Culture of Pagellus bogaraveo: Present knowledge, problems and perspectives

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Culture of *Pagellus bogaraveo*: Present knowledge, problems and perspectives

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SUMMARY – In 1991, a research project was initiated on the "Development of culture techniques on new species", in order to find alternatives to traditional consolidated cultures. The result of this research was conclusive as regards blackspot sea bream *(Pagellus bogaraveo* B.), a species with a high commercial value, with acceptable biological characteristics for development in aquaculture. To date, considerable progress has been made in research in the field of reproduction, where spawning periods and the optimum conditions required for obtaining natural spawns have been defined. Embryonic development and the morphometric characteristics of the larvae have also been defined. Larval culture has been developed without difficulty, and data on the influence of temperature and density in prefattening is also conclusive. A further important part of this information available to us is conclusive on fattening. Evidently, with the lack of a specific feed, which is currently under development, blackspot sea bream presents a clearly differentiated behaviour depending on if this is in cages or in tanks. The problems found for culturing this species, from the biological point of view, do not, in principle, appear to be unsolvable. In fact, it is expected that the production cycle will be closed this year, with individuals born in captivity. The general outlook for culturing blackspot sea bream is currently hopeful. It may be assumed that within a period of about three years, we may have a technology developed for the industrial production of blackspot sea bream.

Key words: *Pagellus bogaraveo*, diversification, fish farming.

RESUME – *"La culture de* Pagellus bogaraveo *: Connaissances actuelles, problèmes et perspectives". En 1991 nous avons entrepris un projet de recherche sur "Le développement des techniques de culture de nouvelles espèces" avec l'objectif de trouver des alternatives aux cultures traditionnelles déjà consolidées. Le résultat de ces recherches a été concluant par rapport à la daurade (*Pagellus bogaraveo *B.), espèce d'une grande valeur commerciale avec des caractéristiques biologiques acceptables pour être cultivée dans le domaine de l'aquiculture. Les recherches faites jusqu'à présent dans le domaine de la reproduction ont été considérablement développées, avec une définition des saisons de ponte et des meilleures conditions requises pour l'obtention de pontes naturelles. Le développement embryonnaire et les caractéristiques morphométriques des larves ont été aussi définis. La culture larvaire s'est développée sans problèmes et les données relatives à la température et à la densité lors du pré-grossissement sont également concluantes. Un autre point à signaler avec des informations concluantes est le grossissement, domaine dans lequel, faute d'un aliment spécifique qui est actuellement en voie de développement, la daurade présente un comportement clairement différencié lorsqu'elle est cultivée dans des cages ou dans des réservoirs. Du point de vue biologique, les problèmes rencontrés pour la cultiver ne semblent pas, en principe, insolubles ; à ce sujet, la fermeture du cycle de production est prévue pour cette même année, avec des exemplaires nés en captivité. Les perspectives de la culture de la daurade sont actuellement encourageantes. Il y a lieu d'imaginer que dans un délai de quelque trois ans, nous aurons les moyens d'appliquer une technologie plus avancée pour la production industrielle de la daurade.*

Mots-clés : Pagellus bogaraveo*, diversification, ferme marine.*

Introduction

In Spain, the first studies conducted on Blackspot sea bream as a marine aquaculture species date from the early nineties. Turbot farming technology was also launched in the early nineties, with a production of 300 MT, increasing from 300 to 1100 MT between 1990 and 1992. This shows that production technology had, by this time, reached a climax, despite the dependence on juveniles from the foreign market.

It was precisely at this point that the growing turbot industry fell into a serious crisis, as a result of a collapse in the market, when the idea began to take shape to look for an alternative species for rearing. This would make it possible to diversify the risks in an industry already, in itself, considered to be a high risk, both due to the delicate nature of the species involved and the instability of the market.

Among the sparids, sea bream in our market is one of the species with greater potential for rearing at industrial level. If we analyze the factors to confirm this, we note that they are twofold, biological and commercial.

From the biological point of view, analyzing the stages in the rearing process, such as adaptation to captivity and reproduction, larval culture, prefattening and ongrowing, resilience to handling and susceptibility to illnesses, the balance is positive, particularly when taking into account that this is a preliminary study of a species. In view of this, it is logical to assume that a greater knowledge would be gained on the species the more its rearing is researched.

From the market point of view, sea bream is a species with a high, very stable value all year round, with an increasing importance in sales over the Christmas period, as it is one of the main products of Spain's gastronomic culture at this time of year. Furthermore, among the sparids, this is possible the species with most possibilities for expansion into other international markets due to its area of distribution and acceptability in the markets.

