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Research Article
Evaluation of the Ecological Potential of Fish Production Ponds in the Eastern Region of Cameroon

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Abstract
Background and Objective: Fish production in both soilless and ponds remains low in Cameroon. To improve the capacity of pond fish farming systems to produce competitive marketable fish in sufficient quantity, ecological indicators of the productivity of fish farming practices were assessed in 16 dam ponds from January to December, 2021 in the Eastern Region of Cameroon. **Materials and Methods:** The 4 fish farming practices, namely, unfertilized pond culture (control), fertilized with chicken droppings, fertilized through the composter and fish-rice farming were tested in four repetitions each. The ponds were stocked with male fry of *Oreochromis niloticus* (22.68±2.22 g; 0.5 ind/m^2) and with juveniles of *Heterotis niloticus* (70±1.12 g; 1 ind/100 m^2) and *Cyprinus carpio* (40.33±7.02 g; 1 ind/100 m^2). Water physicochemical characteristics and zooplankton production parameters (rotifers, cladocerans and copepods) were collected monthly. The fish were weighed and measured at the beginning and end of the study according to standard methods. **Results:** The dissolved oxygen, nitrite and nitrate values were higher in fish-rice ponds. The highest density values for rotifers (11.354±1803 ind/L), cladocera (1769±502 ind/L) and copepods (11.117±2107 ind/L) were recorded in ponds fertilized with chicken droppings. As for species richness, rotifer (23), cladoceran (13) and copepod (11) were richer, respectively, in ponds fertilized with chicken droppings, fish-rice farming and composter. The highest weight gain values of *Oreochromis niloticus* (508.33±183.20 g), *Heterotis niloticus* (2341.67±291.54 g) and *Cyprinus carpio* (1405.03±307.12 g) were obtained in ponds fertilized with chicken droppings. **Conclusion:** A polyculture of fish in ponds fertilized with chicken droppings gives better results in terms of the quantity of zooplankton and fish produced. It should also be encouraged in fish-rice ponds and compost ponds to improve the quantitative production of fish.

Key words: Ecological, fish, production, ponds, Cameroon, aquaculture

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Global aquaculture production has developed considerably in recent decades thanks to the results of research and innovations in the mastery of farm management and new production techniques[1]. An important milestone was reached in 2014 when the aquaculture sector's contribution to the supply of fish for human consumption exceeded that of the fisheries sector for the first time[1]. Indeed, the average fish consumption per person was 20.5 kg in 2018[2]. However, with the depletion of fish stocks caused by the overexploitation of the waters, aquaculture production, thanks to the efforts made to develop it, is the only viable alternative for filling the fish deficit and meeting supply[2]. This progress is spectacular in certain countries in Asia, Latin America and Europe, but can only be observed to a limited degree in Africa and more particularly in Sub-Saharan Africa and Cameroon is no exception. Despite the rich hydrographic potential, national fisheries production is only 289,764 ton/year, with nearly 10,000 ton/year (3%) coming from aquaculture for an estimated annual demand of 400,000 ton/year[3]. This low contribution from aquaculture at the national level is linked to various major constraints that are recognized as hindering the development of this activity, not least of which is poor knowledge of the functioning of fishpond ecosystems, an important factor for optimizing the highly developed fish farming industry. Thus, a study on the evaluation of the ecological potential of these fishponds would be a way to sustainably improve the production of fish farming systems on earthen ponds, as is the case in the Eastern Region of Cameroon. Most of the market fish harvest comes from semi-intensive fish ponds[4]. Thus, assessing a country's fish production yields depends on knowledge of fish pond productivity. However, this study will enable us to develop an effective management strategy for the ecological relationships of the pond in all its diversity. This research would enable analysis of the functional elements of ponds through the physico-chemical and zooplanktonic characteristics of the water, as well as those linked to the production yields of fish species[5-7]. This will be assessed, as well as their fish production yields in terms of different fish farming practices, to define conditions for improving fish production.

MATERIALS AND METHODS

Study period and area: The study was conducted from January to December, 2019 in the agro-ecological zone of the dense forest with bimodal rainfall of the East-Cameroon Region, Department of Lom and Djerem, with geographical coordinates 5°14'11.66 North Latitude and 13°54'51.84 East Longitude. The average temperature fluctuates between 23 and 25°C. The annual rainfall varies from 1500 to 1800 mm, with 2 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).

