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Feeding *Dentex dentex* with dry diets: Growth response and diet utilisation

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SUMMARY - Common dentex is a Mediterranean sparid that has been put forward by several authors as being highly suitable for intensive aquaculture. Nevertheless, the basic nutrient requirements for this species have not been studied and the available information concerning the suitability of commercial diets used for rearing other sparid fish for dentex is scarce. In an initial experiment, we took fish of 100 g average initial weight and fed them on four commercial pellet diets (three sea bream feeds and one extruded diet for turbot), using fresh food as a control. One of the diets tested (58% protein DM, 24.7% fat DM and 24.4 KJ g^{-1} of gross energy) produced a high survival index (90.5%), as well as a good Instant Daily Growth (0.72) and Food Conversion Ratio (1.8), with results very close to those obtained with fish fed the fresh food control ration. A second trial was conducted using fish of 60 g average initial weight, fed at 2% (Dm basis) with fresh food or with a practical diet (diet composition on dry matter basis: 57.4% protein, 14.4% fat and 21.8 KJ.g^{-1} of gross energy). Mortality was very low in all tanks, and the best growth performance and diet utilization was observed in fish fed dry diet. In addition, dietary canthaxanthin added to the diet (50 ppm) was found to preserve the natural skin colour of the animals. These results confirm the possibilities of dentex intensive rearing using dry artificial diets.

Key words: Dentex, feeding, dry diet, growth.

RESUME - *"Alimentation du* Dentex dentex *avec des granulés secs : croissance et utilisation du régime." Le denté commun est un sparidé méditerranéen presentant d'excellentes perspectives pour l'élevage intensif. Cependant, leurs besoins nutritifs n'ont pas été étudiés et même il n'y a pas trop d'information disponible au sujet des possibilités d'utilisation pour le denté de l'aliment commercial destiné à d'autres poissons. Ainsi, dans notre premier essai, des dentés communs (100 g de poids moyen) ont été élevés et nourris à base de trois aliments commerciaux pour daurade et d'un autre pour turbot, ainsi qu'un aliment frais utilisé comme aliment témoin. Le taux de survie (90,5%), le taux de croissance spécifique*

(0,72) et le taux de conversion alimentaire (1,8) dans le groupe de poissons nourris avec un des granulés secs pour daurade (58% protéine m.s., 24,7 % graisse m.s. et 24,4 KJ.g^{-1} d'énergie totale), sont très semblables aux résultats obtenus avec de l'aliment frais. La seconde expérience fut réalisée avec des poissons (60 g de poids moyen) nourris à base d'aliment frais ou bien à base de granulés secs produit dans notre laboratoire (composition sur matière sèche: protéine 57,4%, graisse 14 % et 21,8 Kj.g^{-1} d'énergie totale). La mortalité totale des groupes fut très faible. La croissance, ainsi que l'utilisation nutritive du régime furent favorables pour les lots nourris avec granulés secs. D'ailleurs, l'addition à la diète d'un pigment: canthaxanthine (50 ppm) fut efficace pour maintenir la couleur naturelle des animaux. Les résultats indiquent de très bonnes possibilités d'utilisation des granulés secs pour la nourriture du denté.

***Mots-clés** : Dentex, alimentation, régime de granulés secs, croissance.*

INTRODUCTION

At present, Mediterranean finfish aquaculture is mainly based on the intensive production of a couple of species: sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*). The production techniques of these species are very well developed and in recent years a great increase in production has taken place. The results of this success have been lower market prices and some financial problems for many farms (Stephanis and Divanach, 1993). Diversification of cultured fish species therefore seems to be a good strategy for the future of finfish mariculture in Mediterranean countries. In this respect, some species of autochthonous sparids have been reported as highly suitable for aquaculture (Abellán *et al.*, 1994). Common dentex (*Dentex dentex*) is one of these species, is highly appreciated by consumers and, according to several authors, has excellent possibilities of reproduction in captivity at farm scale, due to their high fecundity rate and good egg and larval development (Glamuzina *et al.*, 1989; Bibiloni *et al.*, 1993a).

