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RESEARCH ARTICLE

Length-weight relationships for three elasmobranch species from the Sea of Marmara

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Abstract

Length-weight relationships were estimated for three elasmobranch species from the Sea of Marmara. Specimens were collected by beam trawl between September 2011 and July 2014. A total of 192 individuals (130 *Raja clavata*, 45 *Scyliorhinus canicula*, 17 *Torpedo marmorata*) were examined. Results indicated that *R. clavata* and *S. canicula* have positive allometric growth and *T. marmorata* has negative allometric growth. Due to the lack of data on length-weight relationships of elasmobranch species in the Sea of Marmara, these results contribute to our knowledge of this species.

Keywords: Marmara Sea, length-weight relationship, *Raja clavata, Scyliorhinus canicula, Torpedo marmorata*

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Introduction

The Sea of Marmara, which has the surface area of 11,500 km^2 and the volume of 3,378 km^3, is connected to the Black Sea in the north by the İstanbul Strait and to the Aegean Sea in the south by the Canakkale Strait. The fish fauna of the Sea of Marmara includes a total of 257 species (Bilecenoğlu *et al.* 2014). Of these, 35 are sharks and batoids, corresponding to 53% of total shark species in Turkey (Bilecenoğlu *et al.* 2014). In the Sea of Marmara, elasmobranches are not targeted by any specific fishing operation and catches of sharks and rays are considered as by-catch or incidental. Sharks and rays are incidentally captured by commercial fishing boats mainly by purseseiners, gill-netters and trammel-netters (Kabasakal 2009). Catch statistics on elasmobranch species are not enough and length and weight data which provide a very useful tool for estimating growth rates, length and age structures, and the improvement of the knowledge regarding fish population dynamics are still missing (Froese 2006). They asist in estimating weight from length as required in the assessment of yield and calculation of biomass (Garcia *et al.* 1998; Lteif *et al.* 2016). Due to the scarcity of data on length-weight relationships of elasmobranch fish in the Marmara Sea, the parameters for three elasmobranchs are reported in this study; *Raja clavata* Linnaeus, 1758, *Scyliorhinus canicula* (Linnaeus, 1758) and *Torpedo marmorata* Risso, 1810.

Materials and Methods

Samples were caught in the Sea of Marmara (Figure 1) using a beam trawl with a codend mesh size of 32 mm and tow duration restricted to 30 minutes between September 2011 and July 2014. A total of 229 hauls were analyzed at depths ranging from 50 to 150 m. All elasmobranch species were separated from each tow and identified using the identification guides of FAO species identification sheets (Serena 2005). After the catching, the specimens were initially preserved in a plastic box with ice, then transported to the laboratory. Total length (TL) and weight measurements were made in the laboratory to the nearest 0.1 cm and 0.01g, respectively.

