# Effect of Feeding Frequency on the Growth of Tilapia (*Oreochromis niloticus*) in Earthen Ponds

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Keywords: Feeding frequency- Nile tilapia- *Oreochromis niloticus*


## Summary

*Duplicate groups of Nile tilapia fingerlings (30.9 g) were fed at three different frequencies, i.e. 2, 3 and 6 meals a day, in six 400 m² earthen ponds. Fish stocked at 22.4 g/m² (about 60 ind. /are) was thus fed an experimental diet containing 25% protein from vegetal origin. The feed was daily distributed, by hand, at equal time intervals between 8 a.m. and 3 p.m. After fifteen weeks trials, significantly (p< 0.05) best growth was obtained in the 6 times a day treatment (daily growth rate 1.3 g/day, as compared to 0.9 g/day for each of the two other treatments). It could be noticed that increase in the feeding frequency was associated with increase in growth rate and decrease in FGR (from 1.6 to 1.3). In term of fish production, there was an estimated extra tilapia production of 8.7 kg/are/year with the 6 times a day frequency, comparatively to the two other treatments. In an environment where labour is not actually limiting, the study suggests that Nile tilapia in production ponds should be fed six times a day.*

## Résumé

**Influence de la fréquence de rationnement sur la croissance du tilapia (*Oreochromis niloticus*) en étang**

*Six lots de juvéniles du tilapia* Oreochromis niloticus *(39 g de poids moyen initial) ont été soumis, en duplicats stochastiques, à 3 fréquences d'alimentation quotidienne : 2 repas, 3 repas et 6 repas par jour. Les poissons étaient stockés dans des étangs de terre de 400 m², à une biomasse de 22,4 g/m² (soit environ 60 individus/are). L'aliment composé contenait 25% de protéines de sources exclusivement végétales. La distribution était réalisée tous les jours à la main, à intervalles de temps égaux entre 8 heures et 15 heures. Après 15 semaines d'élevage, les poissons recevant six repas par jour grandissaient significativement plus vite (p< 0,05). L'augmentation de la fréquence journalière d'alimentation s'est en général traduite non seulement par une croissance plus élevée des poissons (gain individuel journalier variant de 0,9 à 1,3 g/jour), mais aussi par une amélioration du taux de conversion de l'aliment (de 1,8 à 1,3). En nourrissant les tilapias six fois par jour plutôt que deux ou trois fois, un supplément de productivité piscicole estimé à 8,7 kg/are/an a pu être enregistré. En conséquence, dans une situation de main-d'œuvre compétitive par rapport au prix de vente ultérieur du poisson produit, l'étude recommande de nourrir le tilapia en étang de production au moins six fois par jour.*


## Introduction

An important portion of the total production cost in tilapia farming in the tropics is constituted by supplemental feeding (9). Many studies have therefore been conducted on the use of alternate and local available by-products in fish feed (20), as on the effect of feeding level on fish growth (5, 16). Practical formulas and feeding charts derived from these studies were adopted and are broadly utilized today by tilapia farmers (24). Yet, how many time to distribute the daily regime, precisely to warm-water species where need of reliable practical data for improving the profitability of farm is higher, still remains insufficiently studied. In salmonids, the physiology of the digestive track only authorizes slow metabolism, so that increasing the number of meals above two times a day does not result in higher fish growth (7, 8, 14, 25, 27). On the other hand, herbivorous fish species with relatively small stomach and long intestine such as tilapias have this tendency in the wild to feed more or less continuously during the day (18). In addition, the optimum feeding frequency may depend on fish size and water temperature (4). Many scientists have investigated on feeding frequency in tilapias. Macintosh and De Silva (15) recommend feeding tilapia fry at least 8 times, and adults 4 times a day. Melard (17) suggests 9 times a day for the Nile tilapia, *Oreochromis niloticus*, of 80 to 100 g size and 6 times for 240 to 300 g size. Rel-

