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GROWTH PERFORMANCE OF EEL (*ANGUILLA ANGUILLA*), NILE TILAPIA (*OREOCHROMIS NILOTICUS*) AND GREY MULLET (*MUGIL CEPHALUS*) CULTURED IN CAGES UNDER TWO FEEDING SYSTEMS

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SUMMARY

The present experiment was carried out during one growing season for 240 days in cages. The objective of the study was to investigate growth performance of elvers reared in cage in polyculture system with Nile tilapia and mullet using a commercial diet plus trash fish under the Egyptian conditions. Also the study aimed to develop a guideline for fish farmers to improve their production level. The three treatments applied were commercial diet containing (45% crude protein) plus trash fish (Tr1), commercial diet (20% crude protein) plus trash fish (Tr2) and the same diet as (Tr2) but without eel stock (Tr3). Each treatment was performed in triplicates. Cages used in this study were 3x5x5 m^3 in diameters and stocked with 500 eel elvers (35 g average weight), 2000 Nile tilapia (25 g average weight) and 1000 Grey mullet with an average weight of 22g at the experimental start except the Tr3, which was stocked with tilapia (2000) and mullet (1000) without eels and received the same dietary treatment as in Tr2. Fish of both treatments were fed on the commercial diets plus the trash fish at a rate of 2 to 1 according to the fish biomass of each cage. Results obtained can be summarized as follows: 1- Final averages of body weight for eel, Grey mullet and Nile tilapia in treatment 1(commercial diet 45% crude protein plus trash fish) were significantly higher than their corresponding species in the other treatments. 2- Final fish weights of eel, Nile tilapia and Grey mullet per cage in treatment 1 were 90.3, 399 and 170.2 Kg, respectively, which were higher by 6.7, 18 and 13.5 % than that obtained in the other treatments. 3- Net returns in LE per cage were 2010.7, 2320.3 and 1187.4 LE for treatments Tr1, Tr2 and Tr3, respectively. Based on the results obtained in this study, a polyculture of eel, Nile tilapia and Grey mullet could be applied in cages using a mixture of commercial diet containing 45% protein with trash fish at a ratio of 2 to 1 for best yield and growth performance. However the highest net returns were achieved using the 20% protein diet with trash fish due to the lower costs of the diet.

Keywords: Cage culture, eel, tilapia, mullet

INTRODUCTION

The family (Anguilla) comprises a single genus of 16 species of freshwater eels; from these species only one of them is known in Egypt as Thobban El- samak *Anguilla anguilla*. The species known in Egypt lakes the pelvic fins. They are distributing along the River Nile especially the north Delta region near lakes of Brollos, Manzalah, Edco, Maryout and coastal Lagoons (GAFRD, 1997).

The extensive culture in the Mediterranean Lagoons is based on elvers, which are allowed to enter the impounded areas through the manipulation of tidal flows and which are grown in the fertile lagoon waters (Pillay, 1990).

In Egypt, elvers are available at pump station No. 11, Borollos, Gamasa and El-Max in Alexandria. The Egyptian eel is a fish species of high value especially in the Japanese and European markets. Eel farms will be successful in Egypt because of the following reasons 1- Egypt climate is very suitable for eel farming. 2- production costs in Egypt is lower than in Japan and Taiwan (GAFRD, 1997). Family Anguillidae had varies feeding rates according to water temperature, size and food type. Kafuku and Ikenoue (1983) reported that the optimum temperature for eels of 10 gm body weight was 25C°. They added that the ideal feeding rate for small elvers is about 6-8 % of the total biomass; 2-6% for young eels and 1-3% for the adults daily, when fed on commercial diets containing 20-30% crude protein and boiled trash fish. Concerning the culture of tilapia and mullet in floating cages, Abdel-Hakim and Sherif (1999) showed that tilapia could be cultured together with mullet and common carp in floating cages throughout the period from March to November in Egypt. They reported that the expected

production from tilapia; mullet and common carp is estimated by 756; 162 and 227 Kg, respectively, when they stocked together in floating cages of a total volume of 24 m^3 at densities of 70; 45 and 15 fingerlings of tilapia; mullet and carp m^3, respectively. The same authers reported also that a diet containing 25% protein is required to produce a feed conversion ratio of 1:2 during the production period. The present study was carried out to investigate growth performance of elvers reared in cage culture in polycultre system using a commercial diet containing trash fish under the Egyptian conditions. Also the study aimed to develop a guideline for eel farmers to improve their production level.

