



## Age, Growth and Gonado-somatic Index of the Red Mullet (*Mullus barbatus ponticus* Essipov, 1927) in the Eastern Black Sea coast of Turkey

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ARTICLE INFO	ABSTRACT
<p>Research Article</p> <p>Received : 10/05/2018 Accepted : 10/12/2018</p> <p>Keywords: Red mullet <i>Mullus barbatus ponticus</i> South-Eastern Black Sea Growth Preproduction period</p>	<p>In this study, the age, growth, and gonado-somatic index (GSI) of the Red mullet (<i>Mullus barbatus ponticus</i> Essipov, 1927) from the Eastern Black Sea coast of Turkey were examined. A total of 1466 <i>M. barbatus ponticus</i> were sampled between September 2010 and August 2011 from trammel net landings in Rize. The total length of Red mullet ranged from 7.42 cm to 17.80 cm and weight ranged from 9.59 g to 50.93 g, regardless of the sex. The sex ratio (♂/♀) was 0.46, with almost twice more females than males. The growth performance of <i>M. barbatus ponticus</i> in the study area is similar to that of the western populations of the same sub-species. A closed season of at least three months (from May to July) banning the use of even the stationary fishing gear will be beneficial for the sustainable stock of management of <i>M. barbatus ponticus</i> in the Black Sea.</p>

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## Türkiye'nin Doğu Karadeniz Sahillerinde Barbunya Balığının (*Mullus barbatus ponticus* Essipov, 1927) Yaş, Büyüme ve Gonado-somatik İndeksi

MAKALE BİLGİSİ	ÖZ
<p>Araştırma Makalesi</p> <p>Geliş : 10/05/2018 Kabul : 10/12/2018</p> <p>Anahtar Kelimeler: Barbun <i>Mullus barbatus ponticus</i> Güney Doğu Karadeniz Büyüme Üretim öncesi dönemi</p>	<p>Bu çalışmada, Türkiye'nin, Doğu Karadeniz sahillerinden örneklenen Barbunya (<i>Mullus barbatus ponticus</i> Essipov, 1927) balığının yaş, büyüme ve gonado-somatik (GSI) indeksi incelenmiştir. Rize sahillerinden uzatma ağı ile Eylül 2010-Ağustos 2011 tarihleri arasında toplam 1466 <i>M. barbatus ponticus</i> örneklenmiştir. Karadeniz barbun balığının (dişi+erkek) boyu 7,42 cm ile 17,80 cm, ağırlığının ise 9,59 g ile 50,93 g. arasında olduğu belirlenmiştir. Cinsiyet oranı (♂/♀) 0.46 olduğu hesaplanmış, popülasyon içindeki dişi oranının hemen hemen erkeklerden 2 kat daha fazla olduğu bulunmuştur. Bu bölgedeki <i>M. barbatus ponticus</i>'un büyüme performansı, batı popülasyonlarının alt türlerine benzemektedir. En azından üç ay (Mayıs, Haziran, Temmuz) avcılığın yasaklanması hatta uzatma ağlarının yasaklanması, Güney-Doğu Karadeniz'deki <i>M. barbatus ponticus</i>'un sürdürülebilir stok yönetiminde yararlı olacaktır.</p>



## Introduction

The Red mullet (*Mullus barbatus ponticus* Essipov, 1927) is an endemic fish that inhabits the entire coast of the Black Sea, including the Sea of Azov, along with two other sister taxa, the “common” red mullet (*Mullus barbatus* L.) and the striped red mullet (*Mullus surmuletus* L.) (Whitehead et al., 1986). Together with the whiting, red mullets are among the main commercial species caught by bottom trawls and seine nets in the southern part of the Black Sea (Gönener and Erkoyuncu, 2005; Gönener and Bilgin, 2010; Özdemir et al., 2005). According to fisheries data, 507 and 345 tons of all red mullet species were caught from the Black Sea in 2010 and 2016, respectively (TUIK, 2012; 2018).

Due to its market value, there have been many studies regarding the biology, mortality and exploited ratio of *M. barbatus ponticus* along the Black Sea coast of Turkey (Polat, Bostancı and Yılmaz 2005; Şahin and Akbulut, 1997; Genç, 2000; Süer, 2008; Aksu et al., 2011; Kasapoğlu, 2018).

The objective of this study is to investigate age, growth, and gonado-somatic index (GSI) of *M. barbatus ponticus* from the Eastern Black Sea coast of Turkey and to compare the results with the existing literature.

