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Growth and life cycle of the common cuttlefish *Sepia officinalis L.* (Mollusca: Celaphapoda) *in* Bouzedjar bay (Western Algerian Coast)

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Abstract

Life-history traits and exploitation of the common cuttlefish Sepia officinalis L. 1758 on the algerian slope (south-western Mediterranean) have been studied through monitoring of the commercial trawl fishery between January and December 2012. Monthly length frequency distribution of commercial catches showed that the dorsal manttle length (DML) of female ranged between 5 and 26 cm, while males ranged from 6 to 26 cm DML. Females represented more than 55% of the individuals caught, while their monthly development also showed a annual predominance of females. The monthly followed parameters of reproduction were the percentage of each maturity stage, GSI, and Kn. The results obtained reveal that this species reproduces all the year with a strong rate of reproduction in hot season. The length at which 50% of females were mature was estimated as 18.7 cm DML. The length-weight relationship showed a negative allometry for females and males. While the Von Bertalanffy growth parameters differed greatly between them, with values for maximum theoretical size and for the growth coefficient of females (DML_∞ = 59.6mm DML and k = 0.42 $year^{-1}$, respectively) being higher than those for males (DML_∞ = 72.2 mm DML; k = 0.34 $year^{-1}$).

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Introduction

Sepia officinalis L. commonly known as the cuttlefish and is a common Cephalopod Mollusc and is a necto-benthic species of coleoid cephalopod occurring predominantly on sandy to muddy bottoms from the coastline (2-3 m depth) to approximately 200 m depth, but most abundant in the upper 100 m (Guerra, 2006).

Their geographical distribution covers the Mediterranean Sea and the waters of the eastern Atlantic from southern Norway and northern England to the north-western coast of Africa (Roper *et al.,* 1984; Khromov *et al.*, 1998). Its takes a great economic importance due to its commercial value and its landed weight, which gives it a special place among the cephalopod species exploited. In Algeria, it is caught by fishing trawlers and small-scales fisheries. Their catches reached 85 tons in 2012 in the western of Algeria.

The importance of cuttlefish as a global resource of fishing continues to increase, but it's very short life cycle and variable growth rates make its stock volatile and vulnerable. Many studies have been published on the biology, ecology, and fishery of this red species in the Mediterranean. And Atlantic areas: reproductive biology (Onsoy and Salman, 2005; Idrissi *et al.*, 2008; Akyol *et al.*, 2011), diet (Castro and Guerra, 1990; Alves *et al.*, 2006; Neves *et al.*, 2009a), biometrics and population genetics (Shaw and Pérez-Losada, 1999; Perez-Losada *et al.*, 2002; Wolfram *et al.*, 2006).

On the southern Mediterranean coast, the knowledge of the *S officinalis* populations is still fragmentary, since it is limited to some remarks on the species. Therefore the present paper as to provide new information on *S. officinalis* concerning the length frequency distribution, sex- ratio and length-weight relationship, together with and overview of the spawning season because it is important to understand their life cycle and their population dynamics. Such information is essential for assessment and management.

Study area

The hydrodynamic environment of the northern African coast is mainly conditioned by the strong influence of water interchange through the Strait of Gibraltar, a shallow and narrow channel 320 m deep and 14 km wide that connects the Mediterranean to the Atlantic Ocean. This strait allows low-density Atlantic waters to intrude into the Mediterranean as surface waters, while denser Mediterranean waters (high salinity waters resulting from low freshwater supply and high evaporation) travel at mid-depths into the Atlantic Ocean. The inflow of Atlantic water spreads along the Algerian coast, resulting in a general, anti-clockwise flow that forms the Almeria-Bouzedjar front, an anti-cyclonic gyre that joins the Iberian Peninsula to Algeria, and which also has small cyclonic gyres linked to it (Millot, 1999). The Atlantic waters flow into the Algerian sub-basin as the Algerian current, a relatively narrow and deep current, 30-50 km wide and 200-400 m deep at the coast, which becomes thinner (in depth) and wider (in horizontal extension) in an easterly direction (Benzohra and Millot, 1995).

