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Effects of frequency of feeding on feed intake, growth and survival of Nile Tilapia, *Oreochromis niloticus* reared in hapas implanted in pond in Togo

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Abstract
A test was conducted to determine the effect of feeding frequency on feed intake, growth and survival of tilapia *Oreochromis niloticus*, reared in hapas implanted in pond. Twelve hapas of $1m^3$ were installed in a 150 m² pond in three lines representing the three repetitions of the four treatments which are the feeding frequencies. *Oreochromis niloticus* tilapia fingerlings with an average initial weight 4.12 ± 0.33 g, were stocked at a density of 50 fish per hapa. They are fed with a standard food (Raanan, 32% crud protein) at different frequencies (F): 1; 2; 3 or 4 meals per day and at the rates of 8 to 3% of the biomass from the first to the sixth month of the trial. After 6 months of experiment the survival rate varied from 92 ± 0.0% (F4) to 78.7 ± 13.3% (F1). Growth was effective in all lots with final mean weights varying from 181.6 ± 3.3 g (F4) to 124.3 ± 1.8 g (F1). It took 2.6 ± 0.1 (F1) to 2.1 ± 0.0 (F3) kilogram of feed to produce 1 kg of fish; the latter (F1; F3) having respectively gained daily 0.71 to 1.05 g per day. Economic analyzes by comparing the products obtained with the charges involved show a profit margin of -4,992.2 F CFA (F1); 490.0 F CFA (F2); 3,718.0 F CFA (F3); -268.9 F CFA (F4). Three feedings per day (F3) appear to be the best frequency for this feeding, however two feedings can allow the farmer to go about other activities.

Keywords: frequency of feeding; zootechnical performance; *Oreochromis niloticus*; hapas

1. Introduction
The development of aquaculture in the West African sub-region is mainly based on certain species such as tilapia (*Oreochromis niloticus*), carp (*Cyprinus carpio*) and catfish (*Clarias gariepinus* and *Heterobranchus longifilis*) [1]. Among these cultivated species, the tilapia *Oreochromis niloticus* is a very hardy fish that is resistant to disease, pollution and poor water quality. All these attributes make this species an excellent candidate for fish farming [2]. In breeding, this species is omnivorous, valuing animal husbandry waste and accepts commercial feed. Despite all these potentialities, aquaculture production of this species is struggling to develop in Togo because of certain constraints such as the lack of efficient fry, quality feed and technical expertise in the management of farming, in particular the frequency of food distribution [3]. In fish farming, the survival and growth of fry can be influenced by various parameters including water quality [4], stocking density[5], and especially feeding frequency [6]. The influence of this last parameter on growth in *Oreochromis niloticus* allows us to say that it plays a determining role in the improvement of zootechnical performance [7]. The use of appropriate feeding technique is necessary in order to maximize the efficiency of feed conversion and growth [8] and reduce the cost of production[9] because in aquaculture feed represents more than 50% of the cost of production[10]. It is with this in mind that this study is initiated to assess the growth performance of tilapia at different feeding frequencies.

2. Materials and Methods
2.1 Experimental procedure
This study was carried out from January to July 2018 at the Donomade Model Farm (FeMoDo); located in the Maritime region 31 km northeast of the city of Tabligbo in Togo. Six hundred (600) fingerlings monosex male tilapia *Oreochromis niloticus* (4.12 ± 0.33 g) stocked in hapas two weeks before experiment start to acclimatize them to new conditions,

were used. They were then randomly distributed into 12 hapas of $1m^3$ fixed in a 150 m^2 pond and 50 fish per hapa, forming four treatments with three replicate. The tested treatments are the feeding frequencies (F). The daily ration to be distributed was divided into 1; 2; 3 or 4 meals based on a commercial food (Raanan) dosing 32% protein per day. A serving spoon allowed the ration to be served. Thus, for all treatments, the daily ration varied from 8 to 3% during the test period. Control fisheries were made every two weeks in order to record the biomass and the number of live fish and readjust the ration according to the average weights obtained. Three times a week, at 08:00, before feeding, temperature (27.5 4 ± 1.86 °C) and dissolved oxygen (4.35 ± 1.39 mg / L) were measured with oxymeter coupled with a thermal probe (VWR - DO210) and pH (7.05 ± 0.35) was measured with a pH meter (APERA PH20). Small additions of water to supplement the losses by infiltration and by evaporation have been made in order to allow the fish to live in optimal farming conditions.

2.2 Production parameters calculated
Parameters shown in Table 1 were calculated to assess experimental feeding frequencies effect during the test.

