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Research Article

EFFECTS OF THE SITE AND TYPE OF FERTILIZER ON THE STRUCTURE AND ZOOPLANKTON DISTRIBUTION IN FISH FARMING PONDS IN THE HIGHLANDS OF WESTERN CAMEROON

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A B S T R A C T

In order to contribute to the improvement of fry production, a study on the zooplanktonic productivity according to the site and type of fertilizer was conducted between January to December 2017. For this purpose, 15 ponds of which 03 in Bamendou fertilized with cowpat; 04 in Batié of which 02 fertilized with pig manure and 02 with Wheat bran; 01 in Dschang fertilized with chicken manure; 04 in Fokoué of which 02 fertilized with pig manure and 02 not fertilized and 03 in Foumbot fertilized with cowpat were chosen so as to determine the altitude variation and the type of fertilizer. Sampling of biotic and abiotic characteristics was done monthly. Results showed that the highest values of the temperature (23±00°C), pH (7.44±0.67 IU) and transparency (81.17±4.13 cm) were observed in the basins of Dschang fertilized with chicken manure. For the structure and distribution of zooplankton, the highest values of the densities (177±85 ind/L) and of biomass (24.64 g PS) of rotifers were noticed Batié fertilized with pig manure and the least values (15 ind/L et 0.14 g PS) in non fertilized ponds of Fokoué. Meanwhile, the density and the biomass of cladocerans (72 ind/L ; 102.2 g PS) and copepods (80 ind/L ; 91.18 g PS) were higher in ponds of Bamendou fertilized with cowpat. Then the structure and zooplankton distribution are affected by the site and type of fertilizer.

INTRODUCTION

Malnutrition suffered by African populations is greatly due to protein deficiency from animal origin [1]. According to [2], fish constitute a source of animal protein very important in Africa and in the rest of developing countries. However, the satisfaction of the populations in fish needs still remain insufficient because of the stagnation of fishery products, the overexploitation of livestock of aquatic natural resources and the low development of fish farming [3]. This low development of fish farming could be due numerous constraints among which the unavailability of fry for the poisoning of fish ponds. In fact, fry need feed of small size due to their small buccal openings and their high nutritive values for survival. Amongst feed of small size often used, zooplankton constitute an important food in the breeding of prawns and young fish [4,5,6] mainly because of their small size [7,8], their nutritional quality [9] and their high rate of reproduction [10,11]. These are the main elements of the marine trophic network since they are situated between the autotrophs and the big heterotrophs [12].

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Long ago, the success of fry farming has been linked to the utilization of zooplankton *Artemia* [13]. Yet, the main worldly provisioning in *Artemia* comes from harvest effectuated in the salty lakes and due to the fact that this species is exclusively marine [14]. Besides, its production in livestock breeding is scarce since it requires specific installations, intensive labour and a high cost of production [15]. Hence, there is a necessity to master the production of zooplankton in fresh water with a low cost of production such as rotifers, cladocerans and copepods. In Cameroon, some works [16,17,18,19] has been carried on the study of zooplankton in fishponds and concrete box. Nonetheless, these studies are not only localized in one site but are also limited in time. To the best of our knowledge, no study has been conducted aiming to determine the structure and the distribution of zooplankton in all fish ponds in the Western region of Cameroon. Moreover, other aspects still remain explorable, however the absence of knowledge on the factors of production of zooplankton could pertubate the efficient strategies of management of these ecosystems.

MATERIAL AND METHODS

Period and site of study

The study was carried out from January to December 2017 in the fish ponds of Western Cameroon. The region is situated in the Nord hemisphere (LN: 5°17'0''-5°18'53'' and LE: 10°17'0''- 10°19'31''). It shares its boundaries with the regions of North-West and the Adamawa to the North, that of Littoral to the south, from the center to the East and South-West to West. The annual precipitation and average temperature are 1500mm and 25°C respectively. This zone is characterized by a long rainy season (mid-March to mid-November) and a short dry season (mid-November to mid-March).