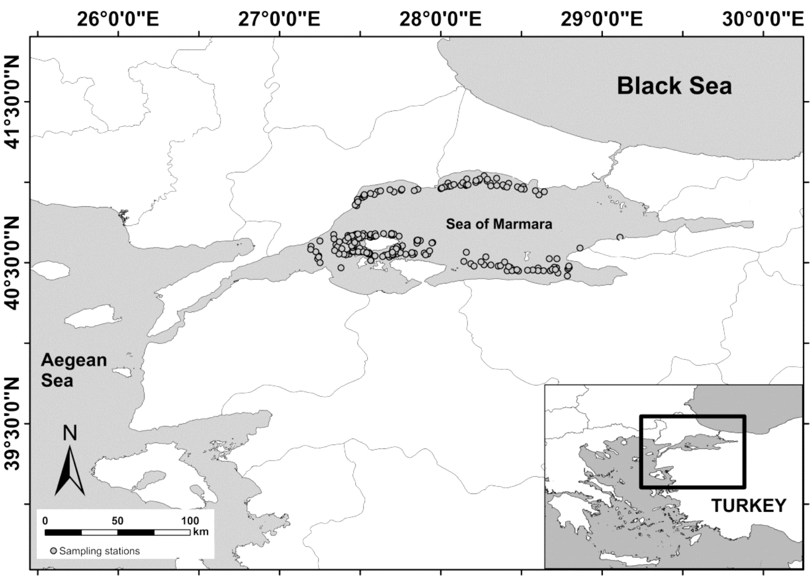

Figure 1. Sampling stations in the Sea of Marmara

The relation between the length and the weight is given by the equation $W=aL^b$, where W is the total weight (g), L the total length (cm), a the factor and b the exponent. The parameters of the length-weight relationships were estimated by linear regression analysis (least squares method) and the association degree between variables was calculated by the determination coefficient (r^2). Additionally, data were submitted to an analysis of variance (ANOVA) to estimate the 95% confidence limits of b (Gaspar *et al.* 2001; Vaslet *et al.* 2008).

Results and Discussion

For this study a total of 192 individuals were sampled, belonging to 3 elasmobranch species; *Raja clavata*, *Scyliorhinus canicula* and *Torpedo marmorata*. Sample sizes, minimum and maximum length and weight values, parameters of length-weight relationship (*a* and *b*), 95% confidence intervals of *b* and the coefficient of determination (r^2) are given in Table 1 for three species. These results provide new information of length and weight for these species in the Sea of Marmara. Only two studies had been done about length-weight relationships of the elasmobranch species in the Sea of Marmara (Bök *et al.* 2011; Demirel and Dalkara 2012). Previous studies providing length-weight relationships for elasmobranch species are given in Table 2.

The *b* coefficient of *R. clavata*, *S. canicula* and *T. marmorata* were 3.53, 3.39 and 2.98, respectively. According to Carlander (1969) the exponent *b* should normally fall between 2.5 and 3.5. Condition of specimens as well as the difference in the condition between small and large specimens vary between seasons, localities and years, resulting in different weight-length relationships (Froese 2006). The choice of sampling gear may affect the size range of the specimen captured, thus the size range of "*a*" and "*b*" for the estimation of the length-weight relationships (Rastgoo *et al.* 2016). Therefore the length-weight relationships presented in this study are only useful and efficient for the elasmobranch populations inhabiting in the Sea of Marmara.

Table 1. Length-weight relationships for elasmobranch species caught in the Sea of Marmara (M: Males; F: Females; Both: Combined sexes).

			Length(cm)		Weight (g)		Relationship parameters			
Species	**Sex**	**n**	**Min**	**Max**	**Min**	**Max**	**a**	**b**	**95% CI of b**	**r^2**
Raja clavata	M	66	12.8	69.5	6.18	1993.33	0.00053	3.60	3.48-3.72	0.98
	F	64	11.3	67.5	4.48	1702.58	0.00081	3.50	3.39-3.60	0.99
	Both	130	11.3	69.5	4.48	1993.33	0.00069	3.53	3.46-3.61	0.98
Scyliorhinus canicula	M	13	15.3	37.0	7.55	172.91	0.00048	3.53	3.12-3.94	0.97
	F	32	18.1	43.7	10.4	234.10	0.00087	3.35	3.12-3.57	0.97
	Both	45	15.3	43.7	7.55	234.10	0.00077	3.39	3.20-3.57	0.97
Torpedo marmorata	M	8	10.5	27.2	23.69	384.87	0.01903	2.97	2.43-3.53	0.97
	F	9	15.5	38.0	87.59	1018.08	0.02505	2.90	2.37-3.44	0.96
	Both	17	10.5	38.0	23.69	1018.08	0.01959	2.98	2.68-3.28	0.97

Moreover, our research provides the first reference on length-weight relationships for *T. marmorata* in this geographical area. Length-weight relationship can serve as a good tool to induce laws to limit the overexploitation of elasmobranch fishes through direct fishing and bycatch by establishing a minimum catch weight limit with the use of lengths measured at sea (Lteif *et al.* 2016). It is hoped that the data provided here will be helpful in future fisheries activities and conservation of these species of elasmobranchs.

