International Journal of Fisheries and Aquatic Studies 2018; 6(6): 259-263

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(6): 259-263

www.fisheriesjournal.com
Received: 05-09-2018
Accepted: 06-10-2018

Ben-Bani Abdelbasset
Centre Régional de l'Institut National de Recherche Halieutique, PK 7 Route d'Essaouira, Agadir, Maroc, Morocco

Sedki Said
Centre Spécialisé en Zootechnie et Ingénierie Aquacoles Marines, Institut National de Recherche Halieutique, BP 31 M'Diq, Maroc, Morocco

Nhhala Hassan
Centre Spécialisé en Zootechnie et Ingénierie Aquacoles Marines, Institut National de Recherche Halieutique, BP 31 M'Diq, Maroc, Morocco

Chebbaki Kamal
Centre Spécialisé en Zootechnie et Ingénierie Aquacoles Marines, Institut National de Recherche Halieutique, BP 31 M'Diq, Maroc, Morocco

Idhalla Mohamed
Département d'Aquaculture, Institut National de Recherche Halieutique, Bd Sidi Abderrahmane 2 Aïn Diab, Casablanca, Maroc, Morocco

Kheyyali Driss
Institut Agronomique et Vétérinaire Hassan II, Madinat Al Irfane, BP, Rabat, Maroc, Morocco

Bouhaimi Abdellah
Université Ibn Zohr, Faculté des Sciences, BP, Cité dakhla, Agadir, Maroc, Morocco

Moukrim Abdellatif
Université Abdelmalek Essadi, Faculté des Sciences, BP. M'Hannech II, Tétouan Maroc, Morocco

Correspondence
Ben-Bani Abdelbasset
Centre Régional de l'Institut National de Recherche Halieutique, PK 7 Route d'Essaouira, Agadir, Maroc, Morocco

Effect of protein/lipid ratio of the diet on the growth performance and feed utilization of common meagre (*Argyrosomus regius*, Asso 1801) juveniles

Ben-Bani Abdelbasset, Sedki Said, Nhhala Hassan, Chebbaki Kamal, Idhalla Mohamed, Kheyyali Driss, Bouhaimi Abdellah and Moukrim Abdellatif

Abstract
The objective of this work was to study the effect of dietary protein and lipid levels on common meagre by assessing the effect of the protein/lipid ratio (P/L) on the growth performance and food conversion. Four diets (A1, A2, A3 and A4) with P/L respectively of 4.66, 3.88, 3.28 and 2.84 were tested on two replicates of fish with an initial weight of 44.7±0.9g during 11 months. Body weight presents two phases of growth in all treatments corresponding to low and high temperature periods. Fish fed on A1 exhibited the best SGR (0.4±0.021). However, no statistical differences were observed between the treatments. FCR and EER were better in A1 and showed significant difference ($p<0.05$) between the four lots. Survival rates varied from 94 to 96%. The results of this study suggest that the decrease of the P/L ratio in the diet affects negatively the growth and feed utilization in meagre.

