Effect of dietary protein level and stocking ratios of striped mullet (*Mugil cephalus*) and Nile tilapia (*Oreochromis niloticus*) in polyculture system in net enclosures on growth performance and feed utilization

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ABSTRACT

An experiment was carried out in order to determine the effect of stocking ratio (SR) and dietary crude protein levels (P %) of striped mullet (*Mugil cephalus*) and Nile tilapia (*O.niloticus*) on growth performance under the polyculture system in net enclosures. Mullet (M): Tilapia (T) were stocked at three ratios (3:7, 5:5 and 7:3) at the same total stocking density of 10 fishes per each of 18 (0.7 m^3) net enclosure covered with nylon nets to avoid fish jumping. Striped mullet and Nile tilapia fingerlings of initial body weight ± SE 2.25 ± 0.07g and 6.5 ± 0.06 g, respectively were stocked at the three ratios tested. The three polyculture ratios and two protein levels (17% and 25% crude protein) were evaluated in 3 x 2 factorial arrangement for their effect on growth performance and feed utilization of both species. Final body weight (FBW) of striped mullet and Nile tilapia fingerlings increased significantly (P<0.05) with increasing Nile tilapia ratio. Striped mullet fingerlings maintained at SR_2 and SR_3 exhibited significantly less FBW than those maintained at SR_1. Averages of FBW were found to be (7.33 ± 1.00, 5.95 ± 0.68 and 5.89 ± 0.37g) for $SR_{1,\ 2\ and3}$, respectively. The best FBW of Nile tilapia was observed with the SR_1 followed by SR_3 and SR_2. They were found to be 13.40± 0.04g, 11.90 ± 0.24g and 11.55 ± 0.05g, respectively. Striped mullet fingerlings maintained at the diet containing 25% crude protein exhibited significantly (P<0.05) greater FBW than those maintained at the diet containing 17% crude protein. The averages of FBW were found to be 7.07±0.14g and 5.71±0.32g, respectively. Also, with respect to Nile tilapia, FBW followed the same trend. It was greater with the diet containing 25% crude protein than with the diet containing 17 % crude protein. The differences among FBW of tilapia were insignificant (P>0.05). The FBW averages were found to be 12.42 ± 0.53g and 12.20 ± 0.58g for protein levels 17 and 25%, respectively. Obviously, the best FCR value was observed when fish maintained at 25% dietary crude protein diet. It was found to be 2.09 ± 0.05, but it was not differed significantly from FCR of fish maintained at 17% dietary crude protein which was 2.30 ±0.08. From these results it was recommended that the polyculture stocking ratio of 3 Mullet: 7 Tilapia was the best ratio for both striped mullet and Nile tilapia fingerlings under the polyculture system and the best level of protein for striped mullet was 25%, while there were no significant differences in FCR among Nile tilapia fingerlings maintained at 17% or 25% dietary crude protein.

Keywords: striped mullet, Nile tilapia, protein, stocking ratio, polyculture.

INTRODUCTION

Nile tilapia (*Orcochromis niloticus*) could be reared in fresh and brackish water. In recent years, it has begun to describe tilapia as the future "aquatic chicken" (Pillay, 1990). On the other hand, striped mullet (*Mugil cephalus*) also has been the species of choice in all areas because of the fast growth rate and the comparatively large size of the adults. The monoculture method is the first practice in fish culture. But, the Egyptian fish farmers noticed early that under the climatic conditions of Egypt, strong and long lasting sunshine, intensive fertilization and feeding, the ponds yield large amounts of phytoplankton which is not utilized by a single fish species.Therefore, they preferred another world wide known system of fish culture which called the polyculture system. The success of this system depends on the choice of the right combination of fish species (Cruz and Laudencia, 1980). In such conditions, polyculture can even show synergistic effects, when one species improves the environmental conditions and food supply of the other. Then, the growth rate of each species would be higher under polyculture than in monoculture system (Yashouv, 1969; Yashouv and Halevy, 1972 and Reich, 1975).

Several studies indicated that, fish stocking density affects the amounts of natural food available per fish, the level of supplemental feeding required (Tang, 1970; Moore, 1986; Hepher, 1988 and Milstein, 1992), and thus, the intensity of inter - and intra - specific food competition. Fish cultured together should be carefully analyzed in order to optimize both fish performance (growth and yield) and economic profitability of the combined system. Few efforts demonstrated the effect of stocking ratios in polyculture system of fish species on fish performance in small tanks (Papoutsoglou ***et al***., 1992), in cages (D'Silva and Maugan, 1992) and in earthen ponds at the same stocking density (Karplus ***et al***., 1996). Yashouv (1972) came to the conclusion that the presence of *Mugil cephalus* in a pond decreases the yields of other fish. Thus, fish polyculture ratio was arbitrarily fixed on the basis of their feed and feeding habits, intra and interspecific compatibility and ecological fitness.

