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EFFECT OF DIETARY PROTEIN LEVELS ON GROWTH PERFORMANCE AND POND PRODUCTIVITY OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*), EEL (*ANGUILLA ANGUILLA*) AND GREY MULLET (*MUGIL CEPHALUS*) REARED IN POLYCULTURE SYSTEM

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ABSTRACT

This study was carried out in a fish farm at Fowwa; Kafr-El Sheik Governorate, A.R.E. The study aimed to investigate the growth performance of eel; grey mullet and Nile tilapia fishes reared in earthen ponds as well as pond productivity as affected with dietary protein levels. Nine earthen ponds each of total area of 2000m^2 represented three dietary protein levels (20; 32 and 44%) with three replicates for each protein level. Fish species were stocked in each pond at densities of 2000;1000 and 800 with an average initial weight of 20; 29 and 31 g for tilapia; mullet and eels; respectively. The study started in 15. 4. 2000 and lasted in 15. 12. 2000. Results obtained are summarized in the following: 1- Final body weights of Nile tilapia increased significantly with each increase in the dietary protein level from 20 to 32 or 44%. 2- Final body weights of eels increased significantly with each increase in the protein level fed, however for mullet final weights of fish fed on 32 or 44% protein level were significantly superior than those fed on the lower protein level. 3- Final body length of both Nile tilapia and eels increased significantly with each increase in the protein level fed, while in mullet final body length of groups fed the 32 or 44%protein level were significantly higher than that of the 20%protein level. 4– Specific growth rate during the whole experimental period improved significantly in tilapia and eel as the level of protein increased from 20 to 32 or 44%, however the specific growth rates of mullets fed the 32 or 44%

dietary protein were significantly higher than those fed the 20% protein diet. 5- Protein levels fed seemed to have no significant effects on dressing percentages of tilapia, while it released significant effects on this trait in eels and mullet. 6- Protein levels fed had significant effects on the proximate analysis of whole bodies of tilapia; eel and mullet. Based on results obtained in this study and on the economical evaluation it could be concluded that tilapia; mullet and eel can be cultured together in earthen ponds and growth parameters of the three species improved with each increase in the protein level fed from 20 to 32 and 44%, however from the economical point of view a diet containing 32% protein seemed to be the best in terms of ratio of returns to total costs.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*), eel (*Anguilla anguilla*) and grey mullet (*Mugil cephalus*) are considered in Egypt as fish species of high market value. Tilapias and mullet response very good to pond polyculture however information on the integration of eels to polyculture in earthen ponds are very limited. Afifi *et al.* (1996), reported that both tilapia and mullet responded in their growth performance when they stocked together in earthen pond fertilized with chicken manure super phosphate and urea with supplementary diet containing 13% crude protein. Ease cultivation of tilapia and mullet, resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently organic domestic and agricultural wastes into high quality protein, good growth rates and amenability to intensification are some of the basic characteristics of both species which make them ideal candidates for intensive and semi-intensive culture (Afifi *et al.*, 1996). Baradach *et al.* (1973) noted that total yield of tilapia and carp was usually increased by 13 to 35% when mullets were added. Moreover, they added that, mullet brought a higher price than carp or tilapia.Similar results were reported by Abdel-Hakim and Sadek (1986) and Sadek and Hammad (1990) using polyculture systems of tilapia, mullet and carp. Tilapia; mullet and eel differ significantly in their feeding habits, which make the polyculture of the three species promising. Grey mullet is filter feeder, feeding on algae; diatoms, small crustaceans and decayed organic matter (Bishara, 1967; Hickling, 1970; and Odum, 1970). As M. cephalus grow, it changes

its feeding habits to consume mainly micro algae and detritus (Thomson, 1966). Grey mullet is commonly cultured with tilapia and carp species in Egypt. Specially, tilapia and mullet are popular and favored by the Egyptian consumers for their good quality flesh and comparatively larger size of their adults. Therefore, both species are highly priced and feasible or culture in fishponds. One way of increasing the food availability in fishponds is by chemical or / and organic which is often a mean of increasing the primary natural productivity of the ponds as reported by FAO (1980). Supplementary or complete artificial feeds are more effective way of increasing the available foods for fish compared to fertilization and consequently fish production per unit area. Development of artificial feeds became prudent and important for intensive fish culture in Egypt especially for tilapia (Hamza, 1996), however, supplementation of complete formulated ratios is a (principal) factor in aquaculture to increase growth and production of reared fish. Meanwhile, realization of the optimum protein level for cultured fish would help in reducing the costs and maximizing the feed conversion efficiency (Charles *et al.*, 1984; Sampath, 1984 and Chiu *et al.*, 1987). Recently, Abdel- Hakim *et al.*, (2000) studied the effect of dietary protein level (45% or 20% crude protein plus trash fish) on the performance of Nile tilapia; mullet and eels cultured together in cages. They reported that final weights after 240 days rearing period of Nile tilapia; grey mullet and eels fed on the 45% protein diet plus trash fish were significantly higher than that of the group fed on the 20 % protein diet plus trash fish. The same authors reported also that the total cage production of the three species was 659 Kg for fish fed the 45% protein diet plus trash fish fed the 45% protein diet plus trash fish compared to 596,3 Kg for fish fed on the 20% protein diet plus trash fish.

The aim of the present study was to investigate the effect of dietary protein level on growth performance and economical efficiency of Nile tilapia; grey mullet and eel cultured in earthen ponds under polyculture forming system.

