Review Article on Protein and Energy Requirements of Tilapia and Mullet

Alaa A. El-Dahhar
Animal and Fish Production Department Faculty of Agriculture (Saba Basha)
Alexandria University

ABSTRACT

Tilapia and mullet requirements for protein and energy have been extensively investigated. Although, studies on mullet species are little but the information need for feeding and nutrients requirements of mullets led us to review them to be available for researchers and famers. Results of research studies indicated that optimum dietary protein and energy requirements of both species affected by several factors such as stoking density, feeding rate and protein to energy ratio. Growth declines with increasing stocking density. Several studies have shown that providing adequate energy with dietary lipids can minimize the use of more costly protein as an energy source. However, increasing energy may produce fatty fish, reduce feed consumption and inhibit the utilization of other feed stuffs. A guide of feeding of Nile tilapia could be developed using feed consumption and FCR to establish a wide range of conditions from which feeding rate could be calculated. The formulation of diets for a fish species needs special understanding for the nutritional requirements of these species. The results of both species are of great importance for reducing farm costs and increasing profitability.

Key words: Nile tilapia, mullet, requirements, protein, energy, feeding guide tilapia.

INTRODUCTION

Tilapia and mullets are the most important fish species for mono and polyculture in Egypt. Nile tilapia (*Oreochromis niloticus*) constitutes about 70% of the Nile and lakes catch. They are important for their palatability, high nutritive value, reasonable price, high growth rate, reproduction and tolerance to adverse water quality (Balarian, 1979 and Ishak, 1980). Also, mullets (*Mugillidae*) are a promising species for commercial aquaculture and have strong market demand and high price in many countries (e.g. Brazil, Cuba, Colombia, Venezuela, Spain, Egypt and elsewhere) (Benetti and Fagundes Netto 1991, Guinea and Fermandez, 1991 and El-Dahhar, 2000 a).

Proteins are the major organic material in fish tissue, constituting about 45 to 75% of the total body consumption on dry matter basis (Hepher *et al*., 1983). Determination of protein and energy requirements of fish is of great importance for reducing production costs and hence increases the farm profitability. This kind of work was done for tilapia (Winfree and Stickney, 1981; Jackson *et al*., 1982; Wang *et al.* 1985; Shiau and Huang, 1989 and 1990; Wu *et al.*, 1994 & 1995 and El-Dahhar *et al.*, 1999b & 2000, El-Dahhar 2000a, Cho and Jo, 2002, El-Sayed *et al.*, 2003, Ahmad *et al.*, 2004 and Khattab *et al.*, 2004). It has also been determined for mullets (Albertini-Berhaut, 1974; Alexis and Papaparaskeva-Papoutsoglou, 1986; Papaparaskeva-Papoutsoglou and Alexis, 1986; and El-Dahhar, 2000 b and c). The results of these research studies have shown that optimum dietary protein level for maximum weight gain of tilapia ranges from 20-56% dietary crude protein level, while, the optimum dietary protein requirements of mullet ranges from 15-45%.

However, variations in protein requirements could be due to different reasons; including fish stocking density, feeding rate, feeding quality, fish size, and water temperature (Green and Teicher-Coddington, 2000). Jauncy and Ross (1982) summarized the factors affecting the optimum dietary protein level for fish and other animals to be protein to energy ratio, amino acid profile, digestibility of dietary protein, physiological state of the fish and feed intake.

Factors affecting the protein and energy requirements

Effect of fish stocking density

Green and Teicher-Coddington, (2000) estimated growth functions and weekly feed consumption of the newly hatched tilapia based on specific growth rate recorded in several experiments. Also, Dambo and Rana (1992) presented data on the growth rate of Nile tilapia, 28 days post hatch. Growth of fry was recorded weekly at five stocking densities (2, 5, 10, 15 and 20 fish/L) adapted from the data of Dambo and Rana (1992) and Green and Teicher-Coddington, (2000) (Table 1). While, daily feeding ration is calculated based on fish growth data presented in Table 1 using a declining basis every 7 days (Table 2).

Table 1: ***The individual weight of early life stage of tilapia based on specific growth rate adapted from the data of Dambo and Rana (1992) and Green and Teicher-Coddington, (2000). Estimated fish growth is given weekly for different stocking rate.***

	Fish stocking rate				
	2 fish/L	5 fish/L	10 fish/L	15 fish/L	20 fish/L
Day	(mg/fish)				
1	10.56	10.56	10.56	10.56	10.56
7	35.64	33.25	32.93	31.54	31.48
14	147.35	126.71	124.13	113.04	112.57
21	609.16	482.93	467.91	405.16	402.57
28	2,518.26	1,840.61	1,763.74	1,452.14	1,439.65

Table 2: ***The daily feed consumption per fish during 28-d sex reversal treatment period calculated weekly. Daily ration were calculated as a declining percent of the fish biomass from fish growth data presented in Table 1. Data are adapted from the data of Dambo and Rana (1992) and Green and Teicher-Coddington, (2000). Estimated ration is given for different stocking rate.***

	Fish stocking rate				
	2 fish/L	5 fish/L	10 fish/L	15 fish/L	20 fish/L
Day	(mg/fish)				
1	3.80	3.80	3.80	3.80	3.80
7	12.83	11.97	11.86	11.35	11.33
14	30.94	26.61	26.07	23.74	23.64
21	111.91	87.70	84.84	72.93	72.44
28	251.82	184.06	176.37	145.21	143.97

[1] Daily ration calculated weekly as: fish weight X % biomass feeding rate. Feeding rates used in calculation were: 36% of biomass/d for days 1-7; 21% of biomass/d for days 8-14; 15% of biomass/d for days 15-21; and 10% of biomass/d for days 22-28.

Feeding rates used in the calculations adapted from Dambo and Rana (1992) and Green and Teicher-Coddington, (2000) were: 36, 21, 15 and 10 % of biomass/d for days 1-7; 8-14; 15-21; and 22-28 respectively (Table 2). Obviously, growth declines with increasing stocking density (Table 1) and hence the individual feed consumption declines with the increase of the fish stocking density (Table 2).

The effects of stocking density and dietary protein level on performance of Nile tilapia were studied by Khattab *et al.* (2004). The fish stocking densities were 15 or 30 fish / 100 L of water, while diets were 25, 35 or 45 % crude protein. Maximum growth of fish (initial size 1.8-2.5 g) was obtained with the 45 % protein level diet at the low stocking density. Poorest growth was on the 25 percent protein diet in fish stocked at high density. In a related study Ahmad *et al.,* (2004) fed fry, fingerlings and adult Nile tilapia diets containing 25, 35 or 45 % crude protein to study their effects on fish performance. The dietary protein was a mixture of fish meal, soybean meal, wheat bran and ground corn. All diets were nearly isocaloric. The best growth for fry exhibited with 45 % crude protein diet, while fingerlings and adult grow the same with 35 and 45 % protein diets. Protein level also impacted FCR.

Effect of feeding rate

Feeding rate is affected by major factors e.g. maintenance and maximum growth requirements and feed utilization (Hepher *et al*., 1983). Under intensive farming conditions, fish growth depends to large extent on supplementary feed, whereas the cost of feed constitutes an appreciable portion of the total production costs. Taking into account the fish nutritional requirements and the diet composition in the determination of the feeding rate may help in saving feed and increasing fish growth rate and hence increasing the income of the fish farms. Thus, many authors have investigated the optimum protein level for the best growth and feed utilization of tilapia (Hepher *et* al., 1983; De Silva et al., 1989; Clark et al. 1990; El-Dahhar, 1993; and El-Dahhar *et al.*, 1999 a and b) and also for mullet (Brusle, 1981; Papaparaskeva-Papoutsoglou and Alexis 1986; Benetti and Fagundes-Netto, 1991; Guinea and Fermander, 1991; and El-Dahhar, 2000 b).

An interaction between feeding rate and the concentration of protein in the diet has been found in many fish species reared in several conditions. Weight gain of catfish decreased linearly as dietary protein level increased at a satiate rate of feeding, while, when the fish were fed at a restricted feeding rate, weight gain increased linearly as dietary protein level increased (Li and Lovell, 1992). They also stated that feed allowance of the fish fed at the satiate rate of feeding decreased with the increase of protein level and was not affected when the fish were fed at restricted rate of feeding. These reports indicated that when the fish were fed at satiate rate of feeding, they get all energy requirements and the increase in dietary protein reduce growth rate linearly with the rate of increment due to the low feed consumption (Mangalik 1986; Li and Lovell, 1992a and b). However, when the fish fed at restricted feeding part of the energy requirements has received and so, the increase in the dietary protein contents may cover the remaining part of it and hence, increasing dietary protein level, increase the fish growth rate (Li 1989; Reis *et al*, 1989 and El-Dahhar and Lovell 1995). Moreover, adequate energy in the form of dietary lipid spares the protein to perform its function, i.e. build-up of tissues (Parazo 1990). However, a high level of energy may produce fatty fish and decrease feed consumption (Page and Andrews 1973; Prather and Lovell 1973). The effects of dietary energy level combined with the number of meals provided daily to Nile tilapia were studied (Cho and Jo, 2002). Low and high energy levels and one, two or three meals a day with the same amount of feed offered daily for the three treatments. These treatments were evaluated in two experiments; one in winter and the other in summer. The authors reported that high energy diets are not needed to improve performance in either season, but two meals a day during summer improve performance, whereas one meal a day is sufficient during winter.