A similar process occurred with species such as gilt head bream, sea bass or turbot, not to mention salmon or trout, where farming techniques were improved, food and enrichers, both artificial and natural, were optimized, to attain current exploitation levels. Sea bream is a species which, if we were to compare initial data on growth, behaviour in captivity and availability of a specific technology, we would find that, in terms of other sparids, presents substantial advantages over other groups, as it has adequate rearing technology and a widespread national and international market able to absorb production.

Sea bream is still not, however, produced for the market. The information available in scientific publications is still not abundant, and what there is refers more to sea bream from the viewpoint of its biology, behaviour and catching in the natural environment. The decrease in catches in the natural environment, however, linked to the high market price, and the increasing interest in other countries as regards rearing sea bream, mean that its development is progressing rapidly, both in research projects and in private initiatives from companies in the sector.

Catching individuals in the natural environment

The area of distribution for sea bream in the Atlantic stretches from Norway to Cabo Blanco, Madeira and the Canaries, while it is common in the Mediterranean in the Straits of Gibraltar to the Adriatic, whereas it is practically non-existent in the Black Sea (Hureau and Monod, 1973).

The starting point for any fish rearing experience basically involves catching individuals in the natural environment, for tests on behaviour. In terms of the subsequent result, the decision is taken as to the feasibility or otherwise of the project.

Sea bream off the north west of the Iberian peninsula is caught at different depths, in terms of the size of the individuals, the complexity of the manoeuvre increasing as fish size increases. In fact, the smallest sized individuals are caught on the continental platform, at about 50 metres depth, weighing approximately 150 g. Fish of this size are caught one by one with hooks, with the ship anchored, baited with mussel (*Mytillus galloprovincialis*) or worms (*Nereis diversicolor*). The individuals are slowly raised on board to avoid damage and lesions, and are then placed in 1000 L circular tanks with running water. Once on board, the tanks are covered to avoid damage to the eyes (cataracts) as they have come from areas with less light and stress, thus making them more vulnerable to any type of pathology.

The fish are then conveyed to the laboratory by land (approximately 1 km) and stabled in a tank where they are immediately treated with a green malachite mixture (0.6 g/1000 L) and 35% formol (0.25 ml/L) to deparasitize them and avoid infections caused by handling. Once stabled, they are kept to a diet for two or three days, after which they are directly fed a dry commercial food for gilt head bream (Europa, measuring 3 mm in diameter), which are accepted with no difficulty.

Preliminary ongrowing results for these individuals (Fig. 1) were hopeful (Peleteiro *et al.*, 1994). Tests conducted on behaviour such as ongrowing, were very favourable, even when considering that they are fish caught in the natural environment and, therefore, subjected to an out of the ordinary selection process.

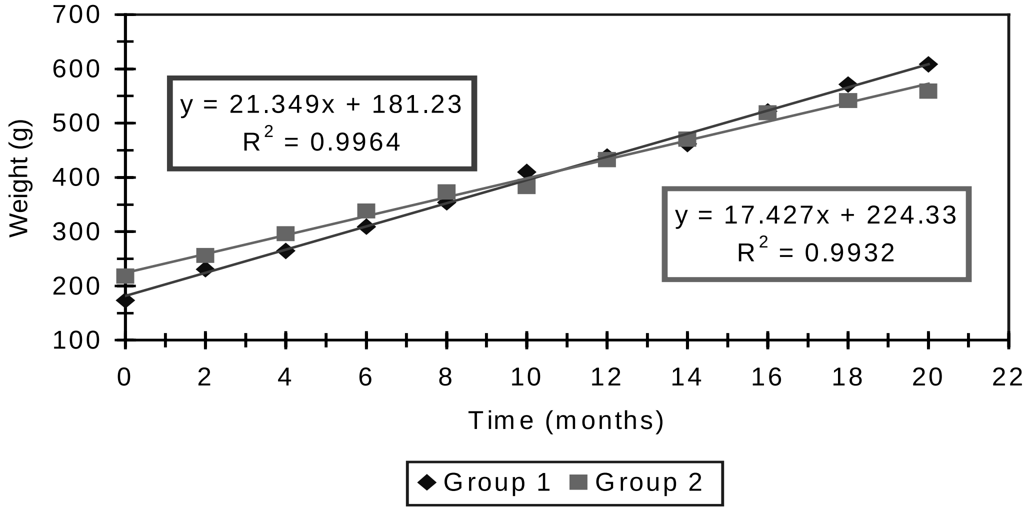

Fig. 1. Growth in weight of the sea bream batches (*Pagellus bogaraveo* B.) from the natural environment (Peleteiro *et al.*, 1994).

Bathymetric distribution of sea bream (Sánchez, 1993) ranges from 50 to 300 metres (caught by trawling). Adult individuals are caught, however, with longline at greater depths, from 300 to 500 metres. These individuals for rearing are caught with commercial longliners, turning about at very slow speeds in order to avoid decompression problems when being brought to the surface. These individuals, weighing from 700 g to 1500 g, are placed in dark tanks on board ship to avoid the appearance of eye cataracts, changing them to a slight semi-darkness once in the laboratory tanks for the reproducers.

