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First Results on Spawning and Larval Rearing of the Brown Meagre (*Sciaena umbra*)

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ABSTRACT

The aim of the present study is to investigate spawning and larval rearing of brown meagre (*Sciaena umbra*). This is an important species in the Mediterranean Sea because of its beauty, calm swimming, large otoliths, souvenir potential, aggregative behaviour, excellent flesh and accessibility. Although this species is regarded as Near Threatened (in IUCN Red List Status), the demand increases the fishing. Green water technique was used for rearing the brown meagre larvae. Diameter of eggs was recorded as 1457.31±47.29 µm. Yolk was homogenous with oil globules of 371.59±18.15 µm at the centre. Hatching process began after 39 hours. Hatching rate (H_R) was observed as 92.17±0.24%, and larvae inflated swim bladder around 97.33±0.94%. The brown meagre juveniles reached to 40.08±1.98 mm of total length (TL) with 10.96±0.08 mm body height (BH) and 662.27±21.23 mg body weight (BW) after 55 days of post-hatching. Survival (SR) was recorded as 72.5±0.70% at the end of study. Since the brown meagre is a threatened species, with high economic interest, is a possible candidate for commercial aquaculture both food and restocking the depleted natural fisheries.

INTRODUCTION

Brown meagre (*Sciaena umbra*) is a Mediterranean sciaenid having both of commercial and ecological values; it is aimed by commercial and recreational fishing (Colla et al., 2018) and it is included in Annex 3 of the Protocol on Specially Protected Areas and Biological Diversity of the Mediterranean to the Barcelona Convention (Basin, 1995). The fish are long from 30 to 40 cm but may reach to 60 cm in length. The flat abdomen and strongly curved back give an easily recognizable shape. Two dorsal fins and straight-ending caudal fin are yellow with a black margin. Grey body has golden and silver spots (Bay-Nouailhat, 2007). Analysis of gut content indicated that this species feeds mainly on crustaceans (Engin & Seyhan, 2009) and the most important taxon identified was decapods, which were present in 96% of stomachs, and represented 92% of total prey weight. The other dominant food species were amphipods and isopods, which occurred in 25% and 23% of stomachs, respectively (Chater et al., 2012). *S. umbra* lives in Eastern Atlantic from Mauritania to the English Channel, and in the Mediterranean Sea, the Black Sea and the Azov Sea. In Europe, this species is influenced increasingly by commercial and recreational fishing (Harmelin et al., 2015). Also, there is a loss of estuarine habitats, and reductions caused by divers and spear fishermen (Chao, 2015). The stocks have been substantially decreased because of habitat degradation, behavioural characteristics in their life cycle traits and recreational fishing in the northern Mediterranean Sea (Harmelin et al., 2015). Notwithstanding, *S. umbra* has potential for fisheries in the Aegean and Black Sea (Turkey). Two white and big bone stones behind the eyes and over the brain, are used in urolithiasis (Ergin et al., 2017). Thus, demand increases the fishing pressure although it is considered Near Threatened, globally (in IUCN Red List Status).

The early life stages of fish are critical stages where major efforts in intensification are needed to raise growth and inhibit mortality (Can, 2013). Chatzifotis et al. (2006) reported first data on the growth of cultured brown meagre *S. umbra* using different diets. However, to date, the first larval stages of *S. umbra* has not been performed. This study was aimed to investigate brown meagre larval rearing in green water technique.

MATERIAL AND METHODS

Broodstock Collection and Management

Acquisition of broodstock was done using professional fishing boats in which the live fish were captured and transported in a 450 l volume tank equipped with oxygenation. Fish were caught between June 2010 and May 2011, and the study has been carried out at Olivka Agricultural Products Industry and Trade Inc in Milas-Muğla. After arriving at the hatchery in the Aegean region, the fish were treated prophylactically with oxytetracycline (applied in 50 ppm baths for 2 h) and formalin (200 ppm for 1 h) for a period of 7 days. The fish were measured, weighed and stocked in a 5000 l rectangular concrete tank at 0.63 kg m^3. Sex of specimens was determined by using a cannula. Broodstock was recorded between 350 g and 900 g in weight, and 25-36 cm in total length. The ratio of male to female was noted as 2:3. Eggs and milt were collected from 5 selected fish. Broodstock spawned naturally (Fig. 1a). Initially, the fish were fed on frozen cuttle fish (*Sepia officialis*), shrimp (*Palaemon elegans*), anchovy (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*).

