



Growth and mortality of *Serranus cabrilla* (Linnaeus, 1758) (Actinopterygii: Perciformes: Serranidae) from Bou Ismail Bay, off Algeria, south-western Mediterranean

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ABSTRACT

This study was conducted to determine the growth and mortality parameters of the comber *Serranus cabrilla* (Linnaeus, 1758) in the central region of the Algerian coast. A total of 1568 specimens were collected from January 2016 to April 2018. Total length (TL) varied between 9.3 and 26.2 cm. The maximum total length recorded in the Mediterranean Sea for the species is 26.2 cm (TL_{max}). The von Bertalanffy growth parameters were estimated using ELEFAN I routine in FiSAT II program ($L_{\infty} = 32.80$ cm; $K = 0.41$ yr⁻¹; $t_0 = -0.39$ yr⁻¹) and those related to the length-weight relationship are as follows: $W_{\infty} = 372.15$ g; $a = 0.012$ and $b = 2.96$ ($r^2 = 0.93$). Total mortality (Z) and natural mortality (M) coefficients stood at 2.63 yr⁻¹ and 0.43 yr⁻¹, respectively. The calculated exploitation rate, $E = 0.84$, indicated that *S. cabrilla* population is overexploited.

Keywords: Bony fish, Comber, Population dynamics, Serranids, *Serranus cabrilla*

Introduction

The comber *Serranus cabrilla* (Linnaeus, 1758), is a teleost fish of commercial interest, common in the Mediterranean, Western Black Sea and Atlantic Ocean, from the British Isles to the Cape of Good Hope, including the Azores, Madeira and the Canary Islands (Fisher *et al.*, 1987). This species frequents rocky and sandy bottoms and areas with the seagrass *Posidonia oceanica*. It is found between 0 and 450 m depth (Carpenter and De Angelis, 2016), but usually only down to 90 m (Fisher *et al.*, 1987). Most published data are limited to the Atlantic Ocean and the eastern Mediterranean *viz.*, the Canary Islands (Tuset *et al.*, 1996), the Portuguese coasts (Gordo *et al.*, 2016), the southern coasts of Tunisia (Bouain, 1981; Bouain, 1983) and the Turkish coasts (Politou and Papaconstantinou, 1995; Tserpes and Tsimenides, 2001; Turker-Cakir and Torcu-Koc, 2002; Torcu-Koc *et al.*, 2004; Ilhan *et al.*, 2010).

Landings of the comber along the Algerian coast are important since the fifties (Dieuzeide *et al.*, 1959) to the current period. Studies on diet (Rachedi *et al.*, 2018) and growth (Rachedi and Dahel, 2019) have been carried out in the Gulf of Annaba from the eastern Algerian coast, but no studies are available from the central region. The species is heavily exploited by trammel nets and bottom trawl in the Bou Ismail Bay. However, the status of its stock remains unknown. Knowledge of growth and mortality parameters

are needed for fitting population dynamics models and for demographic analyses (Khan and Khan, 2014).

The current study provides the first information on some biological parameters of *S. cabrilla* from the Algerian coast of Bou Ismail Bay in the south-west Mediterranean.

Materials and methods

Study area and sampling

From January 2016 to April 2018, 1568 specimens of *S. cabrilla* were sampled from catches realised off the Bou Ismail Bay. This bay is located in the central part of the Algerian coast, between 36.63°N, 2.40°E and 36.80°N, 2.89°E. It is bounded by the cape of Mount Chenoua from the west and Ras-Acrata from the east (Fig. 1).

For each collected specimen, the total length (TL, in cm) and total weight (TW, in g) were measured to the nearest cm and 0.01 g precision, respectively. *S. cabrilla* is a simultaneous hermaphrodite species (García-Díaz *et al.*, 1997), which does not allow sex to be determined.

Data analysis

The von Bertalanffy growth parameters were estimated as follows (von Bertalanffy, 1938):