MATERIALS AND METHODS

This experiment was carried out in the branch of the River Nile (Rasheed branch) at Kafr-El-sheikh Governorate, Egypt for eight months (one growth season). The water at the experimental side is considered as freshwater with an average salinity ranging between 3.2 to 4.1 g/L. The experiment started at 1^{th} April and lasted at the end of November 1999.

Experimental cages

Nine cages each of 3x5x5 m^3 in diameters with a total water volume of 75m^3 each were used in this study. The Nine cages represented three treatments in triplicates. The water depth in the area of the present study was about 5 m and fluctuated in a range of + 2 m due to the tide of the Mediterranean Sea in this area. The sides of the cage were surrounded with nets to the bottom of the river and bottom of the cage is made of nets of the same mesh.

The nets used in the construction of the experimental cages were of a 9mm-mesh size. The Cages were fixed from the corners with wood bars to maintain the frame of the cage. The first three cages (replicates) of the first treatment group were stocked with 500 elvers; 2000 Nile tilapia and 1000 Grey mullet per cage and fed on a commercial diet containing 45% crude protein (Table2) plus trash fish at a ratio of 2 to 1 (Tr1). The second three cages (Tr2) were stocked with the same fish species at the same rates and fed on a diet containing 20% crude protein (Table2) plus the trash fish at the ratio 2:1. Cages of third treatment (Tr3) were stocked with Nile tilapia (2000) and Grey mullet (1000) per cage without eel and fed the same diet as (Tr2) with trash fish at the same ratio. Fish of the experimental cages were fed on the diets at a rate of 5% of the fish biomass divided into portions to be fed three times daily. The feeding times were at 10 a.m. 12 and 2 p.m. daily. The experimental diets were mixed daily with minced boiled trash fish at a ratio of 2:1.

Experimental fish

Cages were stocked in a polyculture system with eel species (*Anguilla anguilla*), which represents the carnivorous fish species (fed on insects, crustaceans and boiled trash fish or commercial formulated diets containing 40- 50% protein at least), Nile tilapia species (*Oreochromis niloticus*) which represents the detritophagic species (fed on zooplankton, plant detritus, zoobenthos and commercial diet) and Grey mullet species(*Mugil cephalus*)a detritophagic species (fed on zooplankton, detritus and commercially formulated diet). Fish used in this study and their stocking rates are shown in the Table (1).

Table 1. Fish species and stocking rate of the experimental cages

Common name	Scientific name	Stocking rate /cage			Initial body Weight (g)
		Tr1	Tr2	Tr3	
Thobban El-samak	*Anguilla anguilla*	500	500	_	35
Nile tilapia	*Oreochromis niloticus*	2000	2000	2000	25
Grey mullet	*Mugil cephalus*	1000	1000	1000	22

Samples and measurements

Body weights (g) were measured biweekly till harvesting in a random sample of (50 fish of eels, 100 fish of Grey mullet and 200 fish of Nile tilapia) in each cage. The body weights were recorded by weighing the whole sample. Initial body weights to the nearest gram were recorded at the time of cage stocking. Water temperature, pH and O_2 contents were measured daily at 12 p.m. using temperature and dissolved oxygen meter (YSI model 57) and pH meter (model Corning 345). Determinations of

water quality parameters (salinity, ammonia) were carried out every two weeks according to the methods described by Boyd (1979).

Table 2. Composition of the commercial diets used in the study

Ingredients	Diet 1(45% CP)	Ingredients	Diet 2(20% CP)
Meat meal (54%CP)	30%	Meat meal(54%CP)	5%
Fish meal (72%CP)	30%	Fish meal(72%CP)	7 %
Yellow corn (9%CP)	25%	Yellow corn(9%CP)	43%
Soybean meal (44%CP)	10%	Wheat bran(15.7%CP)	15%
Fat	5%	Rice bran(13%CP)	20%
		D.C.M* (40%CP)	10%
Total	100 %		100 %
Calculated			
Crude protein	44.45	Crude protein	20.56
Lysine	1.26	Lysine	0.54
Methionine	0.53	Methionine	0.29
GE** Kcal /Kg diet	4155		3728.8
Analyzed			
Crude protein CP	44.10	Crude protein CP	19.8
Ether extract EE	11.16	Ether extract EE	6.2
Crude fibers CF	4.30	Crude fibers CF	6.68

*Decorticated cottonseed meal.
**GE:gross energy calculated according to NRC 1983.

