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Reproductive Parameters of Three Populations of *Oreochromis Niloticus* (Linnaeus, 1758) in the Sudano-Guinean Altitude Zone of Cameroon

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Abstract

In order to contribute to the improvement of aquaculture production, reproductive parameters of three populations of *Oreochromis niloticus* of Cameroon were studied between March and May 2019 at the research station of Foumban. At this effect, a total of 81 parents (27 males and 51 females with respective weight 124 ± 6g and 144 ± 5g) coming from three hydrogeographicals origins (Niger, Sanaga and IRAD Station) were randomly distributed in triplicate in nine concrete tanks of a m² each with a sex ratio of one male for two females (1♂/2♀). Throughout the test, six females carrying eggs in the oral cavity were collected in each population and 45 days after the start of the trial, all the offspring were collected and the adults sacrificed. At the end of experiment, the IRAD population presented highest significant values ($p \leq 0.05$) regardless of the performances considered. The values of the gonado-somatic and the gonado-metric characteristics significantly lower ($p \leq 0.05$) were obtained in Niger population (GSR = 0.04 **±** 0.02**,** GSI = 0.05 **±** 0.03 and GMR=0.19 **±** 0.08; GMI**=** 0.24**±**0.07). Considering sex, males presented the lowest significant values ($p \leq 0.05$) for all the characteristics studied (GSR = 0.04**±**0.01**,** GSI = 0.04**±**0.01 and GMR= 0.23**±**0.08; GMI**=** 0.29**±**0.09).

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Introduction

Human societies are facing a huge challenge of food supply enough rich in protein and that of providing livelihoods to an estimated population of over nine billion by mid-21st century [1]. In Africa, food shortages in animal protein are sources of metabolic diseases suffered by a good part of its population [2] [3]. Of all sources of protein, fish is a reserve of 16.6% animal protein and 6.5% of total protein consumed in the world [4]. However, given the stagnation of fisheries landings since the late 1980s, it is to aquaculture that we owe a continued and impressive growth of the fish supply for human consumption [1]. By the same author, aquaculture production in 2016 was 80 million tons of fish, including tilapia as the second group and the Nile tilapia as the third species most occurred. Moreover, among all species of tilapia, *Oreochromis niloticus* commonly known as Nile tilapia is the main species used in aquaculture in inland waters of Africa [5]. It is the major source of income for African fish farmers [6, 7]. However in recent years, it is observed in Cameroon farms a deteriorating growth performance, including uncontrolled reproduction and a very early maturation of this species, resulting in low productivity of its livestock. In an effort to search for solutions, the different problems had been subjected to international expertise. After analysis, [8] recommended in its report, a genetic selection work to improve the reproductive and growth characters of the strain. Further, according to the same author, it exists in Africa, wild and domestic populations, that could show excellent potential for livestock in the African fish farming conditions. However, to our knowledge, no study of reproductive performance of *Oreochromis niloticus* populations of Cameroon has never previously been realized. The aim of this work is to contribute to the improvement of the Nile Tilapia production through the mastery of the reproductive performance of different populations of Cameroon. More specifically it is to evaluate the effect of the origins of population on reproductive performances, gonado-somatic and gonado-metric characteristics.

Material and Methods

Origin of Sample

Cameroon is drained by four watersheds namely the Sanaga, Congo, Niger and Chad. The Nile Tilapia is naturally widespread in the watersheds of the Benue (Niger) and Lake Chad [9]. Today it is present in all the Cameroonian water where it breeds naturally [10]. In terms of importance, when collecting fish in the wild by producers and logistics, fish were collected in the basins of Niger (precisely at the Lagdo dam) and the Sanaga (at the Mape dam). In addition, the domestic population of the pilot IRAD station of Foumban formerly imported from RCA [11] was used.

Period and Area of Study

The study took place from 20 March to 05 May 2019 at the IRAD's farm of Foumban, more precisely at the fish station of Koupa-Matapit (LN: 5º 21' to 5 ° 58 'and LE: 10º 17' to 11º 02 '). The average altitude is 1145 m. The climate is Sudano-Guinean and includes one rainy season (March - October) and one dry season (November - February). The annual average temperature and rainfall are 22ºC and 1800mm respectively.