Keywords: Aquaculture, nutrition, meagre, growth, feed utilization

1. Introduction
The common meagre (*Argyrosomus regius*, Asso 1801) is a sciaenid semi-pelagic species distributed in Mediterranean, Black Sea and East Atlantic Ocean from Norway to Congo [1]. It lives in coastal area between 15 and 200 meters and enters estuaries and lagoons [2, 3, 4].
The *A. regius* is among the last species having raised a potential interest for the diversification of the finfish farming industry in Mediterranean countries. This species was scored at the eighth position out of a total of 27 species evaluated [5]. Many biological characteristics as fast growth in captivity, good feed conversion and capability of adaptation to several environmental conditions make meagre an interesting candidate for aquaculture diversification [6, 7, 8, 9]. Furthermore, it presents a high quality of flesh and capability of being refrigerated for a long time, which is favourable for industrial processing [2, 10].
The first studies of breeding with wild reproducers were realized in France in the late 90's [11, 12, 8]. However, until now and in comparison to other species produced by Mediterranean aquaculture, such as sea bass and sea bream, not much studies exist on the nutritional needs of meagre [13, 14, 11, 15]. Indeed, the aquaculture production of meagre in Mediterranean countries is based on use of diet formulated for sea bass and sea bream [11]. Nevertheless, the development of specific diet for meagre requires the establishment of the dietary nutrients levels to optimize the growth and the nutrient efficiency. According to Martínez-Llorens *et al*. (2011) [13], meagre fed on diet containing 47% of crude protein and 20% of crude lipid showed the best growth and efficiency results. Moreover, in the same experiment, meagre fed on diet with protein/lipid ratio of 44/25 and 43/21 obtained the significantly lowest protein and energy efficiency [13]. More recent work [11], showed that meagre fed on diet with 53% of crude protein and 17% of crude lipid present better performances than those fed on diet containing 35 and 43% of crude protein at the same level of lipid content. More studies should be taken in order to define the dietary nutrient requirements and the optimum protein/lipid ratio for meagre.
The aim of this trial is to contribute to the study of the nutritional needs of meagre by evaluating growth and feed utilization in juveniles of meagre feeding four diets with different levels of proteins and lipids.

2. Materials and methods
2.1 Experimental diets
Four experimental diets were fabricated in the facilities of the Agronomic and Veterinary Institute Hassan II (Rabat, Morroco). The diets were named A1, A2, A3 and A4 and contain different proteins/lipids and protein/energy ratios. The proximate composition of the experimental diets is presented in Table 1.

Table 1: Proximate composition of the diets (given as % of dry weight)

	A1	A2	A3	A4
Proteins	50.8	49.7	48.5	47.4
Lipids	10.9	12.8	14.8	16.7
Ash	2.9	2.8	2.8	2.7
Nitrogen-Free-Extract (NFE)[1]	23.1	22.7	22.3	21.7
Proteins/lipids (P/L)	4.66	3.88	3.28	2.84
Gross Energy[2] (Kcal/100 g)	497.3	506.9	517.4	526.2
P/E (mg/Kcal)	102.1	98	93.7	90.1

[1]NFE: Nitrogen-free extract = 100-(%moisture+%ash+%protein+%lipid+%fiber)
[2](1g protein = 23.7 kJ = 5.66 kcal, 1g lipids = 39.5 kJ = 9.44 kcal, 1g carbohydrate = 17.2 kJ = 4.11 kcal)

2.2 Fish, growth trial and sampling
The juveniles of meagre used were produced in the Specialized Centre in Aquaculture of the National Institute of Fishery Research in M'diq (Morocco). For the experiment, juveniles of an average weight of 44.7 g ± 0.9 were distributed equally and randomly in eight tanks and were fed with a mixture of the four diets during two weeks, twice a day and six days per week in order to permit their acclimation to the experiment conditions. The trial was carried out in polycarbonate cyclindro-conical tanks of 500 l supplied with seawater at a renewal of 70%.h^{-1} during all the period of the experiment. The seawater was previously filtered and the oxygen level was maintained around saturation by using air stone bubbler in each tank. The temperature and oxygen survey was realised using a portative multiparametric probe (Horiba U10). The fish were exposed to natural phtothermal conditions of M'diq city situated in the North of Morocco.

At the commencement of the trial, the initial stocking density was 30 fish per tank corresponding to 2.8 kg.m^{-3} and an average biomass of 1340 g ±27 per tank. Two tanks were assigned arbitrarily to each diet. During the 11 month of the experiment, fish were fed manually "ad libitum" once a day and six days per week. The diets were distributed carefully to avoid over-feeding. In addition, the uneaten pellets were collected at the end of each day and the amount of diet consumed by fish in each tank was recorded. For the growth performances, all fish were sampled monthly by measuring individual weight and total length using respectively the balance (max 4100 g; d= 0.1) and the ichtyometer. Before any sampling, the juveniles of meagre were starved for 24 hour to reduce stress and were anesthesied first by using 2-phenoxyethanol 0.3 ml l^{-1} before weighing. During the final sampling, the livers of 10 individuals per tank were weighed for calculation of hepatosomatic index (HSI). At the end of the feeding experiment, the next indices were calculated as following:

Condition factor (CF) = 100 x body weight (g) / (body length $(cm))^3$

Biomass gain (BG) = Final biomass - Initial biomass

Feed conversion ratio (FCR) = Feed consumed (g) / Wet weight gain (g)

Survival (%) =100 x (Final number of fish / Initial number of fish)

SGR (specific growth rate) = 100 x [ln final weight (g)–ln initial weight (g)]/trial duration (days)

Protein efficiency ratio (PER) = Fish wet weight gain (g) / Protein intake (g).

Energy efficiency ratio (EER) = Fish wet weight gain (g) / Energy intake (g).

Hepatosomatic index (HSI) = 100 x (liver weight (g) / whole body weight (g)

2.3 Statistical analysis
Data were treated by using one-way Analysis of Variance (ANOVA) to test the effects of the four experimental diets. Tukey and Fisher LSD methods were employed to rank the groups when significant differences were found ($P<0.05$). Statistical analyses were made by using Minitab 17 Software.

3. Results
3.1 Temperature and dissolved oxygen
During the experiment, the value of the temperature varied between 15.9 and 21.7 °C with an average of 18.7±1.9 °C. We observed two different periods: the first one from January to May with an average of 17.1±0.7 and the second one from June to November with an average of 20.7±0.9. The oxygen ranged from 4.7 to 7.5 mg/l.

3.2 Survival rate
No significant differences were detected in survival rates showing the adaptability of meagre to the rearing environment. Indeed, survival rates varied at the end of the experiment from 94 to 96% (Table 2) without any correlation with the different experimental diets.

3.3 Growth, feed intake and condition factor
The results of growth parameters are reported in table 2 and figures 1 to 3. No significant differences were detected between specific growth rates (SGR) of the different lots. However, fish fed pellets containing the highest proteins level and the lowest lipids level scored the best weight SGR. Indeed, the fish fed the diet A1 (P/L 4.66 and P/E 102.1 mg/kcal) exhibited a SGR of 0.4±0.021 against 0.37 for those fed the diets A2, A3 and A4. The curves showing the monthly evolution of body weight and length present the same trend for the four diets (Figure 1 and 2). Nevertheless, for the body weight we identify two phases of growth from January to June and from July to November corresponding obviously to the high temperature during the summer and autumn seasons comparing to the winter and spring seasons. The best performance in term of gain of biomass was realised by fish fed the diet A1 followed successively by those fed A2, A3 and A4. Indeed, significant difference ($p<0.05$) was observed in gain of biomass between the juveniles receiving A1 and A4. It seems that there would be a positive correlation between the Proteins/Lipids (P/L) ratio and the gain of biomass (Figure 3). In term of the condition factor (CF), no statistical differences were observed between the different treatments. However, lot A1 with a value of 1.00±0.01 recorded the highest CF followed successively by A2 with 0.98±0.01, A3 with 0.97±0.002 and finally by A4 with an average value of 0.95±0.05.

Table 2: Specific growth rate, biomass gain, feed conversion ratio, survival rate, condition factor, hepatosomatic index, protein efficiency ratio and energy efficiency ratio calculated at the end of the experiment.

	A1	A2	A3	A4
$SGR_W{}^{*}$	0.40 ± 0.021	0.37 ± 0.004	0.37 ± 0.010	0.37 ± 0.002
$SGR_L{}^{*}$	0.13 ± 0.008	0.13 ± 0.000	0.13 ± 0.005	0.13 ± 0.008
BG (kg)	3.17 ± 0.22^{a}	2.89 ± 0.07^{ab}	2.81 ± 0.13^{ab}	2.77 ± 0.09^{b}
FCR	1.48 ± 0.01^{a}	1.62 ± 0.03^{b}	1.70 ± 0.01^{c}	1.75 ± 0.01^{d}
SR	96	95	95	94
CF	1.00 ± 0.01	0.98 ± 0.01	0.97 ± 0.002	0.95 ± 0.05
HSI	1.30 ± 0.04^{a}	1.42 ± 0.03^{b}	1.47 ± 0.04^{c}	1.55 ± 0.08^{d}
PER	1.33 ± 0.08	1.24 ± 0.04	1.21 ± 0.03	1.21 ± 0.02
EER	0.14 ± 0.008^{a}	0.12 ± 0.004^{ab}	0.11 ± 0.003^{ab}	0.11 ± 0.002^{b}

