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Effect of Crop Stocking Ratios of Nile Tilapia, Common Carp, Silver Carp and Catfish in Polyculture in Concrete Ponds with 10 cm Clayey Loam on Growth Performance and Total Yield

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ABSTRACT

Eight 12.5 m^2 concrete ponds with 10 cm clayey loam from soil (pH 7.5) were used to test the effect of different crop composition ratios of Nile tilapia (*Oreochromis niloticus),* common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and African catfish *(Clarius gariepinus)* reared in polyculture system, on water quality, growth, fish production and economic efficiency. The present study included 4 crop composition ratios: 75% tilapia + 6.25% common carp + 6.25% silver carp + 12.5 % catfish (T1), 60% tilapia + % 10 common carp + 10% silver carp + 20 % catfish (T2), 50% tilapia + 12. 5 %common carp + 12. 5% silver carp + 25 % catfish (T3) and 60% tilapia + 5 %common carp + 5% silver carp + 30 % catfish (T4). All ponds were stocked at the rate of 6 fish/m^2. The present work was conduct over a 4 month experimental period to establish the growth and productive performance. Phytoplankton and zooplankton were enhanced by using healthy alternative organic fertilizer (rigir treated by EM) at a rate of 1 kg/pond/week. Experimental fish (tilapia, common carp and catfish) were fed with fish rigir, at a rate of 3% of total tilapia, common carp and catfish biomass. One-way ANOVA showed that **a**ll water quality variables were not significantely affected by different crop composition treatments except for secchi-disk reading (cm). Results of growth performance of different fish species in different crop composition ratios indicated that mean individual growth rate was highest for lower density and lowest for the higher density of each species. Final tilapia body weight was 159.3, 171.0, 150.5 and 141.0 g for T1, T2, T3 and T4, respectively, with significant difference ($p < 0.05$). While, final catfish body weight was 180. 5, 195.3, 151.0 and 153.0 g for T1, T2, T3 and T4, respectively, with significant difference ($p < 0.05$). Also, Final body weight of carp species was significant difference in different crop composition treatments ($p<0.05$). Total fish production at the end of the experimental period (120-day) were highest in T2 ($p < 0.05$) followed in a descending order by the T1, T3 and T4 polyculture system treatment. Net profit for T2 polyculture system treatment was significantly higher than other treatments. From the economic point of view it can be clearly reported that, the least cost-effective treatment was the second one (T2). It can be concluded that, the best species-combination (crop composition) ratios in polyculture system was T2 (60% tilapia + % 10 common carp + 10% silver carp + 20 % catfish) which recorded the highest fish production and net profit.

Keywords: species combination polyculture system, Nile tilapia, silver and common carp and African catfish, growth performance, economic evaluation.

INTRODUCTION

The polyculture of several fish species that feed on different natural recourses is an important management technique for efficient utilization of the production potential in ponds. Synergistic interaction among fish species manifested by higher growth and yield in polyculture were found (Essa et al, 1989; Milstein, 1992 and Abdel-Tawab et al., 2007). Fish in polyculture systems represent a possibility for increasing the total yield. This is especially with species differing their feeding habits which are cultured to maximum use of all available natural as well as using supplementary feed in ponds. In order to achieve increased production, the species stocked must have different feeding habits and occupy different atrophic niches in the ponds. common carp, tilapia, silver, grass carp and to a certain extent, mullet and bighead carp all differ in their feeding habits, and their culture in a pond increases total fish yield (Hepher and pruginin 1981). In addition to the above consideration, other factors should be taken into account. Yashouv (1971) demonstrated that the yield of silver and common carp, cultured together in polyculture is higher than that of either species alone. A similar effect has been seen when culturing common carp and tilapia (Hepher and Pruginin 1981) red tilapia and common or silver carps (Essa, 1989). In practice, one should take in to account, not only production, but also market price of each of the fish produced and potential income from the different possible combinations. Management consideration, such as possibility of intermediate harvesting and the size differences among species should be considered. A polyculture system is important for rapid growth of fish and cost control of feed. Determination of crop composition ratios of fish in a polyculture system may help to save feed while promoting fish growth and production, thus increasing profitability. An alternative for controlling the effects of unwanted population, polyculture of tilapia with a predator that eats tilapia fry and fingerlings, has been proposed by Guerrero (1980), De Graaf (1996), El-Gamal et al. (1998), and Fagbenro (2004). Among the most popular predators used for biological control of tilapia reproduction is African catfish, *Clarias gariepinus*. In addition to controlling tilapia reproduction, polyculture increases productivity by a more efficient utilization of the ecological resources in the pond (Lutz 2003). Stocking two or more complementary species can increase the maximum standing crop of a pond by taking advantage of a wider range of available foods and ecological niches. Nile tilapia, *Oreochromis niloticus*, is an omnivorous filter feeder and African catfish is considered as a predator targeting fish fry and fingerlings. Tilapia is the main cultured fish species in Egypt, contributing 43.5% of farmed fish production and 24% of total fisheries production (GAFRD 2007). The aim of the present study was to identify the optimal species combination (crop composition) ratios in polyculture system of Nile tilapia (*Oreochromis niloticus)*, common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and African catfish *(Clarius gariepinus)*) on water quality, growth and productive performance as well as economic efficiency under Egyptian conditions.

