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Protein and energy requirements of gilthead bream (*Sparus aurata* L.) fingerlings: Preliminary results

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SUMMARY – Protein and energy requirements of *Sparus aurata* fingerlings were studied at high and low temperatures. Eight diets containing three protein levels of about 40, 45, and 51% in combination with three lipid levels of 11, 16, and 21% and variable carbohydrate content were fed to satiation to populations of 2.1-2.8 g initial weight at 25ºC or 10-14ºC. In a third experiment the better performing diets at satiation and those with higher protein content were fed to satiation or under restricted feeding at high temperatures. At high temperatures, diets 7 and 8, containing 51% of protein with either 16 or 21% of lipids, seemed to better support performance when fed to satiation. At low temperatures, Diet 7 also showed the best performance, although not different from the diet with 46% protein and 21% lipids. When feeding levels were reduced feed efficiencies improved but higher dietary content of protein was necessary for optimum performance.

Keywords: Protein, energy, gilthead bream, nutrition.

***RESUME –** "Besoins en protéines et énergie des juvéniles de daurade royale (*Sparus aurata *L.). Résultats préliminaires". Les besoins en protéines et énergie des juvéniles de* Sparus aurata *ont été étudiés à hautes et basses températures. Huit régimes contenant trois niveaux de protéines d'environ 40, 45 et 51% combinés à trois niveaux de lipides de 11, 16 et 21% et une teneur variable en hydrates de carbone ont été distribués à volonté à des populations d'un poids initial de 2,1-2,8 g à 25ºC ou 10-14ºC. Dans une troisième expérience, les régimes donnant les meilleures performances à volonté et ayant une plus forte teneur en protéines ont été distribués à volonté ou de façon restreinte à de hautes températures. A haute température, les régimes 7 et 8 contenant 51% de protéines avec soit 16 soit 21% de lipides semblaient donner de meilleures performances lorsqu'ils étaient distribués à volonté. A faible température, le régime 7 montrait également les meilleures performances, bien que n'étant guère différent du régime à 46% de protéines et 21% de lipides. Lorsque les niveaux d'aliment étaient réduits, l'efficacité alimentaire s'améliorait mais une plus grande teneur en protéines alimentaires était nécessaire pour des performances optimales.*

***Mots-clés :** Protéines, énergie, daurade royale, nutrition.*

Introduction

Fish have a high protein requirement, which is partly due to the fact that these utilize a significant portion of dietary protein in order to meet their energy needs (Cowey, 1993; Kaushik and Medale, 1994). The major feed ingredient used in fish industry is fishmeal known for its optimal composition in protein, essential amino acids, and fatty acids. In recent years the exponential increase of aquaculture, augmented the demand for this protein source in fish industry, which however is not of unlimited supply and its levels are expected to critically reduce between the years 2005 and 2010. A crucial point for the sustainability of the Aquaculture sector is therefore a reduction of fish meal use in fish diets, which can be partly achieved through formulation of diets of lower protein content (Dosdat *et al*., 1996).

Reduction of protein content can be achieved by increasing the energy supplied by other constituents of the diet like fat and carbohydrate. However the inclusion of high levels of different energy sources in feeds for aquaculture may reduce growth by reducing feed intake and as a consequence the total protein intake. The protein sparing effect of other energy sources has been demonstrated in a number of fish, like salmonids (Johnsen *et al.,* 1993; Weatherup *et al*., 1997), red sea bream (Takeuchi *et al.,* 1991), striped bass (Nematipour *et al.,* 1992) and sea bream (Vergara *et al*., 1996; Company *et al.,* 1999a) by improvements in growth and protein efficiency. Nevertheless some other researchers did not find any protein sparing effect in sea bass and sea bream (Lanari *et* *al.,* 1998; Peres and Oliva Teles 1999a; Company *et al*., 1999b). Results could however be affected by the feeding levels used. Information about the protein/energy requirements of sea bream reared at low temperatures is also lacking.

