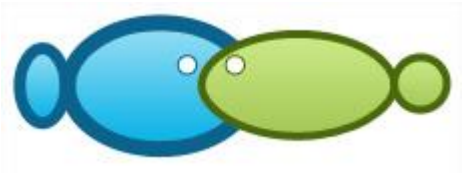

Size at first sexual maturity of anchovy, *Engraulis encrasicolus* in Senegalese waters

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Abstract. The study of size at first sexual maturity of anchovy, *Engraulis encrasicolus*, in Senegalese waters was carried out from samples collected in the eastern coastal marine area of the Cape Verde peninsula over the period April-October 2019, since there was no-catch of *E. encrasicolus* from November to March. The size at first sexual maturity (L_{50}) determined was 9.6 cm total length (TL) for males and 9.8 cm for females. By determining key reproductive parameters of *E.encrasicolus* in the Senegalese waters, this work reinforces the scientific base references of the fishing sector, which are key elements in the decision-making processes of fishing policies in Senegal.
Key Words: small pelagic, biological indicators, critical sites, management.

Introduction. The anchovy, *Engraulis encrasicolus,* belongs to the Actinopterygii class, Teleost infraclass, Engraulidae familiy of fish. A coastal pelagic species very common in the Mediterranean and in the eastern Atlantic (Zarrad et al 2006; Mezedjri et al 2013), *E. encrasicolus* is the only representative of the Engraulidae family in the tropical eastern Atlantic (Gaamour et al 2004; Khemiri & Gaamour 2009). It is a small coastal pelagic fish, gregarious, living in very dense schools (Brehmer et al 2007; Bertrand et al 2008). It enters estuaries, bays (Planque et al 2007) and descends offshore to around 150 m deep on muddy bottoms (Fisher et al 1987). The anchovy performs seasonal migrations of small amplitudes (Brochier et al 2018). The high abundances of *E. encrasicolus* are observed in waters with temperatures between 18 and 20°C in the Mauritanian coasts (Bâ 1988) and between 22 and 23°C in Senegalese waters (Diankha et al 2015).

In Senegal, *E. encrasicolus* fishing has increased disproportionately in recent years (Thiao 2012). This phenomenon is explained by the increased demand for the species by a new clientele represented by the Bourkinabés, who use anchovy in dried form (Dème 2012; Dème et al 2019). Besides, this led to the installation of clandestine anchovy processing sites, especially in the localities of Bargny and Hann (Dakar) (Mbaye 2019 et al; Dème et al 2019). *E. encrasicolus* is mainly landed at Bargny and Yenne where it is dried and then sold to fishmeal factories. This fact also increases the fishing pressure exerted on the species. Fishing such a small fish, especially using the purse seine or the beach seine with a very fine mesh, raises another problem linked to the capture of juveniles, mainly of Sardinella (Thiaw et al 2020), horse mackerel and other small pelagic fish (Ndour et al 2020). In the context of fishery management (Ndour et al 2014), the anchovy fishery has always caused controversies in Senegal. This has led fishery managers to question whether the anchovies caught in Senegal are juveniles or adults. To bring an answer to this question, the present study is carried out for the first time to determine the size at first sexual maturity of *E. encrasicolus* in the Senegalese waters.

Material and Method

Study area. Located on the eastern coast of the Cape Verde peninsula (Dakar, Senegal), the study area extends from Anse Bernard to Yenne and covers the sites of Hann, Mbao, Bargny and Yenne (Figure 1). The choice of this area is explained by its potential to host high concentrations of anchovy. In addition, it represents the main area of fishing and processing of the species.

