Effects of Different Feeding Rates on Growth Performance and Body Composition of Red Tilapia, *Oreochromis mossambique* x *O. niloticus*, Fingerlings

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**Abstract** In aquaculture feeding rate is an important factor affecting the growth of fish and thus determining the optimal feeding rate is important to the success of any aquaculture operation. The aim of this study was to determine the optimal feeding rate for red tilapia (*Oreochromis* sp.). A 12-week feeding trial was conducted to examine the effects of different levels of the feeding rates on the growth performance and body composition of red tilapia, (*Oreochromis* sp.). Fish of an average initial weight of 0.9±0.01 g were stocked in 12 glass aquaria (80 L each) at a rate of 15 fish per aquarium. All fish were fed the same diets contained 33.8% crude protein at a feeding rate of 1, 3, 5 and 7% of body weight daily. The results revealed that there was a significant differences in growth performance and feed utilization parameters with increasing feeding rates up to 5 % (P < 0.01). The best final body weight (g), specific growth rate (SGR % day $^{-1}$), gain in weight (%), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival rate (%) were recorded with fish fed on feeding rate of 5% body weight daily compared with others. Whole fish moisture and protein contents were not significantly influenced (P > 0.05) by feeding rates. Lipid and ash contents were significantly (P < 0.05) influenced by feeding rates. These findings suggest that feeding rate of 5% of body weight daily can be considered as the optimal feeding rate for red tilapia fingerlings which significantly enhance fish growth, feed utilization and body composition parameters.

**Keywords** Red tilapia; Feeding rate; Growth performance; Feed utilization

**1 Introduction**

Tilapia (*Oreochromis* sp.) are now commercially important fish and grown in almost 100 countries. They have become among the most important food fishes in the world (Lim and Webster, 2006, Chowdhury, 2011). According to FAO (2012), global tilapia production, which totaled less than 500,000 metric tons in the early 1990s, topped 3.5 million metric tons in 2011. In 2012 it increased up to 2.7%. Further increase was recorded as 3.4% in 2013 and this year it is expected to approach around 3.9 million tons.

According to El-Sayed (2006) the attributes that makes tilapia as an ideal candidate for aquaculture, especially in developing countries are: rapid growth, omnivorous fish, can use high proportion of inexpensive plant sources in their feeds, relatively tolerance to a wide range of water quality parameters such as water temperature, dissolved oxygen (DO), salinity, pH, light intensity and photoperiods, resistance against stress and diseases. Short generation interval and low supplementary feed require in natural environment and can take the commercial feed immediately after yolk-sac absorption. The growing popularity of tilapia among consumers and the ever increasing need to improve food production, impose the need to search for production alternatives for tilapia culture. However, the red tilapia, *Oreochromis* sp., is increasing in popularity among producers due to its attractive color, increased marketability and high salinity tolerance in some strains.

With the increasing production of aquaculture, feed has become of the most expensive elements. Feeding management in terms of optimization of feeding rate is essential in culture of marine and freshwater fishes and it has become one of the critical areas of research in the field of aquaculture (Dong-Fang et al., 2003). Therefore, to reduce excessive expenses, numerous studies have been focused on the feeding rate of fish species (Qin and Fast, 1996; Dong-Fang et al., 2003). Feeding rates vary across species and at each...
developmental stage and this has driven research to be focused on these areas. Overfeeding and waste food disrupts the water quality (Ng et al., 2000) while inadequate food supply has direct impact on production cost (Mihelakakis et al., 2002).

Several factors influence the feeding rate in aquaculture system. These include fish size, species and rearing systems (Cho et al., 2003). In addition, feeding rate is influenced by the presence of the nutrients in the feed (Mihelakakis et al., 2002). By controlling the feeding rates, farmers can successfully reduce cost; maximize growth whilst managing other factors such as individual size variation and water quality which are considered important in rearing of fish in culture conditions (FAO, 2012). Feeding rate is an important factor affecting the growth of fish, and thus determining the optimal feeding rate is essential to the success of any aquaculture operation (Wing-Keong et al., 2000).

