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Reproductive Biology of *Chelon dumerili* (Steindachner, 1870) in Saloum Delta, Senegal (West Africa)

Alioune FAYE[1*], Coumba DIENG[2], Alassane SARR[2], Waly NDIAYE[2] and Malick DIOUF[3]

[1]*Institute of Environmental Sciences, Faculty of Science and Technology; Cheikh Anta Diop University of Dakar; BP: 5005, Dakar, Senegal.*
[2]*University Institute of Fisheries and Aquaculture; Cheikh Anta Diop University of Dakar; BP: 5005, Dakar, Senegal.*
[3]*Department of Animal Biology, Cheikh Anta Diop University of Dakar; BP: 5005; Dakar, Senegal.*
[*] *Corresponding Author; E-mail : alioune5.faye@ucad.edu.sn; Tél.: +221 77 378 73 25.*

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ABSTRACT

The present study evaluated the sex ratio, evolution of gonado-somatic index and stages of sexual maturity, condition factor and size of first sexual maturity of *Chelon dumerili* (*Mugilidae*) to determine its reproductive parameters. From June 2016 to May 2017, a total of 360 individuals of *C. dumerili* were sampled in Sangomar Marine Protected Area (MPA), In Saloum Delta, Senegal. The sex-ratio was significantly in favor of females (61.67%). Based on the monthly evolution of gonadal maturation stages and gonado-somatic index, the reproductive period of the species was determined to be from March to May. The condition factor varied between 0.60 and 0.88 with an average value of 0.84 ± 0.07. Male individuals of *C. dumerili* reached the size of first sexual maturity at a lower total length than females (23.6 cm and 24.5 cm respectively). Thus, for this species whose reproductive biology has not been well documented until now, knowledge of the reproductive parameters is essential to put in place measures for the sustainable management of the resource.

Keywords: MPA, Sangomar, Senegal, *Chelon dumerili*, reproductive parameters.

INTRODUCTION

Fishes of the *Mugilidae* family are abundant and largely widespread in estuaries of tropical and temperate regions where they represent a major commercial resource (Pombo et al., 2005; Honorine, 2019). In West Africa, only the genera *Mugil* and *Liza* are known from this family (Honorine, 2019; Djadji, 2013). In Senegal, the *Mugilidae* family is one of the most abundant taxa (Lawson and Abayomi, 2010). Because of its commercial, nutritional and ecological importance, this family deserves special attention. *C. dumerili*, previously known as *Liza dumerili*, is one of the most abundant species of this family in Saloum delta, in the central part of Senegalese coast. However, the studies carried out on *C. dumerili* reproductive biology are insufficient. In Senegal, a few studies, focused on descriptive aspects and growth aspects

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(Ndiaye, 2020), have been conducted in on *C. dumerili*. It is exploited particularly intensively in Saloum Delta. It is a species with significant socioeconomic value in this area.

The objective of this work was to determine some reproductive aspects of *C. dumerili* in Saloum Delta's waters in order to improve knowledge on this species biology for its rational exploitation in Senegal.

MATERIALS AND METHODS

Study area

This study was carried out in the Marine Protected Area (MPA) of Sangomar located in the Saloum Delta (13° 35' and 14° 10' north and 16° 50' and 17° 00'). With an area of 87,437 ha, a large part of the Sangomar MPA is included in the Saloum Delta Biosphere Reserve (RBDS) in Senegal. The Sangomar MPA is bounded to the north by the Joal-Fadiouth MPA, to the south by the Saloum Delta National Park, to the east by the Palmarin Community Nature Reserve (RNCP) and the municipalities of Djirnda and Bassoul and to the West by the Atlantic Ocean (Ba, 2019).

A total of 5 fishing stations were chosen and distributed in the different parts of the Sangomar MPA (Figure 1). Thus, the Sofna and Bakina stations are located in the area of the mouth of the Saloum, the Mariniane and Djimsane stations were located on the main arm of the Saloum and the Sarema station is in a salt-water channel.

