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Age, growth and mortality of black goby *Gobius Niger* Linneaus, 1758 (Family: Gobiidae) from the south-eastern Black Sea

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Abstract

This study intends to determine the most reliable structure for age estimation and to assign the population parameters from two fishing grounds under different fishing pressures. The age, growth and mortality of the black goby from the Kızılırmak-Yeşilırmak shelf area (KYSA) and Melet River shelf area (MSA) were investigated through 2751 specimens. The reliability of the age structures were controlled by the estimated aging criteria, such as agreement, the average percentage error and the coefficient of variation. The von Bertalanffy growth model was used to reveal the growth parameters, and the growth curves derived from two regions were compared by Likelihood ratio test. The total mortality rate was estimated by the method of Linearised Catch Curve and the natural mortality rate by Pauly's empirical formula. Otolith is found to be the most reliable aging structure for the black goby. The equations of the von Bertalanffy growth model were estimated as $L_t = 13.26 [1 - e^{-0.31 (t - (-1.43))}]$ and $\varphi = 1.73$ for KYSA, as $L_t = 13.96 [1 - e^{-0.29 (t - (-1.42))}]$ and $\varphi = 1.75$ for MSA. The growth model derived from the samplings of KYSA and MSA were detected as significantly different according to likelihood ratio test.

Keywords: von bertalanffy growth model, otolith, fishing, population parameters

Introduction

The black goby (*Gobius niger* Linneaus, 1758) is a member of the Gobiidae family, which is well known by its successful adaptation to different environmental conditions (Miller, 1986) [1] It inhabits coastal areas and can adapt to the freshwater and marine ecosystems. Besides, it is also abundant along estuarine zones and lagoons. The black goby distributed along sandy and muddy habitats within a depth range of 1–70 m (Miller, 1986) [1]. The presence of seagrass can positively affect the abundance of the black goby (Malavasi *et al.*, 2005) [2]. The black goby is a common species in marine benthic habitats, with a very wide distribution throughout the Eastern Atlantic and Mediterranean Sea: throughout North Africa from Cape Blanc, Mauritania north and eastwards to the Suez Canal and Eastern Black Sea and also along the Eastern Atlantic coast northwards to Trondheim (Norway) and Baltic Sea (Miller, 1986; Mater *et al.*, 2003; Froese and Pauly, 2019) [1, 3, 4]. The black goby is an important member of the demersal fish fauna and a carnivorous species feeding on small fish and benthic invertebrates (Joyeux *et al.*, 1991) [5]. The species has no commercial value but has ecological importance since it is the prey for the carnivorous fish species living in the same habitat (Rafrafi-Nouira *et al.*, 2016) [6].The black goby is caught by the bottom trawl fishery in the Black Sea where the target species are mostly the whiting and the red mullet and is defined as 'discard' among the 'catch on board'. The gobiids are often preferred as a model organism for pollution indication (Katalay and Parlak, 2002) [7] due to their features, such as their widespread distribution, high population abundance, adaptation to different environments, sexual dimorphism and living and feeding on benthos (Ramsak *et al.*, 2007) [8].There are a number of studies regarding the abundance, distribution, habitat selection, life history, feeding habits, behaviour, reproductive biology, ecology, genetics, parasites, pollution, environmental interaction and ichthyoplankton of black goby. Silva and Gordo (1997) [9], Bouchereau and Guelorget (1998) [10], Kinacigil *et al.*, (2008) [11] and Filiz and Togulga (2009) [12] gave information about the biological characteristics of the species, such as its growth, feeding and reproduction. Malavasi *et al.*, (2005) [2] studied about the distribution of the species, its abundance and habitat selection. Fabi and Giannetti (1985) [13] estimated the growth parameters from otolith readings sampled from the Adriatic Sea. Ilkyaz *et al.*, (2011) [14] determined the age characteristics by using the otoliths from Izmir Gulf. Joyeux *et al.*, (1991) [5], Mazzoldi and Rasotto (2002) [15], Rasotto and Mazzoldi (2002) [16], Mazzoldi *et al.*, (2005) [17] and Locatello *et al.*, (2007) [18] conducted seminal vesicles of male black gobies, focusing on reproductive behaviour of parent males. Katalay and Parlak (2002) [7] and Ramsak *et al.*, (2007) [8] defined the black goby as an indicator species for pollution and searched for the effects of pollution on skeletal deformation and blood cells. The black goby is a euryhalin species and can easily adapt to both fresh and saline water, which makes it an appropriate model for cell volume studies. Trischitta *et al.*, (2004) [19] studied ion transfer to black goby intestines in both isotonic and hypertonic environments. Demirhan and Can (2007) [20], Kalayci *et al.*, (2007) [21], Ikyaz *et al.*, (2008) [22] and Ak *et al.*, (2009) [23] reported the parameters of the length-weight relationship of the species.

