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RESPONSE OF GREY MULLET (*MUGIL CEPHALUS L.*), CULTURED IN EARTHEN PONDS, TO DIETS OF VARYING PROTEIN LEVELS

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SUMMARY

Grey mullet, Mugil cephalus L., fingerlings averaging 14 g in weight were assigned randomly to four tested diets. Fish were reared in eight 2.5 feddan (fed.) earthen ponds with stocking rate of 2500 fish/fed. Diets contained 22 (D_1), 24 (D_2), 27 (D_3) and 29% (D_4) crude protein were fed to fish at a rate of 3% of their fresh body weight. The duration of the study was 214 days. Water was supplied from one canal ending of the river Nile.

Results showed that fish growth performance increased ($P \leq 0.05$) with increasing the dietary protein level from 22 to 29%. The feed conversion ratio (FCR) decreased ($P \leq 0.01$) but protein efficiency ratio (PER), protein productive value (PPV%) and energy productive value (EPV%) decreased ($P \leq 0.01$) with increasing the protein level in the diet. Carcass dry matter and crude protein increased with increasing dietary protein level, while ether extract, ash and gross energy contents decreased. Survival rates were nearly similar within the tested diets. Harvested fish and net fish production/fed., increased with increasing dietary protein level. The net revenue/fed. was the best with D_4 as compared with the other tested diets. From the above mentioned results, it could be concluded that D_4 (29% CP level) was the most effective under the present experimental conditions. Further studies on the nutritional requirements and the relationship between the nutritional factors are needed to develop balanced diets of M. cephalus aiming to permit the highest growth performance, decreasing feeding costs and increasing profit.

Keywords: Grey mullet, dietary protein level, growth, feed utilization, body composition and economical evaluation.

INTRODUCTION

Grey mullet (*Mugil cephalus L.*) is an important commercial fish specie in Egypt. It shows a great potential to be used in aquaculture, they are fast growing, of high quality flesh, tolerate salinity, tolerate wide range of temperature. They are illiophagous and omnivorous in their feeding habits (Khan and Fatima, 1994), respond well to inexpensive methods of fertilization and they readily accept

supplemental feeds (Bradach *et al.*, 1972; Hepher & Pruginin, 1981; Roy, 1985; Hamza *et al.*, 1988; El-Sayed, 1991; Nour *et al.*, 1993 a,b; El-Sayed, 1994; Abdelghany *et al.*, 1995; Cardona *et al.*, 1996; and Ojaveer *et al.*, 1996). El-Ghobashy *et al.* (1993) reported that supplementary feeds have a great role in improving fish production and profitability in fish farms.

Protein is responsible for a large part of the cost of most prepared feeds. Therefore, the expensive protein fraction should be optimally utilized. Diets with the optimum protein: energy ratio produces the best growth, feed utilization and protein retention (Ellis and Reigh, 1991). Ojaveer *et al.* (1996) reported that the most published literature on Grey mullet covers their ecology and nutrition in the wild and only a few attempts have been made to estimate their dietary requirements or optimum protein/energy ratio. At Fayoum Governorate, fish producers use supplemental diets along with a constant rate of fertilization. These diets differ in their CP levels, such levels ranged between 22 and 29%.

The present study aimed to gain information on response of Grey mullet to diets differing in their crude protein level.

MATERIALS AND METHODS

The experiment was conducted in a commercial fish farm near Shakshouk village, El-Fayoum, Egypt from 1/4/1995 to 31/10/1995 (harvesting date). Eight rectangle-shaped earthen ponds, each of 2.5 fed. (1.05 ha) area with a water level of 1.4 m were used. They were supplied with water from the canal ending of the river Nile, (4 ppt salinity) by 6 inch pump. Water turnover rate was 1/14 of water volume/month/pond. Ranges of water quality data during the experimental period was; 22.7-26.3° C temperature, 4-6 mg/l dissolved oxygen, 7.9-8.2 pH and 0.12-0.16 mg/l ammonia. All values were considered to be within acceptable limits for Grey mullet (Swingle, 1961; Hickling, 1962; Schmittou, 1973; Sivalingam, 1975; Korringa, 1976; and Salman *et al.*, 1982).

