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Length-weight relationship, reproductive aspects and condition factor of the elegant cuttlefish *Sepia elegans* Blainville, 1827 off the northern coast of Morocco, Eastern Atlantic Ocean

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ABSTRACT

The elegant cuttlefish, *Sepia elegans* Blainville, 1827, represents an important component in the marine ecosystem off the northern coast of Morocco, the eastern Atlantic Ocean. The aim of this work was to determine the length-weight relationship, reproductive aspects, and condition factor of elegant cuttlefish, *Sepia elegans*. From February 2018 to January 2020, 4796 cuttlefish specimens were collected from the commercial catch, of which 2820 were females and 1965 males (with 11 undetermined). The evolution of the sex ratio showed a dominance of females over all seasons with an overall value of 0.69. The length-weight relationship (LWR) was calculated; it showed negative allometric growth. Results defined a positive correlation between the width of the cuttlebone and the length (p>0.05). Monthly monitoring of the gonadosomatic index (GSI), the relative condition factor (K*n*), and the stages of sexual maturity in the elegant cuttlefish revealed that it has an extended reproductive period of population with two peaks of spawning. The findings of this study showed well-being and good health condition for both sexes since the mean relative condition factor was 1.023±0.16 and 1.011±0.15 for females and males, respectively. In addition, females' and males' lengths at first maturity (Lm_{50}) were 3.8 and 3.2 cm, respectively.

INTRODUCTION

Sepia elegans (Blainville, 1827), commonly known as the elegant cuttlefish, is one of the most important cephalopods in terms of landed weight, fished by a coastal trawler off the northern Atlantic coast of Morocco **(MAIA, fishing statistics data)**. National captives' elegant cuttlefish in the northern Moroccan coast is linked to the number of active coastal units, up to eighty active units' land in the port of Casablanca. In 2020, the productivity of the elegant cuttlefish was 110.27 Tonnes, while the port of Casablanca with 92%, i.e. 101.51 Tonnes of the total landings **(MAIA, fishing statistics data)**.

The fishing of the elegant cuttlefish in the Mediterranean started in 1963 **(Mangold, 1963)**, in the northern Spanish shelf, where it's ranked among the top ten common cephalopods caught in terms of biomass in 1990 **(Velasco *et al*. 2012)**. Accordthe ing to **Valdés & Déniz-González (2015)**, *Sepia elegans* is the most abundant and commercially important sepiidae species **(Jereb & Roper, 2005; Khromov *et al*. 1998)**. In the northern Moroccan coast, *Sepia elegans* is the second sepiid species in terms of catch volume after the common cuttlefish *Sepia officinalis*, with a significant percentage of catches in some areas of its distributional range **(Reid *et al*. 2005)**. Due to the growing demand in the export markets, there has been an increase in the production of this species.

In the eastern Mediterranean, this species has been fish at depths between 150 m and 250 m and found on sandy and muddy bottoms **(Salman, 2015)**. *Sepia elegans* have also been recorded in brackish, estuarine environments of low salinities (18–25%), indicating a relatively high degree of tolerance **(Castro & Guerra, 1990)**. In north-western Spain, the estuary of the Ria de Vigo, *Sepia elegans* is fairly common in areas characterized by a muddy-rocky habitat, with common depths of 30m **(Guerra & Castro, 1989)**. Its bathymetric distribution varies quite significantly with seasons **(Mangold, 1963)**.

In Morocco, elegant cuttlefish are little or no monitored, as the main interest in studies of cephalopod resources and it has always been focused on exploitable species that are of high economic value (octopus, cuttlefish, and squid). The present study focused on the biological indicators of elegant cuttlefish through commercial contribution off the northern coast of Morocco, eastern Atlantic Ocean. The choice of this species is relies on knowing biological information in order to provide a sound fishery management. Even though, its occurrence has become increasingly noticeable in recent years in trawlable areas of the continental shelf.

This study was aimed to determine the length-weight relationship, reproductive aspects, and condition factor in the elegant cuttlefish *Sepia elegans*, off the northern coast of Morocco, eastern Atlantic Ocean.

MATERIALS AND METHODS

Study area

The Northern coast of Morocco, eastern Atlantic Ocean, stretching between Spartel Cape and Sidi ifni (34°47' N and 29 °22' N), extends towards the Atlantic Ocean by a gently sloping continental shelf with a bathymetry of about 160 meters **(Orbi *et al*. 1998)**. The Atlantic coast characterized by a very extensive mudflat 10 miles wide, bordered on the coast by medium and fine sands and limited seaward by biogenic sands **(Bayed & Glémarec, 1987; Regragui, 1991)**. The tide is semi-diurnal type with an average period of 12 h and 25 min. The climate of the Moroccan Atlantic coast is semi-arid. This area is under the upwelling caused by changing air temperatures in response to ‘Alizés’ winds from that blow parallel to the coastline. These winds generate upwelling, the most important hydrological feature in the region **(Bayed, 2003; Haddi *et al*. 2022)**.

Sampling

A total of 4796 elegant cuttlefish was collected randomly from February 2018 to January 2020, between Kenitra (34°N) and El Jadida (33°N) using commercial catch units **(Fig. 1)**.

During the study period, coastal trawler fleets carry out trips ranging from 2 to 5 days in the sea, at depths from 60 m to 500 m. It has been found in cold waters and inhabits areas that are characterized by a muddy-sandy habitat. The species *Sepia orbignyana* seems to *Sepia elegans*, are sympatric and cohabiting the same ecosystem, often found in samples with a considerable proportion. Elegant cuttlefish is a species that coexists with species of great commercial interest, especially the common hake (*Merluccius Merluccius*) and the pink shrimp (*Parapenaeus Longirostris*).

