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Growth performance of *Oreochromis niloticus* Linnaeus, 1758 (Perciformes: Cichlidae) based on *Pennisetum purpureum* (Poaceae) and *Musa sapientum* (Musaceae) in ponds in Yaounde (Cameroon)

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Abstract

To evaluate the influence of natural diet on growth performance of *Oreochromis niloticus* Linnaeus, 1758 (Perciformes: Cichlidae), a growth study was conducted in ponds from April to September 2012 in Yaoundé (Cameroon). The characterization of zooplankton such as Rotifers (*Lecane bulla, Lecane papuana, Rotaria* sp., *Brachionus calyciflorus, Filinia terminalis, Asplanchna brightwelli, and Trichocerca* sp), Cladocerans (*Moina micrura* and nauplii larva), and Copepods (*Mesocyclops* sp.) was carried out. After 180 days of breeding, the final average weight, average size, survivor and growth observed at the end of daily experience in each environment was recorded. Daily growth between Pond 1 and Pond 2 showed a significant difference ($p< 0.05$). From ponds 3 and 4, there was no significant difference ($p>0.05$) in the growth rates. The final average weight observed in different environments, showed that the aquatic area 1 gave the highest final average weight (89.43±57,22 grams), followed by aquatic area 4 (43± 19,39 grams), aquatic area 2 (29±9,52 grams) and finally aquatic area 3 (38±15,39 grams). The final average size was recorded in each pond, (13.02 ± 3, 49 cm) for pond 1, (12.72 ± 1, 94 cm) for pond 2; (12,02±3,21cm) for pond 3, and (43±3,53cm) for pond 4. The survival rate was also recorded at the end of breeding. It appears from this study that the survival of fish is highest in the aquatic area 2 (82.5%) followed by aquatic area 1 (79%), aquatic area 3 (66%) and aquatic area 4 (65%).

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Introduction

Food security is a major problem for developing countries (Nathanaël *et al.*, 1998). FAO (1999) states that approximately 828 million people worldwide suffer from malnutrition due to a deficiency of proteins in their diet. FAO (2006) believes that the intensification and diversification of fish production systems will help to deal with this problem. Fish is therefore proposed as a promising alternative to increase the availability of proteins especially in rural Africa. However, out of 59.4 million tons of fish produced in the world in 2004 (Fisheries and Aquaculture), Africa had contributed only for 1.1%, of which 1.6% is from aquaculture (FAO, 2006). The lack of fingerlings, the relatively low level of education of some farmers and especially the rising cost of food remains the main cause of the low fish production (Pouomogne, 2005).

A study was carried out in Yaounde from January to June 2011 through a survey concerning consumers and producers. Strong contribution to this study used a survey conducted in Yaounde. It allowed us to understand the difficulties faced by fish farmers and lack of freshwater fish in the Cameroonian market (Nchoutndignigni *et al.*, 2013). According Siddhuraju & Becker (2003), the major constraint to the development of fish farming in developing countries is the cost of the food. This cost is estimated at about 50% as revealed by Slembrouck, 1991, Gourène, 2002. *Oreochromis niloticus* Linnaeus, 1758; (Perciformes: Cichlidae) was selected as the test organism in this study for its great aquaculture and commercial value. Tilapia is the third most important cultured fish group in the world, after carps and salmonids. Their firmness and adaptability to a wide range of culture systems has led to the commercialization of tilapia products in more than 100 countries. Nile tilapia represents approximately 84% of global tilapia production. In 2008, Nile tilapia culture alone was ranked as the fifth among the most cultured species in the world, with a total aquaculture production of 2.3 million tons (FAO, 2009). In 2010, it is anticipated that global Nile tilapia production will reach nearly 2.5 million tons (FAO, 2010). Accurate diagnosis of the constraints on the different types of operations must be performed in advance to allow the statement of appropriate models of production according to the geographical disciplines, livestock, ecological, biological, socio-economic and nutritional as in other agricultural areas. Experimentation involves a focus on theoretical and practical research to synthesize research and development. It is in this context that this study was initiated.

