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PRELIMINARY OBSERVATIONS ON THE RELATIVE GROWTH AND PRODUCTION OF TILAPIA SPECIES CULTURED IN CAGES AT THREE STOCKING DENSITIES

By

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ABSTRACT

Relative growth rate and productivity of *Tilapia* species (*T. nilotica* and *T. galilaea*) were studied for fish reared in cages in the Serow fish farm, Egypt. Both species were reared under three different stocking densities 100, 200 and 300 fish/m^3.The fish were fed daily with supplementary food of 20% protein content at 5% of the stock weight.Control cages of each type of fish at the lowest stocking density were maintained without supplementary feeding.

Results indicated that the individual growth rate of both species decreased with increased stocking densities with a best aggregate stocking rate of 200 fish/m^3 for both species.The maximum production rates of 32.0 and 17.4 kg/m^3/six months and final average size of 178.7 and 108.7 gm/fish were recorded for *T.nilotica* and *T. galilaea* respectively.The range of food conversion ratios for *T. nilotica* were between 2.83 and 3.57 while for *T. galilaea* were 3.88 and 5.20 with efficiency decreasing with increasing stocking density. Survival rates at the three densities ranged between 97.5—100% indicating that *Tilapia* species are able to withstand a certain degree of crowding, which is an important characteristic in the intensive culture of the fish.

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INTRODUCTION

Tilapia species are considered the most important fish in Egypt and are considered the basis of the fisheries sector there since they represent over 70% of Egyptian fish landings, (Ishak *et al.* 1985). In Egypt, the need for increasing fish production is necessary in view of the high demand for fish as a relatively cheap source of animal protein. Recently attention has been focused on fish farming as having the best potential for achieving new sources of fish production. So, the interest in aquaculture potential has been directed mainly towards the development of pond culture, either in shallow or deep ponds (Ishak, 1985). A polyculture system of mullets (*Mugil cephalus and Mugil capito*), Tilapias (*Tilapia nilotica, T.galilaea and T. zillii*) and the common carp (*Cyprinus carpio*) has been developed.

According to Hickling(1962), the method of raising fish in enclosures was described for the first time by Lafont and Saveun in 1951 in Cambodia. This method of fish culture has been expanded to other countries of the far east (Ling, 1967; Bardach *et al.,* 1972 and Coche, 1976).

In the United states of America (USA) the cage fish culture method was introduced for the first time in 1964 in Alabama (Trotter, 1970). Many other countries such as United States of Soviet Republic (USSR) (Gribanov *et al.,* 1968), Canada (Seguin, 1970), United Kingdom (UK) (Milne, 1972) and Chile (Arroyo, 1973) became interested in culturing fish in cages.

Recently, initial experiments have been started in the Philippines for *Tilapia mossambica* and *Tilapia nilotica* in cages (Guerrero, 1979). In Africa no experience in this field had been obtained before 1974. Some observations were made on *Clarias lazera* (Kimp and Micha, 1974) in the Central African Republic. In Tanzania, some semi–intensive rearing was done using *Tilapia esculenta* and *Tilapia zillii* in lake Victoria (Ibrahim *et al.,* 1974).

The possibilities for cage fish culture in lake Kainji, Nigeria, as well as in the Niger River which are immediatelly below the Kainji dam, were studied by FAO. A research programme is being implemented with four *Tilapia* species namely *T. galilaea, T. meanopleura, T. nilotica and T. zillii* being cultured (UNDP/FAO, 1975).

The aim of the present study is to introduce additional methods of fish farming in Egypt and to evaluate the growth rate and productivities of *T. nilotica and T. galilaea* reared in cages at different stocking densities.

MATERIALS AND METHODS

Fish fries of *T. nilotica* and *T. galilaea* were reared in the Serow experimental fish farm situated on the southern shore of lake Manzalah, Egypt, were kept for six months and fed upon available pellet feeds in the farm to reach the fingerling size. The fish were collected thereafter either by seining which is suitable for collecting fish of less than 20 gm., or by cast net that can collect the whole range of sizes. The fish caught were transported in plastic containers to tanks containing clear water for size determination which was found to range from 7.0–12.5 cm in total length with corresponding weight range of 7.0–31.4 gm and from 8.0–13.5 cm and 8.0–38.0 gm for *T. nilotica* and *T. galilaea* respectively. The sized fish were then transported to a large happa suspended in the experimental pond and left there for one week for the fish to get acclimated to the experimental conditions. Meanwhile dead and unhealthy fish were eliminated daily.

The dimensions of the floating cages (which were used for rearing Tilapia) were 2x2x1.5 meter and 1x1x1.5 meter with submerged portion of one meter depth. Therefore the capacity of the net cage which was always submerged in water was 4 m^3 and 1 m^3 respectively and accordingly, the initial stocking densities of the fish were estimated.

Each species was reared in two cages volumes (4 m^3 and 1 m^3) at three different stocking densities 100, 200 and 300 fish/m^3 and in duplicate cages for each volume. Control cages for each species were stocked with the least stocking density (100 fish/m^3) and also maintained whithout supplementary food throughout the period of the experiment. The food used for feeding the fish in cages contained 20% porteins and was given at a daily rate of 5% of the weight of the stock, based on monthly determination of the total weight of the stock in each cage. The water temperature ranged between 23–31°C throughout the whole period of experiment.

The water flow of the pond was adjusted in a way to assure continuous renewal of the water throughout the experiment period. The inlet and the outlet gates were screened by galvanized wire which has a suitable mesh size to avoid the entrance of wild fish and their larvae or their eggs especially the predator species such as the cat fish *Clarias lazera* and the Nile perch *Lates niloticus*.

