Mediterranean Aquaculture Journal 2023 10 (1):32-39

Original Article

Age, growth, and mortality of the *Gilthead Seabream*, Sparus aurata (Family: Sparidae) in Bardawil lagoon, North Sinai, Egypt

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ABSTRACT: Age, growth, and mortality of the Gilthead Seabream, Sparus aurata were studied from a small-scaled fishery of Bardawil lagoon, (North Sinai, Egypt).499 specimens of Sparus aurata varied from 9.7 to 29 cm with weights ranging between 16.6 and 325.3 g were collected from April to October during fishing season 2020-2021. The relationship between length and weight was W= 0.0239 L2.8357 (R2 = 0.9677) Age was determined by otoliths and age groups 0 to 5 years were observed. Growth in length and weight at the end of each year was calculated. The growth parameters of the von Bertalanffy equation were calculated as (L∞ = 39.38, K = 0.1615 year-1, t0 = -2.31 year-1, and W∞= 798.5). The growth performance index was 2.40 for length and 1.14 for weight. Mortality rates were 0.794 year-1; 0.25 year-1 and 0.54 year-1 for total, natural, and fishing mortality, respectively. The current exploitation rate (E) = 0.68.

Key word: Bardawil lagoon, gilthead seabream (*Sparus aurata*), Length &Weight relationship, Age, growth, and mortality.

Received: Mars, 27, 2023

Accepted: May, 12, 2023

1. INTRODUCTION

The gilthead seabream (*Sparus aurata* Linnaeus, 1758) is a perciform fish, belonging to the family Sparidae and to the genus Sparus. It inhabits the Atlantic coasts of Europe, the Mediterranean, and the Black Sea (rare) (Muhammed *et al.* 2010). Sparidae fishes are found predominantly and widespread throughout the Mediterranean Sea and Eastern Atlantic coast (FAO, 2005). It is one of the most intensively cultured species in fish farms in Mediterranean countries due to the quality of its meat (Faggio et al., 2014). It is one of the most important marine species in fishery and aquaculture, especially in the Mediterranean area (Muhammed *et al.* 2010). The species is found in both marines and brackish water environments such as coastal lagoons and estuarine areas, in particular during the initial stages of its life cycle (Moretti et al., 1999).

Gilthead Sea bream is commercially fished and farmed, especially in Europe (FAO, 2005 and Heather *et al.*, 2018). Since it is one of the most expensive; it is targeted for intensive fishing. Gilthead Sea bream, *Sparus aurata* mainly exploited in Bardawil lagoon by trammel and gillnets as well as hand line technique (Salem, 2011).

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Age, growth rates, and other population biology of *Sparus aurata* have been studied in several Mediterranean countries such as Croatia (Kraljevic and Duleic, 1997); Algeria (Chaoui, *et al*., 2006); Egypt (Mehanna, 2007; Salem, 2010; Salem, 2011; Zaher *et al*., 2015).

Length-weight relationship (LWR) and condition factors are important to study the biology of a fish. According to Le Cren (1951), knowledge of the length-weight relationship of a fish is essential, since various important biological aspects, namely, the general well-being of fish, appearance of first maturity, onset of spawning, etc., can be assessed with the help of condition factor, a derivative of this relationship. This relationship might change over seasons or even days (De Giosa *et al*., 2014). It is argued that b may change during different periods illustrating the fullness of the stomach, general condition of appetite, and gonads stages (Zaher *et al*., 2015).

Age and growth are vital components for understanding the ecology and life history of any fish species.

Knowledge of the individual growth rates and age is required to determine the success and degree of establishment as well as to predict the fish's impact on other fauna. Age and growth rate information can be used to compare dynamics among water bodies, years, and fish sizes; describe trends over time; examine total mortality rates; and determine the general status of a population. Age is one parameter necessary to assess population dynamics and the state of exploited resources (Allain and Lorance, 2000).

The current work attempts to assess *Sparus aurata* age, growth, and mortalities in Bardawil lagoon by identifying age groups estimating growth rate and growth parameters, estimate mortality and utilization rates.

MATERIALS AND METHODS

1. **Study area:**

Bardawil lagoon **Fig (1)** is an important source of local and economic fishes in North Sinai, and it plays an essential role in the fish production in Egypt, where it produces very economically important species of fishes such as sea bass, sea bream, sole, grey mullet, eel, meager and white grouper (GAFRD, 2020).