The objective of this work is to characterize the trophic effect of *Pennisetum purpureum* (Poaceae) and *Musa sapientum* (Musaceae) *on* growth performance of *Oreochromis niloticus* in earthen ponds in Yaounde.

Materials and methods

Study site

Geographical situation

Yaounde which is, the political capital of Cameroon (Central Africa), is located on the western edge of the southern Cameroonian plateau with geographical coordinates being latitude 3 ° 52 ' North and Longitude 11 ° 32' East, with an average altitude of about 750 m above sea level. (Sanchoir, 1995). The landscape is hilly and the city lies on several hills which are 25 to 50 m high (Eno-Belinga and Kabeyene 1982; Ekodeck, 1984). The experimental ponds for our research are located within the University of Yaoundé I (Fig.1).

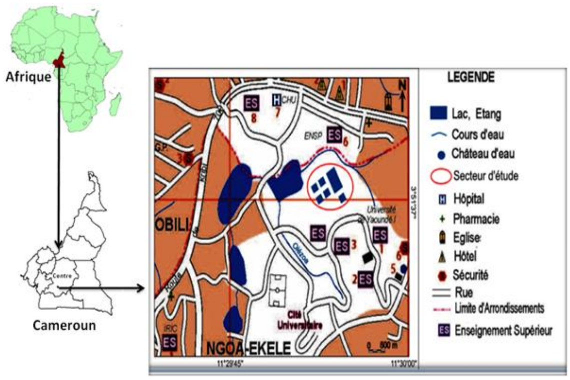

Fig. 1. Location of the study site.

Climatology and Vegetation

This work was conducted in the forest zone of southern Cameroon. This area is a semi-deciduous forest in equatorial Africa. The aquatic environment is degraded by urbanization and low sanitary facilities. The forest alternates with vast areas of savannah which are interspersed with gallery forest. The climate is an equatorial one which is, characterized by two dry seasons (a long dry season from January to March and a short dry season from July to August) alternating with two rainy seasons (small rainy season from September to mid-November and a long rainy season from mid-March to June) of relatively uneven and variable duration from one year to another (Suchel, 1987). Soils are ferro-lateritic with pH value ranging from 4.5 to 5.8 (Yongué-Fouateu, 1986).

Hydrography

The hydrographic network of the Mfoundi division has 14 tributaries flowing through the city and it's surroundings in the North-Southern direction. In different sub-basins of the river's network, vegetables are grown and artisanal fish breeding is practiced. Olézoa is a stream of the river system, located in the Yaoundé V district. It supplies our ponds that one located in the marshy area on the University of Yaounde I school compound. It meets with the Mingoa and Aké on the right bank of Mfoundi and stretches to the lower Mfoundi airport situated in the southern part of Yaounde.

Materials

Biological materials

The trial was conducted with 800 larvae of *Oreochromis niloticus* with an average weight of 1.6 ± 0.11 g which were reproduced at the Aquaculture Station Melen-Yaoundé. The plant material consisted of *Pennisetum purpureum* and *Musa sapientum* which was collected in the swamp of the Campus of the University of Yaounde I.

Technical equipment

The technical equipment was composed of farm structures (4 fish ponds of 100 m² each constructed bypass), a roll of nylon wire, posts (bamboo) to identify forties, a measuring tape (0001 m near) and an ichtyometer (nearly 0001 m) to measure respectively the sizes of fish and a portable electronic balance HX-T (0.01 g) for weight measurements. The physical and chemical water parameters (pH, dissolved oxygen, water temperature, transparency) were measured using a thermometer, a pH meter (Schott Geräte CG818), an oxymeter (Schott Geräte HQ30d) and a SECCHI disc (30cm diameter).

