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Biologic characteristics of *Scomber japonicus* (Houttuyn, 1782) in Tunisian waters (Central Mediterranean Sea)

Hassen ALLAYA[1,2]*, Abdallah HATTOUR[2], Ghailen HAJJEJ[2] and Monia Trabelsi[1]

[1]Faculty of Sciences, University Campus, University of Tunis, 2092 El Manar Tunis, Tunisia.
[2]National Institute of Sea Sciences and Technologies (I.N.S.T.M), 2025, Salammbô, Tunis, Tunisia.

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Some biological parameters of chub mackerel, *Scomber japonicus*, were studied in the Tunisian waters. A total of 368 specimens were collected between January 2009 and December 2010. The fork lengths ranged between 16.3 and 31.8 cm. Overall female: male ratio was 1:1.03. In the report of gonadosomatic index (GSI) and gonad macroscopic observation, spawning season was estimated to be from December to February and from June to August. The hepatosomatic index (HSI) increased in October-November and May in females, and increased in September-October and May in males. The length-weight relationships for *S. japonicus*, were $Wt = 0.0119FL^{2,9909}$ for females, $Wt = 0.0096FL^{3,0691}$ for males, $Wt = 0.0111FL^{3,0186}$ for pooled data, indicating a significant isometry growth pattern ($P<0,005$) for the two sexes separately and for all samples.

Key words: *Scomber japonicus*, Tunisian water, sex ratio, growth, spawning.

INTRODUCTION

Chub mackerel (*Scomber japonicas* Houttuyn, 1782), is a cosmopolitan middle-sized pelagic species with a very wide distribution over the continental shelf of the tropical and subtropical regions of the Atlantic, Indian, Pacific Oceans and adjacent seas. It is a primarily coastal species, found from the surface down to 300 m depth (Collete and Nauen, 1983). Together with other small and middle pelagic fish species, chub mackerel is an essential element of the marine ecosystem due to its biomass at intermediate levels of the food web, playing a relevant role in associating the lower and upper tropic levels (Rice, 1995; Bakun, 1996; Cury et al., 2000).

This species, which Dieuzeide et al. (1955) indicates represent the genus Pneumatophorus, was indicated in Tunisia by Le Danois (1925), Gruvel (1926), Postel (1956), Bourgois and Farina (1961), Ben Mustapha (1966), Azzouz (1971), Ktari-Chakroun and Azouz (1971), Ben Othman (1971a, b, 1973) and Hattour (2000).

As reported by Ben Othman (1973), this species is more abundant in the south than in the north of Tunisia. It is numerous in bottom of brown algae (50 to 60 m) and fewer in echinoderms bottoms (80 to 130 m) (Ktari-Chakroun and Azouz, 1971).

In Tunisia, the total biomass of *S. japonicus* is 12143 tons which represent 3.95% of the total small pelagic of Tunisian water. The exploitable potential of this fish was 4847 tons which represents 5.7%(Hattour et al., 2004) of all the potential. This fish presents an important socio-economic effect; indeed, it implicates an important population of fisherman.

*Corresponding author. E-mail: hassen.allaya@yahoo.fr. Tel: +216 71 872 600. Fax: +216 71 871 666.

