EFFECT OF FEEDING FREQUENCY AND STOCKING DENSITY ON THE PERFORMANCE OF MONO SEX NILE TILAPIA IN CONCRETE TANKS

D.M.S.D. El-Saidy, A.M.H. Abo Ashour, A.A. El-Fiky and Asmaa E. Alaam

Department of Poultry Production, Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt.

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ABSTRACT*: A 22-weeks factorial design 2 x 3 x 2 (two feeding frequencies, three stocking densities and two replicates) rearing trial was conducted in concrete tanks with average initial weight of 2.8 ± 1.3 g/fish and average initial length of 5.2 ± 0.9 cm/fish of mono-sex male Nile tilapia, Oreochromis niloticus, to examine the effects of two feeding frequencies (2 and 4 times daily) and three stocking densities on growth performances, production traits, feed utilization and body composition. Twelve concrete tanks 4 m^3 each (2 x 2 x 1.25 m, long, width, and height) were stocked with either 200, 400 or 600 fish for each tank to give a stocking rate of 50, 100 and 150 fish /m^3, respectively and maintained at a flow rate of 8 L/min. The results revealed that, mean final weight (g/fish), mean final length (cm/fish), gain in weight (g/fish), gain in weight %, gain in length %, daily gain (g/fish), SGR (% per day) were significantly ($P \leq 0.01$) the best at the lowest stocking density. While, total production and net production exhibited significantly ($P \leq 0.01$) the opposite trend. Harvests and production estimates increased with increasing stocking density. No significant differences ($P > 0.05$) were found between feeding frequency in terms of gain in weight, mean final length, gain in weight (%), gain in length (%), average daily gain (g/fish), SGR (%/day), feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and total feed intake (g/fish). While mean final weight (g/fish) and all production traits were significantly influenced by feeding frequency. The highest stocking density (150 fish/m^3) had significantly the best FCR, FER, PER and feed intake (g/fish). Whole body moisture, ash and crude fiber contents were not significantly affected by either stocking density or feeding frequency. Whole-body protein content was significantly affected by stocking density, but not significantly affected by feeding frequency. While whole body crude fat content was significantly affected by feeding frequency, but not significantly affected by stocking density it can be concluded that, stocking density of 150 fish /m^3 of mono-sex male Nile tilapia reared in concrete tanks at feeding frequency of four times/day exhibited the highest production and net profit and would seem to be the most desirable density*

under this system conditions.

Key words: ***Feeding frequency, stocking density, body composition, mono sex mail -Nile tilapia***

INTRODUCTION

Tilapia are now recognized as one of the most important species of fish for cultivation in fresh water, and have been widely cultivated in the world because of their tolerance and adaptability to an extensive range of environments (Pullin & Capilli, 1988). These characteristic have resulted in rapid expansion of tilapia cultivation, especially in Africa, Middle East and Asia, and more recently for the developing domestic markets in South and Central Americas (Costa–Pierce 1997).

Tilapias can become the world's most important warm water cultured fishes (FAO, 1980). Among all cultured tilapia species, Nile tilapia (*Oreochromis niloticus*) has emerged as the single most important species. The attributes which make Nile tilapia so suitable for fish farming are its general hardness, ease of breeding, rapid growth rate, ability to efficiently convert organic and domestic wastes into high quality protein, and good taste (Balarin and Haller, 1982).

Rearing density is one of the most important factors influencing the results of controlled fish cultivation. Commercially applied densities are not simply those promoting optimal growth and survival, but are based on the economics of the operation (Purser & Hart, 1991; Logan & Johnston, 1992). The goals of fish farmers could be: (1) extremely rapid growth; (2) maximum biomass production; (3) a balance of yield cost and numbers of fish; (4) high fish quality; or (5) a compromise between these aims (Brauhn *et al*., 1976). Increasing fish density provides a means to increase production without a concomitant increase in system costs. Baker & Ayles (1990) noted that optimum density could differ from that at which mean growth rate was maximal, as production is the product of density and growth rate. This effect has been illustrated in numerous studies where increasing density increased growth rate and decreased survival (Atay *et al*., 1988; Papoutsoglour *et al*., 1998). High density culture of tilapia has been successful (Balarin and Haller, 1983) but comparing results is difficult because individual studies do not address the full complex of parameters.

One problem facing fish culturists is the need to obtain a balance between rapid fish growth and optimum use of the supplied feed. Increased feeding frequency has been shown to improve the growth of various fish species (Andrews and Page, 1975). Two or three feedings a day have been

found to be sufficient for maximum growth of a number of species such as grouper *Epinephelus tauvina* (Chua and Teng, 1978), sea bass *Dicentrarchus labrax* (Tsevis *et al*., 1992) and rainbow trout (Grayton and Beamish, 1977). Optimum feeding frequency seems to be dependent on fish size, since fingerlings require a higher number of daily feeding for good growth and survival (Folkvord and Otter. 1993). Social dominance hierarchies affect feeding behavior of fish fed in groups and thus, probably, the required number of feedings per day (Jobling, 1995), which makes it difficult to distinguish between the effects of food availability, food dispersion and optimum number of daily meals on an individual level. Rouhonen (1986) reported that the average growth rate increased and size variation decreased in a group of juvenile Atlantic salmon when they were fed up to 60 times a day. For larger Atlantic salmon, Thomassen and Fjaera (1996) found no effect of feeding frequencies of 3, 9 or 27 times in a day. The aim of the present study was to investigate the effects of stocking density and feeding frequency on growth performance, production traits, feed utilization, body composition and finally the economic feasibility of Nile tilapia (*Oreochromis niloticus*) mono-sex male reared in concrete tanks.

MATERIALS AND METHODS

Location and experimental designs.