MATERIALS AND METHODS

The experimental design and fish culture technique

This experiment was conducted in outdoor concrete ponds (2.5 m x 5.0 m x 1.0 m) with 10 cm clayey loam from soil (pH 7.5) earthen bottom at the Central Laboratory for Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, Egypt. Before starting the experiment all ponds were drained completely and then were exposed to sun rays for two weeks till complete dryness. The concrete ponds bottom was lined with 10 cm clayey loam from soil (pH 7.5) before filling water. Ponds were then refilled with fresh water coming from Ismailia Nile branch through a canal to the experimental station. The ponds were filled with fresh water to 1.0 m depth and water was added weekly to compensate for evaporation losses. The experiment was laid out in a completely randomized design with four treatments with two replicates for each treatment. Eight ponds were stocked in a polyculture with the Nile tilapia, *(Oreochromis niloticus*), common carp *(cyprinus carpio*L.*)*, silver carp *(Hypophthalmichthys molitrix Val*) and African catfish, (*Clarius gariepinus)*, fingerlings in different crop composition ratios at density of 6 fish/m^2. (75 fish in each pond). The treatments applied were: 75% tilapia + % 6.25 common carp + 6.25% silver carp + 12.5 % catfish (T1), 60% tilapia + % 10 common carp + 10% silver carp + 20 % catfish (T2), 50% tilapia + % 12. 5 common carp + 12. 5% silver carp + 25 % catfish (T3) and 60% tilapia + 5 %common carp + 5% silver carp + 30 % catfish (T4). Nile tilapia, *(Oreochromis niloticus*), fingerlings (24.5 - 25.5 g) common carp *(cyprinus carpio*L.*)* fingerlings (6.5-7.3 g), silver carp *(Hypophthalmichthys molitrix Val*) fingerlings (8.0-8.8 g) and African catfish, (*Clarius gariepinus)* fingerlings (33.1-36.2 g), were obtained from Abbassa fish hatchery. Fish were fed a fish rigir at a daily rate of 3% of total tilapia, common carp and catfish biomass only, because silver carp feed mainly on phytoplankton (Essa, 1989).

Fish rigir was submitted six day a week and readjusted biweekly. The total growing periods were 120 days for polyculture treatments. Rigir and fish rigir is a new product for fish farm produced by Misr El-Salam International Company for producing organic fertilizer, Alexandria Governorate. Rigir consists of chicken manure but compressed and heat treated in order to be free from parasites, salmonella, shigella and E. coli. Fish rigirs consists of 60% compressed chicken manure and heat treated plus 20% yellow corn, 10% soybean and 10% rice bran plus some feed additive (sodium alginate, selenium, antifungal drug and saccharromycine). Chemical analysis of fish rigirs and rigirs shown in Table (1). Rigir as a healthy alterative organic fertilizer treated with efficient microbial (EM) was used in all experimental ponds to accelerate the primary productivity (phytoplankton and zooplankton) at a dose of 1.0 kg/pond/week.

Growth Parameters

Live body weight of random sample of 20 fish of tilapia, 5 fish of catfish and 4 fish of common carp and silver carp were weighted from each pond biweekly. Fish yield was weighted and total production of each species were determined. Parameters of relative growth rate (RGR %), species growth rate (SGR %), daily weight gain and feed utilization were calculated according to Jauncey (1982) by using the following equations:

Weight gain = W2 – W1; Where W1 and W2 are the initial and final fish weigh, respectively; Daily weight gain = weight gain / T ; where T is the interval time in days.

Specific growth rate (SGR) = 100 (Ln W2 – Ln W1) / T;

Relative growth rate (RGR) = 100 (W2-W1) / W1; Feed conversion ratio (FCR) = feed intake / weight gain;

Water quality analyses

Water samples for chemical analyses were collected at 2-weeks intervals from four sites from each concrete pond with 10 cm earthen bottom between 09:00 and 09:30 am at 30 cm depth. Dissolved oxygen and water temperature were measured at 30 cm depth with a YSI model 58 Oxygen Meter (Yellow Spring Instrument Co., Yellow Springs, Ohio, USA). Water conductivity was measured with a YSI model 33 Conductivity Meter (Yellow Spring Instrument Co., Yellow Springs, OH, USA). Unionized ammonia was measured by using HACH kits (Hach Co., Loveland, CO, USA). The pH was measured using a pH-meter (Fisher Scientific, Denver, CO, USA). Total alkalinity and total hardness were measured by titration as described by Boyd (1984).

Table 1. chemical composition of fish rigir and rigirs treated with efficient microbial (EM) used in this study (% DM basis) .