Feeding Nile tilapia (7.2g initial BW) at satiation rate using 32% crude protein diet, fish weighted 22.9g after 4 weeks with FCR was found to be 1.7 (El-Dahhar, 2000 a). On the other hand, using 3% of BW restricted feeding daily by a diet containing 32% dietary crude protein, Nile tilapia grow from 4.5g to 6.4g in 5 weeks with FCR about 3.0 (Srour, 1999). The very low feeding rate used by Srour, 1999, decreased growth rate sharply and decline FCR of Nile tilapia. In an attempt to increase growth rate of tilapia and improve the Egyptian fish farms profitability a feeding guide for tilapia has been done (El-Dahhar, 2000 a).

El-Dahhar, 2000a reported a feeding guide for tilapia depending on the calculation of the Hatchery Constant (HC) (Table3). $HC = 3 \times conversion \times \Delta L \times 100$ according to Ensminger and Olentine (1978). The calculation of feed as a percentage of the fish body weight daily was calculated by the equation $(3 \times FCR \times \Delta L \times 100)/L$ *in inches* according to Haskell (1959).

In Table (3), the wide range of $HC\ (5\text{–}20)$ enables the fish farmers to feed tilapia in different water quality using daily feeding rate predicted in advance. Adjustment of feeding rate and frequency of used feed could be calculated by sampling and measuring fish to calculate the proper *HC* of the area in which the farm located. Determination of feeding rate needs some idea on the fish size, water temperature, biomass in the culture vessel (De Silva and Anderson, 1995).

The relationship between specific growth rate and the ration of specific size of fish at a specific temperature also should be taken into consideration as feeding rate determined. In several experiments on sex reversed Nile tilapia from hatch to marketable size using the hatchery constant calculations Amer 2007 stated that FCR improved from 1.6 during the fry period (0.01- 7.49g) to 1.4 during the fingerlings period (15.0-256g) and also improved to 0.83 during the growing period (95-213g).

Table (4) is designed to show the effect of fish species and the fish size on feeding rate adapted from different research studies. Baloyi *et al.*(1995) reported that *O. mossambicus* fry fed at 3, 4.5 and 6% of body weight on trout pellets and bream pellets, feed intake and feed conversion efficiency were not affected by type of feed or feeding frequency. Dissolved oxygen was not affected by type of feed or feeding frequency but decreased with increasing feeding level.

Table 3: ***Feeding guide for Nile tilapia. Adapted from El-Dahhar, 2000a.***

Length in In.:	**0.469**	**0.815**	**1.142**	**1.476**	**1.823**	**2.169**	**2.516**	**2.862**	**3.209**	**3.555**	**3.902**	**4.248**	**4.594**	**4.941**
Cm:	**1.19**	**2.07**	**2.90**	**3.75**	**4.63**	**5.15**	**6.39**	**7.27**	**8.15**	**9.03**	**9.91**	**10.79**	**11.67**	**12.55**
Weight g	**0.02**	**0.14**	**0.43**	**1.11**	**1.76**	**2.70**	**4.20**	**6.46**	**9.90**	**14.4**	**19.9**	**25.0**	**31.5**	**39.0**
Number/Kg	**50,000**	**7,143**	**2,326**	**901**	**568**	**385**	**238**	**155**	**101**	**70**	**50**	**40**	**32**	**26**
Hatchery Constant	**Percent of body weight to feed daily**													
5.0	**10.7**	**5.6**	**5.3**	**3.4**	**2.8**	**2.3**	**1.9**	**1.7**	**1.5**	**1.3**	**1.2**	**1.1**	**1.0**	**0.9**
5.5	**11.7**	**6.2**	**4.7**	**3.8**	**3.1**	**2.6**	**2.1**	**1.8**	**1.6**	**1.4**	**1.3**	**1.2**	**1.1**	**1.0**
6.0	**12.8**	**6.7**	**5.1**	**4.1**	**3.3**	**2.8**	**2.3**	**2.0**	**1.7**	**1.5**	**1.4**	**1.3**	**1.2**	**1.1**
6.5	**13.9**	**7.3**	**5.5**	**4.5**	**3.6**	**3.0**	**2.5**	**2.2**	**1.9**	**1.7**	**1.5**	**1.4**	**1.3**	**1.2**
7.0	**14.9**	**7.9**	**6.0**	**4.8**	**3.9**	**3.3**	**2.7**	**2.3**	**2.0**	**1.8**	**1.6**	**1.5**	**1.4**	**1.3**
7.5	**16.0**	**8.4**	**6.4**	**5.2**	**4.2**	**3.5**	**2.9**	**2.5**	**2.2**	**1.9**	**1.7**	**1.6**	**1.5**	**1.4**
8.0	**17.1**	**9.0**	**6.8**	**5.5**	**4.5**	**3.7**	**3.1**	**2.7**	**2.3**	**2.1**	**1.9**	**1.7**	**1.6**	**1.5**
8.5	**18.1**	**9.6**	**7.3**	**5.9**	**4.7**	**3.9**	**2.3**	**2.8**	**2.5**	**2.2**	**2.0**	**1.8**	**1.7**	**1.6**
9.0	**19.2**	**10.1**	**7.7**	**6.2**	**5.0**	**4.2**	**3.5**	**3.0**	**2.6**	**2.3**	**2.1**	**1.9**	**1.8**	**1.7**
9.5	**20.3**	**10.7**	**8.1**	**6.5**	**5.3**	**4.6**	**3.9**	**3.3**	**2.8**	**2.4**	**2.2**	**2.0**	**1.9**	**1.8**
10.0	**21.3**	**11.2**	**8.5**	**6.9**	**5.6**	**4.6**	**3.9**	**3.3**	**2.9**	**2.6**	**2.3**	**2.1**	**2.0**	**1.9**
10.5	**22.4**	**11.8**	**9.0**	**7.2**	**5.8**	**4.9**	**4.1**	**3.5**	**3.1**	**2.7**	**2.4**	**2.2**	**2.1**	**2.0**
11.0	**23.5**	**12.4**	**9.4**	**7.6**	**6.1**	**5.1**	**4.3**	**3.7**	**3.2**	**2.8**	**2.6**	**2.3**	**2.2**	**2.1**
11.5	**24.5**	**12.9**	**9.8**	**7.9**	**6.4**	**5.3**	**4.5**	**3.8**	**3.3**	**3.0**	**2.7**	**2.5**	**2.3**	**2.1**
12.0	**25.6**	**13.5**	**10.2**	**8.3**	**6.7**	**5.6**	**4.6**	**4.0**	**3.5**	**3.1**	**2.8**	**2.6**	**2.4**	**2.2**
12.5	**26.7**	**14.0**	**10.7**	**8.6**	**7.0**	**5.8**	**4.8**	**4.2**	**3.6**	**3.2**	**2.9**	**2.7**	**2.5**	**2.3**
13.0	**27.7**	**14.6**	**11.1**	**8.9**	**7.2**	**6.0**	**5.0**	**4.3**	**3.8**	**3.4**	**3.0**	**2.8**	**2.6**	**2.4**
13.5	**28.8**	**15.2**	**11.5**	**9.3**	**7.5**	**6.3**	**5.2**	**4.5**	**3.9**	**3.5**	**3.1**	**2.9**	**2.7**	**2.5**
14.0	**29.9**	**15.7**	**11.9**	**9.6**	**7.8**	**6.5**	**5.4**	**4.6**	**4.1**	**3.6**	**3.3**	**3.0**	**2.8**	**2.6**
14.5	**30.9**	**16.3**	**12.4**	**10.0**	**8.1**	**6.7**	**5.6**	**4.8**	**4.2**	**3.7**	**3.4**	**3.1**	**2.9**	**2.7**
15.0	**32.0**	**16.9**	**12.8**	**10.3**	**8.4**	**7.0**	**5.8**	**5.0**	**4.4**	**3.9**	**3.5**	**3.2**	**3.0**	**2.8**
15.5	**33.0**	**17.4**	**13.2**	**10.7**	**8.6**	**7.2**	**6.0**	**5.1**	**4.5**	**4.0**	**3.6**	**3.3**	**3.1**	**2.9**
16.0	**34.1**	**18.0**	**13.6**	**11.0**	**8.9**	**7.4**	**6.2**	**5.3**	**4.6**	**4.1**	**3.7**	**3.4**	**3.2**	**3.0**
16.5	**35.2**	**18.5**	**14.1**	**11.4**	**9.2**	**7.6**	**6.4**	**5.5**	**4.8**	**4.3**	**3.8**	**3.5**	**3.3**	**3.1**
17.0	**36.2**	**19.1**	**14.5**	**11.7**	**9.5**	**7.9**	**6.6**	**5.6**	**4.9**	**4.4**	**4.0**	**3.6**	**3.4**	**3.2**
17.5	**37.3**	**19.7**	**14.9**	**12.0**	**9.7**	**8.1**	**6.8**	**5.8**	**5.1**	**4.5**	**4.1**	**3.7**	**3.5**	**3.3**
18.0	**38.4**	**20.2**	**15.3**	**12.4**	**10.0**	**8.3**	**7.0**	**6.0**	**5.2**	**4.6**	**4.2**	**3.8**	**3.6**	**3.4**
18.5	**39.4**	**20.8**	**15.8**	**12.7**	**10.3**	**8.6**	**7.2**	**6.1**	**5.4**	**4.8**	**4.3**	**4.0**	**3.7**	**3.5**
19.0	**40.5**	**21.3**	**16.2**	**13.1**	**10.6**	**8.8**	**7.4**	**6.3**	**5.5**	**4.9**	**4.4**	**4.1**	**3.8**	**3.5**
19.5	**41.6**	**21.9**	**16.6**	**13.4**	**10.9**	**9.0**	**7.5**	**6.5**	**5.7**	**5.0**	**4.5**	**4.2**	**3.9**	**3.6**
20.0	**42.6**	**22.5**	**17.1**	**13.8**	**11.1**	**9.3**	**7.7**	**6.6**	**5.8**	**5.2**	**4.7**	**4.3**	**4.0**	**3.7**

Results of feeding studies suggested that increased frequency and time of day feeding may significantly influence growth rates (Noeske-Hallin *et al.*, 1985). Jarbo and Grant (1997) indicated that weight gain of the larger chennel catfish in the treatment receiving two daily feeding was 10 to 15% greater than channel catfish fed once daily ($P < 0.05$).

