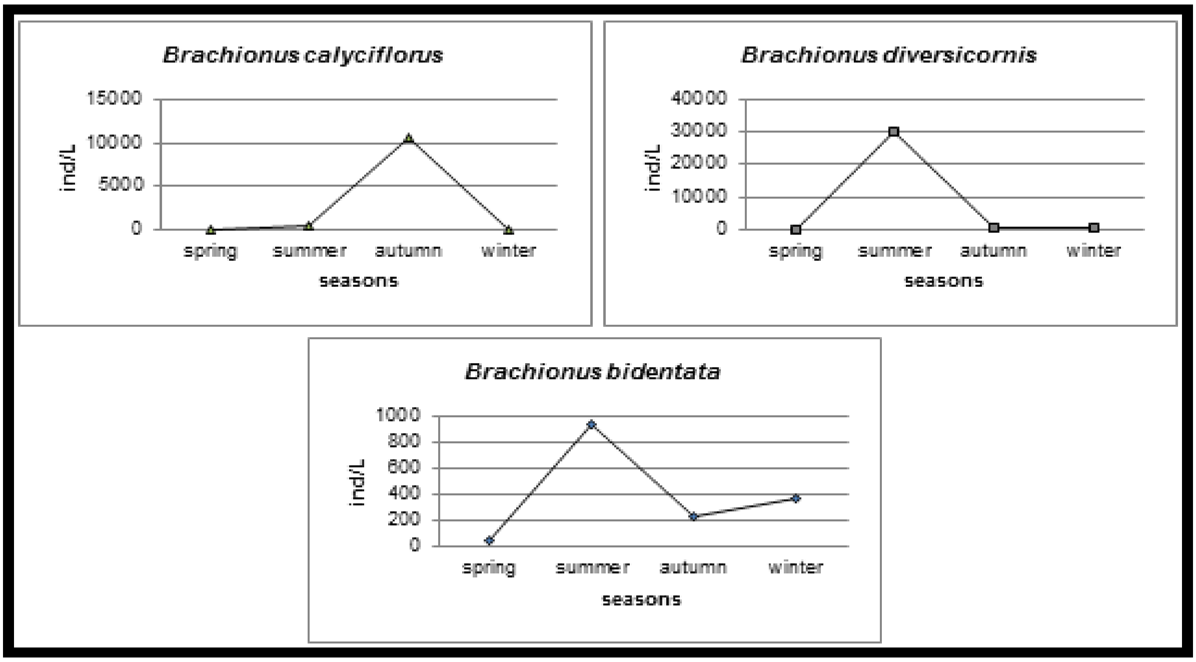

Fig.5. Seasonal dynamics of *Brachionus diversicornis*, *B. calyciflorus and B. bidentata.*

The species *B. diversiconis* was very abundant in summer
(98% of its global density).

Brachionus calyciflorus, showed low densities in winter and spring (less than 25 ind/L) and much higher ones in summer (around 113ind/L). However, in autumn, *B. calyciflorus* showed an average density of 3501ind/L and reached its highest levels by accounting for 96% of its total density (Fig.5).

Brachionus bidentata was present the year-round at densities of 76, 86, 124 and 313 ind/l in fall, spring, winter and summer respectively (Fig.5). The proportions of this species decreased in this order: summer (52.24%)>winter (20.65%) > spring 14.38%) > fall (12.71%).