MATERIALS AND METHODS

1-Experimental ponds : The present study was carried out in nine earthen ponds belonging to a fish farm at Fowwa; Kafr-El Sheik Governorate, Egypt. Total water area of each pond was 2000m^2 with

a water depth one-meter. Before the experimental start all ponds were drained completely and after that ponds were exposed to sunrays for 12 days till complete dryness. Ponds were then refilled with fresh water coming from Rushed Nile branch through a canal to the fish farm. All experimental ponds were equipped with screens at the water in- and outlets to prevent the entrance of wild fish and escaping of the experimental fish. Water level was maintained at one-meter level throughout the whole experimental period from 15th April to 15th of December year 2000.

2- Experimental Diets: The nine experimental ponds represented three dietary protein levels (20; 32 and 44%) and each level was tested in three replicates (triplicates). The composition of the experimental diets is illustrated in Table (1). Experimental diets were offered at a rate of 3% of total pond fish biomass from the experimental start till the end of October 2000 there after it was reduced to 1% till the end of the experiment at 15th December 2000. The experimental diets were offered .in two equal parts twice daily at 10 a.m. and at 2 p.m. Feed was offered in floating fodder made of P.V.C pipes as a frame with a net inside the frame to keep the feeds available for the fish. Each experimental pond was provided with 8 old car tires in pond water as housing for the eels.

3- Experimental fish: Every experimental pond was stocked with 2000 fingerlings of Nile tilapia (*Oreochromis niloticus*) mixed sex with on average initial weights averaging between 20.28 to 20.87 g, 1000 grey mullet fingerlings (*Mugil cephalus*) with initial weight 29.86 to 30.25 g and 800 elvers (*Anguilla anguilla*) with initial weights ranging from 31.55 to 32.50 g.

4- Records maintained: Individual body weight to the nearest 0.1 g and body length to the nearest 1 mm. Were measured at the start of the experiment in samples of 150 fish from each species and repeated every four weeks periods throughout the experimental period. Fish samples were withdrawn from the experimental ponds by sinning collected in a tank containing water from the experimental ponds and returned back to ponds after measuring their weights and lengths. Proximate analysis of whole fish bodies was carried out at the end of the experimental period in 15 fish each species and carcass test was also done in samples of 15 fish each species. Analyses of whole fish bodies as well as the experimental diets were performed according to

the methods described by A.O.A.C (1990). Parameters of condition factor (K) and specific growth rate (SGR) were calculated according to the following equations FCR= feed intake (dry weight g.) / body weight gain(g.)
SGR= Ln weight2 – Ln weight1/ period in days.
K= weight(g)x 100 /length(cm)

Statistical Analysis: Statistical evaluation of results was carried out according to Harvey computer program (1990). Duncan's Multiple Range test was applied to detect the significance of differences of various parameters among the treatments (Duncan,1955).

RESULTS AND DISCUSSION

Body weight and length

Results presented in Table (2) show the effect of dietary protein level on body weights of tilapia; eel and mullet. At the start of the experiment averages of initial weight of tilapia; eel and mullet fish had ranged between 20.28- 20.87; 31.55-32.50 and 29.86 to 30.25g, respectively, and differences among the treatment group within each species were insignificant indicating that the distribution of the fish into the experimental groups for each species was random.

For tilapia, averages of body weights after 4 weeks of the experimental start were found to be 45.25; 65.75 and 67.09g for groups fed on the 20;32 and 44%protein levels respectively (Table 2). Analysis of variance for results at this period indicate that groups fed the diets containing 32 or 44% protein had significantly ($P<0.05$) superior body weights compared to those fed on the 20% protein level. During the periods 8; 12; 16; 20; 24 and 28 weeks after experimental start averages of tilapia body weights increased significantly ($P<0.05$) with each increase in the protein level fed (Table 2). At the end of the experimental period (32 weeks after start) final body weights of tilapia were found to be 173.51; 202.91 and 224.89g for protein levels 20;32 and 44%, respectively. The statistical evaluation of result show that averages body weights increased in a significant linear manner with each increase in the dietary protein level fed from 20 to32 or 44%. Those results indicate that the protein requirements of growing Nile tilapia lay above 20% crude protein and the 32%protein levels seemed to cover its dietary protein

requirements. These results are in accordance with those reported by Cruz and Laudencia (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 4o% in tilapia diets fish growth performance and the best performance was obtained by the group fed on the 30% protein diet. Also 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 presented in Table (2) are also in complete accordance with the results obtained by El- Sagheer (2001), who showed that body weights of mono sex Nile tilapia cultured intensively in earthen ponds increased significantly as the dietary protein level increased from 25% to 32%. Results of Table (2), show that averages of eel body weight, for the groups fed on the 44% protein level, at periods 4 and 8 weeks after experimental start were significantly ($P<0.05$) heavier compared to those fed the 20 or 32% protein levels. During periods 12; 16; 20; 24 and 28 weeks after start averages of body weights of eel increased significantly ($P<0.05$) with each increase in protein level fed. At the end of the experimental period i.e. 32 weeks after start averages of eel body weights for the groups fed on 20; 32 and 44% protein diets were found to be 162.91; 192.5 and 227.00g, respectively and final weights increased in a significant ($P<0.05$) order with each increase the protein level fed. These results indicate that elvers grow better polycultured ponds with protein levels up to 32%. Lower protein levels may require longer periods than 32 weeks to achieve reasonable market weights, however this depends completely on the eel size demand. These results are in accordance with those reported by Abdel-Hakim *et al* (2000), who found that eels cultured with tilapia and mullets in cages had significantly ($P<0.05$) superior Final weights with diet containing 44.45% protein plus trash fish compared with a diet containing 20% protein plus trash fish. Concerning mullet body weights Table (2), averages of body weights of this fish at periods 4; 8; 12; 16; 20; 24 and 28 weeks after start for the groups fed the dietary protein levels 32 or 44%were significantly ($P<0.05$) superior than those fed the 20% protein diet and differences in this trait among the 32 and 44% protein levels were insignificant. At the end of the experimental period averages of mullet body weight for the groups fed on 20; 32 or 44% protein diets were 172.01; 221.52