On the other hand, Meenakumari and Arivindan (1995) stated that feed utilization and growth of *O. mossambicus* (Peters) were affected by different feeding regimes. Feeding the fish to satiation daily was the best feeding regime compared to fish fed to satiation and restricted feeding regime alternatively every 6 days and restricted feeding regimes of 8% body weight for 60 days. Buckley and Groves

Table 3: Extended

Length in In.:	5.287	5.634	5.980	6.327	6.673	7.020	7.366	7.713	8.031	8.287	8.508	8.720	8.937	9.252
Cm:	13.43	14.31	15.19	16.07	16.95	17.83	18.71	19.59	20.40	21.05	21.61	22.15	22.70	23.50
Weight g	48.0	59.0	69.0	81.0	95.0	111.0	127.8	145.0	162.5	180.0	197.4	215.1	233.2	252.5
Number/Kg	21	17	15	12	11	9	8	7	6	6	5	5	4	4
Hatchery Constant	Percent of body weight to feed daily													
5.0	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
5.5	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6
6.0	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
6.5	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
7.0	1.2	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8
7.5	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9
8.0	1.4	1.3	1.3	1.2	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9
8.5	1.5	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0
9.0	1.6	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.0
9.5	1.7	1.6	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1
10.0	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
10.5	1.8	1.7	1.6	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.2
11.0	1.9	1.8	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3
11.5	2.0	1.9	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3
12.0	2.1	2.0	1.9	1.8	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4
12.5	2.2	2.1	2.0	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.5
13.0	2.3	2.1	2.0	1.9	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5
13.5	2.4	2.2	2.1	2.0	1.9	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6
14.0	2.5	2.3	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.6
14.5	2.5	2.4	2.3	2.1	2.1	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7
15.0	2.6	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7
15.5	2.7	2.6	2.4	2.3	2.2	2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.9	1.8
16.0	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9
16.5	2.9	2.7	2.6	2.4	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	2.0	1.9
17.0	3.0	2.8	2.7	2.5	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0
17.5	3.1	2.9	2.7	2.6	2.5	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.0
18.0	3.2	3.0	2.8	2.7	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.2	2.1
18.5	3.3	3.1	2.9	2.7	2.6	2.5	2.5	2.4	2.3	2.3	2.3	2.2	2.2	2.2
19.0	3.3	3.1	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2
19.5	3.4	3.2	3.0	2.9	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.3
20.0	3.5	3.3	3.1	3.0	2.8	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.4	2.3

(1979) and Paraso (1990) studied the effect of dietary protein and energy level of feed on body composition and protein utilization of finfish and rabbit fish, respectively. They found that body lipid increased and moisture decreased as feeding rate increased. Also, El-Dahhar, 1993 found that carcass protein of Nile tilapia fry 0.2 g has slightly increased with increasing feeding rates. Moreover, moisture in the body decreased significantly ($P < 0.05$) with increasing feeding rates. This was in accordance with the increase of lipid contents in the body, which increased with increasing feed intake ($P < 0.05$). The results of El-Tawil (1998) have shown that with increasing feeding rates from 2 to 14 % of BW daily, weight gain of Nile tilapia (0.63 g) increased. Final body weight increased with increasing feeding rates up to 10 % of BW daily. Increasing feeding rate beyond 10 % had no significant effects on growth. The results of research concerning gain at this period of life of Nile tilapia are variable. That finding was supported by Popma (1984) and Green (1992) who showed that weight gain of Nile tilapia increased during the first five weeks with increasing the rate of feeding, but gains were slow owing to the small size of fish.

El-Dahhar (1993) in two experiments also arrived to similar results with Nile tilapia fry of initial body weight 0.21 and 0.6g. He found that weight gain increased with increasing feeding rate up to 13 and 12% of the total body weight daily, respectively. Also, Zonneveld and Fodholi (1991) found that with increasing feeding rate, yield declined. They also stated that net protein utilization of red tilapia decreased when the amount of feed increased.

Other fish species acted like tilapia. With channel catfish, Andrews, 1979 found that the fish fed 110 % of a control-feeding rate that approximated *ad libitum* had significantly reduced weight gain compared with catfish fed the control rate. This reduction was not caused by adverse water quality. Catfish fed 90% of the control rate in that study had similar weight gain as fish fed the control rate. Gatline III *et al*., (1986) fed catfish diets containing 25 and 35 % crude protein at incremental feeding rate (0-5 % of BW daily). They found that weight gain increased linearly ($r^2 = 0.95$) as feeding rate increased up to 3.5 % BW daily of the 25 % crude protein diet and 2.5% of BW daily of the 35 % crude protein diet. Feed efficiency of these catfish declined with the higher feeding rates. Likewise, catfish grow better when they were fed 4 % of BW daily than 6 % of BW daily at 26°C (Andrews and Stickney, 1972).

Table 4: *Effect of fish species and size on feeding rates.*

Fish species	Body Weight (BW, g)	Feeding rate range % BW	Protein level %	Optimum feeding rate	Author (s)
Catfish	2.5	0 – 5	35	2.5	Gatlin *et al.*, 1986
Catfish	2.5	0 – 5	25	3.5	Gatlin *et al.*, 1986
Shrimp	0.5	5 – 25	35	15 – 20	Lovell, 1989
Shrimp	0.5 – 2	3 – 21	35	12 – 15	Lovell, 1989
Shrimp	2 – 5	3 – 15	35	8 – 12	Lovell, 1989
Shrimp	5 – 10	1 – 12	35	6 – 8	Lovell, 1989
Nile tilapia	1	13 –15	40	12	El-Dahhar, 1993
Nile tilapia	6	2 – 7	35	5	El-Dahhar, 1993
Nile tilapia	0.63	2 – 14	32	10	El-Dahhar *et al.*, 1999b
Striped mullet	0.2	1 – 13	38	9	El-Dahhar, 2000 a

Feed conversion ratio (FCR, feed/gain) is also affected as feeding rate changes. The best FCR of Nile tilapia juvenile (0.63g initial BW) was exerted with 12% feeding rate with the value of 1.75 (El-Dahhar *et al*.,1999b). Relationship between feeding rates and FCR is important in the fish culture. If fish are fed at too high rate, much food is wasted and if feeding rate is too low, approaching the rate required for maintenance, growth is very slow, and the rate of conversion very high. It was found that when Nile tilapia were fed at rate lower than satiation, fish fed the higher protein diets grow faster and hence protein requirements increase.

Dietary protein to energy balance
For tilapia

At inadequate energy levels dietary protein will be used as an energy source (Cowey, 1980), more protein is used for energy, the more ammonia is produced, and the more energy is lost as heat. But at an adequate energy level, dietary protein will be spared for growth (El-Sayed, 1987). Several studies have shown that providing adequate energy with dietary lipids can minimize the use of more costly protein as an energy source (Ringrose, 1971; Lee and Putnam, 1973; and Watanabe, 1977). If insufficient energy is available or if there is an excess amount of protein in relation to the concentration of dietary energy, the extra protein will be used as a source of energy (Phillips, 1972; Prather and Lovell, 1973; and Helland and Gisdale-Helland 1998). However, increasing energy may produce fatty fish, reduce feed consumption and inhibit the utilization of other feed stuffs (Page and Andrews, 1973; Takeda *et al.*, 1975; Shiau and Huang, 1990 and El-Dahhar and Lovell, 1995). Also increasing the energy in Nile tilapia feed in the form of oil produce fish with fatty liver and edema in the abdominal portion (El-Dahhar and El-Shazly, 1993).

Other fish species were also affected by protein to energy balance. Adron *et al.*, 1976 reported that the protein-sparing action of dietary carbohydrate is less marked than that of dietary lipid. Their results indicated that in general the growth of fish increased as the lipid content (energy) increased in the diet up to 15%. Takeuchi *et al.* (1978) also reported that when the lipid content exceeded 18% with 35% protein diet, no further growth increase was observed in rainbow trout. Apart from satisfying the requirement of a fish for essential fatty acids, dietary lipid acts as a source of energy. In general, 10-20% lipid in fish diets gives optimal growth rates without producing an excessively fatty carcass (Cowey and Sargent, 1979). Interspecific variation in the ability of different species to utilize lipid as a source of energy is prevalent. Takeuchi *et al.* (1978) found that rainbow trout fed diets with a fixed protein level of 32%, with lipid varying from 5 to 15% and with corresponding decreases in carbohydrate, did not show increased growth or food conversion rates.