$$TL = L_{\infty} \times (1 - e^{-K(t - t_0)})$$

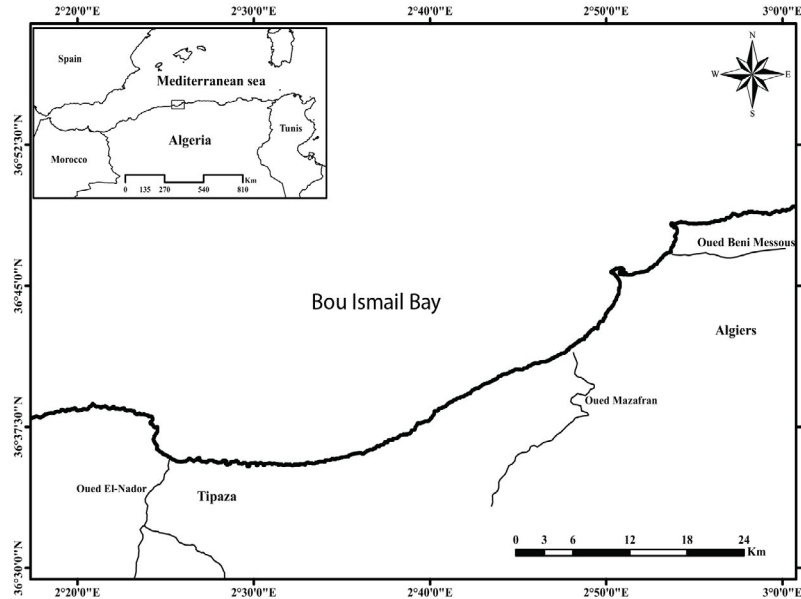


Fig. 1. Bou Ismail Bay on the central coast of Algeria, SW Mediterranean

where TL: fish total length (cm); L_{∞} : asymptotic total length (cm); K: growth coefficient (yr^{-1}) and t_0 : theoretical age when fish has zero length (yr^{-1}).

L_{∞} and K were calculated on the basis of size-frequency distribution with a class interval of 2 cm in total length (Fig. 2), using the ELEFAN I routine integrated into FiSAT II program (Gayanilo *et al.*, 2005).

Pauly's equation (1983) calculates t_0 :

$$\log(-t_0) = -0.3922 - 0.2752 \times \log L_{\infty} - 1.038 \times \log K$$

The phi-prime (ϕ') growth performance index, proposed by Munro and Pauly (1983), compares the growth parameters with previous studies:

$$\phi = \log K + 2 \log L_{\infty}$$

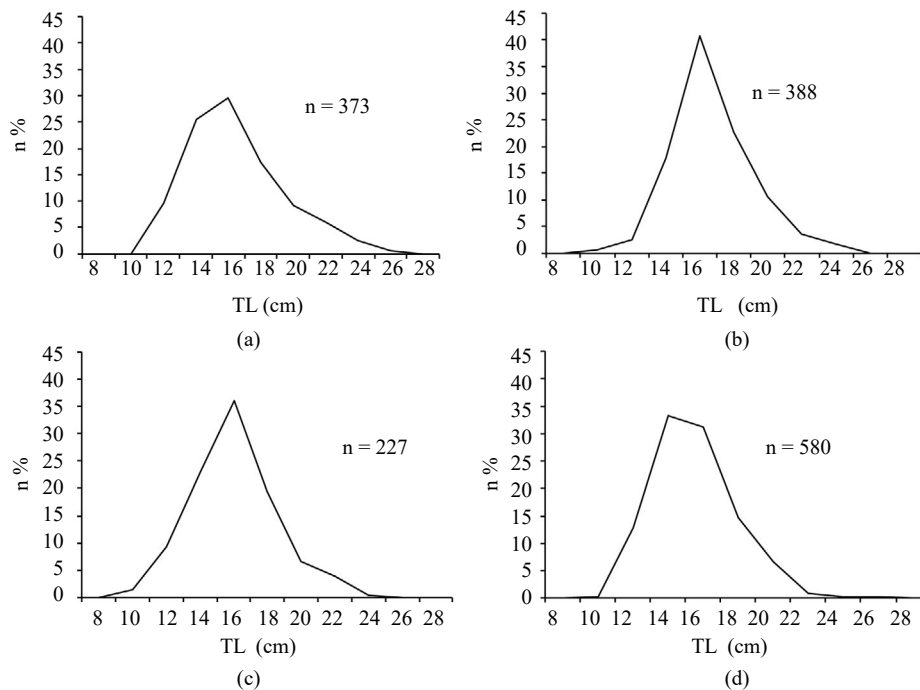


Fig. 2. Seasonal evolution of size-frequency polygons of *S. cabrilla* in Bou Ismail Bay, SW Mediterranean. (a) Winter; (b) Spring; (c) Summer and (d) Autumn

The length-weight relationship was established from 1181 data pairs (TL; TW). This relationship in fishes, considered as an allometric growth model (Le Cren, 1951) is written as:

$$TW = a TL^b$$

where TW: fish total weight (g), TL: fish total length (cm), b: length-weight factor (slope) and a: constant.

