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Physico-chemistry characterization and zooplankton specific diversity of two fishponds in Yaoundé (Cameroon, Central Africa)

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Abstract

The specific composition and structure of zooplankton in two fish ponds (one being natural E1 and the other man-made E2) in Simbock, Yaoundé, was studied in relation to some physico-chemical variables, between April and December 2007. Physico-chemical parameters were measured according to the techniques described by APHA (1985). Biological analysis was done, using specific identification keys. Sixty nine zooplankton species, mostly coastal, periphytic and cosmopolitan, were identified, rotifers being the most abundant (71%). Eight of these species were recorded for the first time in Cameroon: the Copepod *Diaptomus sp.*, the Rotifer *Macrochaetus sp.* and the Cladocerans *Leydigia australia, Pleuroxus chappuini, Daphnia magna, Chydorus baroisi, Guernella monodi, Moinodaphnia macleayi.* Zooplankton abundance was low (less than 400 ind. / L) throughout the study. Thus the water bodies showed limited food resources. Cladocerans density was high before the stoking (at the beginning of the study) and became very low one month after. This group is probably a preferred food for fry and juvenile fish. Index values of Shannon and Weaver together with Evenness of Pielou demonstrated that these environments are highly diverse and reveals a more or less equal distribution between species. Biocenotic and biotic parameters confirmed that these waters are oligotrophic (E1) and oligomesotrophic (E2); therefore they can't fully meet the expectations of the farmers. It is recommended that farmers should have a basic understanding of the biology and ecology of the water bodies used for fish production.

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Introduction

Zooplanktons are important component in the structure and functioning of pond ecosystems. Indeed, by their grazing activity, these organisms are an essential trophic link between primary producers and higher organisms (Shiel, 1995; Pourriot and Francez 1986; Lair *et al.*, 1998). Hence Haberman (1998) suggested that over 60% of the lake primary production are transferred from zooplankton to fish fry. According to Amoros (1984); Nogrady and Pourriot (1995), Piasecki *et al.* (2004) and Brassard (2009) zooplankton is the most important source of protein for fry, planktivorous and omnivorous fishes. Zébazé Togouet *et al.* (2006) also showed that these organisms are sensitive to the modifications of environmental conditions and are excellent indicators of pollution. In view of the zooplanktons role in aquatic environments, knowledge of their specific diversity and structure in small water collection is necessary for the development of an effective management strategy.

However, few studies have examined the dynamics of zooplankton in fishponds located in the equatorial zone. Thus, Gras and Dussart (1966) and Pourriot (1968) in Lake Tchad, Green (1977) in the crater lakes of western Cameroon, Kling (1988) in the lake Ossa, Zébazé Togouet (2000) in Yaoundé Municipal Lake are the main cited work. To the best of our knowledge, nothing has been done in Yaoundé on zooplankton dynamic in fishponds. This work report for the first time the zooplankton community diversity (Rotifers, Cladocerans and Copepods) of two fishponds located in Yaoundé (in the Central Region of Cameroon), in relation with their physicochemical parameters.

Material and methods

Study area

The two studied water bodies are located at Simbock in the Mefou watershed (latitude from 3°48'40" to 3°49'50" North and longitude from 11°27'30" to 11°28'30" East). They are bordered at North by Mendong Camp SIC, at South by the Mefou Bridge, at East by the Yaoundé-Kribi main road and at West by Mefou River (Fig. 1). These ponds have the following characteristics:

- The first one "E1" has a surface area of about 2 200 m² and an average depth of 0.7 m. It is a dead arm of the Mefou River (Fig. 2A) located at Simbock which is a popular residential area. The pond is regularly overcame by water lilies and the banks are not well kept.

- The second pond called "E2" is excavated in the marshy valley of Simbock (Fig. 2B) and its source originates 5 km upstream of the water body. It has a surface area of 5 000 m² and a maximum depth 1.5 m. The water level was maintained by a farmer who controlled the state of the banks as well as the bed of the water channeling runoff and provided organic fertilization (Feed or kitchen waste) temporaly.

In the study area, the climate was of a sub-equatorial type "Yaoundéen" (Suchel, 1987) with four seasons: a long dry season (mid November - mid March), a short rainy season (mid March - end of June), a short dry season (July - mid August) and a long rainy season (mid August - mid November). The rainfall is moderated (annual average 1 576 mm) and varies over the years with the average annual temperature being 24.2 ± 2.6 ° C (Suchel, 1987).

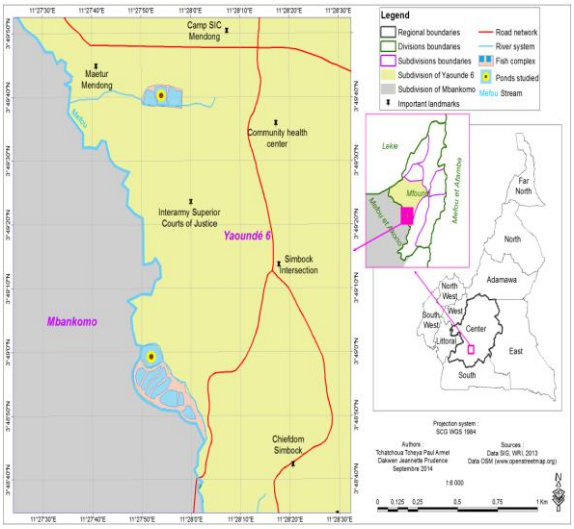

Fig. 1. Presentation of the study site.

