BioEx - Journal
Britain International of EXACT Sciences Journal
Publish: | January - May - September |
E-ISSN: 2686-1208
P-ISSN: 2686-1216
http://biarjournal.com/index.php/bioex

Reproductive Performance of Nile Tilapia (Oreochromis Niloticus Linnaeus, 1758) Fed on Periphyton and Rice Bran in Gemena City (Sud-Ubangi Province) in Democratic Republic of the Congo

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Abstract:

The overall aim of this study was to evaluate the reproductive performance of Oreochromis niloticus reared in ponds fed with periphyton and rice bran. It was carried out using a database resulting from an experiment carried out in the Gemena town hall, South Ubangi province in the Democratic Republic of Congo with Oreochromis niloticus fry fed on periphyton and rice bran. The methodological approach consisted of sampling the physico-chemical parameters of the pond water and the reproductive parameters, in particular the gonado-somatic ratio (GSR), the condition factor (K), fecundity and oocyte size. After analysis by pond category, it was found that the two treatments differed in terms of gonado-somatic ratio and condition factor. Treatment T1 is characterised by a relatively better value (RGS varying from 0.35 to 5.03 and K varying from 0.47 to 6.75) than treatment T0 (RGS varying from 0.34 to 3.91 and K varying from 0.20 to 3.26). The absolute fecundity of Oreochromis niloticus in the ponds with rice bran and those with periphyton varied respectively from 216-1504 and 279-1570. In contrast, the relative fecundity was 3.17-15.7 for the ponds with rice bran and 5.49-17.2 for the ponds with periphyton. These values correspond to total lengths of 11.6-18.1 Cm and 14.6-22.2 Cm, respectively. Oocyte diameter ranged from 0.95-2.00 mm, with an average of 1.63±0.05 mm, and from 0.89-2.15 mm, with an average of 1.59±0.05 mm, for females from ponds with rice bran and those with periphyton, respectively. At the end of this study, the results obtained showed that the females fed with periphyton showed a higher relative fecundity than those fed with rice bran. The data collected on the reproductive parameters indicate better reproductive performance in ponds fed with periphyton than in ponds fed with rice bran.

Keywords:
Reproduction; Oreochromis niloticus; Periphyton; Rice bran; Gemena

I. Introduction

Uncontrolled reproduction of Nile tilapia (Oreochromis niloticus) leads to the production of small fish populations with low commercial value. The reproductive age of tilapia varies according to environmental conditions (Lacroix, 2004). The first maturation size of tilapia varies between 14 and 20 cm, i.e. around 2 months of rearing. However, this size can vary within the same population due to fluctuating environmental conditions (qualitative and quantitative food shortages, etc.). They reproduce easily in enclosed waters, starting to spawn as early as 3 months old and repeating several times a year (Azaza et al., 2004). Under optimal conditions in lakes, O. niloticus begins to reproduce at around 2 to 3 years of age, whereas under stressful conditions in poorly managed rural fish farms, it can already reproduce at around 3 months of age. The fecundity of a female tilapia is relatively low and highly variable depending on its weight, the seasons and other environmental conditions. A 100 g female can lay 1200 eggs and a 700 g female around 3800 eggs (Moreau, 1979). The breeding season for this species is exponentially continuous throughout the year (7 to 8 clutches/year). Eggs are around 2 to 3 mm in size. The fry are protected by their mother and do not leave her until they are 10 mm long and able to search for food. If the water temperature is between 25°C and 28°C and the salinity is less than 15%, they can reproduce every 30 to 40 days. (Fanda, 2012).

In fish, the weight of eggs contained in the ovaries at maturity can reach 30% of body weight. The growth of the gonads, and especially the ovaries, takes place partly at the expense of body reserves mobilised under the action of oestradiol, but also directly from the nutrients available in the diet, the quality and quantity of which may have direct or indirect repercussions on the quantity and/or quality of the gametes. For example, the inhibition of gametogenesis following experimental fasting in cyprinids (de Vlamming, 1971) probably results in part from the suppression of gonadotropic secretion rhythms (Gillet et al., 1980).

In practice, certain approaches to nutritional requirements in relation to the quality of vitellogenesis have already been carried out, using the ovulation and fertilisation rate (Horvath, 1978b) or the hatching rate (Horvath, 1978b) as quality criteria. The feeding level of stocked O. niloticus broodstock is obviously influenced by various factors such as stocking density, the natural productivity of the pond and the type of feed used (Bryceson et al., 2005). A production of 29 fry/m2/day was obtained using an artificial feed with high protein content (35% crude protein) at a rate of 3% of the biomass/day. From a commercial point of view, however, a feed composed of 25% fishmeal and 75% rice bran appears to be of sufficient quality to ensure satisfactory fry production. However, this feeding is stopped as soon as primary productivity increases (Peterson et al., 2004).

