JKAU: Mar. Sci., **Vol. 22**, No. 2, pp: 3-17 (2011 A.D. / 1432 A.H.)
DOI : 10.4197/Mar. 22-2.1

Growth, Feed Utilization and Body Composition of White Sea Bream *Diplodus sargus* Juveniles Offered Diets with Various Protein and Energy Levels

Shymaa M., Shalaby , Ashraf Y. El-Dakar[1], Olfat M. Wahbi and **Imad P. Saoud[2]**

Aquaculture Division, National Institute of Oceanography and Fisheries, Al-Anfoshy, Alexandria, Egypt.
[2] Fish Resources and Aquaculture Department, Suez Canal University, El-Arish, Egypt.
[3] Department of Biology, American University of Beirut, Beirut, Lebanon.
Imad.Saoud@aub.edu.lb

Abstract. White sea bream *Diplodus sargus* is a valued table fish in the Mediterranean region and elsewhere (Black Sea and Eastern Atlantic), and is a candidate aquaculture species in various countries. Understanding dietary protein requirements and protein to energy ratios is imperative for development of a successful culture of this species. A ten week experiment was performed to estimate growth performance of *D. sargus* juveniles offered diets with various levels of protein and energy. Six diets were formulated to contain three levels of protein (25, 35 and 45%) plus two levels of lipids (8 and 12%), and were offered to white sea bream juveniles in triplicate tanks, three times daily, to satiation. Survival was greater than 93% in all treatments. Growth increased with increasing dietary protein and increasing lipid content of the diets. Feed intake increased with increasing dietary protein but was not affected by dietary lipid levels. Protein efficiency decreased with increasing dietary protein levels. Moisture, protein and ash levels in the fish were not affected by dietary protein but body lipid content increased with increasing dietary protein. Dietary protein levels seemed to affect red blood cells. A greater proportion of immature red blood cells were found in blood of fish offered the 25% and the 45% protein diets than in blood of fish offered the 35% protein diet. Results of the present work suggest that a 45% protein, 12% lipid diet results in good growth of *D. sargus*

juveniles but might affect blood composition and thus be detrimental if offered to the fish for a long period of time.

Keywords: white sea bream, *Diplodus sargus*, protein requirement, dietary energy level

Introduction

Aquaculture of fresh water fish, mainly tilapia, is quite successful in Egypt. Marine aquaculture is less well developed and consists almost exclusively of sea bass, *Dicentrarchus labrax* and sea bream, *Sparus auratus*. Developing aquaculture protocols for other high value fish species in order to diversify and improve fish farming is thus very important (El-Dakar, 1999; and Dores *et al.,* 2000). White sea bream, *Diplodus sargus* has good market demand in Egypt and internationally, with prices on par with those of *S. auratus* (Papageorgiou, 2000). White sea bream is a valued table fish in the Mediterranean region and elsewhere, and is a candidate aquaculture species in various countries (Cejas *et al.,* 1993; and Abellan and Garcia-Alcazar, 1995).. It is an omnivore and feeds low on the food chain, (Figueriedo *et al.,* 2005), it adapts easily to captivity (Sa *et al.,* 2006), and its juvenile growth rate is similar or even exceeds that of gilthead sea bream (Cejas *et al.,* 1993; and Abellan and Garcia-Alcazar, 1995). Additionally, white sea beam culture protocols resemble those of other sea bream species, especially at larval and fingerling stages (Cejas *et al.,* 1993; and Abellán and Basurco, 1999).

Studies that determine nutritional requirements of candidate aquaculture species are essential for development of culture protocols (Robaina and Izquierdo, 2000). Knowledge of dietary protein and energy requirements for fish is thus a primary consideration when formulating fish diets (Lee and Kim, 2001). Increasing protein level in diets can lead to improved fish production, especially for carnivorous fish although, excessive dietary protein is not economical for fish culture. Improper protein and energy levels and/or improper protein to energy ratios will result in an increase in fish production cost and a deterioration in water quality (Yang *et al.,* 2002). Insufficient energy in diets reduces protein efficiency due to increased dietary protein use for energy and concomitantly increases ammonia production thus affecting water quality (El-Dakar, 1994; Shyong *et al.,* 1998; Shalaby, 1998; and El-Dakar *et al.,* 2003). Conversely, excessive energy in diets can lead to increased body

lipid deposition and growth reduction due to possible reduction of necessary nutrients for growth (El-Dakar, 1994; and Van der Meer *et al.,* 1997; Shyong *et al.,* 1998; Shalaby, 1998; and El-Dakar *et al.,* 2003). Accordingly, the optimization of protein to energy ratio in diets plays an important role in protein and energy utilization in fish (Kaushik, 1994; and Lee and Kim, 2001).