and 225.96 g respectively (Table 2) and differences among groups in final weights were significant ($P<0.05$) for the favor of groups fed the 32 or 44% protein levels. These results indicate that mullets may require a dietary protein level of 32% and levels above that are not able to cause a pronounced increase in final weights. These results are in accordance with the findings of Papapreskeva and Alexis (1986), who showed that the growth of Mugil capito, of 2.2 g initial weight, 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 (14 g initial weight) in response to increasing dietary protein levels as they tested diets containing 38; 49and 60% protein levels with 4,54; and 5.02 K cal/g gross energy. Results of Abdel-Hakim *et al* (2000), revealed also that final weights of grey mullet cultured in cages together with tilapias and eels and fed on a died containing 44.45% crude protein plus trash fish were significantly higher compared with those of mullets fed on a 20% protein diet plus trash fish. Results of tilapia; eel and mullet body length (cm) as affected with protein level fed in polyculture system are presented in Table(3).At the experimental start differences in body length among treatment groups within each species were insignificant. As presented in the same table, in tilapia averages of body length 4 weeks after experimental start of groups fed on diets with 32 or 44% protein levels were significant ($P<0.05$) higher than those fed on the 20% protein level. At periods 8; 12;16;20;24 and 28 weeks after experimental start, averages of body length (cm) of tilapia increased significantly ($P<0.05$) with each increase in the protein level fed. At the end of the experimental period (32 weeks after start); averages of final body length for tilapia groups fed the 20; 32 and 44% protein were found to be 25.45; 27.31 and 28.23 cm respectively, and the statistical evaluation of results revealed that tilapia final length increased significantly ($P<0.05$) with each increase of the dietary protein level fed. Those results are in accordance with those reported by Cruz and Laudencia (1976); Hughes(1977);Viola and Zohar (1984);Wang *et al.* (1985) and Abdel-Hakim and Moustafa (2000).

Concerning body length of eels as affected with protein level fed , at periods 4 and 8 weeks after experimental start, the group fed on the 44% protein level showed significantly ($P<0.05$) longer bodies compared to those fed on the 32 or 20%protein levels.

During periods 12; 16; 20; 24; 28; and 32 weeks after experimental start body length of eels increased in a significant ($P<0.05$) order with each increase in the dietary protein level fed from 20 to 32 or 44%. These results agree with the findings of Abdel-Hakim et al (2000), who came to similar results with eels cultured in cages with mullet and tilapia.

Averages of mullet body length for groups fed the 32 or 44% protein diets were significantly ($P<0.05$) higher than those fed on the 20% protein diet at periods 4; 8; 12; 20; 28 and 32 weeks after start, however at periods of 16 and 24 weeks after start mullet body length increased significantly ($P<0.05$) whit each increase in the protein level fed. These results confirm those reported by Papapreskeva and Alexis (1986), *Ojaveer et al.*, (1996) and Abdel-Hakim *et al.* (2000).

Results of condition factor for the fish species fed on the tested diets during the experimental periods are illustrated in Table (4). At the experimental start differences in K values within each species among the experimental groups were insignificant.

Concerning tilapia average K values differed significantly ($P<0.05$) among the tested protein levels during the periods 4; 8; 12; 16; 20; 24 and 28 weeks of age for the favor of the lowest (20%) protein level indicating that fish of this group grew more in length than the other groups. At the end of the experimental period averages of K value of tilapia fed on the diets containing 20; 32; or 44 protein levels were 1.06; 1;00 and 1.00, respectively and the groups fed on the lowest level had higher ($P<0.05$) K values compared to the higher levels. Results of K values for tilapia indicate that these values in all treatments decreased with each advance in age. These results are in agreement with the findings of Moriarty (1983). reported that K values of Nile tilapia fed diets containing 35; 30; 25 and 20% protein were 1.80; 1.87;1.87 and 1.88 respectively after 98 days experimental period.

Concerning eels; averages of K value of this species did not differed significantly among the experimental groups at the start of the study. During the experimental periods 4; 8 and 28 weeks after start K values were the highest ($P<0.05$) with the groups fed the 32% protein level followed in a decreasing order by those fed the 20 and those fed the 44% protein levels respectively (Table 4).During periods 16;20 and 24 weeks after start groups fed the 20 and 32% protein diets showed significantly ($P<0.05$) higher K values than the

group fed on the 44% protein diet. These results are in accordance with the findings of Panfili and Ximens (1992).

