



## RESEARCH ARTICLE

### Length-weight relationship, sex ratio and condition factor of *Merlangius merlangus* (Linnaeus, 1758) from the Sea of Marmara, Turkey

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#### ABSTRACT

In this study, some biological properties of *Merlangius merlangus* (Linnaeus, 1758) were examined. In this context, relationship of length-weight, distribution of length-frequency, sex ratios and condition factors were examined. A total of 303 individuals were taken by random sampling from fishing vessels (beam trawl) in the Sea of Marmara. Minimum length and weight values of all sample individuals was found 10.0 cm and 6.6 g, maximum length 41.2 cm and 535 g was found. The average length was found 17.15±0.49 cm and the average weight was 47.03±7.57 g. Length-weight relationship for all samples as  $W=0.0044TL^{3.1777}$  regression coefficient  $r^2=0.98$  was determined. Growth type, positive allometric was determined for all samples and both sexes ( $b>3$ ;  $P<0.05$ ). The sex ratio (F:M) was calculated as 1:1.27. The mean values of condition factor (K) were calculated as 0.729±0.089, 0.733±0.091 and 0.737±0.081 for male, female and combined sex respectively. There are no significant differences between male and female ( $P>0.05$ ).

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#### Introduction

*Merlangius merlangus* (Linnaeus, 1758), belongs to the Gadidae family and it is demersal fish species (Hureau, 1986). *M. merlangus* is one of the economically important fish species in Turkey (Sağlam and Sağlam, 2012). There are many studies on this species such as biology, population characteristics, growth parameters, diet, mortality rates and biomass in Black

Sea and Aegean Sea (Samsun and Erkoyuncu, 1998; Özyaydın and Taşkavak, 2006; Kalaycı et al., 2007; Ak et al., 2009; Samsun, 2010; Kasapoğlu and Düzgüneş, 2014; Mazlum and Bilgin, 2014; Samsun and Akyol, 2017; Samsun et al., 2017; Türker and Bal, 2018; Taylan et al., 2018; Aksu, 2020). However, there are a few studies on growth and biological characteristics of *M. merlangus* in the Sea of Marmara (Göksungur, 2004; Bök et al., 2011; Demirel and Dalkara, 2012).

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It is necessary to carry out such studies continuously monitoring study for fisheries management and fisheries biology the conservation of economically important species aquatic ecosystems. The population parameters such as length-weight relationship, length frequency, condition factors and biological parameters are important data sources for fisheries and fisheries management. Especially length and weight parameters gives information about the growth type of fish, whether growth is isometric or allometric (Ricker, 1975).

In this study, relationship of length-weight, distribution of length-frequency, condition factor and sex ratio of whiting were determined. It is expected that the data of the study may be source for both the fisheries of the region and fisheries science.

## Material and Methods

A total of 303 samples were sampled by randomly from fishing vessels (beam trawl) and commercial fisheries in fishing season (between September and April, 2019) in the Sea of Marmara. The beam trawl had 5 m width and 50 cm mouth opening; with a cod end 32 mm mesh size. Samples, total length (cm) with 1 mm precision, weight (g) with 0.01 g accuracy recorded and macroscopically sex (female and male) was determined.  $W=aL^b$  equation was used to determine the length-weight relationship (LWR) of fishes (Ricker, 1975). Where,  $W$  indicates the weight of the fish in g,  $L$  the total length in cm,  $a$  the condition of the fish, and  $b$  to the growth type of the fish. Student t test was used to determine the growth type (if;  $b=3$ , isometric;  $b<3$ , negative allometric;  $b>3$ , positive allometric) (Ricker, 1975). Fulton's condition factor was calculated (Froese, 2006).

$$K = \left( \frac{W}{L^3} \right) \times 100$$

According to the formula given above;  $W$  indicates fish weight (g),  $L$  indicates total fish length (cm).

## Results

### Length-Weight Relationships

The length-weight relationship was calculated according to all of the samples examined and gender groups, and it was found that the regression coefficient between the relationships was high. Growth types for each gender group and all samples were calculated and growth was found to be positive allometric for all. The results of the examples are given in Table 1.

