



## First data on reproduction and growth parameters of the cuttlefish (*Sepia officinalis* L.) in Oran bay (Western Algeria coasts)

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### Abstract

This study presents the first data of growth and reproduction parameters of cuttlefish (*Sepia officinalis*) fishing in Western coasts of Algeria, in Oran. Such information is essential for assessing commercial potentialities of its stock, life history, and actual management of its fishery. For this purpose, a total of 581 cuttlefish, including 328 females and 253 males were collected monthly from January to December 2013. Cuttlefishes were measured, weighed, maturity assessed, and reproductive systems were removed and investigated in the laboratory. Length at first sexual maturity was determined following the length class in which at least 50% of the cuttlefish specimens were sexually mature. Spawning periodicity was determined studying the monthly gonadosomatic index (GSI). The estimated parameters of growth using the equation of Von Bertalanffy were  $L_{\infty} = 60$  cm;  $K = 0.16$ ;  $t_0 = -0.35$  for females and  $L_{\infty} = 75$  cm;  $K = 0.29$ ;  $t_0 = -0.69$  for males. According to the length-weight relationship; allometry is negative for both males and females. The female-male ratio was 1.3:1. The size at first maturity was estimated as 9.2 cm for females and 8.9 cm for males. Monthly values of the gonadosomatic index suggest that the spawning period of this species occurs between February and April, with a peak in March for females and between March and May, with a peak in April for males.

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## Introduction

The common cuttlefish, *Sepia officinalis* L. 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 (Roper *et al.*, 1984). 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.

The importance of cuttlefish as a global resource of fishing continues to increase, but its very short life cycle and variable growth rates make its stock volatile and vulnerable. Several studies has been devoted to the study of the biology of the common cuttlefish (*S. officinalis*) on several Mediterranean and Atlantic areas on different aspects: 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). However, in Western coast of Algeria, no scientific studies on growth and reproduction parameters of this species have been published. While it is necessary to dispose detailed scientific information on its biology for a better management of its stock.

The present study is a description of the reproductive biology and growth parameters of the cuttlefish (*S. officinalis*) based on the samples collected. The study aims to provide information on length frequency distribution, sex ratio, length-weight relationship, size at maturity, the spawning season and discuss the reproductive strategies of the cuttlefish in the Western coast of Algeria.

## Materials and methods

### Data collection

*S. officinalis* specimens used in this study were sampled monthly from Oran bay (western coasts of Algeria), between January 2013 and December 2013.

However, *S. officinalis* was not found in July and August. The cuttlefish were caught by commercial trawlers. In total, 581 specimens, 328 females and 253 males were sampled and treated in detail at the laboratory (AQUABIOR).

The length of dorsal mantle (ML) of sampled individuals was measured to the nearest millimeter. The total body wet weight (BW), the gonad mass (GW) and the digestive gland weight were taken to the nearest 0.1 g. Stages of maturity were determined macroscopically using gonad stage scale stated by Lipinski (1979) (Table 1).

### Growth parameters

Growth was expressed in terms of Von Bertalanffy equation:

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

Where  $L_t$  is the length (ML in mm) at growth time  $t$ ,  $L_{\infty}$  the asymptotic length,  $K$  the von Bertalanffy growth coefficient and  $t_0$  is the theoretical age at which the size is zero. The model was estimated from the analysis of the distribution frequency of size using the LFDA program (length Frequency Distribution Analysis). The method used is ELEFAN, based on the algorithm described by Pauly (1987).

### Length-weight relationships

The relationship of size - weight was fitted to the equation:  $BW = a ML^b$ , where  $BW$  is the weight of cuttlefish (g),  $ML$  the dorsal mantle length of the cuttlefish (mm),  $a$  constant and  $b$  the rate of allometry, parameters  $a$  and  $b$  of the length-weight relationship was estimated by linear regression analysis based on logarithms:

$$\log(BW) = \log(a) + b \log(ML)$$

The ratio of allometric  $b$  varies from 2 to 4, but it is most often close to 3. Isometry growth  $b = 3$  (the specific density of the animal not changes). Positive allometry  $b > 3$ , the weight of cuttlefish increases faster than its length. Negative allometry  $b < 3$ , the cuttlefish weight increases slower than its length.