In this connection growth in length of eels between 1 and 2 years vary: 6.2 cm in a Spanish estuary (Arias & Drake 1985), 6.1 cm in a Portuguese lagoon (Gordo and Jorge 1991), between 4.5 and 8.4 cm in northern European rivers (Rasmussen & Therkildsen 1979; Moriaty 1983; Vollestad & Jonsson 1988) and from 5.1 to 9.4 cm in lake environments (Berg 1985; Paulovis & Biro 1986; Nagiec and Bahnswy 1990). In mullet, protein levels fed did not released any significant effects on condition factors calculated at 4; 8; 12 and 32 weeks after experimental start Table (4), however during the periods 16 and 24 weeks after start K values of mullet groups fed on the 20 or 32 % protein levels were significantly ($P<0.05$) higher than those of mullets fed on the 44% protein diet. On the other hand at periods 20 and 28 weeks of age K values of groups fed on the lowest protein level (20%) were significantly ($P<0.05$) higher than the protein levels (32 or 44%) as shown in Table (4). These results are in accordance with that reported by Papapreskeva and Alexis (1986), who showed that growth performance parameters of mullet, of an initial weight of 2.2g, 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 from 38; 49 or 60%. The fluctuations observed in K values of mullet during the experimental periods of present study (Table 4) may attribute to the abundance of the natural food in the ponds beside the artificial diets, thus grey mullet is a filter feeder, feed on algae, diatoms, small crustacean and decayed organic matter (Bishara, 1967;Odum, 1970).

Specific growth rate (SGR).

As presented in Table (5); tilapia showed improvements in SGR values with increasing the dietary protein levels from 20 to 32 or 44%during the periods from start to 4 weeks; 4-8 weeks and 8 to 12 weeks. During the periods 12 to 16; 16-20 and 20-24 weeks SGR values favored significantly ($P<0.05$) the lower protein levels compared to the higher ones. During the whole experimental period group fed on the 44% protein level showed the highest SGR value ($P<0.05$) followed in a significant ($P<0.05$) decreasing order by those fed on the 32% and the 20% protein levels respectively. These

results indicate in general that SGR of Nile tilapia improved with increasing the protein level fed. These results are in accordance with the findings of Abdel-Hakim and Moustafa (2000). Concerning eels; SGR values fluctuated significantly ($P<0.05$) among the tested protein levels during the experimental periods (table 5). During the whole experimental period (start-32 weeks), the highest SGR Value was obtained by the group fed on the 44% protein diet followed in a significantly ($P<0.05$) decreasing order by those fed on the 32 and 20% protein levels, respectively.

These results are in accordance with the findings of Abdel-Hakim et al. (2000), who reported that growth performance parameters of eel cultured in cages with tilapia and mullet improved with increasing the dietary protein levels from 20% to 45%.

Carcass traits.

Carcass traits of the studied fish species including dressing; inedible part; head and viscera percentages to final body weights are presented in table. In tilapia, protein level fed had no significant effects on dressing and inedible parts percentages (Table 6), however head and viscera percentages seemed to be significantly ($P<0.05$) influenced with protein level fed. In this connection Moustafa (1993); reported that dressing percentages of Nile tilapia reared in cages increased significantly from 56.35; to 58.48 or to 60.38 and 61.63 % as the dietary protein level increased from 20 to 24; 28 or 32%, respectively. The same author reported that percentages of total inedible parts decreased as the dietary protein level increase. The contradiction between our results and that of Moustafa (1993) in this hence may attribute mainly to the fact that this author cultured the tilapia in cages as a sole fish species, while in this study tilapia was cultured in earthen ponds together with eel and mullet where the natural food was available beside the artificial diet.

As presented in Table (6), dressing percentages of eel groups fed on diets containing20; 32 and 44% protein were found to be 80.61; 81.49 and 86.22%, respectively. The statistical evaluation of results showed that group of eels fed on the 44% protein level had significantly ($P<0.05$) higher dressing percentages compared to the 20 and 32%protein levels. Meanwhile, the group fed on the highest protein level (44%) had significantly ($P<0.05$) the lowest inedible parts percentage compared to the lower levels (32 or 20%), which may reflect the negative relationship between dressing and inedible

parts percentages. These results are in accordance partially with the findings of Abdel-Hakim *et al.* (2000).

Dressing percentages of mullet groups fed on diets containing 20 or 32% protein were slightly higher than those fed on the 44% protein diets. however differences were significantly ($P<0.05$) for the favor of lower dietary protein levels Table(6). The reverse trend was observed in the percentage of inedible parts where mullet fish fed on diets containing higher protein levels (32 or 44%) had higher ($P<0.05$) percentage of inedible parts. Results presented in the same table indicate also that there were significantly ($P<0.05$) differences in head and viscera percentages of mullet among the protein levels tested. These results are in agreement with the findings of Abd El-Maksoud (2000), who reported that protein level fed showed significantly differences in carcass traits of grey mullet.

Chemical composition of whole body.

Results of Table (7), revealed that the 32% protein level increased significantly ($P<0.05$) percentages of moisture and protein contents in tilapia whole bodies compared to the 20 and 44% protein levels.

On the other land fat contents in tilapia whole bodies of groups fed the 20 or 44% protein diets were significantly ($P<0.05$) higher than those fed the 32% protein diet. Ash contents of the tilapia whole bodies seemed to be insignificantly affected with the protein levels tested. These results are in partial agreement with the findings of Moustafa (1993), who reported that increasing the protein levels in diets of Nile tilapia reared in cages from 20 to 24; 28 or 32% increased the protein contents in the whole fish body.

The same author showed also that increasing the protein level fed increased total body fat of Nile tilapia reared in cages, however it decreased the total body ash contents. Results in Table(7), concerning whole body composition of eel, showed that protein levels tested released insignificant effect on moisture contents, however eels fed on 32 or 42% protein diets had higher moisture percentages in the whole bodies compared to those fed that 20% protein diet. Results of the same table revealed that protein contents decreased significantly ($P<0.05$) with each increase in the protein level fed and fat percentages showed the reverse trend. These results may indicate that fat contents in eel whole bodies increased on the costs of the protein contents.