The instability of this current leads to the development of a series of coastal eddies, associated with a non-wind-induced upwelling. The Mediterranean deep waters also flow along the Algerian continental slope with a general anticlockwise circulation, and it is hypothesized that they induce intense currents in the whole deep layer and near the bottom (Millot *et al.*, 1997).

According to the FAO, the most important fishing activity in Algeria during the 1990s was targeted at small pelagic species, which represented 75% of the landings.

Materials and methods

From January 2012 to December 2012, monthly random samples of cuttlefish were studied. A total of 959 specimens was measured and analysed in the laboratory. The specimens were measured (Dorsal mantle lenght: DML, in cm), weighed (g), and sexed. For females, the maturity stage was determined and the gonad weight was also obtained. Maturity was determined by macroscopic observation, and six gonadal stages were adopted. Two biological indices were estimated for each single female sampled: gonado-somatic index (GSI), as a percentage of gonad weight in relation to total weight, and relative condition index (K_n), as the observed weight in relation to the expected weight, estimated from the length-weight relationship by considering all data (Le Cren,1951). A monthly length-frequency distribution of catches was also estimated separately for females and males.

The sex-ratio was calculated for the whole population, and also by size class and month, as the percentage of females in the total number of individuals. In each case, the χ^2-test was used to assess the predominance of sexes. For females, the percentage of each maturity stage, GSI, and K_n were estimated by month.

The percentual maturity by length was estimated considering only data obtained during the period of maximum reproductive activity of females. The length at which 50% of the females presented spermatophores was also estimated for the whole year. Both curves were modelled using the generalized logistic curve:

$$SL = \frac{e(S1 + S2 * L)}{1 + e(S1 + S2 * L)}$$

The adjustment was undertaken following the non-linear least squares estimation, using the STATISTICA software (StatSoft Inc., 2001). Monthly length frequency distributions of commercial catches were estimated separately by sex. Length-weight parameters were calculated by sex, applying the potential relationship:

$$W = a * DML^b$$

Where W is the total fresh weight (g), DML is the length (cm), and *a* and *b* are the parameters to be estimated, with *b* being the coefficient of allometry.

For the estimation of size-age relationship, the Von Bertalanffy growth function (VBGF) was used:

$$L_t = L\infty(1 - e^{-k(t - t_0)})$$

Where DML_∞ is the maximum theoretical size (cm DML), L_t is the size (cm DML) at age t (years), *k* is the growth coefficient ($years^{-1}$), and t_0 is the theoretical age at which the size is zero. For the estimation of these parameters, the LFDA program. (Kirkwood *et al.*, 2001) was applied to monthly length frequency distributions of catches, using the ELEFAN method and taking the "best combination" (score) of the parameters.

Results

In the cuttlefish catches from the commercial trawl fishery, males predominated over males (57 and 43%, respectively; χ^2 -test, $p < 0.005$). Their monthly length frequency distribution by sex [table. 1] showed a clear predominance of females in 2012. The length range of females caught was 8-16 cm DML, predominating (fig. 1).

Table 1. Global Sex-ratio of common cuttlefish *Sepia officinalis L.* caught in the commercial trawl fishery by the results of the χ^2 -test are also shown (* : $p < 0.05$).

Sex	*Number*	*Percentage %*
Females	522	54 *
Mâles	437	46
Total	959	100

The monthly development of the sex-ratio also showed a annually predominance of females (fig. 2).

Ripening gonads of females reveal that this species reproduces all the year with a strong rate of reproduction in hot season (fig.3a). The GSI of females also showed a clear peak between June and August, while their Kn was at a minimum from May to

September (fig. 3b, 2c). Female L50 lengths were estimated at 18.5 DML (fig. 4).