Methodological approach

Treatment and Sampling

The breeding cycle took place between April 2011 and September 2011 in four earthen ponds of 100m² (Fig.2) each containing, 200 fingerlings (1.6g) in Yaoundé (table 1). The following treatments were observed: dose of 20kg/fortnightly/pond/plant species. The plants were chopped in to fine particles ranging between 2-5 mm. Adjustments were made every 15 days after collection. The temperatures of water, dissolved oxygen, pH, and water transparency of each rearing area were measured every two weeks (between 8am-9am and from 16pm-17pm). During the180 days of rearing, thirty fishes (30) were taken from each pond every two weeks. This sampling was done using fishing net (Fig.6A and Fig.6B). Sampling of biotic parameters was done on a bimonthly basis and focused on fish. At the beginning of the experiment, the biomass of fishes in each area were determined to the nearest gram. At the end of the trial, all fishes from each farm structure was counted and weighed together to the nearest gram. The final mean weight (g), survival (%), daily growth (g/d) was determined from the data collected. These parameters were calculated as follow:

Faw (g) = tw/fnf with **faw:** final average weight, **tw:** total weight, **fnf:** final number of fish.

Sr (%) = fnf/inf x100 with **Sr:** Survival rate, **inf:** initial number of fish

Dg (g/d) = (faw - Miw)/t with **Dg:** Daily growth, **Miw:** Mean initial weight, **t:** duration of livestock

For growth comparison with respect to the characteristics of the rearing environment, we used linear regression and the analysis of variances (ANOVA) respectively. Differences were considered significant at the 5% level. Statistical analyses were performed using STATISTICA5.1 software (Statsoft, Inc.).

Results

Physico-chemical characteristics

The average temperature in the four ponds was between 26.1°C (Fig.5). The average dissolved oxygen varied very little and is about 5.24 mg / l. The pH of the water was fairly constant (around neutrality that is PH=7). Suspended solids vary little between April, May and September, with an average value of 39.25 mg / l. The oxygen content increased very little in the month of April and May in the four ponds and remained constant throughout the cycle. Water transparency fluctuated in April and May in all ponds and was found to decrease with increasing Suspended Solids with an average value of 23.97 cm.

Table 1. Characteristics of experimental ponds and put in charge.

Ponds	1	2	3	4
Surface (m^2)	100m^2	100m^2	100m^2	100m^2
Species	*O. niloticus*	*O. niloticus*	*O. niloticus*	*O. niloticus*
Volume of water (m^3)	100	100	100	100
Number of Species	200	200	200	200
Traitment	PP	PP	MS	MS

MS :*Musa sapientum* ; PP :*Pennisetum purpureum*.

Table 2. Characterization of zooplankton in experimental ponds.

Group	Pond 1	Pond 2	Pond 3	Pond 4
Cladocerans	-	-	*Moina micrura*	-
Copepods			*Larve nauplii*	-
			Mesocyclops sp	-
Rotifers	*Lecane bulla*	*Lecane bulla*	*Filinia terminalis*	*Rotaria* sp
	Lecane papuana	*Brachionus calyciflorus*		-
	Rotaria sp	-	-	-
	Brachionus calyciflorus		-	-
	Asplanchna brightwelli		-	-
	Trichocerca sp	-	-	-

Biological characteristics

Characterization of zooplankton such as Rotifers, Cladocerans and Copepods (Table 2) in the different farming structures gave us a specific richness totalizing 13 species: (46.15%) in area 1, (30.76%) in area 3, (15.38%) in area 2 and finally (7.69%) in area 4. We have an abundance of Rotifers in pond 1 and 2. The following species were found: *Lecane bulla, Lecane papuana, Rotaria* sp., *Brachionus calyciflorus, Asplanchna brightwelli, and Trichocerca* sp. Pond 3 consisted of Copepods such as *Moina micrura* and nauplii larva,Cladocerans such as *Mesocyclops* sp. and finally, Rotifers namely *Filinia terminalis*. Pond 4 consisted only of *Rotaria* sp.

Table 3. Growth daily survival rates and average final weight recorded *Oreochromis niloticus* high during180 days in earthen pond. The results are expressed as (Mean ± SEM) of two replicates.

