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Ichtyologie

AGE ESTIMATION AND GROWTH PATTERN OF THE GILTHEAD SEABREAM *SPARUS AURATA* (PISCES: SPARIDAE) OF THE GULF OF GABES, TUNISIA

par

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Samples of gilthead seabream *Sparus aurata* (N=1065), used in this study, were caught in the Gulf of Gabes (Tunisia) from March 2008 to February 2010. Total length ranged from 10 to 35 cm. Parameters of the length-weight relationship ($TW = aTL^b$) for all individuals were a = 0.0107 and b = 3.0799. The youngest specimen in this study was 0+ years, whereas the oldest one was 7 years. The Von Bertalanffy growth parameters for both sexes were: $L\infty$ = 47.18 cm, k = 0.116 and t0 = -2.954 years.

Keywords: Gilthead seabream (*Sparus aurata*), age and growth, Gulf of Gabes.

Estimation de l'âge et de la croissance de la daurade royale *Sparus aurata* (Poissons : Sparidae) dans le golfe de Gabès, Tunisie

L'âge et la croissance de la daurade royale *Sparus aurata* (Linnaeus, 1758) du golfe de Gabès ont été étudiés par scalimétrie. Les variations mensuelles de l'allongement marginal des otolithes ont montré que la valeur minimale est enregistrée au mois de mai aussi bien pour les mâles que pour les femelles. En se basant sur les clés taille-âge, nous avons déterminé les paramètres de l'équation de Von Bertalanffy qui sont pour les deux sexes pris ensemble $L\infty$ = 47,18 cm, K = 0,116 et t0 = -2,954 an.

Mots-clés : Daurade royale (*Sparus aurata*), âge et croissance, golfe de Gabès.

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Introduction

The gilthead seabream *Sparus aurata* is common in the Mediterranean Sea, but very rare in the Black Sea (BÂNÂRESCU, 1964). It is also present in the North-eastern Atlantic Ocean, from the British Isles to Cape Verde and the Canary Islands (BAUCHOT & HUREAU, 1986). There have been several studies on wild populations in Atlantic Ocean (ARIAS, 1980; PITA *et al.,* 2002) and in the Mediterranean Sea (LASSERRE, 1976; ARNAL *et al.,* 1976; SUAU & LÓPEZ, 1976; FERRARI & CHIEREGATO, 1981; WASSEF & EISAWY, 1985; ROSECCHI, 1987; KRALJEVIĆ & DULČIĆ, 1997; MEHANNA, 2007). Some biologic aspects were studied in Tunisian waters (CHAUVET, 1979 and KSOURI, 1981).

In Tunisia, *S. aurata* is of a great commercial interest both in traditional fisheries and in marine aquaculture. In the Gulf of Gabes, the species represents more than 15% of sparid fishes landed in the area (an annual mean of 291 tons for the last three years). The Gulf of Gabes is a large area situated on the southern-east coastline of Tunisia, extending over about 750 km from Cape Kapoudia (35th parallel) to the Tunisian-Libyan border (Figure 1). This maritime zone, bathed by Atlantic masses waters (BRANDHORST, 1977, TCHERNIA, 1978), includes a large continental component characterized by the presence of extensive beds of the seagrass,

