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Effects of the Type of Fertilizer on the Taxonomic Composition and Zooplankton Distribution in Ponds of Batie in Western Cameroon

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Abstract

One of the major constraints in fish farming is the unavailability of good quality of fish fry which is highly dependent on zooplankton. For this purpose, a study on the taxonomic composition and distribution of zooplankton in ponds in the high plains of Western Cameroon was carried out from January 2016 to December 2017. A total of 12 samples were monthly collected in order to evaluate the physicochemical characteristics of water and the diversity of zooplankton. Results on water quality showed that the significantly ($p<0.05$) higher values of temperature (21.64 ± 0.81°C) and dissolved oxygen (4.85 ± 1.54 mg/L) were observed with Wheat bran. For the zooplanktonic fauna, 39 species of which 35 are identified in ponds fertilized with pig manure and 30 in fish ponds fed with Wheat bran. From these species, 28 rotifers, 06 Cladocerans and 01 Copepods were identified in ponds fertilized with pig manure while 23 rotifers, 06 cladocerans and 01 copepod in fishponds fed with Wheat bran. Species such as *Notholca sp*, *Platyias sp*, *Alona rectangulata* and *Macrorhix laticornis* were only represented in ponds fed Wheat bran (that is, a percentage of 10.26% of the specific total richness). Meanwhile, 8 species *Brachionus urcealaris, Keratella cochlearis*, *Keratella cochlearis var type*, *Trichocerca similis*, *Polyarthra vulgaris*, *Filinia opoliensis*, *Ceriodaphnia cornuta* and *Diaphanosoma volzi* were exclusively represented in areas fertilized with pig manure (that is, a percentage of 23.08%). Generally, the season did not affect the zoo planktonic distribution.

Keywords: Fertilizer; Distribution; Taxonomy; Zooplankton

Introduction

The role of zooplankton in the aquatic ecosystems is not to be shown anymore. In fact Haberman [1] estimated more than 60% of aquatic primary production transferred by zooplankton to fish fry. Thus, the reproductive success of fishes does not only depend on physical conditions of the environment, but also highly depend on biological factors. Zooplankton constitute feed in prawn and fry farming [2-4] mainly due to their small size [5,6], their nutritional quality [7] and their high rate of reproduction [8,9]. Because of its sensitivity to climatic changes, zooplankton has long been used to evaluate the impact of global changes on aquatic ecosystem [10]. Hence, studying this group of organisms is necessary for the elaboration of a management strategy of halieutic resources. In Cameroon, few works have been done mainly on the distribution of zooplankton in lentic environment [11-14]. Most works been done on faunistic registration and population dynamic [12]. These works are not only scarce but are localized in the littoral and centre region of Cameroon. Only the works of Nana et al. [15] tried to define the taxonomic composition of zooplankton in the ponds of Western Cameroon. However, these works exclusively concerned ponds fertilized chicken manure. To the best of our knowledge it's difficult to define the biodiversity and the distribution of zooplankton in ponds fertilized with pig manure and Wheat bran.

Nevertheless, the determination of zooplanktonic biodiversity could edify in the sampling of zooplankton designated for the culture and nutrition of fish. This is because there exists heterogeneity size amongst zooplankton on one hand and the selection of fish species on zooplankton on the other hand. Additionally, the distribution which helps in the characterization of the composition and the evolution of zooplanktonic community will permit the planification of collections; hence the aim of this study.

Materials and Methods

Zone and period of study

The study was carried out from January to December 2017 in the ponds of Batié (LN: 5°17'0"- 5°18'53" and LE: 10°17'0"- 10°19'31") in the Sudano-Guinean zone of Western Cameroon. The average altitude is 1700 m and the ground are ferralitic. The climate is the tropical type modified by the altitude of two seasons: a long rainy season (Mid-March to Mid-November) and a short dry season (Mid-November to Mid-March). The average annual temperature is between 17°C and 20°C and precipitations vary between 1621-1800 mm [16].