The trial was carried out in concrete tanks in fish research laboratory at the Faculty of Agriculture, Minufiya University, Egypt, the experiment was conducted between May 2007 and October 2007 (22 weeks). The trial giving a total of ١٢ tanks; each of them was 2 x 2 x 1.25m. Water level in the concrete tanks was kept at one-meter depth to maintain the water volume at 4m^3. The concrete tanks were supplied with fresh water at a rate of 8 1/min. The tanks were provided with continuous aeration through an air compressor. The walls and bottoms of the tanks were scraped and cleaned weekly to minimize algal growth. Also, all tanks were drained and cleaned every 15 days during fish sampling.

Tank preparation and fish stocking:

A set of 4800 Nile tilapia (*Oreochromes niloticus*) fry mono sex male were purchased from Al-Abasa hatchery and acclimated to environmental condition, at fish research laboratory, Faculty of Agriculture, Minufiya University. Fish of an average initial weight of 2.8 (g/fish) and an average initial length of 5.2 (cm/fish) were distributed into tanks represent two feeding frequency [2 times/ day and 4 times/ day] and within each feeding frequency tested three stocking densities (50, 100 and 150 fish/m^3] were tested.

The feeding frequency and stocking densities were tested on Nile tilapia during an experimental period of 154 days. The experimental design is illustrated as following:

Treatment	Tank No.	Feeding frequency(FF) (times/day)	Stoking density(SD) (fish/m^3)	Fish/tank ($4m^3$)
1	1,2	2	50	200
2	3,4	2	100	400
3	5,6	2	150	600
4	7,8	4	50	200
5	9,10	4	100	400
6	11,12	4	150	600

Feeding regime:

Composition and proximate analysis of the practical diet used in the present study are presented in Table (1). The practical diet formulated from locally ingredients to contain 33.8 % crude protein and 4.5 kcal/g diet gross energy and covering all nutrient requirements of Nile tilapia. In preparing the diet, dry ingredients were first ground to a small particle size (approximately 250µm) in a willey mill. Ingredients were thoroughly mixed and then thoroughly added water to obtain a 30 % moisture level. Diet was passed through a mincer with die into 2.5-mm diameter spaghetti-like strands and was dried under sun for 8 h. After drying the diet was broken up and sieved into appropriate pellet sizes. Diet was stored at –20 C in plastic-lined bags until fish were fed. The fish were fed with a daily quantity of food equivalent to 5% of fish biomass in each tank during the whole experimental periods (22 weeks). Fish in each treatment were fed manually their daily amount of food two or four times daily, six days per week for 22 weeks. About 20% of fish in each tank were randomly sampled and measured at 4 weeks intervals for total length (L) to the nearest millimeter (mm) and body weight (Wt) to the nearest 0.1g.

Water quality analysis:

Water temperature and dissolved oxygen were measured every other day using YSI model 58 oxygen meter (Yellow Springs Instrument Company, Yellow Springs, OH, USA). Total ammonia and nitrite were measured once weekly according to Golterman(1978) using a DREL 2000 Spectrophotometer

(Hach Co., Loveland, CO). Total alkalinity and chloride were monitored once a week using the titration method according to Golterman(1978) and pH was monitored twice weekly using an electronic pH meter (pH pen, Fisher Scientific, Cincinnati, OH).

Growth performance parameters:

Growth response, production and feed utilization parameters were calculated as follows: SGR (% day^{-1}) = 100(Ln final weight - Ln initial weight)/ days; Net production = final biomass - initial biomass (kg/tank); Gain in weight (g/fish)= mean final body weight - mean initial body weight; Gain in total length = mean final body total length -mean initial total length (cm/fish) ; Condition factor (K) = 100(Wt/L^3), where Wt is fish body weight (g), L is total length (cm); Feed conversion ratio (FCR) = total dry feed fed (g)/total wet weight gain (g); Protein efficiency ratio (PER) = total wet weight gain (g)/ total dry protein fed (g); Feed intake (g/fish) was recorded daily and calculated at the end of the experiment. Net income was determined by the difference between the sale price of the fish after harvest and the costs of fingerlings and food according to Hengsawat, *et al.,* (1997).

Body composition analysis: -

For body composition analysis, 12 fish from each tank at harvest were randomly sampled and stored at –20 C for subsequent chemical analysis. Analysis of samples for diet and fish were made as follows, dry matter after desiccation in an oven (105 C for 24 h.), ash incineration at 550 C for 12 h., crude protein (microkjeldahl, N x 6.25), crude fat (ether extraction by Soxlhet method) and crude fiber, according to the methods of AOAC (1995).

Statistical analysis:

Data were analyzed using the SAS General Linear Models procedure (Statistical Analysis Systems 1993) as a 2 x 3 factorial for significance between two feeding frequency, among three stocking density, and among their interaction (Zar, 1984). Duncans multiple range test (Duncan's, 1955) was used to compare differences among individual means. All percentage and ratio data were transformed to arc sin values prior to analysis (Zar, 1984).

Table 1. Major ingredients and proximate analysis of the diet fed to mono-sex male Nile tilapia *O. niloticus* intensively reared in concrete tanks at different stocking density and feeding frequency.

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 [1]	1.5
Calcium di-basic phosphate	2.0
Molasses	2.0
L-methionine	1.0
L-lysine HCl	0.5
Proximate analysis[2] (% as fed)	
Moisture	9.8
Crude protein	33.8
Crude fat	10.4
Ash	7.9
Crude fiber	6.7
NFE [3]	31.4
Gross Energy (kcal/g diet) [4]	4.5

[1] Premix supplied the following vitamins and minerals(mg or IU)/ kg of diet, vit. A, 8000 I.U.; vit. D3, 4000 I.U.; vit. E 50 I.U.; vit. K3, 19 I.U.; 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).

[2] Values represent the mean of three sample replicates.

[3] Nitrogen free extract (NFE) = {100 - (moisture + crude protein + crude fat + ash + crude fiber)}

[4] 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).

RESULTS

Water quality:

Throughout the duration of the study, water quality parameters were not significantly different (P > 0.05) among treatments and averaged ± SE: water temperature, 26.7 ± 0.6 C; dissolved oxygen, 4.6 ± 0.3 mg/L; pH, 7.8 ±

0.4; total ammonia, 0.3 ± 0.1mg/L; nitrite, 1.54 ± 0.3 mg/L; alkalinity, 191 ± 42mg/L. Water quality parameters were within the acceptable range for tilapia growth (Stickney, 1979).