(a)

(b)

Fig. 2. A view of the two studied water bodies. A = Pond E1; B= Pond E2.

Sampling

The samples were collected during 9 months from April to December 2007 with a bimonthly sampling frequency. Samples were collected only between the surface and 0.5 m depth in each pond because of the low water depth and the low spatial variation of physico-chemical parameters in tropical areas. The samples for physico-chemical analysis were collected using a 1000 cc double cork polyethylene bottles. Biological samples were collected by filtering 50 litres of water through a zooplankton net of 64 µm mesh size. A sample of 100 cc filtered divided in two parts was then kept for laboratory analysis. The first half of the subsample was fixed by adding few drops of 5% formalin for identification and enumeration while the second half was used for life observations.

Abiotic characterization of ponds

Parameters such as temperature, water transparency, pH, dissolved O_2 were measured on the field respectively using a mercury thermometer, a 30 cm Secchi disk, a SCHOTT portable pH meter (CG 818) and an Oxymeter Oxy 380. In the laboratory, color, Suspended Solids (SS), nitrogen forms (NH_4^+, NO_2^-) and orthophosphate were measured using a spectrophotometer HACH DR/2000 according to APHA recommendations (Greenberg, 1985).

Biotic characterization of ponds

The samples for the fauna study were observed with a stereomicroscope (WILD M 5) and a microscope (Olympus CK2 UL WCD 0.30) when necessary for the identification and enumeration of species of rotifers, cladocerans and copepods using identification keys of Pourriot (1968), Koste (1978), Zébazé Togouet (2000) and Fernando (2002) for rotifers; Dussart (1980), Defaye et Dussart (1995), Zébazé Togouet (2000) and Fernando (2002) for copepods ; Rey et S^t. Jean (1980), Amoros (1984), Zébazé Togouet (2000) and Fernando (2002) for cladocerans . The counting of at least 100 individuals per sample poured into Petri dishes (30 mm diameter) gridded into small squares of 3 mm side (Legendre et Watt, 1972) was carried out. If the number of 100 organisms could not be reached, the counting was duplicated or continuing until all the sample was counted. Density of individuals in the sample was calculated using the following formula:

$D = \frac{v}{v'.V} \times n$ expressed as ind/L

with v = total volume of sub sample; v'= volume of the fraction of sub sample poured into the Petri dish for counting; V = filtered water volume on the field; n = number of individuals contained in v'.

All data collected were used to describe the structure of the zooplankton population in the water. In fact:

- The diversity index of Shannon and Weaver (1949) was used to establish the link between the number of species and number of individuals. According to Barbault (1990), the formula is as follows:

$H' = -\sum\left[\frac{ni}{N}\text{Log}\left(\frac{ni}{N}\right)\right]$ with *ni* = number of species i present in the medium

Σ = sum of the results obtained for each species
N = total number of individuals in the sample
S = number of species
Log = logarithm to base 2
H' = Shannon and Weaver Diversity index expressed as bit/ind.

- The Eveness Pielou index (J) measures the evenness (or uniform distribution) of species with respect to a theoretical equal distribution for all species. Its formula is as follows:

$J = \frac{H'}{Log S}$ with H' = index of Shannon and Weaver

J ranges from 0 (dominance of a single species) to 1 (equal distribution of individuals in the population).

- The Sorensen similarity index is used to compare biological differences between water bodies. The following formula was used:

$S = \frac{2c}{a+b} \times 100$ with *S* = Similarity Sörensen

a = number of species in E1
b = number of species in E2
c = number of species common to the two ponds.

Statistical data analysis

The rank correlation of Spermann was used to assess the level of dependence between the physico-chemical and biological variables in the same water body. To highlight the influence of care provided by the farmer to the water on the functioning of the environment, Mann Withney test was used.

Results

Physico-chemistry of the environment

Fig. 3 showed the temporal variation of physico-chemical parameters in the two water bodies. Temperature varied slightly, ranging from 26.05 + 0.96 °C for E1 and 27.44 + 1.19 °C for E2. The waters of the two ponds were slightly basic with average pH values of 7.4 + 0.71. The values of Suspended Solids levels were higher in the two fishponds and showed a very high value (165 mg/L) in E2 in August. In fact, E2 water had high color values in April (892 Pt/Co). Consequently, transparency of water was more pronounced in E1 than E2 even if it is also highly variable in time. The percentage of saturation of oxygen increased and was similar in the two water bodies. Levels of nitrogen (NO_2^- and NH_4^+) and orthophosphates levels were less than 1 mg/L in both water bodies. Whatever the ponds, there was negative correlation between dissolved oxygen (r = -0.540), NO_2^- (r = -0.544) and the depth of disappearance of Secchi disc; between suspended solid (r = -0.483), ammonia (r = -0.666) and pH. There was positive correlation between ammonia (r = 0.560), SS (r = 0.561) and color.

