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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

Nabil F. Abdel-Hakim[1], Mohamed N. Bakeer[2] and Magdy A. Soltan[3]

(1) Fac. Agric. Al-Azhar University.
(2) Central Laboratory for Aquaculture Research at Abbassa, Sharkia Governorate, Egypt.
(3) Fact. Agric. Moshtohor, Zagazig University, Banha Branch.

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ABSTRACT

This study was carried out in a fish farm at Fowwa, Kafr El-Sheik Governorate, A.R.A. 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 by dietary protein levels. Nine earthen ponds, each of total area of 2000 m^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 eel, respectively. The study started in 15.4. 2000 and lasted in 15.12.2000. Results obtained are summarized in the following: 1- Final body weight of Nile tilapia increased significantly with each increase in the dietary protein level from 20 to 32 or 44%. 2- Final body weight of eel 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 (20%). 3- Final body length of both Nile tilapia and eel increased significantly with each increase in the protein level fed, while in mullet final body length of fish 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 rate of mullet fed the 32 or 44% dietary protein was 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 eel 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 performance 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 eel 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 ponds 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 system 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 culture in fishponds. One way of increasing the food availability in fishponds is fertilization of ponds by chemical or/and organic fertilizers 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 for 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 with complete formulated diets 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 (20 or 44.5% crude protein plus trash fish) on the performance of Nile tilapia, mullet and eel cultured together in cages. They reported that final weights after 240 days growing period of Nile tilapia, grey mullet and eel fed on the 44.5% 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 659.5 kg for fish fed the 44.5% 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 farming 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 for each pond was 2000 m^2

with a water depth of one meter. Before the experimental start all ponds were completely drained 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 outlet 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, 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 (15th April, 2000) till the end of October 2000, thereafter 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: Each experimental pond was stocked with 2000 fingerlings of mixed sex Nile tilapia (*Oreochromis niloticus*) with an average weight of 20.28 to 20.87 g, 1000 grey mullet fingerlings (*Mugil cephalus*) with initial weight averaged 29.86 to 30.25 g and 800 elvers (*Anguilla anguilla*) with initial weight 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 for each specie and monthly repeated 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 for each specie and carcass test was

also done in another 15 fish for each specie . Proximate analysis of whole fish bodies as well as the experimental diets were performed according to the methods described by AOAC (1990). Parameters of condition factor (K) and specific growth rate (SGR) were calculated according to the following equations:

Condition factor (K)=100 [W/L^3], where W=weight of fish in grams and L = Total length of fish in cm.

Specific Growth Rate (SGR)= $100(LnW_2-LnW_1)/T_2-T_1$, where W_2 is the weight at T_2 and W_1 is the weight at T_1 and Ln is the natural log.

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

RESULTS AND DISSCUSSION

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 ranged between 20.28 - 20.87, 31.60 - 32.5 and 29.86 - 30.25 g, respectively, and the differences among the treatment groups within each specie were insignificant indicating that the distribution of fish into the experimental groups for each specie was random.

For tilapia, averages of body weights after 4 weeks of the experimental start were found to be 45.25, 65.75 and 67.09 g for fish groups fed the 20, 32 and 44% protein level, respectively. Analysis of variance for results at this period indicated that fish 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 dietary protein level fed (Table 2). At the experimental end (32 weeks after start) final body weights of tilapia were found to be 173.51, 202.91 and 224.89 g for fish fed the experimental diets 20, 32 and 44% dietary protein,

respectively. Statistical analysis of results show that averages body weight increased in a significant linear manner with each increase in the dietary protein level fed from 20 to 32 and 44%. These results indicated that protein requirements for 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 dietary protein level in tilapia diets from 25 to 30 or 35% increased significantly body weight and growth rate. Also, Wang *et al.,* (1985) reported that increasing protein level from 13 to 40% in tilapia diets improved 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 gain of Nile tilapia increased significantly with each increase in the dietary protein level fed from 20 to 24, 28 and 32%. Results of body weight presented in Table (2) are also in complete accordance with the results obtained by El-Sagheer (2001), who showed that body weight of mono sex Nile tilapia cultured intensively in earthen ponds increased significantly as the dietary protein level increased from 25 to 32%.

