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The influence of different dietary energy content and feeding regimes on growth and feed utilization of European sea bass (*Dicentrarchus labrax*, L.)

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ABSTRACT: The growing importance of European sea bass in aquaculture poses the problem to find suitable and efficient feeding for this specific fish. In order to assess the influence of different dietary energy content and feeding regimes, it has been carried out a trial on ongrowing European sea bass at average initial weight of about 68g. 744 fish were randomly allocated to 12 800L tanks in a closed recirculation system provided by biofilter and UV lamps. Marine water was kept at a temperature of about 22 °C and dissolved oxygen level never falls below 90% of saturation. Isoproteic (47% crude protein) extruded experimental diets were formulated with three different lipid levels i.e. 16% (diet 16:D16), 24% (diet 24:D24) and 32% (diet 32:D32). For each diet, two feeding regimes were set up in duplicate: satiation and 80% of satiation. Feed intake (FI) were recorded daily. After 77 days, fish were bulk weight and growth, SGR and FCR were calculated. Furthermore, after diets chemical analyses, protein and lipid intake were determined. Finally, in order to check feeding costs, the economic efficiency ratio was calculated. Statistical analyses of all data were performed using a two-way analysis of variance (ANOVA). When *p* values showed significance, individual means were compared using Tukey's multiple range test to detect intergroup significant differences. On a statistical basis, feeding regimes influenced all parameters analysed, whereas diet only FCR, FI, protein and lipid intake and EER. In the group of fish fed to satiation, the diet with the lowest energy content (D16) gave very interesting results for feed intake, FCR and EER. They scored the highest feed intake, a FCR slightly higher than satiation groups fed D24 and D32 but not statistically different from them and the lowest EER.

Keywords: European sea bass, *Dicentrarchus labrax*, ratio, energy, feed intake, growth

Introduction – European sea bass production in Europe has been doubled in the last decade reaching more than 100.000 mt in 2008 (F.E.A.P., 2008) with a continuous increase year by year. In order to maximize productions and mitigate the environmental impact, it is important to satisfy nutritional requirements of fish by means the improvement of feed formulation and feed management. In Europe salmonid farming has played the main role in aquaculture industry and hence most nutritional studies have been concentrated on these fish. Because of the existence of several differences between salmonids and European sea bass the importance of specific research on sea bass nutritional requirements is highlighted (Ballestrazzi et al., 1994; Boujard et al., 2004). The aim of this study was to demonstrate the influence on different dietary energy content and feeding regimes on growth and feed utilization in European sea bass.

Material and methods – Three isoproteic (47% CP) extruded diets with a pellet diameter of 4 mm were formulated in order to contain three different lipid levels by replacing fish oil with wheat starch: 160 g kg^{-1} (D16), 240 g kg^{-1} (D24) and 320 g kg^{-1} (D32). The fish were fed twice a day six days a week and once on Sundays by automatic feeders. Each diet was randomly assigned to four groups of fish. Of these four groups, two were fed approximately 20% in excess of satiation level (satiation group). After each single meal, uneaten feed was collected from the outlet water in plastic strainers and weighed after drying in a stove overnight at 105°C in order to determine the daily feed consumption. The others two groups received a feed ration equivalent to the 80% average feed intake of the fish fed to saturation during the previous 24 h (80% satiation group). The experiment was carried out at the Laboratory of Aquaculture, University of Bologna, Cesenatico, Italy. Ongrowing European sea bass (*Dicentrarchus labrax*) were acclimated for four weeks before the experiment. 62 animals per tank were randomly distributed into 12 800 l square tanks with a conical bottom. Tanks were provided with natural seawater and connected to a closed recirculation system consisting of a mechanical sand filter, an ultraviolet light and a biofilter. Water exchange rate was 100% hour^{-1}. Temperature has been kept constant at 22±1°C all throughout the experiment; photoperiod has been held constant at a 12-h day length through artificial light (350 lx at the water surface — Delta Ohm luxmeter HD-9221; Delta-Ohm, Padua, Italy). Oxygen level was equal or above to 90% of saturation. Ammonia (≤0.1 mg L^{-1}), nitrite (≤0.2 mg L^{-1}) and nitrate (≤50 mg L^{-1}) were determined spectrophotometrically once a week (Spectroquant Nova 60, Merk, Lab business) at 12.00 a.m. At the same time, pH (7.8–8.0) and salinity (25–31 g L^{-1}) have been also determined. The fish were bulk weighed at the start of the experiment and after 77 days (end of the experiment). The data obtained were used in order to calculate Specific Growth Rate (SGR), Feed Conversion Rate (FCR) and Feed Intake (FI). The experimental diets were analyzed for dry matter (drying to constant weight in a stove at 105°C), crude protein (N x 6.25, determined by the Kjeldahl method), crude lipid (Folch et al., 1957) and ash content (incineration to constant weight in a muffle oven at 450 °C). Intake of protein (g Kg^{-1} day^{-1}) and lipid (g Kg^{-1} day^{-1}) as well as Economic efficiency ratio (€ kg^{-1}) were calculated as described in the table footnotes. Unitary costs of feed used in the formula were provided by Skretting Italy, Mozzecane VR, Italy (D16, 1.015 €/Kg; D24, 1.200 €/Kg; D32, 1.385 €/Kg). All statistical analyses were performed using Prism 4.0 package (Graphpad, Usa). Arcsine √ transformations of percentage data were performed to achieve homogeneity of variance. The effects of the feeding regime (satiation, 80% satiation) and the dietary composition (D16, D24, D32) and their interactions were tested using a two-way analysis of variance (ANOVA). When p values showed significance, individual means were compared using Tukey's multiple range test to detect intergroup significant differences. Tank fish bulk weight and tank feed consumption were used as the experimental unit to determine growth performance and feed utilization. Differences between treatments group were considered significant at $p \leq 0.05$. Data are presented as mean ± SD; superscript common letters indicate significant differences.