Table 2. Length-weight relationships of elasmobranch species in the Turkish waters

Species	N	Length-weight relationship	Area	Source
Raja clavata	29	$W = 0.0016L^{3.29}$	North Aegean Sea	Filiz and Mater (2002)
	37	$W = 0.0016L^{3.30}$	North Aegean Sea	Filiz and Bilge (2004)
	27	$W = 0.0019L^{3.24}$	Black Sea	Demirhan and Can (2007)
	77	$W = 0.0037L^{3.08}$	NE Mediterranean	Yeldan and Avşar (2007)
	32	$W = 0.0322L^{2.60}$	North Aegean Sea	Yarmaz (2009)
	226	$W = 0.00163L^{3.32}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	24	$W = 0.00001L^{2.867}$	The Sea of Marmara	Bök *et al*. (2011)
	792	$W = 0.0018L^{3.26}$	Mediterranean	Saygu (2011)
	75	$W = 0.023L^{2.64}$	Mediterranean	Başusta *et al.* (2012)
	137	$W = 0.0006L^{3.52}$	Central Aegean Sea	Eronat and Özaydın (2014)
	170	$^{*}W = 0.113L^{2.420}$	The Sea of Marmara	Demirel and Dalkara (2012)
Raja miraletus	13	$W = 0.0001L^{4.15}$	North Aegean Sea	Filiz and Bilge (2004)
	52	$W= 0.00173L^{3.27}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
Raja radula	25	$W = 0.0030L^{3.22}$	North Aegean Sea	Karakulak *et al.* (2006)
	295	$W = 0.0012L^{3.36}$	NE Mediterranean	Yeldan and Avşar (2007)
	23	$W = 0.0029L^{3.21}$	North Aegean Sea	Yarmaz (2009)
	204	$W = 0.00205L^{3.32}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	62	$W = 0.0174L^{3.07}$	Mediterranean	Saygu (2011)
	16	$W = 0.0017L^{3.33}$	Central Aegean Sea	Eronat and Özaydın (2014)
Rostroraja alba	187	$W = 0.0006L^{3.44}$	Central Aegean Sea	Özaydın *et al*. (2007)
	126	$W = 0.00194L^{3.27}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	10	$W = 0.0016L^{3.32}$	Central Aegean Sea	Eronat and Özaydın (2014)
Dasyatis pastinaca	256	$W = 0.0014L^{3.31}$	Eastern Mediterranean	Ismen (2003)
	29	$W = 0.0149L^{2.81}$	North Aegean Sea	Filiz and Bilge (2004)
	12	$W = 0.1168L^{3.12}$	North Aegean Sea	Karakulak *et al.* (2006)
	334	$W = 0.0020L^{3.24}$	NE Mediterranean	Yeldan and Avşar(2007)
	71	$W = 0.00074L^{3.55}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	78	$W = 0.0011L^{3.46}$	Central Aegean Sea	Eronat and Özaydın (2014)
	385	$W = 0.023L^{2.76}$	Gulf of Antalya, Levantine Sea	Özbek *et al.* (2015)
Dasyatis marmorata	21	$W = 0.002L^{3.23}$	Gulf of Antalya, Levantine Sea	Özbek *et al.* (2015)
Dasyatis centroura	4	$W = 0.00001L^{4.04}$	Gulf of Antalya, Levantine Sea	Özbek *et al.* (2015)
Dipturus oxyrinchus	8	$W = 0.0007L^{3.40}$	North Aegean Sea	Filiz and Bilge (2004)
	179	$W = 0.00083L^{3.35}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	8	$W = 0.0309L^{3.13}$	Central Aegean Sea	Eronat and Özaydın (2014)
Myliobatis aquila	14	$W = 0.0008L^{3.34}$	North Aegean Sea	Filiz and Bilge (2004)
	66	$W = 0.00027L^{3.56}$	Saros Bay, North Aegean Sea	Yığın and Ismen (2009)
	54	$W = 0.0005L^{3.42}$	Central Aegean Sea	Eronat and Özaydın (2014)

Table 2. Continued.