Averages of eel body weight for group fed on 44% protein diet at period 4 and 8 weeks after the experimental start were significantly ($P<0.05$) heavier compared to those fed the 20 or 32% dietary protein levels (Table 2). During the other experimental periods averages of eel body weight increased significantly ($P<0.05$) with each increase in protein level fed. At the experimental end (32 weeks after start) averages of eel body weights for the fish groups fed on 20, 32 and 44% protein diets were found to be 162.91, 192.5 and 227.00 g, respectively and final weights increased in a significant ($P<0.05$) order with each increase in dietary protein fed. These results indicated that elvers grow better in polycultured ponds with protein level up to 32%. Lower protein levels may require longer periods than 32 weeks to achieve reasonable market weights, however this depends completely on eel size demand. These results are in accordance with those reported by Abdel-Hakim *et al.,* (2000), who found that eel cultured with tilapia and mullets in cages had significantly ($P<0.05$) superior final weights with diet containing

44.5% protein plus trash fish compared with a diet containing 20% protein plus trash fish.

Concerning mullet body weight, Table (2) show that average body weight of this fish specie at all experimental periods for groups fed the dietary protein levels 32 or 44% were significantly ($P<0.05$) superior than those fed the diet contained 20% crude protein and the 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 fish groups fed on the diets contained 20, 32 or 44% protein level were 172.01, 221.52 and 225.96 g, respectively (Table 2) and the differences among fish groups in final body weight were significant ($P<0.05$) for the favor of groups fed the diets contained 32 or 44% crude protein. These results indicated that, mullet require a dietary protein level of 32% and the higher levels 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*, 2.2 g initial weight, increased with increasing dietary protein content 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; 49 and 60% protein with 4.54, 5.02 Kcal/g gross energy. Abdel-Hakim *et al.,* (2000) revealed also that final weight of grey mullet cultured in cages together with tilapia and eel and fed on a diet containing 44.5% crude protein plus trash fish were significantly higher compared to those of mullet fed on a 20% protein diet plus trash fish.

At the experimental start, differences in body length for the three fish species studied (tilapia, eel and mullet) were insignificant (Table 3). After 4 weeks from the experimental start, body length of Nile tilapia fed on diets contained 32 or 44% crude protein found to be significantly ($P<0.05$) higher than those fed on the 20% protein level group. During the other experimental periods body length of tilapia increased significantly ($P<0.05$) with each increase in the dietary protein level fed. At the end of the experimental period (32 weeks after start); averages of final body length for tilapia groups fed the diets contained 20, 32 and 44% crude 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 in the dietary protein content. These results are in agreement 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 eel as affected by dietary protein content, at the experimental periods 4, 8, 24 and 28 weeks after experimental start, fish group fed on the 44% protein level showed significantly ($P<0.05$) longer bodies compared to those fed on the 20 or 32% protein levels. During periods 12, 16, 20 and 32 weeks after experimental start body length of eel increased in a significant ($P<0.05$) order with each increase in 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 eel cultured in cages with mullet and tilapia.

Averages mullet body length for fish groups fed the 32 or 44% protein diets were significantly ($P<0.05$) higher than those fed the experimental diet contained 20% crude protein 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 ($P<0.05$) with each increase in dietary protein content. These results confirm those reported by Papapreskeva and Alexis (1986), Ojaveer *et al.,* (1996) and Abdel-Hakim *et al.,* (2000).

Results of condition factor (K) for fish species fed on the experimental diets during the different experimental periods are illustrated in Table (4). At the experimental start differences in K values within each specie among the experimental groups were insignificant. K values of Nile tilapia differed significantly ($P<0.05$) among the tested protein levels during the most experimental periods for the favor of the lowest (20%) dietary protein level indicating that fish of this group grew more in length than the other groups. At harvesting average values of K for fish fed the diet containing 20, 32 or 44% crude protein were 1.06; 1.00 and 1.00, respectively and the fish group fed the diet contained the lower protein content had higher K vales compared to the fish fed the diet contained higher protein levels. Results of K values for tilapia indicated that values in all treatments decreased with each advances in age.