RESULTS AND DISCUSSION

Tilapia nilotica

The experiment started with fingerlings of *Tilapia nilotica* which had an initial average weight 14.2 gm and the length averaged 9.3 cm (Tables 1 and 2). In Egypt, it is well known that T*ilapia nilotica* is the most popular fish (El–Zarka *et al.,* 1970). In the present investigation it has been shown that the rearing of this species in cages about either of 1 m^3 or that of 4 m^3, gave an average weight of about 195, 177 and 124 g/fish at stocking densities 100, 200 and 300 fish/m^3 respectively. However, in case of the control group where there are no supplementary feed, the average size attained is 41.0 g/fish. The mean net production in case of 200 fish/m^3 was found to be 32 kg/m^3 with an average weight of 177 g./fish after 180 days (Tables 3 and 4). This is considered as a table size.

The cages stocked with 100 fish/m^3 showed a greater average growth rate per fish per day, in the small cage the rate is 1.02 g. and in the large one 1.01 g. The rate of growth per day decreases as the stocking density increases to 200 and 300 fish/m^3 (Tables 3 and 4) . It is 0.89 and 0.54 g. for the small cages and 0.90 and 0.68 g. in the large cages respectively.

Coche (1975) reported an average production of 61.1 kg/m^3 in the Ivory Coast using 1 m^3 floating cage stocked with an average 340 fish/m^3 (size 29 g.) within 125 days. Such discrepancy between the result of Coche (1975) and the present investigation may be ascribed on the base of food and the local ecological and climatic conditions where he used pelleted food of 25% protein. But the food used for this investigation was the commercial food for the lifestock of not more than 20% protein. Moreover, Coche (1975) used an initial size of 28.8 g. while in the present investigation the weight used was 14.2 g./fish.

The statistical analysis shown in Table 5a indicates that the differences between the mean weight of the fish obtained from the cages at different stocking densities and attained from the control group are significant at the 1% level ($P < 0.99$). The comparison between the cages stocked at lower stocking density (100 fish/m^3) which is supplied with supplementary feed and those stocked with higher stocking densities fed also with the same feeding ratio (5% by weight) indicated that at the stocking densities of 100 fish/m^3 and 200 fish/m^3, no statistically significant differences were found between the mean weight of fish either in case of 1 m^3 cages or that of 4 m3 cages (Table 5b). However, at the stocking density of 100 fish/m^3 and that of 300 fish/m^3 the differences between the mean weight of the individual fish are statistically significant at 0.1% ($P < 0.99$) in both cages of 1 m^3 and 4 m^3. This indicates that in the foresaid two capacity cages, the mean weight of fish attained at stocking density of 100 fish/m^3 is significantly greater than that gained at 300 fish/m^3 in spite of the relatively lower total production of fish per cage at the lower stocking density. However, the fish obtained from the cages of stocking density 300 fish/m^3 are not preferable for the table size and their price is less.

Further t-test analysis were made to determine the effect of cage volume on production. The results shown in Table 5c indicate that there were no statistically significant differences between the mean weight of fish obtained from the cages of 1 m^3 and that attained from the cages of 4 m^3 in most of the cages at the different expermimental stocking densities. Only a signifigant difference was found between the mean weight of cage 1 m^3 and 4 m^3 at the stocking density of 300 fish/m^3 which may be an experimental error.

The feed conversion rate in the present investigation is 3.57. However, Pagan (1970) reported a conversion ratio of 1.2-1.7 by intensive floating pellets as feed. Coche (1975) gave the value of 2.8 as an average conversion ratio for the same species. It may be assumed that these different values given by different authors are due to the quality of feed used and to other environmental factors.

Table 1

Average growth in Length of Tilapia nilotica (avg. wt. 14.2 g/fish) reared in cages of different sizes and at different stocking rates.

Month	Days after Stocking	Stocking Density (Fish/m^3)							
		100 (Control)		100		200		300	
		Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.
I. One m^3 cagea (1 x 1 x lm)									
May 15 th	0	7.0-10.0	8.6±0.9	7.0-11.5	8.8±1.2	7.5-11.0	9.4±0.8	8.0-12.0	9.8±1.3
Jun. 15th	30	8.9-12.0	10.5±0.9	8.2-14.0	11.7±1.5	8.0-13.8	11.0±2.5	8.0-14.0	10.2±2.0
Jul. 15th	60	9.5-13.2	11.1±1.2	12.5-18.8	15.1±1.6	10.8-15.2	12.9±1.5	10.8-17.0	13.5±1.9
Aug. 15th	90	9.8-15.0	12.0±1.5	14.4-22.3	17.1±5.6	13.1-22.0	17.0±2.4	12.0-18.5	15.0±1.5
Sept.15th	120	11.0-16.5	13.4±1.5	17.1-22.0	19.6±1.6	14.8-22.6	18.8±2.3	14.0-19.0	15.9±1.3
Oct. 15th	150	11.5-17.0	14.0±1.5	18.8-24.0	21.8±3.1	18.6-23.7	20.8±4.5	15.5-22.0	18.3±1.8
Nov 15th	180	12.0-17.5	14.3±1.5	17.8-25.0	22.3±1.5	16.8-24.0	21.6±2.2	17.0-21.0	19.1±1.2
II. Four m^3 cages (2 x 2 x 1 m)									
May. 15th	0	7.0-10.5	8.7±1.0	7.7-11.0	9.4±0.8	8.0-12.5	10.0±1.6	7.4-11.6	8.7±0.3
Jun. 15th	30	9.0-12.0	10.4±0.9	10.0-14.0	12.3±1.2	9.5-14.0	11.8±1.3	8.0-13.0	10.6±1.8
Jul .15th	60	9.5-13.0	11.0±1.4	11.5-18.0	14.4±1.9	11.6-17.0	14.1±1.7	10.0-17.5	13.4±2.1
Aug. 15th	90	9.5-15.0	11.9±1.4	13.1-21.0	17.2±2.7	13.6-21.0	16.4±2.7	11.5-18.0	15.1±1.7
Sept.15th	120	11.0-16.0	13.2±1.6	15.8-22.5	18.1±1.7	15.5-23.4	17.5±2.3	11.5-20.3	16.8 ±4.8
Oct. 15th	150	11.5-16.0	13.6±1.4	10.0-24.0	21.5±1.9	18.0-24.0	21.4±1.6	15.5-21.5	18.5±1.6
Nov. 15th	180	11.5-16.5	13.9±1.3	19.5-25.0	23.2±1.7	19.0-25.0	21.7±1.8	17.5-22.2	19.5±1.4