Ingredients	REM*	Fish rigir
Crude protein %	**15.75**	**13.44**
Ether extract %	**1.81**	**3.31**
Crude fiber %	**13.91**	**12.0**
Ash %	**39.13**	**40.61**
NFE [**] **%**	**29.4**	**30.64**
Dry matter %	**88.81**	**86.9**
Humidity %	**11.19**	**11.9**
pH	**8.05**	**11.6**
EC (mmhos/cm)	**4.24**	**4.22**
Total nitrogen %	**2.54**	**2.15**
Organic matter %	**59.79**	**59.1**
Organic carbon %	**29.62**	**34.28**
C:N ratio	**13:1**	**15.9:1**
Total phosphorus %	**1.79**	**2.17**
Total potassium %	**1.91**	**1.48**

****REM = rigir treated with efficient microorganisms,***

***** NFE (nitrogen free extract) = 100 – (protein% + lipid% + ash% + fiber%) and C:N=carbon:nitrogen.***

Economical evaluation

The cost of fish rigirs, rigirs treated with efficient microbial (EM) as a healthy alternative organic fertilizer required to produce a unit of fish biomass were estimated using a simple economical analysis. The estimation was based on local market retail prices (at the current time) of fish rigirs, rigir and fish. These prices (in LE/Kg) were as follow; fish rigirs, 1.35 and rigirs, 0.90.

Statistical analysis

The data obtained were presented as means ± SD of three replicates and analyzed by one way ANOVA test (Snedecor and Cochran 1982). All differences among means were considered significant at $P < 0.05$ using Duncan's multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Water quality parameters

Ranges of water quality parameters in ponds for the complete farming period were as follows: temperature, 26.5–26.7 °C; dissolved oxygen (DO), 5.41–5.9 mg L^{-1}; pH, 8.00–8.1; salinity 0.34 – 0.37 (ppt) ; alkalinity, 439 – 450 mg L^{-1}; ammonia-N, 0.51–0.59 mg L^{-1}; Nitrite (No_2), 0.02 – 0.05 mgl^{-1}; total dissolved solid 470 - 485 (ppm) ; total hardness 269 – 285 mg $L^{-1;}$ electric conductivity 701.0 – 710.0 µmhos/cm and Secchi-disk reading, 20.9–22.5 cm. All values were within the permissible limits in pond water for fish culture as reported by Boyd (1982). As presented in Table 2, all water quality variables were not significantly affected by different treatment except for Secchi-disk reading (cm) which there was significant difference ($P < 0.05$) in overall Secchi-disk reading between both (T2 and T3), and between (T1 and T4). These findings may be attributed to the high ratio of silver carp in these treatments compared to other treatments. These results indicated that high crop composition ratios of silver carp had affect on natural primary productivity (phytoplankton) in water column this is due to natural feeding habits. These results are in accordance with those reported by Zhang, et al., (2006), who reported that stocking of silver carp (55 g/m^3) was most efficient at controlling microcystis blooms and increasing water clarity. In the end all parameters recorded for water quality were in acceptable limits for fish growth (NACA, 1989; Boyd 1990).

Biological parameters

The phytoplankton in the ponds consisted of green, euglena chlorophyta, diatoms and cyanophyta. Table (3) showed that phytoplankton

Table 2 : ***Average water quality criteria (means ± SE) as affected by different crop composition ratios of fish in polyculture system in concrete pond with earthen bottom during the whole experimental period, (120-days).***

Parameters	Treatments				Test of sig.
	T1	T2	T4	T4	
Temperature (^{O}C)	26.5 $_a$ ± 0.65	26.57 $_a$ ± 0.69	26.7 $_a$ ± 0.73	26.61 $_a$ ± 0.73	N.S
Dissolved oxygen (mg/l)	5.41 $_a$ ±0.81	5.55 $_a$ ±0.88	5.9 $_a$ ±0.83	5.7 $_a$ ±0.77	N.S
Secchi disk reading (cm)	21.5 $_b$ ±1.3	22.3 $_a$ ±1.53	22.5 $_a$ ±1.43	20.9 $_c$ ±1.51	**
NH_3 (mg/L)	0.59 $_a$ ± 0.18	0.55 $_a$ ± 0.15	0.53 $_a$ ± 0.15	0.51 $_a$ ± 0.15	N.S
NO_2	0.05 $_a$ ±0.00	0.02 $_a$ ±0.00	0.03 $_a$ ±0.01	0.02 $_a$ ±0.002	N.S
PH (unite)	8.05 $_a$ ±0.11	8.00 $_a$ ±0.11	8.03 $_a$ ±0.11	8.1 $_a$ ±0.11	N.S
Salinity (ppt)	0.35 $_a$ ±0.02	0.37 $_a$ ±0.02	0.35 $_a$ ±0.02	0.34 $_a$ ±0.02	N.S
Electric conductivity (µmbos/cm)	705.0 $_a$ ±25.0	703.0 $_a$ ±25.0	701.0 $_a$ ±25.5	710.0 $_a$ ±19.5	N.S
Total dissolved solid (ppm)	485.0 $_a$ ±15.5	479.0 $_a$ ±16.2	470.0 $_a$ ±16.5	479.0 $_a$ ±16.0	N.S
Total alkalinity(mg/L)	441.0 $_a$ ±29.0	450.0 $_a$ ±29.5	439.0 $_a$ ±29.0	445.0 $_a$ ±21.0	N.S
Total hardness(mg/L)	280.0 $_a$ ±13.5	285. 0 ± $_a$ 15	269.0 $_a$ ±13.0	275.0 $_a$ ±12.5	N.S

Treatment means within a row followed by different superscripts are significantly different ($P < 0.05$).

Table 3 : Average number of phytoplankton groups (means ± SE) as affected by different crop composition ratios of fish in polyculture system in concrete pond with earthen bottom during the whole experimental period (120-days).

