

LENGTH-WEIGHT AND LENGTH-LENGTH RELATIONSHIP OF HORSE MACKEREL, *TRACHURUS TRACHURUS* (LINNAEUS, 1758), IN THE SEA OF MARMARA*

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Abstract

In this study, 547 *Trachurus trachurus* specimens were examined. Of these 319 (58.31%) were female and 228 (41.68%) were male. The sex ratio (female/male) was calculated as 1:1.39 and was found to be significantly different between males and females ($P<0.05$). The minimum and maximum lengths of the sampled individuals were calculated as 8.5 cm and 16.0 cm, respectively. Furthermore, the length–weight relationship for all individuals was determined to be $W=0.01L^{2.9385}$, and the corresponding regression coefficient was found to be $R^2=0.8897$. Regression coefficient (R^2) value in the length–length relationship equation ranged from 0.88 to 0.93, with the highest ($R^2=0.93$ observed in females; TL/FL) and the lowest ($R^2=0.83$) recorded in males; TL/SL). These findings are expected to the conservation and sustainable management of fish stocks in the field of fisheries biology in the region.

Keywords: Length-weight relationship (LWRs), Length-length (LLRs) relationship, Horse mackerel, *Trachurus trachurus*, Sea of Marmara.

MARMARA DENİZİ'NDEKİ İSTAVRİTİN *Trachurus Trachurus* (LİNNAEUS, 1758) BOY-AĞIRLIK VE BOY-BOY İLİŞKİSİ

Özet

Bu çalışmada, 319 (58.31%) dişi ve 228 (41.68%) erkek olmak üzere toplam 547 *Trachurus trachurus* örneği incelenmiştir. Cinsiyet oranı (dişi/erkek) 1:1.39 olarak hesaplanmıştır. Dişiler ile erkekler arasında farkın anlamlı olduğu belirlenmiştir ($P<0.05$). Örneklenen bireylerin minimum ve maksimum boyları 8.5 ve 16.0 cm olarak belirlenmiştir. Ayrıca tüm bireylerin boy-ağırlık ilişkisi ve regresyon katsayısı $W=0.01L^{2.9385}$ $R^2=0.8897$ olarak hesaplanmıştır. Boy-boy

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ilişkisi denkleminde regresyon katsayısının (R^2) 0.88 ile 0.93 arasında değiştiği belirlenmiştir. En yüksek değer 0.93 (dişilerde; TL/FL), en düşük değer ise 0.83 (erkeklerde; TL/SL) olarak belirlenmiştir. Çalışma bulguları balıkçılık biyolojisi ve bölge için sürdürülebilir halde stokların korunması ve yönetimine katkı vereceği düşünülmektedir.

Anahtar Kelimeler: Boy-ağırlık ilişkisi (LWRs), boy-boy ilişkisi (LLRs), istavrit, *Trachurus trachurus*, Marmara Denizi.

Introduction

The significance of length–weight relationships (LWRs) and length–length (LLRs) in fishery assessments, management, and species conservation has been well established (Garcia et al., 1998; Haimovici and Velasco, 2000). Nevertheless comprehensive knowledge of the ichthyofauna of the Sea of Marmara. There is essential for marine ecology and fisheries management, given the limited available on continental little information on the continental ichthyofauna in this region (Bilecenoğlu et al., 2000; Tuncer et al., 2008).

This study investigated the length–weight and length–length relationship parameters of the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara and compared them with previously reported data. Horse mackerel, a species belonging to the Carangidae family, exhibits migratory, and semi-pelagic behavior and is commonly found in shallow coastal waters across several regions, including the northeast Atlantic, Mediterranean Sea, including the Sea of Marmara, and Black Sea (Polonsky, 1969; Nasri et al., 2021). Given its substantial economic values, there is an increasing demand for the conservation and sustainable management of horse mackerel stocks.

This study aimed to determine the length–weight and length–length relationship of *T. trachurus*, and with the expectation that its findings will substantially contribute to regional fisheries and promote sustainable management.

Material and Method

A total of 547 specimens of *T. trachurus* were collected from commercial fishing boats operating around the Kapıdağ Peninsula in the South Marmara Sea of Türkiye. These fish were measured in the field for total length (TL), fork length (FL), and standard length (SL) to the nearest mm, and weighed (W, wet weight) to the nearest g. The following relationships were established using linear regression analysis: $TL=a+bFL$; $FL=a+bSL$ and $TL=a+bSL$; $SL=a+bFL$.

