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THE EFFECT OF TIMING OF FEED SUPPLEMENTATION ON GROWTH PERFORMANCE AND PRODUCTION OF NILE TILAPIA, COMMON CARP AND SILVER CARP IN POLYCULTURED FERTILIZED PONDS

By

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Key Words: Fish growth, Nile tilapia, common carp, silver carp, time of first feeding, FCR, fish production, proximate analysis.

ABSTRACT

The time of first application of artificial feed to fertilized earthen ponds was evaluated. Earthen ponds (surface area 1000 m^2 each) were used in this study. Each pond was initially fertilized with 75 kg chicken manure two weeks before fish stocking, then it was biweekly fertilized with 15 kg chicken manure, 2 kg urea (46.5%N) and 10 kg monosuperphosphate (15.5% P_2O_5). To each pond, 1000 fish of Nile tilapia; Oreochromis niloticus (10-15 g/fish), 200 fish of common carp; Cyprinus carpio (7-13 g/fish) and 1000 fish of silver carp; Hypophthalmichthys molitrix (1.5-2.0 g/fish) were stocked. Four treatments were used in the present study. They differed in timing of supplementary feed addition which was initiated as follows: after zero day (continued for 135 days; T1), after 45 days (continued for 90 days; T2), after 90 days (continued for 45 days; T3) and no added supplemental feed (control). Fish were fed at rate of 3% of live body weight with fish diet (25% crude protein) twice daily. The obtained results showed that the growth parameters of Nile tilapia and common carp was maximized at T1 and T2 with insignificant difference.

(P>0.05), meanwhile that of silver carp was maximized at T3. The maximum overall fish production was obtained at T1 and T2 with non-significant difference (6.1 and 6.2 ton/ha, respectively), while the minimum one was obtained at control (2.9 ton/ha). The optimum feed conversion ratio was obtained at T2 (1.04).

INTRODUCTION

An important aspect of successful aquaculture management in semi-intensive culture system is the supply of basic nutrients in the form of phosphorus, nitrogen and carbon as well as feed supplementation. This is a principal factor commonly used in pond culture to increase fish growth and to allow fish intensification. Early studies indicated that the feed supplementation to fertilized fishpond resulted in significant higher growth rates and greater fish production than fertilization alone (Green, 1992; Diana *et al.*, 1994; Diana *et al.*, 1996; Diana, 1997).

Hepher (1978) suggested that the critical standing crop and carrying capacity would increase with supplemental feeds. He also hypothesized that fish growth in well-fertilized ponds or in supplementally fed ponds will be similar until critical standing crop is reached. After fish reached critical standing crop, growth should decline in these ponds, while supplementally fed ponds should continue to produce good growth until water quality becomes limiting due to high loading rates.

The cost of feed is one of the largest expenses in fish production. Some concern should strive to reduce this expense by feeding the correct amount of feed at the right time to insure maximum efficiency. Meanwhile, realization of the optimum feeding regime for cultured fish would help to reduce feed wastes, costs and maximizing feed conversion efficiency (Sampath, 1984; Charles *et al.*, 1984; Chiu *et al.*, 1987; Diana, 1997).

In Egypt, the use of Nile tilapia, common carp and silver carp are common in polyculturing the earthen ponds. The aim of using fish multispecies (polyculture) was to increase fish yield through utilization of the natural food where the cultured fishes have different food habits. Nile tilapia and common carp could consume artificial feeds efficiently, while silver carp response to artificial feeds is not efficient.

However, natural food should be taken into account and such fish yields will be attained only if the fish population maximally utilizes the trophic basis in the pond. The previous studies were done with monoculture of Nile tilapia and no knowledge was available about the first feed initiation in polyculture system in Egypt. Therefore, this study was carried out to investigate the optimum timing of feed supplementation in fertilized earthen ponds on growth performance of Nile tilapia, common carp and silver carp as a polyculture system.