Characteristics of collection ponds of zooplankton

Zooplanktons were collected in 5 sites of which Bamendou, Batié, Dschang, Fokoué and Foumbot. For this purpose, 15 fish ponds were chosen so as to reflect the variation of altitude and the type of fertilizer. The choice of these ponds was also based on the stability of the breeder. The characteristics of ponds used are resumed in table 1

After homogenizing the samples, two (2) sub-samples of 10 ml of each filtering were collected using a pipette and placed in a squared petri dish of 90 mm for the inventory of organisms like rotifers, cladocerans and copepods. The identification of these organisms group was done using a binocular magnifyer and objectives 4X and 10X by means of identification keys and works of [21,22,23,24,25] following the classic technics. The individual density was calculated using the following formula:

$D = n / V1 * V2 / V3$ Where: D = density (individual/liter); n = number of counted individuals; V1 = volume of filtering collected; V2 = volume of concentrated filtering; V3 = total volume filtered water).

The zooplanktonic biomass was calculated by multiplying the average dry weight (PS) of each group of zooplankton by their density.

Table 1 Somes characteristics of collection ponds of zooplankton

Sites and numbers of ponds	Species of fish bred	Types of Fertilisers	Altitude (m)	Geographic position
Batié				
1	Carp, Tilapia and Catfish	Wheat bran	1500	LN : 5°17'-5°18' et LE : 10°17'- 10°19'
2	Carp, Tilapia and Catfish			
3	Carp, Tilapia and Catfish	Pig manure		
4	Carp, Tilapia, Catfish and Kanga			
Bamendou				
5	Tilapia, carp	Compost cowpat	1400	LN : 5°22'-5°28' et LE : 10°52'-10°54'
6	Tilapia, carp, Catfish, Kanga			
7	Tilapia, Carp, Catfish			
Fokoue				
8	Tilapia, Carp, Catfish, Kanga	Pig manure	1276	LN : 5°34'-5°36' et LE : 10°14'-10°17'
9	Tilapia; Catfish			
10	Tilapia			
11	Catfish, Tilapia, Kanga	No fertiliser		
Dschang				
12	Tilapia, Catfish, Carp	Chicken manure	1391	LN : 5°44'-5°48 et LE : 9°85'-10°05'
Foumbot				
13	Tilapia, Catfish	Compost cowpat	1120	LN : 5º 20' à 5º 22' et LE : 10º 17' à 10º 21'
14	Tilapia, Catfish			
15	Tilapia, Catfish			

Trial conduct and data collection

Determination of physicochemical characteristics of water

The physicochemical characteristics of water such as temperature, dissolve oxygen, pH, transparency and electric conductivity were monthly measured *in situ* respectively with the help of an oxy-thermometer, pH-meter, Secchi disk and a conduct meter of mark HANNA. The dosage of nutritive salt including: nitrate, nitrite and phosphate were done every 2 months using a spectrophotometer marked HACH respectively according to the methods of nitra ver III, nitri ver III, and phos ver [20].

Sampling of zooplankton

The zooplankton was monthly collected between 6 and 8 am in order to avoid all vertical migration relative the sun rise. The sample 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 of 20 liters /pond was filtered with plankton sieve of 40 µm mesh. After obtaining the filtering, 250 ml of this later was introduced into bottles priory labeled and fixed in formalin 5% in the proportions of ¾ of samples and ¼ of formalin. Then these samplings were taken to the laboratory for analyses.

Dry weights of rotifers, copepodites and adults of copepods, larvas of copepods and cladocerans are 0,18 ; 1,36 ; 0,08 and 1,32 µg respectively [26,27,28].

Statistical analysis

Data collected was submitted to one way analysis of variance (ANOVA 2). When a significant difference existed, the Duncan's test was used at 5% threshold to separate means [29]. The software SPSS (*Statistical Package for Social Sciences*) version 20.0 was used.

RESULTS

Physicochemical characteristics of water

The influence of the sites and types of fertilizers on the physicochemical characteristics of water is resumed in table 2. The significantly ($p<0.05$) highest values of the temperature, pH and transparency was observed in the basins of Dschang fertilized with chicken manure. When comparing the type of fertilizer independently of the sites, the significantly high value of the electric conductivity ($p<0.05$) was observed in ponds of Batié fertilized with pig manure.