Trial conduct and data collection

A visit was initially done at the piscicultural farm in order to define the type of fertilizers used by the farmers. This helped us to identify two type of fertilizer (pig manure and Wheat bran). Data collection was done in 4 ponds of cultured fish species that is, carp (*Cyprinus carpio*), tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) in polyculture with surface area 400 m² each of which two fertilized daily with pig manure and the other two fed with Wheat bran.

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The physicochemical characteristics of water such as the temperature, dissolved oxygen, pH, transparency and the electrical conductivity were measured monthly *in situ* respectively with the help of a thermo-oximeter, pH-meter, Secchi disk and a thermo-conductivity meter with brand Hanna. The dosage of nutritional salts like nitrate, nitrite and phosphate were determined every 2 months using a spectrophotometer with brand HACH according to the methods of nitra ver III, nitri ver III and phos ver V respectively recommended by Zébazé [17].

Zooplankton was collected monthly between 6 and 8 am so as to avoid any vertical migration relative to sun rise. The sampling was carried out at twenty different position of the water column of each pond using a calibrated polyethylene container of 1 liter capacity. A total volume of 20 liters/pond was filtered with a plankton sieve of 40 µm mesh. After obtaining the filtering, 250 ml of this later was introduced into bottles priory labeled and fixed with formalin 5% in proportions of ¾ of samples and ¼ of formalin. Finally, these samples were taken to the laboratory for analyses.

After homogenizing the samples, two (2) sub-samples of 10 ml of each filtering were collected using a pipette then placed in a squared petri dish of 90 mm for the inventory of organisms like rotifers, cladocerans and copepods. The identification of these groups was done using a MOTIC binocular magnifyer and objective 4X with the help of identification keys and works of Koste et al. [5,18-22] following the classic technics. The individual density was calculated according to the following formula:

$D=n/V_1 \times V_2/V_3$

Where: D=Density (individuals/liter); n=Number of individuals counted; V_1=Volume of filtering collected; V_2=Volume of concentrated filtering; V_3=Total volume of filtered water.

The results of the zooplanktonic density obtained helped in the calculations of different indices permitting the characterization of the composition and the evolution of zooplanktonic community including:

Diversity index of Shannon-Weaver (H'):

$H'=-\Sigma (ni/N) \times \log_2 (ni/N)$,

where ni=Effective of species; N=Total effective of individuals considering all species; $\log_2$=Logarithm of base 2.

Equitability of Pielou (J):

$J=H'/\log_2 S$,

where H'=Shannon Wearver Index, $\log_2$: Logarithme of base 2 and S=Number species present.

Statistical analysis

Data collected was submitted to one-way analysis of variance (ANOVA-1). When a significant difference existed, the Duncan's test was used at 5% threshold to separate means [23]. The software SPSS version 20.0 was used.

Results

Physicochemical characteristics of water

The influence of the type of fertilizer on the physicochemical characteristics of water is resumed in Table 1. Apart from the temperature, dissolved oxygen and transparency, the values that were highest of all these characteristics were significantly ($p<0.05$) registered in ponds fertilized with pig manure. The lowest values observed in ponds fertilize with Wheat bran. For the transparency, no significant ($p>0.05$) difference was noticed among treatments. However, the highest values were observed in ponds fed Wheat bran. The significantly ($p<0.05$) higher values of the temperature and dissolved oxygen were observed with Wheat bran.

The richness and distribution of families, genus, species and zooplanktonic groups