Superscript letters indicate significant differences (p<0.05).
* Specific Growth Rate of body weight and length

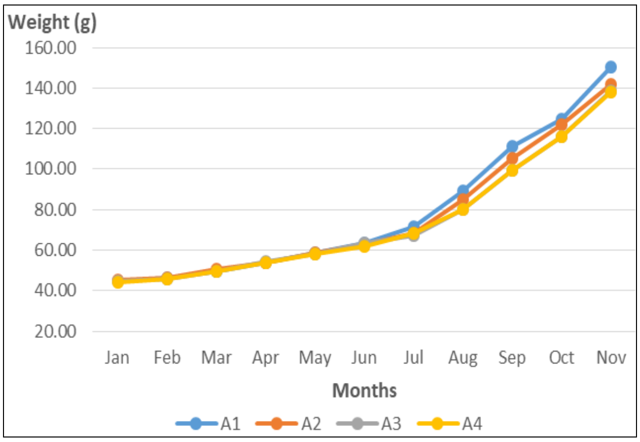

Fig 1: Monthly evolution of the body weight of fish fed with the different experimental diets

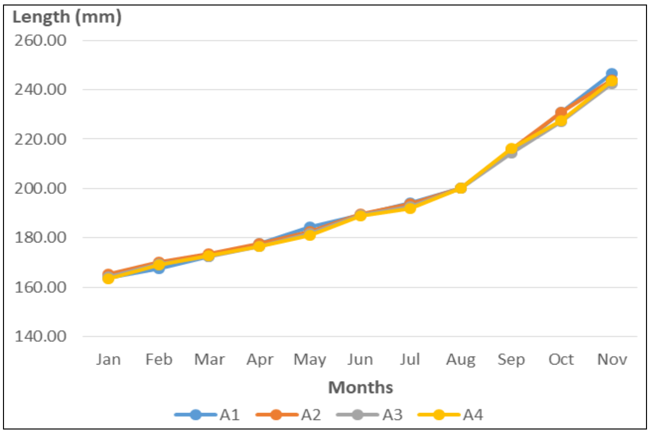

Fig 2: Monthly evolution of the body length of fish fed with the different experimental diets

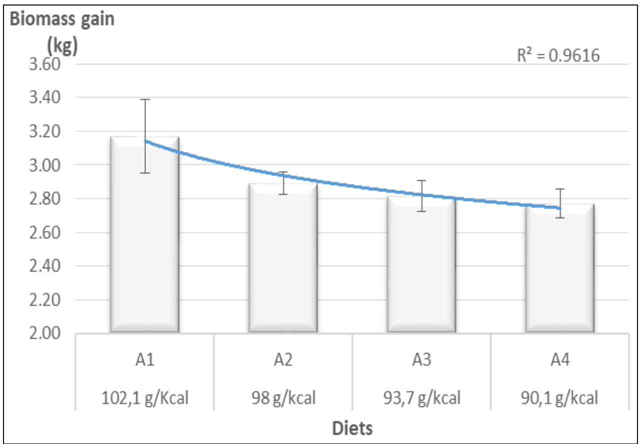

Fig 3: Biomass gain of fish fed the different experimental diets

3.4 Feed conversion ratio (FCR), hepatosomatic index (HSI), protein efficiency ratio (PER) and energy efficiency ratio (EER)

In contrast with the result obtained in the growth parameters, FCR was significantly higher (p<0.05) in fish fed on diet A4 followed successively by A3, A2 and A1 (Table 2 and figure 4).