The results of the length-weight relationship by sex showed similar values of b for females and males, both <3 [table 2] (Fig 5a, b). By contrast, the Von Bertalanffy growth function gave high differences by sex [table 3], with values of DML∞ and k for females higher than for males.

Table 2. Parameters of the Von Bertalanffy growth function (DMLL∞: maximum theoretical size of DML; k: growth coefficient; t0: theoretical age at which the size is zero) for *S. officinalis.*

Sexe	L∞ (cm)	K (an^{-1})	t_0
Females	59.6	0.19	-0.42
Males	72.2	0.34	-0.67

Table 3. Parameters of the length-weight relationship for *common cuttlefish Sepia officinalis L*: W = a • CLb ; where W is the total fresh weight (g) and CL is the carapace length (mm). The determination coefficient values (r2) and the number of individuals measured (n) are also shown.

Sexe	a	b	r^2
Females	0.003	2.894	0.916
Males	0.001	2.828	0.920

Discussion

This study completes the description of the growth and reproductive biology female in the algerian water. The results allow us to observe that they do not differ to those obtained in other regions.

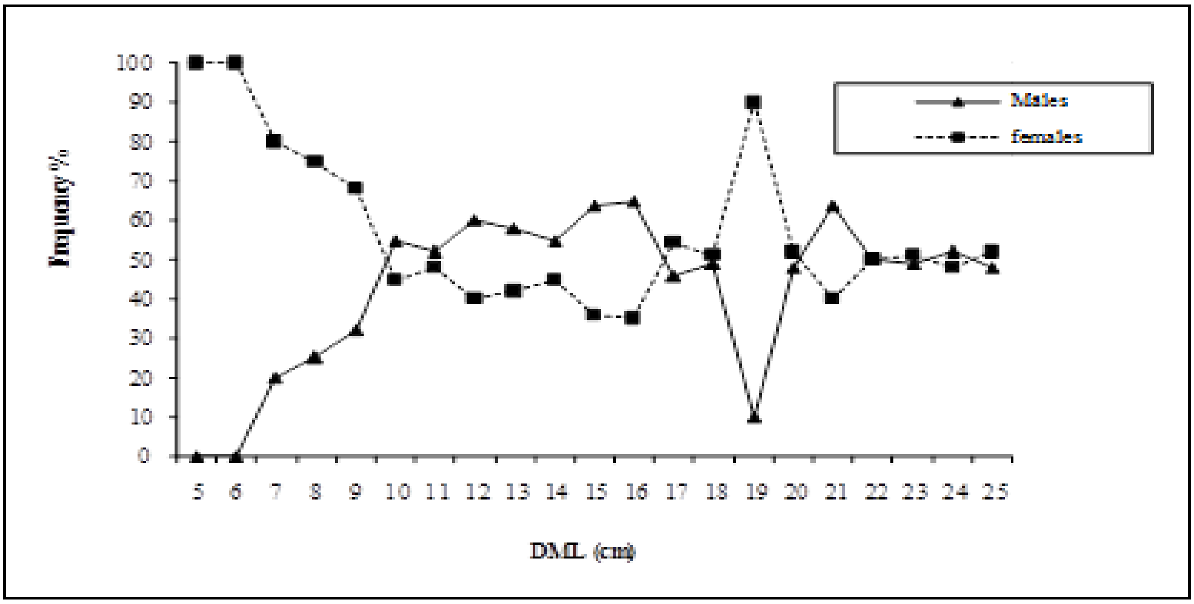

Fig. 1. Sex-ratio (females: circles; males: squares) of common cuttlefish *Sepia officinalis L.* caught in the commercial trawl fishery. The results of the χ 2 -test are also shown (* $p < 0.05$).

The monitoring of the evolution of the gonado-somatic index, and condition index (kn) during the year 2012 shows a minimum value from October to December. The study by Manfrin Piccinetti and Giovanardi (1984) shows evidence of a spawning period which extends all year with a peak in spring and summer.