The economic success of controlled production of fish depends mainly on the cost of feed and particularly on protein, the most expensive component in artificial diets. Therefore, it is necessary to keep the proportion of protein down to optimum levels for good growth and feed conversion. Many studies have been carried out to get suitable artificial diets for fishes cultured in monoculture system (Kesamura ***et al***., 1982; El-Sayed and Teshima, 1992; El-Dahhar, 1994; Kaushik ***et al***., 1995 and El-Dahhar ***et al.,*** 1999 and

2000). On the other hand only a few studies on the formulation of suitable artificial diets have been reported (Yashouv and Ben-Shachar, 1967; Vallet *et al*., 1970; Albertini - Berhaut and Vallet, 1971 and El-Dahhar et al., 1999). Most of the available information is limited to their natural feeding habits (Albertini-Berhaut, 1974 and De Silva and Wijeyaratne, 1977). However, the results from these studies are not able to determine the optimal dietary protein levels for the same fish species under the polyculture systems.

This study was carried out to determine the optimum stocking ratio (SR) and dietary crude protein levels (P%) of striped mullet (*Mugil cephalus*) and Nile tilapia (*O.niloticus*) under the polyculture system in net enclosures. Also the present study aimed to evaluate the effect of polyculture stocking ratios, dietary crude protein levels on growth performance of striped mullet and Nile tilapia fingerlings reared in polyculture system.

MATERIALS AND METHODS

An experiment was carried out at the fish farm of the Faculty of Agriculture, (Saba - Basha), Alexandria University to study the effect of dietary protein levels and stocking ratios on growth and feed utilization of striped mullet (*Mugil cephalus*) and Nile tilapia (*Oreochromis niloticus*) in a polyculture system performed in net enclosures. Eighteen net enclosures each of 0.7 m^3 were placed in an earthen pond of 0.75 feddan with an average depth of 0.8 - 1 m. The pond was filled by fresh water from the water supply canal. Water was added only to make up for losses due to evaporation and water was filtered through a screen to prevent the entrance of wild fish.The eighteen net enclosures represented the three tested stocking ratios and the two protein levels each in triplicates.

Diets formulation and preparation

Two experimental diets were used in this experiment with two different protein levels (17% and 25% crude protein). The two diets were commercially manufactured in Barsiq Factory Bohira governorate, Egypt. The composition and chemical analysis of the experimental diets are presented in Table (1). Diets were formulated from commercial ingredients of fish meal, wheat flour, wheat bran, soy bean meal, yellow corn, bone meal, vitamins and minerals. Formulated dry mixtures were passed through a sieve (0.6 mm diameter bole) before mixing into the diets. Mixtures were homogenized in a food grader mixer attachment Model NFGA (Kitchen aid St. Gosph, MI 49085 USA). Boiling water was then blended into the mixtures using the ratio of 50% for pelleting. The diets were pelleted using meat grinder machine with a 1.5 mm diameter and then were dried carefully and kept in plastic bags until they were used.

Table (1): *Composition (% dry diet) and proximate analysis of the experimental diets*

Ingredients :	Diet No. A	Diet No. B
Wheat bran	24.4	14.7
Yellow corn	29.3	29.3
Wheat flour	---	---
Soy bean meal	2.9	9.8
Fish meal	2.5	8.7
Cotton sead meal	9.8	9.8
Wheat shorts	24.4	14.7
Meat meal	2.4	8.7
Molass	2.0	2.0
Bon meal	2.0	2.0
Vit & Min. Mix*	0.3	0.3
Total	100	100
Proximate analysis (%)		
Moisture	9.22	10.23
Crude protein	17.23	24.89
Crude fat	15.64	17.53
Crude fiber	6.81	7.24
NFE	42.44	30.99
Ash	8.66	9.12
Calculated ME	245	245
K cal / 100g**	70.33	101.59
P / E ratio		

**Vitamin and mineral mixture /kg Premix: Vitamin A, 4.8 million IU; D3, 0.8 million IU ; E, 4g; K, 0.8 g; riboflavin, 1.6 g; B6, 0.6 g; B12, 4 mg; pantothenic acid, 4 g; nicotinic acid,8 g; folic acid, 0.4 g; biotin, 20 mg; choline chloride, 200 g; Cu, 4g; I, 0.4 g; Iron, 12 g; Mn, 22 g; Zn, 22 g; Se, 0.4 g.*

*** Metabolizable energy k cal / 100 g diet (NRC, 1993).*

Experimental design

Mullet (M): Tilapia (T) fingerlings were stocked at three stocking ratios (3 : 7, 5 : 5 and 7 : 3) at the same total stocking density of 10 fishes per each of the 18 (0.7 m^3) net enclosure covered with nylon nets to avoid fish jumping. Striped mullet and Nile tilapia fingerlings of initial body weight ± SE 2.25 ± 0.07g and 6.5 ± 0.06g respectively were stocked at the three stocking ratios mentioned before. The three stocking ratios and two protein levels (17% and 25% crude protein) were evaluated in 3 x 2 factorial arrangement for their effect on growth performance and feed utilization of both species. Diets were fed at a rate of 4% of fish biomass. Fish were fed six days/week, twice a day at 9:00 and 14:00h. The experiment was lasted for seven weeks.