Several preliminary studies have shown that this species displays high growth rates, both in juveniles and larger animals (Bini, 1968; Bibiloni *et al.*, 1993b; Riera *et al.*, 1993; Efthimiou *et al.*, 1994). Nevertheless, in most cases survival rates have been very low. This fact has been attributed to a special sensitivity to pathogenic agents, aggressive behaviour among individuals (including cannibalism) and/or inadequacy of diets used. In most published works, fresh food (trash fish and squid) or moist pellets have been used to simulate natural food. However, in other more recent studies where dry feed was used, results have been quite disappointing due to the poor acceptance and/or poor growth and consequent poor feed efficiences (Efthimiou *et al.*, 1994; Riera *et al.*, 1995).

We are therefore dealing with a species with unknown basic nutritional needs and for which there is incomplete information about whether the commercial diets used for rearing other marine fish (sparids and others) might be suitable for dentex, at least as a starting point from which to develop more specific dry feeds.

This paper reports the results obtained with dentex about evaluation of acceptance, growth promoted and nutritive utilisation of several commercial diets for sea bream and turbot, using fresh food as a control diet.

A second trial, using information obtained in the first one, evaluated a practical diet (dry pellet) of known composition compared to fresh food once again.

MATERIAL AND METHODS

Experiment 1

During this feeding trial four commercial diets (dry pellets) were tested: diet S1, S2 and S3 for sea bream and diet T for turbot. As control we use fresh food: a mixture composed of 50% fish (bogue) and 50% squid. The proximate composition of the dry diets and fresh food was determined according to AOAC methods (AOAC, 1980) and gross energy content measured by means of an adiabatic bomb calorimeter. See Table 1 for composition of diets.

Table 1. Proximate composition and energy content of the diets used in Experiment 1 (DM basis).

	Diet				
	F	S1	S2	S3	T
Crude protein (%)	79.0	50.6	58.2	58.5	51.4
Crude fat (%)	9.5	19.5	22.7	24.7	16.0
Ash (%)	10.3	9.9	8.4	11.1	11.1
Nitrogen-Free Extract (%)	1.2	20.0	10.7	5.7	21.5
Gross energy ($KJ.g^{-1}$)	22.9	23.5	24.1	24.4	22.4
Digestible energy* ($KJ.g^{-1}$)	19.8	19.4	21.0	21.2	18.6
Protein / Digestible energy Ratio ($g.J^{-1}$)	39.9	26.1	27.7	27.6	27.6

* Calculated using the values given by Takeuchi *et al.* (1991) for red sea bream.

The fish used in the experiment (ca. 100 g average initial weight) were provided by GESA Piscifactoría (Alcudia, Spain) and were distributed between ten 1000 litre capacity tanks (50 fish per tank); the tanks continuously supplied with sea water (8 l min^{-1}) at 21 ± 1 ºC (pH 8.2 ± 0.1), and having an average dissolved oxygen of 7.3 ± 0.8 mg/l.

After a ten-day adaptation period, two tanks were randomly assigned to each diet. Feed was offered to the animals *ad libitum* twice a day, over a 13 week experimental test period. Fish were individually weighed at the beginning and end of the experiment and group-weighed every 15 days; in all cases, fish were previously starved for 24 hours and lightly anaesthetized with MS-222 (Sandoz).

Experiment 2

A second feeding trial was carried out in order to compare the growth and diet utilisation of dentex fed with dry pellets made from high-quality ingredients, as compared with animals fed a fresh food (50% fish (*Sardinella sp*), 50% squid) control diet. Diet ingredients and analytical composition are shown in Tables 2 and 3 respectively. The dry diet was formulated to be almost isocaloric with the fresh food control feed and with a similar protein - digestible energy ratio. The dry diet was cold pelleted (3 mm diameter) and stored at - 4 ºC until used. As in Experiment 1, fresh food was frozen until 24 hours before use.