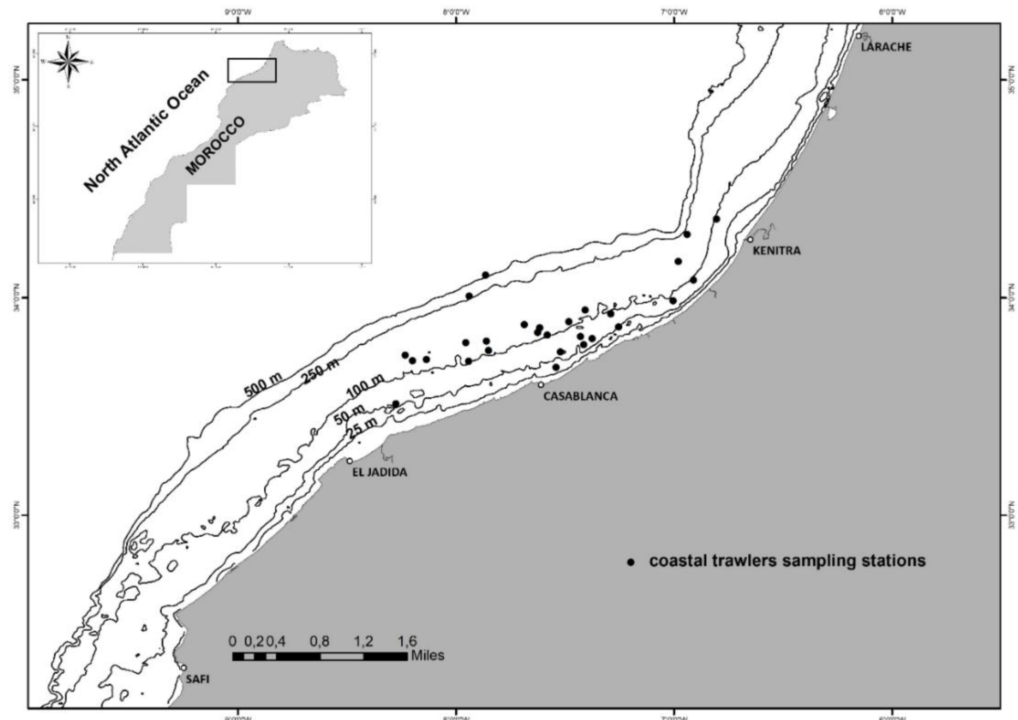


Fig. (1): Commercial sampling stations of *Sepia elegans* between (34°N) and (33°N)

Measurements

For each individual, the dorsal mantle length (DML) was measured to the nearest centimeter, total weight (g), and eviscerated weight (removed all internal organs) (g) were estimated nearest 0.01, and gonad weight to the nearest 0.01 (g).

Samples were examined under a triocular magnifying glass after dissection. The maturity stage was assigned visually using a maturity scale adapted for cuttlefish **(Follesa & Carbonara, 2019; Arkhipkin, 1992)**.

Macroscopic observations of the gonads were made it possible to distinguish mature individuals, with developed gonads occupying at least 2/3 of the abdominal cavity. In males, slight pressure on the abdomen causes the flow of sperm. In females, the ovaries are yellowish and highly developed, with visually ova. At the same time, the width and the length of the cuttlebone measured with a meter ribbon. Only cuttlefish with measurable mantle length, i.e. with unbroken cuttlebone, were retained.

Length-weight relationships

The relationship between dorsal mantle length (DML) and total weight (TW) for females and males separately is expressed by the linear form equation **(Torres *et al.* 2017)**

$$\mathbf{TW = a\,DML^{\mathit{b}}} \quad (1)$$

Parameters **a** and **b** were estimated by linear regression of least squares.

The width of cuttlebone and length correlation

In cephalopods, sexual dimorphism exists precisely in the Sepiidae. These are specific sexual modifications, characterized by changes in the size of the cuttlebone **(Nouvel, 1937)**. The width of the cuttlebone (l) and the length (L) have been correlated by the regression analysis using the linear regression model.

Reproductive biology

The sex ratio (SR) reflects the ratio of the number of male individuals to the number of females. Sex ratio was calculated as Male: Female (i.e. 1M: xF= number of Females/ number of Males).

Size at first sexual maturity (Lm_{50}): The length at which 50% of individuals are mature **(King, 2013)**. For accurately estimate Lm_{50}, only mature and older individuals caught during the spawning period should be sampled. The size of the first maturity was determined for females, males, and also for all-sex sample.

Gonadosomatic Index (GSI): To establish the sexual cycle and determine the spawning period, monthly changes in the gonadosomatic index **(Bougis, 1952)** were monitored by the following equation:

$$\mathbf{GSI = (GW/EW) \times 100} \qquad (2)$$

Where: GW= gonad weight (including ovary weight, oviduct complex weight, and nidamental gland weight for females, and Needham's sac, spermatophoric complex, and penis for males) in grams; EW: Eviscerated weight of the cuttlefish (g).

Relative condition factor (K*n*)

The relative condition factor (K*n*) value is the parameter of fitness, well-being, or feeding condition **(Anene, 2005)**. The monthly relative condition factor (K*n*) was determined individually for both sexes by using the modified equation of **Le Cren (1951)**:

$$\mathbf{K}\boldsymbol{n} = (\mathbf{W}/\hat{W}) \qquad \textbf{(3)}$$

In the above equation, $\hat{W}$ is the expected weight of individual fish TW = a LDM^b where the earlier estimated b value and W is observed weight of the sample.

A high K*n* value indicated favourable environmental conditions otherwise, low values indicated the unfavourable environmental condition **(Blackwell *et al*., 2000)**.