Growth performance

For determining fish weight, all fish of the three replicates of each treatment were recorded biweekly on the early morning and kept in fiberglass containers filled with fresh water from the same pond to avoid stress during recording fish weights. All fish of the replicates were returned to their net enclosures immediately after weighing. At the end of the experiment, several measurements, namely, mean fish weight, body weight gain (Gain), specific growth rate (SGR), percent weight gain (Gain %) and feed conversion ratio (FCR) were taken according to the following equations:

Gain = final body weight - initial body weight

SGR = 100 (Ln final body weight - Ln initial body weight) / time (days)

Gain % = 100 (weight gain / initial body weight)

FCR = feed intake / weight gain

Analytical methods

Meat and supplementary feed analysis

At the beginning of the experiment, samples of fish from mullet and tilapia were selected randomly and were frozen for proximate analysis. At the end of the experiment, all fish in each net enclosure were taken and subjected to proximate analysis. Chemical analysis of homogenized fish and experimental diets were carried out according to the methods described by the Association of Official Analytical Chemists (AOAC, 1990). The percent dry weight of the fish was determined by Oven drying portions of the fish at 70°C for 48-72h and passed through a meat grinder into one composite homogenate per net enclosure.

Crude protein was determined by the macro-kjeldahl method. Lipids was determined in a Soxhlett apparatus by extracting with petroleum ether (60-80°C) for 12h and ash of the diets by burning in a muffle furance at 600°C for 2h.

Physical and chemical analysis of water

Three water samples were collected from the source of water (supply channel) and mixed together to be one sample and analyzed before entrance to the ponds. Quality of pond water was checked weekly to determine its temperature, dissolved oxygen, salinity, pH, alkalinity, total hardness, total ammonia, nitrate, nitrite, phosphate and secchi disk visibility.

Water temperature °C and dissolved oxygen (DO) mg/L were measured before sunrise using an Cole polmer oxygen meter (Chicago Illinois 60648) at 2.5m from the bank beside the drainage gate at depth of 25 cm Model 5946-55.

Chloride was determined by titration against standard 0.014N silver nitrate. Beckman pH meter was used to determine the pH values. All these methods were conducted according to the American Public Health Association (APHA, 1985).

Statistical analysis

The analysis of variance and least significant difference test were carried out according to Snedecor and Cochran, (1981).

RESULTS

Final body weight (FBW) of striped mullet and Nile tilapia fingerlings as affected by stocking ratios and dietary crude protein levels are summarized in Table (2). FBW of each species increased significantly ($P<0.05$) with increasing Nile tilapia ratio to mullet. Striped mullet maintained at SR_2 and SR_3 exhibited significantly less FBW than those maintained at SR_1. The best FBW of Nile tilapia was observed at the SR_1 followed by SR_3 and SR_2. Statistical analysis indicated that FBW was in beneficial response with dietary crude protein level for each of striped mullet and Nile tilapia fingerlings. Striped mullet fingerlings maintained at diet containing 25% crude protein exhibited significantly ($P<0.05$) greater FBW than those maintained at diet containing 17% crude protein. Also, with respect to Nile tilapia, FBW folloed the same trend. It was greater insignificantly ($P>0.05$) with the diet containing 25% crude protein than with the diet containing 17 % crude protein.

The greater increase in striped mullet FBW was obtained with fingerlings maintained at 25 % dietary crude protein at the SR_1, followed by 25%, SR_2; 25%, SR_3; 17 %, SR_1; 17%, SR_3 and 17%, SR_2. The best FBW of Nile tilapia was observed when fingerlings maintained at both 25 % and 17% dietary crude protein at SR_1, followed by 25%, SR_3; 17%, SR_3; 25%, SR_2 and 17 %, SR_2 (Table 2), respectively. Weight gain (WG) and specific growth rate (SGR) of striped mullet and Nile tilapia are shown in Table (2). WG of striped mullet increased with increasing tilapia in the polyculture ratio. The greatest (but not significant) WG of mullet was observed at SR_1 followed by SR_2 and SR_3 respectively. While with respect to Nile tilapia, analysis of variance of the data showed that differences within WG were significant ($P<0.05$). The best WG was observed at SR_1, (6.80 ± 0.11 g) followed by SR_3 and SR_2, (5.54 ± 0.11 g and 4.96 ± 0.06 g), respectively .

The results concerning body weight gain of striped mullet and Nile tilapia as affected by dietary crude protein levels followed the same trend observed for final body weight. It is clear from Table (2) that WG of mullet is greater with the diet containing 25 % dietary crude protein at SR_1 and SR_2 with insignificant differences ($P>0.05$) among them. They were followed by WG of mullet maintained at 25 %dietary crude protein at SR_3; 17 %, SR_1; 17%, SR_3 and 17 %, SR_2. There were insignificant differences ($P>0.05$) among 17% dietary crude protein, SR_1; 25 %, SR_2 and 25 %, SR_3 treatment groups in WG of mullet. With respect to Nile tilapia, the best WG were noticed when the fingerlings maintained at 25 % or 17 % dietary crude protein both with the first stocking ratio (SR_1) followed by that of Nile tilapia maintained at 25 %, SR_3; 17%, SR_3; 25%, SR_2 and 17%, SR_2. Average SGR of striped mullet and Nile tilapia are summarized in Table (2). The data indicated that SGR of each of striped mullet and Nile tilapia increased gradually with increasing tilapia in the stocking ratio. Irrespective of protein levels, statistical analysis did not reveal any significant differences ($P>0.05$) in the SGR of mullet due to different stocking ratios. The results presented in Table (2) show that the best SGR of mullet was observed at the first stocking ratio SR1 averaged (2.12 ± 0.13) followed by SR2 and SR3 with the averages of 2.01 ± 0.14 and 1.87 ±0.12, respectively.