Parameters	Treatments				Test of sig.
	T1	T2	T4	T4	
Euglena (org./L)	392103 $_a$ ± 115315	351012 $_b$ ± 11335	362931 $_b$ ± 3150	359101 $_b$ ± 135905	**
Chlorophyta (org./L)	232101 $_a$ ±6553	211001 $_b$ ±59001	221113 $_b$ ±39110	370311 $_a$ ±28110	**
Cyanophyta (org./L)	19330 $_a$ ±6310	18590 $_a$ ±9215	16110 $_b$ ±5310	13925 $_b$ ±6351	**
Diatoms (org./L)	9100 $_a$ ± 8110	9000 $_a$ ± 8000	9110 $_a$ ± 7515	8001 $_b$ ± 7160	N.S
total phyto. (org./L)	652634 $_a$ ±8231	589603 $_b$ ±6310	609264 $_a$ ±4101	751338 $_a$ ±1431	**

Means within a row followed by different superscript are significantly different ($P < 0.05$).

(euglena) was significantly higher ($p < 0.05$) for T1 (392103 org/l) than the other treatments and the lowest number was obtained at T2 (351012 org/l). On the other hand, for phytoplankton (diatoms) densities, there was no significant difference ($p > 0.05$) between all treatments. Also, Table 3 indicated that phytoplankton (chlorophyta) densities in T1 and T4 were significantly higher than T2 and T3 ($P < 0.05$) and cyanophyta densities in T1 and T2 were significantly higher than T3 and T4 ($P < 0.05$). In this concern, Zhang, et al., (2006), found that stocking of silver carp could be an appropriate in highly productive lake shichahai, which naturally lacks of large cladoceran zooplankton. They confirmed that a fish stocking density of 55 g/m3 was most efficient at controlling microcystis bloom and increasing water clarity. A top-down effect by tilapia feeding on planctonic community is exhibited in direct and indirect aspects. In direct effect, selective feeding by tilapia on large plankton, particularly zooplankton results in a decrease in predatory pressure on small phytoplankton which exert high productivity and make a full use of nutrients in waters due to large absorptive surface area and low precipitating index (Carpenter et al., 1987). In indirect effect, disturbance by tilapia while swimming around enhances water movement and nutrient cycle. Phytoplankton samples were analyzed to detect changes in species composition and biomass to clarify reasons for these differences in physical and chemical variables (Zimba et al. 2002). Nile tilapia, *Oreochromis niloticus*, have the ability to filter-feed on phytoplankton (Turker et al., 2003a, 2003b) and, concomitantly, produce a second crop of marketable animal in polyculture systems (Dos Santos and Valenti 2002). Dunseth (1977) reported that tilapia stocked at a pond surface area of 0.25/m2 did not affect algae populations when compared with ponds without tilapia. Tilapia can filter seston and create a top–down effect which decreases the abundance of zooplankton and increases phytoplankton biomass (primary production), P/R index (Yuan et al., 1993a). And nitrogenous and phosphorus cycle rates (Yuan et al., 1993b). There was a pack relation between the number of phytoplankton organisms and tilapia, silver, common carp and catfish ratios. Also, zooplankton showed slightly significant difference ($p < 0.05$) among all treatments (Table 4). From Tables 3 and 4 it was observed that there was a reverse relationship between fish stocking and plankton biomass, but the species composition did not significantly ($p > 0.05$) affect plankton biomass.

Table 4 : Average number of zooplankton groups (means ± SE) as affected by different crop composition ratios of fish in polyculture system in concrete pond with earthen bottom during the whole experimental period (120-days).

Parameters	Treatments				
	T1	T2	T4	T4	Test of sig.
copepods (org./L)	**63_a ± 31.5**	**57_a ± 23**	**45_b ± 100**	**51_{ab} ± 20**	*
Cladocerans (org./L)	**105_a ±58**	**100_a ±45**	**95_{ab} ±31**	**93_{ab} ±31**	*
Rotifers (org./L)	**10137_a ±91011**	**9311_a ±3110**	**9101_{ab} ±5110**	**10310_a ±63100**	*
Ostracods (org./L)	**390_a ± 190**	**351_a ± 115**	**310_{ab} ± 109**	**360_{ab} ± 101**	*
Nauplil . (org./L)	**380_a ±109**	**390_a ±210**	**310_b ±195**	**360_{ab} ±120**	*
Others(org./L)	**35_a ±20**	**31_a ±15**	**21_b ±5**	**19_b ±8**	*
Total zoo.No. (org./L)	**11110_a ±193**	**10240 a ±91011**	**9882 ±91011**	**11128 ±91011**	*

Means within a row followed by different superscript are significantly different (P < 0.05).