MATERIALS AND METHODS

Eight earthen ponds (surface area 1000 m^2) were used in this study. The ponds were located at Central Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, Sharqia, Egypt. These ponds were firstly drained and cleaned, then supplied with freshwater from

Ismailia canal throughout El-Wady canal to a depth of 100 cm. Water depth was readjusted in all ponds. The experiment was continued for 135 days. Water temperature was 23.6-28.7 °C, dissolved oxygen was 5.2-7.6 ppm, pH was 8.5-8.8 and ammonia 0.5-0.88 ppm.

Each pond was initially fertilized with 75 kg chicken manure two weeks before fish stocking, and then it was biweekly fertilized with 15 kg chicken manure, 2 kg urea (46.5% N) and 10 kg monosuperphosphate (15.5% P_2O_5). The inorganic fertilizers were dissolved and splashed on the water surface of ponds.

Cultured fish were obtained from Abbassa nursery ponds and acclimatized in indoor tanks for 15 days. Fifty fish of each species were frozen at –20 °C for chemical analysis. Then, to each pond, 1000 fish of Nile tilapia; *Oreochromis niloticus* L. (10-15 g/fish), 200 fish of common carp; *Cyprinus carpio* L. (7-13 g/fish) and 1000 fish of silver carp; *Hypophthalmichthys molitrix* V. (1.5-2.0 g/fish) were stocked.

Four treatments were used to estimate optimal timing for the first feed application. Two ponds randomly assigned to each treatment. All ponds received organic and inorganic fertilization, while first supplementary feeding was initiated on the first day and continued for 135 days (T1), after 45 days and continued for 90 days (T2) and after 90 days and continued for 45 days (T3) of experiment beginning as well as only fertilized ponds without supplemental feeding (control). Fish were fed at rate of 3% of live body weight with fish diet (25% crude protein), that was provided to fed-ponds twice daily. Every two weeks, 50 fish of each species from each pond were sampled, and individual weight was measured. The amounts of given feed were readjusted accordingly.

Water samples for biological and chemical analyses were collected biweekly at 30 cm depth from each pond. Dissolved oxygen and temperature were measured at 30 cm depth with a YSI model 58 oxygen meter (Yellow Spring Instrument Co., Yellow Springs, Ohio, USA) and water conductivity was measured with a YSI model 33 conductivity meter (Yellow Spring Instrument Co., Yellow Springs, Ohio, USA). The pH value and ammonia were measured colorimetrically by using Hach kits (Hach Co., Loveland, Colorado, USA). The different chemical parameters were analyzed according to APHA (1985).

At the end of the experiment, the ponds were drained and fish were harvested and weighed. Proximate chemical analysis of each species was done according to AOAC (1990). The different growth parameters and feed utilization were calculated as follows:

$$\text{Weight gain} = W_1 - W_0$$
$$\text{Daily weight gain} = (W_1 - W_0) / T \text{ (days)}$$
$$\text{Specific growth rate (SGR)} = 100 (\ln W_1 - \ln W_0) / T \text{ (days)}$$

Where W_0 and W_1 are the initial and final weights, respect, and T is the number of days of the feeding period.

$$\text{Feed conversion ratio (FCR)} = FI / (B_1 - B_0)$$

Where FI, B_0 and B_1 are the feed intake, the biomass at the start and end, respectively.

The obtained data were conducted to one-way analysis of variance (ANOVA) following Snedecor and Cochran (1982) and differences between means were done at the 5% probability level using Duncan's new multiple range tests (Duncan, 1955).

RESULTS

Concerning fish growth, Table 1 shows that the growth of Nile tilapia was maximized at T1 and T2 (162.0 and 162.1 g/fish, respectively), while the minimum growth was obtained at control (77.2 g/fish). Accordingly, fish weight gain showed the same trend and the maximum value was obtained at T1 and T2 without significant difference (148.2 and 148.5 g/fish, respectively; P>0.05). The minimum weight gain was obtained at control (63.6 g/fish). Similarly, the maximum daily weight gain of Nile tilapia was obtained at T1 and T2 without significant difference (1.12 and 1.13 g/d, respectively; P>0.05), while the minimum one was obtained at control (0.48 g/d). Also, SGR was maximum at T1 and T2 without significant difference (1.86 and 1.88 %/d, respectively; P>0.05), while the minimum one was obtained at control (1.32 %/d).

