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Age and growth of gilthead sea bream (*Sparus aurata* Linnaeus, 1758) from Northern Aegean Sea (Turkey)

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ABSTRACT

The age and growth of gilthead sea bream (*Sparus aurata* Linnaeus, 1758) were studied in the present study. A total of 126 specimens were collected from commercial fishmongers during the period between January 2015 and December 2015 from the northern Aegean coasts of Turkey. Fork length and the total weight of aged specimens ranged from 29.5 to 48.0 cm and from 425.00 to 2100.00 g, with a mean of 38.5 cm and 101.23 g, respectively. The length-weight relationship was estimated as $W = 0.0053FL^{3.03}$ ($R^2 = 0.95$). The von Bertalanffy growth equations were computed as $L_\infty = 52.8$ cm, $k = 0.29$ year^{-1}, $t_0 = -1.25$ year for all samples. The growth performance index (Φ') was found as 2.91. There is no study on the biology of the species for the northern Aegean Sea. Therefore, this study provides valuable information for the species in this area.

Keywords: Gilthead Sea bream, Growth parameters, *Sparus aurata*, Northern Aegean Sea, Turkey.

1. INTRODUCTION

Life history traits like age, growth, reproduction and mortality are principal factors in fisheries research and management (Mgaya and Mahongo, 2017). Fish age is an important biological variable for calculating growth parameter and mortality (Campana, 2001). In this connection, von Bertalanffy (1934) growth parameters (VBGPs), essential for the development of a variety of fisheries models and the management of fisheries resources, could be used for the indirect estimation of other parameters using existing empirical equations (Froese and Binohlan, 2003). Examples of indirectly estimated parameters include: (a) natural mortality from growth parameters (Pauly, 1980) or from t_{max} (Hoenig, 1983), (b) length at first maturity from L_∞ and/or K (Froese and Binohlan, 2000), (c) age at first maturity from t_{max} (Froese and Binohlan, 2000), (d) optimum exploitation length from L_∞ or length at first maturity (Froese and Binohlan, 2000), (e) trophic level from L_{max} (Stergiou and Karpouzi, 2002), (f) mouth size from L_{max} (Karpouzi and Stergiou, 2003), and (g) tail area from L_{max} (Karachle and Stergiou, 2005).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer's Catalog of Fishes, 2020). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al., 2014) while they previously were listed as distinct and separate (Golani et al., 2006; Nelson, 2006; Mater et al., 2011). As far as it is known, 24 Sparidae species within 13 genera (*Boops* Cuvier, 1814; *Centracanthus* Rafinesque,

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1810; *Dentex* Cuvier, 1814; *Diplodus* Rafinesque, 1810; *Evynnis* Jordan and Thompson, 1912; *Lithognathus* Swainson, 1839; *Oblada* Cuvier, 1829; *Pagellus* Valenciennes, 1830; *Pagrus* Cuvier, 1816; *Sarpa* Bonaparte, 1831; *Sparus* Linnaeus, 1758; *Spicara* Rafinesque, 1810; *Spondyliosoma* Cantor, 1849) from Turkish territorial waters were reported (Mater et al., 2011) and there are two more species (*Crenidens crenidens* Forsskål, 1775 and *Rhabdosargus haffara* Forsskål, 1775) in the Eastern Mediterranean (Golani et al., 2006) which are lessepsian (Paruğ and Cengiz, 2020).

The genus *Sparus* is represented by one species, worldwide: *Sparus aurata* (Linnaeus, 1758). Gilthead sea bream (*Sparus aurata* Linnaeus, 1758), an inshore species that frequents *Posidonia oceanica* beds and rocky and sandy areas, is common in the Mediterranean Sea, but very rare in the Black Sea (Bânârescu, 1964). It is also present in the eastern part of the Atlantic Ocean, from Britain to Cape Verde and the Canaries (Bauchot and Hureau, 1986). This fish has a high commercial importance for fishery and aquaculture (Teles et al., 2018). For this reason, gilthead sea breams are captured with traditional bottom trawl nets, coastal purse-seines, bottom set longline and hand lines, and are regularly present to the markets in Turkey (Akyol and Gamsız, 2011). According to the Turkish Statistical Institute, *Sparus aurata* yield from fisheries and aquaculture production were 583.7 t and 109.749 t, respectively (TurkStat, 2021)