After approximately 20 days of adaptation, the diet was prepared with anchovy and sardines every other day. Adlibitum feeding was performed twice a day to 2% of the stock biomass. The egg collector of 100 l volume with a 500 µm net was installed in the tank drainage for eggs collection. Hatching rate was determined volumetrically by siphoning of unfertilized and dead eggs one day after the completion of hatching. Egg diameter was measured with a light microscope (Olympus CX22) (Fig. 1b). Buoyant eggs were incubated in equal amounts in 2 cylindroconical tanks. Incubators with a volume of 250 l of water were kept in dark at 20°C. Aeration at a rate of 40 ml per minute has been applied with minimal water renewal (<85 %). During the incubation, density of incubators was recorded as 1300 eggs l^{-1}. The experiment has been established using two replications.

Rearing of Larvae

Larvae were produced in two (5000 l) fibreglass tanks using green water rearing method which is the most natural

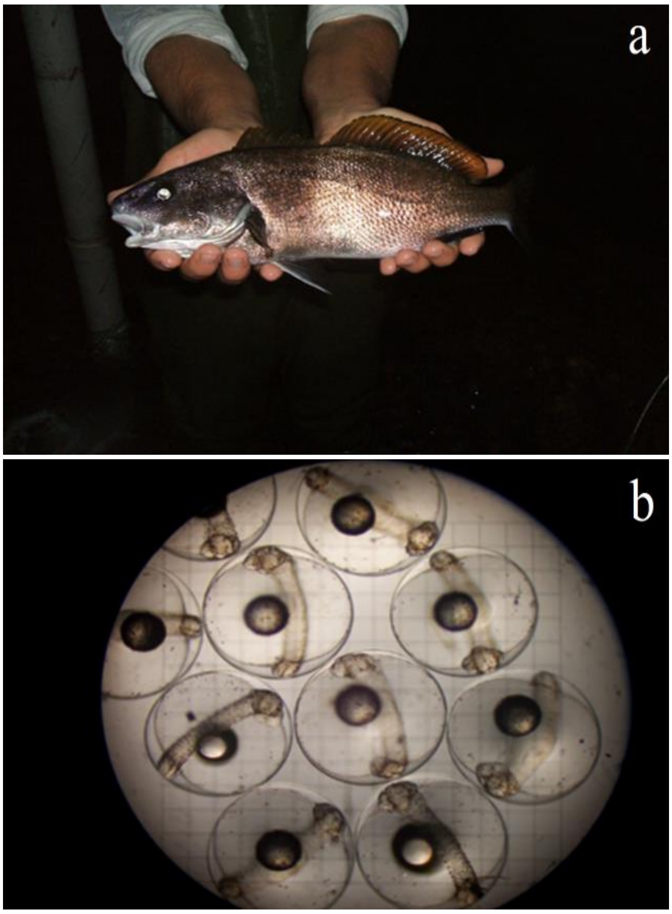

Figure 1. a) *Sciaena umbra* broodstock. b) Eggs of *Sciaena umbra*

among commercially employed production technique for marine larvae. The larvae densities were initially consisted to 40-43 individuals l^{-1}. Water was filtered (10 µm porosity filters) and sterilised with UV. Initially, aeration was provided with 3 ceramic diffusers in tanks. However, only one diffuser was placed at the centre of tanks after first feeding. Temperature ranged between 20.5°C and 21.5°C during rearing the larval stages. Water flow rate was noted as 70 ml. sec^{-1} up to day 7, measured as 145 ml. sec^{-1} after 10 days of post-hatching (dph), 200 ml sec^{-1} at 11-12 dph and increased to 1000 ml sec^{-1} at 20 dph. The photoperiod was begun with light intensity at ~0 lux at the beginning of larval stage. When mouth opening was observed (the third day), light