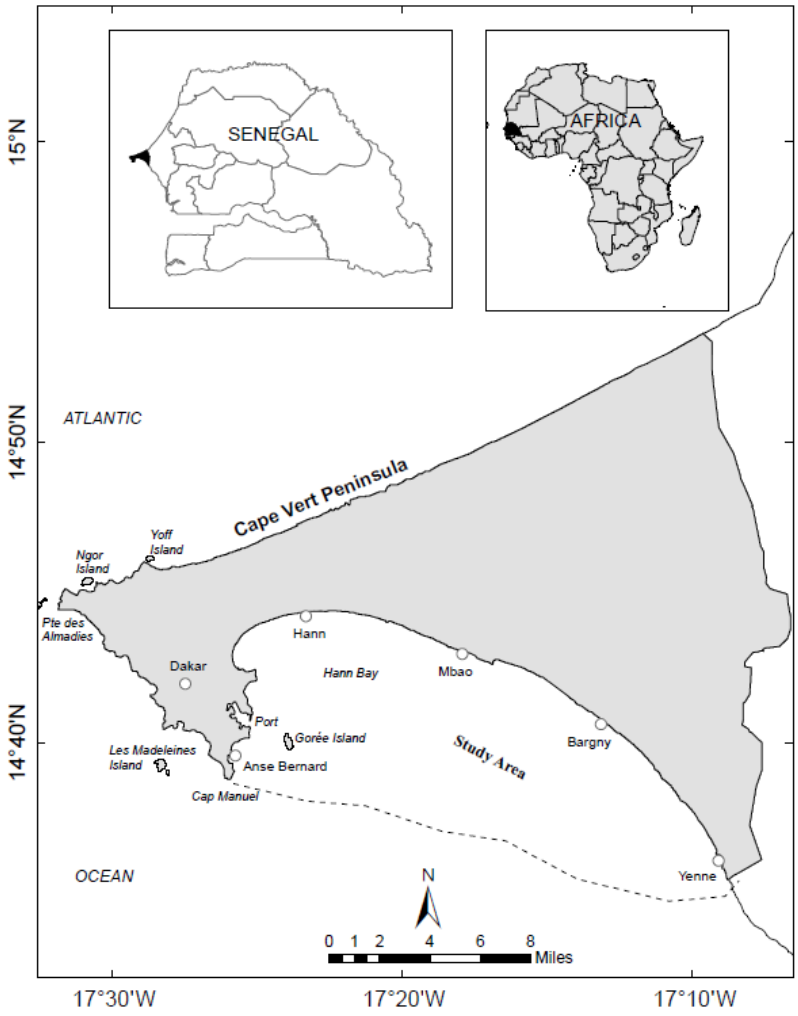

Figure 1. Location map of the study area.

Data sampling. The sampling was carried out during the period April-March 2019. However, the *E. encrasicolus* having been encountered in the area only between April and October, the data processed relate to this period. Analysis of information collected from fishermen on the behavior of the species reveals that *E. encrasicolus* is only present in the area during the period April-October. This period also covers its breeding period, a thing which approves the sufficiency of the data used in the study to analyze the size at first sexual maturity of *E. encrasicolus*.

The samples were collected from landings of purse seine or beach seine, designed with two types of mesh: one part of the net was of 8 mm mesh and the other part was 12 mm each. During all the sampling months, the same types of fishing gear were used. Individuals were measured using an ichthyometer, weighed using a balance precision of 1g and the stages of their sexual maturity were determined. The sizes of the individuals ranged from 5.0 to 13.5 cm in total length (TL).

Data processing. The size at first sexual maturity is that at which 50% of individuals in the population are sexually mature. It is determined during the breeding period of the

species, which extends from May to October, in accordance to the fishermen opinions, who support that *E. encrasicolus* is only present in the area during the period April-October for breeding. For its calculation, the samples collected during the reproduction period are sorted by sex and by size class of 0.5 cm. The proportion (Pm) of individuals whose stage of sexual maturity is greater than or equal to stage 3 is calculated for each class. The pairs of values (length, Pm) are adjusted by a logistic curve (King 1995) whose mathematical expression is as follows:

$$Pm = 1/(1+\exp(-r(L-L_{50}))$$

Where:
Pm - the proportion of mature individuals;
r - the slope;
L - the length of the fish in cm.

Results and Discussion. The L_{50} determined in the populations of *E. encrasicolus* was 9.6 cm TL for males and 9.8 cm TL for females (Figure 2). The size at first sexual maturity, determined in this study, is consistent with the L_{50} obtained in Morocco (9.82 cm TL for males and 9.96 cm TL for females) by Baali et al (2017) and to those found in Côte d'Ivoire for males: 9.7 cm when converted in TL (Ouattara et al 2015). The similarity of our results to those obtained in Morocco and in Côte d'Ivoire coastal marine areas lies in the existence of a common physical phenomenon (the straight and the opposite Canary currents) producing similar environmental conditions in these waters.