Energy in marine fish diets is generally increased by increasing lipid content of the feed. However, Sa *et al.* (2006) found that excessive lipid in *D. sargus* diets caused a reduction in growth while Ozorio *et al.* (2006) found no effect of lipid level on growth performance. Studies varying both dietary protein and energy levels have demonstrated fish capability to spare protein when non-protein energy sources (NPES), lipid and carbohydrate, are added to the diet (McGoogan and Gatlin, 1999, 2000; Nankervis *et al.,* 2000; Shalaby *et al.,* 2001; Meyer and Fracalossi, 2004; and Kim and Lee, 2005). However, the use of NPES in fish diets must be properly evaluated because excessive use results in reduction of feed intake, deposition of lipids, and inhibits the utilization of other nutrients (Ai *et al.,* 2004). Accordingly, use of proper P/E ratio should be taken into account when fish diets are formulated. White sea bream appear to be able to grow very well using a wide range of dietary protein, starting from as low as 25% (Sa *et al.,* 2002, 2006, 2007, 2008). Nevertheless, information on protein to digestible energy ratios necessary for optimal growth of *D. sargus* juveniles is lacking.

A few studies have been performed to study nutritional requirements of white sea bream (Sa *et al.,* 2006, 2007; and Ozorio *et al.,* 2006). Based on findings by these authors, the present work was designed to study the effect of a narrow range of dietary protein inclusion at two energy levels, on growth, feed utilization, and body composition, of white sea bream juveniles.

Materials and methods

The present work was performed at the Fish Nutrition Lab., Aquaculture Division, National Institute of Oceanography and Fisheries (NIOF) in Alexandria, Egypt. Six experimental diets were formulated to contain three levels of protein (25, 35 and 45%) plus two levels of lipids (8 and 12%). Calculated digestible energy of the diets ranged from 16.1 to 17.6 kJ/g. Ingredient composition of the experimental diets is

presented in Table (1). Fishmeal was produced locally from small "trash" fish purchased at the fish market. Fish were oven dried at 60 ºC for 48 hours then ground, sieved and stored at -20 ºC until use as an animal protein source. Soybean meal (44%) was used as a plant protein source. Yellow corn, corn starch and sunflower oil served as energy sources. The experimental diets were prepared by mixing dry ingredients with boiling water. The mash was then extruded in a meat grinder through a 1 mm die, and pellets air dried to less than 10% moisture and stored at -20 °C.

Eighteen 70-L glass aquaria (70 × 40 × 30 cm) were used in the study. All aquaria were filled with filtered sea water. Approximately 35% of the water was exchanged daily and aeration was provided using submerged air diffusers and a reciprocating air blower. Photoperiod was maintained at 12:12 L:D. Salinity, temperature, pH, and dissolved oxygen were measured daily and remained at approximately 35‰, 27 ± 2ºC, and 7.8 ± 0.2, 6.8 ± 0.3 mg/kg, respectively. Ammonia and nitrite nitrogen were measured periodically using a LaMotte saltwater aquaculture kit and remained below 0.2 mg/L.

Table 1. Ingredients and proximate analysis of experimental diets.

	Diet No.					
Ingredients %	1	2	3	4	5	6
Fish meal	19	19	34	34	48	48
Soybean meal	25	25	25	25	25	25
Yellow corn	15	15	15	15	15	15
Corn starch	34.85	30.85	21.25	17.25	8.56	4.56
Fish oil	4.15	8.15	2.75	6.75	1.44	5.44
Vitamin & mineral mix[1]	2	2	2	2	2	2
Dry matter	97.99	98.89	98.89	99	98.78	98.86
% DM basis						
Crude protein	25.25	25.3	35.75	35.8	45.55	45.6
Total lipid	7.98	11.99	8	12.01	8.02	12.02
Crude Fiber	3.55	3.51	3.55	3.54	3.57	3.55
Ash	6.77	6.67	8.57	8.55	10.31	10.26
Carbohydrates	56.45	52.53	44.13	40.1	32.55	28.57
GE (KJ/g)[2]	19.1	20.0	19.4	20.3	19.7	20.6
DE (KJ/g)[3]	16.7	17.6	16.4	17.3	16.1	17.0
P/DE (g/KJ)	1.5	1.4	2.2	2.1	2.8	2.7

[1] Eco Vit, Egyptian Veterinary products and feed additives Co., Demyatta, Egypt. The vitamin and premixprovided the following per kg of experimental diet: 15 000 IU, 0.7 g, 15 000 IU, 2 mg, 2.5 mg, 2 mg, 10 mg, 3 mg, 5 mg, 2 mg, 2 mg, 5.5 mg, 200 g, 90 g, 40 g, 2.5 g, 48 g, 3.6 g, 23.5 g, 8 g, 450 mg, 200 mg and 20 mg of vitamin A, vitamin C (Stay C_, 35% active), vitamin D3, vitamin E, vitamin B2, vitamin K3, nicotineamide, vitamin B6, vitamin B12, vitamin B1, folic acid, Ca-D-pantothenate, calcium, phosphate, sodium, copper, magnesium, manganese, zinc, iron, cobalt, iodine and selenium.

[2] GE = Gross energy in the diet.

[3] DE = Digestible energy.