### Distribution of Length-Frequency

For all individuals, the minimum length 10 cm and 6.6 g. The maximum length 41.2 cm, maximum weight of 535 g was determined. The minimum, maximum, average and standard error values of the lengths and weights of the samples are given in Table 2.

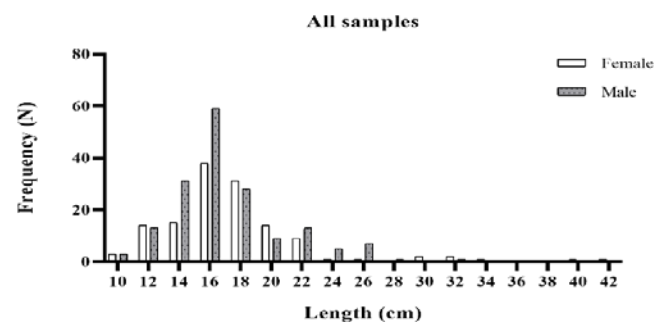


Figure 1. Distribution of length-frequency of *Merlangius merlangus*

Table 1. Parameters of length-weight relationship and growth type of *Merlangius merlangus*

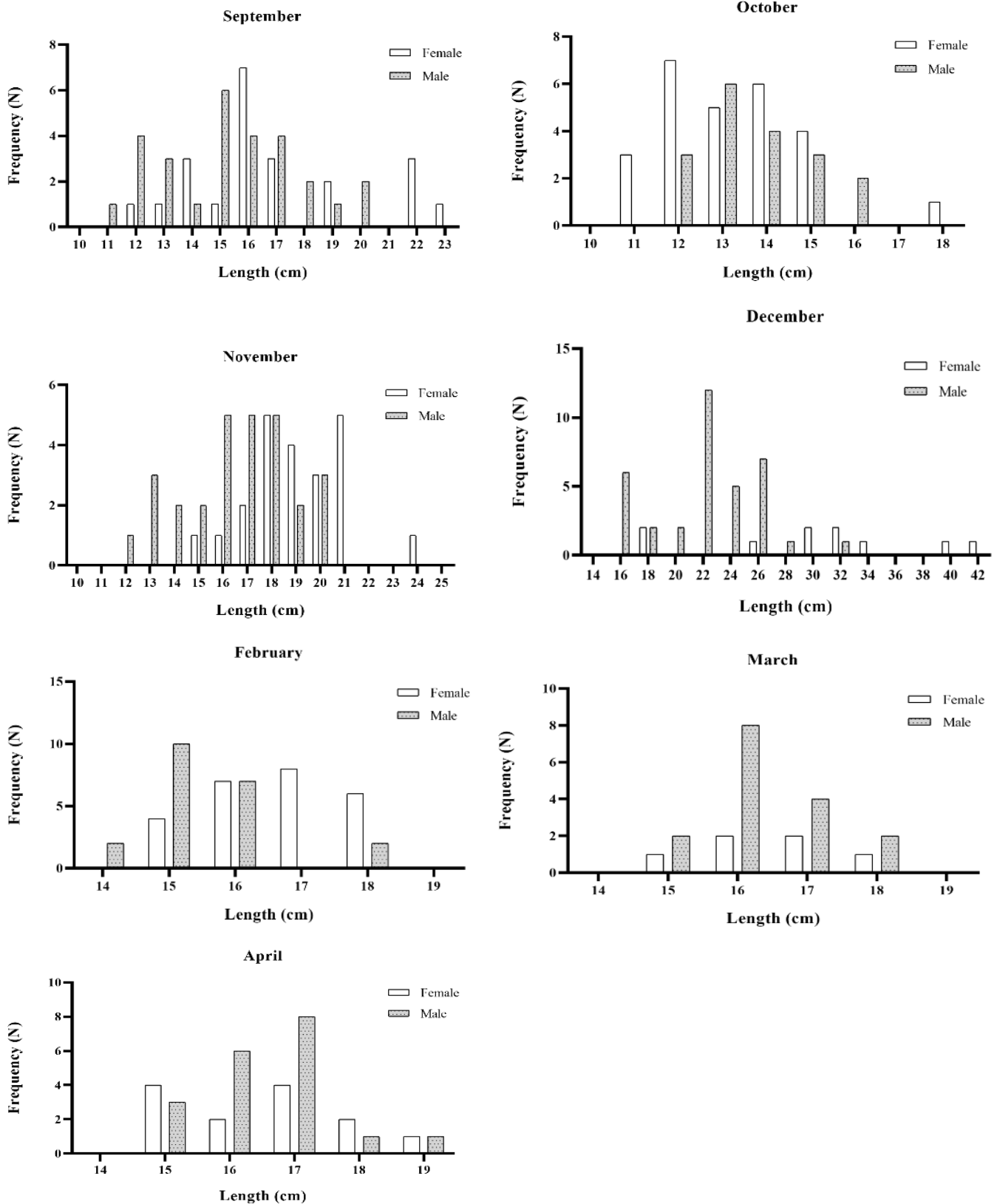
Sex	N	a	b	±95% CI of b	SE(b)	r <sup>2</sup>	Growth Type	P
F	133	0.0039	3.2281	3.152-3.303	0.038	0.9821	+ Allometric	<0.05
M	170	0.0052	3.1168	3.045-3.188	0.036	0.9776	+ Allometric	<0.05
F+M	303	0.0044	3.1777	3.122-3.224	0.026	0.9796	+ Allometric	<0.05

