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Effects of doses of chicken manure on the biodiversity of zooplankton populations in ponds

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Abstract
In order to evaluate zooplankton biodiversity for the purpose of optimizing fish production in pond, the effect of doses of chicken manure was assessed from May to November 2016 in 9 ponds (5.7 x 5.7x 1 m) with a residual flow rate of 0.05 l/s. At each of the randomly selected ponds, one of the doses 0; 800 and 1000 kg / ha was administered weekly. The results showed that, nitrites (5.64 ± 0.19 mg/l), nitrates (6.23 ± 0.13 mg/l) were significantly ($p<0.05$) higher in pond fertilized at 1000 kg/ha, the opposite being observed with dissolved oxygen (3.53 ± 0.18 mg/l) and transparency (32.29 ± 2.50 cm). A total of 84 species belonging to rotifers (53 species), cladocerans (18 species) and copepods (7 species) groups were identified independently of treatment. The lowest values of zooplankton richness (21 species) were registered in the control pond, while the highest richness (59 species) was observed in the treatment 1000 kg / ha.

Keywords: Zooplankton, biodiversity, chicken manure, pond

1. Introduction
In Africa and more specifically in Cameroon, the role of aquaculture in the economy remains marginal. In fact, the contribution of the aquaculture and fishing sector as a whole is less than 1% of GDP [1]. Today, it accounts for less than 0.1% of total fish intakes despite water surfaces covering nearly 3.5 million hectares, spread over four major river basins [1].Commercial fish farming is 90% from fertilized ponds. However, its development is confronted with several constraints, particularly fry insufficiency, which is closely linked to larval feeding due to the production of live prey that must be available in sufficient quantity and quality for the passage of the larval stage at alevin [2]. In hatcheries, saltwater zooplankton, especially Artemia, are the most commonly used live prey for larval feeding. However, its availability in local markets remains difficult, because, its production technique is very sophisticated and the cost is high. The production of the zooplankton from organic fertilizers, including animal waste (poultry droppings, cow dung and pig droppings) is no longer demonstrated. Indeed, several authors have reported that droppings improve the physicochemical characteristics of water as well as zooplankton densities [3], which are the living prey of fish. Several studies have been carried out on the production of zooplankton, especially in tanks and aquaria from animal dung [2, 3] in order to improve the feeding of the larvae of zooplankton. Like any animal, the plasticity of the fish diet depends on the diversity of living prey in its environment. However, little work has been done on the study of the diversity of zooplankton populations in a pond [4, 5].
The objective of this study was to evaluate zooplankton biodiversity for the purpose of optimizing fish production. More specifically, the aim is to evaluate the effect of chicken manure on the physicochemical characteristics of water, the richness and relative abundance of zooplankton populations, and the indices of species diversity and equitability.

2 Material and Methods
2.1 Period and area of the study
The present study was carried out from May to November 2016 at the University of Dschang Application and Research Farm (FAR) (LN: 5 ° 44'-5 ° 36 'and LE: 10 ° 06'-9 ° 85 ', altitude: 1392 -1396 m) in the Sudano-Guinean zone characterized by a short dry season (mid-November to mid-March) and a long rainy season (mid-March to mid-November).
The annual rainfall varies between 1500 and 2000 mm and the temperatures oscillate between 14 °C (July-August) and 25 ° C (February).

2.2 Conduct of the study and data collection
Chicken manure were collected within the same farm and kept at room temperature. A sample was taken to determine the dry matter, total nitrogen and phosphorus concentration summarized in Table 1.

Table 1: Composition (in%) of chicken manure.

Fertilizer	Composition (in%)		
	Dry matter	**Nitrogen**	**Phosphorus**
Chicken manure	80.2	2	1.5

Zooplankton production was conducted in 9 ponds of the same area (5.7 x 5.7 m) and depth 1 m, with a flow rate of 0.05 l/s, fed from a holding lake located at 100 m. In order to eliminate unwanted organisms and to increase the alkalinity of the medium, the ponds were put in assec for a period of 7 days and limed with quicklime at a dose of 400kg / ha.