Juveniles of *D. sargus* were caught in a seine net off the coast of Alexandria, Egypt and transported live to a large fiberglass tank filled with seawater. Fish were maintained in the tank for two weeks and offered a commercial fish feed twice daily to apparent satiation. At the start of the experiment, fish were sorted manually to similar size. Ten fish (average body weight, 0.57 g/fish) were randomly distributed into each of the aquaria. During the first three days of the experiment, dead fish were replaced with individuals of the same size. A 3 × 2 factorial design with three randomly chosen replicate tanks per dietary treatment was used. The feeding trial lasted 10 weeks and the fish were fed by hand three times daily (9.00, 12.00 and 15.00 hrs) to apparent visual satiation, 6 days a week. Fish were weighed biweekly after one day of fasting.

Diets and fish samples were analyzed according to AOAC (1990). At the end of the experiment, five fish from each tank were randomly removed and dried at 60 ^{o}C for 48 hrs to estimate moisture content. Dried samples were then finely ground and stored at -20 ^{o}C. Samples were analyzed for protein content using the micro-Kjeldahl method (N × 6.25) and lipids extracted using the Soxhlet method with ethyl ether as solvent. Ash content was determined by burning the samples in a muffle furnace at 600 ^{o}C for two hrs. Gross energy content of experimental diets and fish samples were calculated by using factors of 5.65, 9.45 and 4.22 kcal/g for protein, lipid and carbohydrate, respectively (NRC, 1993). Digestible energy content was estimated from standard physiological fuel values as 4, 9 and 4 kcal/g for protein, carbohydrate and lipid, respectively (Garling and Wilson, 1976).

Blood samples were collected directly from caudal artery after severing the caudal peduncle. Thin smears were dried, fixed with methyl alcohol and stained with Giemsa stain. Erythrocytes were examined for variation in size and shape using a light microscope (X100). Specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency (PE), protein retention efficiency (PRE) and energy retention (ER) were calculated as:

$$SGR = 100 \times (\ln FBW - \ln IBW) / t$$

where FBW is final body weight (g), IBW is initial body weight (g) and t is time in days.

$$FCR = \text{weight of feed offered to fish (g)} / \text{weight gain of fish (g)}$$

$$PE = \text{weight gain of fish (g)} / \text{protein fed (g)}$$

$$PRE = [\text{protein retained (g)} / \text{protein fed (g)}] \times 100$$
$$ER = [\text{energy retained in fish (J)} / \text{energy offered to fish (J)}] \times 100$$

All statistical analyses were performed using MSTAT-C. Analysis of variance (ANOVA) was carried out according to Snedecor and Cochran (1982) using two-way ANOVA with fixed-effect model and parameters with significant differences among treatment means were subjected to Duncan′s Multiple Range-Test ($\alpha = 0.05$) (Duncan, 1995).

Results and Discussion

Survival and growth parameters of white sea bream offered the experimental diets for 10 weeks are shown in Table (2). Survival was greater than 93% in all tanks and there were no significant differences ($P > 0.05$) among treatments. Specific growth rates of the fish ranged between 3.7 and 4.2 %/d, similar to results reported by Sa *et al.* (2006) for *D. sargus* with an initial weight of 1.5 g but much greater than SGR reported by Sa *et al.* (2006, 2007, 2008) when the initial weight of the fish was more than 14g. Our results corroborate statements by these authors that white sea bream grow rapidly when very small but growth slows significantly when fish are larger.

Table 2. Effect of different dietary protein and oil levels on growth and survival of white sea bream *Diplodus sargus* juveniles.

Diet no.	CP	Lipid	Initial Wt. (g/fish)	Final Wt. (g/fish)	Wt. Gain (g/fish)	SGR (%/day)	Survival %
1	25	8	0.57	7.90 ^{f}	7.34 ^{f}	3.77 ^{f}	96
2		12	0.56	8.35 ^{e}	7.79 ^{e}	3.86 ^{e}	93
3	35	8	0.56	9.10 ^{d}	8.54 ^{d}	3.99 ^{d}	100
4		12	0.56	9.55 ^{c}	8.99 ^{c}	4.06 ^{c}	97
5	45	8	0.56	10.05 ^{b}	8.19 ^{b}	4.13 ^{b}	100
6		12	0.57	10.95 ^{a}	10.39 ^{a}	4.24 ^{a}	96
Protein level P				0.001	0.001	0.001	0.17
Energy level E				0.001	0.001	0.001	0.34
Interaction PxE				0.051	0.054	0.001	0.37
PSE*				0.08	0.08	0.03	2.60

* PSE = Pooled Standard Error

Final body weight, and SGR of fish in the present experiment were significantly influenced by both dietary protein and energy levels ($P < 0.01$); both measures improved as dietary protein and energy levels increased. Growth of white sea bream increased with increasing dietary protein from 25 to 45%, suggesting that crude protein requirements for maximum growth for white sea bream may be at or more than 45% of the diet. These results are not supported by previous studies by Sa *et al.* (2006, 2008). Sa *et al.* (2006) found that a 38% protein diet was sufficient for proper growth of *D. sargus* and Sa *et al.* (2008) reported that 27% dietary protein was sufficient for maximal growth.