The process of transporting and acclimatization is similar to that for juveniles, but the process of adaptation to captivity in these adults is far slower, particularly as regards accepting the food. Instead of dry feed, they are given mussel and squid mixed with sliced fish. In fact, the larger the individual, the less are the chances of survival, it being more difficult for individuals weighing more than 1000 g to adapt to captivity.

Reproduction

The reproducing stage in the natural environment of sea bream varies in terms of latitude and longitude. Off the Azores, reproduction occurs between January and April, reaching peak spawning activity between February and May (Krug, 1986). In the Bay of Biscay, spawning season is similar (Sánchez, 1983), whereas off England, spawning commences in September, ending in October (Olivier, 1928).

In captivity, spawning coincides more or less with these periods, and in the Bay of Biscay, the reproducing period occurs from March through to May (Fernández-Pato *et al.*, 1990), and off the north-west of the Iberian peninsula (Fig. 2) from February through to May (Olmedo *et al.*, 1998).

Sea bream presents proterandic hermaphroditism. In the juvenile stages, both in captivity and in the natural environment, individuals are found with three different types of gonads (Krug, 1990):

(i) Functional males (males) – 29% of the population.

(ii) Non-functional ovotestis (hermaphrodites) – 32% of the population (see plate).
(iii) Functional ovaries with part of the testicle degenerated (females) – 38% of the population.

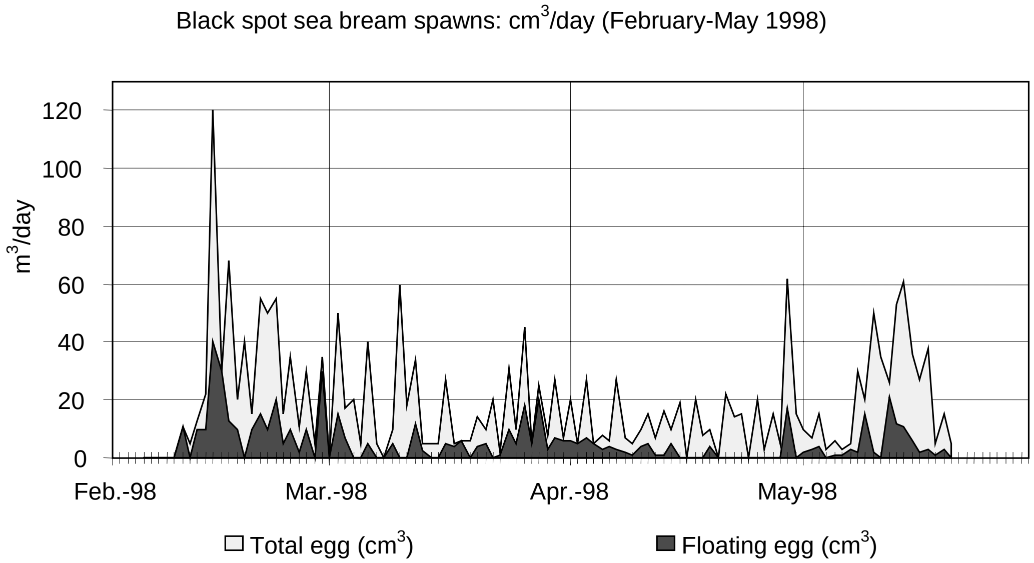

Fig. 2. Natural spawns from sea bream in captivity (Olmedo *et al.*, 1998).

First maturity in males occurs at 27.7 cm in length (5 years) and at 34.6 cm in length (8 years) in the female (Krug, 1990). First maturity here is understood to refer to the length at which 50% of individuals are mature. Sánchez (1983) found that wild individuals did not attain first sexual maturity and a weight of 650 g and 35 cm length until the fifth year.

In captivity, however, the first spawns in individuals caught in the natural environment, occur after the third year of captivity (fourth year of life) (Fernández-Pato *et al.*, 1990). In our professional experience at the OC in Vigo, (IEO), individuals born in captivity experience their first feasible spawns during the fourth year of life.

Estimated fecundity in sea bream (Krug, 1990) lies in a range between 73,000 and 1,500,000 ovocytes for females of between 29 and 41 cm length. Nevertheless, it is logical to consider that by being fish with proterandric hermaphroditism, males mature considerably before females.