A net of 50 mm mesh was attached to the alimentation pipe of each pond to prevent the intrusion of fish from the reservoir. At each of the randomly selected ponds, one of the doses of 0; 800 and 1000 kg / ha of chicken manure was administered weekly as fertilizer. Each dose was repeated three times.

The transparency, temperature, pH, dissolved oxygen and electrical conductivity were directly measured in the field using respectively a secchi disk, Thermo-Conductivity meter, ThermopH-meter, pH meter, Thermo-Oximeter and Thermo-Conductivity meter HANNA

The nitrite, nitrate and phosphate were determined using molecular absorption spectrophotometric (HACH DR / 2000 spectrophotometer) according to Apha techniques [6].

Zooplanktons were collected bimonthly between 6 and 8 am in order to avoid their vertical migration to the bottom after sunshine. 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 sieve plankton of 40 µm mesh. A volume of 350 ml zooplankton concentrate was recovered, fixed by addition of 5% formalin (¼ volume of the concentrated sample) and stored in plastic bottles for quantitative and qualitative analyzes. Two types of analysis were carried out namely: qualitative analysis and quantitative analysis.

2.2.1 Qualitative analysis
Only rigid integument species have been identified. Indeed, all the samples have been fixed with formalin which by these chemical properties modifies the shape of the species with flexible integument.

After homogenization, 10 ml of the sample were taken by means of a calibrated pipette and introduced into a Petri dish 90 mm in diameter. Species identification was performed using a MOTIC binocular loupe.

- **Rotifer identification**

It was possible thanks to the use of the keys of determinations and works of [7-10].

- **Cladocerea identification**

It was based on the observation of morphological characters, such as the shape of the body, the shape of the cephalic capsule in ventral or dorsal view, the shape of the rostrum and the detailed examination of the appendages of the post-abdomen. The observation of these characters was only possible after dissection with the binocular loupe MOTIC using munities mounted on pen or mandrel. The keys to determinations and works were those of [7, 11-13].

- **Copepods identification**

The copepods were identified on the basis of body shape, length of antennules and antennae, lateral ornamentation of segments of the abdomen, position of ovigerous sacs, and rostrum shape. The identification was made after dissections with the binocular loupe MOTIC by means of the munities. The keys to determinations and works were those of [7, 12, 14].

2.2.2 Quantitative analysis of zooplankton
Counting individuals was done simultaneously as identification. The count was done in duplicate [14] under the binocular loupe brand MOTIC. The counts of at least 100 individuals per sample were made.

2.3 Statistical analysis
The data collected were submitted to the Turkey test and one-way analysis of variance (ANOVA 1). In case of significant differences between means, the Duncan test was applied to separate them at the 5% significance level. SPSS 20.0 software (Statistical Package for Social Sciences) and Graph-pat were used for the analysis.

3 Results
3.1 Physicochemical characteristics of water according to doses of chicken manure
The influence of manure dose on the physicochemical characteristics of water is summarized in Table 2. Transparency, dissolved oxygen, nitrites, nitrates and phosphates are significantly (p<0.05) varied with the treatment. For transparency and dissolved oxygen, the highest values were recorded in the control treatment. Nitrite and nitrate were significantly (p< 0.05) higher in fertilized pond. However, no significant difference (p > 0.05) was observed when comparing the doses of the fertilized ponds. As for the conductivity and temperature no significant difference (p > 0.05) was observed between the treatments, however the values of the conductivity increased with the treatment dose.