This is true. thus eels fed on higher protein diets grow faster and utilized the dietary protein as energy source which resulted in deposition of more fat rather than body muscles. In mullet fish. groups fed on diets containing 20 or 44% protein diets showed significantly ($P<0.05$) higher moisture contents in their whole bodies compared to those fed the 32% protein diet (Table7). Protein contains in whole mullet bodies did not affected significantly with the protein levels tested, however it decreased slightly with each increase in the protein level fed. Percentages of fat in the whole body dry matter of mullet were higher ($P<0.05$) in the groups fed on the lowest (20%) and the highest (44%) protein levels compared to the 32% protein level. Ash percentages of the whole mullet bodies were higher ($P<0.05$) in the groups fed on 32 and 44% level compared to that fed the 20% protein level. These results are in accordance with those reported by Abdel- Maksoud (2000), who showed that increasing protein levels fed in mullet diets from 22 to 24; 27 or 29% released significant effects in dry matter; crud protein; fat; ash and gross energy contents of the whole body.

Total fish production (Kg. / Feddan).

Total fish yields (Kg./ Feddan) of the species stocked (tilapia; eel and mullet) as affected with dietary protein levels fed are presented in table (8). Results revealed that total fish yields at harvesting for Diet(1); Diet (2) and Diet (3) were found total 1190.88; 1414.56 and 157.2 Kg. Fish / Feddan respectively. These results indicate that increasing the dietary protein level fed from 2o to 32% resulted in an increase in fish total yield by 18.7% and a further increase in the protein level to 44% resulted in an increase in the total yield by 32.2% compared to the lowest level fed (20 % protein). These results may indicate that in polyculture system of Nile tilapia eel and mulltes diets containing protein levels 32% or above (44%) are required for better yields of the three species cited above. These results are in partial agreement with the findings of Abdel-Hakim and Moustafa (2000), who reported that total yield of Nile tilapia cultured in cages increased in a linear manner with each increase in the dietary protein level fed from 20 to 24; 28 or 32%. Also Abdel-Hakim *et al* (2000), reported that increasing the protein level on diets of Nile tilapia in cage polyculture with eel and mullet from 20% plus trash fish to 45% plus trash fish increased the cage total yield of the three species at harvesting from 596.3 Kg to 659.5 Kg. Results of Table (8)

show also that the contribution of .tilapia in the total harvest had ranged between 54.2% (Diet 3) to 54.8 and that of eel between 18.9(Diet 1) to 20.1% (Diet 3), while the contribution of mullet in the total harvest ranged between 25.7% (Diet 3) and 26.3% (Diet 1).

Economic Evaluation

Results of costs including variable; fixed and interest on working capital for the treatments applied are shown in table (9). Results revealed that costs of fish fingerlings and labor are similar in the treatments applied table (9), however the feed costs differed according to the protein level fed and were the lowest for the diet containing 20% protein (1904.8 LE) and increased to 2616 and 3345.3 LE for the diets containing 32; 44% protein levels respectively. Total operating costs (Variable + Fixed costs) per Feddan increased from 5974.7 LE (200%) to 6755.8 LE (113.07%) and 7557 LE (126.4%) for Diet (1); Diet (2) and Diet (3), respectively. The differences in total costs had attributed to the differences in feed costs, thus the diets tested differ in their protein contents and consequently the price of feeding. Total returns in LE / Feddan for Diet (1); Diet (2) and Diet (3) were 5974.4; 6755.8 and 7557 LE, respectively (table 9). Net returns per Feddan in LE for Diet (1); Diet (2) and Diet (3) were 4311.2; 8524.7 and 8718.6 LE and its percentage to the lowest net returns Diet (1) 100 were found to be 197.7 and 202.2 % for Diet (2) and Diet (3), respectively. The percentages of net return to total costs were 72% ; 126% and 115.3% for Diet (1); Diet (2) and Diet (3), respectively. These results indicate that feeding Nile tilapia in polyculture with eel and mullet in earthen ponds on diets containing 32% crude protein resulted in best economic efficiency and increasing the dietary protein levels above 32% may increase the economic parameters but slightly compared to the 32%protein level. These results are in complete agreement with results of Abdel-Hakim *et al.* (2000), working with the same fish species but reared in cages.

Conclusion

Based on results obtained in this study and on the economical evaluation it could be concluded that tilapia; mullet and eel can be

cultured to gether in earthen ponds and growth parameters of the three species improved with each increase in the protein level fed from 20 to 32 and 44%. however from the economical point of view a diet containing 32% protein seemed to be the best in terms of ratio of returns to total costs.

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Table (1): Composition of the experimental diets.

Diets› / Ingredients˘	Diet (1)% 20%CP	Diet (2)% 32%CP	Diet (3)% 44%CP
Yellow corn	36	16	10
Wheat bran	20	12	-
Fish meal (72.3%C.P)	5	15	30
Meat meal	-	-	30
Soybean meal(44%C.P)	6	13	25
Rice	14	13	-
Decorticated Cotton Seed Meal	11	15	-
Poultry Slaughter by-Products	5	13	-
Fat	-	-	2
Vitamin premix*	1.5	1.5	1.5
Mineral mixture**	1.5	1.5	1.5
Total	100	100	100
Calculated diet composition as fed			
Protein %	20	32	44
Gross energy k cal/kg Diet***	3198	3303	4155
Analyzed % on dry matter basis			
Moisture	10.20	9.61	8.61
Crude protein (C.P)	20.08	32.07	44.10
Ether extract (E.E)	6.543	6.83	10.16
Crude fibers	6.72	5.81	4.36
Ash	6.06	8.873	11.03

*Each gram of vitamin premix contains 20.000Iuvit. A2000 IU vit. D3, 400 vit. E, 20 mg Niacin, 4.5 mg riboflavin, 3mg pyridoxine, o.o13 mg vit. B12, 100 mg chorine chloride and 2 mg vit K.