Sampling strategy

A total of twelve (12) experimental fishing campaigns were carried out monthly from June 2016 to May 2017. The fishing operations were carried out using a 250 m long, 20 m height and with a 14 mm mesh size experimental purse seine.

360 individuals of *C. dumerili* were sampled. These individuals were caught using purse seines and beach seines during experimental fisheries. For each individual, the total weight and the eviscerated weight were determined using a 0.1 g precision electronic scale. Total length and fork length were measured with a 1 mm precision ichthyometer.

Sex-ratio

The sex ratio was defined as the proportion of each sex, determined by macroscopic observation of gonads in a given population (Baali, 2017). In this study, the sex ratio was expressed as a percentage of the females. It was calculated according to the following equation:

$$SR = \frac{Nf}{Nf+Nm} \times 100$$

Where SR : sex-ratio, Nf : number of females, Nm : number of males

Evolution of gonad maturity

A scale of sexual maturity, composed of different stages, could characterize the development of the gonads. This scale was related to the macroscopic aspect of the gonad and its weight evolution. The principle of assigning a stage to a fish consisted in frequently observing a fairly large number of gonads. This observation provides the most representative image possible of the stage of maturity of the population studied (Derbal, 2007). The maturity scale of Fontana (1979) based on the study of *Sardinella* from the Congo was adopted for this study.

Gonado-somatic index

The gonado-somatic index (GSI) is defined as the proportion of gonad weight to eviscerated weight of fish. GSI variation reflects periodic changes in gonad weight caused by maturation. The stage of gonad development, as well as seasonal variation in GSI provides information on the spawning strategy and timing of a species (West, 1990). The GSI was calculated using the following formula (Bougis, 1952):

$$GSI = \frac{GW}{EW} \times 100$$

Where GSI: gonado-somatic index, GW: gonad weight in grams (g), EW: eviscerated weight in g.

Size at first sexual maturity (L_{50})

The size at first maturity is the size at which 50% of individuals are mature (Chikou et al., 2011; Kraidy et al., 2014). This parameter was determined from female and

male by calculating the proportion of mature female and male in 1 cm size class in the reproductive period. A logistic function linking percentages of mature fish and total length was used (Amenzoui et al., 2005):

$$\% M = \frac{100}{1 + e^{-a(TL - L_{50})}}$$

Where **%** M: percentage of mature individuals by size class, a: constant, TL: Total length in centimeters (cm), L_{50}: constant corresponding to the average length of first sexual maturity.

Condition factor

The condition factor provides information on the physical condition of a fish (Paugy and Lévêque, 2017). It is a parameter often used to compare the overall physiological state of populations during a seasonal cycle (Lizama and Ambrósia, 2002). It also provides information on the storage of energy reserves necessary for gametogenesis (Fehri-Bedoui, 2002). The condition factor is calculated using the following formula:

$$K = \frac{TW}{TL^3} \times 10^2$$

Where K is the condition factor, TW: the total weight in g, TL: total length in cm.

Statistical analysis

Statistics and graphics were done with Microsoft Word and Excel softwares.