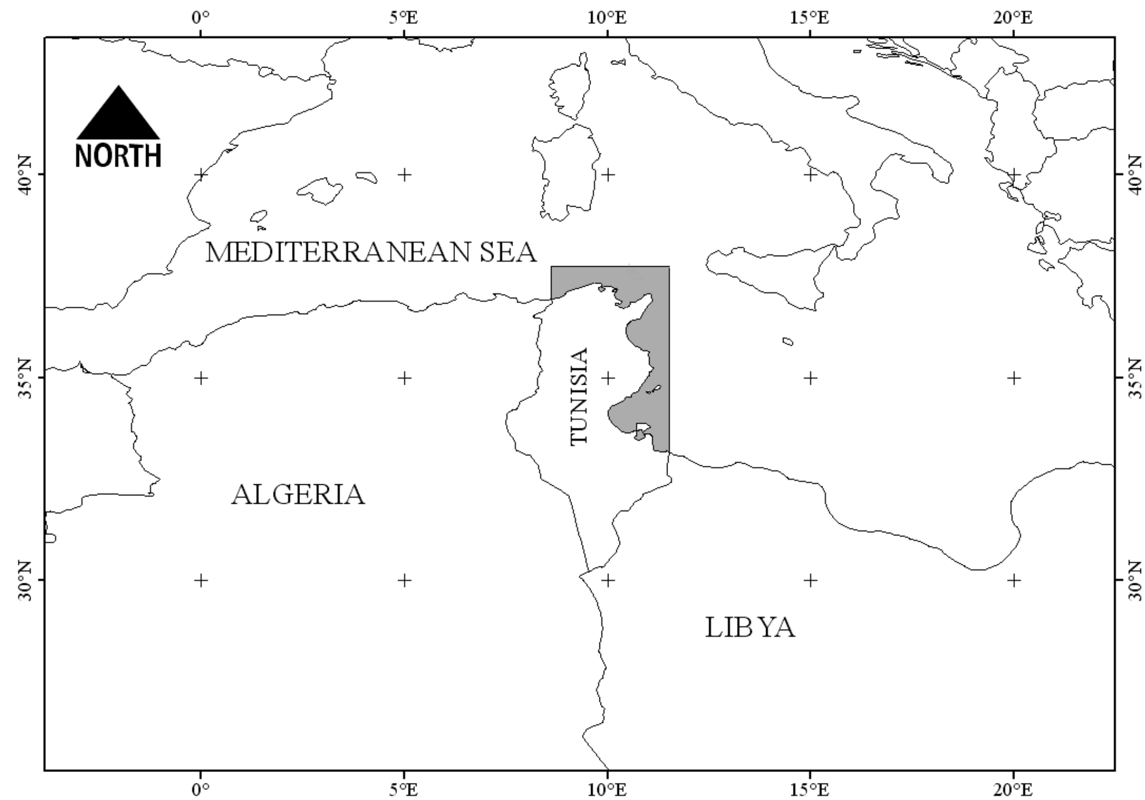

Figure 1. Map of Tunisian water.

The present study aims to determine some biological parameters of this species.

MATERIALS AND METHODS

A total of 368 chub mackerel (187 males and 181 females) were collected Between January 2010 and December 2010 from commercial catches from the Tunisian waters (Figure 1) with different fishing gear (purse seine, light fishing, gill nets, longlines, pelagic trawl and beach seine). For each specimen, the following parameters were recorded: the sex, the fork length (Fl) measured to nearest 1 mm using a measuring board, the total weight (Wt) and the eviscerated weight (We) measured to the nearest 1 g, the gonad weight (Wg) and liver weight (Wl), weighed on a digital balance with a precision of 0.0001 g.

The sex-ratio was determined thus:

$$SR = [\text{Female number}/\text{total number}] \times 100$$

To identify the spawning period, the gonadosomatic index (GSI) was calculated:

$$GSI = [(Wg) / (We)] \times 100$$

The hepatosomatic index (HSI) was also calculated:

$$HSI= [(Wl) / (Wt)] \times 100$$

To compare the change in size based on weight variation between females and males, the condition factor (K) was determined:

$$K = [(Wt) / (FL)^3] \times 100$$

The length-weight relationships were calculated following a logarithmic transformation of the exponential regression formula: $W = aL^b$ (Ricker, 1973), where *W* is body weight (g), *L* is fork length (cm), *a* is the intercept and *b* is slope (Tesch, 1971). Student's t-test was used to determine whether the coefficient *b* was significantly different from 3 (Teissier, 1948). The overall sex ratio was assessed using Chi-square test (Zar, 1996).

RESULTS

Size distribution

The size distribution, for all the samples, was from 16.3 to 31.8 cm with an average of 22.07 cm. The classes of size between 18 and 26 cm represent 82.88% (Figure 2). For the males, the size varied from 16.3 to 27.3 cm with an average of 21.67 cm, and for females, the size varied from 17 to 31.8 cm with an average of 22.48 cm. The classes of size from 18 to 26 cm represent 84.49 and 81.21%, respectively, for males and females (Figure 3). The difference in class of size repartition was significant ($P<0.05$).