El-Dahhar and Lovell (1995) fed Mozambique tilapia in glass aquaria with purified diets in which protein concentrations were 25, 30 and 35 % each with three levels of energy (250, 300 and 350 kcal / 100 g diet). They found that the optimum P/DE ratio for rapid growth was 99.7 mg protein / kcal. Tilapia could exhibit maximum growth compared to other species of fish, when fed relatively at low levels of dietary crude protein (NRC 1993). Shiau and Huang (1989) fed hybrid tilapia (*Oreochromis niloticus x O.* aureus) different level of protein from 0 to 56% in seawater cages. The data show that the dietary protein levels from 24 to 40% produced identical growth. The authors recommended 24% dietary crude protein to be optimum for tilapia hybrid in seawater. In 1990, the same authors used lipid to adjust the dietary energy level. Levels of 6%, 9%, 12%, 15%, 18%, and 21% were used to form diets containing 190, 230, 270, 310, 350, or 390kcal/100g diet respectively with two dietary protein levels (21% and 24%). Gain of the fish fed diets with 24% protein level increased with increasing energy level up to 230kcal/100g dietary energy level. When the energy level of the diet is 310 kcal/100g, the dietary crude protein for hybrid tilapia reared in seawater tanks can be lowered from 24% to 21% without affecting weight gain or feed efficiency. However, formulation of diets for a fish species needs special understanding for the nutritional requirements of this species. Moreover, the minimum crude protein for tilapia depends upon the rearing system applied (Twibell and Brown 1998). El-Dahhar *et al*., (2000) found that final body weight (FBW) of Nile tilapia juvenile (3.7g initial body weight, BW) increased significantly ($P < 0.01$) with increasing dietary crude protein level from 12 to 24 %. Fish that maintained at 20 or 24% dietary crude protein exhibited significantly the greatest mean FBW compared to that fed 12% protein diet. Increasing the level of protein from 20 to 24% did not exert significantly additional advantage fish growth. But when the metabolizable energy (ME) levels increased from 245 to 262 kcal ME/100g using the same dietary protein levels, fish that fed on diets containing 245 kcal ME/100g exhibited significantly greater FBW than that fed on diets containing 262 kcal ME/100g. In applied study in winter season, El-Tawil (2006) fed Nile tilapia fry (1.3 g initial BW stocked at 25 fish / m^2) diet containing two levels of crude protein (20 or 25 %) each with or without chemical fertilizers. The fertilizers used were 15 kg / feddan/wk of mono superphosphate (15.5 % $P_2 O_2$) and 19 kg / feddan / wk urea (46 % N). He found that FBW was significantly ($P < 0.05$) affected by fertilization. But it did not affected by increasing dietary crude protein level from 20 to25 % ($P > 0.05$). On the other hand the best survival percent (63.1%) was exhibited with the group fed at 25% dietary crude protein level without fertilization versus 31.6% for the group fed at 20% dietary protein level without fertilization.

Generally, it was concluded that increasing dietary crude protein concentration had a positive effect on weight gain and survival especially in the first stages of growth (Winfree and Stickney 1981; Shiau and Huang, 1989 and 1990; Clark *et al*., 1990; El-Dahhar, 1994 and 2000a; Twibell and Brown, 1998; El-Dahhar *et al.* 1999b and Tawil 2006). The reason of overestimated values in some of these studies is likely to be due to some factors. De-Silva and Anderson (1995) summarized these factors to be:

1. energy values of the diets used are not generally determined but are assumed to be similar to other animals,
2. inadequate information on amino acids composition of the diets,
3. variation in the digestibility of the dietary protein sources

El-Dahhar *et al.,* (2000) with Nile tilapia found that a large portion at the significant interaction detected between protein and energy could be explained on the basis of a significant improvement in final body weight (FBW) for some of the studied groups when given diets with different levels of protein or energy. He also stated that differences among fish maintained at 20 % dietary protein with 245 kcal ME/100g diet and 24 % dietary protein with both 245 and 262 kcal ME/100g diet were not significant. In his work, He also found that feed consumption increased as dietary crude protein increased without any significant differences in the feed consumption due to increasing energy level in the diet. Feed conversion ratio (FCR) of juvenile fed the higher levels of protein 20 or 24% during the experimental period was superior by about 28.3 or 35.1%, respectively compared to that fed low level of protein (12%). These results were compared favorably with those obtained by Mazid *et al*. (1979) for *T. zillii;* by Jauncey (1982) for *Sarotherodon mossambicus* and by Shiau and Huang (1989) for hybrid tilapia (*O. niloticus* X *O. aureus*). They found that FCR decreased with increasing dietary crude protein level. However, no considerable differences were found in FCR among fingerlings given diets with different levels of energy. Therefore tilapia requirements for protein level cannot be generalized, since it varies according to the protein to energy ratio. Balance between dietary protein and energy is essential in fish feed formulation.

Shiau and Huang (1990) found with hybrid tilapia using six energy levels from 190–390 kcal/100g and two dietary crude protein levels (21 and 24%), that 67.7 mg protein/kcal of ME was the optimum protein to energy ratio when 21% dietary crude protein was fed. With Nile tilapia, Twibell and Brown (1998) found that 65.1mg protein /kcal of gross energy were optimal for 21-g fish when the diet contained 28% crude protein from all plant protein sources. But, diets containing the same P/E ratios and differing in protein and energy concentrations produced different growth rates (Winfree and Stickney, 1981). Shiau and Huang (1989) suggested that protein might be spared by lipid as long as the caloric requirements are met, thus permitting more efficient utilization of protein. With other fish species, dietary protein and energy for best performance and protein sparing of hybrid *Clarias* catfish were found at 35% protein and 325-kcal digestible energy/100g (Jantrarotai ***et al.***, 1998). However, Li and Robinson (1999) reduced the fish body fat of channel catfish by reducing the available dietary energy. They found that fish fed diet with 28% crude protein and 277 kcal DE/100g had the same weight gain and feed conversion efficiency of fish fed diet with 32% protein and 272 kcal DE/100g. They added that it would not be economical to reduce channel catfish body fat with diets low in DE: P ratios (28% protein and 238 kcal DE /100g). Since this practical diets lowers the body fat, it depresses weight gain of the channel catfish.

Viola and Arieli (1982) reported that dietary oil supplementation does not produce gains in growth and food utilization of tilapia in contrast with other fish species such as carp, trout and catfish. They utilize oil supplements quickly and efficiently. This difference has various implications for the practical nutrition of tilapia, including the warning that energy estimates of feed stuffs for carp, trout or catfish should not be applied to tilapia. The high fat, high energy feed stuffs such as fishmeal, when used with tilapia, may have to be evaluated on a protein basis alone and may be replaceable by vegetable protein sources that do not contain as much fat. Also, a previous work on Nile tilapia has shown that higher mortality due to edema and fatty liver were happened with diet containing high levels of oil (El-Dahhar and El-Shazly, 1993). In this work the way to solve the problem of high mortality of tilapia fed high level of lipids was by using low level of lipid emulsified with equal amount of water using 0.7 % phosphatedyl choline (lecithin). Likewise, flounder *Paralichthys olivaceus* responded better on the low energy (300kcal/100g diet) than high energy diet (400kcal/100g diet) at all protein levels (30, 40 and 50%) (Lee *et al*., 2000). In this study, increasing dietary protein level up to 50 at 300kcal/100g diet improved the performance of fish. Therefore, the proper ratio of dietary energy to dietary protein may vary according to the fish species for which the diets were presented.

Dietary protein requirements for mullet

Mullet exhibit numerous traits which are considered beneficial for aquaculture (Nash and Shehadeh 1980; Benetti, 1985; Papaparaskeva-Papoutsoglou and Alexis, 1986 and El-Dahhar, 2000 b) including the ability to adapt to rear in the polyculture system. The cost of the controlled production of fish depends mainly on the cost of feed, which constitute most of the economical expenses, and crude protein is typically the most expensive component in artificial diets for fish. The optimum dietary protein needed for maximum growth and feed utilization is essential in the formation of well-balanced and low cost artificial diets.

Much of the nutritional research with fish species has focused on minimizing crude protein in the diet for mullet (Albertini-Berhaut, 1974; Papaparaskeva-Papoutsoglou and Alexis, 1986; and El-Dahhar, 2000 b, c and d luzzana *et al*., 2005). These researches were tending to reduce the cost of feed. In a laboratory study El-Dahhar (2000 b) fed striped mullet (*Mugil cephalus*) larvae of 0.2g initial BW at incremental dietary crude protein levels from 14 to 38% to determine protein requirements. They found that 26% dietary crude protein level is the level needed for maximum growth and feed utilization. Also, Papaparaskeva-Papoutsoglou and Alexis (1986) fed young grey mullet (*M. capito*) of average initial

BW 2.5g, five semi-purified diets containing 12–60% protein. They found that 24% protein was required for maximum growth at 23 ^{o}C. While, Alexis and Papaparaskeva-Papoutsoglou(1986) found that the dietary protein content of 15% resulted in sufficient growth equal to 26, 37 and 50% dietary crude protein levels for grey mullet of 12.5g initial BW. The optimum protein level of the diet can be lowered if the energy level is increased, due to protein sparing action of energy nutrients with mullet and other fish species (Lee and Putnam, 1973 with rainbow trout; Machiels and Henken, 1985 with African catfish; Serrano *et al*., 1992 with red drum; Shiau and Peng, 1993 with Nile tilapia; Jantrarotai *et al*., 1998 with hybrid *Clarias* catfish and El-Dahhar, 2000c and d with striped mullet). However, increasing energy in catfish diet may decrease feed efficiency and leads to increase fat deposition (Reis *et al*., 1989). Also, growth and feed efficiency of flounder declined with the increase of dietary energy (Lee *et al*., 2000). But, increasing energy in a diet for *Mugil capito,* indicates a better utilization of protein (Alexis and Papaparaskeva-Papoutsoglou, 1986 and El-Dahhar, 2000 c).

The dietary energy available to mullet is an important factor for the different behavior of fish to use protein as an energy source (Alexis and Papaparaskeva-Papoutsoglou, 1986). The sources of protein (fish and hemoglobin meal, soybeen meal and torula yeast meal) as practical diets to feed grey mullet (*Mugil cephalus*) for eight weeks had no effect on fish weight gain %. Only torula meal reduced growth performance (Luzzana *et al.,* 2005).