Statistical analysis

All data were expressed as mean ± standard deviation. Test F was used to identify significant differences (p=0.01) in the length-weight relationship between sexes. The student's t-tests was used to evaluate the hypothesis of isometry (b = 1 or b = 3). Analysis of covariance (ANCOVA) test was performed to detect significant differences between male and female cuttlebones. The test was performed to verify whether there were differences between the slopes of sexes. The chi-square analysis was performed to test deviations in sex ratio. The student's t-test was conducted to identify significant differences in Gonadosomatic index and Relative condition factor (K*n*) among females and males. Where, statistical analysis was conducted using SPSS 25 software.

RESULTS

Size structure of the cuttlefish

The total mantle length of *S. elegans* varied between 1.6 and 6.4 cm, with a mean mantle length of 4.11 ± 0.38 cm. The modal size class in the sample was 4 cm. Seasonally, mature individuals and small immature recruits were found in numbers, a first cohort was identifiable in summer with 5% **(Fig. 2)**, and the mean mantle length frequencies were 30% during the sampling. In autumn, the mantle length frequencies of mature individuals were 98%, with the highest coefficient of variance was 13% **(Fig. 2)**. However, winter shows bimodal distributions as two size classes at 4 and 4.5 cm. The size frequency varies respectively from 28%, 28%, and 29%, to 28%, with an almost equal coefficient of variance **(Fig. 2)**. In spring, the highest frequency was founded with 35% on two class sizes at 4.5 and 4 cm, respectively, with the unimodal distribution. While in summer, the average size class was 4.15 and 4.17 cm, with a frequency of 30 % and 18 %, respectively **(Fig. 2)**. Results showed a high coefficient of variance with 17.09 %, which means that it has varied from the average size of the elegant cuttlefish **(Fig. 2)**.

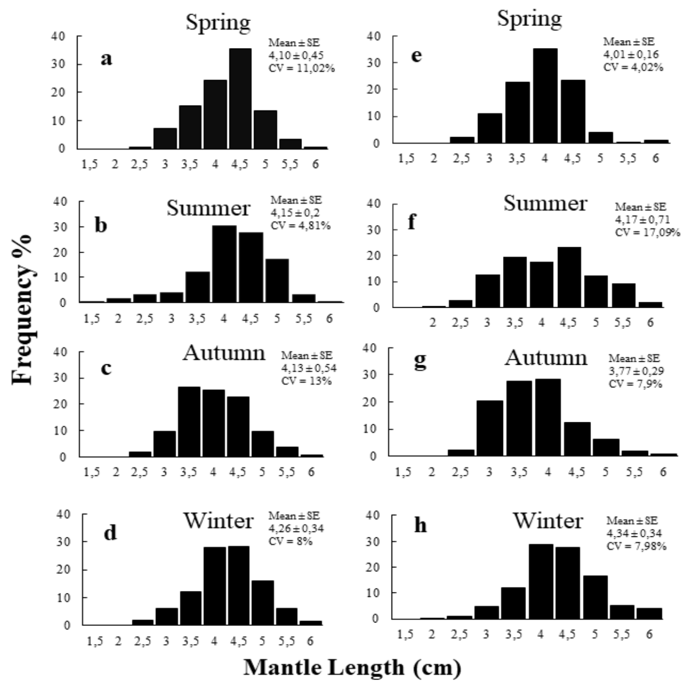


Fig. (2): Seasonal Mantle length (cm) distribution of *S. elegans*.
SE: Standard error, CV: Coefficient of variance

Length–weight relationship

For each month of sampling, females were the largest ranging in size from 1.6 cm to 6.4 cm in dorsal mantle length compared to 2 cm to 5.7 cm for males. The total weight ranged from 1.2 to 22.46 g in males and from 1.5 to 26.8 g in females.

The obtained results showed a significant correlation for male, female, and sexes combined. For males, the relationship was correlated ($r^2 = 0.808$; $p=0.001$) and showed a negative allometric growth ($b= 2.36$). Slope (b value) of dorsal mantle length and total weight relationship of females indicated a negative allometric growth ($b=2.44$) and also showed a significant correlation ($r^2 = 0.862$; $p=0.001$). When the length weight was compared by ANCOVA ($F=579, 12$; $p=0.001$), it showed that there was difference between the regression lines, as a result of females being larger and heavier than males **(Fig. 3)**.

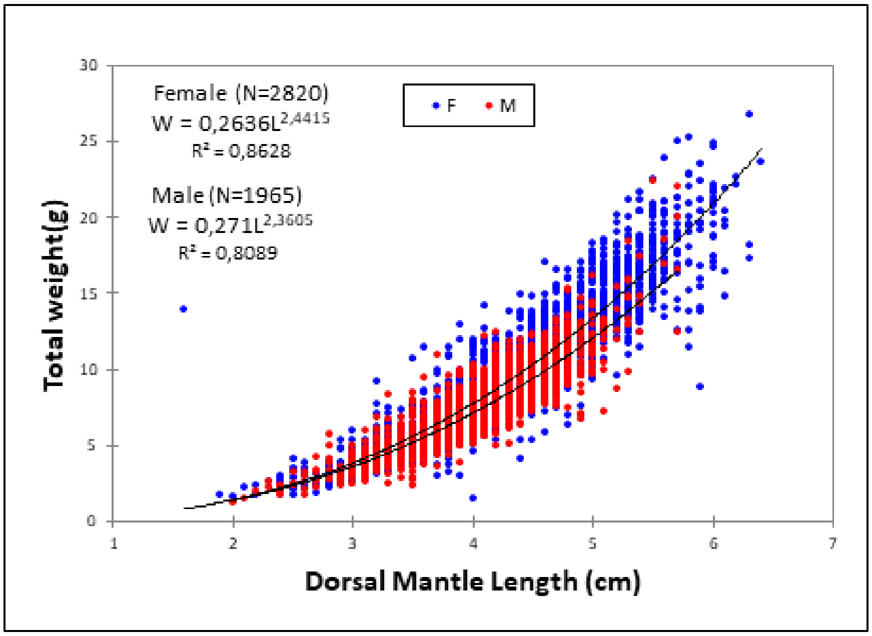


Fig. (3): Dorsal Mantle Length-Total weight relationship between the two sexes of *S. elegans*