**Each gram contains 0.83 Ca, 0.63P, 0.78 Na, 0.018 Mn, 0.011 Zn and 0.001 Cu.The Mixture was prepared by mixing 35parts of dicalcium phosphate, 3 parts of mineral premix and 2 part 0f common salt.

***Calculated by differences.

Table (2) Least square means and standard error for the effect of protein level on body weight of Nile tilapia *O. niloticus* Eel and Mullet.

Diet	No.	Start	4 week	8 week	12 week	16 week	20 week	24 week	28 week	32 week
Tilapia										
D1(20%P)	90	20.28±0.28 a	45.25±1.16 b	51.72±1.27 c	80.21±1.25 c	105.90±1.45 c	122.29±1.67 c	147.00±1.61 c	157.81±1.48 c	173.51±1.50 c
D2(32%P)	90	20.87±0.28 a	65.75±1.16 a	81.94±1.27 b	106.86±1.25 b	122.68±1.45 b	148.96±1.67 b	160.48±1.61 b	175.41±1.48 b	202.91±1.50 b
D3(44%P)	90	20.64±0.28 a	67.09±1.16 a	110.01±1.27 a	124.39±1.25 a	152.39±1.45 a	161.23±1.67 a	177.00±1.61 a	202.89±1.48 a	224.89±1.50 a
Probability		P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Eel										
D1(20%P)	90	31.55±0.66 a	51.38±6.27 b	71.77±6.59 b	92.08±2.53 c	111.13±4.73 c	133.09±4.84 b	142.40±6.81 b	154.09±0.97 c	162.91±1.71 c
D2(32%P)	90	31.60±0.66 a	57.22±6.27 b	76.77±6.59 b	111.27±2.53 b	132.21±4.73 b	140.93±4.84 b	150.50±6.81 b	163.72±0.97 b	192.50±1.71 b
D3(44%P)	90	32.50±0.66 a	92.69±6.27 a	113.18±6.59 a	136.93±2.53 a	174.52±4.73 a	184.23±4.84 a	199.06±6.81a	208.77±0.97 a	227.00±1.71 a
Probability		P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Mullet										
D1(20%P)	90	29.86±0.42 a	46.25±3.37 b	53.35±7.56 b	82.63±7.50 b	105.97±1.55 c	121.43±3.60 b	148.47±4.18 b	161.17±5.48 b	172.01±7.31 b
D2(32%P)	90	30.25±0.42 a	60.29±3.37 a	102.16±7.56 a	125.27±7.50 a	126.55±1.55 b	155.06±3.60 a	169.34±4.18 a	187.10±5.48 a	221.52±7.31 a
D3(44%P)	90	29.92±0.42 a	60.90±3.37 a	104.60±7.56 a	126.43±7.50 a	146.37±1.55 a	160.27±3.60 a	171.51±4.18 a	188.58±5.48 a	225.96±7.31 a
Probability		P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05

Values are means±SE of three replications

Means within each column having different letters were significantly different (P<0.05)

Table (3): Least square means and standard error for the effect of protein level on body length of Nile tilapia *O. niloticus* Eel and Mullet.

Diet	No.	Start	4 week	8 week	12 week	16 week	20 week	24 week	28 week	32 week
Tilapia										
D1(20%P)	90	10.56±0.04 ab	13.58±0.10 b	14.59±0.08 c	16.30±0.08 c	18.07±0.12 c	19.26±0.17 c	22.58±0.19 c	22.93±0.16 c	25.45±0.13 c
D2(32%P)	90	10.67±0.04 a	15.00±0.10 a	16.40±0.08 b	18.01±0.08 b	19.18±0.12 b	22.52±0.17 b	23.36±0.19 b	25.33±0.16 b	27.31±0.13 b
D3(44%P)	90	10.49±0.04 b	14.94±0.10 a	18.16±0.08 a	19.13±0.08 a	22.62±0.12 a	23.34±0.17 a	25.33±0.19 a	27.27±0.16 a	28.23±0.13 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Eel										
D1(20%P)	90	19.99±0.57 a	19.89±0.47 b	20.59±0.49 b	21.20±0.28 c	22.00±0.20 c	23.04±0.47 c	23.40±0.13 b	23.68±0.19 b	23.80±0.80 c
D2(32%P)	90	18.97±0.57 a	19.92±0.47 b	20.59±0.49 b	22.09±0.28 b	23.11±0.20 b	24.48±0.47 b	23.65±0.13 b	23.78±0.19 b	24.53±0.80 b
D3(44%P)	90	20.34±0.57 a	19.03±0.47 a	29.72±0.49 a	28.89±0.28 a	30.58±0.20 a	31.12±0.47 a	31.24±0.13 a	35.32±0.19 a	35.58±0.80 a
Probability		P>0.05	P<0.05	P<0.05	P<0.001	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Mullet										
D1(20%P)	90	13.90±0.06 a	15.03±0.31 b	16.05±0.61 b	17.81±0.60 b	19.46±0.26 c	20.44±0.24 b	23.77±0.23 c	24.34±0.43 b	26.09±0.15 b
D2(32%P)	90	13.94±0.06 a	16.50±0.31 a	19.32±0.61 a	20.95±0.60 a	20.30±0.26 b	24.11±0.24 a	24.70±0.23 b	27.21±0.43 a	28.39±0.15 a
D3(44%P)	90	13.85±0.06 a	16.55±0.31 a	18.01±0.61 a	20.65±0.60 a	23.76±0.26 a	24.17±0.24 a	25.80±0.23 a	26.92±0.43 a	28.61±0.15 a
Probability		P>0.05	P<0.05	P<0.05	P<0.001	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05

Values are means±SE of three replications

Means within each column having different letters were significantly different (P<0.05)

Table (4) Least square means and standard error for the effect of protein level on condition factor (K) of Nile tilapia *O. niloticus* Eel and Mullet.