Table 2 Physicochemical characteristics of water according to the sites and types of fertilizers

Physicochemical characteristics of water	Sites and types of fertilizers						
	Bamendou	Batié		Dschang	Fokoué		Foumbot
	Cowpat	Pig manure	Wheat bran	Chiken manure	Pig manure	No fertilizer	Cowpat
Temperature (°C)	20,32± 1,08^{a}	21,03±0,53^{b}	21,64±0,81^{c}	23±00^{d}	20,37±0,88^{e}	20,36±0,80^{e}	20,36±0,81^{e}
pH (UI)	7,70±0,51^{a}	7,75±0,39^{a}	7,43±0,53^{b}	7,44±0,67^{b}	7,41±0,45^{b}	7,59±0,47^{b}	7,17±0,36^{c}
Conductivity (µS/cm)	64,00±19,59^{a}	105,64±23,93^{b}	51,42±16,84^{c}	57,33±10,57^{c}	53,64±3,54^{c}	48,21±8,43^{d}	64,19±3,93^{a}
O_2 (mg/l)	6,26±1,05^{a}	4,39±1,21^{b}	4,85±1,54^{c}	5,82±0,72^{d}	5,29±1,59^{c}	5,68±1,18^{d}	5,68±1,56^{d}
Transparency (cm)	81,64±4,27^{a}	40,93±3,47^{b}	39,16±6,73^{b}	81,17±4,13^{a}	56,21±5,38^{c}	30,50±6,63^{e}	58,68±3,01^{c}
Nitrate (mg/l)	2,31±0,31^{a}	3,97±3,58^{b}	2,43±2,21^{a}	2,84±1,22^{a}	1,34±0,41^{c}	1,13±0,26^{c}	1,45±0,36^{c}
Nitrite (mg/l)	2,66±0,43^{a}	9,91±4,32^{b}	6,54±4,92^{c}	4,27±1,15^{d}	2,88±0,91^{a}	2,34±1,22^{a}	2,26±0,53^{a}
Phosphate (mg/l)	0,002±0,004^{a}	2,81±2,02^{b}	0,03±0,04^{a}	0,004±0,008^{a}	0,19±0,40^{a}	0,17±0,37^{a}	0,51±1,22^{a}

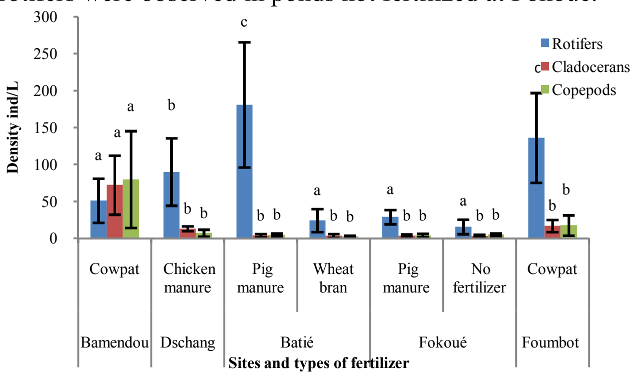
a, b, c, d; values affected with the same letter on the same line do not differ significantly (p>0.05)

For the dissolved oxygen, it was significantly low in ponds of Batié fertilized with pig manure while the highest values were noticed in Bamendou with cowpat. In Batié and Fokoué, the amount of dissolve oxygen was significantly ($p<0.05$) high in ponds receiving wheat bran and ponds receiving no fertilizers respectively. Independently of the sites, the values of phosphates were low during the whole period of the study no matter the type of fertilizer. Generally, the nutritive values of salt was significantly higher ($p<0.05$) in ponds fertilized with pig manure at Batié, the lowest were observed at Fokoué and Foumbot no matter the type of fertilizer.

Density of zooplanktons

The influence of the sites and types of fertilizers on the total zooplanktonic density is illustrated by figures 1. With the exception of ponds of Bamendou receiving cowpat, the density of rotifers were significantly ($p<0.05$) higher compared to other groups of zooplankton no matter the site. The densities of copepods and cladocerans increased significantly ($p<0.05$) in Bamendou compared to that of rotifers. Meanwhile, no significant ($p>0.05$) difference was observed between the densities of zooplanktonic goups in ponds of Batié independenltly of the type of fertilizer. The monthly evolution of the density of rotifers, cladocerans and copepods according to the sites and types of fertilizer is illustrated in figure 2. Apart from Bamendou, where the densities of cladocerans and copepods were high, they were generally low no matter the site. Hence, the pic of density of cladocerans and copepods was registered in May in ponds fertilized with cowpat of Bamendou.

