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GROWTH PERFORMANCE AND PRODUCTION OF *OREOCHROMIS NILOTICUS* USING POLYCULTURE SYSTEMS AND FERTILIZERS

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ABSTRACT

Nile tilapia (*Oreochromis niloticus)* with an average weight of 40.0 g were reared with *Sarotherodon galilaeus* (initial weight of 51.0 g) and *Clarias gariepinus* (initial weight of 73.0 g) at three different combinations of monoculture, duoculture and polyculture systems. The fishes were stocked in seven earthen ponds with varied areas at a density of 4 fish/ m^2 during 210 days and fed on wheat bran. Some rearing ponds were fertilized weekly with a mixture of triple superphosphate and urea.

At the end of the rearing period, the polyculture combination gave better growth rate and production for *O.niloticus* than in duoculture and monoculture systems. The average monthly increments were 21.1g and 29.0 g in ponds 2,3 (polyculture ponds), while in duoculture and monoculture, 18.7 g in pond 6 and 16.6 g in pond 4 were obtained. The specific growth rate and percentage weight gain reached their highest values for *O.niloticus* (0.85, 4.98 in pond 3 and 0.73, 3.64 in pond 2) using polyculture combination. On the other hand, *O.niloticus* showed better growth rate when cultured with *Clarias gariepinus* than with *S.galilaeus*. Its average weight was 131.0 g in pond 6 (*O. niloticus* with *Clarias gariepinus* and 128.5 g in pond 7 (*O.niloticus* with *S.galilaeus*).

It was also observed that in the fertilized ponds, maximum growth in weight and production were recorded (0.379, 0.165 and 0.158 kg/m^2 for the three fish species respectively). In pond 3 (fertilized), the average final weight was 244.0 g for *O.niloticus*, 188.5 g for *S. galilaeus* and 332.0 g for *Clarias gariepinus*. The food conversion ratio has also the optimum value (3.14) for *O.niloticus* reared in polyculture system and fertilized pond.

INTRODUCTION

The Nile tilapia (*O.niloticus*) are considered the most important fish in Egyptian water and are the basis of the fisheries sector, since they represent over 70% of Egyptian fish landings (Ishak *et al.*, 1985). Attention has been focused on fish farming as having the best potential for achieving new sources of fish production.

The rearing of *O.niloticus* only (monoculture) or in combination with other fish species as *T.zillii* or *C.carpio* (duoculture or polyculture systems) remains one of the most promising methods for increasing of growth rate and marketable size of *Tilapia* species (Dadzie, 1982). Hogendoorn and Koops (1983) also showed the influence of mixed culture of *C.gariepinus* and *O.niloticus* on the growth rate and production in earthen ponds. Furthermore, Macintosh and De Silva (1984) reared *O.mossambicus* with *O.niloticus* and *O.aureus* in a polyculture system and noticed that the growth and survival of cultured fishes varied with different stocking densities and food ration. Similarly, Degani *et al.* (1985) determined the effects of culturing *Anguilla anguilla* at various densities with *T.aurea* on the growth and production.

Other combinatons for *O.niloticus* with various fish species in polyculture or duoculture systems were used by many authors in different localities with available environmental conditions, types of feeding sources and water quality (El-Serafy *et al.*, 1993; Sweilum, 1995; Abdel-Halim *et al.*, 1997 and Zaghloul, 2000).

On the other hand, the addition of nitrogen and phosphorus as fertilizers to fish ponds stimulates the phytoplankton to increase, which leads to increasing of fish production in ponds (Boyd, 1976). Similarly, Seymour (1980) reported that the carrying capacity and yield of fish ponds can be increased by fertilization which encourages growth of phytoplankton and in turn the amount of food available to the fish. Therefore, most fish ponds are fertilized to increase phytoplanktonic production which increases fish growth and yield (Yusoff & Mc Nabb, 1997). Moreover, the fertilization also stimulates the growth of the zooplankton organisms in fish ponds which are also considered a main natural food for rearing fish (Jana & Chakrabarti 1997). Consequently, increasing of phytoplankton and zooplankton organisms in the fish ponds leads to improvement of water quality in ponds (Wahby, 1974; Essa *et al.*, 1988 and Njoku, 1997). The purpose of the present study is to determine the effects of species combination and chemical fertilization on the growth rate and total production of Nile tilapia (*O.niloticus*) in earthen ponds. It deals also with the influence of fertilization on water quality and planktonic production in fish ponds.