This study aims to determine the most reliable structure for age estimation, to identify some life history traits and any possible effect on these traits because of different fishing pressures within two different areas and to compare the growth parameters derived from two sampling areas of the black goby inhabiting the South-Eastern Black Sea.

Materials and Methods

Study Area

This study was conducted along the continental shelf of the South-Eastern Black Sea within two different areas; the Kızılırmak-Yeşilırmak shelf area (KYSA) and the Melet River shelf area (MSA) (Fig. 1.). KYSA is a relatively large shelf area formed by two large rivers along the steep southern Black Sea coasts, and MSA is a small but unique shelf area along the South-Eastern Black Sea coasts. These two areas are separated by a submarine canyon through Ünye Taşkana Cape, which forms a natural barrier especially for demersal species. The sampling was realised by bottom trawl nets (with a length of 32 m of trawl lead line, 18 m of trawl bag, a mesh size of 13 mm and 36.5 m of total length), within a depth range of 10–90 m between 2010 (April, Jun, October)–2011 (January, April, Jun), by a seasonal experimental survey. All haul operations were standardised to 30 min with a speed of 2 knots.

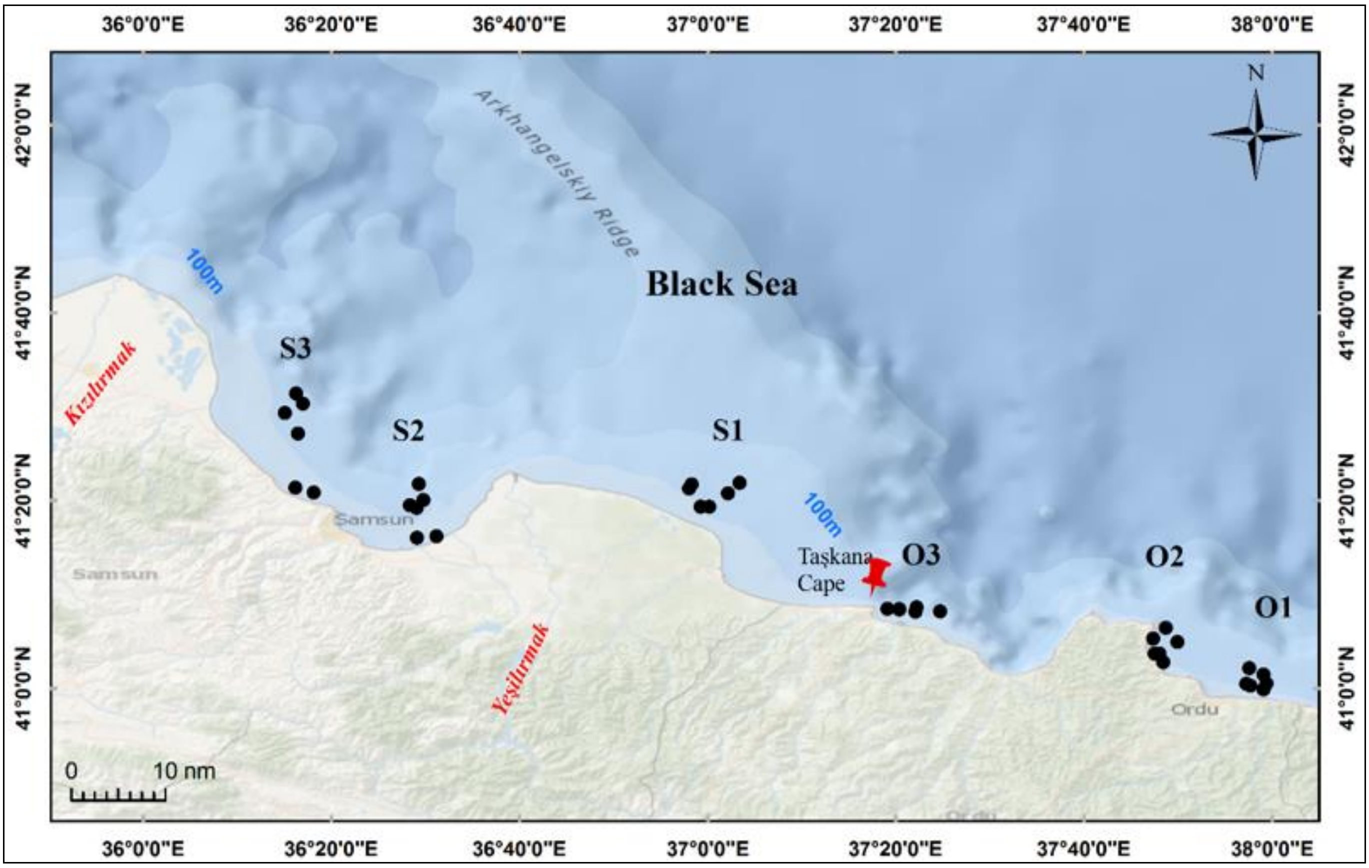

Fig 1: Study area (KYSA (S1, S2 and S3) and MSA (O1, O2 and O3).

Age and growth

The total length (TL, cm; 0.1 mm precision) and weight (W, 0.01 g precision) of each specimen were recorded and their sexes were determined in the laboratory. In females, gonads are tubular with capillaries and a yellow-orange colour in the mature stages, while male gonads are soft-textured, flat and white-cream in colour. Three hard structures-scales, vertebrae and otolith (sagitta)- were removed from individuals, cleaned by appropriate procedures (Chugunova, 1963) [24] and stored dry till the age determination process. Structures were examined as placed in alcohol under the stereo binocular microscope, by 30X magnification and reflected light for otoliths and by 20X magnification and reflected light for vertebra. The scales were investigated by 20X magnification and transmitted light. The individual age of each hard structure was read for three times independently by two readers. Age data was used to calculate the agreement (%), and the precision of age readings was measured by the average percentage error (APE, %) and the coefficient of variation (CV, %). The average percentage error (APE) (Chilton and Beamish, 1982) [25] was calculated to compare reproducibility of age determination between readings by the following equation: $APE_j = 100 \times \frac{1}{R}\sum_{i=1}^{R}\frac{|X_{ij}-X_j|}{X_j}$ where X_{ij} is the its age determination of the j_{th} fish, X_j is the mean age of the j_{th} fish, and R is the number of times each fish is aged.