Biological analysis of the environment

Specific composition of populations studied.

Sixty species of zooplankton were identified in E1 and 42 in E2. Rotifers were the most dominant group in terms of species richness (43 in E1 and 28 in E2) (Table 1 and 2). Seven species of Copepods were recorded in each pond. Cladocerans were more or less abundant with 10 species in E1 and 7 in E2. *Tropocyclops confinis*, *Rotaria citrina* in E1 and *Asplanchna brightwelli, Tropocyclops confinis* and *Moina micrura* in E2 mainly occured. However, the evolution of the species richness appears to be similar in the two water bodies, even if E1 had a relative higher number of species.

The species richness of the different zooplankton groups (Fig. 4) showed that the highest number of rotifers was found in November (20 species for E1 and 15 for E2) and the lowest number in May for E1 and July for E2. The species belonging to the Brachionidae family were more common in E1 than in E2. Whatever the period, *Platyias quadricornis, Rotaria citrina* and *Lecane bulla* were the most common species of rotifers in E1 and *Asplanchna brightwelli, Brachionus calyciflorus* and *Polyarthra vulgaris* in E2.

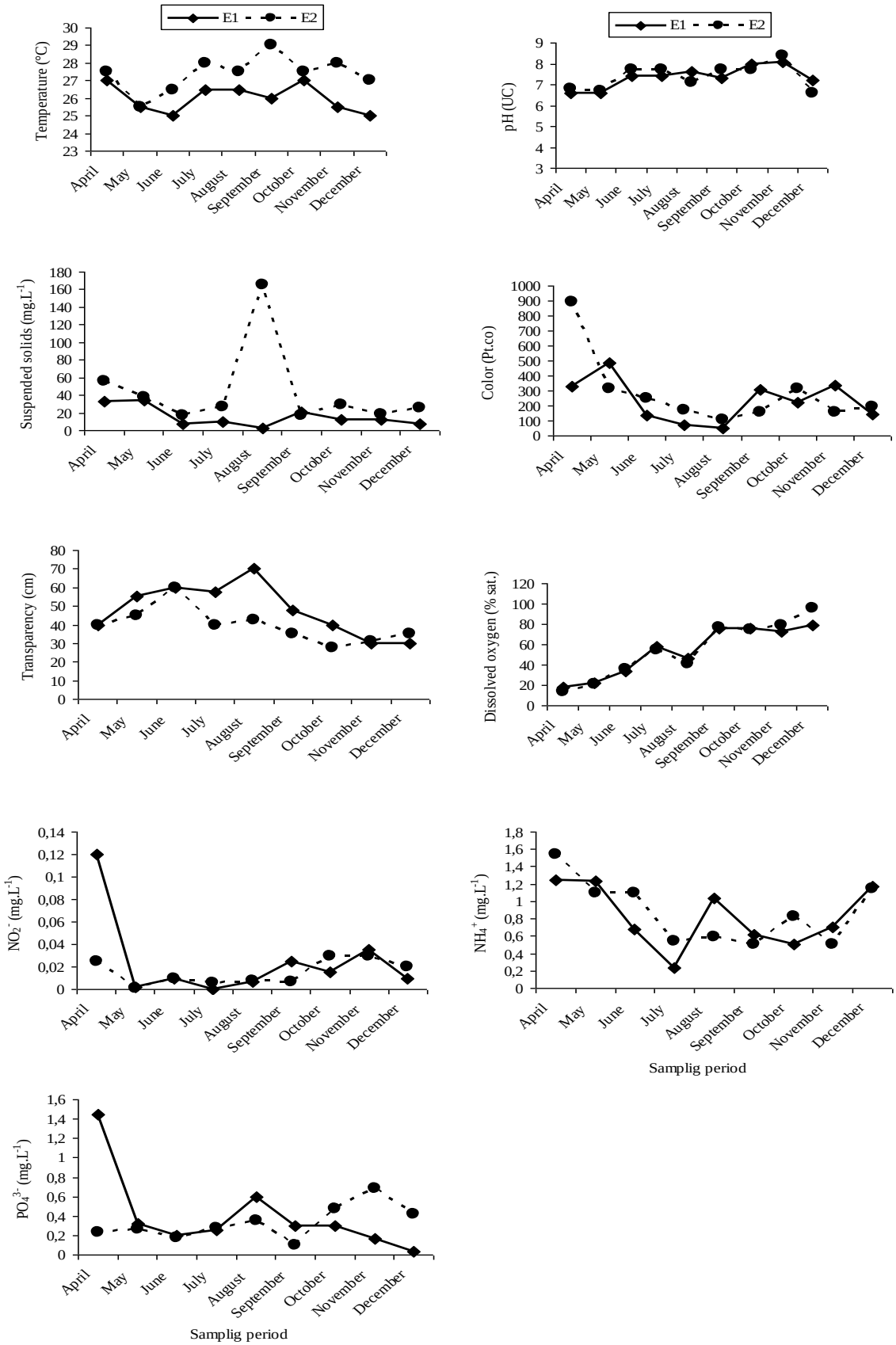

Fig. 3. Temporal variation of physico-chemical parameters studied in the two water bodies.

