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GROWTH PERFORMANCE OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FINGERLINGS RAISED IN AN EARTHEN POND

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ABSTRACT. An experiment was conducted to evaluate the growth performance of Nile tilapia fed with supplemental feed (25% crude protein) at 50% satiation. Juvenile Nile tilapia (average weight 6.4 g) were stocked in an earthen pond at 2.4 fish m^{-2}. The pond was fertilized twice weekly with a mixture of superphosphate and urea fertilizer (68 kg ha^{-1}). The annual fish yield was 6880 kg ha^{-1}. The mean weight of harvested fish ranged from 110 to 250 g. The food conversion ratio (FCR) was 0.82, the average daily weight gain (ADG) was 0.9 g d^{-1} and the specific growth rate was 1.55 % d^{-1}. This study demonstrated that 50% satiation feeding is an effective feeding rate for improving the production of Nile tilapia cultured in a fertilized, freshwater earthen pond.

Key words: NILE TILAPIA (*ORECHROMIS NILOTICUS*), EARTHEN POND, GROWTH PERFORMANCE

INTRODUCTION

Fish culture is an important component of many rural development projects in areas suffering from animal protein shortage. Tilapias are one of the most popular fish for culture and have been introduced into many countries around the world. In recent years, attention has been focused on developing tilapia culture. The production of farmed tilapia in the world is rising, and production of it reached 1099268 tons in 1999 (FAO 2001). In Egypt tilapia is one of the most important cultured fish. The suitability of tilapia for culture comes from its tolerance of a wide range of environmental conditions as well as its utilization of food from the lowest trophic levels (Abdel-Baky 1997).

Tilapia can be grown in pond culture with the help of inexpensive organic and inorganic fertilizers which increase pond productivity in terms of plankton production and which, in turn, leads to greater fish production (Diana and Lin 1998, Liti et al. 2002).

The feeding strategy influences the profitability of a tilapia production operation. The amount of feed provided is usually determined as a percentage of the body weight of the cultured fish. Under culture conditions where some natural food is available, from 3 to 5% of the total weight of reared fish is a reasonable rule of thumb for providing pelleted food (Nwanna and Balarinwa 2001). The present study was

aimed at minimizing feed and fertilizer costs for the production of Nile tilapia, *Oreochromis niloticus* raised in an earthen pond. The plan of nutrition was to feed the fish to about 50% satiation by supplemented pelleted food and to develop natural food resources induced by inorganic fertilization to provide another 50%.

MATERIALS AND METHODS

The experiment was conducted in an earthen pond with a surface area of 4800 m^2 (about 0.5 ha). It is located on the southern bank of the El-Salam canal near Damietta City, Egypt. No aeration was provided, but water was pumped continuously into the pond to replace losses due to evaporation and seepage. The water level was kept at a depth of 1.2 m. Nile tilapia juveniles (6.0 cm total length and 6.4 g body weight on average) were obtained from the fish hatchery at El-Manzalah Fish Farm, Egypt. The fish were transported in oxygenated plastic bags early in the morning. The pond was stocked with fish at a rate of 2.4 fish m^{-2}. The experiment was run for 210 days from May 1 to November 30, 2001. The fish were fed a pelleted diet (Table 1) at a rate of 3% of fish biomass four times a week (estimated as 50% satiation). The pond was fertilized with inorganic fertilizer at a level of 12.5 P (806.5 g superphosphate) to 12.5 N (270 g urea) (6.8 mg l^{-1} of the mixed fertilizers) (Abdel-Baky et al. 2000).

TABLE 1

Composition and proximate biochemical analysis of supplemental pelleted diets (25% crude protein)

Ingredients		Composition (%)				
Name	%	Protein	Fat	Carbohydrate	Fiber	Gross energy, (Kcal $100g^{-1}$)
Soybean meal	20	48.0	15.7	31.4	5.5	110.45
Wheat bran	18	15.7	8.6	64.4	2.8	79.40
Yellow corn	35	8.8	4.6	81.3	2.3	152.23
Corn gluten meal	7	62.0	2.2	-	1.3	25.95
Molasses	5	3.9	0.1	-	-	1.23
Fish meal	7	72.0	10.0	-	0.7	35.13
Bone meal	3	12.0	-	-	-	2.03
Limestone	5	-	-	-	-	-
Total	100	25.4	7.16	46.33	2.55	406.42

Water quality parameters (Table 2) were determined every two weeks according to APHA (1992). Water samples for plankton determination (Table 3) were taken on three occasions. At the end of the study, 10-20 fish were taken, weighed, measured and frozen for body composition analysis (moisture, protein, lipid, and ash contents)