Animal material: The study was conducted with 4 species of fish, namely, 14,000 male fry of *Oreochromis niloticus* (Nile tilapia) with an average weight of 22.68±2.22 g and an average total length of 11.12±1.08 cm; 648 juvenile *Heterotis niloticus* (kanga), average weight 70±1.12 g and average total length 18.23±2.01 cm; 648 juveniles of *Cyprinus carpio* (common carp) with an average weight of 30.33±3.02 g and total length of 17.04±1.21 cm and 4050 fries of *Hemichromis fasciatus* (gendarme fish) with an average weight of 6±1.2 g and average total length 4.01±0.12 cm. These fry and juveniles came from natural reproduction, except those of the common carp, which were obtained by semi-artificial reproduction in the fishponds of the aquaculture station of the MINEPIA of Bertoua. The species used were chosen in such a way as to respect the type of polyculture practiced by fish farmers in the area.

Farming structure: A total of 16 dam ponds (water renewal rate: 5±3 L/sec) with an average area of 1750±200.38 m^2 and an average depth of 1.42±0.13 m were used. These ponds were chosen based on the different breeding practices implemented by the fish farmers in the area. These are unfertilized production ponds, fertilized with chicken droppings, fertilized with the composter and fish-rice farming in four repetitions each.

Conduct of the study: By agreement with the collective of stakeholders (fish farmers and researchers), the selected ponds were rehabilitated before the start of the study. This involved draining the entire pond and then exposing the silt to the sun for a week to reduce parasites harmful to fish production, followed by impounding the various ponds. Subsequently, 20 kg/ha/day of broiler droppings were added to the ponds. The droppings were collected from a farm in Bertoua and stored at room temperature (23 and 25°C), with average values for dry matter (84.3±4.03%), total nitrogen (3±0.08%) and total phosphorus (1.7±0.2%). The compost pit (which occupies 10% of the total area of the pond) was made up of fresh kitchen waste (cocoyan and banana peelings) and fresh plant material

(*Chromolaena odorata* and *Tithonia diversifolia* leaves). Thus, an input of 1500 kg/ha/month of kitchen waste (50%) and plants (50%) was applied in each pond concerned. The waste was stirred once a week to facilitate mineral release. A sample of 1 L of water taken from the pond was analyzed at the beginning of the study to determine the following contents: Nitrite: 0.03±0.01 mg/L, nitrate: 2.28±0.10, ammonium: 0.22±0.02 mg/L and phosphate: 0.20±0.01 mg/L from test kits. The fish-rice ponds were planted with rice seedlings (NERICA 56 variety) previously produced in the growers' nurseries and occupying 1/3 of the pond's total surface area. The spacing between the rice plants was 40 cm to facilitate fish circulation. Once the ponds had been rehabilitated, the stocking was carried out with fry of *Oreochromis niloticus* males of average weight 22.68±2.22 g, at a density of 0.5 tilapia/m^2 and *Hemichromis fasciatus* (used as species predator to control sexing errors) with an average weight of 16±0.2 g at a density of 10% of the total density of *Oreochromis niloticus*. Juveniles of *Heterotis niloticus* with an average weight of 70±1.12 g and of *Cyprinus carpio* with an average weight of 40.33±7.02 g were stocked at a density of 1 ind/100 m^2 each in the ponds.

Data collection and characteristics studied

Assessment of water's physicochemical characteristics: During the study, transparency, temperature, dissolved oxygen, pH, nitrites, nitrates and phosphates were measured *in situ* and monthly between 6 and 10 hrs according to the methodology recommended by Rodier *et al.*[8]. Transparency was measured by inserting a weighted Secchi disk connected to a centimeter-scale rod into the water at 4 different points in the pond to read the registered value. Temperature and pH were measured by inserting the electrode of a HANNA pHep® (Kharghar, GST-27AACCH2670Q1Z4) multi-parameter into the water at 4 different points in the pond to record the marked value. The dissolved oxygen content of the water was measured by introducing the electrode of a Handy Polaris Oxy-thermometer (Denmark, OxyGuard International A/S Farum Gydevej 64, DK-3520 Farum) into the water at 4 different points in the pond to record the marked data.

The water sample was taken using a 1 L polyethylene beaker. Nitrites, nitrates, ammonium and phosphates were measured using MACHEREY-NAGEL VISCOLOR ECO® test kits (Germany, Neumann-Neander-Str, 6-8 52355 Düren) and results were expressed in mg/L. Nitrogen and phosphorus are chemical elements derived from the mineralization of organic compounds essential for primary production, which form the basis of the fish food chain.