Values of the b factor provide information on fish growth (Froese, 2006): when $b > 3$ (positive allometric growth), then there is a significant positive relationship between weight and length which indicates that weight will increase faster with the increase in length.

However, when $b < 3$ (negative allometric growth), it indicates that fish grows faster in length than in weight. When $b = 3$ (isometric growth), the weight of the fish increases proportionally with length. The null assumption of isometric growth ($H_0: b = 3$) was tested by Student's *t*-test, using the following formula (Schwartz, 1992):

$$\text{with: } t = \frac{[b-3]}{S_b}$$

$$S_b = \sqrt{\frac{\left(\frac{S_y}{S_x}\right)^2 - b^2}{n-2}}$$

where S_b is the standard error of the slope for $\alpha = 0.05$ to test significant differences among slopes (b and 3) between two regressions, S_y is the standard deviation of the variable $\ln TW$ and S_x is the standard deviation of the variable $\ln TL$.

The instantaneous total mortality rate (Z) was estimated by length converted catch curve method using the FiSAT II program (Gayani et al., 2005). Natural mortality (M) was calculated from the empirical formula proposed for the Mediterranean fishes by Djabali et al. (1993):

$$\log M = 0.736 - 0.114 \times \log L_\infty + 0.522 \times \log K - 0.583 \times \log T$$

where L_∞ and K are parameters from the von Bertalanffy equation and T is the mean annual bottom temperature between 0 and 100 m, $T = 18^\circ\text{C}$ (MEDAR Group, 2002).

Fishing mortality (F) was obtained with the formula: $F = Z - M$ and the exploitation rate E was estimated by dividing fishing mortality on total mortality (Z). The exploitation rate indicates whether the stock is underexploited ($E < 0.5$) or overexploited ($E > 0.5$), based on the assumption that the stock is optimally exploited when $F = M$ or $E = 0.5$ (Gulland, 1971).

Results and discussion

Growth parameters

A total of 580 individuals were collected in fall, 388 during spring and 373 in winter. The total length ranged from 9.3 to 26.2 cm TL and total weight from 10.34 to 221.56 g. The smallest one was sampled in spring and the largest in winter. Specimens were more abundant in sizes between 14 and 16 cm TL during most seasons (Fig. 2).

Growth parameters of *S. cabrilla* are shown in Table 1. In Bou Ismail Bay, the values of asymptotic length (L_∞) and growth rate (K) were 32.8 cm and 0.41 yr^{-1} , respectively and the value obtained from the growth performance index (ϕ') was 2.64 yr^{-1} .

The von Bertalanffy equation determined for *S. cabrilla* is represented by the following formula and its curve is illustrated in Fig. 3.

$$TL = 32.8 [1 - e^{-(0.41(t + 0.39))}]$$

Length-weight relationship

The relationship between total length and total weight (Table 2 and Fig. 4) was:

$$TW = 0.012 TL^{2.963}$$

According to the *t*-test, we observed an isometric growth of this species in Bou Ismail Bay ($b = 2.963$; $S_b = 0.024$; $r^2 = 0.93$; $\alpha = 0.05$; $t = 1.55 < 1.96$): the weight of this fish increased proportionally with its length.

The growth in weight of *S. cabrilla* can be described by the following model:

$$TW = 372.15 [1 - e^{-0.41(t + 0.39)}]^{2.963}$$

Table 1. Growth parameters (L_∞ , K, t_0) of *S. cabrilla* in the Mediterranean Sea and the Atlantic Ocean

Authors	Region	N*	Length range (cm)	L_∞^* (cm)	K* (yr^{-1})	t_0^* (yr^{-1})	ϕ'^* (yr^{-1})	Method
Bouain (1983)	Tunisia	-	-	31.85	0.095	- 1.48	1.98	Scales
Tserpes and Tsimenides (2001)	Cretan Shelf Greece	1004	6.3-19.7	22.29	0.39	- 0.59	2.29	Otolith
Torcu-Koc et al. (2004)	Edremit Bay Turkey	595	8.6-22.3	33.6	0.11	- 3.17	2.10	Otolith
Ilhan et al. (2010)	Aegean Sea	1452	7.4-22.5	23.88	0.298	- 1.58	2.23	Otolith
Gordo et al. (2016)	Eastern Atlantic	471	12-26.5	25.26	0.21	- 1.72	2.13	Otolith
Rachedi and Dahel (2019)	Gulf of Annaba Algeria	1250	11-23.9	24.94	0.38	- 0.45	2.37	ELEFAN I
This study	Bou Ismail Bay	1568	9.3-26.2	32.8	0.41	- 0.39	2.64	ELEFAN I