Table (2): *Mean ± standard error (SE) of initial and final body weight (BW),weight gain and specific growth rate (SGR) of striped mullet (M) and Nile tilapia fingerlings (T) as affected with dietary crude protein levels(17and 25 %) and stocking ratios (3:7, 5:5 and 7:3).*

Protein levels %	Stocking ratios (SR) M:T	Initial BW (g)	Final BW (g)	Gain (g)	SGR (%/d)
		Striped mullet (*Mugil cephalus*)			
17	**3:7**	2.33 ± 0.19^{a}	6.33 ± 0.25^{b}	4.00 ± 0.34^{bc}	1.93 ± 0.19^{ab}
	5:5	2.17 ± 0.07^{a}	5.27 ± 0.15^{c}	3.10 ± 0.15^{c}	1.71 ± 0.07^{b}
	7:3	2.28 ± 0.00^{a}	5.52 ± 0.10^{c}	3.24 ± 0.10^{c}	1.70 ± 0.03^{b}
25	**3:7**	2.53 ± 0.20^{a}	8.33 ± 0.19^{a}	5.80 ± 0.04^{a}	2.30 ± 0.11^{a}
	5:5	1.99 ± 0.01^{a}	6.63 ± 0.18^{b}	4.64 ± 0.18^{ab}	2.31 ± 0.60^{a}
	7:3	2.22 ± 0.27^{a}	6.57 ± 0.12^{b}	4.28 ± 0.31^{bc}	2.04 ± 0.20^{ab}
Pooled means					
17		2.26 ± 0.05^{g}	5.71 ± 0.32^{h}	3.45 ± 0.18^{h}	1.78 ± 0.07^{h}
25		2.25 ± 0.16^{g}	7.07 ± 0.14^{g}	4.91 ± 0.25^{g}	2.22 ± 0.08^{g}
	3:7	2.43 ± 0.10^{x}	7.33 ± 1.00^{x}	4.90 ± 0.43^{x}	2.12 ± 0.13^{x}
	5:5	2.43 ± 0.10^{x}	5.95 ± 0.68^{y}	3.87 ± 0.36^{x}	2.01 ± 0.14^{x}
	7:3	2.25 ± 0.03^{x}	5.89 ± 0.37^{y}	3.76 ± 0.27^{x}	1.87 ± 0.12^{x}
		Nile tilapia (*O. niloticus*)			
17	**3:7**	6.66 ± 0.17^{a}	13.36 ± 0.08^{a}	6.69 ± 0.13a	1.32 ± 0.06^{a}
	5:5	6.56 ± 0.09^{a}	11.50 ± 0.17^{c}	4.93 ± 0.09c	1.08 ± 0.01^{d}
	7:3	6.27 ± 0.06^{a}	11.75 ± 0.13^{bc}	5.37 ± 0.16bc	1.17 ± 0.03^{c}
25	**3:7**	6.52 ± 0.24^{a}	13.43 ± 0.07^{a}	6.91 ± 0.17a	1.39 ± 0.06^{a}
	5:5	6.62 ± 0.07^{a}	11.60 ± 0.17^{c}	4.98 ± 0.10c	1.08 ± 0.01^{d}
	7:3	6.38 ± 0.20^{a}	12.22 ± 0.15^{b}	5.70 ± 0.10b	1.20 ± 0.02^{b}
Pooled means					
17		6.50 ± 0.12^{g}	12.20 ± 0.58^{g}	5.67 ± 0.27g	1.19 ± 0.04^{g}
25		6.51 ± 0.07^{g}	12.42 ± 0.54^{g}	5.86 ± 0.28g	1.23 ± 0.05^{g}
	3:7	6.59 ± 0.07^{x}	13.40 ± 0.04^{x}	6.80 ± 0.11x	1.36 ± 0.04^{x}
	5:5	6.59 ± 0.03^{x}	11.55 ± 0.05^{y}	4.96 ± 0.06z	1.08 ± 0.01^{y}
	7:3	6.33 ± 0.06^{x}	11.90 ± 0.24^{y}	5.54 ± 0.11y	1.19 ± 0.02^{y}

Means in the same column with different superscript are significantly different (P<0.05)

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On the other hand, there were significant differences (P<0.05) between SGR of Nile tilapia fingerlings maintained at different SRs. The best SGR was recorded at SR_1 (1.36 ± 0.04) followed by SR_3 and SR_2 with the averages of 1.19 ± 0.02 and 1.08± 0.01, respectively. Differences between SGR of tilapia maintained at SR_2 and SR_3 were not significant (P>0.05).

SGR of mullet maintained at the diet containing 17 % crude protein (1.78 ± 0.07) was less significantly ($P<0.05$) than those maintained at the diet containing 25 % crude protein (2.22 ± 0.08). With respect to Nile tilapia, SGR was greater with the diet containing 25% crude protein than with the diet containing 17 % crude protein. Statistical analysis show that there were insignificant differences within SGR of tilapia ($P>0.05$). They were found to be 1.23 ± 0.05 and 1.19 ± 0.04, respectively.