The richness and distribution of zooplankton are presented in Tables 2 and 3. The highest specific richness was observed in ponds fertilized with pig manure. While, the highest values of richness of families were registered in ponds receiving Wheat bran. They included species like *Notholca sp*, *Platyias sp*, *Alona rectangulata*, *Macrorhrix laticornis*. 08 species (that is a percentage of 23.08% of the total richness of species) of which *Brachionus urcealaris, Keratella cochlearis*, *Keratella cochlearis var type*, *Trichocerca similis*, *Polyarthra vulgaris*, *Filinia opoliensis*, *Ceriodaphnia cornuta*, *Diaphanosoma volzi* were mainly represented in ponds fertilized with pig manure. From the 13 families, the Macrothricidae was only represented in fishponds fertilize with Wheat bran. No matter the type of fertilizer, the copepod group was generally the least represented. Meanwhile that of rotifers was the most represented. Infact, in ponds fertilized with pig manure, the zooplankton was made up of 35 species of which 28 rotifers, 06 cladocerans and 01 copepod. Nevertheless, of the 30 species of zooplankton identified in ponds fertilize with Wheat bran, 23 were rotifers, 06 cladocerans and 01 copepods.

Diversity index of zooplanktonic species

The monthly evolution of the Shannon and equitability index according to the type of fertilizer is shown in Table 4. Generally, the season did not affect the distribution of zooplankton. Thus, in a global manner, the Shannon and equitability index is low. The highest values of Shannon index were observed in December in ponds receiving Wheat

Physicochemical characteristics of water	Types of fertilizer	
	Pig manure	Wheat bran
Temperature (°C)	21.03 ± 0.53[a]	21.64 ± 0.81[b]
pH (UI)	7.75 ± 0.39[a]	7.43 ± 0.53[b]
Conductivity (µS/cm)	105.64 ± 23.93[a]	51.42 ± 16.84[b]
O_2 (mg/l)	4.39 ± 1.21[a]	4.85 ± 1.54[b]
Transparency (cm)	39.16 ± 6.73[a]	40.93 ± 3.47[a]
Nitrate (mg/l)	3.97 ± 3.58[a]	2.43 ± 2.21[b]
Nitrite (mg/l)	9.91 ± 4.32[a]	6.54 ± 4.92[b]
Phosphate (mg/l)	2.81 ± 2.02[a]	0.03 ± 0.04[b]

a, b: Values affected with the same superscripted letter does not differ significantly ($p>0.05$)

Table 1: Effects of the type of fertilizer on the physicochemical characteristics of water.

Zooplanktonic classes	Type of fertilizer		Total
	Pig manure	Pro-vender	
Species	35 (89.74)	30 (76.92)	39 (100)
Genus	19 (86.36)	19 (86.36)	22 (100)
Families	12 (92.31)	13 (100)	13 (100)

Table 2: Effects of the type of fertilizer on the richness of zooplanktonic classes.

Groups	Type of fertilizer	
Families	**Pig manure**	**Wheat bran**
Genus	-	-
Species	-	-
Rotifers	-	-
Brachionidae	-	-
Brachionus	-	-
Anuraeopsis fissa	X	X
Brachionus calyciflorus	X	X
Brachionus angularis	X	X
Brachionus ruben	X	X
Brachionus patulus	X	X
Brachionus falcatus	X	X
Brachionus urcealaris	X	-
Keratella	-	-
Keratella cochlearis	X	-
Keratella tropica	X	X
Keratella cochlearis var type	X	-
Notholca	-	-
Notholca sp	-	X
Platyias	-	-
Platyias sp	-	X
Trichocercidae	-	
Trichocerca	-	-
Trichocerca rousseleti	X	X
Trichocerca chattoni	X	-
Trichocerca similis	X	-
Trichocerca elongata	X	X
Trichocerca pusilla	X	X
Trichocerca sp	X	X
Ascomorpha	-	-
Ascomorpha hyptomus	X	X
Lecanidae	-	-
Lecane	-	-
Lecane lunaris	X	X
Lecane bulla	X	X
lecana elsa	X	X
Synchaetidae	-	-
Polyarthra	-	-
Polyarthra vulgaris	X	-
Polyarthra remata	X	X
Mytilina	-	-
Mytilina mucronata	X	X
Notommatidae	-	-
Cephalodella	-	-
Cephalodella gibba	X	X
Philodinidae	-	-
Rotaria	-	-
Rotaria rotaria	X	X