The monthly evolution of the densities of rotifers presented the same tendency and profil no matter the type of fertilizer. With the exception of the month of June, the density of rotifers was higher during the whole period of the study in ponds fertilized with pig manure of Batié while the lowest density values of rotifers were observed in ponds not fertilized at Fokoué.



a, b, c, d; histograms of the same motif affected with the same letter are not significantly different (p>0.05)

Figure 1 Density of zooplankton group as a function of sites and types of fertilizers

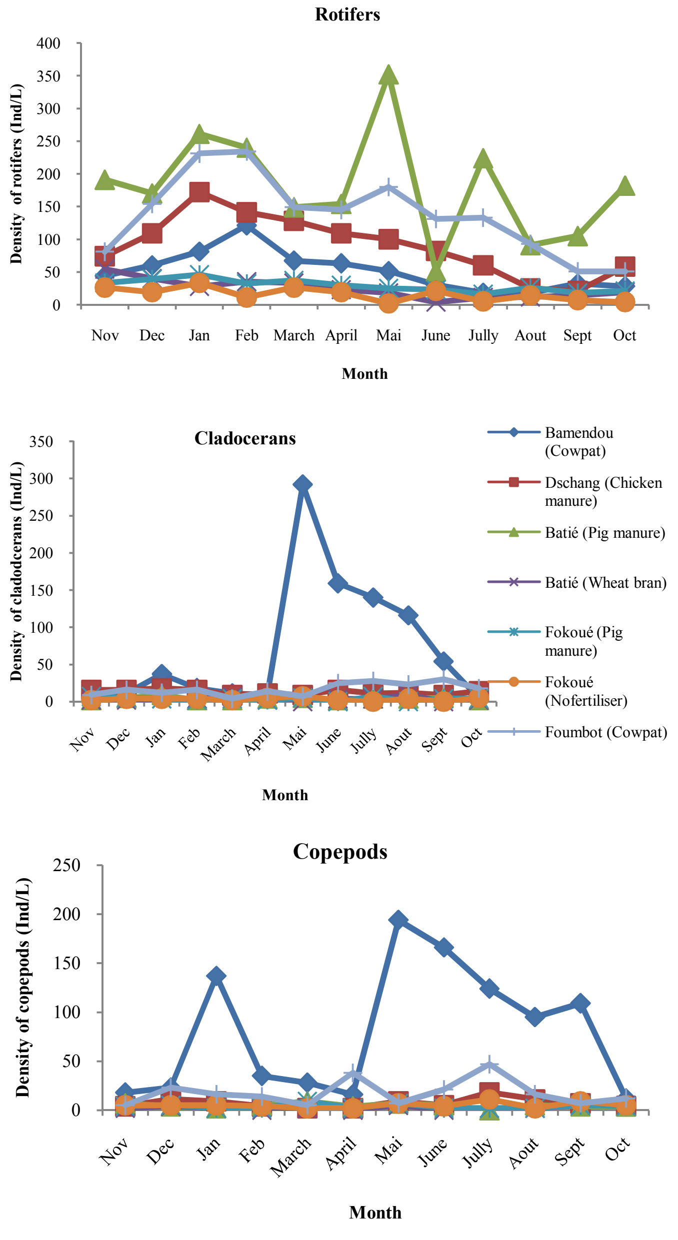
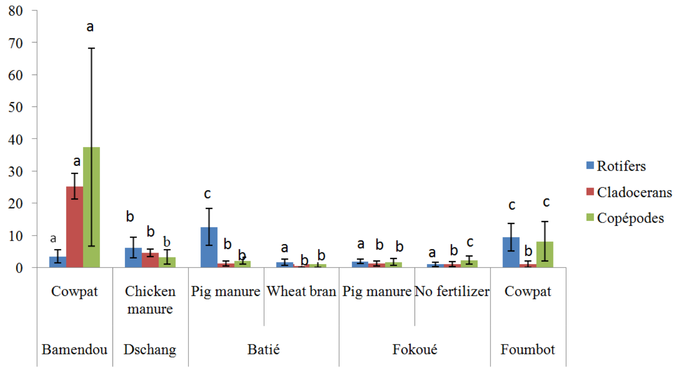