Dietary lipid also affected weight gain. However, because Sa *et al.* (2006) and Ozorio *et al.* (2006) reported that dietary lipid had no effect on white sea bream growth, we have to assume that growth difference observed among treatments of the present experiment must be due to the small differences in dietary energy densities between the 8% lipid diets and the 12% lipid diets. This suggests that increasing dietary energy possibly provides for a more efficient utilization of dietary protein by white sea bream. Similar improvements of fish protein utilization with increasing dietary energy were observed in rabbitfish *Siganus rivulatus* by Shalaby *et al.* (2001) and in red snapper *Lutjanus campechanus* by Miller *et al.* (2005). Sa *et al.* (2007) showed that dietary energy for *D. sargus* could be obtained from carbohydrates rather than lipids, and that fish offered iso-energetic diets grew similarly when diets contained 64% protein and no carbohydrates, or 38% protein and 36% carbohydrates.

Feed intake, FCR and protein efficiency of white sea bream offered the experimental diets are shown in Table (3). Feed intake was affected by dietary protein level ($P > 0.05$) but not by lipid level. There was no interaction between protein level and energy density of the diet with regards to feed intake. However, the data seem to suggest that protein affected feed intake only at low lipid levels. Feed intake decreased at low protein and lipid levels which contradicts findings by Ozorio *et al.* (2006) that *D. sargus* ingest more food when dietary protein levels decrease. Sa *et al.* (2008) state that fish consume less feed when diets are not balanced but find that white sea bream increase feed intake to compensate for low protein density of feeds. This suggests that our low protein/low lipid diet was not a balanced nutritional source for the fish. The reason is probably the low protein to carbohydrate level of the diet (see Sa *et al.,* 2007).

Table 3. Effects of various dietary protein and energy levels on feed and nutrient utilization of white sea bream *Diplodus sargus* juveniles. (CP = Crude protein; FI = Feed intake in g/fish; FCR = Feed conversion ratio; PE = Protein efficiency; PR = % Protein retention; ER = % Energy retention)

Diet	CP	Lipid	FI	FCR	PE	PR	ER
1	25	8	7.36 [b]	1.66 [a]	2.40 [a]	44.99 [a]	20.78 [c,d]
2		12	8.51 [a]	1.76 [a]	2.25 [a]	37.99 [b]	18.79 [d]
3	35	8	8.44 [a]	1.51 [b]	1.86 [b]	32.40 [b,c]	23.13 [b,c]
4		12	8.79 [a]	1.46 [b]	1.93 [b]	34.95 [b]	24.75 [b,c]
5	45	8	9.45 [a]	1.44 [b]	1.53 [c]	26.70 [c]	25.14 [a,b]
6		12	9.25 [a]	1.24 [c]	1.78 [b]	32.68 [b,c]	28.88 [a]
Protein level P			0.006	0.006	0.001	0.005	0.002
Energy level E			0.105	0.29	0.32	0.26	0.27
Interaction PxE			0.128	0.49	0.07	0.12	0.10
Pooled standard error			0.28	0.05	0.06	1.80	1.12

Protein efficiency decreased with increasing dietary protein level, but was not influenced by dietary energy levels ($P > 0.05$). A decrease in protein retention efficiency with increasing dietary protein was expected and is frequently reported in the literature (see Cho *et al.,* 2001; and Ozorio *et al.,* 2006). Statistically, PRE was not affected by energy density. However, when treatments with 35% protein were removed from the data set, a significant effect of dietary energy on protein retention was detected. Data in Table 3 suggest such an effect even though statistically not shown. Reports of dietary energy effects on protein retention in various other sea breams are mixed, with some authors reporting no effect while others reporting an obvious effect (Company *et al.,* 1999; Santinha *et al.,* 1999; Vergara *et al.,* 1999; Espinos *et al.,* 2003; Skalli *et al.,* 2004; and Ozorio *et al.,* 2006). Results of the present experiment suggest that feed energy density has a sparing effect on proteins but the energy can be of a carbohydrate source rather than a lipid source. Energy retention was not significantly ($P > 0.05$) affected by dietary lipid levels but did increase with an increase in dietary protein. These results were expected because protein content of the various feeds varied much more than lipid content and the total caloric value from protein in the feeds was greater than the caloric content of lipids.

Moisture, protein and ash contents of fish carcasses were not affected by neither dietary protein nor dietary lipid levels. However, fat content of fish tended to increase with increasing dietary protein level. Similarly, Sa *et al.* (2006) reported no effect of dietary protein on whole body protein proportion of white sea bream while Sa *et al.* (2008) observed a slight effect when diets contained 48.7% protein. Ozorio *et al.*

(2006) reported an effect of dietary lipids on body protein content. The discrepancy among results of various experiments is most probably because of differences in fish size, nutritional history, dietary composition *etc*. Nevertheless, to most aquaculturists, the proximate composition of fish can vary within reason without affecting marketability of the product. Protein efficiency and protein retention are more important variables affecting economic returns.

