Effect of Dietary Protein and Oil Levels on Growth Performance of African Catfish (*Clarias Gariepinus*)

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Abstract: This study was conducted in two separate experiments at Fish Research Center, Suez Canal University to investigate the effect of protein and oil levels on growth performance, survival rate, body composition and economical efficiency of fry and fingerlings catfish (*Clarias gariepinus*). **In the first experiment**, 900 fry of African catfish *Clarias gariepinus* with an average body weight (0.8 ± 0.2 g) were reared in six groups for 120 days under optimal conditions and fed on experimental diets contain 35%, 40% and 45% protein. Within each protein level, two oil levels (6% and 8%) were used, representing six levels of gross energy (GE), being (454.76, 465.88, 458.56, 470.16, 464.98 and 471.11 kcal /100g) with P/E ratios ranged between 76.96 to 97.64 mg protein / kcal. The results indicated that the highest growth performance, survival rate and economical evaluation were obtained in group of catfish fry fed diet containing 40% crude protein, 8% oil and 470.16 kcal/ 100g GE (P/E ratio of 85.50 mg protein / kcal). **In the second experiment**, 450 fingerlings with an average body weight (13.00 ± 0.2 g) were reared in six groups for 120 days under optimal conditions and fed on experimental diets contain 30%, 35% and 40% protein. Within each protein level, two oil levels (6% and 8%) were used, representing six levels of gross energy (GE) (451.10, 458.00, 454.76, 465.88, 458.56 and 470.16 kcal /100g) with P/E ratios ranged between 67.20 to 88.10 mg protein / kcal. The results indicated that the highest growth performance, survival rate and economical evaluation were obtained in group of catfish fingerlings fed diet containing 35% crude protein, 8% oil and 465.88 kcal/ 100g GE (P/E ratio of 77.10 mg protein / kcal). Therefore, it could be concluded that the requirements of catfish fry were (40% crud protein and 8% oil) and for fingerlings were (35% crud protein and 8% oil) in terms of growth performance, survival rate and economic evaluation under the same experimental conditions.

Keywords: Catfish, protein requirements, oil requirements, growth performance.

INTRODUCTION

Culture of African catfish, *Clarias gariepinus* has received considerable attention since the early 1970s (Richter, 1976).These studies confirmed the considerable culture potential of the species. African catfish is a suitable alternative to tilapia in subsistence fish farming in Africa and using low grade feed composed of some local agricultural by-products, the yields of catfish from ponds could be as much as 2.5 times higher than those of tilapia (Hogendoorn, 1983). According to Ellis and Reigh (1991), the determination of protein requirement is very critical factor in aquaculture production. This stem from the fact that fish feed constitutes over 60% of the production costs. According to Sang- Min and Tae- Jun (2005), protein requirement have been studied in aquaculture species with the aim of determining the minimum amount required to produce maximum growth and not be used for energy. Lipid is a major source of metabolic energy in fish. Being highly digestible, it has greater sparing action than dietary carbohydrate or protein, thereby playing a definite role in feed utilization. Since dietary lipid level is a dominant factor in determining palatability (Boonyaratpalin, 1991), it is important that a proper amount of lipid should be incorporated in fish diet. Excess amount of lipid in diet besides creating problems in the manufacture, may produce fatty fish (Cowey and Sargent, 1977). Providing adequate energy through dietary lipids can minimize the use of more costly protein source (McGoogan and Gatlin III, 2000). High-energy diets can also lead to excessive energy deposition as carcass lipids (Abdelhamid *et al.,* 1995) and reduced growth rate (Daniels and Robinson, 1986). The ability of fish to use lipid as a ready source of energy and to spare protein for growth has been investigated in many fish species (Sargent *et al.*, 1989). Excess carcass lipid accumulation and reduced growth rate due to increased dietary energy have also been shown for African catfish, *Clarias gariepinus* (Machiels and Henken, 1985), channel catfish *Ictalurus punctatus* (Mohsen and Lovell, 1990) and Indian major carp *Cirrhinus mrigala* (Hassan and Jafri, 1996). The dietary protein to energy ratio in fish diets is of great importance. Levels of dietary protein and energy not only influence growth and body composition, but also digestive enzyme activities and plasma metabolites in various fishes (Yamamoto *et al.,* 2000). The objective of the present study was to investigate dietary protein and lipid interaction and its influence on the growth, feed and protein utilization and body composition leading to optimization of protein to energy ratios (P/E ratio) for African catfish, *Clarias gariepinus* fry and fingerlings and to improve the cost-effectiveness of feeds for this species and optimize the culture conditions under semi- intensive or intensive aquaculture exploitation.

MATERIALS AND METHODS

Two experiments were conducted at Fish Research Center, Suez Canal University, Ismailia, Egypt to study the effect of different protein and oil levels on growth performance, survival rate and economic evaluation of African catfish fry and fingerlings. The experiments were carried out through (Oct. 2006 - Jan. 2007) for 120 days. Fry and fingerlings fish were cultured in plastic and rectangular fiberglass tanks, respectively, where the fish were depending only on the artificial feeds.

Rearing System:

The two experiments were carried out using dechlorated tap water. Water temperature was measured daily using an oxygen meter temperature prob. (YSI modle L57) and maintained at 25 ±1 °C through the experimental period by using a 100 W electric automatic heater controlled with a Deem 10/1193 thermometer linked to an on/off controller. Photoperiod regime was adjusted at 12hL: 12h D. Water pH was measured daily using pH meter, the mean of pH values was 7.2 ± 0.5. Other water quality parameter including ammonia nitrogen as (NH_3 –N) and dissolved oxygen were measured every two days using Tecnion Auto Analyser II standered methods (SCA, 1982) and oxygen temperature meter (YSI modle 57), whereas the range of total ammonia was 0.08- 0.37 mg/ l and dissolved oxygen was in range of 5-6 mg/l during the experiments,. Each tank was cleaned and up to one third of water was replaced daily, at the end of each week, all the water was replaced.