Assessment of zooplankton diversity and productivity: A 10 L water sample containing zooplankton was filtered through a 50 µm mesh zooplankton net (shape: Conical, depth: 40 cm and diameter: 20 cm) following the methodology recommended by Canadian Council of Ministers of the Environment[9]. After filtration, a 30 mL sub-sample of zooplankton concentrate was retained, labeled, fixed with 5% formalin in the proportions of 25% formalin and 75% sample and stored in 50 mL plastic bottles for quantitative and qualitative analyses in the laboratory[10].

Identification of the various zooplankton species was carried out using the processes and identification keys described by previous studies[11-14]. After homogenization of the sample, 10 mL was taken using a calibrated pipette and introduced into a 90 mm diameter Petri dish, squared into 5 mm squares. Zooplankton species were identified using a Motic binocular magnifier with a 2× objective. The identification of rotifer, cladoceran and copepod species was based on the study of body shape, size, cephalosome, presence or absence of antennae, thorax, abdomen, appendages and carapace. Zooplankton individuals were counted according to the methodology recommended by Benfield *et al.*[11]. The counting was carried out under the binocular magnifying glass as previously described. The aim was to count at least 100 individuals per sample, as recommended by Frontier[13]. When this figure was not reached, counting was continued until the sample was exhausted[15].

Density (D): Density is defined as the numerical abundance of organisms in an ecosystem[16]. It was calculated using the following formula:

$$D = \frac{n \times 1000}{V}$$

where, n is number of individuals found in the volume of water analyzed under the microscope, V is volume of water analyzed (in mL) and 1000 is conversion constant in liters.

Biomass (B): Biomass (average individual dry mass of zooplankton) in micrograms of dry weight was calculated using the method developed by Legendre *et al.*[16]:

$$B = D \times W$$

where, D is density (ind/L) and W is dry weight (µg).

Relative abundance index (RAI): Relative abundance reflects the prevalence of each zooplankton species in a body of water. It was calculated using the following formula:

$$RAI = \frac{NG}{NT} \times 100$$

where, NG is number of individuals of the given species and NT is total number of individuals.

Evaluation of growth characteristics of different fish species: To limit losses of available natural food in the production ponds due to disturbances following emptying, measurements were taken at the beginning and the end of the study. Thus, 30% of the total number of fish of each of the three species were sampled at random, weighed and measured, respectively, using an SF-400 electronic balance, precision 1 g, capacity 5000 g and an ichthyometer graduated in centimeter, precision 1 mm.

Weight gain (g): This assessment is used to assess the weight growth of fish during breeding. It is calculated by the following formula:

$$GP = Pmf\text{-}Pmi$$

where, Pmi is initial average weight (g) and Pmf is final average weight (g).

Specific growth rate: The specific growth rate is used to assess the weight gained by the fish each day as a percentage of its live weight. It is calculated using the following formula:

$$TCS = \left[\frac{LnP_f - LnP_i}{t}\right] \times 100$$

where, P_f is final average weight of the individuals during the test (g), P_i is initial average weight of the individuals during the test (g) and t is time or duration of the growth test period (day).

Condition factor K: The condition factor K gives a good idea of the fatness of the fish, that is to say, the relative importance of body mass to its length. It is calculated using the formula of Abanikannda *et al.*[17] following:

$$K = PT \times \frac{100}{LT^3}$$

with PT is total weight (g) and LT is total length (cm).

Fish yield (RP (kg/ha)): The fish yield is equal to the weight or volume of a harvest per unit area. It is calculated using the following formula:

$$RP = \frac{\text{Net biomass (kg)}}{\text{Area (ha)}}$$

Statistical analysis: The 1-factor Analysis of Variance (ANOVA) was used to compare the physicochemical characteristics of water, zooplankton and growth of the four fish species to evaluate fish farming practices. Duncan's test at the 5% threshold was used to separate the means in the event of significant differences between the treatments. Analyses were performed using SPSS (Statistical Package for Social Sciences) Version 20.0 statistical software.

Ethical consideration

Ethics approval and consent to participate: This study was carried out in strict accordance with recommendations of institutional guidelines for the care and use of laboratory animals. Fish were humanly handled with respect to the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

RESULTS

Water physicochemical characteristics as a function of fish farming practices: The effect of the type of fish farming practice on the physicochemical characteristics of the water. Table 1 showed that the values of transparency, temperature and pH were not significantly different ($p>0.05$). Conversely, dissolved oxygen, nitrite and nitrate values were significantly ($p<0.05$) higher in fish-rice ponds compared with other practices. Ammonium and phosphates were significantly ($p< 0.05$) higher in ponds fertilized with chicken droppings.