TABLE 2

Some water quality parameters of the irrigation canal and fish farm

Parameters	Irrigation canal		Fish farm	
	Mean ± SD	Range	Mean ± SD	Range
Temperature (°C)	29.1 ± 2.5	24.0-31.5	29.2 ± 2.5	24.0-31.5
Turbidity (NTU)	0.94 ± 0.51	0.33-1.88	1.40 ± 0.75	0.56-2.85
pH	6.46 ± 0.24	6.0-6.87	6.80 ± 0.43	6.1-7.65
Dissolved oxygen (ppm)	8.19 ± 0.54	7.2-8.8	7.29 ± 0.72	6.1-8.4
Total dissolved salts, TDS (ppm)	3221 ± 1009	2400-5600	5891 ± 1652	2795-7900
Alkalinity (ppm)	0.37 ± 0.10	0.28-0.56	0.52 ± 0.03	0.47-0.59
Phosphate (ppm)	0.48 ± 0.21	0.23-0.86	0.69 ± 0.27	0.27-0.99
Nitrite (ppm)	0.34 ± 0.20	0.06-0.60	0.58 ± 0.41	0.07-1.35
Nitrate (ppm)	0.48 ± 0.25	0.12-0.78	0.71 ± 0.34	0.23-1.30
Ammonia (ppm)	0.32 ± 0.11	0.142-0.570	0.38 ± 0.09	0.191-0.480

according to the methods described by AOAC (1995). Growth performance parameters of the harvested fish were calculated as follow:

Weight gain (WG, kg) = final weight (kg) – initial weight (kg);

Average daily gain (ADG, g d^{-1}) = weight gain (g) / time (days);

Specific growth rate (SGR, % d^{-1}) = 100 × (Ln final weight (g) – Ln initial weight (g)) / time (days);

Food conversion ratio (FCR) = food consumed (kg) / weight gain (kg);

Relative food consumption (R) = 100 (food consumed (g) / 0.5 (final weight (g) – initial weight (g)) x time (days));

Protein efficiency ratio (PER) = live weight gain (g) / protein consumed (g).

The market value of Nile tilapia varies with size: fish of an average weight of 110 g was sold at 0.5 USD per kg, fish of an average weight of 145 g was sold at 0.8 USD per kg while those of an average weight of 250 g were offered at market for 1.2 USD per kg.

RESULTS AND DISCUSSION

The mean values of water quality parameters measured in the pond and irrigation canal are summarized in Table 2. Water temperature ranged from 24.0 to 31.5°C. This temperature range has been reported as the optimum range for tilapia growth and yield (Meske 1985). Alkalinity, pH, and dissolved oxygen were within optimum ranges for tilapia growth. Tilapia can survive in pH ranging from 5 to 10, but they do

TABLE 3

Phytoplankton (No. of cell l^{-1}) and zooplankton (No. of organisms l^{-1}) standing crop of dominant species in an earthen fish pond treated with inorganic fertilizers

Organisms	July		September		November	
	No.	%	No.	%	No.	%
Phytoplankton						
Chlorophyceae						
Zygnema	1.01×10^5	5.03	1.10×10^5	3.10	0.91×10^5	8.98
Mougeotia	-	-	0.90×10^5	2.53	-	-
Subtotal	1.01×10^5	5.03	2.00×10^5	5.59	0.91×10^5	8.98
Bacillariophyceae						
Diatoma	1.10×10^5	5.48	1.20×10^5	3.38	0.92×10^5	9.08
Nitzschia	1.20×10^5	5.97	1.30×10^5	3.66	0.90×10^5	8.88
Navicula	1.03×10^5	5.13	-	-	-	-
Tabellaria	0.90×10^5	4.48	-	-	-	-
Subtotal	4.23×10^5	21.05	2.50×10^5	6.98	1.82×10^5	17.97
Phytoflagellata						
Gonium	1.12×10^5	5.57	-	-	1.40×10^5	13.82
Pleodorina	1.22×10^5	6.07	0.3×10^5	0.96	-	-
Euglena	-	-	-	-	0.90×10^5	8.88
Volvox	0.9×10^5	4.48	1.40×10^5	4.47	2.00×10^5	19.74
Chlidomonas	0.61×10^5	3.04	-	-	1.30×10^5	12.83
Eudorina	-	-	-	-	1.80×10^5	17.77
Chlamydomonas	11.0×10^5	54.75	28.00×10^5	89.46	-	-
Astasia	-	-	1.60×10^5	5.11	-	-
Subtotal	14.85	73.92	31.30×10^5	87.43	7.40×10^5	73.05
Total (all Phytoplankton)	20.1×10^5	75.42	35.80×10^5	82.2	10.13×10^5	88.94
Zooplankton						
Protozoa						
Dileptus	-	-	0.90×10^5	14.63	-	-
Chilodonella	-	-	1.80×10^5	29.27	-	-
Paramecium	-	-	1.20×10^5	19.51	-	-
Subtotal	-	-	3.90×10^5	100	-	-
Crustacea						
Daphnia	0.90×10^5	32.14	0.58×10^5	9.43	0.26×10^5	20.63
Nauplius larvae	1.05×10^5	37.50	0.9×10^5	14.63	0.54×10^5	42.86
Cyclops	0.85×10^5	30.36	0.77×10^5	12.52	0.46×10^5	36.51
Subtotal	2.80×10^5	100	2.25×10^5	-	1.26×10^5	100
Total (all Zooplankton)	2.80×10^5	24.58	6.15×10^5	14.47	1.26×10^5	11.06
Grand Total (Phytoplankton + Zooplankton)	22.89×10^5	100	41.65×10^5	100	11.39×10^5	100