Lipid content of the fish was affected by protein levels in the diet (Table 4). Similar results were observed by Ozorio *et al.* (2006), but not by Sa *et al.* (2006, 2007, 2008). However, data from Sa *et al.* (2008) suggest a decrease in body lipid proportion as protein to energy ratio (P/E) of the diet increased. Results of the present work suggest an increase in body lipids with an increase in dietary P/E. Again we believe the discrepancies among results are because of various factors listed above and more work needs be done before conclusions are made.

Table 4. Effects of various dietary protein and energy levels on body composition of white sea bream *Diplodus sargus* juveniles.

Diet	Dietary protein	Lipid	Moisture	Protein	Lipid	Ash
Initial fish			75.00	15.51	4.25	5.16
1	25	8	69.57	17.02	6.20[b]	5.72
2		12	71.72	16.8	6.35 [b]	5.13
3	35	8	70.6	17.36	6.47 [b]	5.32
4		12	69.25	17.97	7.44 [a]	5.27
5	45	8	69.95	17.37	7.31 [a]	5.02
6		12	68.8	18.28	7.49 [a]	5.29
Protein level P			0.37	0.25	0.006	0.21
Energy level E			0.06	0.34	0.05	0.31
Interaction PxE			0.14	0.21	0.18	0.05
PSE*			0.83	0.535	0.22	0.14

* PSE = Pooled Standard Error

Blood smears of fish offered the 25% protein, 8% fat diet contained an abundance of immature red blood cells. The immature erythrocytes had lightly staining cytoplasm, large nuclei, and thick chromatin threads (Fig. 1). This condition was even more pronounced in fish offered the diet with 45% protein and 8% fat (Fig. 2). However, in fish offered the 35% protein, 8% fat diet, erythrocytes structure appeared normal. Most of the cells were mature, with a homogenous cytoplasm and condensed nuclear material (Fig. 2). In fish offered diets with 12% lipid inclusion, red blood cells became deformed. Blood of fish offered the 25% protein, 12% lipid diet exhibited poikilocytosis, abnormally shaped erythrocytes

(bud-shaped and tear-shaped). At higher dietary protein levels (35% & 45%) fish became aenemiatic, erythrocytes aggregated and lysed, and white blood cell developmental stages increased (Fig. 5 and 6). Vacuoles in blood cells of fish fed protein level of 45% suggested decreased haemoglobin content (Fig. 6).

