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Growth performances of three populations of *Oreochromis niloticus* (Linnaeus, 1758) in Sudano-Guinean altitude zone of Cameroon

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Abstract

In order to contribute to the improvement of aquaculture production, growth performances of three populations of *Oreochromis niloticus* from Cameroon were studied in the IRAD station of Foumban. A total of 600 post-larvae (0.03 ± 0.01g) from three hydrogeographics origins (Niger, Sanaga and IRAD Station) were randomly distributed in duplicate in 6 concrete tanks of 1 m^2 each at a density of 100 ind./m^2. The main results were as follows: except for survival rate and food consumption, all other growth performances were significantly influenced. Furthermore, except the nutrient quotient which highest significative value was achieved in the population of the IRAD station, the value of all the others characteristics were significantly very high in the population of Niger Basin.

Keywords: *Oreochromis niloticus*, population, growth, performances, Cameroon

Introduction

Capture fisheries and aquaculture produced approximately 148 millions of tons of fishes in 2010 worldwide. Whereas before the 1990s, aquaculture provided only 7% of fish for human consumption, the rate rose to 26% in 1994 and 39% in 2004 (FAO, 2016) [16]. Moreover, the global per capita consumption of fish has increased from an average of 9.9 kg / capita / year in 1960 to 14.4 kg in 1990 to 19.7 kg in 2013, with preliminary estimations for 2014 and 2015 pointing to 20kg. However, given the stagnation of fisheries landings since the late 1980s, that is aquaculture that must be continued and impressive growth of the fish supply for human consumption (FAO, 2018) [17]. The freshwater aquaculture has always been dominated by carps (71.9%) (FAO 2010) [14] but forecasts of FAO (2014) [15] reported that *O. niloticus* in 2035 might have a higher production compared to other species.

In Cameroon, it is a sudanian specie widespread in the basins of the Bénoué River and Lake Tchad (Vivien 2010). Today the species is present in all Cameroonian running water where it reproduces naturally (Efole, 2011) [13]. According Brummett *et al.* (2004) [9] Tilapia have also been introduced in the Sanaga from the Bénoué River in the 1960s during the construction of the dam Mbakaou. Also, another population was imported from Central African Republic to Foumban research station to be reproduced and disseminated throughout the national territory. *Oreochromis niloticus* is the main species used in aquaculture in Cameroon in various systems. However, in recent years, it is observed in cameroonian farms a deterioration of its growth performances (dwarfism, slow growth) resulting in low productivity of its livestock. Facing this situation, producers are using the natural environment to improve their production. Yet very little information is available on the growth performances of different populations of *Oreochromis niloticus* from Cameroon. The objective of this work is therefore to contribute to the improvement of Nile Tilapia productivity through the mastery of the growth performances of different populations of Cameroon. Specifically, is evaluating the effect of the origin of the population on growth performances, relative productivity and growth of 3 populations of *Oreochromis niloticus* Cameroon.

Material and Methods

Period and area of study

The study took palce from March to May 2018 at the IRAD fishing station at Foumban, more

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precisely at the Koupa-matapit fish farm (5º 21 'to 5 ° 58' North LE: 10º 17 'to 11º 02' 10 ° 48.826 'East Longitude) and an altitude of 1147m in the Western Region of Cameroon. The climate is of the Sudano-Guinean-type and includes a rainy season (March-October) and a Dry season (November-February). The average values of the temperature and the rainfall recorded annually respectively are 22 ° C and 1800 mm (Pouomogne, 1998) [38].

Animal material

A total of 600 of fry *Oreochromis niloticus* precisely 200 from each hydrogeographic origin (Basin Niger, Sanaga and Foumban hatchery) were used. The fry were collected at the nursery tanks of the IRAD fish station with a mean weight of 0.34 ± 0, 04 g, and medium length 2.91 ± 0,21Cm.

