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Culture of common dentex (*Dentex dentex* L.): Present knowledge, problems and perspectives

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SUMMARY – Among the sparidae, common dentex is one of the species with greater possibilities for aquaculture in the Mediterranean area. Its commercial success, ease of reproduction in captivity and high growth rates corroborate this fact. Although on-growing tests have been conducted (Bini, 1968), it was only towards the end of the 1980's and early 90's when the first data on reproduction, development and larval culture appeared, and at a later on on-growing (nutrition and feeding). The information currently available is relatively scarce, and leads us to deduce that there are still many problems to be solved before achieving intensive farming of this species. Reproduction appears to pose serious problems, spontaneous spawns being obtained with relative ease, although they are restricted to a certain season in the year. As regards larval culture and prefattening, difficulties such as high mortality rates appear, which is probably due to pathological and nutritional problems, cannibalism, inadequate environmental conditions, etc., and, in summary, a lack of appropriate technique for breeding larvae and young fish. For successful farming, it is essential to obtain quality larvae and high survival rates. To do so, it is necessary to determine the nutritional requirements of this species and to establish culture parameters: density, oxygen, temperature, photoperiod, light intensity, feeding sequence, types of tanks, etc., in the different stages of the process. This article reviews current knowledge of techniques for dentex culture.

Key words: *Dentex dentex*, reproduction, larval rearing, on-growing.

RESUME – "La culture du denté commun (*Dentex dentex* L.) : Connaissances actuelles, problèmes et perspectives". D'entre tous les sparidés, le denté est l'une des espèces qui offrent le plus grand nombre de possibilités dans l'aquaculture de la zone méditerranéenne. Son succès commercial, sa facilité pour se reproduire en captivité et ses grands taux de croissance en sont des preuves. Même si des essais d'engraissement ont été faits au préalable (Bini, 1968), ce n'est qu'à la fin des années 80 et au début des années 90 que sont apparues les premières données sur la reproduction, le développement et la culture larvaire et postérieurement sur le grossissement (nutrition et alimentation). De nos jours les informations dont nous disposons sont relativement peu abondantes et on peut en déduire qu'il reste encore plusieurs problèmes à résoudre avant d'atteindre la culture intensive de cette espèce. La reproduction ne semble pas poser trop de problèmes et il est possible d'obtenir des pontes spontanées avec une relative aisance mais toujours restreintes à une certaine période de l'année. Quant à la culture larvaire et le pré-grossissement, ils présentent des difficultés comme de hautes mortalités dues, probablement, à des problèmes pathologiques, de cannibalisme, d'alimentation et nutrition, des conditions environnementales inadéquates, etc., et en définitive à l'absence d'une technique appropriée pour l'élevage et l'alevinage. Si on veut réussir une culture il faut obtenir des larves de qualité et avec des larges pourcentages de survie. Pour cela il faut déterminer les besoins nutritifs de cette espèce et établir les paramètres : densité, oxygène, température, photopériode, intensité lumineuse, séquence d'alimentation, types de réservoirs, etc., des différentes phases de la culture. En faisant ce travail, les connaissances actuelles des techniques sur la culture du denté ont été révisées.

Mots-clés : *Dentex dentex*, reproduction, élevage larvaire, grossissement.

Introduction

Fish culture in the Mediterranean is essentially based on two species, sea bream and sea bass, with productions which have increased in a spectacular way in recent years, from 37,179 mt in 1994 to 76,000 mt (provisional data) in 1998 (<http://www.feap.org/basses.html>). This increase in production has led to market saturation and a fall in price. One of the forms in which market supply may be increased and a contribution be made to development and/or expansion of aquaculture is to diversify the species being cultured. In this regard, dentex is one of the candidate species which offers good possibilities.

Common dentex, *Dentex dentex* L., is a demersal carnivorous sparid living on rocky bottoms at depths of between 15 and 20 m, although it may reach 150 m. It may attain a maximum length of 100 cm and a weight of 12 kg, although the individuals caught are not normally more than 50 cm in length. In the natural environment, reproduction occurs from April to June. The area of distribution covers the Mediterranean and the Atlantic from the Bay of Biscay to Senegal. It is a highly valued species in most of the Mediterranean countries, where it is marketed fresh, bringing a high market price.

Dentex culture commenced very recently, in terms of the culture of traditionally Mediterranean species such as the gilthead bream and sea bass, and relatively few references are available on this. Until very recently, the bibliography on its biology, ecology and more especially, on its culture, were very scarce (Bini, 1968; Lo Bianco, 1909). The latter conducted on-growing in aquariums from wild juveniles measuring 13-14 cm; after 14 months, these attained a size of 27 cm and a weight of 300 g. Glamuzina *et al.* (1989) for the first time, achieved reproduction in captivity using hormonal induction techniques. Maturation of the gametes was spontaneous and asynchronous, and spawnings were sequential. These authors concluded that it is a proterandric hermaphrodite. They also conducted larval culture, achieving survival for up to day 12.

Currently, we have data on embryonic and larval development (Glamuzina *et al.*, 1989; Jug-Dujakovic *et al.*, 1995), larval culture (Francicevic, 1991; Riera *et al.*, 1993; Pastor *et al.*, 1995, 1997; Abellán *et al.*, 1997), reproduction (Glamuzina *et al.*, 1989; Riera *et al.*, 1993; Méndez *et al.*, 1995; Abellán *et al.*, 1997), on-growing (Bibiloni *et al.*, 1993; Riera *et al.*, 1993, 1995) and food and nutrition (Efthimiou *et al.*, 1994; Tibaldi *et al.*, 1996; Cardenete *et al.*, 1997a,b,c,d).