In fish farming, feed represents the largest item of expenditure in the production cycle of marketable fish. The cost of feed is one of the major constraints on the emergence of fish farming in developing countries. (Bamba et al., 2008). In fact, the use of raw materials such as fishmeal is thought to be at the root of this cost, which aquaculturists consider to be high. Recent research has demonstrated another important source of natural food, periphyton. Immediate analysis has shown that periphyton contains 27.19% crude protein, 18% lipids and 52% carbohydrates. The protein, lipid, carbohydrate and ash contents of periphyton epilithic algae were 8-10, 2-5, 52-60 and 25-38% respectively (Rohitash et al., 2017). Rice bran, on the other hand, is a balanced protein material, rich in minerals (phosphorus), carbohydrates and vitamin B1 (Bocek, 2007).

The current trend is to replace fishmeal in whole or in part with inexpensive protein sources in order to reduce aquaculture's dependence on industrial fishery products and spare marine resources (Pouomogne, 1995; Médale and Kaushik, 2009). With this in mind, a great deal of work has been done to identify local protein sources that can replace fishmeal and fish oil (Akegbejo-Samson et al., 2008). Among these sources, plant proteins have been identified and used successfully in fish farming (Pouomogne, 1995; Azaza et al., 2006; Yougbaré, 2017). One of the constraints to making full use of these plant proteins is the presence of anti-nutritional factors (Medale & Kaushik, 2009).

In tropical areas, and particularly in sub-Saharan Africa, the chronic shortage of fish products for human consumption on local markets makes it difficult to use these products in animal production. Initiatives have therefore been taken to replace fishmeal, which is generally imported at very high prices, with local products. Periphyton can therefore be used in family fish farming to increase fish production in the Gemena town council in order to combat the food insecurity that is rife among households in the town. The objective of this study is to evaluate the reproductive performance of Oreochromis niloticus reared in ponds fed with periphyton and rice bran.

II. Research Method

2.1 Study Area

This study was carried out in the town hall of Gemena (Figure 1), in the province of Sud-Ubangi in the Democratic Republic of Congo. Its geographical location is :

a. Latitude : 4° 8' 37" North, 3° 33' 27" South;
b. longitude 18° 18' 0" East and 19° 15' 0" West.
c. It has a minimum elevation of 330 m and a maximum elevation of 644 m. It covers an area of 50 km2 and has a population of 1,050,748 (De Saint Moulin, 2005).latitude : 4° 8' 37" Nord, 3° 33' 27" Sud;.