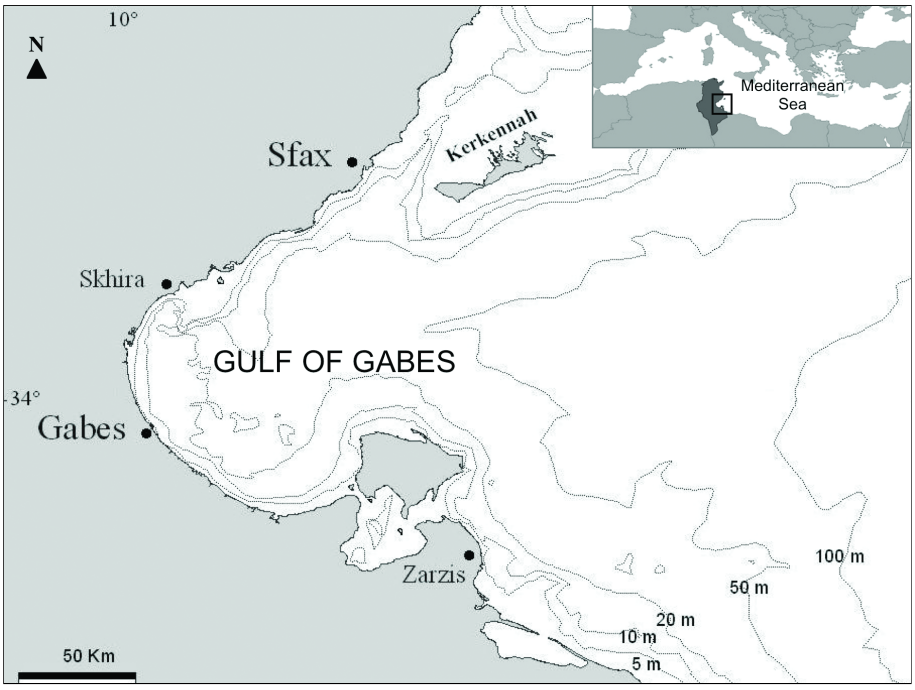

Figure 1

Geographical position of the Gulf of Gabes (Tunisia).
Position géographique du golfe de Gabès (Tunisie).

Posidonia oceanica (KTARI-CHAKROUN & AZOUZ, 1971, BEN OTHMEN, 1973). It shelters varied piscatorial resources (AZOUZ, 1971) and notably of the benthic species exploited for a long time by the artisanal and industrial fisheries.

Despite its commercial importance, little is known regarding the life history parameters of *S. aurata* in Tunisia, particularly in the Gulf of Gabes. The present study provides information on age structure and growth rates of the gilthead seabream *Sparus aurata* in the Gulf of Gabes, and the results may serve as a guideline for managing stock of this species.

Materials

A total of 1065 specimens of *S. aurata* were obtained by a random stratified sampling from commercial catches at different fishing ports of the Gulf of Gabes between March 2008 and February 2010. The species is currently caught in the area with longlines, trammel nets and traditional traps called locally "cherfias", which are fixed fisheries known in the south of the country and particularly in the Kerkennah islands where waters are shallow and the tidal range is important.

For each specimen, the total length (TL) was measured to the nearest mm, total fish weight (TW) and eviscerated fish weight (EW) to the nearest 0.1 g. The relation of total weight to total length was calculated applying the exponential regression equation (RICKER, 1973):

$$TW = aTL^b \quad (1)$$

where a and b are the parameters to be estimated.

Methods

The sample available for age and growth studies consisted of scales of 668 individuals (62.72%). Scales were removed from the back of the pectoral fin. The scales (ten for each specimen) were removed for determining age by interpreting growth rings. Each scale was read three times by different reader using a compound microscope at a magnification between 10× and 20× with a black background and under reflected light. Disturbance ring on the scales were distinguished from annual rings based on their irregularity; disturbance rings were not continuous across whole scales and showed thickening. For validating the periodicity of increments formation, the marginal increment was measured (PANFILI *et al*., 2002). Measurements were always made along the longest axis of the scale. Once the rings were confirmed to be annual, each specimen was assigned to a year class taking into account the data of capture, the annuli counts and their formation period, and the reproductive biology of the species in the area (PANFILI *et al*., 2002).

Through a direct calculation method (JABEUR, 1999), the age of the fish corresponding to each length at the time of capture was determined. Age taking into consideration the spawning period and the period of growth of the species studied as well as the date of capture of the considered individual was calculated. The month of growth as being the beginning of the age groups was considered. Approximate age in months was determined by adding the time elapsed between the capture date and the date of cessation of growth. Thus a length at age key at the time of the capture has been established for this species.