Table 2

Average growth in weight of *Tilapia nilotica* (avg. wt. 14.2 g/fish) reared in cages of different size and at different stocking rates.

Month	Days after Stocking	Stocking density (fish/m³)							
		100 (Control)		100		200		300	
		Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.
I. One m³ cagea (1 x 1 x lm)									
May. 15th	0	7.2–18.0	11.7±3.1	7.2–25.0	13.8±4.0	7.5–20.0	13.6±9.0	9.5–28.1	17.6±10.2
Jun. 15th	30	12.8–26.0	19.1±4.5	9.8–40.8	28.4±8.9	10.5–38.8	25.9±9.0	9.6–40.8	26.2±11.9
Jul. 15th	60	13.1–31.0	20.7±6.5	32.8–90.0	65.6±14.2	30.5–70.3	50.2±14.7	30.5–80.0	49.7±16.1
Aug. 15th	90	14.0–14.0	25.0±6.6	49.0–184.2	82.1±27.9	44.5–166.0	93.9±42.2	31.8–100.0	65.9±14.5
Sept. 15th	120	23.1–55.5	36.3±25.5	86.0–166.0	126.1±25.2	53.5–172.2	109.1±36.4	50.0–101.0	74.8±13.0
Oct. 15th	150	24.0–59.0	39.0±14.4	115.0–257.0	190.4±47.2	110.0–277.7	162.6±44.5	69.0–145.0	102.5±24.7
Nov. 15th	180	27.5–62.0	42.2±7.9	130.0–260.0	197.0±44.2	125.0–277.0	174.6±45.5	78.8–140.0	113.9±20.5
II. Four m³ cages (2x2x1 m)									
May. 15th	0	7.3–17.0	12.3±4.1	8.0–22.0	13.3±3.1	9.0–31.4	17.2±8.3	7.4–22.0	11.3±3.3
Jun. 15th	30	13.0–24.0	18.9±3.8	22.0–41.3	32.8±7.3	15.0–45.0	30.7±9.1	9.8–40.0	25.4±11.9
Jul. 15th	60	13.5–30.0	20.5±5.9	32.0–95.0	61.1±19.9	32.0–69.0	53.3±11.1	22.5–80.0	43.9±16.7
Aug. 15th	90	19.0–37.0	36.7±3.8	44.0–165.0	94.0±27.7	50.0–160.0	81.4±36.7	31.3–105.0	66.7±16.5
Sept. 15th	120	22.0–55.0	35.2±11.0	70.0–214.5	118.0±35.7	61.0–189.6	24.1±38.0	26.0–134.2	78.5±25.5
Oct. 15th	150	27.0–55.0	38.0±9.5	110.0–260.0	186.4±51.4	110.0–250.0	167.2±39.9	72.0–154.0	111.3±25.5
Nov. 15th	180	27.5–54.6	39.0±9.9	130.0–261.0	194.5±48.5	117.0–280.0	178.7±51.9	90.0–190.0	133.2±25.5

Table 3

Growth, production, food conversion ratio and mortality for *Tilapia nilotica* (avg. wt. 14.2 g./fish) reared in cages for aperiod of six months under different stocking densities.

Item		Stocking density (fish/m³)			
		100 (Control)*	100	200	300
Initial avg. wt. of fish	(g)	11.7	13.8	13.6	17.6
Final avg. wt./fish	(g)	42.2	197.0	174.6	113.9
Gain in weight	(%)	260.7	1372.5	1183.8	547.2
Initial avg. length	(cm)	8.6	8.8	9.4	9.8
Final avg. length	(cm)	14.3	22.3	21.6	19.1
Gian in length	(%)	54.7	153.4	129.8	94.9
No. of fish/cage		100.0	100.0	200.0	300.0
No. of loss		2.0	—	2.0	5.0
% Survival		98.0	100.0	99.0	98.3
Initial wt. of fish/cage	(kg)	1.2	1.4	2.7	5.3
Total crop/cage	(kg)	4.1	19.7	34.6	33.6
Gain in wieght/cage	(kg)	2.9	18.3	31.9	28.3
Production rate	(kg/m³)	2.9	18.3	31.9	28.3
Total feed	(kg)	—	63.5	114.0	126.5
Feed convertion coefficient		—	3.74	3.57	4.47
Price/kg/feed		—	4.5	4.5	4.5
Cost/kg/fish		—	15.6	16.1	20.1
Avg. gain/fish/day	(g)	0.17	1.02	0.89	0.54

* Maintained without supplementary feed.

Table 4

Growth, production, food conversion ratio and mortality for *Tilapia nilotica* (avg. wt. 14.2 g./fish) reared in cages for a period of six months under different stocking densities. (Capacity of cage $4m^3$).