Interaction of SGR data between protein levels and stocking ratios was significant for both fish species striped mullet and Nile tilapia. The highest SGR of striped mullet as demonstrated in Table (2) was observed when its fingerlings were fed at the diet containing 25 % crude protein at the second polyculture ratio SR_2, followed by 25 %, SR_1; 25 %, SR_3 and 17%, SR_1, respectively. There were insignificant differences among these groups. And the least SGR averaged 1.71 ± 0.07 and 1.70 ± 0.03 were recorded with 17 % dietary crude protein at SR_2 and 17 % with SR_3, respectively. The results show that SGR of mullet given the diet containing 25% crude protein at SR_3 was significantly similar to that given the diet containing 17 % crude protein at SR_1, SR_2 and SR_3. With respect to Nile tilapia, the best SGR was observed with diets containing 25 % and 17% dietary crude protein both at SR_1 compared to other tilapia treatment groups. There was insignificant differences between these two treatment groups, followed by 25 %, SR_3; 17 %, SR_3; 25 %, SR_2 and 17 %, SR_2, respectively. The results presented in Table (2) show that the difference between SGR of tilapia was not significant when fingerlings maintained at 17 % and 25 % crude protein both at SR_2 and they were found to be the less significant values than those observed with the other treatment groups.

Weight gain (percent of initial weight) of striped mullet, Nile tilapia fingerlings and the total biomass and its statistical analysis are shown in Table (3). Obviously, gain % of striped mullet improved by increasing tilapia in the stocking ratio. Statistical analysis did not reveal any significant differences in the gain % of striped mullet when fish maintained at SR_1, SR_2 and SR_3. With respect to Nile tilapia, the results presented in Table (3) showed that gain % was decreased significantly ($P<0.05$) with increasing mullet in the stocking ratio from SR_1 to SR_2, followed by increasing at SR_3. The results showed that gain% of the total biomass revealed that gain % followed the same trend observed for gain % of striped mullet.

Irrespective of stocking ratios, the results in Table (3) indicate that gain % of striped mullet developed significantly ($P<0.05$) by increasing dietary crude protein level from 17% to 25%. With respect to Nile tilapia, fingerlings

Table (3)*: Mean ± standard error (SE) of weight gain (percent of initial weight.) of striped mullet (M) and Nile tilapia fingerlings (T) as affected with dietary crude protein levels(17and 25 %) at three stocking ratios (3:7, 5:5 and 7:3).*

Protein Levels%	Stocking Ratio (SR) M : T	Weight gain (% of initial wt.)		
		Striped mullet	Nile tilapia	Total biomass
17	3 : 7	175.56 ± 25.37^{bc}	102.16±5.71^{a}	138.86 ±12.79^{bc}
	5 : 5	143.48 ± 9.47^{c}	75.12 ± 0.55^{b}	109.30 ± 4.96^{c}
	7 : 3	142.11 ± 4.33^{c}	84.18 ± 3.20^{b}	113.15 ± 0.57^{c}
25	3 : 7	247.81 ± 34.67^{a}	108.51±6.25^{a}	178.16 ± 20.11^{a}
	5 : 5	232.83 ± 9.73^{ab}	75.30 ± 0.58^{b}	154.07 ± 5.17^{ab}
	7 : 3	191.54 ±28.88^{abc}	87.49 ± 1.60^{b}	139.52 ±14.61^{bc}
Pooled means				
17		153.72 ± 9.62^{h}	87.15 ± 4.40^{g}	120.44 ± 6.10^{g}
25		224.06 ± 15.76^{g}	90.43 ± 5.20^{g}	157.25 ± 9.24^{g}
	3 : 7	211.69 ± 25.10^{x}	105.33±4.05^{x}	158.51 ± 13.81^{x}
	5 : 5	188.16 ± 20.88^{x}	75.21 ± 0.42^{y}	131.69 ± 10.51^{x}
	7 : 3	166.82 ± 17.11^{x}	85.83 ± 1.76^{y}	126.33 ± 8.80^{x}

Means in the same column with the same superscript are not significantly different (P<0.05).

maintained at 25% dietary crude protein had higher gain % than those maintained at 17% dietary crude protein, but the differences among them were not significant (P>0.05). The same trend was observed with respect to the total biomass.

Interaction of gain % data between the two factors P% and SR was significant for both fish species and their total biomass. Obviously, the best gain % values of striped mullet were observed when fingerlings maintained at 25% dietary crude protein at any stocking ratio (SR_1, SR_2 or SR_3) without any significant differences between them (Table 3). The least gain % values of striped mullet were obtained when fingerlings maintained at 17% dietary crude protein at any stocking ratio (SR_1, SR_2 or SR_3). They were less significantly ($P < 0.05$) than that of mullet maintained at 25% protein with the three stocking ratios.

With respect to Nile tilapia, the best gain % values were observed when fingerlings maintained at 25% or 17% dietary crude protein at SR_1. These values were higher significantly ($p<0.05$) than those found at 17%, SR_2; 17%, SR_3; 25%,

$SR2$ and 25%, SR_3. Analysis of variance of the data showed that differences within gain % of Nile tilapia were not significant ($P>0.05$) within the treatments of 17%, SR_2; 17%, SR_3; 25%, SR2 and 25%, SR_3. The same trend was observed with respect to the total biomass. The best gain % was recorded with 25%, SR_1 followed by gain % of fish maintained at 25%, SR_2; 25%, SR_3; 17%, SR_1; 17%, SR_3 and 17%, SR_2, respectively.