Sea bream in captivity require large volumes to obtain natural spawning. Fernández-Pato *et al.* (1990) obtained spawns in 10 m^3 tanks with a load density of 3 kg/m^3. Conversely, Peleteiro *et al.* (1997) obtained feasible spawns in 32 m^3 and 1.7 kg/m^3 tanks after a change of constant thermoperiod (14°C), at a natural thermoperiod (12-21°C). This leads us to consider the thermoperiod as a unchain of the process of gonad maturation.

It appears evident that the greater the tank volume, the better the results obtained in natural spawns. According to A. Sánchez (pers. comm.), sea breams maintained in cylindrical tanks with a diameter of 8 m and 3 m depth (120 m^3 useful space) spontaneously spawn in natural light and temperature conditions, with a commercial feed specific for reproducers.

Female sea bream experience ovulatory cycles with an approximate period of 48 hours, each ovulation having from 20 to 30 cm^3 of eggs per individual (Peleteiro *et al.*, 1997), weighing 1-1.5 kg which creates the need to develop a good stock of reproducers to obtain an acceptable amount of eggs for incubation and larval culture.

Natural spawns are gathered by overflow in a collector fitted with a 500 µ mesh. Fertilization occurs early in the morning so that when the eggs are collected, they are already in the morular or blastular stage, approximately 4 hours following fertilization. The eggs collected by the tank overflow are spherical in shape, transparent and 1.19 + 0.0215 mm in diameter, with a single drop of fat 0.025 mm in diameter. Embyronic development is described by Peleteiro *et al.* (1997), and lasts 54 hours at 14 ± 1°C from the time of collection, or 58 hours from the assumed fertilization time.

Once spawn volume is calculated (870 + 46 eggs/cm^3), the eggs are transferred to the incubators. Incubation is in 110 l cylindroconical tanks, or if small spawns are involved, in 5 litre containers with a 500 µ mesh in the bottom to allow for water exchange. The percentage of hatching in eggs collected from natural spawnings is approximately 25.3%, this being calculated on the incubated fertilized egg.

At the time of hatching, larvae measure 3.7 + 0.0935 mm in length. The yolk-sac takes up approximately two thirds of the length of the larva. The length and height of the yolk-sac are 1.27 + 0.0561 mm and 0.52 + 0.0663 mm respectively (Fernández-Pato *et al.*, 1990; Peleteiro *et al.*, 1997). Larvae are maintained in the incubators with running water and aeration until the day prior to opening the mouth in which they are transferred to the larva culture tanks.

Induction tests have been conducted on sea bream spawning, using progressively higher doses of 5, 10 and 15 g of LHRHa, at two week intervals between each dose (Peleteiro *et al.*, 1997). Injected females were already in advanced stages of maturity (Fig. 3), nevertheless there was no positive reaction to this type of induction.

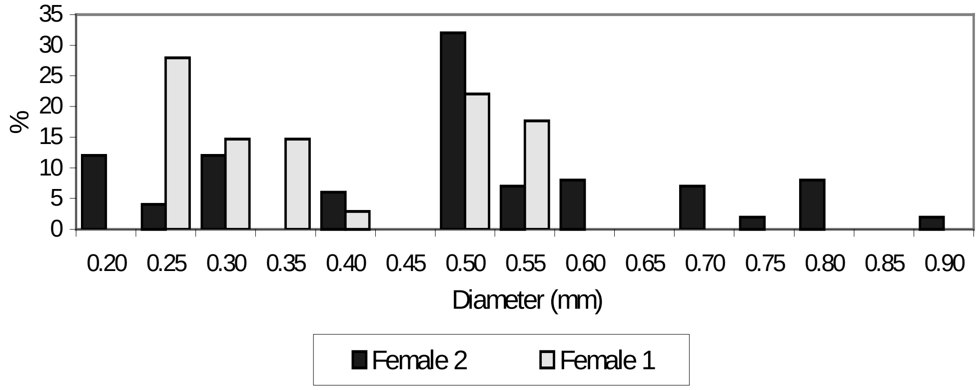

Fig. 3. Distribution of the diameter of ovocytes from two sea bream females in the advanced stage of maturity (Peleteiro *et al.*, 1997).

Patti and Micale (1993) examine the possibility of manipulating the photoperiod as a system for controlling the increase in weight in detriment to sexual maturity, noting an increase in density of the melano-chromatophages in the individuals in which the photoperiod had been manipulated.

From the time of hatching to the opening of the mouth, there was an approximate delay of 115 hours at 14°C, and 138 hours until the digestive system was fully functional (Peleteiro *et al.*, 1997). The total length of the larva at this point was 4.92 + 0.052 mm, and it was from this moment onwards that larval culture really commenced.

In terms of the pathology of adult individuals, it is necessary briefly to refer to the exophthalmy and inflation of the swim-bladder, possibly caused by stress situations giving rise to buoyancy and, therefore, starvation due to the inability to reach the food. Both can be solved, by extracting the air with a syringe, but in the case of exophthalmy, vision cannot be regained and colouring darkens. But however, the individual may continue eating, searching for food by combing the tank bottom.