Species	N	Length-weight relationship	Area	Source
Gymnura altavela	9	$W = 0.0268L^{2.96}$	North Aegean Sea	Filiz and Bilge (2004)
	107	$W = 0.0090L^{3.23}$	NE Mediterranean	Yeldan and Avşar(2007)
	7	$W = 0.0156L^{3.09}$	Çandarlı Bay, North Aegean Sea	Akalın *et al*. (2015)
Raja asterias	113	$W = 0.0020L^{3.27}$	NE Mediterranean	Yeldan and Avşar (2007)
	30	$W =0.000002L^{3.242}$	The Sea of Marmara	Bök *et al*. (2011)
	17	$W = 0.0007L^{3.47}$	Central Aegean Sea	Eronat and Özaydın (2014)
Squalus acanthias	32	$W = 0.0031L^{3.11}$	North Aegean Sea	Filiz and Mater (2002)
	565	$W = 0.0037L^{3.05}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	8	$W = 0.00003L^{2.619}$	The Sea of Marmara	Bök *et al*. (2011)
Squalus blainvillei	27	$W = 0.0030L^{3.07}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	18	$W = 0.00004L^{2.476}$	The Sea of Marmara	Bök *et al*. (2011)
	308	$W = 0.0048L^{2.96}$	Central Aegean Sea	Eronat and Özaydın (2014)
Scyliorhinus canicula	110	$W = 0.0016L^{3.18}$	North Aegean Sea	Filiz and Mater (2002)
	637	$W = 0.0012L^{3.26}$	North Aegean Sea	Filiz and Bilge (2004)
	187	$W = 0.0006L^{3.44}$	Central Aegean Sea	Özaydın *et al.* (2007)
	1888	$W = 0.0017L^{3.17}$	Saros Bay, the North Aegean Sea	Ismen *et al*. (2009)
	108	$W = 8E\text{-}06L^{2.88}$	Northern Aegean Sea	Yarmaz (2009)
	189	$W = 0.004L^{2.869}$	The Sea of Marmara	Demirel and Dalkara (2012)
	1210	$W = 0.0012L^{3.26}$	Central Aegean Sea	Eronat and Özaydın (2014)
Etmopterus spinax	11	$W = 0.0017L^{3.17}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	116	$W = 0.0031L^{3.12}$	Sığacık Bay, Aegean Sea	Bilge *et al.* (2010)
	150	$W = 0.0052L^{2.94}$	Antalya Bay	Güven *et al.* (2012)
	129	$W = 0.0035L^{3.08}$	Central Aegean Sea	Eronat and Özaydın (2014)
	12	$W = 0.3514L^{1.76}$	Northern Aegean Sea	Gönülal (2017)
Galeus melastomus	303	$W = 0.0016L^{3.18}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	544	$W = 0.0026L^{3.00}$	Antalya Bay	Güven *et al.* (2012)
	235	$W = 0.0019L^{3.14}$	Central Aegean Sea	Eronat and Özaydın (2014)
Scyliorhinus stellaris	11	$W = 0.02L^{3.23}$	Central Aegean Sea	Ilkyaz *et al*. (2008)
	12	$W = 0.0009L^{3.37}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	92	$W = 0.0039L^{2.98}$	Southern Aegean Sea	Bilge *et al.* (2014)
	19	$W = 0.0006L^{3.46}$	Central Aegean Sea	Eronat and Özaydın (2014)
	28	$W = 0.041L^{3.10}$	Northern Aegean Sea	Gönülal (2017)
Hexanchus griseus	7	$W = 0.0002L^{3.61}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
Heptranchias perlo	18	$W = 0.0047L^{2.90}$		
Mustelus asterias	7	$W = 0.0006L^{3.40}$		
Mustelus mustelus	24	$W = 0.0008L^{3.33}$	North Aegean Sea	Filiz and Mater (2002)
	35	$W = 0.0011L^{3.25}$	North Aegean Sea	Filiz and Bilge (2004)
	148	$W = 0.0027L^{3.05}$	Central Aegean Sea	Ilkyaz *et al*. (2008)
	70	$W = 0.0034L^{2.98}$	Saros Bay, North Aegean Sea	Ismen *et al*. (2009)
	4	$W = 0.0974L^{2.77}$	Antalya Bay	Güven *et al.* (2012)
	74	$W = 0.0053L^{2.84}$	Southern Aegean Sea	Bilge *et al.* (2014)
	41	$W = 0.001L^{3.27}$	Central Aegean Sea	Eronat and Özaydın (2014)
	11	$W = 0.0014L^{3.31}$	North Aegean Sea	Gönülal (2017)