### Sex ratio

The sex ratio was calculated monthly and annually. It's the proportion states of male to female cuttlefish in a population and indicates the dominance of sex of species in a given population.

### Length at first sexual maturity

The size at first maturity was estimated separately for each sex according to the percentages of mature specimens by length class.

### Gonadosomatic index

The gonadosomatic index (GSI) was calculated for both sexes, as follows:

$$\text{GSI} = (\text{Weight of gonad} / \text{Weight of cuttlefish}) * 100$$

The average gonadosomatic index values were calculated monthly to determine the period for reproduction.

### Digestive gland index

The condition of the whole individuals was determined by following the monthly evolution of the digestive gland index, according to Cortez *et al.*, (1995).

$$\text{DGI} = (\text{Weight of digestive gland} / \text{Weight of cuttlefish}) * 100.$$

### Statistical analysis

All data were expressed as mean  $\pm$  standard deviation and were statistically compared by one way variance analysis or ANOVA 1 (gonadosomatic index) and by non parametric variance analysis of Kruskal-Wallis and Mann-Whitney *U*-test (digestive gland index) (d'Hainaut 1975a, 1975b). Significant deviations from the 1:1 sex-ratio were tested using a Chi-square ( $\chi^2$ ) test.

## Results and discussion

### Size structure of cuttlefish population

Dorsal mantle length (cm) of all sampled individuals ranged from 6.5 to 23.8 cm, and the body weight (g) between 55 and 1360 g.

**Table 1.** Gonad maturity scale used for *Sepia officinalis*.

Stage	Males	Females
I	Gonad very small and difficult to find	Gonad very small and difficult to find
II	Gonad translucent	Gonad translucent or whitish, with no structure visible, Nidamental glands enlarged. Accessory nidamental glands appear white enlarged.
III	Gonad appears enlarged. No particles visible in Needham's sac	Gonad no longer translucent, and some structure visible. Nidamental glands further enlarged. Accessory nidamental glands appear beige-yellow.
IV	Gonad large. Spermatophores visible in Needham's sac	Gonad large and many eggs visible but may be compressed together in proximal part of oviduct. May be different egg stages in the distal part of the oviduct. Accessory nidamental glands appear orange.
V	Spermatophores in gonoduct. Few or no spermatophores visible in Needham's sac	As above but almost all eggs are large, most in the proximal part of the oviduct. Accessory nidamental glands may appear red.
VI	Spent	Spent

The length frequency showed that the most important class sizes in our sample were between 10 and 12 cm for both sexes (Fig. 1). Akyol *et al.* (2011) reported that the mantle length of all individuals of cuttlefish was varied from 5.5 to 22.4 cm, with a peak mantle length frequency at 11-12 cm in Izmir bay. While in Iskenderun bay, Duyzak *et al.* (2014) reported that the 9.0-9.9 cm size classes was highly representative

in the study and ML values were ranged from 4.8 cm to 19.2 cm. In the northern Adriatic Sea, the sample sizes of cuttlefish for both sexes were varied from 3.5 to 18.0 cm (Bettoso *et al.*, 2016). In this study, 59% of the caught cuttlefish were lower than 12 cm in mantle length. This can be explained by the over-fishing on the species in the Oran bay. The same observation was reported by Onsoy and Salman (2005) and Akyol *et al.* (2011) in Izmir bay.

### Length-weight relationship

The relationships between total body weight (g) and dorsal mantle length (cm) values of males, females and combined sexes are given in Table 2. The allometric scaling of females and males of *S. officinalis* is lower than 3 indicating a negative

allometric growth. Similar findings have been reported by Bakhayokho (1982) on *S. officinalis* of Senegal, Dunn (1999) in English Channel, Oued Inejih (1990) in Mauritania, Bello (1991) in Balearic Islands and by Abdel Razek (2014) in Eastern Libya.

**Table 2.** Length–weight relationship parameters for both sexes of *Sepia officinalis*.

	a	b	r <sup>2</sup>	n
Males	0.46	2.45	0.94	253
Females	0.44	2.50	0.92	328
Total	0.43	2.49	0.92	581

a: constant, b: the rate of allometry, n: number of cuttlefish.