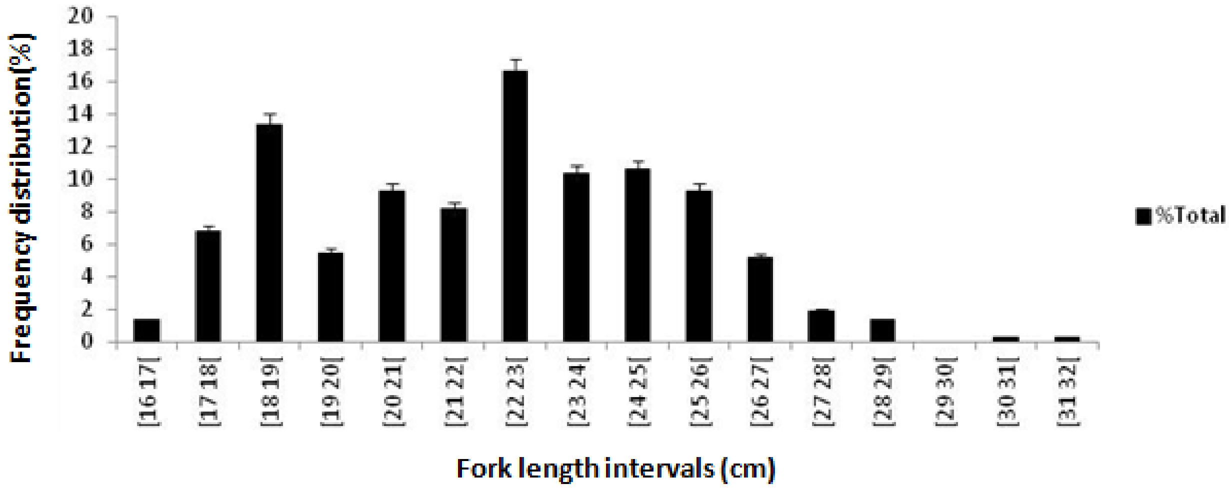

Figure 2. Frequency distribution of fork length for *S. japonicus*. Vertical bars indicate confidence interval (± 95% CI).

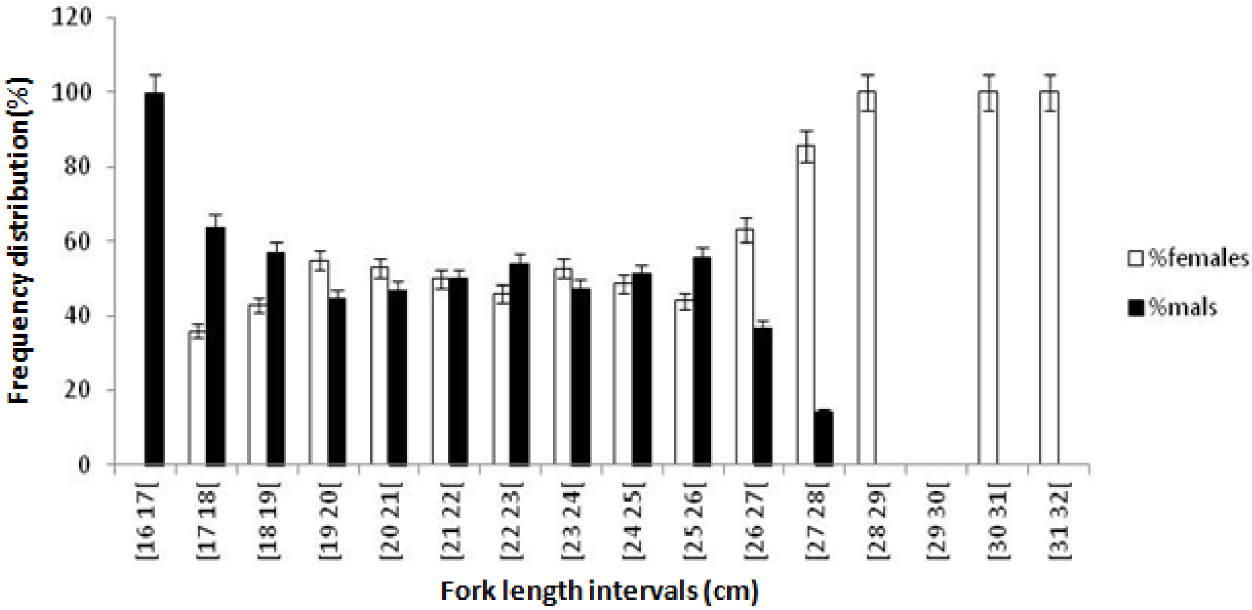

Figure 3. Frequency distribution of fork length by sex in *S. japonicas.* Vertical bars indicate confidence interval (± 95% CI).