MATERIAL AND METHODS

Site of work:

The experimental work was conducted in earthen ponds at El-Kanater El-Kahyria Fish Farm, National Institute of Oceanography and Fisheries, Cairo, Egypt. The Fish Farm includes seven earthen ponds with different surface areas and stocking density as indicated in Table 1.

The ponds were filled with Nile water and the water depth in ponds ranged from 150 to 155 cm, while water temperature was from 24 to 25°C (Table 2).

Fertilization:

Ponds 1,3 and 5 were fertilized with a mixture of triple super-phosphate (6.26 g/m^2 per week) and urea (3.06 g/m^2 per week) according to Wahby (1974) and Green *et al.* (1989). while the ponds 2, 4,6 and 7 were maintained as control without fertilization.

Feeds and samples:

Reared fish were fed on wheat bran, five days every week, one time per day at 3% feeding rate. Water temperature, transparency, and pH value were measured daily in each pond. Dissolved oxygen, phosphate, ammonia and nitrate were determined biweekly in ponds according to Arnold *et al.* (1980). The phytoplankton and zooplankton samples were collected monthly from ponds by a plankton net with 20 or 50 micron mesh size, while bottom fauna were collected with a modified Ekman grab (area of 255 m^2), (Table 3). The weight of fish was measured monthly from a random sample in each pond during the period from April, 15^{th} to November, 15^{th}, 2000. The specific growth rate (SGR) and percentage weight gain (PWG) were estimated using the equations of Jauncey & Ross (1982), while the food conversion ratio (FCR) was calculated according to Anderson *et al.*(1984) formula.

SGR =[Ln final weight-Ln initial weight/ Rearing period (day)] x 100.

PWG = [Final weight- Initial weight / Initial weight] x 100.

FCR = [Food given / Gain in weight] x 100.

Statistical analysis:

The means of the experimental results were statistically analysed using students T Test and F test of significance as described by Berlly & Lindgren (1990) applying the following:

$$\text{T calculated value} = \bar{x}_1 - \bar{x}_2 / \frac{SD_1}{\sqrt{n_1}} + \frac{SD_2}{\sqrt{n_2}}.$$

F calculated value =Mean square to treatment/Mean square to error.

RESULTS AND DISCUSSION

The results indicate that the weight of *O. niloticus* reared in pond 2 (polyculture system) increased from an average of 40.5 g to 188.0 g (Table 4) at the end of rearing period (210 days), while in pond 6 (duoculture) and 4 (monoculture) the initial weight (40.0 and 41.0 g) increased to 171.0 and 157.5 g. It was also noticed that the mean increment of fish reached its highest value (21.1 ± 3.5 g monthly) in pond 2 and the lowest value (16.6 ± 7.8 g monthly) in pond 4. F- test of significance shows that the differences between the average increment of *O.niloticus* (Table 5) reared in three combinations (poly,duo and monoculture) were insignificant($p > 0.05$).

The present results suggested that the growth rate of Nile tilapia was higher in polyculture system than in duo or monoculture and the duoculture was better than monoculture system. Consequently, the specific growth rate and percentage weight gain reached their maximum values (0.73 and 3.64) for *O.niloticus* reared in polyculture system, while the minimum values (0.64 and 2.84) were observed in monoculture. The total production of *O. niloticus* was 243.38 kg /pond corresponding to kg/feddan in polyculture system (pond 2) and 110.68 kg/pond corresponding to kg/feddan in monoculture system (pond 4), (Table 6). This may be attributed to the variety of feeding behaviour and metabolic activity of the reared fish species. In turn, there is no competition for supplementary or natural food between the reared fishes. Thus the increase of stocking density of one species in the rearing ponds may lead to a decrease of growth rate.