Here the coefficient of variation (CV) (Chang, 1982) [26] was used to assess consistency in repeated age determinations, expressed as the ratio of the standard deviation to the mean that can be written as: $CV_j = 100 \times \frac{\sqrt{\sum_{i=1}^{R}\frac{(X_{ij}-X_j)^2}{R-1}}}{X_j}$. The length-weight relationships (LWR) of the specimens were calculated with equation $W = a \times TL^b$, where W is the total weight in g, TL is the total length in cm, a is the intercept and b is the slope of regression (Froese, 2006) [27]. The parameters were estimated by linear regression of log-transformed data. Kolmogorov-Smirnov Z test was performed to check if there is any significant difference in the length and weight distributions between localities and sexes and a t-test was performed to check the mean total length and weight. The sex ratio was calculated, and a χ^2 test was applied to test any significant difference in the sex ratio. Differentiation of LWRs between sexes were tested by ANCOVA ($\alpha = 0.05$). The growth parameters were estimated using the von Bertalanffy growth model (VBGM) (Von Bertalanffy, 1938)

[28]. The Levenberg-Marquardt algorithm was used for estimation of parameters. The VBGM parameters were calculated for KYSA, MSA (female, male and pooled data) and for the whole sampling. $L_t = L_\infty(1 - e^{-K(t-t_0)})$ Where L_t is the total length (cm) at age, L_∞ is the asymptotic length (cm), K is the growth curvature (year^{-1}), t is the age (year) and t_0 is the 'age of the fish at zero length'. The growth curves were compared with the likelihood ratio test (LRT). The growth performance index (φ) was estimated using Pauly and Munro's formula (Pauly and Munro, 1984) [29]: $\varphi = \log K + 2 \log L_\infty$

Mortality

The total mortality rate (Z) was calculated by the 'Linearised Catch Curve Method' for each sampling area using the linear regression method. Pauly's (1980) [30] empirical formula was used to estimate the value of natural mortality rate (M): Log M = $-$0.0066 - 0.279 × Log L_∞ + 0.6543 × Log K + 0.463 × Log T where, L_∞ and K are the VBGM parameters and T is the mean annual temperature at the surface in ºC habitat. Fishing mortality (F) was derived from the difference between the total and the natural mortality. All analyses were carried out using SPSS v17.0.1 and R-3.0.2 (R Development Core Team, 2013) [31] softwares.