In this article, current knowledge on reproduction and larval culture techniques and on-growing are reviewed. The main problems involved in culturing and the outlook for the future are also analysed.

Reproduction and spawning

General aspects of reproduction

Dentex dentex is a gonochoric species with separate sexes. Riera *et al.* (1993) reached this conclusion after examining histological sections of gonads in 61 dentex individuals, the majority being from culture (1 of 1 year old and 57 of 2 years old), without noting a single case of hermaphroditism.

These results coincide with those obtained by ourselves after conducting frequent studies on gonads, over a 30 month period, in 190 fish from commercial catches. Histological examination led us to state that there are individuals of both sexes in all weight classes from 66 g (Fig. 1). This differs from the data provided by Bauchot (1986), Glamuzina *et al.* (1989) and Méndez *et al.* (1995) who deduce that it is a proterandric hermaphrodite.

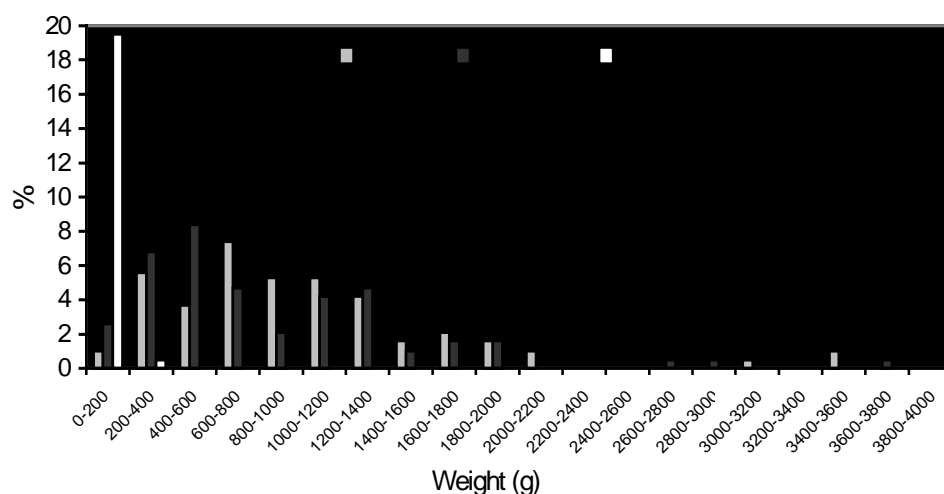


Fig. 1. Percentage distribution of males, females and undifferentiated individuals of dentex (n = 190) sampled in weight classes.

According with our studies, sexual differentiation occurs when they reach a weight of about 70 g and a size of 18-19 cm, at an approximate age of 8 months. Figures 2 and 3 show, respectively, the evolution of the gonadosomatic index (GSI) in male and female individuals, and the seasonal variation in average size of oocyte in females from commercial catches in the Mediterranean (Alicante coast), between February 1993 and June 1995 (unpublished data). At sea, wild individuals start spawning towards the end of March, ending mid June. The GSI peaks in May, coinciding with the height of the spawning season. The lowest GSI values and values of less than 1 correspond with oocyary atresia.

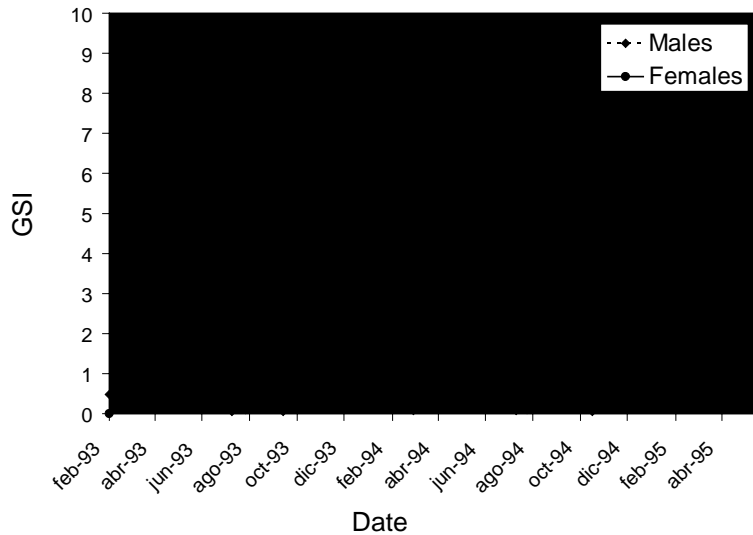


Fig. 2. Seasonal changes in gonadosomatic index (GSI) in wild caught dentex (males and females).