The present work gives preliminary results of experiments conducted in recent years in our laboratory with the aim of determine protein/energy requirements of gilthead bream fingerlings at high and low temperatures as well as for evaluating the effect of feeding levels on these requirements.

Materials and methods

General description of the experiments

Three consecutive experiments were performed. In the first the protein and energy requirements of gilthead bream fingerlings were determined by feeding to satiation with eight diets differing in their protein and energy content. The rearing was performed during summer months. In the second experiment similar diets and initial fish sizes to those of the first experiment were used but fish were reared at low winter temperatures. In the third experiment two of the high protein diets that gave the best performance in the first experiment were used at apparent satiation as well as at two restricted feeding levels. A third diet which had a higher protein content and a high lipid level was also used at two restricted feeding levels so as to provide evidence of whether the protein content of the diets was a limiting factor of growth at restricted feeding for the first two diets.

Diets

The raw materials used for diet formulation were fish meal LT in order to secure a high protein digestibility and fish oil as a lipid source. Dextrin was used as a carbohydrate source in the first two experiments and gelatinized starch in the last one. The nutrient content of all the diets used in the three experiments is presented in Table 1.

Table 1. Composition (% dry matter) of diets used for feeding gilthead bream in the three experiments

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9
Summer experiment satiation									
Protein	40.3	40.7	45.4	46.9	45.7	51.2	50.9	50.6	
Fat	10.5	21.4	11.0	16.3	21.4	11.8	16.2	21.6	
E (kJ/g)	20.39	22.8	20.8	22.1	23.2	21.4	22.2	23.5	
Winter experiment									
Protein	41.7	41.5	47.1	46.4	47.5	52.6	53.5	52.1	
Fat	11.3	21.3	11.9	15.8	21.5	12.4	16.7	21.7	
E (kJ/g)	19.7	22.1	20.1	20.9	22.5	20.6	21.7	22.7	
Summer experiment restricted feeding									
Protein							52.6	52.5	57.5
Fat							15.0	20.7	20.4
E (kJ/g)							21.2	22.6	22.7

Rearing

Experiment 1

Groups of 40 fish of an average weight of 2.1 g were distributed in sixteen cylindrical tanks of 100 l each (two groups per diet), connected to an open flow through system. Sea water of 38‰ salinity was used of a temperature of 25°C. Fish were fed by hand to satiation for 54 days. The whole population was weighed every two weeks after anaesthetization.

Experiment 2

Fish having an average weight of 2.8 g were used at a water temperature of 10-14°C. Fish were fed by hand to satiation for 81 days. The rest of the rearing conditions were as before.

Experiment 3

Fish having an average weight of 1 g were used at a water temperature of 25°C. Fish were fed by hand for 55 days. For Diets 7 and 8 three feeding levels were used to apparent satiation and at about 90% (level A) and 80% (level B) of satiation. Diet 9 was fed at two levels similar to the restricted levels of Diet 8.

Statistical analysis

One way ANOVA was used for finding significant differences at a 5% significance level. Comparison among means was performed by using the Newman-Keuls test.

Results

Experiment 1

A strong correlation between feed consumption and energy content of the diet was found ($p = 0.004$, $r = -0.67$). Feed consumption ranged from 5.3 to 3.5% of the mean average weight over the rearing period and was reduced with the increase in energy content (Fig. 1). The highest weight increase was exhibited by Diet 7, which contained 51% protein and 16% lipids (Fig. 2). However a significant difference was apparent only when compared to Diet 3. Increasing the lipid content to 21.6% (Diet 8) did not appear to improve growth. Feed efficiency was affected by the type of diet and Diets 7 and 8 indicated the best feed efficiency, which was significantly better than that of the rest of the diets. Diets 7 and 8 were also characterized by a low daily protein consumption compared to the other diets.