Using protein as an energy source could be happened in other fish species. De la Higuera *et al*., (1977) indicated that doubling the amount of lipid supplied in rainbow trout diets with a constant protein level, decreased protein metabolism in form of glutamic pyrovic transaminase activity in the liver almost by four times. Lipids are good sources efficiently utilized for energy and have a sparing action for protein to be used as a source of energy. That has been reported for rainbow trout (Lee and Putnam, 1973; Watanabe, 1977 and Watanabe *et al*., 1979), for halibut (Helland and Gisdale-Helland, 1998) and for mullet (Alexis and Papaparaskeva-Papoutsoglou, 1986 and El-Dahhar, 2000 c). This protein sparing action of lipids has also been repeatedly proven (Jürss, 1981). He observed a decrease in transaminase activity with the decrease of protein content and increase in the lipid content of the diet for rainbow trout. Data presented by El-Dahhar, (2000 c and d) clearly demonstrated that performance of striped mullet (*Mugil cephalus*) maintained at diets containing 175 to 265 kcal ME /100g was superior at 250 kcal ME/100g compared to other treatments when dietary protein level was stable at 26%. In this work, He also stated that when striped mullet fed at three dietary protein levels (18%, 22% and 26%) and three dietary ME levels (200, 225 and 250 kcal/100g diet), weight gain, survival and feed efficiency improved as dietary energy increased up to 250 kcal/100g diet. Differences in performance among protein levels in this trial were most pronounced in fish fed 26% protein diets, which resulted in the fastest growth. In relation to the interaction between dietary ME and protein levels, striped mullet larvae exhibited the greatest survival, weight gain and feed utilization when they were maintained at 22% dietary protein with 250 kcal ME /100g diet than the other protein levels at all ME levels used. These differences in survival and weight gain can be attributed to the increased feed intake and feed efficiency exhibited at 250 kcal ME /100g diets. Data from previous study in which various dietary protein levels from 14 to 38% at 245 kcal ME/100g diets (El-Dahhar, 2000 d), support that striped mullet maintained at 26 % dietary crude protein level exhibited superior growth characteristics when lipid contents was about 6.3%. In El-Dahhar (2000 c) study, increasing the amount of energy in the form of lipid (about 15%) decreased dietary crude protein needed for maximum survival and growth from 26% to 22%.

With *Clarias gariepinus* catfish, Machiels and Henken (1985) related growth and feed efficiency to be functions of dietary protein intake. They found that increasing protein intake of fish fed diets with different protein levels improved growth and feed efficiency. In El-Dahhar (2000 c) study the data clearly indicated that fish fed the 26 % protein diets consumed more protein than those fed lower protein diets and therefore grew and utilized feed better. Energy retention (ER) which was low in fish fed the low protein diets, is in agreement with that reported for *M. capito* (Alexis and Papaparaskeva-Papoutsoglou, 1986). However, for *M. cephalus*, the PPV was also low for the fish fed the lower (14%) protein diet leading El-Dahhar (2000 d) to conclude that some protein was used for energy. This is in contrast to his finding (El-Dahhar, 2000 c) where PPV of fish fed the low protein diets was similar to that for fish fed higher protein diets. This is probably because fish fed the low protein diets consumed enough non-protein energy so that the energy intake of fish in this group was the highest, known from its least ER value.

El-Dahhar (2000 c) found that increasing energy levels over 235 kcal ME/100g had no beneficial effects on fish performance. This had shown that increasing both protein and energy to the optimum levels resulted in better growth of fish and improved feed efficiency. The difference may relate to energy source. Since in studies of Jantrarotai *et al*., (1998) with *Clarias* catfish and El-Dahhar (2000 d) with striped mullet *M. cephalus*, carbohydrate was the major energy source whereas in El-Dahhar (2000 c) study more lipid was used for energy. He tested this assumption, in which corn oil was added in graded levels to achieve three levels of ME. In this work, optimum growth, survival and dietary utilization of striped mullet *M. cephalus* were attained at 22% protein and 250 kcal ME/100g. The protein level was lower and the energy level was the same as the previous result with striped mullet (El-Dahhar, 2000 b). Furthermore, the improved growth rates as well as protein sparing effect were observed in fish fed higher energy diets in El-Dahhar (2000 c). These findings did not present in the previous study with striped mullet (El-Dahhar, 2000 b), where He found that 26% protein was needed for maximum growth and feed utilization when carbohydrate as a source of energy was higher than lipid. The difference in protein requirement for striped mullet *M. cephalus* (El-Dahhar, 2000 c) (22%) and his previous study (El-Dahhar, 2000 b) may due to the different ratios of carbohydrate and lipid. From these results, it could be concluded that striped mullet *M. cephalus* utilize energy with a low ratio of carbohydrate to lipid more efficiently and this resulted in a protein sparing effect.

The results of fish performance and body composition for striped mullet *M. cephalus* (0.173g initial BW) obtained by El-Dahhar (2000c) are in general agreement with those obtained for the same fish of nearly similar size 0.2g initial weight (El-Dahhar, 2000b). However, a diet containing 22% crude protein with 250 kcal ME /100g resulted in greater survival, growth and feed utilization. While, a protein content of 26 %, when the energy level was 245 kcal ME /100g, was found to be optimal for striped mullet *M. cephalus* in the previous study. Higher availability of protein mixture of El-Dahhar (2000c) to the fish, which had a slightly different composition than the previous one (shrimp meal: soybean meal: fishmeal ratio of 1: 1: 1 compared to 1: 2: 1 ratio of the previous study) could be a reason of the difference.

It appears therefore that striped mullet *M. cephalus* required protein and energy less than other fish species studied so far. Further experiments would clarify the relative importance of various energy sources for survival, growth and feed utilization.

Maintenance and maximum growth requirements of protein and energy For tilapia

Diets containing 25% protein are mostly extruded and usually used for feeding tilapia in Egypt. In practice, tilapia fed these diets reach marketable size (100g or more) in 140-160 days. However, Nile tilapia (31g BW) fed graded dietary crude protein from 14% to 38% raised under laboratory conditions grow up to100g without significant differences in growth rate (Fayed, 1997). Also in previous work on Nile tilapia two weeks after hatch (0.02g) to marketable size (250g) in 40 wk, El-Dahhar (2000a) found that fish growth rate has not affected by changing dietary crude protein form 20 to 38% except in the first stage of growth from 0.02g to 7.0g. In this period of growth, the author suggested 25% dietary crude protein level to be optimal for Nile tilapia larvae (from hatch to 7.0g) and 20 % dietary protein level to be optimal for the remaining period to marketable size (250g). In a feeding trial to substitute animal protein by a mixture of plant protein feedstuffs at different dietary protein levels 25, 30, 35, 40 and 45% using torula yeast (*Candida utilis*) as a protein source Olvera-Novoa *et al*., 2002 found that dietary protein levels had no significant effects on *O. mossambicus* (peters) fry weight gain.

On the other hand, the use of low quality protein even at higher level of dietary protein, leads fish to use protein as a source of energy which increase ammonia secretion and deteriorate water quality.

With a good relation to the nutrients requirements of fish and its availability in the fish diet Cho *et al*. (1994) summarized the most important sources of pollution in aquaculture systems to be:

1. the low digestibility of diets which maximize feces volume,
2. sub-optimal energy diets increase the amount of feed required for maximum growth,

3. unbalanced protein to energy ratio increase excretion of nitrogenous compounds,
4. unbalanced nutrients, decrease growth and feed utilization efficiency of the culture organism, and
5. unpalatable feed decrease feed consumption and feed efficiency.

For minimizing the sources of pollution in the water system, feeding level should be determined accurately to save feed and increase the fish growth.

Growth of fish depends on food supply, and production costs increased with increasing its coasts. Determination of feeding rate with respect to the nutritional requirements, dietary composition and the effect of environmental conditions may help in saving feed or promoting fish growth, and thus increase the income of the fish farmers. Maintenance, maximum growth requirements and feed utilization for all purposes are essential for establishing feeding level of a fish species (Hepher, *et al.*, 1983).

El-Dahhar *et al*. (1999b) in a feeding trial on Nile tilapia *Oreochromis niloticus* used 32% crude protein diet to feed fish at seven feeding level from 2 to 14% of the fish BW daily. They recommended 7mg protein/g BW and 76cal gross energy /g BW daily as maintenance requirements for Nile tilapia fry 0.63g. Also, from the same data 32mg protein and 395.2cal gross energy/g BW daily were recommended as the maximum growth requirements for the same Nile tilapia fry. The data of the same authors indicated that 24 % dietary crude protein is the minimum needed for maximum growth and feed efficiency of 0.76-g Nile tilapia fed at incremental dietary crude protein levels from 12-32% in 2:1 plant protein: animal protein ratio. This means that 30.6mg protein / g BW is needed daily as the best growth requirements.

A comparison between results of protein and energy maintenance and maximum growth requirements of tilapia spp demonstrate that some differences between results were found to be due to different experimental conditions, e.g. fish size, feeding rate, rearing temperature and others. The smaller fish required more than larger fish due to the higher metabolic rate of them (Halver, 1988). El-Dahhar, 1993 and 1994 stated that at the same temperature, increasing fish size decreased maintenance and maximum growth requirements for both protein and energy. He also recommended 52, 48, 36, 17.3 and 13.3 mg protein /g BW for 0.2, 0.66, 1.0, 6.3and 9.6 g BW *O. niloticus*. Also, Schaberclus (1933) found a 24.48 kcal /(kg

BW .d) as energy requirement for carp weighted 12g and 7,97 kcal / (kg BW .d) for 600g carp. At the same time temperature affected requirements. Hepher *et al*., (1983) found that specific routine metabolism of red tilapia was 25.4 cal / day at 20.9°C and 36.7 cal / day at 24.3°C. The same author also found that energy maintenance requirement of red tilapia (phenotypically *Oreochromis niloticus)* fingerlings 1.0g BW increased from 51 to 73 cal/g BW as water temperature increased from 20.9 to 24.3°C.