The Von Bertalanffy growth curve was fitted to the observed length at each age of the resulting age-length key by means of a Marquardt's algorithm for non-linear least-squares parameter estimation (SAILA *et al.*, 1988). The form of the growth curve (BEVERTON & HOLT, 1957) is:

$$L_t = L_\infty(1 - e^{-kit-t_0}) \quad (2)$$

where L_t is the fish length at age t (year), L_∞ the theoretical asymptotic length, k the growth rate coefficient, and t_0 the theoretical age when fish length is zero.

We have determined, through a direct calculation method (JABEUR, 1999), the age for each fish length at the moment of capture. In this calculation, we considered the spawning period, the annual deposition period of growth ring of growth cessation and the date of capture of the individual considered.

Results

Fish ranged in size from 10 to 35 cm, weighing between 11g and 350 g. 520 were male ranged from 10 to 30 cm in length (11-200 g in weight) and 442 females ranged from 12 to 35 cm (20-350 g in weight). 76 were hermaphrodites individuals

Table 1

Length-weight relationships (TW = aTL^b and GW = aTL^b) for male, female and all individuals of *Sparus aurata* from the Gulf of Gabes; **a**: intercept, **b**: slope, **CI b**: Confidence interval of b, **R²**: coefficient of determination, **N**: sample size and $\mathbf{t_{cal}}$: t-test calculated.

Relations taille-masse (TW = a*TL*b *et GW = aTL^b) pour les mâles, les femelles et sexes confondus de* Sparus aurata *du golfe de Gabès ;* ***a*** *: constante,* ***b*** *: constante,* ***CI b*** *: Intervalle de confiance de b,* ***R²*** *: coefficient de détermination,* ***N*** *: effectif et* $\boldsymbol{t_{cal}}$ *: t-test calculé.*

		a	b	CI b	R²	N	t_{cal}	allometry
Females	Whole fish weight (g)	0.0077	3.1879	0.067	0.9524	442	5.532	positive
	Gutted fish weight (g)	0.0078	3.16	0.063	0.9563	442	4.971	positive
Males	Whole fish weight (g)	0.0131	3.0081	0.056	0.9553	520	0.283	isometric
	Gutted fish weight (g)	0.011	3.044	0.05	0.9648	520	1.721	isometric
All fish	Whole fish weight (g)	0.0107	3.0797	0.036	0.9632	1065	4.317	positive
	Gutted fish weight (g)	0.0099	3.0826	0.033	0.9689	1065	4.878	positive

ranged in size from 17 to 27 cm and weighed from 50 to 300 g. The sex of the remaining 27 fish could not be determined macroscopically.

Length-weight relationship parameters for males, females and the two sexes considered together are presented in Table 1. Positive allometric growth was observed for females and all fish. For males, weight increased isometrically with length (Table 1). Significant difference in the allometric coefficient was found between males and females (*t*-test, $t = 5 > t_{0.05,962} = 1.965$).

The growth rings on scale were clear and 63% were readable. Marginal increment analysis showed that a single annulus was formed during May each year (Figure 2).

Table 2

Parameters of the Age-Length Key for female, male and all individuals of *Sparus aurata* from the Gulf of Gabes (March 2008-Febrary 2010).

Clé Age-Longueur des femelles, mâles et sexes confondus de Sparus aurata *du golfe de Gabès (Mars 2008-Février 2010).*

	Size (cm)								
	Females			Males			All Individuals		
Age group (years)	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	14.8	14.13	15.29	14.25	12.74	15.1	13.41	11.26	14.62
I	17.28	16.12	18.37	16.64	15.36	17.81	16.81	14.99	18.47
II	19.79	18.6	20.91	18.87	18	19.77	20.05	18.74	21.25
III	22.04	21.1	23	20.37	19.91	20.98	22.36	21.45	23.27
IV	23.88	23.16	24.47	21.74	21.65	21.82	24.03	23.41	24.72
V	25.11	24.86	25.48	22.55	22.55	22.55	25.06	24.82	25.29
VI	26.5	26.27	26.87	23.23	23.19	23.28	26.03	25.85	26.25

