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-RESEARCH ARTICLE-

Length–Weight Relationship and Condition Factor of Red Mullet (*Mullus barbatus barbatus* Linnaeus, 1758) from the Western Black Sea, Turkey

Dilek Türker[1], Habib Bal[2*]

[1]University of Balıkesir, Faculty of Science and Arts, Department of Biology, Balıkesir, Turkey

[2]Livestock Research Institute, Department of Fisheries, Bandırma, Balıkesir, Turkey

Abstract

A total of 1021 specimens of red mullet *Mullus barbatus barbatus* Linnaeus, 1758 were collected by using bottom trawl between April and December 2013 from Western Black Sea of Turkey. Total fish length ranged from 6.9-14.5 cm and weight ranged from 2.60-31.36 g. The length-weight relationships were determined for males, females and combined sexes as $W=0.0055L^{3.25}$, $W=0.0065L^{3.17}$, $W=0.0059L^{3.21}$ respectively. All fishes have been found to be positive allometric growth ($b>3$, $P<0.001$). The results indicated further that the length-weight relationships were highly correlated ($r^2>0.93$, $P<0.001$). Fulton's condition factor (K) was calculated as 0.968±0.16 for females, 0.970±0.14 for males and 0.974±0.12 for all individuals respectively.

Keywords:

Length-weight relationship, Red mullet, *Mullus barbatus barbatus*, Western Black Sea.

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Introduction

The length-weight relationship (LWR) is great importance in fish biology, physiology, ecology and fishery assessment (Gonçalves et al., 1997). The conversion of growth in length equations to growth in weight and is also useful for between region comparisons of life histories of species (Binohlan & Pauly, 1998; Radkhah & Eagderi, 2015). Therefore, the biology and physiology of fish species that are economically important should be well known. Red mullet is a species within the genus *Mullus*, the natural spreading area is the Middle East coast of the Atlantic Ocean and

* *Corresponding author, Habib Bal, e-mail: habipbal@hotmail.com*

the Mediterranean (Whitehead et al., 1986, Fischer et al., 1987). Natural habitat forms the sandy and muddy grounds of the sea at depths of 10-300 m (Quero et al., 1990). Red mullet is a demersal species having significant economic value in Turkish fishery. In 2016, the total catch was 1453 tons. 7.2% of this amount belongs to western Black Sea (TUİK, 2017). It is necessary the follow up and management stocks of economic fish species. Some of the previous studies on *Mullus barbatus* as follow; some biological parameters (Cherif et al., 2007), age, growth and reproduction (Akyol et al., 2000; Papaconstantinou et al., 1981), growth parameters (Kınacigil et al., 2001), population parameters (Özbilgin et al., 2004), length-weight relationships (Çelik & Torcu, 2000; Demirhan et al., 2007; Özaydın & Taskavak, 2006; Karakulak et al., 2006; Kasapoğlu & Düzgüneş, 2013).

This study aims to determine the length-weight relationships and condition factors of important commercial red mullet species in Zonguldak and Amasra coast of the Western Black Sea. Also these results will contribute to the stock assessment and management of fisheries in the region.

Materials and Methods

The study was conducted between April and December 2013 in the coasts of Zonguldak (41°27′45.29" N 31°46′57.96" E; 41°28′10.31" N 31°47′04.98" E) and Amasra (41°44′33.56" N 32°21′16.91" E; 41°44′48.51" N 32°21′39.69" E), Western Black Sea (Figure 1). The surveys were carried out using commercial fishing vessel (12 m, 200 hp). Fishing gear used was bottom trawl nets of 22 mm cod-end mesh size. Average haul duration was 30 min. and towing speed varied from 2.5 to 3.0 knots at 25–75 m depths. Samples were preserved in iceboxes for further examination in the laboratory. Specimens were measured to the nearest 0.1 cm total length (*TL*) and weighed to the nearest 0.01 g total weight (*TW*). Parameters of the length-weight relationships were calculated by method using the equation $W= aL^b$, where *W* is the total weight (g), *L* is the total length (cm) *a* is a coefficient related to the body form and *b* is an exponent indication growth. The parameters *a* and *b* were calculated by the least squares method using the logarithmic form of the equation. Fulton's condition factor (*K*) was calculated using the equation (Froese, 2006) $K= (W/L^3)*100$, where *W* is the total weight (g), *L* is the total length (cm*)* Descriptive statistics were derived using Excel (Microsoft Excel® 2010). The hypotheses of growth type were tested by student *t*-test.

