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MASS PRODUCTION OF OREOCHROMIS FRY IN CONCRETE PONDS

BY

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ABSTRACT

Twenty four spawning concrete ponds (2 x 1 x 0.65) were used to study the effect of two protein levels 25, 35% and two broadfish sex ratio 1:2 & 1:3 (male:female) on larvae production of ***O. niloticus, O. aureus*** *and* ***O.galilaeus****. Factorial design (3x2x2) was utilized. Feeding rate was 3% of the total broadfish biomass daily (6 days/week) for 161 days. Another twelve rearing concrete ponds (8x2.7 x 0.7m) were prepared to receive the hatched larvae during the nursing period (60 days) . Feeding rate of the fry was 20 % at the first 30 days and then decreased to 10% of the total biomass at the following 30 days of rearing period. The diet of fry contains 40 % protein in a powdered form. The results showed that:*

*Increasing dietary protein level from 25 to 35% and broadfish sex ratio (male:female) 1:2 instead of 1:3 increased grow performance of broadfish, total number of newly hatched larvae and total advanced fry and survival rate after 60 days of spawning for all the tilapia species (****Oreochromis niloticus, O. galilaeus and O. aureus****), respectively.*

Growth performance and survival rate of larvae increased in the early spawning (May and June), then decreased in the late spawning (September) for ***O. niloticus*** *and in August in both* ***O. aureus*** *and* ***O. galilaeus****. Feed conversion ratio was better in larvae hatched in May than larvae hatched in August or September.*

INTRODUCTION

The success of intensive tilapia culture depends to a large extend on supplemental feeding and a great amount of fry production, but production of tilapia fry in ponds has not been adequate. The need for increasing fry production is therefore imperative. Tilapia researchers world-wide have concluded that one of the most important requirements for the advancement of tilapia culture is the development of systems for mass production of fry (David and Lesli, 1983). Therefore, the development of tilapia hatcheries was felt to be the key of expansion of the fish culture industry (Pullin, and Lowe McConnel, 1982; Mires, 1982; Rafael and Garacia, 1983).

Fry should be produced to satisfy the needs of the culturist and at a cost that will permit financial success.

Among factors considered to be important in fry production are broad fish age and size, broad fish stocking density, broad fish sex ratio, broad fish nutrition, frequency of removing broad fish or fry from the breeding unit, type of container, water quality and rate of water exchange (Silvera, 1978; Hughes sand Behrends, 1983; Lee, 1977; Coche, 1982; Mires, 1982).

Rosa (1990) showed that, the dietary intake of broadstock fish can also have profound effects on their fecundity. But Springate and Bromage (1985) stated that, there were no significant effects of reduced feed rate either on the broadstock or on the survival and performance of the eggs and fry produced.

The objectives of this study were to evaluate the effects of the different dietary protein levels in broadfish diets and broadfish sex ratio on production of larvae and survival rate until 60.0 days after hatching for ***Orechromis niloticus, O. aureus and O. galilaeus.***

MATERIALS AND DISCUSSION

The aim of this experiment is to evaluate the effects of different protein levels (25% and 35%) and broadfish sex ratio (1:2 and 1:3) on fry production of three species on tilapia from 7/4 to 15/9/92.

Experimental fish:

Oreochromis niloticus, Oreochromis aureus and ***Sarotherodon galilaeus*** broad stock were taken from Abbis Fish Farm, Alexandria, ***O. niloticus*** broad fish had body weights of 115-120 g for males and 73-76 g for females. ***O. aureus*** had body weights 75-79.5 g for males and 50-53 for females. ***S. galilaeus*** had body weights 80.5-85.5 for males and 62-65 g for females.

Experimental ponds:

Twenty four spawning concrete ponds are used in this study. The ponds were 2.0 m long x 1.0m wide. Water level was maintained at approximately 0.65 m depth. Water lost by evaporation or seepage was replenished daily. Partial change of about-two thirds of water was done weekly. Complete change of water was done every two weeks.

Experimental Diets:

Two diets were formulated to broadstock fish containing 25 or 35% crude protein. One diet was formulated for feeding the fry containing 40% crude protein.

The rate of feeding was 3% of the total fresh fish biomass of broadstock fish in each pond daily (6 days/week) for 161 days. While the diet of fry was in powder form and the rate of feeding was 20% of the total biomass at the first month from hatching and decreased to 10% in the second month. The feed was given at 10 a.m. six days a week with amounts adjusted at two-week intervals in response to weight gain. The composition of three diets used in the experiment are in Table (1).

Experimental design:

For each species of tilapia, there were two treatments of protein levels with two treatments of broadfish sex ratio with two replicates each in a completely randomized factorial (3x2x2) design.

Table (1): Composition and proximate analysis of the two experimental diets used in the experiment expressed as % of dry weight on DM. basis.