Density of the three zooplankton groups as a function of fish farming practices: The density value of zooplankton groups was significantly ($p<0.05$) higher in ponds fertilized with chicken droppings compared with other fish farming practices, regardless of the zooplankton group considered (Fig. 1).

Biomass of the three zooplankton groups as a function of fish farming practices: The biomass value of zooplankton groups was significantly ($p<0.05$) higher in ponds fertilized with chicken droppings compared with other fish farming practices, regardless of the zooplankton group considered (Fig. 2).

Richness of the three groups of zooplankton as a function of fish farming practices: The value of species richness of rotifers, cladocerans and copepods species were significantly ($p<0.05$) richer, respectively, in the ponds fertilized with

Table 1: Physicochemical characteristics of water as a function of fish farming practices

Physicochemical characteristics of water	Fish farming practices			
	Control (n = 4)	Chicken droppings (n = 4)	Fish-rice farming (n = 4)	Composter (n = 4)
Transparency (cm)	45.33±5.39[a]	38.14±3.69[a]	40.12±3.54[a]	39.76±3.91[a]
Temperature (°C)	26.00±0.80[a]	26.41±1.18[a]	26.00±0.94[a]	26.08±0.70[a]
pH	6.94±0.40[a]	7.08±0.21[a]	7.04±0.26[a]	6.99±0.17[a]
Dissolved oxygen (mg/L)	5.34±1.20[b]	4.17±0.93[b]	7.52±1.65[a]	5.54±0.83[b]
Nitrites (mg/L)	0.02±0.01[c]	0.03±0.01[b]	0.04±0.01[a]	0.04±0.00[a]
Nitrates (mg/L)	2.40±1.80[b]	3.50±1.47[a]	3.83±1.21[a]	3.39±1.20[a]
Ammonium (mg/L)	0.33±0.05[b]	0.36±0.08[a]	0.30±0.05[b]	0.28±0.05[a]
Phosphates (mg/L)	0.21±0.03[c]	0.31±0.08[a]	0.26±0.05[b]	0.22±0.03[a]

[a-c]Means assigned the same letter on the same line do not differ significantly at the 5% level and n: Number of ponds according to fish farming practices

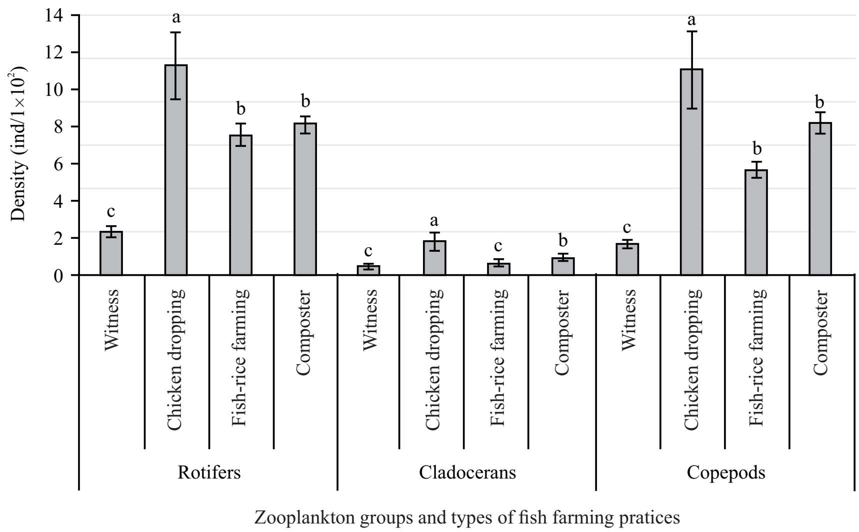

Fig. 1: Density of the three zooplankton groups as a function of fish farming practices, [a-c]Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same group of zooplankton

