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Spatio-temporal dynamics of zooplankton communities (Rotifers, Cladocerans, Copepods) and water quality of Lake Léré (TCHAD)

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Abstract— *Lake Léré is situated in the Mayo-Kebbi locality southwest of Chad, it is the site for RAMSAR since 2001 hosting manatee (Trichechus senegalensis). This lake has been under study with the aimed of determining the structure of zooplankton community from February 2016 to April 2017. For this study, three sampling stations were chosen and divided into 2 to 3 layers from water surface towards the bottom. A total of 49 zooplanktonic species were identifiedin LakeLéré. This was dominated by Rotifers community with more than 75% (38 species).Rotifers and Copepodsdominated withabundance proportions of 78.10 and 60.04% respectively in the dry season. This was relatively higher compared to the rainy season (21.89 and 39.95%). In the Cladocère communities, a higherabundance was observed in the rainy season of 85.39% and 14.6% in the dry season. Therewere no significant differences between the physicochemical parameters, the sampling stations and between the different sampling levels.Thehigh values of Sorensen similarity index, shows the homogeneity of the waters of the lake and justifies the absence of significant differences in the specific richness between stations. The specific richness of zooplankton community in Lake Léré and its physico-chemical variables lead to a conclusion of the mesotrophic state of the lake's waters.*

Keywords*— *zooplankton, specific diversity, spatio-temporal distribution of Lac Léré, Chad.

I. INTRODUCTION

Nowadays the low proportion of fresh water in the biosphere, the rampant demography and the accelerated urbanization, makes this water, an increasingly precious commodity. In fact, 97% of the biosphere is in the form of salt water, in the sea and the oceans (Serra, 1999) while fresh water is distributed in bodies of water reservoirs and groundwater, only represents 0.57% (Vikram Reddy, 2005). According to UNESCO (2003), industrial effluents, chemicals waste materials and agricultural waste constitute the main part of the waste discharged into waters bodies and this waste represent about two million tons per day. The discharge of domestic waste inwater is also an important source of aquatic environmentspollution (Foto Menbohan *et al*, 2006; Zébazé Togouet, 2011).

The results of an enrichment of a hydrosystem with nutrients,favors the growth of primary producers (Othoniel, 2006) and leading in a long term eutrophication (Zébazé Togouet, 2011). The latter is manifested by an excessive proliferation of plants, a degradation of the water quality, a deoxygenation of the environment, a modification of the water profile and a decrease in biodiversity (Lemoalle *et al*., 2006; Zébazé Togouet, 2008 and 2011). Biodiversity being the engine of the functioning of an ecosystems (Hooper *et al*., 2005), its imbalance leads to the dysfunction of the ecosystem, hence the need to maintain the quality of surface water which offers several services to the society. A physico-chemical and biological evaluation is a prerequisite for this (Schuwirth and Reichert, 2012). Zooplanktons are aquatic organism, which plays a vital role in hydrosystems,it is considered to be a faithful marker of variations in environmental conditions, mainly in lentic medium (Angeli, 1980; Pourriot *et al*. 1982; Zébazé Togouet, 2011).

In Chad, as in most African countries andparticular in the Sahel, the preservation of aquatic ecosystems is of paramount importance for sustainable socio-economic and cultural development. In addition to the harmful effects of anthropogenic activities, there are problems of drought and accelerated degradation of natural resources since the beginning of this decade (El hadj Sene *et al*., 2006).

Among the aquatic ecosystems of Chad, Lake Léré, located in the Binder-Léré wildlife reserve has been a RAMSAR site since 2001. This lake is home to several protected species like the Lamentin (Trichechus senegalensis) (Beakgoubé, 2011). In addition to being a fish tank exploited by the whole locality through fishing, Lake Léré offers many services in the agricultural field through the use of its waters for irrigation and the exploitation of its watershed. These activities undoubtedly influence the state of health of this ecosystem, which can cause an imbalance at long term. The latest hydrobiological studies carried out on this ecosystem concern the work of Pourriot (1971) and Gras and Saint-Jean (1971). An assessment of the state of health of this ecosystem is therefore essential to understand its evolution and ensure a sustainable management and maintenance. The study of the spatial heterogeneity of zooplankton has other important implications in the structure and functioning of hydrosystems (Pinel-Alloul, 1995).

The objective of this work is therefore to determine the specific richness and spatial structure of zooplankton in relation to the physicochemical characteristics of the waters in Lake Léré 46 years later.

II. MATERIAL AND METHODS

Study site

Located in the West region of Mayo-Kebbi, the Léré subdivision is between latitude 9th and 10th degrees north and between longitude 14th and 15th degrees east (Pabong Dagou *et al*, 2002). The climate is the Sudano-Sahelian type, with a long dry season which extends from October to April, and a short rainy season from May to September (Djonfoné, 2003). Rainfall varies between 700 and 1100 mm with an average of 834 mm per year (Pabong Dagou *et al*, 2002), and a maximum in August (Lévêque, 1971).

Lac Léré proper is locatedbetween latitude 9 ° 38 North and longitude 14 ° 13 East (Pabong Dagou *et al*, 2002), at an altitude of 231 m (Lévêque, 1971), on the border between Cameroon and Chad along the coast of the Mayo-kebbi which connects the Chadian basin to the Niger basin. This lake has a surface area of 40.5 km^2 at low water and is presenta large flat-bottomed basin oriented from East to West, about 13 km long and 5 km wide (Lévêque, 1971). Its maximum depth is 8 m with an average depth of 4.5 m at low water. It is fed by river Mayo-Kebbi, after it has crossed Lake Tréné.

This crossing of the lake by river Mayo-Kebbi, justifies the choice of the two sampling stations located at the entrance and the other at the exit of the lake. This will help us better understand the physico-chemical and biological quality of the lake, the samples were also collected at a third station which is located between the first two. At each station, samples were collected at different depth. Thus, the sampling stations for this study are shown in Figure 1:-

- Station S1, is located at the entrance to the lake about 0.95 km from the shore, consists of two sampling points with one at the water surface and the other 2.5 m deep;

- Station S2, located 4.23 km from station S1 and it is made up of three sampling points: surface, middle (2.5 m deep) and depth (4.5 m deep)

- Station S3, located at the exit of the lake at 4.47 km from station S2, made up of three sampling points: surface, middle (2.5 m deep) and depth (4.5 m deep).

Sampling was also done at the banks of the lake along the vegetation (herbarium) between the different sampling stations. This gave us a more precise idea of the specific richness of zooplankton.

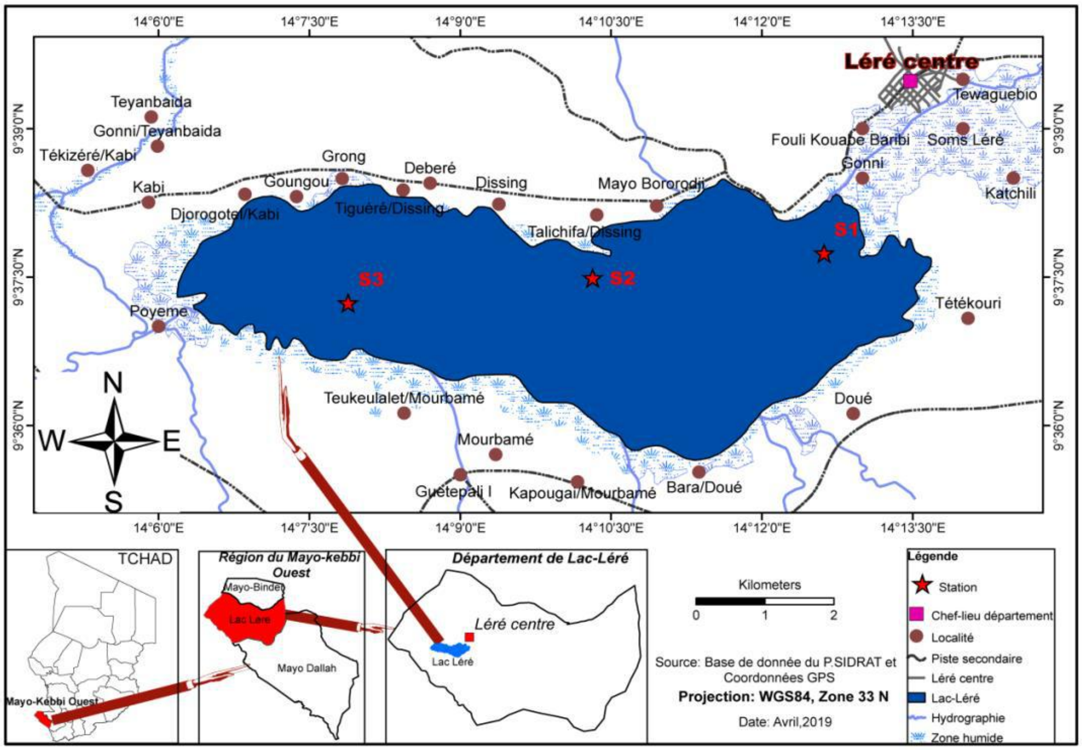

Fig.1: Geographic location of Lac Léré and the different sampling stations

Sampling and analysis of samples

The samples were collected from February 2016 to April 2017, water for physicochemical analyzes where collected for a duration of 15 months while the biological saples were collected for 13 months covering all the seasons. Sampling was carried out on a monthly basis, between 11 a.m. and 1 p.m. The water was sampled on the surface, using a 20 L bucket, and in depth using a 3L Van Dorn bottle. For the physico-chemical analyzes, the samples were stored in 1L polyethylene bottles filled to the brim, placed in a refrigerated enclosure and sent to the laboratory no more than 4 hours after collection. For biological analyzez, 20 L of water was filtered through a sieve of 0.64 µm mesh opening, then stored in 100 cc flasks and fixed in 5% formalin for courting and identification in the laboratory.