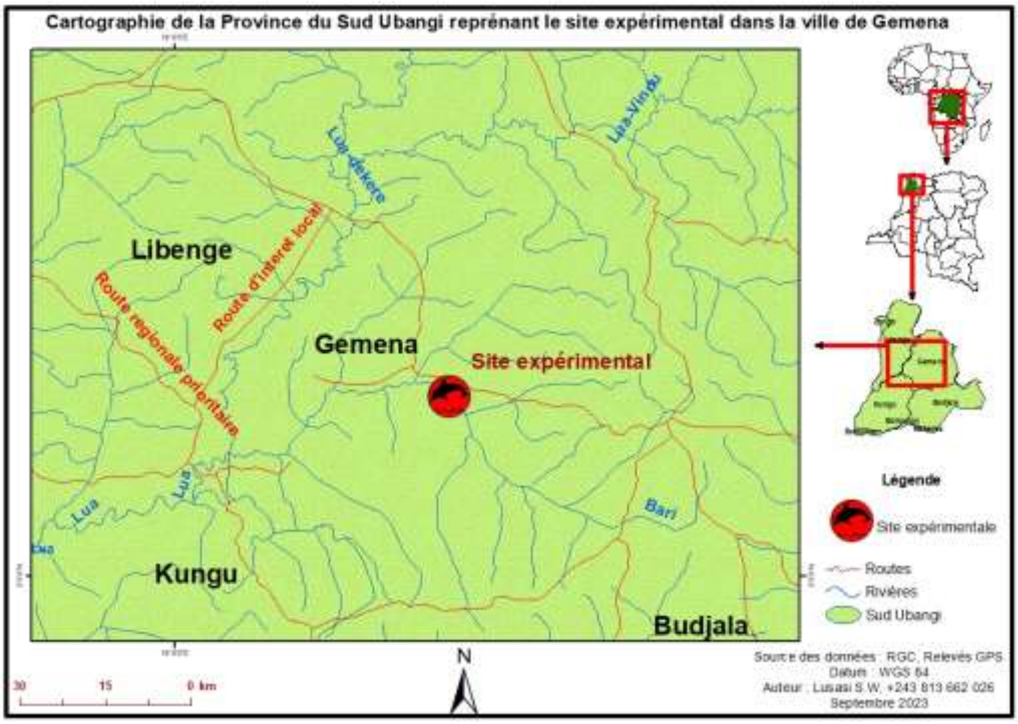

Figure 1. Map of South Ubangi province showing the experimental site in the town of Gemena.

2.2 Material

Fry of the species *Oreochromis niloticus* Linneaus, 1758 with an initial average weight of 10 g and an average size of 5 cm were used as biological material for the investigations. The other non-biological material used consisted of :

a. A plastic barrel to store the fish after harvesting;
b. A precision scale weighing up to 5000 grams;
c. A digital camera for taking photographs;

d. Two fish collection nets;
e. ACM Baxtram scale for weighing fish and stomach contents;
f. A lath graduated to the nearest millimetre for measuring the fish.

2.3 Methods

As part of the study, we used the experimental method, which involved sampling the physico-chemical parameters of the pond water and the reproduction parameters of the farmed fish.

a. Experimental System

We used the randomised complete block design (Figure 2). There were only two treatments (To: treatment without periphyton and T1: treatment with periphyton) with six replicates. The ponds were built as diversions alongside the Mai ya mpoto stream. Each pond covered an area of one hectare and was one metre deep. We had twelve ponds arranged in six blocks of two ponds per block. Bamboo stems were planted vertically in six of the twelve ponds, over the entire surface area of the pond, at a rate of 9 stems/m2, to facilitate the development of periphyton, and in the other six ponds there was no planting at all.

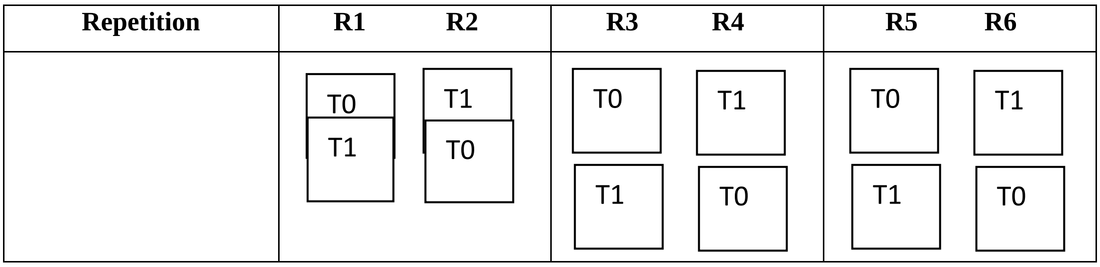

Figure 2 . Experimental system used in the experiment.

Legend :
a. To: Treatment without periphyton (traditional system) ;
b. T1 : Treatment with periphyton (new technology) ;
c. R1: first repetition;
d. R2: second repeat;
e. R3: third repeat;
f. R4: fourth repeat;
g. R5: fifth repeat;
h. R6: sixth repetition.

b. Fry Loading and Feeding

The ponds were stocked one month after impoundment to allow the periphyton to colonise the bamboo stems (Figure 3). A total of 2400 fry (200 fry per pond) were placed in twelve ponds.

With regard to the feeding of the fry experimented with primary production (natural food), periphyton was the basic food for the fish in six ponds where the bamboo stems were placed, and in the other six ponds where no bamboo stems were placed, the fish were fed rice bran twice a day between 9 am and 3 pm. The quantity of feed distributed to the fish in this second batch was equivalent to 10% of the total fish biomass (Lusasi *et al.*, 2019). The experiment lasted six months, from 10 April to 10 October 2022.

c. Weighing and Measuring the Fish

Fry were weighed and measured to estimate the weight and linear growth of the fish tested in this study. The weight and size of the fish were assessed in two stages : at the beginning and at the end of the experiment. The weight, expressed in grams, was taken to the nearest gram (0.1 g) using an ACM Baxtram precision electronic balance. The number of fry was counted at the end of the experiment to estimate mortality

Figure 3. Experimental set-up (A) ; Bamboos fixed in the pond (B) ; Data collection (C) ; Loading the pond (D) ; Fish collection (E) ; *Oreochromis niloticus* Linneaus, 1758 (F).

