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Some parameters of growth, mortality and exploitation rate of round sardinella, *Sardinella aurita* Valencienne, 1847 (Pisces Clupeidae), fished in Oran bay (Algeria)

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ABSTRACT

Growth and mortality parameters of *Sardinella aurita* Valencienne, 1847 (Pisces Clupeidae) were estimated based on length frequency distribution data. A total of 894 sardinella were collected between march 2008 and March 2009, from Oran bay (Algeria). The parameter b in the present study (W = a. Ltb) is 3.1 and indicates that *S. aurita* had major allometric growth. The von Bertalanffy growth parameters were estimated by using the software FISAT II and showed that the asymptotic length (L ∞) is = 34.21 cm for females and 33.68 cm for males. The growth coefficient (K) is 0.47(1/year) for females and 0.39(1/year) for males. The value of total instantaneous rate of mortality (Z) is 2.41 and the natural mortality rate (M) is 0.79. The fishing mortality was obtained by F=Z - M = 1.62 year -1. The exploitation rate (E) is 0.67 year -1 and indicates that the stock of *S. aurita* from Oran waters is in overexploitation state.

KEY WORDS Bay of Oran; exploitation; growth; mortality; *Sardinella aurita*.

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INTRODUCTION

The round sardinella, *Sardinella aurita* Valencienne, 1847 (Pisces Clupeidae), is a marine pelagic fish that is widely distributed throughout tropical and subtropical seas including the entire Mediterranean Sea and Black Sea (Froese & Pauly, 2000). Clupeidae are key species in the marine food chain and their presence is needed to maintain the balance of ecosystems (Smith et al., 2011). Sardine fishery is one of the most important fisheries worldwide and one of the most important species of Algerian fisheries. The *S. aurita* is a very common and frequent fish in Algerian coasts (Djabali et al., 1993).

The aim of the present study is to estimate the following parameters: growth, mortality and exploitation rate, which are required for assessing and managing the stock of *S. aurita.*

MATERIAL AND METHODS

Sampling

A total of 894 specimens of *S. aurita* were collected monthly during the period from March 2008 to March 2009, from the commercial catch of Oran coast. Our study area is located in the north-west of Algeria and south-west of the Mediterranean Sea (Fig. 1). The port of Oran is situated at the bottom of gulf, between the tip of the Canastel and Cape Falcon northwest of Ain el Turk (Kerfouf et al., 2010; Keddar et al., 2016).

The total length (TL, in centimeters) and the total weight (TW, in grams) for each specimen were measured. The length frequency distributions were arranged in 1.0 cm intervals. A ichtyometer of 50 cm has been used to determine the size of the fish. When assessing the metric characters, the standard methods of FAO have been applied. The sexes were determined by macroscopic observation of the gonads.

The length frequency distribution of the species was represented by percentage length frequency at intervals of 1 cm. The length frequency data analysis was made to estimate the Von Bertalanffy growth model represented as $L_t = L_\infty$ (1 – exp-k (t-to). Where L_t is the average predicted length at time t, L_∞ is the hypothetical asymptotic length, K the growth coefficient, t_0 the hypothetical time at which fish length equals 0 and t is the age. The growth parameters such as K, L_∞ and t_0 were estimated by the method ELEFFAN using the FISAT II.

Length-weight relationships

The length-weight relationships were determined according to the equation: $WT = aLT^b$; WT is the total body weight (g), LTis the total length (cm), while "a" is constant and "b" is length exponent. The "a" and "b" and "r" values were calculated from linear regression of the fish length and weight measurements, which we express as: Log W= Log a + b Log Lt. The relation is isometric when b=3. If b<3 the allometry is positive and when b>3 the allometry is negative.

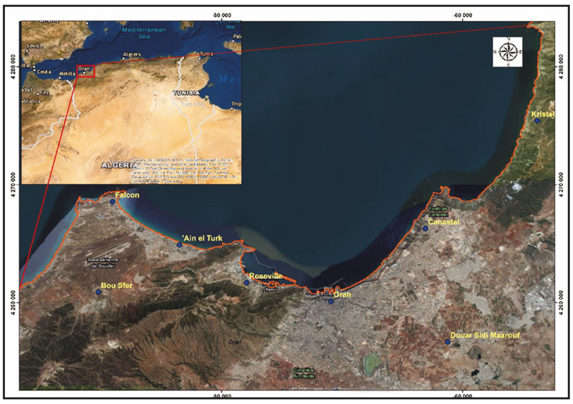

Figure 1. Study area: Oran bay, Algeria.