Diet	No.	Start	4 week	8 week	12 week	16 week	20 week	24 week	28 week	32 week
Tilapia										
D1(20%P)	90	1.72±0.02 a	1.81±0.02 c	1.67±0.01 b	1.85±0.01 a	1.79±0.03 a	1.70±0.05 a	1.27±0.01 a	1.31±0.02 a	1.06±0.01 a
D2(32%P)	90	1.72±0.02 a	1.95±0.02 b	1.86±0.01 a	1.83±0.01 a	1.74±0.03 a	1.30±0.05 b	1.24±0.01 a	1.08±0.02 b	1.00±0.01 b
D3(44%P)	90	1.79±0.02 a	2.01±0.02 a	1.84±0.01 a	1.78±0.01 a	1.26±0.03 b	1.16±0.05 b	1.09±0.01 b	1.00±0.02 c	1.00±0.01 b
Probability		P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Eel										
D1(20%P)	90	0.46±0.03 a	0.66±0.01 b	0.82±0.01 b	0.97±0.03 a	1.04±0.02 a	1.09±0.41 a	1.11±0.02 a	1.16±0.02 b	1.21±0.02 b
D2(32%P)	90	0.46±0.03 a	0.72±0.01 a	0.88±0.01 a	1.03±0.03 a	1.07±0.02 a	0.97±0.41 a	1.14±0.02 a	1.22±0.02 a	1.31±0.02 a
D3(44%P)	90	0.39±0.03 a	0.38±0.01 c	0.43±0.01 c	0.57±0.03 b	0.61±0.02 b	0.61±0.41 b	0.65±0.02 b	0.47±0.02 c	0.51±0.02 c
Probability		P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Mullet										
D1(20%P)	90	1.11±0.02 a	1.36±0.01 a	1.29±0.07 a	1.46±0.05 a	1.44±0.06 a	1.42±0.02 a	1.11±0.02 a	1.12±0.02 a	0.88±0.06 a
D2(32%P)	90	1.10±0.02 a	1.34±0.01 a	1.44±0.07 a	1.31±0.05 a	1.58±0.06 a	1.12±0.02 b	1.14±0.02 a	0.95±0.02 b	0.94±0.06 a
D3(44%P)	90	1.13±0.02 a	1.34±0.01 a	1.34±0.07 a	1.43±0.05 a	1.09±0.06 b	1.14±0.02 b	1.00±0.02 b	0.96±0.02 b	0.99±0.06 a
Probability		P>0.05	P>0.05	P>0.05	P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P>0.05

Values are means±SE of three replications

Means within each column having different letters were significantly different (P<0.05)

Table (5): Least square means and standard error for the effect of protein level on specific growth rate (SGR) of Nile tilapia *O. niloticus* Eel and Mullet.

Diet	No.	0-4 week	4-8 week	8-12 week	12-16 week	16-20 week	20-24 week	24-28 week	28-32 week	0-32 week
Tilapia										
D1(20%P)	3	2.68±0.07 b	0.53±0.04 c	1.37±0.06 a	0.93±0.07 a	0.48±0.05 a	0.61±0.05 a	0.24±0.04 b	0.32±0.03 b	0.90±0.01 c
D2(32%P)	3	3.82±0.07 a	0.74±0.04 b	0.88±0.06ba	0.46±0.07 b	0.65±0.05 a	0.17±0.05 b	0.37±0.04 ab	0.48±0.03 a	0.95±0.01 b
D3(44%P)	3	3.93±0.07 a	1.65±0.04 a	0.41±0.06 c	0.68±0.07 ab	0.19±0.05 b	0.31±0.05 b	0.45±0.04 a	0.34±0.03 b	0.99±0.01 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
Eel										
D1(20%P)	3	1.63±0.18 b	1.11±0.04 a	0.83±0.05 b	0.63±0.05 b	0.60±0.06 a	0.22±0.06 a	0.26±0.09 a	0.19±0.05 b	0.69±0.01 c
D2(32%P)	3	1.98±0.18 b	0.98±0.04 a	1.23±0.05 a	0.58±0.05 b	0.21±0.06 b	0.22±0.06 a	0.28±0.09 a	0.54±0.05 a	0.75±0.01 b
D3(44%P)	3	3.47±0.18 a	0.67±0.04 b	0.65±0.05 b	0.81±0.05 a	0.18±0.06 b	0.25±0.06 a	0.17±0.09 a	0.29±0.05 b	0.81±0.01 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P>0.05	P>0.05	P<0.05	P<0.05
Mullet										
D1(20%P)	3	1.46±0.11 b	0.48±0.20 b	1.46±0.08 a	0.83±0.08 a	0.45±0.06 ab	0.67±0.08 a	0.28±0.03 a	0.22±0.07 b	0.73±0.02 b
D2(32%P)	3	2.29±0.11 a	1.36±0.20 a	1.56±0.08 b	0.32±0.08 b	0.54±0.06 a	0.29±0.08 b	0.34±0.03 b	0.44±0.07 ab	0.83±0.02 a
D3(44%P)	3	2.36±0.11 a	1.16±0.20 ab	1.27±0.08 a	0.49±0.08 b	0.31±0.06 b	0.23±0.08 b	0.31±0.03 b	0.60±0.07 a	0.84±0.02 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05	P>0.05	P<0.05	P>0.05	P<0.05	P<0.05