The chemical analyses of tested diets of fish were carried out according to the AOAC. (1990) methods. Samples were collected from different sites of the experimental cages randomly to represent the water of the whole cage. The economical evaluation of results was carried out according to the market prices in 1999 for the diets, trash fish, labors, fish fingerlings and marketable fish in LE.

Statistical analysis

Statistical analysis of data was carried out according to Harvey computer program (1990).

RESULTS AND DISCUSSION

Water quality parameters:

Averages of water quality parameters measured during this experiment are illustrated in Table 3. The averages of water pH values had ranged between 7.85 to 8.35 degree which indicate the suitability of the water pH for the activities of the fish species cultured in the experimental cages. The dissolved oxygen contents of the water had ranged between 7.10 to 8.2 mg/l on the average during the experimental period and were in the permissible levels of fish culture. Water total ammonia (mg/l), Salinity g/l and temperature °C were found to be 0.6 to 1.3 mg/L, 3.2 to 4.1 g/l and 28.06 to 30.7°C, respectively (Table 3), which indicate the suitability of cage water for fish growth and development. These results are in accordance with those reported by El- Gendy (1998), Abdel- Hakim *et al.*(1999) and Abdel- Hakim *et al.* (2000). Results of Table 3 are also in agreement with those reported by Noda (1977) and Kafuku and Ikenoue (1983), who showed that the optimum temperature is 25°C and above for the10 grams eels. Also, Baradach *et al.*(1972) reported that the optimum growth of eels could be achieved with water temperatures ranging between 20-28 °C.

Table 3. Averages of water quality parameters of cages during the experimental period (240 days)

Treatments	PH	D.O mg/L	Ammonia mg/L	Salinity	Temperature c°
Tr1	8.15±0.24	8.20±.34	0.60±0.06	3.3±0.04	28.06±0.73
Tr2	8.35±0.24	7.80±.34	0.75±0.05	4.1±0.07	28.62±0.74
Tr3	7.85±0.24	7.10±.34	1.30±0.07	3.2±0.08	30.70±0.65

Growth performance

Averages of initial body weights of eels in treatments Tr1 and Tr2 were 35.2 and 35.8g, respectively and differences among the two groups stocked with eels were insignificant (Table 4). At the end of the experimental period, averages of final weights for both groups cited above were 200.8 and 188.12 g., respectively. The analysis of variance for results indicates that the Tr1 had significantly ($P< 0.05$) heavier final weights of eels compared to Tr2. These results indicate that feeding the

growing eels on a diet containing 45% crude protein improved significantly the final weights compared to the diet containing 20%, since the amount of trash fish fed was almost similar in both groups. The superiority of group Tr1 in final body weight may attributed to the fact that the ration fed to this group may cover the nutritional requirements from lysine and methionine (Table 2). These results are in agreement with the findings of Noda (1977) and Kafuku and Ikenoue (1983), who reported that final body weights of eels improved when elvers were fed on diets containing 30% protein with boiled trash fish compared to 20% protein level with trash fish. In this connection, Ezzat *et al.* (1984), reported that the growth rate of eels (*Anguilla anguilla*) in Lake Manzala is highest by the end of its second year of fresh water life. Results of Usui (1991) showed that cultured eels in Japan are fed on artificial diet made of chiefly fishmeal with added carbohydrates and consists of about 52% protein, 24% carbohydrate, 10% water, 4% fat and 10% ash. As presented in Table (4), average of daily gains in weight for eels in Tr1 and Tr2 were 0.69 and 0.63 g, respectively and the statistical evaluation of the results indicate the superiority ($P< 0.05$) of Tr1 in average daily gain compared to the Tr2. Data in the same Table shows also that the survival rate of eels for both treatment groups was 90%, which reflect no influence of the dietary treatments on this trait. Results revealed also that the total productions of eels per cage at harvesting for Tr1 and Tr2 were 90.3 and 84.6 Kg, respectively (Table 4). These results indicate that feeding eels in polyculture system using fixed cages on a diet containing 45% protein with trash fish increased the total production of eels by about 6.7% compared to those fed on a diet containing 20% protein with trash fish.