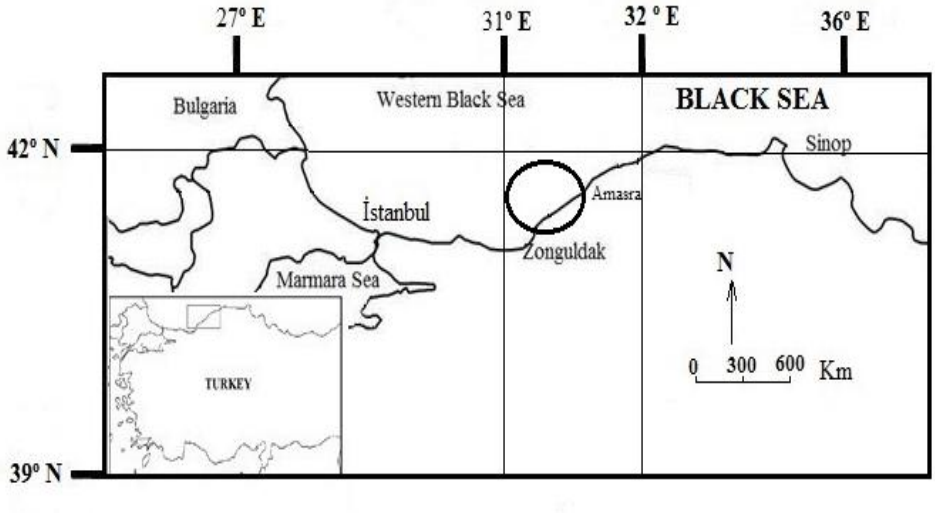

Figure 1. Map of study area

Results

In this study, 1021 *Mullus barbatus* fish species (613 males, 408 females) were examined. There were about 60.03% males and 39.96% females, the sex ratio (F: M) was 1.00:1.50. The total fish size varies between 6.9-14.5 cm, with the most dominant length being 9 cm (Figure 2) and weights varies between 2.60-31.36 g.

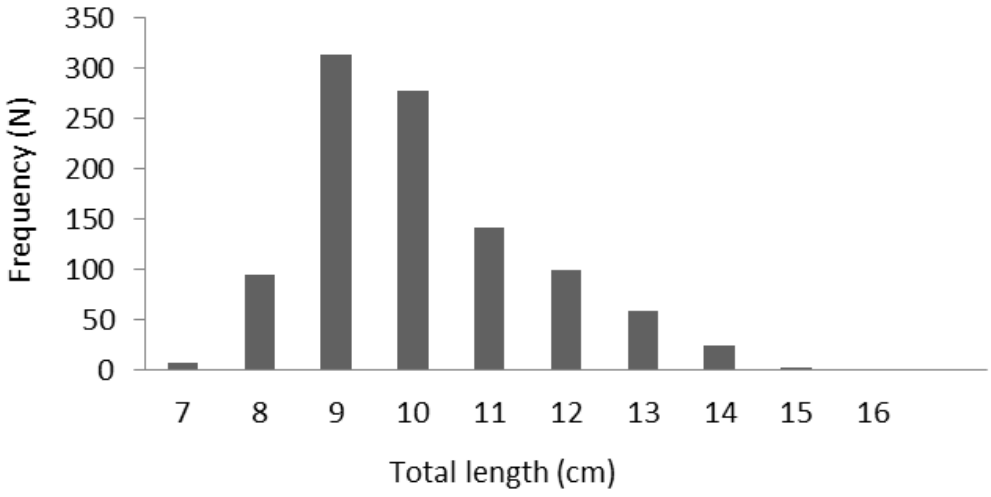

Figure 2. Total length frequency distribution of all *Mullus barbatus*

The samples size, minimum, maximum lengths and weights, length-weight relationships of each sex groups are given in Table 1.