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Received on 05. 11. 99 and accepted for publication on 18. 04. 00

atively to water temperature, young tilapia (< 100 g) shall be fed 4 or more times a day at 24°C, and one time only at 16°C (13). Definitely, in normal temperature conditions, tilapia should be fed frequent small meals, as stipulated by Jauncey and Ross (10). This may either need automatic feeders, which use is difficult to impliment in most developing countries, or may be of very high labor cost, which therefore requires better optimisation. In addition, many of the above reported data are derived from experiments conducted in intensive rearing infrastructures such as aquaria and raceways. The present investigation was carried out at the Foumban Fishculture Research Station (Cameroon) to supply more *in situ* information on the feeding frequency of Nile tilapia reared in an earthen pond environment.

## Material and methods

### Ponds

Six earthen ponds were used in the study (size: 360 to 410 m$^2$, mean depth: 0.8 m near the outlet and 1.4 m near the drain pipe). They were individually supplied by gravity from the surface water of an upstream reservoir. Pond bottoms were exposed to sun for five weeks; cleaning and quicklime application (125 kg/ha) were performed to eradicate parasites. Ponds were then refilled, with water passing through sieves attached to the inlet pipes to prevent the entrance of wild fish.

### Fish

The fish used in this study was obtained from the spawning of *Oreochromis niloticus* broodstock available at the station. At the beginning of the experiment, six ponds were stocked with hand-sexed all-male juveniles averaging 39.3 ± 1.1 g, at a density of 0.57 fish/m$^2$. This low biomass is based on past experiments in similar nutritional conditions, expecting a relatively satisfactory average final sizes of fish (21, 23). Sexing was performed by visual appreciation of the urogenital opening of each fish (2, 13).

### Diet and experimental procedures

The experimental diet contained 27.5% crude protein (N* 6.25, AOAC, 1975), all from vegetal origin (Table 1). The formulation of this diet has taken into account the nutritional requirements of tilapias (20), while exploiting relatively cheap agro-industrial by-products available in Cameroon (23), and the natural productivity of the experimental ponds used in the study as quantified by Pouomogne (21). Dried ingredients were ground, mixed and sacked (50 kg bags) by a local feed manufacturer (Société des Provenderies du Cameroun, Bafoussam).

The experimental diet was randomly assigned to duplicate sets of ponds according to the following feeding frequencies: (i) 2 meals a day, respectively at 8 a. m. and at 2.30 p. m. (treatment T1); (ii) 3 meals a day, at 8.15 a. m., 11.30 a. m., and 2.45 p. m. (treatment T2); (iii) 6 meals a day, at 8.30 a. m., 9.45 a. m., 11 a. m., 0.15 p. m., 2.00 p. m. and 3 p. m. (treatment T3). Daily amount of feed was modified from Marek's feeding table (16). A prior study under environmental conditions similar to the one of this trial showed this amount was close to optimum (22). The corresponding ration for each pond was subsequently divided into equal meals according to the experimental frequency. Each meal was distributed by hand, inside a floating wooden-made frame fitted in the ponds. The trial lasted for 109 days, sampling being done at 3-week intervals and the amount of diet fed was adjusted accordingly. At the end of the trial, all fish were counted and weighed. In addition, individual weights and total lengths were reordered for a sample of 60 fish per pond.

**Table 1**
**Composition of the experimental diet (% of dry matter)**

| Ingredients | % |
|---|---|
| Rice bran | 3 |
| Cotton oilcake | 18 |
| Soybean meal | 1 |
| Brewery draff | 16 |
| Peanut oilcake | 15 |
| Palm kernel meal | 1 |
| Vitamin and mineral premix (1) | 2 |
| Lysine | 0.5 |
| Limestone ($CaCo_3$) | 0.5 |
| Total | 100 |
| Proximate analyses (Dry matter basis) | |
| Crude protein (%) | 27.5 |
| Crude fat (%) | 12.8 |
| Ash (%) | 13.6 |
| Gross energy (kJ/g) | 18.1 |

(1) Provided by a local animal feed manufacturer and said to contain per kilogram: 27 g calcium, 10 g phosphorus, 6 g iron, 3.5 g zinc, 2.4 g manganese, 600 mg cooper, 20 mg iodine, 26 mg cobalt, 4 mg selenium, 45000 IU vitamin A, 14000 IU vitamin D, 90 mg vitamin E, 18 mg vitamin K, 16 mg vitamin B12, 113 mg pentothenic acid, 27 mg riboflavin.