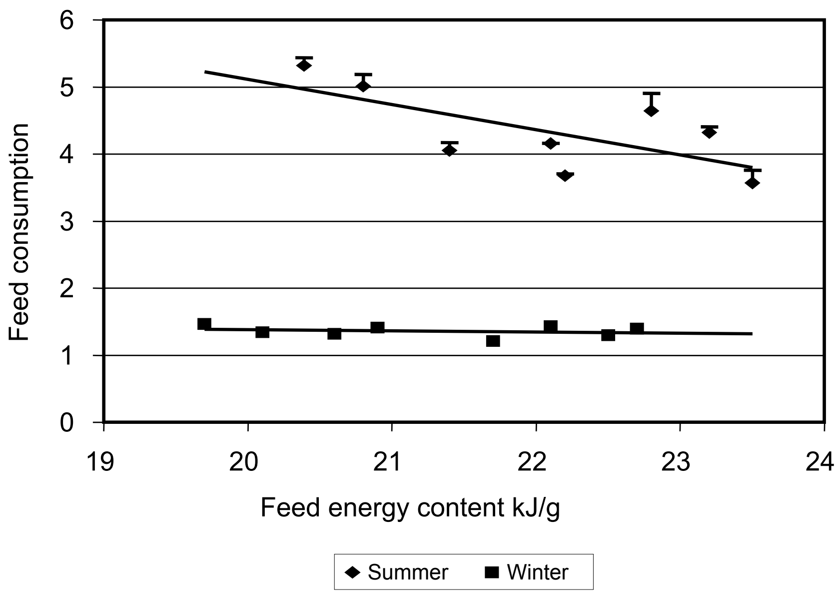

Fig. 1. Daily feed consumption (% of average fish weight) of gilthead bream fingerlings in relation to the energy content of the feeds at high and low rearing temperatures (Exp. 1 and 2).

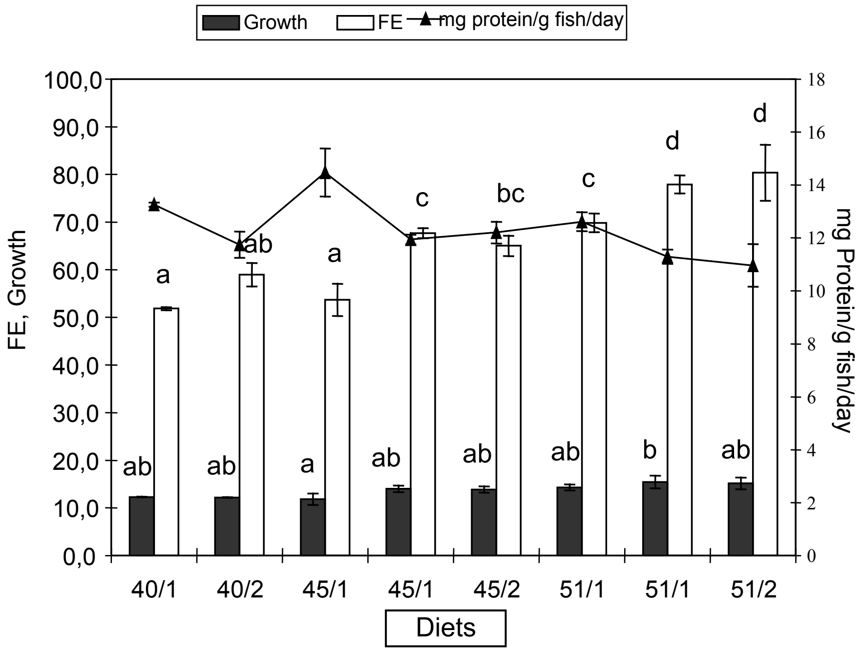

Fig. 2. Feed efficiency (FE), weight increase (g), and protein consumption (mg protein/g fish/day) of gilthead bream fingerlings fed different diets at high temperatures (Exp. 1).

Experiment 2

Feed consumption was lower than that of experiment 1 and was not related to the energy content of the diet (Fig. 1). The weight increase was best for Diets 5 and 7 but these values were not significantly different from the rest of the diets with the exception of Diets 1 and 3 (Fig. 3). Protein consumption by fish fed these diets indicated intermediate values compared to the rest of the diets. Diet 7 showed the highest value for feed efficiency, which was significantly different than all other diets with the exception of Diet 5. Increasing the lipid content from 16.7% to 21.7% from Diets 7 to 8 reduced significantly feed efficiency.