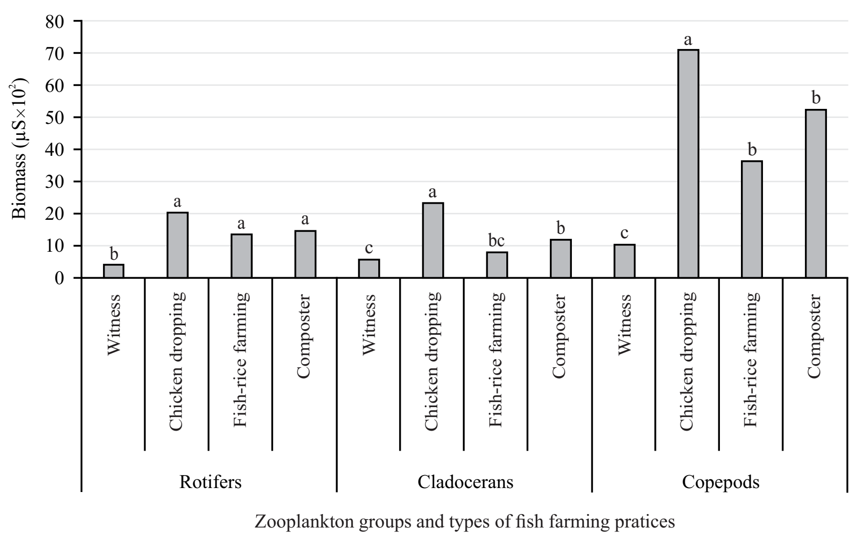

Fig. 2: Biomass of the three zooplankton groups as a function of fish farming practices, [a-c]Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same group of zooplankton

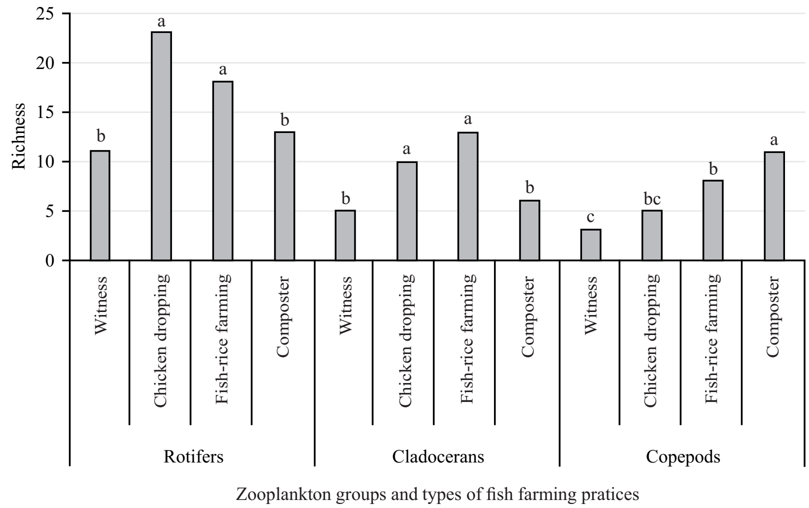

Fig. 3: Richness of the three zooplankton groups as a function of the type of fish farming practices, a-c Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same group of zooplankton

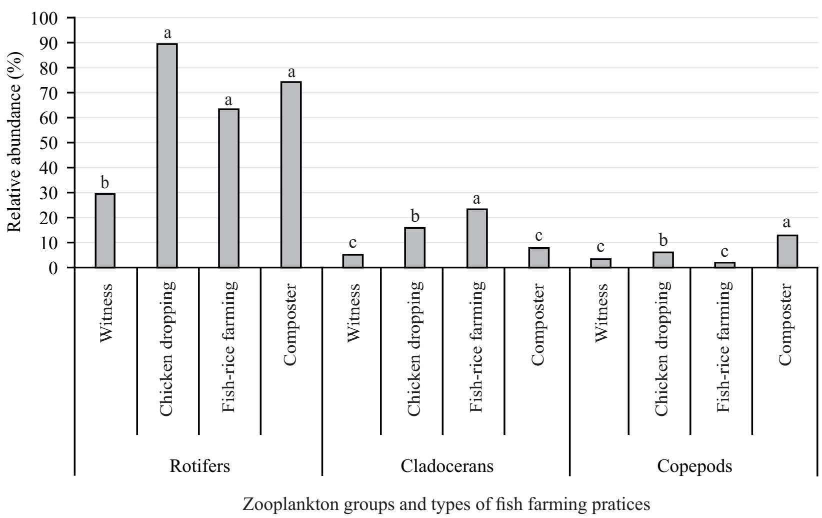

Fig. 4: Relative abundance of the three zooplankton groups as a function of the type of fish farming practices, a-c Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same group of zooplankton

chicken manure, fish-rice farming and compost pit compared with those of the other fish farming practices (Fig. 3). However, the lowest values were recorded in the control ponds, irrespective of the of the zooplankton group considered.