Grey mullet fingerlings were obtained from Mariut Co. for Fish Farming, Alexandria. Then, they were reared in 1/2 Fed., pond till they reached about 14 g fresh body weight. Fingerlings of 14 g ± 0.1 fresh body weight were assigned randomly to ponds at a rate of 2500 fish/fed., where two ponds represented one of the four dietary treatments used. Ponds were supplied with three kg urea (46.5% N) and 15 kg superphosphate (32% P_2O_5), biweekly. Fish were supplemented with the experimental diets, once daily, at a rate of 3% of fresh body weight six days/wk. Diets were soaked in water for 1.5 h. before use to sediment in suspended feeders beside pond banks. Urea was dissolved in water and trisuperphosphate was soaked in water for 24 h, then, they sprayed in ponds. The composition of diets, their chemical analysis and their calculated essential amino acids profile are shown in Tables 1 & 2.

Fish were sampled and their fresh body weight was obtained at the start, and at two wk, intervals until harvesting. Dietary feeding rates were adjusted through the two wk, intervals weighing of fish for the next period. Samples of fish were killed at the start and at harvesting, weighed, minced, mixed well and kept at -20° C until chemical analysis.

Chemical analysis of the experimental diets and fish bodies were conducted according to AOAC (1984) methods. Water temperature, pH, dissolved oxygen and

Table 1. Ingredients and chemical analysis of the experimental diets

Item	Diets			
	1	2	3	4
Ingredients, %				
Fish meal	15	15	15	15
Soybean meal	6	12	20	25
Sunflower meal	10	10	10	10
Wheat bran	26	24	20	18
Rice bran	24	21	17	15
Yellow corn	18	17	17	16
Bone meal	0.7	0.7	0.7	0.7
Vitamins & Minerals [1]	0.3	0.3	0.3	0.3
Total	100	100	100	100
Chemical analysis;				
CP, %	22.24	24.33	27.21	29.01
EE, %	5.99	5.82	5.78	5.71
CF, %	7.47	7.26	7.00	6.86
NFE, %[2]	57.07	55.13	52.26	51.11
Ash, %	7.23	7.46	7.75	7.31
GE,[3] Kcal/g	4.55	4.52	4.54	4.55
CP/GE, mg/Kcal	48.88	53.83	59.93	63.76
CP/GE, mg/Kj	11.68	12.87	14.32	15.24

Each Kg premix contained 2000000 I.U vitamin A; 400000 I.U vitamin D_3; 4000 mg vitamin E; 300 mg vitamin K_3; 200 mg vitamin B_1; 800 mg vitamin B_2; 4000 mg Nicotinic acid; 2.0 mg B_{12}; 2000 mg Pantothenic acid; 300 mg vitamin B_6; 200 mg Folic acid; 10 mg Biotin; 100 mg Choline; 1600 mg Cu; 156 mg I; 6421 mg Fe; 12800 mg Mn; 9000 mg Zn; 32 mg Se; 53 mg Cobalt and 1400 mg Ethoxyquine.

2 Calculated by difference.

3 Measured with a ballistic Bomb calorimeter, CBB-330-0101- Galenkamp.

Table 2. Calculated essential amino acids profile of the experimental diets (% of diet protein)

Amino acid	Diets			
	1	2	3	4
Arginine	8.14	7.97	7.75	7.69
Histidine	2.92	2.84	7.79	2.76
Isoleucine	5.22	5.34	5.40	5.45
Leucine	9.04	8.96	8.82	8.72
Lysine	6.65	6.62	6.62	6.62
Methionine	2.74	2.63	2.46	2.38
Phenylalanine	5.04	4.97	5.26	4.96
Theronine	4.59	4.48	4.34	4.27
Tryptophan	1.44	1.44	1.43	1.45
Valine	6.65	6.45	6.28	6.20

total ammonia were obtained through centigrade thermometer, Orion digital pH meter model 201, Cole Parmer oxygen meter model 5946 and Hanna instruments

ammonia test kit (HI 4829), respectively. Gross energy of samples were determined using Gallenkamp ballistic bomb calorimeter model CBB-330.

Statistical analysis was conducted according to Steel and Torrie (1980) using analysis of variance and Waller-Duncan least significant difference (LSD) to compare between means when significant F values were observed.

RESULTS AND DISCUSSION

Results in Table 1 showed that the tested experimental diets contained 4.54 Kcal, GE/g 22, 24, 27 and 29% dietary protein levels for D_1, D_2, D_3 and D_4, respectively.

