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Reproductive biology of *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) in the western coast of Algeria

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ABSTRACT The study of the reproduction of *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) of the Algerian West coast - carried out from September 2015 to August 2016 - related to 472 specimens, whose overall length ranged between 14.6 cm and 28.4 cm. The ratio of gonad weight to total weight was assessed monthly, and the evolution of the stages of sexual maturity revealed that, for *D. vulgaris*, the period of reproduction is between October and February with an oviposition in January. The sex ratio related to the size showed that males are dominant in the classes of small sizes (14–18 cm) and females dominate in the classes of great sizes (19–29 cm).

KEY WORDS *Diplodus vulgaris;* reproduction; Algeria; Western Mediterranean.

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INTRODUCTION

The common two-banded sea bream *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) is a demersal species distributed in the Mediterranean and the Black Sea, along the French Atlantic up to Senegal (including the archipelago of the Madeira Islands, the Azores, and the Canaries), and even in Angola and in South Africa (Bauchot & Hureau, 1986, 1990). In this paper, we studied the sex ratio, the period of reproduction, the size of the first sexual maturity, as well as the process of differentiation of the gonads of *D. vulgaris* of the Algerian West coast.

Many authors have studied the reproduction of *D. vulgaris*, including Gonçalves & Erzini (2003), on the Southern coasts of Portugal; Lechekhab (2007), Nouacer et al. (2007) in the Golf of Annaba; Vienna & Adib (2007) in the Syrian coasts; and Hadj Taieb et al. (2012) in the Tunisian coasts.

However, to our knowledge, no study has been ever carried out in the western coast of Algeria.

MATERIAL AND METHODS

This study on the reproduction of *D. vulgaris* was carried out on a sample of 472 specimens between September 2015 and August 2016. The studied samples came from commercial unloading of goods in the port of Beni-Saf (Fig. 1).

Once at the laboratory, the samples were measured (in mm) and weighed (in mg). We determined the total weight (Wt), the weight of the gonads (Wg) and the weight of the liver (Wl). The fishes were dissected to determine the sex of each individual, as well as the various stages of sexual maturity.

The sex ratio indicates the rate of masculinity or of femininity in a batch. We calculated the rate of males (% male = number of males × 100/total number of males and females) and the rate of females (% females = number of females × 100/total number of males and females).

To describe the maturation stages of the gonads, and detect the period of reproduction, we assessed the gonadosomatic index (GSI), i.e. the calculation of the gonad mass as a proportion of the total body mass, which is a tool for measuring sexual maturity in correlation to ovary or testes development:

$$GSI = [Wg / Wt] \times 100$$

Moreover, in order to monitorate the physical conditions of the fish, two additional physiological indexes were considered: the first, the hepatosomatic index (HSI) (i.e. the ratio of liver weight to total body weight), allows to assess changes in liver weight during the reproductive cycle and is used as a measure of energy reserves and metabolic activity:

$$HSI = [Wl / Wt] \times 100$$

The second, the condition factor (or condition index) (Kn), reflects the changes in the general state of the fish according to the seasons, especially during the laying period. In fact, it is a way to measure the overall health of a fish by comparing its weight with the typical weight of other fish of the same kind and of the same length and is calculated dividing the actual weight (Wt) by the expected (theorical) weight (Wth):

$$Kn = [Wt / Wth] \quad \text{with } Wth = aLb$$

where L = total length of the fish (in cm); a and b = constants.

We also assessed the size of the first sexual maturity (Lt 50), i.e. the length for which 50% of the individuals are mature (Fontana, 1969). Finally, the calculation of the percentage of ripe fish gathered, starting from stage 2 of sexual maturity, was done by sex and size class of 1 cm. The determination of sex and the stages of sexual maturity of each sampled individual was based on the following morphological criteria: the color, the form and the vascularization of the gonads. In this study, we used the macroscopic scale of maturity of the gonads suggested by Mann & Buxton (1998), who reported and described four different stages:

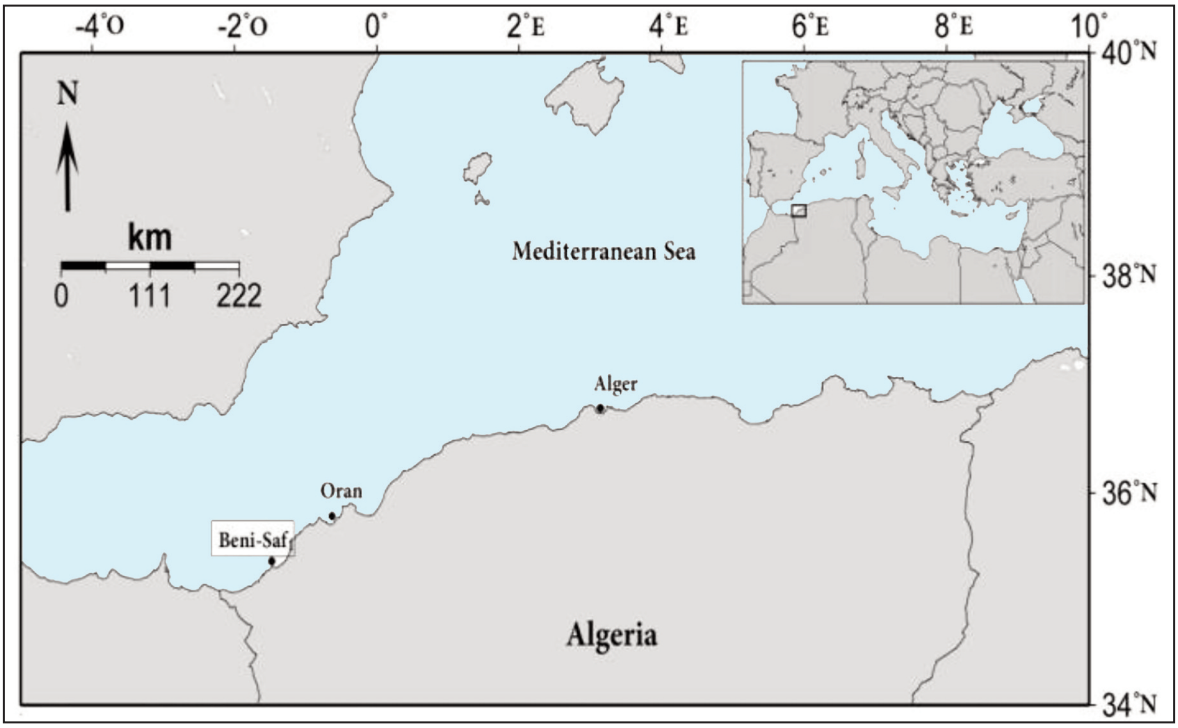

Figure 1. Study area: the bay of Beni-Saf (Algeria).

Stage I: immature. Gonads are small. Thin and transparent testicles. Long and thin ovaries of translucent orange color;

Stage II: beginning of maturation (evolution of the gonads). The gonads increase in size. The testicles thicken and are white. The ovaries become inflated and of orange/yellow color. The eggs are visible to the naked eye;

Stage III: maturation and oviposition. The testicles are very large and inflated. They are white, but become often rosy as the season of reproduction progresses. Very large yellow ovaries. The translucent eggs are visible;

Stage IV: post oviposition. The testicles decrease in size and are of pink/gray color. The ovaries are injected with blood and of reduced size. The gonads can stay unchanged for several months.

RESULTS

After a sampling carried out on 472 specimens in 12 months and after having eliminated from the samples unidentified fishes, taking into account that hermaphrodites were classified as males or females according to the predominance of the gonads, females represented 54.82% and males 45.57%. Females are thus significantly ($p<0.05$) more numerous than males (Fig. 2) as confirmed also by the calculation of a statistical test of the χ^2 type. The sex ratio according to the size shows that males are dominant in the classes of small sizes (14–18 cm), while females dominate in the classes of great sizes (19–29 cm).

We noticed that the GSI values were higher in December and January, when they reached 1.67±0.23 and 1.87±0.36, respectively. The peaks observed correspond to the period of oviposition (Fig. 3). Then, it decreased gradually until April, during the period of sexual rest. The lowest values were observed during October (0.26±0.06) and September (0.18±0.04). The monthly follow-up of the HSI showed an annual peak (1.05) in January; the condition factor was stable throughtout the year with a slight increase in January as well (Fig. 3). The examination of the samples, according to the size, revealed that the population of *D. vulgaris* reached its first maturity (Lt 50) at 17.5 cm (Fig. 4).

The stages of maturity, according to Mann & Buxton (1998), are illustrated in figure 5. In females, the higher values for stage II and III were observed since October, with maximum values of stage III occurring in January. Most of the ovaries at stage IV were observed in March.

In males, stages II and III were observed since November, with maximum values of stage III during January. It was also observed that stage I was always present throughout the year with minimal values recorded from November to January in both sexes.

DISCUSSION AND CONCLUSION

The evolution of the stages of sexual maturity and the histological study of the gonads, as well as the gonadosomatic index, led to the same results thus confirming that the reproduction period of *D. vulgaris* starts in October and ends in February.

Our sampling consisted of 472 specimens, 246 females, 206 males, and 20 whose sex could not be determined. Of these, 14 hermaphrodites have been classified as males or females according to the predominance of the gonads and considered as such for the sex ratio which revealed, in general, an apparent predominance of the females compared to the males. Lechkhab & Djebar (2001) showed that, in *D. vulgaris*, males are met in the classes of small sizes while females are bigger. According to Warner & Hoffman (1980), this is explained by the fact that the males are younger and that early maturation blocks their somatic development.

