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PAPER

The first spontaneous spawning of red drum *Sciaenops ocellatus* L. in Europe: broodstock management and early larval stages

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Abstract

The present paper reports a research on reproductive parameters and larval rearing of red drum (*Sciaenops ocellatus*) maintained in captivity for the first time in Europe. Red drum juveniles were obtained from United States in the late 90s. In early January 2013, 40 in total male and female red drums ranging from 34 to 47 cm in length were held in a 25 m³ rectangular tank with a closed recirculating system with a water flow of 6000 L/h, located in Lesina (FG) fish farm (Southern Italy). Water temperature and salinity ranged between 21.0 and 28.8°C and from 25 to 27 g/L respectively. The fish were fed commercial feed pellet (46% protein) at 1.1% of body weight daily. Sexual maturation occurred during the natural breeding season of red drum. Approximately 43 spawns were recorded by the end of July and continuing to mid-September, with mean number of 66.5 millions of eggs collected overall on spawn period. Batch fecundity (3.325*10⁶ ova per female) and relative fecundity (361.41 ova/g body weight) were calculated. Fertilisation rate was 30 to 80%. Larvae were hatched at a mean total length of 2.40±0.33 mm and showed a gradual increase in size of approximately 0.378 mm/day for the first 40 day after hatching (DAH). Cannibalism was observed as larger larvae preyed on smaller ones; to limit the phenomenon red drum population was selected for size at 35 DAH. Reliable information on fecundity and larval stage is essential for encouraging *Sciaenops ocellatus* farming also in Mediterranean countries.

Introduction

The red drum is an important fish for United States aquaculture and stock enhancement. Although this carnivorous and euryhaline sciaenid is endemic to the Gulf and Atlantic coasts of the US, its aquaculture production is expanding in several countries (Parker, 1993). In the 1980s *Sciaenops ocellatus* specimens were introduced in captivity/cultivation in: Central America and Caribbean (Bahamas, Martinique, Virgin Island); South America (Ecuador) (Froese and Pauly, 2004); Taiwan and Hong Kong (Liao *et al.* 1994; Wilson, 2004). Red drum is a not autochthonous species in the Mediterranean area. This species has desirable characteristics for aquaculture such as rapid growth, a wide salinity tolerance (Gatlin, 2002), and large commercialisation size useful for fish processing industry. In Israel, red drum culture trials have begun with the importation of eggs and fry from the US in the early 1990s. The species is now being grown in several fish farms on the Mediterranean and Red Sea coasts of Israel (Kissil, 1996) and it may be expected that the success of these culture trials will favour importing of eggs and the high market value of this species will encourage its expansion also to other Mediterranean countries.

In our work, a spontaneous spawning obtained from a red drum broodstock – kept in captivity for more than 5 years – is reported for the first time in Europe. Methods for natural spawning and early developmental stages of red drum as well as the first attempt of larval rearing of this species in Southern Italy are described.

Materials and methods

Red drum juveniles were obtained from United States in the late 90s. In early January 2013, 40 male and female red drums ranging from 34 to 47 cm in length were kept together in a 25 m³ rectangular tank in a closed recirculating system with a water flow of 6000 L/h. Water temperature and salinity ranged between 21.0 and 28.8°C and from 25 to 27 g/L respectively. Fish were maintained on a natural photoperiod and low light intensity, preserved from any kind of disturbance (noise, handling, *etc.*) and they were not sampled to avoid altering reproductive behaviour.

Sciaenops ocellatus were fed at 1.1% body weight/day with frozen squids and sardine (*Sardina pilchardus*) integrated with commer-

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Key words: Red Drum; *Sciaenops ocellatus*; Spontaneous spawning; Broodstock management; Larval rearing.

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cial dried organic feed (ECOLIFE Pearl 864; BioMar, Grangemouth, UK). Pellets of 4.5 mm in diameter, composed of fish meal, organic pea and soybean meal, fish oil, mineral and vitamin premix, were supplied every day *ad libitum*. The reference diet was formulated to contain approximately 46% crude protein and 15% lipid. This diet satisfied and/or exceeded all known nutrient requirements of red drum (Gatlin and Hardy, 2002).