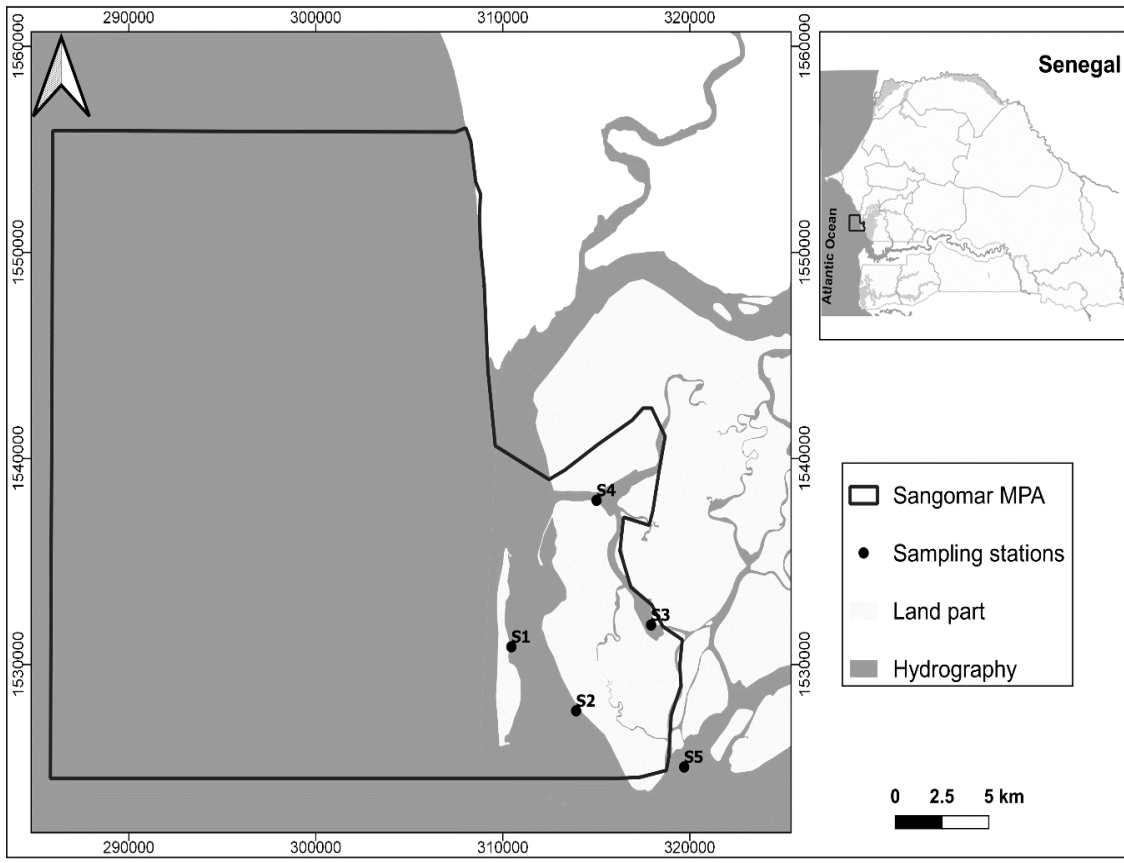

Figure 1: Geographic location of the study area.

RESULTS

Sex-ratio

A sample of 360 individuals of which 222 females and 138 males was used to calculate the sex-ratio of *C. dumerili.* These numbers corresponded to a sex ratio of 61.67% of females and 38.33% of males. The analysis of this result showed a significant predominance of females compared to the males. Considering monthly variations, the sex ratio was in favor of females except for the months of April, June, November and December. A superiority of females was observed continuously from July to October (Figure 2).

Reproductive periods

Peak breeding seasons were determined by annual monitoring of the gonado-somatic index (GSI) and development of sexual maturation stages. There was a correlation between the variations in the mean GSI and those of the stages of sexual maturity. The variation in the stages of sexual maturity showed that the proportions of individuals with advanced sexual maturity (stages IV, V) were larger from March to May. On the other hand, the proportion of immature individuals (stages I and II) and at the beginning of maturation was larger from June to January (Figure 3a). The annual evolution of the GSI made it possible to identify a major peak in April. Thus, there was an ascending phase that lasted from February to April, corresponding to the gonadal maturation period, and a descending phase that extended from April to June, corresponding to the spawning season (Figure 3b). The main reproduction period of *C. dumerili* was therefore from March to May.

Condition Factor

The monthly values of the average condition factor of *C. dumerili* ranged from 0.60 to 0.88 with an average of 0.84 ± 0.07. The results obtained showed that the condition factor gradually decreased from January to April until it reached its minimum value (0.60). From April, it rose to 0.75 in May and June before showing a slight increase with slight fluctuations for the rest of the year (Figure 4).

Size at first sexual maturity

C. dumerili was characterized by a size difference between males and females at sexual maturity. Analysis of the results on sizes at sexual maturity revealed that in this species, sexual maturity was reached at a larger size in the female (Figure 5a) than in the male (Figure 5a). The sizes at sexual maturity in females and males were 24.5 cm and 23.6 cm, respectively.