Animal Material and the Conduct of the Test

Eighty-one (81) spawners including 54 females (average weight 124 ± 6g) and 27 males (average weight 144 ± 5g) have been used. Thus 18 females and 9 males of each Hydrogeographic origin were randomly distributed in three concrete tanks (length 1.5 m, width 0.7 m, height 0.8 m) equipped with a system to bring and overflow and fully drainable by gravity. The completely randomized design with 3 treatments ("Sanaga" = fish population of Sanaga, "Niger" = population of Niger, and "Koupa" = population of IRAD station of Foumban) and 3 repetitions was used. Thus, 54 females and 27 males were divided into triplicate randomly into 3 lots and within 9 tanks.

The implementation of the trial began 07 May 2019 by cleaning the tanks and putting them in Assec (let dry on the sun) for seven days. After this period, the impoundment (put in water) has been made in order to obtain a water depth of 60 cm. Three days later, the fish were randomly distributed at a density of 9 individuals / m² and a sex ratio of 1 male for 2 females. When putting the fishes into tanks, a sample of 10% of the total fishes was weighed and measured individually, using respectively an electronic balance (reference: BF-400, accuracy 0.1g) and an ichtyometer (1 mm accuracy).

During the test, all treatments received 20% protein feed twice per day, consisting in fishmeal, soybean meal, yellow corn meal, blood meal, palm oil and vitamin premix prepared at the IRAD station as described by [12]. The ratio of 5% of the biomass as was applied during the experiment for feeding as in [13].The physico-chemical parameters of water such as dissolved oxygen, pH and temperature were measured directly "in situ" weekly. The females were monitored daily to identify those carrying eggs in their oral cavities (enlargement of the oral cavity, aggressiveness, continuous circular movement). Six females per population were collected throughout the trial in post-laying phase. After collecting the eggs, the females were carefully returned to the water and all the eggs present in the oral cavity were counted to determine the absolute fertility.

Forty-five days after the implementation of the test, the tanks were drained, adults and juveniles collected and counted. In order to evaluate the gonado-somatic and the gonado-metric parameters at the end of reproduction, all spawners were weighed and eviscerated. The gonads were removed and weighed, as well as the eviscerated fishes.

Data Calculation

At the end of this test some characteristics were determined or calculated. The total or absolute productivity is the average number of offspring (fry, alevins and eggs) produced per female. The relative productivity is the number of offspring produced per g of females stored. The productivity of the system is the average daily production of offspring per m² of the operated area. Absolute fecundity is determined by counting the total number of newly recovered egg of the oral cavity of the female. Gonado-Somatic Ratio (GSR) and gonado-Somatic Index (GSI) correspond respectively to the gonad weight (GW) in percentage of the body weight (BW) (GSR = GW / BW * 100) and the eviscerated fish weight (EW) (GSI = GW / EW * 100). The formula used to calculate the Gonado-metric Ratio (GMR) and gonado-metric Index (GMI) was respectively GMR = GW / TL * 100 and GMI = GW / SL * 100. Where GW = gonad weight (g); BW = body weight; EW = eviscerated fish weight (g); TL = fish's total length (cm) and SL = fish's standard length (cm).

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 F test was used to determine the significance of the effect of sex and means clustering were compared pairwise using the t test of Student. All analyzes were performed using the SPSS software version 21. 0.

Results

Gonado-Somatic and Gonado-Metric Parameters by Sex and Origin of Population

The gonado-somatic ratio, the gonado-somatic index, the gonado-metric ratio and the gonado-metric index of the fish population of the Koupa research station are significantly lower ($P \leq 0.05$) than those of the Niger and Sanaga watersheds and whose values were comparable ($P \geq 0.05$) between these two populations. Considering the sex and regardless of the characteristic considered, the males presented the lowest significant values ($P \leq 0.05$). (Table 1)

Reproductive Performance According to the Origin of the Populations

From Table 2, we can see that, regardless of the considered characteristic, the highest significant values ($P \leq 0.05$) were obtained in the population of the fish hatchery IRAD of Koupa and the lowest in the population of the Sanaga watershed.

Correlations Between Different Reproductive Performances

It appears in Table 3 that no negative correlation coefficient has been significant. Moreover, values of the affected coefficients vary from strong ($p \leq 0.05$, $r = 0.832$) to very strong ($p < 0.01$, $r = 0.999$), correlation coefficients higher significant were obtained between productivity per g of female and system productivity ($p < 0.01$, $r = 0.998$) between the productivity per g of total production and female ($p < 0.01$, $r = 0.999$) and between the system productivity and total production ($p < 0.01$, $r = 0.998$).