With respect to K values of eel, Table (4) show that during most of the experimental periods K values of this specie significantly differed among the experiment diets and fish group fed the diet

contained 32% protein had the highest K vales followed in a decreasing order by those fed the 20 and 44% diets, respectively. These results are in accordance with the findings of Panfili and Ximens (1992).

In this concern growth in length of eel between 1 and 2 years vary:6.2 cm in a Spanish estuary (Arias and 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 and Kildsen, 1979; Moriaty, 1983; Vollestad and Jonsson, 1988) and from 5.1 to 9.4 cm in lake environments (Berg 1985; Paulovis and Biro 1986; Nagiec and Bahnsawy 1990). In mullet, protein levels fed did not released any significant effects on condition factors at 4, 8, 12 and 32 weeks after experimental start (Table 4), however during the periods 16 and 24 weeks K values 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 the experimental start K values of fish groups fed the lowest protein level (20%) were significantly ($P<0.05$) higher than fish groups fed the higher protein levels (32 or 44%). These results are in accordance with that reported by Papapreskeva and Alexis (1986), who showed that growth performance parameters of mullet increased with increasing dietary protein from 12 to 24%, while beyond the level of 24% growth was decreased. Also Ojaveer *et al.,* (1996) observed decreases in growth of grey mullet (14 g) 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 attributed to the abundance of the natural food in the ponds beside the artificial diets, thus grey mullet is a filter feed, fed on algae, diatoms, small crustacean and decayed organic matter (Bishara, 1967 and Odum, 1970).

Specific growth rate (SGR):

As presented in Table (5), tilapia showed improvement in SGR values with increasing the dietary protein level from 20 to 32 or 44% during the periods from start to 4 weeks, 4-8 and 8-12 weeks. During the periods 12-16, 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 fish group fed on the 44% protein level showed the highest SGR 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 eel, SGR values fluctuated significantly among the tested protein levels (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 and the same trend was also observed in mullet fed the different protein levels (20, 32 and 44%). 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 44.5%.

Carcass traits:

Carcass traits of the studied fish species including dressing, inedible parts, head and viscera percentages to final body weight are presented in Table (6). In tilapia, protein level fed had no significant effects on dressing and inedible parts percentages, however head and viscera percentages seemed to be significantly influenced by protein level fed. In this connection, Moustafa (1993) reported that dressing percentages of Nile tilapia reared in cages increased significantly from 56.35, 58.48, 60.38 to 61.63% as the dietary protein content increased from 20, 24, 28 to 32%, respectively. The same author reported that percentages of total inedible parts decreased as the dietary protein level increased. The contradiction between our results and that of Moustafa (1993) in this hence may attributed mainly to the fact that this author cultured the tilapia in cages as a sole fish species, while in our 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 containing 20, 32 and 44% protein were found to be 80.61, 81.49 and 86.22%, respectively. The statistical analysis of results showed that eel group fed on the 44% diet had significantly ($P<0.05$) higher dressing percentage compared to the 20 and 32% protein level diets. Meanwhile, the group fed on the highest protein level (44%) had the lowest inedible parts compared to the lower

levels (20 or 32%), which may reflect the negative relationship between the percentages of dressing and inedible parts. These results are in accordance partially with the findings of Abdel-Hakim *et al*., (2000).

Dressing percentage of mullet groups fed on diet containing 20 or 32% protein were slightly higher than those fed on the 44% protein diet, however differences were significant ($P<0.05$) for the favor of lower dietary protein levels. The reverse trend was observed in the percentage of inedible parts where mullet fed on diets containing higher protein levels (32 or 44%) had higher percentage of inedible parts. Results presented in the same table indicate also that there were significantly ($P<0.05$) differences in head and viscera among the protein levels tested. These results are in agreement with the findings of Abdel-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 hand, fat content of tilapia 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 tilapia seemed to be insignificantly affected by dietary protein levels tested. These results are in partial agreement with the findings of Moustafa (1993), who reported that increasing dietary protein level in Nile tilapia diets reared in cages from 20 to 24, 28 and 32% increased the protein contents in the whole fish body. He also added that, increasing dietary protein level increased total fat and decreased the total ash in whole body of Nile reared in cages.