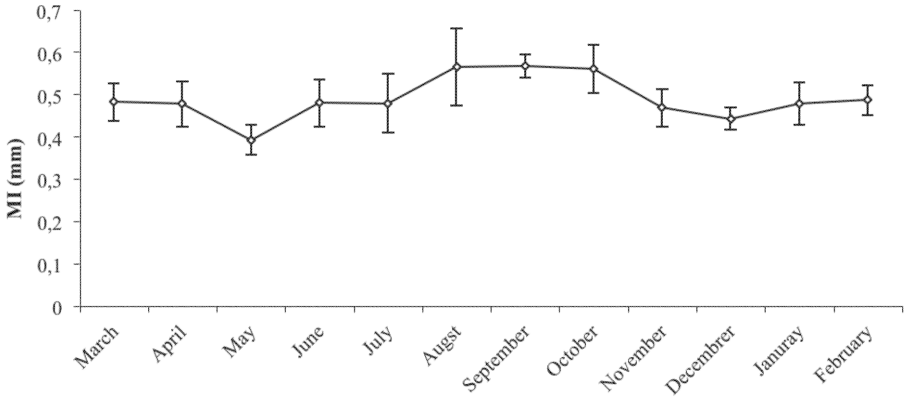

Figure 2

Monthly evolution of the marginal increment (MI) of scales of *Sparus aurata* of the Gulf of Gabes.
Évolution mensuelle de l'allongement marginal (MI) des écailles de Sparus aurata *dans le golfe de* Gabès.