All over the world, the information on the age and growth of *Sparus aurata* were given in the Alexandria (Egypt) (Wassef, 1978), in the Bardawil lagoon (Egypt) (Ameran, 1992; Khalifa, 1995; Tharwat et al., 1998; Abd-Allah, 2004; Mokbel et al., 2020), in the Cádiz (Spain) (Arias, 1980), in the Ebre (Spain) (Suau and Lopez, 1976), in the eastern Adriatic (Croatia) (Kraljević et al., 1998), in the Graveyron and Thau (France) (Lasserre and Labourg, 1974; Lasserre (1976), in the Gulf of Gabes (Tunusia) (Hadj Taieb et al., 2013; 2015), in the Gulf of Lion (France) (Mercier et al., 2011), in the Mellah Lagoon (Algeria) (Chaoui et al., 2006), in the Mirna Estuary (Croatia) (Kraljević and Dulčić, 1997), in the Port Said (Egypt) (Mehanna, 2007), in the Segura (Spain) (Arnal et al., 1976). In the southern Aegean Sea, only one reference exists with information about its growth (Akyol and Gamsız, 2011), whereas, there is no study on the biology of the species for the northern Aegean Sea. The main objective of the present study was to determine age and growth of gilthead sea bream around the northern Aegean Sea to provide data on their biological information in a data-poor area.

2. METHODOLOGY

The northern Aegean coasts of Turkey are divided into sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökçeada and Bozcaada Islands and the Edremit Bay (Cengiz, 2021) (Fig 1). The northern Aegean areas are characterized by an extended continental shelf, smooth muddy/sandy bottoms and higher nutrient concentrations (Maravelias and Papaconstantinou, 2006) and have higher phytoplankton and zooplankton abundance compared with the southern Aegean Sea (Theocharis et al., 1999).

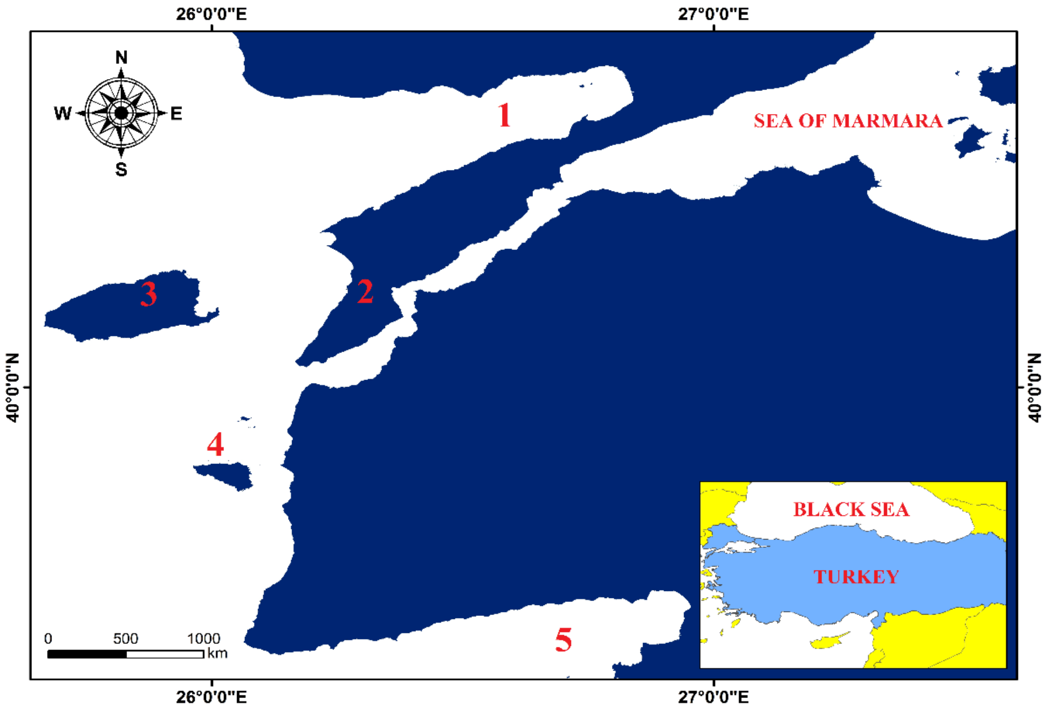

Figure 1. Northern Aegean coasts of Turkey (1: Saros Bay; 2: Gallipoli Peninsula; 3: Gökçeada Isl.; 4: Bozcaada Isl.; 5: Edremit Bay).