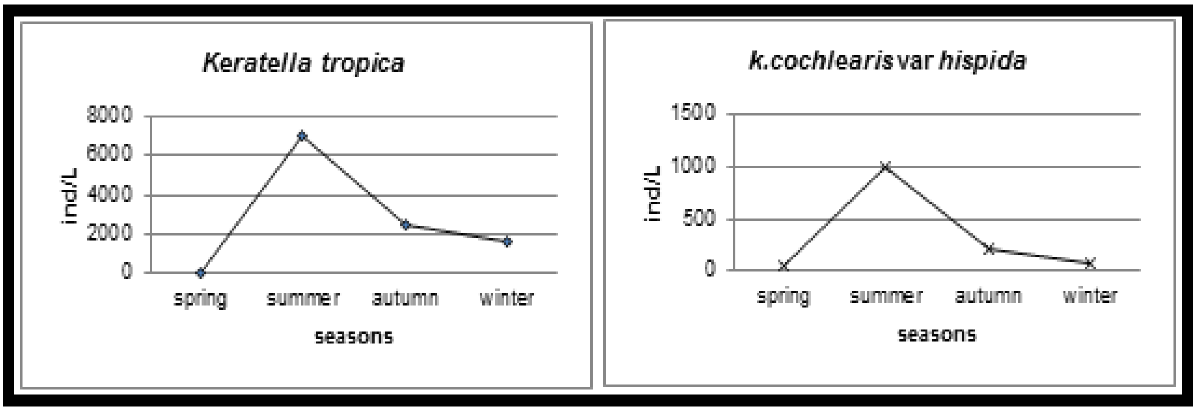

Fig.6. Seasonal dynamic of species *Keratellatropica*and*Keratellacochlearisvarhispida.*

Brachionus diversicornis showed strong positive correlations with *K. tropica* (r = 0.90, p < 0.001), with *K. c.v. hispida* (r = 0.80, p < 0.001) and with *B. bidentata* (r = 0.84, p < 0.0006) and a strong negative correlation with *P. camplanata* (r=-0.89, p <0.0001). In regard to the species *Brachionus calyciflorus*, we noted a highly significant positive correlation with chlorophyll-a (r=0.71, p<0.009) and a significant positive correlation with*K. c.v. hispida*(r=0.70, p< 0.018). The species *B. bidentata* is strongly and positively correlated with *B. diversicornis* ($r=0.84$, $p<0.0006$), with *K. c.v.hispida*($r=0.77$; $p<0.0034$) and with *K. tropica* ($r=0.85$; $p< 0.0004$) and negatively correlated with *P. camplanata* ($r =-0.89$; $p <0.0001$).

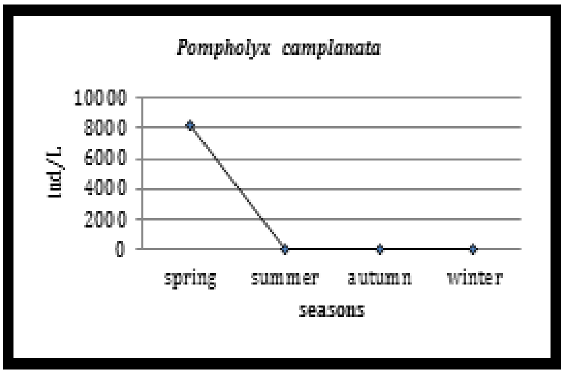

Fig.7. Seasonal dynamic of species *Pompholyxcamplanata.*

Seasonal dynamics of the species of the genus Keratella

Keratella tropica is present all year-round with seasonal medium densities of the order of 28, 540, 841 and 2326 ind/L respectively in spring and winter. In autumn and summer (Fig.6),the proportions of the species, *K. tropica* decrease according to the following order in summer>autumn>winter>spring.

The presence of *Keratella cochlearisvarhispida* is noted throughout the year; the seasonal average densities recorded are of the order of 15, 22, 68 and 332 ind/L in spring, winter, fall, and summer respectively. The seasonal dynamics of this species is illustrated by the proportions of 8% in winter and spring, 16% in autumn and 76% in summer (Fig.6).

The species *Keratella cochlearisvarhispida*, in addition to the correlations noted with the 3 species of the *Brachionus* genus, it shows positive highly significant correlations with *K. tropica* ($r=0.83$, $p<0.0008$) and with temperature ($r=0.79$; $p< 0.002$) and negative highly significant correlations with *P. camplanata* ($r = - 0.73$, $p < 0.007$). In addition to the positive correlations identified with *B. bidentata* and *B. diversiconis*, the species *K. tropica* shows a highly significant negative correlation with *P. camplanata* ($r = - 0.90$; $p < 0.0001$).

Pompholyx camplanata species

The average densities recorded by *Pompholyx camplanata* species range from 16ind/L in summer to 2748 ind/L in spring(Fig.7).This species is strongly present in spring(97% of its overall density).

Pompholyx camplanata shows negative correlations highly significant with *Keratella c.v. hispida* ($r = -0.73$; $p < 0.01$) and very highly significant with *Keratella tropica* ($r=-0.90$; $p<0.001$), *Brachionus bidentata* ($r=-0.89$; $p<0.001$) and *Brachionus diversicornis* ($r=- 0.89$; $p <0.001$).