Results

In this study, a total of 2,751 (1,175 females and 975 males, 601 undetermined) black goby individuals were sampled from both regions. A total of 1,740 individuals (732 females and 674 males) were sampled in KYSA and 1,011 (443 females and 301 males) were sampled in MSA. It was observed that individuals were distributed along a wide depth range from 10 to 90 m. The sex ratio (F: M) was 1:0.92 and 1:0.68 for KYSA and MSA, respectively. While there was no significant difference in sex ratio from 1:1 (χ^2 test, $P > 0.05$) in the KYSA, it was significantly different in the MSA (χ^2 test, $P < 0.001$).Table 1 presents the descriptive statistics for the length and weight of the sample obtained from two different areas. The mean total length and weight differed significantly between males and females in KYSA (t test, $t_{1404} = -13.55$, $P < 0.001$ and $t_{1344.7} = -12.49$, $P < 0.001$). A significant difference was determined both in the mean values of total length (t test, $t_{742} = -8.84$, $P < 0.001$) and weight (t test, $t_{547.4} = -8.69$, $P < 0.001$) between sexes in the sampling collected from all MSA stations. The descriptive statistics of total length and weight was also tested for any significant difference between two sampling locations. The mean values of total length (t test, $t_{1932.7} = -5.43$, $P < 0.001$) and weight ($t_{1794.7} = -6.58$, $P < 0.001$) between KYSA and MSA indicated significant differences. The length (K-S test, $Z = 3.303$, $P < 0.001$) and weight frequency distributions (K-S test, $Z = 2.927$, $P < 0.001$) were also found to be significantly different. The length-weight relationships were defined with the estimated equation of W = 0.0057 $L^{3.30}$ (95% C.I. for b 3.27–3.32) for KYSA and with W = 0.0045 $L^{3.39}$ (95% C.I. for b 3.36–3.42) for MSA, revealing positive allometry for both regions. The LWR pattern differed statistically between KYSA and MSA (ANCOVA, $F = 45.72$, $P > 0.001$). The otolith, vertebra and scale structures of the black goby were compared to find out the most accurate age estimates, and statistical measurements for the reader-structure pairs were presented in Table 2. Among all structures, the sagittal otolith was chosen as the most reliable aging structure for the black goby, with the highest agreement percentage (93%) and the lowest APE (10.93–10.51) and CV (7.23–7.18). Ages varied between 0 and 5 years old. The mean age values were 2.20 year in females and 2.52 year in males. The most dominant group in the whole sample was age 2 (31.76%), followed by age 3 (25.75%), age 1 (25.53%), age 4 (8.08%), age 0+ (6.26%) and age 5 (2.62%). Age 2 was the dominant group in age composition for both sexes and sampling regions. While the second most dominant group in age composition was age 1, with a rate of 28.07% in the KYSA and age 3, with a rate of 28.64% in MSA. The age composition was statistically different between the two sampling regions (K-S test, $Z = 2.278$, $P < 0.001$). VBGM parameters and phi prime values were indicated in Table 3. The growth trends were significantly different between KYSA and MSA (LRT, $\chi^2 = 12.98$, $P < 0.05$). In both regions, it was observed that the length-at-age values are larger in female specimens than males. The difference in growth rate between sexes was more pronounced in MSA. There were significant differences between growth curves of sexes in KYSA (LRT, $\chi^2 = 25.41$, $P < 0.001$) and MSA ($\chi^2 = 36.78$, $P < 0.001$).The total mortality rate was calculated as 1.26 year^{-1} and 1.01 year^{-1} for KYSA and MSA, respectively. The natural mortality rate was 0.65 year^{-1} in KYSA and 0.66 year^{-1} in MSA. The fishing mortality rate F was estimated as 0.61 year^{-1} for KYSA and 0.35 year^{-1} for MSA.