The physicochemical variables were determined in the field and in the laboratory. The transparency of water, expressed in m, was measured in situ using a 30 cm diameter white Secchi disc, weighted and attached to a graduated cord. The temperature, TDS, hydrogen potential (pH), electrical conductivity, dissolved oxygen contents of the water were measured in situ using an OAKTON brand multiparameter; the results are expressed respectively in ° C, mg / L, Conventional Units (U.C.), $\mu S.cm^{-1}$ and percentage of saturation. Water color and turbidity expressed respectively in Platinium-Cobalt Unit (U.Pl-Co) and Formazine Turbidity Unit (FTU), the nitrogen forms and orthophosphates, expressed in $mg.L^{-1}$ were evaluated in the laboratory by colorimetry using the Palintest 7100 spectrophotometer, following the methods of APHA (1998) and Rodier *et al* (2009). CO_2, expressed in mg / L, was determined by volumetry.

For biological variables, identification and counting were performed on the fixed sample under a WILD M5 binocular magnifier at 500X magnification.Identification of the rotifers is based on the morphology, the shape of the chitinous shell, the number and arrangement of spines and the number of toes. The sodium hypochlorite tissue digestion technique (Sanoamuang 1993, Sergers 1995 a) allowed the study of Rotiferous mastas whose identification was not possible with a binocular microscope by observing their morphologies. These maxtas characteristic of each species, were mounted between slid and slid plate cover and observed under the Olympus CK2 UL WCD 0.30 microscope. With regard to cladocera, the identification was made on the observation of morphological characters such as body shape, cephalic region (cephalic crest, expansions in points of lateral edges, invagination of posterior edges), carapace, detailed examination of the post abdomen, appendages. The identification of copepods was done following the shape of the body, lateral ornaments of the segments ofthe abdomen, the shape of the antennae and antennae, the position of the ovarian bags. In some cases, identification was done after dissection. Thus, with the aid of minutiae, the individuals placed on a blade are dissected in order to be able to locate the fifth pair of legs, the shape of which is characteristic of each species. This dissection is carried out under an Olympus CK2 ULWCD 0.30 inverted microscope.

The works and identification keys used to identify rotifers are those of Koste (1978), Pourriot & Francez (1986), Segers (1994, 1995), Shiel (1995), Zébazé Togouet (2000) and Wallace & Snell (2001). In cladocerans, those of Amoros (1984), Rey and Saint Jean (1980), Shiel (1995), Smirnov & Korovchinsky (1995), Zébazé Togouet (2000) and Fernando (2002) are used. The keys and works consulted for the identification of copepods are those of Lindberg (1957), Dussart (1980), Van De Velde (1984), Dussart and Defaye (1995), Alekseev (2002) and Fernando (2002).

Counting of the organisms was done on the fixed sample. 10 mL of this previously homogenized sample was extracted using a pipette and placed in a 30 mm diameter petri dish squared of 3 mm sides. The Petri dish squared prepared prevents any repetition of counting (Gannon, 1971). All the zooplanktonic organisms contained in this volume were counted at 500X magnification under a binocular magnifying glass of brand WILD M5. For a fixed sample of 100 mL, the counts were made each time on 10 mL until 400 individuals were obtained or until the sample was exhausted.

When identification was not possible under a magnifying glass, the individual was mounted between slid plate and slid plate cover for observation under an optical microscope. The density of individuals was calculated using the formula D = (nx 1000) / V where D is the density (expressed in individuals per liter), n is the number of individuals found in the volume of water analyzed under the microscope and V is the volume of water filtered in the field (20 L).

Certain physico-chemical data enabled the calculation of the organic pollution index (IPO). It is obtained using BOD_5, nitrites, phosphates and ammonium values. In the absence of BOD_5 values, the values of ammoniacal nitrogen (NH^{4+}), nitrites (NO^{2-}) and orthophosphates (PO_4^{3-}) made it possible to calculate the pollution index (IPO) during this study. The principle of this calculation is to distribute the values of these three polluting elements (ammoniacal nitrogen, orthophosphate nitrites) each of the five classes contain on Table 1 has an ecological significance. The average of the class numbers of each parameter gives the IPO values divided into 5 pollution levels (Table 2).

Table 1: Limits of Organic Pollution Index classes (Leclercq, 2001)

Classes	Paramètres		
	NH_4^+ (mg/L)	NO_2^- (µg/L)	PO_4^{3-} (µg/L)
5	< 0,1	≤ 5	≤ 15
4	0,1 - 0,9	6-10	16 - 75
3	1 - 2,4	11-50	76 - 250
2	2,5 – 6	51 – 150	251 -900
1	> 6	> 150	> 900

Table 2: Classification of pollution level based on organic pollution classes.

Class mean	5,0 – 4,6	4,5 – 4,0	3,9 – 3,0	2,9 – 2,0	1,9 – 1,0
Organic pollution level	Nulle	low	Moderate	High	Very high

Various indices allowing the characterization, composition and the evolution of the zooplankton made it possible to analyze the biological data

- The specific richness which is the total number of species in a sample;

- The SHANNON-WEAVER diversity index, which made it possible to characterize the structure of the stands. Its formula is H' = $H' = -\Sigma \, Pi \times \log_2 Pi$ where Pi represents the relative abundance of taxon i;

- The equitability index J of Piélou which made it possible to measure the distribution of species of the stand compared to an equal theoretical distribution for all the species It is obtained by the formula: J = H '/ log2 S where H' is the SHANNON-WEARVER index and S the number of species present. The index J varies from 0 (dominance of a single species) to 1 (equal distribution of individuals in stands);

- The Sorensen similarity index used to compare the different stations with each other. Its formula is $S = [2c \;/\; (a + b)] \times 100$ with a = number of species present in the first station, b = number of species present in the second station and c = number of species common to both stations;

- The frequency of occurrence (F) expressed as a percentage which is the ratio of the number of samples where this species is present by the total number of samples taken. It provides information on the consistency of a species or a taxon in a given habitat without any indication of its quantitative importance (Dajoz, 2000). According to their percentage of appearance, five categories of species are distinguished (Dufrêne & Legendre, 1997). :

Table 3: Categories of species according to frequency of occurrence

Espèces	**Pourcentage d'apparition**
Omnipresent	100 %
Regular	75 à < 100 %
Constant	50 à < 75 %
Passive	25 à < 50 %
Rare	moins de 25 %

This index is based on the presence / absence matrix and is calculated according to the relationship: F = (P_i × 100) / P_t Where Pt = the total number of samples and pi = the number of samples where the species i is present.

- The redundancy analysis (RDA) made it possible to determine the abiotic factors which influence the abundance of zooplanktonic species in the different groups. The result of this analysis is presented by a graph on which the abiotic variables, the species and the sampling sites are projected. The Redundancy Analysis was performed using CANOCO for Windows software version 4.5

III. RESULTS AND DISCUSSION

Physico-chemical characteristics

The transparency of Lac Léré varied from 0.5 to 1.1 at station S1, and from 0.5 to 1.5 at stations S2 and S3. The minimum value was recorded in the rainy season in the months of May 2016 at stations S1 and S2 and in June 2016 at station S3. In the dry season, transparency was greater (Figure 2, A), the maximum values were recorded in March 2016 and 2017 respectively at stations S1 and S2, and in October 2017 at station S3.