*N: Number of specimens; L_∞ : Asymptotic total length; K: Growth coefficient; t_0 : Theoretical age when fish has zero length; ϕ' : Performance index



Fig. 3. Estimated mean growth curve in length of *S. cabrilla* in Bou Ismaïl Bay, SW Mediterranean

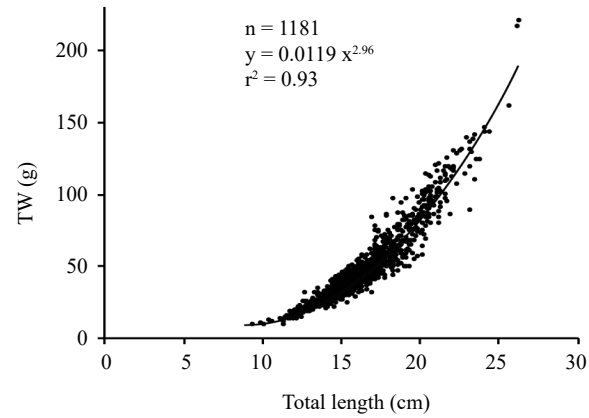


Fig. 4. Length-weight relationship of *S. cabrilla* from Bou Ismaïl Bay, SW Mediterranean

Table 2. Length-weight relationship parameters of *S. cabrilla* in the Mediterranean Sea and the Atlantic Ocean

Authors	Region	N*	Length range (cm)	a*	b*	r ²	Type
Gonçalves <i>et al.</i> (1997)	Portugal	171	12-30.2	0.00007	2.66	0.91	Negative allometry
Merella <i>et al.</i> (1997)	Balearic Islands	23	7.2-18.6	0.016	2.82	0.99	Isometry
Moutopoulos and Stergion (2002)	Aegean Sea Greece	466	9.5-25.1	0.01867	2.81	0.93	Isometry
Torcu-Koc <i>et al.</i> (2004)	Edremit Bay Turkey	595	8.6-22.3	0.0311	2.67	0.88	Negative allometry
Ilhan <i>et al.</i> (2010)	Aegean Sea Turkey	1452	7.4-22.5	0.0111	2.99	0.98	Isometry
Ozvarol (2014)	Gulf of Antalya Turkey	52	9-18.5	0.0091	3.048	0.960	Positive allometry
Gordo <i>et al.</i> (2016)	Eastern Atlantic	471	12-26.5	0.0097	3.05	0.94	Isometry
Rachedi and Dahel (2019)	Gulf of Annaba Algeria	1250	11-23.9	0.008	3.066	0.89	Isometry
This study	Bou Ismaïl Bay	1181	9.3-26.2	0.0119	2.96	0.93	Isometry

*N: Number of specimens; a: Constant; b: Length-weight factor

Mortality and exploitation rates

The instantaneous total mortality rate (Z) calculated by the lengths converted catch curve was 2.63 yr^{-1} . The value of natural mortality (M) calculated from Djabali's equation (1993) was 0.43 yr^{-1} and the fishing mortality rate was $F = 2.2 \text{ yr}^{-1}$. The calculated exploitation rate of the population was $E = 0.84$.

Discussion

This study is the first of its kind to give results on the growth parameters of *S. cabrilla* from the central coast of Algeria. It was based on length-frequency data which can, provide valuable information on the life history of fish species (Pauly, 1987).

The minimum individual size (TL = 9.3 cm) is bigger than the minimum size found in the Eastern Mediterranean (TL = 6.3 cm; Tserpes and Tsimenides, 2001). The largest measured specimen (26.2 cm in TL), is larger than the largest one reported in the Mediterranean, TL = 25.1 cm (Moutopoulos and Stergion, 2002); it is the biggest to date in the Mediterranean Sea for the species. However, it is smaller than the Atlantic specimen (TL = 30.2 cm) reported by Gonçalves *et al.* (1997).

The von Bertalanffy growth parameters of *S. cabrilla* estimated by the ELEFAN I method in the Bay of Bou Ismaïl are quite different from those of the Eastern Mediterranean and the Eastern Atlantic (Table 1), which were based on otolith readings (Tserpes and Tsimenides, 2001; Torcu-Koc *et al.*, 2004; Ilhan *et al.*, 2010 and Gordo *et al.*, 2016).