Table 1. Parameters of length-weight relationships for *M.barbatus*

		Length (cm)		Weight (g)		Relationships parameters				
Sex	n	min-max	mean±SD	min-max	mean±SD	a	b	95%CI of b	SE(b)	r²
F	408	7.0-14.3	9.62±0.07	2.88-31.36	9.38±0.25	0.0065	3.17	3.07-3.26	0.050	0.934
M	613	6.9-14.5	9.67±0.05	2.60-31.29	9.57±0.21	0.0055	3.25	3.17-3.30	0.041	0.938
F+M	1021	6.9-14.5	9.65±0.38	2.60-31.36	9.50±0.92	0.0059	3.21	3.12-3.29	0.043	0.936

F: female, M: male, n: sample size, min: minimum, max: maximum, a: intercept, b: slope of the relationship, SE (b): standard error of the slope.

According to Tesch 1971, all *b* values range from 2 to 4. In this study, *b* value was found to be 3.17 in females, 3.25 in males and 3.21 in total respectively. Growth types were determined as positive allometric all sex groups species (b>3, P<0.001). Length-weight relation graph is plotted (Figure 3) and it is determined that the degree of relation is very high (r^2=093, P<0.001). Also, Fulton's condition factor (K) was calculated as 0.968±0.16 for females, 0.970±0.14 for males and 0.974±0.12 for all individuals respectively.

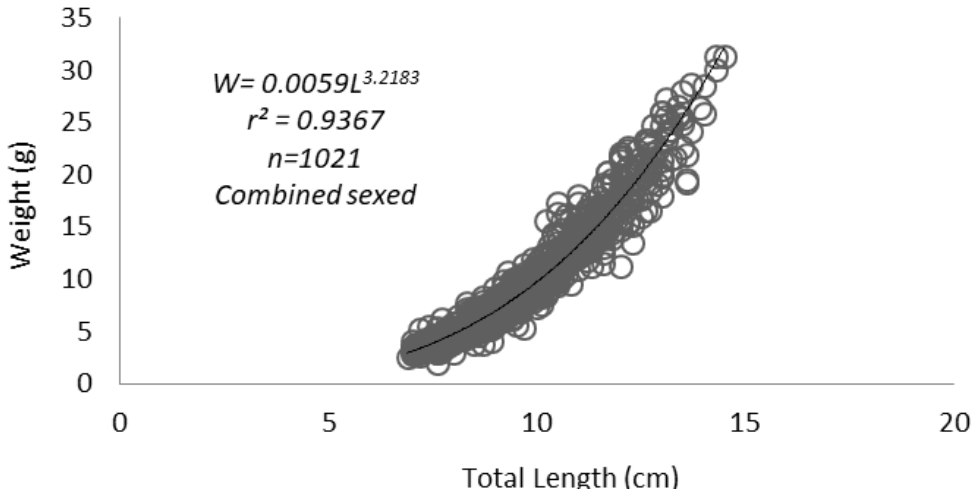

Figure 3. Length-weight relationship of *M. barbatus* in Western Black Sea

Discussion

The parameter *b* may vary seasonally, even daily and between habitats. Thus, the length-weight relationship in fish is affected by a number of factors including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat, (Bagenal & Tesch, 1978; Gonçalves et al., 1997; Taskavak & Bilecenoglu, 2001; Erguden et al., 2009). When *b* is equal to 3 or close to 3, growth in the fish is said to be isometric, fish becomes more robust with increasing length (Bagenal & Tesch, 1978). Similarly when *b* is far less or greater than 3, growth in the fish is allometric the fish becomes thinner with increase in length (King, 1996). The