The relationship between a fish length (TL; cm) and weight (W; g) is typically expressed by the simple power function $W=aL^b$ (Ricker, 1979). The exponent 'b' values offer insights into the type of fish growth. Additionally, length–weight relationships enable the estimation of fish condition and facilitate life-history comparisons between regions. These parameters (a, b) are important in fish biology and stock assessment studies. When $b=3$, indicates isometric growth (I). If $b>3$, it signifies positive allometric growth ($+A$). Conversely, if $b<3$, it represents negative allometric growth ($-A$)

(Froese, 1998; Moutopoulos and Stergiou, 2002). Statistical analysis was conducted using the Sigma Plot 14.5 program.

Results

Throughout the study period, 547 individuals were sampled, comprising 319 females (58.31%) and 228 males (41.68%). The calculated sex ratio (female/male) stood at 1:1.39, which was significantly different between the two genders ($P < 0.05$). Total lengths, standard lengths and fork lengths of all samples ranged from 8.5 to 16.0 cm, 7.0 to 14.0 cm, and 7.5 to 14.8 cm, respectively. The length frequency distribution of all samples is provided in Figure 1, while Figure 2 illustrates the length frequency distribution for males, females is given Figure 2.

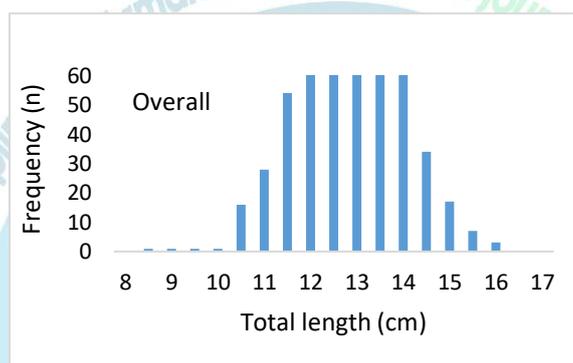


Figure 1. Length frequency distribution of overall samples of the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

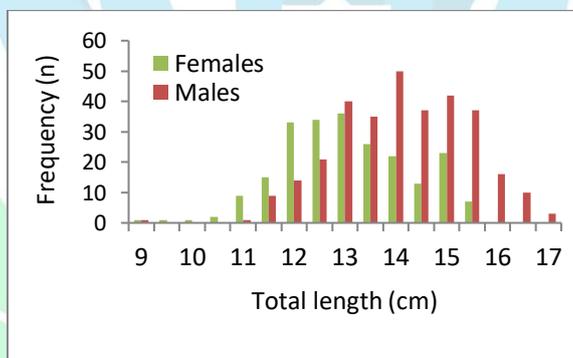


Figure 2. Length frequency distribution of males and female samples of the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

The length–weight relationships for males, females and overall samples were estimated. The Figure 3 and Figure 4 depict graphical representations of the length–weight relationships for females and males. The calculated 'b' value for female, male and all individuals was less than 3, indicating a negative allometric growth type ($b < 3$; $P < 0.001$). The data are given in Table 1.

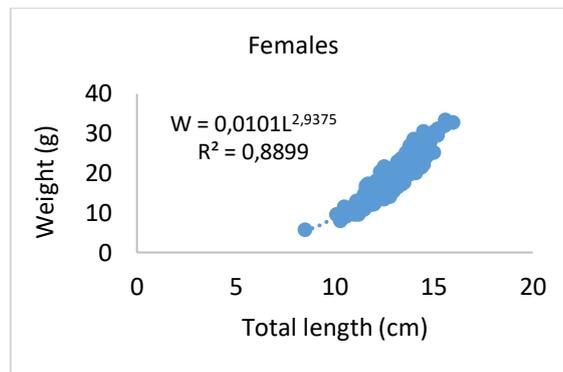


Figure 3. The length–weight relationships (LWRs) females of horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