Item		Stocking density (fish/m^3)			
		100 (Control)*	100	200	300
Initial avg. wt. of/fish	(g)	12.3	13.1	17.2	11.3
Final avg. wt./fish	(g)	39.0	194.5	178.7	133.2
Gain in weight	(%)	217.1	1384.7	939.0	1078.8
Initial avg. length	(cm)	8.7	8.5	10.0	8.7
Final avg length	(cm)	13.9	22.2	21.7	19.5
Gain in length	(%)	59.8	133.7	177.0	124.1
No. of fish/cage		400.0	400.0	800.0	1200.0
No. of loss		10.0	2.0	2.0	25.0
%survival		97.5	99.5	99.8	97.9
Initial wt. of fish/cage	(kg)	4.9	5.2	13.8	13.6
Total crop/cage	(kg)	15.9	77.5	142.5	156.5
Gain in weight/cage	(kg)	10.3	72.3	128.7	142.9
Production rate	(kg/m3)	2.6	18.1	32.2	35.7
Total feed	(kg)	—	251.0	364.5	482.0
Feed convertion coefficient		—	3.47	2.83	3.37
Price kg/feed		—	4.5	4.5	4.5
Cost kg/fish		—	15.6	12.7	15.2
Avg. gain/fish/day	(g)	0.15	1.01	0.90	0.68

* Maintained without supplementary feed.

Table 5a

Comparison between the mean weight of *Tilapia nilotica* (14.2 g/fish) of the control cages of 1 m^3 & 4 m^3 volume and the mean wieght of *T. nilotica* in the cages of the same volume.

Item	Cage Volume	100 f/m^3(control) & 100 f/m^3	100 f/m^3(control) & 200 f/m^3	100 f/m^3(control) & 300 f/m^3
T-test	1 m^3	17.24	14.34	16.32
	4 m^3	15.71	13.22	17.22

Table 5b

Comparison between the mean wieght of *T. nilotica* (14.2 g/fish) reared in cages with the first stocking density 100 f/m^3 and the other two density 200 and 300 f/m^3 in cages of volume 1 m^3 and those of 4 m^3 by using t−test.

Item	Cage volume	100 f/m^3 & 200 f/m^3	100 f/m^3 & 300 f/m^3
T−test	1 m^3	1.77	8.57
	4 m^3	1.11	5.60

Table 5c

Comparison between the mean weight of *T. nilotica* (14.2 g/fish) reared in cages of volume 1 m^3 and 4 m^3 having the same stocking density by using t−test.

Item	1 m^3 & 4 m^3 (100 f/m^3 (control)	1 m^3 & 4 m^3 (100 f/m^3)	1 m^3 & 4 m^3 (200 f/m^3)	1 m^3 & 4 m^3 (300 f/m^3)
T−test	1.26	0.23	0.30	2.95

Table 6

Average growth in length of Tilapia galilaea (avg. wt. 19.3 g/fish) reared in cages of different sizes and at different stocking rates.

Month	Days after Stock	Stocking density (fish/m^3)							
		100 (Control)		100		200		300	
		Range	Mean + S. D.	Range	Ncan + S. D.	Range	Mean + S. D.	Range	Mean + S. D.
I. One m^3 cages (1 x 1 x 1 m)									
May 15th	0	9.0−13.5	11.0±1.3	8.0−12.8	10.0±1.2	8.0−12.2	10.3±1.1	9.0−12.6	10.4±1.2
Jun. 15th	30	10.0−13.0	11.3±1.0	10.5−15.5	12.5±1.3	8.6−13.6	11.1±1.7	9.5−13.5	11.5±1.5
Jul. 15th	60	11.7−14.0	12.3±5.4	17.8−15.8	14.1±0.9	10.5−15.5	12.5±1.0	10.5−14.0	11.8±0.9
Aug. 15th	90	11.5−15.0	13.1±1.1	14.5−18.0	16.2±1.0	11.8−17.4	14.6±1.5	10.6−14.0	12.6±0.9
Sept.15th	120	11.8−15.5	13.5±1.4	15.5−20.5	17.9±1.5	14.0−19.0	16.6±1.6	11.8−15.0	12.9±0.8
Oct. 15th	150	12.0−16.5	14.4±0.8	16.5−17.0	19.0±1.6	15.5−19.0	17.7±1.1	13.0−17.0	15.1±1.2
Nov. 15th	180	12.0−16.0	14.1±1.1	17.5−22.3	19.6±1.3	16.0−19.5	18.2±1.2	14.0−18.0	15.5±1.0
II. Four m^3 cages (2 x 2 x 1 m).									
May. 15th	0	9.3−13.0	11.3±1.2	8.9±12.5	10.2±1.1	9.0−13.5	10.6±1.3	8.2−12.5	10.5±1.0
Jun. 15th	30	10.5−13.5	11.9±0.8	10.5−14.0	12.3±1.0	9.5−14.5	11.2±1.4	9.2−15.0	11.1±4.0
Jul. 15th	60	10.5−13.8	12.0±2.8	12.5−16.0	14.2±1.6	10.7−15.3	11.6±1.5	10.8−15.0	12.0±1.2
Aug. 15th	90	11.0−13.8	12.4±2.3	13.5−19.0	16.6±1.9	12.3−16.0	14.5±4.8	10.8−15.0	12.8±1.5
Sept.15th	120	11.5−15.0	12.6±0.9	16.5−21.0	19.6±1.4	13.5−18.2	16.4±1.4	13.0−18.0	15.4±1.4
Oct. 15th	150	12.0−15.0	13.6±0.9	18.2−21.5	19.7±1.0	16.0−19.5	17.9±0.9	14.0−19.0	16.2±0.9
Nov. 15th	180	12.5−14.5	13.7±0.6	18.7−23.0	20.7±1.2	17.5−20.0	18.6±0.8	15.5−20.0	17.2±1.5