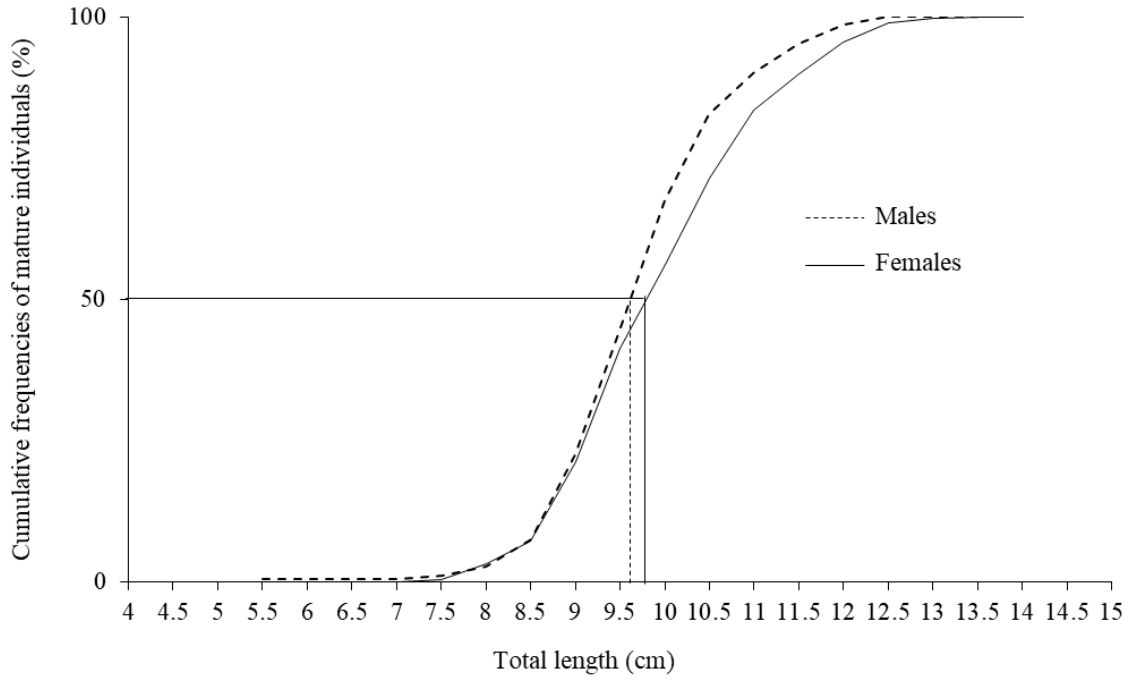

Figure 2. Size determination curves at first sexual maturity (L_{50}) in males and females of *Engraulis encrasicolus*, caught in the eastern coastal marine area of the Cape Verde peninsula over the period from April to October 2019.

In contrast, the obtained L_{50} values are lower than those obtained in Mauritania (10.9 and 11.2 cm TL) by Bâ (1988) and in Algeria, which vary from 11.4 cm TL (Hemida 1987) to 12.5 cm TL (Mezedjri et al 2013; Djabali & Hamida 1989). However, the obtained L_{50} values are higher than the L_{50} values in Tunisian coastal zones (Gaamour et al 2004), as shown in Table 1. Compared to Mauritania the difference could be explained by the changes in the environmental conditions which must have occurred during the last thirty years, given that there is no recent study having updated the L_{50}. Moreover, compared to other study locations, the difference noted could be explained by the specific

environmental features of ecosystems from one geographic area to another. Indeed, the coastal areas in northern Morocco, Algeria and Tunisia are influenced by the physical processes variability, compared to the study area.

Table 1

Synthesis of existing work on the size at first sexual maturity of *Engraulis encrasicolus* in the Eastern Atlantic and the Mediterranean

Regions	*L_{50} (cm)*	*Size type*	*References*	*Size converted into TL**	*Sexes*
Baie de Boussmail, Algeria	11.4	TL	Hemida (1987)	11.4	-
Golf of Stora (Skikda)	12.5	TL	Mezedjri et al (2013)	12.5	Both sexes
Algeria	11.4	FL	Djabali et al (1988)	12.3	-
Bay of Algiers	11.2	FL	Djabali & Hamida (1989)	12.1	Males
Bay of Algiers	11.6	FL	Djabali & Hamida (1989)	12.5	Females
Moroccan Atlantic coast	9.82	TL	Baali et al (2017)	9.82	Males
Moroccan Atlantic coast	9.96	TL	Baali et al (2017)	9.96	Females
Mauritania waters	10.1	FL	Bâ (1988)	10.9	Females
Mauritanian waters	10.4	FL	Bâ (1988)	11.2	Males
Ivorian Coasts	7.5	SL	Ouattara et al (2015)	8.8	Males
Ivorian Coasts	8.3	SL	Ouattara et al (2015)	9.7	Females
Golfe de Tunis	7.5	TL	Gaamour et al (2004)	7.5	-
Senegal	9.6	TL	This study	9.6	Males
Senegal	9.8	TL	This study	9.8	Females

*The relationships between total length–standard length and total length–fork length were calculated using the Sinovčić & Zorica (2006) formula: TL=1.1405LS+0.2420 and TL=1.0425 LF+0.3944. TL-total length; FL-fork length; SL-standard length.

Conclusions. As a first study dealing with the size at the first sexual maturity (L_{50}) of *E. encrasicolus* in Senegal, this study represents an important step in the production of knowledge on the life cycle of this species. By determining the size at the first sexual maturity, the study contributes to the process of sustainable management of small pelagic resources in Senegal. Therefore, this work reinforces the scientific base references of the fishing sector, a key element in the decision-making processes of fishing policies in Senegal. As a reminder, in Senegal, the *E. encrasicolus* fishery has always caused controversies due to the small size of the species, inducing the involuntary capture of juveniles of other fish species. So, a future morphometric analysis between *E. encrasicolus* and Sardinella juveniles could contribute to the design of a selective fishing technique for *E. encrasicolus*.

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