Experimental Fish:

African catfish, *Clarias gariepinus* fry and fingerlings were used for this study. The fry were obtained from artificial spawning at Fish Research Center, Suez Canal University. The fingerlings were obtained also from the same Center. Fish were nearly at the same size and body weight and apparently healthy. In experiment (1), fry weights (0.8± 0.2g) were obtained and acclimated to laboratory conditions for two weeks before being randomly divided into six equal experimental groups (50 fry /tank, three replicates for each treatment). Each fish subgroup (replicate) was placed in an individual experimental tank (100 l). In experiment (2), 450 fingerlings (13.1±0.02g) were obtained and acclimated to laboratory conditions for two weeks before being randomly divided into six equal experimental groups (25 fingerlings /tank, three replicates for each treatment). Each fish subgroup (replicate) was placed in an individual experimental tank (100 l). The experimental fry were weighed every week and fingerlings were weighed every two weeks using (Mettler PM6000) balance to the nearest 0.1g to adjust the daily feed rations for the following two weeks.

Experimental diets and fish feeding:

Three experimental diets were used in experiment (1) contained 35, 40 and 45% crude protein, whereas the experimental diets in experiment (2) contained 30, 35 and 40% crude protein. Each experimental protein level contained two levels of oil (6 and 8%), the source of oil was corn oil. The composition and proximate analysis of the experimental diets for both experiments are presented in (Tables 1 and 2, respectively). The experimental diets were prepared by individually weighing of each component and thoroughly mixing the mineral and vitamin premixes with corn. The mixture was mixed by hand for about 30 minutes to ensure that the mixture was well homogenized and then blended with oil for about 15 minutes. Water was added at 20-30% V/W until the mixture became suitable for making granules and pelleted to a suitable size by pelleting machine. An appropriate diet was used to give pellets of desired sizes (1.0 mm for 1st experiment and 3.0 mm for 2nd experiment) depending on fish size. Pellets were dried by sun shin. The dried pellets were then packed in polythene bags, sealed and kept frozen until used. Fry catfish were fed *ad libitum* 10 times / day and fingerlings were daily offered 5% of body weight, feed was divided into two equal meals at 9:00 am and 4:00 pm every day. After a stipulated period of feeding (20 to 30 min.) unconsumed feed, if any was collected on a fine mesh sieve, dried, weighed and subtracted from feed offered. Fish were deprived of feed on the day of weighing and tanks were thoroughly scrubbed and rinsed with water.

Experimental methodology

Samples of fish and diet:

Fish samples from the two experiments were randomly taken at the beginning and at the end of the experiments. Eight fish were taken for body composition analysis and carcass test. Fish samples exposed to proximate analysis were homogenized together for each treatment via ultra-turrax and oven dried (60- 80 °C for 48 hrs) then kept in vials till analysis. While viscera and liver were weighted to calculate viscerosomatic and hepatosomatic index. All diets and fish were analyzed for their proximate composition by standard AOAC methods (AOAC, 1995)

Statistical analysis:

The statistical evaluation of results was performed by using the general linear models procedure of SAS (SAS Institute, 1998) appropriate for one way design and Duncan's multiple range test (Duncan, 1955) was carried to detect the significant differences among means.

RESULTS AND DISSUCUTION

Growth performance of catfish fry and fingerlings

As presented in (Tables 3 and 4), at the end of the experiments increasing dietary protein and lipid content significantly ($P<0.05$) increased final body weight, weight gain, and SGR of catfish fry and fingerlings, respectively. The differences among the groups for averages of BW at the experimental start were insignificant ($P\geq0.05$) indicating the homogeneity of the experimental groups at the start of the experiments. Analysis of variance for final body weight in the first experiment showed that the group of fry fed diet 4 which containing (40.2 % protein, 11.80 % lipid % and 470.16 kcal/ 100g) had a significantly highest BW compared to other groups. However, the lowest significantly final body weight (30.00 and 33.91 g) were observed in groups of fry fed diets 1and 2. On the other hand, the fish group fed on diet 4 had significantly ($P<0.05$) higher SGR than the rest of experimental groups. At the end of the experiment, feed conversion

Table (1): Diet composition used for fry in experiment 1.

Ingredients	Protein levels					
	35%		40%		45%	
	Diet 1 (6 %oil)	Diet 2 (8 % oil)	Diet3 (6% oil)	Diet 4 (8 %oil)	Diet 5 (6% oil)	Diet 6 (8 %oil)
Fish meal (herring)	26	26	30	30	37	37
Soybean meal (dehulled, solvent extracted)	32	35	40	40	42	42
Yellow Corn	34	29	22	20	13	11
Corn Oil	6	8	6	8	6	8
Vitamin premix [1]	1	1	1	1	1	1
Mineral premix [2]	1	1	1	1	1	1
Total	100					
Proximate analysis:						
Moisture	5.60	5.70	5.80	5.50	5.60	5.70
Crude Protein	35.00	35.90	40.40	40.20	45.40	45.30
Crude Fat	9.80	11.70	9.80	11.80	10.10	11.20
Ash	3.50	3.50	3.70	3.70	3.70	3.70
Fiber	6.10	6.10	6.80	6.80	7.70	7.50
NFE [3]	40.00	37.10	33.50	32.00	27.50	26.60
GE (kcal/100g) [4]	454.76	465.88	458.56	470.16	464.98	471.11
P / GE ratio [5]	76.96	77.06	88.10	85.50	97.64	96. 16

Table (2): Diet composition used for fingerlings in experiment 2.