## Material and Method

Monthly samplings of Red mullet were randomly collected between September 2010 and August 2011 from commercial trammel net landings, set off coast of Rize in the South-East Black Sea (Figure 1). The trammel nets were 1600 m in length, with a mesh size of 16 mm (bar length). During the study, 1466 specimens were sampled. For each individual, the total length (TL) was measured to the nearest millimeter using a digital Vernier caliper. The weight (W) of each individual was determined on a top-loading digital balance with a precision of 0.01 g.

Mann-Whitney U test was used to determine whether there was a statistically significant difference between length and weight.

The length–weight relationship was calculated by applying the power regression equation

$$W = aTL^b \text{ (Ricker, 1975)}$$

Where,

W : Total weight of the samples (g),

TL : Total length of the samples (cm),

a : Constant (intercept),

b : Constant (slope of regression line).

After dissection of the bodies, the gonads were separated and weighed. The gonado-somatic index (GSI) was calculated as indicated by Wootton (1990).

$$\text{Gonado-somatic index (GSI)} = \frac{W_g}{W - W_g} \times 100$$

Where,

W<sub>g</sub> : Total gonad weight (g) and

W : Total weight (g) of fish.



Figure 1 Map showing the sampling area in the Black Sea coasts off Rize, NE Turkey

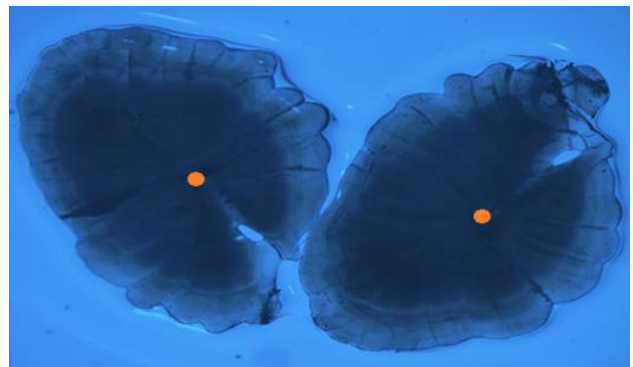


Figure 2 Image of otoliths of *M. barbatus ponticus* (age: II; length: 13.8 cm; month of capture: June)

A chi-square test was performed to assess any significant difference in the sex ratio.

Age were determined via otoliths (Holden and Raitt, 1974). Otoliths were examined using a stereo-microscope for the presence of growth bands. Annual rings on the whole otolith were counted by two readers in glycerin under a Stereo-microscope. The age were estimated from otoliths by 2 readers using a stereoscopic microscope. The first of June was adopted as the birth-date reference for age assignment purposes. The von Bertalanffy growth function was used to estimate the age–length relationship (Ricker, 1975).

$$L_t = L_\infty (1 - e^{-K(t-t_0)})$$

Where,

L<sub>t</sub>(cm) : Length at age t,

L<sub>∞</sub>(cm) : Asymptotic maximum length;

K(year<sup>-1</sup>) : von Bertalanffy growth constant and

t<sub>0</sub> : Theoretical age at zero length.

Growth performance of Red mullet was estimated using the index

$$\Phi' = \log K + 2 \log L_\infty \text{ (Whitehead, et al., 1986).}$$

The von Bertalanffy growth function was used to estimate the age–weight relationship (Ricker, 1975).

$$W_t = W_\infty (1 - e^{-K(t-t_0)})^b$$

Where,

- $W_t$  (g.) : Weight at age t,
- $W_\infty$  (g.) : Asymptotic maximum weight,
- $K$  (year<sup>-1</sup>) : Von Bertalanffy growth constant and
- $t_0$  : Theoretical age at zero length,
- $b$  : Constant (slope of regression line).

**Results**

In this study, the age, growth and gonado-somatic index of Red Mullet, an economically important species caught in the Eastern Black Sea coasts in September 2010 and August 2011 fishing seasons, were determined.

*M. barbatus ponticus* sample consisted of 889 females, 407 males and 170 juveniles. The overall sex ratio (♂/♀=0.46) differed significantly from 1:1 ( $\chi^2=19.360$ ,  $P<0.001$ ). Total lengths and weights of males ranged 7.42–16.97 cm (mean 11.88±1.65 cm) and 9.81–49.87 g (mean 16.05±6.76 g), respectively. For females, total lengths and weights ranged 7.65–17.80 cm (mean 13.68±1.58 cm) and 9.59–50.93 g (mean 25.05±10.86 g), respectively. There were statistically significant differences between lengths and weights (Mann–Whitney  $U$  test=2512301;  $P<0.001$ ) of females and males. The length–frequency distribution of *M. barbatus ponticus* sampled in the study is shown in Figure 3.