Optimal water quality (Dissolved Oxygen >6 mg/L; total ammonia nitrogen <0.3 mg/L) according to Holt (2005) was maintained by biofiltration and oxygen injection. A low-pressure electrical blower provided aeration via air stones and maintained DO levels at or near saturation.

The egg collector was checked daily and floating eggs were collected from the outflow of the broodstock tank in a collecting basket set with a 500 µ nitex net. The floating eggs were then collected and placed into a 10 L basket for cleaning and counting, under gentle aeration. Sediments and particulate matter were allowed to settle down and were then siphoned out. After the eggs were allowed to resettle, their average depth was determined, and the length and width of the basket were measured. The number of fertilised eggs per mL was estimated by counting the eggs in five

replicates of 1 mL, after vigorous agitation. The total volume of eggs was calculated and multiplied by 1100 (1100 eggs occupy 1.0 mL). This determined the total number of eggs for a given spawn. Percentage fertility was then calculated by counting the number of fertilised eggs in a sample of 100. Eggs with a well developed embryo were considered as live eggs.

The floating eggs were then placed into aerated 1000 L, conical bottom, fiberglass tanks connected to a closed water circuit (1 L/min) for hatching. Incubating temperature and pH were the same as that achieved at spawning time. Salinity had to be maintained at 27 g/L for optimal hatching to occur (Holt *et al.*, 1981b). Fry were held in the hatch-out tanks until they absorb the yolk sac and develop eyes, mouthparts, and a digestive tract. This took approximately 3 days at 26°C (Holt *et al.*, 1981a).

Twenty four hours post hatching, the larvae were transferred into 4000 L conical tanks, where they were reared for 35 days under gentle aerated water and total ammonia below 0.5 mg/L. Temperature, salinity, oxygen concentration and prey density were recorded daily. Throughout rearing, larvae were maintained on a natural light cycle.

Results and discussion

Spawning and incubation

Techniques for year-round spawning are well established for this species (Holt, 2005). Temperature and photoperiod are the most important environmental factors controlling gonad spawning and recrudescence in red drum. Table 1 reports the conditions under which spontaneous spawning as herein observed. Spawning started in summer with the increase of temperature and daylength photoperiod. In Figure 1, the estimated egg numbers per spawning and daily temperature are reported.

The main spawning season began at the end of July and continued until mid-September 2013, with a fecundity peak in August ($3 \cdot 10^6 \pm 2.5 \cdot 10^5$ eggs estimated) and in September ($5.3 \cdot 10^6 \pm 2.2 \cdot 10^5$ and $7.03 \cdot 10^6 \pm 3.1 \cdot 10^5$ eggs estimated, at the beginning and in mid September, respectively) (Figure 1). The first spontaneous spawn was registered in the early morning of 28 July 2013, between 05:00 and 07:00 h. The spawning period lasted from 28 July to 17 September (52 days) with almost daily emissions. In particular, 43 spawning events occurred.

Percentage fertility was then calculated and

ranged from 30 to 80%. Batch fecundity ($3.325 \cdot 10^6$ ova per female) and relative fecundity calculated (361.41 ova/g body weight) agree with Waggy *et al.* (2006) who reported a range of $0.16 \cdot 10^6$ to $3.27 \cdot 10^6$ ova and of 42 to 447 ova/g respectively.

Eggs were positively buoyant, transparent, spherical and had an average diameter of 0.98 ± 0.04 mm. They had a single golden oil droplet of 0.2 to 0.4 mm in diameter. No more than 1 million eggs were placed in a tank. Red drum eggs hatched in 24 hours at 26°C. Three days after hatching the yolk sac was absorbed and eyes, mouthparts and digestive tract were developed (Holt, 1990, 1992).

Larval rearing

Larvae hatched at a mean total length of 2.40 ± 0.33 mm. Newly hatched larvae exhibited a free, passive swimming behaviour and had 2 chromatophore bands, one at the vent and the other mid way between the vent and tip of the notochord, the first one being the most distinct (Figure 2). The mouth is not functional at this stage. One day after hatching (1 DAH), larvae reared at 26°C were very similar to newly hatched larvae, adopting a vertical position in the water column and remaining quiet most of the time. At 2 DAH, larvae swam freely in the water column, yolk sac length decreased considerably and eyes showed high differentiation with initial stages of pigmentation. A short digestive tract was observed.

