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The Length-Weight Characteristics of Five Elasmobranch Species (Pisces: Chondrichthyes) from Izmir Bay (Aegean Sea Coast of Turkey): Spring 2018

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A R T I C L E   I N F O

A B S T R A C T

In this study, a total of 364 samples were collected and 349 of them belonged to, 349 specimens of *Dasyatis pastinaca*, 6 of *Gymnura altavela*, 5 of *Torpedo marmorato*, 2 of *Aetomylaeus bovinus* and *Mustelus mustelus*, were obtained by-catch in trammel nets off the Izmir Bay (Aegean sea coast of Turkey) during period of spring in 2018. Males of *D. pastinaca* ranged from 28–62 cm and females from 31.5-94 cm total length. The analysis of the angular coefficient (*b*) demonstrated that growth (in weight) in relation to length was isometric in males and females of *D. pastinaca*. Morphologic measurements of a total of 60 individuals to represent all individuals of the population, t test in independent groups to determine differences in males and females and all other morphometric measurements were statistically tested by multiple regression analysis (stepwise method). Therefore, difference between mean values obtained according to sexes was not found different. However, A linear correlation between weight- pelvic length for females and weight-preanal length for males according to multiple regression analysis in male and female individuals. Isometric and positive allometric growths were calculated for species of *Torpedo marmorata* and *Gymnura altavela*, respectively.

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Introduction

Length weight relationship is a very important data for calculation of growth rates, length and age structures and other constituents of fish population dynamics in fisheries management. Although chondrichthyes species are quite large and the largest predators, they are involved in off-target fishing (Eronat and Başusta, 2018).

An analysis of threat levels across all sharks, rays and chimaeras has revealed the Mediterranean Sea as a key hotspot of extinction risk (IUCN, 2021). The level of threat may be worse because uncertainty in species status remains moderately high in the Mediterranean Sea; of the 73 assessed species 13 remain Data Deficient. (Dulvy et al., 2016). cartilaginous fish species distributions in Turkey showing 75% of cartilaginous fish fauna in the Mediterranean sea (Bradaun et al., 2012) are created.

Although their distribution in the Mediterranean is not homogeneous; When the distribution of cartilaginous fish species according to our seas is examined; It is known that there are 64 species in the Levantine Sea and ranks first (Eronat and Bizsel, 2015; Sakalli et al., 2016; Yücel et al., 2017). Number of known species in Levantine Sea is followed by Aegean with 61 species, Marmara Sea with 36 species and Blacksea with 9 species respectively (Bilecenoglu et al., 2014).

The number of species distributed in Turkish and World seas observed during the research, which are members of Dasyatidae (*Dasyatis pastinaca*), Torpedinidae, (*Torpedo marmorata*), Gymnuridae (*Gymnura altavela*), Myliobatidae (*Aetomylaeus bovinus*), Triakidae (*Mustelus mustelus*) families, are 7-99; 1-24; 3-16; 4-19; 4-46 respectively (Froese and Pauly, 2020; Bilecenoğlu et al., 2014). 3 of the 5 species (*Dasyatis pastinaca, Gymnura altavela* and *Mustelus mustelus*) observed during research are vulnerable (VU), the other 2 species (*Torpedo marmorata* and *Aetomylaeus bovinus*) are data deficient (DD) in red list category (IUCN, 2020).

Since Elasmobranchii species have a K-selected (long life) life cycle, they show low growth rate and low resistance to fishery operation death (Hoenig and Gruber, 1990; Frisk et al., 2001). In commercial fisheries, liabilities, restrictions and prohibitions related to fish capture have been regulated to protect current fisheries sources and provide their sustainable management. For the purpose involved, Regulation of Commercial Fisheries on the notification amendment (2016/35) for the amendment of the notification no 4/1 by Ministry of Agriculture and Forestry Republic of Turkey was published in the Official Gazette and validated in 2018. Sharks and Manta rays are included in the group of fisheries' species which are commercially forbidden to catch.

Studies on Cartilaginous species across Turkish seas belong to Demirhan et al. (2005) and Demirhan and Seyhan (2007) in Black Sea, Bök et al., 2011) in Marmara Sea, Işmen (2003), Yeldan and Avşar (2007), Yeldan et al. (2008), Yeldan et al. (2009), Duman and Başusta (2013), Girgin and Başusta (2016), Guven et al. (2011) in the Mediterranean sea, Filiz and Mater (2002) and Eronat and Özaydın (2014) in Aegean sea.