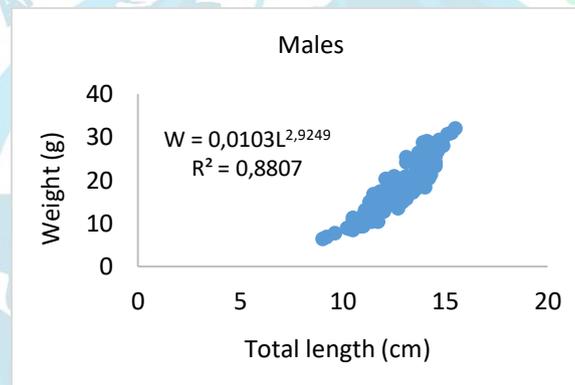


Figure 4. The length–weight relationships (LWRs) males of horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

Table 1. Summary statistics for parameter estimation of the simple power function $W = aT_L^b$ for the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

Sex	n	L _{min-max} (cm)	Length–Weight Relationship			Student's t-test for <i>b</i>		GT
			a	b (±SE)	R ²	t	p-value	
Overall	547	8.5-16	0.010±0.004	2.9385 ±0.044	0.8897	66.30	<0.001	A
Male	228	9-15.5	0.0103±0.003	2.9249±0.065	0.8807	48.07	<0.001	A
Female	319	8.5-16	0.0101±0.005	2.9375 ±0.041	0.8899	50.62	<0.001	A

* n is the sample size; a: intercept, b: slope; b(±SE) is the standard error of the slope b; R² is the coefficient of determination; A: negative allometric; GT: growth type.

Length–length relationships (LLRs) for female, male and all individuals of horse mackerel *T. trachurus* samples were calculated and all data are presented in Table 2.

Table 2. Length-length relationships (LLRs) of the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in the Sea of Marmara

Sex	n	a	b	Relations	Equations	R ²
Males	228	0.378	0.88	TL/FL	TL=0.378±0.88FL	0.91
		0.511	0.81	TL/SL	TL=0.511+0.81SL	0.88
		0.536	1.02	SL/FL	SL=0.536+1.02FL	0.91
		0.460	0.88	FL/SL	FL=0.460±0.88SL	0.91
Females	319	0.938	-0.22	TL/FL	TL=0.938-0.22FL	0.93
		0.010	0.85	TL/SL	TL=0.850+0.01SL	0.91
		0.368	1.04	SL/FL	SL=0.368+1.04TL	0.92
		0.526	0.88	FL/SL	FL=0.526±0.88SL	0.92
Overall	547	0.264	0.89	TL/FL	TL=0.264+0.89FL	0.92
		0.351	0.82	TL/SL	TL=0.351±0.82SL	0.90
		0.503	1.02	SL/FL	SL=0.503±1.02FL	0.91
		0.495	0.88	FL/SL	FL=0.495±0.88SL	0.91

*n is the sample size; a: intercept, b: slope; R² is the coefficient of determination; TL: total length (cm); SL: standard length (cm); FL: fork length (cm).

Discussions

The exponent 'b' of *T. trachurus* often falls within the range of 2 to 4, with a typical value close to has a value close to 3, (Tesch, 1971). In the Black Sea and Mediterranean regions, the lowest 'b' value recorded was 2.44 (Bayhan and Uncumusaoğlu, 2022), while the highest value recorded 3.51 (Samsun and Sağlam, 2021). However, the 'b' value 2.44 was excluded from the analysis because of its significant deviation in the Box-whiskers plot (Figure 5).

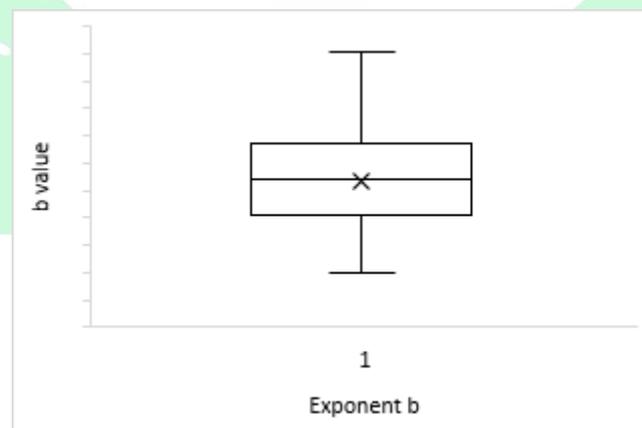


Figure 5. Box-whiskers plots of the exponent b of the length-weight relationships ($W=aL^b$) for the horse mackerel *Trachurus trachurus* in the Black Sea and Mediterranean (b values are taken from Table 3). The central box shows the median, and the vertical line represents the range of values.