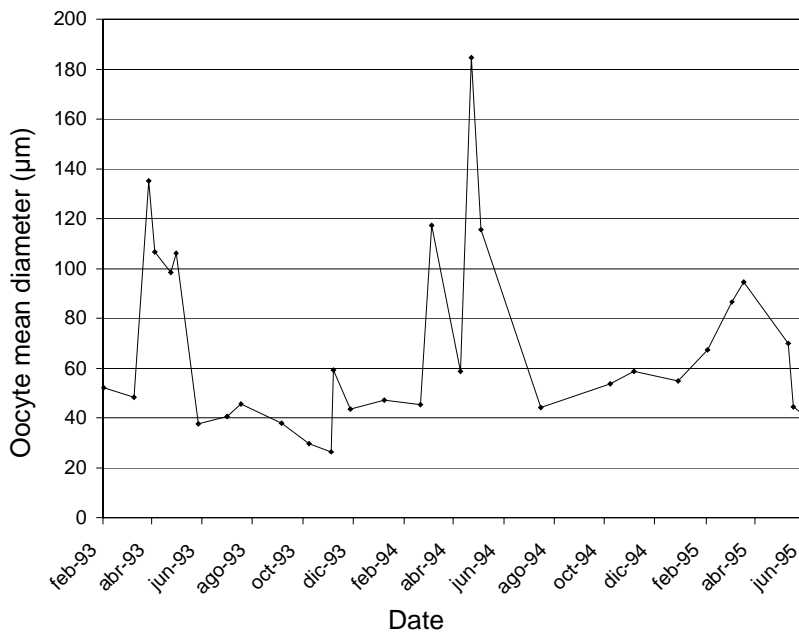


Fig. 3. Seasonal changes in oocyte mean size of wild dentex.

Source of broodstock

Broodstock may be obtained from the natural environment by catching juveniles or adults using

fishing techniques. Transfer to the laboratory should be in oxygenated tanks with anaesthesia, it being advisable to apply prophylactic treatments prior to stabling. Currently, at laboratories where the biological cycle of this species has been successfully completed, broodstock may also be formed from individuals born in captivity.

Broodstock maintenance

Reproducers from wild juveniles adapt very well to captivity, and are maintained in circular fibreglass tanks and rectangular concrete or cement tanks, with volumes in the range of 20 to 100 m³ at densities of 3-7 kg/m³. These require good aeration and a minimum water renewal of 10% of the volume of the tank/h. Temperature and salinity (37-40‰) are as at sea, with the natural photoperiod. Both if the male-female ratio is 0.72 (Abellán *et al.*, 1997) and if it is 1.39 (Pastor *et al.*, 1995), quality spawns are obtained. Daily food intake is based on low commercial value fish, bogue, picarel, etc. and commercial foods. Once or twice a week, squid, crab, etc., are supplied (especially 1 or 2 months prior to spawning). In order to achieve good quality spawns and greater genetic variability, it is advisable to replace a percentage of reproducers with wild animals on an annual basis.

Maturation and spawning in captivity

Dentex reaches sexual maturation and reproduces for the first time at two years of age (Riera *et al.*, 1993; Abellán *et al.*, 1997) when average body weight is 923±92.2 g. Maturation in captivity is spontaneous and asynchronous in tanks with no control of temperature or of the photoperiod, and without hormonal treatment. There is no evidence on record that experiments or analysis of the effects of photoperiod and temperature have been conducted on maturation and spawning. Dentex is a partial spawner and natural spawns occur daily, at nightfall and early in the morning, over a period from the end of February or early March to the end of June, at temperatures ranging from 15°C to 25°C, the highest intensity occurring in May at 17.5-23.5°C (Méndez *et al.*, 1995; Pastor *et al.*, 1995; Abellán *et al.*, 1997). Figure 4 shows the evolution of spawning during the reproduction period at the Oceanographic Centre in Murcia.

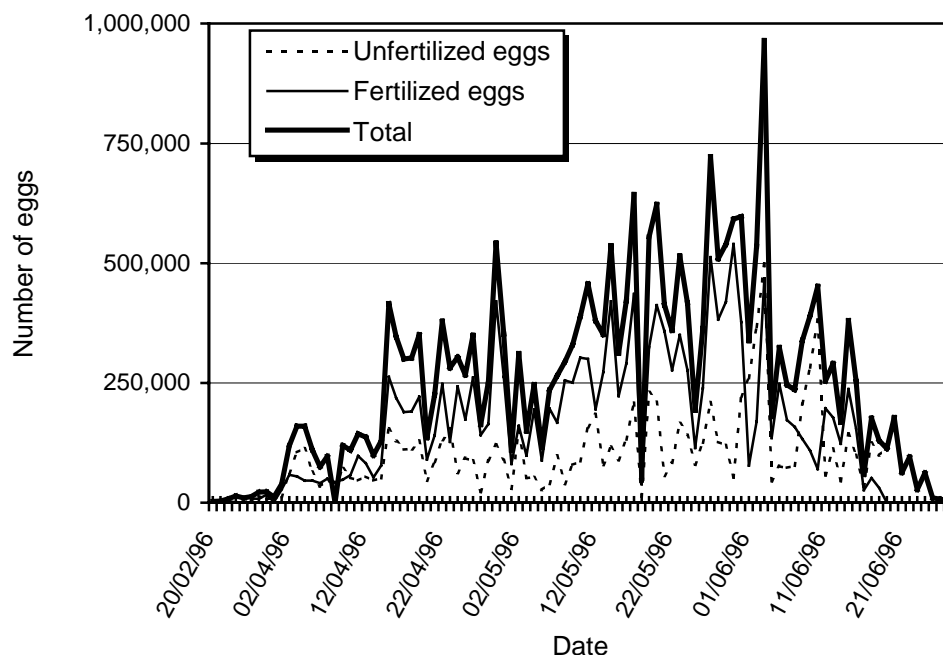


Fig. 4. Natural spawns from common dentex in captivity.