Sex-ratio

In this study, it was found that 187 specimens (50.18%) were male, 181 specimens (49.82%) were female, overall sex ratio between females and males was 1:1.03, and there was a significant relation in the sex ratio according to the Chi-square test (χ^2obs = 47.76>> χ^2 the = 3.84; $p < 0.05$).

The sex ratio for the Tunisian Sea chub mackerel population fluctuated with size (Figure 3). Specifically, males were dominant in the smaller length classes (FL < 19.0 cm, f/m =0.37), while in the larger length classes, the sex ratio was in the favor of females (FL > 26.0 cm, f/m = 0.75).

The overall mean monthly sex ratio displayed seasonality (Figure 4 and Table 1). Thus, in January, June and July a higher prevalence of males was observed, while in April, May and December, females were predominant. Sex ratios were significantly divergent from 1:1 in both periods (January, June and July: χ^2obs = 23.24 >> χ^2 the = 3.84; $p < 0.05$; April, May and December: χ^2obs = 21.46 >> χ^2 the = 3.84; $p < 0.05$).

Nevertheless, the proportion of males and females was almost 1:1 in the rest of the year (Figure 4).

Spawning period

The GSI for males and females increased twice, between

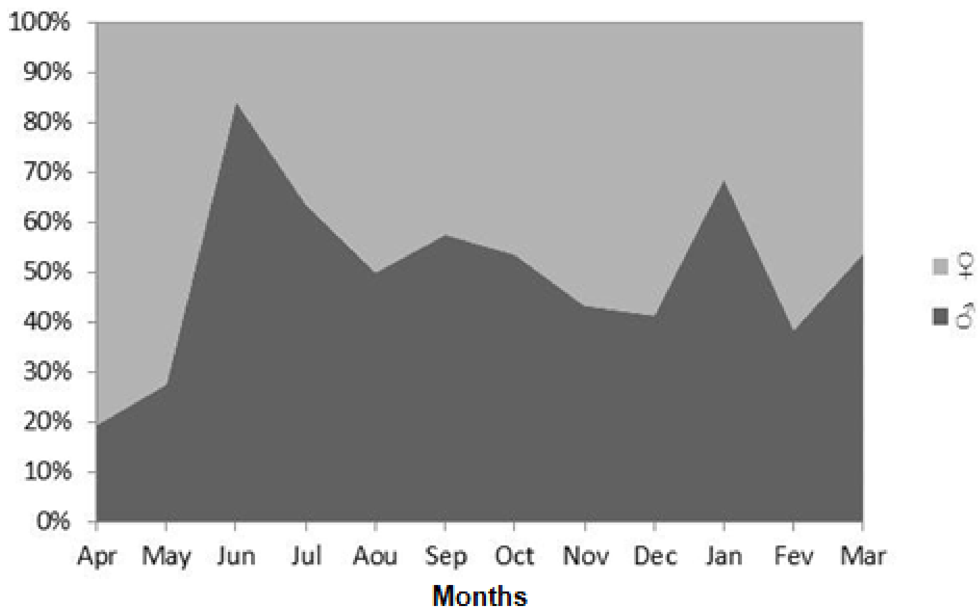

Figure 4. Monthly sex ratio variation for *S. japonicus.*

Table 1. The monthly *S. japonicus* sample size distribution.

Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total	32	26	26	36	29	38	33	28	33	28	30	29
Females	10	16	12	29	21	6	12	14	14	13	17	17
Males	22	10	14	7	8	32	21	14	19	15	13	12

December and February and between June and August. For females, the first peak is in July and the second is in January with respectively GSI of 6.55 and 7.30. For males, the first peak is in June and the second is in January with respectively GSI of 7.83 and 6.24 (Figures 5 and 6). The female average GSI was 3.07 while the male average was 3.57.

The hepatosomatic index

The HSI presented two peaks, in May and October-November for females, and in May and September-October for males. For females, the first peak reached 2.78 and the second reached 2.21 while for males, the first and the second peak reached, respectively, 2.67 and 2.43 (Figures 5 and 6). The female average HSI was 1.40, while the male average was 1.63.

The condition factor

The condition factor was similar between females and males when Fl was between 16 and 22 cm. But above this interval, the male K was superior to the female K. The maximum female K was 1.21 when FL was also between 27 and 28 cm and the average was 1.15. While the maximum male K was 1.32 when the FL was between 27 and 28 cm, the average was 1.20 (Figure 7).