In addition, it has been evident from several studies that feeding rate and meal frequency can influence the production performance of tilapia. Study with polyculture farming of tilapia, common carp and silver carp showed that growth performance, body fat and gross energy gain increased as feeding rate (0 to 5% and to apparent satiation) increased (Abdelghany and Ahmad, 2002). Tambaqui showed better outcome than to apparent satiation increased (Abdelghany and Ahmad, 2002). Tambaqui showed better outcome using 10% feeding rate and 3 times per day at growth phase (Silva et al., 2007). Research from pikeperch (6.4 g) give enhanced growth at 2% feeding rate and 3 times per day (Wang et al., 2009). Furthermore, (Yuan et al., 2010) found increased growth performance, protein and lipid contents with increasing feeding (rate and Riche et al., 2004) reported that growth efficiency of tilapia increased if they allowed for four hours satiation feeding.

Therefore, the purpose of this study was to evaluate the effects of different feeding rates on growth performance and body composition of hybrid tilapia (Oreochromis mossambicus x O. niloticus) which would improve larval rearing management during the serious period of larval period.

2 Materials and methods
2.1 The experimental diet
The formulated diet containing 33.8% crude protein and 4.5 kcal/g dry matter, gross energy. All ingredients were first ground to a small particle size (approximately 250 mm) in a Wiley mill (Labx Company, Midland, ON, Canada). The proximate compositions of feed ingredients are given in Table 1. Dry ingredients were thoroughly mixed prior to adding water to 40% moisture. The diet was passed through a mincer with diet into 1-mm diameter spaghetti-like strands, sun dried and stored in airtight containers.

Proximate composition of the experimental diet was determined according to AOAC methods (2000), also crude fiber in fish diet was determined according to methods of AOAC methods (2000). Total carbohydrate content (nitrogen-free extract (NFE)) of the experimental diet (was calculated by difference. Gross energy (GE) was calculated using the gross energy values for the macronutrients (23.4 kJ g fat and 17.2 kJ g\textsuperscript{-1} protein, 39.8 kJ g\textsuperscript{-1} carbohydrate, fiber was not included in calculation).

2.2 Fish, facility and feeding trial
Red tilapia, Oreochromis mossambiquse x O. niloticus fingerlings were obtained from a local fish hatchery (21 kilo Marriott, Alexandria Governorate, Egypt). Fish were acclimated to laboratory conditions for one week in fiber glass tank 1000 L. At the beginning of the experiment, twelve 80-L glass aquaria were each stocked with 15 fish with an initial average weight 0.9± 0.01 g. The aquaria were supplied with aerated and chlorine free fresh water at a rate of 250 mL/min. Overhead fluorescent lighting was set at 14:10 (light: dark). The experimental diet was fed to triplicate groups of fish twice daily (0800 and 1400) at different feeding rates of 1, 3, 5 and 7% of body weight during the period of 12 weeks feeding. Each group of fish was weighed at the beginning and every 2 wk throughout the experimental period. The aquaria were cleaned daily and two thirds of the water replaced before feeding.

Water temperature and dissolved oxygen were measured every other day using a YSI Model 58 oxygen meter. Total ammonia and nitrite were measured twice weekly using a DREL, 2000 spectrophotometer. Total alkalinity and chloride were monitored twice weekly using the titration method, pH was monitored twice weekly using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH). During the 12-week feeding trial, the water-quality parameters averaged (± SD): water temperature, 25.6
± 0.9°C; dissolved oxygen, 6.5 ± 0.5 mg/l; total ammonia, 0.20 ± 0.14 mg/l; nitrite, 0.07 ± 0.05 mg/l; total alkalinity, 181 ± 45 mg/l; chlorides, 575 ± 150 mg/l; pH, 8.5 ± 0.2.

Table 1 Major ingredients and proximate analysis of the diet fed to red tilapia, Oreochromis sp. fingerlings for 12-week period

| Ingredients                  | (%) |
|------------------------------|-----|
| Fish meal (60% C.P)          | 8.0 |
| Soybean meal (44% C.P)       | 62.0|
| Wheat bran                   | 8.0 |
| Yellow corn meal             | 10.0|
| Soybean oil                  | 5.0 |
| Vitamins and minerals premix a| 1.5 |
| Calcium di-basic phosphate   | 2.0 |
| Molasses                     | 2.0 |
| L-methionine                 | 1.0 |
| L-lysine HCl                 | 0.5 |