### Growth

The parameters of Von Bertalanffy growth equation, determined for the overall specimens and females and males separately are shown in the Table 3.

The Von Bertalanffy growth parameters of our study were different from Dunn (1999) funding in English Channel and from Medhioub (1986) in the Normandy coasts.

**Table 3.** Parameters of equation Von Bertalanffy.

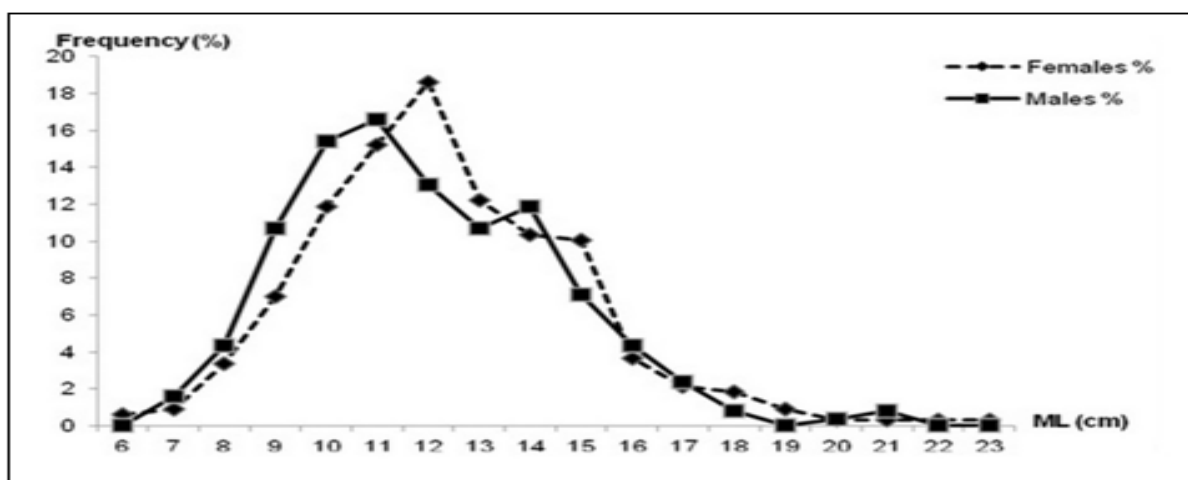
	L <sub>∞</sub>	K	t <sub>0</sub>
Males	75	0.29	-0.69
Females	60	0.16	-0.35
Total	24.64	0.68	-0.97

L<sub>∞</sub>: the asymptotic length, K: the von Bertalanffy growth coefficient, t<sub>0</sub>: is the theoretical age at which the size is zero.

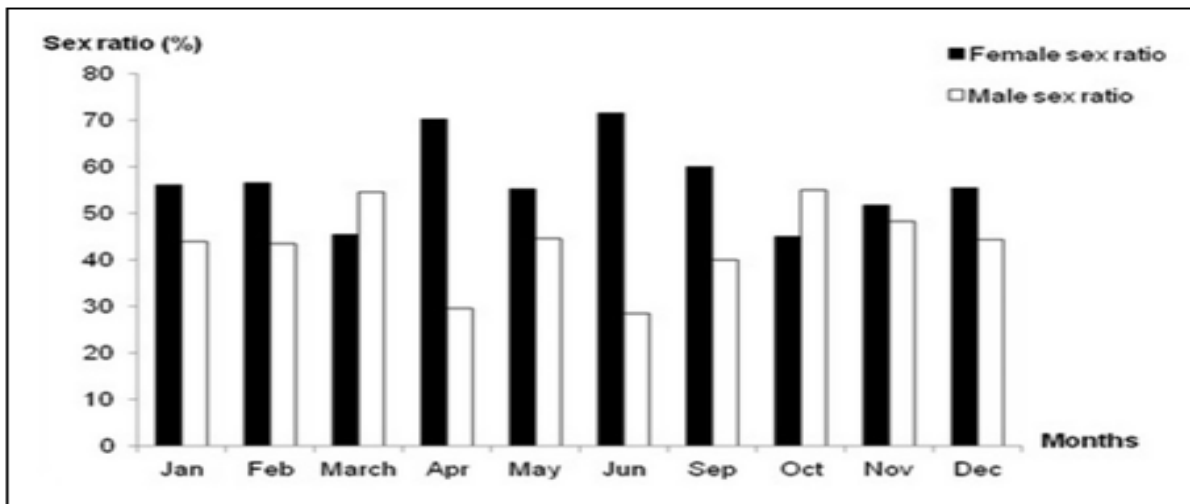
### Sex ratio

Globally sex-ratio, calculated on 581 sexed individuals during the whole sampled period, is significantly ( $p < 0.05$ ) in favor of females with a percentage of 56.45%,