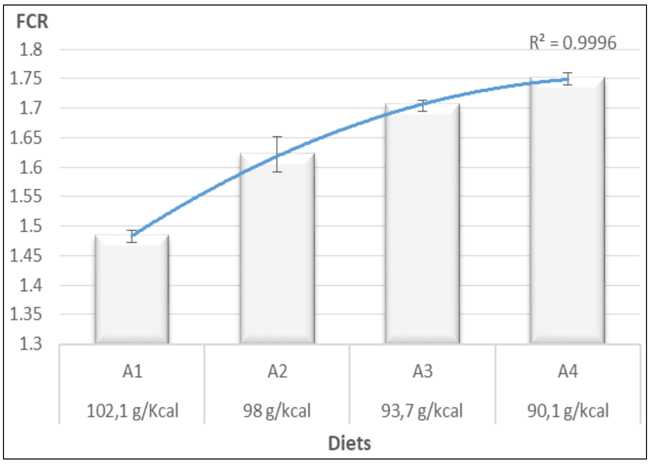

Fig 4: Feed conversion ratio of the different experimental diets

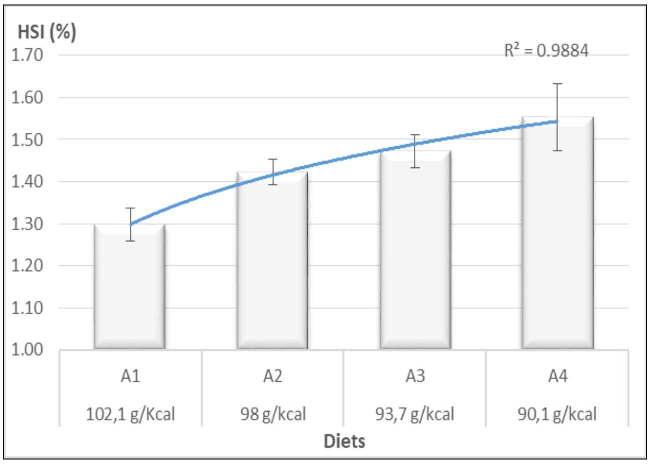

Fig 5: Hepatosomatic index (HSI) of fish fed the different experimental diets.

At the end of the experiment, HSI ranged from 1.30 to 1.55% and was influenced by the P/E and P/L ratios (Figure 5). Indeed, significant differences (p<0.05) were obtained between the different lots (Table 2). The highest value of 1.55±0.08 was obtained by fish fed on diet A4 followed in decreasing order by those fed on A3 with a value of

1.47±0.04 then lot A2 with 1.42±0.03 and finally by fish fed on A1 with an average value of 1.30±0.04. The protein efficiency ratios (PER) from different dietary groups varied between 1.21 and 1.33, but they were not significantly different. However, PER values tended to decrease with the decreasing of P/E and P/L ratios. The energy efficiency ratio (EER) had the same trend as noted in the PER with values ranged from 0.11 to 0.14 (Table 2). A significant difference ($p<0.05$) was observed between fish fed on the highest and lowest P/E and P/L ratios.

4. Discussions

The water temperature is an important factor in improving growth of fishes. The increase of the temperature induces the increase of growth until a maximum value after which the growth is decreasing [16]. In the case of the common meagre, the suitable value of temperature cited in the bibliography ranged from 14 to 23 °C [13] with an optimum between 17 and 21 °C [4, 17]. In our case as described above, the temperature varied between 15.9 and 21.7 °C inducing two phases of growth corresponding to low and high temperature periods. The decrease of growth was also reported by Estévez *et al.* (2010) [17] who obtained a negative growth in low temperature (average of 15.6 ± 1.7 °C) which they considered below the optimum threshold for this species. According to this study and the others cited below we can said that meagre grows better in high temperature.

