Growth and reproduction studies on gilthead seabream (*Sparus aurata*) in Beymelek Lagoon, Turkey

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Abstract

In the present study, age, growth, length-weight relationship and reproduction were investigated in gilthead seabream (*Sparus aurata* L., 1758) collected from Beymelek Lagoon (Antalya, Turkey) between February 2006 and July 2007. The age, total length and weight of samples ranged from 0^+ to 4 years, 10.6 to 35.5cm, and 18 to 928g, respectively. Growth was described by the standard form of the von Bertalanffy growth equation and the estimated parameters were $L\infty = 44.6$cm, $k = 0.394yr^{-1}$ and $t_0 = -1.331$yr. Length-weight relationship was determined as $W=0.0174TL^{2.9769}(R^2=0.965)$, and weight increased with size isometrically (b = 2.9769) for all fish. Sex inversion occurred mainly at 26 cm in total length and females reached sexual maturity at 28.5 cm. The spawning period was from December to February, while the gamete emission peaked in December.

Keywords: Gilthead seabream (*Sparus aurata*), Growth, Reproduction, Length-weight relationship, Beymelek Lagoon, Turkey

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Introduction

The gilthead seabream (*Sparus aurata* L., 1758) is an eurohaline and eurythermal fish (Chaoui *et al.*, 2006) belong to the family Sparidae. It is an inshore species which inhabits seagrass beds and sandy bottoms as well as the surf zone, commonly to depths of about 30 m, but adults may occur at 15m depth (Sola *et al.*, 2006). Adult individuals may migrate into lagoons or estuaries (Chaoui *et al.*, 2006).

Gilthead sea bream occurs naturally in the Mediterranean Sea and Black Sea (rare), and in the Eastern Atlantic (Sola *et al.*, 2006). In 2004, the world aquaculture and capture production of gilthead seabream was 90.995 and 8.914 tonnes, respectively (Sola *et al.*, 2006). It is considered as a popular fish due to its delicious taste and nutritive values. The main producers are Greece, Turkey, Spain and Italy, in the Mediterranean region. In Turkey, the total production was 21.304 t (879 t catch and 20.435 t aquaculture) in 2004 (according to the Turkish Statistical Institute, 2006, http://www.tuik.gov.tr/VeriBilgi.do).

In spite if their popularity, there have been few studies about the natural populations of this species (Lasserre & Labourg, 1974; Arnal *et al.*, 1976; Suau & López, 1976; Arias, 1980; Kraljević & Dulčić, 1997; Chaoui *et al.*, 2006). This species enters into Turkish lagoons in spring and migrate to sea in summer or winter periods. During migrating, they are caught by traps and in other seasons by trammel nets.

There are a total of 72 lagoons in Turkey having a total of 38.000 ha surface area. But, nowadays many of them are out of use for fisheries (Elbek *et al.*, 2003). Beymelek Lagoon is one of active lagoons. In this lagoon, the Sparidae family is represented by seven species (*Sparus aurata*, *Lithognathus mormyrus*, *Diplodus sargus*, *D. annularis*, *Boops boops*, *Oblada melanura*, *Sarpa salpa*). Of these sparid species, gilthead sea bream has an important place with a production of about 5.8 t in 2006, that is, 40.5% of all species and 92.2% of sparid fishes. However, some biologic characteristics of gilthead seabream in Beymelek Lagoon were investigated by Küçükkara (1999) there is still a need for further study about this species in the lagoon. Therefore, in this study, the growth, length-weight relationship and reproduction of gilthead sea bream living in Beymelek Lagoon were investigated.

Materials and methods

Beymelek Lagoon, with about 255 hectare surface area, is situated in the west coast of Turkey (30° 04' E, 36° 16' N). During our study, its mean temperature and salinity were 22.4°C and 12.8‰, respectively.

Fish samples were collected by gillnets with mesh sizes (stretched mesh) of 40, 44 and 50mm and trammel nets with mesh size of 56, 60, 70 and 80mm at the three different localities of Beymelek Lagoon (Fig. 1) in 2006 and 2007.