Weight length relationship

The values of b which was 3 for females, males and all samples suggested that chub mackerel follow the law of the cube (Figures 8, 9 and 10) (Table 2). The R^2 value in all cases was higher than 0.959, indicating that this species have a close correlation between Wt and FL. that for this fish, weight increased proportionally with length.

DISCUSSION

In this study, specimens fork length varied from 16.3 to 31.8 cm. As shown in Table 4, the results as compared to worldwide data for the same species, are quite variable. So, from these comparisons, we stated that chub mackerel reaches its maximum length particularly along the Southwest Atlantic coasts (Argentina) where rich upwelling regions are present along the coasts, providing optimum feeding regimes. In this study, we show that the highest percentage of size was between 18 and 26 cm, so the explication is that our samples were taken from commercial cached fish, which had a relatively important

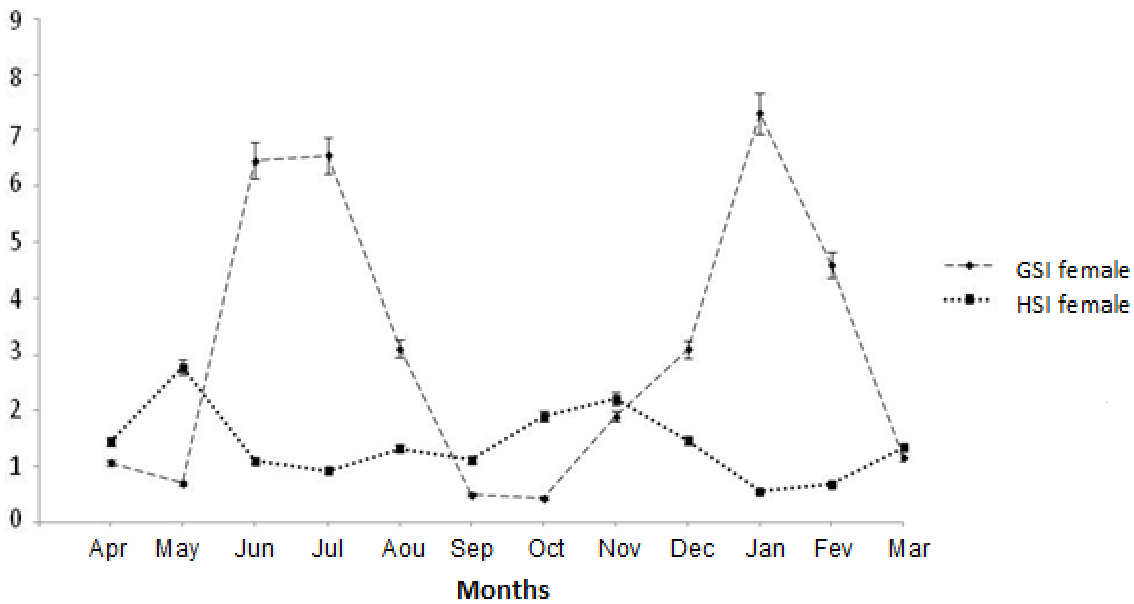

Figure 5. *S. japonicus* mean monthly gonadosomatic index and hepatosomatic index for females. Vertical bars indicate confidence interval (± 95% CI).