	Diet No.		
	1*	2*	3**
Ingredients :			
Fish meal	20.5	29.1	35.0
Soybean meal	28.4	39.8	35.0
Wheat milling by-products	47.9	27.9	--
Rice bran	---	---	26.8
Corn oil	3.0	3.0	3.0
Vitamin and mineral mix.	0.2	0.2	0.2
Proximate analyses :			
Dry matter (DM%)	91.7	91.1	93.2
% on DM basis :			
Crude protein (P)	25.8	36.1	40.5
Ether extract (EE)	3.8	4.8	9.7
Ash	9.9	9.9	11.4
Crude fiber (CF)	3.6	3.4	3.4
Nitrogen free extract (NEE)	56.9	45.8	35.0
Gross energy (GE)1 k cal/100g DM	415.2	437.3	464.5

* Brood fish diets

** Larvae diet

1. Calculated on the basis of 5.65, 4.1 and 9.5 K cal GE/g protein, NFF and EE respectively

Management:

After broad fish were spawning. newly hatched larvae were collected with a dip net and individually counted, then put in ponds of fry (8.0 m long x 2.7 m wide x 0.7 m depth). Sample of 20 hatched larvae were taken to estimate initial weight and total length. Two randomized samples, 10 fry each, were taken from each pond every two weeks to be weighed and total length recorded. Fry mortality were recorded daily and after two months total survival of fry was estimated and growth parameters as well. Fry production was quantified in 4 ways: total number of fry/treatment, number of fry/female of broadfish, number of fry/female/day, number of fry/gram female.

RESULTS AND DISCUSSION

The aim of the experiment is to evaluate the effects of the different dietary protein levels (25 and 35% C.P) and broad fish sex ratio (1:2 and 1:3) (male: female) on production of larvae and survival rate until 60.0 days after hatching for ***Oreochromis niloticus, O.aureus*** **and** ***O. galilaeus.***

Body weight and growth performance of broad fish:

Data concerning average initial and final body weight, body gain average daily gain, (ADG) and specific growth rate (SGR) are found in Table (2) and Fig (1). The highest growth was obtained when the broadfish were fed on the diet containing 35% crude protein with broadfish sex ratio 1M:2F, and the lowest growth was obtained when the broad fish were fed on the diet containing 25% crude protein with broadfish sex ratio 1:3 at all ***Oreochromis*** species. On the other hand, the body gain in ***O. niloticus*** was the highest one (42.2) g and the body gain in ***O. aureus*** was the lowest (29.0) g while the body gain in ***O. galilaeus*** was between the two values (38.3) g. ADG and SGR showed the same trend.

Total production of Larvae:

The results of the present study showed that total larvae production difference between tilapia species (***Oreochroms niloticus*, *O. aureus*** **and** ***O. galilaeus***) (10116, 7711 and 8993 larvae) during spawning period respectively.

