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Assessment of zooplankton productivity in polyculture ponds of three species of fish (*Oreochromis niloticus, Heterotis niloticus* and *Hemichromis fasciatus)* in the forest zone of East Cameroon

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Abstract

The assessment of zooplankton productivity in polyculture ponds of three species of fish was carried out from January to December 2019 in the binomial rainfall forest zone of East Cameroon with the aim of optimizing fish production. For this purpose, 09 different fish ponds including 03 unfertilized, 03 fertilized with chicken manure and 03 fertilized through an intra-pond compost bin were used. The physicochemical characteristics of the water, zooplankton and fish growth were collected monthly in the various production ponds using standard methods. At the end of the study it emerges that the values of transparency, pH, dissolved oxygen, nitrites, ammonium and phosphates significantly ($p<0.05$) varied with the modes of breeding. The highest nitrite (0.05 ± 0.01 mg/l) and ammonium (0.37 ± 0.11 mg/l) values were recorded in ponds fertilized with chicken droppings. For transparency (35.37 ± 4.47 cm) and dissolved oxygen (5.97 ± 1.03 mg/l), the highest values were recorded in unfertilized ponds. However, no significant difference ($p>0.05$) was observed between the husbandry methods with regard to temperature and nitrates although the higher nitrate values (3.83 ± 1.03 mg/l) were recorded in intra-pond compost ponds. A total of 101 species of zooplankton, 33 genera and 20 families were identified regardless of the farming methods. Of these 101 species, 91 were present in all the different farming methods. The densities of rotifers species (59) were the highest, followed by cladocerans (19) respectively in ponds fertilized with hen dung and through the intra-pond compost bin and the weakest (36 rotifers and 10 cladocerans) in unfertilized ponds. Densities of copepod species (05) were higher in the unfertilized pond. The average weight values of fish species were significantly ($p<0.05$) affected by farming methods. The highest values of mean weight (362.50 ± 77.24 g), specific growth rate (0.75 ± 0.06 %g/j) and Fulton's condition factor K (3.57 ± 0.77 g/cm) of *Oreochromis niloticus* and *Hemichromis fasciatus* were recorded in ponds fertilized with chicken droppings. As for *Heterotis niloticus*, the highest values of mean weight (1825.00 ± 502.95 g) and specific growth rate (0.88 ± 0.08 %g/d) were obtained in compost ponds. In view of the results, we can recommend that fish farmers should practice *Oreochromis niloticus* the breeding in ponds fertilised whit chicken manure and the other hand *Heterotis niloticus* breeding of in intra-pond compost.

Keywords: productivity, zooplankton, pond, polyculture, fish

1. Introduction

In Africa and in developing countries, fish is a very important source of animal protein to meet the needs of populations. Faced with the stagnation of products from capture fisheries, and the strong demand for fish, aquaculture, specifically fish farming, is the only viable alternative to meet this demand (FAO, 2019) [11]. Recent trends show an increase in aquaculture production as a result of research into various production systems. In the rural world, the bulk of fish production is based on polyculture models in ponds and carried out in extensive and / or semi-intensive systems (Mikolasek *et al*., 2009) [17]. Polyculture fish farming allows better exploitation of the pond's ecological niches, in order to improve fish production yields (Pouomogne *et al*., 2005) [22]. Feeding fish species in ponds involves the use of animal and / or plant excreta as a source of fertilization in production environments (Pouomogne *et al.*, 2005) [22]. These fertilizers stimulate the development of phytoplankton and by extension the production of zooplankton. The latter is made up of all the microorganisms of animal origin suspended in the water column which mainly feeds on phytoplankton. Zooplankton is an important element in the structuring and functioning of pond ecosystems.