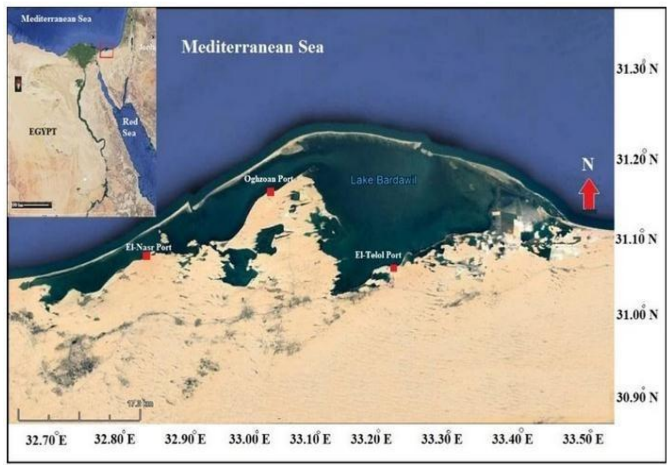


Fig (1): Map of Bardawil lagoon

2. **Sampling**

Monthly random samples of 499 Gilthead Seabream individuals (*Sparus aurata*) were collected from the El-Tilol landing site from the Bardawil lagoon between April and October during the fishing seasons 2020-2021. The total length of *S. aurata* individuals from the tip of the snout to the end of the caudal fin was measured to the nearest centimeter and the total weight was recorded to the nearest 0.1 gram. Otoliths were removed, cleaned, and stored dry in labeled vials.

3. **Data analysis:**

By reading otoliths by stereomicroscope, the age was determined. Lengths by age were back-calculated using (Lee's, 1920) equation: Ln = (Sn/Sx) Lx, where: Ln = is the length of fish at age "n ", Sn = is magnified otolith radius to "n "annulus, Sx = is magnified total otolith radius, Lx = is the fish length at capture. The length-weight relationship was computed using the formula of (Le Cren, 1951) ($W = aL^b$, where: a and b are constants, whose values were estimated by the least square method).

Theoretical growth in length and weight was obtained by fitting the von Bertalanffy growth model, using the (Ford, 1933; Walford, 1946) method: $L_t = L_\infty [(1 - e^{-k(t - t0)})]$, Where: L_t = the length at age t, L_∞ = the asymptotic length at t∞, K = growth coefficient and t_0 = age at which the length is theoretically nil. The calculation of constants of the Von Bertalanffy growth model by the Ford–Walford method can be derived as follows: K = - Ln the slope = - Ln b, L_∞ = intercept / 1 – slope = a / 1 – b, where the age ($t_\circ$) at length zero was measured by the following formula $t_0 = t + 1/ k \, Ln (L_\infty - L_t) \backslash L_\infty$.

The growth performance index (φ) was estimated for length as $\varphi = \log K + 2 \log L_\infty$ (Pauly and Munro, 1984) where: K and L_∞ are parameters of von Bertalanffy.

Estimation of total mortality (Z) from a linearized catch curve based on age composition data (Ricker, 1975) Z= -b, Natural mortality coefficient (M) measured by the average of Ursin formula (1967): $M=W'^{-(1/3)}$ where W′: is the average weight of fish in the catch, and (Hewitt and Hoenig, 2005) equation: $Ln(M) = 1.44 - 0.982 * Ln(t_{max})$ where t_{max} is the age of the oldest fish. Fishing mortality (F): It was calculated as F=Z-M. Exploitation rate (E): was calculated after (Gulland, 1971) where E = F/Z.

RESULTS AND DISCUSSION

Length–weight relationship measured of Sea bream, *S. aurata* collected from Bardawil lagoon and 499 specimens of *S. aurata* varied from 9.7 to 29 cm with weights ranging between 16.6 and 325.3 g were assessed from October to April during the fishing season 2020-2021. The equation thus derived in respect of the length-weight relationship for both sexes as $W = 0.0239 L^{2.8357}$ (R^2 = 0.9777) and shown in fig (2).

