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Reproductive Biology of the Canary Dentex *Dentex Canariensis* (Steindachner, 1881) Landed off the Dakar Peninsula, Senegal

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Abstract: *This study on the reproduction of the Canary dentex (Dentex canariensis) is the first of its kind to be carried out on the Senegalese coast. Samples were collected monthly in strata of 30 individuals from December 2021 to November 2022. For each individual, sex, stage of sexual maturity, total length (TL, mm), fork length (FL, mm), total weight (TW, g), eviscerated weight (EVW, g), visceral weight (VW, g), gonad weight (GW, g) and gonad section weight (GSW, g) were recorded. The gonado-somatic ratio shows that the Canary dentex breeds between March and June, with a peak in April and May. The fertility study involved 23 females. Sizes of individuals ranged from 200 to 376 mm (TL) for females and 222 to 385 mm (TL) for males, while total weights varied between 95.31 and 721.31 g (TW) for females and 146.9 to 843.2g (TW) for males. Females reach sexual maturity at 227.4 mm (TL), while Males reach at a length of 261.4 mm (TL). Mean absolute fecundity was estimated at 14,428 oocytes (± 6,553). The corresponding mean relative fecundity was 55 oocytes (± 28) per gram of mature females. Oocyte diameter ranged from 0.37 to 1.31 mm. These results could be of great interest for the management of this species, as well as the development of its fisheries on a local, regional and sub-regional scale.*

Key words: *Dentex canariensis*, reproduction, Dakar Peninsula, Senegal.

INTRODUCTION

Sparids, particularly those of the genus Dentex, are highly prized fish with high nutritional and commercial value. The Canary dentex *Dentex canariensis* is widely distributed in the eastern Atlantic, from the Western Sahara to Angola, rarely exceeding the Canary Islands (Bonnet, 1969). As a top predator, this species of sea bream is a

potential indicator species for the structure and functioning of the coastal ecosystems on which it depends (Kouame et al., 2018; Semier et al., 2021; Niaye et al., 2022). Although the biology and ecology of the main species of coastal demersal fish have been the subject of numerous studies (Domain, 1980; Champagnat and Domain, 1978; Chabanne, 1987), the reproduction of *D. canariensis* is poorly documented on the Senegalese coast and in the sub-region. The few studies available in the bibliography referring to its reproduction are fragmentary and were carried out on the Ghanaian coasts (Rijavec, 1973; Showers, 1993; Clottey, 2020).
As reproduction is considered to be the most crucial feature in the life cycle of a fish population (Ismail et al., 2018), information on it is very important for biodiversity conservation and sustainable management of the species' fisheries (Tzanatos et al., 2008; Damalas et al., 2010).

This study was initiated to provide new data on the reproduction of *D. canariensis* on the Senegalese coast, with the aim of identifying the spawning period (s), determining the size at first sexual maturity and assessing its reproductive potential (fecundity).

MATERIEL AND METHODS

STUDY SITE AND FISH COLLECTION

The study area is located in the Dakar region (Figure 1). Samples were collected monthly in strata of 30 individuals from December 2021 to November 2022. The fish were caught by artisanal fishermen (line or longline) and landed at the Soumbédioune fishing station. This site, located on the western side of the Dakar peninsula, is a small bay stretching over a sandy beach of more than 1 km and covers an area of around 1 km² (Diatta et al., 2014).