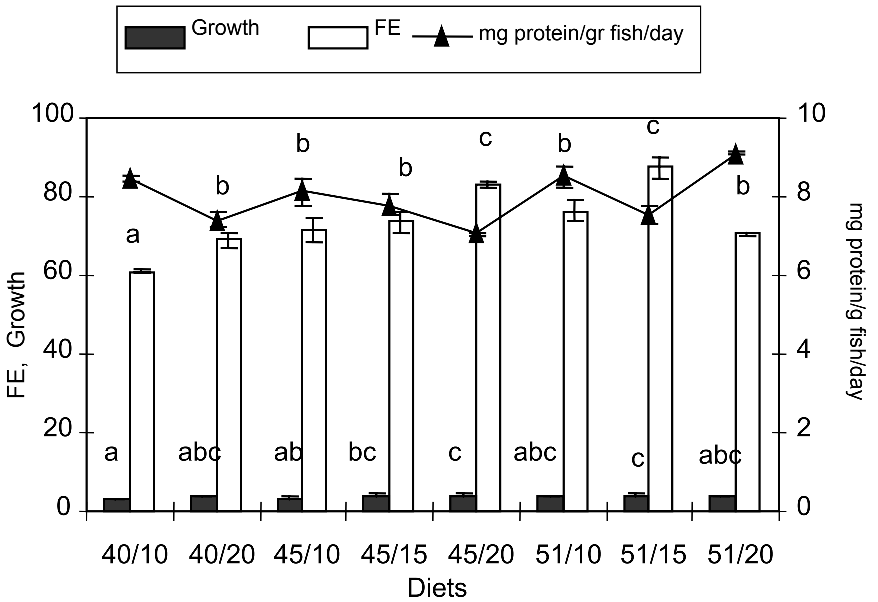

Fig. 3. Feed efficiency (FE), weight increase (g), and protein consumption (mg protein/g fish/day) of gilt bream fingerlings fed different diets at low temperatures (Exp. 2).

Experiment 3

There was a clear trend for reduced weight increase as well as for improved feed efficiency with the reduction of feed intake for each dietary treatment. Feed efficiency was best for Diet 9 at the lowest feeding level. This value was not significantly different than that of the same diet at the higher feeding level as well as of Diet 8 at the lowest feeding level (Fig. 4). In general values of feed efficiency were much higher than those of the first experiment, while protein consumption was lower.