Thus the present findings agree with those of previous investigators, among them, Dadzie (1982) who reared *O.niloticus* in different cultured systems with *T.zillii* and *C.carpio* and noticed that

O. niloticus had the fastest growth when raised in polyculture with *T.zillii* and *C. carpio,* while in case of duoculture (*O. niloticus* with *T. zillii*) and monoculture (*O. niloticus* only) the poorest growth rate was recorded. Similarly, Hogendoorn & Koops (1983) mentioned that the growth of neither Nile tilapia (*O.niloticus*) nor Nile catfish (*C .gariepinus*) was found to be affected by the presence of the alternate species, indicating the absence of interspecies competition.

The same trend was also postulated by Macintosh & De Silva (1984) when stocked *O. niloticus* with *O. mossambicus* and *O. aureus* in a polyculture system at different stocking densities and observed that the increasing of stocking density leads to elevation of the mortality, consequently decreasing of weight gain and production. Degani *et al.* (1985) stocked *A.angilla* at different densities in monoculture and polyculture systems with *O. aureus* and noticed that the growth of *A.anguilla* was more rapid in a polyculture system with low density than those of monoculture with high density.

On the contrary, Jobling *et al.* (1998) reared the baltic salmon (*Salmo salar*) with brown trout (*Salmo trutta*) in monoculture and duoculture systems for three months and observed that salmon cultured in duoculture ponds (223 ± 9.0 g) tended to have lower body weights than those reared in monoculture (242 ± 10.0 g). Such discrepancy between the result of Jobling *et al.* (1998) and the present study may be due to the variety of experimental conditions (water temperature was 2.7-3°C and the fish reared in tanks, 0.35 m^3) and the salmon fed on a commercial diet containing 46% protein level with twice feeding frequency per day.

On the other hand, the final weight (171.0 g) and monthly average increment (18.7 ± 4.9 g) of *O.niloticus* reared in pond 6 (*O. niloticus* with *C. gariepinus*) were more than in pond 7 (*O. niloticus* with *S. galilaeus*). Statistical analysis with T test showed that, the difference between the average increment in ponds 6 and 7 was not significant ($p>0.05$). This may be mainly because *C. gariepinus* is a carnivorous fish, preying on fry produced from the experimental fish during the rearing period. Thus the supplementary food was eaten by reared fish and not by producing fry. The same observations were also mentioned by Hassanen (1987) and El-Agamy *et al.* (1992) in their studies on culture of *C. gariepinus*.

Table (2) shows the effect of chemical fertilizers (triple super phosphate and urea) on water quality of rearing ponds. It was noticed that, the transparency of pond water reached its highest values (71.2, 60.6 and 65.7 cm) in non fertilized ponds (2,4 and 6) while the lowest values (32.3, 30.5 and 35.0 cm) in fertilized ponds (1,3 and 5). This is due to the high fertility of ponds water with increasing of phytoplankton and zooplankton organisms. Consequently, the dissolved oxygen, phosphate and nitrate reached their maximum values (8.8, 1.8 and 4.7 mg/l) in the fertilized pond 3 at which the concentration of ammonia had the lowest limit (1.1 mg /l) and pH value has a suitable value (7.4). This may be attributed to increase of photosynthesis with increasing Chlorophyta in the ponds which leads to elevation of oxygen level and lowering of carbon dioxide (CO_2) which in turn influences the pH value and other chemical characteristics of ponds water. These observations are in accordance with the fendings of Wahby (1974), Tuburan *et al.* (1989) and Njoku (1997).

Examination of pond water showed that the maximum number of phytoplankton organisms (17700, 23700 and 20800 cell/l) were observed in fertilized ponds (1,3 and 5) and Chlorophyta (green algae) was the most abundant group (44.3 %), (Table 2). while the lowest numbers (1200, 7200 and 8000 cell /l) were recorded in non fertilized ponds (2,4 and 6). Seymour (1980) reported that the production of fish ponds can be increased by fertilization which encourages growth of phytoplankton and in turn the amount of food available to the rearing fish. Spataru *et al.*(1983) studied the natural food of carp and tilapia species reared in fertilized ponds and noticed that there was a high dominance for plankton organisms in water and in gut of fishes after fertilization of the ponds.