Table 1: Physicochemical characteristics of water according to doses of chicken manure

Physicochemical characteristics of water	Doses of chicken manure (kg/ha)		
	Control(0)	**800**	**1000**
Transparency (cm)	$74,16 \pm 10,10^a$	$43,26 \pm 10,61^b$	$32,29 \pm 2,50^b$
Temperature (ºC)	$20,65 \pm 0,11^a$	$20,42 \pm 0,35^a$	$20,45 \pm 0,36^a$
O_2 (mg/l)	$5,34 \pm 1,42^a$	$4,37 \pm 0,18^{ab}$	$3,53 \pm 0,18^b$
pH (UI)	$7,53 \pm 0,25^a$	$7,44 \pm 0,22^{ab}$	$7,43 \pm 0,04^{ab}$
NO_2^-(mg/l)	$2,03 \pm 0,13^a$	$4,92 \pm 0,09^b$	$5,64 \pm 0,19^b$
NO_3^-(mg/l)	$2,40 \pm 0,22^a$	$5,58 \pm 0,26^b$	$6,23 \pm 0,13^b$
PO_4^{3-}(mg/l)	$1,28 \pm 0,05^a$	$3,79 \pm 0,05^b$	$3,34 \pm 0,07^c$
Conductivity (µs/cm)	$36,79 \pm 4,28^a$	$37,75 \pm 4,47^a$	$39,81 \pm 1,50^a$

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

3.2. Richness of families, genus and species of zooplankton

The richness of the families, genus and species of zooplankton summarized in Table 3 shows that, regardless of the dose, 83 species distributed in 31 genera and 17 families belonging to the groups of rotifers, cladocerans and copepods were identified in the treatments.

The rotifer group represented by 53 species, 17 genera and 11 families was the most diverse, followed by cladocerans represented by 18 species, 8 genera and 6 families. The least diversified copepods were represented by a family consisting of 7 genera and 7 species. The lowest values of zooplankton richness (21 species) were registered in the control pond, while the highest richness (59 species) was observed in the treatment 1000 kg/ha. The families of Brachionidae, Dicranophoridae, Lecanidae, Synchaetidae, Chydoridae, Daphnidae and Cyclopidae were identified in all treatments, representing 41.17%, while the Philodinidae, Scaridiidae and Trochosphaeridae, representing 17.64%, were identified only in the fertilized pond at 1000 and 800 kg / ha, respectively. The Cyclopideae family was more represented in genus (22, 58%), followed by Brachionidae (12.90%), especially in the 1000 kg / ha treatment.

In terms of genus, *Euchlanis, Lecane, Polyathra*, *Alona*, etc. representing 25.80% of the total were identified in all treatments, whereas the genus *Microcyclops, Halicyclops, Brachionus, Macrothrix, Diaphanosoma, Encentrum, Dicranophorus* and *Platyias* (25.80%) have been identified only in fertilized ponds. Similarly, *Moina, Simocephalus* and *Filinia* were only identified in the 800 kg / ha treatment, *Resticula* and *Scaridum* in the 1000 kg / ha treatment. *Lecane* (24.09%), followed by *Trichocerca* (7.22%), were more represented in species, respectively in treatments 800 and 1000 kg / ha.

Table 3: Composition of zooplankton as a function of the dose of chicken manure

Groups / Families / Genus / Species	**Control**	**Dose of chicken manure(kg/ha)**	
	0	800	1000
Rotifers			
Brachionidae			
Brachionus			
Brachionus bidentata		X	X
Brachionus quadridentatus		X	X
Brachionus sp.		X	
Keratella			
Keratella tropica	X		X
Plationus			
Plationu spatulus	X		X
Platyias			
Platyias leloupi		X	X
Platyias quadricornis		X	X
Notommatidae			
Cephalodella			
Cephalodella inquila			X
Cephalodella physalis		X	
Cephalolepadella bottgeri		X	X
Resticula			
Resticula melandocus			X
Dicranophoridae			
Dicranophorus			
Dicranophorus sp.			X
Dicronophorus caudatus		X	
Encentrum			
Encentrum putorius		X	X
Encentrum sp.		X	X
Euchlanis			
Euchlanis sp.		X	X
Euchlanis triquetra	X	X	X
Trochosphaeridae			
Filinia			
Filinia terminalis		X	
Lecanidae			
Lecane			
Lecane aguessi		X	
Lecane aquila		X	X
Lecane blachei			X
Lecane bulla	X	X	X
Lecane closterocerca		X	X
Lecane curvicornis		X	
Lecane decipens		X	X
Lecane doryssa			X
Lecane elsa	X	X	
Lecane hornemanni			X
Lecane luna	X		X
Lecane lunaris	X		X