The length–weight relationship showed a positive allometric growth in females and males (Figure 4). There was no significant difference in the allometric coefficient between females and males ( $P>0.001$ ;  $f=6.10E-37$ ).

The von Bertalanffy growth curve parameters-asymptotic length ( $L_\infty$ ), growth coefficient ( $K$ ), theoretical age at length zero ( $t_0$ ) and age ranges of the Red mullet specimens are presented in Table 1.

The length-weight relationships were calculated for each sex and sexes combined are shown in Table 1 and Figure 4.

The age of *M. barbatus* samples ranged between 0 and 4. The maximum age group was determined as 4 years for each sex. Females were dominant in each age group (Table 1).

There were no significant differences in length groups between sexes ( $P<0.05$ ). The estimated growth performance indexes ( $\Phi'$ ) indicated that females had a bit higher growth rates than males (Table 1).

GSI values of *M. barbatus ponticus* are shown in Figure 5. According to the monthly results, gonad weights started to increase in March and continued till June. A sharp decrease (during spawning) occurred in July and continued until August.

**Discussion**

In the present study, the sex ratio of *M. barbatus ponticus* of Rize differed significantly from 1:1. Recent studies of the Black Sea showed a male-scarce sex ratio for *M. barbatus ponticus* (Şahin and Akbulut, 1997; Genç, 2000; Süer, 2008). In general, more females in fish populations may indicate greater rates of reproduction (Wootton, 1982).

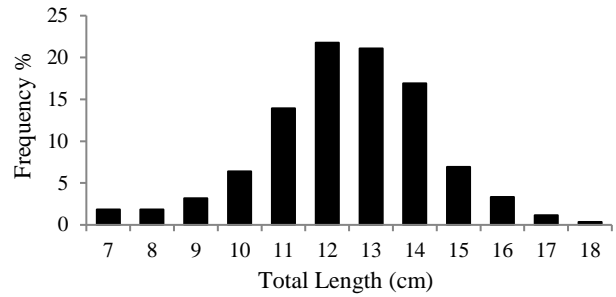


Figure 3 Length–frequency distribution of Red mullet (*Mullus barbatus ponticus* Essipov, 1927) *Mullus barbatus ponticus* Essipov, 1927)

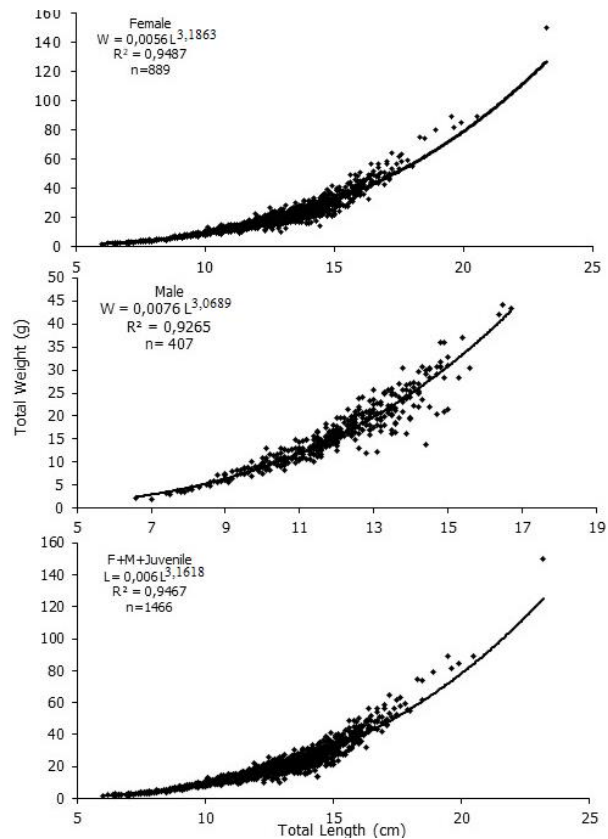


Figure 4 Length–weight relationships of females, males and all specimens of Red mullet (*Mullus barbatus ponticus* Essipov, 1927)

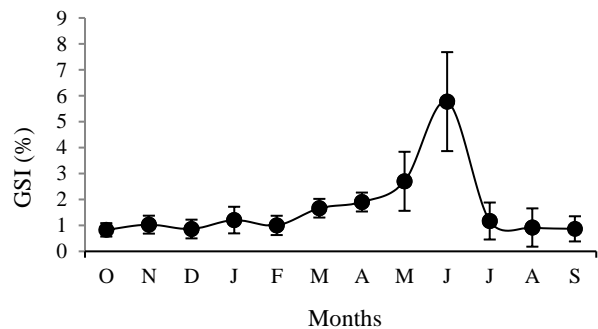


Figure 5 Monthly variation of gonadosomatic index values (GSI) of *M. barbatus*(Essipov, 1927) female specimens