The water temperature of Lake Léré varied from 20 (middle of station S2 in February 2017) to 32.7 ° C (surface of station S1 in April 2016) for an annual average of 28.2 ° C ± 2 , 50. At all 3 stations and in most of the sampling points, the maximum values were recorded at the surface. The values of color varied from 0 (surface and depth of S2 in March 2017) to 580 Pt Co (Depth of S3 in June 2016). High values were recorded in depth in all the sampling stations. The turbidity during the study period varied from 0 (middle of S2 and S3) to 78 FTU (depth of S2, June 2016) for an annual average of 13.6 ± 13.2 FTU. Like color, highest values of turbidity were recorded at depth. The evolution of the TDS and electrical conductivity are more or less similar in the three stations. These TDS values oscillated between 30 (surface of S3) and 78.1 mg / L (Depth of S3). As for those of electrical conductivity, they oscillated between 60 (surface of S3) and 156 $\mu S.Cm^{-1}$ (depth of S3) for an average of 95.7 ± 13.8. The values of color and turbidity were higher in the rainy season than in the dry season unlike the values of TDS and conductivity (Figure 2 C, D, E and F).

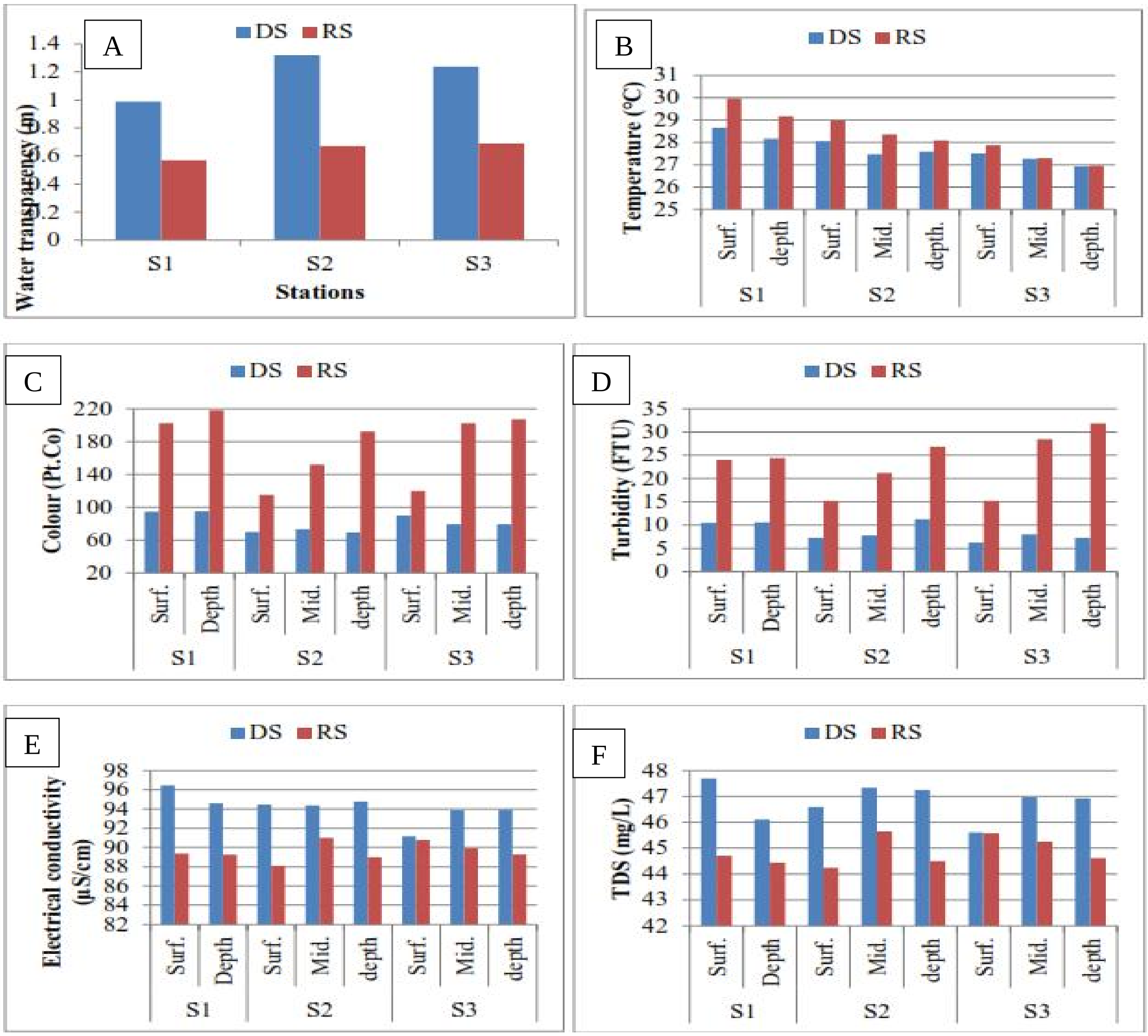

Fig.2: Seasonal variations of transparency (A), temperature (B), color (C), turbidity (D), TDS and electrical conductivity (F) during the period of study

The pH of the water is more or less neutral and fluctuated from 5.3 (depth of S1) to 8.6 CU (area of S1) with an average of 7.3 ± 0.53. In the rainy season, the waters of Lake Léré were more basic. Dissolved oxygen values fluctuated between 35 (depth of S3) and 109% (surface of S1) for an average of 64.8 ± 18.7. Carbon dioxide (middle of S2), fluctuated between 7 and 105.6 mg / L (area of S1) for an average of 29.5 ± 20.9 mg / L.

The orthophosphate contents varied between 0.1 (S3 middle) and 66 mg / L (S3 surface) for an average of 18.2 ± 13.9 mg / L. All maximum values were recorded at the surface of the three stations. Talking of nitrogenousforms, nitrates presented the highest values, particularly at the surface of all the stations, their values oscillated between 0.1 and 9 mg / L, for an average of 1.7 ± 1.4. as for nitrites, it presented lowest values which oscillated between 0 and 0.1 mg / L for an average of 0.02 ± 0.02 mg / L. NH^{4+} showed values between 0 and 0.3 mg / L for an average of 0.03 ± 0.07 mg / L.

The Organic Pollution Index (IPO) varied between 3.05 (depth S3) and 3.44 (middle S3) during the study period and indicates a moderate level of pollution in all the sampling stations.