Figure 1: Sampling stations in Beymelek Lagoon

For each fish, the total length (TL, mm) and the total weight (W, 0.1g) were measured. About 10-15 scales were taken from the left side of the body, between the end of pectoral fin and the beginning of the dorsal fin and stored dry in paper envelopes for determining the age of the specimens. The sex of all specimens was recorded by macroscopic examination of the gonads as immature, male, female or intersexual. The fish were considered as immature if they had no clearly identifiable sex; males if they had only testes and females if they had only ovaries. Individuals were considered as hermaphrodites when male and female parts of the gonads occurred in equal or different proportions. The gonads of each female were removed from fish and recorded measuring (GW) to 0.01g.

The age was determined by scale reading (Lagler, 1966). Thereafter, the von Bertalanffy growth equation was used to describe the growth of gilthead seabream (Pauly, 1984; Sparre & Venema, 1998): $L_t = L_\infty (1-\exp(-k(t-t_0)))$; where L_t is the total length at-age t, k is the growth rate coefficient, L_∞ is the asymptotic length and t_0 is the theoretical age at length zero.

To compare the growth parameters obtained in this study with those reported by other authors for the same species, the growth performance index (Φ') was estimated (Munro & Pauly, 1983): This index has the form: $\Phi' = \text{Ln}(K) + 2*\text{Ln}(L_\infty)$, where k is the growth coefficient, and L_∞ is the asymptotic length.

The length-weight relationship was calculated by the equation $W=a*TL^b$, where W is the total body weight (g), L is the total length (cm), a is a coefficient related to the body form and b is exponent indicating isometric growth when equal to 3 (Wootton, 1990; Anderson & Neumann, 1996). The parameters a and b were estimated by linear regression on the transformed equation: $\log_{10}(W) = \log_{10} a + \log_{10}(TL)$.

The timing of sex reversal was estimated by analysing the variation of the sex ratio (males/females) among the classes (Kraljević *et al.*, 1995, 1996). In order to determine the length at primary maturity (the length at which 50% of the fish had become mature) of female gilthead seabream only individuals collected during the spawning period were used. A logistic curve was fitted to the proportion of sexually mature individuals by length and the parameters were estimated using a least square method applied to a non-linear fit (King, 1995).

The reproductive period was determined by analysing the monthly variation in the gonad somatic index [GSI = (GW/W)*100]. Correlation between GSI and temperature was tested using the Spearman rank correlation coefficient (r_s) according to Zar (1999) and correlation coefficient was estimated by using PAST version 1.50 software.

Results

During the study, a total of 1881 gilthead seabream were investigated. The age of the specimens ranged from 0^+ to 4 years. It was determined that the age of about 94% of the specimens was below 1 year old. The one year age group comprised only 5% and the other two age groups comprised only 1% of the specimens (Fig. 2).

The mean lengths of fish assigned to each age group were used to fit the von Bertalanffy growth model. Growth parameters in length for the von Bertalanffy equation were estimated as: $L\infty$=44.6cm, k=0.394 yr^{-1} and t_0=-1.330 yr, yielding $L_t = 44.6*[1-e^{-0.394(t+1.330)}]$. The growth performance index (Φ) is equal to 6.664.