Lecane nana	X		
Lecane obtusa		X	
Lecane pyriformis		X	
Lecane quadridentata		X	
Lecane stichaea		X	X
Lecane tenulseta		X	
Lecane tudicola			X
Lecane furcata	X	X	
Lepadellidae			
Lepadella			
Lepadella patella			X
Lepadella sp1		X	
Lepadella sp2		X	
Xenolepadella			
Xenolepadella monodactyla			X
Xenolepadellasp.			X
Mytilinidae			
Mytilina			
Mytilina acantophora			X
Mytilina ventralis	X		X
Synchaetidae			
Polyathra			
Polyathra bicerca	X		X
Polyathra vulgaris	X	X	X
Philodinidae			
Rotaria			
Rotaria rotatoria			X
Scaridiidae			
Scaridium			
Scaridium longicaudum			X
Trichocercidae			
Trichocerca			
Trichocerca elongata			X
Trichocerca pletessa		X	
Trichocerca pusilla			X
Trichocerca rattus			X
Trichocerca scipio		X	X
Trichocerca sp.		X	
Cladocerans			
Chydoridae			
Alona			
Alona costata			X
Alona protzi			X
Alona rustica		X	
Alona sp.		X	
Alona verrucossa	X	X	
Chydorus			
Chydorus brevilabris	X		X
Bosminidae			
Bosmina			
Bosmina longirostris		X	
Bosmina sp.	X	X	
Bosminopsis deitersi		X	
Daphnidae			
Ceriodaphnia			
Ceriodaphnia cornuta	X		X
Ceriodaphniapulchella	X	X	X
Ceriodaphnia quadrangula			X
Ceriodaphnia sp.			X
Simocephalus			
Simocephalus sp		X	
Sididae			
Diaphanosoma			
Diaphanosoma brachyurum		X	
Diaphanosoma sp.			X
Macrothricidae			
Macrothrix			
Macrothrix laticornis		X	X
Moinidae			

Moina			
Moina macropa		X	
Copepods			
Cyclopidae			
Cryptocyclops			
Cryptocyclops linjanticus			X
Cryptocyclops sp.	X	X	X
Eucyclops			
Eucyclops sp.	X	X	X
Eucyclops stuhlmanni		X	X
Halicyclops			
Halicyclops sp		X	X
Mesocyclops			
Mesocyclops salinus	X	X	X
Mesocyclops sp.		X	X
Microcyclops			
Microcyclops sp.		X	X
Paracyclops			
Paracyclops sp.		X	X
Thermocyclops			
Thermocyclops emini			X
Thermocyclops neglectus			X
Thermocyclops sp.	X		X

3.3. Relative abundance of zooplankton

The total relative abundance of zooplankton by dose is summarized in Table 4. It appears that the highest percentage was recorded in the 1000 kg / ha treatment. The identified zooplankton groups were dominated by rotifers, followed by copepods in the control treatment. The same trend was observed in the treatment 1000 kg / ha, but with higher values. On the other hand, cladocerans were rather abundant in the 800 kg / ha treatment.

Table 4: Relative abundance of zooplankton as function of manure doses

Groups of zooplankton	**Relative abondance (%)**		
	Control	**800 kg/ha**	**1000 kg/ha**
Rotifères	14,45	38,55	45,78
Cladocères	6,02	13,25	10,84
Copépodes	4,81	9,63	12,04
Total	25,28	60,63	68,66

The relative specific abundance of rotifers, cladocerans and copepods as a function of the doses of manure is illustrated in Fig 1 to 3.