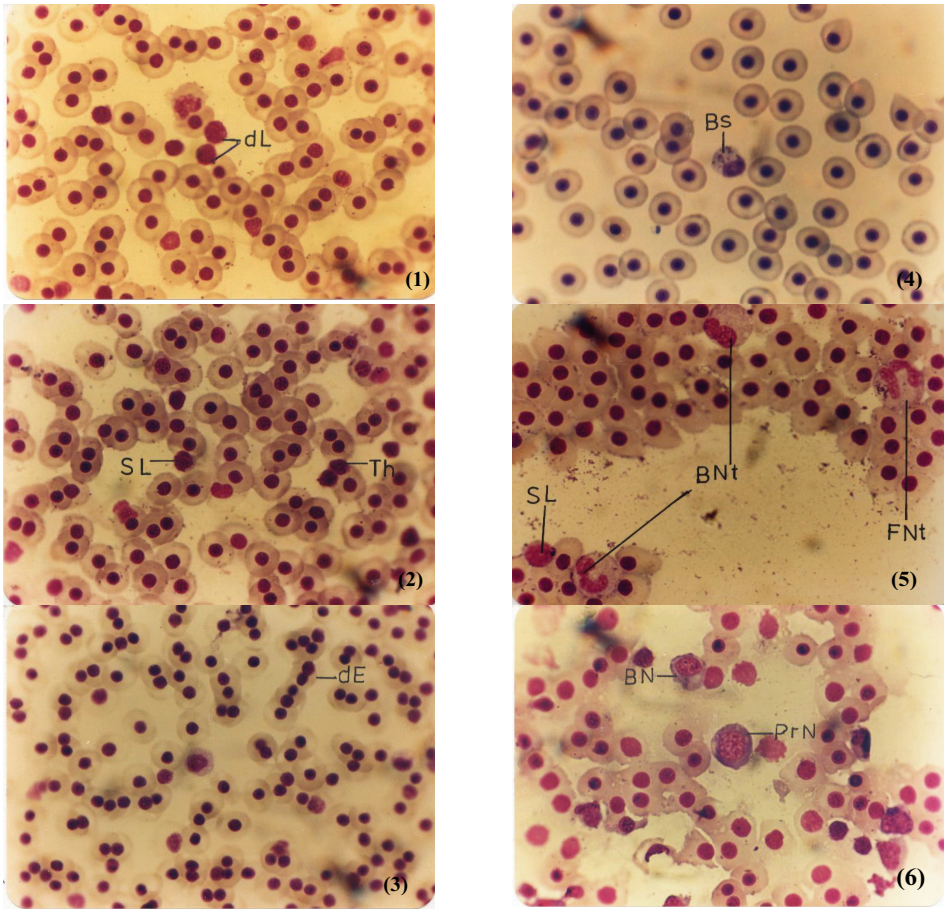

Fig. 1-6. Blood film of fish fed diets of 8% fat ×100. 1: Fish fed diet 25% protein showing, immature erythrocytes; 2: Fish fed diet of 45% protein showing, immature erythrocytes; 3: Fish fed diet of 35% protein showing, mature erythrocytes. (4-6): Blood film of fish fed diets of 12% fat ×100; 4: Fish fed diet of 25% protein showing bud and tear-shaped erythrocytes; 5: Fish fed diet of 35% protein showing aggregated and lysed erythrocytes and increases in granulocytes; 6: Fish fed diet of 45% protein showing, vacuolated erythrocytes. Developing lymphocytes (dL), small lymphocyte (sL), thrombocyte (Th), dividing erythrocyte (dE), Basophilic granulocytes (BS), developmental stage of neutrophilic granulocyte (BNt, FNt) and developmental stage of erythrocyte (PrN).

In conclusion, results suggest that although white sea bream grow best when offered a 45% protein 12% lipid diet, haematological evaluations warn that a high protein and lipid diet might affect blood cells and thus be detrimental to the fish on the long term. Until we understand white sea bream nutritional requirements better, we would suggest offering the fish diets with 35% protein and 8% lipids.

References

Abellan, E. and **Basurco, B.E.** (1999) *Marine Finfish Diversification: Current Situation and Prospects in Mediterranean Aquaculture.* Options Mediterraneennes, No. 24, CIHEAM, Zaragoza, Spain.

Abellan, E. and **Garcia-Alcazar, A.** (1995) Pre-growout experiences with white seabream (*Diplodus sargus sargus,* Linnaeus, 1758) and sharpsnout seabream (*Diplodus puntazzo,* Cetti, 1977), Marine Aquaculture Finfish Species Diversification. *Cahiers Options Mediterranéennes.,* **16 :** 57–63.

Ai, Q., Mai, K., Li, H., Zhang, C., Zhang, L., Duan, Q., Tan, B., Xu, W., Ma, H., Zhang, W. and **Liufu, Z.** (2004) effect of dietary protein to energy ratios og growth and body composition of juvenile Japanese seabass, *Lateolabrax japonicus*. *Aquaculture,* **230:** 507−516.

AOAC (1990) Official Methods Analysis of Association of Official Analytical Chemists. 15th edn. Published by the Association of Analytical Chemists. Virginia, 2220, USA.

Cejas, J., Samper, M., Jerez, S., Fores, R. and **Villamandos, J.** (1993) Perspectivas de cultivo de breca (*Pagellus erythrinus*) y sargo (*Diplodus sargus*); primeros resultados de crecimiento comparado con la dorada (*Sparus aurata*). In: *Actas del IV Congreso Nacional de Acuicultura, 21−24 September 1993* (Cervino, A., Landin, A., de-Coo, A.A., Guerra, A. and Torre, M. (Eds.)), Vilanova de Arousa, Galicia, Spain, pp: 127−132..

Cho, S.H., Jo, J.Y. and **Kim, D.S.** (2001) Effects of variable feed allowance with constant energy and ratio of energy to protein in a diet for constant protein input on the growth of common carp *Cyprinus carpio* L. *Aquaculture Research,* **32**: 349−356.

Company, R., Calduch-Giner, J.A., Perez-Sanchez, J. and **Kaushik, S.J.** (1999) Protein sparing effect of dietary lipids in common dentex (*Dentex dentex*): a comparative study with sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). *Aquatic Living Resources,* **12:** 23−30.

Dores, E., Narciso, L., Morais, S. and **Pousão-Ferreira, P.** (2000) Larviculture of the white sea bream (*Diplodus sargus*, Linnaeus, 1758): A new approach. In: Aqua 2000. Special Publication No. 28, Nice, France, 2-6 May 2000 European Aquaculture Society, Oostende, Belgium 187 pp.

Duncan, D.B. (1955) Multiple range and multiple F-Test. Biometrics. **11:** 1−42.

El-Dakar, A.Y. (1994) Studies on Aquatic animals: Shrimp nutrition. *Ph.D Thesis.* Alexandria University, Egypt.

El-Dakar, A.Y. (1999) Effect of different feeding levels on performance of rabbitfish, *Siganus rivlatus*, fingerlings. Egyptian journal Aquatic Biology and Fisheries. **3:** 35–56.

El-Dakar, A.Y., Hassanen, G.D.I., Ghoneim, S.I. and **Zenhom, O.A.** (2003) Daily optimum energy feeding of rabbitfish *Siganus rivulatus*: Effect of dietary energy level at various feeding rate on performance of rabbitfish, Siganus. Book of Proceeding, Vol. 1. *Aquaculture America Conference* 2003. American Aquaculture Society, Baton Rouge, Louisiana USA.