Filiniaterminalis species:

The species *Filiniaterminalis* records average densities of the order of 4, 40, 55 and 322 ind/L respectively in winter, fall, spring and summer(Fig.8).The presence of this species is strong in summer (76% of its overall density) and very low in winter (barely 1% of its overall density).

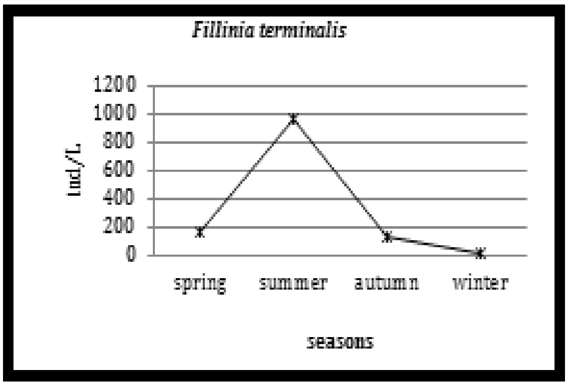

Fig.8. Seasonal dynamic of species *Filinia terminalis.*

The species *Filinia terminalis* shows positive significant correlations with *Keratella c.v. hispida* ($r = 0.61$, $p < 0.05$), with NH4 ($r = 0.68$, $p <0,05$) and with temperature ($r = 0.67$, $p < 0,05$) and negative significant correlations with conductivity ($r = - 0.64$, $p < 0,05$).

Principal components analysis

The ACP on 18 biotic and abiotic variables enabled us to explain 61.73% variability inter months (Fig.9a, 9b). Axis 1 explains 36.22% of the total variability (Fig.9a); this axis is correlated positively with N-NH4 ($r = 0.83$; $0.70 = cos^2$), N-NO3 ($r = 0.82$; $cos^2 = 0.67$), P-PO4 ($r = 0.78$; $cos^2 = 0.61$), Temp. ($r = 0.78$; $cos^2 =$

0.61), Chl-a (r = 0.64; cos^2 = 0.42), and negatively with DO (r = - 0.76; cos^2 = 0.57). On the positive pole of this axis are projected additional variables F. term. (r = 0.80; cos^2 = 0.64), *K. coch*(r = 0.74; cos^2 = 0.55), K.tro (r = 0.69; cos^2 = 0.48), *B. bid*(r = 0.62; cos^2 = 0.39) and *B. div*(r = 0.48; cos^2 = 0.23) (Fig.9b).

Axis 2 explains 25.51% of the total variability; it is positively correlated with conductivity (r = 0.85; cos^2= 0.72) and pH (r = 0.66; cos^2 = 0.43) and negatively with TURB (r=-0.76;cos^2=0.58).The factorial helped to explain the difference between groups of hot months of summer and autumn where the rotifers are more abundant and the cold months where they are poorly represented (Fig.9a).