2.4 Fish Reproductive Parameters

After six months of rearing, the ponds were completely emptied in order to harvest all the fish. A sample of 240 fish from the 12 ponds was taken to determine the reproductive parameters. These fish were then weighed before dissection and gonad sampling. The gonads were weighed and only those containing mature oocytes ready for spawning were preserved in 5% formalin for later analysis.

Analysis of reproductive parameters, including gonado-somatic ratio (GSR), condition factor (K), fecundity and oocyte size, was then carried out on female individuals only. We selected a sample of 40 fish, 20 from ponds with periphyton and 20 from ponds without periphyton.

2.5 Determining the Gonado-Somatic Ratio and the Condition Factor

The gonado-somatic ratio (GSR) is a measure that describes the difference in fish maturity by expressing gonad weight as a percentage of body weight. Normally the RGS value increases as gonad development approaches maturity; the value begins to decrease as the fish begins to spawn (Shoko *et al.*, 2005). The RGS was calculated using the formula (De vlamming *et al.*, 1982): $(PGO \times 100)/Pt$ where PGO = gonad weight (in grams); Pt= total body weight (grams).

The condition factor (K) is used to compare the 'fatness' and well-being of a fish and, according to Bagenal, 1978, heavier fish at a given length are in better condition. The condition factor was calculated as follows (Paully, 1993) : K= (P×100)/L , where P and L are respectively the individual weight of the fish (grams) and the total length (in centimetres).

2.6 Determining Fertility and Oocyte Diameter

Fecundity is estimated from gonads in the final stages of maturity by counting the oocytes with the largest diameter (Duponchelle *et al.*, 1998). Absolute fecundity is the total number of oocytes mature before the next oviposition period. Relative fecundity is the total number of mature oocytes per gram of female body weight (Bagenal, 1978).

To obtain representative samples of the entire gonad, small portions were taken from the posterior, medial and anterior regions of two lobes of the ovary. These samples were weighed and the mature oocytes counted. The total number of mature oocytes in the ovary was estimated by multiplying the number of mature oocytes in the sample by the ratio of the weight of the ovary to the average weight calculated on the samples (Hunter *et al.*, 1992 ; Shalloof & Salama, 2008).

Le diamètre ovocytaire a été estimé à partir des mensurations faites sur 30 ovocytes pris au hasard sur les gonades d'une femelle au stade de maturation $5/5^{+}$. Le diamètre ovocytaire a été déterminé en calculant la moyenne arithmétique des mensurations relevées sur le grand diamètre de l'ensemble des ovocytes mesurés (Legendre & Ecoutin, 1996).

III. Result and Discussion

3.1 Fish Breeding Parameters

a. Gonadal-Somatic Ratio and Condition Factor

Results for the gonado-somatic ratio and the condition factor are presented in Table 1.

Table 1. Gonado-somatic ratio (GSR) and condition factor (K) of females in the two treatments.

	T0		T1		
Parameters	Min-Max	Average	Min-Max	Average	P
RGS	0.34-3.91	2.5±0.8	0.35-5.03	3±0.11	0.005
K	0.20-3.26	1.60±0.01	0.47-6.75	1.70±0.02	<0.001

The results in Table 1 show that the gonado-somatic ratio ranged from 0.34 to 3.91%, with an average of 2.50±0.08 in treatment T0, and from 0.35-5.03%, with an average of 3±0.11 in treatment T1. A difference in RGS was observed between females in the two treatments (p=0.005), with treatment T1 having a higher mean RGS than treatment T0. The same trend was observed for the condition factor.

b. Fertility and Egg Diameter

Fertility and oocyte diameter were analysed for each of the two treatments for females at sexual maturity stages 5 and 5+. Fertility and oocyte diameter data are presented in Table 2.

Table 2. Fertility and oocyte diameter of females reared in ponds without periphyton and ponds with periphyton.