Table 1. Variation of gonado-somatic ratio, Gonado-somatic index, gonado-metric ratio and gonado-metric index according to sex and origin populations

variables	factors	x̄ ± SD	variables	factors	x̄ ± SD
	Population			**Population**	
	Sanaga	0.05 ± 0,01^{ab}		Sanaga	0.06 ± 0,02^{ab}
	Koupa	0.04 ± 0,02^{b}		Koupa	0.05 ± 0,03^{b}
	Niger	0.06 ± 0.01^{a}	**IGS**	Niger	0.07 ± 0.01^{a}
RGS	**Sex**			**Sex**	
	Female	0.06 ± 0,02^{a}		Female	0.07 ± 0,02^{a}
	Male	0.04 ± 0,01 ^{b}		male	0.04 ± 0,01^{b}
	Population			**Population**	
	Sanaga	0.37 ± 0.15^{a}		Sanaga	0.43 ± 0,19^{a}
	Koupa	0.29 ± 0,08^{b}		Koupa	0,34 ± 0,07^{b}
	Niger	0.40 ± 0,06^{a}		Niger	0.49 ± 0,09^{a}
RGM	**Sex**			**Sex**	
	Female	0.36 ± 0,14^{a}	**IGM**	Female	0.45 ± 0,10^{a}
	Male	0.23 ± 0,08^{b}		male	0.29 ± 0,09^{b}

a, b and c: mean affected with the same letter for the same characteristic indicate that there is no significant difference between populations or sex ($P \geq 0.05$). SD= standard deviation and x̄ =mean

Table 2. Reproductive performances of *Oreochromis niloticus* depending on the origin of populations

Characteristics	**Origin of the population**		
	Niger Basin	**Sanaga basin**	**Station Koupa**
	x̄± SD	**x̄± SD**	**x̄± SD**
F-absolute	391.50 ± 28,99^{b}	352.00 ± 9,89^{c}	504.50 ± 13,43a^{a}
F-relative	3,09 ± 0,10^{b}	2.71 ± 0,01^{c}	3.91 ± 0,32^{a}
P-total	844.00 ± 45,25^{b}	823.50 ± 44,55^{b}	1005.00 ± 25,46^{a}
P-on	1,62 ± 0,04^{b}	1.60 ± 0.12^{b}	1,96 ± 0,08^{a}
P-system	18.75± 0,50b	18,30± 0,49b	22.33± 0,28a
P / female	211.00 ± 11,31b	205.87 ± 11,14b	251.25 ± 6,36a

a, b and c: mean affected with the same letter on the same line were no significant differences between populations ($P > 0.05$). F = fertility, P = productivity, S= standard deviation. x̄ = mean

Table 3. Correlations between different reproduction performances								
variables	**Fabsolu**	**Ptotal**	**Prelativ**	**Psystèm**	**Frelative**	**biomass**	**weight**	**P / female**
Fabsolue	1							
Ptotal	0.832 *	1						
Prelativ	0.848 *	0.942 **	1					
Psystèm	0.832 *	0.998 **	0.942 **	1				
Frelative	0.977 **	0.787	0.871 *	0.787	1			
biomass	-0.131	0,056	-0.281	0,056	-0.331	1		
weight	0.078	0,181	-0.127	0,181	-0.133	0.918 **	1	
P / female	0.832 *	0.999 **	0.942 **	0.998 **	0.787	0,056	0,181	1

*, **= bearing securities are significant at ($p \leq 0.05$) and ($p \leq 0,01$) F = Absolute fecundity, P = productivity

Discussion

Characteristics of the Gonads

The gonado-somatic and gonado-metric characteristics are generally higher in females than in males. This corroborates the results obtained by [14]. These features may vary depending on the species, age, type of food, sex and origin of populations. [15] observed that the GSR and GSI end of females and males (2.57% to 3.22% against 64% to 0.81%) were unaffected by the type of food. However, [16] comparing three natural populations of *Oreochromis niloticus* in southern Benin indicated that only gonadosomatic index of females varied depending on the origin of population and for all those gonad index parameters, the higher values were obtained in female corroborating our findings that our values were lower than those obtained by the author. This could be explained by the low temperature of our study area (22°C).

Absolute or Total Fecundity

In our experience the absolute fecundity and relative fecundity varied significantly between different populations. This is contrary to the results obtained by [17, 18] that studied reproductive performances strains of *Oreochromis niloticus* from Egypt, Ghana and Ivory Coast and found no significant difference in the relative fecundity, egg size, hatching rate and length of larvae, 24 hours after hatching. On the other hand, great variability in fertility in female *Oreochromis niloticus* same size, was reported by [19, 20] as is the case in *Tilapia zillii* [21, 22]. This is attributed to a genetic difference [23, 22] and a possible complex interaction of fertility, egg size and timing of egg laying [22].