	Pennisetum purpurerum		*Musa sapientum*		F	P
Parameters	Pond 1	Pond 2	Pond 3	Pond 4		
Daily growth (g/j)	0.63	0,56	0,40	0,41	0.52	>0.67
Standard error	±0,4	±0,2	±0,2	±0,4		
Survival (%)	79^a	82,5^a	66	65	7.51	<0.0001
Standard error	±3,9	±2,7	±1,86	±1,86		
Final average weight (g)	89.43^a	29^a	38^b	43^b	6.46	<0.0001
Standard error	±57,22	±9,52	±15,39	±19,39		
Final average size (cm)	13.02	12.72	12.08	12.76	0.21	>0.89
Standard error	±3,49	±2.04	±3,16	±3,53		

On each line, the values (Mean ± SEM, F, P) assigned by different letters are significantly different (P <0.05), ANOVA test. The absence of letters a, b on the same line indicates no significant difference (P> 0.05).

The final mean weights, survival rate, growth seen at the end of daily experience in each environment are listed in Table 3. Daily growth between Pond 1 and Pond 2 showed that it was faster in area 1 than in area 2 (Table 3). This difference was significant (p <0.05) while, the daily growth in area 3 and 4 had a balance leading to a non-significant difference (p> 0.05). The final mean weight (Table 3) observed in different environments, showed that area 1 gave the highest final average weight (89, 43±57.22g), followed by area 4 (43±19,39grams), area 2 (29±9.52g) and finally area 3 (38±15.39grams). The average final size was recorded in each pond and we had (13.02± 3, 49 cm) for pond 1 (12.72±2.04 cm) for pond 2, (12.02 ±3,21cm) for pond 3 and (12.76±3, 53 cm) for pond 4. The survival rate (Table 3) was also recorded at the end of breeding. It appears from this study that the survival of fish was high in area 2 (82.5%) followed by area 1 (79%), area 3 (66%) and area 4 (65%). Determining the relationship between the final average weight of each pond, and the environmental variables, we can observe a strong correlation between an increase in weight and Dissolved Oxygen (Standard error of estimate: 0.68, p <0.05) and secondly, between an increase in size and Dissolved Oxygen (Standard error of estimate: 0. 86, p<0.05) and a weak correlation between the temperature and size p>0.05, Standard error of estimate: 0.19 (Fig.3, and Fig.4). From these results, it shows that, the size and weight of *Oreochromis niloticus* increase with an increase in dissolved oxygen. Comparison (ANOVA) of daily growth values obtained in different ponds showed a significant difference (p>0.05).

Table 4. Physico-Chemical characteristics of experimental ponds.

	Pennisetum purpurerum		*Musa sapientum*		F	P
Parameters	Pond 1	Pond 2	Pond 3	Pond 4		
Temperature (°C) Standard error	26,38 ±0.7	25,53 ±2.2	25,79 ±3.0	26,7 ±1.91	0.38	>0.76
Dissolved oxygen (mg/l) Standard error	5,48[a] ±0.3	5,31[a] ±0.8	4,76[b] ±1.1	5,42[b] ±0.8	0.9	<0.44
Transparency (cm) Standard error	20.34[a] ±2.51	22[a] ±3.78	25.75[b] ±3.33	25.17[b] ±4.31	3.17	<0.04
PH Standard error	7[a] ±0.1	7,04[a] ±0.04	7,16[a] ±0.12	6,93 [a] ±0.22	1.87	<0.16
SS (mg/l) Standard error	18.25[a] ±4.92	15.75[a] ±3.59	16.83[b] ±4.98	21.25 [b] ±2.64	1.98	<0.14

SS: Suspended Solids; pH: potential of hydrogen. (Mean ± SEM, F, P) assigned by different letters are significantly different (P <0.05), ANOVA test. The absence of letters a, b on the same line indicates no significant difference (P> 0.05).

Discussion

The physicochemical characteristics observed in the different ponds are high in ponds fed with *Pennisetum purpurerum* (Dissolved Oxygen: 5.48±0.64) and are low in ponds fed with *Musa sapientum* (Dissolved Oxygen: 4.76±1.79). All other environmental variables lie in the intervals recommended for breeding tilapia This agrees with studies carried out by Hem S. *et al.*, 1994 ; Philippart *et al.*, 1987 ; and Ross L.G., 2000).