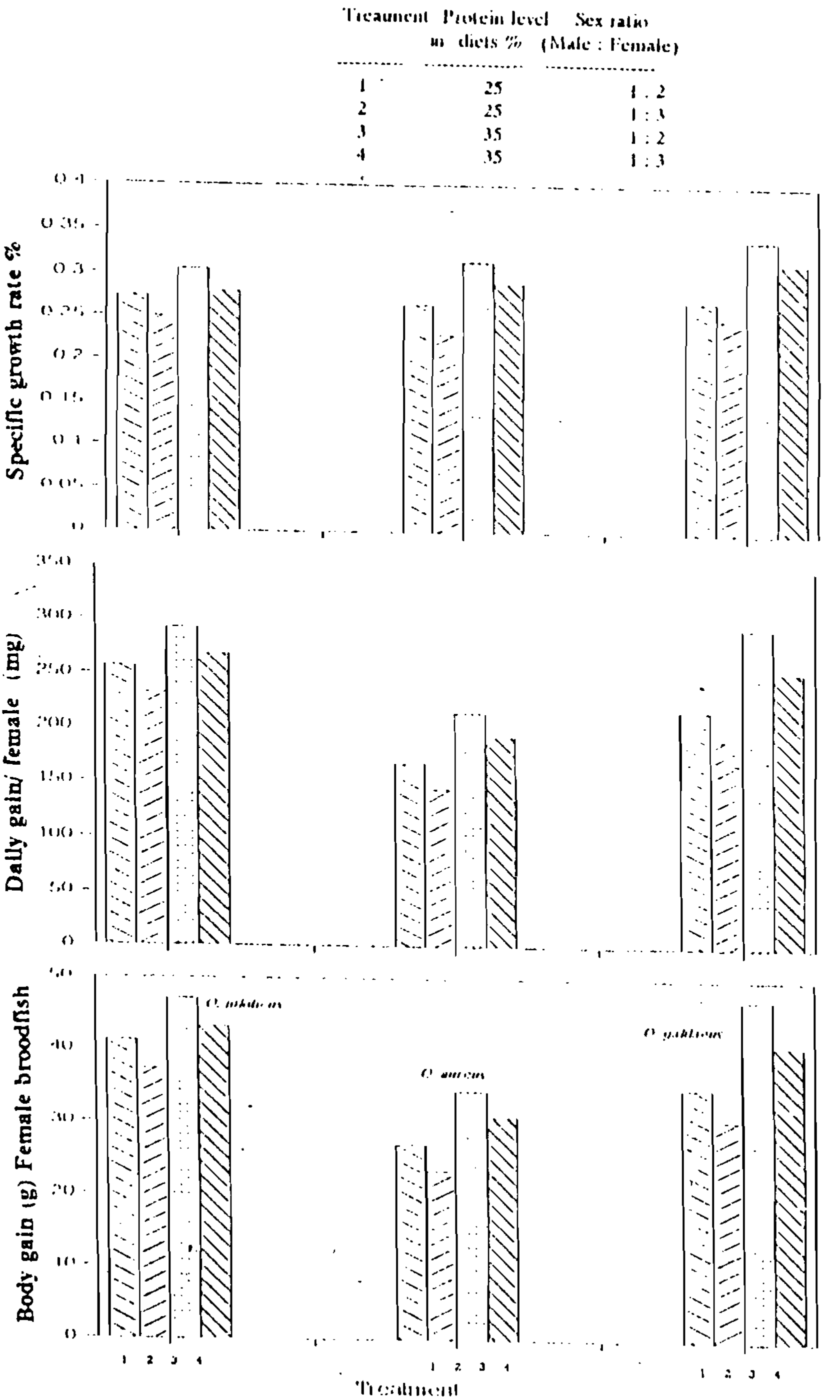


Figure 1: Body gain, Average daily gain and specific growth rale/female broadfish at different protin levels and broadfish sex ratio in the 2nd experiment.

Table (2): Growth perfomance of female brcodfish of some cichlid species in concrete ponds for 161 days.

Treat No.	Protein level %	Fish body			Fish body		
		Proodfish sex ratio (M:F)	Initial	Final	Gain	ADG* (mg/f/day)	SGR** (% day)
Oreochromis niloticus							
1	25	1 : 2	74.0	115.2	41.2	255.9	0.28
2	25	1 : 3	73.0	110.3	37.3	231.7	0.25
3	35	1 : 2	75.0	122.0	47.0	291.9	0.31
4	35	1 : 3	74.5	117.7	43.2	268.3	0.28
Mean ± (S.E)			74.13[a] (0.43)	116.3[a] (2.45)	42.18[a] (2.02)	262.13[a] (12.5)	0.28[b] (0.01)
Oreochromis aureus							
5	25	1 : 2	51.0	78.0	27.0	167.7	0.27
6	25	1 : 3	51.4	74.8	23.4	145.3	0.23
7	35	1 : 2	51.5	86.0	34.5	214.3	0.32
8	35	1 : 3	52.0	83.0	31.0	192.6	0.29
Mean ± (S.E)			51.48[c] (20.5)	80.45[c] (2.51)	28.98[c] (2.41)	180.0[c] (14.96)	0.28[c] (0.02)
Sarotherodon galilaeus							
9	25	1 : 2	63.5	98.5	35.0	217.4	0.27
10	25	1 : 3	62.8	93.5	30.7	191.0	0.25
11	35	1 : 2	64.5	111.5	47.0	293.5	0.34
12	35	1 : 3	63.0	104.0	41.0	254.4	0.32
Mean ± (S.E)			63.45[b] (0.38)	101.88[b] (3.86)	38.25[b] (3.69)	239.0[b] (22.32)	0.30[a] (0.02)
L.S.D. ($P < 0.01$)			2.18	4.14	3.19	19.69	0.012
C.V. %			2.27	3.34	5.67	5.68	3.32

* average daily gain

** specific growth rate

Table (3) : Means for total hatching new larvae (± standard Error of *Oreochromis niloticus, O. aureus* and *S. galilaeus* in concrete ponds after 161 days.

Treat No.	Protein level %	Sex ratio (M:F)	Total No. of newly hatched larvae	Number of Newhatch. larvae/female	Number of n.h.L./female/ day	Number of n.h.L./g female
O. niloticus						
1	25	1 :2	1833	458	6.8	4.8
2	25	1 : 3	2212	369	5.1	4.0
3	35	1 : 2	3358	840	11.9	8.4
4	35	1 : 3	2713	452	5.9	4.7
Mean ±(S.E)			2529 (330)	530 (105.5)	7.4 (1.50)	5.5 (0.95)
O. aureus						
5	25	1 :2	1715	429	5.3	6.6
6	25	1 : 3	1417	236	2.7	3.7
7	35	1 : 2	2637	659	8.0	9.6
8	35	1 : 3	1942	324	3.9	4.7
Mean ±(S.E)			1928 (259.5)	412 (91.5)	5.0 (1.15)	6.2 (1.3)
S. gulilaeus						
9	25	1 :2	1975	494	6.8	6.0
10	25	1 : 3	1826	304	4.8	3.8
11	35	1 : 2	2769	692	10.0	7.8
12	35	1 : 3	2423	404	5.3	4.8
Mean ±(S.E)			2248 (215)	474 (82.5)	6.7 (1.15)	5.6 (0.85)

Treatment	Protein level in diets %	Sex ratio (Male : Female)
1	25	1 : 2
2	25	1 : 3
3	35	1 : 2
4	35	1 : 3