At 3 days old (2.48 ± 0.21 mm mean total length) (Figure 2) red drum have eyes and mouthparts and can begin to feed (until this

time, they have been living on yolk sac reserves for food). Larvae, stocked at 20-30 per litre, were first fed with live rotifers (from day 3 to days 11 after larvae have hatched) at a rate of 5-10 rotifers/mL, previously enriched (Brinkmeyer and Holt, 1998) with commercial DHA Protein Selco® (INVE, Chonburi, Thailand), an amino acids, phospholipids, DHA enriching product emulsified with vitamin C, in accordance with the instructions provided by the producer. At 8 days old larvae measured 4.37 ± 0.25 mm mean total length. On days 12 post-hatch, red drum larvae were fed

Table 1. Conditions under which spontaneous spawning of red drum was obtained at Ittica Caldoli s.r.l. fish farm [Lesina (FG), Southern Italy].

Tank size, metric tons	25
Filtration system	CB, S
Fish/tank, n	40
Sex ratio (M:F)	1:1
Mean fish size, kg	9.2
Max. regime temperature, °C	28.8
Min. regime temperature, °C	21.0
Max. regime photoperiod, HL	14.3
Min. regime photoperiod, HL	9.5
Spawning photoperiod, days	52
Mean no. eggs/spawn period, millions	66.5
Feeding regime, % BW per day	1.1

CB, conventional biofilter; S, sand; HL, hours of light; BW, body weight.

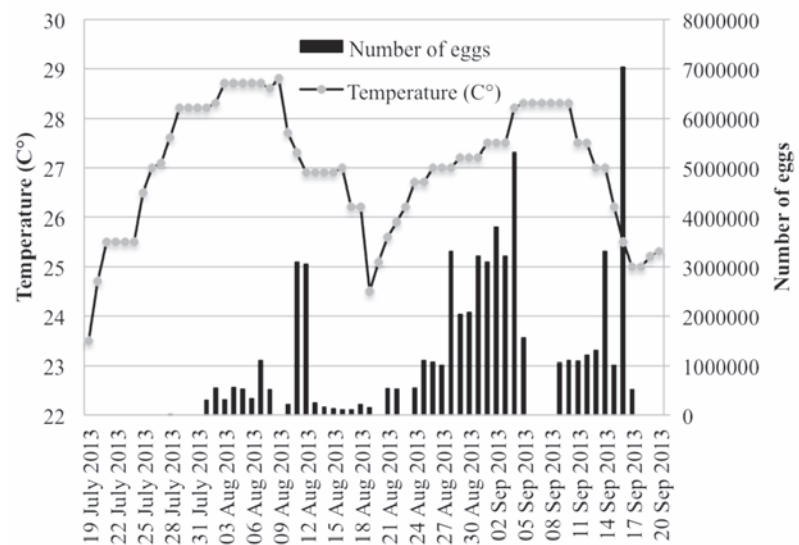


Figure 1. Number of spawned eggs by *Scienops ocellatus* broodstock and daily temperature.

enriched *Artemia* (brine shrimp) nauplii. *Artemia* nauplii were maintained in the culture tank between 0.5 and 2.0/mL. Fourteen DAH larvae measured 5.17 ± 0.27 mm mean total length (Figure 3). Larvae may be gradually trained or weaned to eat a prepared food (100-200 microns dried pellet) on day 20 until 40 DAH (Holt, 1993; Lazo et al., 2000, 2002). On day 33 post-hatch red drum larvae measured 14.05 ± 0.23 mm mean total length (Figure 3). Larvae showed a gradual increase in size of approximately 0.378 mm/day at 26°C, more than the value reported by Holt (1990) for the first 14 days at 30°C (0.30 mm/day).