They are hypersensitive to turbidity in the water, a fact which causes massive mortality rates due to problems of this type deriving from poor handling when cleaning the tank bottom and walls, and even due to the turbidity caused by storms or elements alien to the installation.

Larval culture

Larval culture starts at the point before the mouth is opened, coinciding with a 37% decrease in yolk-sac volume 95 hours after egg hatching. Larvae are measured 4.72 + 0.089 when being transferred to the rearing tanks. At this point (Fig. 4), loss in diameter of the grease drop (0.20 + 0.0302 mm) is already evident (Peleteiro *et al.*, 1997).

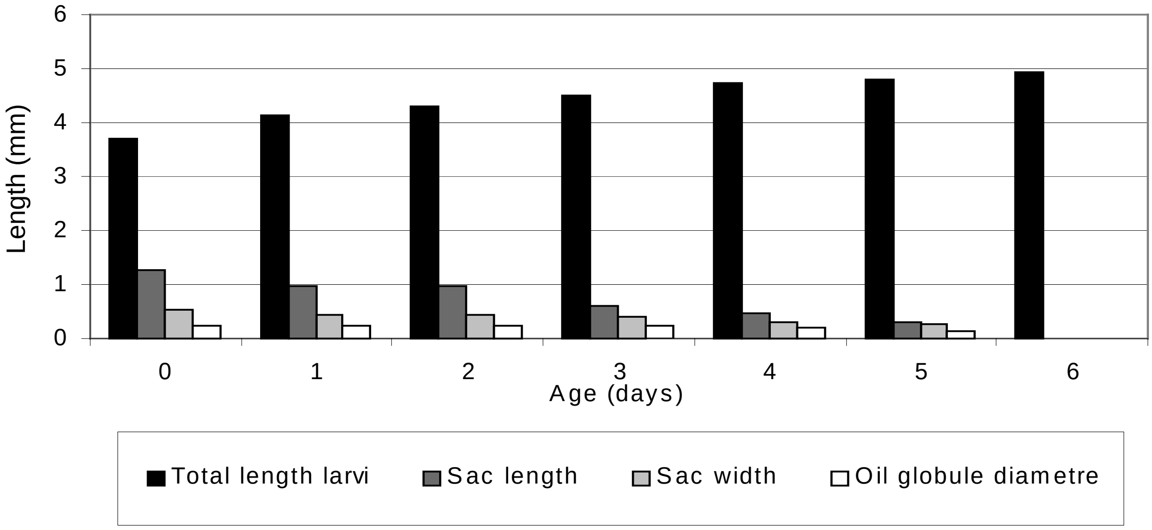

Fig. 4. Consumption of the yolk-sac of sea bream larvae born in captivity.

Once prior sampling of the larvae is taken, these are transferred to the standard design culture tanks, which are circular and slightly angled at the bottom. Tank walls are black on a white background, which is often a drawback as the larvae tend to go to the bottom. Volumes ranged from 1000 to 10,000 litres, depending on the number of larvae.

This is a species which, generally, does not accept excessively high loads during any of the stages of rearing. In fact, larval culture gives better results with low densities, in the order of 10 larvae/litre.

Culture tanks are previously filled with water filtered through 1 μ and sterilized with ultraviolet light and phytoplankton (*Isochrysis galvana*), in a density of 150,000 cells/ml, and rotifer (*Braquionus plicatilis*) at a density of 5 rot/ml (Olmedo *et al.*, 1998) in order to familiarize the larvae with the food. When the larvae have been transferred, heaters are installed to raise the temperature of the water to 18°C. When the mouth is opened and the digestive system is functional, movements indicating that food is being caught are clearly evident, this begin a further quality criteria in the larvae.

The rotifer is previously enriched with Isochrysis galvana and renewed daily, if required. A continuous photoperiod of 24 hours of light/daylight is used (Fig. 5), since this gives a significantly higher growth rate than with a normal photoperiod (Olmedo *et al.*, 1998).

It is essential to clean the tank bottom and walls at regular intervals, and to maintain algae concentration at a constant, by decreasing the volume of water and refilling with filtered water and phytoplankton.

The culture is maintained in a closed circuit, with rotifer at densities not exceeding 10 rot/ml until day 30 when nauplius of saline artemia are added, overlapping with the rotifer feed for a few days. A few days later, once the rotifer has disappeared, metanaplus of enriched artemia is added with *Isochrysis galvana*, or any artificial (non-fat)enricher, approximately until day 50 when they are weaned with a commercial feed (Pro Acqua Nutricial, S.A.), and the prefattening period commences (Olmedo *et al.*, 1998). As from the second stage of live feed with nauplius of artemia, the circuit is opened for one hour. Subsequently, this time is gradually increased until the time for weaning when the circuit is open.