Ingredients	Protein levels					
	30%		35%		40%	
	Diet 1 (6 %oil)	Diet 2 (8 % oil)	Diet3 (6% oil)	Diet 4 (8 %oil)	Diet 5 (6% oil)	Diet 6 (8 %oil)
Fish meal (herring)	20	20	26	26	30	30
Soybean meal (dehulled, solvent extracted)	30	30	35	35	40	40
Yellow Corn	42	40	31	29	22	20
Corn Oil	6	8	6	8	6	8
Vitamin premix [1]	1	1	1	1	1	1
Mineral premix [2]	1	1	1	1	1	1
Total	100					
Proximate analysis:						
Moisture	5.8	6.6	5.6	5.7	5.8	5.5
Crude Protein	30.50	30.80	35.00	35.90	40.40	40.20
Crude Fat	9.65	11.50	9.80	11.70	9.80	11.80
Ash	3.27	3.27	3.50	3.50	3.70	3.70
Fiber	5.14	5.11	6.10	6.10	6.80	6.80
NFE [3]	45.64	42.72	40.00	37.10	33.50	32.00
GE (kcal/100g) [4]	451.10	458.00	454.76	465.88	458.56	470.16
P / GE ratio [5]	67.61	67.20	76.96	77.10	88.10	85.50

1- Vitamin mixture (per Kg feed): 10000 I.U. Vit. A, 1000 I.U. Vit. D3, 50 mg Vit. E, 100 mg Vit. B1,100 mg Vit. B2, 100 mg Vit. B6, 100 mg Vit. B12, 20mg Vit. K3,200 mg Vit. C, 500mg Nicotinic acid,500mg Inositol, 200 mg Ca- Pantothenate, 20 mg Folic acid, 5000 mcg Biotin and 2000 mg Cholinchloride.

2- Mineral mixture (per Kg feed): 16.40g CaH_2PO_4, 5.50 mg $MgSO_4 . 7H_2O$, 7.53g, NaCl, 4.50g K_2SO_4, 2.0g Fe-Gluconate, 0.40g $ZnSO_4 . 7H_2O$, 50mg $MnSO_4 . H_2O$, 15mg $CuSO_4$, 4.75 mg KI and 0.25mg $CoCl_2 . 6H_2O$.

3- Nitrogen free extract = 100 – (% Moisture + %Protein + %Fat + %Fiber + %Ash).

4- Gross Energy based on protein (5.65 Kcal/g), fat (9.45 Kcal/g) and carbohydrate (4. 11 Kcal/g). According to (NRC, 1993).

5- Protein / energy ratio. (mg protein / Kcal GE) Ingredients were obtained from local market.

ratio values were (1.4, 1.6, 1.6, 1.7, 1.8 and 1.9% /d) for fish groups fed on diets 4, 3, 6, 5, 2 and 1, respectively). There was a trend of increasing growth performance with increasing inclusion level of dietary lipid at each protein level (Table 3). These results are in agreement with the results of Jantrarotai *et al.* (1998) for *Clarias* catfish and Hassan *et al.* (1995) for other species. Dietary energy may the primary source of variation in growth rate with lower weight gain for low energy diets a result of insufficient energy consumption. A gradual increase in growth with each incremental level of dietary energy up to 470.16 kcal/ 100g GE strengthens the assumption that with increased energy more protein was utilized for tissue building and hence growth, but with supplementation above 470.16 kcal/100g dietary gross energy (diet 4) growth rate declined. A P/E ratio of 85.50 (40 mg protein/ 470.16 kcal/kg of GE) is suggested for optimum growth, in agreement with the studies on this species (Machiels and Henken, 1985). Similar trends have been obtained in Tilapia *O.niloticus* (De Silva *et al.,* 1991) and Indian major carp *Cirrhinus mrigala* (Hassan and Jafri, 1996). While, as presented in (Table 4), the differences among the groups of final BW at the end of the 2nd experiment indicating that,the group of catfish fingerlings fed diet 4 had a significantly (P<0.05) highest BW compared to the other groups. The group of catfish fingerlings fed diet 1 and 2 had a significantly lower (P<0.05) BW than the rest of experimental groups. Growth response of fish fed diet 4 sharply increased. There was a trend of increasing growth performance with increasing inclusion level of dietary lipid at each protein level on the basis of final body weight and weight gain. This trend was not maintained above 465.88 kcal/100g (35.90% protein and 11.70% lipid) diet 4 (P/E ratio 77 mg protein per kcal GE), which produced best growth performance. At low dietary energy levels protein may be used for energy, as has been demonstrated in *Clarias* catfish (Jantrarotai *et al.*, 1998) and other species (Hassan *et al.,* 1995). Dietary energy may be the primary source of variation in growth rate with lower weight gain for low energy diets a result of insufficient energy consumption. The fixed ration level (5% of body weight) used here might also have prevented the fish from consuming more feed to compensate for energy supply from low energy diets. As a result, fish presumably catabolized dietary protein to meet some of its requirements for energy rather than depositing it as growth. A P/E ratio of 77.10 is suggested for optimum growth, in agreement with the studies on this species (Machiels and Henken, 1985) and catfish, *Chrystchthys nigrodiguath* (Erondue *et al.*, 2006). These results indicate that the highest SGR values were obtained at the end of the experiment for group of catfish fed diet 4. Similar trends have been obtained in *Clarias gariepinus* (Machiels and Henken, 1985), Tilapia (*O.niloticus*) (De Silva *et al.,* 1991) and Indian major carp (*Cirrhinus mrigala*) (Hassan and Jafri, 1996). Also, these results are in complete accordance with those reported by Erondue *et al.* (2006), they showed that optimum requirement of protein was 35% for catfish fingerlings *Chrysichthys nigrodigitatus*. However, Jamabo and Alfred- Ochiya (2008) found that, growth rate and weight gain of *Heterobranchus bidorsalis* fingerlings increased progressively with dietary protein level to a maximum at 40%.