The eggs are pelagic, floating and transparent, and are collected at the outlet level in the tank in

500 µm plankton nets. Eggs have an average diameter ranging from $958\pm 7\mu\text{m}$ (Glamuzina *et al.*, 1989) to $1089\pm 19\mu\text{m}$ (Abellán *et al.*, 1997), noting a decrease in size as the reproduction season progresses and as temperature increases. The unfertilised eggs fall to the bottom of the tank, while the fertilised eggs float on the water surface. Viability rates are generally high throughout almost the entire spawning period, the average viable egg percentage being 62%, reaching a maximum of 90% in May, and a minimum of 30% at the start and end of the spawning season (Abellán *et al.*, 1997).

Fecundity in our plant was estimated at 760,000 eggs/kg in females with an average weight of $807\pm 45\text{ g}$ during the first year of reproduction, and 1,500,000 eggs/kg in females with an average weight of $1600\pm 69\text{ g}$ during the second year (Abellán *et al.*, 1997). Efthimiou *et al.* (1994) and Méndez *et al.* (1995) give average fecundity rates of over one million and of one million eggs/kg respectively. Riera *et al.* (1993) estimate that a 1.4 kg female spawns, uninterruptedly, for two months, from 20,000 to 35,000 eggs/day. These fecundities are far higher than those noted by Glamuzina *et al.* (1989) of 97,000 eggs/kg in 600-800 g females which were induced hormonally.

Incubation

The fertilised eggs are transferred to cylindroconical incubators with a capacity of 0.5 or 1 m³, with continuous but slow water renewal and soft aeration, or alternatively, the eggs may be placed directly into culture tanks with water renewal and suitable aeration. The latter set up is more suitable as it does away with the step of transferring them from incubators to the tanks with the newly born larvae.

Egg density in the incubator may be up to 10,000 eggs per litre, whereas in culture tanks, stocking density ranged from 30 to 50 eggs/l (Abellán *et al.*, 1997) and 120 eggs/l (Pastor *et al.*, 1997). The period of incubation varies with water temperature, which is usually the same spawning temperature. Embryonic development has been described by various authors and has a duration of 79 h 10 min-81 h 5 min at a temperature of 17°C (Glamuzina *et al.*, 1989; Jug-Dujakovic *et al.*, 1995). Pastor *et al.* (1997) establish the incubation period and the duration for embryonic development at 17.6°C in 56 h 10 min, giving hatching rates of over 90%.

Larval rearing

Larval culture covers the entire larval development stage, starting with the newly born larva and ending with the metamorphosis which starts on day 21-22, finalising on day 35 (Franicevic, 1991). This includes live food and adaptation to inert feed. Larval development has been described by Jug-Dujakovic *et al.* (1995) (up to 7 days at 17°C) and by Pastor *et al.* (1997) (up to 15 days at 17.6°C).

Newly born dentex larva is planktonic and transparent, with a size ranging from $2.17\pm 0.2\text{ mm}$ (Glamuzina *et al.*, 1989) and $2.61\pm 0.04\text{ mm}$ at 17-18°C (Pastor *et al.*, 1995, 1997). Other authors note sizes for newly born larvae of $2.28\pm 0.08\text{ mm}$ (Jug-Dujakovic *et al.*, 1995) and $2.60\pm 0.10\text{ mm}$ (Abellán *et al.*, 1997). At 17°C the yolk sac is completely reabsorbed on day 5 when the larva measures 3480 µm (Jug-Dujakovic *et al.*, 1995) and on day 4 after hatching at 22°C (Abellán *et al.*, 1997).

In accordance with our observations, the first swim bladder inflation occurs between days 8 and 11 of age, depending on the temperature (19 and 23°C).

Culture conditions

Larval culture takes place in circular fibreglass tanks with a capacity of 1 to 10 m³. Initial egg density is from 30 to 120 eggs/l.

Culture temperature varies between 15 and 25°C (end of February-end of June). The pH and salinity levels are as at sea, the latter being from 37 to 40‰. Aeration and water renewal should be sufficient as to maintain dissolved oxygen at between 5 and 7 mg/l. Water quality is maintained by renewing the water, ranging from 30% of the total volume of the tank/day to 20%/h depending on age; also the tank bottom is regularly cleaned by siphoning. The water surface should be kept clean by using a skimmer to allow the larvae to inflate the swim bladder and to avoid malformations associated with the lack of bladder.

Trials with different photoperiods show that the best results in terms of growth, survival and percentage of bladder inflation are obtained with a regime of 18 hours light and 6 hours dark. Continuous dark or continuous light are not suitable, nor are short periods of light, since in these conditions larvae die before day 15. As regards light intensity, in the preliminary trials conducted, no differences were noted in survival nor in growth on day 11 of age when using light intensities from 500 to 1500 lux.

Larval feeding

The newly hatched larvae feed from their vitelline reserves up to days 3-6 of life when they are able to catch prey from the environment and start exogenous feeding. At a temperature of 18°C, mouth opening occurs on day 4 when the larva has a size of 3.60 ± 0.06 mm (Pastor *et al.*, 1995) and at 17°C this occurs on day 6, 130 h after hatching; at this moment the mouth is completely open (Jug-Dujakovic *et al.*, 1995) and although it has a maximum diameter of 246-310 μ m, the size of the functional mouth ranges from 98 to 124 μ m (Glamuzina *et al.*, 1989).