intensity was increased to 10–40 lux and continued to day 6 after which it was increased day by day, ranging between 20-105 lux at 7 dph, 40-250 lux at 8 dph, 75-450 lux at 9 dph, 35-450 lux at 10 dph, 120-440 lux at 11 dph, 125-635 lux at 12 dph and 280-610 lux at 13 dph. Phytoplankton (*Nannochloropsis oculata*) was added twice daily to maintain a green culturing environment at a concentration of 2-4. 10^5 cells ml^{-1} until 20 dph. (Shields et al. 1999; Papandroulakis et al. 2001).

Rotifers (*Brachionus plicatilis)* were enriched with *N. oculata* and commercial products (A1 DHA Selco and DHA Protein Selco, INVE) in 1000 l cylindroconical tanks at the density of 400 to 600 individuals ml^{-1} before feeding on larvae. Larvae were initially fed on rotifers (10 prey ml^{-1}, from 3 dph to 20 dph), followed by AF (from 9 dph to 11 dph, (3–5 prey ml^{-1}), enriched EG48 *Artemia sp.* (starting in 11 dph, A1 DHA Selco, INVE) and artificial diet (INVE Aquaculture). From 9 dph, larvae were fed on a mixed diet of *Artemia* and rotifer. Larvae were fed on commercial diets (INVE Aquaculture) at 20-55 dph.

A surface skimmer was used between 4 and 15 dph for surface cleaning to maintain swim bladder inflation. Oxygen level measured between 6.0 and 7.0 mg l^{-1}.

Post-Larvae Growth

About 25 dph, larvae (25-50 mg) were transferred to two rectangular tanks (10 m^3 each), and they were reared to 55 dph. The photoperiod was natural (light intensity ranged from 400 to 500 lux). The density of the culture was 15.300-16.425 larvae per m^3. The water temperature was maintained at 21.5-22.5°C whereas oxygen was at 5.9–7.8 mg l^{-1}. Larvae were fed manually with a commercial diet (Proton 2 150-300 µm; 54% protein, 15% lipid). Fish were sampled to measure total length (TL), body weight (BW), total height (TH), yolk sac diameter and oil globule diameter (Fig. 2a and 2b).