Similarly, Green *et al.*(1989) observed that the addition of nitrogen and phosphorus fertilizers to fish ponds (triple superphosphate and urea) stimulates the productivity of phytoplankton organisms, thus increasing tilapia production in the ponds. The same observations were also recorded by Knud-Hansen & Batterson (1994) who mentioned that most of fish culture ponds were fertilized to increase phytoplanktonic production which would increase fish yield. Furthermore, Yusoff & Mc Nabb (1997) found that addition of combined triple superphosphate and urea to fish ponds not only significantly increased ($p > 0.05$) total phytoplankton densities, but also caused a shift from Cyanophyta (blue –green algae) dominance to Chlorophyta (green algae).

On the other hand, addition of fertilizers to fish ponds stimulates the increase of zooplankton and benthos in ponds. Table (3) shows that the highest number of zooplankton organisms (620, 740 and 690 cell / l) was observed in fertilized ponds (1,3 and 5) with the dominance of cladoceran spp. (31.16 %). The bottom fauna (benthos) which was represented by chironomid larvae and tubifex worms also increased in fertilized ponds (82, 117 and 100 organism (m^2) than that in non fertilized ones. Rappaport *et al.*(1977) mentioned that the number of zooplankton and chironomid larvae which are the most important source of natural food for freshwater fishes (carp and tilapia) were highly increased by addition of organic and inorganic fertilizers to the fish ponds.

Furthermore, Groeneweg & Schlüter (1981) made a mass culture of rotifers (*Brachionus* sp.) by fertilization of fish sponds with organic fertilizers. Similarly, Geiger (1983) reported that zooplankton production and manipulation in striped bass rearing ponds were carried out by using a combination of organic and inorganic fertilizers. Essa *et al.* (1988) noticed that, the zooplankton production increased significantly ($p < 0.05$) in fish ponds by addition of fertilizer compounds which provides a continuous supply of organic matter containing elements (carbon, nitrogen and phosphorus) required for increasing the natural food for fishes, while Jana & Chakrabarti (1997) used different rates and frequencies of organic fertilizers for the culture of cladoceran zooplankton (*Daphnia* sp.).

Generally, the present results indicated that the growth rate and production of the cultured fish were higher in fertilized ponds which had a high water fertility and suitable water quality. The final weight and average increment of *O. niloticus* in pond 3 (244.0 and 29.0 gm) were more than in pond 2 (188.0 and 21.1 g) (Table 4). The difference between the average increment in the two ponds was significant at 5% ($p < 0.05$) and insignificant at 1% ($p > 0.01$). Table (6) shows that the total fish production of *O.niloticus* was 455.17 kg in pond 3 (fertilized) and 243.38 kg in pond 2 (non fertilized). On the other hand, the specific growth rate and percentage weight gain of the cultured fishes were higher in pond 3 (fertilized) than in pond 2 (non fertilized). The same observations were also recorded by Green *et al.*(1989), El- Serafy *et al.*(1993) and Nojku (1997).

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Table 1. Fish ponds and stocking densities

Pond No	Pond area (m^2)	Fish species and stocking density (4 fish/m^2)			
		O.niloticus	*S.galilaeus*	*C.gariepinus*	Stocking rates
1	450	900	900	-	1: 1
2	900	1800	1200	600	3:2 : 1
3	1200	2400	1600	800	3: 2 : 1
4	300	1200	-	-	-
5	750	2250	-	750	3:1
6	800	2400	-	800	3:1
7	525	1050	1050	-	1:1

Table (2): Water quality in ponds throughout the rearing period.
(* ponds 1,3 and 5 were fertilized).