Feed and nutrient utilization

Feed consumption (FC) and feed conversion ratio (FCR) for Nile tilapia and mullet as affected by dietary protein level and stocking ratio are shown in Table (4). Feed consumption increased significantly ($P<0.05$) with increasing tilapia in the stocking ratio. The highest FC was recorded when fish maintained at the first stocking ratio (SR_1) (137.75 ± 0.41g), followed by (104.5 ± 2.07g and 92.91 ± 0.57g) at SR_2 and SR_3, respectively. The FC of fingerlings maintained at 25% dietary crude protein diet was significantly ($P<0.05$) higher than of those obtained the 17% dietary crude protein diet (114.33 ± 7.03g and 109.11 ± 6.51g), respectively irrespective of stocking ratio. The FC of fish maintained at 25% dietary crude protein at SR_1 was highly significantly than that recorded wth the other treatment groups ($P<0.05$). It was followed by FC of fish maintained at 17%, SR_1; 25%, SR_2; 17%, SR_2; 25%, SR_3 and 17%, SR_3.

Regardless of protein level fed, FCR improved slightly in fingerlings of both tested species when maintained at SR3 compared to other stocking ratios tested (Table 4). However, statistical analysis did not reveal any significant differences ($P>0.05$) in FCR of among the tested stocking ratios. Obviously, the best FCR value was observed when fish maintained at 25% dietary crude protein (2.09 ± 0.05). It was not differ significantly from FCR of fish maintained at 17% dietary crude protein (2.30 ±0.08) regardless of stocking ratio. The higher FCR values were obtained when fingerlings maintained at diet containing 17% crude protein with SR_1 or SR_2 without significant differences ($P>0.05$). There were no significant differences among the other treatment groups in FCR.

Average water quality records during the experimental period were found to be within the normal limits for both species (Temp., 24.2±1.8 °C; DO, 7.2±0.61 ppm; pH, 8.5±0.1; Total Alkalinity, 283±4.5 ppm; NH_4^+, 0.8±0.0 ppm; No_2^- 0.41 ±0.0 pm; No_3^-, 0.23 ±0.0 ppm and Orthophosphate, 1.42±0.03 mg / L).

Table (4) : Mean ± standard error (SE) of total weight gain, offered feed and feed conversion ratio (FCR) of striped mullet (M) and Nile tilapia fingerlings (T) per net enclosure as affected with dietary crude protein levels (17and 25 %) at three stocking ratios (3:7, 5:5 and 7:3).

Protein Levels%	Stocking ratio (SR) M : T	Total weight gain g ± SE	Offered feed g ± SE	FCR
17	3 : 7	58.85 ± 1.67[a]	134.58 ± 1.98[b]	2.29 ± 0.09[ab]
	5 : 5	40.17 ± 1.17[d]	100.28 ± 0.94[d]	2.50 ± 0.05[a]
	7 : 3	42.78 ± 4.01[cd]	92.46 ± 0.96[e]	2.16 ± 0.21[b]
25	3 : 7	65.76 ± 1.28[a]	140.92 ± 1.21[a]	2.14 ± 0.06[b]
	5 : 5	50.78 ± 3.44[bc]	108.72 ± 1.67[c]	2.14 ± 0.11[b]
	7 : 3	47.05 ± 1.97[cd]	93.36 ± 0.70[e]	1.98 ± 0.08[b]
Pooled means				
17		47.27 ± 3.20[g]	109.11 ± 6.51[h]	2.30 ± 0.08[g]
25		54.53 ± 3.10[g]	114.33 ± 7.03[g]	2.09 ± 0.05[g]
	3 : 7	62.31 ± 1.81[x]	137.75 ± 0.41[x]	2.21 ± 0.06[x]
	5 : 5	45.48 ± 2.88[x]	104.5 ± 2.07[y]	2.30 ± 0.09[x]
	7 : 3	44.91 ± 2.22[y]	92.91 ± 0.57[z]	2.07 ± 0.11[x]

Means in the same column with different superscript are significantly different (P<0.05).

DISCUSSION

The results of the present study revealed that, with increasing the stocking rate of mullet in the stocking ratio, final body weight and weight gain of both striped mullet and Nile tilapia fingerlings decreased (Table 2). The decrease in body weight gain may be due to the interspecific competition between mullet and tilapia for food. Moreover, the increase in mullet ratio affects its growth due to the intraspecific competition between mullet fingerlings. These results are in agreement with those reported by Yashouv (1972). He came to the conclusion that the presence of *Mugil cephalus* in a pond decreases the yields of other fish.