Testudinellidae	-	-
Filinia	-	-
Filinia opoliensis	X	-
Filinia terminalis	X	X
Hexarthra	-	-
Hexarthra sp	X	X
Cladocerans	-	-
Daphniidae	-	-
Ceriodaphnia	-	-
Ceriodaphnia cornuta	X	-
Daphnia	-	-
Daphnia sp	X	X
Sididae	-	-
Diaphanosoma	-	-
Diaphanosoma volzi	X	-
Chydoridae	-	-
Alona	-	-
Alona rectangulata	-	X
Alona costata	X	X
Bosmonidae	-	-
Bosmina	-	-
Bosmina sp	X	X
Moinidae	-	-
Moina	-	-
Moina micrura	X	X
Macrothricidae	-	-
Macothrix	-	-
Macrorhrix laticornis	-	X
Copepods	-	-
Cyclopidae	-	-
Tropocyclops	-	-
Tropocyclops sp	X	X
X: Présent; - : Absent		

Table 3: Effects of the type of fertilizer on the distribution of species, genus and families of zooplankton.

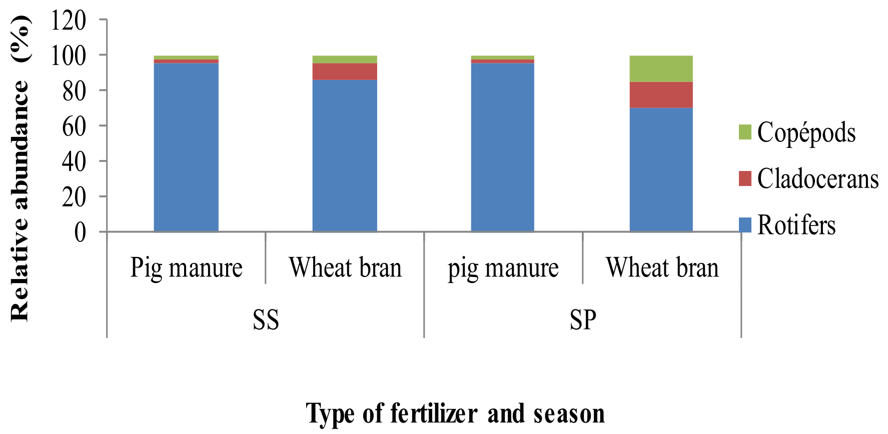
Season	Months	Shannon index		Equitability index	
		Pig manure	Wheat bran	Pig manure	Wheat bran
Dry	November	1.73	2	0.66	0.66
	December	1.8	2.29	0.66	0.7
	January	1.66	2.01	0.6	0.61
	Febuary	1.75	2.16	0.64	0.67
	March	2.07	1.94	0.61	0.63
Rainy	April	2.03	1.67	0.62	0.66
	May	2.16	1.89	0.53	0.67
	June	1.05	1.04	0.65	0.65
	July	1.58	1.68	0.68	0.69
	August	2.02	1.99	0.66	0.67
	September	1.99	1.47	0.6	0.68
	October	1.7	2.21	0.67	0.66

Table 4: Evolution of the Shannon and equitability diversity index according to the type of fertilizer and season.

bran. The minimal value of this index is noticed in June no matter the type of fertilizer.

Relative abundance of zooplanktonic groups

Figure 1 illustrates the effects of the type of fertilizer and the seasons of collection on the relative abundance of zooplankton. Rotifers were most abundant regardless the season and the type of fertilizer. Nonetheless, the highest values were observed in the dry season in ponds fertilized with pig manure. In the dry season, the highest relative abundance was registered in rotifers. It is followed by the cladocerans in ponds fertilize with Wheat bran and copepods in ponds fertilized with pig manure. Meanwhile, in the rainy season the abundance of copepods and cladocerans were comparable irrespective of the type of fertilizer.



SS: Dry season; SP: Rainy season

Figure 1: Effect of the type of fertilizer and season on the relative abundance.