Furthermore, the final weight of common carp was maximized at T1 and T2 without significant difference (587.5 and 593.1 g/fish, respectively; P>0.05), while the minimum one was obtained at control (210.9 g/fish). The higher weight gain was obtained at T1 and T2 without significant difference (582.3 and 576.9 g/fish, respectively; P>0.05) whereas the lowest one was obtained at control (200.2 g/fish). Similarly, the high daily weight gain of common carp was obtained at T1 and T2 without significant difference (4.37 and 4.41 g/d, respectively; P>0.05), while the lowest one was obtained at control (1.52 g/d). Also, the high SGR was obtained at T1 and T2 with the same value (3.06 %/d), while the least one was obtained at control (2.26 %/d).

On the other hand, the maximum final weight of silver carp was obtained at T3 (271.6 g/fish) and the least one was obtained at control, T1 and T2 without significant difference (251.2, 234.3 and 243.5 g/fish, respectively). Also, the higher weight gain was obtained at T3 (269.8 g/fish) and the least one was obtained at control, T1 and T2 without significant difference (249.4, 232.5 and 241.7 g/fish, respectively). Similarly, the maximum daily weight gain was obtained at T3 (2.04 g/d) and the least one was obtained at control, T1 and T2 without significant difference (1.89, 1.76 and 1.83 g/d, respectively). Also, SGR was maximized at T3 (3.83 %/d), while the least ones were obtained at control, T1 and T2 without significant difference (3.74, 3.69 and 3.73 %/d, respectively).

Table (1): Growth performance parameters of Nile tilapia (*O.niloticus*), common carp (*C.carpio*) and silver carp (*H.molitrix*) affected by different timing of supplemental feeding in fertilized earthen ponds.

Items	T1	T2	T3	Control
Nile tilapia				
Initial wt. (g/fish)	13.73 ^{a} ± 0.03	13.55 ^{a} ± 0.08	13.70 ^{a} ± 0.03	13.60 ^{a} ± 0.05
Final wt. (g/fish)	162.0 ^{a} ± 4.6	16[illegible].1 ^{a} ± 3.9	108.0 ^{b} ± 1.2	77.2 ^{c} ± 0.4
Wt. Gain (g/fish)	148.2 ^{a} ± 4.5	148.5 ^{a} ± 4.0	94.3 ^{b} ± 1.2	63.6 ^{c} ± 0.4
Daily gain (g/d)	1.12 ^{a} ± 0.03	1.[illegible] ^{a} ± 0.03	0.71 ^{b} ± 0.009	0.48 ^{c} ± 0.003
SGR (%/d)	1.86 ^{a} ± 0.02	1.88 ^{a} ± 0.023	1.57 ^{b} ± 0.009	1.32 ^{c} ± 0.009
Common carp				
Initial wt. (g/fish)	10.60 ^{a} ±0.17	10.[illegible]5 ^{a} ±0.09	10.90 ^{a} ±0.01	10.65 ^{a} ±0.14
Final wt. (g/fish)	587.5 ^{a} ±2.7	59[illegible].1 ^{a} ±6.8	298.3 ^{b} ±4.7	210.9 ^{c} ±4.6
Wt. Gain (g/fish)	576.9 ^{a} ±2.5	58[illegible].3 ^{a} ±6.8	287.4 ^{b} ±4.7	200.2 ^{c} ±4.5
Daily gain (g/d)	4.37 ^{a} ±0.01	4.[illegible] ^{a} ±0.12	2.18 ^{b} ±0.03	1.52 ^{c} ±0.03
SGR (%/d)	3.03 ^{a} ±0.009	3.[illegible] ^{a} ±0.030	2.50 ^{b} ±0.080	2.26 ^{c} ±0.006
Silver carp				
Initial wt. (g/fish)	1.80 ^{a} ±0.03	1.76 ^{a} ±0.05	1.73 ^{a} ±0.04	1.80 ^{a} ±0.03
Final wt. (g/fish)	234.3 ^{b} ±1.3	24[illegible].5 ^{b} ±2.6	271.6 ^{a} ±3.8	251.2 ^{b} ±8.1
Wt. Gain (g/fish)	232.5 ^{b} ±1.3	24[illegible] ^{b} ±2.6	269.8 ^{a} ±3.8	249.4 ^{b} ±8.1
Daily gain (g/d)	1.76 ^{b} ±1.35	1.[illegible] ±0.02	2.04 ^{a} ±0.03	1.89 ^{b} ±0.06
SGR (%/d)	3.69 ^{b} ± 0.017	[illegible] ±0.015	3.83 ^{a} ±0.029	3.74 ^{b} ±0.040