Breeding structure

Six concreted tanks (length 1.5m, width 0.7m, height 1m) were used. A water supply system consisting of a PVC pipe and valves arranged in parallel, allowed the entry and control of the flow of water in each of these tanks. A mosquito net was installed at the entrance for water filtration and to prevent predators from entering the bins. The average flow rate per tank was 0.008 l / s. A basin was placed under a floating plastic frame allowed to collect food refusals from each tray. Each tray was covered with a net screen over which straws were placed to prevent the entry of predators into the bins and also create a shading to facilitate food consumption (Coulibaly *et al*., 2000) [39].

Conduct of the test

The 200 fry of each treatment (BN treatment: *Oreochromis niloticus* coming from the Niger Basin; BS treatment: *Oreochromis niloticus* coming from Sanaga Basin and SI treatment: Population coming from IRAD's fishing farm of Koupa-Matapit) were randomly distribute in two tanks. Each treatment was distributed in duplicate. All treatments received 35% protein feed twice per day, consisting in fishmeal, soybean meal, yellow cornmeal, blood meal, palm oil and vitamin premix. The physicochemical characteristics of the water (pH, temperature and dissolved oxygen) were measured weekly. At the end of try, the live weight, the total and standard lengths as well as the refusals collected made it feasible to evaluate the following growth characteristics:

Food consumption (FC) = food served - refusal; Weight gain (WG) = final weight - initial weight; Average daily gain (ADG) = (final weight-initial weight) / (time (day)); Specific growth rate (SGR) = ((lnfinal weight- lninitial weight) * 100) / (day time); Consumption Index (CI) = Quantity of Food Consumed / Weight gain; and Survival rate = (Number of initial fish - final number of fish) * 100 / (Number of original fish); the nutrient quotient = (Quantity of food distributed / Weight Gain) * 100

Statistical analysis

The data were submitted to the one-way analysis of variance (ANOVA 1). When the effect of the waterway of origin was significant, the Duncan test was used to separate the means clustering at 5% threshold. The regressions tests were done using Excel 2007. All analyzes were Performed using the SPSS software version 21. 0.

Results

Evolution of K condition factor and specific weight growth rate of *Oreochromis niloticus* depending on the origin of populations

The evolution of body weight and condition factor K depending on the origin of populations is illustrated in Figure 1. It follows that these two features have evolved in reverse. Thus, regardless of the considered population, live weight was increasing throughout the try with the highest significant values in the population of Niger. Moreover, except for the 3rd month where the K condition factor of the population of Koupa station was higher, the population of Niger basin presented significantly higher values than the populations of IRAD Foumban hatchery and the Sanaga basin.

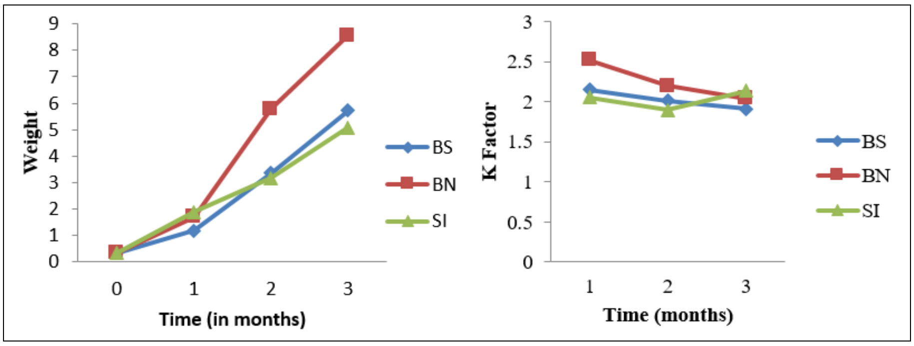

Fig 1: Monthly evolution of body weight and condition factor (K) of *Oreochromis niloticus* post-larvae

Post-larval growth performances of *Oreochromis niloticus* depending on the origin of populations