parameters *b* of length-weight relationships was significantly different from 3 and it is show that positive allometric growth for all sexes. Parameter *b* values in this study was similar obtained from the North Aegean Sea (Karakulak et al., 2006), Marmara Sea (Bök et al., 2011), Black Sea (Kasapoğlu & Düzgüneş, 2013). However there are also studies showing that the *b* value is different (Çelik & Torcu 2000; Kalaycı et al., 2007; İşmen et al., 2007). The reason for the different result of *b* value there may be ecological differences or variability such as temperature and food supply. Individuals in any fish population growing in the same areas during the growth of the individuals in different populations some differences can be observed (Tıraşın, 1993). Fulton's condition factor (K) another important parameter for evaluation of fish stock and used in fish biology. According Le cren (1951) condition factor of fish population may change with age, growth and gonad development. In this study, Fulton's condition factor (K) showed insignificant variation for male and female individuals of *M. barbatus* ($P>0.05$).

Also, the main reason why the size of the fish specimens constituting the study material is dominated by small individuals This can be explained by the choice of fishing gear, nets and intense fishing in the coast of Western Black Sea. The length-weight relationships results of previous studies were given in Table 2.

Table 2. Results of previous studies in different location

Study Area	**Length Type**	**Length (cm) (min-max)**	**Weight (g) (min-max)**	**n**	**a**	**b**	**r^2**	**GT**	**Authors**
Adriatic Sea	TL	17.3-24.7	-	-	-	3.12	-	-	Dulcic & Kraljevic (1996)
Portugal	TL	16.9-25.0	-	-	0.0142	2.93	-	-	Mendes et al. (2004)
Edremit Bay	FL	9.4-18.7	13.4-87.6	474	0.0157	2.98	0.96	-	Çelik & Torcu (2000)
Eastern Black Sea	TL	6.8-18.0	1.40-63.8	421	0.0054	3.22	0.96	-	Demirhan et al. (2007)
North Eastern Mediterranean	TL	8.2-22.0	4.96-106.26	451	0.0032	3.06	0.94	I	Sangun et al. (2007)
İzmir Bay	FL	7.5-20.0	5.57-123.0	479	0.0102	3.17	0.96	-	Özaydın & Taskavak (2006)
Northern Aegean Sea	TL	12.5-22.3	-	76	0.0049	3.27	0.94	A^+	Karakulak et al. (2006)
Middle Black Sea	TL	6.6-18.4	2.94-60.1	176	0.0111	2.96	0.98	I	Kalaycı et. al. (2007)
Marmara Sea	TL	10.0-15.7	9.54-46.5	99	0.0049	3.32	0.91	A^+	Bök et al. (2011)

Black Sea	TL	5.3-19.0	1.2-73.4	2693	0.0074	3.12	0.96	A^+	Kasapoğlu & Düzgüneş (2013)
Antalya Bay	TL	8.7-21.5	-	1565	0.0071	3.16	-	A^+	Özvarol (2014)
Saros Bay	TL	6.0-24.7	2.0-200	3386	0.00762	3.09	0.96	-	İşmen et al., 2007
İskenderun Bay	TL	6.9-15.7	3.41-51.3	212	0.0072	3.16	0.95	-	Çiçek (2015)
Western Black Sea	TL	6.9-14.5	2.6-31.3	1021	0.0059	3.21	0.93	A^+	Present study

n: sample size, TL: total length, FL: fork length, min: minimum, max: maximum, a: intercept, b: slope of the relationship; r^2: coefficient of determination, GT: Growth type; A^+: Positive allometric; I: Isometric; A^- : Negative allometric.

This research is new contribution on length-weight relationship and condition factor for *M. barbatus barbatus*. The results of this research could be used as a reference for fisheries and stock management in the area. It also allows the comparison with the results of the research made in other regions.

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