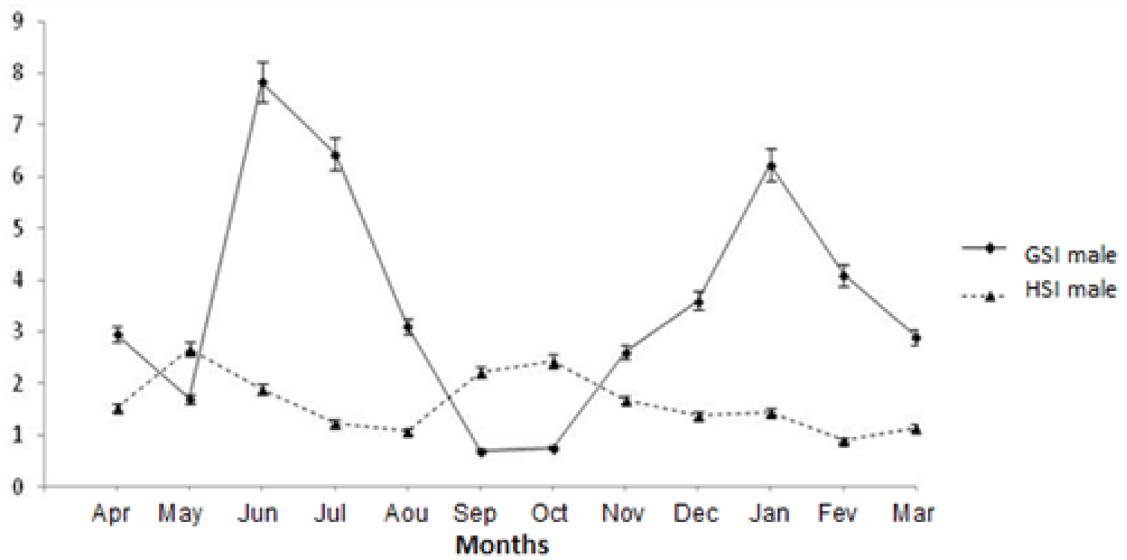

Figure 6. *S. japonicus* mean monthly gonadosomatic index and hepatosomatic index for males. Vertical bars indicate confidence interval (± 95% CI).

sizes. In this case, we can elucidate the phenomenon by differential development between the two sexes. This hypothesis can be proved by the condition factor results. So the female condition factor was inferior to the male when FL is above 22 cm; this indicates that weight gain was greater in males than in females but the length gain was more important for females than for males when the size of the fish was above 22 cm.

The GSI for males and females increased twice between December and February and between June and August; this indicates that this species is biannually spawning. The spawning season of the chub mackerel varied between regions, usually extending over a period of 3 to 5 months. Our results are similar to those found in Tunisian water by Hattour (2000). Our results are also similar to those of Techetach et al. (2010) who estimated that spawning period of this species, in Moroccan North Atlantic coast, is from December to March and June to July with a peak in January. But in Turkish water, Cengiz (2012) indicated that spawning period was between June

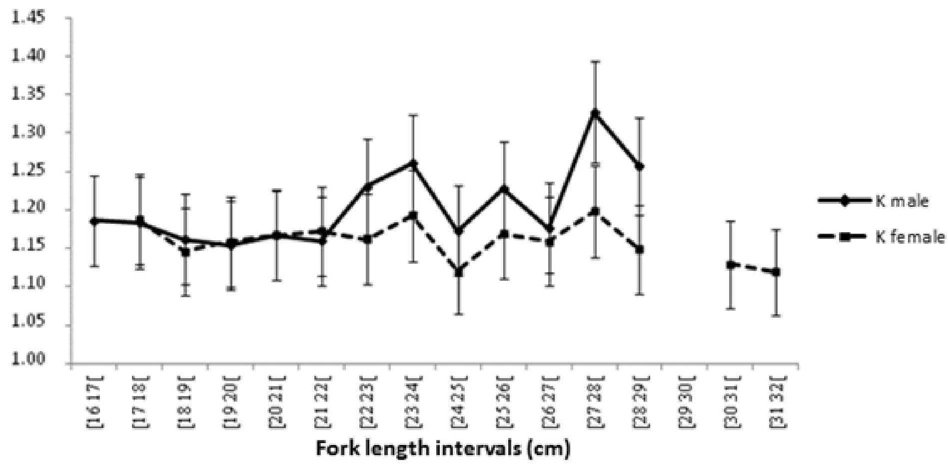

Figure 7. Condition factor variation (K) in function of size class for female and male *S. japonicus*. Vertical bars indicate confidence interval (± 95% CI).