Table 1. Species richness, frequency of appearance (%) and abundance (ind./L) of Rotifers collected in two ponds during the study period.

Famillies	Species	Freq. (%)		Abundance																	
				Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
	Macrotrachela sp.	16,6	11,1							1				1	1					1	1
Philodinidae	*Rotaria citrina* ++	77,7	27,7	1	2	2		1	1	1		4	1	1		4	1	2		2	2
	Rotaria sp.	16,6	11,1		1			1			1					1				1	
Asplanchnidae	*Asplanchna brightwelli* +	38,8	72,2	1			1	1	1	1	1	1	2			1	2	1	4		11
	Asplanchna priodonta +	5,5	22,2						1						1	1			1		7
	Anuraeopsis fissa +	11,1	27,7	1							1								2	1	22
	Brachionus angularis +	27,7	22,2	1												1		2	3	1	23
	B.calycyflorus +	22,2	66,6		1			1	3		4	1	3		1		1	1	3		
	B.falcatus +	11,1	38,8	1	4	1	4										1				3
	B.quadridentatus	5,5	27,7	1	3								1				1		1		
Brachionidae	*B.Leydigi* +	5,5	22,2		1		2		1			1									
	B.rubens	5,5	22,2		1										1	1					5
	B. plicatilis	11,1																1			
	Keratella quadrata +	5,5																1			
	Plationus patulus	44,4	5,5	1						1		1		1				21			
	Platyias quadricornis	55,5		2		1				1		1		1		1		1			
Collothecidae	*Collotheca sp.*		11,1				1														
Colurellidae	*Lepadella patella*	16,6								1				1		1					
Conochilidae	*Conochilus sp.*	27,7	22,2	1						1		1		2	2				3		
Dicranophoridae	*Dicranophorus caudatus*	5,5		1																	
	Dicranophorus grandis	5,5																1			
Epiphanidae	*Epiphanes clavulata*	11,1												1		1					
Euchlanidae	*Euchlanis dilatata*	16,6				1						1									
Hexarthridae	*Hexarthra mira*	5,5	22,2	1			1						1		1				1		
	Lecane bulla ++	66,6	22,2	1	1		1	1		1		1	1	1		3		1	1	1	
	Lecane closterocerca	16,6										1						1			
	Lecane leontina	5,5																1			
	Lecane luna	5,5										1									
	Lecane lunaris	5,5														1					
Lecanidae	*Lecane hamata*		5,5		1																
	Lecane papuana	11,1	11,1				1									1		1			
	Lecane sp.	11,1		1						1											
	Lecane stichaea	11,1																1			
	Lecane subtilis	5,5	5,5		1											1					
	Lecane undulata	5,5		1																	
Mytilinidae	*Mytilina ventralis*	22,2	16,6									1		1		1		1	1		2
	Cephalodella bottgeri	16,6										1				1				1	
	C. physalis	16,6						1				1		1							
Notommatidae	*C. gibba*		5,5		1																
	Notommata codonella	11,1	11,1													1				1	1
	Macrochaetus sp.°	16,6		1								1		1							
Scaridiidae	*Scaridium longicaudum*	16,6				1										1		1			
	Polyarthra dolicoptera +		27,7						2		3		1						1		
Synchaetidae	*Polyarthra vulgaris* +	11,1	66,6		9		1		1				2		2		1	1	1		3
	Synchaeta pectinata +	16,6	50									1	5		2		3	1	1		3
Trichocercidae	*Trichocerca chattoni*		27,7								1						1		1		6
	Trichocerca tchadiensis +	16,6	33,3	1	1							1	1				1	1	2		10
Trichotriidae	*Trichotria tetractis*	16,6	0							1								2			
Total	48 species			17	27	6	13	6	10	10	11	21	18	22	11	21	12	29	26	9	99

Freq (%) = Frequency (number of sample with the species/ total number of sample) x 100

\+ = represent pelagic species

++ = represent periphytic species

° = represent new record for the Cameroon fauna

Table 2. Species richness, frequency of appearance (%) and abundance (ind./L) of micro-crustaceans collected in two ponds during the study.