Fish mortality and exploitation ratio

Determining mortality rates is critical for determining abundance of fish populations. Using the model Z=M+F with M being Natural mortality and F being Fishing mortality, the natural mortality was calculated using Pauly's empirical equation (1980). It assumes that there is a relationship between size and natural mortality. Pauly's method was based on the correlation of M with von Bertalanffy growth parameters (K and L_∞) and temperature (Gunderson, 2002): Log M = - 0.0066 – 0.279. Log L_∞ + 0.6543. Log K + 0.4634. Log T°. Where: L_∞ = asymptotic length, K = growth coefficient, T = average annual temperature of the stock's habitat, in °C, considered at 18 °C for *S. aurita*. The Pauly (1984) method was used to estimate total mortality by using FISAT II (Gayanillo et al., 2005). The exploitation rate was estimated by the formula suggested by Gulland (1971) through the following relation: E = F/Z. Where: E = exploitation ratio, i.e., the fraction of deaths caused by fishing. F = fishing mortality coefficient. Z = total mortality coefficient. This is based on the assumption that a stock is optimally exploited at E = 0.5 when F equals M (Gulland, 1971) - E<0.5 underexploited stock, and E>0.5 overexploited stock.

RESULTS AND DISCUSSION

In this study, 894 individuals are treated, 546 females and 348 males.

The length frequency distribution of *S. aurita* by length and by sex, established monthly for the period from 2008 to 2009, is shown in figure 3. The total length of the samples during the sampling period ranged between 10.7 cm and 32.5 cm. The average length of the females (20.58 cm) is higher than that of the males (19.06 cm). The difference between the average sizes of females and males is significant (ε > 1.96). The minimum lengths are 10.7 cm for the females and 12.2 cm for the males, whereas the maximums are 32.5 cm for the females and 32 for the males. The length-frequency distribution throughout the study period shows a preponderant total length of 15 and 16 cm over others (Fig. 2). The length-weight relationship of *S. aurita* indicated a positive allometry for female and males and was found out to be $WT=0.005\ LT^{3.08}$ for female and WT=0.005 LT 3.12 for males (Fig. 3). The analysis by sex showed a significant difference in the b coefficient. The degree of association between the two variables length and weight, is expressed by a correlation coefficient (r). The correlation coefficient is higher when its value is close to +1. The coefficient is estimated in this study at 0.97 for female and 0.98 for males. The computed annual mortality rates Z, M and F were 2.41, 0.79 and 1.62, respectively. The rate of exploitation (E) was estimated as 0.67, which indicate overfishing during the period of study and that the stock of *S. aurita* is heavily exploited. The maximum size (Lmax) attained by *S. aurita* in Oran waters is 32.5 cm while the smallest specimen measure 10.7 cm. Similar results were found by Bosiljka & Gorenka (2012) on the same species. The maximum size attained by an animal occurs when it grows to 95% of its asymptotic length according to the relationship Lmax = 0.95 $L\infty$ (Moses, 1990). The length distribution of round sardinella indicates that the females were more present in longer length classes, especially in total length classes over than 26 cm; males were more frequent in the smaller ones. Such differences could be explained by lower mortality and higher growth in females than in males (Bosiljka & Gorenka, 2012). The von Bertalanffy model has been shown to have a better fit than other growth equations. In general, growth is affected by a variety of factors, such as food quantity and quality, and temperature

The results showed that the asymptotic length ($L\infty$) of female (34.21 cm) and of male (33.68 cm) appeared to be higher than estimates reported by Chavance et al. (1985), on *S. aurita* caught in Oran bay. Nevertheless, the results are similar to those found by Bebars (1981), Bouaziz et al. (2001) and Dahel et al. (2016) (Table 1). The difference in a symptotique length can also be attributed to the fishing season, geographical reach of fishing activities and subsequently the dominating fish length during each fishing season, noise pollution from outboard motors and industrial activities, fishing pressure and environmental degradation (King, 1991). The estimate for growth coefficient (K) in this study is similar to observations for other populations (Chavance et al., 1985; Amrouche & Etsouri, 2006) (Table 1). Differences in growth patterns may be the result of differences in genetic structure and/or differences in temperature, density of food and diseases (Pauly 1994, Wootton 1998). Rohit et al. (2012) reported, the difference in growth rate can be attributed to several reasons including prevailing eco-biological conditions of the habitat from time to time. The exponent b of the length-weight relationship of the analyzed specimens showed positive allometric growth (b=3.08>3 for female and b=3.12 >3 for males) and indicates that the weight grows slightly faster than the size of the fish. The same values were found for the sardinella of the central region of the Algerian coast (Bouaziz et al., 1998), on the sardinella of the Tunis coasts (Kartas, 1981) and also in the Aegean Sea (Tsikliras et al., 2005). Claro & García-Arteaga (1994) indicate that this species also showed positive allometric growth. Once the growth parameters were known, it was possible to estimate the instantaneous total mortality. In the