Table 1: Growth performances depending on the origin of *Oreochromis niloticus* post-larvae populations

variables	Origins of populations					
	Niger		Sanaga		Koupa	
	M ± E	CV (%)	M ± E	CV (%)	M ± E	CV (%)
LT (cm)	7.43 ± 0.88 ^{a}	12	6.51 ± 1.18^b	18	6.16 ± 0.51^b	8
LS (cm)	6.11 ± 0.77^a	12.3	5.18 ± 1.0^b	19	5.01 ± 0.46^b	9.1
PV (g)	8.56 ± 1.29^a	15	5.72 ± 1.43^b	25	5.09 ± 0.61^b	12
GP (g)	8.22 ± 1.31^a	16	5.38 ± 1.42^b	26	4.75 ± 0.60^b	13
ADG (g / day)	0.09 ± 0.01^a	17	0.06 ± 0.03^b	25	0.05 ± 0.01^b	10
CST (% g / d)	3.53 ± 0.22^a	6	2.99 ± 0.31^b	10	2.98 ± 0.12^b	4

SGR (% cm /d)	1.09 ± 0.04^{a}	8	0.90 ± 0.11^{b}	13	0.87 ± 0.06^{b}	7
K	2.25 ± 0.07^{a}	3	2.00 ± 0.08^{b}	4	2,03 ± 0.06^{b}	3
QN	1.74 ± 0.04^{c}	2.4	2.53 ± 0.08^{b}	3.2	3.09 ± 0.05^{a}	1.6
CI	0.58 ± 0.01^{a}	1.7	0.40 ± 0.02^{b}	5	0.36 ± 0.01^{b}	2.8
FC (g)	1343.00 ± 25.46^{a}	1.9	1335.00 ±12.73^{a}	1.8	1381.00 ± 28.28^{a}	2

a, b and c: affected the average of the same letter on the same line were no significant differences between populations (P> 0.05). LT and LS = total length and standard; PV = bodyweight, GP = weight gain, ADG = average daily gain, CST and SGR = specific growth rate, FC= food consumption, CI= consumption index and QN= nutritive quotient

It is apparent from Table 1 that, regardless of the considered characteristic, the highest significant values were obtained with the people of Benue while these values were comparable between the populations of the Sanaga Basin and the hatchery of Koupa. In addition, the values of all the growth characteristics of the population of the Sanaga are more dispersed, while those of the population of the Koupa experimental station are more homogeneous, exception the food consumption.

Relative growth of *Oreochromis niloticus* depending on the origin of populations

Table 2: Relationship of length-weight of *Oreochromis niloticus* post-larvae

Origins of populations	Equations	R^2	at	b	Type of growth
Niger	Pf=0,1063LS^{2,41}	0.913	0.106	2.41	lowerbound
Station	Pf = 0,1263LS$^{2.28}$	0.855	0.126	2.28	lowerbound
Sanaga	Pf = 0,0583LS$^{2.74}$	0,972	0.058	2.74	lowerbound

Pf = final weight, LS = standard length, R^2 = coefficient of determination, a = constant, b = allometric coefficient

The table 2 shows that the weights of *Oreochromis niloticus* individuals are strongly associated with standard lengths. This relationship follows a power type equation and coefficients of determination (R^2) are very strong. Furthermore, the allometric coefficient (b) ranges from 2.28 (Koupa) to 2.74 (Sanaga) and growth is the allometric type lower bound regardless of the origin of the population.

Biomass, survival, production and productivity related to the origin of the population

Table 3: Biomass, biomass gain, survival and productivity related to the origin of the population

Variables	Origins of populations		
	Niger	Sanaga	Koupa
	Average	Average	Average
Bf (g)	803.00 ± 5,65^{a}	563.50 ± 51.619 ^{b}	498.00 ± 16.97 ^{b}
GB (g)	772.50 ± 3,55^{a}	531.00 ± 53.740 ^{b}	467.50 ± 16,26^{b}
P (g / m² / d)	8.92 ± 0.04 ^{a}	5.90 ± 0.60 ^{b}	5.19 ± 0.20 ^{c}
S (%)	93.50 ± 0.70 ^{a}	91.50 ± 0.71 ^{a}	93,00 ± 1,41^{a}

Bf = final biomass, GB = biomass gain, P = productivity or production, S = survival rate.