The length-weight parameters of the same species may be different in the population because of feeding, reproduction activities and fishing etc. Therefore, we need to know length-weight relationships of fish species which are captured in a given place in a certain period of time (Bayhan et al., 2008, Gurkan et al., 2010). The study conducted for this purpose established length-weight relationships of three elasmobranch species inhabiting Izmir Bay in Aegean Sea of Turkey in 2018.

Material and Methods

The present study examined 364 individuals of 5 cartilaginous species (*Dayatis pastinaca*, *Torpedo marmorata*, *Gymnura altavela*, *Aetomylaeus bovinus* and *Mustelus mustelus*) captured as discards using trammel nets on the boats in İzmir Bay, Aegean sea during period of Spring in 2018. Total length (TL, cm) and weight (W; 0.01g) of the fishes brought to the laboratory were measured, respectively. In order to determine relationship between length and weight, $W = a \times L^b$ was used, where W is total fish weight, L total length, *a* its condition factor coefficient and *b* its width (Ricker, 1975). b=3 means that

growth is isometric, $b<3$ that growth is of negative allometry and $b>3$ that growth has positive allometry (Karachle and Stergiou, 2012). 8 morphometric characters were measured in a total of 60 samples to represent all individuals of *D. pastinica* population and obtained mean values were statistically tested by t-test and morphometric characters by stepwise method in multiple regression analysis with weight being dependent variable. Statistical calculations were tested with an meaning level of $P<0.05$ using IBM SPSS 25.0.

Results

The study examined a total of 365 cartilaginous species of fish with 349 *Dayatis pastinaca*, 7 *Gymnura altavela*, 2 *Aetomylaeus bovinus*, 2 *Mustelus mustelus* and 5 *Torpedo marmorata*.

All examined individuals of *Dasyatis pastinaca* showed length group values of 28- 94 cm with 35- 44.5 cm length range by 68.5 % ranking as the first, followed by 45-54.9 cm by 17.8 %. Mean total length and weight values of the species were 42.5±0.44 cm and 385.26± 20.79 g, respectively. Total length- weight relationship was found $W= 0.0022L^{3.18}$ ($r^2 = 0.995$) with a positive allometric growth (Table 1).

5 individuals of *Torpedo marmorata* species exhibited minimum maximum length range of 20.5- 29.5 cm Its mean total length and weight values were 23.9±1.53 cm and 293± 68.81g, respectively. Total length and weight relationship was $W= 0.0108^{3.20}$ ($r^2= 0.969$) with an isometric growth (Table 1).

7 individuals of *Gymnura altavela* had a minimum maximum length range of 31.5- 68 cm. Its mean total length and weight values were 43.73±5.36 cm and 2699.83± 1035.29 g, respectively. Total length weight relationship was $W = 0.9109L^{3.22}$ (r^2 0.861) with a positive allometric growth (Table 1).

However, with less than 5 individuals *Aetomylaeus bovinus* and *Mustelus mustelus* showed minimum, maximum and mean total length and weight values. As a result, *Aetomylaeus bovinus* (2 individuals) had mean total length and weight of 128±52.16 cm and 6960±6058.05 g, respectively. 2 individuals of *Mustelus mustelus* showed mean total length and weight of 87.9±3.11 cm and 2201.8 ±173.79 g (Table 2), respectively.

Table 1. Length-weight relationships of 3 elasmobranch species by-catch in trammel nets off the Izmir Bay

N	LC		WC		Relationship Parameters					
	TL Range (cm)	Mean TL (±SE)	W Range (g)	Mean W (±SE)	*a*	*b*	SE of *b*	95% Cl of *b*	r^2	R
				Torpenidae[1] (3♀+2♂)							
5	20.5-29.5	23.9±1.53	185-560	293±68.81	0.0108	3.195	0.330	2.535-3.855	0.969	IS
				Dasyatidae[2] (∑)							
349	28-94	42.5±0.44	85-4985	385.2±20.79	0.0022	3.179	0.015	3.149-3.205	0.995	AL
				Dasyatidae[3] (♀)							
172	31.5-94	42.62±0.66	153.4-4985	404.59±35.56	0.0017	3.245	0.167	2.911-3.579	0.688	IS
				Dasyatidae[4] (♂)							
152	28-62	41.2±0.09	85-1095	314.9±14.78	0.0040	3.009	0.100	2.809-3.209	0.865	IS
				Gymnuridae[5] (3♀+3♂)							
6	31.5-68	43.73±5.36	670-6920	2699.83±1035.29	0.0109	3.215	0.053	3.109-3.321	0.861	AL