In experiences with larval feed, conducted by Martínez-Tapia *et al.* (1990) using microencapsulates or live feed, it was concluded that artificial diet is an alternative for use in aquaculture, but as a part of an inert complementary diet of live feed.

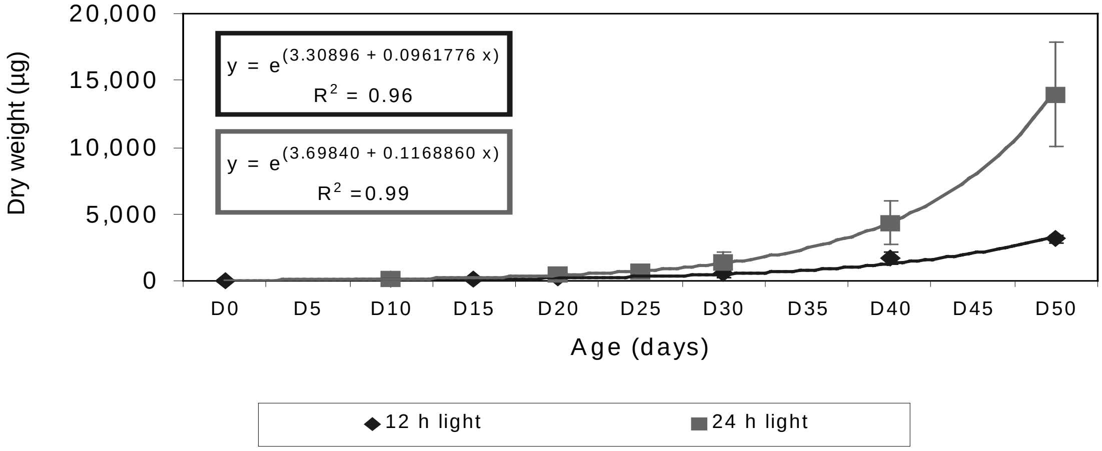

Fig. 5. Growth of sea bream larvae born in captivity and subjected to two types photoperiod (Olmedo *et al.*, 1998).

Growth of the larvae of this species (Fig. 6) is similar to that of other sparids such as the Spanish common bream (*Pagellus erythrinus*) and the gilthead bream (*Sparus aurata*), (Cejas *et al.*, 1993) or white sea bream (*Diplodus sargus*) and the sharp-snout sea bream (*Diplodus puntazzo*), (Abellán *et al.*, 1994).

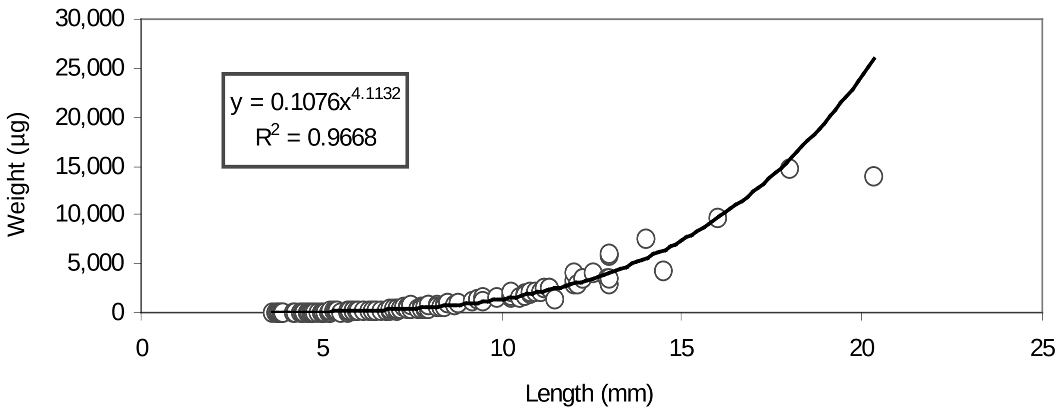

Fig. 6. Size-weight ratio of juveniles during the larval stage (Olmedo *et al.*, 1998).

Generally, excepting sensitivity to handling, noted during all stages of rearing of this species, larval culture presents no special complications, and adapts perfectly to the techniques already known for rearing other species. The survival rate in this period ranged from 5 to 10%.

Both exophthalmy and inflation of the swim-bladder are now evident in larval culture, which in a manner refutes the theory that this may be due to a problem of depression. These are the only two pathologies detected during the larval culture stage.