From Table 3, we can see that, except the survival rate and food consumption rates that are comparable in between the different populations, the values of biomass, biomass gain and productivity were significantly elevated ($P < 0.05$) with the population of the Niger basin and comparable in between the population of the Sanaga Basin and the hatchery of Koupa.

Discussion

The growth of tilapia varies greatly from one species to another and from one population to another. This change is also linked to the strain used, food sources available, the demographic structure of populations, predation and fishing techniques, to the surface and the location of the stream (Lazard 2009, Ouattara, 2009) [26, 33] and stage of breeding. However, as the reproduction, growth in different populations or strains is very poorly documented unlikely the diet and the nutrition of this species or the breeding techniques and systems. Overall, the different characteristics of the populations we studied varied significantly depending on the origin of the population. This is in accordance with the observations of Hulata *et al.* (1993) [21] that worked on different hybrid *Oreochromis niloticus* x *Oreochromis aureus*, showed that their water source significantly affects the growth characteristics such as weight final average, average daily gain, survival, efficiency and sex ratio. Similarly, in *Menidia menidia* (Conover and Kynard, 1981) [10] showed that the sex ratio of this species is linked to the original populations or strains used. In addition, Mairesse *et al.* (2006) [27] in a study of the Perch (Perch), the total lipid content was significantly different between the population of the Rhine River and Lake Geneva (1.21 and 1.48%, respectively). In this study, weight gain (4.75 to 8.22), as well as average daily gain varied significantly from one population to another, which does not compound with the results obtained by Amoussou *et al.* (2017) [3], reported that the weight gain (24.65 ± 12.86 g to 32.74 ± 17.71 g) and average daily gain will not vary significantly between populations from three watersheds in southern Benin. This can be explained by the high stocking density and the rearing stage because according to Mensah *et al.* (2014) [28] the values of the weight gain depends on the physiological state of the storage density, strain or fish origin and even loading size. Depending on the strain used, tilapia feeding and farming conditions may have average daily gain from 2 to 4 g per day (Lazard, 2009) [26]. Furthermore, depending on the loading density of *Oreochromis niloticus*, Bamba *et al.* (2008) [7] obtained weight gains ranging from 40.24 ± 7.64g to 54.03 g ± 7.76 g for 10 individuals / m² and 36.65 ± 5.73 g to 46.11 ± 5.87 g 13 m² for individuals, unlikely to that study where we had a density of 100 individuals per square meter. Depending on the rearing stage, our values were comparable to those of Parrel *et al.*, 1986 [35] using fish of the same weight and to those obtained by Lazard and Leveque (2006) [24] who obtained an average individual weight of 5 g after two months of aging in water, with a dry feed containing 20% of fish meal, from fry average weight of 0.9 g; This corresponds to a gain in daily weight equal to 68.33 mg / day. Similarly, Thabet, (2017) [41] has obtained average daily gains (0,027g / d) in larval rearing well below to those of the present study ranging from 0.05 to 0.09. On the other hand, our results are lower than those obtained by several authors. Depending on the strain or the origin of the strains or populations (Morissens *et al.*, 1996) [29] observed the daily earnings of 2.81 ± 0.07 g / day for Bouaké strain 2.50 ± 0.05 g / day for the Daloa strain and 2.50 ± 0.10 g / day for the Burkina Faso strain, and according to Nana *et al.*, (2018) [31] 0.20 ± 0.09 g / d with fish whose initial weight was 10 g against 0.04 g for this study. Furthermore, the final weight of fish obtained in this test after 3 months of breeding which is between 5 and 9 g are significantly higher than the 1.7 g, 1.4 and 2.5 obtained after 2 months of larval rearing respectively (Thabet, 2017; CTA, 2015 and ISTM, 2009) [41]. Depending on the strain or the origin of the strains or populations (Morissens *et al.*, 1996) [29] observed the daily earnings of 2.81 ± 0.07 g / day for Bouaké strain 2.50 ± 0.05 g / day for the Daloa strain and 2.50 ± 0.10 g / day for the Burkina Faso strain and according Nana *et al.* (2018) [31] 0.20 ± 0.09 g / d with fish whose initial weight was 10 g against 0.04 g for this study. Furthermore, the final weight of fish obtained in this test after 3 months of breeding which is between 5 and 9 g are significantly higher than the 1.7 g, 1.4 and 2.5 obtained after 2 months of larval rearing respectively (Thabet, 2017; CTA, 2015 and ISTM, 2009) [41].