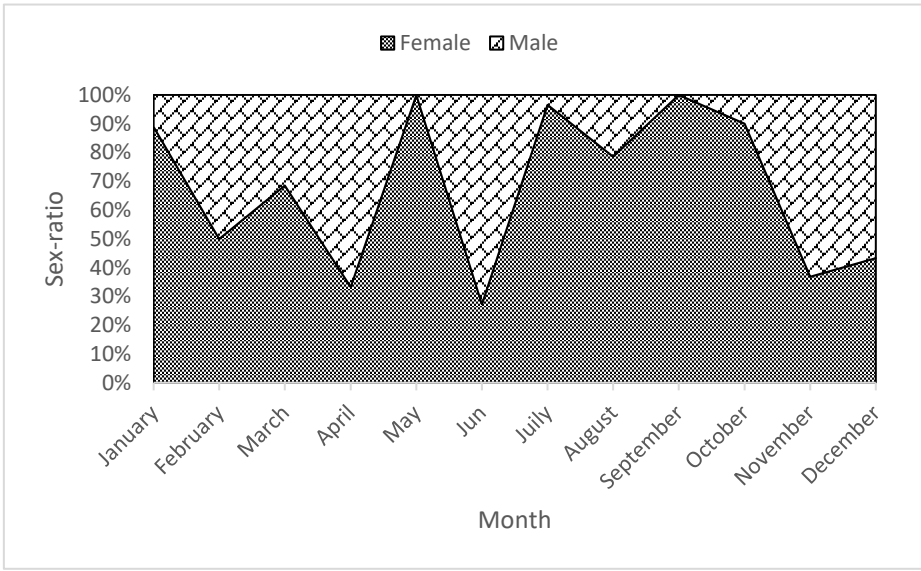

Figure 2: Monthly variation of the sex ratio of *C. dumerili*

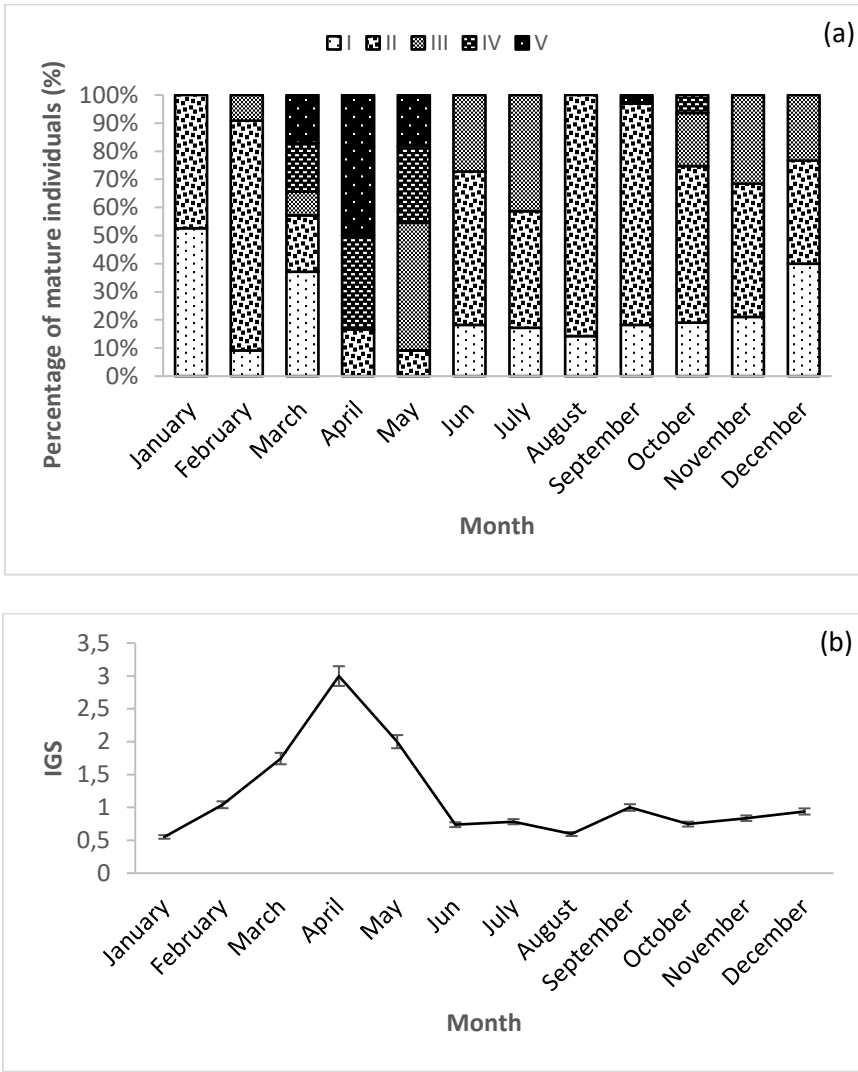

Figure 3: Monthly evolution of sexual