Note: N: number of sampling; F: female; M: male; a: intercept; b: slope of the relationship; r<sup>2</sup>: coefficient of determination; SE(b): standard error of b; CI: confidence interval.

Table 2. Parameters of length and weight of *Merlangius merlangus*

Sex	N	TL (cm)		TW (g)	
		(Min-Max)	Mean±SE	(Min-Max)	Mean±SE
F	133	10.0-41.2	17.46±5.16	6.7-535	53.95±38.61
M	170	10.0-32.6	16.83±0.49	6.6-272.36	40.70±7.57
F+M	303	10.0-41.2	17.15±0.49	6.6-535	47.03±7.57

Note: N: number of sampling; F: female; M: male; TL: total length, cm; TW: total weight, g; SE: standard error.



**Figure 2.** Distribution of length-frequency in catch seasons of *Merlangius merlangus*

It has been determined that the size distribution of the samples is generally between 14 and 18 cm. In this study, 68% of all samples are over 18 cm (Figure 1).

The length-frequency all samples and distributions according to the months were calculated and graphics were drawn (Figure 2).

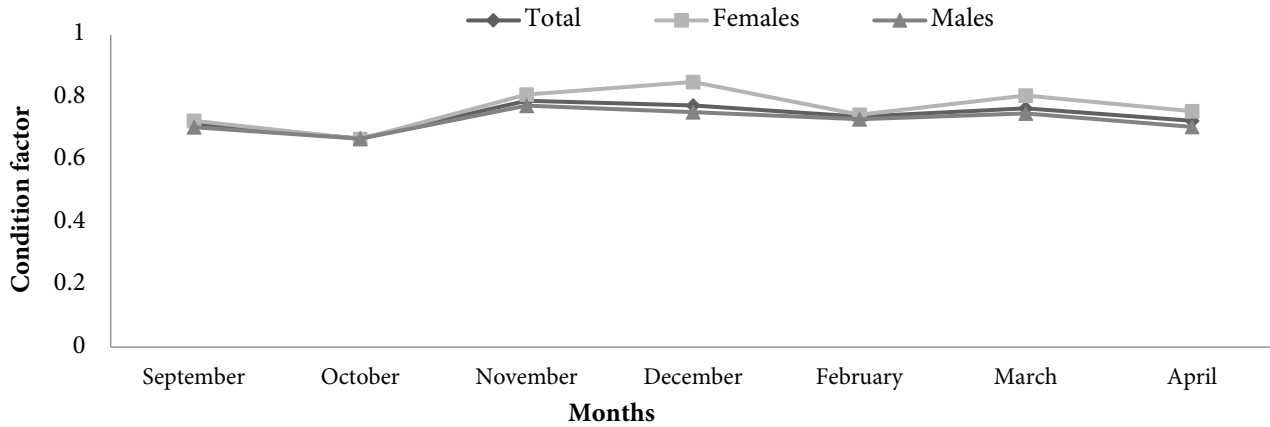


Figure 3. Condition factor of *Merlangius merlangus* in the Sea of Marmara

Table 3. Comparison parameters of length-weight relationship, growth type, sex ratio and condition factor with previous studies