Tilapia galilaea

The experiment started with *Tilapia galilaea* of an average weight 19.3 g. and an average length 10.5 cm (Tables 6 and 7). It is clear that (from Tables 8 and 9) as the stocking density increases from 100 to 300 fish/m^3 the rate of growth decreases. It is also clear that the size of the cage has no effect at the low stocking density of the fish (Fig. 4). After a period of 180 days, the gain in weight percent is 660% for the 1 m^3 cage of stocking density 100 fish/m^3 and 812% for the 4 m^3 cage of the same stocking density. At the stocking density of 200 and 300 fish/m^3, the percentage gain in weight is reduced to 438.6% and 188.5% for 1 m^3 cages but 424.8% and 328.1% for the 4 m^3 cages respectively. for the control group the percentage gain in weight is less than the group gains additional food, being 87.6% for the 1 m^3 cages and 67.4% for the 4 m^3 cages.

The maximum average weight gain per fish per day is attained at the stocking density of 100 fish/m^3, being 0.63 g. for the small cage and 0.79 g. for the large one. It decreases by increasing the stocking density from 200 to 300 fish/m^3, being 0.45 g. and 0.21 g. for the small cages and 0.49 g. and 0.32 for the large ones respectively. In case of the control group, the gain in weight per day is 0.11 g. for the small cage and for the large cage is 0.08 g.

The net production obtained at the stocking density of 200 fish/m^3 from the cages of 1 m^3 and 4 m^3 is 16.3 kg/m^3 and 17.4 kg/m^3; the average weight of fish is 99.1 g . and 108.1 g. respectively (Tables 8 and 9). The conversion coefficient of feed is 4.6 for the fish stocked in 1 m^3 and 4.37 for that stocked in the cages of 4 m^3. In both cases the average weight is considered to be marketable size and there is no significant difference between them. However this small variation may be attributed to the differences in the initial weight at stocking (17.3–22.1 g./fish). Also there are minor variations in the feed conversion coefficient which may be due to the utilization of the food by the fish in the larger surface area.

The maximum and the minimum average weight of fish is attained at the end of rearing period at stocking density of 100 and 300 fish/m^3 respectively, (131.4 g. and 57.7 g. for the small cages and 159.6 g. and 76.2 g. for the large ones), while the moderate size is attained at the stocking density of 200 fish/m^3, (99.1 g. for the 1 m^3 cages and 108.1 g. for the 4 m^3 cages). It is also clear that the feed conversion ratio is also reasonable in all cages.

Fisher t−test was applied to the data to determine the effect of stocking density on cage volume and supplementary feed (Table 10a). It is evident that all the fish that were given the supplementary feed gave better results than that in the control cages where the value between the means differ significantly at 1% level ($P < 0.99$). Moreover, a comparison between the mean weight of fish stocked at the lowest rate and supplied with feed and other stocking densities fed with the same ratio of food show that the cages of 100 fish/m^3 is the best where the mean weights differ significantly at 1% level ($P < 0.99$) from the mean weight of the other two cages (Table 10b).

A comparison between the mean weight of fish at different stocking densities reared in cages of 1 m^3 and those reared in 4 m^3 proved that there is no statistically significant differences between them in the lower density (100 fish/m^3). However, at the stocking rates of 200 and 300 fish/m^3, the mean weight of fish obtained from the 4 m^3 cages was higher than that of 1 m^3 at the 5% level ($P < 0.95$) (Table 10c). Moreover, the total production obtained from the cage of 4 m^3 is much higher than that obtained from the cage of 1 m^3 capacity. Under the given circumstance it can be infered that the stocking density of 200 fish/m^3 and that of 300 fish/m^3 in the cage of 4 m3 may be used in case of *Tilapia galilaea.*

Table (11) shows the different values of length, weight and age for *Tilapia* species in different Egyptian Delta Lakes. The superiority of these parameters for fishes from Lake Mariut over those from lakes, Manzala, Borolos, Nozha Hydrodrome and Serow is probably due to the high productivity. The primary production of Lake Mariut was found to be the highest among the other lakes (Samaan, 1966).

Table 7

Average growth in weight of Tilapia galilaea (avg. wt. 19.3 g/fish) reared in cages of different sizes and at different stocking rates.

Month	Days after Stock	Stocking density (fish/m³)							
		100 (Control)		100		200		300	
		Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.	Range	Mean + S. D.
I. One m³ cages (1 x 1 x 1 m)									
May 15th	0	13.0–33.0	21.7±7.2	8.0–33.0	17.3±6.9	11.1–29.5	18.4±5.7	11.0–33.0	20.0±6.9
Jun. 15th	30	15.0–30.0	22.7±4.9	22.0–53.0	35.0±9.2	11.0–40.6	26.0±8.5	18.0–43.0	28.7±9.2
Jul. 15th	60	20.0–40.0	28.9±5.9	40.0–76.4	53.9±9.6	22.0–53.0	35.9±9.3	20.0–45.0	30.8±7.1
Aug. 15th	90	26.0–50.0	34.1±6.4	58.0–95.0	75.5±10.9	28.8–77.0	55.1±13.1	25.0–49.0	34.8±6.5
Sep. 15th	120	22.0–52.0	37.5±9.5	65.0–148.0	98.0±27.3	43.0–117.0	77.2±20.1	30.0–48.0	37.1±5.8
Oct. 15th	150	30.0–60.0	42.9±9.4	78.0–163.0	119.5±30.1	66.0–118.8	93.0±17.7	39.0–80.0	54.9±12.8
Nov. 15th	180	28.0–56.0	40.7±13.1	80.0–190.5	131.4±31.2	70.0–130.0	99.1±22.0	40.0–80.0	57.7±13.7
II. Four m³ cages (2 x 2 x 1 m)									
May 15th	0	13.0–38.0	22.1±8.0	9.5–32.0	17.5±6.8	9.0–33.2	19.9±7.1	9.0–31.0	17.8±6.0
Jun. 15th	30	19.0–38.0	26.8±4.7	22.0–46.0	33.7±7.7	15.0–48.0	27.4±8.3	12.0–60.0	25.9±11.1
Jul. 15th	60	20.5–34.0	27.8±3.3	69.0–70.0	52.7±11.5	24.8–56.8	27.2±9.9	22.5–48.0	31.4±7.5
Aug. 15th	90	21.5–40.0	30.5±5.2	45.0–118.0	80.0±24.0	30.0–69.5	52.5±10.7	25.0–60.0	73.2±10.6
Sep. 15th	120	28.0–55.0	32.9±6.5	71.0–175.0	117.9±32.2	40.0–99.0	72.3±16.8	39.5–87.0	59.0±12.3
Oct. 15th	150	28.0–53.0	36.5±8.5	104.0–180.0	137.2±22.3	70.0–120.0	95.9±15.3	50.0–93.0	60.0±13.7
Nov. 15th	160	30.0–46.0	37.0±5.1	114.0–216.0	159.6±35.4	85.0–135.0	108.0±16.0	53.0–125.0	76.2±21.8