For mullet

Mullet growth like most fish species depends to large extent on supplementary food, and the cost of feed constitutes the principal part of the total production costs. Furthermore, feeding rate for mullet is still based on the feeding rate of other species rather than on mullet data. Determination of feeding rate with respect to the nutritional requirements, dietary composition and the effect of environmental conditions may help in saving feed or promoting fish growth. For establishing feeding level of a fish species, some major factors should be taken into consideration, e.g. maintenance requirements, growth requirements and feed utilization for all purpose (Hepher, *et al*., 1983). Mullet maintenance requirement is determined in several studies.

El-Dahhar, 2006 reported the amount of protein and energy requirements for maintenance and maximum growth of striped mullet (*Mugil cephalus*) (0.195-g initial BW). The author recommended 3.9 mg protein /g BW and 30.2 cal gross energy /g BW to be maintenance requirements calculated from mathematical models established by the relationships between BW gain and the increase of protein and energy intake. He also recommends 26% dietary protein to be optimum level for striped mullet 0.2-g for maximum growth and feed utilization. This protein optimum is similar to that reported for grey mullet (*Mugil capito*) of weight 0.8 and 3g by Vallet *et al*. (1970) and for grey mullet 2.5g by Papaparaskeva-Papoutsoglou and Alexis (1986).

Mullet have been variously described as vegetarian, planktophagous, detritivorous, omnivorous and even carnivorous (Brusle, 1981; and Benetti and Fagundes Netto 1991). They change their food performances from carnivorous to herbivorous as they grow bigger (Albertini-Berhaut, 1974). Thus their ability to use protein as an energy source could be affected by dietary crude protein levels (Alexis and Papaparaskeva-

Papoutsoglou, 1986 and El-Dahhar, 2000 b and c). The same authors also stated that the metabolic behavior of the fish studied so far to digest protein could be attributed to various factors. Genetically, utilizing protein as an energy source is an important factor taken into account while determining of the requirements of a fish species. The metabolism of carnivorous fish might geared towards the use of protein as an energy source which may be affected by dietary protein level. Dietary energy level is another factor. Doubling the lipid content of rainbow trout diets using constant protein level, decreases protein metabolism in the form of glutamic pyrovic transaminase activity in the liver by almost four times (De la Higuera *et al*., 1977). Lipids are known to be efficiently utilized as an energy source and their protein sparing action has been reported (Lee and Putnam, 1973 and Watanabe *et al*., 1983).

Alexis and Papaparaskeva - Papoutsoglou, (1986) reported a decrease in the daily protein and energy requirements of ***M. capito*** from 13.5 to 5.3 mg protein / g BW daily and 215.3 to 190.3 cal gross energy / g BW daily as ***M. capito*** increase in BW from 2.5 to 12.7g (Table 5).

Table 5: *Comparison between results of maintenance and maximum growth requirements of some fish species. Taken from El-Dahhar (2006)*

Fish species	Body weight (g)	Water Tempe-rature (°C)	Maintenance Requirements		Maximum Growth Requirements		Dietary Protein Level (%)	Author(s)
			Protein mg/g BW	Energy Cal/g BW	Protein mg/g BW	Energy cal/g BW		
Striped mullet	0.19	24.5	3.9	30.2	34.6	345.6	38.0	El-Dahhar, 2000b
Striped mullet	0.2	24.5			26.3	382.7	26.0	El-Dahhar, 2000b
Grey mullet	2.5	23.3			13.5	215.3	25.5	Alexis and Papaparaskeva-Papoutsoglou, 1986.
Grey mullet	12.7	24.0			5.8	190.3	15.0	Papaparaskeva-Papoutsoglou and Alexis, 1986.
Nile Tilapia	0.2	27.5	10.0	106.9	48.0	513.1	39.6	El-Dahhar, 1993.
Nile Tilapia	0.63	27.0	7.0	76.5	32.0	395	32.0	El-Dahhar *et al*., 1999b
Nile Tilapia	0.76	27.0			30.6		24.0	El-Dahhar *et al*., 1999b
Red Tilapia	1.0	24.3		73.0				Hepher *et al*., 1983.
Red Tilapia	1.0	20.9		51.0				Hepher *et al*., 1983.
Nile Tilapia	1.0	27.5	8.6		36.0		30.2	El-Dahhar, 1994.
Hybrid T.	2.9	26.0	4.2		11.9		24.0	Shiau & Huang, 1989.
Nile Tilapia	3.6	27.0			25.8		20.0	El-Dahhar *et al*., 2000
Nile Tilapia	6.3	27.5	4.3		17.5		34.9	El-Dahhar, 1993.
Nile Tilapia	9.6	27.5	3.6		13.3		26.6	El-Dahhar, 1994.
Red Tilapia	11.4	20.0	3.7		42.0		28.2	Zonneveld & Fadholi, 1991.
Catfish	8.5	27.3	1.3	15.1	8.8	99.8	25.0	Gatlin III *et al*., 1986.
Catfish	9.6	27.3	1.3	15.1	8.8	99.8	35.0	Gatlin III *et al*., 1986.

Data are based on recalculation of original data.

Also, they recommend a decrease in the optimum dietary protein requirement from 25.5 to 15% as BW increased from 2.5 to 12.7g. El-Dahhar, (1993 and 1994) and El-Dahhar *et al*., (1999b and 2000) stated that at the same temperature, increasing fish size decreased maintenance and maximum growth requirements for both protein and energy (Table 5). The same author also recommended 52,48, 36, 17.3 and 13.3 mg protein / g BW for 0.2, 0.66, 1.0, 6.3and 9.6 g BW *O. niloticus*. Hepher *et al*., (1983) found that specific routine metabolism of red tilapia was 25.4 cal / day at 20.9^{o}C and 36.7 cal / day at 24.3^{o}C. The same author also found that energy maintenance requirement of red tilapia (phenotypically *Oreochromis niloticus)* fingerlings 1.0g BW increased from 51 to 73 cal/g BW as water temperature increased from 20.9 to 24.3^{o}C.

REFERENCES

Adron, J .W.; Blar, A.; Cowey, C. B. and Shanks, A. M. (1976). Effects of dietary energy level and dietary energy source on growth feed conversion and body composition of turbot (*Scop*htholmus *maximus* L.). Aquaculture, 7: 125-132.

Ahmad, M.H. Abdel-Tawwab, M. and Khattab Y.A.E., (2004). Effect of dietary protein levels on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.) with different initial body weights. Pages249-263. In Stickney, R.R. (2005). Tilapia update 2004: Second installment. World Aquaculture 36 (2). P 8-10.

Albertini-Berhaut, J., (1974). Biology des stages juvéniles de Téléostéens Mugilidae *Mugil auratus* Risso 1810, *Mugil capito* Cuvier 1829 et *Mugil saliens* Risso 1810. II. Modifications du régime alimentaire en relation avec la taille. Aquaculture, 4: 13-27.

Alexis, M. N. and Papaparaskeva-Papoutsoglou, E., (1986). Aminotransferase activity in the liver and muscle of *Mugil capito* fed diets containing different levels of protein and carbohydrate. Comp. Biochem. Physiol., . 83B. (1): 245-249.

Amer, T.N.A., (2007). The use of liquid fertilizers in natural food production and its effect on fish growth. Ph.D. Dissertation. Faculty of Agriculture Saba Basha, Alexandria University.

Andrews, J. W. (1979). Some effects of feeding rate on growth, feed conversion and nutrient absorption of channel catfish. Aquaculture, 16: 243-246.

Andrews, J. W. and Stickney, R. R. (1972). Interaction of feeding rates and environmental temperature on growth food conversion, and body composition pf channel catfish. Trans. Am. Fish. Soc. 101, 94-99.

Balarian, J. D., (1979). Tilapia: A guide to their biology and culture in Africa. University of Sterling Press. 1-79P.

Baloyi, J. J.; Kusvabadika, B.; Binali, W.; and Zimudzi, F. (1995). The effect of feeding different amounts of commercial fish pellets at tow feeding frequencies on the growth performance of

Oreochromis mossambicus. Journal of the Zimbabwe Society for Animal Production 7: 209-211.

Benetti, D. D., (1985). MSc Thesis, University of Sterling, Scotland , UK.

Benetti D. D. and Fagundes Netto, E.B. (1991). Preliminary results on growth of mullets (*Mugil liza* and *M. curema*) fed artificial diets. World Aquaculture. 22(4) 1-3.

Brusle, J. (1981). Aquaculture of Grey Mullets. Cambridge University Press, IBP 26: 185-212.

Buckley, J. T. and Groves, T. D. D., (1979). Influence of feed on body composition of finfish. In J. E. Halver and K. Tiews (1978). Fish Feed Technology. Vol. Π. Heenemann. Barlin pp. 334-343.

Cho, C. Y., Hynes, J. D. Wood K. R. and Yoshida H. K. (1994). Development of high-nutrient-dense, low-pollution diets and prediction of Aquaculture wastes using biological approaches. Aquaculture 124:293-305.

Cho, S.H. and Jo, J.Y. (2002). Effect of dietary energy level and numbers of meals on growth and body composition of Nile tilapia *Oreochromis niloticus* (L.) during summer and winter seasons. Journal of the World Aquaculture Society 33: 48-56.

Clark J. H. Watanabe, W. O.; Erns, D. H. Wicklund, R. I. and Olla, B. L. (1990). Effect of feeding rate on growth and feed conversion of Florida red tilapia reared in floating marine cages. Journal of the world Aquaculture Society.21: 16-24.

Cowey, C. B., (1980). Protein and amino acid requirements of finfish. In Oslage, H. J. and Rohr, K. (Editors), Proc. Eur. Aquaculture. Assoc. Symp. Protein Metabolism and Nutrition, EAAP Publication No. 27, pp. 729-774.