Fish growth and production:

Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* , final weight (g), final length (cm/fish), gain in weight (g), gain in length (cm), gain in weight (%) gain in length (%) and specific growth rate (%/day) after 22 weeks of rearing in concrete tanks in the present study are presented in table 2. It is evident from this table that, there were no significant differences in the initial weight and length of fish at the beginning of the experiment. At the end of the trial, average final weight and length were affected significantly by stocking density but final length was not influenced by feeding frequency. The highest average final weight and length of fish were recorded with the lowest stocking density (50fish/m^3) and the lowest were recorded in the highest stocking density (150fish/m^3). There were no significant interactions between stocking density and feeding frequency. There was a negative relationship between stocking density and final average weight and length of fish. When the stocking density was increased, the final average body weight and length of fish was decreased. Average gain in weight (g/fish), average gain in weight (%), average gain in length (cm/fish) and average gain in length (%) were affected significantly ($P \leq 0.01$) by stocking density but not influenced by feeding frequency. The highest average gain in weight (g) and gain in length (cm) of fish were recorded with the lowest stocking density (50fish/m^3) and the lowest were recorded in the highest stocking density (150fish/m^3). The lowest stocking density gave faster growth and had 5.6 folds more than the highest stocking density. The specific growth rate (%/day) were affected significantly ($P \leq 0.01$) by stocking density but not influenced by feeding frequency. The highest specific growth rate (% /day) was recorded with the lowest stocking density (50fish/m^3) and the lowest were recorded in the highest stocking density (150fish/m^3). The lowest stocking density had a specific growth rate of 3.7 (%/day), while the highest stocking density had a SGR of 0.94 (%/day). There were no significant interactions between stocking density and feeding frequency.

There was a negative relationship between stocking density and average gain in weight (g/fish) and average gain in length (cm/fish). When the stocking density was increased the average gain in weight and average gain in length of fish was decreased.

Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* average daily gain (g/fish/day), condition factor (K), total production and net production after 22 weeks of rearing in concrete tanks are presented in table 3. It is evident from this table that, average daily gain (g/fish/day) was affected significantly ($P \leq 0.01$) by stocking density but not influenced by feeding frequency. The highest average daily gain (g/fish/day) was recorded with the lowest stocking density (50fish/m^3) and the lowest were recorded in the highest stocking density (150fish/m^3). The lowest stocking density gave faster growth and had a daily gain of 0.27 (g/fish/day), while the highest stocking density had a daily gain of 0.17 (g/fish/day). Either stocking density or feeding frequency did not influence condition factor (K) significantly. The means of condition factors were 1.81, 1.78 and 1.73 for stocking density of 50fish/m^3, 100fish/m^3 and 150fish/m^3, respectively. The means of condition factors were 1.74 and 1.78 for feeding frequency of 2 times daily and 4 times daily, respectively. There were no significant interaction between stocking density and feeding frequency in terms of average daily gain and condition factor. There was a negative relationship between stocking density and average daily gain (g/fish).When the stocking density was increased the average daily gain of fish was decreased. Total production (kg/m^3) and net production (kg/ m^3) of the present experiment provided a picture for the stocking density and growth rate. Total production (kg/m^3) and net production (kg/m^3) were significantly ($P \leq 0.01$) the best at the highest stocking density (150fish/m^3). Harvests and production estimates increased with increasing stocking density. Significant differences ($P \leq 0.05$) were found between feeding frequency in terms of total and net production (kg/m^3). At the end of the experiment, total production was 3.04 kg/m^3 at the lowest stocking density (50fish/m^3) and 4.32 kg/m^3 at the highest stocking density (150 fish /m^3). Production data were the opposite to the individual weight during the growth period, that the individual weight decreased with the increasing stocking density (Table 2 & 3), while total production increased with increasing stocking density. Stocking density and feeding frequency showed a significant ($P \leq 0.05$) effect on net production and total production (Table3).

Table 3. Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* average daily gain (g/fish/day), condition factor (K), total and net production(kg/m3) after 22 weeks of rearing in concrete tanks. Values are means ± SD.

Items	Average daily gain (g/fish/day)	Condition factor (K)	Total production (kg/ m^3)	Net production (kg/ m^3)
Stocking density	**	N.S.	**	*
50 fish/m^3	0.27 ± 0.009 [a]	1.81 ± 0.14	3.04 ± 1.5 [b]	2.76 ± 1.4 [b]
100 fish/m^3	0.22 ± 0.008 [b]	1.78 ± 0.16	3.71 ± 1.4 [a]	3.43 ± 1.3 [a]
150 fish/m^3	0.17 ± 0.008 [c]	1.73 ± 0.34	4.32 ± 1.3 [a]	3.89 ± 1.3 [a]
Feeding frequency	N.S.	N.S.	*	*
2 times/day	0.19 ± 0.007	1.74 ± 0.15	3.51 ± 1. 3 [b]	3.18 ± 1.3 [b]
4 times/day.	0.22 ± 0.009	1.78 ± 0.34	3.98 ± 1.4 [a]	3.61 ± 1.4 [a]
SD x FF	N.S.	N.S.	N.S.	N.S.

1. Significant level: N.S. = $P > 0.05$, * = $P \leq 0.05$, ** = $P \leq 0.01$.
2. Means that have the same superscript letters within each classification column are not significantly different from each other.
3. SD = Stocking density; FF = Feeding frequency.

Feed utilization:

Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and feed intake (g/fish) after 22 weeks of rearing in concrete tanks are presented in Table 4. From this table, the results of feed conversion ratio, feed efficiency ratio, protein efficiency ratio and total feed intake were significantly ($P \leq 0.01$) affected by stocking density. But not affected significantly by feeding frequency. The best results of FCR, FER and PER were obtained at the highest stocking density 150 fish/m^3. There were no significant differences between fish stocked at 50/m^3 and 100/m^3 in terms of FCR, FER and PER. The lowest feed intake (g/fish) was obtained at the highest stocking density of 150fish/m^3 and there were significant differences ($P \leq 0.01$) between it and fish stocked at 50 fish/m^3 and 100fish/m^3. The highest food intake was achieved at lowest stocking density of 50 fish /m^3. There was no significant interaction between stocking density and feeding frequency in terms of all feed utilization parameters.