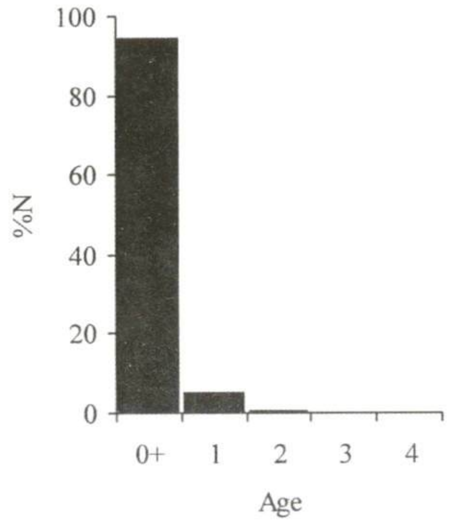

Figure 2: Age-frequency distribution of gilthead seabream from Beymelek Lagoon

The total length of fish specimens ranged from 10.6 to 36.5cm (Fig. 3) and weight ranged from 18 to 928g (Fig. 4). Length-weight equation was determined as $W=0.0174TL^{2.9769}$(R^2=0.965) and represented in Figure 5. The slope (b value) of the length-weight relationship was not significantly different (χ^2-test; P>0.05) from the theoretical value of 3. This result showed that weight of gilthead sebream increased isometrically with total length in Beymelek Lagoon.

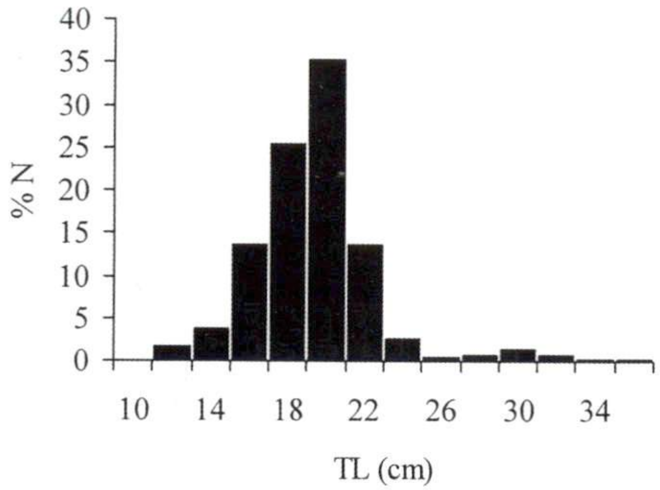

Figure 3: Length-weight frequency distribution for gillthead seabream in Beymelek Lagoon