LC: Length Characteristics, WC: Weight Characteristics, [1]*Torpedo marmorata* Risso, 1810, [2]*Dasyatis pastinaca* (Linnaeus, 1758), [3]*Dasyatis pastinaca*, [4]*Dasyatis pastinaca*, [5]*Gymnura altavela* (Linnaeus, 1758), R: Relationship (*t* - test), IS: isometric, AL: + allometry, Aegean Sea Coast of Turkey) (N: number of individuals, a: intercept, b: slope, SE: standart error, CI: confidence limits, r^2: coefficient of determination

Table 2. Descriptive statistics for *Mustelus mustelus* and *Aetomylaeus bovinus* caught in in trammel nets off the Izmir Bay (Aegean Sea Coast of Turkey)

Familia/Species	Sex	N	TL(cm) Min.-Max.	TL(cm) Mean±SE	TW(g) Min.-Max.	TW (g) Mean±SE
Triakidae[1]	♂	2	84.8-91	87.9±3.11	2025.5-2378.1	2201.8±173.79
Myliobatidae[2]	♀	2	76-180	128±52.16	920-13000	6960±6058.05

[1]*Mustelus mustelus* (Linnaeus, 1758), [2]*Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817)

Table 3 Morphometric measurement values of *Dasyatis pastinaca* caught in in trammel nets off the Izmir Bay (Aegean Sea Coast of Turkey)

Measurements	♂ (29)		♀ (31)	
	Min.-Max.	Mean±SE	Min.-Max.	Mean±SE
TL (cm)	29.5-76	42.11±1.71	34.5-94	45.42±2.35
Width of Disc (cm)	17.4-38.45	21.89±0.88	18-47.6	23.66±1.14
TW (g)	110-2075	388.45±75.68	200-4985	599.03±163.12
Preanal Length (cm)	13-32	17.14±0.78	14.1-41	18.95±1.04
Prepelvic Length (cm)	12.5-30.5	16.18±0.811	13.3-40	18.29±1.00
Prepectoral Length (cm)	10.5-23.5	13.76±0.58	11.6-30	14.63±0.76
Body Height (cm)	2.1-7	3.25±0.18	2-10	3.54±0.31
Head Length (cm)	7.3-17	9.61±0.41	8-21	10.35±0.51
Eye Diameter (cm)	1.2-1.8	1.43±0.03	1.2-2.1	1.53±0.04
Preorbital Length (cm)	3.2-6.5	3.91±0.17	3.7-8.5	4.20±0.23

8 characters of 60 samples of *D.pastinaca* to represent all its individuals were measured (Table 3). All the mean values were statistically tested.

In conclusion, significance test between two mean values from morphometric measurements of sexes did not show any differences. On the other hand, for females by multiple regression analysis, W =-2195.7±152.825 prepelvic length in males, a linear relationship was obtained between weight and preanal length as W =-1244.04±94.511 preanal length.

Discussion

The species examined in the study were those captured by trammel nets of the boats in İzmir Bay. Therefore, numbers of individuals of some species are quite low.

Studies previously made on length- weight relationship for 5 species examined in the present study are shown in Table 4. Considering those perfomed on the species *Dasyatis pastinaca* in previous years, value *b* are usually greater than 3 implying that it is positive allometric which is similar to the present study (Table 2) whereas value *b* is generally of negative allometry in the species *Torpedo marmorata*, which is different from our study (Table 2). As for the studies on *Gymnura altavela*, Filiz and Bilge (2004) and Ozaydın et al. (2007) found b<3 to show that the species is of negative allometry while Yeldan and Avşar (2007), Ilkyaz et al. (2008) and the present study found that b >3 to show a positive allometric value (Table 2).