Parameters	Ponds without periphyton		Ponds with periphyton		
	Min-Max	Averrage	Min-Max	Averrage	P
Absolute fecundity	216-1504	508±31.9	279-1570	675±39.8	<0.001
Relative fecundity	3.17-15.7	7.70±0.38	5.49-17.2	12.2±0.33	<0.001
Ovocyte diameter (mm)	0.95-2.00	1.63±0.05	0.89-2.15	1.59±0.05	<0.001
Total lenght (Cm)	11.6-15.1	14.0±0.14	14.6-22.2	25.0±0.13	<0.001

The data in Table 2 show that the absolute fecundity of Oreochromis niloticus in ponds without periphyton and those with periphyton varies from 216-1504 and 279-1570 respectively. In contrast, the relative fecundity is 3.17-15.7 for ponds without periphyton and 5.49-17.2 for ponds with periphyton. These values correspond to total lengths of 11.6-15.1 Cm and 14.6-22.2 Cm, respectively. Oocyte diameter ranged from 0.95-2.00 mm, with an average of 1.63±0.05 mm, and from 0.89-2.15 mm, with an average of 1.59±0.05 mm, for females from ponds without periphyton and those with periphyton, respectively. For these observed parameters (Table 2), the trend is such that fish reared in ponds with periphyton perform better than those reared in ponds with rice bran.

3.2 Discussion

The data collected on reproductive parameters indicate reproductive success in ponds with periphyton compared with ponds with rice bran. This is consistent with previous observations (Duponchelle et al., 1998) that reproductive traits in O. niloticus are influenced in particular by differences between strains, including the origin and history of their domestication (Mair et al., 2004; Osure & Phelps, 2006).

RGS is an important aspect of fish reproductive biology, and a good understanding of it improves the interpretation of fish population reproduction models (Mahboob & Sheri, 2005). In fish, RGS is an indicator of the state of reproductive activity, and is correlated with gonad development following the mobilisation of energy for sperm and egg reproduction (Duponchelle et al., 1998). The RGS results obtained show that the maximum values are 3.91% and 5.03%, respectively in females reared in ponds with rice bran and those with periphyton. These values are close to the maxima of 3.6% to 4.8% reported by Babiker & Ibrahim (1979), and Srisakultiev & Wee (1988). On the other hand, they are close to those of 6-7% recorded by Melard (1986). Macintosh et al, (1988), and Shoko et al. (2005) for females of the same species under fish farming conditions.

The assessment of fecundity is one of the fundamental requirements for the study of fish population biology and dynamics (Shallof & Salama, 2008 ; Kingdom & Allison, 2011). The number of eggs produced by fish at any given time is a key biological trait that attracts much attention when considering fish populations for aquaculture. Proliferation of juveniles with consequent competition for vital resources can occur in rearing structures if broodstock frequently lay a large number of eggs associated with a high hatching success rate and negligible predation (Arizi et al., 2014). Some authors have observed marked differences in fecundity between species, which often reflect different reproductive strategies (Murua & Saborido-Rey, 2003). Esmaeili et al. (2009) attributed these differences to the effects of age, egg size and genetic factors.

Relative fecundity was 3.17-15.7 for ponds with rice bran and 5.49-17.2 for ponds with periphyton. These values correspond to total lengths of 11.6-15.1 Cm and 14.6-22.2 Cm, respectively. This result (difference between feeds) is in agreement with the observations of previous studies indicating on the one hand that egg production in O. niloticus is mainly related to the strain of the female (Smitherman et al., 1988) and on the other hand that fecundity is apparently influenced by genetic factors, as well as by environmental conditions, in particular those influencing the nutritional status of the fish (Tshadik & Bart, 2007). Witthames et al. (1995) add that within a given species, fecundity can vary according to differences in adaptation to specific environments (reflecting the difference in reproductive strategy mentioned above).

As previously mentioned, the Nile Tilapia O. niloticus is characterised by early and excessive reproduction, resulting in the production of numerous small individuals. The results of the present study showed that this less economically interesting behaviour is more evident in ponds with periphyton. Bolivar et al. (1993) recommend including both a faster growth rate and a delayed maturation age as the most important rearing objectives for Nile Tilapia.

IV. Conclusion

The overall aim of this study was to evaluate the reproductive performance of Oreochromis niloticus reared in ponds fed with periphyton and rice bran. The results of this research showed that females fed with periphyton showed a higher relative fecundity than those fed with rice bran. The data collected on the reproductive parameters indicate better reproductive performance in the ponds fed with periphyton than in the ponds fed with rice bran. In view of the results of our investigations, we suggest that detailed identification studies be carried out on the different taxonomic groups of species that make up periphyton, in order to gain a clearer understanding of this natural food source, which constitutes a palliative solution to fish feeding in the Gemena city.

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