Table 4. Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and feed intake (g/fish) after 22 weeks of rearing in concrete tanks. Values are means ± SD.

Classification	FCR	FER	PER	Feed intake (g/fish)
Stocking density	**	**	**	**
50 fish/m^3	3.13 ± 0.8^{b}	0.34 ± 0.09^{b}	1.01 ± 0.28^{b}	124.3 ± 38.2^{a}
100 fish/m^3	3.57 ± 1.7^{b}	0.33 ± 0.13^{b}	0.99 ± 0.39^{b}	106.9 ± 27.5^{b}
150 fish/m^3	2.04 ± 1.3^{a}	0.62 ± 0.25^{a}	1.81 ± 0.76^{a}	43.2 ± 7.3^{c}
Feeding frequency	N.S.	N.S.	N.S.	N.S.
2 times/day	2.79 ± 1.6	0.46 ± 0.22	1.35 ± 0.6	74.50 ± 39.3
4 times/day	2.67 ± 1.5	0.49 ± 0.27	1.46± 0.8	81.46 ± 44.5
SD x FF	N.S.	N.S.	N.S.	N.S.

1. Significant level: N.S. = $P > 0.05$, * = $P \leq 0.05$, ** = $P \leq 0.01$.
2. Means that have the same superscript letters within each classification column are not significantly different from each other.
3. SD = Stocking density; FF = Feeding frequency.

Body composition:

The effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* whole fish body proximate composition (%) of Moisture, crude protein, crude fat and crude ash after 22 weeks of rearing in concrete tanks are presented in Table 5. It is evident from this table that whole body moisture and ash contents did not significantly ($P > 0.05$) influenced by either stocking density or feeding frequency. Whole body protein contents were not significantly influenced by feeding frequency, but were significantly ($P \leq 0.01$) influenced by stocking density. The highest whole body protein content was recorded with fish stocked at 100fish/m^3, but the lowest was at 50fish/m^3. Whole body fat contents were not significantly influenced by stocking density, but were significantly ($P \leq 0.01$) influenced by feeding frequency.

Table 5. Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* whole fish body composition (%) of moisture, crude protein, crude fat and crude ash after 22 weeks of rearing in concrete tanks. Values are means ± SD, dry mater basis.

Classification	moisture	crude protein	crude fat	crude ash
Stocking density	N.S.	**	N.S.	N.S.
50 fish/m^3	70.0 ± 0.13	42.9 ± 0.45 ^{b}	30.1 ± 0.39	12.2 ± 0.76
100 fish/m^3	72.4 ± 1.2	44.7 ± 0.49 ^{a}	28.0 ± 1.9	12.2 ± 1.13
150 fish/m^3	72.3 ± 2.4	43.5 ± 0.96 ^{b}	28.0 ± 3.9	11.0 ± 2.13
Feeding frequency	N.S.	N.S.	**	N.S.
2 times/day	70.5 ± 0.64	43.2 ± 0.91	30.3 ± 0.85 ^{a}	11.8 ± 0.72
4 times/day	72.5 ± 2.1	44.1 ± 0.98	27.1 ± 2.61 ^{b}	11.7 ± 2.02
SD x FF	N.S.	N.S.	N.S.	N.S.

1. Significant level: N.S. = $P > 0.05$, * = $P \leq 0.05$, ** = $P \leq 0.01$.
2. Means that have the same superscript letters within each classification column are not significantly different from each other.
3. SD = Stocking density; FF = Feeding frequency.

Economic information:

The economic information for mono sex male Nile tilapia reared in concrete tanks for 22 weeks at three stocking densities at two feeding frequencies are presented in Table 6. From this table the net profits were directly related to stocking density and feeding frequency. The fingerlings cost (Lever Egyptian) increase by increasing stocking density. Also, the food cost and total cost (Lever Egyptian) increases by increasing stocking density. From the economic information, it can be concluded that the highest net profit (Lever Egyptian) was achieved at stocking density of 150 fish /m^3 at 4 times/day feeding frequency in concrete tanks.

Table 6. Economic information for mono-sex male Nile tilapia intensively reared in concrete tanks for 22 weeks at three stocking densities and two feeding frequencies (F.F.).

	F.F. 2 times/day			F.F. 4 times/day		
	Stocking density			Stocking density		
Parameters	50 /m^3	100 /m^3	150 /m^3	50 /m^3	100 /m^3	150/m^3
No. fish stocked / tank (4m^3)	200	400	600	200	400	600
No. fish harvested	200	400	600	200	400	600
Survival rate (%)	100	100	100	100	100	100
Initial wt. stocked (kg/tank)	0.56	1.12	1.68	0.56	1.12	1.68
Total production (Kg/tank 4m^3)	8.0	14.0	15.9	9.7	15.7	18.6
Net production (Kg/tank 4m^3)	7.4	12.9	14.2	9.1	14.6	16.92
Food used (kg/tank 4m^3)	23.02	47.6	29.9	28.2	49.6	33.84
Fingerling cost (0.15 LE*./fish)	30.0	60.0	90.0	30.0	60.0	90.0
Food cost (1.7 LE. /kg diet)	39.1	81.0	50.8	47.96	84.4	57.5
Total cost (LE.)	69.1	141.0	148.8	77.9	144.4	147.5
Value of harvest (11 LE. /kg)	88.0	154	174.9	106.7	172.7	204.6
Net profit (LE.)	18.9	13.0	26.1	28.8	28.3	57.1

LE. = Lever Egyptian (about 0.18 Dollar).

Fingerlings cost calculated as 150 L.E./1000 fingerlings.