Thus, it is an essential food for fish and exclusively for larvae and juveniles of fish due to its high protein content of around 54% (Agadjihouèdé *et al.*, 2011) [1], and excellent indicators of fish quality. Water in aquatic environments (Zébazé *et al*. 2006; Ahangar *et al*. 2012; Primo *et al*. 2015) [27, 2, 24]

In Cameroon, studies have been carried out on the productivity of zooplankton through fertilizers of animal origin (chicken droppings, pig manure, guinea pig droppings) in ponds and in tanks (Efole *et al*., 2017; Nana *et al*., 2018; Songmo *et al*., 2018; Dakwen *et al*., 2019; Kenfack *et al*., 2019, etc.) [25, 5]. The work of Kenfack *et al.* (2019) investigated the taxonomic composition and distribution of zooplankton in fish production ponds in West

Cameroon. However, few studies have been carried out on the evaluation of zooplankton production as well as the growth performance of fish in polyculture ponds, particularly in the Eastern Region of Cameroon. However, other aspects can still be explored in order to improve fish production by controlling the productivity of the pond. The objective of this study was therefore to assess the effect of the farming method on the diversity and productivity of zooplankton populations as well as on fish production.

2. Material and methods

2.1. Zone and period of the study

The study was carried out from January to December 2019 in different ponds in the agro-ecological zone of the dense forest with bimodal rainfall in East Cameroon (Lom and Djerem Divisions more precisely in the districts of Mandjou (13°62'5"N and 14°08'5"E), Bertoua 1er (04°34'30"N and 13°41'04"E) and Diang (04°35'00"N and 13°21'00"E)). The average temperature fluctuates between 23 and 25°C. The annual rainfall ranges from 1500-1800 mm, with two rainy seasons (mid-March to mid-June and mid-August to mid-November) and two dry seasons (mid-November to mid-March and mid-June to mid -August).

2.2. Animal material

A total of 1090 fry of three (03) species of fish including 950 *Oreochromis niloticus* (nile tilapia) of average weight 22.68 ± 2.22 g and total length 11.12 ± 1.08 cm; 55 *Hemichromis fasciatus* of average weight 6 ± 1.2 g and total length 3.12 ± 0.08 cm and 83 *Heterotis niloticus* (kanga) of average weight 70 ± 1.12 g and total length 21.11 ± 1.08 cm were used in this study. These fry were the result of natural reproduction in fish production ponds. These different species were chosen to respect the farming model practiced by fish farmers in the study area.

2.3. Breeding structure

In total, 09 production ponds including 03 unfertilized ponds, 03 ponds fertilized with chicken droppings and 03 ponds fertilized through the intra-pond compost bin were used to collect the production characteristics of zooplankton and different fish species (table 1). The choice of production ponds was made respectively on the basis of areas with functional production ponds with high fish-breeding potential and on the stability of the fish farmer.

Table 1: Characteristics of collecting fish ponds and zooplankton

Modes of breeding	Surface area (m^2)	*Oreochromis niloticus*	*Heterotis niloticus*	*Hemichromis fasciatus*
unfertilized				
1	1300	221	11	22
2	1000	170	10	17
3	700	119	4	12
chicken droppings				
1	600	102	6	10
2	700	119	7	12
3	1700	289	5	29
intra-pond compost				
1	700	119	4	12
2	1300	221	17	22
3	750	128	6	13

2.4. Conduct of the study

The ponds chosen underwent a number of reorganizations before the start of the study, namely: the draining of the pond which consisted of the total emptying of the pond and the exposure of the mud from the plate to sun for a week, filling and stocking of the ponds. These ponds were stocked with juveniles of male *Oreochromis niloticus* at a density of 0.17 tilapia/m²; *Hemichromis fasciatus* fry at a density of 10 % of the total density of *Oreochromis nilotucus* and used as a predator species to control sexing errors. Juveniles of *Heterotis niloticus* at a density of 0.01 to 0.08/m² were also stocked. At the start and end of the study, the fish were weighed and measured using a 10 g precision balance and a centimeter-scale ichthyometer, respectively. Two types of fertilizers were used monthly, namely chicken droppings and the intra-pond compost bin. An average intake of 24 kg/ha/day of chicken droppings was used in the fertilized ponds. The intra-pond compost bin consisted of kitchen waste and plants (62 kg). The waste was stirred once a week to facilitate the release of minerals.

2.5. Data collection and characteristics studied

The physicochemical characteristics of water were measured monthly in situ. Transparency, pH, temperature and dissolved oxygen were measured using a Secchi disc, a HANNA brand pH meter, and a Handy Polaris brand oxy-thermometer, respectively. The determination of nitrites, nitrates, ammonium and phosphates was carried out using VISCOLOR ECO® test kits from MACHEREY-NAGEL and the results are expressed in mg/l.