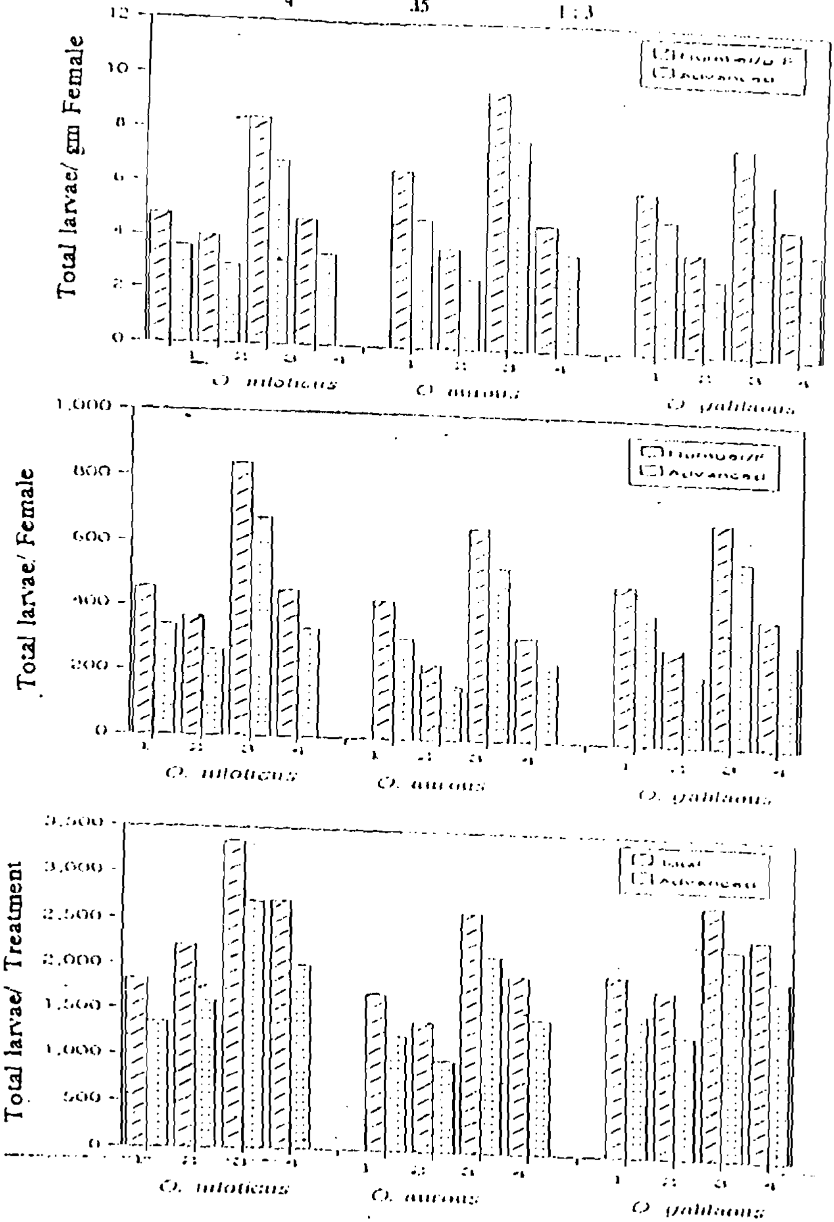


Figure 2: Larvae production and advanced fry 2-3 cm after nursing period of ***Orechromis*** sp. at different levels of crude protein in diets and broadfish sex ratio at the 2nd experiment.

This difference is probably due to the size of species so the average initial weights were 74.1, 51.5 and 63.5 for ***O. niloticus, O. aureus*** and ***O. galilaeus*** respectively. Siraj ***et al.***, (1983) in his study on ***O. niloticus*** reported that a range of fecundity as low as 580 eggs per clutch for year class I (44 g) females to as high as 1820 eggs per clutch for year class III (280 g) females. But the present data indicated that the number of larvae for each gram of female were (5.5, 6.2 and 5.6 fry) for ***O. niloticus, O. aureus*** and ***O. galilaeus*** respectively because the relative fecundity decreased with the increase of body size.

The data in the present study showed also that, the highest production of larvae was obtained when the broad fish were fed o the diet containing 35% crude protein with broadfish sex ratio of one male:two females and the lowest production was obtained when the broadfish were fed at the diet containing 25% crude protein and broadfish sex ratio one male:three females for the three species of tilapia Table (3) and Fig. (2). The results clearly showed the importance of protein level in the diet of broadfish on larvae production and also the importance of broadfish sex ratio at the same time.

Advanced fry and survival rate:

The data in this present experiment indicate also the effect of the protein level in broadfish diets on broadfish sex ratio on advanced fry after 60 days from hatching Table (4) and Fig. (2). The highest total advanced fry were when the broad fish were fed on 35% protein and sex ratio (one male:two females) 2704,2152 and 2302 for ***O. niloticus, O. aureus*** and ***O. galilaeus*** and survival rate% was 80.5, 81.2 and 90.3% respectively. The lowest advanced fry obtained when broadfish were fed on the diet that contain 25% protein and broadfish sex ratio 1:3 (1592, 1000, 1337) for the same species and survival rates % were 71.9, 70.6 and 73.3% for ***O. niloticus, O. aureus*** and ***O. galilaeus*** respectively.

Santiago, (1985) working on tilapia breeders fed with pelleted supplemental diets containing 20 or 40% crude protein at a daily feeding rate 1% of fish biomass for 24 weeks in cages and tanks, found that the 40% protein diet consistently gave the higher fry production and growth of breeders than 20% protein diet. Breeders without supplemental feeding, invariably had the least number of fry and the lowest body weights.