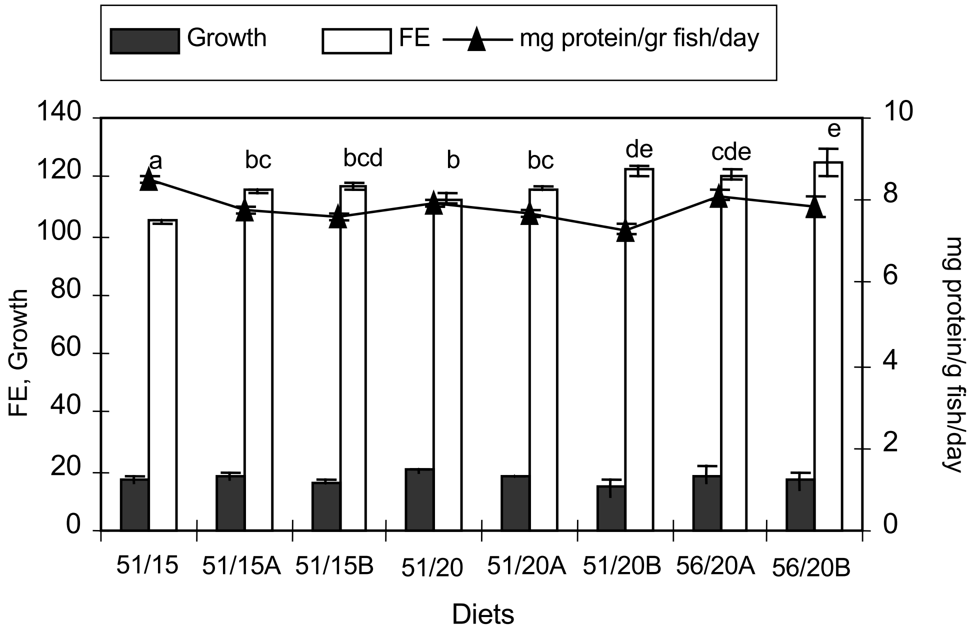

Fig. 4. Feed efficiency (FE), weight increase (g), and protein consumption (mg protein/g fish/day) of gilthead bream fingerlings fed diets at different feeding levels (Exp. 3).

Discussion

The energy content of the feed is considered to be the main factor controlling feed consumption in finfish (Jobling and Wandsvik, 1983; Kaushik and Luquet, 1984; Kaushik and Oliva Teles, 1985; Boujard and Medale, 1994; Paspatis and Boujard, 1996). This has been also shown for gilthead bream with the use of automatic feeders (Kentouri *et al*., 1995). This dependence was clear for the high temperature experiment while no such effect was apparent for the low temperature experiment. It might be possible that other factors than feed energy content could affect feed consumption more strongly at low temperatures.

The mostly similar weight increase observed for the summer experiment could be due to the variable feeding rates of the different dietary groups. Regulation of feed intake by sea bream to attain the same final weights when fed with diets varying in protein and energy content was also shown in previous studies (Marti-Palanca *et al*., 1996; Santinha *et al*., 1999). Selection of the diet resulting in best performance characteristics should therefore be based on feed utilization parameters too. On the basis of both fish growth and feed efficiency both Diets 7 and 8 performed best. Since lipid is more expensive than carbohydrate, the combination of 51% protein (the highest level used in the present study) with 16% lipids appears to be the more cost effective diet for fish of this size when feeding is performed to satiation. This corresponds to an energy content of 22.2 kJ/g feed. A similar energy content has been found to give best performance parameters in studies where *ad libitum* feeding was used (Marti-Palanca *et al.,* 1996; Santinha *et al.,* 1999), however with higher or lower protein content respectively. This difference might be due to the different size of fish or diet formulation used.

The diet giving the best results both in terms of growth and feed efficiency at low temperatures was again Diet 7 which, contrary to what was found at high temperatures, was not significantly different from Diet 5. The generally lower potential for growth at low temperatures could be the main reason of the lack of difference observed in these two diets. This result is in agreement with results for sea bass juveniles, fed with isoenergetic diets to satiation at two water temperatures (Peres and Oliva Teles, 1999b).

Reduction of feeding at high temperatures improved significantly feed efficiencies (Fig. 4). It has been shown that high feeding levels favour the occurrence of a state of "metabolic starvation" in gilthead bream characterized by increased levels of growth hormone, which increases energy expenditure so that excessive fat deposition is avoided (Perez-Sanchez *et al*., 1995; Marti-Palanca *et al*., 1996; Company *et al*., 1999a). When feed efficiency was plotted against feeding level (Fig. 5) a significant negative relation was apparent at both temperatures. However the effect was much stronger for the low temperature. Since feed consumption at low temperatures was small some other factors might influence the relationship of feed efficiency to the consumption of feed.