Results of growth performance of Grey mullet (Table 3) indicated that protein level in the diet had significant effect ($P \leq 0.05$) on growth performance. The highest body weight, weight gain, daily weight gain/fish and specific growth rate % (SGR%) were obtained with D_4 followed by D_3, D_2 and D_1, respectively. In this connection results of Nour *et al.* (1993b) showed that growth performance of Grey mullet (*Mugil cephalus*) 4 g, reared in net enclosures in fresh water and fed supplemental diets containing 4.78 kcal/g (gross energy) was increased with increasing dietary protein level from 25 to 40%. However Ojaveer *et al.* (1996) observed decrease in growth of Grey mullet, 14 g, in response to increasing dietary protein level when they used 38, 49 and 60% CP levels with 4.54, 5.02 and 5.02 kcal/g as gross energy in aquaria. The results of Papapareskeva and Alexis (1986) showed that the growth of Mugil capito, 2.2 g, increased with increasing protein content of the diet from 12 to 24%, while beyond this level it was decreased. These results indicated that the response of growth performance of fish to dietary protein level depends on other nutritional factors in the diet, feeding system, feeding rate, initial weight of fish and environmental conditions.

Table 3. Growth performance of Grey mullet fed the experimental diets

Item	Diets			
	1	2	3	4
Initial weight (W_1),g/fish	14.75	14.55	14.08	14.55
Final weight (W_2), g/fish	200.5^{D}	252^{C}	298.5^{B}	322.25^{A}
Weight gain, g/fish[1]	185.75^{D}	237.45^{C}	284.42^{B}	307.70^{A}
Daily gain, g/fish[2]	0.87^{D}	1.11^{C}	1.34^{B}	1.44^{A}
SGR, %[3]	1.23^{c}	1.34^{b}	1.43^{ab}	1.45^{a}

1, Weight gain = $W_2 - W_1$

2, Daily gain = $(W_2 - W_1)/T$ *where* T is the time in days.

3, SGR%, Specific growth rate = $\{(\ln W_2 - \ln W_1)/T\} \times 100$.

where; ln is the natural log. and T is the time in days.

^{a,b,c,d}Means within same row having different superscripts, differ significantly ($P \leq 0.05$)

^{A,B,C,D}Means within same row having different superscripts, differ significantly ($P \leq 0.01$)

Data of feed utilization (Table 4), regardless of the amount of the natural feed consumed by fish, show that the efficiency of feed utilization was affected ($P \leq 0.01$) with the tested diets. Where, the best feed conversion ratio (FCR) was obtained with D_3 followed by D_2, D_4 and D_1, respectively. The low protein diet provides fish with insufficient nutrients, thus reduce efficiency of feed utilization. Also, dietary protein level and source had an effect on amino acids profile of the diet (Tables 1 and 2)

which affected feed utilization of the diet. Also, Steffens (1981); Lovell (1989); El-Sayed (1991); Cho (1992) and NRC (1993) reported that the relationship between dietary protein level and efficiency of feed utilization depends on species, age and size of fish, environmental factors, protein quality, energy level, energy source and amount of feed. With Grey mullet, these points need further investigations. However, the data of protein efficiency ratio (PER) and protein productive value (PPV%) showed that D_1 was more effective than D_2, D_3 and D_4, respectively. The efficiency of protein utilization decreased with the increase in protein level. Such observation was established by Papaparaskeva and Alexis (1986); Kandasami *et al.* (1987); El-Sayed (1991); Nour *et al.* (1993b); Ojaveer *et al.* (1996). They reported that the most dietary protein utilization reached with a dietary protein level which is far lower than that necessary for maximum growth rate. However, energy utilization were the best with D_1 and D_2 followed by D_3 and D_4, respectively. Thus, reflects the relationship between feed intake of the diets and the energy retained in the body of fish.