Fryer and Iles, 1972; Lowe-McConnell, 1982, recorded that, the breeders of tilapia fed with the 40% CP diet consistently gave the highest fry production. It is probable that more females fed with the diet were able to spawn at higher frequency, and the number of eggs spawned increased as female body weight increased. Uchida and King (1962) indicated that a high protein diet of 35 to 40 percent protein results in maximum fry production.

Santiago *et al.*, (1981) in his earlier experiments in aquaria fed on high quality feeds near or at satiation level and eggs were removed from the buccal cavity of the broading ***O. niloticus*** females showed that frequency of spawning and number of eggs spawned increased slightly as a dietary crude protein level increased. Finally all the results of this reported literature were in agreement with the present study as the high level of dietary protein consistently produced the highest fry production. It is probable that more females fed with the diet were able to spawn at higher frequency, and the number of eggs spawned increased as female body weight increased.

Huges and Behrends (1983) found the best production of ***Oreochromis niloticus*** larvae were obtained with five broadfish/m^2 and a sex ratio of one male to two females and a mixture of year class I and II females with a total weight of 491 g/m^2, using suspended net enclosures in concrete tanks. Essa (1993) in his studies on the mass production of ***O. niloticus*** fry in concrete basin, found that the highest fry production was attained using breeders with weights of 80-130 gm and a narrow sex ratio of male to female (1:1 and 2:3) and the use of pelleted diet of animal and plant protein mixture.

Numerous reported recommend an optimum broad stock sex ratio where fry production is maximized (Legner, 1978; Planquette and Petel 1977; Rothbard, 1979; Uchida and King, 1962). The results of the present study are in agreement with those reported which indicate the importance of using the lowest sex ratio male to female (1:1 or 1:2) to increase the fry production.

Table (4): Means for advanced fry (3-4 cm length) ± standard Error and survival rate after 60 days of hatching for some cichlid species in concrete ponds (8.0 mL. x 2.7 mW. x 0.7 depth).

Treat No.	Protein level %	Sex ratio (M:F)	Total advanced fry	Advanced fry/female	Advanced fry/gram femal	Survival %
O. niloticus						
1	25	1 : 2	1368	342	3.6	74.6
2	25	1 : 3	1592	265	2.9	71.9
3	35	1 : 2	2704	676	6.8	80.5
4	35	1 : 3	2013	335	3.4	74.2
Mean ± (S.E)			1919 (294)	405 (92)	4.2 (0.9)	75.3 (1.85)
O. aureus						
5	25	1 : 2	1255	314	4.8	73.2
6	25	1 : 3	1000	167	2.6	70.6
7	35	1 : 2	2152	538	7.8	81.2
8	35	1 : 3	1464	244	3.6	75.3
Mean ± (S.E)			1468 (247)	316 (80)	4.7 (1.15)	75.1 (2.25)
S. galilaeus						
1	25	1 : 2	1541	410	5.0	82.9
2	25	1 : 3	1337	223	2.8	73.3
3	35	1 : 2	2302	576	6.5	90.3
4	35	1 : 3	1975	329	3.9	81.7
Mean ± (S.E)			1789 (216.5)	385 (74.5)	4.6 (0.8)	82.1 (3.5)

Table (5): Means + (Standsrd error) of the growth performance, feed convedrsion ratio (FCR) and survival rate (%) of hatched larvae of <u>Oreochromis</u> species after nursing period (60 days).

Month	*O. niloticus*						*O. aureus*						O. galilaeus					
	Body weight		Growth perf.			survival rate %	Body weight		Growth perf.			surv. rate %	Body weight		Growth perf.			Surv. rate%
	Final (mg)	Gain (mg)	ADG	SGR	FCR		Final (mg)	Gain (mg)	ADG	SGR	FCR		Final (mg)	Gain (mg)	ADG (mg/day)	SGR (%/day)	FCR	
May mean ± S.E.	481[a] 27.6	466[a] 27.6	7.76[a] 0.46	6.37[a] 0.53	0.97[d] 0.03	85.1[a] 2.0	435.9[a] 15.6	419.9 15.6	7.0[a] 0.3	5.5[a] 0.06	1.24[c] 0.01	81.0[a] 2.7	361.3a 11.5	346.3a 11.5	5.77a 0.2	5.30a 0.06	1.29d 0.01	84.40a 1.4
June	336.3[b] 11.9	348.3[b] 11.9	5.8[b] 0.2	5.3[b] 0.1	1.15[c] 0.01	76.0[ab] 2.5	353.6[b] 21.2	33 7.8[b] 21.2	5.62[b] 0.36	5.14a 0.11	1.37[b] 0.04	75.1[b] 2.2	309.1b 6.2	294.1b 6.2	4.9b 0.1	5.02b 0.02	1.35c 0.01	84.88a 3.9
July	303.5[b] 6.4	288.5[b] 6.4	4.8[b] 0.1	5.0[b] 0.04	1.31[b] 0.02	73.8[b] 1.7	249.4[c] 12.4	234.4[c] 12.4	3.9[c] 0 2	4.67[a] 0.1	1.43[a] 0.03	74.19[bc] 2.5	232.7c 7.6	217.7c 7.6	3.62b 0.13	4.56c 0.06	1.41b 0.02	83.11a 4.5
August	207[c] 8.2	193[c] 8.2	3.21[c] 0.14	4.8[c] 0.5	1.47[a] 0.02	71.4[b] 2.0	157.6[d] 6.4	142.9[d] 6.2	2.38[d] 0.2	3.69[b] 0.26	1.9[a] 0.1	72.2[c] 3.4	128.3d 6.1	114.3d 6.1	1.90c 0.1	3.68d 0.08	1.58a 0.03	77.98b 3.6
Sept.	188[c] 15.6	175[c] 15.6	2.92[c] 0.26	4.44[c] 0.14	1.48[a] 0.04	70.1[b] 0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand mean	308.56	294.16	4.90	5.18	1.28	75.28	299.13	283.75	4.73	4.75	1.49	75.82	257.85	243.10	4.05	4.64	1.41	82.59
L.S.D. 0.01	70.012	70.012	1.248	0.36	0.145	10.49	64.38	64.38	1.14	0.98	0.18	3.18	20.34	20.34	0.37	0.06	0.06	2.43
C.V.%	4.93	5.17	5.23	1.61	1.94	5.02	3.68	3.88	4.11	3.51	1.86	1.71	1.35	1.43	1.64	0.28	1.04	0.50