The SGR values obtained in this study are better than those achieved by Korkut *et al*. (2016) [18] who recorded a SGR of 0.32% day^{-1} with fish fed diet contained 45% of crude proteins and 16% of crude lipids. Fountoulaki *et al*. (2017) [19] tested diets at different protein/lipid levels on meagre at industrial scale and recorded SGR values ranging from 0.37 to 0.46% day^{-1} which are approximatively the same as those obtained in this work. The same results were founded by Chatzifotis *et al*. (2010) [20]. Indeed, these authors obtained a SGR of 0.46% day^{-1} by using diets with a high percentage of protein and at temperatures above 22 °C. However, in others works [7, 17, 21] the SGR achieved was higher. In fact, Estévez *et al.* (2010) [17] tested different levels of plant proteins on the ongrowing of *Argyrosomus regius* and the SGR ranged from 1.31 to 1.82% day^{-1}. Also, Chatzifotis *et al*. (2011) [21] investigated the effect of protein and lipid dietary levels on growth of meagre by conducting two experiment. In the first one, they used fish fed four isolipidic diets (17.5% crude lipids) containing 40, 45, 50 and 54% of protein and in the second one, fish were fed four isonitrogenous diets (50% crude protein, dry matter) each containing 12, 15, 17 and 20% of crude lipids. They reached a SGR of 1.2% day^{-1} and concluded that the best protein/lipid ratio for meagre is 50/17. Cardoso LF (2013) [22] confirmed this result in term of protein level. Indeed, this author demonstrated that juveniles of meagre fed on diet containing 50% of crude protein presented the best results in specific growth rates. Similarly, Velazco (2014) [11] tested four isolipidic diets (17% of crude lipid) with different digestible protein levels (35%, 43%, 49% and 53%) and showed that meagre fed on diet with 53% of crude protein present better performances than the others. All these studies showed that meagre requires high levels of dietary protein, which is not different from other strictly carnivorous species that have high requirements of dietary protein [23, 24]. However, at inadequate energy level, proteins are used as source of energy while at an adequate energy level, proteins are used for the anabolic functions [25]. Moreover, the optimum P/E ratio in the diet enhance dietary proteins utilization by the protein sparing effect on fish [23, 26]. This last situation can both reduces waste and improves fish growth and the economic performance of aquafeeds [21, 27]. Lipids can be used as source of energy and essential fatty acids in the diet [20]. For the meagre, Panagiotidou *et al*. (2007) [28] mentioned that during ongrowing, the lipid needs in the diet are 17%. Chatzifotis *et al*. (2010) [20] had made similar observation after comparing three isonitrogenous experimental diets containing 13, 17 and 21% of lipids. Other studies suggested that the optimum dietary lipids for meagre can be placed between 15 and 20% [22, 18, 19]. In the present study, the high value of HSI and FCR and low growth and PER obtained in fish fed the highest lipid diet showed that the excessive dietary lipid levels can induce higher fat deposit and reduced growth performances. The same results were indicated for meagre [20], European sea bass [29] and gilthead sea bream [30]. Also, Korkut *et al*. (2016) [18] compared the effect of three isonitrogenous diets containing 16, 18 and 20% of lipids and founded the highest value of HSI in meagre fed diet with 20% of crude lipid. Moreover, the whole body composition seems to be affected by a high amounts of dietary lipids [31, 21]. According to the above, we can say that since it is a “lean species”, meagre do not requires high levels of dietary lipids. Also, the change of body composition may not be appreciated by the consumer and suggests that the increasing of lipid level in aquafeeds for meagre has to be done with more precaution.

5. Conclusion

The common meagre *Argurosomus regius* can be considered as a potential candidate for the diversification of Mediterranean and specifically Moroccan aquaculture. The improvement of its raising requires the development of specific well-balanced aquafeed which also needs further researches in nutrient requirements.

6. Acknowledgment

The authors would like to acknowledge Professor Hajar BENBANI for her review of the English of this article.