Zooplankton sampling

A volume of 20 litters of water per pond was collected by means of a zooplankton net of 50 µm mesh opening (shape: conical, depth: 40 cm and diameter: 20 cm) connected on a rod of length 1.20 cm. The zooplankton net was drained horizontally in the water for a distance of at least 20 m at a water depth of 30 cm from each pond. The process was repeated 3 times in each pond. After filtration, a sub-sample of 30 ml of zooplankton concentrate was retained, labelled, fixed with 5 % formalin in the proportions of 25 % formalin and 75 % of the sample and stored in 50 ml plastic bottles for quantitative and qualitative laboratory analysis (Zébazé *et al.*, 2000) [28].

After homogenization of the sample, 10 ml was taken using a calibrated pipette and placed in a 90 mm diameter Petri dish, gridded in 5 mm squares for an inventory of zooplankton organisms. The identification and counting of the species of rotifers, cladocerans and copepods were carried out using a MOTIC brand binocular magnifier with 2X objective according to the methodology and identification keys described by Legendre & Watt, (1972) [16], Amoros (1984) [3], Durand and Levêque (1980) [6], Pourriot and Francez (1986) [23], Dussart and Defaye (1995) [7], Frontier (1972 and 1973) [12] and Zébazé (2000) [29].

- The density of zooplankton was calculated using the following formula:

$D = (n \times 1000)/V$ where n: number of individuals found in the volume of water analysed under the microscope, V: volume of water analysed (in ml) and 1000: conversion constant in litters

The results of the zooplankton density obtained made it possible to calculate the various characteristic indices of the composition and evolution of the zooplankton community, in particular:

- Shannon & Weaver diversity index (H')

$H' = -\Sigma[(ni/N) \times \log_2 (ni/N)]$ where Ni: number of species i in a sample, N: total number of individuals in the sample, s: number of species and log2: logarithm to base 2.

- J Pielou or equity index

$J = H'/\log_2 S$ where H' = Shannon and Weaver diversity index, log2 = logarithm to base 2 and S = number of species present

- Simpson index

$C = \Sigma Ni (Ni-1)/N (N-1)$ or Ni: number of individuals of the given species and N: total number of individuals

The growth characteristics of the different fish species were calculated using the following formulas:

- Average weight

$Pm = BT/N$; Where Pm = average weight, BT = Total biomass (g) and N = number of samples

- Specific growth rate:

$TCS = [(LnPf - LnPi)/t] \times 100$ Where Pf = Final average weight of individuals during the test (g), Pi = Initial average weight of individuals during the trial (g), t = time or duration of the growth test period (day)

- Fulton's condition Factor K (load capacity of the medium): $K = W \times 100/LT^3$ with W = total weight (g), LT = total length (cm)

-Total length:

$Lt = Lt/N$ with Lt: Average total length (cm), N: Number of individuals.

2.6. Statistical analysis

The data collected was subjected to one-way analysis of variance (ANOVA 1). Where there were significant differences between the sources of variation, Duncan's test at 5% threshold was used to compare the means. The statistical software SPSS Version 20.0 (Statistical Package for Social Sciences) was used for these analyzes.

3. Results

3.1. Physicochemical characteristics of water

The results relating to the physicochemical characteristics of water (Table 2) show that the values of transparency, pH, dissolved oxygen, nitrites, ammonium and phosphates significantly ($p<0.05$) varied with the breeding method. The highest nitrite and ammonium values were recorded in compost ponds. The highest values of transparency and dissolved oxygen were recorded in unfertilized pond. As for temperature and nitrates, no significant difference ($p>0.05$) was observed between the farming methods. The highest nitrate values were recorded in compost ponds.