### Water sampling; chemical analysis

Water quality parameters were recorded regularly (Hach test kit model FF-2). Temperature in particular was daily monitored between 1 to 2 p. m. at 20 cm deep. At the start of the trial, these parameters were as follows: temperature 26.5°C; pH 6.8; dissolved oxygen 5 mg/l; total hardness less than 20 mg $CaCO_3$/l. Moisture (24 h oven, 105°C), crude protein (Kjeldahl method), crude fat (ether extracted), ash level (24 h furnace, 550°C) and gross energy content (adiabatic bomb calorimeter, gallenkamp CB 100) of the experimental diet were determined according to AOAC standard methods (1).

### Calculations and statistical analysis

Growth and feed utilization parameters were computed. Datas were subjected to Analysis of Variance, and Duncan's Multi-Range Test was used to evaluate specific differences between the treatments means, after verification of the normal distribution of individual sizes within each group of fish (26). The calculations were performed using the SAS statistical package.

## Results and discussion

### Water quality

Recorded temperatures varied from 26 to 28°C, dissolved oxygen from 3 to 8 mg/l, and pH from 6.0 to 6.9; no significant correlation was observed with the applied

treatments. Referring to the data reported by Balarin and Hatton (2), water temperature and dissolved oxygen remained within the optimum gaps for tilapias, while pH were sub-optimal.

### Growth

Fish fed 6 meals a day grew significantly ($p< 0.05$) more than those receiving 2 or 3 meals a day for the whole duration of the experiment (Figure 1).

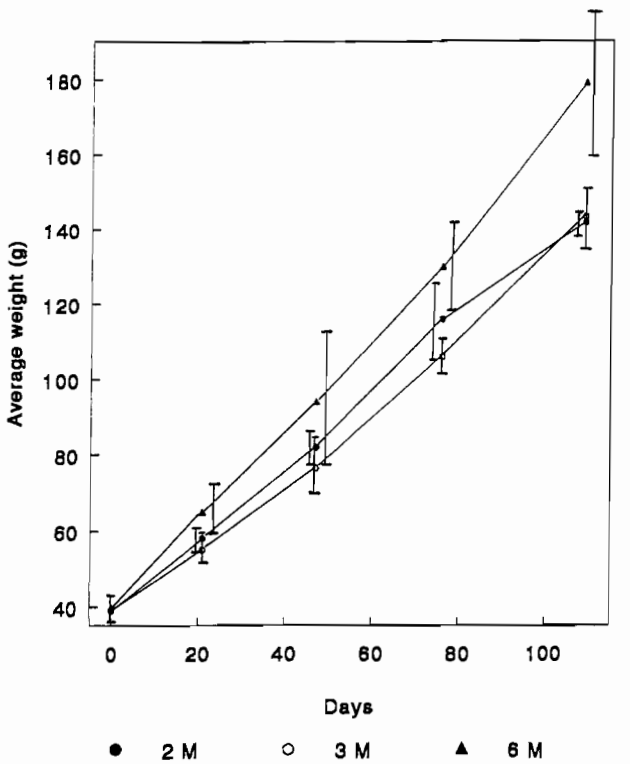


Figure 1: Growth of *Oreochromis niloticus* fed at different feeding frequencies. (2M, 3M and 6M equal to 2, 3 and 6 meals a day, respectively).