Feed utilization of catfish fry and fingerlings.

The results of feed intake (FI) during the experiment (1) were 56.16, 59.58, 72.53, 74.77, 57.05 and 58.4 g /fish for catfish fry fed on diets 1,2, 3, 4, 5, and 6, respectively with significant (P <0.05) differences among these means (Table 3). These results indicated that, as protein content in catfish fry diets increased, feed intake (FI) will be significantly increased (P<0.05). These results are in agreement with (Yamamoto *et al.*, 2000). The same trend was observed on catfish fingerlings during experiment (2) where increasing the dietary protein content from 35 to 40 % significantly increased (P<0.05) feed intake. FI for catfish fingerlings during the experimental period were 64.4, 73.00, 71.00, 72.8, 69.7 and 69.4 g / fish fed on diets 1,2, 3, 4, 5, and 6, respectively with significant (P <0.05) differences among these means (Table 4). For fry and fingerlings catfish fed diets containing 40% protein, 470.16 kcal GE /100g diet (P/E ratio of 85.5mg protein /Kcal) and 35% protein, 465.88 kcal GE /100g diet (P/E ratio of 77.10 mg protein /Kcal) consumed the higher amount of feed. Wafa (2002) found that, feed intake in hybrid tilapia (*O. niloticus x O. aureus*) increased with increasing P/E ratio 80 to 100 mg protein / Kcal and decreased when P/E ratio increased to 120 mg protein / Kcal. While, the results of FCR indicated that the best values were obtained at the end of experiment for group of catfish fed diet 4 followed in a decreasing order by diets 3, 6, 5, 2 and 1, respectively (Table 3). Moreover, feed efficiency (FE) increased as the dietary energy level increased at each protein level being highest (P <0.05) for diet 4 and lowest for diet 1. There were significant differences (P<0.05) in FE between the higher protein diets (Table 3). At the lower protein level, FE improved very slightly with increasing lipid/energy level. At the high protein level, FE was best for the 8% lipid diet (4). Improved feed conversion efficiency, up to a certain level of dietary energy inclusion (through lipid), has also been reported by earlier workers (Yamamoto *et al.*, 2000). On the other hand, FCR values obtained at the end of experiment (2) for groups of catfish fingerlings fed the experimental diets are presented in (Table 4). The results showed that group of fish fed on diet 4 was the best one. Moreover, feed efficiency increased as the dietary energy level increased at both higher protein levels being highest (P ≤0.05) for diet 4 and lowest for diet 2. There were significant differences (P <0.05) in FE among diets (Table 4).At the lower protein level, FE improved very slightly with increasing lipid /energy level. At the high protein level, FE was best for the 8% lipid diet (4). Improved feed conversion efficiency, up to a certain level of dietary energy inclusion (through lipid), has also been reported by earlier investigations on the same species (Yamamoto *et al.*, 2000), while Erondue *et al.* (2006) found that no significant differences in FE of *Chrystchthys nigrodiguath* fed on different protein levels. *Clarias gariepinus* fingerlings fed the high protein / high lipid diet (6) exhibited a reduction in FE. This could be attributed to reduced feed intake by those fish, because of the high energy content of the diet, resulting in lower protein intake (Daniels and Robinson, 1986), or to the hindrance of digestion and absorption of other nutrients by the high energy content in the diet (Dupree *et al.,* 1979). On the other hand, the results of PER indicated that the highest PER values were obtained at the end of experiment for the groups of fry fed diet 4 followed in a decreasing order by diets 3, 2, 1, 6, and 5, respectively. Protein utilization, measured in term of PER, increased to some extent with increasing dietary lipid at higher protein levels suggesting improved use of dietary protein for growth up to 470.16 kcal/100g GE (diet 4). PER declined for diets containing the highest dietary protein levels. The pattern of changes in PER in relation to dietary energy is similar to observations on hybrid Clarias catfish (Jantrarotai *et al.,* 1998), Indian major *carp* (*Cirrhinus mrigala*) (Hassan *et al.,* 1995), Nile tilapia (*O.niloticus*) and African catfish (*Clarias gariepinus*) (Machiels and Henken, 1985). Several factors, including dietary energy content and source, influence protein utilization (Steffens, 1981). However, the results of experiment (2) cleared that the highest PER values were obtained at the end of experiment for group of catfish fed diet 4 followed in a decreasing order by diets 1,3,2,6 and 5, respectively. Protein utilization, measured in term of PER increased to some extent with increasing dietary lipid at both higher protein levels suggesting improved use of dietary protein for growth up to 469.64 kcal/100g GE (diet 4). PER declined for diet 6 containing the highest dietary energy level. The pattern of changes in PER in relation to dietary energy is similar to observations on hybrid Clarias catfish (Jantrarotai *et al.,* 1998), Indian major carp (*Cirrhinus mrigala*) (Hassan *et al.,* 1995), Nile tilapia (*O.niloticus*) and African catfish *Clarias gariepinus* (Machiels and Henken, 1985). As present in Table (3 and 4) there were significant differences (P≤0.05) among groups of catfish fry and fingerlings fed different protein and oil levels. The groups of fry and fingerlings fed diet 4 in both of the first and second experiment (40% protein, 8% oil) and (35% protein, 8% oil), respectively had significantly higher survival rate (92% and 96%).