With respect to the proximate analysis of eel, Table (7) show that the dietary protein content released insignificant effect on moisture content of fish bodies, however eel fed on 32 or 44% protein diets had higher moisture content in the whole bodies compared to those fed the 20% protein diet. Results of the same table revealed that protein content decreased significantly ($P<0.05$) with each increase in the protein level fed and fat percentage showed the reverse trend. These results may indicate that fat content in eel whole

bodies increased the costs of the protein content. This is true, thus eel fed on higher protein diets grow faster and utilized the dietary protein as energy source which resulted in deposition of more fat rather than muscles in fish bodies. In mullet, fish groups fed on the diets containing 20 or 44% protein showed significantly ($P<0.05$) higher moisture content in their whole bodies compared to those fed the 32% protein diet (Table 7). Protein content in whole mullet bodies did not affected significantly the protein levels tested, however it decreased slightly with each increase in the protein level fed. Percentages of fat in the whole dry matter of mullet were higher in the groups fed on the lowest (20%) and the highest (44%) protein levels compared to the 32% protein level. Ash contents of the whole mullet bodies were higher in fish 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 in mullet diets from 22-29% released significant effects in dry matter, crude protein, fat, ash and gross energy content of the whole body.

Total fish production (Kg/Feddan):

Total fish yield (Kg/feddan) of the species stocked (tilapia, eel and mullet) as affected by dietary protein content are presented in Table (8). Results revealed that total fish yield at harvesting found to be 1190.88, 1414.56 and 1575.2 kg/fed for the three experimental diets contained 20, 32 and 44% crude protein, respectively. These results indicated that increasing dietary protein from 20 to 32% resulted in an increase if fish yield by 18.7% and a further increase in protein level to 44% resulted in an increase in the total yield by 32.2% compared to the lowest protein level fed (20%). These results may indicate that in polyculture system of Nile tilapia, eel and mullet diets containing protein levels 32% or above (44%) are required for better yield of the three species. 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 content from 20 to 32%. Also, Abdel-Hakim *et al*., (2000), reported that increasing dietary protein content for Nile tilapia reared in cages with eel and mullet from 20% plus trash fish to 44.5% plus trash fish increased the cage total yield of the three fish species at harvesting

from 596.3 to 659.5 kg. Results of Table (8) show also that the contribution of tilapia in the total yield ranged between 54.2% (Diet 3) to 54.8 (Diet 1) and that of eel between 18.9 (Diet 1) to 20.1% (Diet 3), while the contribution of mullet in the total yield ranged between 25.7% (Det 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 of this table revealed that costs of fish fingerlings and labor are similar in all treatments applied, however the feed costs differed according to protein content of these diets 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 and 44% crude protein, respectively. Total costs per feddan increased from 5974.7 LE (100%) to 6755.8 LE (113.07%) and 7557 LE (126.4%) for diet1 (20% CP), diet2 (32% CP) and diet3 (44% CP), respectively. Differences in total costs were attributed to the differences in feed costs, thus the diets tested differ in their protein contents and consequently the feeding costs. Total returns in LE/Feddan for diet1, diet2 and diet3 were 10285.6, 13280.5 and 16275.6 LE, respectively (Table 9). Net returns/Feddan in LE were found to be 4311.2, 8524.7 and 8718.6 LE for the three experimental diets, diet1 (20% CP), diet2 (32% CP) and diet3 (44%), respectively. The percentage of net return to total costs were 72, 126 and 115.3% for the three diets diet1 (20% CP), diet2 (32% CP) and diet3 (44%), respectively. These results indicated that feeding of Nile tilapia in polyculture with eel and mullet in earthen ponds on diets containing 32% crude protein resulted in best economic efficiency compared to the other two protein levels 20 and 44%. 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 together in earthen ponds and growth parameters of the three species improved with each increase in dietary protein level fed from

20 to 32 and 44%, however from the economical point of view a diet containing 32% seemed to be the best in terms of ratio of returns to total costs.