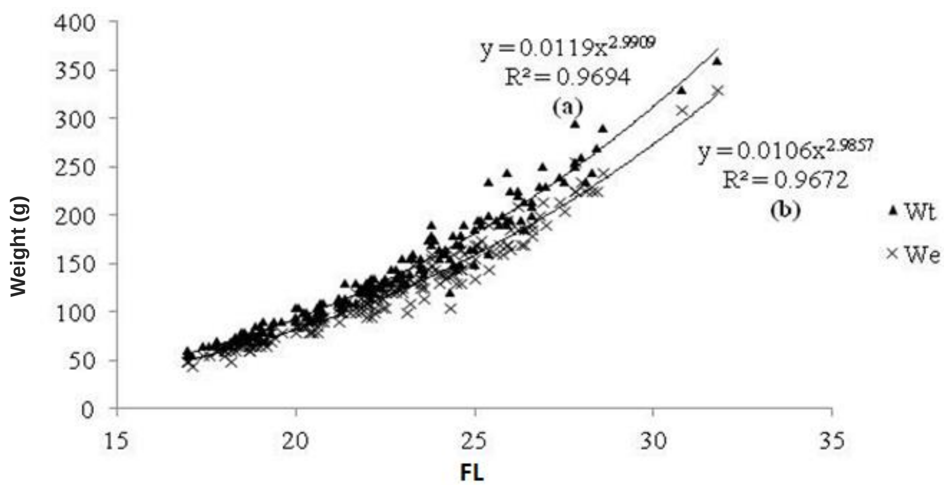

Figure 8. Relationship between fork length and (a) total weight and (b) eviscerated weight of *S. japonicus* females.

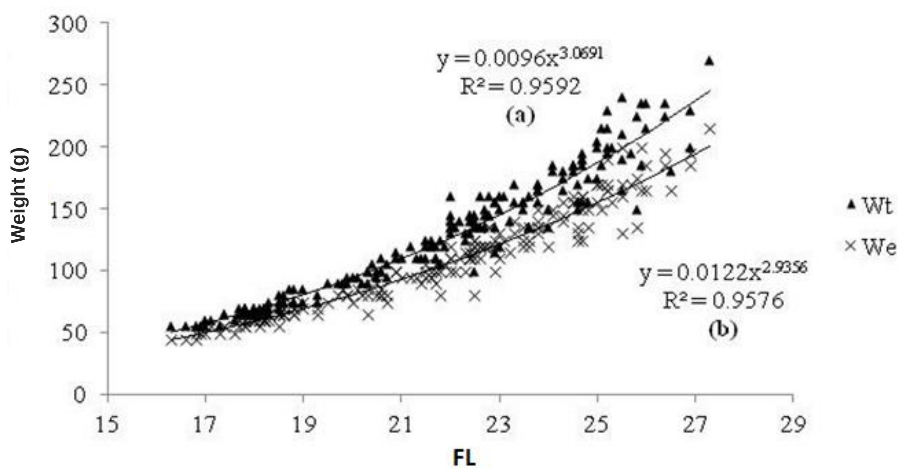

Figure 9. Relationship between fork length and (a) total weight and (b) eviscerated weight of *S. japonicus* males.

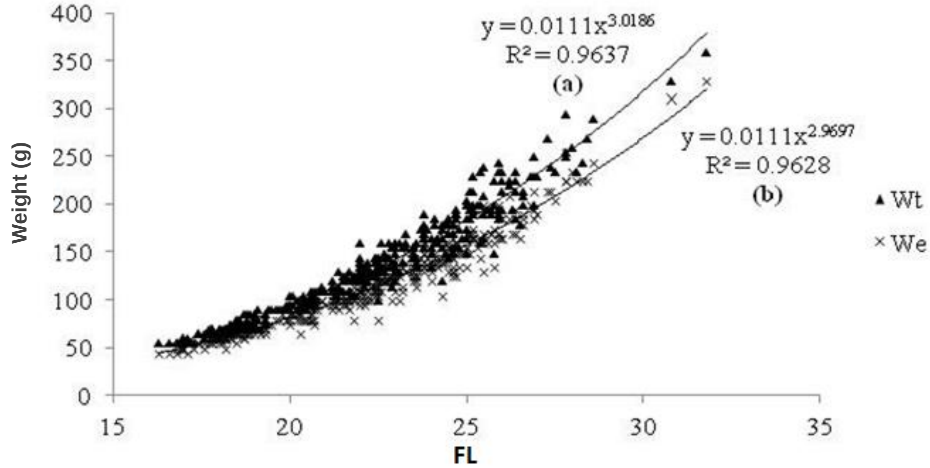

Figure 10. Relationship between fork length and (a) total weight and (b) eviscerated weight of *S. japonicus* (all samples).