The width of cuttlebone and the length correlation

The variation in width of cuttlebone (l) as a function of length (L) for *S. elegans* showed a positive correlation for sampling. The length and width values are in positive correlation, different from 0 with a significance level p=0.05. Average cuttlebone length in males is 4.09 cm range (2.3 - 5.4 cm). Average cuttlebone length in females is 4.41cm range (1.2 - 6.1cm). Average cuttlebone width in males is 1.18 cm range (0.6 - 1.7cm). Average cuttlebone width in females is 1.37 cm range (0.5 - 2.2 cm).

At less than 2.5 cm of the length of the mantle, the two regression lines of males and females seem to have the same allure **(Fig. 4)**, beyond, the right relative to the males has a slope (0.21) less important than that of the females (0.29) thus express a noticeable widening of the cuttlebone of females.

Reproductive Biology

Sex-Ratio

Overall, the sex ratio calculated on 4785 elegant cuttlefish over the sampling period, females are favour with a percentage of 59%, while males represent 41% of the cuttlefish observed **(Fig. 5)**.

The proportion of sexes observed in each season were deviated significantly from 1:1 ($p<0.05$) except in spring **(Table 1)**. Also, the total yearly Chi-square does not signify (X^2=17, 71; df =1, $p<0.05$).

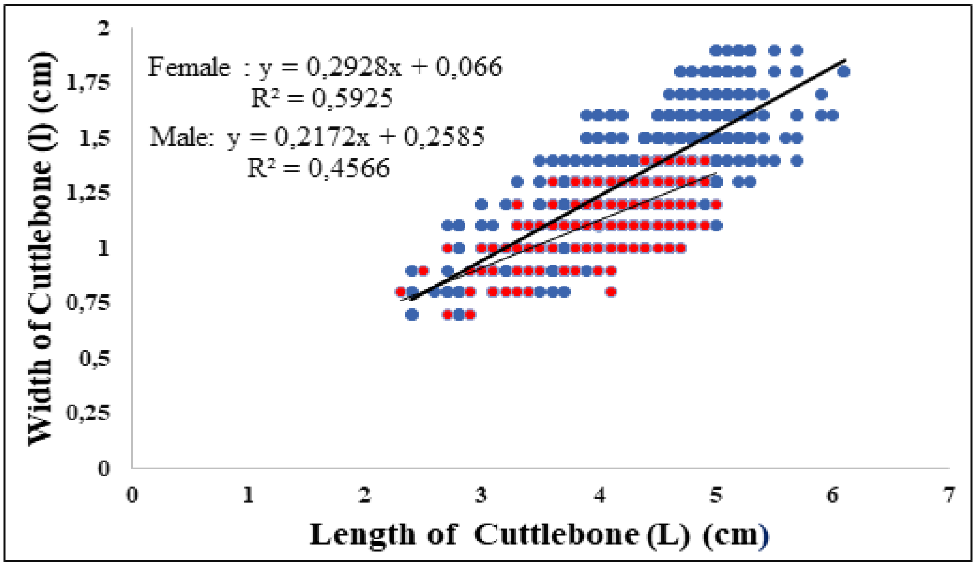


Fig. (4): Variation by sex of width (l) as a function of the length (L) of the Cuttlebone *S. elegans*

Table (1): Sex ratios of *S. elegans* from commercial catches

	Sex	**Season**				**Total**
		Spring	**Summer**	**Autumn**	**winter**	
Number of cuttlefish	**Male**	481	673	465	346	**1965**
	Female	866	843	641	470	**2820**
Ratio	**Male**	0.55	0.79	0.72	0.73	0.69
	Female	1	1	1	1	**1**
Significance		NS	*	*	*	**NS**
Chi square		15.97	6.93	0.43	0.6	**17.71**

***= $p < 0.05$ NS= non-significant**

Maturity scale

The determination of the sex and stage of sexual maturity of *S. elegans* is based on macroscopic observation of 2820 females' gonads, and 1965 males to know the state of maturity of the population, and the changes that occur there over time. Four stages of sexual maturity for females *S. elegans* **(Tables 2 & 3)** and three stages of sexual maturity were determined for males, according to the gross morphology of the gonads and the macroscopic development of the nidamental gland.