With regard to rotifers, *Lecane bulla* species belonging to the family Lecanidae was the dominant. However, the highest proportions were recorded in the 800 kg / ha treatment. The species *Polyathra bicerca*, *Cephalodella inquila* and *Rotaria rotatoria* were dominant respectively in the control treatment and those at 800 and 1000 kg / ha.

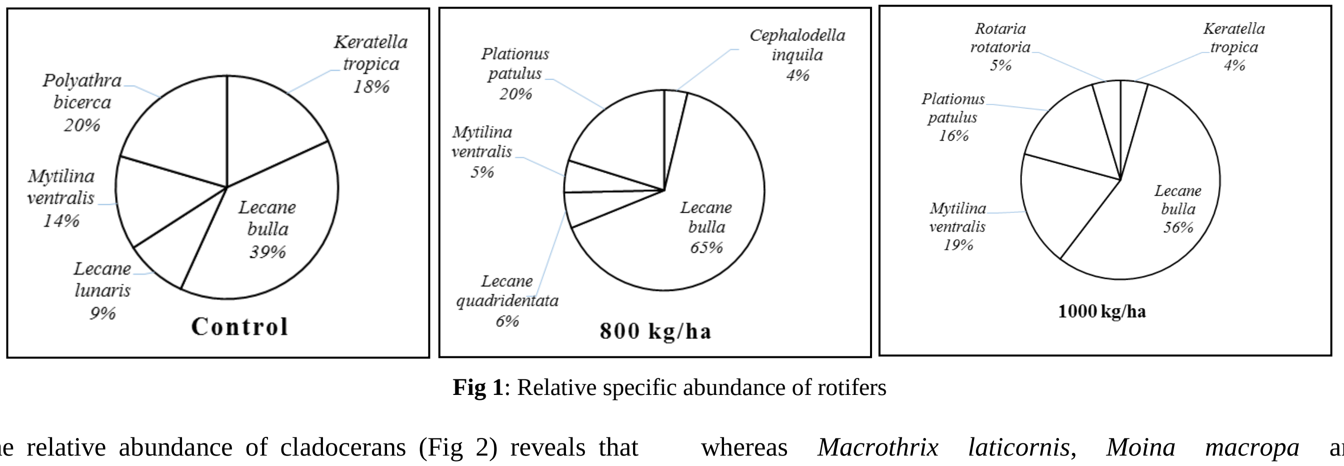

Fig 1: Relative specific abundance of rotifers

The relative abundance of cladocerans (Fig 2) reveals that *Ceriodaphnia cornuta*, *C. pulchella* and *Alona verrucossa*, *Bosmina sp* were more abundant in the control treatment whereas *Macrothrix laticornis*, *Moina macropa* and *Diaphranosoma brachyurum* species were more abundant respectively in the treatments 800 and 1000 kg / ha.