Table 1: The descriptive statistics of length and weight measurements of black goby individuals samples from two different regions

	KYSA			MSA		
	Female *n* = 732	**Male *n* = 674**	**Pooled *n* = 1740**	**Female *n* = 443**	**Male *n* = 301**	**Pooled *n* = 1011**
Total length range	4.7–12.6	4.5–12.5	3.6–12.6	3.3–12.4	5.3–13.4	3.3–13.4
Mean total length (cm)	8.37 ± 0.05	9.43 ± 0.06	8.49 ± 0.04	8.99 ± 0.08	10.04 ± 0.09	8.88 ± 0.06
Weight range	0.90–25.19	0.86–22.92	0.35–25.19	0.30–25.64	1.15–27.01	0.20–27.01
Mean weight (g)	7.29 ± 0.139	9.99 ± 0.165	7.65 ± 0.106	9.02 ± 0.211	12.35 ± 0.32	8.98 ± 0.171

Table 2: Measures for the reliability of age structures in the black goby

		Mean age		**Agreement (%)**	**Average percent error (%)**		**Coefficient of variation (%)**	
Hard structures	**N**	**Ager**		**Ager**	**Ager**		**Ager**	
		1.	**2.**	**1-2**	**1.**	**2.**	**1.**	**2.**
Otolith	1066	2.28	2.32	93	10.93	10.51	7.23	7.18
Vertebrae	1068	1.89	1.75	78	19.34	20.5	15.38	16.02
Scale	1065	2.40	2.65	75	23.92	24.6	16.58	17.33

Table 3: The von Bertalanffy growth parameters for the black goby in the southern Black sea coast

	Sex	n	L_∞	K	t_0	φ
KYSA	♀	730	12.57	0.30	-1.69	1.68
	♂	673	12.95	0.36	-1.39	1.78
	$\sum_1$*	1737	13.26	0.31	-1.43	1.73
MSA	♀	443	12.33	0.39	-1.23	1.77
	♂	300	15.22	0.24	-1.95	1.74
	$\sum_2$*	1009	13.96	0.29	-1.42	1.75