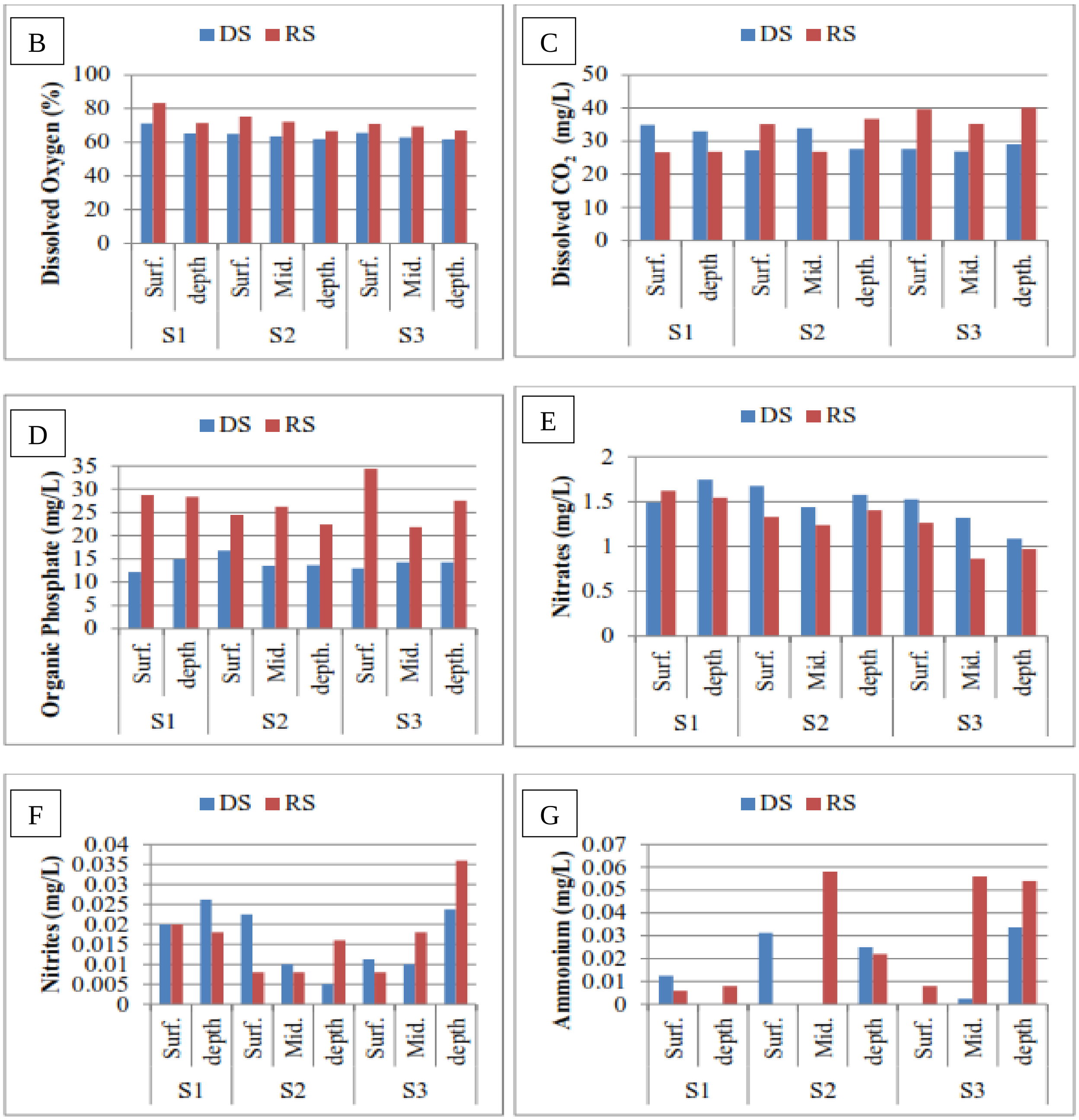

Fig.3: Seasonal variations in pH (A), dissolved oxygen (B), CO2 (C), orthophosphates (D), nitrates (E), nitrites (F), ammonium ions (G) during the study period.

Table 4:Average and extreme values of water physico-chemicalparametersin Léré lakeduring the studyperiod

		S1P1	S1P2	S2P1	S2P2	S2P3	S3P1	S3P2	S3P3
pH	Moy ± σ	7,34 ± 0,02	7,11±0,12	7,36±0,14	7,30±0,04	7,22±0,04	7,32±0,07	7,37-0,03	7,28-0,02
	Min-Max	6,1 - 8,6	5,3 – 8,4	6,36 - 8,46	6 - 8,4	6,5-7,8	6,5 - 8,5	6,4 - 8,5	6,5 - 8,3
Coul	Moy ± σ	129,4±60,1	135,9±77,8	85,6±24,7	97,6 ± 28,3	120,3 ± 53	100 ± 46	134,7 ± 46	144,7 ± 67,1
	Min-Max	10- 280	15-280	0-80	10-185	0-380	20-230	45 - 460	45 - 580
Turb	Moy ± σ	15,05±8,48	17,23±2,8	11,3±4,24	13,8±1,41	19,17±2,8	10,35±5,6	15,64±9,9	18,17±7,07
	Min-Max	4-34	6-46	4-38	0-52	4-78	4-30	0-44	2-76
Cond	Moy ± σ	94,24±1,2	93,14±1,3	96,64±23	100,2±38,5	97±22	96,3±31,1	99±32,9	99,9±38,9
	Min-Max	80-104	81-101	81-133	84-155	80-132	60-146	83-148	84-156
TDS	Moy ± σ	46,87 ± 0,70	46 ± 4,03	48,1±12,2	50,3 ± 19,5	48,4±11	48,2±15,5	49,6±16,3	50±19,9
	Min-Max	40-52	40-50,7	41-66,8	42-77,6	40-66	30-73	42-74	42-78,1
Tem	Moy ± σ	29,3±0,8	28,6±0,8	28,5±1,5	27,8±0,5	27,9±0,3	27,7±0,6	27,3±0,4	27±0,14
	Min-Max	22,7-32,7	21,2-32,5	22,4-32	20-31,1	21,7-30,9	21,8-30,8	22,4-30	22,1-30
Oxy	Moy ± σ	73,8±7	65,8±12,7	66,6±12,7	64,8±9,9	63,2±0,7	65,4±14,9	63,3±14,1	62±14,8
	Min-Max	45-109	37-105	40-105	40-101	39-106	37-107	37-103	35-105
Orth	Moy ± σ	19,7±6,2	20,1±4	20,1±1,7	20,1±3,9	17±1	22,2±8,5	18,2±7	20,2±5,2
	Min-Max	4,2-62	5,4-62	4,9-64	5-62	2,5-42	2,2-66	0,1-49	3,8-56
CO2	Moy ± σ	33,18±1,2	31,9±3,3	30,3±3	31,4±2,7	31,4±7,4	31,8±0,4	29,3±1,1	33,3±2,6
	Min-Max	13,2-105,6	11,4-92,4	9,7-76,8	7-89,8	11,4-80	7,9-83,2	8,8-65,6	10,6-83,2
Nitra	Moy ± σ	1,9±0,4	1,9±0,1	2,3±0,4	2,2±1,2	1,6±0,4	2,3±5,7	1,5±1,9	1,4±0,9
	Min-Max	0,6-5,2	0,6-4,2	0,6-7,6	0,5-8,2	0,3-3,2	0,8-9	0,1-3,8	0,3-4
Nitri	Moy ± σ	0,02±0,01	0,02±0,01	0,02±0,01	0±0,02	0,01±0	0,01±0	0,01±0	0,02±0,02
	Min-Max	0-0,07	0-0,07	0-0,13	0-0,04	0-0,06	0-0,05	0-0,06	0-0,13
Aum	Moy ± σ	0,06±0,1	0,02±0,1	0,04±0,02	0,05±0,15	0,04±0,1	0,02±0,1	0,03±0,1	0,05±0,1
	Min-Max	0-0,36	0-0,15	0-0,18	0-0,22	0-0,21	0-0,22	0-0,2	0-0,2
IPO	Moy ± σ	3,17 - 0,33	3,21 - 0,41	3,40 - 0,32	3,38 - 0,26	3,31 - 0,30	3,40 - 0,27	3,41 - 0,29	3,10 - 0,45
	Min-Max	2,67-3,67	2,67- 3,67	2,67-3,67	3 - 3,67	2,67 - 3,67	3 - 3,67	3 - 4,33	2,33 - 3,67
Tspce	Moy ± σ	0,8±0		1,1±0,7			1±0,1		
	Min-Max	0,5-1,1		0,5-1,5			0,5-1,5		

Legend: Min = minimum; Max = maximum; Avg = Average; pH, Col = colour, Turb = turbidity Cond = electrical conductivity ($\mu S.Cm^{-1}$); TDS = total dissolved solids, Temp = temperature (° C), Oxy = Dissolved oxygen (% saturation), CO_2 = carbon dioxide (mg / L), Trans = transparency (cm), NO^{3-} = Nitrate (mg / L), NO^{2-} = nitrite (mg / L), NH^{4+} = ammonium (mg / L), PO_4^{3-} = orthophosphate (mg / L), IPO = organic pollution index

The H test of Kruskal-Wallis carried out for all the physico-chemical parameters shows no significant difference, neither between the stations, nor between the different sampling points of the stations. However, the seasonal variations of certain physico-chemical parameters notably colour, turbidity, pH and dissolved O_2, were significantly higher in the dry season than in the rainy season (the test U of Mann-Whitney; $p \leq 0.05$). The Mann-Whitney test showed no significant differences in the different forms of nitrogen from one season to the next.

Biological characteristics

Specific richness

During this study, 49 species of zooplankton were collected from the waters of the lake. Among these species, there are 38 Rotifers belonging to 10 families, 5 Cladocera belonging to 3 families and 6 Copepods all from the same family (Table 5). At the surface of the three sampling stations, 27, 22 and 19 species of rotifers were identified in S1, S2 and S3respectively. At the depths of the lake, 22 species of rotifers were recorded at station S1, 26 at S2 and 25 at S3. While in the middle sampling stations, S2 and S3 recorded 25 species of Rotifers. The family Brachionidaewas the most abundant in all the sampling stationsand was closely followed by Trichocercidae and Testidunellidae.

Out of the 49 species identified in Lake Léré, six of them were recorded at the level of the herbarium or during dragging. These species are *Brachionus quadricornis*, *Lecane murayi*, *Rotaria neptuna*, *Macrothrix hirsticornis*, *Chydorus piger* and *Tropocyclops* sp.