Espinos, F.J., Tomas, A., Perez, L.M., Balasch, S. and **Jover, M.** (2003) Growth of dentex fingerlings (*Dentex dentex*) fed diets containing different levels of protein and lipid. *Aquaculture,* **218:** 479−490.

Figueiredo, M., Morato, T., Barreiros, J.P., Afonso, P. and **Santos, R.S.** (2005) Feeding ecology of the white seabream, *Diplodus sargus*, and the ballan wrasse, *Labrus bergylta*, in the Azores. *Fisheries Research,* **75:** 107−119.

Garling, D.L. and **Wilson, R.P.** (1976) Optimum dietary protein to energy ratio for channel catfish fingerlings, *Ictalurus punctatus*. *Journal of Nutrition,* **106:** 1368–1375.

Kaushik, S.J. (1994) Nutritional strategies for the reduction of aquaculture wastes. In: Proceedings of FOID' 94 (ed. by K.-D. Cho), 115–132. *The Third International Conference on Fisheries and Ocean Industrial Development for Productivity Enhancement of the Coastal Waters*, 3–4 June 1994. National Fisheries University of Pusan, Korea.

Kim, L.O. and **Lee, S.M.** (2005) Effect of dietary protein and lipid levels on growth and body composition of of bagrid catfish (*Pseudobagrus fulvidraco*). *Aquaculture.* **243:** 323−329.

Lee, S.M. and **Kim, K.D.** (2001) Effect of dietary protein and energy levels on the growth, protein utilization and body composition of juvenile masu salmon (*Oncorthynchus masou Brevoort*). *Aquaculture Research,* **32:** 39−45.

McGoogan, B.B. and **Gatlin III, D.M.** (1999) Dietary manipulation affecting growth and nitrogenous waste production of red drum (*Sciaenops ocellatus*): I. Effects of dietary protein and energy levels. *Aquaculture.* **178:** 333−348.

McGoogan, B. and **Gatlin, D.M.** (2000) Dietary manipulations affecting growth and nitrogenous waste production of red drum, *Sciaenops ocellatus*. *Aquaculture.* **182** (3–4): 271–285.

Meyer, G. and **Fracalossi, D.M.** (2004) Protein requirement of jundia (*Rhamdia quelen*) at two dietary energy concentrations. *Aquaculture.* **240:** 331−343.

Miller, C.L., Davis, D.A. and **Phelps, R.P.** (2005) The effects of dietary protein and lipid on growth and body composition of juvenile and sub-adult red snapper, *Lutjanus campechanus* (Poey 1860). *Aquaculture Research.* **36:** 52–60.

Nankervis, L., Matthews, S. and **Appleford, P.** (2000) Effect of dietary non-protein energy source on growth, nutrient retention and circulating insulin-like growth factor I and triiodothyronine levels in juvenile barramundi, *Lates calcarifer*. *Aquaculture,* **191:** 323–335.

National Research Council, NRC (1993) *Nutrition Requirements of Fish*. National Academy Press. Washington, D.C. pp.114.

Ozorio, R.O.A., Valente, L.M.P., Pousao-Ferreira, P. and **Oliva-Teles, A.** (2006) Growth performance and body composition of White seabream (*Diplodus sargus*) juveniles fed diets with different protein and lipid levels. *Aquaculture Research,* **37:** 255−263.

Papageorgiou, P.A. (2000) Marketing development for new Mediterranean aquaculture species: Enterprise strategies. In: Recent advances in Mediterranean aquaculture finfish species diversification Zaragoza: CIHEAM-IAMZ, 2000. 394 p. (Cahiers Options Méditerranéennes; v. 47) pp: 11-24.

Robaina, L. and **Izquierdo, M.S.** (2000) Methodological strategies for the determination of nutrient requirements in finfish. *Cahiers Options Méditerranéennes,* **47:** 25−41.

Sá, R., Pousão-Ferreira, P. and **Oliva-Teles, A.** (2002) Dietary proteína requirements of white sea bream (*Diplodus sargus*) juveniles. In: *Proceedings 10th International Symposium on Nutrition and Feeding in Fish*, Rhodes, Greece, 2-7 June 2002, 165pp.

Sá, R., Pousão-Ferreira, P. and **Oliva-Teles, A.** (2006) Effect of dietary protein and lipid levels on growth and feed utilization of White sea bream (*Diplodus sargus*) juveniles. *Aquaculture Nutrition,* **12:** 310−321.

Sá, R., Pousão-Ferreira, P. and **Oliva-Teles, A.** (2007) Growth performance and metabolic utilization of diets with different protein: carbohydrate ratios by white sea bream (*Diplodus sargus,* L.) juveniles. *Aquaculture Research,* **38:** 100–105.

Sá, R., Pousão-Ferreira, P. and **Oliva-Teles, A.** (2008) Dietary requirement of white sea bream (*Diplodus sargus*) juveniles. *Aquaculture Nutrition,* **14:** 309−317.

Santinha, P.J.M., Medale, F., Corraze, G. and **Gomes, E.F.S.** (1999). Effects of dietary protein: lipid ratio on growth and nutrient utilization in gilthead seabream (*Sparus aurata* L.). *Aquaculture Nutrition,* **5:** 147−156.