The best mixture for high production in the present study was 70% tilapia and 30% mullet. These results were in agreement with those reported by Tichert - Coddington (1996) for *Clossona macropomum* and *Oreochromis niloticus*. He found that, total production increased curvilinearly, and feed conversion ratios decreased curvilinearly as the rate of stocked tilapia increased. He found also that the best species mixture for high production, was 75% tilapia and 25% tambaquí. The same trend was found in the study reported by Papoutsoglou *et al.*, (1992). In this study, two polyculture groups (60% carp (C) - 40% tilapia (T) and 60% tilapia - 40% carp) were reared using a closed circulated system. The aim of the experiment was to investigate the interactions between the species and their influence on fish growth characteristics, under polyculture conditions. The highest final yield (132.5 kg/m^3) was found with the group of (60% T - 40% C) compared to the group of (60% C - 40% T), which attained a final yield 126.1 kg/m^3.

In this connection, the achievement of the well known advantages of polyculture fish rearing, in the case of an intensive production system, is mainly based on fish ethology, food habits and the percentage combination of species (Papoutsoglou *et al.,* 1992).

Hafez (1991) found that, body weight and body length of tilapia fish under the polyculture system (with mullet and carp) varied with mullet stocking rate and the differences in body weight and length due to mullet stocking rate were significant ($P< 0.01$) in most growth stages studied. The same findings were also observed when dealing with either mullet or carp fish.

The results of the present study show that the biomass increased for both species Nile tilapia and striped mullet at increasing stocking density of their own species, but the individual weight was greatly reduced with increasing mullet in the stocking ratio.

These results are in agreement with those reported by Hogendoorm and Koops, (1983) in the poluycultre of *Oreochromis niloticus* and *Clarias lazera*. Furthermore, Cohen and Ra'anan (1983) showed that, both the total prawn yields and average weights were independent of tilapia stocking rate under the polyculture production system of tilapia hybrids and fresh water prawn *Machrobrachium rosenbergii*.

The results of the present study indicated that tilapia was highly responsive to changes in stocking ratios than mullet. However, differential sensitivity of mullet and tilapia to changes of their own stocking density cannot be deduced from this study because these two species were tested under different densities. Previous studies have shown that even at the low stocking rate, density had a noticeable effect on the rate of growth and the increase in mullet stocking rate was followed by decrease in the body weight of tilapia under the polyculture fish production system (Snow, 1983 and Hafez, 1991).

Growth is a complex phenomenon, but can be viewed most simply as an increase in body cell mass which in animals relates to development of skeleton, such as fish, is accompanied by an increase in axial length. It is now well established in vertebrates, including fish, that growth is regulated by hormones which act together with genetic and nutritional factors that influence growth (Power, 1990).

Averages of SGR of striped mullet and Nile tilapia fingerlings as affected by stocking ratios are presented in Table (2). The data indicate that SGR of each of striped mullet and Nile tilapia increased gradually with increasing tilapia stocking rate with a reduction in mullet stocking rate. The best SGR of both mullet and tilapia was observed with the first polyculture ratio mixture (3 M : 7 T). It is clear that increasing stocking rate of Nile tilapia with decreasing striped mullet at the same time increased BW gain and hence, the amount of supplementary feeding increased which was more suitable for Nile tilapia due to the decrease in the interspecific competition for food between Nile tilapia and striped mullet fingerlings. Moreover, Nile tilapia excreted partly digested food which fell to the bottom and served as food for benthic organisms - the main food item of striped mullet fingerlings. This synergistic effect was explained by Yashouv (1971) as a mutual effect on food resources. He showed that silver carp excreted partly digested algae as pellets which fell to the bottom and served as food for benthic organisms, the main food item of common carp. On the other hand, common carp stirred the bottom, bringing up organic matter which served as food for silver carp.

Rouse and Kahn, (1998) evaluated the effect of tilapia on growth and survival of red claw crayfish in red claw-tilapia polyculture. They observed a reduced red claw performance when cultured with tilapia. Similar results were reported when red claw was cultured with tilapia (Karplus *et al*., 1995). The authors explained that red claws are generally considered non-aggressive, especially when compared with other clawed crustaceans. His lack of aggressiveness is suggested as a cause for decreased growth in polyculture with tilapia.

The results of the present study indicated that weight gain (% of the initial weight) of striped mullet, Nile tilapia and the total biomass improved by increasing tilapia to mulet ratio (Table 3). Although, statistical analysis of the data showed that differences in gain % due to the studied effects of striped mullet fingerlings and the total biomass were not significant (P>0.05) when fish maintained at any stocking ratio, the polyculture group of 70% tilapia - 30% mullet still the best species mixture for high gain percent, and also for high production as presented in Table (4). The higher total weight gain in this polyculture group reflects less inter-and intra-specific competition for food and high utilization efficiency of the supplemental diets. Previous studies have shown that fish stocking density affects the amounts of natural food available per fish and the level of supplemental feeding required (Moore, 1986and Hepher, 1988). The stocking ratio of fish species was arbitrarily fixed on the basis of their feed and feeding habits. In essence, polyculture is an attempt to get maximum utilization of pond waters by stocking fish with complementary characteristics (Lakshmanan *et al*., 1971).