Table 2: physicochemical characteristics of water with respect to the breeding methods

Physicochemical characteristics of water	Breeding methods		
	Unfertilized	**Chicken manure**	**Intra-pond compost**
Transparency (cm)	35.37: 4.47^{a}	28.54±3.69^{b}	30.00±4.65^{b}
Temperature (°C)	26.24: 0.39^{a}	26.41±1.18^{a}	26.53±0.71^{a}
pH (UI)	6.84±0.17^{b}	6.87±(.21^{b}	7.03±0.26^{a}
Disolved oxygen (mg/l)	5.97±1.03^{a}	4.05±(.82^{b}	4.47±1.33^{b}
Nitrites (mg/l)	0.03±0.01^{b}	0.05±(.01^{a}	0.05±0.01^{a}
Nitrates (mg/l)	2.87±1.22^{a}	3.79±: .19^{a}	3.83±1.03^{a}
Ammonium (mg/l)	0.26±0.04^{b}	0.36±(.08^{a}	0,37±0.11^{a}
Phosphates (mg/l)	0.22±0.04^{b}	0.31±(.08^{a}	0.27±0.07^{ab}

A, b: the means bearing the same letters for the same row are not significantly different ($p>0.05$).

3.2. Zooplankton density

The influence of breeding method on zooplankton density is shown in Table 3. In general, the breeding methods significantly ($p<0.05$) affected zooplankton density. The highest density values were recorded in ponds fertilized with hen dung and lowest in unfertilized ponds. When considering zooplankton groups, densities were significantly ($p<0.05$) affected by the breeding method except for the copepod group. The highest density values of rotifers and cladocerans were recorded in ponds fertilized with hen dung. As for the copepod densities, the highest values were obtained in compost ponds.

Table 3: zooplankton density with respect to the breeding method

Density	Breeding method		
	Unfertilized	**Chicken manure**	**Intra-pond compost**
Zooplankton	3.99±0.63^{b}	4.63±0.61^{a}	4.18±0.68^{ab}
Rotifers	3.87±0.67^{b}	4.53±0.65^{a}	4.06±0.73^{ab}
Cladocerans	3.02±0.35^{b}	3.52±0.72^{a}	3.29±0.45^{ab}
Copepods	2.18±1.17^{a}	1.84±1.53^{a}	2.60±0.62^{a}

A, b: the means bearing the same letters for the same row are not significantly different ($p>0.05$).

Richness and distribution of families, genera and species of zooplankton

The richness and distribution of families, genera and species of zooplankton (Tables 4 and 5) show that, independently of the mode of breeding, 101 species divided into 33 genera and 20 families belonging to the groups of rotifers, cladocerans and copepods have been identified in the different ponds. The group of rotifers represented by 70 species, 18 genera and 14 families was the most diverse, followed by that of cladocerans represented by 26 species, 10 genera and 5 families. The less diverse group of copepods is made up of 5 species, 5 genera and one family. The highest values for zooplankton species (79 species) were recorded in the pond fertilized with chicken droppings and the lowest (51 species) in the unfertilized pond. The families of Epiphanidae and Philodinidae were identified only in unfertilized ponds and those of Lepadellidae, Euchalanidae and Notommatidae in pond fertilized with hen dung. In terms of genus, *Lepadella, Epiphaes, Rotaria* and *Cryptocyclops* were only identified in unfertilized ponds; the genera *Euchlanis, Culurella, Cephalodella, Alonella*, and *Acroperus* in ponds fertilized with chicken manure; *Asplanchnipus* in intra-pond compost ponds.

Table 4: Influence of the breeding method on the richness of zooplankton classes

Zooplankton classes	Total	Breeding method		
		Unfertilized	Chicken manure	Intra-pond compost
Families	20	16 (80)	17 (85)	15 (75)
Genera	33	24 (72.72)	26 (78.78)	20 (60.60)
Species	101	51 (50.49)	79 (78.21)	63 (62.37)