Means with same letter in same row are not significantly different ($P<0.05$).

Control = Natural feed only, T1 = Natural feed + supplemented feed from the beginning experimental period (135 days), T2 = Natural feed + supplemented feed at 45 days from the beginning experimental period and T3 = Natural feed + supplemented feed at 90 days from the beginning experimental period.

The higher overall fish production (Table 2) was obtained at T1 and T2 without significant difference (6.1 and 6.2 ton/ha, respectively; P>0.05), while the minimum one was obtained at control (2.9 ton/ha). It also noticed that the contribution of Nile tilapia to the total production increased by increasing the feeding period (50.9, 48.4, 44.0 and 24.1 % with T1, T2, T3 and control, respectively; Fig 1). Contrarily, the contribution percentage of silver carp was decreased by increasing feeding period (31.1, 32.2, 44.0 and 62.1% with T1, T2, T3 and control, respectively). Common carp contribution percentages were slightly fluctuated and ranged from 12.0% at T3 to 19.4% at T2.

Regarding the feed utilization, Fig 2 showed that the feed amount given to T1 was the biggest followed by that of T2 and T3. Feed intake was fluctuated without significant difference at T1 and T2 (671.5 and 622.8 g/fish, respectively). Similarly, the optimum FCR was obtained at T1 and T2 without significant difference (1.12 and 1.04, respectively).

Concerning the gain in fish body composition, data in Table 3 show that the gain in dry matter, crude protein, total lipids and ash in Nile tilapia were maximized at T2 (48.27, 23.83, 18.34 and 6.1 g/fish, respectively). The least ones were obtained at control (15.29, 9.42, 2.13 and 3.80 g/fish, respectively). Similarly, the higher gain of different parameters of body composition in silver carp was obtained at T2 (67.26, 42.61, 13.88 and 10.77 g/fish with dry matter, crude protein, total lipids and ash, respectively). The least ones were obtained at control except ash gain was the lowest at T1 and T3 without significant difference. On the other hand, the higher gain of different parameters of body composition in common carp was obtained at T1 (210.32, 106.58, 84.95 and 18.73 g/fish with dry matter, crude protein, total lipids and ash, respectively). The least ones were obtained at control 43.61, 32.56, 5.91, 5.06 g/fish with dry matter, crude protein, total lipids and ash, respectively).

The economic analysis (Table 4) indicated that all of the treatments in this experiment would generate profit, while the T2 was the most profitable, and T1 was predicted to loss money. Total variable costs and the values of fish harvest were higher in ponds treated by inorganic fertilizer plus supplementary feed than those treated by fertilization alone. Also, Table 4 indicated that the maximum fish value and subsequently the higher profit were obtained at T2, while the least one was obtained at control (fertilization alone).