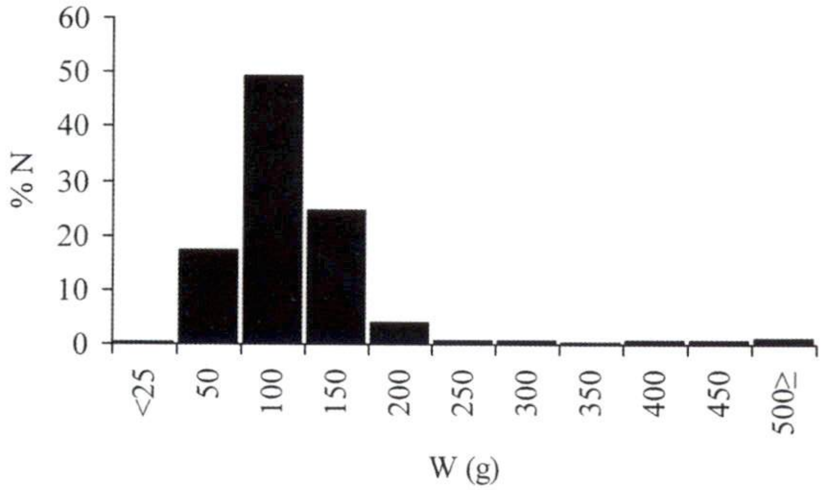

Figure 4: Weigh-frequency distribution for gillthead seabream in Beymelek Lagoon

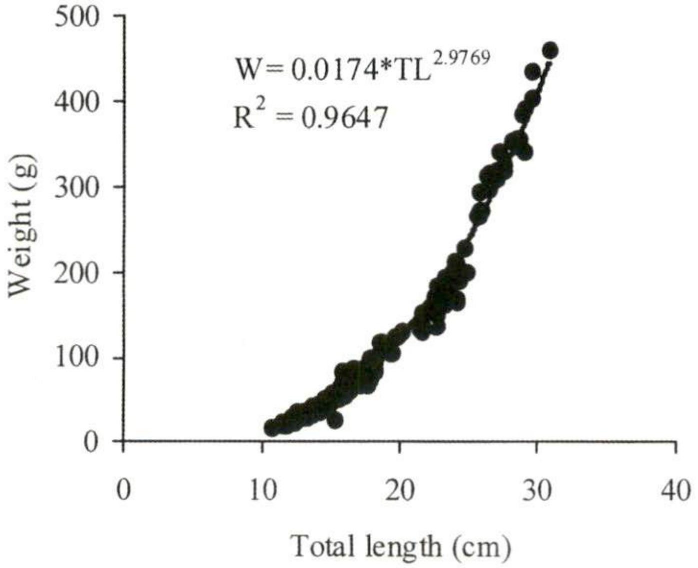

Figure 5: Length-weight relationship of gilthead sea bream in Beymelek Lagoon
(Sex ration, sex reversal length at first maturity)

A total of 1881 gilthead seabreams were investigated, but the sex of only 219 individuals could be determined. Among the sexed specimens, 107 were males, 97 females, and 15 intersexuals. The overall ratio of females to males was 1:1.11 and the χ^2-test revealed that it did not differed significantly (P>0.05) from the theoretical 1:1 sex ratio.

All specimens under 14cm in total length were juveniles. Males were predominant in the smaller and females in the larger length classes, confirming the protandric nature of the gilthead seabream hermaphroditism. Sex inversion was observed initially at lengths between 24 and 26cm (50% of the population). All specimens larger than 34cm were females (Fig. 6).

The total length of female gilthead seabream at 50% maturity was determined as 28.5 cm. Thereafter, percentages of mature fish for different lengths were calculated using the formula $P_L = 100/[1+e^{-0.8291 * (L - 28.5)}]$ and then the maturity curve was drawn from these values as seen in Figure 7.

The GSI was almost consistent from February to October and then sharply reached to its pick in December (Fig. 8). The spawning period started in December and lasted until February. Significant negative correlation was found between mean GSI values and surface water temperatures (r_s = -0.680, n=11, P<0.05). The complete gonad maturation occurred at the lowest surface temperature (about 15°C, Fig. 8).