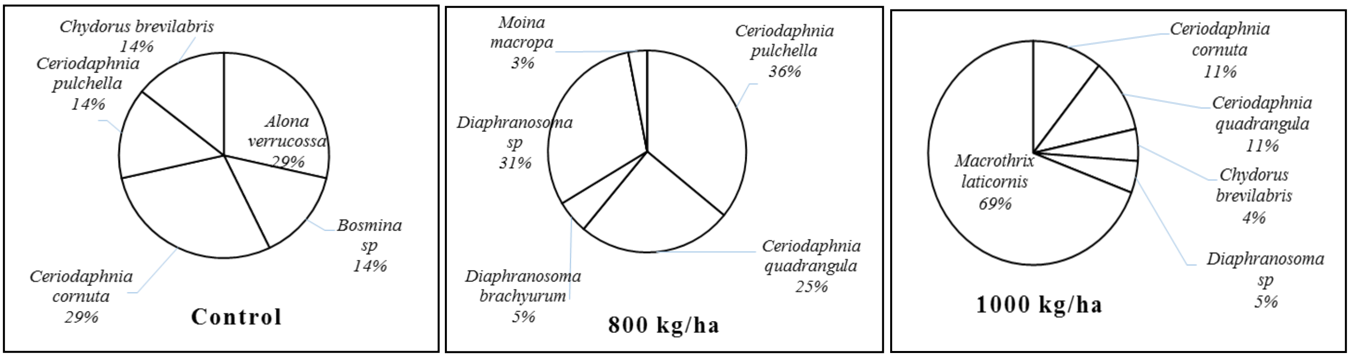

Fig 2: Specific relative abundance of cladocerans

The specific relative abundance of copepods (Fig 3) shows that the species *Thermocyclops sp* was the most abundant followed by *Cryptocyclops sp* and *Mesocyclops salinus*. However, they were more represented in 800 treatments followed by 1000 kg / ha.

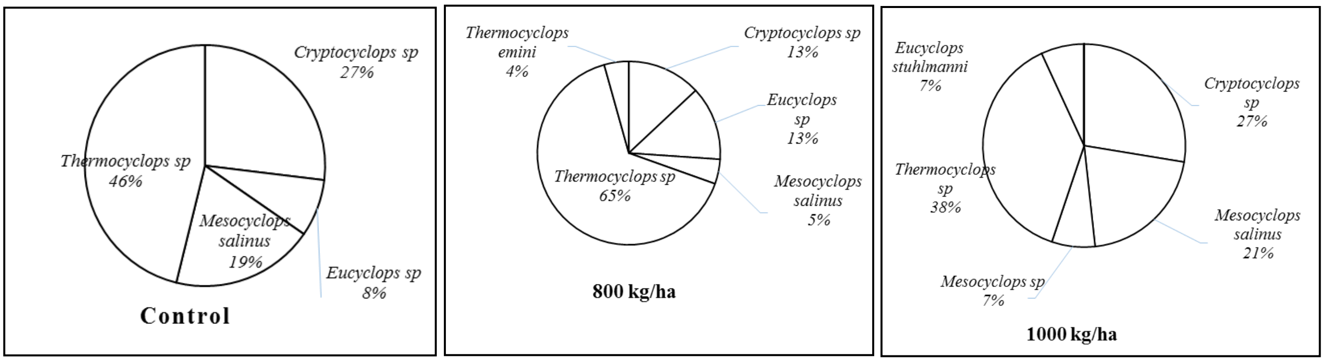

Fig 3: Relative Abundance of Copepods

3.4. Index of diversity and equitability of zooplankton

The Shannon & Weaver diversity index and equitability as a function of the dose of chicken manure are summarized in Table 5. It appear that, diversity increased with dose. Thus, the highest value was obtained in a fertilized pond at a rate of 1000 kg / ha and the lowest in an unfertilized pond.

Table 5: Index of species diversity of zooplankton as a function of the dose of chicken manure

Indice de diversité (bits/ind)	Dose of chicken manure (Kg / ha)		
	Control	800	1000
Shannon & Weaver	0,79	1,76	2,37
Equitabilité J	0,25	0,46	0,57

4. Discussion

Results on the physicochemical characteristics of water showed that dissolved oxygen, transparency, nitrites, nitrates and phosphates were significantly affected by manure doses. Thus, the concentrations of nitrate ions and phosphates were higher in fertilized pond. Our values were below 11.06 mg / l of nitrates and 12.56 mg / l of phosphates obtained by Akodogbo *et al* [3] on the production of zooplankton based on pig droppings in buckets.