Otoliths based age determination studies of *M. barbatus ponticus* showed that the species lived up to 6 years (Şahin and Akbulut, 1997; Süer, 2008) and 9 years (Genç, 2006) in the Black Sea. *M. barbatus ponticus* is a fast growth species during the first age of the lifespan, but the rest of its life growth rate is reduced and this is a general characteristic of demersal fish such as scorpaenids (Cailliet et al., 2001). Our results showed that *M. barbatus ponticus* is a slow growing species in its general lifespan (K=0.226 for females and K=0.233 for males) and reaches its first maturation stage in the first year of its life (Genç, 2006).

According to our study findings, K value was calculated as 0.233 for male, 0.226 for female and 0.261 for all individuals. In other studies conducted in the same region; for male and female individuals as 0.154 and 0.082 respectively (Süer 2008); 0.204 and 0.231 (Sahin and Akbulut, 1997). In another study, it was calculated as 1.44 for female, 0.353 for male and 0.140 for all individuals (Aydın and Karadurmuş, 2013). The findings of the studies performed at different dates in the same region and our findings support each other. However, very recent in two studies, the K value for all individuals was calculated as 0.135 (İsme et al., 2000) and 0.435 (Kinacigil et al., 2001) (Table 2). In other studies conducted on the Aegean coasts, different K values were calculated. The K value for all individuals was calculated as 1,500 and 0,332 (Çelik, and Torcu, 2000; Çoral, 1998). Studies conducted in the Mediterranean; The K value for all individuals was 0.565 (Özbilgin et al., 2004), and in a different study, it was calculated as 0.125. Another study in the Gulf of Saros; for female, male and all individuals, the K value was 0.180; 0.140 and 0.160 respectively (Arslan and İsmen, 2014) (Table 2). Differences in study findings in different areas; the ecological area is connected to nutrients and environmental conditions.

The analysis of *M. barbatus ponticus* gonado-somatic indexes (Figure 5) indicated that spawning off Rize occurred in July during the sampling period; in fact, (Genç, 2006; Şahin and Akbulut, 1997) reported a spawning period between May and August in the Black Sea.

*M. barbatus ponticus* reaches its first maturation in the first year of its life (Ricker, 1975). Turkish fishery regulations do not specify any landing size for *M. barbatus ponticus*, while the minimum sizes of *M. barbatus* and *M. surmuletus* are 13 cm and 11 cm, respectively. Because the populations of all these taxa occur together in the Black Sea, it is very important to separate the different fish species from each other. Inspectors should apply the 13 cm,

given that *M. barbatus ponticus* is just a sub-species of *M. barbatus*.

In order to compare the growth of different populations of the same species, it is better to use the index  $\Phi'$  instead of  $L_\infty$  and K individually (Sparre and Venema, 1998). Estimated  $\Phi'$  values of *M. barbatus ponticus* studied by different authors in the Black Sea and other area are shown in Table 2. In general, females have a better growth performance than males, and the values derived from this study are close enough to those for other populations of the Black Sea. In this study, the calculated growth performance index ( $\Phi'$ ) was 2.13 for females, 2.09 for males and 2.14 for sexes combined (Table 1). This finding is very closed with the early studies (Arslan and İsmen, 2014; Genç, 2006; Süer 2008; Şahin and Akbulut, 1997) while the values were lower than the results by Aydın and Karadurmuş (2013), on the other hand higher than the Aksu et al. (2011) findings (Table 2). The different growth performance indexes ( $\Phi'$ ) are clarified with the different sampling areas and the sampling methods in these studies. The difference in growth performance between eastern populations and those from Sinop on the west may arise from employing different aging methods (Aksu et al., 2011).

The growth parameters of *Mullus barbatus ponticus* in this study are close to the findings by Kasapoğlu (2018) and Genç (2000), while the values were lower than the results by İsmen et al. (2000) and Özvarol et al. (2006).

When the findings of Gonado-Somatic index were taken into account, Metin (2005), Akyol et al. (2000) and Arslan and İsmen (2014) found that the reproduction period was between April and August. In our findings, it was determined that the reproduction has come between May and July (Figure 5). Our findings are very close to those obtained in previous studies.