7. References

1. Quéro JC, Vayne JJ. Le maigre, *Argyrosomus regius* (Asso, 1801) (Poissons, Perciformes, Sciaenidae) du golfe de Gascogne et des eaux plus septentrionales. Revue des Travaux de l'Institut des Pêches Maritimes. 1987; 49(2):35-66.
2. Poli BM, Parisi G, Zampacavallo G, Iurzan F, Mecatti M, Lupi P *et al*. Preliminary results on quality and quality changes in reared meagre (*Argyrosomus regius*): body and fillet traits and freshness in refrigerated commercial-size fish. Aquaculture International. 2003; 11(3):301-311.
3. Lagardére JP, Mariani A. Spawning sounds in meagre *Argyrosomus regius* recorded in the Gironde estuary, France. Journal of Fish Biology. 2006; 69(6):1697-1708.
4. El-Shebly A, El-Kady MAH, Hussin A, Yeamin Hossain M. Preliminary observations on the pond culture of meagre *Argyrosomus regius* (Asso, 1801) (Sciaenidae) in Egypt. Journal of Fisheries and Aquatic Science. 2007; 2(5):345-352.
5. Quéméner L, Suquet M, Mero D, Gaignon JL. Selection method of new candidates for finfish aquaculture: the case of the French Atlantic, the Channel and the North Sea coasts. Aquatic Living Resource. 2002; 15(5):293-