(*) including female, male and unidentified individuals

Discussion

In the sampling area, the black goby was more abundant than the other co-habiting gobiid species (*Neogobius melanostomus* and *Mesogobius batrachocephalus*) (KARTRIP 2020) [32]. It is a major component of the food web as the prey of larger predators along the bentho-pelagic of the southern Black Sea coast (KARTRIP 2020) [32]. Miller (1986) [1] and Bouchereau and Guelorget (1998) [10] stated that the black goby lives at depths of 2–70 m. In a study conducted along the Western Black Sea coasts, the distribution range for the black goby was determined as 10–90 m (Yildiz *et al.*, 2018) [33] and as 30–90 m in another study regarding the Sea of Marmara (Demirel and Dalkara, 2012) [34]. In this study, the males were found to be dominated by the females in the sampling in contrast to other studies (Filiz, 2007; Ilkyaz *et al.*, 2008; Filiz and Togulga, 2009) [35, 36, 12]. Silva and Gordo (1997) [9] and Filiz and Togulga (2009) [12] stated that the spawning period of the species extends from March to September. Mazzoldi and Rasotto (2002) [15] and Rasotto and Mazzoldi (2002) [16] reported the period as April–August. In the reproduction period, the parental males of black goby guard the nest until the eggs hatch (Mazzoldi, 1999) [37]. The dominancy of females may seem reasonable during the sampling period, since the most of the catch was caught in May and July in this study. The studies reported a decrease in the number of males, especially in spring and summer and males become dominant again after the spawning period (Silva and Gordo, 1997) [9]. A similar case appears in MSA. During the reproduction period, females were dominant and in other periods, sex ratios were almost equal. The higher frequency of younger individuals along KYSA made the length frequency distributions dissimilar. The skewness in MSA distribution is more significant by a coefficient of –0.528. In general, the skewness in the length frequency distribution of male individuals is stronger and the kurtosis (0.249) is more distinct where the length frequency distribution for females displayed negative kurtosis (–0.346). In this study, the maximum total length (L_{max}) was recorded as 13.4 cm, and the minimum was 3.3 cm. The differences in the reported maximum lengths may possibly be a result of the sampling methods or environmental variations. Larger size values were observed in the Aegean Sea and Sea of Marmara (Filiz and Togulga, 2009; Ilkyaz *et al.*, 2008; Ilkyaz *et al.*, 2011) [12, 36, 14] than in the Black Sea. Silva and Gordo (1997) [9] in the Obidos Lake recorded as L_{max} 15.0 cm. The reported maximum length ranges for lagoons ranged from 9.2 to 14.4 cm (Mazzoldi and Rasotto, 2002; Rasotto and Mazzoldi, 2002) [15, 16]. In the Aegean Sea, the maximum length was reported as 16.3 cm by Ilkyaz *et al.* (2011) [14] and as 15.2 cm by Filiz and Togulga (2009) [12]. In the Sea of Marmara, Demirel and Dalkara (2012) [34] reported the maximum length as 14.3 cm. In the Black Sea it is recorded as 13.2 cm by Demirhan and Can (2007) [20], as 15.7 cm by Ak *et al.* (2009) [23], as 15.8 cm by Kasapoglu (2016) [38] and as 13.4 cm by Yildiz *et al.* (2018) [33]. This study defined a positive allometric LWR for the black goby in all cases. The estimations of *a* and *b* parameters were found to be significantly different between sexes and between two sampling regions. The parameters a and b may vary due to sex, season, year, locality and length range and be effected by gonad development and factors such as nutritional condition, temperature and salinity (Froese, 2006) [27]. The allometry (either negative or positive) in LWR of this species was widely reported by other studies (Table 4). This study reported that sagittal otoliths were the most reliable structure for the age estimations of the black goby. A number of researchers made use of otoliths for age determination of the species (Fabi and Giannetti, 1985; Rasotto and Mazoldi, 2002; Kinacigil *et al.*, 2008; Filiz and Togulga, 2009; Ilkyaz *et al.*, 2011) [13, 15, 11, 12, 14]. Age 2 was the dominant age group in this study. It was stated that it was age 1 in the Obidos Lake (Silva and Gordo, 1997) [9] and in the Candarlı Bay (Aegean Sea) (Filiz, 2007) [35], age 2 in the Adriatic (Fabi and Gianetti, 1985) [13] and in the Izmir Bay (Aegean Sea) (Filiz and Togulga, 2009) [12] and age 3 in the Izmir Bay (Ilkyaz *et al.*, 2011) [14]. The growth rates of male and female individuals were found to be significantly different. The males were larger in length and weight than females of the same age. The sexes have different growth rates (Fabi and Giannetti, 1985; Joyeux *et al.*, 1991; Silva and Gordo, 1997; Filiz, 2007; Filiz and Togulga, 2009) [13, 5, 9, 35, 12], as it is similarly recorded in this study. Just about any factor that might possibly influence growth has been shown to have an effect, including temperature, food availability, nutrient availability, light regime, oxygen, salinity, pollutants, current speed, predator density, intraspecific social interactions, and genetics (Helfman *et al.*, 1997) [39]. In the sample, the age composition of females revealed younger age groups than of males. Also, the females that reach older ages were less in number. On the other hand, it is observed that the sampling derived from KYSA reveals a younger age profile. The reason may be related with the fact that KYSA is a major fishing ground of bottom trawls and the black goby is one of the most common bycatch species on the board, which means that it is also exposed to high fishing pressure nearby the target fish species. The fishing of larger and older specimens for long periods may possibly cause a younger population. The maximal life span was determined as 5 years in this study. The life span of the black goby was reported as 4 years by Miller (1986) [1], Rasotto and Mazzoldi (2002) [15], 5 years by Fabi and Gianetti (1985) [13], Filiz (2007) [35], Filiz and Togulga (2009) [12] and Kasapoglu (2016) [38] and 7 years by Kinacigil *et al.*, (2008) [11] and Ilkyaz *et al.*, (2011)[14]. KYSA and MSA, having different fishing pressures, display significantly different growth parameter estimations. The level of fishing pressure may affect the population characteristics such as age composition, length and weight distributions (Suer, 2016) [40]. In all cases (within sexes and regions) sexual differences were reflected in the growth characteristics, and the compared growth models were found to be different. The comparison of growth parameters with the reported data for the black goby was presented in Table 5. In this study, the phi-prime value was estimated lower than the other studies, which also means that the growth performance of the black goby is relatively low in the South-Eastern Black Sea. The overfishing in KYSA may have negative impacts on the black goby population. The black goby does not have commercial value but has a high discard rate, displaying a higher total mortality rate than that of MSA (KARTRIP 2020) [32]. Especially, the difference in fishing mortality is more significant, explaining the impact of constant fishing pressure on fish populations. Kinacigil *et al.* (2008) [11] reported that Z = 0.807 year^{-1}, M = 0.717 year^{-1}, F = 0.091 year^{-1} and E = 0.112 year^{-1}, with no fishing pressure on the black goby stock in Izmir Bay (Aegean Sea). For the Black Sea stock sampled from the Central and Eastern Black Sea, Kasapoglu (2016) [38] recorded Z = 0.68 year^{-1}, M = 0.54 year^{-1} and F = 0.14 year^{-1}, which are relatively low values estimated for KYSA in this study. The black goby has ecological importance in the benthopelagic ecosystem of the Black Sea since it is one of the main preys of many benthopelagic and demersal species, such as whiting and turbot which have high commercial values (Ross *et al.*, 2016) [41].