Trawling is widely used for *M. b. ponticus* fishing, and there is a five-month closed season (between May and September) in the Black Sea. The sampling area of this study is permanently banned for trawling. Generally, Gill and trammel nets are the only fishing gears used to catch *M. b. ponticus* in the sampling area. Small fish (<11 cm TL) obtained negligible levels within our samples (Figure 4.) implied that young fish did not exploit with trammel net fisheries probably due to selectivity of this type of fishing gears in the study area. Therefore, there is no time limitation for stationary gears fishing *M. b. ponticus*. To protect spawning stocks and sustainability fisheries for the red mullet a closed season should be applied during the maturing and spawning period (between May and July).

Table 1 Length and weight at age (cm),  $L_\infty$ , K,  $t_0$ , and  $\Phi'$  of Red mullet 1466 specimens obtained from trammel nets in the South-East Black Sea Off Rize coasts.

Sex	$L_0 \pm SD$	N	$L_1 \pm SD$	N	$L_2 \pm SD$	N	$L_3 \pm SD$	N	$L_4 \pm SD$	N	$L_\infty$	K	$t_0$	$\Phi'$
J	6.82±0.41	170	--	--	--	--	--	--	--	--	--	--	--	--
F	7.65±0.29	889	11.23±0.68	518	13.82±0.17	179	15.67±0.81	98	17.80±0.56	7	24.66	0.226	-1.66	2.13
M	7.42±0.32	407	10.97±0.96	236	13.02±0.19	82	14.89±0.98	47	16.97±0.67	3	23.04	0.233	-1.68	2.09
All	7.27±1.01	1466	11.17±0.87	754	13.65±0.18	261	15.41±0.92	145	17.67±0.61	10	23.18	0.261	-1.45	2.14
	$W_0 \pm SD$		$W_1 \pm SD$		$W_2 \pm SD$		$W_3 \pm SD$		$W_4 \pm SD$		$W_\infty$			
J	7.92±3.08		--		--		--		--		--			--
F	9.59±1.36		14.55±5.31		27.15±5.11		33.92±4.86		50.93±4.12		152.6			
M	9.81±1.23		14.18±6.40		27.85±5.71		34.10±4.86		49.87±8.12		115.4			
All	8.12±2.27		14.47±7.04		27.67±3.51		34.08±5.10		50.49±7.39		124.3			

F: Female, M: Male, J: Juvenile, L: Length (cm) at age, W: Weight (g) at age, N: Number of specimens, SD: Standard deviation

Table 2  $L_{\infty}$ , K,  $W_{\infty}$  and  $\Phi'$  values of Red mullet derived from studies in different locations of the Black Sea and other area.

Author	Sex	$L_{\infty}$	K	$W_{\infty}$	$\Phi'$	Aging method	Study area
This study	F	24.66	0.226	50.93	2.13	Otoliths	Rize
	M	23.04	0.233	49.87	2.09	Otoliths	
	All	23.18	0.261	50.49		Otoliths	
İşmen et al. (2000)	All	30.80	0.135			Otoliths	Karadeniz
Kınacıgil et al. (2001)	All	19.04	0.438			Otoliths	Karadeniz
Süer (2008)	M	25.25	0.154		1.99	Otoliths	Samsun
	F	39.36	0.082		2.10	Otoliths	
Genç (2000)	M	22.20	0.213		2.02	Otoliths	Trabzon
	F	25.60	0.238		2.19	Otoliths	
Şahin, Akbulut (1997)	M	21.03	0.204		1.95	Otoliths	Trabzon
	F	21.26	0.231		2.02	Otoliths	
Aydın, Karadurmuş (2013)	F	25.40	0.144	171.40		Age scale	Karadeniz
	M	19.30	0.353	72.47		Age scale	
	All	27.40	0.140	202.40	4.36	Age scale	
Aksu et al. (2011)	All	20.15	0.011		0.65	Length-frequency	Sinop
Kasapoğlu (2018)	All	24.60	0.220			Otoliths	Hopa-Sinop
Çelik, Torcu (2000)	All	26.08	1.500			Otoliths	Ege
Çoral (1998)	All	26.18	0.332			Otoliths	Ege
Özbilgin et al. (2004)	All	24.26	0.565			Otoliths	Ege
Özvarol et al. (2006)	All	30.30	0.104	336.50		Otoliths	Akdeniz
Atar, Mete (2009)	All	27.90	0.115			Otoliths	Akdeniz
	F	26.60	0.180		2.11		
Arslan, İşmen (2014)	M	28.30	0.140		2.06	Otoliths	Saros Bay
	All	28.70	0.160		2.10		

F: Female, M: Male, J: Juvenile, L: Length (cm) at age, W: Weight (g) at age, N: Number of specimens, SD: Standard deviation

This study represents a review data on age, growth and gonado-somatic index of Red Mullet living in the coasts of the East Black Sea Off Rize coasts. The results of this study can be reference for researchers in the future.

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