The feeding regimen is based on phytoplankton, rotifer and *Artemia*. Following the schedule applied to sea bream, modifications have been made to the feeding sequence which may now be as follows: from the time of mouth opening on days 3-4 and up to days 18-20, rotifers and phytoplankton are distributed. Since the mouth is small, rotifer should be selected (<100 μ m) for the first few days (Glamuzina *et al.*, 1989; Franicevic, 1991). Rotifer concentration in the culture tank varies according to larva age, normally being maintained at between 10 and 20 rotifers/ml. From days 13-14 onwards, and up to day 18, *Artemia* nauplii are administered with a concentration of 1.5-5/ml. Then and until days 30-35, enriched *Artemia* metanauplii are administered, and inert food may be started from day 21 or 22. The change from one type of food to another is not made suddenly, but rather by gradually substituting one with the other.

Food is given at least twice daily. Rotifer is cultured with baker's yeast and phytoplankton (*Nannochloropsis* sp., *Chlorella* sp., etc.). The phytoplankton is added to the culture medium throughout the rotifer feeding stage. In order to increase the nutritional value of the live food, both the rotifer and the *Artemia* are enriched with commercial products rich in highly unsaturated fatty acids (HUFA).

Weaning or the change from live to inert food is usually initiated once the metamorphosis has begun, as from days 21-22. Martínez *et al.* (1997) after determining a series of enzymatic activities related to the digestive process in dentex larvae throughout their development and after checking the rapid activity of proteases in response to the supply of inert food, suggest the possibility of initiating weaning between days 25 and 35. For the weaning different commercial foods designed for sea bream or other species are used. The Fig. 5 shows the different feeding schedules used.

Growth and survival

During the larval stage, growth rates are high, particularly when compared with other sparidae such as sea bream (Fig. 6). Figure 7 describes larval growth (length) up to day 30 when we start with different stocking densities (30, 50 and 65 eggs/litre) during larval culture. No significant differences are noted between the different treatments.

The same does not occur, however, when we note the evolution of growth in terms of weight, starting with the same densities (Table 1). The best results on day 90 (5.72 ± 1.78 g) correspond to an initial density of 30 eggs/litre. These results are comparable with those noted by Efthimiou *et al.* (1994) (5.17 g), are higher than those obtained by Bibiloni *et al.* (1993) (3 g) and far higher than those obtained in sea bream culture (1.3-1.5 g) on day 90.

Survival rates are very low. At the ages of 30, 60 and 90 days, they are always higher when the initial density is 30 eggs/litre (Fig. 8) (Abellán *et al.*, 1997). These results are better than those obtained by Pastor *et al.* (1995), who reported average survival rates of 2.5% on days 50-55, but are lower than those noted by Bibiloni *et al.* (1993) who achieved a 2% survival rate on day 90.