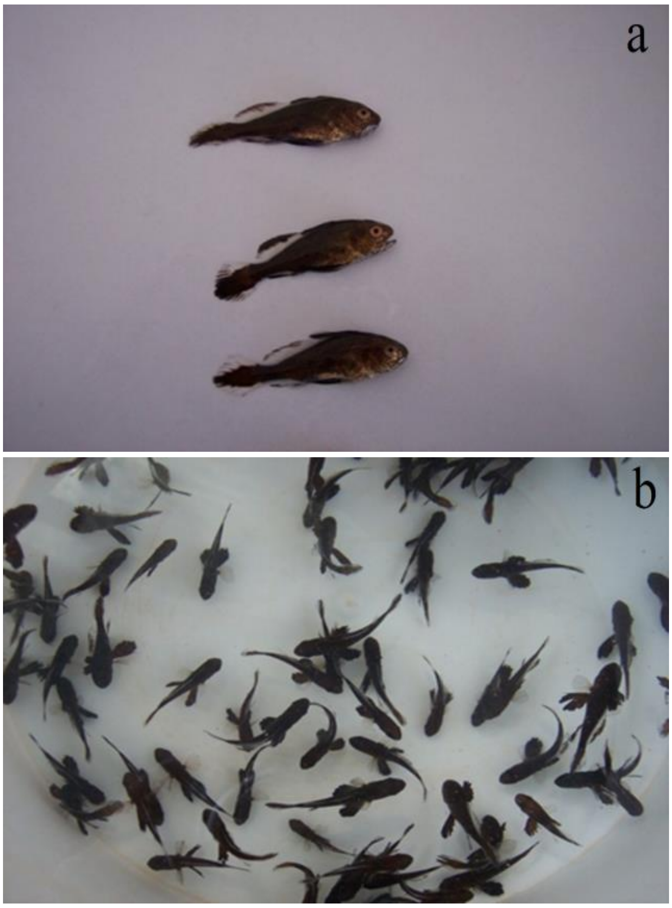

Figure 2. a) The post larvae of *Sciaena umbra*. b) The fries of *Sciaena umbra*

Statistical Analysis

The descriptive statistics of the continuous variables were given as mean ± SD. To verify the homogeneity of variances data were submitted to Levene test. To check the normality assumption in this study, data were determined by Shapiro–Wilk test. Regression analyses of TL/TW, total TL/TH, and TL, TW and TH/larva age (dph) were carried out by Microsoft Excel 2010.

RESULTS

Broodstock and Spawning

Males used as broodstock were noted as 350 g TW 25 cm TL, 900 g TW 36 cm TL; females were 450 g TW 29 cm TL, 600 g TW 32 cm TL, 800 g TW 34 cm TL. Approximately 785 g eggs obtained from the broodstock. While buoyant eggs were 740 g, sinking eggs were 65 g. By counting the eggs it was seen that 800-900 (874±16.25) per in 1 g. The eggs were observed to be transparent, spherical and 1380–1530 µm in diameter (1457.31±47.29 µm). The yolk was homogenous with oil globules of 344–390 µm (371.59±18.15 µm) at the centre, and unsegmented. Hatching began after 39 hours, and was completed after 40 hours in 20.5±0.5°C. The hatching rate of the eggs in the incubators was 92.66±1.20%. It is critical in aquaculture in relation to egg quality since it affects the final number of fish. Thus, brown meagre is a good candidate for aquaculture.

Larval Development

Newly hatched pre-larva was 4.86±0.26 mm in TL, 1.35±0.13 mm in body height and 1.38±0.50 mg in weight. The oil globule diameter was between 0.41±0.07 mm and 0.21±0.05 mm up to 3 dph. The yolk sac height decreased to 0.64±0.19 mm from 0.78±0.09 mm whereas the yolk sac length stayed the same (as 1.33 mm) during the first 6 days after hatching (Fig. 3a and 3b). The mouth opening of the pre-larva occurred on the 3rd day. The first peak in mortality was approximately 15%, and occurred between 8-13 dph. It was correlated with the death of the larvae, which could not become reconciled with diet, or the ability to digest rotifers, as was concluded by microscopic observation. The larvae densities were 41.50±2.12 individuals l^{-1}. Interestingly, before feeding started, at the 4th dph, although surface cleaning was not started the swim bladder formation was observed around 97.33±0.94%, the second cycle of raised loss of larva was (approximately 10%) observed on 23-25 dph. Cannibalism was observed between 35 dph and 40 dph. At the end of study, survival was 72.5±0.70% from pre-larva. The final number of the brown meagre juveniles was ~288000, which reached 40.08±1.98 mm total length with 10.96±0.08 mm body