This would be related to the composition of manure in mineral elements and also the high temperature of the water (31.28 ºC against 20.50 ºC in our ponds) having contributed to the decomposition of the organic matter. In addition, the concentrations of nitrate ions and phosphates were higher than those recorded by Kumara *et al* [16] in nursery tanks fertilized with chicken manure and cow dung. Such a difference would be due to the lack of fry in our ponds that feed on the organic matter in suspension responsible for the increase of the mineral elements after decomposition.

The transparency of the water in the fertilized ponds was significantly lower. This trend could be related to the distribution of seston elements in the water column, including plankton swarming. Dissolved oxygen was significantly lower with the largest amount of fertilizer. This is certainly related to the activity of bacteria that are more numerous in environments receiving organic matter. Deoxygenation is the consequence of the oxidation of organic matter, carried out biologically or chemically [17].

The average temperature and pH in the fertilized ponds were in the favorable range of plankton development, respectively 20-30 °C; 6.5 - 7.5; reported by Carballo *et al*; FAO [18, 19].

Results on the influence of droppings on zooplankton biodiversity showed that the species richness, generic and familial, as well as the relative abundance of zooplankton increased significantly with the doses of dung. The number of species identified independently of the doses was greater than 41 species obtained by [20] in Mwembe Lake and 30 species identified by [20] in a traditional aquaculture system, "Whedos".

The observed differences are due to several factors including the effect of the doses of dung, the sampling effort (twice a month against one), the size of the plankton net (40 μm against 40 and 64 μm) and the predation of fish.

The specific richness of zooplankton in fertilized pond was significantly higher compared to that of control ponds. This trend corroborates that reported by [21]. Species richness was less than 131 species and subspecies harvested by [7] in Lake Municipal de Yaoundé. The differences can be explained on the one hand, in the hypertrophic state of the lake favorable to the opportunistic species, on the other hand, the size and the sampling season. Indeed, the structure of zooplankton populations is influenced mainly by the sampling season [20].

The distribution of species richness of zooplankton groups showed that rotifers were more dominant, followed by

cladocerans. Our results are dissimilar to the dominance of cladocerans, followed by rotifers as reported by Elegbe *et al* [21]. Qualitative dominance of rotifers was previously mentioned in eutrophic and mesotrophic media by [22, 23].
Indeed, the dominance of rotifers is linked to the fact that they are the opportunistic organisms that ingest the bacteria and the dominant organic detritus in the eutrophic ecosystems [24]. The composition of the zooplankton population showed that the *Lécane bulla* species belonging to the family Lecanidae (rotifers) was more dominant. This trend has been dissimilar to that of Brachionidae reported by other authors [21, 25, 26]. The difference obtained would be the physicochemical characteristics of the water. Indeed, the Brachionidae are the biological indicators of the hypereutrophic media. With regard to copepods, the species *Thermocyclops sp*. belonging to the family Cyclopidae was more dominant. This observation is due to the fact that Cylopidae grow best in shallow waters rich in organic matter. The higher specific rotifer diversity in our study supports the hypothesis that in ponds there may be a higher proportion of rotifer species at any given time than microcrustaceans.

Conclusion

The present study of the effect of doses of chicken manure on zooplankton biodiversity has shown that the physicochemical characteristics of water have been significantly affected by the doses of droppings. Indeed, nitrite, nitrate and phosphate were higher at the 1000 kg / ha dose, the reverse was observed with dissolved oxygen and transparency.
A total of 84 species belonging to rotifers (53 species), cladocerans (18 species) and copepods (7 species) groups were identified independently of treatment. The richness, relative abundance of families, genus and species was significantly affected by the doses of chicken manure. The lowest values of zooplankton richness were registered in the control pond, while the highest richness was observed in the treatment 1000 kg/ha. The rotifer group followed by cladocerans was the most diversified independently of dose.
In view of findings, the present study can recommend the dose 1000 kg / ha. In fact, in rearing, the higher diversity obtained at this dose will serve a wide spectrum of larval feeds.

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