Familles	Species	Fréq. (%)		Abundance															
				Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
Chydoridae	*Chydorus eurynotus*	5,5	5,5								1							1			
	Leydigia australis °		5,5														1				
	Pleuroxus chappuini °		5,5										1								
	Alona gluttata +++	50	22,2	1	12	1		1		1						1	1			1	1
	Chydorus baroisi °	11,1														2					
	Kurzia longirostris +++	5,5						1													
Daphnidae	*Ceriodahnia cornuta* +	22,2	22,2	1	20					1	1		1			1		1			
	Daphnia magna °		11,1														1		1		
Moinidae	*Moina micrura* +	50	98,8	3	229	1	2		7	1	8	1	2		2		3	1	3	1	
	Moinodaphnia macleayi °	5,5		1																	
Macrothricidae	*Guernella monodi* °	5,5																1			
	Guernella raphaelis +	5,5		1																	
	Macrothrix laticornix	5,5																1			
Total of Cladocerans	**13 species**			7	261	2	2	2	7	3	10	1	5		2	4	5	5	4	2	1
Cyclopidae	*Afrocyclops gibsoni*	5,5	22,2		6						3					1	1				
	Mesocyclops salinus +	22,2	55,5	1	9		2				1			1	2				3	1	5
	Microcyclops sp.	33,3	55,5	2	11		1			1	1					1	5	1	2	2	7
	Tropocyclops confinis	94,4	100	5	33	1	2	1	4	2	7	5	10	1	5	2	12	4	6	1	28
Diaptomidae	*Diaptomus sp.*°	16,6	16,6		1						1	1				1		1	1		
Total of Copepods	**7 species**			11	88	2	19	3	17	4	29	12	22	3	14	8	30	13	32	7	93
Larvae	Copépodite	22,2	61,1		9		6	1	3		5	2			3			1		1	18
	Nauplii	94,4	100	3	19	1	8	1	10	1	11	4	12	1	4	3	12	6	20	2	35

Freq (%) = Frequency (number of sample with the species/ total number of sample) x 100

+ = represent pelagic species

++ = represent periphytic species

++ + = represent coastal species

° = represent new record for the Cameroon fauna

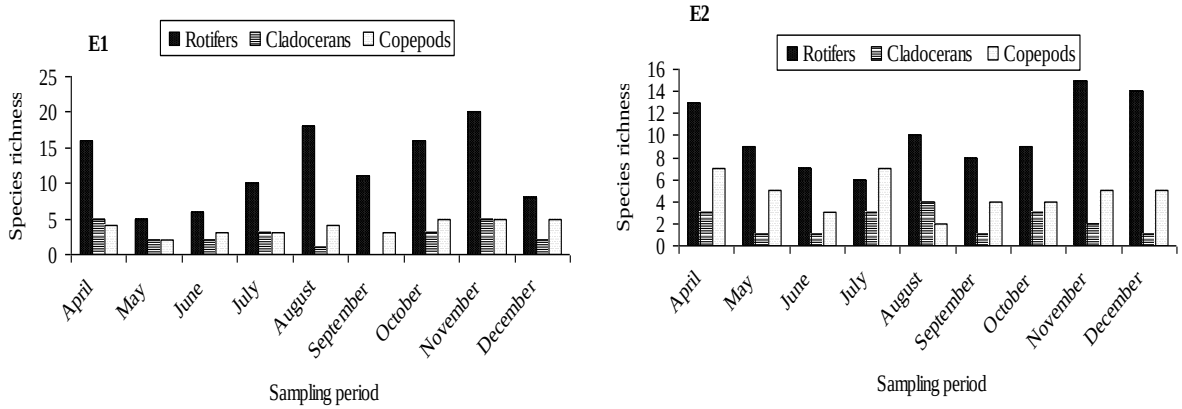

Fig. 4. Temporal variation of the species richness of the different group of zooplankton collected in the two ponds.

The number of Cladocerans varied from 0 to 5 in E1 with *Moina micrura* and *Alona gluttata* being the most present, while in E2, 1 to 4 species were noticed with the high occurrence of *Moina micrura*. However, the Daphnidae family (*Ceriodaphnia cornuta*) was poorly represented in both water bodies, Daphnia *magna* being collected at the frequency of 11.1 % in E2. At the other hand, the species richness of copepods varied from 2 to 5 species in E1 and 2 to 7 in E2 with *Tropocyclops confinis* being predominant.

Whatever the ponds, there was negative correlation between species richness of Copepod and depth of disappearance of Secchi disc (r = -0.59). There was also no significant difference of species richness between the two ponds.

Zooplankton abundance

Two hundreds and fifteen and 868 organisms were collected in E1 and E2 respectively with an average value of 24 ind. /L in E1 and 97 ind./L in E2. Rotifers were the most abundant (59 %) in E1 and Copepods in E2 (40 %). Cladocerans were least abundant in E1 (12 %) and rotifers in E2 (26 %). The evolution of the global abundance during the study (Fig. 5) showed two peaks in E2; one in April represented by Cladocerans (70%) and the other in December supported by Copepods (48%) and Rotifers (51%). However, between these two periods, there was drastic decrease of the total density in May in E2 supported by the almost complete disappearance of Cladocerans (from 261 to 2 ind./L). Also, a reduction in the abundance of all zooplankton studied was observed in September. Unlike E2, E1 observed a more or less stable net abundance throughout the study period, Rotifers being the most abundant irrespective of the month, followed by Copepods. Except for their high density observed in E2 in April, Cladocerans were the least abundant group in both water bodies.