The specific weight and linear growth rate varied significantly depending on the origin of the population. This corroborates the results obtained by Amoussou *et al.* (2017) [3]. However, the values of the linear specific growth rate (0.87 to 1.09) are greater than those of the same author (0.63 to 1.15) as the weight gain is lower but comparable to the results obtained by Algrient *et al.* (2019) [2] who obtained values ranging from 1.92 to 2.25 in two species of African catfishes. On the other hand, these values are higher than those reported by Owusu-Frimpong *et al.* (2005) [34] which are 1.22 ± 0.03% per day and 0.80 ± 0.04% per day respectively for *Oreochromis niloticus* individuals reared in cages and hapas. The linear growth rate reported in this study are similar to those reported from *Oreochromis niloticus* by Gbaï (2014) [20] in Ivory Coast (0.48%) and by Amoussou *et al.*, (2017) [3] in Benin.

The nutrient quotient unlikely to the observations of Amoussou *et al.* (2017) [3] varied significantly depending on the origin of population although the values obtained in this experiment (1.74 ± 0.04 to 3.09 ± 0.05) are similar (1.7 ± 0.3 to 3.44 ± 2.1). On the other hand, the values obtained in this study are much higher than those observed by Bamba *et al.* (2007) [8] and Bamba *et al.* (2008) [7] in tanks and ponds in Ivory Coast and larval rearing by Philippart *et al.* in 1982, INSTM in 2009 (1.97) and by the CTA in 2015 (1.32) and similar to those of Thabet (2017) [41] which is of the order of 2.25 and 2.51. In addition, depending on the diet, the *Oreochromis niloticus* larvae reared in concreted bins suggest that a diet without fish meal gave a nutrient ratio of 0.98 and 1.3 (Bamba *et al.* 2007) [8]. *Oreochromis niloticus* fingerlings to the density of 10 to 13 individuals per square meter gives the nutrient quotient ranged from 1.13 to 1.87 (Bamba *et al.*, 2008) [7]. In Congo (Ngokaka *et al.*, 2010) chronicles the respective nutrient quotients of 10.2 ± 0.2 and 12.2 ± 6.3 of *Oreochromis niloticus* in ponds and floating cages. In addition, (Amoussou, *et al.*, 2014) [4] have observed values of 2.72, 0.97 and 7.37 for this parameter in the cages, the bodies of water in Burkina Faso. During this (Ouattara *et al.*, 2005) relate to an isolated strain of Tilapia *Sarotherodon melanotheron* extremely high values of nutrient quotients 17.66 ± 0.54, 6.13 ± 2.23 and 8.28 ± 1.75 in concreted containers, ponds and cages respectively. These different nutrient quotients are explained not only by the quality of food used during these experiments, but also by the genetic potential of fish. In short, the more nutritional quotient is low, the food is better and the better fish grows (Amoussou *et al.*, 2017) [3].