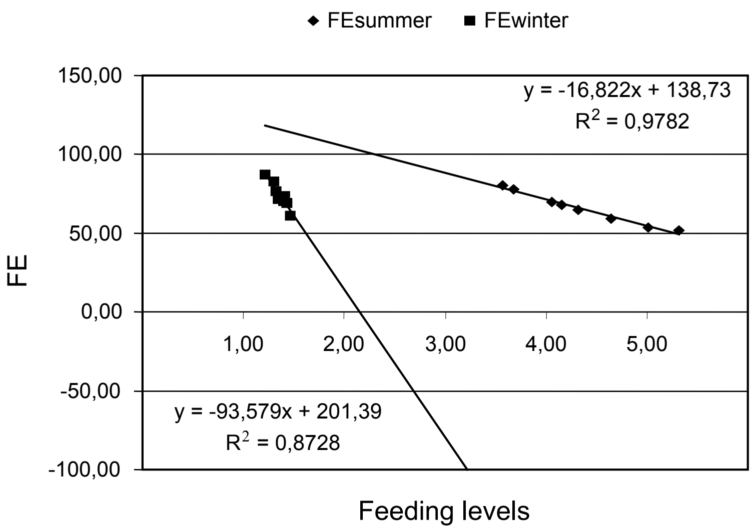

Fig. 5. Feed efficiency (FE) at high and low temperatures in relation to feeding levels (Exp. 1 and 2).

When restricted feeding was used the best results in terms of both growth and feed efficiency were obtained at higher protein levels (57%) than those used in the previous studies. Protein consumption did not appear to be limiting for other diets since protein consumption at both feeding levels of Diet 9 was similar to that of most of other diets tested. The better performance could therefore be a result of a better protein and energy balance resulting to better feed assimilation.

Lupatsch *et al*. (2001) calculated the digestible protein and energy requirements for gilthead bream in terms of daily consumption to avoid differences due to different feeding levels. The suggested daily consumption for fish of 10 g was 0.13 g/fish/day and 4.55 kJ/fish/day for protein and energy respectively. Values of 0.19 and 8.2 respectively were calculated for Diet 7 performing best in the first experiment and 0.16 - 6.5 and 0.14 -5.6 for Diet 9 at the A and B restricted feeding levels, respectively. All values determined in the present experiment refer to crude and not digestible nutrient values so are expected to be higher than digestible nutrient values. It is however apparent that feeding to satiation increases the requirement for protein and energy possibly due to a worsening of digestibility and metabolic utilization of dietary nutrients.

References

Boujard, T. and Medale, F. (1994). Regulation of voluntary feed intake in juvenile rainbow trout fed by