The individuals of sampled *Sparus aurata* from commercial fishmongers randomly were taken during the period betwwen January 2015 and December 2015 from the northern Aegean coasts of Turkey. The samples were measured to the nearest centimeter (fork length), weighed to the nearest 0.01 g (total weight). The length-weight relationship was estimated by fitting an exponential curve, $W = aL^b$ (Le Cren, 1951). Parameters *a* and *b* of the exponential curve were estimated by linear regression analysis over log-transformed data $\log W = \log a + b \log L$, where *W* is the total weight (g), *L* is the fork length (cm), *a* is the intercept, and *b* is the slope or allometric coefficient, using the least-squares method. The *b* value that is higher than 3 shows positive allometric growth, while the *b* value that is lower than 3 indicates negative allometric growth. It is isometric growth when the *b* value is equal to 3 (Bagenal and Tesch, 1978). The growth type was identified by Student's *t*-test.

The ages of the specimens were checked using scales. Scales were removed from the base of the pectoral fin and from the flanks below the dorsal fin. They were cleaned in 5% sodium peroxide and then immersed in glycerol in a black Petri dish, and annuli, defined as opaque and hyaline zones were counted by using a binocular microscope (Akyol and Gamsız, 2011). Growth parameters were estimated by using the von Bertalanffy growth equation: $L_t = L_\infty [1 - e^{-k(t - to)}]$, where L_t is fish length (cm) at age t, L_∞ is the asymptotic fish length (cm), t is the fish age (years), t_0 (years) is the hypothetical time at which the fish length is zero, and k is the growth coefficient (year^{-1}). FAO-ICLARM Stock Assessment Tools FISAT II) were used to estimate growth parameters, which were calculated with the non-linear least-squares method. The growth parameters obtained in this study were compared with the parameters obtained in other studies from various geographical areas using the growth performance index (Φ') (Pauly and Munro, 1984). It was estimated using the formula, $\Phi' = \log(k) + 2 \times \log(L_\infty)$.

3. RESULTS

The sample size is 126 individuals, coming from the commercial capture of the northern Aegean Sea coasts of Turkey. Faced with the impossibility of dissecting the fish, because they are intended for sale, then it has been considered all samples, as a whole. The mean ± standard error (and range) of fork length and the total weight of specimens were 38.5 ± 0.34 (29.5 – 48.0) cm (Fig 2) and 1090.00 ± 30.86 (425.00 – 2100.00) g, respectively. The length-weight relationship was estimated as $W = 0.0053FL^{3.03}$ ($R^2 = 0.95$) (Fig 3). The *b*-values and *t*-test results indicated positive allometric growth.

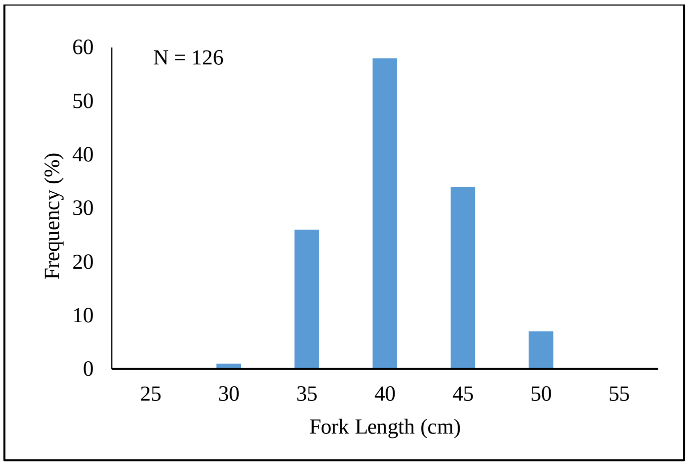

Figure 2. The length-frequency distribution for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

Results obtained from the scale reading indicated that the ages of the fishes were found to be within the range of II to VI years. Table 1 indicated the fishes belonging to age groups III and IV were the most dominant. The von Bertalanffy growth equations were computed as L_∞ = 52.8 cm, k = 0.29 year^{-1}, t_0 = -1.25 year for all samples (Fig 4). The growth performance index (Φ') was found as 2.91.