Table 1. Length frequency distribution of combined sexes of *S. aurata* (♂♀) collected from Bardawil lagoon

Length group (cm)	Frq.	Obs. L	Obs. W
9-9.9	1	9.7	16.6
10-10.9	5	10.5	20.9
11-11.9	9	11.4	24.7
12-12.9	21	12.4	31.9
13-13.9	17	13.4	37.3
14-14.9	30	14.5	47.3
15-15.9	55	15.5	56.0
16-16.9	124	16.4	66.4
17-17.9	98	17.4	75.5
18-18.9	52	18.3	97.6
19-19.9	22	19.2	101.3
20-20.9	21	20.2	119.1
21-21.9	14	21.4	151.5
22-22.9	10	22.3	171.2
23-23.9	6	23.3	188.8
24-24.9	3	24.2	207.2
25-25.9	4	25.1	215.1
26-26.9	3	26.2	254.2
27-27.9	1	27.5	283.4
28-28.9	1	28.5	317.2
29-29.9	2	29.0	325.3
	499		

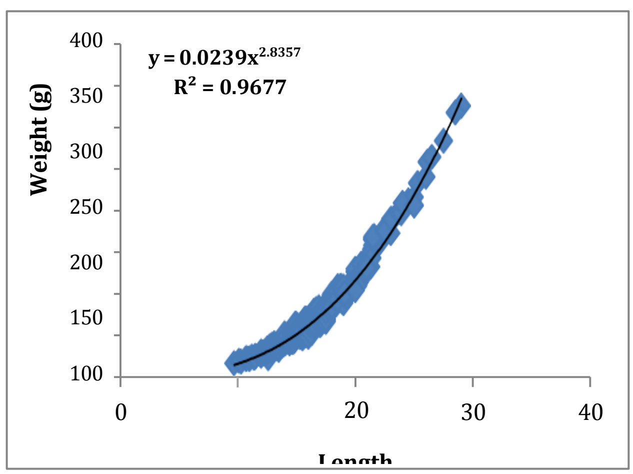


Fig (2): Length-weight relationship of *S. aurata* (♂♀) collected from Bardawil lagoon during fishing season 2020- 2021

The length-weight relationship equation for *S. aurata* showed a negative allometric in which b= 2.8357, these results agree with (Mourad, *et al*., 2008) who found that, the value of (b) in the Gulf of Tunis exhibit negative allomatric growth (b=2.76).

Also, it agrees with both (Salem, 2010 and Mehanna *et al*., 2014) they resulted that, the value of (b) in Bardawil lagoon, north Sinai, Egypt was 2.759 and 2.7984 respectively.

On other hand, this result disagrees with that of (Wassef, 1978) who found that, the value of (b) in Mediterranean Sea water, positive allometric growth (b>3) b= 3.2216. (ChaOui *et al*., 2006) estimated the length-weight relationship for *S. aurata* in Mellah lagoon (north-eastern Algeria) where the value of (b) was 3.06. Also, (Hadj-Taieb *et al*., 2013) the relationship equation showed a positive allometric in which b= 3.0799 in Tunisia, and (Ozaydin and Taskavak, 2006) In Spain by the value of b=3.164.

The relationship between body length and weight can be changed with many condition factors such as season, sex, quality and quantity of food, maturity stage, and techniques of sampling (Le Cren, 1951).

The age composition of *S. aurata* in Bardawil lagoon during the season 2020 - 2021 was determined by the annual rings of otolith of 499 species. Five age groups plus age group zero were observed with the percentage of fish of each age group shown in Table (2).

From this table, the age group I is dominant and contributes 37.9 %, but the total number of fishes caught in age group V show more low frequencies for sexes combined from *S. aurata* in Bardawil lagoon. On the other hand, it is clear that the frequency of fish increases gradually from age – group 0 ((less than one year) to reach its maximum in age-group I for combined sexes and then decreases with the increase of age.

Table 2: Age composition of *S. aurata* collected from Bardawil lagoon during the season, 2020- 2021

Age group	Sexes combined	
	number	%
age0	189	37.9
age1	204	40.9
age2	39	7.8
age3	26	5.2
age4	22	4.4
age5	19	3.8
SUM	499	

This result disagrees with Khalifa (1995) who estimated the age by 6 years for *S. aurata* in Bardawil Lagoon and Al-Zahaby *et al*. (2018) who found that the catch of *S. aurata* is composed of four age groups plus age group zero.