Total production= total biomass at the end of the experiment (kg/tank 4m^3).

Net production= final biomass – initial biomass (kg/tank 4m^3).

DISCUSSION

There are several factors supporting the use of intensive fish culture in recirculating systems. Increasing land costs and decreasing freshwater supplies are the main reason for intensification of fish farming in Egypt, though additional advantages include savings in manpower and easier stock management. Increased fish yields in conventional, static ponds or reservoirs was accomplished by a combination of management procedures, the most important among them being the use of supplementary feed, polyculture, and auxiliary aeration during the night (Sarig, 1989). Higher yields were obtained in specially designed smaller units, 50-1000m^3 (Van Rijn *et al*. 1986), which differ from conventional ponds in design. These are made of concrete or are plastic-lined, and their configuration allows periodical removal of organic matter from the bottom. Most of these units are operated in a semi-closed mode, allowing optimal use of water and hence, minimal water discharges. Due to their reduced environmental impact, national and

regional authorities support their development. Pollution control is, therefore, another factor underlying the development of intensive systems. Finally, culture of fingerlings (mainly tilapia) during off-season in heated, indoor systems is rapidly expanding, and so, heat conservation can be counted as an additional factor promoting the use of intensive recirculating systems.

Feeding frequency and stocking density are important factors affecting growth and maturation of cultured fish (Huang and Chiu, 1997). As stocking density increases, competition for food and living space usually intensifies providing one of the most effective controls on animal production (Huang and Chiu 1997). The effects of density may be divided into two categories: the density dependent and the density-independent. The stocking density that significantly negatively affects the growth of fish was considered as the density dependent category, such as the cases found for chinook salmon, *Oncorhynchus tshawytscha* (Martin and Wertherimer, 1989), and Nile tilapia, *Oreochromis niloticus* (L.) (Siddiqui *et al*., 1989). In the present study, the similar case of negative curvilinear relationship was found between stocking density and growth weight of Nile tilapia (Table 2).

The effect of stocking density on tilapia fingerlings might be dependent upon the biological characteristics of fish, such as, tolerance to environmental change, life stage, sex, social interaction and behavior, so that the density effect on growth and production might be explainable by their competition for territories, with similar case found for African catfish (Haylor, 1991). Behavioral studies on red tilapia indicating that growth inhibiting antagonistic behavioral patterns was generally unabated even at the highest stocking density (Suresh and Lin, 1992). The stress on fish caused by the crowdedness may be the other explanation for the effect of stocking density. Hogendoorn and Koops (1983) also found that the highest biomass (Harvest) was achieved at the highest stocking density for African catfish cultured in ponds. Culture of Nile tilapia, *O. niloticus* in cages showed that the highest stocking density (100 fish /m^3) achieved the highest biomass after five and half months (Daungsawasdi *et al*., 1986). Similar results were obtained in our experiment, the highest biomass was achieved at stocking density of 150 fish /m^3 at 4 times/day feeding frequency.

The growth of Nile tilapia was affected significantly by the stocking density not by the feeding frequency. Fish reared at low density grow better than those reared at high density (Table 2), and the differences were significant. Final mean weight was inversely proportional to stocking density, particularly evident when average weight of fish reared at the lowest stocking density was significantly different from weight of fish reared at the higher densities. Stocking density also affected the growth of *C. macrocephalus* x *C.*

gariepinus **hybrids cultured in concrete ponds at three different densities (Jarimopas *et al*., 1999). Fish reared at the highest density had the lowest final mean weight. These results may be attributed to the fish at low density consume maximum amount of food available and grow fast (Essa and Nour, 1988). Also, Hepher *et al.* (1989) reported that slow growth of fish at high density was probably due to that the individuals disturbing each other during feeding and normal activity.**

While final harvest and production values were directly related to stocking density, there must be some density at which mortality is severe for a variety of causes and growth rate is reduced. When this occurs, production will be reduced. This critical level was not reached in our experiment, although the stocking density of 150 fish/m^3 was high. One reason for the ability of Nile tilapia to maintain high production levels when available oxygen present and unionized ammonia is reduced. Rearing densities of 150 fish/m^3 for fingerling would seem to be the most desirable in the system studied. There was a strong trend for both production and final harvest to increase with increasing stocking density (Table. 3). These results are in agreement with those of Cruz and Ridha (1989) from studies on tilapia (*Oreochromis spilurus*) reared in cages. Also, Al-Jerian (1998) reported that production of fish culture are generally depended on the stocking density, flow rates, daily feed consumption rate and feeding frequency.

In the present study feeding frequency not significantly influenced the growth performance and feed utilization parameters. One problem facing fish culturists is the need to obtain a balance between rapid fish growth and optimum use of the supplied feed. On contrast to our results, increased feeding frequency has been shown to improve the growth of various fish species (Andrews and Page, 1975). Two or three feedings a day have been found to be sufficient for maximum growth of a number of species such as grouper *Epinephelus tauvina* (Chua and Teng, 1978), sea bass *Dicentrarchus labrax* (Tsevis *et al*., 1992) and rainbow trout (Grayton and Beamish, 1977). Optimum feeding frequency seems to be dependent on fish size, since fingerlings require a higher number of daily feeding for good growth and survival (Folkvord and Otter. 1993). Social dominance hierarchies affect feeding behavior of fish fed in groups and thus, probably, the required number of feedings per day (Jobling, 1995), which makes it difficult to distinguish between the effects of food availability, food dispersion and optimum number of daily meals on an individual level. Rouhonen (1986) reported that the average growth rate increased and size variation decreased in a group of juvenile Atlantic salmon when they were fed up to 60 times a day. Earlier, Shelbourn *et al*. (1973) reported that Sockeye salmon fry showed significantly higher growth rate when fed continuously for 15h a day in comparison to being fed to satiation three times a day. For larger Atlantic

salmon, Thomassen and Fjaera (1996) found no effect of feeding frequencies of 3, 9 or 27 times in a day.