Table 4. Feed utilization of Grey mullet fed the experimental diets

Item	Diets			
	1	2	3	4
Feed intake, g/fish	618.22	738.44	870.30	1007.51
FCR	3.33^{A}	3.11^{C}	3.06^{D}	3.27^{B}
Protein utilization:				
PER	1.35^{A}	1.32^{B}	1.20^{C}	1.10^{D}
PPV	55.7^{A}	54.73^{B}	49.34^{C}	45.23^{D}
Energy utilization:				
EPV	30.02^{A}	30.13^{A}	28.39^{B}	25.98^{C}

FCR, Feed converion ratio = (feed, g / weight gain, g).
PER, Protein efficiency ratio = (protein gain, g / protein intake, g).
PPV, Protein productive value = (protein retained, g/protein intake, g)× 100.
EPV, Energy productive value = (retained energy, kcal / energy intake, kcal)×100
^{A,B,C,D} Means within same row having different superscripts, differ significantly ($P \leq 0.01$)

Body chemical composition at the end of the experiment is shown in Table 5. Significant differences ($P \leq 0.05$) in percentage of body DM, CP, EE, ash and GE content at the end of the experiment were obtained. The DM and protein percentages increased with the increase of dietary protein. However, body EE, ash percentages and GE contents were decreased with increasing the dietary protein level. Increasing of body fat with decreasing dietary protein may be related to fat synthesis from carbohydrate, since dietary lipid was kept almost constant. The positive relationship between dietary protein and body protein may be due to use fat as a source of energy and sparing dietary protein for growth as indicated by El-Sayed (1991). In this connection Essia *et al.* (1982) found positive association between dietary protein and fat contents and those in fish meat of Grey mullet which reared in mixed culture with tilapia. Nour *et al.* (1993b) found that the percentage of caracas CP, EE and DM of Grey mullet which reared in net enclosures in fresh water were positively correlated with increasing dietary protein level from 25 to 40%, while ash content was negatively correlated and the differences were not significant in DM% and CP%, but were significant ($P \leq 0.05$) with EE% and ash%. Ojaveer *et al.* (1996) observed that the body protein of Grey mullet reared in aquaria tended to increase in response to

elevated dietary protein content, while carcass ash was little affected by the diets. There are some differences between their values and that obtained herein, may be due to the difference of final weight of fish, the culture date, diet composition and other environmental factors.

Table 5. Body chemical composition of Grey mullet fed the experimental diets, on DM basis

Item	Diets			
	1	2	3	4
DM, %	30.00[b]	31.10[ab]	31.60[a]	32.00[a]
CP, %	57.53[C]	58.82[B]	59.29[B]	60.84[A]
EE, %	25.95[A]	24.66[B]	24.26[C]	23.45[D]
Ash, %	16.52[a]	16.52[a]	16.45[a]	15.71[b]
GE, Kcal/100 g	581.59[ab]	584.62[a]	579.82[b]	579.80[b]

[a,b]Means within same row having different superscripts, differ significantly (P≤ 0.05)
[A,B,C,D]Means within same row having different superscripts, differ significantly (P≤ 0.01)

Table 6 presents the production efficiency of fish as affected by tested diets. Survival rate was nearly similar, about 98.1%, as obtained by Abdelghany *et al,* (1995). The mortality was possible due to injuries incurred during sampling.

Fish body weight at harvesting and net fish production/fed., with D_4 were higher than those of D_3, D_2 and D_1, respectively. This result reflects the effect of tested diets on growth performance as indicated above.

Table 6. The effect of the experimental diets on production efficiency of Grey mullet

Item	Diets			
	1	2	3	4
fish No./fed at:				
The start.	2500	2500	2500	2500
Harvesting[1]	2460	2440	2460	2450
Survival rate, %[2]	98.40	97.6	98.4	98.0
Fish body weight/fed., kg at:				
The start	36.875	36.375	35.200	36.375
Harvesting	493.23	614.88	734.31	789.513
Net production/fed., kg[3]	456.355	578.505	699.11	753.138
Relative % of net production	100	127	153	165

1, Fish body weight, Kg/ feddan × No. of fish / Kg
2, (Fish No. at harvesting/fish No. at the start) × 100.
3, Fish body weight, Kg at harvesting-fish body weight, Kg at the start

Table 7 shows the economic efficiency of Grey mullet as affected by experimental diets. The income from D_2, D_3 and D_4 was higher than that obtained by D_1 by 24, 75 and 104%, respectively. However, the total costs for D_2, D_3 and D_4 was higher than that of D_1 by 8, 21 and 30%, respectively. Such differences resulted in increasing the net returns of D_2, D_3 and D_4 than D_1 by 57, 190 and 260 %,

respectively. Even though the net revenue/total cost % cleared that D_4 was superior than D_3, D_2 and D_1, respectively.