Fish of ca. 60 g average initial weight were placed into four circular fiber-glass tanks (1000 l capacity) in groups of 30 individuals per tank. Each tank was supplied with sea water at a rate of 8 l min^{-1}, and continuous aeration provided in the tanks during the whole experiment. Water temperature and dissolved oxygen were measured daily: water temperature ranging from 16 to 18.5 ºC (mean of 17.4 ºC), and oxygen varying from 6.5 to 8.3 mg/l.

Table 2. Ingredients used to prepare the dry feed in Experiment 2.

Ingredient	g / 100 g of diet
Peru fish meal[a]	68.7
Casein	3.25
Ovalbumin	6.02
Cod-liver oil	6.2
Dextrin	8.83
Betaine	0.5
Ascorbic acid	2
Vitamin premix[b]	2
Mineral premix[c]	2
CMC[d]	0.5

a. 68.9 % CP, 11.9 % fat.
b. As described by Sierra (1995), plus 5 mg of canthaxanthin.
c. Composition described by Sierra (1995).
d. Carboxymethyl cellulose

After a 7-days adaptation period, fish were weighed (following a fasting period of 24 hours) and thereafter at two-weekly interval over the experimental period of 18 weeks; fish being lightly anaesthetized using MS-222 (1:20.000 w/v) before all weighings.

As before, each diet was randomly assigned to two experimental tanks. However, during this experiment fish were pair-fed at an initial daily rate of 2 g of food (DM) / 100 g of live weight so as to avoid food wastage. The daily ration was divided into four meals spaced at 3-4 hour intervals.

During both experiments, food intake and mortality were recorded daily and nutritive and growth indexes calculated using the following formulae:

Food Conversion Rate: FCR = feed intake (g DM) / gain in wet body weight (g)
Instant Daily Growth: IDG = 100 * (Ln final weight - Ln initial weight) / days
Protein Efficiency Ratio: PER = weight gain (g) / protein intake (g)

Table 3. Proximate composition and energy content of feeds used in Experiment 2 (DM basis).

	Diet	
	Fresh food	Dry diet
Crude protein (%)	70.1	57.4
Crude fat (%)	15.1	14.4
Ash (%)	11.2	13.2
Nitrogen-Free Extract (%)	3.6	15.0
Gross energy ($KJ.g^{-1}$)	22.7	21.8
Digestible energy* ($KJ.g^{-1}$)	20.8	19.2
Protein / Digestible energy Ratio ($J.g^{-1}$)	33.7	30.0

* Calculated using the values given by Takeuchi *et al.* (1991) for red sea bream.

Statistical analyses were carried out using the CSS:Statistics 4.0 for Windows package (Statsoft Inc.). Results were subjected to a one-way ANOVA and Duncan's multiple range test was used to compare means (Steel and Torrie, 1980). The significant statistical level was established at $p<0.05$.

RESULTS AND DISCUSSION

The composition of the diets used in Experiment 1 (Table 1) reveal great differences with respect to protein and, especially, fat (9.5 to 24.7%). Despite this, the observed average gross energy content measured were very similar (the T diet being somewhat lower), as well as the theoretical protein/digestible energy ratio for the dry feed. This ratio is evidently much greater in the fresh feed, which has the highest protein and the lowest fat content.

The results obtained for growth and diet utilisation during Experiment 1 are shown in Table 4. Of particular note was that, by the end of the experiment, most of the groups of fish had practically doubled their initial average body weight, with the exception of fish fed with the turbot diet (T), which had a slightly lower weight increase. Nevertheless, since there were differences in the initial body weights, it is more useful to take the IDG value into account when evaluating growth. Although there were no significant differences for this index between treatments, it is noticeable that fresh food, together with diet S3, promoted more growth than the other three diets. Similar results were also found for diet utilisation.