(): Percentage of species recorded

Table 5: Effect of farming method on the distribution of zooplankton species

Groups	Families	Genra	Number of species		
			Unfertilized	Chicken manure	Intra-pond compost
		Brachionus	9	16	12
		Platyias	1	2	1
	Brachionidae	*Keratella*	3	3	0
		Lepadella	1	0	0
	Lecanidae	*Lecane*	10	16	9
	Synchaetidae	*Polyathra*	4	6	4
	Trochosphaeridae	*Filinia*	1	3	4
	Asplanchnidae	*Asplanchna*	1	2	1
		Asplanchnipus	0	0	4
	Euchalanidae	*Euchlanis*	0	3	0
Rotiferers	Mytilinidae	*Mytilina*	2	0	2
	Trichocercidae	*Trichocerca*	1	2	3
	Gastropodidae	*Ascomorpha*	1	2	1
	Scaridiidae	*Scaridium*	0	2	1
	Lepadellidae	*Colurella*	0	1	0
	Epiphanidae	*Epiphaes*	1	0	0
	Philodinidae	*Rotaria*	1	0	0
	Notommatidae	*Cephalodella*	0	1	0
	Daphniidae	*Ceriodaphnia*	2	1	6
		Simocephalus	3	1	0
		Chydorus	2	4	4
Cladocerans		*Acroperus*	0	1	0
	Chydoridae	*Alonella*	0	2	0
		Alona	0	1	1
		Pleuroxus	0	1	2
	Sididae	*Diaphanosoma*	1	1	1
	Moinidae	*Moina*	1	3	4
	Macrothricidae	*Macrothrix*	1	2	1
		Ectocyclops	1	1	0
		Thermocyclops	1	1	0
Copepods	Cyclopidae	*Cryptocyclops*	1	0	0
		Mesocyclops	1	1	1
		Paracyclops	1	0	1

Zooplankton species diversity indices

The Shannon & Weaver diversity, Piélou and Simpson fairness indices according to the rearing method are summarized in Table 6. In general, these different diversity indices were affected by the rearing methods. The highest values of Shannon & Weaver and Simpson diversity were recorded in ponds fertilized with hen dung, followed by unfertilized ponds. The lowest values were observed in ponds fertilized with the compost bin. As for Piélou fairness, the highest values were recorded in ponds fertilized with hen dung.

Table 6: Index of diversity of zooplankton species according to farming method

Diversity indices (bits / IND)	Breeding method		
	Unfertilized	Chicken manure	Intra-pond compost
Shannon_H	2.37	2.68	2.05
Equitability_J	0.58	0.68	0.63
Simpson_1-D	0.83	0.83	0.77

Growth characteristics of fish species

The influence of rearing style on the growth characteristics of fish species (Table 7) shows that in general, the values of growth characteristics of fish species were affected by the rearing method. In *Oreochromis niloticus*, the values for mean weight, specific growth rate and total length were significantly ($p<0.05$) highest in ponds fertilized with hen dung compared to others. The lowest values were recorded in unfertilized ponds. As for the condition factor K, no significant difference ($p>0.05$) was recorded between the farming methods. In *Heterotis niloticus*, all values of growth characteristics were significantly ($p<0.05$) higher in intra-pond compost ponds, followed by ponds fertilized with hen dung. The lowest value was recorded in unfertilized ponds. In *Hemichromis fasciatus*, mean weight values were significantly ($p<0.05$) higher in ponds fertilized with chicken manure.

Table 7: Growth characteristics of fish species according to the farming method

Espèces	Breeding method	Growth characteristics			
		Pm (g)	TCS (%g/j)	K (g/cm)	Lt (cm)
Oreochromis niloticus	Unfertilized	260.19±41.63^{b}	0.67±0.05^{b}	3.17±0.23^{a}	20.12±0.86^{b}
	Chicken manure	362.50±77.24^{a}	0.75±0.06^{a}	3.57±0.77^{a}	21.70±1.75^{a}
	Intra-pond compost	329.17±87.15^{a}	0.72±0.07^{a}	3.52±0.91^{a}	21.14±1.91^{a}
Heterotis niloticus	Infertilized	1266.67±242.21^{b}	0.79±0.05^{a}	3.02±0.22^{ab}	38.23±2.01^{b}
	Chicken manure	1708.33±340.39^{a}	0.87±0.05^{b}	3.58±0.45^{a}	32.89±3.47^{b}
	Intra-pond compost	1825.00±502.95^{a}	0.88±0.08^{a}	2.63±0.58^{b}	41.01±2.70^{a}
Hemichromis fasciatus	Infertilized	22.92±18.02^{b}	0.30±0.20^{a}	1.14±0.37^{a}	3.47±0.55^{a}
	Chicken manure	36.15±11.32^{a}	0.48±0.08^{a}	1.28±0.91^{a}	4.38±1.23^{a}
	Intra-pond compost	24.26±10.93^{b}	0.36±0.12^{a}	1.04±0.47^{a}	3.72±1.76^{a}

Pm: average weight, TCS: specific growth rate, K: factor condition, Lt: total length. A, b: the means bearing the same letters for the same colon are not significantly different ($p>0.05$).