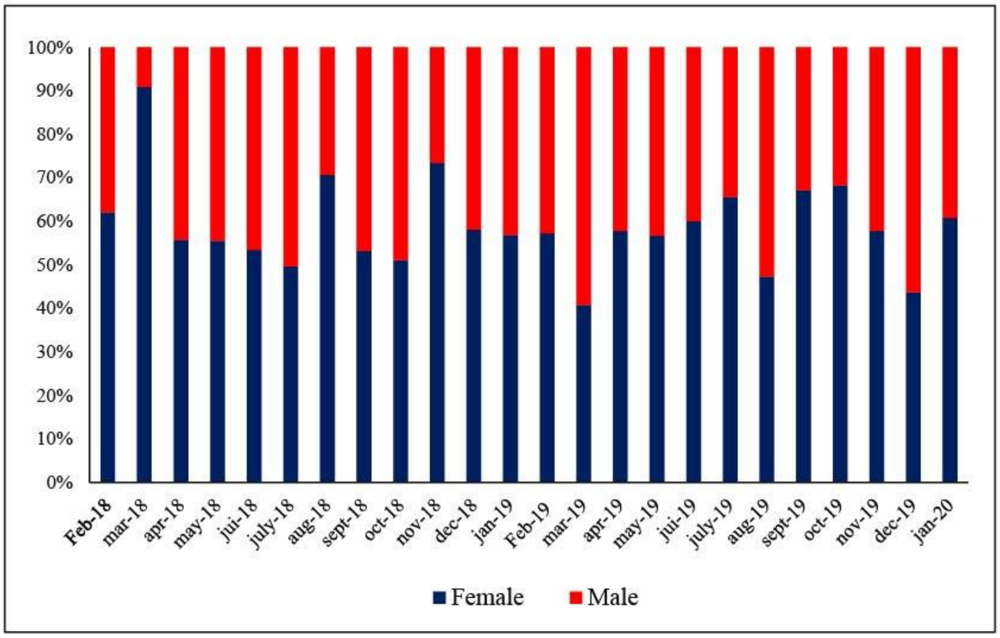


Fig. (5): Monthly variation of the sex-ratio of *S. elegans*

Sexual maturity

The results showed the evolution of the percentages in different stages of maturity for both sexes (male and female) during 24 months **(Fig. 6)**. Stage III was presented throughout the study period with 72.30% of both sexes. During sampling, the predominance of mature individuals indicated that there is an intense reproductive activity of species.

In the maturity stage (III), the percentage of females was 76.15 % in summer, 70.43% in spring, and 83.4% in winter. Meanwhile, males were present with a percentage (>68.78%) in all seasons.

Maturation and size at first maturity

The size at first maturity indicated that females of *S. elegans* reached their first maturity at 2.8 cm DML, meaning that 50% of mature individuals have this size, and the first sexual maturity of the mature male was 2.4 cm DML. The mature size of Lm_{50} was estimated at 3.2 cm in DML for males and 3.8 cm DML for females **(Fig. 7)**, indicating that the males attain maturity earlier than females.

Table (2): Female maturation scale in *S. elegans*

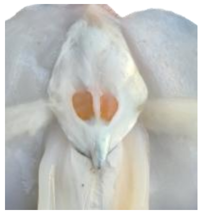
Maturity stage	Pictures	Morphological characters	Gonad weight (g)
Stage I, Immature		Development of nidamental glands and oviducal gland are small and translucid. Ovary very small, no ova apparent.	0.09-0.51
Stage II, Maturing		Accessory glands and oviduct gland can be distinguished. Nidamental glands are clearly visible, thicker and transparent to translucent. NG with a creamy white color, and covers the viscera. The oocytes are simple, medium in size, uniformly whitish ova.	0.26-1.15
Stage III, Prespawning		The ovary contains a higher percentage of large reticulated eggs and some ripe ova with a smooth surface. The oviduct is fully developed but empty.	1.1-1.68
Stage IV, Spawning		Degeneration of the reproductive system occurs after spawning. NG/OG are large but soft and running. The principal NG are swollen and white in color, the accessory NG are coral or pink color. The ovary is very small (compared to stages II and III). Immature oocytes attached to the central tissue and a few loose, large ova in the coelom.	>2.11

Table (3): Male maturation scale in *S. elegans*

Maturity stage	Pictures	Morphological characters	Gonad weight (g)
Stage I, Immature		Development of the testis, the spermatophoric complex very small and semi-transparent.	<0.8
Stage II, Maturing		Gonad appears Testicle more opaque white, channel deferential filled with sperm, tractus containing some small spermatophores.	0.7 - 1.65
Stage III, Spawning		Large testis, Needham's sac packed with spermatophores in reserve, genital opening gaping.	1.58 - 2.86

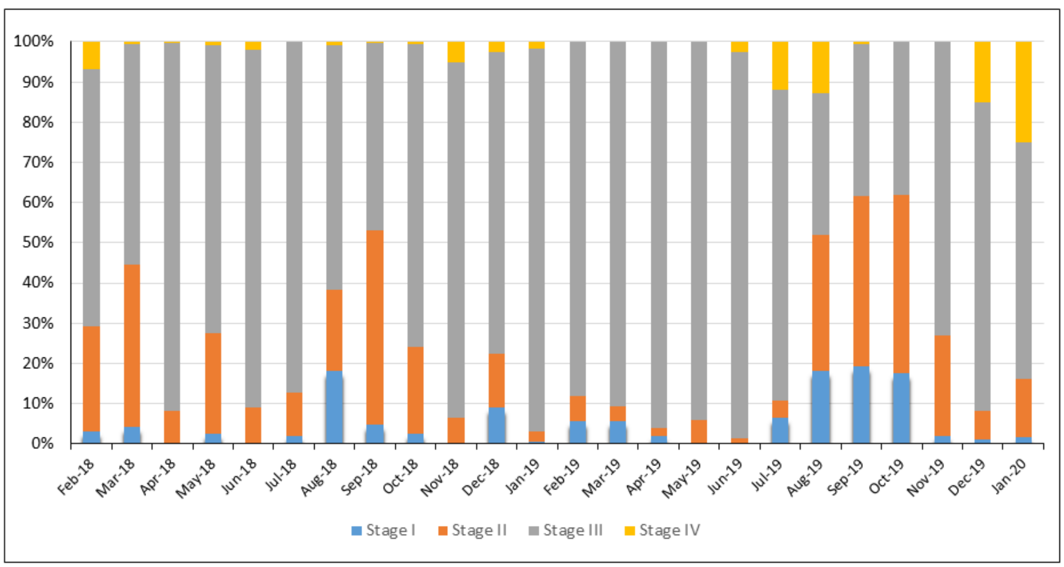


Fig. (6): Evolution in percentage of sexually mature stages of *S. elegans* during the sampling period