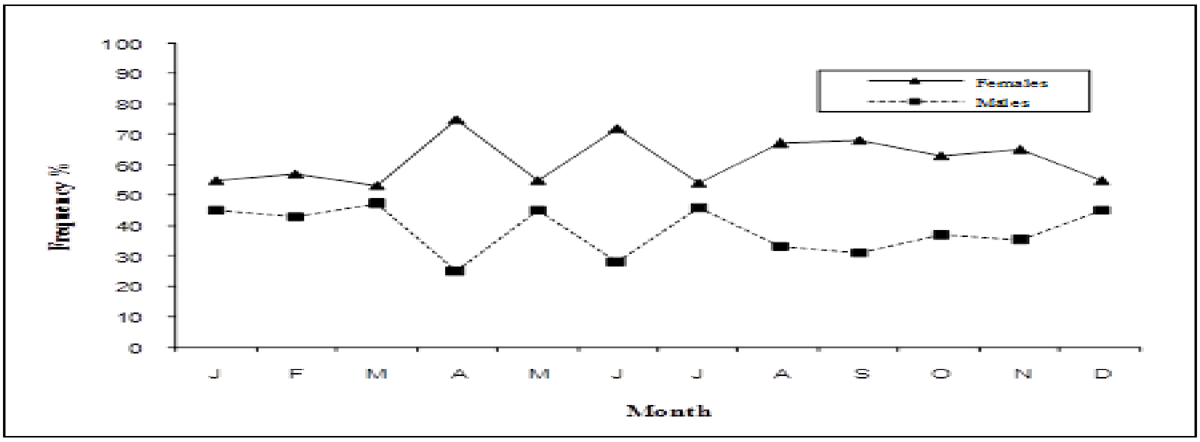

Fig. 2. Sex-ratio (females: circles; males: squares) of common cuttlefish *Sepia officinalis L.* caught in the commercial trawl fishery. The results of the χ 2 -test are also shown (* p < 0.05; white symbols: p > 0.05).