It should be noted that the IDG values obtained than those normaly reported for sea bream of this age (according to calculations with theoretical growth models described for sea bream under farming conditions; Hidalgo and Sierra, 1933). Our Food

Conversion Rates were also similar to those reported for sea bass of similar weight (García-Alcázar *et al.*, 1994) and for two species of bream (Abellán *et al.*, 1994), despite the fact that the breams were of smaller size (20-120g) and presumably of a more rapid growth stage.

Table 4. Growth performance and diet utilization of four commercial feeds and fresh food by dentex in Experiment 1.

	Diet				
	F	S1	S2	S3	T
Initial body weight (g)	114.4	111.2	132.7[a]	107.4	97.6
SEM	±4.9	±4.1	±4.7	±3.9	±3.8
Final body weight (g)	224.4	198.8	229.2	209.1	171.0[a]
SEM	±11.5	±11.3	±8.4	±7.1	±7.7
Instant Daily Growth	0.74	0.63	0.58	0.72	0.60
SEM	±0.02	±0.06	±0.07	±0.04	±0.01
Daily intake (g/100 g BW)	4.02[a]	1.52	1.58	1.25	1.88
SEM	±0.02	±0.06	±0.24	±0.05	±0.04
Food Conversion Rate	1.54[ab]	3.11[a]	3.18[ab]	1.80[b]	3.27[ab]
SEM	±0.06	±0.04	±0.75	±0.03	±0.20
Protein Efficiency Ratio	0.79	0.63	0.64	0.95	0.52
SEM	±0.03	±0.01	±0.15	±0.02	±0.03
Mortality (%)	12.0	38.2[a]	14.0	9.5	5.8
SEM	±7.4	±4.9	±4.0	±3.3	±3.5

Values in the same line with different superscript are significantly different ($p<0.05$).

Food intake was not particularly high, although comparable references are lacking. However, the feed tables given by the manufacturers of the dry feeds used in this research recommended a daily feeding rate between 1.2 and 1.5% body weight for 100 g fish at the temperatures maintained during this experiment. However, all the feed intakes of our experimental fish were within this range or even surpassed it. With respect to the amount of fresh food consumed, the only data available are those of Efthimiou *et al.* (1994), who reported an intake of 4.5% for dentex of 20-30 g maintained at 24 to 26ºC.

The reported Food Conversion Ratios (expressed in dry basis) for fresh food were excellent (1.5%), and were similar or even better than those reported by Riera *et al.* (1993, 1995) for this species when raised in low-density cages. With respect to the dry pellets, diet S3 gave an FCR value that can be considered normal for sea bream and sea bass of that size (García-Alcázar *et al.*, 1994), and better than that obtained for another sparid species of interest in aquaculture, *Diplodus puntazzo*, when fed commercial sea bream pellets (FCR=5) (Abellán *et al.*, 1994). However, the remaining diets tested gave much poorer results (FCR>3), despite the fact that many of them had a proximate composition very similar to that of diet S3. This fact seems to indicate a difference in the quality of the dietary components.

The PER reflects to a large extent the FCR values, with the exception of fish fed with fresh food, where the ratio was very low due to the high protein/energy ratio of the diet; the protein clearly being used as a source of energy rather than for weight gain, as reported in others fish species (Cardenete *et al.*, 1986; Takeuchi *et al.*, 1991; Vergara *et al.*, 1993; De la Higuera and Cardenete, 1993).

The observed gross energy consumed (per 100 g of fish) was very similar for the three diets for sea bream (S), but much greater for diet T. Since fish generaly eat according to their requirements of digestible energy (Weisberg and Lotrich, 1982; Morales *et al.*, 1994), this result seems to suggest that diet T had a lower digestible energy value to the fish. This may have been due to the higher carbohydrate content of this diet (extruded diet for turbot), for which nutrients the dentex does not seem to be well equiped to digest with respect to intestinal amylases (Cardenete *et al.*, unpublished data). These results are in agreement with those of 0Riera *et al.* (1995), who recorded less growth feeding dentex with an extruded diet for turbot (almost identical to the one used during the present experiment) than with fresh food.