As presented in Table 4, averages of initial weights of Nile tilapia for Tr1; Tr2 and Tr3 were 25.4; 25.7 and 25.8g, respectively, and differences in initial weights among the treatment groups were insignificant. Results of the same Table show that the averages of final weight of the same treatment groups cited above were 210; 193 and 185 g, respectively. The statistical evaluation of results indicate that group Tr1 (45 % protein diet) showed significantly ($P< 0.05$) heavier final weights compared to Tr2and Tr3 (20% protein diet), however differences in final weights among the (last two groups (Tr2 & Tr3) were insignificant. The same trend was observed with the results of average daily gain (Table 4). These results are in agreement with the findings of Cruz and Laudenica (1976); Hughes (1977); Viola and Zohar (1984), who showed that increasing the protein level in diets of tilapia from 25 to 30 or 35 % increased significantly body weight and growth rate. Also Wang *et al.* (1985), reported that increasing the protein level from 13 to 40% in tilapia diets increased fish growth performance and group fed on the30% protein diet obtained the best performance. Recently, Abdel-Hakim and Moustafa (2000) reported that final body weight and the daily gains of Nile tilapia increased significantly with each increase in the dietary protein level fed from 20 to 24, 28 and 32 %. Results of survival rate of tilapia (Table 4) show that the survival ranged between 93 to 95% which is considered as a very good survival rate. Tilapia total productions per cage at harvest were found to be 399, 358.9 and 351.5 Kg. for the Tr1, Tr2 and Tr3 group, respectively. These results indicate that tilapia in Tr1 (45% protein + trash fish) with mullet and eels produced 13.5% more weight on the average compared to Tr3 (20% protein +trash fish) with mullets and without eels.

These results are in partial agreement with the findings of Abdel-Hakim and Moustafa (2000) who showed that the total production of tilapia cultured in cages (1 m^3) increased from 14.3 to 18.4, 20.9 and 22.7 Kg as the dietary protein levels increased from 20 to 24, 28 and 32%, respectively. Concerning mullet, averages of initial weights had ranged between 22 to 22.5g at the experimental start with insignificant differences in initial weights among the treatment groups (Table 4). At harvest, mullet final body weights for Tr1, Tr2 and Tr3 were 185, 168 and 155g, respectively (Table 4). Analysis of variance of final body weights indicated that Tr1 had significantly ($P<0.05$) heavier final weights of mullet compared to Tr2 and Tr3. Results revealed also that mullet in Tr2 showed heavier final weights compared to Tr3, however the differences were insignificant. The same trend was observed in averages of daily gains where that of Tr1 was significantly ($P<0.05$) higher than that of Tr2 and Tr3 (Table 4). These results are in partial agreement with those reported by Papapreskeva and Alexis (1986), who showed that the growth of Mugil capito, 2.2 g, increased with increasing protein contents of the diet from 12 to 24%, while beyond this level it was decreased. Also Ojaveer *et al* (1996) observed decreases in growth of Grey mullet, 14g, in response to increasing dietary protein level when they used 38,49 and 60% protein levels with 4.54, 5.02 and 5.02 Kcal/g as gross energy.

As presented in Table 4, averages of survival rates for Tr1, Tr2 and Tr3 were 92, 91 and 93% respectively, which lay within the acceptable range of cage culture. Averages of total mullet yield per cage at harvest for the same experimental groups cited before were 170.2, 152.8 and 144.1 Kg, respectively (Table 4).

Table 4. Growth and production performance of Eel, Nile tilapia and Mullet as affected by treatments applied

Traits	Treatments								
	Eel			N.tilapia			Mullet		
	Tr1	Tr2	Tr3	Tr1	Tr2	Tr3	Tr1	Tr2	Tr3
Initial body weight (g)	35.2±0.71(a)	35.8±0.89(a)	-	25.4±0.62(a)	25.7±0.81(a)	25.8±0.8(a)	22±0.85(a)	22.5±0.68(a)	22.2±0.71(a)
Final body weight (g)	200.8±13.1(a)	188±12.08(b)	-	210±14.2(a)	193±12.3(b)	185±11.8(b)	185±12.2(a)	168±11.3(b)	155±12.1(b)
Average daily gain (g)	0.69±0.18(a)	0.63±0.09(b)	-	0.77±0.23(a)	0.70±0.13(b)	0.66±0.20(b)	0.68±0.21(a)	0.61±0.08(b)	0.55±0.05(b)
Survival rate %	90	90	-	95	93	95	92	91	93
Total production per cage(Kg)	90.3	84.6	-	399	358.9	351.5	170.2	152.8	144.1
% of the smallest value	106.7	100%	-	113.5	102.1	100	118.0	106	100