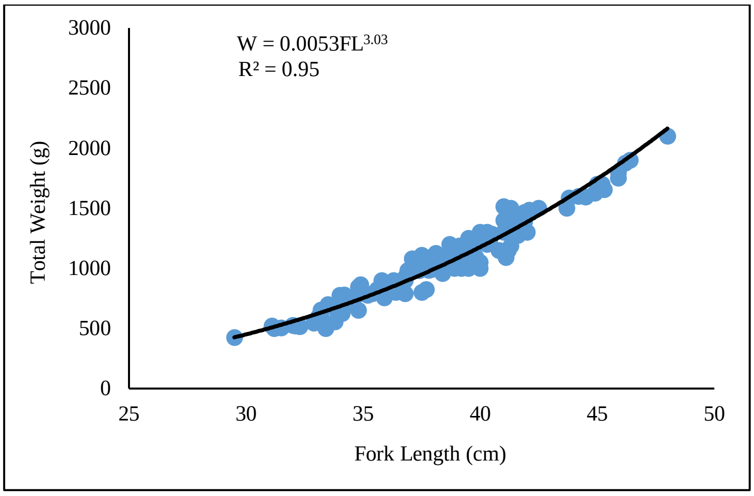

Figure 3. The length-weight relationships for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

Table 1. The age-length key for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

Age (years)	***N***	***Length range (cm)***	***L_{mean} ± S.E.***
II	4	29.5 - 32.1	31.1 ± 0.55
III	77	31.2 - 42.0	37.0 ± 0.30
IV	25	38.0 - 42.3	40.0 ± 0.27
V	12	41.0 - 45.0	43.0 ± 0.43
VI	8	44.6 - 48.0	46.0 ± 0.33

Note: N = sample size, S.E = standard error.

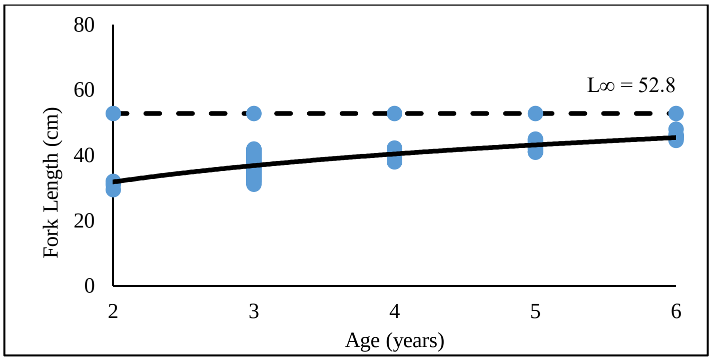

Figure 4. The growth curves for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

Table 2. The length-weight relationships, growth parameters and growth performance indices of *Sparus aurata* reported in the previous literatures.