Discussion

The physicochemical characteristics of water showed that apart from the transparency, all the other characteristics were affected by the type of fertilizer. Thus, the highest electrical conductivity, pH and concentrations in nitrite, nitrate and phosphate were registered in ponds fertilized with pig manure. These results are comparable with the works of Dhawan et al. [24] in ponds fertilized with pig manure and chicken manure respectively compared to those not fertilized. Our values are inferior to 5.59 mg/l of phosphate and 9.38 mg/l of nitrate obtained by Akodogbo et al. [25] in ponds fertilized with pig manure. This could be due to the composition of nutritional salt which is relatively high in pig manure used by this author compared to that used in the present study. On the other hand, the relative high temperatures (28.36°C against 21.03°C inourponds) might have accelerated the process of degradation of organic materials. Similarly, the values of nitrate are inferior to 6.23 mg/l observed by Nana et al. [15] in ponds fertilized at the dose of 1000Kg /ha of chicken manure. This could be due to the nature of the fertilizer used. The concentration of dissolved oxygen increased in fertilized areas towards areas fertilize with Wheat bran. This tendency is similar to that observed by Nana et al. [15] in ponds fertilized with high doses of chicken manure towards ponds that were not fertilized. This is justified by high bacteria load which constitute fertilized area. Infact, bacteria use enormous quantity of oxygen during the decomposition of organic material. Regardless of the type of fertilizer, the values of temperature are arranged within the range of 20-30°C recommended by FAO [26] for a better development of plankton. Hence, the lowest temperatures registered are characteristics of tropical waters.

The distribution of specific richness of zooplanktonic groups showed that rotifers were the most represented, followed by the cladocerans no matter the type of fertilizer. The same tendency was observed by Onana et al. [27] in streams. These results are similar to the works of Nana et al. [15] in ponds fertilized with chicken manure. As a matter of fact, the dominance of rotifers could be due to the fact these organisms represented in freshwaters belong to the ecological niche of small filtrers [28,29] and are characteristics of tropical waters [30]. Moreover, it represents a mode of reproduction by pathogenesis which the most rapid of all metazoan and thus rapidly populate the available niche [31]. Our results do not corroborate with those reported by Elegbe et al. [32] who observed a dominance of cladocerans. Additionally, most species were common to ponds independently of the type of fertilizer. This might be because of the closeness of ponds and the utilization of one and the same canal of water supply.

The monthly evolution of Shannon and equitability index according to the type of fertilizer showed that the Shannon and Weaver diversity index was generally weak. This explains the existence of many predominant species. The minimal values observed in June no matter the type of fertilizer is justified by the high dominance of *Brachionus ruben* species (86% and 89% respectively in ponds fertilized with pig manure and those fertilize with Wheat bran). These observations agree with those of Nzieleu [33] in the Complex Ossa lake (Dizangué Cameroon). Nevertheless, these remarkable low values of the diversity index in these lakes are the works of *Alona rectangulata* species (93%) which are highly represented. This is more appreciated with the equitability index which brings out the disequilibrum of the ecosystem and the poor temporal distribution of species with its little value at 0.7 in all ponds. The highest value of the Shannon index observed in December in ponds receiving Wheat bran is justified by the predominance of rotifer species: *Cephalodella gibba, Brachionus calyciflorus, Brachionusruben et Lecane bulla*. In terms of the relative abundance, the rotifer species were the most important regardless the type of fertilizer and season. This joins the works of other authors reported in tanks situated in the tropical zone [34,35]. These observations are explained by their opportunistic character which helps them to better resist to the variations of environmental conditions [36]. Indeed, rotifers are rather tolerant organisms which resist to the enrichment of organic matter in the environment and the gradual impoverishment in oxygen [12]. Moreover, they have a feeding plasticity towards the available resources and because of their small size which render them less vulnerable to the pressure of predators [37].

Conclusion

The present study showed that with the exception of transparency, all the physicochemical characteristics of water were affected by the type of fertilizer. The taxonomic composition was affected by the type of fertilizer. Thus, the species of the rotifer group were more dominant. No matter the type of fertilizer, the season did not significantly affect the distribution of zooplankton

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