Table 1: Formulas used in the evaluation of livestock production parameters

Production parameters	Formulas
(DWG) : Daily Growth Rate (g/d)	DGR = (Wf – Wi)/ test duration (days)
(FCR) : Food Conversion Ratio	FCR = Q / [(Bf + Bd) – Bi]
(K) : Condition factor	K = 100 x [Weight /(Standard length)^3]
Survival (%)	Survival = 100 x (Nf / Ni)

Nf, Ni: Final fish number, Initial fish number; Q: cumulative quantity of food distributed (g);
Bi, Bd and Bf: initial, dead and final biomass (g); Wi, Wf: initial and final weight (g)

Some economic parameters shown in Table 2 were calculated to evaluate experimental feeding frequencies effect during the test.

Table 2: Formulas used in the economic evaluation of feeding frequencies effect

Paramètres	Formules
Food cost of producing one kilogram of fish (CP)	$CP = \text{One kg feed cost} \times FCR$
Labor cost (LC)	$LC = (Fc \times Nf \times Nd) + Nc \times Cc$
Gross profit margin (GPM)	$GPM = \text{Incomes} - \text{Expenses}$

Fc: feeding cost; Nf: number of feeding / day; Nd: number of feeding days during the test, Nc: number of control fishing during the test and Cc: control fishing cost

2.3 Statistical analyzes
Data were analyzed by one-way analysis of variance (ANOVA I). The LSD Fisher test or test for least significant difference allowed homogeneous groups means discrimination.

Differences were considered significant at 5% level. Statistical analyses were performed using STATISTICA 5.1 program (Stat Soft, Inc.).

3. Results and discussion
3.1 Results
The growth response of *O. niloticus* fingerlings to experimental frequencies is shown in Table 3. Palatability and acceptability of diets were similar for all treatments with no observed rejection. For the total duration of the trial, the survival rates varied from 78.7 ± 6.7%, respectively, to 92 ± 0.0% for treatments F1 and F4 with a significant difference between the mean values of F1 and other treatments (P <0.05).

Table 3: Effects of feeding frequencies on *O. niloticus* survival, daily growth rate (DGR), food conversion ratio (FCR) and condition factor (K) after 168 days of rearing in hapas

Feeding frequencies	S (%)	TCJ (g/j)	TCA	K
F1	78,7 ± 6,7b	0,71 ± 0,05c	2,6 ± 0,2a	2,9 ± 0,3
F2	89,3 ± 4,2a	0,81 ± 0,03b	2,3 ± 0,2b	2,9 ± 0,5
F3	89,3 ± 3,3a	1,00 ± 0,04a	2,1 ± 0,1c	2,7 ± 0,2
F4	92,0 ± 0,0a	1,05 ± 0,08a	2,2 ± 0,3b	2,5 ± 0,2

F1; F2; F3; F4 respectively 1; 2; 3; 4 meals a day.
Mean in a row with different superscripts significantly differ (p<0.05).

The change in the average weight of the different treatments during the test is shown in Figure 1. Note that the average weight kept an upward trend from the start to the end of the experiment. From D0 to D42, the growth of all the treatments was similar. But from D42, the growth of treatments F3 and F4 as well as that of treatments F1 and F2 showed two similar growth trends. However, the final average weights of treatments F3 and F4 were higher than for others (P <0.05).

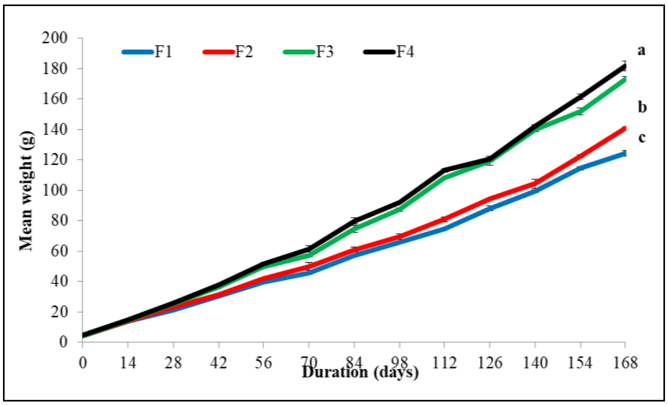

Fig 1: Mean growth of *O. niloticus* fingerlings submit to different feeding frequencies F1; F2; F3; F4 respectively 1; 2; 3; 4 meals a day. The letters a, b and c show that the results are significantly different according to feeding frequency.

The values of the average daily gain of the fish at the end of the test vary between 0.71 and 1.05 g / d respectively for treatments F1 and F4. These values are similar for treatments F3 and F4 (*P*>0.05) but high compared to those of the other treatments (*P*<0.05).

Treatments F1 and F2 have condition factor values that are similar ($P>0.05$) but high compared to other lots ($P<0.05$). However, treatment F4 presents the best overweight.
The feed conversion rate values are low for treatment F3 and high for treatments F1 ($P<0.05$). The values of the F2 and F4 treatments are similar ($P>0.05$). We note that the fish of the different treatments consumed more than 2 kg of feed to produce one kg of fish with better food processing in the fish of treatment F3.