Items	Pond*1	Pond2	Pond*3	Pond 4	Pond*5	Pond6	Pond7
Air temperature (C°)	25.0±3.2	26.0± 3.0	25 5± 3.4	26.0± 4.2	26.0±3.3	25.2± 2.8	25.5±3.5
Water temperature (C°)	24.0 ± 2.7	24.2±3.3	24.0± 2.5	24.5± 3.1	25.0±2.6	24.0± 3.0	24.4± 2.7
Water depth (cm)	150.0± 15.2	155.5± 12.0	153.0± 26.2	150.5± 32.0	155.0± 28.5	150.0± 29.0	150.0±14.5
Transparency (cm)	32.3± 4.8	71.2± 9.0	30.5± 4.4	60.6± 7.2	35.0± 6.4	65.7± 8.8	63.6±7.2
Dissolved oxygen (mg/L)	8.0± 1.7	4.8± 1.1	8.8± 2.5	5.5± 2.0	7.7± 1.9	6.0± 2.0	5. 7± 1.15
Phosphate (mg / L)	1.7± 0.2	0.5± 0.1	1.8± 0.3	0.6± 0.1	1.7± 0.2	0.7± 0.2	0.8± 0.3
Ammonia (mg / L)	1.2± 0.4	1.8± 0.6	1.1± 0.3	1.5± 0.2	1.3± 0.4	1.7± 0.3	1.6± 0.4
Nitrate (mg / L)	3.2± 1.4	0.8± 0.3	4.7± 1.8	1.1± 0.3	4.3± 1.4	0.8± 0.3	0.8± 0.4
pH value	7.7± 1.4	8.5± 1.3	7.4± 1.2	8.0± 1.5	7.8± 1.2	8.2± 1.4	8.6± 1.3

Table (3): The average number and percentage composition of plankton organisms (No. / L) and bottom fauna (No. / m^2) in ponds (The true number of phytoplankton = Number in table x 100).

Organisms	Pond*1		Pond 2		Pond*3		Pond 4		Pond*5		Pond 6		Pond 7	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Phytoplankton														
Chrysophyta spp.	62	35.0	45	37.5	80	33.7	35	48.6	73	35.1	25	31.2	45	32.1
Chlorophyta spp.	85	48.0	50	41.6	105	44.3	22	30.5	95	45.6	35	43.7	60	42.8
Cyanophyta spp.	30	16.9	25	20.8	52	21.9	15	20.8	40	19.2	20	25.0	35	25.0
Total	177	-	120	-	237	-	72	-	208	-	80	-	140	-
Zooplankton														
Ciliophora spp.	250	40.32	140	37.14	280	37.84	130	36.62	260	37.68	120	34.29	140	37.84
Rotifera spp.	120	19.35	80	21.22	150	20.27	75	21.13	140	20.29	80	22.86	80	21.62
Cladocera spp.	180	29.03	105	31.16	210	28.38	100	28.17	200	28.99	110	31.43	120	32.43
Copepoda spp.	70	11.29	52	13.79	100	13.51	50	14.08	90	13.04	40	11.43	30	8.11
Total	620	-	377	-	740	-	355	-	690	-	350	-	370	-
Bottom fauna														
Chironomid larvae	52	63.41	30	60.00	75	64.10	30	57.69	60	60.00	35	62.50	25	55.56
Tubifex worms	30	36.59	20	40.00	42	35.90	22	42.31	40	40.00	21	37.50	20	44.44
Total	82	-	50	-	117	-	52	-	100	-	56	-	45	-

Table (4): Average growth (g) of total weight (t.wt) and monthly increment (inc.) of *O.niloticus* in different rearing ponds.