Growth performance

As shown in Table (5), the average initial body weight (BW) of tilapia, catfish, common and silver carp for all treatments were very similar ranging from 24.5 – 25.5 g (tilapia), 33.1-36.2 g (catfish), 6.5-7.3 g (common carp) and 8.0-8.8 g (silver carp). The results showed that the growth responses of fish species in all treatments were generally satisfactory, and the fish were all healthy and increased progressively with advancement of age (Table 5). Although fish within each species were stocked at similar weights in all treatments, at the end of the experiment, their sizes diverged and overall growth (g day^{-1}), weight gains (g per fish) and final weights (g per fish) varied (Table 5). Therefore, the different species combination (crop composition) ratios in polyculture system affected growth performance and production of fish. In the present study, Nile tilapia, catfish, silver carp and common carp showed reverse relationship between growth responses and stocking ratio of fish species in polyculture system. These results indicated that mean individual growth rate was highest for lower density and lowest for the higher density of each species. It is obvious that Nile tilapia in (T2) had significantly ($P < 0.05$) higher performance in terms of weight gains, specific growth rates, survival and production than those achieved by T1, T3 and T4. Their growth was significantly ($P < 0.05$) increased with increasing stocking ratio of Nile tilapia up to 60 and decreasing the stocking ratio of catfish from 20 to 12.5% (T2 and T1), the 20% catfish ratio in polyculture system was the best overall,

Table 5*: Effect of different crop composition ratios of different fish spices reared in polyculture system on their growth performance and survival percentage in concrete pond with earthen bottom during the whole experimental period(120-days).*

Treatment	Fish species	Parameters			
		Initial weight	Final weight	Daily weight gain(g/day/fish)	Net increment
T1	75%NT	25.2 ± 2.3	159.3 $_{ab}$ ± 3.9	1.12 $_{ab}$ ± 0.15	133.8 $_{ab}$ ± 2.5
	12.5%CF	35.3 ±1.3	180.5 $_{ab}$ ±2.5	1.21 $_{b}$ ±0.09	145.2 $_{ab}$ ±2.9
	6.25%CC	6.5 ±1.5	119.0 $_{b}$ ±1.8	0. 94 $_{b}$ ±0.11	112.5 $_{b}$ ±2.8
	6.25%SC	8.0 ± 2.1	122.5 $_{b}$ ± 2.9	0.950$_{b}$ ± 0.2	114.5 $_{b}$ ± 3.0
T2	60%NT	25.1 ± 2.5	171.0 $_{a}$ ± 4.3	1.22 $_{a}$ ± 0.19	145.9 $_{a}$ ± 3.1
	20%CF	36.2 ±1.5	195.3 $_{a}$ ±2.3	1.33 $_{a}$ ±0.13	159.1 $_{a}$ ±2.8
	10%CC	6.9 ±1.5	115.0$_{b}$ ±1.8	0.90 $_{b}$ ±0.15	108.1 $_{c}$ ±2.8
	10%SC	8.3 ± 2.1	131.0 $_{ab}$ ± 2.5	1.02 $_{ab}$ ± 0.11	122.7 $_{ab}$ ± 2.6
T3	50%NT	24.5 ± 1.8	150.5 $_{b}$ ± 3.3	1.05 $_{b}$ ± 0.13	126.0 $_{b}$ ± 2.8
	25%CF	35.1 ±1.3	151.0 $_{b}$ ±3.2	0.97$_{c}$ ±0.21	115.9 $_{c}$ ±2.6
	12.5%CC	7.1 ±1.2	120.0 $_{ab}$ ±2.5	0.94 $_{b}$ ±0.15	112.9 $_{b}$ ±2.5
	12.5%SC	8.5 ± 1.8	131.0 $_{ab}$ ± 1.9	1.02 $_{ab}$ ± 0.19	122.5 $_{ab}$ ± 2.7
T4	60%NT	25.1 ± 2.3	141.0 $_{c}$ ± 3.1	0.97 $_{c}$ ± 0.13	115.9 $_{c}$ ± 2.6
	30%CF	33.1 ±1.5	153.0 $_{b}$ ±3.3	0.99 $_{c}$ ±0.11	119.9 $_{b}$ ±2.8
	5%CC	7.3 ±1.2	125.0$_{a}$ ±2.9	0.98$_{a}$ ±0.13	117.7 $_{a}$ ±2.5
	5%SC	8.8 ± 1.9	142.0$_{a}$ ± 3.2	1.11 $_{a}$ ± 0.15	133.2 $_{a}$ ± 2.8

Treatment means within a column followed by a different superscript are significantly different ($P < 0.05$).

followed in order by the 12.5% catfish ratio in polyculture system. These results clearly indicate that polyculture tilapia farmers in Egypt can improve their outputs without affecting water quality by stocking African catfish along with tilapia in a polyculture system at a ratio of 20% of catfish and 10% silver and common carp (Table 5) for silver carp, growth rate (g day^{-1}), weight gain (g per fish) and yield (kg ha^{-1}) were not related to the feeding rates. These results suggest that a substantial influence on the growth

Table 5: Continued.