The males averaging about 43.55% individuals observed. Monthly variations in the sex ratio in *S. officinalis* characterized by a predominance of males during October and March, while females predominate during the remaining months (Fig. 2).



**Fig. 1.** Length frequency of cuttlefish *Sepia officinalis*.



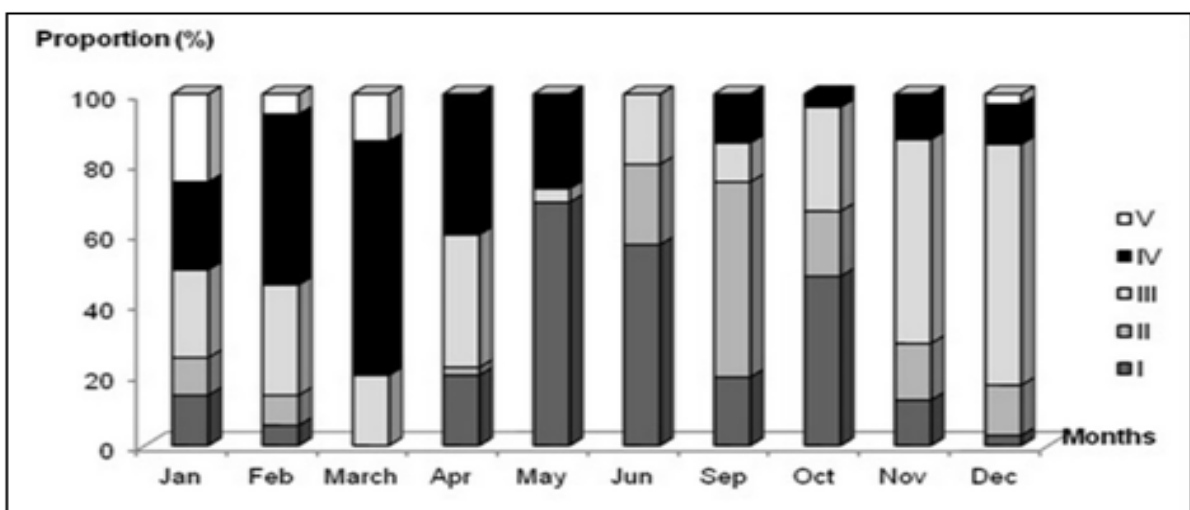
**Fig. 2.** Monthly variation of the sex-ratio of cuttlefish *Sepia officinalis*.

The predominance of females has also been observed by Onsoy and Salman (2005) and Idrissi *et al.* (2008). Whereas males were recorded predominant in Izmir bay (Akyol *et al.*, 2011).

#### Maturation and size at first maturity

The evolution of the different stages of maturation of the gonads during different months of the study is given in Fig. 3 and 4. Mature specimens were observed in all the study period excepting June for both sexes and October for males.

The higher percentage of mature population was observed during February (55.55%; 48.57%), March (55.55%; 66.66%) and April (52.63%; 40%) respectively for females and males. Throughout the year, mature individuals were present; these results suggest that the spawning occurs probably the whole year, with a peak in spring season (March-April). Mangold (1966), Onsoy and salman (2005), Güven and Özbaş (2007) and Duysak *et al.* (2014), reported similar results, in that the population contained mature individuals throughout the year.



**Fig. 3.** Monthly percentage of the maturity stages for females of *Sepia officinalis*.

In this study, the size at which 50% of individuals were sexually matured was found to be at 9.2 cm ML for females (Fig. 5) and 8.9 cm ML for males (Fig. 6).