In the present study, Table 4 showed that feed conversion ratio (FCR) decreased insignificantly (P>0.05) with increasing mullet in the stocking ratio. The noticed insignificant improvement in FCR values with polyculture - group (7 M : 3 T) is attributed to lower food consumption due to the lower growth more than better food utilization. Consequently, it could be said that when mullet : tilapia polyculture ratio increased, the inter-specific competition for food between both species increased, followed by decrease in the body weight of both (Snow, 1983 and Hafez 1991). Similar results were obtained by Lovshin (1980) and Teichert - Coddington, (1996). The authors demonstrated that feeding efficiency of a tampaquí culture was increased tremendously by co-stroking tilapia hybrid, and FCR was more better with the mixture of 75% tilapia and 25% tambaquí than with 25% tilapia and 75% tambaquí. It was found to be 1.13 and 1.30 respectively.

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أثر مستوى بروتين الغذاء ومعدلات تسكين أسماك البورى والبلطى النيلى المرباة تربية مشتركة فى تحاويط شبكية على أداء النمو والكفاءة الغذائية

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٢. المعمل المركزي لبحوث الاستزراع المائي – وزارة الزراعة

أجريت تجربة لتقدير المستوى الأمثل من الاستزراع المتعدد ومستوى البروتين الأمثل لأسماك البوري *Mugil cephalus* والبلطي النيلي *Oreochromis niloticus* في أنظمة الاستزراع المتعدد في تحاويط شبكية. وقد تم تخزين أساك البوري : أسماك البلطي في ثلاثة نسب (٣ : ٧ ، ٥ : ٥ ، ٧ : ٣) في نفس العدد الإجمالي (عشرة أسماك) في كل من ١٨ تحويطة شبكية ذات حجم ٠.٧م٣ علي أن تغطى التحاويط الشبكية بشبكة من النايلون لتجنب قفز الأسماك منها. كانت متوسطات أوزان الأسماك فى بداية التجربة هي ٢.٢٥ ± ٠.٠٧ جم لأسماك البوري و ٦.٥ ± ٠.٠٦ جم لأسماك البلطي النيلي . وقد تم دراسة الثلاثة نسب للاستزراع المتعدد مع نسبتين من بروتين الغذاء ١٧ ، ٢٥ % بروتين باستخدام التجارب العاملية (٣ Í ٢) لمعرفة تأثيرها على نمو الأسماك وكذلك الاستفادة من الغذاء لكل من النوعين. الوزن النهائى لكل من إصبعيات البورى والبلطى النيلى أظهر زيادة معنوية بزيادة نسبة أسماك البلطى النيلى. بالنسبة لإصبعيات البورى كان الوزن النهائى مع نسبة ٥ : ٥ ، ٧ : ٣ أقل معنوياً من الوزن النهائى مع نسبة ٣ : ٧، كانت متوسطات الأوزان النهائية بالنسبة لأسماك البوري (٧.٣٣ ± ١.٠٠ ، ٥.٩٥ ± ٠.٦٨ ، ٥.٨٩ ± ٠.٣٧ جم) على التوالى. بالنسبة لإصبعيات البلطى كان أعلى وزن نهائى مع نسبة ٣ : ٧ يليه الأوزان التى تم الحصول عليها مع نسبة ٧ : ٣ و ٥ : ٥. و كانت متوسطات الأوزان النهائية كما يلى (١٣.٤٠ ± ٠.٠٤ ، ١١.٩٠ ± ٠.٢٤ ، ١١.٥٥ ± ٠.٠٠٥ جم) على التوالى. إصبعيات البورى المغذاة على عليقة تحتوى على ٢٥% بروتين خام أظهرت وزن نهائى أعلى معنوياً من تلك المغذاة على عليقة تحتوى على ١٧% بروتين خام وكانت متوسطات أوزان الأسماك النهائية (٧.٠٧ ± ٠.١٤ ، ٥.٧١ ± ٠.٣٢ جم) على التوالى. أيضاً بالنسبة لأسماك البلطى النيلى، الأوزان النهائية اتبعت نفس الاتجاه الملاحظ مع أسماك البورى. كانت الأوزان باستخدام عليقة تحتوى على ٢٥% بروتين خام أعلى من تلك الأوزان المتحصل عليها باستخدام عليقة تحتوى على ١٧% بروتين خام ولكن الاختلافات بين متوسطات أوزان البلطى النيلى كانت غير معنوية وكانت كما يلى (١٢.٤٢ ± ٠.٥٣ ، ١٢.٢٠ ± ٠.٥٨ جم) على التوالى. أفضل قيم لمعامل التحويل الغذائى (FCR) لوحظت مع الأسماك المغذاة على عليقة تحتوى على ٢٥% بروتين خام (٢.٠٩ ± ٠.٠٥) ولكن هذه القيمة لـFCR لم تختلف معنوياً مع تلك المتحصل عليها مع الأسماك المغذاة على عليقة تحتوى على ١٧% بروتين خام (٢.٣٠ ± ٠.٠٨). من هذه النتائج يمكن استنتاج أن نسبة تخزين الأسماك (٣ بورى : ٧ بلطى نيلى) كانت هى أفضل نسبة تخزين لكل من إصبعيات البورى والبلطى النيلى باستخدام نظام الاستزراع المتعدد فى تحاويط شبكية وأن أفضل مستوى للبروتين فى الغذاء بالنسبة لأسماك البورى كان ٢٥% بينما لم تلاحظ فروق معنوية بين إصبعيات البلطى النيلى المغذاة على علائق تحتوى على ١٧% أو ٢٥% بروتين خام.