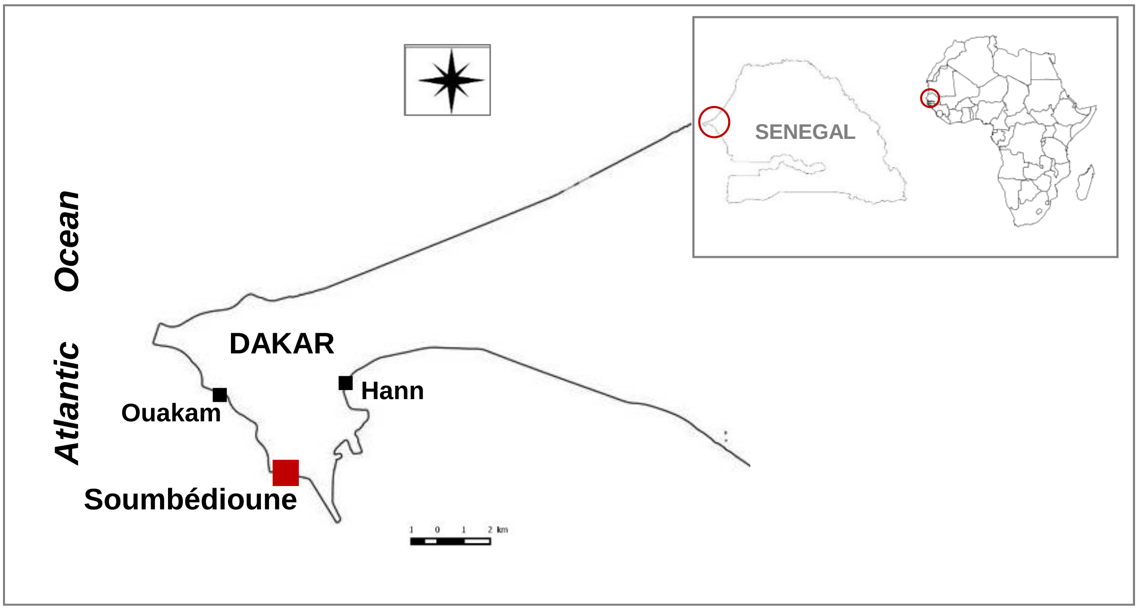

Figure 1. Location of the Soumbédioune sampling station off the Dakar peninsula in Senegal

MEASUREMENT AND DETERMINATION OF SEX AND STAGE OF SEXUAL MATURITY

Measurements and samples of the fish were taken in the laboratory. For each individual, sex, stage of sexual maturity, total length (TL, mm), fork length (FL, mm), total weight (TW, g), eviscerated weight (EVW, g), gonad weight (GW, g) and gonadal section weight (GSW, g) were recorded.

Sex is identified after dissection and visual examination of the gonads. Macroscopic observation of the evolution of gonadal maturation stages was based on morphological criteria (coloration, consistency, vascularization, shape, volume occupied by the gonads in the abdominal cavity, presence or absence of visible oocytes (females) or sperm (males) according to the Loir et al. (2001) scale.
Numerical sex ratios are expressed as percentages of males and females respectively. Rates of masculinity (% males = number of males x 100/ total number of males and females) and femininity (% females = number of females x 100/ total number of males and females) were calculated. A total of 354 individuals were measured, including 238 females (67% femininity) and 116 males (33% masculinity). Sizes ranged from 200 to 376 mm (TL) for females and 222 to 385 mm (TL) for males, while weights varied from 95.31 to 721.31 g (TW) for females and 146.9 to 843.2g (TW) for males.

DATA ANALYSIS

The size class structure was followed. Steps of 25 mm were used for the size classes. The variation of the number of oocytes (n) as a function of total length (TL), the variation of absolute fecundity and relative fecundity as a function of total weight was performed by linear relationships of the form :

$$Y = ax + b$$

The evolution of the gonado-somatic ratio (GSR) provides information on the spawning period and its spread over time. The monthly evolution of the GSR was monitored to establish the sexual cycle and determine the laying period. It is calculated using the following formula:

$$GSR = \frac{GW * 100}{TW}$$

with GW = gonad weight and TW = total weight.
The sexual maturity of organisms that reproduce sexually indicates the stage of development at which they are able to procreate. The size at sexual maturity corresponds to the point at which 50% of the individuals sampled are mature (L50) and present well-developed gonads (ovaries and testes) stage 3 according to the Loir et al. (2001) scale.
L50 was estimated using R software (R-Core-Team, 2024). Only individuals sampled during the spawning period were considered in the analyses. Fish assessed at maturity

stages 1 and 2 were immature, and fish assessed at higher stages were mature. The formula for calculating the L50 is as follows:

$$Y = \frac{1}{1 + e^{-(A+B*X)}}$$

with Y: percentage of mature individuals; A: total length (TL); B*X: corresponds to L50 model constants.
Fecundity was calculated using stage 4 gonads only. This study involved 23 females. Size and weight ranged from 232 to 376 mm (TL) and from 166.15 to 721.31g (TW) respectively. Gonad weights ranged from 4.5g to 31.47g. A 0.05 g section of the GSW was taken. This 0.05g portion was divided between 5 Petri dishes and analyzed under a binocular magnifying glass to determine the number of oocytes by manual counting. Each 0.05 g portion was counted 5 times.
Absolute fecundity (AF) corresponds to the number of mature oocytes contained in the mature gonad. It is calculated by the following formula:

$$AF = \frac{GW * n}{GSW}$$

with GW = gonad weight; GSW = gonad section weight and n = total number of oocytes counted in the section weight.
Relative fecundity (RF) corresponds to absolute fecundity (AF) divided by total individual weight TW (g) :

$$RF = \frac{AF}{TW}$$

To measure oocyte dimensions, images were digitized with LAS-EZ software, using a binocular magnifier (Leica EZ4 D) with a built-in camera. Image J 1.48v software was used to automatically measure the diameter, perimeter and surface area of each oocyte (based on the development of a macro).
Statistical tests were performed using R 4.3.3 software (R Core Team, 2024). The normality of the size variable was tested by comparing the equality of variances of the total length (TL) variable between the two sex groups. The Student's t test was used to compare the mean height between males and females. Correlation tests were carried out between the variables total length (TL) and number of oocytes (n), between absolute fertility (AF) and total weight (TW) and between relative fertility (RF) and total weight (TW). ANOVA and multiple linear regressions were performed on the GSR for all months of the year.

RESULTS

SIZE STRUCTURE

A total of 361 individuals were measured, including 238 females and 123 males. Sizes ranged from 200 to 376 mm (TL) with an average of 253 mm (±1.74) in females, and from 222 to 385 mm (TL) with an average of 271 (±2.52) in males.

The distribution of *D. canariensis* size frequencies has shown an unequal distribution of the population by sex. Females dominated the size classes below 274 mm and were more represented in the sample, while males dominated the larger classes.

Student's t test shows significant differences in mean size (TL) between males and females (p-value = 3.082e-8). Males are statistically larger than females (M(m) = 271.3707 vs. M(f) = 253.7941 mm).

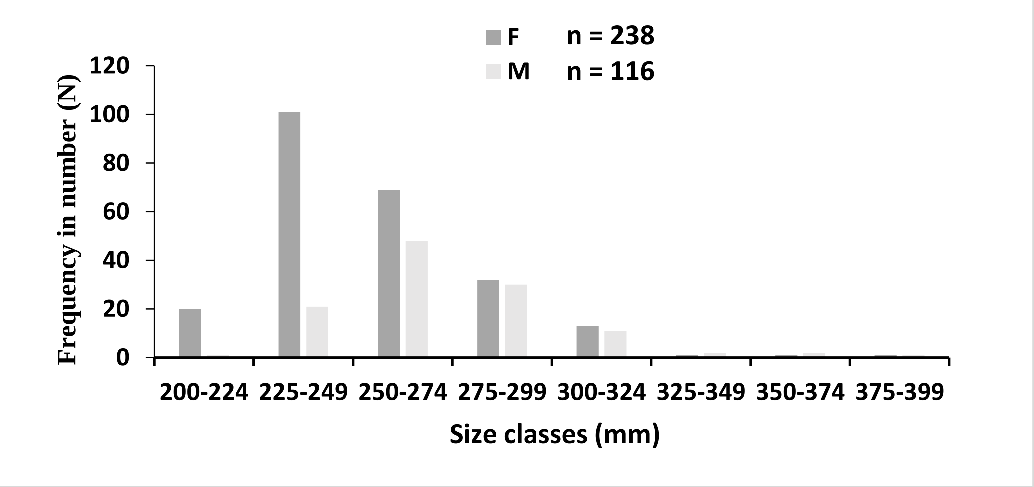

Figure 2. Size frequency distribution of *Dentex canariensis*off the Dakar peninsula in Senegal. M=Male, F=Female, n=number.

RELATIONSHIP BETWEEN TOTAL LENGTH AND NUMBER OF OOCYTES

The relationship between oocyte number and fish size has shown a negative slope and an r correlation of -0.127, indicating that the number of oocytes produced by the fish decreases with increasing fish size (Figure 2). The correlation test between the two variables was not significant at the 5% level (p-value = 0.5611).