- **Correlation between the physicochemical characteristics and the density of zooplankton depending on the farming method**

The correlations between the physicochemical characteristics of the water and the density of zooplankton depending on the type of culture (Table 8) shows which the density of zooplankton correlated significantly ($p<0.05$) negatively and with the pH and nitrates, and positively with nitrites in compost ponds; negatively with nitrites in ponds fertilized with chicken droppings.

When considering zooplankton groups, we observe an average and significant correlation ($p<0.05$) between temperature, pH, dissolved oxygen, nitrites, nitrates, phosphates and density of zooplankton group whatever the breeding method. The density of rotifers correlated negatively and significantly ($p<0.05$) with the temperature in the compost ponds; and dissolved oxygen and nitrates in ponds fertilized with chicken droppings. The density of cladocerans correlated significantly ($p<0.05$) with temperature in unfertilized ponds; and pH in ponds fertilized with hen dung. The density of copepods correlated negatively and significantly ($p<0.05$) with pH and nitrites respectively in unfertilized and fertilized ponds with hen dung; and positively and significantly ($p<0.05$) with nitrites in ponds fertilized with chicken droppings and phosphates in compost ponds. The density of rotifers in unfertilized ponds and that of cladocerans in compost ponds did not correlate significantly ($p>0.05$) with the physico-chemical characteristics of the water. The density of zooplankton groups correlated positively with ammonium in all ponds of the different culture modes.

Table 8: Correlation between the physicochemical characteristics and the density of the zooplankton groups depending on the farming method

Density	Breeding method	Physicochemical characteristics of water							
		Trans	T	pH	O_2	NO_2^-	NO_3^-	NH_4^+	PO_4^{3-}
Zooplankton	Unfertilized	-0.48	-0.56	-0.49	-0.21	-0.33	-0.21	+0.38	-0.05
	Chicken manure	+0.10	-0.40	+0.07	+0.40	-0.831*	+0.03	-0.06	+0.44
	Intra pond compost	+0.04	-0.07	-0.53*	-0.47	+0.621*	-0.617*	+0.32	-0.02
Rotifers	Unfertilized	-0.30	-0.29	-0.53	-0.09	-0.39	-0.09	+0.20	-0.16
	Chicken manure	-0.03	-0.35	-0.41	-0.581*	+0.45	-0.579*	+0.39	+0.41
	Intra pond compost	+0.40	-.602*	-0.05	-0.10	-0.36	-0.19	+0.34	+0.50
Cladocerans	Unfertilized	-0.44	-0.621*	-0.52	-0.24	-0.21	-0.43	+0.35	+0.14
	Chicken manure	-0.40	-0.48	-0.618*	+0.24	-0.57	-0.39	+0.25	-0.11
	Intra pond compost	-0.47	-0.42	+0.05	-0.20	-0.15	+0.48	+0.12	-0.03
Copépodes	Unfertilized	-0.23	-0.36	-0.656*	+0.08	-0.44	-0.32	+0.11	-0.07
	Chicken manure	-0.01	-0.05	-0.55	-0.44	+0.586*	-0.646*	+0.27	+0.689*
	Intra pond compost	+0.55	-0.57	+0.06	-0.18	-0.35	-0.15	+0.52	+0.689*

Trans: transparency, T: temperature, pH: hydrogen potential, O_2: dissolved oxygen, NO_2 : nitrite, NO_3 : nitrate, NH_4 : ammonium, PO_4^{3-}: total phosphate. *. The correlation is significant at the 0.05 level (two-tailed).