Table (3): Means of growth performance, feed and nutrient efficiency±SD of *Clarias gariepinus* fry fed various protein and lipid levels for 120 days.

Parameters	Diet number (Designation protein /lipid %)					
	1 (35/6)	2 (35/8)	3 (40/6)	4 (40/8)	5 (45/6)	6 (45/8)
Average initial weight(g)	$0.80^{a}\pm0.06$	$0.81^{a}\pm0.04$	$0.82^{a}\pm0.01$	$0.810^{a}\pm0.01$	$0.84^{a}\pm0.02$	$0.82^{a}\pm0.06$
Average final weight (g).	$30.00^{f}\pm9.34$	$33.91^{e}\pm6.93$	$46.12^{b}\pm5.68$	$54.70^{a}\pm6.17$	$34.40^{d}\pm8.24$	$37.32^{c}\pm5.76$
Average weight gain (g)	$29.20^{f}\pm10.27$	$33.10^{e}\pm6.87$	$45.33^{b}\pm5.71$	$53.89^{a}\pm6.17$	$33.56^{d}\pm8.35$	$36.5^{c}\pm3.84$
Feed conversion ratio[1]	$1.9^{e}\pm0.13$	$1.8^{d}\pm0.09$	$1.6^{b}\pm0.08$	$1.4^{a}\pm0.08$	$1.7^{c}\pm0.04$	$1.6^{b}\pm0.09$
Specific growth rate (%/day)[2]	$3.00^{d}\pm0.50$	$3.11^{d}\pm0.30$	$3.40^{b}\pm0.24$	$3.50^{a}\pm0.19$	$3.10^{d}\pm0.24$	$3.2^{c}\pm0.17$
Feed intake (g/ fish)	$56.16^{f}\pm0.9$	$59.58^{c}\pm0.8$	$72.53^{b}\pm1.01$	74.77a±0.7	$57.05^{e}\pm0.8$	$58.4^{d}\pm2.00$
Protein intake (g/fish)[3]	$19.42^{f}\pm7.48$	$21.39^{e}\pm3.96$	$29.30^{b}\pm4.95$	$30.06^{a}\pm1.05$	$25.90^{d}\pm0.49$	$26.46^{c}\pm3.37$
Protein efficiency ratio (PER)[4]	$1.50^{c}\pm0.39$	$1.55^{b}\pm0.27$	$1.55^{b}\pm0.25$	$1.79^{a}\pm0.18$	$1.30^{e}\pm0.09$	$1.38^{d}\pm0.22$
Feed efficiency (FE)[5]	$0.52^{e}\pm0.34$	$0.56^{d}\pm0.28$	$0.62^{b}\pm0.18$	$0.72^{a}\pm0.18$	$0.59^{c}\pm0.32$	$0.63^{b}\pm0.29$
Survival rate (%)	80^{a}	85^{b}	90^{d}	92^{f}	88^{c}	88^{c}

Table (4): Means of growth performance, feed and nutrient efficiency ± SD of *Clarias gariepinus* fingerlings fed various proteins and lipid levels for 120 days

Parameters	Diet number (Designation protein /lipid %)					
	1 (30/6%)	2 (30/8%)	3 (35/6%)	4 (35/8%)	5 (40/6%)	6 (40/8%)
Average initial weight (g).	$13.4^{a}\pm0.16$	$13.2^{a}\pm0.04$	$13.1^{a}\pm0.06$	$13.00^{a}\pm0.06$	$13.2^{a}\pm0.12$	$13.00^{a}\pm0.02$
Average final weight(g)	$49.2^{f}\pm6.37$	$51.6^{e}\pm3.73$	$57.5^{b}\pm1.08$	$61.5^{a}\pm4.83$	$54.2^{d}\pm4.31$	$56.4^{c}\pm1.17$
Average weight gain (g)	$35.80^{f}\pm5.71$	$38.40^{e}\pm6.87$	$44.40^{b}\pm10.12$	$48.50^{a}\pm4.00$	$41.00^{d}\pm8.50$	$43.40^{c}\pm7.94$
Feed conversion ratio[1]	$1.8^{d}\pm0.11$	$1.9^{f}\pm0.2$	$1.6^{b}\pm0.11$	$1.5^{a}\pm0.10$	$1.7^{c}\pm0.12$	$1.6^{b}\pm0.20$
Specific growth rate (%/ day)[2]	$1.1^{c}\pm0.23$	$1.1^{c}\pm0.12$	$1.2^{b}\pm0.03$	$1.3^{a}\pm0.10$	$1.2^{b}\pm0.12$	$1.2^{b}\pm0.05$
Feed intake (FI, g/ fish)	$64.4^{d}\pm9.48$	$73.00^{a}\pm3.96$	$71.00^{c}\pm4.95$	$72.8^{b}\pm2.95$	$69.7^{c}\pm8.24$	$69.4^{c}\pm6.37$
Protein intake (g / fish)[3]	$19.64^{f}\pm5.82$	$22.46^{e}\pm2.01$	$24.85^{d}\pm3.92$	$26.13^{c}\pm3.21$	$28.16^{a}\pm1.05$	$27.89^{b}\pm2.90$
Protein efficiency ratio (PER)[4]	$1.82^{a}\pm0.17$	$1.71^{b}\pm0.09$	$1.78^{b}\pm0.05$	$1.86^{a}\pm0.15$	$1.45^{d}\pm0.13$	$1.56^{c}\pm0.11$
Feed efficiency (FE)[5]	$0.55^{c}\pm0.05$	$0.53^{d}\pm0.03$	$0.62^{b}\pm0.02$	$0.67^{a}\pm0.05$	$0.58^{c}\pm0.07$	$0.62^{b}\pm0.10$
Survival rate (%)	88^{e}	90^{d}	94^{b}	96^{a}	92^{c}	92^{c}