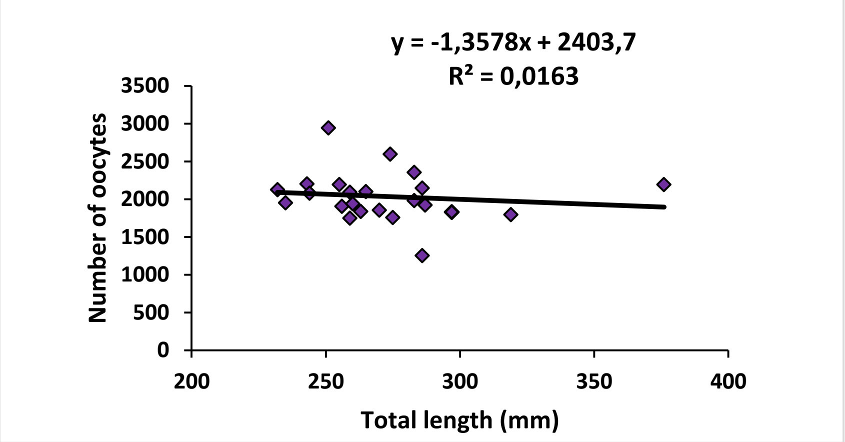

Figure 3. Variation in the number of oocytes as a function of total length of *Dentex canariensis* off the Dakar peninsula in Senegal

TOTAL WEIGHT-RELATIVE FERTILITY RELATIONSHIP

The linear relationship between these two variables TW and RF (r =-0.36) has shown that relative fecundity decreases as fish weight increases (Figure 4). However, the correlation test shows a P-value greater than 5% (p-value = 0.09059). The test is therefore not significant.

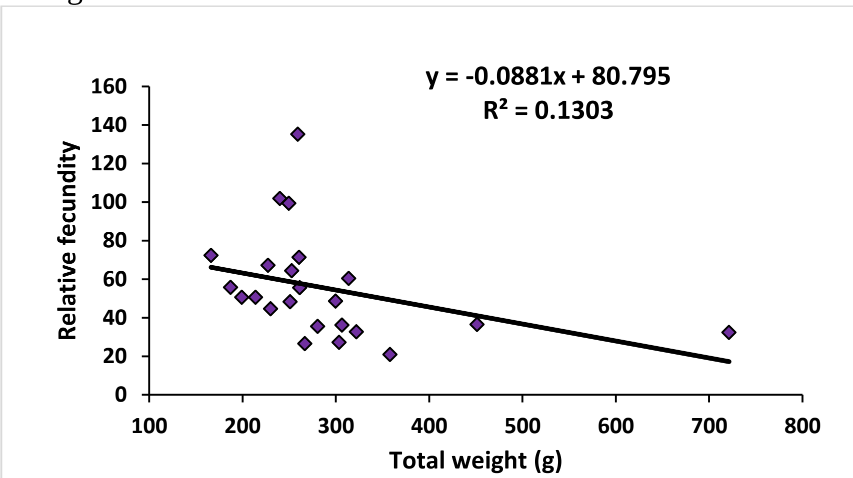

Figure 4.Variation in relative fecundity as a function of total weight of *Dentex canariens* off the Dakar peninsula in Senegal

TOTAL WEIGHT-ABSOLUTE FERTILITY RELATIONSHIP

The correlation between total fish weight and absolute fecundity is r = 0.22 (Figure 5). The linear relationship has shown that absolute fecundity and fish weight move in the same direction. The greater the fish weight, the greater the absolute fecundity. However, the test was not significant (p-value = 0.3121).

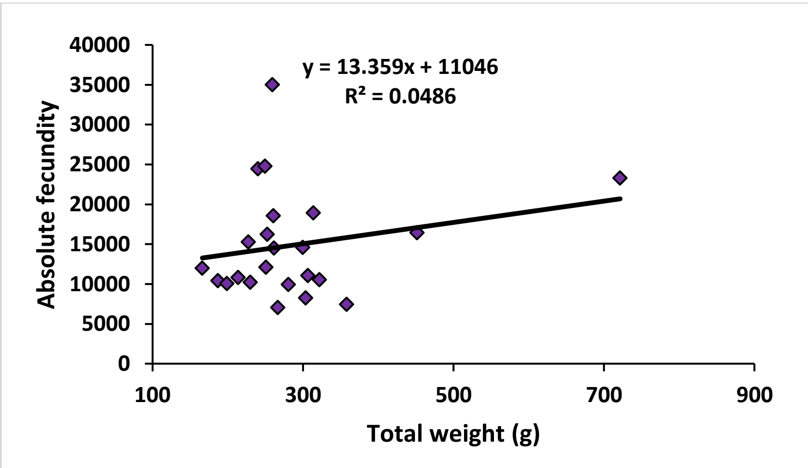

Figure 5. Variation in absolute fecundity as a function of total weight of *Dentex canariens* off the Dakar peninsula in Senegal.