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Table (1): Composition and analysis of the experimental diets

Ingredients	Experimental diets		
	Diet1 (20% CP)	Diet2 (32% CP)	Diet3 (44% CP)
Yellow corn	36	16	10
Wheat bran	20	12	-
Fish meal (72% CP)	5	15	30
Meat meal	-	-	30
Soybean meal (44% CP)	6	13	25
Rice by-product	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 premix**	1.5	1.5	1.5
Total	100	100	100
Proximate analysis			
Moisture	10.20	9.61	8.61
Crude protein	20.08	32.07	44.10
Ether extract	6.54	6.83	10.16
Crude fiber	6.72	5.81	4.36
Ash	6.06	8.87	11.03

* Each gram of vitamin premix contains 20000 IU vit. A , 2000 IU vit.D_3, 400 IU vit E, 20 mg Niacin, 4.5 mg riboflavin, 3 mg pyridoxine, 0.013 mg vit. B12, 100 mg choline chloride and 2 mg vit K.

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

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

Diets	No.	Start	4 week	8 week	12 week	16 week	20 week	24 week	28 week	32 week
Tilapia										
D1(20% CP)	90	20.28±0.28	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% CP)	90	20.87±0.28	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% CP)	90	20.64±0.28	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Eel										
D1(20% CP)	90	31.55±0.66	51.38±6.27 b	71.77±6.59 b	92.08±2.53 c	111.13±4.73 c	133.09±4.84 c	142.40±6.81 c	154.09±0.97 c	162.91±1.71 c
D2(32% CP)	90	31.60±0.66	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% CP)	90	32.50±0.66	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Mullet										
D1(20% CP)	90	29.86±0.42	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% CP)	90	30.25±0.42	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% CP)	90	29.92±0.42	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<0.01	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

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, Eel and Mullet.

Diets	No.	Start	4 week	8 week	12 week	16 week	20 week	24 week	28 week	32 week
Tilapia										
D1(20% CP)	90	10.56±0.04	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% CP)	90	10.67±0.04	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% CP)	90	10.49±0.04	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Eel										
D1(20% CP)	90	19.99±0.57	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% CP)	90	18.97±0.57	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% CP)	90	20.34±0.57	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Mullet										
D1(20% CP)	90	13.90±0.06	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% CP)	90	13.94±0.06	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% CP)	90	13.85±0.06	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

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, 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% CP)	90	1.72±0.02	1.81±0.02 c	1.67±0.01 b	1.85±0.01	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% CP)	90	1.72±0.02	1.95±0.02 b	1.86±0.01 a	1.83±0.01	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% CP)	90	1.79±0.02	2.01±0.02 a	1.84±0.01 a	1.78±0.01	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<0.001	P<0.001	P<0.01	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Eel										
D1(20% CP)	90	0.46±0.03	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% CP)	90	0.46±0.03	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% CP)	90	0.39±0.03	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<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.01	P<0.001
Mullet										
D1(20% CP)	90	1.11±0.02	1.36±0.01	1.29±0.07	1.46±0.05	1.44±0.06 a	1.42±0.02 a	1.11±0.02 a	1.12±0.02 a	0.88±0.06
D2(32% CP)	90	1.10±0.02	1.34±0.01	1.44±0.07	1.31±0.05	1.58±0.06 a	1.12±0.02 b	1.14±0.02 a	0.95±0.02 b	0.94±0.06
D3(44% CP)	90	1.13±0.02	1.34±0.01	1.34±0.07	1.43±0.05	1.09±0.06 b	1.14±0.02 b	1.00±0.02 b	0.96±0.02 b	0.99±0.06
Probability		P>0.05	P>0.05	P>0.05	P>0.05	P<0.01	P<0.001	P<0.001	P<0.001	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, 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% CP)	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% CP)	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% CP)	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<0.001	P<0.001	P<0.001	P<0.01	P<0.001	P<0.001	P<0.05	P<0.05	P<0.001
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	0.26±0.09	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	0.28±0.09	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	0.17±0.09	0.29±0.05 b	0.81±0.01 a
Probability		P<0.001	P<0.001	P<0.01	P<0.05	P<0.01	P>0.05	P>0.05	P<0.01	P<0.001
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 a	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<0.01	P<0.05	P<0.001	P<0.01	P<0.05	P<0.01	P<0.05	P<0.05	P<0.01