Proximate analysis

|                        |       |
|------------------------|-------|
| Moisture               | 9.8   |
| Crude protein          | 33.8  |
| Crude fat              | 10.4  |
| Ash                    | 7.9   |
| Crude fiber            | 6.7   |
| NFE b                   | 31.4  |
| Gross Energy (kcal/g diet) d | 4.5  |

Note: a: Premix supplied the following vitamins and minerals (mg or IU)/kg of diet: vit. A, 8000 IU; vit. D3, 4000 IU; vit. E 50 IU; vit. K3, 19 IU; vit. B2, 25 mg; vit. B3, 69 mg; vit. B6, 20 mg; Nicotinic acid, 125 mg; Thiamin, 10 mg; Folic acid, 7 mg; Biotin, 7 mg; Pantothenate, 15 mg; vit. B12, 75 mg; Choline, 900 mg; vit. C, 500 mg; Manganese, 350 mg; Zinc, 325 mg; Iron, 30 mg; Iodine, 0.4 mg; Cobalt 2 mg; Copper, 7 mg; Selenium, 0.7 mg and 0.7 mg B.H.T, according to Xie et al. (1997); b: Values represent the mean of three sample replicates; c: Nitrogen free extract (NFE) = [100 - (moisture + crude protein + crude fat + ash + crude fiber)]; d: Gross energy was calculated using the gross energy values for the macronutrients (5.6 kcal/g protein, 9.5 kcal/g fat and 4.1 kcal/g carbohydrate) according to Sanz et al. (1994)

2.3 Sample collection and analysis

Analyses of crude protein, moisture, ash and crude fibre were performed by standard procedures (AOAC 2000). At the end of the feeding trial all fish were counted and weighed to calculate percent weight gain (PWG; [FBW – initial BW] × 100%/initial BW), feed conversion ratio (FCR; dry feed consumed/WG), feed efficiency ratio (FER; WG/ dry feed consumed ), protein efficiency ratio (PER; WG/protein intake), specific growth rate (SGR; [ln final BW – ln initial BW] /time days × 100% /days), and survival (No. of fish at the end of the experiment/No. of fish at the beginning of the experiment) × 100 (%).

At the beginning of the study, 15 fish were sampled and frozen at -18°C for analysis of whole body composition. At the end of the feeding trial, six fish from each tank were sampled for biochemical analysis. Fish were homogenized individually for whole body composition and frozen at -18°C for proximate chemical analysis at the laboratory of the faculty of Agriculture at Minufiya University. Samples were analyzed as follows: dry matter after desiccation in an oven (105°C for 24 h), crude protein (micro kjeldahl, N x 6.25), crude lipid (ether extraction by soxhlet method), crude fiber (AOAC 2000), and gross energy (Ballistic bomb calorimeter, Gallenkamp, England).

2.4 Statistical analysis

Each experimental diet was fed to three groups of fish by a completely randomized design. Differences among dietary treatments were tested by one-way ANOVA. The percentage data of weight gain, specific growth rate and survival rate were arcsine transformed before the analysis of variance ANOVA. Differences were considered significant at the P<0.05. The differences among means were determined using Duncan’s multiple range test (Duncan, 1955).

3 Results

The effects of feeding rates on final body weight g/fish (FBW), specific growth rate (SGR % day⁻¹), weight gain g/fish (WG), weight gain % (WG %), feed intake g/fish (FI), feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and survival rate (%) are presented in (Table 2). It is evident from Table 2 that, no significant differences in the survival rate were observed among the different feeding rates % (P>0.05). However, the growth performance in terms of final body weight (FBW), weight gain (g/fish), weight gain (%), and SGR ( % day⁻¹) among fish groups fed different feeding rates of 1,3,5, and 7 % for 12 week were significantly differed (P < 0.01). Fish fed at 1% BW day⁻¹ showed the lowest final body weight (g/fish), gain in weight (g/fish), gain in weight (%) and specific growth rate (SGR % day⁻¹) compared with
others. While fish fed the feeding rate of 5% body weight daily exhibited the best results of final body weight, gain in weight, gain in weight (%) and specific growth rate. Similarly, feed utilization parameters of groups of fish fed the feeding rate of 5% body weight daily exhibited the same trend.