Treatment	Fish species	Parameters		
		SGR	RGR	Survival rate
T1	75%NT	1.53 $_{ab}$ ± 0.01	5.25 $_{ab}$ ± 0.31	98.0 $_{a}$ ± 0.10
	12.5%CF	1.36 $_{a}$ ±0.01	4.11 $_{ab}$ ±0.28	100.0 $_{a}$ ±0.10
	6.25%CC	2.42 $_{a}$ ±0.01	17.3 $_{a}$ ±1.05	100.0 $_{a}$ ±0.10
	6.25%SC	2.27 $_{b}$ ± 0.03	14.31 $_{c}$ ± 1.01	100.0 $_{a}$ ± 0.10
T2	60%NT	1.60 $_{a}$ ± 0.01	5.81 $_{a}$ ± 0.31	96.0 $_{a}$ ± 0.10
	20%CF	1.40 $_{a}$ ±0.01	4.4 $_{a}$ ±0.24	100.0 $_{a}$ ±0.10
	10%CC	2. 34 $_{b}$ ±0.05	15.66 $_{b}$ ±1.09	100.0 $_{a}$ ±0.10
	10%SC	2.30 $_{a}$ ± 0.05	14.78 $_{b}$ ± 1.03	100.0 $_{a}$ ± 0.10
T3	50%NT	1.51 $_{b}$ ± 0.013	5.14 $_{b}$ ± 0.25	91.0 $_{b}$ ± 0.10
	25%CF	1.22 $_{b}$ ±0.01	3.3 $_{b}$ ±0.21	100.0 $_{a}$ ±0.10
	12.5%CC	2.36 $_{b}$ ±0.05	15.9 $_{b}$ ±0.91	98.0 $_{a}$ ±0.10
	12.5%SC	2.28 $_{b}$ ± 0.05	14.41 $_{c}$ ± 1.01	98.0 $_{a}$ ± 0.10
T4	60%NT	1.48 $_{c}$ ± 0.013	4.62 $_{c}$ ± 0.25	91.0 $_{b}$ ± 0.10
	30%CF	1.28 $_{b}$ ±0.01	3.62 $_{b}$ ±0.13	100.0 $_{a}$ ±0.10
	5%CC	2.37 $_{b}$ ±0.03	16.12 $_{b}$ ±1.05	97.0 $_{a}$ ±0.10
	5%SC	2.32 $_{a}$ ± 0.03	15.14 $_{a}$ ± 1.05	97.0 $_{a}$ ± 0.10

Treatment means within a column followed by a different superscript are significantly different ($P < 0.05$).

performance and production of silver carp was attributable to natural food consumption. These results are in agreement with the reported findings that silver carp do not consuming artificial feeds (Cremer & Smitherman 1980) The final weight and survival rate of catfish, silver and common carp at T1, T2, T3 and T4 were primarily attributed to an ecological role of tilapia in polyculture system in concrete ponds with 10 cm loam clayey earthen bottom. It is obvious that the average growth performance of fish reared in concrete pond with 10 cm clayey loam earthen bottom with the ratio of 60% tilapia, 20% catfish, 10% C/C and 10% S/C (T2) surpassed other treatments during the progress of the experimental period (120-day) followed by that of fish with ratio of 75% tilapia, 12.5% catfish, 6.25% C/C and 6.25% S/C (T1) then by the ratio of 50% tilapia, 25% catfish, 12.5% C/C and 12.5% S/C (T3). The lowest growth performance was exhibited by fish in ponds reared with the ratio of 60% tilapia, 30% catfish, 5% C/C and 5% S/C (T4). The present results indicated that the growth performance of the cultured species in different crop composition ratios in polyculture system (tilapia, catfish, C/C

Table 6 : The economical evaluation of fish reared in polyculture system at different treatments during the whole experimental period (120-days).

(%) Treatment of Fish species	Parameters									
	Initial weight	Stocking rate/feddan	Initial stocking den./feddan	Initial stocking wet(kg)/feddan	Survival rate (%)	Pr`oduction/ feddan (kg) of tilapia and catfish	Production/ feddan No. of C/C and S/C	Net Production/feddan (kg) of tilapia and catfish	Initial total cost /feddan (kg)	Total fish rigir intake/feddan (kg)
75%NT	$25.5 \pm 2.3_a$	25200	18900	481.95	98	3010.8		2528.9	2457	4915.3
12.5%CF	$35.3 \pm 1.3_a$		3150	111.19	100	568.6		457.41	472.5	1093.13
6.25%CC	$6.5 \pm 1.5_a$		1575	10.25	100	-------	1575	-------	94.5	-------
6.25%SC	$8.0 \pm 2.1_a$		1575	12.6	100	-------	1575	-------	94.5	-------
75%NT	$25.1 \pm 2.5_a$		15120	379.51	96	2585.5		2205.9	1965.6	4219.2
12.5%CF	$36.2 \pm 1.5_a$		5040	182.45	100	984.3		9	756	1912.4
6.25%CC	$6.9 \pm 1.5_a$	25200	2520	17.39	100	-------	2520	801.9	151.2	-------
6.25%SC	$8.3 \pm 2.1_a$		2520	20.92	100	-------	2520	-------	151.2	-------
								-------		
75%NT	$24.5 \pm 1.8_a$		12600	308.7	91	1896.3			1638	3034.95
12.5%CF	$35.1 \pm 1.3_a$		6300	221.13	100	951.3		1587.6	945	1810.15
6.25%CC	$7.1 \pm 1.2_a$	25200	3150	22.37	98	-------	3087	730.2	189	-------
6.25%SC	$8.5 \pm 1.8_a$		3150	26.78	98	-------	3087	-------	189	-------
								-------		
75%NT	$25.1 \pm 2.3_a$		15120	379.51	91	2131.9			1965.6	3218.9
12.5%CF	$33.1 \pm 1.5_a$		7560	250.24	100	1156.7		1752.4	1134	1899.7
6.25%CC	$7.3 \pm 1.2_a$	25200	1260	9.198	97	-------	1222	906.5	75.6	-------
6.25%SC	$8.8 \pm 1.9_a$		1260	11.09	97	-------	1222	-------	75.6	-------
								-------		