best in a pH range from 6 to 9 (Popma and Masser 1999). Tilapia has a low oxygen demand and can survive at low oxygen levels (Siddiqui et al. 1989).

The investigation of plankton populations in ponds represents the most important step in the complex analysis of an aquatic ecosystem. Plankton organisms consti-

tute an important component of the fish diet, and thus act as an index of the trophic status of a water body. The phytoplankton was dominated by Phytoflagellata and Bacillariophyceae while zooplankton was represented by Crustacea and Protozoa (Table 3).

Growth performance data are presented in Table 4. The average initial weight and total length of stocked fish were 6.4 g and 6.0 cm, respectively. Fish harvest weight ranged from 110 to 250 g and their length from 13 to 27 cm. The average individual weight gain (ADG) was 0.9 g d^{-1}. This result is higher than those obtained by Diana and Lin (1998) and Yi et al. (2002a) for sex-reversed (0.77 g d^{-1}) and mixed sex (0.73 g d^{-1}) Nile tilapia, respectively. On the other hand, higher ADG values were obtained by many authors working on tilapia culture in fertilized earthen ponds (Diana et al. 1995, El-Sayed et al. 1996, El-Shebly 1998, Brown et al. 2002, Liti et al. 2002, Yi et al. 2002b). The higher ADG of fish recorded by the authors mentioned above may be due to the higher initial weight of the stocked fish or to higher rates of the supplemental food offered to the cultured fish. Diana et al. (1995) recorded ADG values between 1.6 and 3.04 g d^{-1}after feeding the cultured fish (initial body weight, 15 g) to full satiation. El-Sayed et al. (1996) had higher ADG values (1.17-1.68 g d^{-1}) after feeding the fish

TABLE 4

Growth performance parameters of *O. niloticus* raised in an earthen pond for 210 days

Parameters	Value
Initial number of fish	11500
Initial total weight (kg)	73.6
Initial mean individual weight (g)	6.4
Final number of fish	10000
Final total weight (kg)	1900
Final mean individual weight (g)	190
Total weight gain (kg)	1826.4
Individual daily weight gain (g d^{-1})	0.9
Specific growth rate (SGR, % d^{-1})	1.55
Survival ratio (%)	87
Total feed given (kg)	1500
Protein consumed (kg)	375
Protein efficiency ratio (PER)	4.87
Relative food consumption (R)	0.78
Feed conversion ratio (FCR)	0.82
Incidence cost (IC)*	0.14
Profit index**	6.7
Annual production (kg ha^{-1})	6880

**Incidence cost = cost of consumed feed / fish produced (kg)*
*** Profit index = value of fish crop / cost of consumed feed*

twice a day with food that contained 23% protein. El-Shebly (1998) had higher ADG values (1.56-3.47 g d^{-1}) by using tilapia with an initial weight range of 33.0 to 66.5 g and offering supplemental food (25% crude protein) twice daily in addition to fertilization. Liti et al. (2002) had a higher ADG (1.2 g d^{-1}) for fish of an initial weight of 89.3 g fed twice a day with food containing 20% protein. Yi et al. (2002b) obtained a higher ADG (2.11 g d^{-1}) for tilapia of an initial weight of 33.2 g which consumed food containing 30% protein in addition to fertilization.

In the present study, the food conversion ratio (FCR) was 0.82. This value was better than that obtained by previous studies on tilapia. Diana et al. (1995) recorded an FCR that ranged from 1.17 to 1.6 for sex-reversed tilapia fed on 30% crude protein to full satiation. Salama and Abdel-Raheem (1995) recorded an FCR of 2.03 and 2.08 for two stocks of mono-sex *O. niloticus* fry. El-Sayed et al. (1996) found that the FCR ranged from 2.2 to 3.15 in Nile tilapia fed on artificial diets twice daily. Very high FCR records (5.56-7.77) were obtained by Essa (1997) for Nile tilapia fed twice daily with standard diets. The lower (better) value of FCR obtained in the present study manifests the importance of feeding fish at 50% satiation coupled with inorganic fertilization. Yi et al. (2002b) reported that applying feed at a lower percentage of satiation makes tilapia more efficient at utilizing natural food. Diana et al. (1994a) determined 50 to 75% satiation feeding to be the most efficient feeding rates for Nile tilapia culture in freshwater ponds. Brown et al. (2002), reported that a better feed conversion ratio was obtained by the fish fed at a reduced level of satiation (2.38) than by those fed to full satiation (3.4).