Table 5: Average abundances of the various zooplanktonic species identified in the waters of Lake Léré and their occurrence (in brackets)

			S1		S2			S3		
Groupe	**Familles**	**Espèces**	**S1Surf**	**S1 Prof**	**S2 Surf**	**S2 Mil**	**S2 Prof**	**S3 Surf**	**S3 Mil**	**S3 Prof**
Rotifères	Asplanchnidae	*Asplanchna sieboldi,*	102 (6)	78(6)	32(4)	28(5)	19(4)	17(6)	38 (3)	23(4)
	Brachionidae	*Brachionus urceolaris*	218 (7)	306 (6)	267(7)	373(7)	929(7)	284(7)	228(6)	297(5)
		Brachionus angularis	189 (10)	152(10)	47(7)	40(5)	20(3)	16(6)	34(3)	26(3)
		Brachionus calyciflorus	14 (5)	25(4)	10(4)	29(6)	24(5)	5(2)	17(4)	18(5)
		Brachionus falcatus	7 (3)	12 (3)	17(4)	8(2)	28(2)	7(3)	2(1)	14(2)
		Brachionus quadridentatus					2(1)			
		Brachionus leydigia	1(1)				2(1)			
		Brachionus b. bidentata		11(2)			4(1)			
		Keratella tropica	199 (9)	208(8)	89(11)	267(10)	356(12)	134(11)	215(11)	340(9)
		Keratella germinata	190 (7)	231(5)	54(5)	132(6)	224(7)	55(7)	111(2)	108(4)
		Notholca jasnivskdi					17(1)	5(1)	47(1)	7(1)
	Epiphanidae	*Epiphanes clavulata*	1(1)		7(2)	2(1)	4(1)	1(1)		4((1)
	Euchlanidae	*Euchlanis dilatata*				2(1)			4(1)	2(1)
	Gastropodidae	*Ascomorpha saltans*	50 (1)	25(2)	16(3)	20(2)	19(3)	2(1)	10(1)	44(2)
		Ascomorpha ecaudis							7(1)	
	Lecanidae	*Lecane bulla*	27 (3)	48(6)	15(4)	94(4)	142(7)	188(3)	241(3)	324 (2)
		Lecane closterocerca		7(1)	23(1)	17(1)	17(1)		114(1)	
		Lecane curvicornis	3 (1)							
		Lecane tudicola	6 (1)			4(1)			6(1)	2(1)
		Lecane triphoma	3 (1)							
		Lecane ovalis	6 (2)				4(1)			
	Synchaetidae	*Polyarthra vulgaris*	80 (7)	188(8)	176(10)	381(9)	209(7)	136(6)	690(7)	582(6)

	Trichocercidae	*Trichocerca elongata*				2(1)				
		Trichocerca pussila	64 (7)	152(7)	28(6)	102(6)	62(6)	54(6)	70(4)	138(4)
		Trichocerca chattoni	118 (11)	148(8)	107(11)	123(11)	91(11)	77(10)	84(9)	108(9)
		Trichocerca iermis	21 (4)	115(3)	27(4)	107(2)	207(1)	10(2)	74(2)	69(5)
		Trichocerca capucina	3 (1)							
		Trichocerca heterodactyla	93 (4)	135(5)	17(2)	40(4)	79(5)	59(4)	41(4)	69(6)
	Testitudinelidae	*Filinia opoliensis*	201(8)	339(9)	85(8)	30(4)	136(8)	92(8)	254(7)	294(8)
		Filinia terminalis	86 (8)	316(9)	67(6)	233(7)	137(9)	139(7)	165(6)	610(8)
		Filinia longiseta	4 (1)		3(1)	4(1)				17(1)
		Filinia pjleri	5 (1)	84(3)	7(3)	6(2)	2(1)		5(1)	11(2)
		Testudinella patina	16 (3)	25(3)	5(1)	17(3)	8(2)		12(3)	15(3)
	Philodinidae	*Rotaria sp*	52 (10)	78(6)	50(6)	81(8)	89(5)	53(7)	93(8)	96(6)
		Rotaria rotataria		34(2)					7(1)	4(1)
Cladocères	Moinidae	*Moina brachiata*	22 (5)	59(5)	88(5)	101(4)	60(3)	8(3)	16(4)	134(5)
	Macrothricidae	*Macrothrix rosea*	2(2)	3(2)	9(3)	4(1)	6(1)	2(1)	19(3)	
		Acroperus harpae	6(2)	26 (3)		2(1)		4(1)	2(1)	2(1)
Copépodes	Cyclopidae	*Metacyclops sp*	4(1)	34 (2)						6(2)
		Thermocyclops crassus								4(1)
		Thermocyclops neglectus	5(1)	21 (2)		3(1)	2(1)	2(1)		
		Cryptocyclops sp1								2(1)
		Cryptocyclops sp2		7(1)						
	Larves	Larves naupléus	251(11)	552(12)	210(12)	545(12)	595(12)	162(11)	540(11)	443(12)
		Larves copépodites	173(11)	298(9)	181(10)	237(13)	307(13)	31(8)	131(11)	362(11)

Spatial and seasonal variations in abundance

Rotifers have been the most abundant group of zooplankton. They contributed 79.16, 70.18 and 86.45% abundances respectively in S1, S2 and S3 at the surface. In depth of the water, their percentages in terms of abundance were 73.09% at S1, 74.48% at S2 and 77.17% at S3. While in the middle, S2 and S3, showed 70.63 and 78.39% rotifers abundances respectively.

As for crustaceans, at surface of S1, the abundances were 30 ind / L or 1.35% and 433 ind / L or 19.48% respectively for Cladocera and Copepods with all stages of development considered. At the depth of water, their abundances were 88 ind / L or 2.36% for Cladocera and 912 ind / L or 24.53% for Copepods. In S2, the abundance percentages of Cladocerae at the surface were 5.9, 3.52 and 1.73% respectively. Copepods from all stages of development contributed 23.88% on the surface, 25.83% in the middle and 23.78% in depth of the water. In S3, as in the first two stations, Cladocera were the least abundant. Their proportions were 0.90% on the surface, 1.12% in the middle and 4.15% in the depth. The Copepods contributed 12.63%, 21.60% and 24.93% from the surface to the depth.

Among the Rotifers, the family Brachionidae, Testitudinellidae and Trichocercidae showed the highest abundances. Among Cladocerae, the family Moinidae distinguished themselves from the others while Copepods were only represented by the family Cyclopidae.

At S1, in the family Brachionidae, the most abundant species was *Brachionus urceolaris* which contributed 9.81% at the surface and 8.23% at the depth. It was followed by *Brachionus angualris* (surface: 8.50%, depth: 4.08%), *Keratella tropica* (surface: 8.95%, depth: 5.59%) and *Keratella germinata* (surface: 8.55%, depth: 6.21%). Among the Testidunellidae, *Filinia opoliensis* (surface: 9.04%; depth: 9.12%) and *Filinia terminalis* (surface: 3.87%, depth: 8.50%) showed the highest abundances.

At the station S2, *Brachionus urceolaris* showed 16.31% at the surface, 12.27% in the middle and 24.44% at depth, *Keratella tropica* (surface: 5.43%; middle: 8.78%; depth: 9 , 36%), *Keratella germinata* (surface: 3.29%, medium: 4.34%, depth: 5.89%), *Filinia terminalis* (surface: 4.09%, middle: 7.66% and depth: 3 , 60%), *Filinia opoliensis* (surface: 5.19%, middle: 0.98%, depth: 3.57%) and *Trichocerca chatonni* (surface: 6.53%, middle: 3.04%, depth: 2 , 39%.) the species in the station showed the highest abundances within their families.

The species that contributed considerably to the zooplanktonic abundances at station S2 were all recorded in station S3 with the exception of *Trichocerca chatonni*. These are, *Brachionus urceolaris* (surface: 18.40%, middle: 6.95%, depth: 7.11%,), *Keratella tropica* (surface: 8.68%, middle: 6.56% and depth: 8, 14%), *Keratella germinata* (surface: 3.56%, middle: 3.38%, depth: 2.58%), *Filinia terminalis* (surface: 9%, middle: 5.03%, depth: 14.61%) and *Filinia opoliensis* (surface: 5.96%, middle 7.75%, depth 7.04%)

Among the cladocerans, *Moina brachiata* was the most abundant in the three sampling stations. At S1, it contributed 0.99% at the surface and 1.58% at depth. At S2 and S3, its proportions were respectively 5.37 and 0.51% at the surface, 3.32 and 0.48% in the middle and 1.57 and 3.20% at depth. The contributions in abundance of copepods are mainly due to nauplea and copepodite larvae which contributed more than 7% in most of the sampling levels. Statistical tests show that there is no significant difference between the different sampling points and the different stations.

Seasonally, rotifers and copepods were more abundant in the dry season than in the rainy season, unlike cladocerans, which had considerable abundance in the rainy season. The Man-Whitney U test indicates a significant difference between the two seasons in the abundance of zooplanktonic species (p = 0.29).