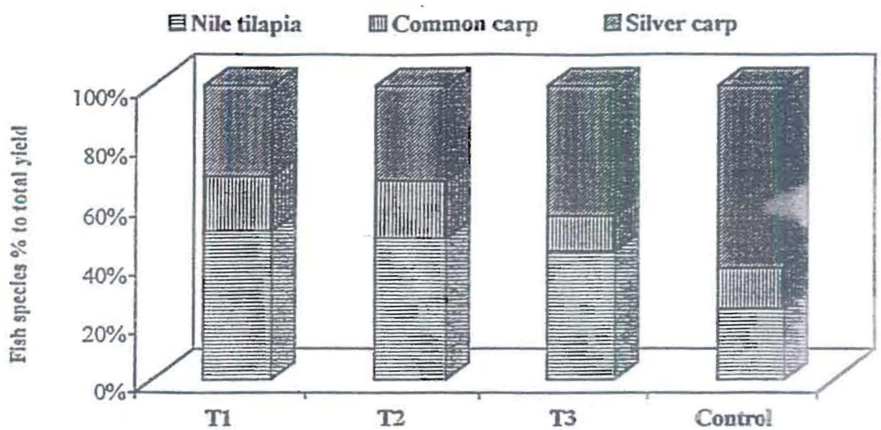

Figure 1. The contribution percentage of Nile tilapia, common carp and silver carp to the total fish yield at different timing of feed supplementation to polycultured fertilized earthen ponds.

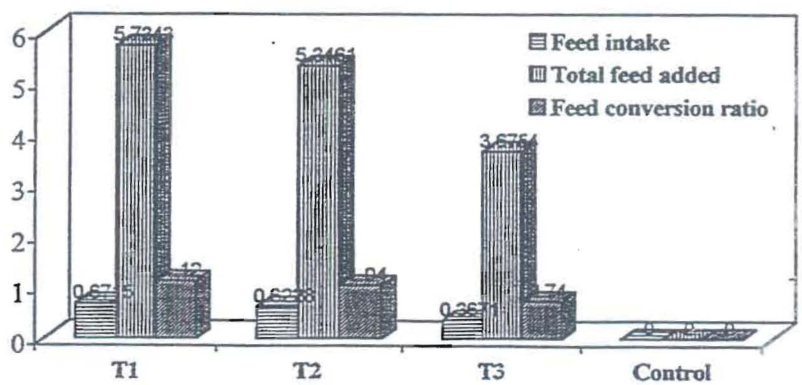

Figure 2. Means of feed intake (kg/fish), total feed added to pond (ton/pond) and feed conversion ratio at different timing of feed supplementation to polycultured fertilized earthen ponds.

Control = Natural feed only, T1 = Natural feed + supplemented feed from the beginning experimental period (days), T2 = Natural feed + supplemented feed at 45 days from the beginning experimental period and T3 = Natural feed + supplemented feed at 90 days from the beginning experimental period.

Table (2) : Production (ton/ha) and survival rate of Nile tilapia (*O.niloticus*), common carp (*C.carpio*) and silver carp (*H.molitrix*) in polycultured fertilized earthen ponds affected by different timing of supplemental feeding.

Treat - ments	Nile Tilapia		Common Carp		Silver Carp		Overall yield (ton/ha)
	Survival (%)	Production wt.(ton/ha)	Survival (%)	Production wt. (ton/ha)	Survival (%)	Production wt. (ton/ha)	
T1	$99.1^{a} \pm 0.4$	$3.1^{a} \pm 0.16$	$95.5^{a} \pm 1.0$	$1.1^{a} \pm 0.01$	$81.2^{a} \pm 0.5$	$1.9^{b} \pm 0.01$	$6.1^{a} \pm 0.17$
T2	$99.0^{a} \pm 0.1$	$3.0^{a} \pm 0.11$	$97.0^{a} \pm 1.0$	$1.2^{a} \pm 0.01$	$82.3^{a} \pm 2.5$	$2.0^{b} \pm 0.06$	$6.2^{a} \pm 0.18$
T3	$92.0^{b} \pm 0.7$	$2.2^{b} \pm 0.03$	$94.2^{a} \pm 1.7$	$0.6^{b} \pm 0.01$	$82.1^{a} \pm 1.8$	$2.2^{a} \pm 0.05$	$5.0^{b} \pm 0.02$
Control	$81.2^{c} \pm 0.5$	$0.7^{c} \pm 0.01$	$88.0^{b} \pm 1.5$	$0.4^{c} \pm 0.01$	$70.5^{b} \pm 0.4$	$1.8^{c} \pm 0.01$	$2.9^{c} \pm 0.01$

Means with same letter in same column are not significantly different ($P<0.05$).