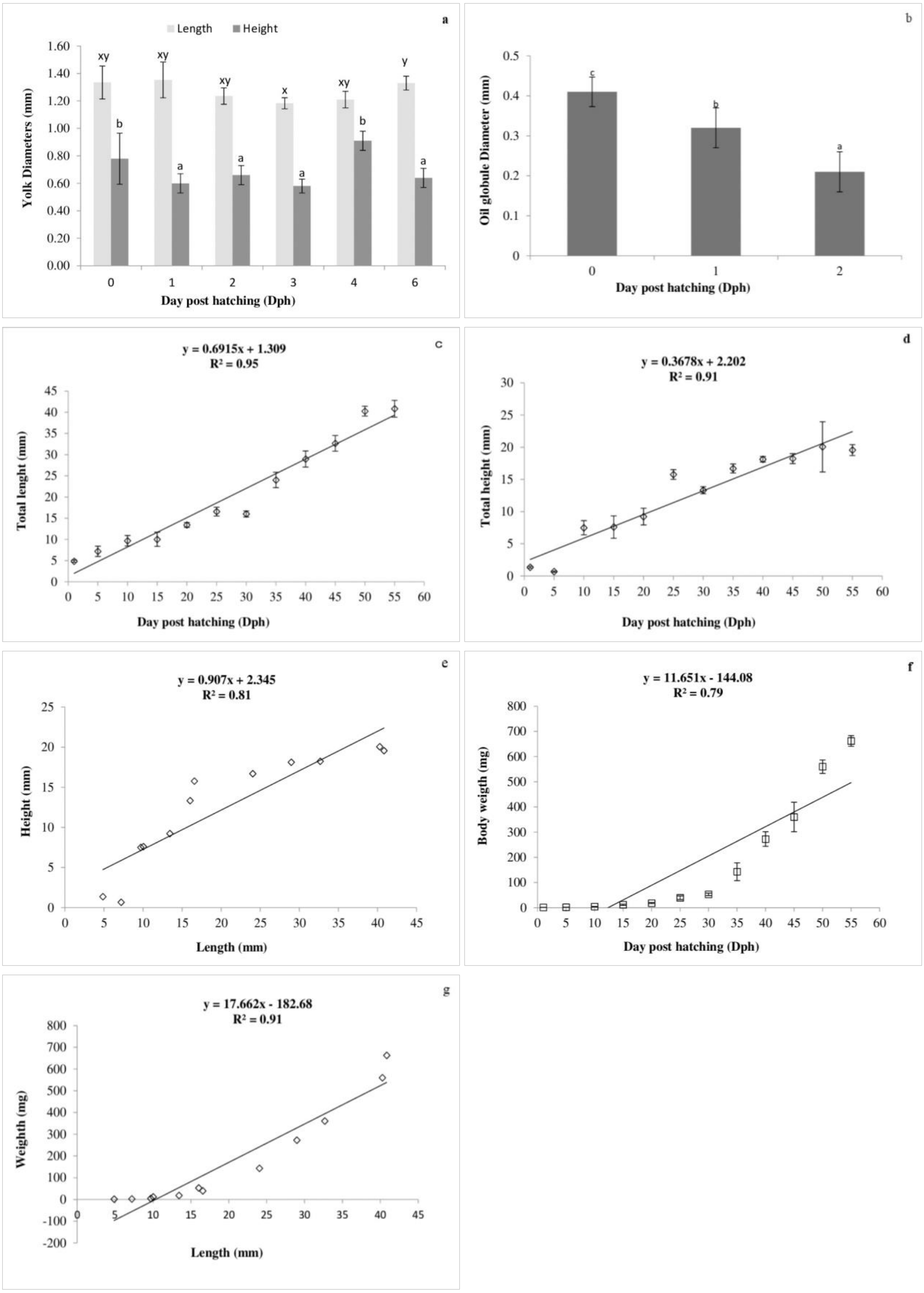

Figure 3. a) Yolk such diameter (length and height) changes of brown meagre during the prelarval stage. b) Oil globule diameter changes of brown meagre during the prelarval stage. c) Total length (mean ± S.D.) of brown meagre larvae during the rearing. d) Total height (mean ± S.D.) of brown meagre larvae during the rearing. e) Height and length relationships of brown meagre larvae during the rearing. f) Weight gain during the larval stage of brown meagre (mean ± S.D.). g) Length and weight relationships of brown meagre larvae during the rearing (n=30)

height and 662.27±21.23 mg body weight (Fig. 3c, 3d and 3f) after 55 dph. Positive correlations were determined in length-height and length-weight relationships of brown meagre larvae during the rearing (Fig. 3e and 3g).