C**owey, C. B. and Sargent, J. R. (1979).** Fish Nutrition. In: W. S. Hoar and D. J. Randal (Editors, Fish Physiology, Vol. VIII. Academic Press, London, pp. 1-69.

Dambo, W. B. and Rana, K. J. (1992). Effect of stocking density on growth and survival of *Oreochromis niloticus* (L.) fry in the hatchery. Aquacultureand Fisheries Management 23:71-80.

Degani, D., Ben-Zvi, Y. and Levannon, D. (1989). The effect of different protein levels and temperature on feed utilization, growth and body composition of *Clarias gariepinus* (Burchell 1822). Aquaculture, 76: 293-301.

De la Higuera, M., Murillo, A., Verela, G. and Zamora, S. (1977). The influence of high dietary fat levels on protein utilization by the trout (*Salmo gairdeneri*). Comp. Biochem. Physiol. 56A, 37-41.

De Silva, S. S. and Anderson, T.A. (1995). Fish Nutrition in Aquaculture. 1st edition. London, Glasgow, Weinheim, New York, Tokyo, Melbourne, Madras.

De Silva S. S.; Gunasekera, R. M. and Atapattu, D. (1989). The dietary protein requirements of young tilapia and an evaluation of the least cast dietary protein levels. Aquaculture, 80,271-284.

El-Dahhar, A. A. (1993). Maintenance and maximum requirements for fry and fingerlings of Nile tilapia (*Oreochromis niloticus*) fed at varying feeding regimes. Alexandria Journal of Agriculture Research. 38 (3) : 179 -197.

El-Dahhar, A. A. (1994). Protein requirements of fry and fingerlings of Nile tilapia (*Oreochromis niloticus*) fed at varying protein level in Egypt. Journal of Agriculture Science, Mansoura University. 19 (1): 117 - 128.

El-Dahhar, A. A, (2000 a). Developing a feeding guide for Nile tilapia *Oreochromis niloticus* based on dietary protein levels fed. Conference of Social and Agriculture development in Sinai. pp 19-37.

El-Dahhar, A. A. (2000 b). Effect of dietary energy and protein levels on survival, growth and feed utilization of striped mullet *Mugil cephalus* larvae. J. Aric. Sci. Mansoura Univ., 25 (8): 4987 – 5000.

El-Dahhar, A. A, (2000 c). Protein and energy requirements of striped mullet *Mugil cephalus* larvae. J. Aric. Sci. Mansoura Univ., 25 (8): 4923 – 4937.

El-Dahhar, A. A. (2006). Review article on mullet larval acclimatization and determination of their nutritional requirements in egypt. Journal of the Arabian Aquaculture Society. 1(2): 19-43.

El-Dahhar, A. A and A. El-Shazly (1993). Effect of essential amino acids (methionine and lysine) and treated oil in fish diet on growth performance and feed utilization of Nile tilapia. Tilapia nilotica. Aquaculture and Fisheries Management. 24: 731-739.

El-Dahhar, A. A and R. T. Lovell, (1995). Effect of protein to energy ratio in purified diets on growth performance and feed utilization of Mossambique tilapia (Oreochromis mossambicus). Aquaculture Research. 26, 451 - 457.

EL–Dahhar A. A., Viola H. Zaki, and Fayed W.M.A., (1999a). Effect of Different Dietary Protein Levels on Growth, Body Composition and Resistance to *Aeromonas hydrophila* in Nile Tilapia (*Oreochromis niloticus*). Egyptian Journal of Aquatic Biology and Fisheries. 3 (3): 93 – 115.

El-Dahhar A. A., Zeweil H. S. and El-Tawil N. E., (1999b). Protein and Energy Requirements of Fry Nile Tilapia, *Oreochromis niloticus* for Maintenance and Maximum Growth. Egyptian J. Nutrition and Feeds 2 (Special Issue): 807-821.

El-Dahhar, A. A., Zeweil H. S. and El-Tawil N. E. (2000). Effect of protein and energy levels in commercial diets on growth performance of juvenile Nile tilapia (*Oreochromis niloticus*). Egyptian J. of Aquatic Biology and Fisheries. 4(2):267-285.

El-Sayed, A. F., (1987). Protein and energy requirements OT *Tilapia zillii* fingerlings. Ph.D. Diss., Michigan State University, East Lansing, MI, USA, 147 pp.

El-Sayed, A. F. and Teshima, S. I., (1992). Protein and energy requirements of Nile tilapia *Oreochromis niloticus* fry. Aquaculture, 103:55-63.

El-Tawil, N. E. (1998). Study on the determined of protein and energy requirements of Nile tilapia fingerlings. M. Sc. Thesis. Faculty of Agriculture, Saba Basha, Alexandria University.

El-Sayed, A.M., Mansour, C.R. and Ezzat, A.A. (2003). Effect of dietary protein level on spawning performance of Nile tilapia *Oriochromis niloticus* broodstock. reared in different water salinity. Aquaculture 220: 619-632.

El-Tawil, N.E.A., (2006). Studies on the effect of fertilization and nutrition on fish performance. Ph.D. Dissertation. Faculty of Agriculture Saba Basha, Alexandria University.

Ensminger, M. E. and Olentine, Jr. C. G. (1978). editors. Feeds & Nutrition Complete. Clovis, California. USA. pp. 1019-1046.

Fayed, W. M. (1997). Effect of nutrition on the resistance of tilapia fish to parasitic infection. M.Sc. Thesis. Faculty of Agriculture, Saba Basha, Alexandria University.

Garling, D. L. and Wilson R. P. (1976). The optimum protein to energy ratio for channel catfish *Ictalaruss punctatus*. Journal of Nutrition, 106: 1368.

Gatlin III, D. M.; Poe, W. E. and Wilson R. P. (1986). Protein and energy requirements of fingerling channel catfish for maintenance and maximum growth. Journal of Nutrition. 116: 2121-2131.

Green, B. W. (1992). Substitution of organic manure for pelted feed in tilapia production. Aquaculture 101:213-222.

Green, B. W. and Teicher-Coddington, D. R. (2000). **Human food safety and environmental assessment of the use of 17α –Methyltestosterone to produce male tilapia in the United States. J. of the World Aquaculture Society, 31:337-357.**

Guinea, J. and Fermandez, F. (1991). The effect of SDA, temperature and daily rhythm on the energy metabolism of the mullet *Mugil saliens*. Aquaculture, 97: 353-364.

Halver, J.E. (1988)(Editor), Fish Nutrition. Academic Press. New York, NY.

Haskell, D. C. (1959). N. Y. Fish Game J. 6,204. Pages 20-28 in J. E. Halver, 1972. editor. Fish Nutrition. Academic Press. New York and London.

Helland, S. J. and Gisdale-Helland, B. (1998). Growth, feed utilization and body composition of juvenile Atlantic Halibut (*Hippoglossus hippoglossus*) fed diet differing in the ratio between the macro nutrients. Aquaculture, 166:49-56.

Hepher, B.; Liao, I. C.; Cheng, S. H. and Hsieh, C. S., (1983). Food utilization by red tilapia – effect of diet composition, feeding level and temperature on utilization efficiencies for maintenance and growth. Aquaculture. 32: 255-275.

Ishak, M. (1980). The fisheris of the Nile. ICLARM, 21-25.

Jackson, A. J., Capper, B. S. and Matty, A. J. (1982). Evaluation of some plant proteins in complete diets for tilapia *Sarotherodon mossambicus*. Aquaculture 27: 97-109

Jantrarotai, W., Stasit, P., Jantrarotai, P., Viputhanumas, T. and Srabua, P. (1998). Protein and energy levels for maximum growth, diet utilization, yield of edible flish and protein sparing of hybrid *Clarias* catfish (*Clarias macrocephalus* X *Clarias gariepinus*). Journal World of the world Aquaculture Society. 29(3): 281-289.

Jarbo, H. H. and Grant, W. J. (1997). The influence of feeding time and frequency on the growth, survival, feed conversion and body composition of channel catfish, *Ictalurus punctatus*, cultured in a threetier, closed recirculating raceway system. Journal of Applied Aquaculture,. 7 (1).

Jauncey, K. (1982). The effect of varying dietary protein level on growth, food conversion protein utilization and body composition of juvenile tilapia (*Sarotherodon mossambicus*). Aquaculture, 27: 43-54.

Jürss, K. (1981). Influence of temperature and ratio of lipid to protein in diets on aminotransferase activity in the liver and white muscel of rainbow trout (*Salmo gairdneri* Richardson). Comp. Biochem. Physiol. 68B, 527-533.

Khattab Y.A.E., Abdel-Tawwab, M. and Ahmad, M.H. (2004). Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry (*Oreochromis niloticus* L.). Pages 264-276. In Stickney, R.R. (2005). Tilapia update 2004: Second installment. World Aquaculture 36 (2). P 8-10.

Lee, D. J. and Putnam, G. B. (1973). The response of rainbow trout to varying protein / energy ratios in a test diet. J. Nutr., 103: 916-922.

Lee, S. M.; Cho, S. H. and Kim, K. D., (2000). Effect of dietary protein and energy on growth and body composition of juvenile Flounder *Paralichthys olivaceus.* J. of the World Aquaculture Society. 31: 306-315.

Li, M. H. and Robinson, E. H. (1999). Effect of reducing energy to protein ratio on weight gain and body fat of juvenile channel catfish *Ictalurus punctatus.* Journal of the world Aquaculture Society. 30(1): 123-127.

Li, Y. and Lovell R. T. (1992). Elevated levels of dietary ascorbic acid increase immune responses in channel catfish. Journal of Nutrition. 115 : 123.

Lovell, R. T. (Editor) (1989). Nutrition and feeding of fish. Van Nostrand Reinhold, New York, NY, 260pp.