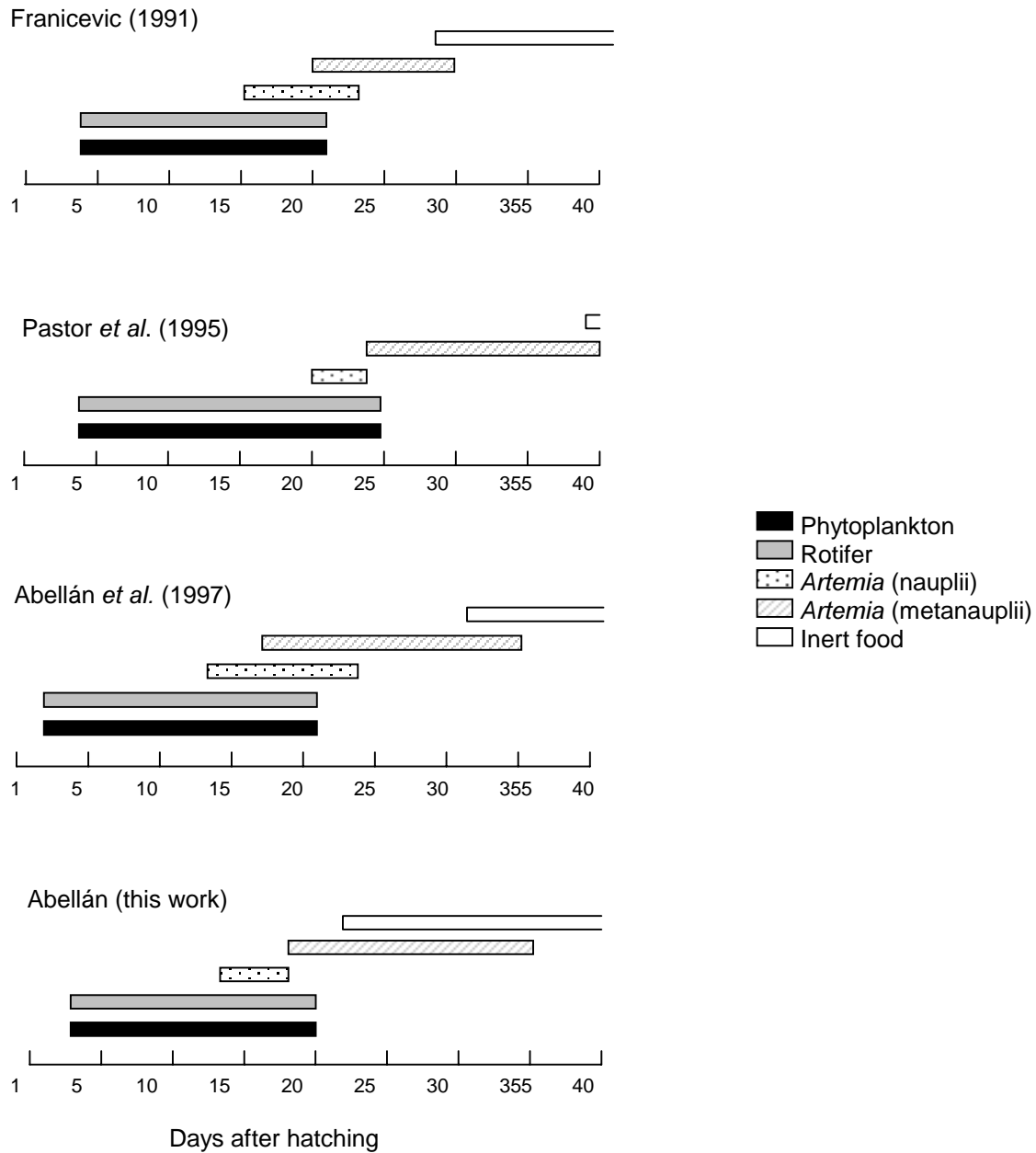


Fig. 5. Different feeding regimes used for dentex larval culture.

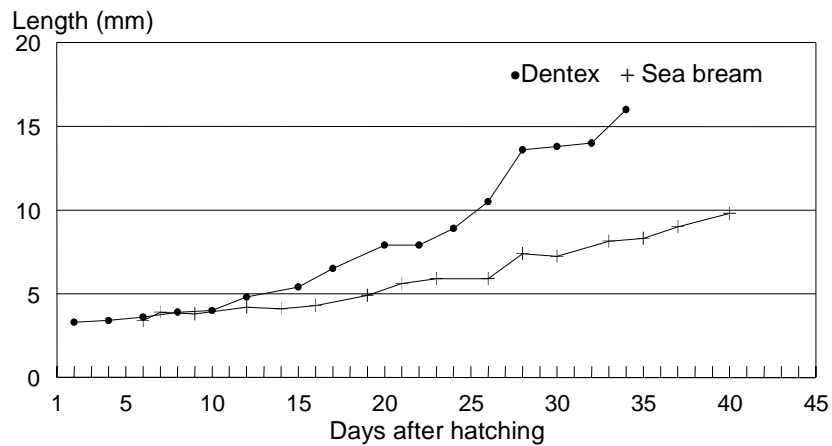


Fig. 6. Comparative growth performance of dentex and sea bream during the larval culture.

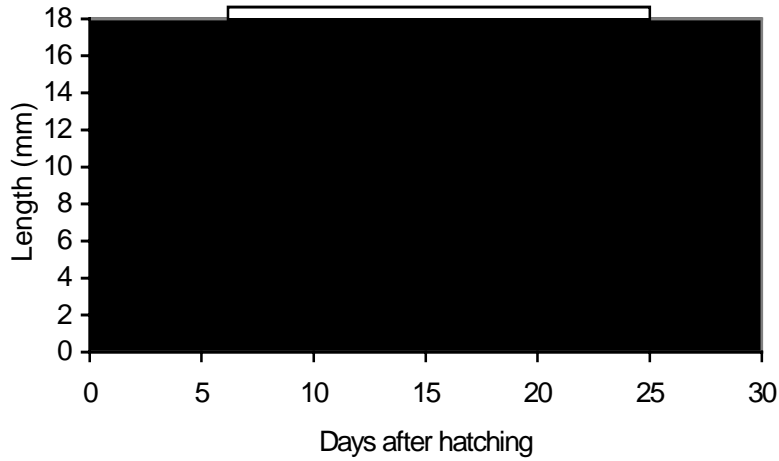


Fig. 7. Growth in length of dentex larvae according to the initial stocking density (no eggs/l).

Table 1. Growth in weight (mean±SD, n = 50) of dentex from day 30 to 90 at different initial stocking densities

Age (days)	Weight (g)		
	30 eggs/l	50 eggs/l	65 eggs/l
30	0.06±0.01	0.06±0.01	0.07±0.02
37	0.15±0.03	0.13±0.31	0.15±0.04
60	1.22±0.37	1.14±0.30	1.09±0.42
66	1.76±0.53	1.37±0.34	–
73	2.65±0.76	1.74±0.76	2.25±4.42
80	3.27±1.19	2.25±1.00	2.65±1.22
90	5.72±1.28	4.80±1.59	4.03±1.40