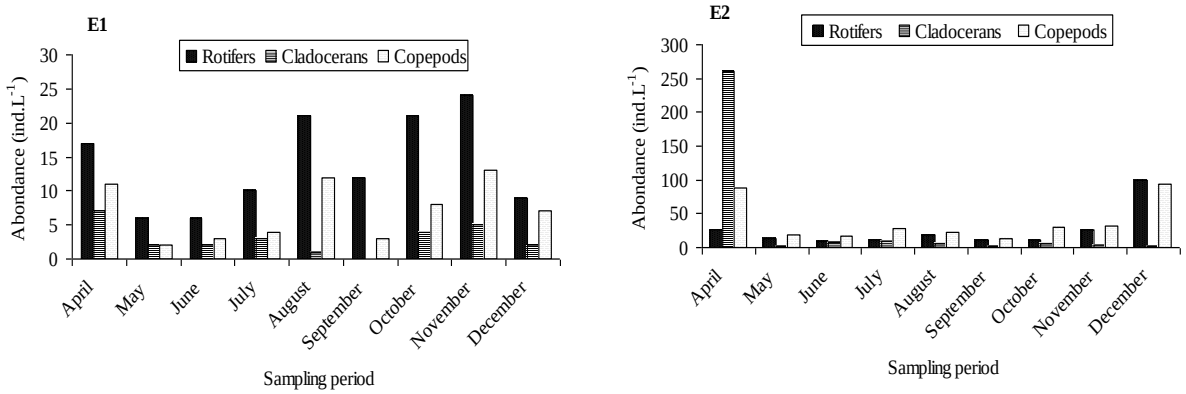

Fig. 5. Temporal variation of abundance of the different group of zooplankton collected in the two ponds.

The temporal variation of abundance of the different zooplankton groups studied is shown in Fig. 6. For Rotifers, *Rotaria citrina* (4 ind/L) and *Lecane bulla* (3 ind/L) were most abundant in August, October and November in E1 while in E2 *Anuraeopsis fissa* , *Brachionus angularis* , *Asplanchna brightwelli* and *Trichocerca tchadiensis* (at least 10 ind./L) were the most abundant in December. Copepods showed almost the same pattern as Rotifers and their abundance was dominated by Tropocyclops *confinis* (4 ind./L in E1 and 28 ind./L in E2). As for Cladocerans, a peak of abundance was observed in April supported by *Moina micrura* (261 ind./L in E2 and 7 ind./L in E1). This study revealed positive correlation between the abundance of all group of zooplankton studied and temperature; the density of microcrustaceans and SS (r = 0.515). A negative correlation was noticed between the density of microcrustaceans (r = -0.585) and the depth of disappearance of Secchi disc. There was a significant difference of abundance between the two ponds.

Specifics diversity and similarity

Table 3 presents the variation of species diversity and similarity indices during the study period. The average diversity index of Shannon and Weaver was slightly higher in E1 than in E2 but remained high throughout the study. The low value of this index was observed in May in E1 supported by *Rotaria citrina* (20%) and in April in E2 supported by *Moina*

micrura (61%). These values were better appreciated with the Pielou evenness index. In both water bodies, the Pielou index was closed to 1; showing that there was an equal distribution of individuals per species. E1 index varied slightly (0.88 to 1) while in E2 the value varied from 0.6 to 0.94. In a nutshell, the two water bodies were only 52% similar as portrayed by the Sörensen similarity index.

Table 3. Variability of Shannon and Weaver (SWI), Pielou (J) and Sorensen (SI) index between the two water bodies.

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
SWI (bits/ind)	E1	3,7	2,3	2,9	2,7	3,5	3	3,5	4	3,3	3,2
	E2	2,43	3,21	2,71	2,94	2,89	3,08	2,91	3,22	3,55	2,99
J	E1	0,9	0,99	1	0,88	0,89	0,98	0,92	0,92	0,97	0,93
	E2	0,6	0,86	0,85	0,79	0,82	0,94	0,8	0,79	0,82	0,82
SI (%)		61,9	52,2	78,6	43,3	43,2	39,8	37,8	53,8	55,9	52

Discussion

Physico-chemical analysis

The values of temperature remained high and varied slightly in both ponds. These observations are in contrast with those obtained by Zébazé Togouet *et al.* (2005) in the same town and can be explained by the disturbance of the Yaoundé climate whose rains have been irregular for the last 10 years (Zébazé Togouet *et al.,* 2011). It can be suggested that the seasonal division established by Suchel (1987) to illustrate the Yaoundé climate has to be reviewed. These observations could also be explained as a result of climate change. The pH of the water was slightly basic and the resulting acidity coincided with the floods recorded in late April and May. Indeed, low pH (<7) can be justified by high levels of dissolved CO_2 during floods (Angelier, 2000) converting carbonate to bicarbonate which is an acidifying element. However, the values of pH remained in the standards of pH (6-9) favorable for aquaculture life (Santos *et al*., 2007).The outstanding values of SS could be justified by the combined action of high fertilization with fertilizer in August and rains causing the mixing of water. The variation of water SS, color and transparency resulted from the combined action of the Yaoundé climate (which is very unstable), the morphometry of the water body (case of E1 with a shallow depth) and the fertilization technique used (spreading) in E2.These reasons can justify the positive correlation obtained between color and water SS.