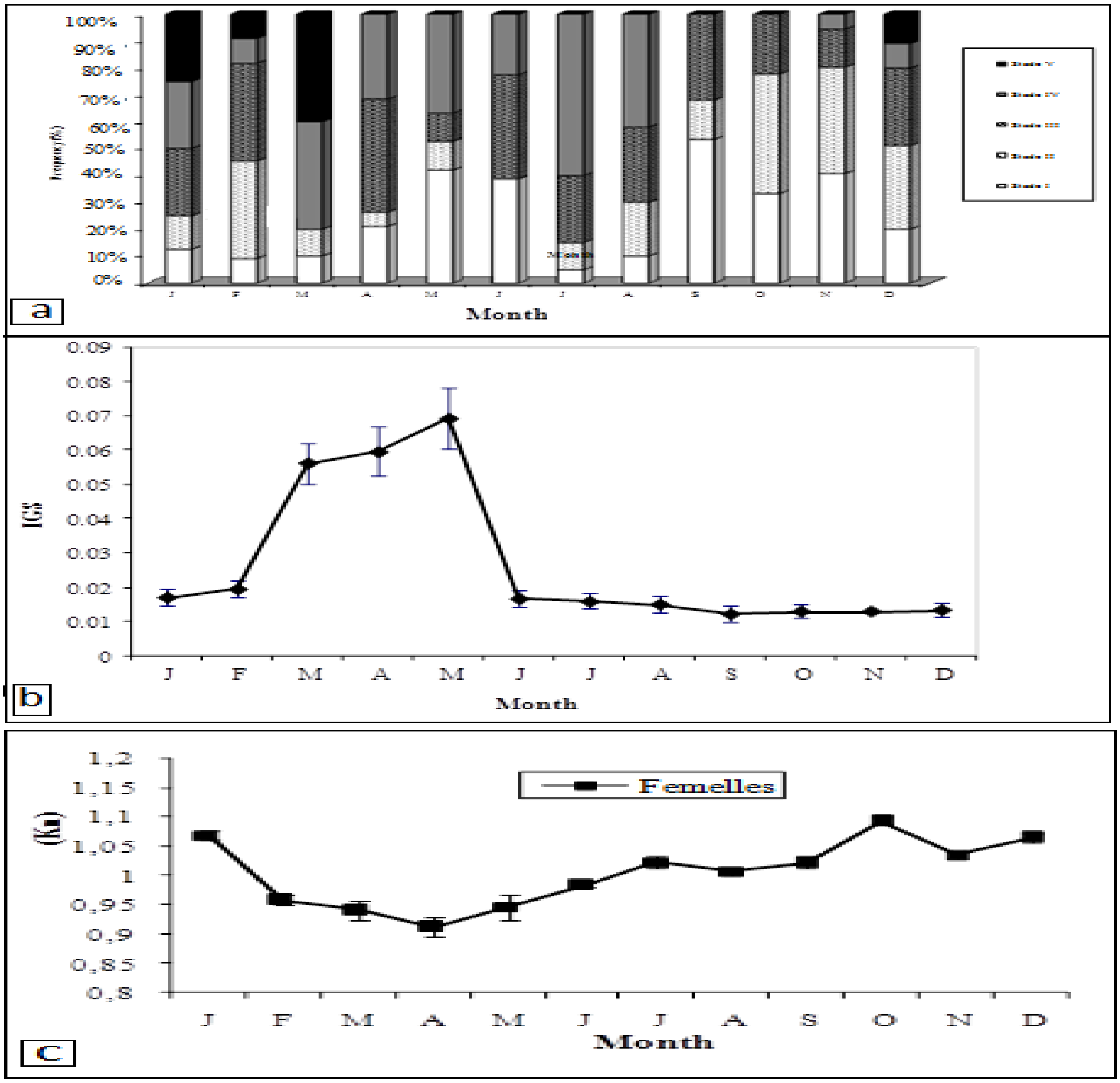

Fig. 3. Monthly values of common cuttlefish *Sepia officinalis L.*f or: a, percentage of each maturity stage for females; b, mean gonadosomatic index (GSI) for females; c, mean Le Cren index (Kn) for females, Error bars represent the standard error.

Their results indicate spawning extending from February to October with a peak from Mars to July. In Adriatic waters, the peak of breeding is found to be in June-July off the coast of Portugal (Jorge and Sobral, 2004).