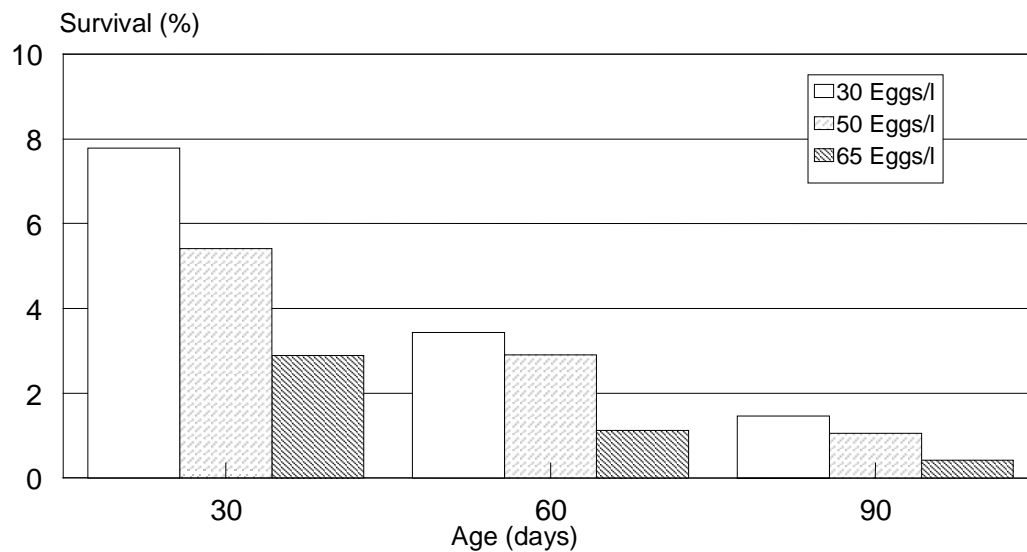


Fig. 8. Survival of common dentex fry at different initial stocking densities.

The different authors disagree when establishing the stages with higher mortality rates. Franicevic (1991) finds the maximum between days 9 and 15 and after day 25. According to Riera *et al.* (1993), the mortality peak rates occur between days 6-15 and 25-30. Pastor *et al.* (1995) find the highest mortality rates between days 9 and 15, and Abellán *et al.* (1997) note a continuous mortality from the start of culture to day 12 and from day 21-22 to 45.

Mortalities during the initial stages of culture may be due, as noted by Glamuzina *et al.* (1989), to the inadequate size of live preys. Furthermore, the general culture conditions and nutritional problems would, in accordance with Pastor *et al.* (1995) be the main causes of larval mortality. These inadequate conditions and the species' sensitiveness to diseases involve certain pathological problems, such as parasitosis caused by the protozoa *Uronema marinum*, which causes high mortality rates at the age of 35 days (Pastor *et al.*, 1995).

Another disease noted by Riera *et al.* (1993) is systemic granulomatosis which appears in the culture from day 70, causing high mortalities. With a vitamin C and E treatment, mortality is halted after 90 days. Other problems include bladder hyperinflation, lordosis and cannibalism, the latter being favoured by the lack of homogeneity in growth.

Ongrowing. Feeding and nutrition

Currently, the bibliography on dentex ongrowing is somewhat lacking. The first studies on growth were made using fresh diets, semi-moist feeds, dry pellet and extruded commercial feeds, designed for other species. Subsequent to these, some studies have been carried out to determine the basic nutritional requirements of dentex. The lack of knowledge on these requirements restricts the possibilities to design specific feeds to obtain maximum growth and profitability.

Riera *et al.* (1993) conducted an ongrowing experience in cages starting with 150 day old fish weighing 15 g, using fresh or frozen fish as food. At 20 months of age, an average weight of 831.3 g was achieved. Later (Riera *et al.*, 1995) also compared in cages the effect on growth of four different diets: fresh, semi-moist feed, pellet feed (43/17) and extruded feed (52/17) for turbot, in 70-80 day old juveniles with an initial weight of 2 g. After 10 months, the batch fed with fish attained an average weight of 274 g as opposed to 272 g (semi-moist feed), 230 g (extruded feed) and 139 g (pellet feed). In both tests, food conversion indices were high and the mortality rates were 60 and 50% respectively.

Efthimiou *et al.* (1994) used a dry diet for sea bream and a moist diet to ongrow dentex juveniles with an average initial weight of 2.4 g. After 6 weeks, the average weight of the individuals fed with dry feed was 16.12 ± 1.58 g, and those fed with semi-moist feed was 31.3 ± 1.45 g. Feed conversion rates (FCR) were very favourable (1.16 and 0.77 respectively), and instantaneous growth rates (SGR) were high (6.1 and 4.5). Mortality, around 50% (48.4% with dry feed and 36.4% with moist) was mainly due to cannibalism.

Cardenete *et al.* (1997c) also tested fresh diets as compared to the commercial dry diets used for ongrowing sea bream and turbot, and studied response in growth and utilization of the diet in individuals with initial weights of 100 g. The diets for sea bream gave an acceptable growth rate result, with favourable feed utilization indices and survival rates of over 90% (SGR = 0.72, FCR = 1.80), these figures being very similar to those obtained using fresh feed (SGR = 0.74, FCR = 1.54).

Based on the data previously obtained, Cardenete *et al.* (1997c) evaluated a experimental diet with a known composition and compared this with a fresh diet, using individuals with an initial weight of 60 g. They reached the conclusion that a diet for dentex containing 57% DM protein, 14.4% DM lipids and a gross energy content of 21.8 kJ/g gives results (SGR = 0.69, FCR = 1.69) comparable to and even better than a fresh diet (SGR = 0.64, FCR = 2.69) in terms of survival, growth and acceptance and utilization of food.

Tibaldi *et al.* (1996) designed seven dry diets with different protein levels (44.3%, 49.3%, 55.7% and 58.9%) and with the same in lipids (17.2%). They conducted tests to determine the protein requirements in dentex with an initial weight of 17 ± 07 g. They reached the conclusion that 49.3% DM of protein may be considered as a preliminary estimate of the protein requirements in dentex of this size (final weight = 24.9 g, SGR = 1.29).