Table 2. Length-weight relationships for *Scombrus japonicus* ($W = a\ FL^b$)

Sex	N	FL (cm)		Wt (g)		Parameters of the L-W relationship					
		Min 1.	Max 1.	Min 2.	Max 2.	a	b	R2	t	S'	Allometry
F	181	17	31.8	55	360	0.011	2.990	0.969	0.228	-	isometric
M	187	16.3	27.3	55	270	0.009	3.069	0.959	1.485	-	isometric
All	368	16.3	31.8	55	360	0.011	3.018	0.963	0.606	-	isometric

N is the sample size; min1. and max1. are minimum and maximum fork lengths in cm; min2. and max2. are minimum and maximum total weight in g; a and b are the parameters of the length-weight relationship and S' is the significance) for females (F), males (M) and all (All) samples.

Table 3. Females : males ratio of *S. japonicas* with regards to geographic areas.

Area	Number	Females : males	Reference
Turkiye (Marmara Sea)	1475	1 :1.08	Tuggac, 1956
Turkiye (Marmara Sea)	2687	1 :0.94	Atli, 1959
California (Northeast Pacific)	-	1 :1.00	Kramer, 1969
South Africa	6718	1 :0.88	Baird, 1978
Argentina	767	1 :0.66	Angelescu, 1979
CanaryIslands	749	1 :1.08	Lorenzo and Pajuelo, 1993
Gulf of California	2554	1 :1.03	Gluyas-Millan and Quifionez-Velazquez, 1997
Hellenic Seas (Northern Aegean)	840	1 :1.10	Kiparissis et al., 2000
Turkiye (Aegean Sea)	520	1 :1.13	Bahar Bayhan, 2007
Tunisia	368	1 :1.03	This study

and August. In general, the spawning season appears to be limited to the first half of the year in the northern hemisphere; during the second half of the year in the southern hemisphere; and all year round in areas near the equator (Castro and Santana, 2000).

The sex ratio of *S. japonicus* varied monthly. We found that in January, June and July, the sex ratio was in favor of the males and this corresponded to the spawning period; the explication is that in this period, there are concurrence of males to females and we can state that before those months, respectively, in December, April and May, the sex ratio were in favor of females which is probably to attract males.

The HSI has peaks above the GSI's peak for both sexes indicating that *S. japonicus* uses hepatic reserves as an energy source providing spawning.

Table 4. Some available studies on length-weight relationship and length range of *S. japonicus* from different localities.

Length range (cm)	Length type	a	b	Area	Reference
-	FL	0.002	3.40	USA (Calfornia)	Knaggs and Parrish, 1973
17.50-44.20	TL	0.028	2.81	Arjentina	Perrotta, 1992
-	TL	-	3.20	Libya	Gasim et al., 1992
18.70-29.60	FL	0.012	2.97	Greece	Petrakis and Stergiou, 1995
15.80-39.50	TL	0.004	3.23	Portugal	Gonçalves et al., 1997
14.50-31.20	SL	$1.17*10^{-6}$	3.48	Gulf of California	Gluyas-Millán and Quiñonez-Velázquez, 1997
12.50-37.40	FL	0.005	3.35	Ecuador	Cucalón-Zenck, 1999
9.10-31.00	TL	$9.65*10^{-7}$	3.50	HellenicSeas	Kiparissis et al., 2000
18.70-29.60	FL	0.012	2.97	Greece	Stergiou and Moutopoulos, 2001
22.90-33.00	TL	0.001	3.70	Greece	Moutopoulos and Stergiou, 2002
9.10-53.00	FL	0.004	3.26	Azores Archipelago (Northeast Atlantic)	Natacha Carvalho et al., 2002
21.30-33.80	TL	-	-	Naxos Island (Greece)	Stergiou et al., 2004
12.50-27.20	FL	0.003	3.41	Izmir Bay	Bayhan, 2007
16.30-31.80	FL	0.011	3.01	TunisianSea	This study

TL = Total length; FL = fork length; SL = standard length; a and b is the parameters of the relationships.

In this study, the relationships established using eviscerated or total fish weights showed an isometric growth, for females (b = 2.990), males (b = 3.069) and all samples (b = 3.018), implying an increase in weight proportional to increase in individual growth (b = 3). Our results are not in agreement with the values reported in Peru (Kotlyar and Abramov, 1982) and in the Pacific (Knaggs and Parrish, 1973) which showed an allometric growth (Table 4)

Studying some biologic characteristics of *S. japonicus* in Tunisian water allows obtaining information used in mathematic models to evaluate stocks which contribute to the development of fishery management strategies for this species.

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