Shalaby, S.M. (1998) Nutrition requirements of rabbitfish, *Siganus rivulatus*, fingerlings. Ph.D thesis, Alexandria University, Egypt.

Shalaby, S.M., El-Dakar, A.Y. and **Ghoneim, S.I.** (2001) Protein sparing effect by carbohydrate in diets of rabbitfish, *Siganus rivulatus*. *Egyptian Journal of the Aquatic Biology and Fisheries,* **5:** 87−98.

Shyong, W.J., Huang, C.H. and **Chen, H.C.** (1998) Effects of dietary protein concentration on growth and muscle composition of juvenile *Zacco barbata*. *Aquaculture,* **167:** 35−42.

Skalli, A., Hidalgo, M.C., Abellan, M., Arizeun, M. and **Cardenete, G.** (2004) Effect of the dietary protein/lipid ratio on growth and nutrient utilization in common dentex (*Dentez dentex* L.) at different growth stages. *Aquaculture,* **235:** 1−11.

Snedecor, G.W. and **Cochran, W. G.** (1982) Statistical methods 6th edn. Iowa State University, Press, Ames, Iowa.

Van der Meer, M.B., Zamora, J.E. and **Verdegem, M.C.** (1997) Effect of dietary lipid level on protein utilization and the size and proximate composition of body compartments of *Colossoma macropomum* (Cuvier). *Aquaculture Research,* **28:** 405−417.

Vergara, J.M., Lopez-Calero, G., Robaina, L., Caballero, M.J., Montero, D., Izquierdo, M.S. and **Aksnes, A.** (1999) Growth, feed utilization and body lipid content of gilthead seabream (*Sparus aurata*) fed increasing lipid levels and fish meals of different quality. *Aquaculture,* **179:** 35−44.

Yang, S.D., Liou, C.H. and **Liu, F.G.** (2002) Effects of dietary protein level on growth performance, carcass composition and ammonia excretion in juvenile silver perch (*Bidyanus bidyanus*). *Aquaculture,* **213:** 363–372.

النمو، الكفاءة الغذائية وتركيب الجسم لأسماك الشراغيش المغذاة على علائق مختلفة في مستويات البروتين والطاقة

شيماء شلبي، و أشرف الدكر[١]، و أُلفت وَهبي، و عماد سعود[٢]

قسم الاستزراع المائي، المعهد القومي لعلوم البحار و المصايد، الأنفوشي، الإسكندرية، مصر

[١] قسم الثروة السمكية و الاستزراع المائي، جامعة قناة السويس، العريش، مصر

[٢] قسم البيولوجي، الجامعة الأمريكية في بيروت، بيروت، لبنان

المستخلص. يعتبر سمك السرغوس طبقا شائعا في منطقة البحر الأبيض المتوسط والعديد من الدول الاستوائية، وهذا النوع من السمك مرشحا للتربية المائية في مختلف البلدان. إن فهم متطلبات البروتين والطاقة في غذاء هذه السمكة أمر حتمي لتطوير التربية المائية وجعلها صناعة ناجحة. ولتحديد معايير النمو لأسماك السرغوس الصغيرة، تم إجراء تجربة مدتها عشرة أسابيع منحت خلالها الأسماك وجبات غذائية تتضّمن مستويات مختلفة من البروتين والطاقة، أعطيت خلالها الأسماك ست وجبات غذائية تحتوي على ثلاثة مستويات من البروتين (٣٥، ٢٥، و٤٥٪) ومستويين من الدهون (٨ و١٢٪)، منحت بمعدل ثلاث مرات يوميا حتى الأشباع. كانت نسبة بقاء الأسماك على قيد الحياة أكثر من ٩٣٪ في جميع الأحواض. ازداد معدل النمو مع ازدياد البروتين الغذائي وازدياد محتوى الدهون الموجودة في الوجبات الغذائية. وقد ازدادت كمية الأكل المستهلكة مع ازدياد البروتين الغذائي لكنه لم يتأثر بمستوى الدهون الموجودة في الغذاء. انخفضت فعالية البروتين مع ازدياد مستوى البروتين الغذائي.

ولم تتأثر كمية المياه ،البروتين و مستوى الرماد في لحم الأسماك ولكنَ محتوى الدهون في الجسم ازداد مع زيادة البروتين. وُجد أن مستوى البروتين في الغذاء له تأثير على كريات الدم الحمراء، فنسبة عدد خلايا الدم الحمراء القليلة النمو ارتفعت في دم الأسماك التي منحت ٢٥ و٤٥٪ من البروتين الغذائي أكثر من الأسماك التي منحت ٣٥٪ من البروتين الغذائي. أظهرت نتائج هذا العمل انّ ٤٥٪ من البروتين و١٢٪ من الدهون هي النتيجة الأمثل لنمو صغار السرغوس ولكن من جهة ثانية قد تؤثر على تركيبة الدم وبالتالي قد تكون ضارة إن منحت للأسماك لمدة طويلة من الزمن.