References	Location	N	Method	L_∞	K	t_0	Age range (year)	Φ'	a	b
Lasserre and Labourg (1974)	Graveyron (France)	126	Scales	42.2	0.45	-0.45	1 - 4	2.90	0.0144	3.07
	Thau (France)	713	Scales	62.0	0.22	-0.77	1 - 4	2.93	0.0226	2.88
Arnal et al. (1976)	Segura (Spain)	135	LFA*	53.0	0.31	-	2 - 6	2.94	0.0289	2.90
Lasserre (1976)	Graveyron (France)	94	Scales	53.4	0.26	-1.34	2 - 5	2.87	0.0541	2.61
	Thau (France)	383	Scales	57.6	0.27	-0.54	1 - 4	2.95	0.0121	3.06
Suau and Lopez (1976)	Ebre (Spain)	611	LFA*	62.1	0.17	-0.53	1 - 7	2.82	0.0112	3.05
Wassef (1978)	Alexandria (Egypt)	-	Scales	70.6	0.17	-	1 - 5	2.93	-	-
Arias (1980)	Cádiz (Spain)	1775	Scales	84.5	0.13	-1.58	1 - 7	2.97	0.0071	3.12
Ameran (1992)	Bardawil lagoon (Egypt)	-	Scales	38.0	0.25	-1.92	1 - 3	2.56	-	-
Khalifa (1995)	Bardawil lagoon (Egypt)	-	Scales	34.5	0.24	-1.41	1 - 6	2.46	0.014	2.98
Kraljević and Dulčić (1997)	Mirna Estuary (Croatia)	314	Otoliths	59.7	0.15	-1.71	1 - 12	2.73	0.0112	3.05
Kraljević et al. (1998)	eastern Adriatic Sea (Croatia)	462	Scales	84.9	0.07	-2.82	1 - 22	2.70	0.0101	3.08
Tharwat et al. (1998)	Bardawil lagoon (Egypt)	-	Scales	38.5	0.29	-1.08	-	2.63	0.013	3.03
Abd-Allah (2004)	Bardawil lagoon (Egypt)	-	Scales	34.0	0.58	-0.70	-	2.83	-	-
Chaoui et al. (2006)	Mellah Lagoon (Algeria)	370	Scales	55.3	0.51	-0.22	1 - 7	3.19	0.0129	3.06
Mehanna (2007)	Port Said (Egypt)	1714	Otoliths	37.9	0.50	-0.60	0 - 4	2.86	0.0123	3.02
Akyol and Gamsız (2011)	southern Aegean Sea (Turkey)	476	Scales	64.9	0.14	-2.47	2 - 7	2.77	0.0515	2.73
Mercier et al. (2011)	Gulf of Lion (France)	142	Otoliths	72.3	0.10	-2.20	1 - 6	2.72	0.0093	3.11
Hadj Taieb et al. (2013)	Gulf of Gabes (Tunusia)	955	Otoliths	38.2	0.20	-1.88	0 - 8	2.47	0.0107	3.07
Hadj Taieb et al. (2015)	Gulf of Gabes (Tunusia)	668	Scales	47.1	0.11	-2.95	0 - 6	2.39	0.0107	3.07
Mokbel et al. (2020)	Bardawil lagoon (Egypt)	688	Otoliths	32.1	0.33	-1.33	0 - 5	2.53	0.0132	3.02
This study	northern Aegean Sea (Turkey)	126	Scales	52.8	0.29	-1.25	2 - 6	2.91	0.0053	3.03

*length-frequency analysis, N = sample size, L_∞ = theoretical asymptotic length, K = growth rate coefficient, t_0 = theoretical age when fish length is zero,
Φ' =growth performance index, a and b = the parameters of the relationships.

4. DISCUSSION

Table 2 summarized the results about the length-weight relationships (LWRs), the growth parameters and growth performance indices between the present study to previous ones. The *b* values in LWRs change between 2.5 and 3.5 (Froese, 2006) or 2 to 4 (Tesch, 1971). In this study, *b* value of *Sparus aurata* correspond to these expected ranges. Generally, the *b* value procured from the same species could change depending on the degree of gonad maturity, sex, diet, sample preservation techniques, stomach fullness (Wootton, 1990; Cengiz et al., 2019), number of specimens analyzed, area/season effects, sampling duration (Moutopoulos and Stergiou, 2002), fishing gear used (Kapiris and Klaoudaos, 2011), and size selectivity of the sampling gear (İşmen et al., 2007).

Growth parameters (L_∞, K and t_0) are the basic input data into various models used for managing and assessing the status of the exploited fish stocks and these parameters facilitate the comparison between growth of fishes belonging to different species or to the same species at different times and different localities (Mehanna et al., 2018). The differences among all growth parameters could be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences and aging methodology used (Monterio et al., 2006), incorrect age interpretation (Matić-Skoko et al,. 2007; Bayhan et al., 2008), size, quantity and quality of food and water temperature (Santic et al., 2002), and differences in length at first maturity (Champagnat, 1983). Besides, the selectivity of the fishing tool used can also affect the estimates of growth parameters (Ricker, 1969; Potts et al., 1998). Therefore, the possible reasons for the differences in the results between the other studies and this study may be related to one or more factors given above.

5. CONCLUSION

This study provided data on the key life history traits of *Sparus aurata*, which has been lacking in the studied region, allowing the development of sustainable management strategies. In times to come, appropriate surveys and long-dated studies could be required to confirm this preliminary estimating. More scientific research should be meticulously conducted to collect fundamental biological data. However, the information obtained from investigations such as the present research should be proclaimed to stakeholders (fishermen, middlemen, fisheries scientists, fishing management authorities etc.)

6. ACKNOWLEDGEMENTS

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