The proximate composition of the experimental fish at the end of the feeding trial as affected by different feeding rates (%) are presented in Table 3. It is evident from this table that no significant difference was found in the moisture and protein contents among the different treatments ($P > 0.05$). Moisture content was high (77.1%) for fish fed low feeding rate (1%). Whereas, the protein content was low at feeding rate of 1% of body weight. Significant differences in the lipid and ash content in fish bodies were observed among treatments, $P < 0.05$ (Table 3). The highest value of ash content was recorded in fish fed on feeding rate (1%) of body weight and the lowest was recorded with fish fed on feeding rate (7%).

Table 2 Growth performance, feed utilization and survival rate of juvenile red tilapia Oreochromis mossambicus x O. niloticus (initial weight 0.9 g/fish) fed the experimental diets for 12 weeks. Values are mean ± SD. Values followed by the same superscript letters in the same row are not significantly different ($P > 0.05$)

| Items               | Feeding rate (%) |
|---------------------|------------------|
|                     | 1%   | 3%   | 5%   | 7%   |
| IBW (g)$^1$         | 0.9±0.01 | 0.9±0.01 | 0.9±0.01 | 0.9±0.01 |
| FBW (g)$^2$         | 1.47±0.06$^d$ | 2.43±0.06$^c$ | 3.93±0.15$^a$ | 3.63±0.12$^b$ |
| WG (g)$^3$          | 0.57±0.06$^d$ | 1.52±0.07$^c$ | 3.03±0.15$^a$ | 2.73±0.12$^b$ |
| WG (%)$^4$          | 63.3±6.4$^d$ | 169.0±8.2$^c$ | 337.7±17.3$^a$ | 218.3±12.7$^b$ |
| SGR (%)$^5$         | 0.58±0.05$^d$ | 1.18±0.04$^c$ | 1.76±0.05$^a$ | 1.66±0.03$^b$ |
| FL (g)$^6$          | 0.81±0.03$^d$ | 2.99±0.02$^c$ | 5.23±0.30$^b$ | 7.50±0.28$^a$ |
| FCR$^7$             | 1.43±0.15$^a$ | 2.00±0.10$^c$ | 1.73±0.06$^b$ | 2.73±0.15$^c$ |
| FER$^8$             | 0.70±0.06$^a$ | 0.51±0.02$^c$ | 0.58±0.02$^b$ | 0.36±0.03$^d$ |
| PER$^9$             | 2.10±0.16$^a$ | 1.50±0.07$^b$ | 1.71±0.05$^b$ | 1.10±0.07$^bc$ |
| Survival (%)$^{10}$ | 70.7±8.1$^a$ | 82.0±10.1$^b$ | 95.7±7.5$^a$ | 85.7±12.5$^a$ |

Note: $^1$: IBW (g) = initial body weight (g/fish); $^2$: FBW (g) = final body weight (g/fish); $^3$: WG (g), weight gain (g/fish) = FBW (g) - IBW (g); $^4$: WG(%), weight gain % = [FBW – IBW] × 100/ IBW; $^5$: FL (g), = amount of feed intake (g/fish); $^6$: Feed conversion ratio (FCR) = dry feed consumed/WG (g); $^7$: Feed efficiency ratio (FER)=WG/ dry feed consumed; $^8$: Protein efficiency ratio (PER)=(WG (g)/protein intake (g)); $^9$: Specific growth rate (SGR day$^{-1}$)= [ln final BW – ln initial BW] × 100/days; $^{10}$: Survival % = (% of fish at the end of the experiment/no. of fish at the beginning of the experiment) × 100)

Table 3 Body composition (% dry basis) of juvenile red tilapia fed the experimental diet with different feeding levels for 12 weeks. Values are mean ± SD

| Items   | Initial | Feeding rate (%) |
|---------|---------|------------------|
|         | 1%   | 3%   | 5%   | 7%   |
| Moisture| 66.9 | 77.1±0.1$^a$ | 73.9±3.3$^a$ | 73.5±3.2$^a$ | 72.1±2.5$^a$ |
| Protein | 56.2 | 50.2±5.0$^a$ | 57.2±9.3$^a$ | 55.4±3.2$^a$ | 58.4±12.5$^a$ |
| Lipid   | 3.1  | 5.5±0.2$^a$ | 3.8±0.1$^b$ | 4.1±0.2$^b$ | 3.3±0.2$^a$ |
| Ash     | 10.2 | 13.0±1.7$^a$ | 9.9±2.4$^{ab}$ | 10.6±10.7$^{ab}$ | 8.4±1.4$^b$ |