Figure 2 Monthly evolution of the zooplanktonic density groups as a function of site and types of fertilizers

Biomass of zooplanktons

The biomass of rotifers was significantly ($p<0.05$) higher compared to other goups in ponds fertilized with pig manure at Batié (figure 3). They are followed by the ponds of Foumbot fertilized with cowpat and those of Dschang fertilized with chicken manure. Meanwhile the ponds of Fokoué and those of Batié receiving wheat bran showed no significant difference between the biomass of zooplanktonic groups. The biomass of copepods and cladocerans as well as their density was significantly ($p<0.05$) higher in Bamendou compared to other sites.



a, b, c, d; histograms of the same motif affected with the same letter are not significantly different ($p>0.05$)

Figure 3 Biomass of zooplankton according to the sites and types of fertilizer

Correlations between the physicochemical characteristics of water and the density of zooplanktonic groups

The correlations between the physicochemical characteristics of water and the density of zooplanktonic groups shows no significant correlation between the physicochemical characteristics of water and the density of zooplanktonic groups no matter the type of fertilizer (table 3). However, the correlations were negative and weak between temperature and the density of rotifers in ponds fertilized with pig manure of Batié and ponds of Foumbot receiving cowpat.

Meanwhile, the values were positive and weak between the electric conductivity and the density of rotifers at Foumbot. The correlations were high between temperature, nitrite and the density of rotifers respectively in the non fertilized basins of Fokoué and the basins fertilized with pig manure. In the non fertilized ponds of Fokoué, the correlations between the density of cladocerans and the transparency were positive and weak. They were negative and high between the transparencies in ponds of Foumbot, positive and high between electric conductivity and pH respectively in ponds fertilized with pig manure of Batié and Fokoué. No significant correlation was observed between the density of copepods and the physicochemical characteristics of water. These correlations were positive and high between the conductivity and oxygen in ponds not fertilized at Fokoué.

Table 3 Correlations between physicochemical characteristics of water and zooplankton density

Zooplanktons groups and sites	Types of fertilizer	Physicochemical characteristics of water							
		Temperature	Transparency	Conductivity	PH	O_2	$NO2^-$	$NO3^-$	PO_4^{3-}
Rotifers									
Bamendou	Cowpat	-0,12	-0,51	-0,13	+0,79	-0,72	-0,83	+0,77	-0,10
Batié	Pig manure	-0,03	-0,25	+0,46	+0,16	-0,41	+0,77	+0,58	-0,37
	Wheat bran	-0,09	-0,02	- 0,83	+0,11	+0,19	-0,58	-0,20	+0,30
Dschang	Chicken	0,00	-0,70	-0,71	-0,43	-0,58	-0,37	-0,65	-0,19
Fokoué	Pig manure	+0,73	+0,90	-0,17	+0,10	-0,73	+0,81	-0,10	-0,54
	No fertilizer	+0,91	-0,45	-0,54	-0,42	-0,57	+0,55	+0,05	-0,39
Foumbot	Cowpat	-0,04	-0,66	+0,02	-0,76	-0,18	-0,17	+0,75	-0,28
Cladocerans									
Bamendou	Cowpat	-0,18	+0,39	+0,57	+0,16	+0,59	+0,51	-0,59	-0,37
Batié	Pig manure	-0,39	-0,09	+0,82	-0,43	-0,33	+0,26	+0,71	+0,22
	Wheat bran	-0,46	-0,64	-0,76	-0,20	-0,40	+0,16	+0,67	+0,05
Dschang	Chicken	0,00	-0,34	+0,17	-0,79	+0,26	+0,28	-0,37	+0,49
Fokoué	Pig manure	-0,44	+0,27	+0,51	+0,82	+0,25	-0,11	+0,26	+0,61
	No fertilizer	-0,14	+0,01	-0,61	-0,27	-0,76	+0,43	-0,36	-0,48
Foumbot	Cowpat	-0,35	-0,94	+0,33	-0,07	+0,74	-0,76	-0,76	+0,25
Copepods									
Bamendou	Cowpat	-0,50	+0,64	+0,10	+0,19	+0,58	+0,27	-0,46	-0,58
Batié	Pig manure	+0,68	-0,39	-0,26	+0,27	-0,25	-0,36	-0,33	-0,67
	Wheat bran	+0,33	+0,28	+0,50	-0,11	+0,14	+0,01	-0,51	-0,50
Dschang	Chicken	0,00	+0,31	+0,14	+0,58	+0,60	-0,10	+0,72	-0,33
Fokoué	Pig manure	+0, 22	-0,32	-0,52	-0,38	-0,37	-0,33	+0,07	-0,45
	No fertilizer	-0,67	+0,38	+0,73	+0,52	+0,84	-0,21	-0,08	+0,67
Foumbot	Cowpat	-0,49	+0,42	-0,19	-0,39	+0,43	-0,28	-0,28	-0,26