Whereas, the first maturity length were observed at 10 cm ML, for females in Golf of Tunis (Najai, 1983) and in the bay of Biscay (Gauvrit, 1997), at 8 cm ML

for females, 5.9 cm ML for males from Sado Estuary (Neves *et al.*, 2009b), at 8 cm ML for females, 11 cm ML, for males in Izmir bay (Akyol *et al.*, 2011).

Nevertheless, this size is smaller than that, of 18.65 cm found by Medhibou (1986) in Normandy coast, of 17 cm found by Idrissi *et al.* (2008) in the southern Moroccan Atlantic, of 18.83 cm found by Akesse *et al.* (2016) in Ivory Coast.

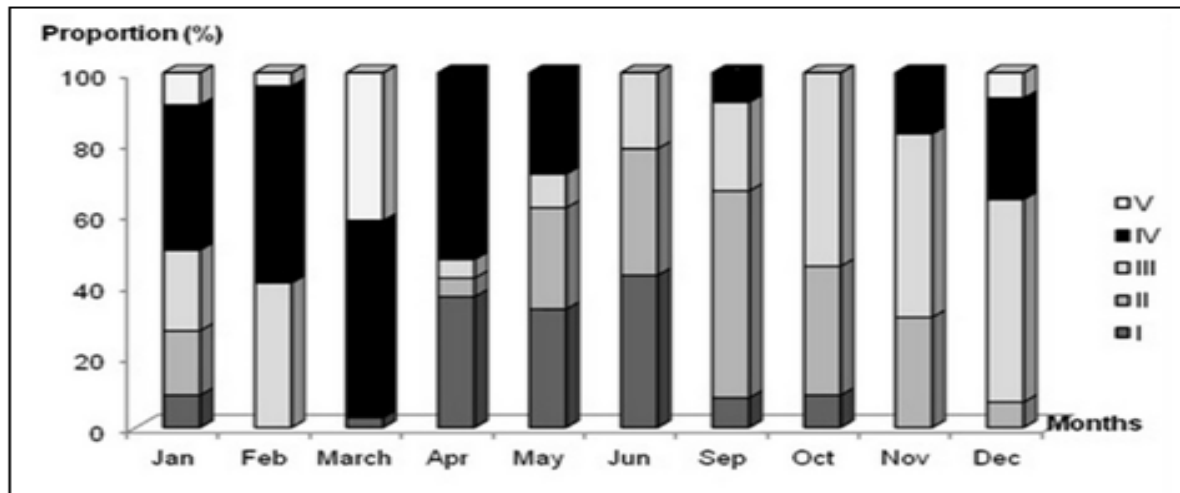


Fig. 4. Monthly percentage of the maturity stages for males of *Sepia officinalis*.

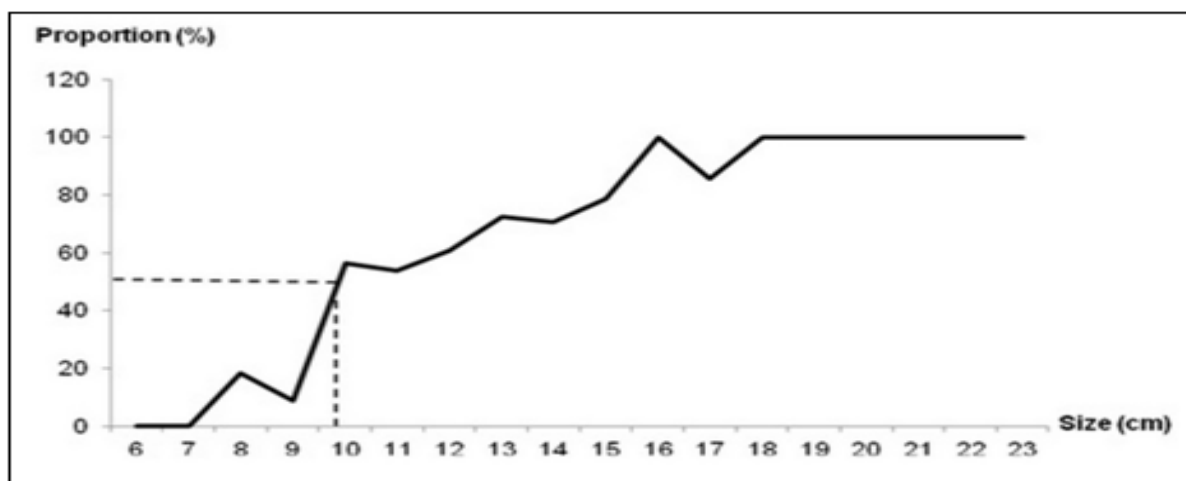


Fig. 5. Percentage of sexually mature females by length classes indicating ML 50%.