Gonadosomatic Index

The GSI of females increased from May respectively in 2018-2019 and reached a principal peak in July, and thereafter it declined till September, then it increased to a secondary peak in November and thereafter it declined up until May **(Fig. 8)**. GSI values were significantly higher for females ($p < 0.05$). Gonadal maturation stages revealed the consistent presence of mature individuals throughout the sampling months. Observations indicate that the peak of the principal spawning season is between May and August, and a second spawning period in November. The GSI of males shows average while stable values were significantly ($p < 0.05$) throughout the sampling months. Over the experimental period, the means from the GSI males and females are different ($p<0.05$).

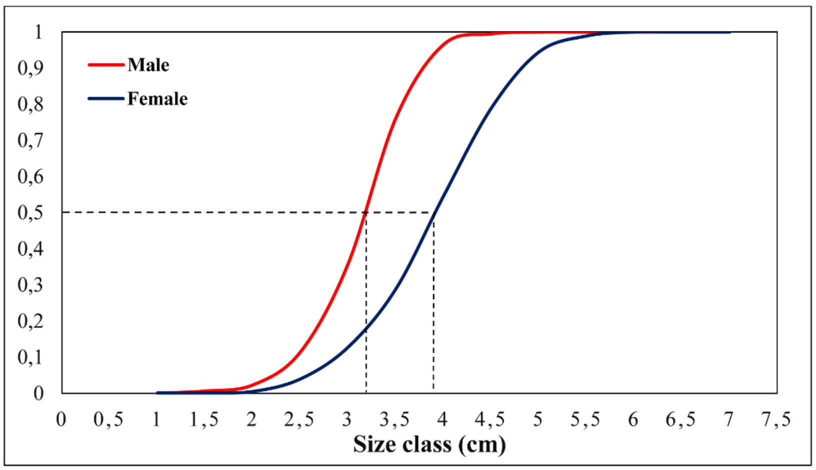


Fig. (7): Male and female distribution of 50% of the population (Lm_{50}) at the first size of maturity of *S. elegans* obtained from commercial catches.

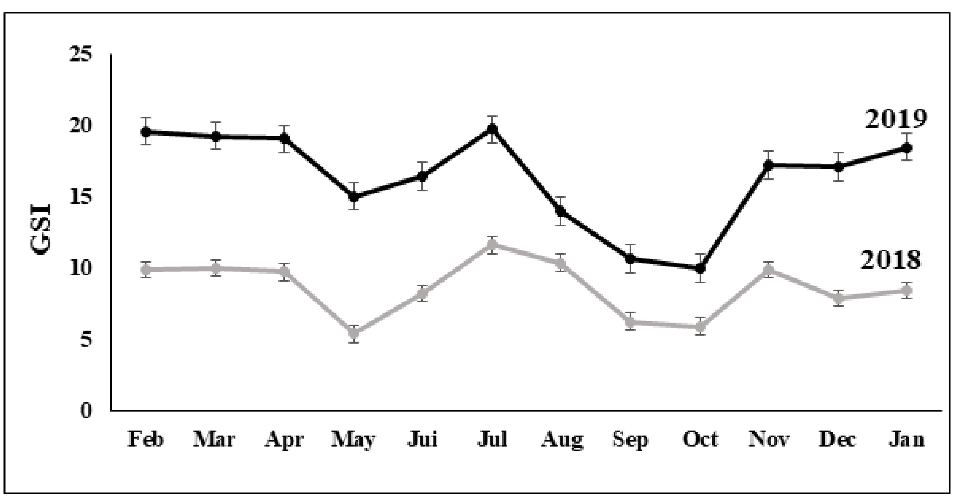


Fig. (8): Monthly Gonadosomatic index values Females of *S. elegans*

Relative condition factor (K*n*)

The monthly variation of the relative condition factor (K*n*) for females of the elegant cuttlefish *S. elegans* in the North Moroccan Atlantic waters showed variations throughout the sample **(Fig. 9)**.

In Females, comparatively high K*n* values were observed from February 2018 to August 2018 and were maintained, with a slight decrease in May 2018. From September 2018 onwards, a gradual fall in the values was noted in November 2018, followed by an increase in December 2018. Again another slight inflection was noticed, in January 2019 with 0.96± 0.08.

The fluctuation of K*n* values of females also denoted a more or less similar trend, with the highest values from February 2019 to September 2019. A slight decrease was noted in October 2019. From November 2019 onwards, the K*n* values were found to be increasing until the end of the sample. The Relative condition factor (K*n*) of females ranged from 0.84±0.13 to 1.15±0.16, with the mean value being 1.023±0.16.

The relative condition factor (K*n*) values of males followed a similar trend to females, the (K*n*) values of males ranged from 0.83±0.1 to 1.17±0.14 with mean K*n* values of 1.011± 0.15. There is no significant difference between the Relative condition factor (K*n*) in males and the Relative condition factor (K*n*) in females ($p < 0.05$).