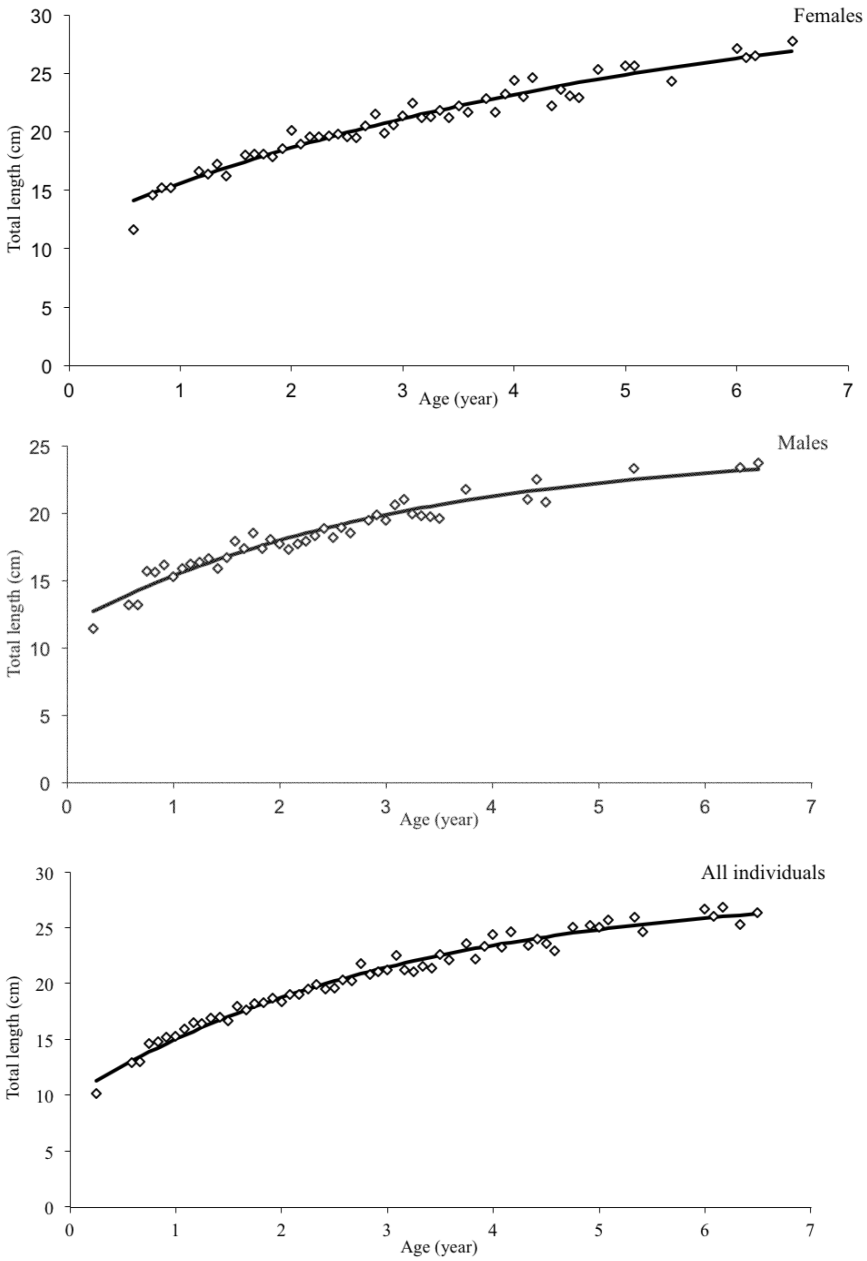

Figure 3

Estimated absolute age at length for females, males and all individuals of the gilthead seabream in Gulf of Gabes, Tunisia, sampled between March 2008 and February 2010.

Age absolu estimé des femelles, mâles et sexes confondus de la daurade royale du golfe de Gabès, Tunisie, échantillonné entre Mars 2008 et Février 2010.

The length used in the age-length key (Figure 2, Table 2) corresponded to averages of length calculated for individuals with the same age in months that we subsequently converted into years.

Males and females were aged from 0+ to 6+ years (Table 2, Figure 3). The parameters of the Von Bertalanffy growth equation for all individuals were estimated at 28.53 ± 1.33 cm, 0.324 ± 0.06 and -1.3 ± 0.29 year for L•, k and t0, respectively (Table 3).

Discussion

The length-weight relationship reveals that females are heavier than males at a given length. This may also be explained by protandry (LASSERRE & LABOURG, 1974; CHAOUI *et al*., 2006), because males predominated in smaller size classes and females in larger ones. Also, weight increases isometrically with length for the two sexes. Similar results have been reported from other areas (WASSEF, 1978).

The use of the von Bertalanffy model to describe growth has been criticised for several reasons (BOOTH, 1997). Nevertheless, it provides a simple description of growth that can be compared between species and species group. The special or original form of the von Bertalanffy equation was chosen for this study because it contains fewer parameters than the Schnute growth model.

The oldest fish was 6 years old in the gulf of Gabes, 7 in Algeria (CHAOUI *et al*., 2006) and 4 in Egypt (MEHANNA, 2007).

Differences in length between males and females of the same age cannot be considered as evidence of an intersexual difference in growth rates because females and males are the same individuals at different phases of sexual succession and it is possible that the largest males in an age group are the first to change sex.

The theoretical maximal length value (L_∞ = 47.18 cm) was close to the size of the largest fish examined and the growth coefficient value (k = 0.116 year^{-1}) indicated relatively low attainment of maximal size. These parameters are similar to those reported by LASSERRE & LABOURG (1974) and THARWAT *et al*. (1998) (Table 3). However, they differ from those obtained by LASSERRE & LABOURG (1974), SUAU & LÓPEZ (1976), AMERAN (1992), KRALJEVIĆ & DULČIĆ, (1997), and CHAOUI *et al*. (2006) and AKYOL & GAMSIZ (2010) (Table 3). The differences in growth between regions can be attributed to the difference in the size of the largest individual sampled in each area, the methods used for assessing the growth equation and the differences in their environmental conditions. The largest fish were found in the studies conducted by LASSERRE (1976), WASSEF (1978) and CHAOUI *et al*. (2006).