The estimated asymptotic length was $L_{\infty} = 32.8 \text{ cm}$ and the growth coefficient K value was 0.41 yr^{-1} . Asymptotic length is bigger than the maximum observed size during our survey (26.2 cm) and bigger than Taylor's approximation (1958 in Pauly, 1984): $TL_{\text{max}}/0.95 = 27.58 \text{ cm}$. It is close to what was found in the Bay of Edremit by Torcu-Koc *et al.* (2004) and in the Tunisian coast by Bouain (1983), however it is higher than those calculated by Tserpes and Tsimenides (2001) and Ilhan *et al.* (2010) in the Eastern Mediterranean; Gordo *et al.* (2016) in the Atlantic and by Rachedi and Dahel (2019) on the east coast of Algeria (Table 1).

The value of the growth performance index (ϕ' = 2.64 yr^{-1}) is slightly bigger than those found in other regions: 2.13 in the Atlantic Ocean (Gordo *et al.*,

2016); 2.29 (Tserpes and Tsimenides, 2001) and 2.10 (Torcu-Koc *et al.*, 2004), 2.23 (Ilhan *et al.*, 2010) in the Western Mediterranean. This would indicate that *S. cabrilla* of the central coast of Algeria grows faster than in the other regions. As for variable minimum and maximum lengths in the different areas, fluctuations in growth parameters (L_{∞} , K) can be explained by variations in the environmental and the ecological factors (temperature, mortality and food availability) from one area to another (Korcu-Koc *et al.*, 2004).

We must consider that different techniques have been used in the regions studied (Bouain, 1983; Tserpes and Tsimenides, 2001; Torcu-Koc *et al.*, 2004; Ilhan *et al.*, 2010; Gordo *et al.*, 2016). The methodology used in each region also explains the differences between the obtained results.

The allometry coefficient “b” was 2.963. Similar results have been reported by Ilhan *et al.* (2010) and Moutopoulos and Stergion (2002) in Aegean Sea, by Gordo *et al.* (2016) in Portugal and by Rachedi and Dahel (2019) in the Gulf of Annaba. Unlike those obtained by Torcu-Koc *et al.* (2004) in Edremit Bay and by Goncalves *et al.* (1997) in Portugal, which showed negative allometric growth. Ozvarol (2014) in the Gulf of Antalya presented positive allometric growth for the species (Table 2). In general, the b parameter is subject to changes due to sample size, environmental factors and seasonality (Froese, 2006).

Growth and mortality estimations are important for understanding population dynamics (Ralston and Williams, 1988). We estimated the natural (M) and total mortality (Z) at 0.43 and 2.63 yr⁻¹, respectively. The estimated M value was close to the value obtained in other regions. Gordo *et al.* (2016) reported a total mortality rate between 0.44 and 0.48 yr⁻¹ in the eastern Atlantic (Portugal), Tserpes and Tsimenides (2001) reported 0.35 yr⁻¹ at the Cretan Shelf (Greece) and Torcu-Koc *et al.* (2004) obtained 0.32 yr⁻¹ in Edremit Bay (Turkey). On the other hand, the value of natural mortality (M = 0.81 yr⁻¹) obtained by Rachedi and Dahel (2019) in the Gulf of Annaba was higher than the value obtained in this study. In fact, according to Sparre and Venema (1996) values of natural mortality coefficients for the same species may be different in distinct areas, depending on the density of predators and competitors whose abundance is otherwise influenced by fishing activities. Even small changes in growth parameters could seriously affect the calculated mortality (Tserpes and Tsimenides, 2001).

The resulting exploitation rate, E = 0.84, is higher than the optimal value (0.5) mentioned by Gulland (1971). Hence, the comber stock of this species is overexploited

in the study region. This situation could have an impact on recruitment if individuals are caught during the reproduction period (Sossoukpe *et al.*, 2013).

Our study was carried out in order to estimate the growth and the exploitation parameters of the comber *S. cabrilla* from Bou Ismail Bay, Algeria. The determined parameters are necessary for the stock assessment and management of this species in the central coast of Algeria. The inshore fishery for the comber *S. cabrilla* in Bou Ismail Bay targets mainly individuals between 14 and 16 cm in total length (59.95%), while larger (24-26 cm) and smaller individuals (9-11 cm) are caught in smaller proportions (1.66%). The length-weight relationship of this species shows that growth in length and weight is isometric (a = 0.0119, b = 2.96, r² = 0.93). The calculated exploitation rate (E = 0.84) reflects a possible overfishing situation. The situation is alarming and the authorities must act immediately in order to preserve the species in the central coast of Algeria.

Acknowledgments

The authors are deeply indebted to all those who helped in collection of fish samples.

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Date of Receipt : 14.05.2020

Date of Acceptance : 15.06.2021