SEX-RATIO

The sex ratio was in favor of females, with 67% of the population female (Figure 6). Males represent 33% of the sample. Monthly monitoring of the sex ratio has shown that females dominated every month of the year except July.

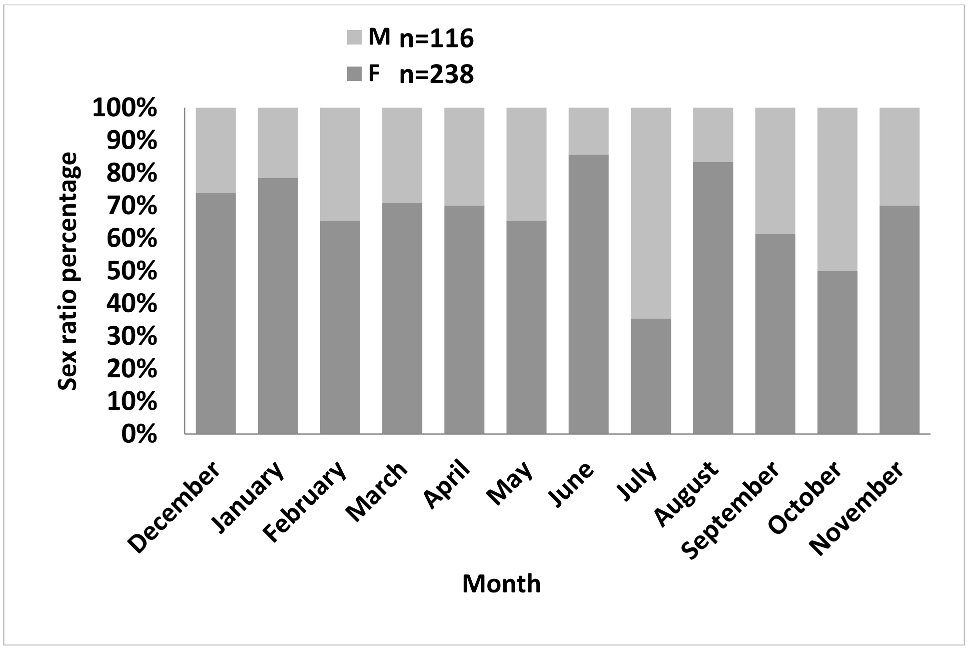

Figure 6. Monthly change in the sex ratio of *Dentex canariensis* off the Dakar peninsula in Senegal. M=Male, F=Female, n=number.

GONADO-SOMATIC RATIO AND REPRODUCTIVE PERIOD

Monthly variations in GSR for males and females of *D. canariensis* seemed to follow the same pattern (Figure 7). GSR ranged from 0.56 to 4.13 for females and from 0.1 to 1.83 for males. The highest values of this ratio were observed for both males and females between March (GSRf = 1.64 and GSRm = 1.37) and June (GSRf = 1.72 and GSRm = 0.86), with a peak in April (GSRf = 4.13 and GSRm = 1.83) and May (GSRf = 3.59 and GSRm = 1.76) corresponding to the development and maturation stages of the gonads, followed by oviposition, which would begin in June. The lowest values were observed between July and January, corresponding to post-spawning and sexual rest. The breeding period is located in the transition phase of the two seasons between April and May. Analysis of multiple variance shows significant P-values in February (p-value = 0.00384), March (p-value = 8.14e-09), April (p-value = 2e-16), May (p-Value = 2e-16) and June (p-value = 7.26e-09) compared with the other months of the year. The overall F-test gives a p-value = 2.2e-16 which is highly significant at the 5% threshold.