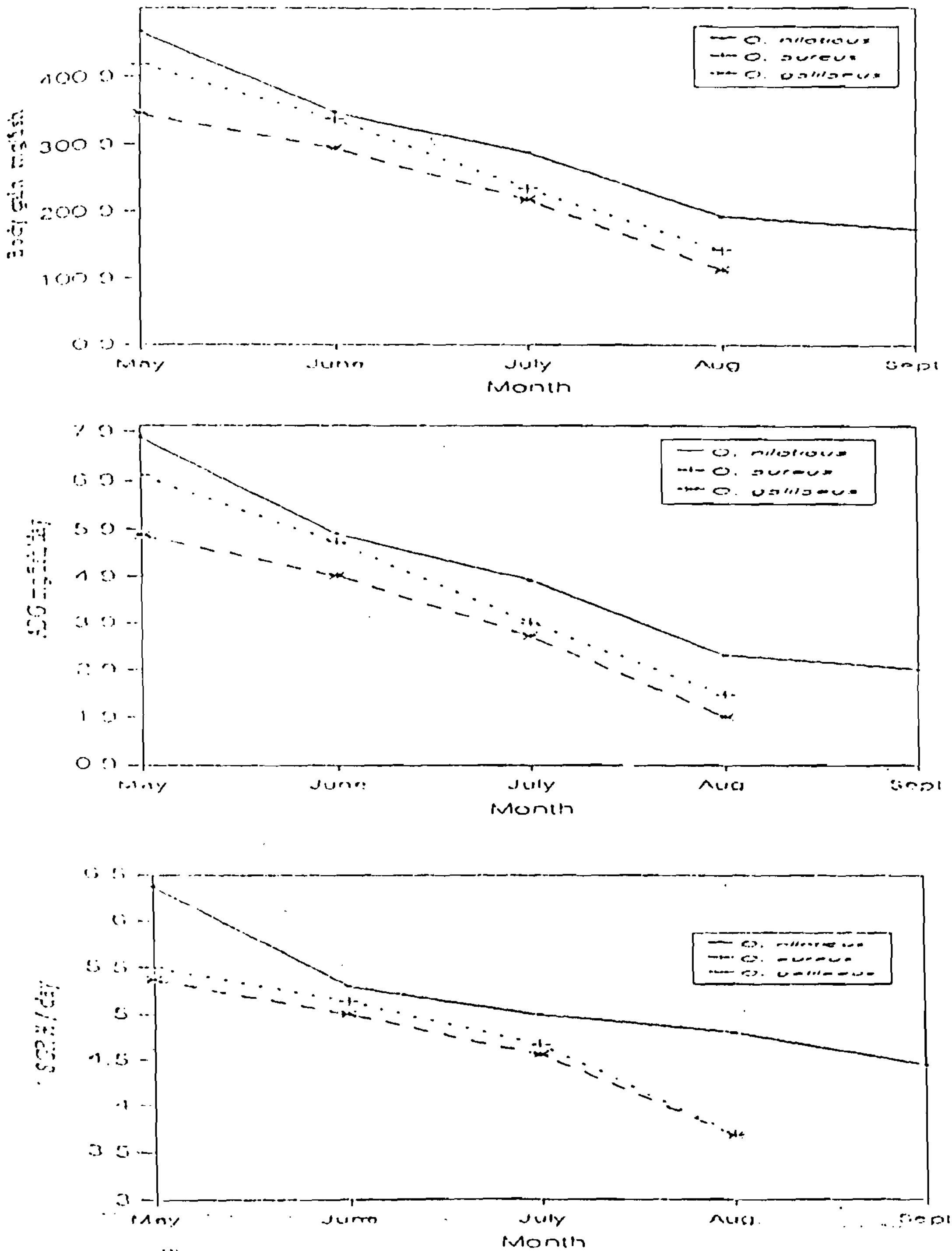
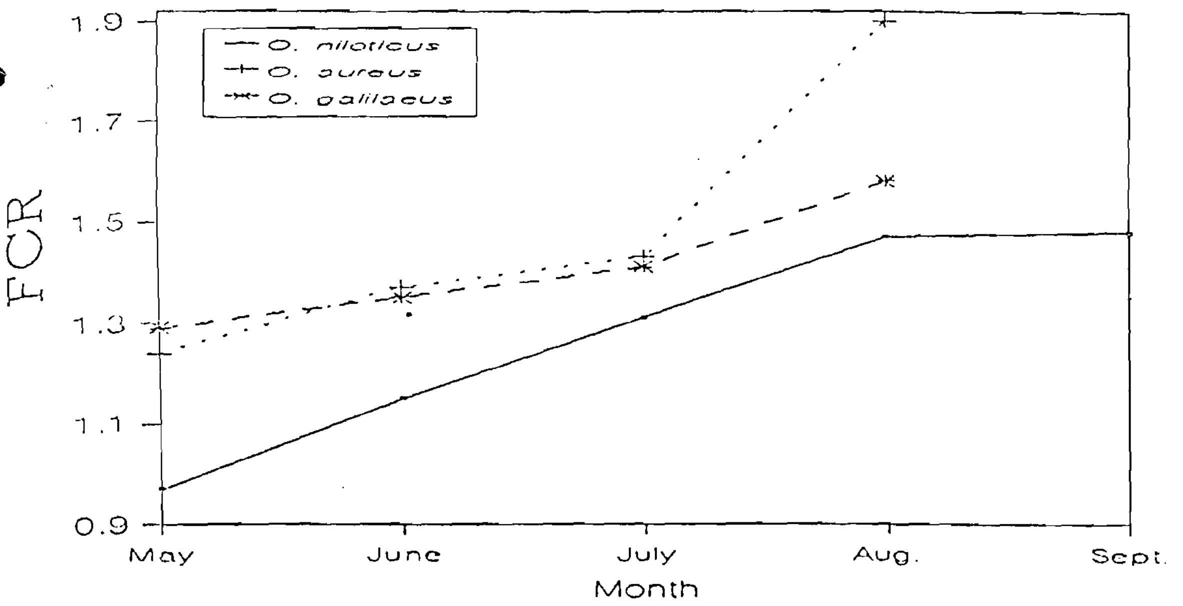