The K condition coefficient or condition factor is a good indicator for characterizing the physiological and nutritional status of the fish. Overall, k condition factors varied significantly according to different population and the calculated values were between 2.00 ± 0.08 to 2.25 ± 0.07, indicating the fish welfare during the experiment. For Fulton (1992) reports that K <1 means that the fish are doing very badly and K> 1 means they are healthy. These results are similar to those of Amoussou *et al.* (2017) [3] although the values of this study are higher (3.67 ± 0.94 to 5.25 ± 1.51). However, our results were stronger than those of Nana *et al.* (2018) [31], which ranged from 1.86 ± 0.08 to 1.94 ± 0.16. Throughout the experiment the K condition factor ranged between 1 and 2. This is in accordance with the results of Ahouansou-Montcho and Laleye (2008) who reported that the K condition factor of *Oreochromis niloticus* from Lake Toho ranged from 1 and 2.

Regarding the study of the mortality, survival rate reported in this study is satisfactory and similar to those reported in the literature for different populations or strains of *Oreochromis niloticus*. Morissens *et al.* (1996) [29] indicates the survival rate equal to 90.20 ± 00% for the Bouaké strain, 94.24 ± 3.09% for Daloa strain and 89.69 ± 1.55% for Burkina Faso strain. Moreover, Amoussou *et al.* (2017) [3] reports the population of Benin survival rates equal to 95.11 ± 10.23% for the Population Oueme river, 82.73 ± 13.97% for the Lake population Toho, 83.10 ± 11.67% for the population of the Couffo river. All these values are in accordance with our results which survival rates are between 91 and 93%. These rates are also comparable to those observed at the end of larval rearing cycle by Thabet (2017) [41] which is the order of 85%, to the one obtained by INSTM (in geothermal water) in 2009 and by the CTA (in fresh water) in 2015.

In terms of relative growth coefficient b, it indicates the type of growth. Indeed, when b is equal to 3, growth is called isometric, and when it is different from 3, the growth is called allometricwhere allometric growth is known from the concepts of negative or minorante allometric if b < 3 and positive or majorantif allometric b > 3 (Froese, 2006). In our study, b is from 2.28 to 3 corroborating the observations of Amoussou *et al.*, (2017) [3] that comparing 3wild populations got the b values ranging from 2.38 to 3.22 and Sirima *et al.* (2009) [40] which refer to the same species of b values of 2.169 to 3.441 in the watershed Comoé (Burkina Faso). However, the majority of individuals have lower values b>3, and thus increasing more in length than in weight. The b values vary depending on several factors. Thus, Avit *et al.* (2012) obtained allometric coefficients of 2.84 ± 0.14 and 2.79 ± 0.23 respectively for fish or rizipisciculture with *Oreochromis niloticus*. Moreover, for Nana *et al.*, (2018) [31], working on the pond fertilization at various doses of *Tithonia diversifolia* the values of the regression coefficient ranging from 2.56 to 2.86. For Ighwela *et al*, (2011) [22] feeding the Nile tilapia with different maltose levels (0.0%, 20%, 25%, 30% and 35%) obtained the respective values of 0.82; 0.87; 0.93; 0.82 and 0.90.

Fry yields also vary significantly depending on the origin of the population, corroborating the observations of Amoussou *et al.* (2017) [3] which magnification values of three populations ranged from 6.16 to 8.18 g / m² / j and Parrel *et al.*, 1986 [35], which has obtained a yield of fry of 6.6 g / m² / d. However, our values are much higher than the results obtained in nursery by Lazard (1984) [25] which was 3.3 g / m² / d, by Popma *et al.* (1984) [37] is 2.7 g / m² / day and in prefattening obtained by Nana *et al.*, (2018) [31] with yields varied from 0.24 to 0.8 g / m² / d.

Conclusions

At the end of the work on the evaluation of growth performances of three populations of *O. niloticus*, it has spring except for the survival and food consumption that were similar among the different populations, all the other performances were significantly influenced. Furthermore, except the nutrient quotient with the highest significance was achieved in the population of the IRAD station of Foumban, the values of all other characteristics were significantly stronger among the population of the Basin of Niger. In addition, regardless of the population considered, populations of *Oreochromis niloticus* from Cameroon showed allometric type of growth with lower bound allometry coefficients less than 3.

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