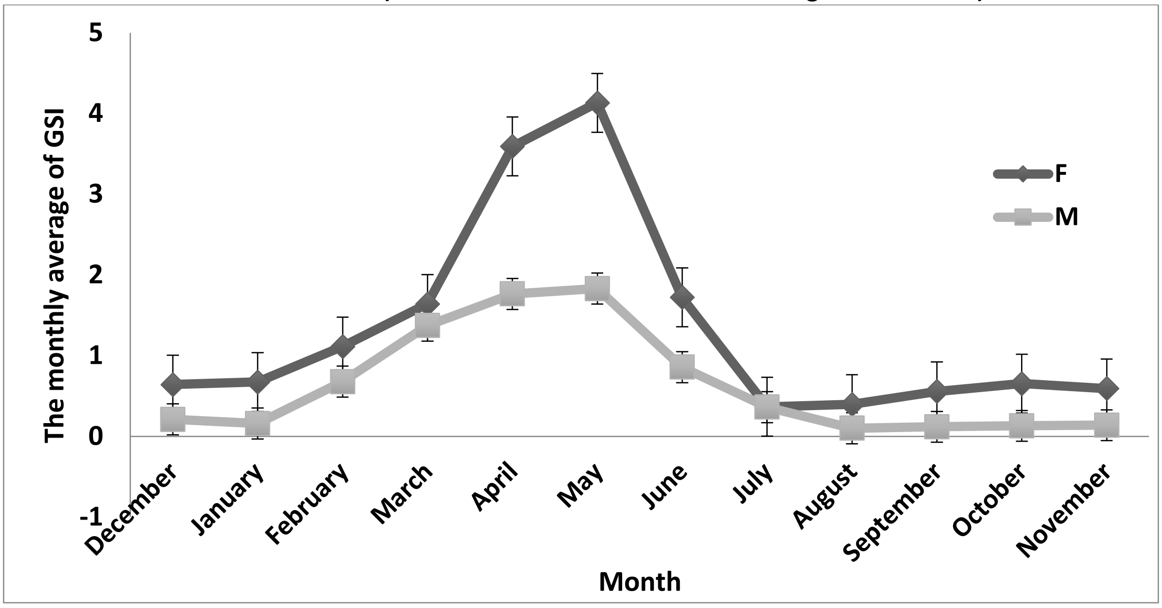

Figure 7. Monthly variation in the gonado-somatic ratio of *Dentex canariens* off the Dakar peninsula in Senegal

Monthly variations in sexual maturity stages (Figure 8) indicated the presence of mature stages (4 and 3) only during the breeding period (between March and June).

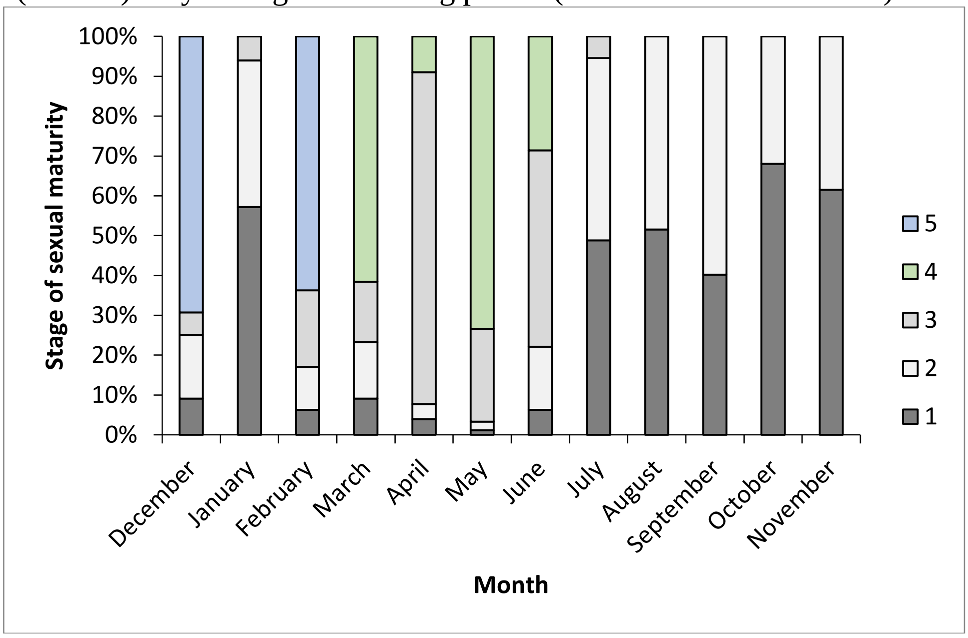

Figure 8. Monthly variation in sexual maturity stages of *Dentex canariensis* off the Dakar peninsula in Senegal

SIZE AT FIRST SEXUAL MATURITY

Figures 9a and 9b show the respective sizes at first sexual maturity of females and males of *Dentex canariensis*. Males were in the size class between 222 mm and 385 mm (TL) and females in the size class between 200 mm and 376 mm (TL). Females mature first at 227.4 mm (TL). In contrast, males reach maturity at a length of 261.4 mm (TL).