Figure 3: Body gain and growth performance of hatched larvae of *Oreochromis* sp. after nursing period (60 days).

Fig. (4)



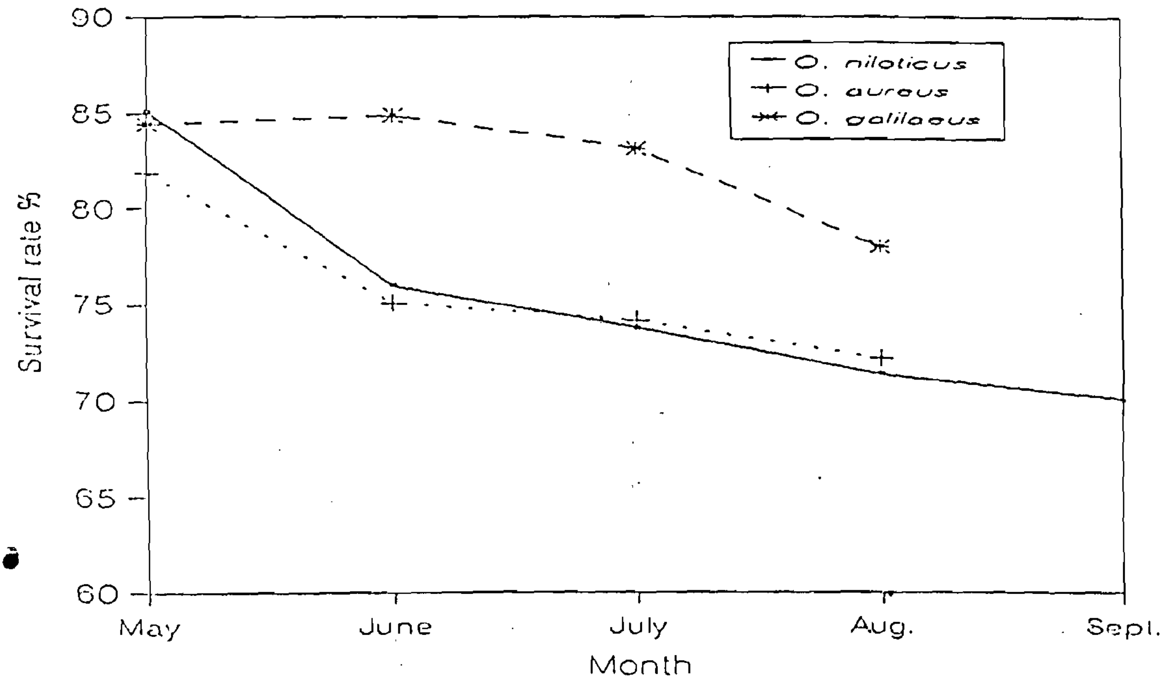


Figure 4: Feed conversion ratio (FCR) and survival rate (%) of hatched larvae of ***Oreochromis*** sp. after nursing period (60 days).

The present data indicated that the time of hatching is more effective on growth performance and survival rate of larva. The highest body gain, survival rate and the best feed conversion ratio were in fry hatched in May and the lowest gain, survival rate and the high conversion ratio were in September for ***O. niloticus*** and in August for ***O. aureus*** and ***O. galilaeus***. Table (5) and Fig. (3,4).