maturity stages (a) and Gonado-somatic index (b) of *C. dumerili*.

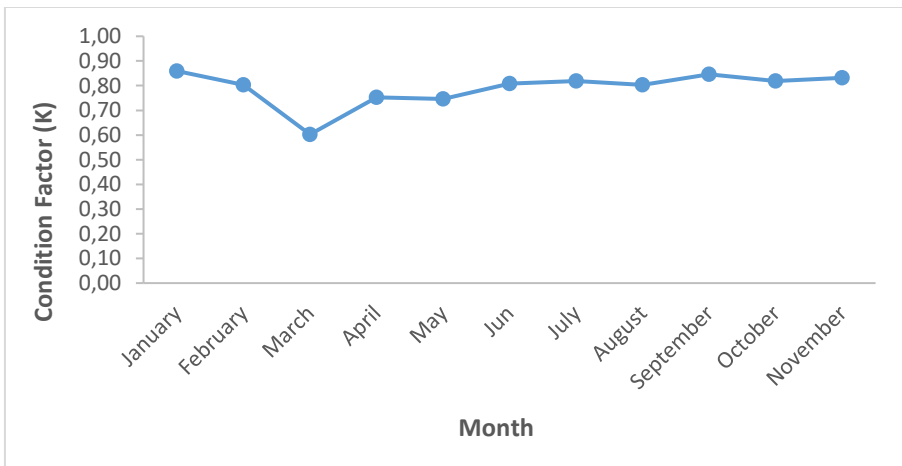

Figure 4: Monthly evolution of condition Factor (K) of *C. dumerili*.