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 parts (%)	Head (%)	Viscera (%)
Tilapia					
D1(20% CP)	15	56.96±0.98	37.67±0.66	26.67±0.75 ab	11.00±0.54 b
D2(32% CP)	15	56.07±0.98	38.30±0.66	27.69±0.75 a	10.50±0.54 b
D3(44% CP)	15	57.87±0.98	37.37±0.66	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% CP)	15	80.61±0.84 b	17.62±0.59 a	6.58±0.32 b	11.04±4.01 a
D2(32% CP)	15	81.49±0.84 b	17.01±0.59 a	7.27±0.32 ab	9.73±4.01 b
D3(44% CP)	15	86.22±0.84 a	11.83±0.59 b	7.94±0.32 a	10.11±4.01 a
Probability		P<0.001	P<0.001	P<0.001	P<0.001
Mullet					
D1(20% CP)	15	66.86±0.27 a	32.20±0.26 b	26.10±0.23 b	6.760±0.26 b
D2(32% CP)	15	66.71±0.27 a	33.52±0.26 a	26.84±0.23 a	6.690±0.26 b
D3(44% CP)	15	65.58±0.27 b	33.87±0.26 a	25.98±0.23 b	7.890±0.26 a
Probability		P<0.001	P<0.001	P<0.05	P<0.01

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

Diet	No.+	Moisture	Protein%	Fat%	Ash%
Tilapia					
D1(20% CP)	15	67.18±0.29 b	41.18±0.79 b	38.87±1.12 a	13.51±0.64
D2(32% CP)	15	69.36±0.29 a	45.88±0.79 a	34.19±1.12 b	14.05±0.64
D3(44% CP)	15	67.75±0.29 b	41.29±0.79 b	39.93±1.12 a	12.23±0.64
Probability		P<0.001	P<0.001	P<0.001	P>0.05
Eel					
D1(20% CP)	15	56.08±3.90	48.16±0.94 a	43.89±0.78 c	5.45±0.26 a
D2(32% CP)	15	63.66±3.90	44.28±0.94 b	47.40±0.78 b	4.99±0.26 a
D3(44% CP)	15	62.98±3.90	34.73±0.94 c	63.38±0.78 a	3.94±0.26 b
Probability		P>0.05	P<0.001	P<0.001	P<0.001
Mullet					
D1(20% CP)	15	64.31±1.68 a	44.34±1.40	41.68±0.80 a	10.38±0.43 b
D2(32% CP)	15	55.95±1.68 b	43.65±1.40	39.07±0.80 b	12.05±0.43 a
D3(44% CP)	15	62.44±1.68 a	41.41±1.40	43.44±0.80 a	11.80±0.43 a
Probability		P<0.01	P>0.05	P<0.001	P<0.01

+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)

Treatment	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)	776.0	270.5	368.0	1414.56	118.7
	54.8%	19.2%	26.0%	100%	
Diet 3 (32% CP)	853.6	316.80	404.8	1575.20	100%
	54.2	20.1%	25.7%	100%	

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

Items	Treatments		
	Diet1 (20% CP)	Diet2 (32% CP)	Diet3 (44% CP)
1- Variable costs (LE/Feddan)			
a. costs of fish fingerlings:			
Tilapia	400	400	400
Eel	1600	1600	1600
Mullet	600	600	600
b. Feeds	1904.8	2616	3345.3
c. labor	533.3	533.3	533.3
Total variable costs (LE/Feddan)	5038.1	5749.3	6478.6
2- Fixed costs (LE/Feddan)			
. 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	100	113.07	126.4
Returns			
*Total return (LE)***	10285.6	15280.5	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% × total operating costs × 240/365 days.