Horrath (1981) in his study about mass production of eggs and larvae of warmwater fish; Essa and Abu El-Wafa (1994) in their study about propagation and rearing of common carp (***Cyprinus carpio***) under hatchery and laboratory conditions, concluded that the growth performance and survival rate of larvae were better in the early spawning than in the late spawning. This result is in agreement with the present study, where the best growth and survival rate were for the larvae hatched in May at all ***Oreochromis*** sp. And the lowest growth and survival were obtained for the larvae hatched in September for ***O. niloticus*** and in August for ***O. aureus*** and ***O. galilaeus***.

REFERENCES

Coche, A.G. 1982. Cage culture of Tilapia. Conference proceeding. 7. International center for Living Aquatic Resources Management, Manila, Philippines, pp. 129-140.

David, G. And Leslie, L. 1983. Mass production of ***Tilapia nilotica*** seed in suspended net enclosures. Page: 394-401 In: Proc. International Symposium on Tilapia in Aquaculuture. Tel Aviv., Israel.

Essa, M.A. 1993. Studies on the mass production of Nile tilapia ***Oreochromis niloticus*** fry in concrete basins. Delta J. Of Science, 17.

Essa, M.A. and Abu El-Wafa, M.A. 1994. Some new observations on the propagation and rearing common carp (***Cyprinus carpio***) under hatchery and laboratory conditions. Bull of the National Institute of Ocean. and Fish. Vol. 21, A.R.E.

Fryer, G. and Iles, T.D. 1972. The Cichlid Fishes of Great Lakes of Africa: Their Biology and Evolution. Oliver and Boyd, Edinburgh, 641 pp.

Horrath, L. 1981. Report of the workshop on the mass production of eggs and larvae of warmwater fish. EIFAC/XII/82/13: Szazhalobatha, Hungary.

Hughes, D.G. and Behrends, L.L. 1983. Mass production of ***Tilapa nilotucs*** seed in suspended net enclosures. International Symp. On Tilapia in Aquac. TEL AVIV, University, Israel, p. 394-401.

Lee. J.C. 1979. Reproduction and hybridization of three Cichlid fishes ***Tilapia aurea*** (Steindachner), ***Tilapia hornorum*** (Trewavas) and ***Tilapia nilotica*** (Linnaevs) in aquaria and plastic pools. Ph.D. Dissertation. Auburn University, Alabama, USA, pp 84.

Legner, E.F., 1978. Mass culture of ***Tilapia zillii*** in pond ecosystems Entomophaga, 23(1):51-5, ASFA, 9, 7591.

Lowe-McConnell, R.H. 1982. The biology and culture of *Tilapias*. Conf. Proc. 7, Intern.Cent For Living Aquatic Resor. Manag., Manila, Philippines, 432, pp.

Mires, D. 1982. A study of the problem of the mass production of hybrid tilapia fry. Confe. Proc. 7; Intern. Center for Living Aquatic Resources. Management, Manila, Philippines, pp. 432.

Planquette, P. And Petel. C. 1977. Data on mass production of ***Tilapia nilotica*** fry. Notes Doc. Peche Piscic., (Nouv. Ser) 14:1-6 (Fr.).

Rafael, D.G. and Garacia, A.M., 1983. Studies on the fry production of ***Sarotherodon niloticus*** in a Lake-based hatchery. Page 388-393. In: Proc. Intern. Symposo. On Tilapia in Aquaculture . Tel Aviv Univ., Israel.

Rothbard, S. 1979. Observation on the reproductive behaviour of ***Tilapia zillii*** and several ***Sarotherodon*** spp. Under aquarium conditions. Bamidgeh, 31(2):33-43.

Rosa, F., 1990. Fecundity & effects of diet. Mediterranean Aquaculture, P. 93-95.

Santiago, C.B. 1985. Amino acid requirements of Nile Tilapia. Ph.D. diss, Auburn University, Auburn, Al. in Nutrition and feeding of Fish. Lovell, T., 1989. Van Nostrand Reinhold, New York.

Santiago, C.B., Banes-Aldaba, M., Laron, M.A. 1981. Effects of varying crude protein levels on spawning frequency and growth of ***Sarotherodon niloticus*** breedings. SEAFDEC Aquaculture Department. Q. Res. Rep., v (4):5-10.

Silvera, P.A.W., 1978. Factors affecting fry production in ***Sarotherodon niloticus*** (Linnaeus). M.Sc. Thesis, Auburn University, Al., U.S.A., 40 pp.

Siraj, S.S., Smitherman, R.O., Castillo, G.S. and Dunham, R.A., 1983. Reproductive traits for three classes of ***Tilapia nilotica*** and maternal effects of their porogeny. International symposium on Tilapia in Aquacuture Proceedings. Tel Aviv Univ. Israel, PP. 210-218.

Springate, J.R.C. and Bromage, N.R., 1985. Effects of egg size on early growth and survival in rainbow trout (***Salmo gairdneri*** R). Aquac., 47:163-72.

Uchida, R.N. and King, J.E., 1962. Tank culture of Tilapia. U.S. Fish Wild. Serv., Fish Bull., 62:21-52.