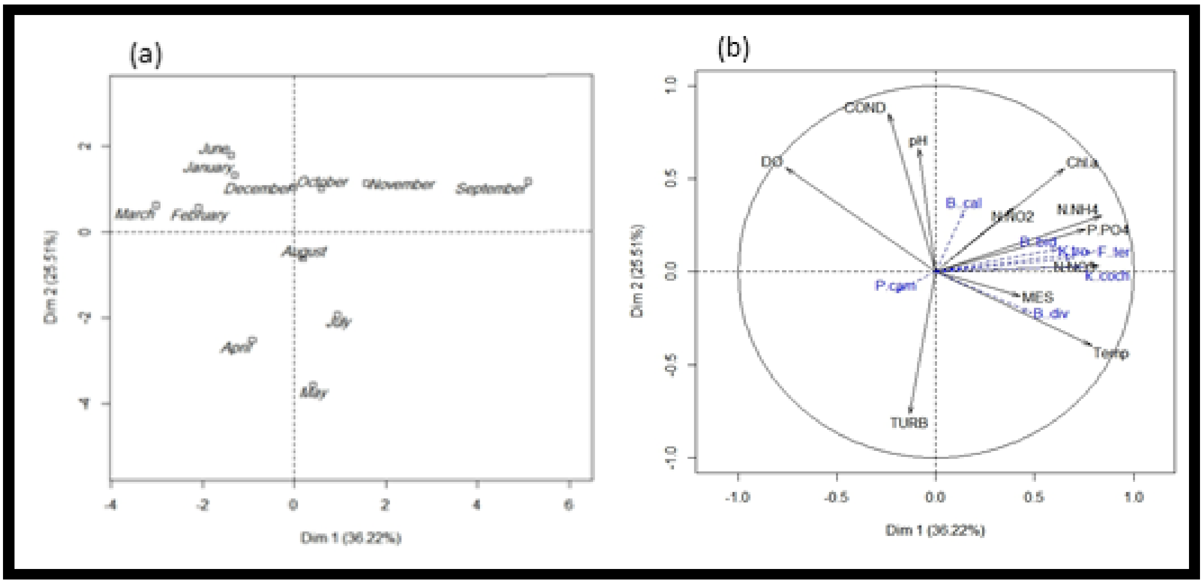

Fig.9. Principal Component analysis based on monthly variations in the Oubeira Lake. Factorial design (1, 2): axis 1: 36.22 %, axis 2: 25.51 %. a) Projection of months on the first two principal axes. b) Correlation circle of biotic and abiotic variables with the first two principal axes.

Rotifersvariations and influence of environmental parameters on species diversity

In the water of the Oubeira Lake we recorded the presence of 43 species whose more than 50% were related to the genera *Brachionus* (12) and *Keratella* (11). We noted, moreover, the presence of 3 species attached to the genera *Filinia* and *Testudinella* and 2 species belonging to the genera *Lecane* and *Pompholyx.*

In this same water pond, Samraoui *et al.* (1998) reported the presence of only 15 species attached to 10 genera. The genera common to those of the study of Samraoui*et al.* (1998) are *Testudinella, Trichotria, Lecane, Cephalodella* the species that were common were only *Trichotria tetractis, Lecane bulla, Lecaneluna.* In the study of Samraoui *et al.* (1998), the genus *Lecane*, showed the highest number of species (5). Also, these authors did not report the presence of the genera *Brachionus* and *Keratella* which presented 12 and 11 species, respectively in this study.

In the same bio-climate stage (sub-humid),ErrahmaniBrahim*et al.* (2015) noted the presence of 76 species of rotifers in Boukourdane dam water. These authors reported that species such as *Polyarthra remata*, *Keratella quadrataquadrata*, *Lecane monostyla*, *Lecane luna, Testudinella patina patina, Brachionus quadridentatusquadridentatus* and *Asplanchna priodonta* were present in more than 73% of the collected samples. These authors reported a strong presence in spring of *Keratella quadrataquadrata, Lecane monostyla, Lecane luna, Brachionus quadridentatusquadridentatus,* in spring; *Hexarthra fennica,* in summer; *Testudinella* *patina patina* and *Filinia longiseta,* in autumn and *Polyarthra remata* and *Asplanchna priodonta*, in winter

In the semi-arid bio-climate stage with temperate winter, Sellam and Arab (2013), in their study on the zooplankton fauna of the water of the dam Ghrib, collected 50106 individuals belonging to the rotifers, divided into fifteen (15) species, two (02) orders and eight) (08) families. These authors noted a high species richness (S=12) in June and low (S=2) in January. This was the case of the Oubeira Lake where ¾ of the species of rotifers were found in summer and autumn (25 and 12 species, respectively) and the remaining 1/4 were collected in winter (7) and spring (4). According to Borges and Pedrozo, (2009), the rotifers increased between May and September. In the Oubeira Lake, we noted a strong presence of rotifers (more than 64% of the whole density) in summer; their proportions were 14%, 11% and 10% in fall, winter and spring, respectively.

Among the 43 species identified in the present study, we noted the predominance of the species *Brachionus diversicornis, Keratella tropica, Pompholyx camplanata, Brachionus calyciflorus, K. cochlearisvar hispida, Filinia terminalis* which represented 27%, 21%, 8%, 6%, 6% and 3%,respectively of the total density (about 3/4 of the total density). In the Ghrib dam, Sellamand Arab (2013) reported the presence of all the genera encountered in the Oubeira Lake.These authors noted that the species of the genera *Brachionus, Cephalodella, Hexarthra* and *Filinia* were observed occasionally; however, they reported the predominance of species *Keratella quadrata* (59.34%) and *Keratella valga* (36.88%).