The farm balance sheet traditionally consists of drawing up an operating account showing the total costs and income of the various treatments (Table 4). From our results, treatment F4 has the best production values. It represents 30.06% of total production against 18.03%; 23.08% and 28.3% respectively for the treatments F1, F2 and F3. However, it demands heavy charges to achieve these results. In addition, only treatments F2 and F3 gave positive gross profit margins.

Table 4: Evaluation of the gross profit margin

Parameters		F1	F2	F3	F4
Biomass produced (kg)		14,8	18,9	23,2	25,1
Production value (F CFA)		32 469,4	41 566,5	50 952,3	55 121,6
Total incomes		3 2469,4	4 1566,5	5 0952,3	5 5121,6
Quantity of food distributed (kg)		43,4	45,1	50,3	58,1
Food cost (F CFA)		32 121,5	33 396,5	37 214,3	43 030,5
Labor	Feeding		2 340	4 680	7 020
	Control fishing	3 000	3 000	3 000	3 000
Total expenses		37 461,5	41 076,5	47 234,3	55 390,5
Gross profit margin (F CFA)		-4992,2	490	3718	-268,9

F1; F2; F3; F4 respectively 1; 2; 3; 4 meals a day.

4. Discussion

For the total duration of the trial, the average survival rates obtained are more or less comparable to the results obtained by [11] in ponds (75% to 94%). The mortalities observed in lot fed one a day are linked to a low ingestion capacity of the food which is served to them once a day. In addition to this low ingestion capacity, there is an aggressiveness between the fish due to the heterogeneity of the size leading to the death of the smallest. Indeed, according to [12], the frequency of feeding leads to heterogeneity of farmed fish. Mortalities observed in general in all the batches combined are most often linked to handling stress and sometimes after periods of heavy rains. There was no repellency in the feed since the fish ate the rations given with apparent greed.
The growth of Nile tilapia *Oreochromis niloticus* fry was influenced by the frequency of feeding. The best growth parameters during the trial were observed at the frequencies of 3 and 4 meals per day, respectively. This suggests that the continuous ingestion of small amounts of feed throughout the day has a favorable effect on growth in fry of Nile tilapia *O. niloticus*. Thus, the fraction of feed fed to the growing fry should be kept to a minimum. This minimum level corresponds to 3 meals per day for better growth results.
Similar results have been reported by [13, 14] who tested the effect of different feeding frequencies on Nile tilapia fry *O. niloticus*, with an initial mean weight of 1 g. These authors concluded that Nile tilapia fry need a frequency of 3 or 4 meals per day to obtain the best zootechnical performance. In fact, for the latter, feeding more than 4 meals per day would exceed the satiety level of the fry of this species, which would result in loss of feed.
In the present study, the amount of food per day was the same for the different treatments, only the number of meals per day differed. However, in this study an improvement in growth performance and feed conversion rate related to increasing the frequency of feeding to an optimum level where growth becomes stable was observed. In addition, the results of the present study demonstrate that the frequency of feeding is a function of the developmental stage of the fish, the species, the proteins and the energy content of the feed, as pointed out by [15]. The feed conversion rate (TCA) values recorded in this study varied with feeding frequencies, with values below 3.5. Indeed, according to [16], a TCA greater than 3.5 is considered bad. The values obtained in this study reflect the good quality of the food distributed. This TCA drift during the test, especially in lot F1 (2.6), is believed to be due to food loss by dispersion through the mesh of the hapas. In fact, when feeding hapas, the excess passes through the mesh of the net and is no longer recoverable. The values of the average daily gains obtained are comparable to those (0.6 to 1.2g / d) of [17]. In this study, the low nutrient quotient values are related to the feeding frequencies which gave the best growth performance. Thus, the results of the present study show that the frequency of three (3) meals per day gives the strongest growth and the weakest TCA during the test. These results are consistent with those of[7] who observed a positive relationship between growth and feeding frequency.
The economic analysis of the zootechnical results obtained at the end of the trial reveals that the production cost per kilogram of fish decreases as the frequency of feeding increases. But conversely, production costs increase as fractionation increases. The use of proper feeding technique is necessary in order to derive economic benefit on the one hand and to maximize feed conversion efficiency and growth on the other[8]. An optimal feeding frequency not only promotes better zootechnical performance but also allows a reduction in production costs[9]. The expenses of F1 and F4 are not covered by their products. However, it is necessary to produce under these conditions 17.05 kg to cover the loads of batch F1. The costs of lots F2 and F3 are covered by their products and lot F3 is more profitable followed by lot F2.

5. Conclusion

At the end of this study, it should be remembered that the frequency of feeding has an effect on the growth parameters in fry of *O. niloticus*. The best production results were obtained in fry fed three (3) and four (4) times per day. However, the frequency of feeding three (3) daily meals seems optimal although a frequency of two (2) meals per day is also interesting from an economic point of view for the culture of Nile tilapia in hapas implanted in an earthen pond. Thus, the farmer engaged in fish farming could adopt a judicious frequency according to his activities.

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