Whatever the water body, the negative correlation obtained between the depth of desapearance of the Secchi disc and nitrite content can be justified by sufficient dissolved oxygen throughout the water column. It was the same for ammonium (NH_4^+) whose average value was below 1 mg/L. Caplancq (1982) reported that nitrate is formed in the presence of oxygen from dissolved nitrogen (NO and NO_2^-) and ammonia (NH_4^+), the latter resulting in most cases from anaerobic heterotrophic activity. The low contents of ammoniacal nitrogen and orthophosphate in the medium could be a result of low fertilization of water and a weak anthropisation of the catchment area; Nzieleu Tchapgnouo *et al.* (2012) already confirmed it in lakes Ossa and Wembe in Cameroon.

The reduced contents of nitrogenous and phosphorylated nutrients, low values of suspended particles, the increasing presence of dissolved O_2 through the water column and very low content of nitrite observed justified the classification of these ponds as either oligotrophic or oligomesotrophic medium.

Species composition and abundance of zooplankton

This study showed that relatively diverse zooplankton populations developed in these ponds, with 49 species of Rotifers, 13 species of Cladocerans and 07 species of Copepods. These microorganisms besides Copepods are mostly small size filter feeders of organic particles (detritus, algae and bacteria) (Dumont, 1977; Benndorf and Henning, 1989). Their

presence in these fishponds probably indicated the existence of detritus, algae or bacteria in these environments. Based on the work of Wylie and Currie (1991), 16-21 % carbon necessary for Cladocerans come from their predatory activity on bacteria. Similarly, the species of the Daphniidae family are known for their bacterivorous activity (Thouvenot *et al.*, 1999). Thus, the low number of species of Daphnids in these ponds could be justified by the presence of bacteria in relatively small quantities, therefore, the relative poverty of water in food resources. Unlike Green and Kling (1988) who reported the scarcity of water fleas of the genus Daphnia in the tropical area and Zébazé Togouet (2000) who confirmed it in Municipal Lakes in Yaoundé, our results indicate the presence of *Daphnia magna* in the pond E2.

The zooplanktons collected in these waters highlight the ignorance of the aquatic microfauna in Cameroon as indicated by Zébazé Togouet *et al.* (2006). Indeed, out of the 69 species of zooplankton collected during this study, eight are new to Cameroon. These species include the Rotifer *Macrochaetus sp.*, the Copepod *Diaptomus sp.* and the Cladocerans *Chydorus baroisi , Leydigia australia , Pleuroxus chappuini , Daphnia Magna, Guernella monodi, Moinodaphnia macleayi* which are cosmopolitan species from lentic environments in the tropics (Josee de Paggi and Koste, 1995).

In terms of total density of the zooplankton collected during the study, Copepods and Rotifers appeared more abundant than Cladocerans, which confirms the observations made by authors in water bodies located in the tropics, of which the most recent are: Nogueira, 2001; Branco *et al.* 2002 and Zébazé Togouet *et al.*, 2005 and 2006. To justify the high abundance of Rotifers compared to Cladocerans in fish ponds studied, two reasons were given:

- Their food - plasticity toward available resources gives them a greater competitiveness in the medium and their small size make them less vulnerable to predation pressure (Dumont, 1977);

- Their opportunistic character which enables them to better withstand variations in environmental conditions (Tundisi - Matsumura *et al.*, 1990).

Pace (1986) reported high abundance of rotifers in freshwater aquatic environment considering them bioindicator of high trophic levels. Branco *et al.* (2002) also established a relationship between high number of species belonging to the genus *Brachionus* (at least 1000 ind./L for *Brachionus angularis*) and high trophic levels. But the density of Rrotifers described in this study was very low; showing that these ponds have limited food resources even after fertilization, thus a low trophic level. Furthermore, the high density of Copepods compared to Cladocerans is in conformity with the work of Mc Naugit (1975), who indicated that not only Copepods are able to escape predation, but are strategic type "k" with a strong ability to grow and reproduce compared to *Daphnia* in oligotrophic environments with limited food resources.

The high value of Shannon and Weaver index obtained in this study was not emphasized by the work of Nzieleu Tchapgnouo *et al.* (2012) who argued about the non equal distribution of organism per species in the oligotrophic Ossa Lakes complex. But when considering the relatively high density of Copepod to that of Cladocerans, the relatively low density/ species richness ratio of rotifers with respect to the other groups and the very low abundance of Brachionidae in these ponds, the confirmation that these environments are slightly enriched in organic matter can be retained. However, this trophic status is not sufficient for good fish productivity. Angeli (1980) observed that fish productivity is highest in eutrophic medium where all zooplanktons consisting mainly of Rotifers, Cladocerans are present. So what is the role of climate and care received by the ponds in this work?

Spatio -temporal distribution of zooplankton

From the 69 species of zooplankton identified during this study, almost 80% are littoral and periphytic. The more or less important presence of littoral and periphytic species whatever the water body is justified by the lateral exchange of material between pelagic and littoral zone favored by shallow ponds and the lack of thermal stratification in the water column as sometimes light reaches the bottom (case of E1) (Zébazé Togouet *et al.*, 2007). The relatively high particle load (suspended solid level > 30 mg /L) at certain period in these ponds is partly responsible for the development of periphytic species in the pelagic zone. These particles originate not only because of welling, but also from the Mefou river runoff that fall into the pond during floods (Nzieleu Tchapgnouo *et al.*, 2012) for E1 or organic fertilizer applied by farmers (Tamassia, 2011) for E2. The most common and abundant species in E1 are mostly littoral and periphytic while in E2, they are known as pelagic species. According to Zébazé Togouet (2008) this difference can be explained by the existence of favorable environmental conditions for their development. Indeed, care taking of dykes and water beds of the water clears the pelagic zone reducing macrophytes which usually play the role of support and shelter for periphyton organisms and therefore makes the pond more accessible to pelagic organisms (Schlumberger, 2002).