Rearing period	Pond 1		Pond 2		Pond 3		Pond 4		Pond 5		Pond 6		Pond 7	
day	t.wt	inc.	t.wt	inc.	t.wt	inc.	t.wt	inc.	t.wt	inc.	t.wt	inc.	t.wt	inc.
0	41.2	-	40.5	-	40.8	-	41.0	-	40.5	-	40.0	-	40.0	-
30	64.5	23.3	61.3	20.8	67.0	26.2	56.5	15.5	59.0	18.5	55.5	15.5	54.0	14.0
60	87.0	22.5	78.0	16.7	96.5	29.5	64.2	7.7	85.0	26.0	71.0	15.5	68.0	14.0
90	103.5	16.5	95.0	17.0	132.5	36.0	77.0	12.8	100.0	15.0	18.5	27.5	86.0	18.0
120	129.3	25.8	120.5	25.5	158.0	25.5	109.0	32.0	140.0	40.0	120.1	21.6	105.5	19.5
150	146.5	17.2	140.0	19.5	180.0	22.0	120.5	11.5	158.0	18.0	140.0	19.9	130.0	19.5
180	168.0	21.5	163.5	23.5	215.5	35.5	140.0	19.5	175.0	17.0	158.5	18.5	150.0	20.0
210	181.0	13.0	188.0	24.5	244.0	28.5	157.5	17.5	184.0	9.0	171.0	12.5	168.5	18.5
M ± SD	-	19.9 ± 4.5	-	21.1 ± 3.5	-	29.0 ± 5.2	-	16.6 ± 7.8	-	20.5 ±10.0	-	18.7 ± 4.9	-	17.6 ± 2.6

Table (5) F-test of significant between the means of *O.niloticus* increments.

Source of variation	Degree of freedum	Sum squar	Mean squar	F. value		
				Calculated	Tabulated	
					5%	1 %
Treatment	2	68.74	34.37	0.92	3.55	6.01
Error	20	672.27	37.35			
Total	18	741.01	41.17			

Table (6): Growth performance, production and feed utilization of reared fishes in different ponds.

Items	Pond 1		Pond 2			Pond 3			Pond4	Pond 5		Pond 6		Pond 7	
	O.n	S.g	O.n	S.g	C.l	O.n	S.g	C.l	O.n	O.n	C.l	O.n	C.l	O.n	S.g
Initial weight/fish (g)	41.2	51.0	40.5	50.5	72.0	40.8	52.0	73.0	41.0	40.5	74.0	40.0	74.0	40.0	51.5
Final weight/fish (g)	181.0	155.5	188.0	141.0	275.8	244.0	188.5	332.0	157.5	184.0	291.0	171	280.0	168.5	138.5
Gain in weight (g)	139.8	104.5	147.5	90.5	203.8	203.2	136.5	259.0	116.5	143.5	217.0	131.0	286.0	128.5	87.0
Gain in weight/day (g)	0.67	0.50	0.70	0.43	0.97	0.96	0.65	1.23	0.55	0.68	1.03	0.62	0.98	0.61	0.41
Number of fish / pond	900	900	1800	1200	600	2400	1600	800	1200	2250	750	2400	800	1050	1050
Number of fish survived	845	840	1650	1050	580	2240	1450	230	950	2000	710	2120	740	870	850
Survival rate (%)	93.9	93.3	91.7	87.5	96.7	93.3	90.7	91.3	79.2	88.9	94.7	90.0	92.5	82.9	80.9
Total production pond (kg)	118.13	87.78	243.38	95.03	456.51	455.17	197.93	189.07	110.68	287.00	154.07	277.72	211.64	111.80	73.95
Production /m^2 (kg)	0.263	0.195	0.270	0.106	0.131	0.379	0.165	0.158	0.369	0.383	0.105	0.354	0.191	0.213	0.141
Food given (kg)	427.0	390.3	8483	452.4	453.9	1435.4	784.6	747.0	336.7	101.0	583.1	1025.5	589.0	408.1	392.0
Food conversion ratio	3.61	4.45	3.48	4.76	3.84	3.14	3.96	3.97	3.04	3.52	3.78	3.62	3.86	3.65	3.77
Specific growth rate	0.60	0.53	0.73	0.49	0.64	0.85	0.61	0.72	0.64	0.72	0.65	0.69	0.64	0.69	0.47
Percentage weight gain (%)	3.39	2.05	3.64	1.79	2.83	4.98	2.63	3.55	2.84	3.54	2.93	3.28	2.78	3.21	1.69

These values are expressed as an average of fish examined in each pond.

O.n = *Oreochromis niloticus*.

S.g = *Sarotherodon galilus*.

C.l = *Clarias* gariepinus.