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

تأثير متسويات البروتين الغذائى على أداء النمو وإنتاجية أسماك البلطى النيلى وثعبان السمك والبورى تحت نظام التربية المختلطة

نبيل فهمى عبد الحكيم * محمد بكير ** مجدي عبد الحميد سلطان***

* قسم الإنتاج الحيوانى كلية الزراعة – جامعة الأزهر

** المعمل المركزى لبحوث الثروة السمكيه بالعباسه – مركز البحوث الزراعية

*** قسم الإنتاج الحيوانى – كلية الزراعة بمشتهر– جامعة الزقازيق (فرع بنها)

أجريت هذه الدراسة فى مزرعة سمكية بمنطقة فوه بمحافظة كفر الشيخ، جمهورية مصر العربية . هدفت التجربة إلى دراسة تأثير مستوى بروتين الغذاء على أداء النمو فى أسماك البلطى النيلى وثعبان السمك والبورى المرباه فى الأحواض الترابية تربية مختلطة وكذلك إنتاجية هذه الأحواض. أستخدم فى هذه الدراسة تسعة أحواض ترابية مساحة الواحد منها ٢٠٠٠م٢ لتمثل ثلاثة مستويات من البروتين الغذائى (٢٠، ٣٢ و٤٤%) حيث مثل كل مستوى فى ثلاثة مكررات. تم تسكين أنواع الأسماك الثلاثة محل الدراسة بمعدلات ٢٠٠٠، ١٠٠٠ ، ٨٠٠ أصبعية بمتوسط وزن فى بداية التجربة ٢٠،٢٩،٣١ جم لكل من البلطى والبورى وثعبان السمك على التوالى. بدأت التجربة فى ٢٠٠٠/٤/١٥ وأنتهت فى ٢٠٠٠/١٢/١٥ أى أستمرت ٣٢ أسبوع. وكان من أهم النتائج المتحصل عليها مايأتى:

١- زادت أوزان الجسم زيادة معنوية فى البلطى النيلى مع كل زيادة فى مستوى بروتين الغذاء من ٢٠ إلى ٣٢ أو ٤٤%.
٢- زادت أوزان الجسم النهائية لثعبان السمك مع كل زيادة فى مستوى بروتين الغذاء فى حين أظهرت أسماك البورى زيادة معنوية فى أوزان الجسم النهائية عند مستويات البروتين ٣٢، ٤٤% مقارنة بالمستوى الأقل (٢٠%).
٣- زادت أطوال الجسم النهائية لكل من أسماك البلطى وثعبان السمك زيادة معنوية مع كل زيادة فى مستوى بروتين الغذاء فى حين أن الأطوال النهائية لأجسام أسماك البورى كانت أكبر فى المجاميع المغذاه على العلائق المحتوية على ٣٢ أو ٤٤% بروتين مقارنة بتلك المغذاه على مستوى بروتين ٢٠%.
٤- معدل النمو النوعى خلال فترة التجربة تحسنت معنوياً فى أسماك البلطى وثعبان السمك مع كل زيادة فى مستوى بروتين الغذاء ، فى حين أن معدل النمو النوعى لأسماك البورى تحسن معنوياً عند التغذية على علائق تحتوى على ٣٢، ٤٤% بروتين مقارنة بتلك المغذاه على العليقة المحتوية على ٢٠% بروتين.
٥- لم يظهر مستوى بروتين الغذاء أى تأثير معنوى على معدلات التصافى فى البلطى النيلى فى حين أنها أثرت على هذه الصفه بثعبان السمك والبورى.
٦- كانت لمستويات البروتين الثلاثة آثاراً معنوية على التحليل الكيميائى لأنواع الأسماك الثلاثة (البلطى وثعبان السمك وكذلك البورى).

بناء على نتائج هذه الدراسة وكذلك التقييم الإقتصادى يمكن الإستنتاج أنه يمكن إستزراع أسماك البلطى والبورى وثعبان السمك إستزراع مختلط فى الأحواض الترابية مع تحسن النمو لكل زيادة فى مستوى البروتين فى العليقة من ٢٠ إلى ٣٢ ، ٤٤% وكذلك من الناحية الإقتصادية تبين أن أفضل عليقه غذائية هى تلك المحتوية على ٣٢% بروتين حيث أعطت أفضل نسبة مئوية لعائد الربح بالنسبة للتكاليف الكلية.