Luzzana, U., Valfré, F. Mangiarotti. M., Domeneghini, C., Radalli, G. Maria, V.M. and Scolari, M., 2005. Evaluation of different protein sources in fingerlings grey mullet *Mugil cephalus* practical diets. Aquaculture Intyernational. 13: 291-303.

Machiels, M. A. M. and Henken, E. (1985). Growth rate, feed utilization and energy metablism of the African catfish, *Clarias gariepinus* (Burchell 1822) as affected by dietary protein and energy content. Aquaculture 44: 271-278.

Mazid, M. A.; Tanaka, Y.; Katayama, T.; Asadur Rahman, M.; Simpson, R. L. and Chichister, C. O., (1979). Growth response of *Tilapia zillii* fingerlings fed isocaloric diets with variable protein levels. Aquaculture, 18: 115-122.

Meenakumari, S.S. and Arivindan, C. M. (1995). Effect of manipulation of feeding frequency on food utilization and growth of *Oreochromis mossambicus* (peters). Indian Journal of Experimental Biology 33 (5): 369-371.

Nash, C. E. and Shehadeh, Z. H. (Editors), (1980). Review of Breeding and Propagation Techniques for Grey Mullet, *Mugil cephalus* L. pp. 1-10.

Nematipour, G. R., Brown, M. L. and Gatlin III, D. M. (1992). Effect of dietary energy : protein ratio on growth characteristics and body composition of hybrid striped bass, *Moron chrysops* × *M. saxatilis.* Aquaculture, 107: 359-368.

Noeske-Hallin, T. A.; Spieler, R. E.; Park, N. C. and Suttle. (1985). Feeding time deferentially affects fattening and growth of channel catfish. Journal of Nutrition 115:1228-1232.

NRC National Research Council, (1993). Nutrition Requirements of Warm Water Fishes and Shellfishes (Revised edition). National Academy Press Washington, DC, 102 pp.

Olvera-Novoa, M.A. Martínez-Palcois, C.A. and Olivera-Castillo, L., (2002). Utilization of torula yeast (*Candida utilis*) as a protein source in diets for tilapia (*Orechromis mossoambicus* Peters) fry. Aquaculture Nutrition. 8: 257-264.

Page, J. W. and Andrews, J. W., (1973). Interaction of dietary levels of protein and energy on channel catfish *Ictalurus punctatus.* J. Nutr., 103: 1339-1346.

Papaparaskeva-Papoutsoglou. E. and Alexis, M. N. (1986). Protein requirements of young grey mullet, *Mugil capito.* Aquaculture, 52: 105-115.

Paraso, M. M., (1990). Effect od dietary protein and energy level on growth, protein utilization and carcass composition of rabbit fish, *Siganus guttatus*. Aquaculture, 86: 41-49.

Phillips, A. M., (1972). Calorie and energy requirements. In: J. E. Halver, 1988 (Editor), Fish Nutrition. Academic Press. New York, NY, pp. 2-29.

Popma, T. J. (1984). Production of mixed-sex population of Tilapia nilotica at three stocking densities. Unpublished Research Report, 1980 to 1984. The International Center for Aquaculture. Fish Production System Development Project, Government of Jamica / USAID.

Prather, E. E. and Lovell, R. T., (1973). Response of intensively fed channel catfish to diets containing various protein-energy ratios. Proc. Annu. Conf. S. E. Assoc. Game Fish Comm., 27: 455-459.

Reis,L. M., Reutebuch, E. M. and Lovell, R. T. (1989). Protein-to-energy ratios in production diets and growth, feed coversion and body composition of channel catfish *Ictalurus punctatus*. Aquaculture, 77: 21-27.

Ringrorse, R.C., (1971). Calorie-to-energy ratio for brook trout (*Salvelinus fontinalis*). J. Fish Res. Board Can., 28(8): 1113-1117.

Schaberclus, W. (1933). In Halver, J. E., Editor. 1988. Fish Nutrition, 2nd Edition. Academic Press, London, England.

Serrano, J. A., Nematipour G. R. and Gatlin III, D. M. (1992). Dietary protein requirement of red drum (*Sciaenops ocellatus*) and relativ use of dietary carbohydrate and lipid. Aquaculture 101: 283-291.

Shiau, S. and Peng, C. (1993). Protein-sparing effect by carbohydrates in diets for tilapia, *Oreochromis niloticus* ×*O. aureus.* Aquaculture, 117: 327-334.

Shiau, S. Y. and Huang, S. L., (1989). Optical dietary protein level for hybrid tilapia (*O. niloticus* x *O. aureus*) reared in seawater. Aquaculture, 81: 119-127.

Shiau, S. Y. and Huang, S. L., (1990). Influence of varying energy levels with two protein concentrations in diets for hybrid tilapia (*O. niloticus* x *O. aureus*) reared in seawater. Aquaculture, 91: 143-152.

Srour, T. M. A. (1999). Studies on tilapia production. Ph. D. Dissertation. Faculty of Agriculture (Saba Basha), Alexandria University.

Takeda, M., Shimeno, S., Hosohawa, H., Hedetoshi, K. and Kaisyo, T., *(*1975). The effect of dietary calorie-to-protein ratio on the growth, feed conversion and body composition of young yellowtail. Bull. Jpn. Soc. Sci. Fish., 41: 443-447.

Takeuchi, T., Watanabe, T. and Ogino, C., (1978). Optimum ratio of protein to lipid in diets of rainbow trout. Bull. Jpn. Soc. Sci. Fish., 44: 683-688.

Twibell, R. G. and Brown P. B., (1998). Optimal dietary protein concentration for hybrid tilapia *Oreochromis niloticus* X *O. aureus* fed all-plant diets. Journal of the World Aquaculture Society 29(1):9-16.

Vallet, F., Berhaut, J., Leray, C., Bonnet, B. and Pic, p., 1970. Preliminary experiments on the artificial feeding of Mugilidae. Helgol. Wiss. Meeresunters., 20: 610-619.

Viola, S., and Arieli, Y., (1982). Nutrition study with high-protein pellet for carp and *Sarotherodon* spp. (Tilapia). Bamidgeh, 35: 9-17.

Wang, K.; T. Jackeuchi and T. Watannabe, (1985). Effect of dietary protein levels on growth of Tilapia nilotica. Bulletin of Japanese Society for Science and fish. 51: 133.

Watanabe, T., (1977). Sparing action of lipids on dietary protein in fish-low protein diet with high calorie content. Technocrat, 10 (8): 34-39.

Watanabe, T.; Kitajima, C. and Fujita, S., (1983). Nutritional values of live organisms used in Japan for mass propagation of fish: a review. Aquaculture, 34: 115-143.

Watanabe, T., Takeuchi, T. and Ogino, C. H. (1979). Studes on the sparing effect of lipids on dietary protein in rainbow trout (*Salmo gairdneri*). In Finfish Nutrition and Fishfeed Technology (Edited by Halver J. E. and Tiews K.), Vol. I, pp. 113-125. Heeneman, Berlin.

Winfree, R. A. and Stickney, R. R., (1981). Effects of dietary protein and energy on growth, feed conversion efficiency and body composition of *Tilapia aurea*. Journal of Nutrition 111:1001-1012.

Wu, Y. V. Rosati, R., Sessa, D. J. and Brown, P. (1994). Utilization of protein-rich ethanol co-products from corn in tilapia feed. Journal of the American Oil Chemists' Society 71: 10411043.

Wu, Y. V. Rosati, R., Sessa, D. J. and Brown, P. (1995). Utilization of corn gluten feed by Nile tilapi. The Progressive Fish-Culturist 57: 305-309.

Zonneveld, N. and Fodholi, R., (1991). Feed intake and growth of red tilapia **at** different stoking densities in ponds in Indonesia. Aquaculture, 99: 83-94.

استعراض مرجعي عن احتياجات أسماك البلطي والبوري من البروتين والطاقة

علاء الدحار
قسم الإنتاج الحيواني والسمكي – كلية الزراعة سابا باشا – جامعة الإسكندرية
ص ب ٢١٥٣١ بولكلي – إسكندرية – جمهورية مصر العربية

في هذه المقالة تم استعراض دراسات احتياجات البلطي والبوري من البروتين والطاقة خلال الفترة من ١٩٨٠ حتى ٢٠٠٧. وقد أظهرت النتائج أن الاحتيجات المثلى من البروتين والطاقة لكلا الجنسين لها مدى واسع من التقديرات وهي تتأثر بعديد من العوامل والتي منها (كثافة تخزين الأسماك، معدلات التغذية والنسبة بين البروتين والطاقة). حيث يتناقص النمو مع زيادة معدلات التخزين وبزيادة مرات التغذية في أثناء النهار قد يؤثر بشكل ملحوظ على معدلات النمو. وقد أظهرت العديد من الدراسات أن إضافة كمية كافية من الطاقة في صورة دهون يمكن أن تقلل استخدام البروتين كمصدر للطاقة ، وعلي أي حال زيادة الطاقة في غذاء الأسماك قد ينتج أسماك دهنية ويقلل من استهلاك الغذاء ويثبط استهلاك مواد الغذاء الأخرى ، وقد تم تقرير دليل لتغذية أسماك البلطي باستخدام معدلات استهلاك الغذاء ومعدل التحول الغذائي وباستخدام مدى واسع من الظروف البيئية أمكن حساب معدل التغذية اليومية تحت ظروف الاستزراع المختلفة، وعلى أي حال فإن تكوين مخاليط الأعلاف المناسبة لتغذية أي صنف من الأسماك يحتاج ذلك إلى فهم خاص للاحتياجات الغذائية لهذا الصنف. وعامة كانت النتائج لكلا الجنسين ذات أهمية كبرى في تقليل تكاليف الإنتاج للمزارع السمكية وزيادة الدخل.