Regarding *Mustelus mustelus*, studies in North Aegean sea (Filiz and Bilge, 2004), Saros Bay (Ismen et al., 2007), Central Aegean sea (Ilkyaz et al., 2008) showed b with positive allometry whereas those in İzmir Bay (Ozaydın et al., 2007) and in Saroz Bay (Ismen et al., 2009) found *b* with negative allometry.

A study on *Aetomylaeus bovinus* by Başusta and Aslan (2018) in Norheast Mediterranean sea presented a length-weight relationship as W = 0.05815×DW$^{2.94}$. However, our study failed to calculate length-weight relationship just because the species was represented with 2 individuals.

The LWR parameters (*a, b*) of the fish are affected by a series of factors such as season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and annual differences in environmental conditions (Bagenal and Tesch, 1978). Such differences in values *b* can be ascribed to one or a combination of most of the factors including differences in the number of specimens examined, area/season effects and distinctions in the observed length ranges of the specimens caught, to which duration of sample collection can be added as well (Moutopoulos and Stergiou, 2002).

According to Dulvy et al. (2016), despite our rapidly improved understanding of Chondrichthyans widespread overexploitation in the Mediterranean basin, no effective chondrichthyan-focused management measures have been successfully implemented, nor enforced. Stock assessments are underway, however assessments are not management measures, but essential precursors to set catch limits for those more productive species that could be brought into sustainability.

The present study in which data of length and weight frequence distribution were assesssed for 5 cartilaginous species across bay of İzmir in Spring 2018 3 of which are included in vulnerable category by IUCN is expected to be of great contribution to fisheries management studies in future.

Table 4. Length–weight relationship parameters of Chondrichthyes fish species obtained by other authors from coasts of Turkey