The economical evaluation of results was carried out according to local market prices when the experiment was done: 1000 tilapia fingerlings = 130 L.E., 1000 catfish fingerlings = 150 L.E., 1000 C/C fingerlings = 60 L.E., but when averaging (119.5:1259) = 700 L.E., 1000 S/C fingerlings = 60 L.E., but when averaging (122.5:1429) = 700 l. E. kg of tilapia (Average) = 7.0 L.E., 1000 kg of treated rigirs = 900 L.E., and 1000 kg of fish rigirs = 1350 L.E.

and S/C) was the highest in fish reared in T2. Also, Lutz (2003) cleared that in addition to controlling tilapia reproduction, polyculture system increases productivity by a more efficient utilization of the ecological recourses in the pond.

Table 6 (containue.) : The economical evaluation of fish reared in polyculture system at different treatments during the whole experimental period (120-days).

(%) Treatment of Fish species	Parameters									
	Cost of fish rigir. L.E/fed.	Cost of treated rigir/feddan L.E.	Labor (one/feddan)	Depreciation material &others	Texas (one feddan)	Total cost/ feddan (L.E.)	% of the smallest value of tocosts	Total returns feddan (L.E.)	Net returns (L.E.)	% of net returns to total cost
75%NT 12.5%CF 6.25%CC 6.25%SC	6635.66 1475.73	4838.4	350	250	150	16818.29	111.45%	17702.3 3201.87 1102.5 1102.5 = 23109.17	6290.88	37.4
75%NT 12.5%CF 6.25%CC 6.25%SC	5695.93 2581.74	4838.4	350	250	150	16890.06	11.93%	15441.93 5613.3 1764 1764 = 24583.23	7693.17	45.55
75%NT 12.5%CF 6.25%CC 6.25%SC	4097.18 2443.7	4838.4	350	250	150	15090.28	100%	11113.2 5111.4 2160.90 2160.90 = 20546.4	5456.12	36.16
75%NT 12.5%CF 6.25%CC 6.25%SC	4345.52 2564.59	4838.4	350	250	150	15748.91	104.36%	12266.8 6345.5 855.4 855.4 = 20323.1	4574.19	29.04

The economical evaluation of results was carried out according to local market prices when the experiment was done: 1000 tilapia fingerlings = 130 L.E., 1000 catfish fingerlings = 150 L.E., 1000 C/C fingerlings = 60 L.E., but when averaging (119.5:1259) = 700 L.E., 1000 S/C fingerlings = 60 L.E., but when averaging (122.5:1429) = 700 l. E. kg of tilapia (Average) = 7.0 L.E., 1000 kg of treated rigirs = 900 L.E., and 1000 kg of fish rigirs = 1350 L.E.

On the other hand, fish reared in T2 and T1 the ratio of tilapia: catfish: C/C: S/C was 0.6: 0.2: 0.1: 0.1 and 0.75: 0.125: 0.0625: 0.0625, respectively, gave higher fish growth performance than that of fish reared in T4 and T3 where the ratio of tilapia: catfish: C/C: S/C was 0.6: 0.3: 0.05: 0.05 and 0. 5: 0.25: 0.125: 0.125, respectively. This might be due to that fish species reared in polyculture system must be in the best combination ratios (best synergistic interaction) to fully utilization of the ecological resources in water column and also, obtain good ambient water quality more healthy fish and good elimination of reproduction of tilapia. On the other hand the slightly poor growth observed in T4 and T3 compared with those in T2 and T1 might be due to the composition ratio is not more suitable that make disturbance in water column that lead to poor water quality. The other explanation for such growth retardation due to over crowding within each species and competition for available food in the water. At the end of the experiment, the surviving fish in all treatments were apparently good, and the survival percentages of Nile tilapia, catfish, silver carp and common carp exceeded 90% in all treatments.

Details of the economics of fish production are given in Table 6. The calculated result shows the economical evaluation including the costs and returns for treatments applied in kg/feddan and income in (L.E) for 120-days. In all treatments which fish reared in different combination ratios in polyculture system T1, T2, T3 and T4 generated a profit (Table 6). Total cost were 16818.29, 16890.06, 15090.28 and 15748.91 L.E./feddan for T1,T2,T3 and T4, respectively and net returns in L.E./feddan were 6290.88, 7693.17, 5456.12 and 4574.10 for T1,T2,T3 and T4, respectively. Percentages of net returns to total costs were 37.4, 45.55, 36.16 and 29.04% for T1, T2, T3 and T4, respectively. These results indicated that although T2 (60% tilapia, 20% catfish, 10% C/C and 10% S/C) recorded the highest total cost but also, achieved the highest net returns followed by T1, T3 and T4.

Based on the obtained results from the present study, fish reared in polyculture system by the ratio of 60% tilapia, 20% catfish, 10% C/C and 10% S/C appears to be most effective and productive among the other tested management treatments and is recommended for use in polyculture ponds with Nile tilapia, catfish, common carp and silver carp under similar conditions of the present study in order to maximize growth, production, income and net profit per unit of area.