In hatchery-rearing conditions, the phenomenon of sibling cannibalism of red drum often has been noted during the larval period, especially when larval pigmentation becomes lighter and aquafarmers have to physically separate the lighter, larger larvae (cannibal) from the darker ones (prey) to avoid cannibalism. Larvae were cultured in the 4000 L cylindrical tank, most of the larger larvae settled on the bottom of the tank, whereas smaller larvae inhabited the upper layer. Cannibalism was observed as larger larvae preyed on smaller ones. The smaller larvae that were frequently preyed upon were those that had the most pigmentation. Skin colours usually become lighter as larvae grow. When turning to lighter colour, red drum larvae became more cannibalistic. The most important factor affecting cannibalism of young red drum was size difference, rather than fish density or water turbidity (Liao and Chang, 2002). In addition, satiation feeding significantly decreased but did not stop cannibalism. Liao and Chang (2002) predicted the peak stage of cannibalism at a total length of 18-19 mm, when the ratio of lower jaw length to total length is higher. This finding is similar to that reported by Dowd and Clarke (1989). However, young larvae of the same size would not cannibalise each other (Chang and Liao, 2003). In order to limit the lost and avoid cannibalism, the red drum population was selected for size at 35 DAH with a total length lower than the peak stage of cannibalism.

Conclusions

In conclusion, after demonstrating that it is possible to obtain spontaneous spawning in captivity in Europe, and having described the larvae of red drum rearing condition, it is time to start to study growth performance parameters of *Sciaenops ocellatus* from juveniles to commercial size. Nonetheless, as aquaculture

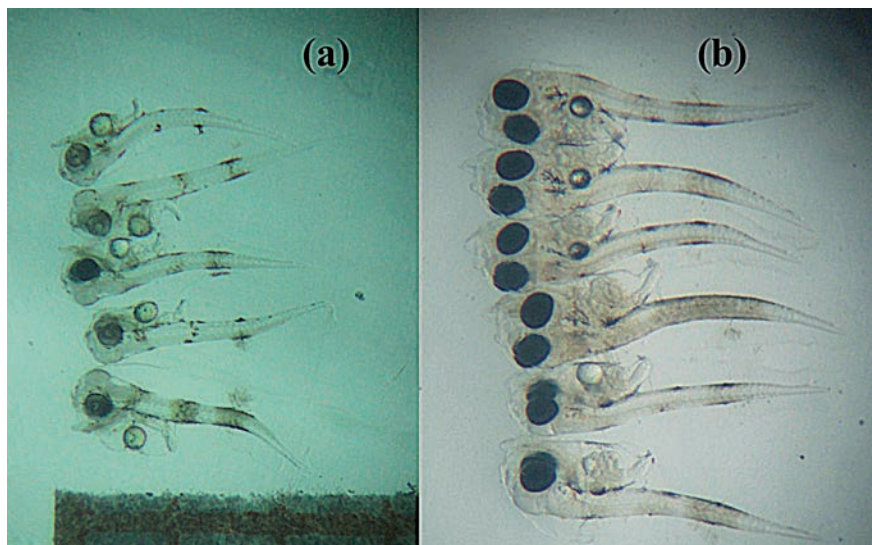


Figure 2. Red drum larvae at: 1 (a) and 3 (b) days after hatching.

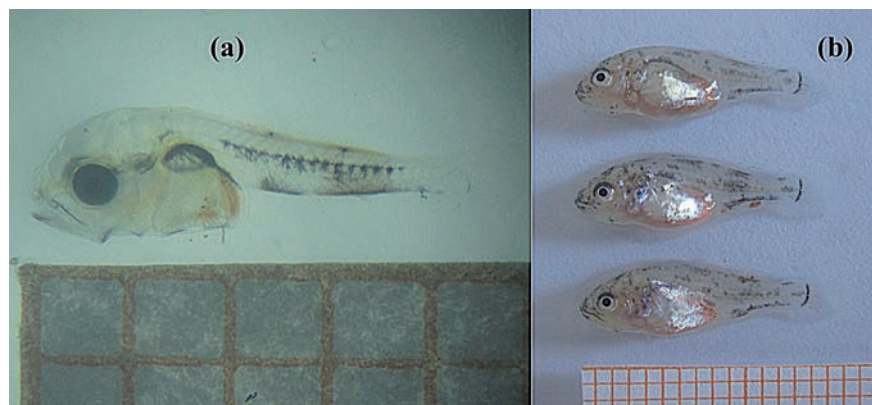


Figure 3. Red drum larvae at: 14 (a) and 33 (b) days after hatching.

technologies become more advanced it is likely that red drum production will continue to rise worldwide through increased efficiency of existing farms and expansion to additional countries. Further research on feed efficiency, disease treatment, temperature tolerance and the rearing in recirculating aquaculture systems will help to ensure the ecologically and economically sound production of this species in coming years.

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