Sex	LT	SR (cm)	WR (g)	N	a	b	r²	Area	A
*Dasyatis pastinaca*									
∑	TL	40.0-74.20	387.83-2955.00	14	0.0085	2.938	0.969		
♂	TL	40.0-74.20	387.83-2955.00	8	0.0092	2.933	0.978	AR1	1
♀	TL	40.30-68.0	392.42-1750.00	6	0.0108	2.857	0.980		
∑	TL	20.0-88.0	-	256	0.0014	3.310	0.940		
♂	TL	20.0-73.0	-	146	0.00237	3.17	0.95	AR2	2
♀	TL	20.5-88.0	-	110	0.00091	3.44	0.94		
∑	TL	23.5-40.61	128.0-401.8.0	10	0.1306	2.170	0.865	AR3	3
∑	TL	37.3-74.2	333.23-2955.0	29	0.0149	2.810	0.850	AR1	4
*	TL	29.2-37.8	*	12	0.1168	2.122	0.642	AR1	5
∑	DW	20.5-66.0	282.0-14602.0	48	0.0126	3.302	0.990	AR4	6
*	TL	44.2-138.0	*	16	0.0023	3.248	0.986	AR5	7
∑	TL	23.4-109.9	22.5-6800.1	334	0.0020	3.242	0.970		
♂	TL	23.4-69.5	22.5-2950.2	145	0.0014	3.338	0.95	AR1	8
♀	TL	29.0-100.9	45.3-6800.1	189	0.0025	3.186	0.97		
∑	DW	19.0-43.2	*	31	0.0102	3.370	0.984	AR6	9
∑	TL	37.5-114.0	282.40-16560	71	0.0007	3.550	0.957		
♂	TL	40.0-110.0	440.0-16560.0	26	0.0005	3.64	0.951	AR4	10
♀	TL	37.5-114.0	282.4-14750.0	45	0.0008	3.54	0.956		
∑	TL	14.60-100.9	22.5-6800.0	346	0.0033	3.1429	*	AR1	11
∑	TL	33.4-138.0	191.38-21100	78	0.0011	3.460	0.968		
♂	TL	36.5-80.0	295.14-4000	36	0.0021	3.29	0.954	AR6	12
♀	TL	33.4-138.0	191.38-21100	42	0.9713	3.51	0.971		
∑	DW	16.60-69.30	94.0-10564.0	384	0.0252	3.080	0.972	AR7	13
♀♂	TL	31.5-94.0	153.4-4985.0	172	0.0017	3.245	0.688	AR5	14
♂	TL	28.0-62.0	85.0-1095.0	152	0.0040	3.009	0.865	AR5	15
∑	TL	28.0-94.0	85.0-4985.0	349	0.0022	3.179	0.995	AR5	16
*Torpedo marmorata*									
∑	TL	9.6-25.0	23.51-340.0	20	0.0488	2.6935	0.9584		
♂	TL	9.6-20.5	23.51-156.94	9	0.1191	2.3461	0.9295	AR1	17
♀	TL	11.0-25.0	27.15-340.0	11	0.0274	2.9227	0.9933		
∑	TL	21.0-38.0	225.0-1275.1	9	0.1297	2.467	0.802	AR3	18
∑	TL	9.2-34	14.88-862.11	37	0.0273	2.910	0.980	AR1	19
∑	TL	16.4-38.9	*	22	0.0139	3.103	0.952	AR1	20
∑	TL	13.2-28.6	52.0-450.0	20	0.0592	2.643	0.987	AR4	21
∑	TL	10.3-37	*	12	0.0535	2.639	0.981	AR5	22
∑	TL	9.9-42	*	35	0.0232	2.980	0.990	AR6	23
∑	TL	9.3-40	16.0-1308.0	117	0.0195	2.986	0.926		
♂	TL	9.3-30.3	16.0-474.0	56	0.0315	2.817	0.921	AR7	24
♀	TL	15.2-40	56.0-1308.0	61	0.017	3.039	0.922		
∑	TL	9.6-39.3	7.98-1310.42	107	0.0230	2.960	0.939		
♂	TL	10.0-27.9	24.57-413.29	48	0.0365	2.79	0.985	AR6	26
♀	TL	9.6-39.3	7.98-1310.42	59	0.0188	3.02	0.985		
3♀+2♂	TL	20.5-29.5	185.0-560.0	5	0.0108	3.195	0.969	AR5	26
*Gymnura altavela*									
∑	TL	37.5-72	1188.0-9000	9	0.0268	2.960	0.980	AR1	27
∑	TL	37.6-95	*	17	0.0449	2.840	0.986	AR5	28
∑	TL	30.2-83.5	360.5-2400.1	107	0.0090	3.234	0.980		
♂	TL	30.7-83.5	360.5-2400.1	38	0.0057	3.358	0.970	AR8	29
♀	TL	30.2-79.8	450.1-1500.0	69	0.0011	3.208	0970		
∑	DW	47.1-88.3	*	9	0.0025	3.270	0.970	AR6	30
3♀+3♂	TL	31.5-68	670.0-6920		0.0053	3.215	0.861	AR5	31

LT: Length type, SR: Size range, WR: Weight range,

A: Author(1: Filiz and Mater, 2002, 2: Ismen, 2003, 3: Turker et al., 2019, 4: Filiz and Bilge, 2004, 5: Karakulak et al., 2006, 6: Ismen et al., 2007, 7. Ozaydin et al., 2007, 8: Yeldan and Avsar, 2007, 9: Ilkyaz et al., 2008,), 10: Yiğin and Ismen, 2009, 11: Yeldan et al., 2009, 12: Eronat and Özaydın, 2014, 13: Girgin and Başusta, 2016, 14: Present study, 15: Present study, 16: Present study, 17: Filiz and Mater, 2002, 18: Turker at al., 2019, 19: Filiz and Bilge, 2004, 20: Karakulak et al., 2006, 21: Ismen et al., 2007, 22: Ozaydin et al., 2007, 23: Ilkyaz et al., 2008, 24: Duman and Başusta, 2013, 25: Eronat and Özaydin, 2014, 26: This study, 27: Filiz and Bilge, 2004, 28: Ozaydin et al., 2007, 29: Yeldan and Avsar, 2007, 30: Ilkyaz et al., 2008, 31: This study

Area (AR1: North Aegean Sea, AR2: North east Mediterranean, AR3: Edremit Bay, AR4: Saros Bay, AR5: Izmir Bay, AR6: Central Aegean Sea, AR7: Iskenderun Bay, AR8: Northeastern Mediterranean),

*: unidentified sex; TL: Total Length; DW: Disc Width; N: Sample size; a and b: Intercept and Slope of Length–Weight Relationships; r², Coefficient of Determination

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