Note: Values followed by the same superscript letters in the same row are not significantly different ($P > 0.05$)
4 Discussion
In the present study, there were significant differences on growth performance as influenced by feeding rates (%). These results are similar with (Van der Meer et al. 1997; El-Saify and Gaber 2002) who found that feeding rates influenced growth rates in both male and female Nile tilapia.

In the present study, Specific growth rates were 0.58 to 1.76 % day\(^{-1}\). Among the four different feeding levels tested, 5% of BW day\(^{-1}\) appeared optimum, since it supported a SGR of 1.76 % day\(^{-1}\) and FCR close to 1.73.

At lower feeding levels, FCR was 1.43 but the growth rate was significantly lower. These results were similar to El-Saify and Gaber (2005) who studied the effects of dietary protein levels (25 and 30%) and feeding rates of 1.2, and 3% on growth performance, production traits and body composition of Nile tilapia, *Oreochromis niloticus* (L.) cultured in concrete tanks and found that fish fed at 1% BW day\(^{-1}\) showed the lowest FCR values, whereas FCR values increased with increasing feeding rates.

On the other hand, an increase of the feeding level above 5% significantly reduced feed utilization (Table 2). The present study demonstrates that feeding levels highly influences specific growth rate. A reduction in feeding level to 1% BW day\(^{-1}\) resulted in a decreased growth rate. Similar results were reported by Essa and El-Ebiary (1995) and Fontaine et al., (1997). Also, presented greater growth when fed with higher feeding rates rather than smaller, these results are in accordance with (Borghetti and Canzi, 1993; Robinson and Li, 1999; Ng et al., 2000; Eroldogan et al., 2004).

Santiago et al. (1987) found that tilapia smaller than 12 mg were fed at 15 to 60% feeding rate and found that survival rates were increased up to (87%) at feeding rate 45% then decreased. Feeding rate (10-35%) in average weight of 0.016 g tilapia showed increased survival rate with increasing feeding rate (El-Sayed, 2002). These results are not in line with our results which found that the survival rate increased with increasing the feeding rates but they were not significantly different.

The fish fed at 5% body weight per day exhibited the best growth (P < 0.05), while there were significant differences in FCR among the fish fed at 1, 3, 5, and 7% body weight per day (P < 0.01). These results are in agreement with that of Marimuthu et al., 2011. Who studied four feeding rates (2, 5, 8 and 12%) on growth, survival and cannibalism of African catfish, *Clarias gariepinus* fingerlings. The results indicated that significantly the best FCR (1.00 ±0.086) was also observed in the 8% feeding rate fed groups whereas no difference was noticed in all the remaining treatments.

While the amount of feed offered to fish has a significant behavior on growth rate, feed can also have a negative effect on growth by abetting the deterioration of water quality (NRC 2011). It has long been recognized that overfeeding is more dangerous than underfeeding. Feed ration greater than optimum feed level would increase the waste food, increase the feed conversion ratio and also deteriorate water quality (Marian et al., 1982, Anderson and Fast, 1991).

In the present study, the whole body fat and ash contents were significantly affected by feeding rates. Different results were found by Al-Hafedh (1999) and El-Saify and Gaber (2005).

Earlier authors have also reported different optimal feeding rates in different fish species. Optimum feeding rate of Other fish species such as *Channa striatus* (5% body weight), *Clarias fuscus* (6% body weight) tambaqui, *Colossoma macropomum* (10%) according to ( Andersone and Fast, 1991; Qin and Fast, 1996; Silva et al., 2007). Also, in the case of juvenile snakehead, Qin and Fast (1996) found that feeding rate greater than 5%/day could reduce growth, apparently due to increased surfacing and swimming activities. It can be concluded that a diet containing 33.8% dietary protein fed at 5% body weight/ day is recommended for maximizing growth and feed utilization of red tilapia fingerlings.

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