Table 8

Growth, production, food conversion ratio and mortality for *Tilapia galilaea* (avg. wt. 19.3 g./fish) reared in cages for six months under different stocking densities. (Cage capacity 1 m³)

Item		Stocking density (fish/m³)			
		100 (Control)*	100	200	300
Initial avg. wt/fish	(g)	21.7	17.3	18.4	20.0
Final avg. wt/fish	(g)	40.7	131.4	99.1	57.7
Gain in wt./fish	(%)	87.6	659.5	438.6	188.5
Initial avg. length	(cm)	11.0	10.0	10.3	10.4
Final avg length	(cm)	14.1	19.6	18.2	15.5
Gain in length	(%)	28.2	96.0	76.7	49.0
No. of fish/cage		100.0	100.0	200.0	300.0
No. of loss		2.0	1.0	—	5.0
% survival		98.0	99.0	100.0	98.3
Initial wt. of fish/cage	(kg)	2.2	1.7	3.7	6.0
Total crop/cage	(kg)	4.0	13.0	20.0	17.0
Gain in wt./cage	(kg)	1.8	11.3	16.3	11.0
Production rate	(kg/m3)	1.8	11.3	16.3	11.0
Total feed	(kg)	—	50.0	76.0	77.0
Feed conversion coefficient		—	4.42	4.6	7.0
Price/kg/feed		—	4.5	4.5	4.5
Cost/kg/fish		—	19.9	20.7	31.5
Avg. gain/fish/day	(g)	0.11	0.63	0.45	0.21

* Maintained without supplementary feed.

Table 9

Growth, production, food conversion ratio and mortality for Tilpia galilaea (avg. wt. 19.3 g./fish)reared in cagesfor six months under different stocking densities. (Capacity of cages 4 m^3)

Item		Stocking density (fish/m^3)			
		100 (Control)*	100	200	300
Initial avg. wt./fish	(g)	22.1	17.5	20.6	17.8
Final avg. wt./fish	(g)	37.0	159.6	108.1	76.2
Gain in wt.	(%)	67.4	812.0	424.8	328.1
Initial avg. length	(cm)	11.3	10.2	10.6	10.5
Final avg. length	(cm)	13.7	20.7	18.6	17.2
Gain in length	(%)	21.2	102.9	75.5	63.8
No. of fish/cage		400.0	400.0	800.0	1200.0
No. of loss		2.0	3.0	5.0	20.0
% survival		99.5	99.3	99.4	98.4
Initial wt. of fish/cage	(kg)	8.8	7.0	16.5	21.4
Total crop/cage	(kg)	15.0	63.5	86.0	90.0
Gain in wt./cage	(kg)	6.2	56.5	69.5	68.6
Production rate	(kg/m3)	1.6	14.0	17.4	17.2
Total feed	(kg)	—	219.0	304.0	356.0
Feed conversion coefficient		—	3.88	4.37	5.20
Price/kg./feed		—	4.5	4.5	4.5
Cost/kg/fish		—	14.5	19.7	23.4
Avg. gain/fish/day	(g)	0.08	0.79	0.49	0.32

* Maintained without supplementary feed.

Table 10a

Comparision between the mean weight of the control cages 1 m^3 and 4 m^3 volume and the mean weight of fish in the cages of the same volume according to t–test.

Item	Cage Volume	100 f/m^3(control) & 100 f/m^3	100 f/m^3(control) & 200 f/m^3	100 f/m^3(control) & 300 f/m^3
T–test	1 m^3	13.40	21.13	4.48
	4 m^3	17.14	21.14	8.75

Table 10b

Comparison between the mean weight of *Tilapia galilaea* (19.3 g/fish) cages with thefirst density 100 fish/m3 and the other low densities 200 and 300 fish/m^3 in cages of volume 1 m^3 and those of volume 4 m^3 by using t−test.

Item	Cage volume	100 f/m3 & 200 f/m3	100 f/m3 & 300 f/m3
T−test	1 m^3	4.23	10.81
	4 m^3	6.23	10.03

Table 10c

Comparison between the mean weight *Tilapia galilaea* (19.3 g/fish) reared in cages of volume 1 m3 and 4 m3 having the same stocking density by using t−test.