Relative abundance of the three zooplankton groups concerning the type of fish farming practices: The effect of the type of fish farming practices on the relative abundance of the three zooplankton groups of interest in fish farming was identified (Fig. 4). Rotifer, cladoceran and copepod species were significantly ($p<0.05$) more abundant in ponds fertilized with chicken droppings, fish-rice farming and compost ponds, respectively.

Effects of type of fish farming practice on weight gain of the four fish species: The weight gain of the four fish species according to the type of farming practice was illustrated in Fig. 5, which shows that the weight gain values of *Oreochromis niloticus* and *Heterotis niloticus* were significantly ($p<0.05$) higher in ponds fertilized with chicken droppings, followed by fish-rice ponds compared with other farming practice. In *Cyprinus carpio*, weight gain was

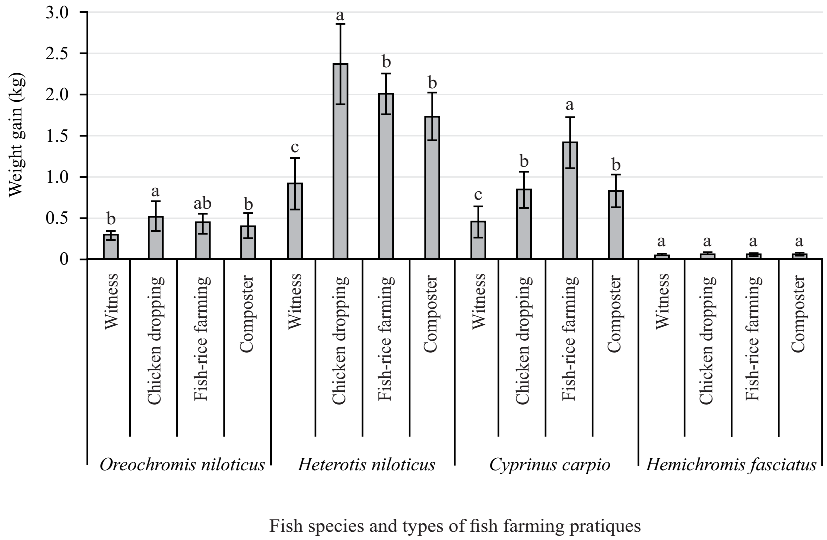

Fig. 5: Weight gain of different fish species according to the types of fish farming practices, [a-c]Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same species of fish

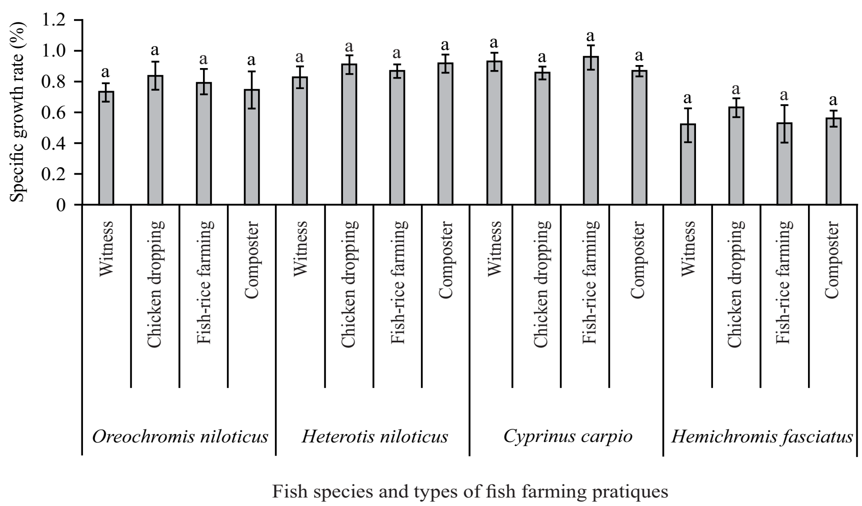

Fig. 6: Specific growth rates of different fish species as a function of type of fish farming practice, [a]Value assigned the same letter on the histogram does not differ significantly at the 5% threshold in the same species of fish

significantly ($p<0.05$) higher in fish-rice ponds compared with other types of fish farming practices. On the other hand, in *Hemichromis fasciatus*, no significant difference ($p>0.05$) was recorded regardless of the type of fish farming practice considered.

Effect of type of farming practice on the specific growth rate of the four fish species: Figure 6 illustrated the effect of fish farming practices on the specific growth rate of the four fish species. It can be seen that specific growth rate values were not significantly ($p>0.05$) different regardless of the type of fish farming practice and the fish species considered. However, the highest values were recorded in the ponds fertilized with chicken droppings and the lowest in control ponds, regardless of the species considered.