* Means in the same row having the same superscript letter are not significantly difference (P ≥ 0.05)
Feed conversion ratio (F.C.R)[1] =Feed given per fish (g) / weight gain per fish (g) (De Silva and Anderson, 1995)
Specific growth rate (SGR[2]= Ln final weight – Ln initial weight / time (days) according to (Jauncey and Ross, 1982)
Protein intake (PI)[3]= Feed intake × Protein % in diets
Protein efficiency ratio (PER)[4]= weight gain per fish (g) / protein intake (g) as reported by (De Silva and Anderson, 1995).
Feed efficiency (FE)[5]= weight gain / feed consumed.

Body Composition:

Body composition data for whole fish carcasses in experiment 1 are shown in (Table 5). At the end of the experiment, all experimental groups exhibited higher percentages of protein and lipid (particularly at high dietary lipid percent), lower percentages of moisture and similar percentages of ash. Body moisture content decreased with increased dietary energy level and the highest value was found for the lowest dietary energy level at each protein level. There was an inverse relationship between moisture and lipid content as reported before by (Abdelhamid *et al.*, 1997, 1998, 2005, and 2007). Body ash contents remained almost constant as reported in previous experiments with African catfish, *Clarias gariepinus* (Abdelhamid, 1988). Body protein content was highest in fish fed diet 6 and lowest in fish fed diet 1, while body lipid content was highest in fish fed diet 4 and lowest in fish fed diet 1. The trend was of increasing (P <0.05) body lipid content with increasing dietary energy at each protein level and this increase was less noticeable at the higher protein level (Table 4). These observations seem in general in agreement with results reported for African catfish, *Clarias gariepinus* (Henken *et al.*, 1986), Indian major carp (Hassan *et al.*, 1995) and trout (Yamamoto *et al.*, 2000). Fattiness is often undesirable in fish cultured for food and increasing the dietary protein level may be a strategy for producing a leaner product (Abdelhamid, 1988); while the results in (Table 6) indicated that, carcass lipid levels were higher in fish fingerlings fed the higher protein diets. These observations seem in general agreement with results reported for African catfish, *Clarias gariepinus* (Henken *et al.*, 1986), Indian major carp (Hassan *et al.*, 1995) and trout (Yamamoto *et al.*, 2000). These results could not support the argument that a higher dietary protein level is not likely to cause a significant increase in body lipid content as conversion of amino acids to deposit lipids has an energetic efficiency of only 53% (Black, 1995). Body lipid and body moisture were inversely related, while body protein and body ash contents remained almost constant as reported in previous experiments with African catfish, *Clarias gariepinus* (Abdelhamid, 1988). Body lipid content was highest in fish fed diet 6 and lowest in fish fed diet 1. The trend was of increasing (P <0.05) body lipid content with increasing dietary energy at each protein level (Table 6). There was an inverse relationship between moisture and lipid content as reported by Abdelhamid (1988) and Abdelhamid *et al.* (1997, 1998, 2005 and 2007).

Table (5): Effect of protein and lipid levels on body composition (% wet weight) of *Clarias gariepinus* fry at the start and end of the experiment.

Item	Initial	Diet Number (Designation protein /lipid)					
		1 (35/6%)	2 (35/8%)	3 (40/ 6%)	4 (40/ 8%)	5 (45/6%)	6 (45/8%)
Moisture	74.12	$72.90^{a}\pm1.77$	$70.70^{c}\pm1.23$	$71.64^{b}\pm0.67$	$69.50^{d}\pm0.83$	$71.50^{d}\pm1.86$	$69.30^{d}\pm0.99$
Crude Protein	15.52	$17.29^{e}\pm 0.40$	$17.40^{d}\pm 0.73$	$18.20^{c}\pm 0.29$	$18.60^{b}\pm 0.58$	$18.60^{b}\pm 0.79$	$18.80^{a}\pm0.59$
Ether Extract	7.74	$7.50^{f}\pm0.49$	$9.20^{c}\pm 0.49$	$7.80^{e}\pm 0.49$	$9.40^{a}\pm0.41$	$7.90^{d}\pm0.67$	$9.30^{b}\pm0.62$
Ash	2.63	$2.31^{a}\pm0.11$	$2.70^{a}\pm 0.29$	$2.36^{a}\pm0.32$	$2.50^{a}\pm0.10$	$2.00^{a}\pm 0.35$	$2.60^{a}\pm0.14$

Values are means ±SD of three replications. Means in the same row having different superscripts are significantly different (P <0.05)

Table (6): Effect of protein and lipid levels on body composition (% wet weight) of fingerlings *Clarias gariepinus* at the start and end of the experiment.

Item	Initial	Diet Number (Designation protein /lipid)					
		1 (30/6%)	2 (30/8%)	3 (35/6%)	4 (35/8%)	5 (40/6%)	6 (40/8%)
Moisture	74.12	$73.11^{a}\pm0.42$	$72.61^{a}\pm0.42$	$71.50^{c}\pm1.06$	$71.90^{b}\pm1.77$	$71.64^{c}\pm0.67$	$69.50^{e}\pm0.83$
Crude Protein	15.00	$16.40^{f}\pm0.32$	$16.19^{e}\pm0.99$	$17.29^{d}\pm0.40$	$17.40^{c}\pm0.73$	$18.20^{b}\pm0.29$	$18.60^{a}\pm0.58$
Ether Extract	7.70	$7.39^{f}\pm0.19$	$8.30^{b}\pm 0.10$	$7.50^{e}\pm 0.49$	$8.20^{a}\pm0.49$	$7.80^{d}\pm0.67$	$9.30^{b}\pm0.41$
Ash	2.66	$2.31^{a}\pm0.0.5$	$2.90^{a}\pm0.25$	$2.31^{a}\pm0.11$	$2.50^{a}\pm0.29$	$2.36^{a}\pm0.32$	$2.50^{a}\pm0.10$

Values are means ±SD of three replications. Means in the same row having different superscripts are significantly different (P <0.05)

Effect of protein and lipid levels on VSI and HIS.