Our values for the absolute fertility (452 ± 39.90 to 43.43 ± 604 eggs per female) are low compared to those reported by [23, 24] and [19], which are 728-1774 respectively, from 600 to 1600 and from 724 to 1669 for the same size range. Our results are in the range (309-1158 eggs per female) reported by [20] and (241-1358 eggs per female) obtained by [25] although the highest number of eggs is far superior to that of our experiment. Our low values can be explained by the large size of our begetters because according to [26] fertility of small females (58g) is bigger than that of large ones (185g).

Absolute, Relative and System Productivities

Comparison of reproductive performances of *Oreochromis niloticus* populations are poorly documented in contrast to studies on systems of production or breeding techniques [16]. However [27] evaluated the reproduction and growth characteristics of a domestic stock of *Oreochromis niloticus* (from the Ivory Coast), two non-domestic stocks (from Egypt and Sagana) and wild individuals (from Lake Victoria). The combined effects on the relative fertility, the percentage of female spawning and the success of incubation were evaluated, and it is clear from this study that the strain of the Ivory Coast has a larvae yield per gram of female eight times higher than that of Lake Victoria. This study corroborates the results we obtained since the various productivities (the total productivity, relative, system and productivity per female) *Oreochromis niloticus* varied depending on the origin of population. On the other hand, this is inconsistent with the observations of [17, 18] that by studying the reproductive performances of O*reochromis niloticus* stem from Egypt, Ghana and Ivory Coast have found no significant difference between the performances considered. The values of the relative productivity (larvae per g female) obtained in this experiment are greater than 1.4 ± 0.3 larvae per g female obtained by [25] with large females (25 cm total length). Low productivity could be explained by the large size of fish used in this test since according to this author, the relative productivity accuses significantly decreasing values depending on the size of females. Hence the values of 9.3 ± 0.7 and 6.8 ± 0.3 1.4 ± 0,2b obtained by the author with females respectively of 15.34 ± 0.25 cm and 20 54 ± 0.32 cm in total length. Moreover, this low productivity is also due to the low participation of large females in the reproductive process. Our results confirm those of [28] [25] who found that older breeding tilapia produce more larvae per clutch but less per unit weight than smaller ones. This is rooted in the social dominance effect because within the same population, the hierarchy is quickly established and dominant females reproduce more frequently than others [29] [30]. In addition [15], reports that the Tilapia males are aggressive by nature and those dominants control the majority of egg-layings and therefore several females do not reproduce.

The productivity of the system is 22.33 larvae / m² / day is less than 32 larvae / m² / d obtained by [25] in a study using the same slice of fish size. Similarly, the absolute productivity observed in our study are much lower than the 451 and 1,598 larvae obtained by [25] for respective female weight 113.4 and 183g. In addition, our values remain low compared to results obtained by [31] (600 larvae / female) and [32] (510 larvae / female). Overall, the low values observed can be explained by the high density used (8 spawners / m^2) because tests by various researchers [33, 34, 35, 36] indicate that the best results are obtained with densities of 2.5 to 5.0 progenitors / m^2. [37] also observed similar results, indicating that a density of 8 begetters / m^2, equivalent to a weight of yearly females 526 g / m^2, leading to significant reductions in the production of larvae. [38] also recommend a density of 5 begetters / m^2. [39], who tested three broodstock stocking densities (4, 7 and 10 ind / m^2), report that the best fry productions are obtained with a density of 4 breeders / m^2. In addition, the single collection would also be responsible for these low values. [40] propose a reproductive management in line with the reproductive cycle of tilapia in ponds. Thus, [36] report daily harvests, with a dip net. Also, [38] experiences showed that the optimal interval between harvests is 10 to 14 days to obtain a maximum offspring.

Conclusions

At the end of our study on the evaluation of gonadal-somatic characteristics gonado-metric and reproductive performances of three populations of *Oreochromis niloticus* from Cameroon, it appears that all gonadal-somatic characteristics and gonado-metrics were significantly affected and females had the highest significant values. In terms of reproductive performances, the population of the IRAD station of Foumban presented performances significantly higher compared to those of populations of the watersheds of Niger and Sanaga.

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