Effect of the type of fish farming practice on condition factor K for the four fish species: The K condition factor of the four fish species as a function of the type of fish farming practices was illustrated in Fig. 7. This shows that in *Oreochromis niloticus* and *Hemichromis fasciatus*, no significant difference ($p>0.05$) was recorded between the K condition factor values regardless of the type of fish farming practice considered. However, the highest values were

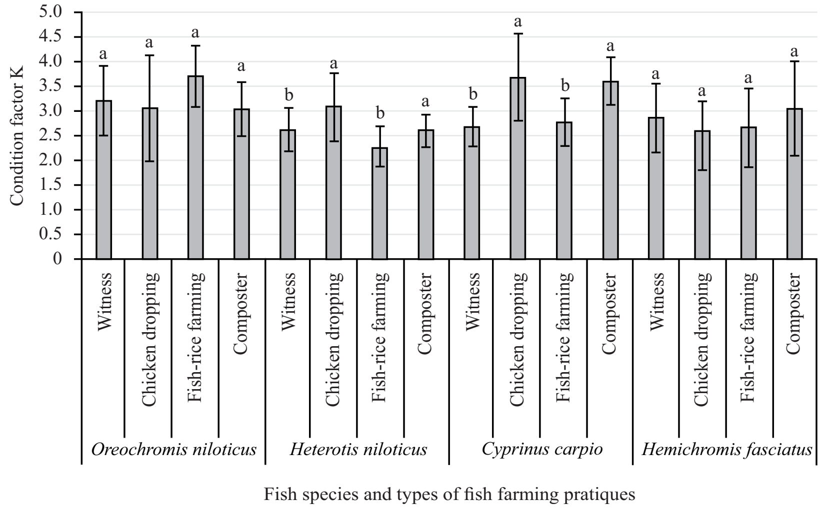

Fig. 7: Condition factor K of different fish species as a function of the type of fish farming practices, [ab]Values assigned the same letter on the histogram do not differ significantly at the 5% threshold in the same species of fish

Table 2: Fish production yield of four fish species as a function of different types of fish farming practices

	Yield (ton/ha/year/species)				
Fish farming practices	*Oreochromis niloticus*	*Heterotis niloticus*	*Cyprinus carpio*	*Hemichromis fasciatus*	Total yield (ton/ha/year)
Control	0.72 ± 0.32^c	0.05 ± 0.04^b	0.02 ± 0.03^c	0.01 ± 0.01^a	0.80 ± 0.04^c
Chicken droppings	1.26 ± 0.64^a	0.12 ± 0.07^a	0.04 ± 0.04^b	0.02 ± 0.04^a	1.44 ± 0.79^a
Fish-rice farming	1.06 ± 0.71^b	0.10 ± 0.06^a	0.06 ± 0.07^a	0.01 ± 0.04^a	1.24 ± 0.88^b
Composter	0.98 ± 0.45^b	0.10 ± 0.03^a	0.04 ± 0.04^b	0.01 ± 0.03^a	1.13 ± 0.55^b

[a,b,c]Means assigned the same letter on the same column do not differ significantly at the 5% level in the same species of fish

recorded in *Oreochromis niloticus* and *Hemichromis fasciatus* obtained, respectively, in fish-rice farming and compost ponds. On the other hand, in *Hemichromis fasciatus* and *Cyprinus carpio,* condition factor K values were significantly (p<0.05) higher in ponds fertilized with chicken droppings and fish-rice farming compared with other fish farming practices.

Fish production yield of fish species as a function of different fish farming practices: The production yield of four fish species according to different fish farming practices were summarized in Table 2.

The production yield values of *Oreochromis niloticus* and *Heterotis niloticus* were significantly (p<0.05) higher in ponds fertilized with chicken droppings compared with other fish farming practices. That of *Cyprinus carpio* was significantly (p<0.05) higher in fish-rice ponds and lowest in unfertilized ponds. On the other hand, no significant difference (p>0.05) was recorded in *Hemichromis fasciatus,* regardless of the fish farming practice considered. As for the total yield of the four fish species, it was significantly (p<0.05) higher in the ponds fertilized with chicken droppings compared with other fish farming practices.