As shown in (Table7), liver lipid deposition levels were higher with increasing dietary lipid at lower protein levels. This result compares favorably with other results obtained for this species (Pantazis, 1999). VSI and HSI did not vary significantly (P ≥0.05) among the test groups. Higher VSIs were found for lower protein diets in other studies (Gallagher, 1999). HSI was insignificantly increased with increasing dietary lipid /energy, probably due to higher liver lipid and liver glycogen accumulation as a result of lower dietary protein to energy ratios (McGoogan and Gatlin III, 1999). While, the values of VSI in Table 8 did not vary significantly (P ≥0.05) among the test groups. There was a trend toward higher VSI and HSI in higher protein diets. VSI increased slightly with increasing dietary lipid /energy level (decreasing P/E ratio) at either dietary protein levels. Higher VSIs were found for higher protein diets in disagreement with earlier studies (Gallagher, 1999). HSI was significantly lower in fish fed the lower protein diets and there was a trend of gradually increased HSI with increasing dietary lipid / energy, probably due to higher liver lipid and liver glycogen accumulation as a result of lower dietary protein to energy ratios (McGoogan and Gatlin III, 1999). As shown in Table (8), liver lipid level increased with dietary lipid level at each protein level and liver lipid levels were higher at the higher protein levels. Deposition of liver lipid showed a strong correlation (Y = -15.4 + 1.35X; r = 0.17; P <0.05) with dietary energy level. This is in agreement with studies on *Clarias gariepinus* (Machiels and Henken, 1985), American eel (Tibbetts *et al.*, 2000) and Indian major carp (Hassan *et al.*, 1995). As with carcass lipid, increasing dietary lipid at each protein level also resulted in greater accumulation of liver lipid. The positive correlation noted between dietary energy and liver lipid content compares favorably with other results obtained for this species *Clarias gariepinus* (Pantazis, 1999).

Table (7): Effect of protein and lipid levels on liver lipid, viscerosomatic index (VSI) and hepatosomatic index (HSI) of fry *Clarias gariepinus.*

Parameters	Diet number (Designation protein /lipid %)					
	1 (35/6)	2 (35/8)	3 (40/6)	4 (40/8)	5 (45/6)	6 (45/8)
Liver lipid %	11.52^{c}±3.18	14.58^{a}±1.58	11.80^{c}±0.80	13.3^{b}±0.90	11.60^{c}±0.60	13.30^{b}±0.90
VSI^{1} %	8.18^{a}±0.60	8.23^{a}±0.80	8.30^{a}±0.30	8.20^{a}±0.10	8.30^{a}±0.20	8.30^{a}±0.30
HSI^{2} %	1.70^{a}±0.20	1.90^{a}±0.30	1.80^{a}±0.40	2.00^{a}±0.60	1.70^{a}±0.30	1.80^{a}±0.20

Table (8): Effect of protein and lipid levels on liver lipid, viscerosomatic index (VSI) and Hepatosomatic index (HSI) of fingerlings *Clarias gariepinus.*

Parameters	Diet Number (Designation protein /lipid %)					
	1 (30/6)	2 (30/8)	3 (35/6)	4 (35/8)	5 (40/6)	6 (40/8)
Liver lipid %	11. 20^{c}± 0.22	13.40^{a}± 0.60	11.40^{c}± 0.33	14.60^{a}±0.90	11.60^{c}±0.56	13.40^{a}±082
VSI^{1} %	8.20^{a}± 0.22	8.30^{a}±0.40	8.22^{a}± 0.22	8.33^{a}±0.36	8.45^{a}±0.24	8.60^{a}±0.30
HSI^{2} %	1.60^{a}±0.20	1.80^{a}±0.33	1.62^{b}±0.40	2.00^{a}±0.44	1.60^{a}±0.33	1.90^{a}±0.22

Values are means ±SE of three replications. Means in the same row having different superscripts are significantly different (P <0.05).
1 Viscero Somatic Index (VSI) = weight of gut / weight of fish x 100 according to (El- Magraby *et al.*, 1972).
2 Hepato Somatic Index (HSI) = weight of liver / weight of fish x 100

Economic study:

Economical efficiency of the experimental diets was calculated, based on the price of ingredients in 2006. As presented in (Table 9) feed cost per Kg gain (LE) was lowest for diet 4 (5.95LE) and increased in diet 5 (8.25LE). The relative percentage of feed cost /Kg fish was 72, 81, 85, 88 and 92 for diets 4, 3, 2, 1 and 6, respectively. Moreover, the relative percentage of feed cost / Kg gain was found to be 72, 80, 85, 87 and 92 (LE) for diets 4, 3, 2, 1 and 6, respectively. The results indicated that diet 4 which contains 40% protein and 8% oil improved growth and feed utilization parameters and reduced the cost of production of Kg of catfish fry. While, calculations of economical efficiency of the experimental diets in experiment 2 presented in (Table 10) showed that, feed cost per Kg gain (LE) was lowest for diet 4 (5.85LE) and increased in diet 5 (7.06 LE). The highest relative percentage of feed cost /Kg fish was 83, 86, 87, 91, 98 and 100 for diets 1, 4, 3, 2, 6 and 5, respectively. Moreover, the relative percentage of feed cost / Kg gain was found to be 83, 86, 87, 93, 96 and 100 (LE) for diets 4, 3, 1, 2, 6 and 5, respectively. The results indicated that diet 4 which contains 35% protein and 8% oil improved growth and feed utilization parameters and reduced the cost of production of Kg of catfish fingerlings.