Values are means±SE of three replications

Means within each column having different letters were significantly different (P<0.05)

Table (6): Least square means and standard error for the effect of protein level on carcass traits of Nile tilapia *O. niloticus*, Eel and Mullet

Diet	No.	Dressing%	Inedible Part%	Head %	Viscera %
Tilapia					
D1(20%P)	15	56.96±0.98 a	37.67±0.66 a	26.67±0.75 ab	11.00±0.54 b
D1(32%P)	15	56.07±0.98 a	38.30±0.66 a	27.69±0.75 a	10.50±0.54 b
D1(44%P)	15	57.87±0.98 a	37.37±0.66 a	24.80±0.75 b	12.57±0.54 a
Probability		P>0.05	P>0.05	P<0.05	P<0.05
Eel					
D1(20%P)	15	80.61±0.84 b	17.62±0.59 a	6.58±0.32 b	11.04±4.01 a
D1(32%P)	15	81.49±0.84 b	17.01±0.59 a	7.27±0.32 ab	9.73±4.01 b
D1(44%P)	15	86.22±0.84 a	11.83±0.59 b	7.94±0.32 a	10.11±4.01 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05
Mullet					
D1(20%P)	15	66.86±0.27 a	32.20±0.26 b	26.10±0.23 b	6.760±0.26 b
D1(32%P)	15	66.71±0.27 a	33.52±0.26 a	26.84±0.23 a	6.690±0.26 b
D1(44%P)	15	65.58±0.27 b	33.87±0.26 a	25.98±0.23 b	7.890±0.26 a
Probability		P<0.05	P<0.05	P<0.05	P<0.05

Values are means±SE of three replications
Means within each column having different letters were significantly different (P<0.05)

Table (7): Least square means and standard error for the effect of protein level on proximate analysis of Nile tilapia O. niloticus, Eel and Mullet.

Diet	No.	Moisture	Protein%	Fat%	Ash%
Tilapia					
D1(20%P)	15	67.18±0.29 b	41.18±0.79 b	38.87±1.12 b	13.51±0.64 a
D1(32%P)	15	69.36±0.29 a	45.88±0.79 a	34.19±1.12 a	14.05±0.64 a
D1(44%P)	15	67.75±0.29 b	41.29±0.79 b	39.93±1.12 a	12.23±0.64 a
Probability		P<0.05	P<0.05	P<0.05	P>0.05
Eel					
D1(20%P)	15	56.08±3.90 a	48.16±0.94 a	43.89±0.78 c	5.45±0.26 a
D1(32%P)	15	63.66±3.90 a	44.28±0.94 b	47.40±0.78 b	4.99±0.26 a
D1(44%P)	15	62.98±3.90 a	34.73±0.94 c	63.38±0.78 a	3.94±0.26 b
Probability		P>0.05	P<0.05	P<0.05	P<0.05
Mullet					
D1(20%P)	15	64.31±1.68 a	44.34±1.40 a	41.68±0.80 a	10.38±0.43 b
D1(32%P)	15	55.95±1.68 b	43.65±1.40 a	39.07±0.80 b	12.05±0.43 a
D1(44%P)	15	62.44±1.68 a	41.41±1.40 a	43.44±0.80 a	11.80±0.43 a
Probability		P<0.05	P>0.05	P<0.05	P<0.05

Values are means ± SE of three replications
Means within each column having different letters were significantly different (P<0.05)

Table (8). The effect of the experimental diets on total fish production Kg. / Feddan.

Treatments	Tilapia	Eel	Mullet	Total	% of the smallest value
Diet (1) 20%CP	652.8	225.28	312.8	1190.88	100%
	54.8%	18.9%	26.3%	100%	
Diet (2) 32%CP	776	270.5	368	1414.56	118.7%
	54.8%	19.2%	26%	100%	
Diet (3) 44%CP	853.6	316.8	404.8	15xz75.2	132.2%
	54.2%	20.1%	25.7%	100%	

Table (9). The effect of the experimental diets on economic efficiency.LE /Feddan.

Items	Treatments		
	1	2	3
(1)Variable costs, LE/ Feddan			
a- Costs of fish fingerlings:			
Tilapia	400	400	400
Eel	1600	1600	1600
Mullet	600	600	600
b-Feeds:			
Commercial diets	1904.8	2616	3345.3
c- Labor	533.3	533.3	533.3
Total Variable costs, LE/Feddan	5038.1	5749.3	6478.6
Fixed costs, LE/ Feddan			
a- Depreciation (materials & others)10%	200	200	200
b- Taxes	200	200	200
Total fixed costs, LE/ Feddan	400	400	400
Total operating costs (Variable & Fixed)	5438.1	6149.3	6878.6
Interest on working capital*	536.3	606.5	678.4
Total costs	5974.4	6755.8	7557
% of the smallest value of total costs	100	113.07	126.4
(2)Return			
Fish sales			
Tilapia	3590.4	4656	5548.4
Eel	4505.6	5680.5	7286.4
Mullet	2189.6	2944	3440.8
Total return (L.E.)**	10285.6	13280.5	16275.6
Net return, LE/ Feddan	4311.2	8524.7	8718.6
% of the smallest value of net return	100	197.7	202.2
% Net returns to total costs	72%	126%	115.3%

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

*The economical evaluation of results was carried out according to market prices in 2001 in L.E.