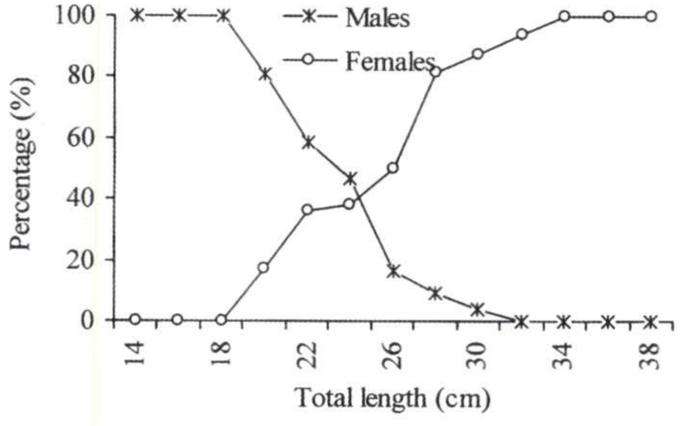

Figure 6: Sex reversal of gilthead seabream in Beymelek Lagoon

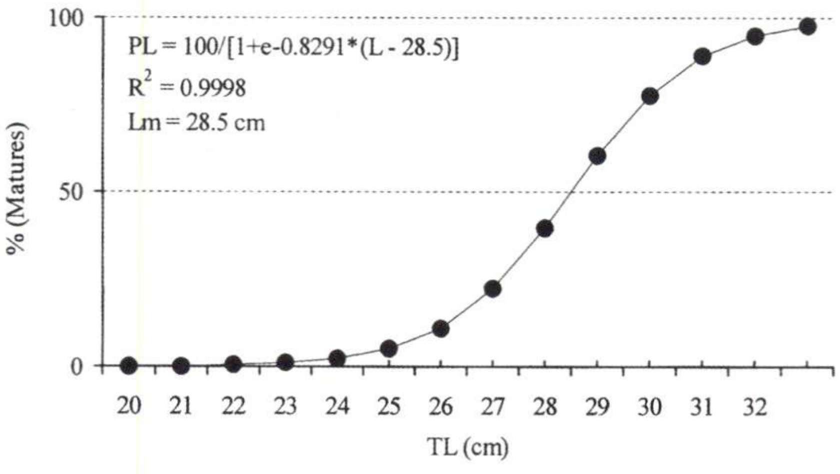

Figure 7: Maturity curve of gilthead seabream in Beymelek Lagoon

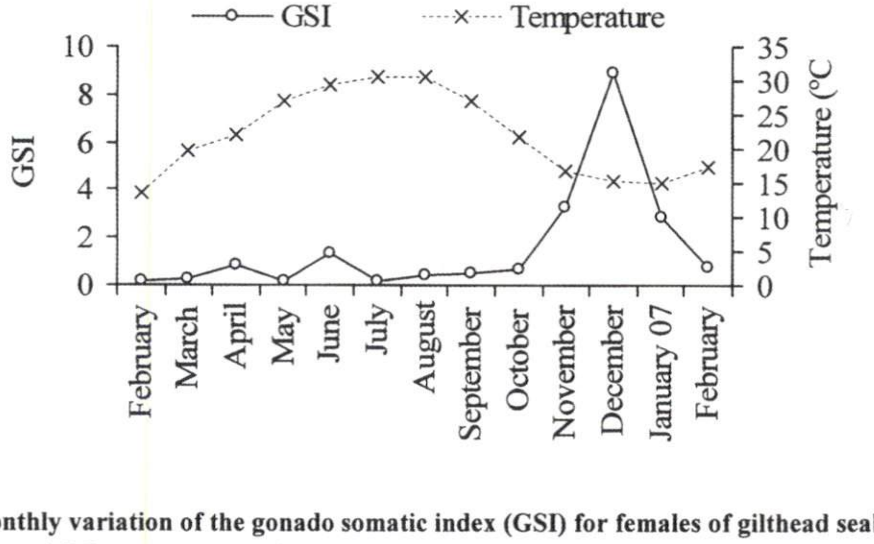

Figure 8: Monthly variation of the gonado somatic index (GSI) for females of gilthead seaberam from Beymelek Lagoon

Discussion

Juvenile of gilthead seabream in Beymelek Lagoon were more abundant (94% in the 0+ age) than older individuals as reported previously (Lasserre, 1976; Kraljević & Dulčić, 1997). Therefore, these results of the present study confirm the importance of lagoons as nurseries for gilthead seabream. However, Küçükkara (1999) reported that the ages of gilthead seabream in the same lagoon ranged from 0+ to 4 years and only about 26.1% of the specimens were in the 0+ age and 40.5% in the age 1. This difference can be attributed to many factors such as fishing pressure, sampling season and method and food ability.