In the present study feeding frequency had no significant effect on feed consumed and feed conversion ratio of fish. This is in agreement with that of Gouranga *et al.* (2006) who reported that feeding three times daily showed the lowest FCR followed by feeding twice daily, no significant difference ($P \geq 0.05$) was observed among the values. On contrast to our results, Kenneth *et al*., (2000) found that the amount of diet consumed by fish fed twice/day was significantly higher 119g diet/fish compared to fish fed all other feeding frequencies. Feed conversion ratio (FCR) of fish fed twice/day was significantly higher (1.50) compared to fish fed once/day (1.28) and once every other day (1.15) but not different ($P \geq 0.05$) from fish fed twice every other day (1.35).

In the present study, it is evident that whole body moisture, ash and fiber contents did not significantly ($P > 0.05$) influenced by either stocking density or feeding frequency. Whole body protein contents were not significantly influenced by feeding frequency, but were significantly ($P \leq 0.01$) influenced by stocking density. Whole body fat contents were not significantly influenced by stocking density, but were significantly ($P \leq 0.01$) influenced by feeding frequency. These results were in agreement with those of El-Saidy and Gaber (2002).

From the above results and the economic information of the study it can be concluded that, stocking density of 150 fish /m^3 of mono-sex male Nile tilapia reared in concrete tanks at feeding frequency of four times/day exhibited the highest production and net profit and would seem to be the most desirable density under this system conditions.

REFERENCES

Al-Jerian, A. A. (1998). Growth of *Oreochromis aureus* at three different water exchange rates. J. Egypt. Ger. Soci. Zool., 27 (a) : 57-62.

Andrews, J.W. and J.W. Page (1975). The effects of feeding frequency of feeding on culture of catfish. Trans . Am. Fish . Soc., 104 :317-321.

AOAC (Association of Official Analytical Chemists) (1995). Official methods of analysis, 16th edition. AOAC, Arlington, Virginia.

Atay, D., M. Olmez, A. S. Gulen and S. Bekcan (1988). The effects of different stocking rates on the growth of rainbow traut (*Salmo gairdneri R.*) in concrete canals at the Cifteler Sakaryabasi Station. Journal of Aquatic Product 2, : 223-233.

Baker, R. F. and G. B. Ayles (1990). The effects of varying density and loading level on the growth of Arctic charr (*Salvelinus alpinus L.*)and rainbow trout (*Oncorhynchus mykiss*).World Aquaculture, 21: 58-62.

Balarin, J. D. and R. D. Haller (1982). The intensive culture of tilapia in tanks, raceways and cages. In: I. F. Muir and R. J. Roberts (Editors), Recent Advances in Aquaculture. Westview Press, Boulder, CO. USA, pp. 265-355.

Balarin, J. D. and R. D. Haller (1983). Commercial tank culture of tilapia. In Fishelson, L., Yaron, Z. (eds), Proceedings of the International Symposium on Tilapia in Aquaculture, Israel, Tel Aviv Univ. Press, pp. 473-483.

Brauhn, J. L., R. C. Simon and W. R. Bridges (1976). Rainbow trout growth in circular tanks. Consequences of different loading densities. US Department of the Inttherior, Fish and Wildlife Service Technical Report 86, 16 PP.

Chua, T. E. and S. K. Teng (1978). Effects of feeding frequency on the growth of young estuary groupers, *Epinephelus taueina* (Forskal), cultured in floating net cages. Aquaculture, 14 : 31- 47.

Costa-Pierce, B. A. (1997). Tilapia Aquaculture in The Americas –Preface. In: Tilapia Aquaculture in The Americas.World Aquaculture Society Conference Proceedings,Vol. 1(ed. by B. A. Costa – Pierce & J. E. Rakocy), Baton Rouge, Louisiana, USA .

Cruz, E. M. and M. Ridha (1989). Preliminary study on the production of the tilapia, *Oreochromis spilurus* (Ganther), cultured in sea water cages. Aquacult. Fish. Manage., 20: 381-388.

Daungsawasdi, S., C. Chomchei, R. Yamorbsin and B. Kertkomut (1986). Net cage culture of Tilapia and Puntius in klong praew irrigation tank. Tech. pap. NIFI No. 64, Bangkhen, Bangkok, Thailand, 10 pp.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11: 1-42.

El-Saidy, D.M.S.D. and M.M. A Gaber (2002). Intensive culture of Nile Tilapia, *Oreochromis niloticus* in concrete tanks in Egypt: Effect of stocking density and feeding levels on growth performance, production traits, feed conversion and body composition. Proc., 1st Sc. Conf. Aqua., El Arish 13-15 Dec. pp. 1-22.

Essa, M. A. and A. M. Nour (1988). Intensification of fish production. Effects of stocking density and supplementary feeding on growth, food utilization and cost of Tilapia hybrid production in cages. Proc. First

Scientific Conf. on the Role of Scientific Research in the Development of Fish Resources., 6-8 Aug., Fac. of Agri., Alex. Univ., Egypt.

FAO (1980). Report of the ad hoc consultation on aquaculture research, FAO Fish. Rep. 238, FAO, Rome, 26pp.

Folkvord, A. and A. H. Otter (1993). Effects of initial size distribution, day length and feeding frequency on growth, Survival, and cannibalism in juvenile Atlantic cod (*Gadus morhua* L.). Aquaculture, 114: 243 -260.

Golterman, H. L., R. S. Clymo and M. A. M. Ohnstad (1978). Methods of physical and chemical analysis of fresh waters. Blackwell Scientific Publications, Oxford, 214pp.

Gouranga, B., K. J. Joy, K. S. Sarat and K. M. Hare (2006). Effect of feeding frequency on growth, survival and feed utilization in fingerlings of *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) in outdoor rearing systems. Aquaculture Research, 37: 510-514.

Grayton, B. D. and F. W. H. Beamish (1977). Effects of feeding frequency on food intake, growth and body composition of rainbow trout (*Salmo gairdneri*). Aquacuulture, 11: 159 – 172.