In the present study, the annual fish yield per hectare was 6880 kg. This value is higher than that obtained by Yi et al. (2002b; 4610 kg ha^{-1} $year^{-1}$) for Nile tilapia reared in a fertilized earthen pond. Lower annual fish yields were also recorded by many authors for tilapia species reared in fertilized earthen ponds in different areas, e.g., Diana and Lin (1998) in Thailand for sex-reversed Nile tilapia (5235 kg ha^{-1}) and Chaula et al. (2002) in Malawi for *O. shiranus* (1748 kg ha^{-1}). The higher fish production which occurred at a lower feeding intensity in the present study may be attributed to either the high productivity and abundance of natural food induced by phosphate and urea fertilizers as reported by Knud-Hansen and Batterson (1994) and Dato-Cajegas and Yakupitiyage (1996). On the other hand, higher annual fish yield was reported by many authors: Brown et al. (2002) in the USA (10875 kg ha^{-1} $year^{-1}$) for sex-reversed Nile tilapia fed at 67% satiation; Liti et al. (2002) in Kenya (8020 kg ha^{-1} $year^{-1}$) for sex-reversed Nile tilapia fed daily on supplemental food (20% protein).

TABLE 5

Body composition analyses (based on dry weight) of *O. niloticus* taken from the fish farm and irrigation canal

	Moisture (%)	Dry weight (%)		
		Crude lipid	Crude protein	Ash
		Irrigation canal		
Mean ± SD	70.71 ± 1.17	22.54 ± 1.81	56.65 ± 1.47	20.81 ± 1.74
		Fish farm		
Mean ± SD	70.13 ± 1.52	24.58 ± 1.58	58.39 ± 1.33	17.03 ± 1.39
P-value	NS	NS	0.0021	NS

NS = non-significant differences ($p > 0.05$)

The biochemical analysis of the whole fish body (moisture, ash, protein and lipid contents) of the harvested fish is shown in Table 5. The data obtained are in accordance with previous studies on tilapia cultured in fertilized earthen ponds (El-Sayed et al. 1996, Essa 1997).

The economic analysis of the experiment (Table 6) indicates that the net return of one hectare cultured with Nile tilapia was 2189 USD (the annual return of one hectare is 3804 USD). These results demonstrate that the practice of using earthen ponds for tilapia rearing can minimize incidence cost and increase the profit index by using a supplemental diet at a low level coupled with inorganic fertilizers.

TABLE 6

Economic return of *O. niloticus* raised in an earthen pond

Item	Price (USD)
Costs:	
Fish fry	300
Fodder used	250
Inorganic fertilizers	33
Working cost	50
Total	633
Gross Return:	
Fish of small size class (mean weight 110 g)	200
Fish of median size class (mean weight 145 g)	667
Fish of large size class (mean weight 250 g)	817
Total	1684
Net return	1051
Net return/hectare	2189

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STRESZCZENIE

WSKAŹNIKI HODOWLANE NARYBKU TILAPII NILOWEJ *OREOCHROMIS NILOTICUS* PODCHOWYWANEGO W STAWACH ZIEMNYCH

Celem badań było określenie tempa wzrostu, składu ciała narybku tilapii nilowej (początkowa masa ciała 6.4 g) żywionego paszą sztuczną zawierającą 25% białka (tab. 1). Eksperyment przeprowadzono w stawie ziemnym, a poziom żywienia wynosił 50% dawki maksymalnej. W czasie podchowu, trwającego 210 dni, bieżąco monitorowano jakość wody, a także skład jakościowy i ilościowy fitoplanktonu i zooplanktonu (tab. 2 i 3). Współczynnik pokarmowy paszy wyniósł 0,82, dzienny przyrost masy ciała 0,9 g d^{-1}, a wskaźnik SGR 1,55 % d^{-1} (tab. 4). Przeanalizowano również wpływ żywienia na skład ciała tilapii nilowej (tab. 5) i ekonomiczne wskaźniki tejże produkcji (tab. 6). Badania wykazały, ze stosowanie uzupełniającego żywienia paszą sztuczną, na poziomie 50% dawki maksymalnej, pozwala zwiększyć efektywność produkcji tego gatunku w stawach ziemnych.

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