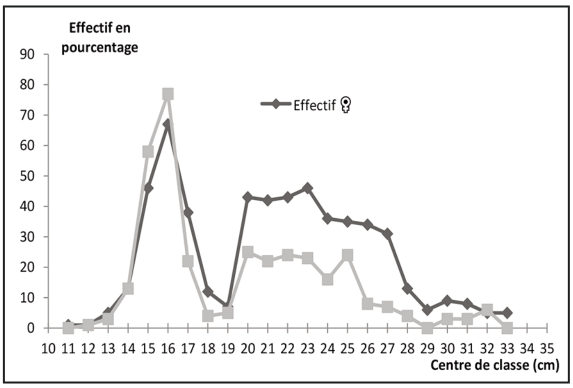

Figure 2. Length-frequency distribution by sex of *Sardinella aurita*.

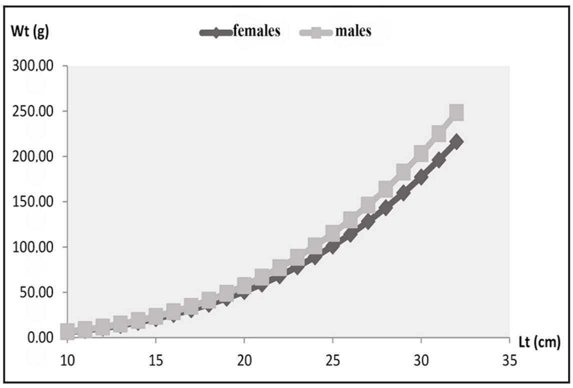

Figure 3. The length-weight relationship of *Sardinella aurita*.

Mediterranean Sea	Sex	L∞	K	T_0	Authors
Egypte	sexes combined	33.11	0.19	-1.34	Bebars (1981)
Algeria	sexes combined	34.96	0.23	-0.707	Bouaziz (2001)
Algeria	sexes combined	26.77	0.45	0	Amrouche & Etsouri (2006)
Oran western coasts	Females Males	25.5 22.9	0.52 0.64	——	Chavance et al. (1985)
Algeria eastern coasts	Females Males	32.26 27.3	0.13 0.18	-1.9	Dahel et al. (2016)
Oran	**Female** **Male**	**34.21** **33.68**	**0.47** **0.39**	**-0.34** **-0.41**	**Present study**

Table 1. Comparison of growth parameters obtained from previous studies for *Sardinella aurita*.

Authors	Study area	Z (an^{1})
Bebars, 1981	Egypte	0.993
Chavance et al., 1985	Oran mâles	1.787
Bouaziz, 2007	Alger	2.51
Amrouche & Etsouri, 2006	Région centre de la côte algérienne	2.4
Sennai, 2003	Ghazaouet	0.96
Present study	Oran	2.41

Table 2. Comparison of total mortality coefficient obtained from previous studies for *Sardinella aurita*.

present investigation, suggested by length frequency distribution, the total mortality (Z), was estimated as 2.41 yr-1. It is defined as the total loss by natural and fishing death of individuals (Table 2).

In this study we observed that the mortality of *S. aurita* is affected more by exploitation of stock. Similar results were found on *S. aurita* of Algiers waters by Bouaziz (2007) and Amrouche & Etsouri (2006).

According to this study, the fishing mortality 1.62 yr-1was significantly higher than natural mortality 0.79 yr-1. The value of the natural mortality (M) obtained is very similar to the results of other authors such as Chavance et al. (1985) and Amrouche & Etsouri (2006). The natural mortality of *S. aurita* can be attributed to environmental stress due to the anthropic activities or to the Fish predation (tuna and other large pelagic fishes) (King, 1984). According to Amrouche & Etsouri (2006), the difference between the natural mortality coefficients can be explained by the climatic conditions of the environment, the season of study, the pollution and the predation. Belveze (1984) describes sardines and sardinella as an unstable and unpredictable species with high natural mortality. In this study, instead, the major cause of mortality of this species is due to fishing activity.

Fishing generally affects the age and length structure of fisheries stocks and fishing induced declines in the length structure (Stergiou, 2002). The present exploitation rate (E = 0.67) is higher than the optimum level (E = 0.5). This indicates the high vulnerability of the species to the fishing gear.

CONCLUSIONS

For a better management of the fishery, some recommendations should be carried out such as: (i) a thorough study of species-gear interactions (Panfili et al., 2002); (ii) conduct scientific fisheries to determine recruitment and selection sizes. In order to ensure sustainable exploitation of *S. aurita* stock, fishing effort should be regulated along with increase in mesh size. Restricting fishing outside the spawning season is considered necessary for sustainable exploitation of these stocks.

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