This difference could be due to the difference in temperature between the environments of life of the species. Richard (1971) showed that high temperatures accelerate the somatic and gonadic growth cuttlefish in controlled conditions.

It is for example the case of the Mediterranean where warmer water increases the growth and accelerates the sexual development of the species.

#### Gonadosomatic index (GSI)

In females (Fig. 7), GSI increased from January to March 2013 where it reaches its maximum with a percentage of  $6.22\% \pm 1.63\%$  ( $p < 0.05$ ), then decreased significantly in May ( $2.08\% \pm 3.26\%$ ) and June ( $0.08\% \pm 0.02\%$ ). Between September and December, GSI value remained low and stable ( $p \geq 0.05$ ). GSI for males (Fig. 7) was higher in April 2013 ( $3.39\% \pm 2.72\%$ ) ( $p < 0.05$ ), then decreased significantly ( $p < 0.05$ ) in June; from September to December, GSI value remained low and stable ( $p \geq 0.05$ ).

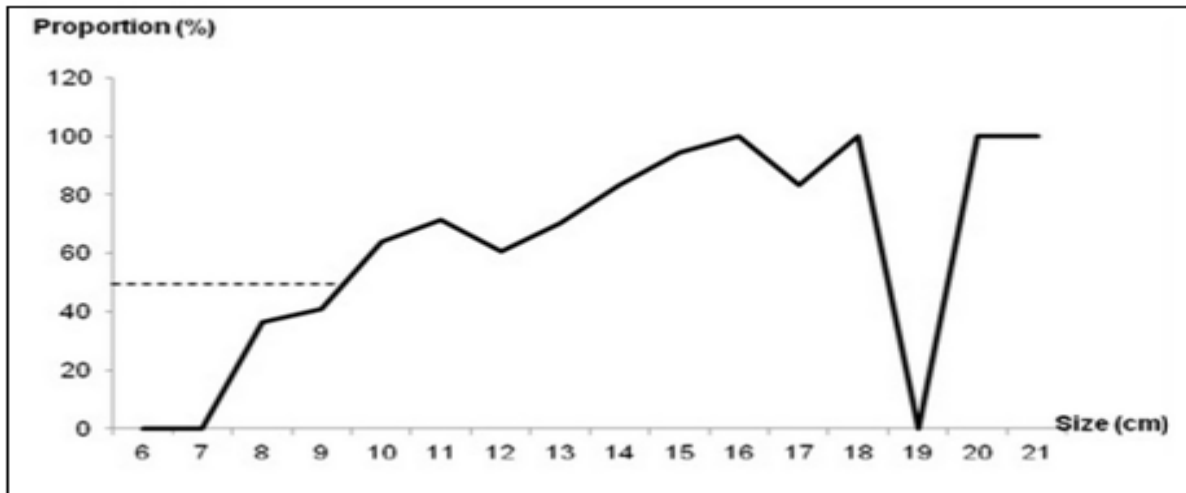


Fig. 6. Percentage of sexually mature males by length classes indicating ML 50%.