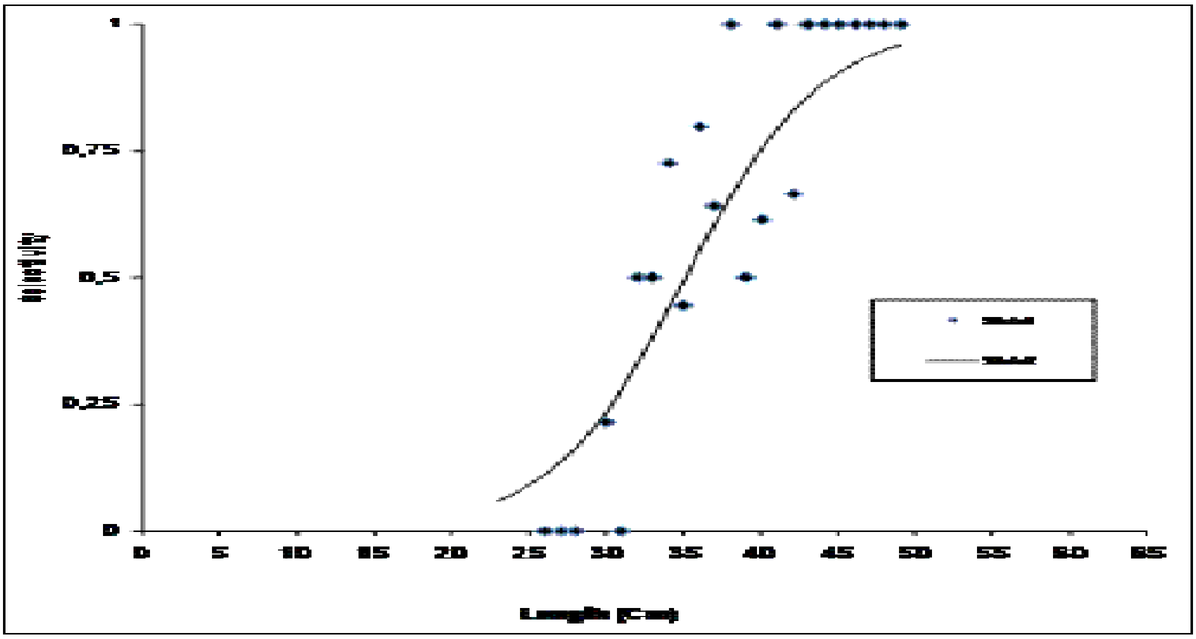

Fig. 4. Observed (points) and theoretical (lines) values of common cuttlefish *Sepia officinalis L*) percentages for mature females (diamonds and continuous line).

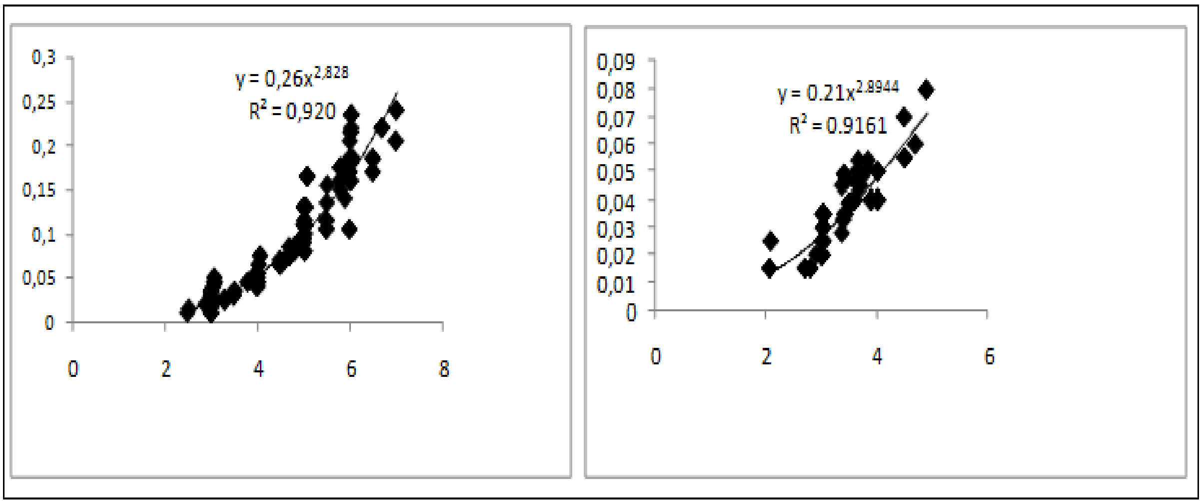

Fig. 5. Parameters of the length-weight relationship for common cuttlefish *Sepia officinalis* $LW = a \bullet CL^{b}$; where W is the total fresh weight (g) and CL is the carapace length (mm).

The parameters of the relationship between size and weight of *S. officinalis* in Bouzedjar are comparable to those obtained by other authors (Dunn, 1999).Dunn (1999) obtained a very similar value of parameters for *S. officinalis* to ours for males but a much lower value for females. Ezzedine-Najai (1997) obtained a K value of 0.429 an^{-1} in the Gulf of Tunisia. The different seasonal values of K are consistent with the observations made by Richard (1971), Jeon (1982), Boletzky (1983), and Medhioub (1986). These authors report that the growth of *S. officinalis* is variable and depends on the water temperature, sexual maturation, food availability and decreased filling of the stomach during the breeding season.

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