In this study, negative allometric growth for *T. trachurus* was determined because the 'b' value, which can be used as an indicator in determining the growth type, is less than 3. However, when examining the previous study results given in Table 3, it is evident that different growth types have been documented. The main factors contributing to this variation include prey–predator relationships, nutrient availability, stage of maturity, morphology, physiological state, metabolic activities, temperature and size (Dulčić and Kraljević 1998; Bhatta et al., 2012; Durrani et al., 2023). The findings of this study regarding the 'b' value closely align with those of Erdoğan et al. (2006), and Karakulak et al. (2006). However, differences were observed when compared with the studies by Demirel and Dalkara (2018), Samsun and Erdoğan (2021), Aydın and Karadurmuş (2012), and Kara et al (2020). The data for comparison of the study results are provided in Table 3.

Table 3. Parameters of length–weight relationship and growth type of the horse mackerel *Trachurus trachurus* (Linnaeus, 1758) in this and previous studies

Researchers	Area	n	L _{min-max} (cm)	LWRs			GT
				a	b	R ²	
Bayhan and Uncumusaoğlu, (2022)	Aegean Sea	10	20.5-24.5	0.0486	2.44	0.81	-A
Karachle and Stergiou, (2008)	Aegean Sea	133	6.3-23.9	0.0062	3.14	1	
Moutopoulos and Stergiou, (2002)				0.039	3.27	0.96	+A
Samsun and Erdoğan, (2021)	Black Sea	479	7.8-18	0.0021	3.51	0.97	+A
Kalaycı et al., (2007)	Black Sea	747	7.3-18.3	0.0086	2.98	0.96	I
Gözler and Baytaşoğlu, (2022)	Black Sea	395	4.9-12.5	0.0143	2.70	0.79	-A
Ak et al., (2009)	Black Sea	267	6-15.7	0.004	3.24	0.94	I
Türker and Bal, (2018)	Black Sea	489	8.0-16.6	0.0056	3.12	0.98	I
Karakulak et al., (2006)	Aegean Sea	264	10.5-24.3	0.0113	2.89	0.91	-A
Demirel and Dalkara, (2018)	Marmara Sea	156	11.2-21.0	0.027	2.95	0.76	I
Erdoğan et al., (2016)	Black Sea			0.0016	2.88	0.98	-A
Erdoğan et al., (2016)	Marmara Sea (Bandırma)			0.012	2.97	0.96	-A
Erdoğan et al., (2016)	Marmara Sea (Şarköy)			0.012	3.00	0.89	I
Erdoğan et al., (2016)	Aegean Sea (Edremit)			0.00067	3.21	0.96	+A
Erdoğan et al., (2016)	Aegean Sea (İzmir)			0.009	3.12	0.93	
Erdoğan et al., (2016)				0.017	2.81	0.83	-A

Continuation of Table 3.

Researchers	Area	n	Lmin-max (cm)	LWRs		R ²	GT
				a	b		
Aydın and Karadurmuş (2012)	Black Sea	1307	6.9-19.02	0.0049	3.17	0.96	+A
Kara et al., (2020)	Aegean Sea	389		0.0047	3.03	0.99	+A
Yücel and Erkoyuncu, 2000	Black Sea		9.4-16.8	0.00759	3.05		
Present study	Marmara Sea	547	8.5-16	0.010	2.93	0.88	-A

In the results of the length–length relationship, it was observed that the relationship parameters (TL/FL) in the study conducted in the Aegean Sea were similar to the results of this study, with the 'b' value calculated as 0.87 and the regression coefficient as 0.99 (Kara et al., 2020). However, because of the lack of other study results of the species and length–length relationship within the research area sufficient discussion on this matter could not be provided.

Conclusions

Conservation and sustainable management of species within an ecosystem, particularly those of significant economic value, are of paramount importance. From this study establish a value database and contribute to ongoing research efforts. Furthermore, they play a pivotal role in the formulation of effective, policies for fishery management and the preservation of the horse mackerel populations within the research area.

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