Results and conclusions – Results are shown in Table 1. Fish adaptation was normal and survival was 100% except for one tank where one fish died during the experiment. Feed intake was statistically influenced by diet and, obviously, by feeding regime. Within satiation groups the highest feed consumption was found in fish fed D16, suggesting higher appetite for them. Statistical differences between groups were found for SGR and FCR too. In the first case only feeding regime was determinant while both variables were involved in FCR. When fish were fed *ad libitum*, FCR was similar between treatments, without statistical differences. Protein and lipid intake as well as EER were also statistically different either for feed composition or ration. On the basis of these data both variables have firmly influenced growth and feed efficiency in ongrowing European sea bass. D16, the diet with the lowest energy level, was very well accepted and utilized by fish within group fed to satiation. This is most probably related to its dietary energy content and DP/DE ratio which could be quite close to European sea bass requirements, at least at the fish size we studied. Interestingly, EER scored the best values in fish fed this diet, both in satiation and in 80% satiation groups. Within the same feeding regime, fish fed D24 and D32 gave very similar results for SGR, FCR, FI, with an EER increase when we consider the fattest diet. In conclusion, European sea bass, at a size range in this experiment seems to prefer lower energy diet (16% of lipid) when fed to satiation. Restricted feeding regime positively influenced feed utilization but reduced specific growth rate. The importance of this finding increases if we consider that feeding costs are directly correlated to the dietary oil content and hence the use of D16 can also contribute to reduce production costs.

Table 1. Growth performance and feed utilization of European sea bass fed experimental diets for 77 days.

	IBW g	FBW g	SGR (% day^{-1})	FCR	FI (% day^{-1})	Prot In (g Kg^{-1} day^{-1})	Lip In (g Kg^{-1} day^{-1})	EER (€/kg)
SAT								
D16	69.9±0.8	145.4±3.0[a]	0.96±0.00[a]	1.40±0.07[a]	1.28±0.07[a]	6.04±0.26[a]	2.11±0.09[c]	1.42±0.08[bc]
D24	69.5±0.7	134.1±4.7[a]	0.85±0.03[b]	1.30±0.02[ab]	1.08±0.05[b]	5.09±0.23[b]	2.51±0.12[b]	1.57±0.02[b]
D32	69.9±0.4	135.3±0.4[a]	0.86±0.03[b]	1.30±0.02[ab]	1.07±0.04[b]	5.03±0.17[b]	3.49±0.12[a]	1.79±0.04[a]
80% SAT								
D16	67.8±1.8	112.5±1.3[b]	0.66±0.02[c]	1.32±0.00[b]	0.85±0.00[c]	4.00±0.00[c]	1.40±0.00[d]	1.33±0.04[c]
D24	67.5±2.0	117.4±6.4[b]	0.72±0.03[c]	1.21±0.05[c]	0.84±0.01[c]	3.97±0.00[c]	1.96±0.01[c]	1.44±0.07[bc]
D32	67.3±1.5	116.6±0.1[b]	0.71±0.03[c]	1.21±0.05[c]	0.83±0.00[c]	3.90±0.01[c]	2.70±0.01[b]	1.65±0.06[ab]
D	ns	ns	ns	*	*	*	*	*
F	*	*	*	*	*	*	*	*
DxF	ns	*	*	ns	*	*	ns	ns

Values are as mean ± standard deviation. * indicates statistical differences, respectively for diet composition (D), feeding regime (F) and the interaction of both (DxF). Values with different superscript letters in the same column are significantly different ($p \leq 0.05$) according to Tukey's multiple range test. IBW = Initial body weight; FBW= final body weight; SGR= Specific growth rate= ((ln final body weight- ln initial body weight)/number of days)x100; FCR = feed conversion rate = g dry feed given / g live weight gain; FI = Feed intake= ((Total Feed intake/Mean weight)/ days) x 100; Protein or Lipid intake = (C_{diet} * Total feed intake)/Mean weight/days, where C_{diet} is the content of the nutrient in the diets; EER=Economic efficiency ratio= (kg^{-1})feed offered (kg) × feed cost (kg^{-1})/weight gain (kg).

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