DISCUSSION

Semi-intensive and extensive systems are the most common fish farming practices in Cameroon. Most fish production comes from small, under-stocked freshwater areas belonging to small rural fish farmers who consider fish farming a secondary activity[18]. This weakness of the various fish farming practices in semi-intensive and extensive systems is due to the poor management of the pond ecology, which is the basis of fish production. Water quality, availability of nutrients and natural food (plankton) and fish growth all require a minimum of constant monitoring. These various practices are mainly reserved for small-scale local fish farmers with little or no financial resources. In addition, the practice of fertilizing fishponds improves the diversity and productivity of zooplankton groups. The high densities of rotifers, cladocerans and copepods recorded in fertilized ponds could be linked to the high levels of nitrites, nitrates, ammonium and phosphates in hen droppings, which are responsible for the natural productivity of the environment. These observations corroborated with the previous study[12], who report that high densities of zooplankton species depend on the trophic status of the ecosystem.

The distribution of the specific richness of zooplankton groups was affected by the type of fish farming practice. Indeed, results obtained during the study showed that rotifers were more dominant in ponds fertilized with hen droppings rich in nutrients (nitrogen, phosphorus and potassium). The same trend was obtained by Algrient *et al.*[19] and Aimeranc *et al.*[20] in ponds fertilized with hen droppings. The qualifying dominance of rotifers has already been mentioned in eutrophic and mesotrophic environments[21]. However, cladocerans were more dominant in pisco-rice ponds. Similar results were reported by Elegbe *et al.*[5], with cladocerans dominating in "whedos". This similarity could be linked to how tree branches in the "whedos" perform the same function as the stems of rice plants in the pond, resulting in the strong development of zooplankton, including cladocerans.

The practice of fish-rice farming and fertilization with compost is more recent in Cameroon than fertilization with chicken droppings. The low level of fish-rice farming could be explained by the fact that rice cultivation and fish farming in the same area require mastery of both crops. As a result, better management of fish farming practices reduces the production time of marketable fish and improves fish yields for fish farmers. However, the best gains in marketable weight of *Oreochromis niloticus* and *Heterotis niloticus* were obtained in ponds fertilized with chicken droppings. These results could be justified by the richness of biogenic elements derived from the decomposition of organic matter responsible for the production of zooplankton species and on the other hand by the presence of benthic invertebrates and microcrustaceans[22-24] responsible for the good growth of fish species. On the other hand, the best weight gain recorded in *Cyprinus carpio* was obtained in fish-rice ponds. Indeed, these results could be explained by the higher availability of natural food in the environment created by the development of algae and periphytic zooplankton species on rice stalks, in addition to zooplankton floating in the water column and by the presence of products from plant decomposition and insects on the small areas used, which improve fish growth[24,25]. These results were similar to those observed in fish-rice ponds[26].

Semi-intensive and extensive fish farming contributes very little to the production of competitive marketable fish in sufficient quantities, due to low technical skills. Furthermore, the lack of respect for the normal production cycle and feeding strategies in the majority of fishponds contributes to yields varying between 1.5 and 15 ton/ha/year[5,26]. Production yields recorded in the present study are lower than the 1.5 ton/ha/year revealed by its authors. Regular fertilization of ponds, which is rarely practiced, could considerably improve fish production in a semi-intensive system. Fertilization with compost and fish-rice farming are generally characterized by low technical skills and, consequently, low yields (0.5 to 2 ton/ha/year) due to production practices based on the natural productivity of the environment[27].

The results of this study show that proper management of organic fertilizers in fish ponds improves fish production yields while reducing environmental pollution. Therefore the use of organic fertilizers to improve fish pond productivity is recommended. However, the lack of high-performance equipment for identifying zooplankton species is a limitation of the study.

CONCLUSION

Fish farming in Cameroon is dominated by an extensive, low-productivity system. The semi-intensive system suffers from a rudimentary level of management and unsuitable feeding strategies. Improving the productivity of fishponds therefore requires the development of a strategy for monitoring, supporting and intensifying fish farming. Furthermore, the use of chicken droppings is the most widely practiced in fishponds and gives better results both in terms of the production of the three groups of zooplankton and that of the four fish species studied. In addition to fertilization with hen droppings, the use of fish-rice farming and composting in ponds also contribute to improving fish production.

SIGNIFICANCE STATEMENT

Different fish farming practices are known to improve the productivity of fish ponds mainly through their stress mitigating effects. Thus, in the present study the effect of different types of fish farming practices on the physicochemical characteristics of water, zooplankton and the growth of fish species was evaluated. This study revealed the scientific fact that the application of different fish farming practices improves fish production yields.

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