Item	1 m^3 & 4 m^3 (100 f/m^3)	1 m^3 & 4 m^3 (100 f/m^3)	1 m^3 & 4 m^3 (200 f/m^3)	1 m^3 & 4 m^3 (300 f/m^3)
T−test	1.32	3.00	1.60	3.59

Table 11

Comparison between length, weight and age of *Tilapia* species in different Egyptian waters.

Region	Authors	Fish Species	Length (cm)	Weight (gm)	Age in years
Noza Hydrodrome	Elster and	*T. nilo.*	9.2	–	1
	Jenson(1960)		20.5	–	2
Lake Maruit	El−Zarka et al	*T.nilo.*	8.37	10.4	1
	(1970)	*T.nilo.*	21.2	180.9	2
		T.gal.	8.25	9.0	1
		T.gal.	21.2	183.9	2
Lake Manzala	El−Zarka et al		8.2	8.9	1
	(1970)		21.2	166.2	2
Lake Borollus	Ishak et al (1985)	*T.nilo.*	9.51	14.3	1
			14.8	54.9	2
Serow fish farm	Present data	*T.nilo.*	14.3	42.2	1.5
(Control)	(No supplementary feeding)	*T.gal.*	13.9	39.1	1.5
Serow fish farm	Present data	*T. nilo.*	21.7	176.7	1.5
(Control)	(Supplementary feeding)	*T.gal.*	18.4	103.6	1.5

It is clear from Tables 3, 4, 8 and 9 and Figures 1, 2, and 3 that, on rearing *Tilapia nilotica* and *Tilapia galilaea* under the same experimental and ecological conditions, *Tilapia nilotica* is better in growth rate and consequently in production rate/m^3 and also has lower feed conversion coefficient.

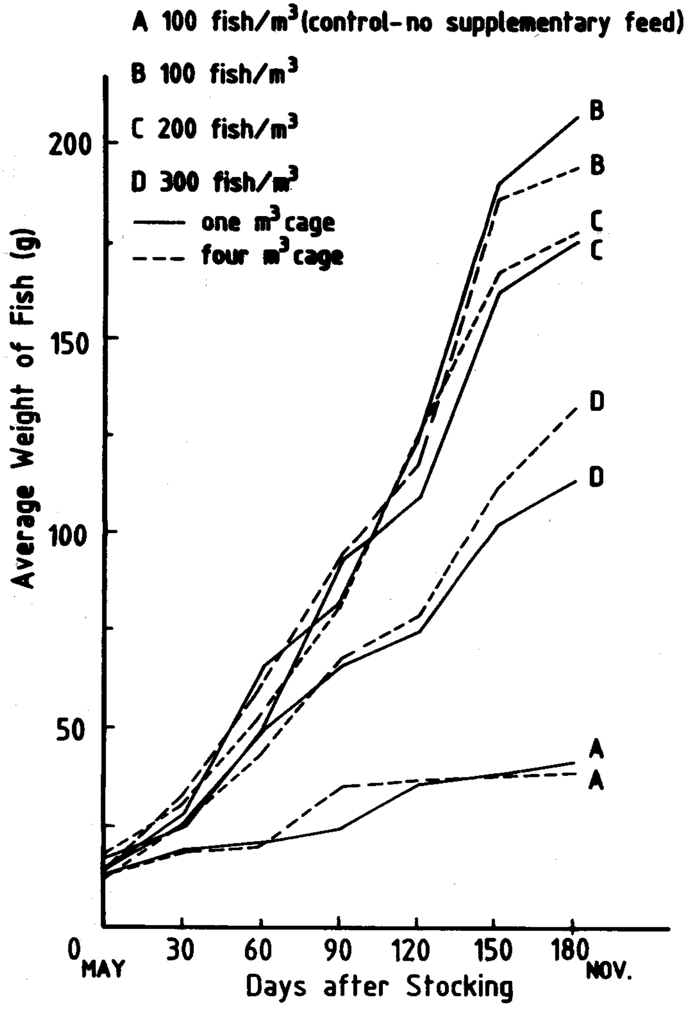

Fig. 1 : Average growth rate of *Tilapia nilotica* reared in cages.

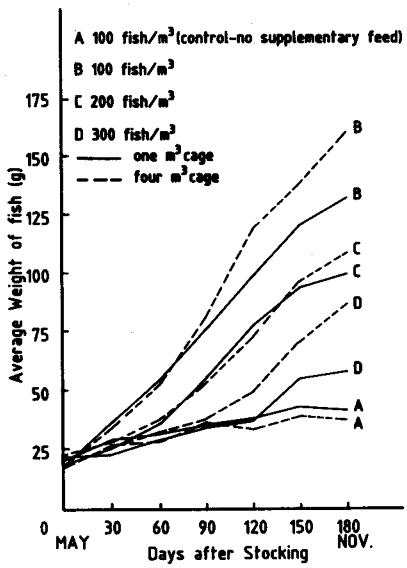

Fig. 2 : Average growth rate of *Tilapia galilaea* reared in cages.

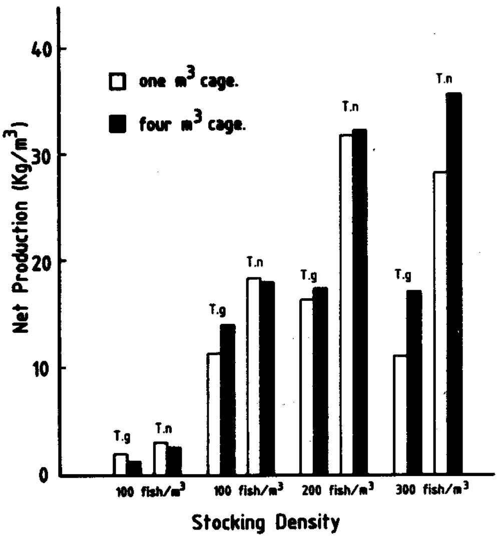

Fig. 3 : Production of *Tilapia galilaea* and *Tilapia nilotica* reared in cages.