Prefattening

Very little published information is available on the development at this prefattening stage, possibly due to the fact that, until recently, there was a lack of individuals born in captivity. Olmedo *et al.* (1997) describe a series of controlled parameters in prefattening experiences conducted on four month old juveniles weighing approximately 2 g, the growth curve for this period being (Fig. 7): P = 2.2073 x e0.0255t (R^2 = 0.9286), with a length-weight ratio of P = 0.019 x L 3.1484 (R^2 = 0.9443) and a daily growth rate of G = 2.65%. Mortality rate for this period was 5.8%.

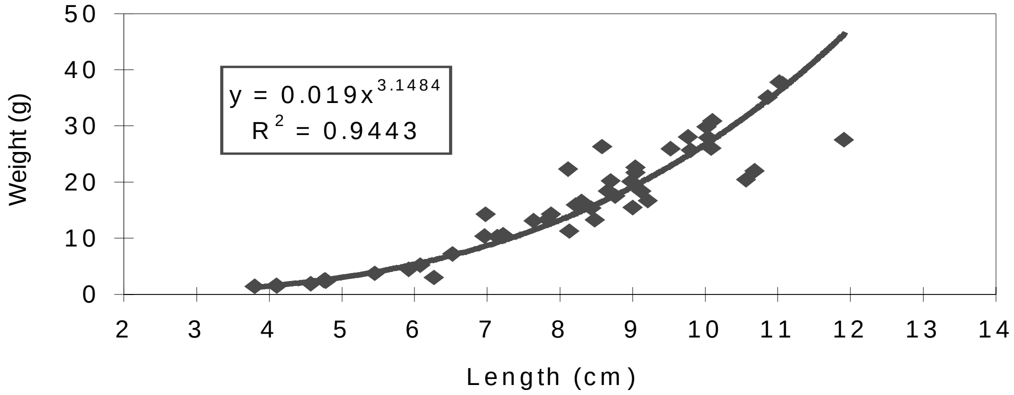

Fig. 7. Length-weight ratio of juveniles during the prefattening stage (Olmedo *et al.*, 1998).

The period of the prefattening stage was defined at approximately 120 days, from 2 to 40 g in weight (Fig. 8), in square culture tanks 0.5 m in height, and a capacity of 500 l, initially using 500/800 mm diameter feed granules, gradually being increased to 2 mm diameter at the final stage of prefattening.

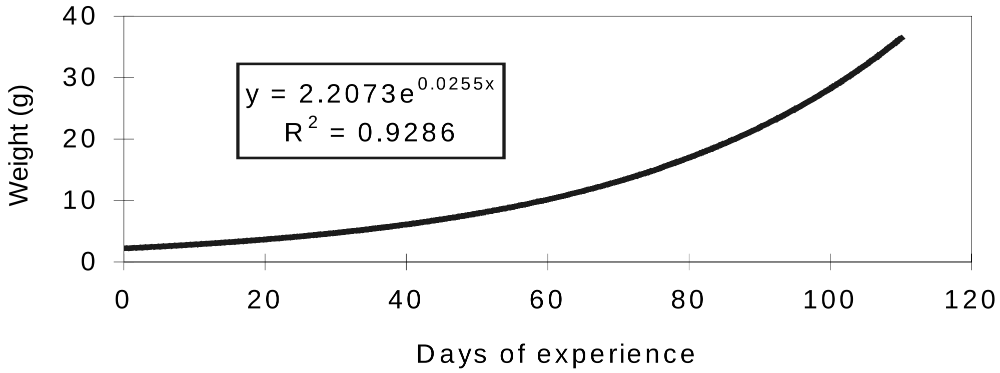

Fig. 8. Growth of juvenile sea bream (Olmedo *et al.*, 1998).

Initial stabling densities are noted of 1.2 and 3 g/l, and no significant differences in growth were found. Differences were observed, however, during this stage, using controlled water at 19°C relative to the water at a room temperature of 16 + 1°C, attaining average weights of 41.5 + 10.36 g and 30.94 + 10.30 g respectively.

No specific pathologies are described for this prefattening stage, except those noted for exophthalmy and inflation of the swim-bladder.

Ongrowing

Published bibliography is available on the ongrowing stage of sea bream rearing, but this mostly refers to preliminary experiments conducted on individuals caught in the natural environment (Greco *et al.*, 1989; Chereguini *et al.*, 1990; Peleteiro *et al.*, 1994; Genovese *et al.*, 1998).

In one of these first experiences conducted on this species, Greco *et al.* (1989) used 50 g individuals caught in the natural environment, attaining the commercial size (200 g) after 180 days, using an experimental diet. Similar results were obtained by Chereguini *et al.* (1990) with 20 g individuals, attaining 300 g after 17 months, using commercial feeds. Peleteiro *et al.* (1994) used wild 173 g and 217 g individuals, which after 14 and 10 months respectively, attained weights of 462 and 383 g, using an experimental diet based on fishmeal, fresh fish and a vitamin and mineral supplement. Mortality rate throughout this period ranged from 5 to 10%.