Haylor, G. S. (1991). Controlled hatchery production of *Clarias gariepinus* (Burchell 1822): Growth and survival of fry at high stocking density. Aquacult. Fish. Manage., 22 : 405-422.

Hengsawat, K., F. J. Ward and P. Jaruratjamorn (1997). The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages. Aquaculture, 152: 67-76.

Hepher, B., A. Milstein, H. Leventer and B. Teltsch (1989). The effect of fish density and species combination on growth and utilization of natural food in ponds. Aquaculture and Fisheries Management, 20 (1): 59-71.

Hogendoorn, H. and W. J. Koops (1983). Growth and production of African catfish, *C. lazera* (C. and V.) I. Effects of stocking density, pond size and mixed culture with tilapia (*S. niloticus*) under extensive field conditions. Aquaculture, 34: 253-263.

Huang, W. B. and T. S. Chiu (1997). Effects of stocking density on survival, growth, size variation, and production of Tilapia fry. Aquaculture Research, 28: 165-173.

Jarimopas, P., S. Nukwan and K. Lawanyawut (1999). production of clarias hybrid (*Clarias macrocephalus* x *C. gariepinus*) cultured in concrete ponds with various stocking rates. Nifi. Newsi, 2 (1): 1-8.

Jobling, M. (1995). Feeding of charr in relation to Aquaculture. Nordic Journal of Freshwater Research, 71: 102-112.

Kenneth, R. T., D. W. Carl, M. Ann, E. Morgans and J. C. Bony (2000). Effects different feeding frequency on growth, Body composition and fillet composition of juvenile sun shine Bass, *Morone chryseps* x *M. saxatilis*, grown in doors. Journal of Applies Aquaculture, 10 : 111-121

Logan, S.H. and W.E. Johnston (1992). Economics of commercial trout production.Aquaculture,100:25- 46

Martin, R. M. and A. Wertherimer (1989). Adult production of Chinook salmon reared at different densities and released as two smolt sizes. Progressive Fish-Culturist, 51: 194-200.

Papoutsoglour, S. E., G. Tzina, vrettos, and A. Athanasiou. (1998). Effects of stocking density on behavior and growth rate of European sea bass (*Dicentrarchus labrax*) juveniles reared in a closed circulated system. Aquaculture Engineering, 18: 135- 144.

Pullin, R. S.V. and J. B. Capili (1988). Genetic improvement of tilapia : Problems and Propspects. In: The Second International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings (ed . by R. S. V. Pullin, T. Bhukaswan, K. Tonguthai & J. L. Maclean), pp. 259-266 . ICLARM , Manila, Philippines.

Purser, J. and P. Hart (1991). Effect of stocking density on the growth of juvenile raionbow trout. Austasia Aquaculture, 5: 46 – 48.

Rouhonen, K. (1986). Biological models related to automatic control in aquaculture. A case study: automatic feeding control. In Automation and Data processing in Aquaculture. Proc. IFAC. Symp. 15-21. August 1986, Trondheim, Norway, Pergam. pp.75-80.

Sanz, A., M. Morales; De La Higuera and G. Cardenete (1994). Sun flower meal in rain bow trout (*Oncorhynchus mykiss*) diets: protein and energy utilization. Aquacult., 128: 287-300.

Sarig, S. (1989). Introduction and state of art in aquaculture. In: Fish Culture In Warm Water Systems. Problems and Trends(ed. by M. Shilo and S. Sarig) pp. 2-19, CRC press. Boca Raton, FL., USA.

Shelbourn, J. E., J. R. Brett and S. Shirahata (1973). Effect of temperature and feeding regime on the specific growth rate of sockeye salmon fry (*Oncorhynchus nerka*), with a consideration of size effect. J. Fish. Res. Bd. Can., 30: 1191 – 1194.

Siddiqui, A. Q., M. S. Howlader and A. B. Adam (1989). Culture of Nile tilapia, *Oreochromis niloticus* (L.) at three stocking densities in outdoor concrete tanks using drainage water. Aquaculture and Fisheries Management,. 20: 49-58.

Statistical Analysis System (1993). SAS/STAT User's Guide Release 6.03 edition. SAS Institute Inc. Cary. NC.

Stickney, R. R. (1979). Principles of Warm Water Aquaculture. John Wiley and Sons, New York, USA.

Suresh, A.V. and C.K. Lin (1992). Effect of stocking density on water quality and production of tilapia in recalculated water system. Aquaculture Engineering, 11: 1- 22.

Thomassen, J. M. and S.O. Fjaera (1996). Studies of feeding frequency for Atlantic salmon (*Sulmo salar*). Aquaculture Engineering., 15: 149-157.

Tsevis, N. S., S. Klaoudato and A. Conides (1992). Food conversion budget in sea bass, *Dicentrarchus labrax* fingerlings under two different feeding frequency patterns. Aquaculture, 101: 293 – 304.

Van Rijin, J., S. R. Stutz, S. Diab and M. Shilo (1986). Chemical, physical and biological parameters of super intensive concrete fish ponds. Bamidgeh, 38(2): 32-43.

Xie S., Y. Cui, Yi Yang and J. Liu (1997). Energy budget of Nile tilapia, *Oreochromis niloticus* in relation to ration size. Aquaculture, 154: 57-68.

Zar, J. H. (1984). Biostatistical Analysis. Prentice Hall, Inc, Inglewood Cliffs, NJ, 620pp.