In the present study the cages stocked with 100 fish/m^3 for *T. nilotica* show a higher growth rate per day where the average is about 1.02 g. either in the 1 m^3 cage or 4 m^3 cage. The rate of growth decreases as the stocking density increases (200 fish/m^3 0.9, 300 fish/m^3 0.5). The results obtained in this investigation are supported by observations of some authors who found that the rate of growth for different fish species decreases as the fish biomass per unit volume of water increase. This phenomenon has been also observed in cages for practically all the cultured fish species, *Ictalurus punctatus* (Collins, 1972); *Tilapia carolina* (Anon, 1973; Tatum, 1974); *Cyprinus carpio* (Gribanov *et al.,* 1968). The survival rates of *Tilapia nilotica* in the experimental cages were high since the fish were acclimatized for about one week after collection and before stocking in cages. It is worth mentioning that in both species of Tilapia, high mortality occurs during handling and transportation of the fish when they are less than 20 g in size. This is due to the high sensitivity of the fish at this size to the unfavourable conditions, i.e. low dissolved oxygen, turbidity, high temperature stressing, and handling which need more care. However, the fish which were more than 20 g. in size showed high tolerance. Therefore, it is suggested that the *Tilapia* fingerlings should be stocked in the cages with the size more than 20 g. Kirk (1972) mentioned that Tilapias especially *Tilapia nilotica* have high survival rate, good growth rate, thermal tolerance and even relative low oxygen requirement.

In case of *Tilapia nilotica* and *Tilapia galilaea* it has been observed that fish attained sexual maturity under cage culture conditions, but no reproduction was observed. Pagan (1969) reported that reproduction does not take place when *Tilapias* are reared in cages. However, Ibrahim, *et al.,* (1974) mentioned that *Tilapia esculenta* and *Tilapia zillii* reach maturity under the cage culture conditions but they did not reproduce in spite of the relatively low fish stocking density. This result has been confirmed by Coche (1976). However, for *Tilapia mossambica;* Baradach, *et al.,* (1972) found that the fish succefully reproduced in the floating cages in lake Atitlan, Guatimala.

In the present study, *Tilapias* that were reared in the experimental cages were not sexually differentiated. However, it is documented that in *Tilapias*, the male in general grows faster than the female (Van Someren and Whitehead, 1960; Fryer and Iles, 1972; Guerrero and Guerrero, 1975). For *Sarotherodon mossambicus* (previously *Tilapia mossambica*) Maybe (1971) concluded that the growth differences between the sexes could be due to male sex–linked higher efficiency for food conversion, i.e. which is genetically controlled. Therefore, the growth rate obtained in this study represents the average of both sexes. Future studies on *Tilapia* cage culture should consider the rearing of males.

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مشاهدات أولية على النمو النسبي وانتاج أسماك البلطي المستزرع في أقفاص بثلاث كثافات مختلفة

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و عـزت بـدوي

إشتملت الدراسة على النمو النسبي وإنتاج أسماك البلطي (النيلي والجاليلي) في أقفاص عائمة بمزرعة السرو - مصر - بثلاث كثافات مختلفة (١٠٠ ، ٢٠٠ ، ٣٠٠ سمكة/ متر مكعب) وكل معدل كثافة جرب في أربعة أقفاص اثنين ذات حجم ١/م٣ والآخـر ذات حجـم ٤/م٣ - وغـذيت الأسماك غذاء صناعي يحتوي على ٢٠٪ بروتين بمعدل يومي ٥٪ من الوزن الكلي للأسماك وأجريت تجربة معدل التحكم لكل نوع من الأسماك بدون غذاء إضافي. وقد تبين من نتائج هذه التجربة أن الزيادة في كثافة الأسماك لكلا النوعين ينتج عنهانقص في معدل النمو الفردي وكان أحسن معدل جماعي في كثافة ٢٠٠ سمكة/متر مكعب حيث أعطى انتاج ٣٢كجم/المتر المكعب ، ١٧,٤كجم/المتر المكعب ووزن ١٧٨,٧جـرام/سمكـة ، ١٠٨,١جـرام/سمكة لأسماك البلطي النيلي والجاليلي على الترتيب.

وقد تفاوت معدل التحويل الغذائي إلى زيادة في الوزن في الكثافات الثلاث بين ٢,٨٣ ، ٣,٤٧ للبلطي النيلي ، ٣,٨٨ ، ٥,٢٠ للبلطي الجاليلي . وكان المعدل بصفة عامة أقل قليلا في الكثافة العالية منه في الكثافات المنخفضة - وبلغ معدل البقاء بعد ١٨٠ يوم في كل من الكثافات الثلاث ١٠٠، ٢٠٠، ٣٠٠ سمكة/متر مكعب في كلا النوعين كما يلي :

٩٩,٥٪ ، ٩٩,٨٪ ، ٩٧,٩٪ للبـلطي الـنيلي ، ٩٩,٣٪ ، ٩٩,٤٪ ، ٩٨,٣٪ للبلطي الجاليلي على التوالي .

ومما تبينه هذه الدراسة أيضا أن معدلات النمو لأسماك البلطي لا تتأثر بدرجة كبيرة حتى عندما تستزرع بكثافة عالية وذلك بمقارنتها بالكثافات الأقل مما يدل على أن هذه الأنواع من الأسماك لها القدرة على تحمل درجة معينة من الإزدحام وهذه الخاصية يمكن الإستفادة منها كثيرا للزراعة المكثفة لهذه الأسماك.