In general, mortality was, quite low in most of the lots, at times being due to jumps or attacks. However, despite this, fish fed diet S1 had a survival rate of only 61.8% which, although much better than that reported by other authors (Efthimiou *et al.*, 1994; Bibiloni *et al.*, 1993b), would not generally be acceptable in intensive farming during the fattening phase, and was probably due to a pathogenic agent introduced through the diet or triggered by it, since the rest of the farming conditions were identical with the other lots.

In addition, it is worth mentioning that fish fed the dry pellet diet displayed discolouration by the end of the experiment, as compared with fish fed the fresh food diet.

In conclusion, it must be noted that the commercial diet for sea bream gave acceptable growth in dentex, with good utilisation indexes and good survival (>90%). Overall, these results are not very different from those obtained using fresh food as a feed source.

Faced with the results from the first experiment, we decided to carry out a second test with a diet of known components and composition to which we added betaine as a feeding attractant (see Table 2). The aim of adding betaine was to obtain better fish acceptance of the pelleted feed, and avoid rejections, as reportedly found in other species (Rumsey, 1991; García-Alcázar *et al.*, 1994). In addition, we included a commercial carotenoid pigment rich in Canthaxanthin, of known effectiveness as a pigmenting agent in salmonids (Torrissen, 1989).

During experiment, the energy levels of the diet and of the fresh food used as a control were similar, as also were the protein/digestible energy ratios (see Table 3).

The most noteworthy result concerning fish growth and food utilisation (Table 5) was the better values obtained with the dry diet compared to the fresh food diet (although in most cases there are no significant differences). However, the fresh food diet gave significantly poorer FCR and PER than the dry diet, indicating that, where there is a similar protein/energy relationship, the diet with less protein was more effective.

Although growth was not very high, (despite of the length of the experimental period), and the IDG did not surpass those obtained with the best diets from the previous experiment, this may have been due to the lower water temperature during the experiment and the fact that the food was rationed below the animal's appetites, (both factors detracting from maximum-growth conditions). It follows therefore that these same circumstances make it difficult to compare these results with those of other species of the same weight.

Mortality was very slight and unequal among the replicates of dietary treatments; the few fish lost (due possibly to pathologies) not allowing a relationship to be seen between this parameter and the type of diet fed.

Finally, physical examination of the fish at the end of the feeding trial showed no differences in pigmentation between treatments, indicating that the dietary Canthaxanthin was absorbed and utilised by the fish.

Table 5. Growth performance and diet utilisation by dentex of fresh food and dry feed in Experiment 2.

	Diet	
	Fresh food	Dry diet
Initial body weight (g)	59.9	59.8
SEM	±1.7	±2.3
Final body weight (g)	117.3	123.2
SEM	±3.9	±4.9
Increase of biomass (%)	88.7	89.0
SEM	±4.4	±8.1
Instant Daily Growth	0.64	0.69
SEM	±0.01	±0.02
Food Conversion Rate	2.69[a]	1.69
SEM	±0.04	±0.02
Protein Efficiency Ratio	0.53[a]	1.03
SEM	±0.01	±0.01
Mortality (%)	6.7	11.6

Values in the same line with different superscript are significantly different ($p<0.05$).

In conclusion, a diet for common dentex containing 57.4% protein and 14.4% lipid (dry matter basis) and a gross energy content of 21.8 $KJ.g^{-1}$, was found to be completely comparable to, (and even better than) a fresh food diet with respect to acceptance, survival, growth and nutrient utilisation efficiency, under the present experimental conditions. These results confirm the possibilities of intensive rearing for this specie using dry artificial diets and is a starting point from which to research and develop more specific dry feeds.

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