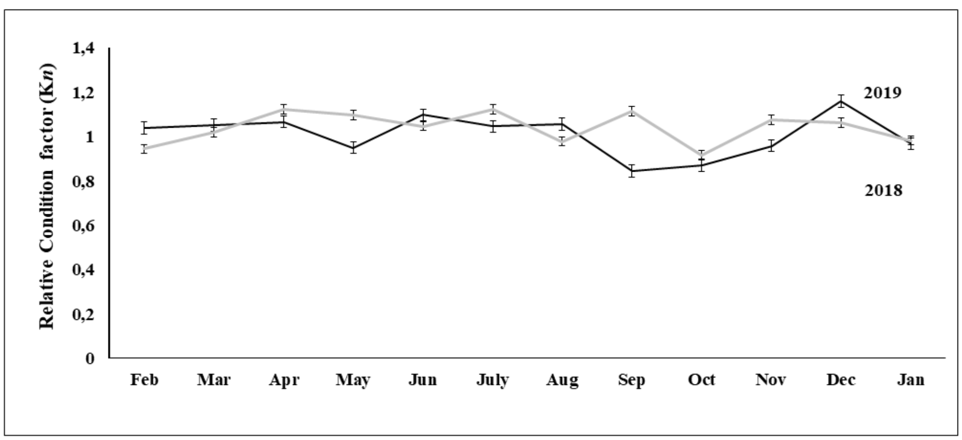


Fig. (9): Monthly evolution of relative condition factor K*n* (mean ± standard deviation) females of *S. elegans*, ($p<0.005$)

DISCUSSION

The elegant cuttlefish *S. elegans* is an important and abundant marine sepiidae species in the port off the northern coast of Morocco, eastern Atlantic. In the current study, the annual landing was important and variable **(Table, 4)**. In 2018, the total production in the port of Casablanca recorded 184002.2 Kg, i.e, 66.67%, followed by the port of Larache with 28.5% in production. The ports of El Jadida, Mehdia, and Safi have contributed less than 5% of the total landings.

Table (4): Total annual landings of cuttlefish *Sepia elegans* (Kg) by port off the northern coast of Morocco, eastern Atlantic Ocean

	2015	**2016**	**2017**	**2018**	**2019**	**2020**
CASABLANCA	174615,2	194897,5	194049	184002,2	133441,7	101509,2
EL JADIDA	230	6473,5	458,5	0	0	0
LARACHE	98768,5	134520	149834	78667,5	40630	38
MEHDIA	2495	2302	8039,5	3460	4198	1187
SAFI	21545,7	25117,7	12517,8	9825,8	9087,1	7539

The total annual contribution of elegant cuttlefish between 2015 and 2017 ranged from 297654.4 Kg to 364898.8 Kg, and the quantity of the landings recorded by the active unit showed fluctuation from one port to another. The port of Casablanca has ensured a high quantity of total production of small cuttlefish, 563561.7 Kg, equivalent to 55%.

The catches showed an overall downward trend from 2018 to 2020, the landings showed a drastic drop of 364898.8 Kg to 110273.2 Kg. The annual contribution by the port of Casablanca is 418953.1 Kg, i.e. 73 % of the total production. The port of Larache showed production of 20.8%, equivalent to 119335.5 Kg. The important production of the elegant cuttlefish is subject to a considerable inter-annual variation. This is mainly due to the instability of hydro-climatic changes **(MAIA, fishing statistic)**.

When it was discovered in the Atlantic Ocean by **(Mangold, 1963)**, *S. elegans* was considered an endemic accessory species in the area **(Clyde *et al*., 1984)**. This study of *S. elegans* is essential to provide useful information for biological indicators in the northern Moroccan coast. The samples of elegant cuttlefish ranged in dorsal mantle length from 1.6 to 6.4 cm and the body weight (g) between 1.2 and 26.8 g. The size distribution frequency has a Gaussian look and shows that, the higher number of individuals collected was concentrated between 3.5 and 5.4 cm, or 87% of the population. The low number of small sizes may be due to the selectivity of the cod-end employed or some environmental factors (water temperature, food availability) **(Guerra & Castro, 1989)**. The maximum size of both sexes from the present paper did not differ from the results obtained in the Adriatic Sea **(Bello, 2006)**. Adult animal sizes in the northern coast of Morocco were smaller than in the North and Central Adriatic **(Manfredi, 2008)**, and Ria de Vigo **(Guerra & Castro, 1989)**. Similar results were obtained from smaller DML in the Gulf of Cadiz **(Torres *et al*., 2017)**, and the largest female was 6.3 cm in Eastern

Mediterranean **(Salman, 2015)**, Adriatic sea **(Bello, 2006)**, and in the Aegean Sea **(Salman, 2015)**.

In our study, length-weight relationships revealed a negative allometric growth of the species off the northern coast of Morocco, eastern Atlantic Ocean, with regression coefficient b being significantly different between two sexes, indicating a higher increase of weight with length in females. The negative allometric values are in accordance with **(Torres *et al*., 2017; Valeiras *et al*., 2012)**, who calculated length-weight relationship in *S. elegans* using the pooled data of males, females and found b = 2.485 and 2.577 respectively. However, similar negative allometric male gutted length-weight relationship has been described from Ria De Vigo, NW Spain **(Guerra & Castro, 1989)**, from the Sicilian channel **(Ragonese & Jereb, 1990)**, and in the Adriatic sea **(Bello, 2006)**. In contrast, higher negative allometric female' values was reported by **(Ragonese & Jereb, 1990; Bello, 2006)**. According to **(Silas *et al*. 1985)**, the slope value was more in females comparing to male for the cuttlefish. The lesser values were reported from **(Salman, 2015)** both sex and **(Guerra & Castro, 1989)** for female.

In this study, mature individuals (both sexes) were present throughout the year, indicating that, the principal spawning period is in spring-summer, and autumn (secondary spawning). The mature *S. elegans* inhabits the detritic bottoms of the offshore in winter to the upper part of the deep vase. In accordance to the **National Institute of Fisheries Research (2019)**, an important mineral richness was in deep water resurgences in the North Atlantic waters. The spawning season gives rise to immature individuals with minimal growth rate, as a result of being exposed to the same environmental conditions (temperature and food availability) **(Bouligand, 2020)**.