DISCUSSION

Because of its attractive features, including the presence of large otoliths, excellent flesh, and calm swimming behaviour, the brown meagre has become an important species in the Mediterranean Sea (Harmelin et al., 2015). Results obtained from the present study have highlighted the ability to rear larvae in captivity. Indeed, the egg diameter was found to be larger than with other marine fish species, for example common dentex (Can et al., 2012) and sea bass (Saka et al., 2001). Certainly, the hatching rate of 92.17 ± 0.24% was similar with those of other studies for sea bass, sea bream (Can et al., 2012), white seabream (Hamzaçebi, 2020) and red porgy (Kolios et al., 1997), but higher than that of common dentex (hatching rate ≤ 85%) (Can et al., 2012). This hatching rate is critical in aquaculture in relation to egg quality since it affects the final number of fish. Thus, brown meagre is a good candidate for aquaculture.

The swim bladder inflation was higher than 95% at 50 and 500 lux light intensity in larval rearing of sciaenid meagre (*Argyrosomus regius*) (Valles & Estevez 2013). In pre-larval stage of meagre larvae up to day 3, the swim bladder inflation was detected (Papadakis et al., 2013). On the 2nd day of shi drum (*Umbrina cirrosa*) larvae, another sciaenid, it was observed that they inflated swim bladder around 90% (Zais et al., 2006). Studies have shown similarity with the results of our study (at the 4th dph in the range of 97.33 ± 0.94%, before starting feeding, although air cleaning was not started), and this is an advantage for culturing because many of the fish, notably sparids, swim bladder inflation takes longer time with lower percentage when compared the sciaenids. The reason of that may related to feeding since feeding may increase the quantity of oil on the water surface and its cleaning is critical at this period for swim bladder formation in most of the cultured fish.

The growth can be affected by the environmental conditional and the bacterial bloom on the culture media (Can et al., 2010). The use of semi-intensive technology for larvae rearing results in higher growth performance and survival than intensive one in marine species (Roo et al., 2010) and semi-intensive larvae rearing is used in the Mediterranean area to increase the quality of juvenile fish (Divanach & Kentouri 2000; Boglione et al., 2003; Russo et al., 2010; Roo et al., 2010). In present study, green water technique, a semi-intensive production system that facilitates the rearing method of several species in larval stages, solving the issues and many of their economical, technical and human outcomes were used (Papandroulakis et al., 2005).

The raised mortality at the beginning of the larval production might have been cause of by lack of adaptation of some larvae to artificial feed (Can, 2013). Cannibalism was the critical factor inducing mortality during the juvenile phase, as well, in similar studies in other Mediterranean species, i.e., sea bass (Kayim et al., 2010) and red porgy (Roo et al,. 2010). Comparable results were observed in present study, especially between 20-30 dph. Cannibalism may be associated with problems of starvation, size dispersion, illumination and stocking density (Dou et al., 2000). Brown meagre (*Sciaena umbra*) has special characteristics and advantages making it a satisfactory candidate for aquaculture, namely the high level of swim bladder inflation before the start of feeding in the first larval stages and the speed of growth when compared to another cultured fish. Moreover, there is an established worldwide market for otoliths, which are used in folk medicine. Brown meagre is a threatened species, with high economic interest. Therefore, it is a possible candidate for commercial aquaculture for food and for restocking the depleted natural fisheries. These first results on the larval stages of *S. umbra* in captivity maintain crucial data for evaluating its culturing potential. However further researches are needed about rearing protocols related to salinity, light and temperature, also feeding strategies to obtain better results on survival and growth.

CONCLUSION

Brown meagre (*Sciaena umbra*) has special characteristics and advantages making it a satisfactory candidate for aquaculture, namely the high level of swim bladder inflation before the start of feeding in the first larval stages and the speed of growth when compared to another cultured fish. Brown meagre is a threatened species, with high economic value. Therefore, it is a possible candidate for commercial aquaculture for food and restocking the depleted natural fisheries.

These first results on the larval stages of *S. umbra* in captivity maintain crucial data for evaluating its culturing potential. However further researches are needed about rearing protocols related to salinity, light and temperature, and also feeding strategies to obtain better results related to survival and growth.

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Compliance with Ethical Standards

Authors' Contributions

The authors contributed equally to this paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent was not required while the study conducted.

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