hand or by self feeders with diets containing two different protein/energy ratios. *Aquat. Living Resour*., 4: 211-215.
Company, R., Calduch-Giver, J.A., Kaushik, S. and Perez-Sanchez, J. (1999a). Growth performance and adiposity in gilthead sea bream (S*parus aurata*): Risks and benefits of high energy diets. *Aquaculture*, 171: 279-292.
Company, R., Calduch-Giner, A., Perez-Sanchez, J. and Kaushik, S.J. (1999b). Protein sparing effect of dietary lipids in common dentex (*Dentex dentex*): A comparative study with sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). *Aquat. Living Resour*., 12(1): 23-30.
Cowey, C.B. (1993). Some effects of nutrition on flesh quality of cultured fish. In: Fish Nutrition in Practice, Proceedings of the IV International Symposium on Fish Nutrition and Feeding, Kaushik, S.J. and Luquet, P. (eds), INRA, Biarritz (France), 24-27 June 1991. *Les Colloques INRA*, No. 61: 227-236.
Dosdat, A., Servais, F., Metailler, R., Huelvan, C. and Desbruyeres, E. (1996). Comparison of nitrogenous losses in five species of teleosts. *Aquaculture*, 141: 107-127.
Jobling, M. and Wandsvik, A. (1983). An investigation of factors controlling food intake in Arctic charr, *Salvelinus alpinus* L. *J. Fish Biol*., 23: 397-404.
Johnsen, F., Hillestad, M. and Austreng, E. (1993). High energy diets for atlantic salmon. Effects on pollution. In: Fish Nutrition in Practice, Proceedings of the IV International Symposium on Fish Nutrition and Feeding, Kaushik, S.J. and Luquet, P. (eds), INRA, Biarritz (France), 24-27 June 1991. *Les Colloques INRA,* No. 61: 391-401.
Kaushik, S.J., and Luquet, P. (1984). Relationship between protein intake and voluntary energy intake as affected by body weight with an estimation of maintenance needs in rainbow trout. *Z. Tierphysiol. Tierernahr. Futtermittelkd*., 51: 57-69.
Kaushik, S.J. and Medale, F. (1994). Energy requirements, utilization and dietary supply to salmonids. *Aquaculture*, 124: 81-97.
Kaushik, S.J. and de Oliva Teles, A. (1985). Effect of digestible energy on nitrogen and energy balance in rainbow trout. *Aquaculture*, 50: 89-101.
Kentouri, M., Divanach, P., Geurden, I. and Anthouard, M. (1995). Mise en évidence du comportement adaptatif de la daurade (*Sparus aurata*) en relation avec la composition de la ration dans une situation de nourissage auto-controlé. *Ichtyophysiol. Acta*, 18: 125-143.
Lanari, D., Ballestrazzi, R. and D'Agaro, E. (1998). The effect of dietary fat and NFE level on growing european seabass (*Dicentrarchus labrax*). I. Growth rate, body composition and nutrient retention efficiency. *Abstracts of the VIII International Symposium on Nutrition and Feeding of Fish*, Las Palmas, Gran Canaria (Spain), 1-4 June 1998.
Lupatsch, I., Kissil, W.G., Sklan, D. and Pfeffer, E. (2001). Effects of varying dietary protein and energy supply on growth, body composition and protein utilization in gilthead seabream (*Sparus aurata* L.). *Aquacult. Nutr*., 7: 71-80.
Marti-Palanca, H., Martinez Barbera J.P., Pendon C., Valdivia M.M., Perez-Sanchez, J.H. and Kaushik, S.J. (1996). Growth hormone as a function of age and dietary protein: Energy ratio in a marine teleost, the gilthead sea bream. *Growth Regulation*, 6: 253-259.
Nematipour, G.R., Brown, M.L. and Gatlin, D.M. III. (1992). Effects of dietary carbohydrate:lipid ratio on growth and body composition of hybrid striped bass. *J. World Aquaculture Soc*., 23: 128-132.
Paspatis, M. and Boujard, T. (1996). A comparative study of automatic feeding and self-feeding in juvenile Atlantic salmon (*Salmo salar*) fed diets with different energy levels. *Aquaculture,* 145: 245-247.
Peres, H. and Oliva Teles A. (1999a). Effect of dietary lipid level on growth performance and feed utilization by European sea bass juveniles (*Dicentrarchus labrax*). *Aquaculture,* 179: 325-334.
Peres, H. and Oliva Teles, A. (1999b). Influence of temperature on protein utilization in juvenile European seabass (*Dicentrarchus labrax*). *Aquaculture*, 170: 337-348.
Perez-Sanchez J., Marti-Palanca, H. and Kaushik, S.J. (1995). Ration size and protein intake affect circulating growth hormone concentration, hepatic growth hormone binding and plasma insuline-like growth factor-I immunoreactivity in a marine teleost, the gilthead sea bream. *J. Nutr*., 125: 546-552.
Santinha, P.J.M., Medale, F., Corazze, G. and Gomes, E.F.S. (1999). Effects of the dietary protein:lipid ratio on growth and nutrient utilization in gilthead seabream *Sparus aurata* L. *Aquaculture Nutrition*, 5: 147-156.
Takeuchi, T., Shiina, Y. and Watanabe, T. (1991). Suitable protein and lipid levels in diet for fingerlings of red sea bream *Pagrus major. Nipp. Suis. Gakk*., 55(2): 521-527.
Vergara, J.M., Robaina, L., Izquierdo, M. and De La Higuera, M. (1996). Protein sparing effect of lipids in diets for fingerlings of gilthead sea bream. *Fish Sci*., 62: 624-628.

Weatherup, R.N., McCracken, K.J., Foy, R., Rice, D., McKendry, J., Mairs, R.J. and Hoey, R. (1997). The effects of dietary fat content on performance and body composition of farmed rainbow trout (*Oncorhynchus mykiss*). *Aquaculture,* 151: 173-184.