The highest survival rate (82.5±2.7) obtained in the present study was observed in the pond fed with *Pennisetum purpurerum*. According to Turner and Robinson, 2000 farmed fishes become aggressive when food is delivered to a specific location in the pond. This behavior would adopt an opportunistic strategy of territoriality. In the present study, with a loading density of 2 per m², this report (number of individuals per square meter) could be used to explain the survival values in different ponds.

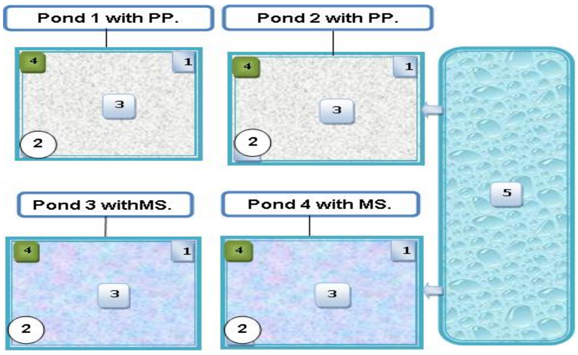

Fig. 2. Experimental setup of the first breeding cycle of *Oreochromis niloticus*. (1) Water inlet, (2) Monk and water outlet, (3) Plate of the pond, (4) Compost, (5) water retention, PP: *Pennisetum purpureum*, MS: *Musa sapientum*.

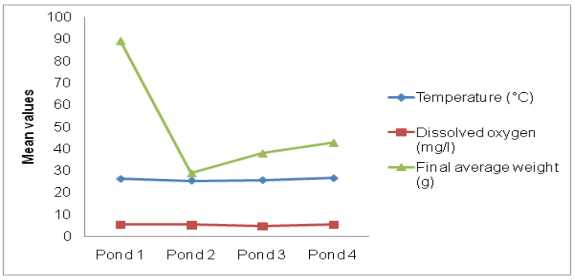

Fig. 3. Influence of dissolved oxygen and temperature on the growth of *Oreochromis niloticus* in Weight 4 ponds.

Daily growth observed at the end of our experiment is better in ponds fed with *Pennisetum purpurerum*. It is well known that fish growth is influenced by many factors including food supply (quantity and quality) and environmental variables (Boyd C.E *et al.*, 1998). Variability of this process is also dependent on the environment. For example in large natural areas that are the Great Lakes of Africa, the Nile tilapia *Oreochromis niloticus* present various growth performances (Getabub A., 1992). A wild population of this species reaches an average weight of 18g in 7 months in Lake Tchad (food scarce), while in intensive farming, for the same period of breeding, another reaches 300 g at high density with artificial feeding and in ponds, they can reach up to 650 gat low density with an abundant supply of natural and artificial food substances (Philippart *et al.*, 1987). According to Boyd and Tucker 1998; temperature is a critical factor for the growth of fish.

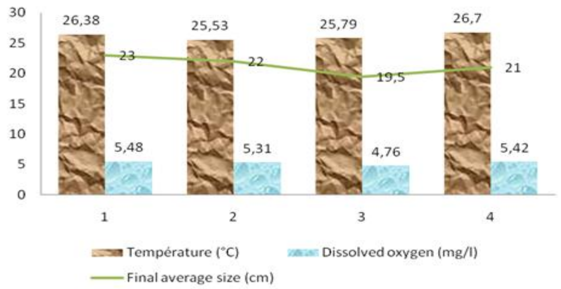

Fig. 4. Influence of temperature and dissolved oxygen on the growth in size of *Oreochromis niloticus*.