In the present study, *Pompholyx camplanata* represented the 4/5 of the density of the rotifers counted during spring. The species *Brachionus diversicornis* (more than 55%) and *Keratella tropica* (12%) represented more than 2/3 the density recorded in summer. More than 4/5 of the density of rotifers in autumn was represented by *Brachionus calycifrolus* (around 70%) and to a lesser extent *Keratella tropica* (15%). In winter, 39 other species predominated representing more than 50% of the total density; however, the species *K. tropica* and *Brachionus bidentata* represented 33 and 7% of the winter density of the rotifers.

According to Montemezzani *et al.*, (2016) the dynamics of the rotifers are more sensitive to the physico-chemical parameters than that of copepods and cladocerans. According to many authors, the dynamics of the rotifers depended on changes in the temperature of the water (Manca and Armiraglio, 2002; Paturej *et al.*, 2017).

Various studies (Saler and Sen, 2002; Scholl and Kiss, 2008) have shown the existence of a significant positive correlation between zooplankton including rotifers and water temperature. This correlation might possibly be due to enhanced rate of population growth due to higher temperatures (Sulahria and Malik, 2012). PCA results showed that *Filinia terminalis, Brachionus bidentata*, *B. diversicornis, B. calyciflorus* and *Keratella tropica* and *K. cochlearis* species were positively correlated with the temperature of water.

Paturej *et al.* (2017) observed peaks of populations of *Filinia terminalis* in warmer months. In the water of the Oubeira Lake, *Filinia terminalis* species showed significant positive correlations with NH_4 ($r=0.68$, $p<0.05$) and temperature ($r = 0.67$, $p < 0.05$) and negative correlation with conductivity ($r = -0.64$, $p = 0.024$).

Brachionus formed the dominant and diversified genus among the rotifers throughout the study period. These species are found extensively in eutrophic waters (Stemberger, 1990; Sampaio *et al.*, 2002). Sladecek (1983) observed that *Brachionus* species were very common in temperate and tropical waters, having alkaline pH. High concentration of rotifers as *Brachionus* species in the water body maybe due the alkaline nature of water. The rotifers prefer a pH in the range of 6.5 to 8.5 (Pourriot and

Meybeck, 1995; Neschuk *et al.,* 2002). In the Oubeira Lake, pH ranged from 8.4 and 8.8, which falls close to the recorded preference.

Various studies (Mageed, 2007; Dieguez and Gilbert, 2002) stated that presence of more than five species of *Brachionus* reflected eutrophication of water bodies. The Oubeira Lake was known to be a hyper-eutrophic water body (Boussadia *et al.* 2015).The chlorophyll-a in an aquatic body is a direct indication of algal growth. According to the OECD criteria (1982), during the present study, its concentration was practically in the eutrophic range (10-13µg/L) from February to May and hyper-eutrophic range (20 - 125 µg/L) during all other months.

According to Berzins and Pejler, (1987) *Keratella* with *Brachionus* was indicative of nutrient rich status of the water body. Many other authors (Nogueira, 2001; Gophen, 2005) also suggest that this genus is the index of eutrophic water. *Brachionus calyciflorus,* in particular, is considered to be a good indicator of eutrophication (Fiasca *et al.,*2014). Further, as per Sampaio *et al.,*(2002), Dulic *et al.,*(2006) and Sousa *et al.,*(2008) *Brachionus* genus is renowned to tolerate polluted waters.

Besides species composition, abundance is considered as a sensitive indicator of trophic state. According to Paturej (2008), density and diversity of rotifers increased significantly within increasing trophic state, elsewhere.

This finding agrees with those of the present study indicating that the Oubeira Lake had undergone progressive increase in rotifers from 15species (Samraoui*et al.,*1998) to 43 species during the present study.

Badsi*et al.* (2010) stated that the indicators of eutrophic conditions are *Brachionus angularis, Brachionus calyciflorus, Filinia longiseta, Pompholyx sulcata, Trichocerca sp, Keratella cochlearis, Keratella quadrata, Anuraeopsis fissa*. As all these species were recorded in the Oubeira Lake, we may conclude that this body water is hyper-eutrophic.

Conclusion

The present study shows that the Oubeira Lake had undergone progressive increase in rotifers from 15, in 1998, to 43 species, in 2016.

The dynamics of the rotifers are sensitive to the physico-chemical parameters. Species composition and abundance of the rotifer community recorded in the Oubeira Lake, show that this body water is hyper-eutrophic. Results of this study offer a basis to formulate sustainable management policies for aquaculture in the Oubeira Lake.

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