In view of the level of significance of the correlations between zooplankton abundance and some physico-chemicals variables (Temperature, SS, transparency) in the ponds studied, the structure of zooplankton is dependent on other factors including the morphometry of the water, the rainfall regime, the source of the water, fertilization and the follow up of the water body (Schlumberger, 2002; Efole Ewoukem *et al.*, 2010 and Nziéleu Tchapgnouo *et al.,* 2012). Thus, the slight variation in zooplankton abundance observed in E1 could be justified by the flexibility of modifications to existing environmental stressors in the water such as the quantity and quality of food (living organisms, organic and inorganic materials), the nature and number of predators, the state of dykes. Similarly, the drastic decrease of zooplankton density in E2 in May would be a consequence of the combined action of the flooding of the pond by runoff on the eve of sampling and predation pressure because the pond was stocked (nearly 6000 individuals according to the farmer) during this period. The low zooplankton density (27 ind. / L) observed in September can be explained by the combined effect of the increase in the water level (dilution effect), the predation pressure practiced by Copepods and fry to the other group of zooplankton and the food competition between Cladocerans and Rotifers zooplancton. These observations were already made by Okogvu (2009) in Ehoma Lake in Nigeria and Nzieleu Tchapgnouo *et al.* (2012) in Ossa Lakes complex in Cameroon. Also, the sharp increase in the density in December could be the result of an increase in the residence time of water in the basin due to the lack of rainfall recorded since November, a special care of the dykes by the farmer and the reducing number of competitive's species of zooplankton. This was established by Ayoagui and Bonecker (2004) in Parana River in Brazil. The same case observed in April could rather be justified by the high mineral and organic fertilizers applied by the farmer before filling the ponds (Lacroix, 2004).

It was observed a drastic decline in the abundance of Cladocerans in May followed by a very low abundance throughout the study. This suggests that fry prefer Cladocerans for their food. In this regard, Amoros (1984) emphasized that Cladocerans provide adequate nutrients for fry and juveniles of many fish species and are used as dried or life food for aquarium fish. The density of rotifers and copepods remains higher than those of Cladocerans from May to the end of the study (change of dominance), but low as compared to the values recorded in April. This explains the fact that primary preys of fry and juvenile fish are Cladocerans while rotifers and Copepods are secondary preys. This is the "switching "effect according to Barbault (1990).

The fact that the average zooplankton abundance in pond E1 represents a quarter of that observed in E2 is justified not only by the improvement of the dykes and bed of the pond but also organic fertilization brought about by the farmer to the water (Tamassia, 2011). However, these values are still very low by the standards of fish ponds, which raised the issue of the quality and quantity of fertilizer used and the technical management of fish ponds. This is consistent with the observations of Gosselain *et al.* (1998) who argued that there is regulation of population structure in an environment where variables such as food availability, predation pressure, competition, the strength of the water current, the amount of organic matter and macrophytes act concomitantly.

Ultimately, the Mann Withney test revealed a significant difference between the two water bodies. In addition to the values of diversity and Evenness indices, there is a gradual loss of the equal distribution of each species when going from E1 to E2. Also, according to the similarity index of Sörensen, these water bodies do not exactly have the same statut on the biological level as while E1 is oligotrophic, E2 is oligo - mesotrophic.

Conclusion

In this study 69 species of zooplankton were identified, including 43 species of Rotifers, 10 species of Cladocerans and 07 species of Copepods for E1. In the same time 42 species among which 28 species of Rotifers, 7 species of Cladocerans and 7 species of Copepods were reported in E2. These species were mostly littoral, periphytic or ubiquitous and among them, 8 were new in Cameroon. Whatever the pond, the abundance of zooplankton recorded in this study were less than 400 ind./L. The direct consequence of the low eutrophication and quality of care was showed to the water, materialized by the high biology diversity index of Shannon and Weaver. Also, the relative variation of zooplankton specific diversity recorded during the study was due to the predation pressure, the quality and quantity of food available and / or different environmental stressors (welling, competition, changes in water level). With regards to the evolution of the density of Cladocerans, this group of zooplankton was the preferential food for fry, the quantity and quality of food available could representing a limiting factor for secondary production and for the ponds fish production.

This work further confirms that zooplankton occupies a strategic position in the food chain of the aquatic environment in general and in particular fish pond. The physico-chemical parameters, the structure of the zooplankton community and indices of diversity and similarity showed that E1 was oligotrophic and E2 oligo - mesotrophic. However, these relatively nutrient deficient waters cannot completely fulfill the expectations of the farmer. Thus, it is important for the farmer to have a basic understanding of the biology and ecology of the water used.

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