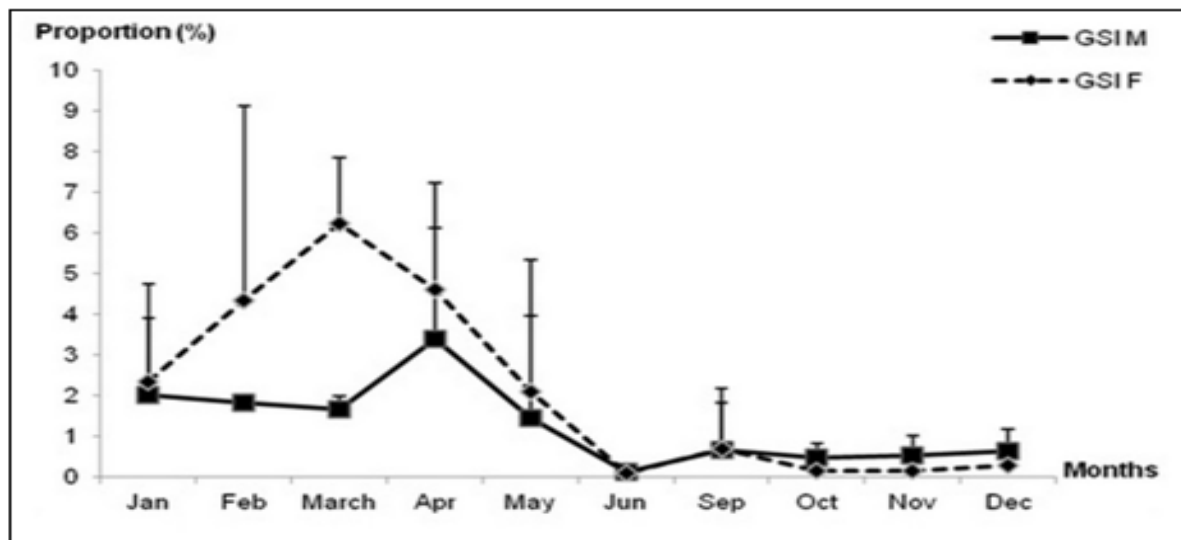


Fig. 7. Monthly variation of gonadosomatic index (GSI) in males and females of *Sepia officinalis*.

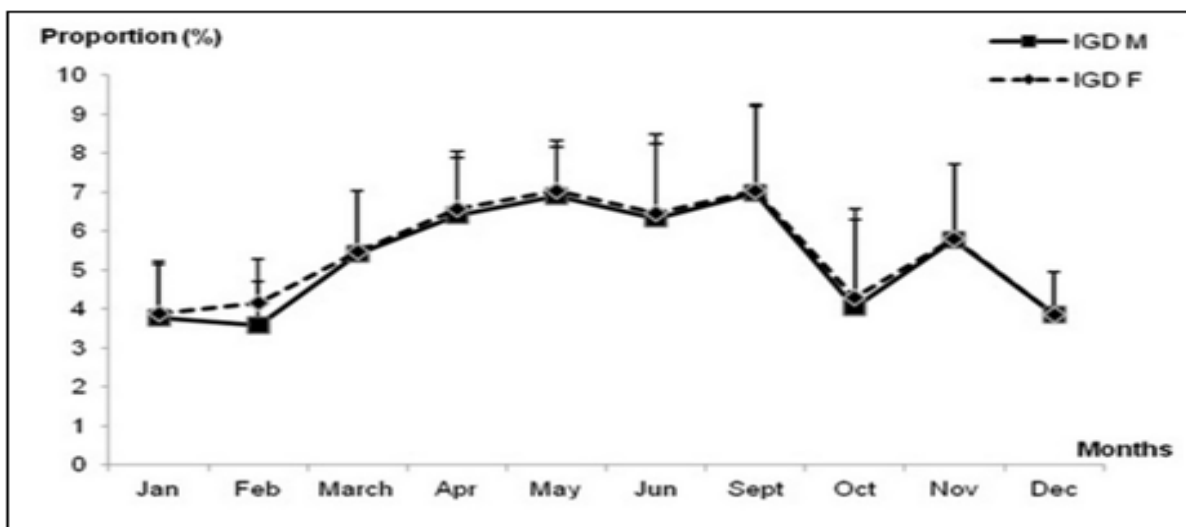


Fig. 8. Monthly variation of digestive gland index (DGI) in males and females of *Sepia officinalis*.

Results of gonadosomatic indices are important for determining the spawning season of cuttlefish. In this study, the reproduction period was between February and April, with a peak in March for females and between March and May, with a peak in April for males. However, through absence of GSI value in July and August, other studies on reproduction period of *S. officinalis* in Oran bay are required.

Data on the biology of the cuttlefish *S. officinalis*, growth and reproduction, are essential for fishery management and stock assessment of this species. The present study has a further importance in being the first work on the reproductive biology of *S. officinalis* from the bay of Oran, Algeria.

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