Table 7. The effect of the experimental diets on economic efficiency of Grey mullet

Item	Diets			
	1	2	3	4
Income, LE/ pond (2.5 fed.)*	10482.1	13000.18	18356.63	21367.50
Variable costs, LE/ pond (2.5 fed.):				
Fingerlings including transport	1300	1300	1300	1300
Urea	135	135	135	135
Superphosphate	450	450	450	450
Labor	624	624	624	624
Irrigation water	451.5	451.5	451.5	451.5
Feeds	2453.55	3046.08	3916.35	4596.75
Total variable costs	5414.05	6006.58	6876.85	7557.25
Fixed costs, LE/ pond (2.5 fed.):				
Opportunity land change	1250	1250	1250	1250
Deprecation (ponds & equipments)	450	450	450	450
Total fixed costs	1700	1700	1700	1700
Total costs, LE/ pond (2.5 fed.)	7114.05	7706.58	8576.85	9257.25
Relative % of total costs	100	108	121	130
Net revenue, LE/ pond (2.5 fed.)	3368.05	5293.60	9779.78	12110.25
Net revenue, LE/ fed.	1347.22	2117.44	3911.91	4844.10
Relative % of net revenue	100	157.17	290.37	359.56
Net revenue / total costs, %	47	69	114	131

* The price of 1 kg fish in average × fish yield / pond

Under the present experimental condition the obtained results show that D_4 was more efficient than D_3, D_2 and D_1, respectively. Further studies on the nutritional requirements and the relationship between the nutritional factors are needed to develop Grey mullet balanced diets aiming to permit the highest growth performance, decreasing feeding cost and increasing profit.

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أستجابة أسماك البورى المرباة فى أحواض أرضية لعلائق تحتوى مستويات مختلفة من البروتين

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أجريت هذه الدراسة بهدف معرفة أثر التغذية على علائق تحتوى مستويات مختلفة من البروتين على نمو وأداء سمك البورى، حيث وزعت إصبعيات البورى (متوسط وزنها ١٤ جم) على ٤ معاملات غذائية كل معاملة فى حوضين (مساحة الحوض ٢,٥ فدان (١,٠٥ هكتار) بواقع ٢٥٠٠ إصبعية للفدان. و كانت مستويات البروتين ٢٢، ٢٤، ٢٧، ٢٩% للعلائق الأولى والثانية والثالثة والرابعة على الترتيب، وغذيت الأسماك على العلائق المختبرة ٦ أيام فى الأسبوع بمعدل ٣% من وزنها الطازج واستمرت التجربة لمدة ٢١٤ يوم، وكانت الأحواض تمد بمياه النيل من نهاية إحدى الترع .

وأوضحت النتائج أن مستوى البروتين فى العليقة له تأثير معنوى على مظهر النمو وكفاءة استخدام الغذاء حيث كان أعلى وزن جسم وأعلى معدل نمو يومى و معدل نمو نوعى مع العليقة الرابعة تلاها الثالثة والثانية ثم الأولى على الترتيب، وافضل كفاءة تحويل غذائى مع العليقة الثالثة يليها الثانية والرابعة ثم الأولى. بينما كانت العليقة الأولى هى الأفضل بالنسبة لكفاءة استخدام بروتين الغذاء ، وقد كان للعلائق تأثير معنوى على التركيب الكيماوى للأسماك حيث زادت نسبة المادة الجافة%، البروتين% بينما مستخلص الأثير الخام والرماد والطاقة الكلية /جم انخفضت مع زيادة مستوى البروتين، وكان معدل الحيوية للأسماك تقريباً متساو مع العلائق المختبرة. بينما وزن السمك عند الحصاد وثمنه وكذا الإنتاج الصافى للعليقة الرابعة افضل منه لباقى العلائق. ويشير هذا إلى أن العليقة الرابعة كانت هى الأفضل تحت ظروف التجربة، ويلزم المزيد من الدراسات عن الاحتياجات الغذائية والعلاقات بين المركبات الغذائية المختلفة ليمكن الوصول لعلائق متزنة لأسماك البوري حتى تحقق أعلى معدلات نمو مع خفض تكاليف التغذية ومعظمة الربح.