In a second experiment, the same authors studied the influence of different levels of protein and lipids in growth and composition of dentex with an initial weight of 20.7 ± 0.2 g. They used diets with three levels of protein (44.4%, 49.5% and 55.8%), and two levels of lipids (12% and 17.3%) at each protein level. They reached the conclusion that increases in the protein level (from 44.5 to 55.9%) in the diets with a low lipid level, improve the SGR and the FCR, this effect being less pronounced between the treatments with higher lipid levels. The results obtained suggest that when protein efficiency or retention are considered, even 44.3% protein content and 17.2% lipid content may be considered as adequate levels to formulate diets suitable for this species.

Cardenete *et al.* (1997a) also conducted tests with feeds with a different protein-energy ratio, in order to determine the ideal ratio to achieve maximum growth rates, diet utilization and efficiency of protein. Juveniles with an initial average weight of 10 g were used, and six diets were tested with three different protein levels (50, 53 and 57% DM), and two gross energy levels (20 and 22 kJ/g). The result of this was six different protein-energy ratios (2.45, 2.54, 2.86, 2.37, 2.45 and 2.64) corresponding to the diets 50/20, 53/20, 57/20, 50/22, 53/22 and 57/22 respectively. For all treatments, the SGR was higher than 3 and the food conversion indices were low (0.78-0.92). For each energy level used, the best use of protein for growth was obtained in the diets with a lower content in this nutrient. The highest growths do not correlate with a given protein level and, therefore, for each energy level there is a variation in the protein-energy ratio producing the best use of the diet (2.54 for diets with 20 kJ/g gross energy, and 2.64 for a higher energy content, 22 kJ/g.). An increase of energy content in the diet caused an overall improvement in the food conversion indices, this effect having also been noted by Tibaldi *et al.* (1996). Finally, a protein "sparing" effect is also noted, promoted by the increased energy in the diet, such that as the gross energy is increased from 20 to 22 kJ/g, the protein level may be decreased from 57 to 50% DM. Even with these proportions, improvements are noted both in growth and in diet conversion or in the use of protein. In any case, the diet which gave the best results in terms of growth and nutritive utilization of diet and protein was 57/22, which had the highest protein and energy content.

Cardenete *et al.* (1997d) studied the effect on growth in dentex with an initial weight of 30 g using diets with different protein and lipid levels. Two levels of protein were tested (54 and 58% DM) and two levels of lipids (17 and 22% DM). Growth rates were higher in lots fed with high protein content diets (58% DM), although an increase in the lipid level (from 17 to 22%) made it possible to improve the nutritive utilization of the diet as well as the protein retention, and to achieve similar results reducing the protein content in the diet (54% DM).

One of the ways to reduce the protein content in feeds entails avoiding their use to give energy by including more economic sources of energy in the diet, lipids and carbohydrates. As regards dentex, it appears that this species has a poor enzymatic equipment to digest the diet carbohydrates. In order to study the capacity of this species to use an easily digestible glucid (dextrin), Cardenete *et al.* (1997b) tested four experimental diets on dentex with an average initial weight of 10 g. These diets were isoproteic (53% protein DM) and isoenergetic (20 kJ/g DM), to the detriment of fat, until a 22% DM content in the diet was attained (21% of gross energy). SGR were high and above 3 in all cases, with no statistically significant differences noted between the batches. These values were higher than those found by Tibaldi *et al.* (1996). The addition of dextrin does not appear to affect the excellent conversion rates (0.75-0.84) obtained. On the contrary, the apparent digestibility coefficients of organic matter and of energy in the diet appear to point to the presence of an effect of adding dextrin to the diet in terms of decreasing both as the concentration of this carbohydrate is increased. To conclude, the gradual increase of dextrin content in diets for dentex juveniles causes slight decreases in digestibility of organic matter and energy, although no changes occur in growth and the use of diet, which is well tolerated at 22% in diets with 53% DM of protein and 20 kJ/g of energy.

Conclusions and recommendations

Research on dentex culture is underway in several Mediterranean countries, and although the results obtained to date, using techniques very similar to those used in the culture of other sparidae, are promising (ease of reproduction in captivity, favourable adaptation to inert food, high growth rates both at the larval stage and in pre-fattening and on-growing, and very favourable food conversion rates), culture of this species presents serious difficulties which must be overcome in order to commence mass rearing, and for it to become a real alternative to other species produced on an industrial scale.

The high mortality rate during larval and post-larval culture is one of the most notable problems facing the development of dentex culture. The low survival rates appear to be caused by pathological problems, absence of swim bladder, malformations, cannibalism, bladder hyperinflation, etc. In order to solve these problems, it is essential to develop specific culturing techniques, at all stages, which allow for improvement of the survival and quality of larvae and juveniles. Research efforts should focus on:

(i) Reproduction

- Control of reproduction, induction to maturation and spawning by modifying environment factors in order to obtain viable quality spawns at any season of the year. Establish optimum parameters and incubation conditions.

(ii) Develop and optimise larval and post-larval culture techniques

- Establish culture conditions: initial stocking density, temperature, photoperiod, light intensity, tank colour, etc.
- Define the optimum larval food sequence. Nutritional requirements. Type, size and density of live prey. Enrichment: type of enrichers.
- Weaning methodology. Design feed.
- Pathology.

(iii) Develop prefattening and on-growing techniques

- Establish culture conditions. Stocking density. Types of tanks and cages.
- Nutritional requirements. Formulate feeds. Rationing. Food guidelines and strategies.
- Establish a base diet to cover the nutritional requirements of dentex at all stages of culture.
- Pathology.

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