Average final body weight, daily growth rate and daily growth coefficient (6) of fish fed the 6 times per day treatment were significantly higher ($p< 0.05$) than those receiving 2 and 3 meals. These parameters varied from 142 g to 179 g, 0.9 to 1.3 g/day, and 1.7 to 2.0 %/day for 2 meals and 6 meals, respectively (Table 2).

Increasing the frequency of feeding tilapia in ponds thus generates significantly better fish growth. Similar observations were reported by earlier scientists in aquaria and raceways [15, 17, 28, and 12 cited by NRC (20)].

### Feed consumption and feed conversion efficiency

Fish fed actively for the whole duration of the experiment. The average consumption was 15.8 g dry matter feed/kg of body weight/day (g DM/kg BW/day), with no significant difference ($p> 0.05$) between the treatments (Table 2). Feed gain rates varied significantly ($p< 0.05$) from 1.3 (6 meals a day) to 1.6 (2 meals a day) and protein efficiency ratios from 2.3 (2 meals) to 2.8 (6 meals). It is interesting to note that the amount of feed consumed by the fish does not significantly change whether the number of meals per day is two or six. On the other hand, the inverse relation between the frequency of feeding and the feed gain rate confirms many previous works on the subject (3, 11, 28). An evaluation of nutrients retention efficiencies could not, unfortunately, be performed in our experiment. However, the study conducted by Tung and Shiau (28) may help us to better understand our own results. While feeding hybrid tilapia fingerlings (7 g) 6 meals a day rather than 2 meals, these authors registered a higher activity of phosphofructokinase (PFK) and 6- phosphogluconate deshydrogenase (6PGD), and an improvement in the nutrients retention.

**Table 2**
**Growth performance and feed utilization parameters for male *Oreochromis niloticus* fed the 3 experimental feeding frequencies for 109 days**

| | Treatments | | | |
|---|---|---|---|---|
| Parameters | 2 meals | 3 meals | 6 meals | EMS |
| Average initial weight (g) | 39.2 | 39.0 | 39.8 | - |
| Average final weight (g) | 141.7a | 143.2a | 179.2b | 26.2 |
| Daily Growth Rate (g/day) | 0.9a | 0.9a | 1.3t | 0.02 |
| Specific growth rate, SGR (%day) | 1.2a | 1.2a | 1.4t | 0.01 |
| Daily Growth Coefficient DGC (%day) | 1.7a | 1.7a | 2.0t | 0.03 |
| Feed Intake C (g DM/kg BW/day) | 16.6 | 15.7a | 15.1a | 3.5 |
| Food conversion rate FCR | 1.6t | 1.5t | 1.3a | 0.02 |
| Protein efficiency ratio PER | 2.3a | 2.4a | 2.8t | 0.05 |

DGR = (Wf-Wi)/growth period
SGR = 100 (ln Wf-ln Wi)/ growth period
DGC = 100 (Wf1/3-Wi1/3)/growth period
C, expressed as dry matter feed consumed (DM), per kg of live body weight of fish (BW), per day
FCR = Dry food intake/weight gain
PER = Weight gain/protein intake

*EMS = Error mean square of the Analysis of Variance; figures in each line having different superscripts are significantly different ($p< 0.05$) from each other. Means of duplicates are reported.

## Conclusion

To conclude, our experiment demonstrates the positive effect of increasing the number of meals on the growth and feed utilization in adult tilapias. As a consequence, assuming that the cost of labour is not usually the limiting factor in most developing countries where semi-intensive pond fish farming is practised, 6 meals a day can be recommended for tilapia weighing from 40 to 180 g as revealed by the study. In short, even in production ponds, tilapia shall be fed small frequent meals, and further investigations should better focus on feeding schedule. The mixed system developed by Nandeesha *et al.* (19) for carp culture could be, for instance, tested in adult tilapias. This technique consists in feeding the fish alternatively 2 to 3 days with an economic diet followed by a more equilibrated compounded pellet the 2 to 3 following days.

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