Regarding the consistent decrease in the whiting population and the collapsed turbot stock, the black goby is a species that needs to be followed biologically in order to maintain the dynamics in the food chain and protect all subcomponents. The species is captured together with target species, and it is evaluated within ‘discard’ prey and discharged from the deck. In fact, this implies an unreported mortality rate. This should be considered while making estimations about population parameters.

Table 4: Comparison of length-weight relationships of black goby

References	Location	*n*	$W = a \times L^b$		
			a	***b***	R^2
Silva and Gordo (1997)	Obidos Lagoon	1426(∑)	0.0072	3.26	0.99
Kalayci *et al*., (2007)	Black Sea	122 (♀)	0.0159	2.89	0.96
		105 (♂)	0.0174	2.84	0.96
		227 (∑)	0.0166	2.87	0.96
Ilkyaz *et al*. (2008)	Central Aegean Sea	618 (∑)	0.0065	3.21	0.97
Filiz and Togulga (2009)	Izmir Bay	1149(∑)	0.0151	2.86	0.92
Ak *et al*. (2009)	Black Sea	208(∑)	0.009	3.04	0.89
Demirel and Dalkara (2012)	Sea of Marmara	83(∑)	0.008	3.129	0.93
Kasapoglu (2016)	Black Sea	68 (♀)	0.0152	2.96	0.94
		44 (♂)	0.0107	2.09	0.95
		112 (∑)	0.0180	2.86	0.95
Calik and Saglam (2017) [42]	Black Sea	113(∑)	0.0135	2.95	0.94
Yildiz *et al*. (2018)	Black Sea	591(♀)	0.01	3.11	0.93
		347(♂)	0.0114	3.03	0.91
		1536 (Σ)	0.0078	3.21	0.94
The present study	KYSA	1740 (Σ)	0.0057	3.30	0.99
	MSA	1011 (Σ)	0.0045	3.39	0.99

Table 5: Comparison of von Bertalanffy growth parameters of black goby

References	Location	L_∞	*K*	t_0	φ
Fabi and Giannetti (1985)	Adriatic Sea	16.58 (♀)	0.190	-2.57	1.73
		18.52(♂)	0.295	-1.69	2.00
Silva and Gordo (1997)	Obidos Lake	16.66 (∑)	0.337	-1.676	1.98
Filiz (2007)	Candarli Bay	14.10 (♀)	0.278	-2.053	1.94
		17.62 (♂)	0.392	-1.198	1.89
		17.11 (∑)	0.323	-1.676	1.98
Kinacigil *et al*. (2008)	Izmir Bay	16.8 (∑)	0.39	-0.04	2.04
Filiz and Togulga (2009)	Izmir Bay	14.84 (♀)	0.321	-2.205	1.92
		16.69 (♂)	0.301	-1.459	1.85
		17.59 (∑)	0.255	-2.174	1.90
Kasapoglu (2016)	Black Sea	17.95 (∑)	0.27	-1.50	----
The present study	KYSA	12.57 (♀)	0.30	-1.69	1.68
		12.95 (♂)	0.36	-1.39	1.78
		13.76 (∑)	0.31	-1.43	1.73
	MSA	12.33 (♀)	0.39	-1.23	1.77
		15.22 (♂)	0.24	-1.95	1.74
		13.96 (∑)	0.29	-1.42	1.75

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