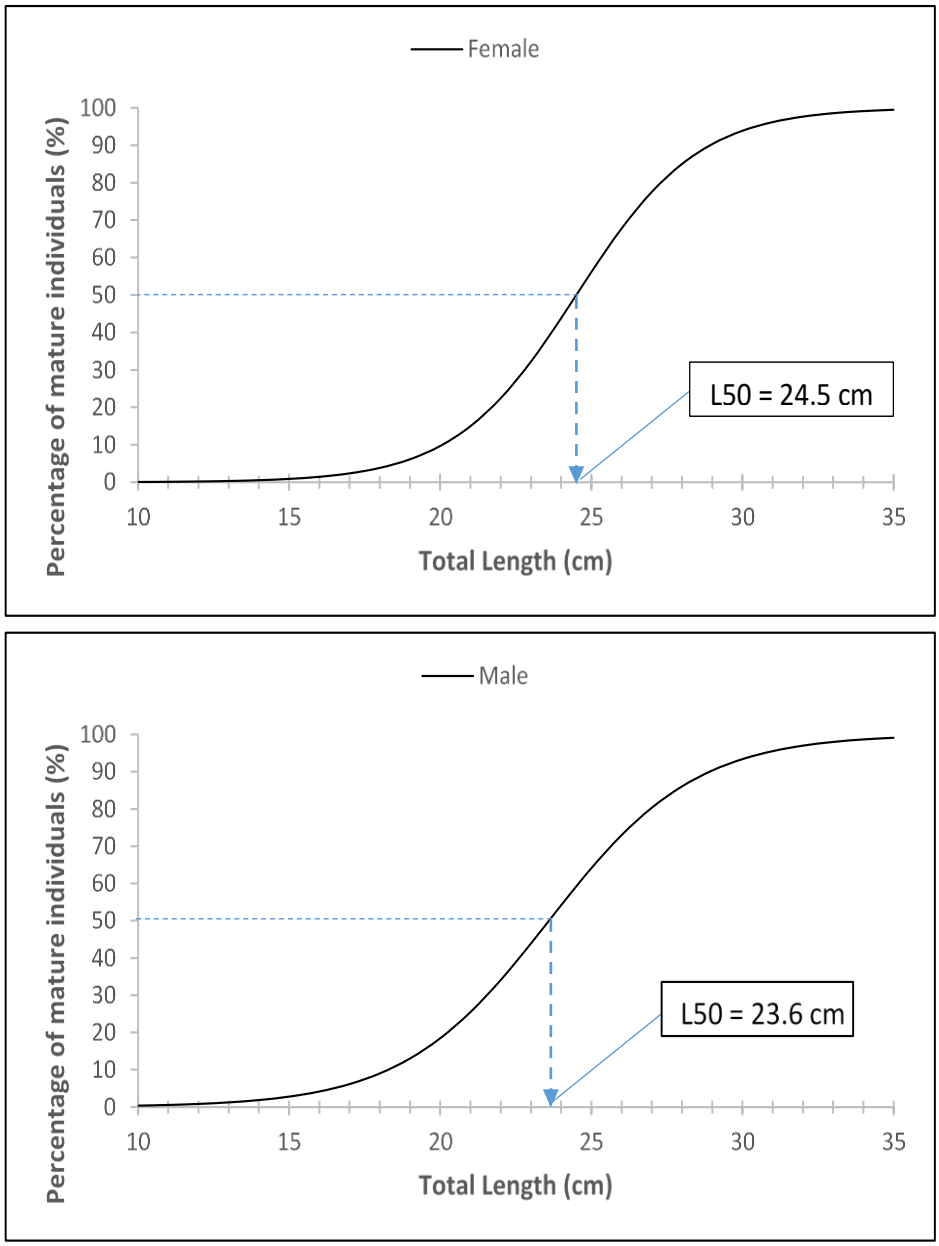

Figure 5: Size at first sexual maturity of female (a) and males (b).

DISCUSSION

A total of 360 individuals of *C. dumerili* including 222 females and 56 males sampled in the present study. The results of the sex ratio indicated a predominance of females (79.85%). These results are in agreement, for the same species, with those of Honorine et al. (2019) and Ndiaye et al. (2020). In contrast, Diaby et al. (2012) noted a male dominated population in Ivory Coast (Table 1).

This predominance of one sex is a frequent phenomenon in many teleosts (Ghaninejad et al., 2010; Abdallah et al., 2013; Honorine et al., 2019). This imbalance in the sex ratio could be explained by several factors, including seasonal segregation of the sexes,

differential distribution based on size and age, natural selective mortality, different migratory activities, or selectivity of fishing gear, which would catch one group more than another (Ould Mohamed Vall, 2004; Chikou, 2006).

The study of the evolution of sexual maturity stages and the variation of the gonado-somatic index (GSI) allowed to locate the breeding periods of *C. dumerili* from March to May. These results were similar to those of Honorine et al. (2019) from the Ivory Coast. However, other studies that indicated breeding periods ranging from September to Novembre (Diaby et al., 2022) in Ivory Coast (Table 2). This suggests that in African coastal countries bordering the Atlantic Ocean, the breeding period of *C. dumerili* is relatively short and takes place almost at different times of the year depending on the locality. Moreover, the shift in the breeding periods of *C. dumerili* in Saloum Delta waters compared to other countries areas could be due to differences in environmental factors. It is therefore generally noted that in most fish, rainfall (Chellappa et al., 2009), temperature changes (Ghaninejad et al., 2010), locations (Efizon, 2021) appeared to be the main, environmental factor modulating spawning period. Therefore, fish of the same species but different locations possibly have different spawning patterns as detected in this study.