GSI values observed in the present study are similar to those found by other authors in the Mediterranean (see Bauchot & Hureau, 1986; Riedl, 1986; Fischer et al., 1987; Cetinić et al., 2002; Zaki et al., 2004; Beltrano et al., 2003; Tsikliras et al., 2010).

The HSI evolves at the same time as the GSI, whereas the minimal values of the condition factor were observed during the month of February. Consequently, it seems that the changes in the HSI and Kn are associated to the sexual cycle. According to D'Ancona (1956), variations of these indexes make it possible to classify *D. vulgaris* among the so-called "oily fish" that is those fish whose liver is not involved in the process of accumulation of lipids.

Lechekhab (2007) too studied the evolution of the hepatosomatic index in *D. vulgaris* from Annaba Golf. He reported a slight increase of this index during the period of reproduction followed by a stabilization.

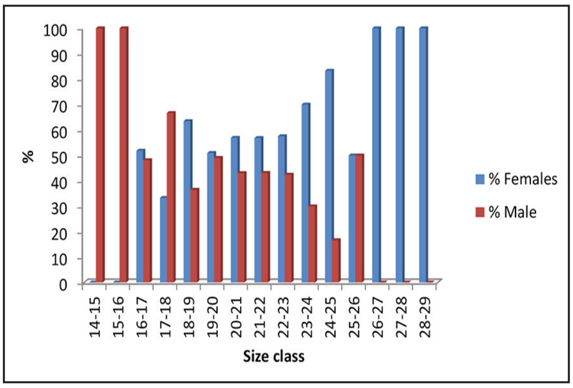

Figure 2. Monthly variation of sex-ratio by size classes for *Diplodus vulgaris* from the bay of Beni-Saf, western Algeria.

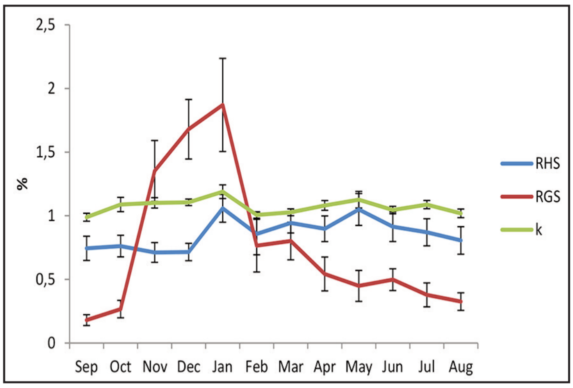

Figure 3. Monthly evolution of GSI, HSI and condition factor (Kn) for *Diplodus vulgaris* from the bay of Beni-Saf, western Algeria.

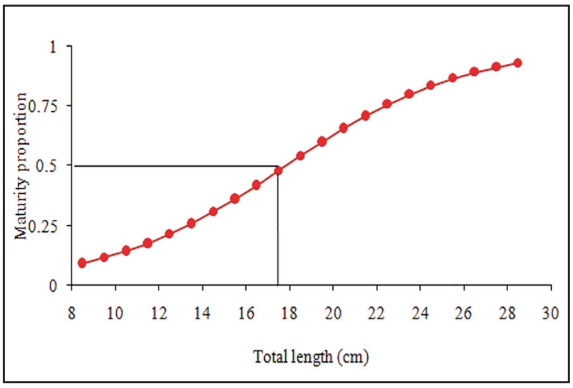

Figure 4. Logistic diagram of the relation between length and maturity for estimating the total length at 50% maturity.

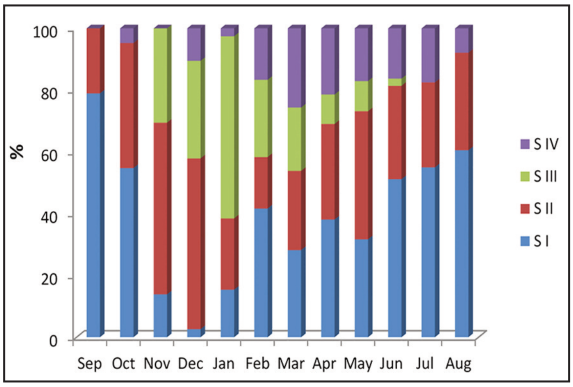

Figure 5. Monthly evolution of stages of sexual maturity for *Diplodus vulgaris* from the bay of Beni-Saf (Algeria).

According to our results, *D. vulgaris* reaches its first sexual maturity at 17.5 cm, matching those found by Gonçalves et al. (2003).

The macroscopic observation of the gonads of *D. vulgaris* confirms that this species has a reproduction period between October and February with a phase of oviposition in January.

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