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تأثير نسب التركيب المحصولى لأسماك البلطى النيلى، القراميط ، المبروك الفضى، والمبروك العادى، المرباه بنظام الإستزراع المختلط بالأحواض الخرسانية ذات الأرضية الترابية على أداء النمو والكفاءة الإقتصادية والمحصول الكلى.

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قسم بحوث الانتاج ونظم الاستزراع السمكى – المعمل المركزى لبحوث الثروة السمكية بالعباسة- مركز البحوث الزراعية

اجريت هذه الدراسة بالمعمل المركزى لبحوث الثروة السمكية بالعباسة – مدينة ابوحماد – محافظة الشرقية ، حيث استخدم ثمانية أحواض خرسانية ذات أرضية ترابية (١٠ سم تربة طينية ذات درجة حموضة ٧,٥) وذلك لدراسة تأثير نسب التركيب المحصولي لأسماك البلطى والقراميط والمبروك الفضى والمبروك العادى فى نظام الاستزراع المختلط على صفات جودة المياه والانتاج السمكى وكذلك العائد الاقتصادى اشتملت هذه الدراسة على ٤ معاملات مختلفة التركيب المحصولى لانواع الاسماك المستزرعة كالاتى: ١) ٧٥% بلطى + ١٢,٥% قراميط + ٦,٢٥% مبروك عادى + ٦,٢٥% مبروك فضى ٢) ٦٠% بلطى + ٢٠% قراميط + ١٠% مبروك عادى + ١٠% مبروك فضى ٣) ٥٠% بلطى + ٢٥% قراميط + ١٢,٥% مبروك عادى + ١٢,٥% مبروك فضى ٤) ٦٠% بلطى + ٣٠% قراميط + ٥% مبروك عادى + ٥% مبروك فضى. حيث ثم تسكين الأسماك بمعدل ثابت (٦سمكة/م٣) وكان متوسط الوزن فى بداية التجربة لسمكة البلطى بين ٢٤,٥ – ٢٥,٥ جم ، ٣٣,١ – ٣٦,٢ جم لسمك القراميط ، ٦,٥ – ٧,٣ جم للمبروك العادى و ٨ – ٨,٨ جم لسمك المبروك الفضى. تم تسميد الاحواض بمعدل ١ كجم/حوض/أسبوع من زرق الدواجن المعامل حراريا والمكبوس (ريجير) وذلك لتنشيط الانتاجية الاولية وتحسين خواص المياه وكذلك تمت التغذية بالفيش ريجير بمعدل ٣% من وزن الأسماك المستزرعة طوال فترة التجربة (١٢٠يوم).

أستخدام فى الدراسة الحالية ٨ أحواض خرسانية ذات أرضية ترابية بمساحة ١٢,٥ م٢ عند عمق مياه ١ م. وأشارت النتائج الى ان متوسط معدل النمو الفردى للاسماك عاليا مع الكثافة المنخفضة ومنخفضا للكثافات المرتفعة (فى نفس النوع) وكان متوسط الوزن النهائى لسمكة البلطى ١٥٩,٣ ، ١٧١,٠ ، ١٥٠,٥ و ١٤١,٠ جم. وبالنسبة لأسماك القراميط ١٨٠,٥ ، ١٩٥,٣ ، ١٥١,٠ و ١٥٣,٠ جم. وسجلت سمكة المبروك العادى متوسط وزن ١١٩,٠ ، ١١٥,٠ ، ١٢٠,٠ و ١٢٥,٠ جم اما بالنسبة لسمكة المبروك الفضى ١٢٢,٥ ، ١٣١,٠ ، ١٣١,٠ و ١٤٢,٠ جم للتراكيب المحصولية الاولى والثانية والثالثة والرابعة على الترتيب لجميع الانواع وبفروق معنوية بين المجموعات. سجلت المعاملة الثانية أعلى معدل نمو نوعى ووزن نهائى وانتاج كلى تلتها المعاملة الاولى ثم الثالثة فالرابعة.

ومن هذة النتائج تم استخلاص ان أفضل تركيب محصولى (نسب الإستزراع) بين الانواع المختبرة فى نظام الاستزراع المتعدد كان فى المعاملة الثانية والمستزرعة بنسب (٦٠% بلطى + ٢٠% قراميط + ١٠% مبروك عادى + ١٠% مبروك فضى) والتى سجلت اعلى معدل انتاج سمكى وكذلك أعلى عائد اقتصادى. أظهر التحليل الاقتصادى انه على الرغم أن المعامله الثانية سجلت أعلى معدل للتكاليف الكلية بالمقارنة بباقى المعاملات الا انها ايضا وعلى النقيض من ذلك سجلت اعلى صافى ربح بالمقارنة بجميع المعاملات.

وتوصى هذه الدراسة بتربية الاسماك بنظام الاستزراع المتعدد وذلك لتعظيم الاستفادة من كل نواحى الحوض (المكان والغذاء) بنسب تركيبية (٦٠% بلطى + ٢٠% قراميط + ١٠% مبروك عادى + ١٠% مبروك فضى) وذلك للحصول على اعلى انتاجية وأعلى عائد إقتصادى.