DISCUSSION

Results relative to the influence of the sites and type of fertilizer on the physicochemical characteristics of water showed that physicochemical characteristics were significantly affected by the sites and types of fertilizer. Thus, the values of temperature were significantly high and observed in ponds of Dschang fertilized with chicken manure while the electric conductivity, phosphate, nitrite and nitrate increased significantly in the basins of Batié fertilized with pig manure. The concentration in phosphate ions (PO_4^{3-}), nitrite (NO_3^-) and nitrate (NO_3^-) were lower compared to those registered by [18] in ponds not poisoned fertilized with chicken manure and pig manure. Such difference could be due to the presence of fish feeding on organic matter or phytoplankton in suspension, responsible for the decrease mineral elements after decomposition. The levels of dissolved oxygen were significantly low with pig manure in the ponds of Batié. These results are comparable to those obtained by [30] during the production of zooplankton from pig faeces and could be due to the nature of fertilizer. The low value of dissolved oxygen obtained is characterized by eutrophic milieu [31].

Deoxygenation is a consequence of oxidation of organic matter realized by chemical or biological pathway [32]. The temperature and the pH were affected by the site and type of fertilizer. Hence, the significantly highest values of temperature were observed in the ponds of Dschang fertilized with chicken manure. These observations are contradictory to those reported by [6,33,30,18] who showed a constant for these characteristics no matter the type of fertilizer.

Nonetheless, the temperature was favourable for the good development of plankton that is the values of 20-30°C preconized by [34].

Results relative to the evolution of zooplanktonic density showed that the pic of total density of zooplankton was observed in May in the ponds of Batié and Bamendou fertilized respectively with pig manure and cowpat. This observation is due to the emptying of the ponds in the months of December compared to other ponds. The period of colonization of ponds by the zooplankton cicumsribed between January and May after which we noticed a drop of density called decolonization [6]. The proliferation of cladocerans and copepods and the regression of rotifers between April and October could be because of the competition between cladocerans and rotifers for the available feed resource for the predation exerted by the copepods on the rotifers and the agitation of waters putting to evidence nutrients. Besides, the high density of copepods compared to other zooplanktonic groups registered in ponds fertilized with cowpat agrees with the observations of [6,16] in basins fertilized with cowpat and faeces of guinea pig respectively.

The high density of rotifers in the ponds of Dschang fertilized with chicken manure and of Batié fertilized with pig manure might explain the phytoplanktonic richness in this milieu in relation to the richness in biogen element. This concord with the works of [35] who reported that the high representation of rotifers in an environment presents an eutrophic level. Such a relation has already been demonstrated by many studies

[36,37,27] who reported a positive correlation between the richness in nutrients and the phytoplanktonic biomass on one hand and between the phytoplanktonic biomass and zooplanktonic on the other hand. This high density of rotifers in the fertilized basins with chicken manure is contradictory to results obtained by [6]. This difference could be explained by the absence of cladocerans in the basins of which according to [38] are feed competitors with rotifers.

CONCLUSION

The present study showed that the physicochemical characteristics of water were significantly affected by the site and type of fertilizer. Thus, the significantly high values of temperature were observed in ponds of Dschang fertilized with chicken droppings while the electric conductivity, the concentrations of phosphate, nitrite and nitrate were significantly high in the basins of Batié fertilized with pig manure. The levels of dissolve oxygen were significantly lower with pig manure in the ponds of Batié.

The density and the zoolanktonic biomass were affected by the sites and types of fertilizer. Hence, the significantly high values of the densities and biomass of rotifers were observed in ponds of Batié fertilized with pig manure while those of cladocerans and copepods were higher in ponds of Bamendou receiving cowpat as fertilizer.

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