Control = Natural feed only,
T1 = Natural feed + supplemented feed from the beginning experimental period (135 days),
T2 = Natural feed + supplemented feed at 45 days from the beginning experimental period and
T3 = Natural feed + supplemented feed at 90 days from the beginning experimental period.

Table (3): Average of body composition gain (g/fish) of Nile tilapia (*O.niloticus*), common carp (*C.carpio*) and silver carp (*H.molitrix*) affected by different timing of supplemental feeding in fertilized earthen ponds.

Items	T1	T2	T3	Control
Nile tilapia				
Dry matter	39.08 ^{b} ±1.23	48.27 ^{a} ±1.33	24.65 ^{c} ±0.29	15.29 ^{d} ±0.08
Crude protein	20.73 ^{b} ±0.64	23.83 ^{a} ±0.63	15.31 ^{c} ±0.18	9.42 ^{d} ±0.05
Ether extract	11.93 ^{b} ±0.36	18.34 ^{a} ±0.46	5.06 ^{c} ±0.06	2.13 ^{d} ±0.01
Ash	6.24 ^{a} ±0.12	6.10 ^{a} ±0.16	4.23 ^{b} ±0.05	3.80 ^{c} ±0.02
Common carp				
Dry matter	210.32 ^{a} ±0.98	183.05 ^{b} ±5.38	86.56 ^{c} ±1.38	43.61 ^{d} ±1.02
Crude protein	106.58 ^{a} ±0.49	92.13 ^{b} ±2.69	43.62 ^{c} ±0.71	32.56 ^{d} ±0.76
Ether extract	84.95 ^{a} ±0.39	75.91 ^{b} ±2.16	34.21 ^{c} ±0.55	5.91 ^{d} ±0.14
Ash	18.73 ^{a} ±0.09	15.01 ^{b} ±0.43	8.73 ^{c} ±0.14	5.06 ^{d} ±0.12
Silver carp				
Dry matter	57.12 ^{bc} ±0.35	67.26 ^{a} ±0.82	61.07 ^{b} ±0.79	56.37 ^{c} ±2.12
Crude protein	38.68 ^{b} ±0.22	42.61 ^{a} ±0.47	38.64 ^{b} ±0.56	38.29 ^{b} ±1.43
Ether extract	9.84 ^{b} ±0.05	13.88 ^{a} ±0.15	13.96 ^{a} ±0.20	8.62 ^{c} ±0.32
Ash	8.55 ^{c} ±0.05	10.77 ^{a} ±0.12	8.47 ^{c} ±0.12	9.92 ^{b} ±0.37

Means with same letter in same row are not significantly different ($P<0.05$).

Table (4): Calculation of variable costs, return and profit (Egyptian pound/ha) for fertilized earthen ponds received artificial feeding for different periods and cultured with Nile tilapia, common carp and silver carp.

Treatments	Fertilizers	Feed	Labor	Variable costs	Return	Profit
T1	478.0	5934.9	1800.0	8212.9	23300.0	15087.1
T2	478.0	5533.1	1500.0	7511.1	23500.0	15988.9
T3	478.0	3804.0	1200.0	5482.0	18200.0	12718.0
Control	478.0	0.0	900.0	1378.0	9600.0	8222.0

Control = Natural feed only,
T1 = Natural feed + supplemented feed from the beginning experimental period (135 days),
T2 = Natural feed + supplemented feed at 45 days from the beginning experimental period and
T3 = Natural feed + supplemented feed at 90 days from the beginning experimental period.