CONCLUSION

This study revealed that the optimum dietary protein, oil and gross energy were 40%, 8% and 465.68 kcal /100g diet, respectively for African catfish fry, *C.gariepinus*. While, the optimum dietary protein, oil and gross energy were 35%, 8% and 465.88 kcal /100 g diet, respectively for African catfish fingerlings *C. gariepinus.* These findings could be recommended to obtain the highest growth performance, survival rate and economic efficiency.

Table (9): Cost of feed required for producing one Kg gain of fry *Clarias gariepinus* fed the Experimental diets in experiment 1

Item	Diet 1	Diet 2	Diet 3	Die 4	Diet 5	Diet6
Cost/Kg diet (LE)	3.80	3.90	4.15	4.25	4.85	4.75
Consumed feed to produce 1 Kg fish (Kg)[1]	1.87	1.76	1.57	1.37	1.66	1.56
Feed cost /Kg fish (LE)[2]	7.11	6.86	6.52	5.82	8.05	7.41
Relative %of feed cost/ kg fish[3]	88	85	81	72	100	92
Feed cost / kg gain (LE)[4]	7.22	7.02	6.64	5.95	8.25	7.6
Relative % of feed cost of Kg gain[5]	87	85	80	72	100	92

Table (10): Cost of feed required for producing one Kg gain of fingerlings *Clarias gariepinus* fed the Experimental diets in experiment 2

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet6
Cost/Kg diet (LE)	3.4	3.45	3.8	3.9	4.15	4.25
Consumed feed to produce 1 Kg fish (Kg)[1]	1.31	1.41	1.23	1.18	1.29	1.23
Feed cost /Kg fish (LE)[2]	4.45	4.87	4.67	4.60	5.35	5.23
Relative %of feed cost/ kg fish[3]	83	91	87	86	100	98
Feed cost / kg gain (LE)[4]	6.12	6.56	6.08	5.85	7.06	6.8
Relative % of feed cost of Kg gain[5]	87	93	86	83	100	96

1-Feed intake per fish per period / final weight per fish kg/ Kg
2-Step 1x step 2
3-Respective figures for step 3 / highest figure in this step
4-Feed intake per Kg gain x step 1
5-Respective figures for step 5 / highest figure in this step
Cost of 1 Kg ingredients used were 9 LE for fish meal, 1.70LE for soybean meal, 1.40 LE for yellow corn, 7 LE for oil, 5 LE for Vit. & Min.
Egypt feed ingredients price in 2006.

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تاثير مستويات البروتين و الزيت على أداء النمو لسمك القرموط الأفريقى

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**الهيئة العامة للثروة السمكية- الإسماعيلية- مصر

أجريت هذة الدراسة فى تجربتين منفصلتين بمركز بحوث الأسماك بكلية الزراعة- جامعة قناة السويس- الاسماعيلية- لدراسة تأثير مستويات مختلفة من البروتين والزيت على كل من أداء النموو معدل البقاء وتركيب الجسم و التقييم الإقتصادى لزريعة وإصبعيات سمك القرموط الأفريقى. **التجربة الاولى:** تم استخدام ثلاثة مستويات من البروتين (٣٥، ٤٠، ٤٥%) ومستويين من الزيت (٦، ٨ %) تحت كل مستوى من البروتين وقد غذيت عليها ٩٠٠ زريعة بمتوسط وزن (٠,٨ ± ٠,٢جم) تم رعايتها فى ستة مجموعات لمدة ١٢٠ يوم فى أحواض بلاستيكية تحت الظروف المثلى. أظهرت النتائج إرتفاع معدلات النمو و البقاء والتقييم الإقتصادى لمجموعة الزريعة التى غذيت على عليقة تحتوى على ٤٠% بروتين و ٨ % زيت تحت مستوى طاقة كلية ٤٧٠,١٦ كيلو كالورى/١٠٠جم عليقة. **التجربةالثانية:** تم فيها إستخدام ثلاث مستويات من البروتين (٣٠، ٣٥، ٤٠%) ومستويين من الزيت (٦، ٨ %) تحت كل مستوى من البروتين وقد غذيت عليها ٤٥٠ اصبعية بمتوسط وزن (١٣ ± ٠,٢جم) تم رعايتها فى ستة مجموعات لمدة ١٢٠ يوم فى أحواض من الفيبرجلاس تحت الظروف المثلى. أظهرت النتائج أن أعلى أداء للنمو ومعدل البقاء والتقييم الإقتصادى كان لمجموعة الأصبعيات التى غذيت على عليقة تحتوى على٣٥% بروتبن و٨ % زيت بمستوى طاقة كلية ٤٦٥,٨٨ كيلو كالورى/١٠٠جم عليقة.

وعلى ذلك يمكن الإستنتاج من هذه الدراسة أن الإحتياجات الغذائية لكل من زريعة وإصبعيات سمك القرموط الأفريقى تحت ظروف التجربة كانت ٤٠ % بروتين، ٨ % زيت و٣٥ % بروتبن، ٨ % زيت- على التوالى- ومن ثم يمكن تطبيق ذلك للحصول على أعلى أداء للنمو والبقاء وكذا تحسين الكفاءة الإقتصادية.