Study area	N	Length (cm) (min-max)	Weight (g) (min-max)	a	b	r <sup>2</sup>	Growth type	Sex ratio	Condition factor (K)	References
MBS	7716	3.2-25.6		0.005	3.07	0.96	A <sup>-</sup>			Aksu, 2020
SEBS	480	11.8-21.9	11.1-21.9							Balık and Öztaş, 2019
WBS	4003	6-25.9	1.60-135.54	0.004	3.25	0.96	A <sup>+</sup>	1:1.85		Yıldız and Karakulak, 2019
WBS	318	7.8-22.7	2.67-76.28	0.006	3.01	0.96	I			Türker and Bal, 2018
EBS	70	12.6-23.3	15.59-95.72	0.007	3.02	0.94				Taylan et al., 2018
CBS	1891	7.5-23.4			2.90					Samsun et al., 2017
CBS	1495	8.8-22.8	5.3-83.2	0.011	2.86	0.92	A <sup>-</sup>			Samsun and Akyol, 2017
EBS	140	10-27	9-118	0.013	2.77	0.91	A <sup>-</sup>			Çalık and Erdoğan Sağlam, 2017
BS	2292	5.9-22.2		0.005	3.15	0.92				Kasapoğlu and Düzgüneş, 2014
SEBS	598	10.6-27.4						1:1.52		Mazlum and Bilgin, 2014
SEBS	1952	11.6-30.7						1:1.35		Bilgin et al., 2012
MS	234	10.6-24.5		0.012	2.83	0.93	A <sup>-</sup>			Demirel and Dalkara, 2012
SEBS	1884	10.3-21	6.4-67.2	0.006	3.04	0.88	I	1:1.38		Sağlam and Sağlam, 2012
MS	166			0.004	3.14		A <sup>+</sup>			Bök et al., 2011
MBS	2238	8.4-31.5	3.35-259	0.004	3.20	0.97	A <sup>+</sup>	1:1.15		Samsun, 2010
EBS	943	6.7-29.5	2.15-241.2	0.004	3.16	0.98	A <sup>+</sup>	1:1.95		Ak et al., 2009
MBS	904	7.7-22.7	2.99-79.79	0.006	3.02	0.96	I			Kalaycı et al., 2007
EAS	100	16.0-31.7	30.27-229.37		2.94	0.96				Özaydın and Taşkavak, 2006
MBS		8.4-31.5		0.004	3.20			1:1.15		Samsun, 2005
MS	920	7-25	5.2-84.6	0.005	3.14			1:1.55	0.746	Göksungur, 2004
EBS	1730	11-30.40	8.23-283.80					1:1.84		Çiloğlu et al., 2001
MBS	1302	9.0-24.0	5.7-118.7	0.003	3.24	0.94	A <sup>+</sup>	1:1.17	0.740	Samsun and Erkoyuncu, 1998
MBS					3.19				0.740	Samsun et al., 1994
MS	303	10.0-41.2	6.6-535	0.004	3.17	0.97	A <sup>+</sup>	1:1.27	0.737	Present study

Note: MS: Marmara Sea; BS: Black Sea; MBS: Middle Black Sea; WBS: Western Black Sea; EAS: Eastern Aegean Sea; CBS: Central Black Sea; SEBS: South-Eastern Black Sea; EBS: Eastern Black Sea.

### Sex Ratio

A total of 303 specimens of *Merlangius merlangus* consisting of 133 females (10.0–41.2cm;  $17.46 \pm 5.16$  TL) and 170 males (10.0–32.6 cm;  $16.83 \pm 0.49$  TL) were examined from the Sea of Marmara. The sex ratio of male: female=1:1.27 was significantly different from 1:1 ( $P < 0.05$ ).

### Condition Factors

The mean highest condition factor was recorded 0.849 in December for females, 0.773 in September for males. The mean low condition factor was recorded 0.668 in October for females, 0.667 in October for males. The mean values of condition factor (K) were calculated as  $0.729 \pm 0.089$ ,  $0.733 \pm 0.091$  and  $0.737 \pm 0.081$  for male, female and combined sex respectively (Figure 3). There are no significant differences between male and female ( $P > 0.05$ ).