The pattern found in *S. aurata* is similar to that observed in the same period and the same area by interpreting growth rings on the otoliths (HADJ TAIEB *et al*., 2013), this species was characterized by moderate asymptotic length (47.18-38.28 cm) and

Table 3

Estimated parameters of the von Bertalanffy growth equation for *Sparus aurata* in different areas.
Les paramètres de l'équation de von Bertalanffy de Sparus aurata *dans différentes régions*.

LT_∞ (cm)	K (year^{-1})	t_0 (year)	Methods	Area	Author
42.29	0.456	-0.451	Scales	Graveyron (France)	LASSERRE & LABOURG (1974)
62.02	0,2221	-0.774	Scales	Thau (France)	LASSERRE & LABOURG (1974)
53	0,315	-	LFA[a]	Segura (Spain)	ARNAL *et al*. (1976)
53.48	0.264	-1.340	Scales	Graveyron (France)	LASSERRE (1976)
56.17	0.265	-0.409	Scales	Adour (France)	LASSERRE (1976)
57.66	0.272	-0.541	Scales	Thau (France)	LASSERRE (1976)
62.19	0.171	-0.531	LFA[a]	Ebre (Spain)	SUAU & LOPEZ (1976)
70.62	0.17	-	Scales	Alexandria (Egypt)	WASSEF (1978)
84.55	0.130	-1.586	Scales	Cádiz (Spain)	ARIAS (1980)
38.05	0.25	-1.92	Scales	Bardawil lagoon (Egypt)	AMERAN (1992)
34.55	0.24	-1.41	Scales	Bardawil lagoon (Egypt)	KHALIFA (1995)
59.76	0.153	-1.711	Otoliths	Mirna (Croatia)	KRALJEVIĆ & DULČIĆ (1997)
38.50	0.30	-1.08	Scales	Bardawil lagoon (Egypt)	THARWAT *et al*. (1998)
34.08	0.58	-0.70	Scales	Bardawil lagoon (Egypt)	ABD-ALLAH (2004)
55.33	0.513	-0.228	Scales	Mellah lagoon (Algeria)	CHAOUI *et al*. (2006)
37.98	0.50	-0.60	Otoliths	Port Said (Egypt)	MEHANNA (2007)
64,97	0.14	-2,47	LFA[a]	Aegean Sea	AKYOL & GAMSIZ (2010)
38.28	0.202	-1.888	Otoliths	Gulf of Gabes	HADJ TAIEB *et al*. (2013)
47.18	0.116	-2.954	Scales	Gulf of Gabes	Present study

[a]LFA, length-frequency analysis.

low growth coefficient (0.116-0.202 year^{-1}) (Table 2). The t_0 values obtained in the present work and for the previous study are negative: -1.888 to -2.954 years. Negative values of t_0 are frequent among species with rapid growth during the first year and slow growth in the following years (CRAIG *et al*., 1997).

It is worth pointing out that here *S. aurata* of the Gulf of Gabes grows less quickly than those of East Mediterranean (ARNAL *et al*., 1976; SUAU & LOPEZ, 1976) and Western Mediterranean (KHALIFA, 1995; ABD-ALLAH, 2004). This phenomenon was also found for other species such as the scorpion-fish *Scorpaena porcus* (BRADAI & BOUAIN, 1988) and the common pandora *Pagellus erythrinus* (GHORBEL & BOUAIN, 1990).

The growth parameters obtained in the present study are reasonable because the theoretical maximum length value is higher than the size of the largest fish sampled and the growth coefficient value indicates a relatively slow attainment of maximum size, characteristic of the long life cycle of the species. Individuals grow fast during their first year, attaining approximately 40% of their maximum length; after the first year, the annual growth rate drops rapidly.

Conclusion

The growth pattern of gilthead seabream populations of the Gulf of Gabes presented in this paper provides several key biological parameters required for age-based stocks evaluation, allowing the development of sustainable management strategies.

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