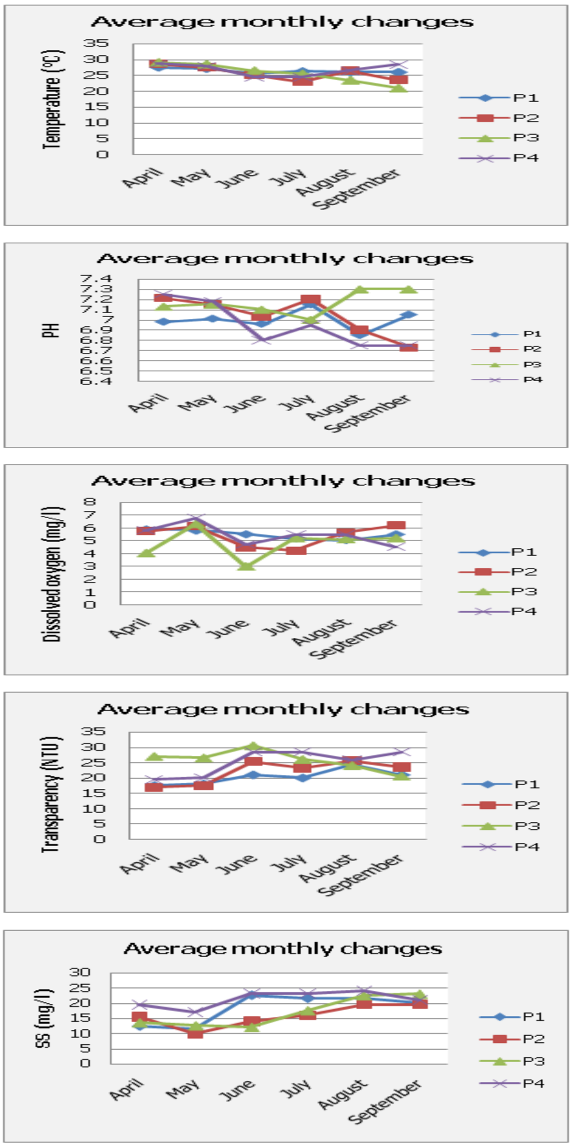

Fig. 5. Average monthly changes in physico-chemical characteristics in four ponds.

Any variation in the environmental benefits of this feature can result in a difference in growth (Halvorsen H. *et al.*, 2000). It has been noted that *Oreochromis aureus* daily growth is greater rat 35 °C than at 27° C (Baras E., and *al.,* 2000). A positive effect of the increase in this variable (22.7 to 30.7 ° C) and the negative impact of the reduction of dissolved oxygen were also observed on the growth of *Oreochromis niloticus* in high ponds 4m² (Melard C., 1986).

Fig. 6. A and B. *Oreochromis niloticus* obtained after 180 days of breeding.

Growth of *Oreochromis niloticus* in our ponds and especially in pond 1 showed proliferation of rotifers, mainly algivorous and in association with Cladocera, grazing activity by transferring more than 60% of primary production in lakes with fish fry that have a great importance in the structure and functioning of ecosystems (Shiel, 1995; Haberman, 1998). They therefore constitute the main source of food fry (Télesh, 1993) and their eggs represent life food of choice for fish aquaculture (Fernando, 1994). In addition, they participate in the cleaning of water bodies by removing the organic matter (De Beauchamp, 1965) and are indicators of water pollution (Fernando *et al.,* 1993). The participation of rotifers in the food chain in ponds *Pennisetum p.,* Gave a highly significant result ($P<0.05$) with a final average weight of 136g.

Conclusion

This study demonstrates the feasibility of fresh water tilapia. This *Oreochromis niloticus* pond farming achieved in the aquatic area of Yaoundé, was made with the objective of enhancing the practice of fish farming which is facing many difficulties since its genesis in Cameroon. Some difficulties included the nursery structures, the expensive cost of food products, and the relatively low level of education of farmers (Pouomogne, 2005; Nchoutndignigni and *al.,* 2013). At the end of this study, it appears that promoting natural food is an alternative for promoting food security in Cameroon. *Pennisetum purpurerum using* as food, *Oreochromis niloticus* achieved good growth with relatively 89, 43 ± 57.22grams as final average weight and 13, 02± 3.49cm in size with an average survival rate of 0.88± 0.68 %. This result is consistent with the application of the natural diet. In addition, environmental values (see Table 5 and 6), such as temperature (26.7±1.87°C) and dissolved oxygen (5.48±0.64mg/l) strongly influenced the increase in weight (Fig.3) and the increase in size (Fig.4) of *Oreochromis niloticus* in our earthen ponds.

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