- **Correlation between the average weight of fish species and the density of zooplankton depending on the farming method**

The correlations between the average weight of fish species and the density of zooplankton as a function of culture (Table 9) generally show that the densities of zooplankton and the average weight of the different species of fish were weakly correlated in all the ponds. The density of zooplankton was weakly and positively correlated with the mean weight of *Oreochromis niloticus* and *Heterotis niloticus* in ponds fertilized with chicken droppings; and with the average weight of *Hemichromis fasciatus* in compost ponds. In compost ponds, the correlation was weak and negative between the density of zooplankton and the mean weight of *Oreochromis niloticus* and *Heterotis niloticus*. There is a weak and negative correlation between the mean weight of *Oreochromis niloticus*, and positive between the mean weight of *Heterotis niloticus* and *Hemichromis fasciatus* in unfertilized ponds.

When we consider the zooplankton groups, we observe a strong, positive and significant correlation ($p<0.05$) between the density of cladocerans and the mean weight of *Hemichromis fasciatus* as well as that significant ($p<0.01$) of copepods in ponds fertilized with chicken droppings. A strong, negative and significant correlation ($p<0.05$) between the density of cladocerans and the average weight of *Heterotis niloticus* in ponds fertilized with chicken droppings.

Table 9: Correlation between the density of zooplankton and the average weight of fish species depending on the farming method

Density	Breeding method	Average weight (g) of fish species		
		Oreochromis niloticus	*Heterotis niloticus*	*Hemichromis fasciatus*
Zooplankton	Unfertilized	-0,03	+0,12	+0,16
	Chicken manure	+0,24	+0,28	-0,68
	Intra pond compost	-0,44	-0,42	+0,18
Rotifers	Unfertilized	-0,33	+0,57	+0,32
	Chicken manure	-0,53	+0,02	-0,61
	Intra pond compost	+0,04	-0,55	+0,33
Cladocerans	Unfertilized	-0,28	+0,18	-0,14
	Chicken manure	+0,34	-0,83*	+0,84*
	Intra pond compost	+0,25	+0,09	-0,09
Copépodes	Unfertilized	+0,04	+0,17	-0,13
	Chicken manure	+0,32	-0,40	+0,95**
	Intra pond compost	-0,22	-0,15	-0,24

*. La corrélation est significative au niveau 0.05 (bilatéral). **. La corrélation est significative au niveau 0.01 (bilatéral).

4. Discussion

The values of the physicochemical characteristics of the water were significantly affected ($p<0.05$) by the method of rearing except for temperature and nitrates. The highest values of transparency and dissolved oxygen were recorded in unfertilized ponds as well as those of pH, nitrites and ammonium were recorded in intra-pond compost ponds. The values of transparency, pH, nitrites, nitrates and phosphates recorded in ponds fertilized with hen droppings and intra-pond compost were lower compared to the results obtained by Nana *et al.* (2018) in ponds fertilized with chicken manure at 800 and 1000 kg. Such a difference could be due to the presence of fish feeding on organic matter or phytoplankton in suspension, responsible for the decrease in mineral elements after decomposition. The same differences were recorded by Kenfack *et al*. (2019) in ponds fertilized with chicken manure and wheat bran. The differences could be due to the type and amount of fertilizer used. The dissolved oxygen levels were significantly low in the fertilized ponds. These results are comparable to those obtained by Kenfack *et al*. (2019) in fish production ponds fertilized with chicken manure and wheat bran. The low value of dissolved oxygen obtained is characterized by a eutrophic medium. Deoxygenation is the consequence of the oxidation of organic matter, carried out biologically or chemically (Njine *et al*., 2007) [19].

The density of rotifers correlated negatively and significantly ($p<0.05$) with the temperature in the intra-pond composting ponds; and with dissolved oxygen and nitrates in ponds fertilized with chicken droppings. The density of cladocerans correlated significantly ($p<0.05$) with temperature in unfertilized ponds; and pH in ponds fertilized with hen dung. That of copepods correlated negatively and significantly ($p<0.05$) with pH and nitrites respectively in unfertilized and fertilized ponds with hen dung; and positively and significantly ($p<0.05$) with nitrites in ponds fertilized with hen droppings and phosphates in intra-pond compost ponds. The density of zooplankton groups correlated positively with ammonium in all ponds of the different breeding methods.