One of the main problems found in ongrowing sea bream is greasing of the viscera, which may be corrected with an appropriate diet, despite the fact that even in nature, it is easy to find this species with a high grease index. Genovese *et al.* (1998) found a relationship between high densities and high coefficients of greasing, but however, found no relationship between the density and the hepatosomatic index and the viscerosomatic index.

It appears evident that these data on ongrowing may be improved upon by using appropriate diets specially formulated for this species, and by optimizing the production systems used. In this regard, the latest experiences conducted, on individuals born in captivity, by researchers at the Oceanographic Centre of Vigo, IEO, and the Aquaculture Studies Centre belonging to the Regional Government of Galicia, show a more than acceptable growth rate for this species.

These experiences conducted in tanks at different temperatures (M. Olmedo, pers. comm.) and in floating cages (F. Linares, pers. comm.), show similar growth rates at different temperatures, and a clear difference both in ongrowing and in the external appearance of the individuals ongrown in cages (Fig. 9).

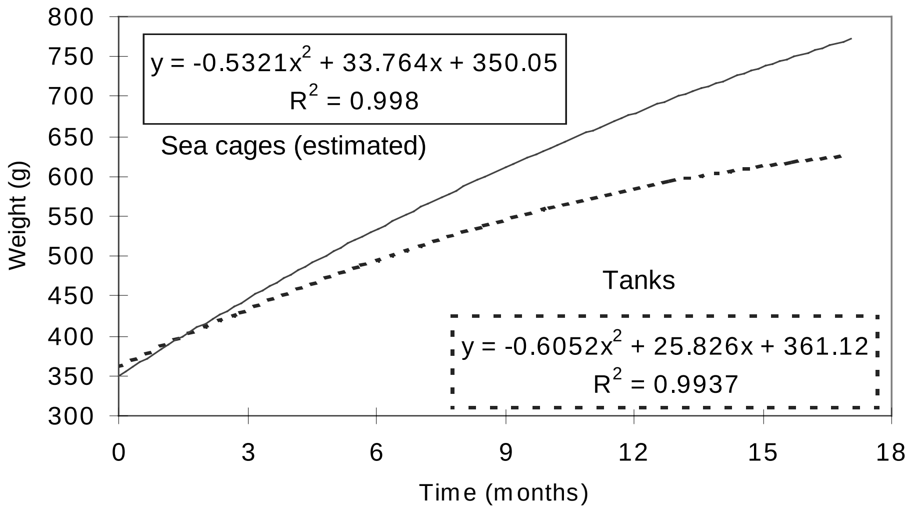

Fig. 9. Estimated growth of sea bream in cages and tanks on land (F. Linares, pers. comm.).

In any case, sea bream growth in tanks on land is similar to that noted for gilthead bream (*Sparus aurata*) in the first stages of research, which highlights the need for efforts to improve the techniques and to be able to optimize production.

Recommendations

Statistical information on this species is complicated due to the fact that, in several cases, it is confused with the axillary sea bream (*Pagellus acarne*), not only because of its external appearance, but also because it is even given the same name in many markets, thus rendering the information available unclear. Furthermore, the fact that this species is not subject to regulations such as TACs and quotas, means that the statistical information available is very wide-ranging as it mixes different species of sparids with common names in the trawl, longline, driftnet and artesenal catch figures.

Off the Spanish coastline, the fishing grounds in the north (Bay of Biscay) and North-west (Atlantic Ocean), and in the Bay of Cadiz (South Atlantic Zone), important setbacks have been experienced, largely due to overexploitation. In the South Atlantic Zone, catches have decreased over the last year from 700 to 200 MT, which in a manner, increases its value in the market due to scarcity.

It is easy to find sea bream in the markets of coastal countries on the Western Mediterranean, such as Italy, Spain, France, Greece or Tunisia, but to date, no market studies on this species have been conducted, although important research experiences are underway regarding the possibilities for farming this species in Italy, Spain and Portugal.

The price for this species on the market (at 1st sale), despite this being subject to fluctuation in terms of catch rates and the season of the year, is fairly stable, at about 10 $, although this may increase to 30-40 $ in certain months.

In Spain, apart from Public Bodies interested in developing this species, there are important initiatives in the private sector, both in aquaculture and in the food sectors. These circumstances provide a substantial impetus for technological development, both in the design of structures and specific feeds or plants. These tend to optimize production and improve yields for this species.

In summary, it is essential to focus research basically on five points:

(i) Control over reproduction.
(ii) Optimize larval culture techniques.
(iii) Determine nutritional requirements in the diverse stages of culture and design of specific feeds.
(iv) Design of floating structures and structures on land to improve yields.
(v) Pathology studies.

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