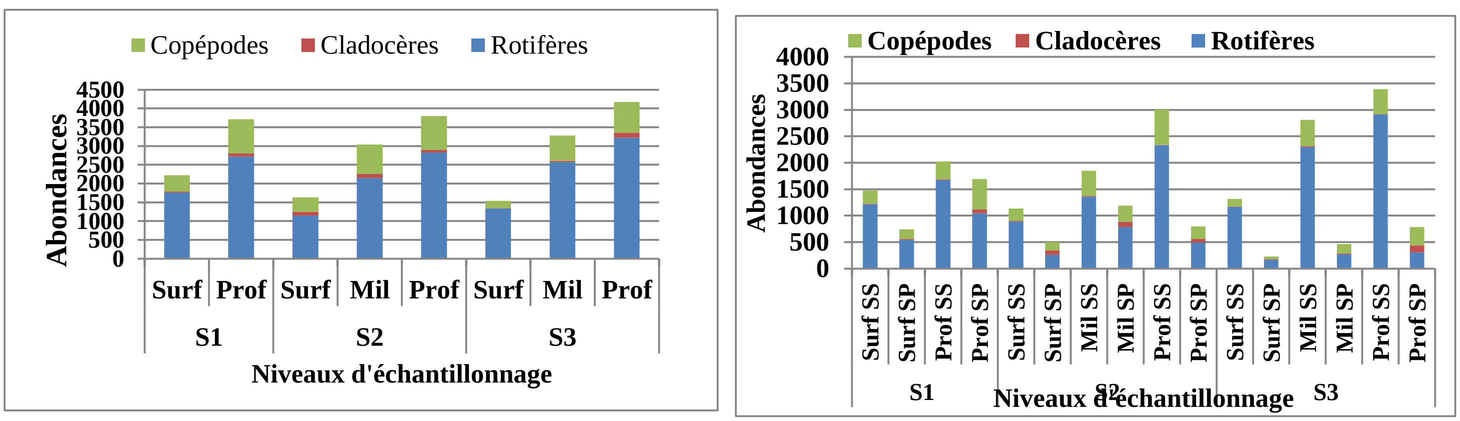

Fig.4: Contribution of rotifers, cladocerans and copepods, to the abundance of zooplankton at different sampling levels throughout the study period (A) and according to the seasons (B). Surf: surface, Mil: middle, Dep: depth, DS: dry season, RS: rainy season.

Population structure

The diversity index of Shannon and Weaver (H ') per sampling station varied between 4.13 (S2 dep) and 4.51 (S1 surf), as for the Pielou equitability index (E), it varied between 0.75 (S1 surf) and 0.94 (S3 surf) in the three stations (Figure 5A). Seasonal variations indicate that the highest values of the Shannon and Weaver diversity index (4.55) and the Pielou equitability (0.98) in the dry season were recorded at the surface of S1 and S3respectively. The lowest values (H '= 3.87; E = 0.83) were all obtained at depth from station S2. In the rainy season, H 'varied between 3.82 and 4.45, obtained respectively at the depth of station S1 and in the middle of station S3. Pielou's fairness index varied between 0.93 and 0.97 obtained in the middle and on the surface of station S2respectively.

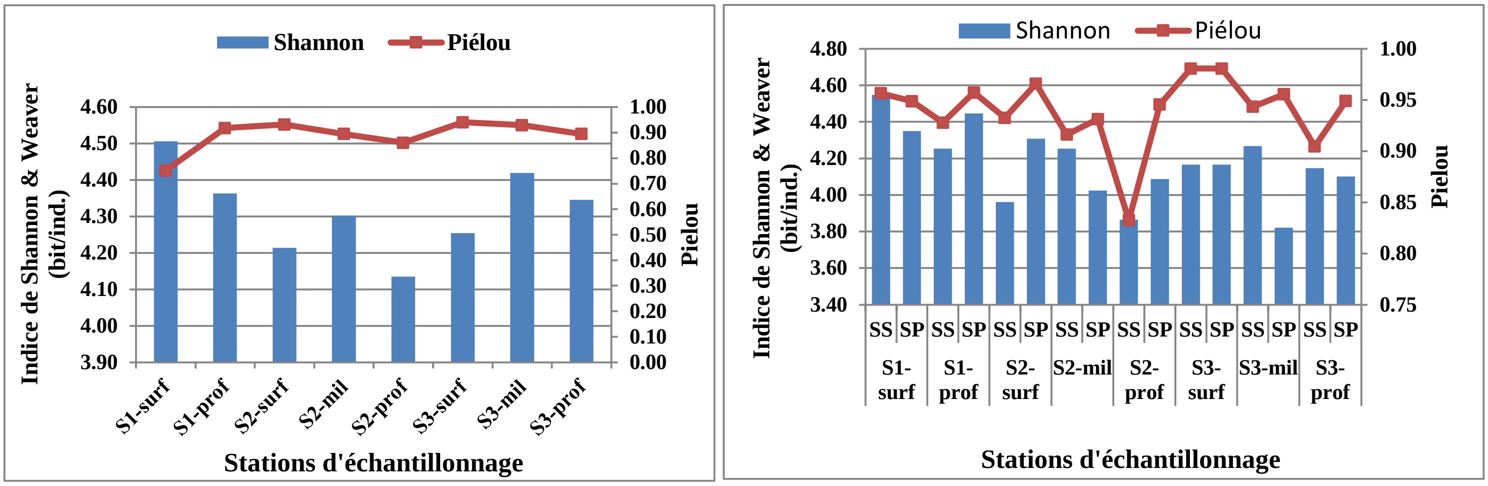

Fig.5: Spatial (A) and seasonal (B) variations of the Shannon and Weaver index and the Piélou fairness index in Lake Léré. S1: station S1, S2: station S2, S3: station S3, DS: dry season, DS: rainy season, Surf: surface, Mil: middle, Dep: depth

The values of the Sorensen similarity index (table 6) between the stations S1 and S2, S1 and S3 and the stations S2 and S3, were very high, indicating that there is a very great resemblance between the three stations

Table 6: Values of the Sorensen similarity index between stations S1, S2 and S3.

Stations	Sorensen Indice
S1-S2	85,71
S1-S3	82,85
S2-S3	85,29

The redundancy analysis (Figure 6) highlights the physicochemical parameters influencing the abundance of zooplanktonic species. Axis I isolates in its positive part the species *Keratella tropica*, *Keratella germinata*, *Brachionus urceolaris*, *Rotaria* sp, *Polyarthra vulgaris*, *Trichocerca heterodactyla*, *Filinia opoliensis*, *Trichocerca pussila*, *Lecane bulla*. These species are found in waters rich in carbon dioxide, with a high pollution index and therefore, little turbid, less mineralized, less oxygenated. In contrast, in its negative part, the species *Moina brachiata*, *Trichocerca chatonni*, *Filinia terminalis*, *Trichocerca iermis*, *Brachionus angularis*, *Asplanchna sieboldi*, *Macrothrix rosea*, the naupléus and copepodites larvae evolve in stations where the waters have high temperatures and are turbid, alkaline, mineralized with a high phosphate and nitrogenous forms. Most of these species are high density rotifers.

In its positive part, axis II isolates the species *Brachionus angularis*, *Brachionus falcatus*, *Asplanchna sieboldi*, *Brachionus leydigia*, *Euchlanis dilatata*, *Macrothrix rosea*, as well as the nauplus larvae which are fond in waters rich in different forms of nitrogen. On the opposite side, these are *Moina brachiata*, *Trichocerca chattoni*, *Filinia pjleri*, *Filinia terminalis* and the copepodite larvae which have a high affinity for environments with alkaline water.