The richness values of families, genera and species of zooplankton obtained were significantly affected ($p<0.05$) with the mode of breeding. The number of species identified regardless of the breeding method was over 83 species obtained by Nana *et al*. (2018) in ponds fertilized with chicken manure and pig slurry; and 40 species obtained by Kenfack *et al*. (2019) in ponds fertilized with chicken manure and wheat bran in West Cameroon. Likewise, in 41 species obtained by Nziéleu *et al*. (2012) in Lake Mwembe and 30 species identified in a traditional aquaculture system, "Whedos". The differences observed are due to several factors including the effect of the doses of fertilizer, the sampling effort (twice a month against one), the size of the plankton net (40 µm against 50 and 64 µm) and the predation of Pisces.

The distribution of zooplankton richness shows that the rotifer group was more diverse, followed by cladocerans regardless of the rearing method. These results are similar to those obtained by Nana *et al.* (2018) and Kenfack *et al.* (2019) in ponds Fertilized with Chicken Manure. This dominance of the rotifers could be due to the mode of reproduction by pathogenesis which is the fastest of all the metazoans and thus rapidly populates the available niche (Nogrady *et al*., 1993) [20]. Indeed, the dominance of rotifers is linked to the fact that they are opportunistic organisms that ingest bacteria and organic detritus dominant in eutrophic ecosystems (Badsi *et al*., 2010) [4]. The values of the Shannon & Weaver diversity, Piélou and Simpson fairness indices were moderately affected by culture, which explains the existence of many predominant species in the different ponds. As for Piélou's fairness, the values obtained were less than 0.8 in all the ponds, which highlights the imbalance of the ecosystem and the poor distribution of species.

The values of growth characteristics of fish species were affected by the rearing method. In ponds fertilized with chicken manure, the average weight gain values of *Oreochromis niloticus* of 5.67 ± 20.7 g and 68.98 ± 1.02 g were respectively recorded and were higher than those of ponds fertilized with intra-pond and unfertilized compost bin. On the other hand, in the intra-pond composting ponds, the values of the average weight gain of *Heterotis niloticus* of 116.67 ± 162.56 g and 558.33 ± 260.74 g were respectively more than those of the fertilized ponds with chicken dung and unfertilized ponds. This could be due to the richness of the environment of large amount of natural foods such as zooplankton and phytoplankton in ponds suitable for feeding fish species reared.

The specific growth rate was higher (0.88 %g/d) in *Heterotis niloticus* regardless of the breeding method. These results are greater than 0.51 %g/d obtained in *Clarias gariépinus* by Zango (2017) [9] and less than 1.21 %g/d obtained in *Clarias jaensis* by Efole *et al*. (2016). This difference could be due to the species. Depending on the rearing method, the highest values of the specific growth rate were recorded in *Oreochromis niloticus* in ponds fertilized with chicken manure and in *Heterotis niloticus* in intra-pond compost ponds.

Values for condition factor K ranged from 1.04 - 3.58 in all species reared regardless of culture. The K condition factor values in *Heterotis niloticus* were significantly affected ($p<0.05$) in ponds fertilized with chicken droppings. In general, the values of the condition factor K were greater than 1 ($K>1$) regardless of the species considered. These results support Fulton's (1992) claim that fish are healthy in the culture environment when $K>1$.

5. Conclusion

The evaluation of zooplankton productivity in fish farming in the forest zone with binomial rainfall of East Cameroon showed that the physicochemical characteristics of the water were significantly ($p<0.05$) affected by the mode breeding except temperature and nitrates. The density, richness and distribution of families, genera and species of zooplankton were significantly affected by the mode of farming. The values of the growth characteristics of the fish species were significantly ($p<0.05$) affected by the rearing mode. The highest average weight values of *Oreochromis niloticus* were recorded in ponds fertilized with hen droppings and those of *Heterotis niloticus* in intra-pond compost ponds. In view of the results, we can recommend that fish farmers should practice *Oreochromis niloticus* breeding in ponds fertilised whit chicken manure and the other hand *Heterotis niloticus* breeding of in intra-pond compost.

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7. References

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