Table 2. Continued.

Species	N	Length-weight relationship	Area	Source
Dalatias licha	3	$W = 0.0117L^{3.00}$	Antalya Bay	Güven *et al.* (2012)
	4	$W = 0.0184L^{3.20}$	Northern Aegean Sea	Gönülal (2017)
Mustelus punctulatus	6	$W = 0.0012L^{3.21}$	Central Aegean Sea	Eronat and Özaydın (2014)
Prionace glauca	6	$W = 0.105L^{3.85}$	Northern Aegean Sea	Gönülal (2017)
Torpedo marmorata	20	$W = 0.0488L^{2.69}$	North Aegean Sea	Filiz and Mater (2002)
	37	$W = 0.0273L^{2.91}$	North Aegean Sea	Filiz and Bilge (2004)
	22	$W = 0.0139L^{3.10}$	North Aegean Sea	Karakulak *et al.* (2006)
	12	$W = 0.0535L^{2.39}$	Central Aegean Sea	Özaydın *et al.* (2007)
	9	$W = 0.1297L^{2.47}$	Northern Aegean Sea	Yarmaz (2009)
	107	$W = 0.023L^{2.96}$	Central Aegean Sea	Eronat and Özaydın (2014)
	10	$W = 0.0208L^{3.09}$	Çandarlı Bay, North Aegean Sea	Akalın *et al.* (2015)
Torpedo nobiliana	92	$W = 0.015L^{3.06}$	Mediterranean	Başusta *et al.* (2012)
	10	$W = 0.0284L^{2.89}$	Central Aegean Sea	Eronat and Özaydın (2014)
Chimaera monstrosa	97	$W = 0.0076L^{3.03}$	Central Aegean Sea	Eronat and Özaydın (2014)

*For *R. clavata*, measurements of disc width were used.

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Marmara Denizi'ndeki üç kıkırdaklı türün boy-ağırlık ilişkileri

Öz

Marmara Denizi'ndeki üç kıkırdaklı türü için boy-ağırlık ilişkileri hesaplanmıştır. Türler orta su trolü ile Eylül 2011 ve Temmuz 2014 arasında toplanmıştır. Toplam 192 birey (130 *Raja clavata*, 45 *Scyliorhinus canicula*, 17 *Torpedo marmorata*) incelenmiştir. Sonuçlarda, *R. clavata* ve *S.canicula* pozitif allometrik büyüme ve *T. marmorata* negatif allometrik büyüme göstermiştir. Marmara Denizi'ndeki kıkırdaklı türlerin boy-ağırlık ilişkileri hakkındaki bilgi eksikliği nedeniyle, sonuçlar türler hakkındaki bilgilerimize katkıda bulunmaktadır.

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