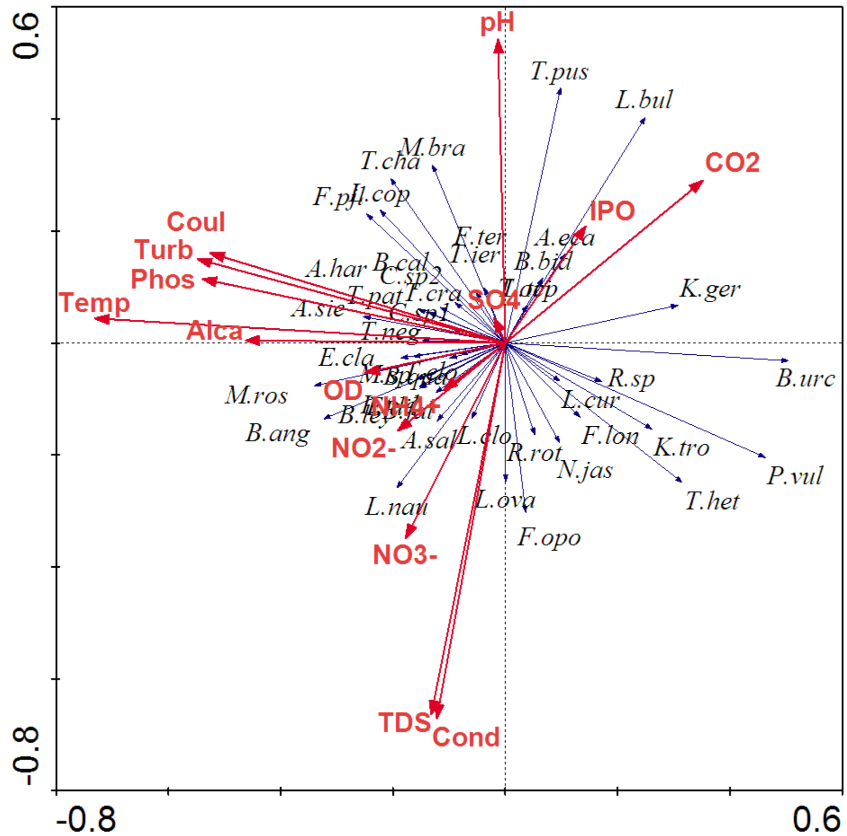

Fig.6: Redundancy analysis of zooplanktonic species and physico-chemical parameters. Alca = Alkalinity, NH^{4+} = Ammonium, BOD = BOD_5, Cond = Conductivity,

DO = Dissolved oxygen, N03- = Nitrates, NO2- = Nitrites, Phos = Orthophosphates, TDS = Total Dissolved Solids, Temp = Temperature, Turb = Turbidity, Col = Color, CO2 = Dissolved carbon dioxide, IPO = Organic pollution index.

3-1- Discussion

3-1-1- Physico-chemistry of the waters of Lake Léré

The temperature values were higher on the surface of all the stations; this could be explained by the sunshine on water surface. It was slightly higher in 2016 during the months of February, March and April, compared to 2017. The rise in temperature is more significant if we consider the work of Lévêque (1971) on Lac Léré, as well as those of Palou (2005) who underlines the fact that, the climate of the Mayo-Kebbi basin experiences very strong variations in temperatures with maxima which exceed 40 ° C and minima which are above 25 ° C. The absence of a significant difference in the water temperature between the different sampling levels as well as between the seasons suggests the absence of thermal stratification within the lake.

The dissolved oxygen contents are higher at the surface than at depth, this can be explained by the high light intensity, thus causing a fairly significant photosynthetic activity compared to the depths of the lake which are not necessarily anoxic. Conversely, the CO_2 content is higher at the depth of the stations.

The average pH of 7.29 obtained corresponds to a neutral pH. This value is in the range of those of natural waters which must not be less than 6 (Ramade, 2005). The value recorded in 1970 was 8 at all levels of the sampling stations (Lévêque, 1971). There is therefore a slight acidification of the waters of Lake Léré.

In the rainy season, color and turbidity had strong values; which would be due to the phenomenon of erosion of the watershed which leads to an excessive supply of dissolved matter by runoff as highlighted by Passinring (2016). In addition, the highest values were recorded at depth from all stations; this would reflect a concentration of deep water in suspended particles.

The value of electrical conductivity recorded in 1970 (89 µS.cm^{-1}) is low compared to the average recorded during this study period (95.74 ± 13.77), this could be as a result of erosion of the watershed from 1970 to the present days (statistical test). The values of these parameters are lower than those found in eutrophic lakes such as the Yaoundé Municipal Lake (Zébazé Togouet, 2008), Lake Nkolbisson (Ndjama *et al*., 2017). Within these lakes, the minimum values recorded were 152 µS.cm^{-1} and 90 µS.cm^{-1} respectively and maximum values were 437 µS.cm^{-1} and 260 µS.cm^{-1}. However, they are higher than those recorded in oligotrophic lakes such as Lake Ossa (Nzieleu *et al*., 2012) where the average recorded was 27 µS.cm^{-1}.

The high content of orthophosphates in the rainy season is could be due to runoff from the watershed during the rainy season. Ryding and Rast (1994), stipulates that a lentic ecosystem is engaged in an accelerated eutrophication process when the PO_4^{3-} contents of its waters are greater than 100 µg. L^{-1}, for this purpose, Lake Léré can therefore, be called a eutrophe. The nitrates contents were higher during the dry season, at low water contain. This is due to evapotranspiration in the dry season, resulting in a high concentration of nitrates compared to the rainy season. These nitrate contents are similar to those obtained by Mama *et al*. (2011) in Lake Nokoué (Benin). The NH^{4+} contents (0 to 0.36 mg / L) were low, they are far lower than those recorded in the Municipal Lake of Yaoundé, a lake qualified as eutrophe (Zébazé Togouet, 2008 and 2011).

Ultimately, the result of the physicochemistry, shows a homogeneity of the waters of Lake Léré and a slight evolution of these waters, mainly due to the erosion of the watershed. However, apart from the temperature, the other physico-chemical parameters mark the seasonality of the lake waters. These waters are less oxygenated, less turbid in the dry season, and rich in orthophosphates in the rainy season. Taking into account the Lewis classification (1980), Lac Léré can be classified as a mesotrophic lake.

Lake Léré Zooplankton

The species identified during this study period consisted of 38 Rotifers, 5 Cladocera and 6 Copepods, whereas in 1970, only 22 species of rotifers were recorded, with practically the same number of Cladocera and Copepods. However, the absence few species during this study period that werereported in 1970, particularly at the herbarium, could be explained by the disappearance of their different micro-habitats. Indeed, Passinring (2006) highlighted that, the elimination or reduction of possibility of plant fixation could be due to exploitation of quarries on the watershed of the lake. This fact was noted by Zébazé Togouet (2008) in the Yaoundé Municipallake where the decline in specific diversity was due to the disappearance of the herbarium as a result of the disappearance of a large number of microhabitats.

However, the works of Pourriot (1971) and Gras and Saint-Jean (1971) was only carried out during the month of February with a single sampling campaign, whilesamplingthis work was done for 13 months taking into account all seasons of the year and a number of sampling stations were fairly represented in the lake. This implies that a number of species could not be identified in 1970 due to the short sampling period. The sampling effort, as well as the duration of the study, makes it possible to consider these results to be closer to the reality (Zébazé Togouet *et al*., 2005). According to Balvay, 2009 long-term studies with a certain sampling frequency are therefore likely to improve knowledge of the composition of planktonic biocenosis and its seasonal and long-term variations. However, some species identified by Pourriot, Gras and Saint-Jean (1971) that were absent during our study period should not be considered extinct from the lake. However, some species may be temporarily absent because they are not abundant, or not sought in their preferred biotope (Balvay, 2009).

The specific richness obtained is higher than those obtained by Adandedjan *et al*. (2017) in Lake Nokoué (Benin) and Fofana *et al*. (2019) in Lake Kaby (Côte-d'ivoire) but it is lower than those obtained by Oueda and Guenda (2011) in the Bagré dam lake (Burkina-Faso) and Tchapgnouo *et al*. (2012) in the Ossa lake complex (Cameroon).

In comparison with the work of Pourriot (1971), Gras and Saint-Jean (1971), the results obtained during this study reveal an increase in the specific zooplankton richness of Lac Léré. Physico-chemical parameters, in particular orthophosphates, conductivity, nitrates, indicate a mesotrophic state of the waters of Lake Léré.

With regard to rotifers, the Brachionidae family is the most represented with 11 species, followed by

Trichocercidae and Testitudinellidae with 6 and 5 species respectively. This family succession is similar to that observed by Nzieleu Tchapgnouo (2016) in Lake Ossa, Zébazé Togouet *et al.* (2005) and Zébazé Togouet (2011) in Yaoundé Municipal Lake which are eutrophic in nature. However, this two lakes host 14 and 17 species of Brachionidae respectivelywhich are greater compared toto the species identified in Lake Léré. Although the richness of a lake in Brachionidae had already been noted as a characteristic of eutrophic environments and of strong eutrophication of the environment (Lair *et al*., 1998), but that of Lake Léré cannot be conferred on the status of a eutrophic lake. Moreover, Lake Léré with its 8 species of the genus Brachionus is similar to Lake Oxbow (Kar Sulata and Kar Devashish, 2013), an oligotrophic lake, whose zooplankton fauna is dominated by Rotifers with 6 species of the genus Brachionus.