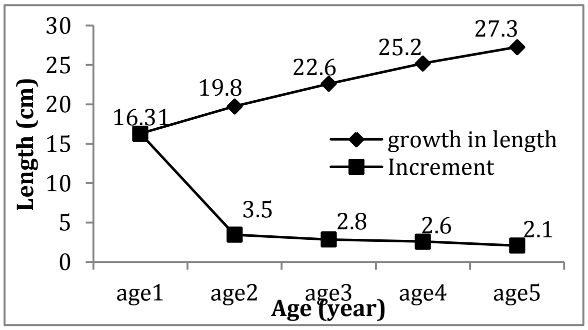
The average back-calculated lengths of *S. aurata* are given in Table (3) as 16.31, 19.77, 22.62, 25.20, and 27.28 cm, and increments in the length of age were 16.31, 3.46, 2.85, 2.59 and 2.08 for the 1st, 2nd, 3rd,4th and 5year of life, respectively. The highest annual increment occurred during the first year of life, while a noticeable decrease was observed in the second year, reaching to minimal value during the Fifth year of life (Fig. 4).

Table 3: Back–calculated length at the end of different life years of, combined *S. aurata* collected from Bardawil lagoon

Age	No. of fish	Observed length (cm)	Observed weight (g)	Average back calculated lengths at the end of each year (cm)				
				I	II	III	IV	V
Males (♂) and Females(♀)								
0	97	13.6	42.2					
I	102	17.5	83.8	**16.31**				
II	10	20.9	141.0	17.99	**19.77**			
III	5	23.4	193.8	19.91	21.50	**22.62**		
IV	4	25.9	242.1	21.19	22.89	24.20	**25.20**	
V	3	28.3	308.6	22.04	23.72	25.08	26.34	**27.28**
			Increment	**16.31**	**3.46**	**2.85**	**2.59**	**2.08**

This result disagrees with (Salem, 2011) in Bardawil Lagoon, he found that the back–calculated lengths for *S. aurata* were 23.38, 27.51, 30.21, and 32.15 cm for ages 1st, 2nd, 3rd, and 4th years respectively. Also, (Mosbh, 2013) resulted that the back-calculated for *S. aurata* in Bardawil lagoon as 17.74, 23.25, 27.6, 31.44, 32.85, and 34.19cm for ages 1st, 2nd, 3rd, 4th, 5, and 6 years respectively.

Fig 4: Growth and annual increment in length (♀♂) of *S. aurata* collected from Bardawil lagoon.



Mehanna *et al*., (2014) found that the mean lengths at an age were back-calculated for *S. aurata* in Bardawil lagoon as 17.5, 23.5, 27.3, and 30.1 cm TL in the 1st, 2nd, 3rd, and 4th year of life respectively.

The average calculated weight for the combined sexes of *S. aurata* is given in Table (4) and it was 65.49, 113.03, 165.60, 225.21, and 281.97g at the end of the first, second, third, fourth, and Fifth years of life respectively in fishing season 2020-2021 in Bardawil lagoon**.** The results in these tables showed that the weight increased successively and reached its maximum at group V up to 281.97 g**.**

Table (4): calculated weight at the end of different years of life (♂♀) *S. aurata* Collected from Bardawil lagoon.

Age	No. of fish	Observed length (cm)	back-calculated length(cm)	Average calculated weights (g) at the end of each year				
				I	II	III	IV	V
Males (♂)								
0	97	13.6	42.2					
I	102	17.5	83.8	**65.49**				
II	10	20.9	141.0	86.51	**113.03**			
III	5	23.4	193.8	115.31	143.40	**165.60**		
IV	4	25.9	242.1	137.66	171.32	200.69	**225.21**	
V	3	28.3	308.6	153.87	189.49	222.06	255.16	**281.97**
			Increment	65.49	47.54	52.57	59.60	56.76

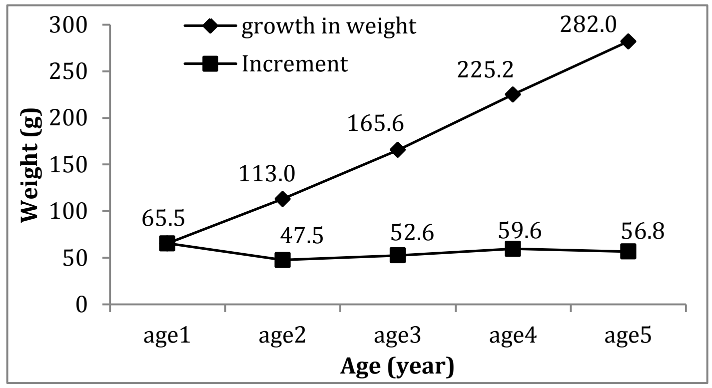


Fig (5): Calculated weight at the end of different years of life (♀♂) of *S. aurata* collected from Bardawil lagoon.