302.
6. Calderón JA, Esteban JC, Carrascosa MA, Ruiz PL, Valera F. Estabulación y crecimiento en cautividad de un lote de reproductores de corvina (*Argyrosomus regius*). Actas del VI Congreso Nacional de Acuicultura, Cartagena, Spain, 1997, 365-370.
7. Ben-Bani A, Sedki S, Talbaoui EM, Nhhala H, Chebbaki K, Akharbach H *et al*. Essai pilote d'élevage du maigre commun (*Argyrosomus regius*, Asso 1801) en cage marine amarrée dans la baie de M'diq (Maroc). Reviews in Biology and Biotechnology. 2007; 6(2):54-59.
8. Monfort MC. Present market situation and prospects of meagre (*Argyrosomus regius*), as an emerging species in Mediterranean aquaculture. Studies and Reviews. General Fisheries Commission for the Mediterranean. No.89, FAO, Rome, 2010, 28.
9. Cárdenas S. Crianza de la Corvina (*Argyrosomus regius*). Fundación Observatorio español de Acuicultura. Consejo Superior de Investigaciones Científicas. Ministerio de Medio Ambiente y Medio Rural y Marino, Madrid, 2010.
10. Hernández MD, Lopez MB, Alvarez A, Ferrandini E, García B, Garrido MD. Sensory, physical, chemical and microbiological changes in aquacultured meagre (*Argyrosomus regius*) fillets during ice storage. Food Chemistry. 2009; 114(1):237-245.
11. Velazco Vargas JL. Contribucion al estudio de las necesidades nutritivas de la (*Argyrosomus regius*, Asso 1801). Tesis doctoral. Universidad Politécnica de Valencia. Valencia, 2014, 181.
12. Soula M. Estimación de parámetros genéticos en corvina, *Argyrosomus regius*, para caracteres de crecimiento, rendimiento y calidad de la carne y del pez. Tesis doctoral. Universidad de Las Palmas de Gran Canaria. Las Palmas, 2012, 193.
13. Martínez-Llorens S, Espert J, Moya J, Jover M, Tomás-Vidal A. Growth and nutrient efficiency of meagre (*Argyrosomus regius*, Asso1801) fed extruded diets with different protein and lipid levels. International Journal of Fisheries and Aquaculture. 2011; 3(10):195-203.
14. Baptista de Moura JF. Replacement of marine derived ingredients in meagre feeds (*Argyrosomus regius*): effects on growth performance and nutrient retention. Dissertação de Candidatura ao grau de Mestre em Ciências do Mar e Recursos Marinhos. Instituto de Ciências Biomédicas de Abel Salazar da Universidade do Porto. Porto, 2013, 52.
15. Couto A, Barroso C, Guerreiro I, Pousao-Ferreira P, Matos E, Peres H *et al*. Carob seed germ meal in diets for meagre (*Argyrosomus regius*) juveniles: Growth, digestive enzymes, intermediary metabolism, liver and gut histology. Aquaculture. 2015; 451(4):396-404.
16. Collett PD, Vinel N, Kaiser H, Baxter J. Determination of the optimal water temperature for the culture of juvenile dusky kob *Argyrosomus japonicus* (Temminck and Schlegel 1843). Aquaculture Research. 2008; 39(9):979-985.
17. Estéves A, Treviño L, Kotzamanis Y, Karacostas I, Tort L, Gisbert E. Effects of different levels of plant proteins on the ongrowing of meagre (*Argyrosomus regius*) juveniles at low temperatures. Aquaculture Nutrition. 2010; 17(2):572-582.
18. Korkut AY, Sert Sait C, Kop A, Gamsız K, Karahan B. The Effect of dietary lipid on the growth Performance of meagre (*Argyrosomus regius* Asso, 1801). The Israeli Journal of Aquaculture – Bamidgeh. 2016; 68:7.
19. Fountoulaki E, Grigorakis K, Kounna C, Rigos G, Nikos Papandroulakis, Diakogeorgakis J *et al*. Growth performance and product quality of meagre (*Argyrosomus regius*) fed diets of different protein/lipid levels at industrial scale. Italian Journal of Animal Science. 2017; 16(4):685-694.
20. Chatzifotis S, Panagiotidou M, Papaioannou N, Pavlidis M, Nengas I, Mylonas CC. Effect of dietary lipid levels on growth, feed utilization, body composition and serum metabolites of meagre (*Argyrosomus regius*) juveniles. Aquaculture. 2010; 307(1):65-70.
21. Chatzifotis S, Panagiotidou M, Pascal D. Effect of protein and lipid dietary levels on growth of juveniles meagre (*Argyrosomus regius*). Aquaculture International. 2011; 20(1):91-98.
22. Cardoso Lopes Fernandes JP. Optimizing the dietary protein/lipid ratio on meagre (*Argyrosomus regius*): effects on growth and lipid deposition. Mestrado em Ecologia Marinha. Faculdade de Ciências. Universidade de Lisboa. Lisboa, 2013, 46.
23. Guillaume J, Kaushik S, Bergot P, Métailler R. Nutrition *et al* imentation des poissons et crustacés. INRA Editions, Paris, 1999, 489.
24. NRC (National Research Council). Nutrient requirements of fish and shrimp. National Academy Press, Washington DC, 2011, 392.
25. El-Sayed AFM, Kawanna M. Effects of dietary protein and energy levels on spawning performance of Nile tilapia (*Oreochromis niloticus*) broodstock in a recycling system. Aquaculture. 2008; 280(1):179-184.
26. Skalli A, Hidalgo MC, Abellan E, Arizcun M, Cardenete G. Effects of the dietary protein/lipid ratio on growth and nutrient utilization in common dentex (*Dentex dentex*) at different growth stages. Aquaculture. 2004; 235(1):1-11.
27. Sankian Z, Khosravi S, Kim YO, Lee SM. Effect of dietary protein and lipid level on growth, feed utilization and muscle composition in golden mandarin fish *Siniperca scherzeri*. Fisheries and Aquatic Sciences. 2017; 20(7):6.
28. Panagiotidou M, Chatzifotis S, Papaioannou N, Papasolomontos S, Pavlidis M, Nengas I *et al*. Effect of dietary lipid levels on growth, feed utilization, body composition and serum metabolites of meagre (*Argyrosomus regius*). Aquaculture Europe. Estambul, Turquia. 2007, 24-27.
29. Péres H, Oliva-Teles A. Effect of dietary lipid level on growth performance and feed utilization by European sea bass juveniles *Dicentrarchus labrax*. Aquaculture. 1999; 179(1): 325-334.
30. Company R, Calduch-Giner JA, Kaushik S, Perez-Sanchez J. Growth performance and adiposity in gilthead sea bream (*Sparus aurata*): risks and benefits of high-energy diets. Aquaculture. 1999; 171(3):279-292.
31. Piccolo G, Bovera F, De Riu N, Marono S, Salati F, Cappuccinelli R *et al*. Effect of two different protein/fat ratios of the diet on meagre (*Argyrosomus regius*) traits. Italian Journal of Animal Science. 2008; 7:363-371.