While the asymptotic length ($L\infty$ = 44.6cm) was similar to the reported value ($L\infty$ = 44.3) by Küçükkara (1999) in the same lagoon about 10 years ago, the growth rate (k=0.394 yr^{-1}) was higher than that of reported k value (0.227yr^{-1}). The asymptotic length was found similar to value estimated by Lasserre and Labourg (1974) in the Craveyron (Fransa) ($L\infty$ = 42.3cm), but smaller than those estimated by Arnal *et al.* (1976) in the Segura (Spain) ($L\infty$ =53cm), Lasserre and Labourg (1974) in the Thau (France) ($L\infty$ =62cm), Adour (France) ($L\infty$ =56.2cm), Suau & López (1976) in the Ebre (Spain) ($L\infty$ =62.2cm), Arias (1980) in the Cádiz (İspanya) ($L\infty$ = 84.6cm) and Kraljević & Dulčić (1997) in the Mirna (Croatia) ($L\infty$ =59.8cm). The growth rate was found higher than those reported by Lasserre & Labourg (1974) in the Thau (k=0.221yr^{-1}) and in the Adour (k=0.265yr^{-1}), Suau & López (1976) in the Ebre (k=0.171yr 1), Arias (1980) in the Cádiz (k=0.130yr^{-1}), Arnal *et al.* (1976) in the Segura (k=0.315yr^{-1}) and Kraljević & Dulčić (1997) in the Mirna (k=0.153yr^{-1}), but smaller than those reported by Lasserre and Labourg (1974) in the Graveyron (k=0.456yr^{-1}), and Chaoui *et al.* (2006) in Mellah Lagoon (k=0.513yr^{-1}). Compared to some other populations, gilthead seabream in Beymelek Lagoon grow faster in the Mirna (Φ'=6.187) (Kraljević & Dulčić, 1997), but slower in Mellah Lagoon (Φ'=7.359) (Chaoui *et al.*, 2006). In the other hand, it was similar to values reported as 6.745, 6.730, 6.785, 6.495, 6.836 in the Thau and Adour (Lasserre & Labourg, 1974), Segura (Arnal *et al.*, 1976), Ebre (Suaua & López, 1976) and Cádiz (Arias, 1980), respectively. It is generally known that lagoon environments are highly productive. However, these comparisons showed that growth of gilthead seabream in Beymelek Lagoon was similar with those of some coastal areas. Growth of gilthead seabream in Beymelek Lagoon may be affected from size distributions and densities of this species and other species.

The relationship between length and weight shown that growth in weight is isometric (b=2.9769) with a 95% confidence interval of $2.9738 \leq CI \leq 3.0262$. In the same lagoon, *b* of length-weight relationship was reported as 3.0245 by Küçükkara (1999) about 10 years ago. This value was higher than that of our study. Dulčić & Kraljević (1996) stated that various factors may be responsible for the differences in parameters of length-weight relationship among seasons and years, such as temperature, salinity, food (quantity, quality and size), sex, time of the year and the stage of maturity. Our calculated growth rate agrees with those of Morey *et al.* (2003) from in Mirna (Croatia) Estuaries and Baleric Island and Iberian coast (Spain) and Chaoui *et al.* (2006) from Mellah Lagoon. However, it contrast with those of Santos *et al.* (2002) in the Algarve coast of southern Portugal, Can *et al.* (2002) in İskenderun Gulf (Turkey) and Sangun *et al.* (2007) in Northeast Mediterranean coast of Turkey (allometric growth). Akyol *et al.* (2007) reported that *b* value for the same species in Gokova Bay (Aegean Sea, Turkey) was 3.034. The length-weight relationship may be influenced by sex, maturity, geographical location, and environmental condition as reported by Balon (1984) and Bagenal & Tesh (1978).

The presence of inter-sexuals and the predominance of males at smaller sizes and females at larger sizes indicate that gilthead seabream in Beymelek Lagoon is a protandric hermaphrodite species. These results agree with those of Chaoui *et al.* (2006) for gilthead seabream in Mellah Lagoon. Although Sola *et al.* (2006) reported that gilthead seabream at over 30 cm in length becomes female, sex inversion of gilthead seabream in Beymelek Lagoon was observed at the length of 24-26 cm (50% of the population). Chaoui *et al.* (2006) reported that sex inversion occurred at a total length of 44 cm. This was higher than that of Beymelek Lagoon. Sex change may be related to individual determinism and environmental and social conditions. First sexual maturity length of female gilthead seabream was determined as 28.5 cm. This length was also smaller than that (32.6 cm) reported by Chaoui *et al.* (2006) for the same species in Mellah Lagoon. This difference may attribute especially to environmental factors. According to Wootton (1990), temperature appears to be the most important factor among those that may influence the reproduction of fishes.

The spawning period of gilthead seabream occurs mainly between December and February, with the maximum gamete emission taking place in December. This period was reported as November and December by Küçükkara (1999) for the same population in Beymelek Lagoon. This period agrees with that (From October to January, with a peak in December) of Chaoui *et al.* (2006) in Mellah Lagoon. The temperature is the most important environmental factor affecting the gonad maturation. The differences observed in the reproductive season between two studies may be explained by the differences in the seasonal variation of the temperature.

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