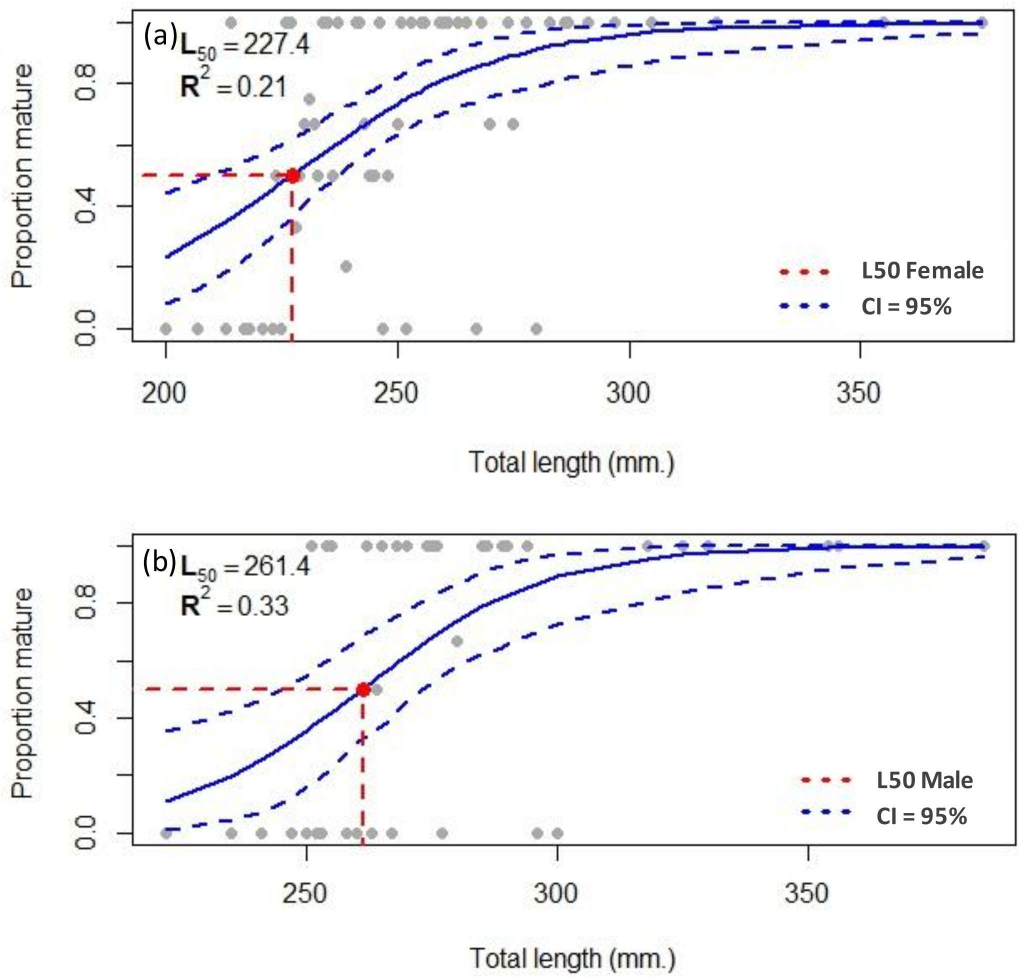

Figure 9. Size at first sexual maturity in females (a) and males (b) of *Dentex canariensis* off the Dakar peninsula in Senegal

FERTILITY

Mean absolute fertility was estimated at 14,428 oocytes (± 6,553) for individual values ranging from 7,073 to 35,046 oocytes. The corresponding mean relative fertility was 55 oocytes (± 28) per gram of mature females, with individual values ranging from 18 to 135 oocytes per gram of mature females. Ovule diameter ranged from 0.37 mm to 1.31 mm.