The specific richness of rotifers in Lac Léré is higher in the dry season than in the rainy season. The fairly large quantity of nutrientsis due to the high values of nitrates during this period, could explain the proliferation of Rotifers, which are mainly herbivores. This result concur with those of Okogwu (2009) and Adandedjan *et al*., (2017), but contrast with those of Ayoagui and Bonecker (2004).

However Ayoagui and Bonecker (2004) and Okogwu (2009) agree that the low rate of cladocerans would cause a lack of competition with the larger rotifers. Indeed, Ayoagui and Bonecker (2004) established that zooplanktonic diversity is increased by the scarcity of dominant competitive species

Among the crustaceans, Cladocères, Chydoridae and Macrothricidae, were the most represented in Lake Ossa followed by family of Bosminidae (Nzieleu Tchapgnouo, 2016). Consisted essentially of littoral and periphytic species, Chydoridae and Macrothricidae presented the same number of species during the two seasons at the stationS1, which is the shallowest point. At the two other stations S2 and S3, the number of species is generally higher in the rainy season than in the dry season. This could be explained by the fact that in the rainy season, these periphytic species would be carriedin runoffcurrentto pelagic environments. This demonstrates the multitude of micro-habitats that the herbarium offers to zooplanktonic species. In Lake Chad, the presence of pelagic species belonging to these families is believed to be due to the reduction in the water level of the lake (Rey and Saint-Jean, 1980).

Likewise after the big rainy season, there is a modification of the lake ecosystems by the supply of nutrients, lowering the water temperature (favorable for the hatching of eggs) with a rise in the level of the lakes water which lead to the flooding of coastal areas rich in eggs (Dejen *et al*., 2004; Mergeay *et al*., 2006). The flood contributes positively to the growth of cladocera populations by bringing new nutrients and mixing the native nutrients present in the different strata of the lakes (Tchapgnouo *et al.*, 2012) thus favoring the production of phytoplankton and, consequently, that of zooplankton. Like in the Yaoundé Municipal lake (Zébazé Togouet, 2008), the large predatory cladocerans were not observed during our study period as well as in 1970.

Among the Copepods, all identified species belong to the Cyclopidae family. They were not represented in the various stations throughout the study period. Gras and Saint-Jean (1971) underline the fact that the rarity of the adult forms of crustaceans is due to the strong predation exerted by the larvae of Chaoborus which are abundantly present in the bottom. During our study, the adult forms were identified mainly during the transition between the two seasons in most of the sampling stations. This can be explained by the abundance of nutrients in this period. Indeed, their developmental cycle depends on the presence of food in the environment (Drira *et al*., 2007), as well as on the temperature (Moison, 2009). According to Zébazé Togouet (2000), the copepod developmental cycle lasts less than a week in tropical regions where the sunshine is higher compared to the temperate zone.

The specific richness in Lake Léré during the study period confirms the assertion of Dumont (1994) concerning the increase in the number of studies in tropical waters which will undoubtedly result in an increase in the number of species described. Zébazé Togouet *et al.* (2005) also underlines that the paucispecificity of Rotifers is due to the scarcity of hydrobiological works in tropical waters. The species encountered are mostly cosmopolitan. This same observation was noted by Pourriot (1970).

In terms of abundance, rotifers were the most abundant zooplankton group during the entire study period, at all sampling stations. They represented 76.55; 72.27 and 79.20% of the abundances, respectively at stations S1, S2 and S3. This is a characteristic of tropical lakes (Bidwell & Clarke, 1977; Okogwu, 2009; Zébazé Togouet, 2011). The numerical dominance of Rotifers over other zooplankton groups in tropical environments can also be explained by their opportunistic nature allowing them to better resist variations in environmental conditions, as well as their greater competitiveness in these environments and their food plasticity vis-à-vis the available resources, but also because of their small size which makes them less vulnerable to the pressure of predation (Dumont 1977, Matsumura-tundisi *et al*., 1990). The abundance of Rotifers being greater in the dry season compared to the rainy season with 78.1 and 21.89% respectively could be explained by the increase in phytoplankton biomass with increase concentration of nitrates in the dry season.These nutrients (phosphates and nitrates) lead to an increase in the phytoplanktonic biomass of the environment (Akodogbo *et al.,* 2014). Moreover, the growth of rotifers is favored by an increase in nutrient levels (Jalal *et al*., 2005). Chiali and Cherifi (2019) also stated that, the difference in the abundance of zooplankton is linked to the conditions of the environment favorable to its development such as nutrients and phytoplankton is considered as an important source of food. As the abundance of Cladocera Crustaceans is preponderant in the rainy season,their predation on Rotifers becomes considerable, hence the low abundance of Rotifers during this same period. Cladocerans represent the least abundant zooplankton group in Lake Léré during the study period with an abundance of 1.90; 3.18 and 2.07% respectively at the stations S1, S2 and S3. This low abundance of Cladocerans is a characteristic of most tropical lakes (Dumont, 1994; Fussmann, 1996; Moss, 1998). Cladocerans in Lake Léré was mainly represented by *Moina brachiata* species. This result is comparable to that of Pont (1977) which shows that the abundances of *Moina brachiata* can reach 98% in the rice fields of Camargue. This species is characterized by the rapidity of its development. Its optimum growth temperature varying between 24 and 31 ° C (Rottmann, 1992) which approaches the average temperature recorded in Léré Lake. Likewise, it adapts to variations in oxygen concentration (Rottmann, 1992).

The abundance of Copepods is mainly due to the larval stages. The low proportion of adult copepods could be explained by several factors, namely predator pressures, currents (Zébazé Togouet, 2008), the ecological logic of food webs (Odum, 1959; Frontier 1977) or the lack of suitable habitatin the biotope for their development (Shiel *et al*., 1998; Lougheed & Chow-Fraser, 1998).

Analysis of the seasonal dynamics of zooplankton in Léré Lake makes it possible to distinguish three periods. At the end of the rainy seasons, during the low water period, there is a drastic decline in the population of cladocera in favor of rotifers. These rotifers, which are more adapted to environmental changes and organic pollution, would be less affected by certain phenomena such as high temperatures and deterioration in water quality, unlike other organisms (Onana *et al*., 2014). During the advanced low water period, the low volume of water and the low nutrient in the environment lead to a relative decrease in abundance and specific richness, which stabilizes until the start of the floods. During the rainy season, the abundance of cladocerans is gradually increased. In fact, the significant supply of nutrients leads to an increase in the specific richness and abundance of zooplankton. The rainy seasons contribute positively to the growth of cladoceran populations by bringing new nutrients and by mixing the old nutrients present in the different strata of the lakes, thus favoring a strong production of planktonic organisms and the drainage of new species of cladocerans bordering other aquatic environments (Tchapgnouo *et al.* 2012).

This dynamics of zooplankton populations is governed mainly by the volume of water but also certain physico-chemical parameters such as nitrates, ammonium ions, electrical conductivity, turbidity, water temperature and pH. Maintaining these parameters at more or less stable values which correspond to the requirements of the zooplankton communities is necessary for maintaining the diversity and stability of the stands.

Spatial and seasonal structure of zooplankton

The values of the Shannon and Weaver diversity and Pielou fairness indices suggest that the different stations contain a more or less equal number of species distributed in an equitable manner. This explains the high values of Sorensen's correlation coefficient which indicates a great similarity between these three stations. Similar observations were made by Saint-Jean (1983), Okogvu and Ugwumba (2006). These observations are however contradictory to those of Adandedjan, (2017) and Fofana (2019) who point out an instability in the structure of the zooplanktonic community respectively in Lake Nokoué and Lake Kaby, due to the variability of conditions of the environment along the water.

The absence of significant differences in the physico-chemical parameters as well as the specific richness between the different sampling levels justifies the homogeneous distribution of zooplanktonic organisms. It also shows the homogeneity of all the waters of Léré lake.

IV. CONCLUSION

Physico-chemical analyzes of the waters of Lake Léré have shown values indicating on one hand that Lake Léré is a mesotrophic lake and on the other hand the absence of stratification within the lake, hence the homogeneous distribution of species. The species newly cited in this study could be due to the sampling effort or to a significant enrichment in nutrients of Lake Léré since 1970 to the present day. Indeed, the population around the lake is estimated at 84,652 inhabitants (Florence & Solkem, 2016) carries out a less intense traditional agro-silvo-pastoral activity, this implies a less anthropogenic impact, not leading to a rapid enrichment of the lake. The physico-chemical parameters govern the zooplankton dynamics. The most resistant rotifers in the group were the most abundant, especially in the dry season than in the rainy season. Cladocera have a dynamic linked to water movements. Thus their abundance is improved in the rainy season. The higher abundance of Copepods in the dry season is mainly due to the larval stages.

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