A, b. means in the same row of each species tested bearing different letters differs significantly ($P<0.05$)

These results indicate that Tr1 produced 18% more mullet over Tr3, while the Tr2 produced only 6% over Tr3 (Table4). In general, results presented in Table (5) show that the total cage productions from the species cultured were 659.5, 596.3 and 495.6 Kg for Tr1, Tr2 and Tr3, respectively. These results may indicate that Tr1 (diet containing 45% crude protein + trash fish) gave the highest production per cage, however the costs remain a limiting factor for such feeding system.

Table 5. Total production per cage (Kg)

	Eel	Tilapia	Mullet	Total	% of the smallest value
Tr1	90.3	399	170.2	659.5	133.07%
	13.7%	60.5%	25.8%	100%	
Tr2	84.6	358.9	152.8	596.3	120.3%
	14.2%	60.2%	25.6%	100%	
Tr3	--	351.5	144.1	495.6	100%
	--	70.9%	29.1%	100%	

Economic Efficiency

As presented in Table 6, total costs per cage including the variable, fixed, taxes and the interest on working capital in LE were found to be 3216.4, 2447.4 and 1788.2 LE for the Tr1, Tr2 and Tr3 groups, respectively. These results indicate that the total costs of Tr3 were the lowest due to the fact that this treatment was not provided with elvers and was fed on the diet containing 20% crude protein which reduced its total costs.On the other hand, the Tr2 showed 36.9% higher costs than the Tr3 due to the costs of elvers and feeds which were fed at higher rates compared to Tr3. As shown in the same Table, Tr1 had 79.9% higher total costs than the Tr3 because of the fact that this group was stocked with elvers and fed on a diet containing 45% protein which is more expensive compared to that fed in Tr2 and Tr3.

Table 6. The effect of the experimental diets on economic efficiency LE/cage

Items	Treatments		
	1	2	3
(1)Variable costs, LE/cage(75m³)			
a-Costs of fish fingerlings:			
Eel	500	500	
Tilapia	200	200	200
Mullet	350	350	350
b-Feeds:			
Commercial diets	866.7	400	333.3
Trash fish	433.3	200	166.7
c- Labor:	266.7	266.7	266.7
d- Fixed costs, LE/cage(75m³):			
Depreciation (cages &materials)20%	111	111	111
Taxes	200	200	200
e-Total operating costs(Variable & fixed)	2927.7	2227.7	1627.7
f- Interest on working capital *	288.8	219.7	160.5
g-Total costs	3216.5	2447.4	1788.2
% of the smallest value of total costs	179.9%	136.9%	100%
(2)Return			
Fish sales			
Eel	1806.7	1692	
Tilapia	2314.2	2082	2038.7
Mullet	1106.3	993.6	936.9
h-Total return (L.E.)**	5227.2	4767.64	2975.6
(h-g)Net return, LE/cage(75m³)	2010.7	2320.3	1187.4
% of the smallest value of net return	169.3%	192.4%	100%
% Net returns to total costs	62.5%	94.8%	66.4%

*15% x total operating costs x 240/365days

**The economical evaluation of results was carried out according to market prices in1999 in LE.

Net returns in LE per cage were 2010.7, 2320.3 and 1187.4 LE for treatments Tr1, Tr2 and Tr3, respectively (Table 6). Percentages of net returns to total costs were 62.5, 94.8 and 66.4% for Tr1, Tr2 and Tr3, respectively (Table 6).

Under the condition of this experiment, results show in general that cages stocked with eel, tilapia and mullet and fed on a diet containing 20% protein plus trash fish at a rate 2:1(Tr2) was economically more efficient than the cages stocked with the same fish species at the same rates and fed the diet containing 45% protein plus trash fish (Tr1). These results may led us to recommend the culture of eels with tilapia and mullet in cages using artificial diets containing at least 20 % protein plus trash fish at a ratio of 2 to 1 for the best net returns. In this connection, Abd El- Maksoud (2000). reported that feeding Grey mullet raised in earthen ponds on a diet containing 29% protein resulted in higher growth performance, decreased feeding costs and increased profit.

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