DISCUSSION

The size-frequency distribution of *D. canariensis* showed an unequal distribution of the population by sex. Females dominated in the lower classes and males in the upper classes. A similar observation was made by Clottey (2020) in Ghana for *D. canariensis*.

The dominance of females in the lower classes and males in the upper classes could be explained by the biology of the species which, according to Clottey (2020), is a protogynous hermaphrodite. According to Morato et al. (2003), sex changes in species affect the size ranges and size frequency distributions of both sexes. This phenomenon is highly recurrent in the Sparidae family (Buxton and Garratt, 1990; Ismail et al., 2018).

The sex ratio in the present study was in favor of females, which were more than double that of males in terms of numbers. This result is the same as that obtained by Showers (1993) in Ghana. On the other hand, Bonnet (1969), Gandega et al. (2011) and Clottey (2020) noted no difference in sex ratio, males and females being equal in number. This difference could be explained by the size ranges of their samples, which were more represented by larger individuals. For protogynous hermaphroditic fish, females should dominate the lower classes and males in the larger sizes (Ismail et al., 2018).

Monitoring of the monthly average GSR of *Dentex canariensis* showed that the species breeds once a year, between March and June, with a peak in April and May. These results differ from those reported in Ghana by Rijavec (1973) and Clottey (2020), who found two spawning periods on their coasts. The presence of mature stage 4 females only during the breeding period (between March and June) indicates that the species breeds only during this period, in contrast to Clottey (2020) where mature stage 4s were present throughout the year. These differences could be explained by differences in climatic conditions and hydrological phenomena that may exist between zones.

The breeding period for *D. canariensis* is located in the transition phase between the cold and warm seasons (April and May), where the only peak during the year has been detected. Gonad development and maturation take place during the cold season, and egg-laying occurs at the start of the warm season (May and June), as a result of rising temperatures (Badji et al., 2017). Indeed, Rijavec (1973) showed that a sudden drop in temperature interrupted gonad maturation in *Pagrus ehrenbergii*, a species closely related to *D. canariens*. Temperature may therefore be a factor influencing reproduction in Sparids (Billard and Gillet, 1984; Mihelakakis and Yoshimatsu, 1998; Saka et al., 2004).

The size at first maturity recorded for females was 227.4 mm and 261.4 mm for males. These data differ from those obtained by Rijavec (1973), who found 219 mm in females and 223 mm in males. This difference could be explained by environmental and demographic factors differing between the two environments. In fact, species that feel more secure in an environment that offers them refuge and food could reproduce earlier, compared with a less stable fish population. Clottey (2020) had estimated length at first sexual maturity, but his results were beyond the limits for comparison with those of this study. In his thesis, he estimated the size at first sexual maturity for males at 517 mm (size class between 460 mm and 650 mm) and females at 316 mm (size class between 300 mm and 320 mm). This difference could be explained by larger local populations on the Ghanaian coast, larger local stocks, the sampling strategy and the fishing gear used. All these studies have shown that females mature first. This could be explained either by the fact that males grow faster than females, or by the phenomenon of sexual inversion in the population requiring more time for males to mature during sex changes. Mean absolute fertility was estimated at 14,428 oocytes (± 6,553) for individual values ranging from 7,073 to 35,046 oocytes. The corresponding mean relative fecundity is 55 oocytes (± 28) per gram of mature females for individual values ranging from 18 to 135 oocytes per gram of mature females. These values are different (significantly lower) from those observed by Clottey (2020), who noted an absolute fecundity ranging from 250,902 (± 9,973) to 6,761,139 (± 805,962) for an estimated mean fecundity of 2,013,315 (± 23,688) (N=53). These differences could be explained by the large number of females involved in Clottey's (2020) studies. In addition, environmental circumstances may have conditioned the choice of oocyte number to the detriment of size (Legendre and Ecoutin, 1996). Indeed, the oocyte diameters obtained by Clottey (2020) were significantly smaller than those obtained in our study (0.10 mm to 0.70 mm vs. 0.37 mm to 1.31 mm).

CONCLUSION

This study provided essential information on the reproductive biology of the Canary dentex *Dentex canariensis*. Analysis of the results from the Dakar peninsula showed variations in various aspects of its reproduction in relation to environmental factors, especially temperature. The gonad maturation and spawning periods identified in this study could serve as indispensable reference indicators for the creation of Marine Protected Areas or the application of biological recovery periods for the sustainable management and rational exploitation of this species.

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