تأثيرعدد مرات التغذية و الكثافات العددية للأسماك على اداء أسماك البلطى النيلى وحيد الجنس ذكور المستزرع فى الأحواض الأسمنتية

دياب محمد سعد دياب الصعيدى ، عاطف محمد حسن ابوعاشور ،
عبد المنعم عبد الحليم الفقى ، أسماء عبد العال علام
قسم إنتاج الدواجن–كلية الزراعة بشبين الكوم–جامعة المنوفية–مصر

الملخص العربى

أجريت هذه التجربة لمدة ٢٢ أسبوع في الأحواض الأسمنتية لدراسة تأثيرعدد مرات التغذية والكثافة العددية للاسماك فى المتر المكعب من المياه على صفات النمو والإنتاج والاستفادة من الغذاء ومكونات الجسم لأسماك البلطي النيلى وحيد الجنس ذكور. استخدام عدد ١٢ حوض أسمنتي سعة كل منها ٤م^{٣} مياه . تم استخدام عدد ٤٨٠٠ إصبعية بلطي نيلي وحيد الجنس ذكور متوسط وزن إبتدائى٢.٨ ± ١.٣جم /سمكة ومتوسط طول ابتدائي ٥.٢± ٠.٩ سم/سمكة، وزعت الأسماك عشوائيا على الأحواض بكثافات عددية ٢٠٠، ٤٠٠ ، ٦٠٠ سمكة/حوض (٥٠، ١٠٠، ١٥٠ سمكة/م^{٣})، وغذيت الأسماك على عليقة تحتوى على ٣٣.٨ % بروتين بمعدل ٥% من وزن الجسم الحي للأسماك في اليوم حتى نهاية التجربة. غذيت الأسماك لمدة ٦ أيام في الأسبوع، على وجبتين أو اربع وجبات يوميا، وتم عمل مكررين لكل معاملة. وفيما يلى أهم النتائج: وجد أن الكثافة العددية للأسماك قد أثرت معنويا عند مستوى ٠.٠١ على متوسط وزن الجسم النهائي، ومتوسط طول الجسم النهائي، والزيادة في وزن الجسم، والزيادة في طول الجسم، والزيادة النسبية في وزن الجسم، والزيادة النسبية في طول الجسم، ومعدل النمو اليومي، ومعدل النمو النسبي اليومي، حيث كانت أفضل النتائج مع الكثافة العددية الأقل (٢٠٠ سمكة /حوض أو ٥٠ سمكة/م^{٣})، وعلى العكس من ذلك، وجد أن الإنتاج الكلى والإنتاج الصافى أظهرت أعلى النتائج مع كثافة الأسماك الأعلى (٦٠٠ سمكة/حوض أو ١٥٠سمكة/م^{٣}). وجد أن عدد مرات التغذية لم تؤثر معنويا عند مستوى ٠.٠٥ على صفات النمو والاستفادة من الغذاء، بينما أثرت معنويا على متوسط وزن الجسم النهائى والانتاج الكلى والانتاج الصافى. وجد أن معامل الحالة للأسماك لم يتأثر معنويا بالكثافة العددية للاسماك أو

عدد مرات التغذية. وجد أن الكثافة العددية ١٥٠سمكة/م٣ أظهرت أفضل النتائج لصفات الاستفادة من الغذاء، كذلك أظهرت النتائج أن مكونات الجسم من الرطوبة والرماد الخام لم تتأثر معنويا بكل من الكثافة العددية للأسماك وعدد مرات التغذية. وجد أن مكونات الجسم من البروتين الخام تأثرت معنويا بالكثافة العددية للأسماك ولم تتأثر معنويا بعدد مرات التغذية. بينما وجد أن مكونات الجسم من الدهن الخام تأثرت معنويا بعدد مرات التغذية، ولم تتاثر معنويا بالكثافة العددية للأسماك

من النتائج السابقة والدراسة الاقتصادية للتجربة نستنتج أن الكثافة العددية ٦٠٠ سمكة للحوض أو ١٥٠ سمكة/م^{٣} مع عدد مرات تغذية أربعة مرات يوميا تبدو أنها المثلي تحت ظروف نظام الاستزراع المستخدم حيث أنها أعطت أعلى إنتاج وكذلك أعلى عائد اقتصادى.

Table 2. Effects of stocking density and feeding frequency on mono-sex male Nile tilapia, *O. niloticus* final weight (g/fish), final length (cm/fish), gain in weight (g/fish), gain in length (cm/fish), gain in weight (%), gain in length (%) and specific growth rate (%/day) after 22 weeks of rearing in concrete tanks. Values are means ± SD.

Items	Average body weight (g/fish)		Average body length (cm/fish)		Average gain		Average gain		SGR
	Initial	Final	Initial	Final	in weight (g/fish)	In length (cm/fish)	In weight (%)	In length (%)	(%/day)
S.D.	N.S.	**	N.S.	**	**	**	**	*	**
50 fish/m^3	2.8 ± 1.3	44.2 ± 14.9^{a}	5.2 ± 0.91	3.3 ± 1.3^{a}	41.4 ± 14.4^{a}	8.1 ± 1.2^{a}	1664.5 ± 713.8^{a}	161.8±38.9^{a}	3.70±0.33^{a}
100 fish/m^3	2.8 ± 1.3	37.1 ± 13.7^{b}	5.2 ± 0.91	2.6 ± 1.4^{b}	34.3 ± 13.4^{b}	7.4 ± 1.6^{b}	1410.0 ± 636.9^{b}	149.5±49.9^{ab}	0.94±0.41^{b}
150 fish/m^3	2.8 ± 1.3	28.8 ± 10.5^{c}	5.2 ± 0.91	1.7 ± 1.4^{c}	26.0 ± 10.6^{c}	6.5 ± 1.7^{c}	1105.3 ± 591.0^{c}	132.4±49.9^{b}	0.94±0.40^{c}
F.F	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S
2 times/day	2.8 ± 1.2	31.6 ± 11.0^{b}	5.2 ± 0.91	2.1 ± 1.3	28.8 ± 10.9	6.81± 1.5	1206.2 ± 582.5	138.6±47.8	1.39 ± 1.09
4 times/day	2.8 ± 1.2	36.6 ± 15.5^{a}	5.2 ± 0.91	2.5 ± 1.7	33.8 ± 15.3	7.31 ± 1.8	1394.0 ± 718.4	147.4±50.6	1.42 ± 1.15
SD x FF	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S

1. Significant level: N.S. = $P > 0.05$, * = $P \leq 0.05$, ** = $P \leq 0.01$.

2. Means that have the same superscript letters within each classification column are not significantly different from each other.

3. SD = Stocking density; FF = Feeding frequency.