### Discussion

Length-weight relationship (LWR) is very important data sources for fisheries. It has many applications in fishery management, ecological studies such as estimating the condition, feeding and spawning (Gonçalves et al., 1997; Stergiou and Moutopoulos, 2001). Although, there are many study on whiting especially Black Sea and Aegean Sea, there is a few information on growth and biological characteristics of *Merlangius merlangus* in the Sea of Marmara (Göksungur, 2004; Bök et al., 2011; Demirel and Dalkara, 2012).

The growth pattern (b) typically varies between 2.0 and 3.5 (Froese and Pauly, 2010). Values of b changeable in different population of same fish species. The growth pattern (b) depends on temperature, salinity, food, conditional of environmental conditions (predation) sex and stage of maturity (Ricker, 1973; Freitas et al., 2017). In this study, the growth pattern (b) of all samples positive allometric ( $b > 3$ ;  $P < 0.05$ ) was found. It is similar to the Bök et al., (2011). However, Demirel and Dalkara, (2012) reported that they found the b value of this species to be negative allometric ( $b < 3$ ;  $P < 0.05$ ). It has been determined that this aspect is not similar to our study results.

In previous studies, growth pattern of b values respectively as five positive allometric (Samsun and Erkoyuncu, 1998; Ak et al., 2009; Samsun, 2010; Bök et al., 2011; Yıldız and Karakulak, 2019), four negative allometric (Demirel and Dalkara, 2012; Samsun and Akyol, 2017; Çalık and Erdoğan Sağlam, 2017; Aksu, 2020) and tree isometric (Kalaycı et al., 2007; Sağlam and Sağlam, 2012; Türker and Bal, 2018) were determined (Table 3).

The growth pattern b value was not significantly ( $b = 3$ ;  $P > 0.05$ ) differences to the 3 (Kalaycı et al., 2007; Sağlam and Sağlam, 2012; Türker and Bal, 2018).

Growth pattern (b), range from 2.77 (Çalık and Erdoğan Sağlam, 2017)-3.24 (Samsun and Erkoyuncu, 1998). It's estimated that the reason for the difference in b value between stocks in different regions and unsuitable environmental conditions due to overfishing.

The coefficient of determination ( $r^2$ ) in previous study range from 0.88-0.98 and highly significant ( $P < 0.05$ ) (Samsun and Erkoyuncu, 1998; Göksungur, 2004; Özaydın and Taşkavak, 2006; Kalaycı et al., 2007; Ak et al., 2009; Samsun, 2010; Bök et al., 2011; Sağlam and Sağlam, 2012; Demirel and Dalkara, 2012; Bilgin et al., 2012; Mazlum and Bilgin, 2014; Kasapoğlu and Düzgüneş, 2014; Çalık and Erdoğan Sağlam, 2017; Samsun and Akyol, 2017; Samsun et al., 2017; Taylan et al., 2018; Türker and Bal, 2018; Aksu, 2020). The coefficient of determination ( $r^2$ ) very high in present study also ( $P < 0.05$ ).

The result about sex ratio in present study is also similar by Erkoyuncu, (1998) and Bilgin et al., (2012) in the Black Sea. But different from the F:M ratio found by Ak et al., (2009) as 1.00:1.95. Condition factor in previous studies, Samsun et al. (1994) 0.740, Samsun and Erkoyuncu (1998) 0.740, and Göksungur (2004) 0.746 values similar to in present study (0.737). These minor differences are thought to be due to changes in the ecosystem. The parameters obtained from LWR, sex ratio and condition factor for previous study is showed in Table 3.

### Conclusion

In present study, it has been determined that the size distribution of the samples is generally between 14 cm and 18 cm. The absence of specimens larger than 18 cm indicates a prey pressure on the species. The regular monitoring studies are essential to understand the dynamics of exploited whiting stocks under the pressure of environmental changes in the Sea of Marmara ecosystem. Therefore, whiting fishery needs new regulation measures and management plans for the sustainable fisheries. It is expected that the data of the study may be source for both the fisheries of the region and fisheries science.

### Compliance with Ethical Standards

### Conflict of Interest

The authors declare that they have no competing interests.

### Ethical Approval

For this type of study, formal consent is not required.

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