DISCUSSION

The results of this experiment revealed that the growth and production of Nile tilapia, common carp and silver carp in fertilized earthen ponds was slower than that in fertilized-fed ponds. These results is in an agreement with Green (1992) and Diana *et al.* (1994), who found that the growth rate and production of Nile tilapia was higher in fertilized-fed ponds than fertilized alone ponds.

For various treatments, first feed application occurred after 0, 45 or 90 days after fish stocking compared to control (fertilized only), and each fish species was stocked at similar weights, so their weights were different when they fed for the first time. Moreover, fish growth in fertilized-feed ponds were higher than that of fertilize-alone ponds and the optimum fish yield could be obtained when supplemental feed was given to fish after 45 days of fish stocking. In that period (45 days), the cultured fishes have the capability to consume natural food and did not need feed supplementation. These results indicate that critical standing crop (CSC) in semi-intensive ponds must occur during the first 45 days of culture. If CSC had not occurred prior to the first feed application in this study, then the first fed fish should have maintained the same growth rate for some time after feeding. Since fish growth increased dramatically after feed application, CSC did not exist in fed ponds.

In this concern, Green (1992) found that feeding or fertilization alone produced similar growth rate of Nile tilapia during the first 30 day, and by the day 60, fish in the fertilize-alone treatment were significantly smaller than in feed-alone or combined fertilizer-feed treatments. Furthermore, Diana *et al.* (1996) found that the first feeding of Nile tilapia in Thailand after 38 and 80 days respectively, resulted in the same size of Nile tilapia at harvest. Similarly, Brown *et al.* (2000) found that the first feeding after 75 days was more profitable than feeding after 45 days in Nile tilapia production in Philippines.

The aim of introducing planktivorous Chinese carps was to increase fish yield through utilization of the phytoplankton and zooplankton where the cultured fishes have different food habits (Spataru, 1977; Cremer and Smitherman, 1980; Spataru *et al.*, 1983). Nile tilapia and common carp could consume both natural and artificial feeds efficiently, while silver carp response to artificial feeds is not efficient. On the other hand, polyculture system consists of common carp, silver carp and tilapia species was found to be the most successful combination where in combination culture each of the species gave higher yield than in monoculture (Yashouv, 1971; Reich, 1975).

In control ponds, the contribution of silver carp yield to total fish yield was the maximum and decreased by increasing feeding period. The effect of common carp on silver carp growth, in control ponds, was beneficial where common carp (as a bottom-feeding species) enhance the growth of silver carp by stirring up bottom sediments, thereby transporting nutrients and detritus to the water column. On the other hand, Milstein (1992) reported that the synergistic effect between common carp and tilapia and between common carp and silver carp occurred only at lower stock densities of either tilapia or silver carp, however, above a density of 1fish/ha of silver, a decline in the growth rate of common carp and tilapia occurred. In fed ponds, the behavior of common carp was different and depends mainly on supplemented feed, so, ponds conditions were not suitable for silver carp growth and there was no stirring up of bottom sediments, thereby transporting nutrients and detritus to the water column was limited. Subsequently, the growth and production of silver carp decreased with increasing feeding period.

By the way, this study provides technical guidance to farmers on the efficient feeding practice that will optimize the costs of fish production in a polyculture system in fertilized earthen ponds. However, the delay of feeding for 45 days did not significantly reduce fish production but significantly reduce the costs, and it is important to maintain pond fertilization to promote the production of natural foods in the ponds. Meanwhile, the delay of feeding not only reduces the costs of obtaining, transporting and storing fish feed, but also reduces the labor required by an amount equivalent to 45 days of feeding. This time could be used by the farmer for other tasks that could potentially improve farm productivity.

Finally, it could be concluded from the results of this study that the first feed supplementation in Egypt should be after 45 days after fish fry stocking in point of view of cost/benefit ratio where fish in that period do not need artificial feed and depend on natural food. It is costless and profitless to supplement feed before reaching critical standing crop.

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