Several authors report the same reproduction patterns. **Guerra & Castro (1989)** observed two peaks of spawning seasons in spring-summer, but winter has also been observed on the Atlantic coast. In the Mediterranean sea, males and females of *S. elegans* overwinter in deep water (>200 m) and migrate into shallower waters in spring-summer to spawn **(Mangold, 1963; Sánchez *et al*., 2010)**. However, in other areas, no seasonal migratory patterns have been observed **(Ragonese & Jereb, 1991)**. Also, **(Salman, 2015)** found that the period of the breeding of *S. elegans* along the Eastern Mediterranean was from July to October, explaining that juveniles from the spring spawning season ripen, during the summer and spawn in autumn. The species egg laying in the coastal waters without getting as close to the coast as *S. officinalis* **(Salman, 2015)**, most of the eggs of this species were collected, in the Port-Vendres between cap Creux in the south and Etang de Salses in the north, on *Alcyonium palmatum*, a typical form of sticky coast mud **(Mangold, 1959; Bouligand, 2020)**. **Dursun *et al*. (2013)** found that *S. orbignyana* has two spawning peaks in spring and autumn. It has been found that *S. officinalis* can have intermittent spawning during its life **(Laptikhovsky, 2003; Saddikioui, 2019)**. **Richard**

(1966, 1967) mentioned that the variation in the timing of spawning season of the same cephalopod species in different regions may be attributed to light and temperature.

The monthly K*n* value showed a high value, for males and females of *S. elegans*. **Fauziyah *et al*. (2020)** found that the squid *L. chinensis* is in good condition and well-being from South Sumatra in Indonesia. **Bennett (1970)** reported that the fishes with the K*n* value > 0.56 were considered in good condition. The high K*n* values recorded may be due to the intense gonadal activity. A similar result was found by **Bello (2006)** comparing tentacle club length and body condition in the south-western Adriatic Sea. Furthermore, it is known that the K*n* values depended on physiological factors like maturity, spawning, and environmental factors like availability of food **(Brown, 1957)**, and also been attributed to a variety of other reasons **(Qasim, 1957)**. Other authors noted that fish usually decrease their feeding activity and use their lipid reserves during spawning which results in a decrease in condition **(Lizama & Ambrósio, 2002)**.

The size at first maturity for male and female *S. elegans* was estimated at 3.2 and 3.8 cm DML. **Cabrera (1970)** reported that it begins sexual maturity at 3 cm DML in the Canary Islands. **Salman (2015)** estimated first maturity at 4.2 and 4.1 cm DML (male and female respectively) in the Eastern Mediterranean. Geographic variation in mean size at maturity has been observed in the sub-species of *S. elegans*, from the Aegean sea **(Dursun *et al.*, 2013)** and, on the south Moroccan Atlantic coast of the common cuttlefish *S. officnalis* **(Idrissi *et al*., 2008)**. *S. elegans* males range, have reached smaller sizes than females. The precocity of males in this study is in agreement with other species of Sepia, such as *S. offcinalis* **(Guerra & Castro, 1988; Idrissi *et al*., 2008)**, *S. orbignyana* and *S. elegans* **(Mangold, 1963)**, and *S. australis* **(Mqoqi *et al*., 2007)**, **Boyle *et al* (1988)** reported that cephalopods' first maturation length decreases from the Atlantic to the Mediterranean, and other results on other Mediterranean cephalopods such as *Sepietta oweniana* **(Salman, 1998)**, *S. officinalis* **(Önsoy & Salman, 2005)**, *R. macrosoma* **(Salman & Önsoy, 2010)**.

The existence of sexual dimorphism of the cuttlebone for *S. elegans* was highlighted by **(Nouvel, 1937)**. In the Gulf of Tunis, the relative width of the cuttlebone of females is always greater than males of *S. officinalis* **(Najai, 1984)**, others results make comparable remarks about the cuttlebone of the Atlantic cuttlefish **(Jeon, 1982)**. This character exists for females to facilitate the setting in reserve of a great number of eggs **(Najai, 1984)**. Moreover, the gonadosomatic index allows comparison of gonadal development with cuttlebone measurements, which reveal differences between the sexes. Therefore, this relationship can be explained by the adaptation of the female body to the development of the gonads, which always have an increased occupation compared to the male gonads. This physical adaptation hypothesis was previously proposed by **(Hewitt & Slait, 1987; Mangold, 2020)**, who mentioned that these changes in *S. officinalis* were due to a phylogenetic trait in which females adapted to their reproductive stages by developing wider cuttlebones than males. The sex ratio of *S. elegans* differs significantly from 1:1 in North Atlantic waters. **Valeiras *et al*. (2012)** found the same result, which is due to the major presence of females on the North Spain continental shelf. The imbalanced sex ratio in favour of males was founded also by **Guerra & Castro (1989)** for the same species in the Ria de Vigo, this difference was linked to the variations in the population structure and different behavioural and distributional patterns of males and females **(Ragonese & Jereb, 1990; Sifner *et al*., 2013)**.

CONCLUSION

The study of the length weight relationship, reproductive biology, and relative condition factor of the elegant cuttlefish, *Sepia elegans*, has being the first work in the Moroccan North Atlantic. The sex ratio is in favour of females during the whole study period. This parameter varies significantly depending on the season of the individuals. The spawning period is an extended reproductive period of the population with two peaks of spawning. In fact, the size at first sexual maturity (Lm_{50}) of the females was greater than that of the males. Data on the reproductive biology of this species are very important in marine ecosystem webs. These data would help in deepen microscopic analysis and fecundity.

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