The monthly values of the average condition factor of *C. dumerili* calculated in the present study were between 0.60 and 0.88 with a mean value of 0.84±0.07. This showed that the condition factor (K) values of *C. dumerili* are relatively low. In fact, relative condition factor (K) equal to or greater than 1 indicated that the fish were in good growth condition (Sachidanandamurthy and Yajurvedi, 2008). Fluctuations in monthly condition factor (K) values depend on several factors such as diet, environmental conditions, maturity and spawning season (Nair et al., 2015). In the present study, the spawning season of *C. dumerili* corresponded to the period when the condition factor values were lower. This result was consistent with that of Alla et al. (2019) for the same species. This caused the fish to lose weight, suggesting that they would also use their energy reserves contained in the muscles and intestines to ensure reproduction.

Knowing the size at first sexual maturity in fish is very important to determine the minimum size at first catch (Mehanna, 2007). The sexual maturity of *C. dumerili* was reached both females and males when the females were larger than the males. This size difference between males and females could be due to a number of factors. The differential growth seen in most teleosts could be a cause of this size disparity in *C. dumerili*. In fact, this would be related to the relative energy distribution for the production of gametes (Weatherley and Gil, 1987). According to Abdallah et al. (2013) the energy expenditure of females for the production of gametes is probably lower than that of males. This could be due to physiological and hormonal effects on gonad development in fish.

The differences in size at first sexual maturity observed between countries (Table 3) would be attributed mainly to the variability of environmental conditions in different areas, with low temperature and photoperiod likely being the main influencing factors (Bilgin et al., 2014).

Table 1: Sex ratios *C. dumerili* percentage of female according to various authors.

Countries	Sex-ratio (%)	Number of individuals	Authors
Senegal	61.67	360	Present study
Senegal	69.19	185	Ndiaye et al. (2020)
Ivory Coast	62.20	373	Honorine et al. (2019)
Ivory Coast	46.71	578	Diaby et al. (2012)

Table 2: Breeding periods of different populations of *C. dumerili* by country.

Countries	Breeding periods												Authors
	J	F	M	A	M	J	J	A	S	O	N	D	
Senegal			■	■	■								Present study
									■	■	■		Diaby et al. (2012)
Ivory Coast				■	■	■							Alla et al. (2019)
Ivory Coast									■	■	■		Diaby et al. (2022)

Table 3: Size at first sexual maturity of *C. dumerili* found in different area.

Countries	Size at first sexual maturity		Type of length	Authors
	Male	Female		
Senegal	23.6 cm	24.5 cm	LT	Present study
Senegal	16.1	19.5	LT	Ndiaye et al. (2020)
Ivory Coast	24.2 cm	24.5 cm	LF	Alla et al. (2019)
Ivory Coast	16.1	19.5	LT	Diaby et al. (2022)

Conclusion

This work allowed us to estimate certain reproductive parameters of *C. dumerili* of the Sangomar MPA in Senegal. The results obtained showed that the gender ratio was in favor of females. The study found that *C. dumerili* reproduced over a relatively short period, which for the present study was set from March to May. The study also showed that male *C. dumerili* individuals reached sexual maturity earlier than females. The variation in the condition factor associated with the gonado-somatic index (GSI) indicated that the species used its muscular energy reserves to develop gametes for reproduction. The results of this study could be used in developing a management plan for the sustainable exploitation of the *C. dumerili* fishery in Senegal.

COMPETING INTERESTS

The authors declare that there is no competing interests.

AUTHORS' CONTRIBUTIONS

MD prepared a validated sampling plan. CD, AF, AS and WN conducted the field sampling. CD took the field notes and entered the data into Excel software. AF processed the data and wrote the draft article. AS and WN have made their corrections

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