In this study the growth parameters of von Bertalanffy for gilthead seabream, *Sparus aurata* were as follow; L_∞ = 39.38, K = 0.1615 year$^{-1,}$ t_0 = -2.31 year^{-1} and W_∞= 798.5.

Kraljevi and Dul (1997) determined the Von Bertlanffy parameters for *S. aurata* in the northern Adriatic, where L_∞= 59.8 cm; K= 0.15 year^{-1}; t_0= -1.71 year^{-1} and W_∞= 5554 g. (Tharwat *et al*., 1998) mentioned that In the Bardawil Lagoon The growth parameters of von Bertalanffy for *S. aurata* L_∞= 38.5 cm, K = 0.297 year^{-1}, t_o= -1.085 year^{-1} and W_∞= 796.3. In Bardawil lagoon (Mehanna *et al*, 2014) growth parameters were found as L_∞, K, and W_∞ was 35.5 cm, 0.4 per year, and 531g respectively. While, (Al-Zahaby *et al*., 2018) resulted that, K = 0.370 year-1, L_∞= 39.17cm, t_o= -0.650 year$^{-1,}$ and W_∞ = 898 g. (Mcllwain *et al*., 2005) mentioned that the differences in growth parameters were due to age, sex, maturity, and sampling period for the same species.

The obtained results indicated that the growth performance index of *S.aurata* was 2.40 for length. Mehanna *et al*., 2014 estimated (*φ*) for the same species in Bardawil Lagoon was computed as 2.7.

Therefore, it could be reported that the environmental condition of Bardawil Lagoon is the retreat for the growth of *S.aurata* under study. Such differences may be attributed partially to the different techniques used, but more likely reflect slight environmental differences such as food availability, Salinity, and temperature (El -Ganainy and Ahmed, 2002).

The total mortality (Z) was calculated for *S.aurata a* was 0.794 year^{-1} fig (6), the natural mortality coefficient (M) was 0.23 year^{-1}, fishing mortality (F) was 0.56, and Exploitation rate (E) was 0.71.

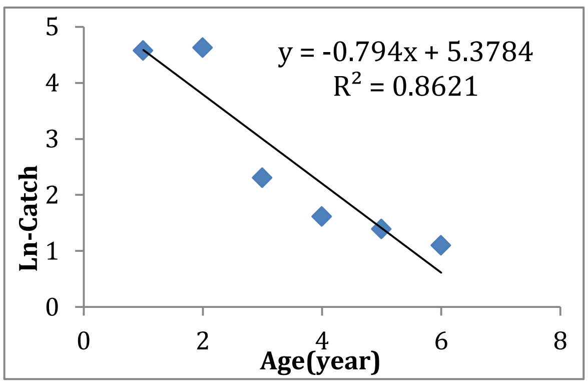


Fig (6): (Z) from a linearized catch of combined sexes of *S. aurata* in Bardawil lagoon.

The present results disagree with the results obtained by (Salem, 2011) the total mortality coefficient Z for the same species in Bardawil lagoon was 1.02 year^{-1}, natural mortality was 0.21 year^{-1}, while the fishing mortality was 0.81 year^{-1}.

The value of exploitation ratio (E): According to (Gulland, 1971) when the exploitation ratio is more than 0.5, this means overexploitation of the fish population. The value of the exploitation ratio (E) for gilthead seabream in the Bardawil Lagoon was 0.71. This means that the *S. aurata* population in the Bardawil Lagoon suffers from overfishing. This is consistence with the results of (Tharwat *et al.*, 1998), who estimated the total exploitation ratio (E = 0.57); (Salman, 2011) found that, the exploitation rate (E) in the Bardawil lagoon, Egypt E= 79.43 %. Also, Al-Zahaby (2018) pointed out that the exploitation rate for the same species (E) = 0.637.

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