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Length-weight relationships of marine species caught by five gears from the Black Sea

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Abstract

The length-weight (L-W) relationships of 19 fish species, 4 molluscs and 2 crustacean species, caught during January 2009 and November 2011, are presented. The mean value of 'parameter b' was 2.881±0.399, ranging from 1.758 to 3.616. The L-W relationships for all studied species were significant (P<0.01), whereas they were isometric only for three species (i.e. *Scorpaena porcus, Pomatomus saltatrix* and *Neogobius melanostomus*).

Keywords: Length-weight relationship, Black Sea.

Introduction

Variability in size has important implications for diverse aspects of fisheries science and population dynamics (Erzini, 1994). To estimate the weight of fish from length, the length-weight relationship (LWR) ($W=aL^b$) is used (Beyer, 1991; Pauly, 1993; Petrakis & Stergiou, 1995; Froese, 1998; Frota *et al*., 2004), which is also a useful tool for evaluating the life history of fish and morphological comparisons between different fish species and/or habitats, time periods and/or regions (Gonçalves *et al*., 1997).

Several studies have been carried out on LWR for fish species in the Black Sea, the Sea of Marmara, the Aegean Sea and the Mediterranean Sea (Taskavak & Bilecenoglu, 2001; Filiz & Bilge, 2004; Karakulak *et al*., 2006; Ozaydin &Taskavak, 2006; Akyol *et al*., 2007; Demirhan & Can, 2007; Ismen *et al*., 2007; Ozaydin *et al*., 2007; Ilkyaz *et al*., 2008; Ceyhan *et al*., 2009; Erguden *et al*., 2009; Keskin & Gaygusuz, 2010). The aim of this study was to provide data on the relationship between the length and weight of species caught during a 3-year sampling period. Therefore, in this work, the LWR equation of 25 species along the Black Sea coasts of Turkey was evaluated based on the first comprehensive survey.

Material and Methods

Surveys were conducted mainly along the Eastern and Central Black Sea coast of Turkey. Sampling coordinates were between 41°23'15'' K – 41°29'32'' D and 41°10'39'' K – 29°34'41'' D. The area between Bosphorus (Sile) and Sakarya River (Sakarya) were also included into the sampling locations for baby clam as shown in Figure 1. The samples were caught using bottom trawl (18 and 22 mm mesh sizes in cod-end), purse seine (mesh size 12 and 13 mm), gillnet nets (stretched mesh size 16, 17 and 18 mm) and hydraulic dredges (350 mm mouth opening, 300 mm long, 8.5 mm bar range). The samplings were carried along the Black Sea coast of Turkey from January 2009 to November 2011. The majority of the measurements were performed on fresh samples but some of them were carried to the laboratory frozen (-18ºC) or on ice, in Styrofoam boxes when necessary.

All species were identified according to the FishBase®, measured (total length, TL) and weighed (total weight, W) to the nearest 0.1 cm and 0.01 g, respectively. The relationship between length and weight was calculated using the $W=aL^b$ equation, in which W is total weight (g), L is TL (cm) and a and b are the equation parameters calculated by the least squares method using the logarithmic form of the equation. Descriptive statistics were derived using Excel (Microsoft Excel® 2007) statistical functions. Student *t* tests and ANCOVA were performed using the Statistica® 8.0 software package.

Results

L-W relationships were estimated for 19 fish, 2 Gastropoda, 2 Bivalvia and 2 Crustacea species. The majority of the samples were represented by Mullidae (26%) and Gadidae (22%). Minimum and maximum lengths, weights, LWR parameters and standard errors of 'b' values were given in Table 1.

Table 1. The results of length-weight relationships of fish species caught from Black Sea, Turkey.

Family	Species	n	Length		Weight		Relationship parameters				Range of b
			Mean(±SD)	Range(cm)	Mean(±SD)	Range (g)	a	b	SE(b)	R^2	Fishbase
Carangidae	*Trachurus mediterraneus*	624	12.30±2.889	6.2-19.5	17.43±11.997	1.71-64.30	0.0050	3.138	0.083	0.972	2.760-3.374
Clupeidae	*Alosa fallax*	68	18.23±3.719	12.4-29.5	54.82±16.123	12.10-232.07	0.0110	2.875	0.501	0.913	2.517-3.680
	Sprattus sprattus	423	7.85±1.044	5.6-10.7	2.82±1.262	1.08-8.14	0.0064	2.921	0.027	0.916	2.510-3.528
Engraulidae	*Engraulis encrasicolus*	1588	10.58±1.751	5.9-14.6	8.15±3.099	1.06-18.10	0.0124	2.711	0.014	0.944	2.300-3.822
Gadidae	*Merlangius merlangus*	2292	12.66 ±2.236	5.9-22.2	17.52± 9.501	1.44-73.68	0.0054	3.146	0.037	0.919	2.926-3.258
Gobiidae	*Gobius niger*	112	10.11±1.338	6.8-15.8	15.26±5.596	4.09-48.85	0.0180	2.856	0.171	0.953	2.841-3.394
	Neogobius melanostomus	172	11.52±3.11	6.5-32.0	27.78±35.953	2.24-313.52	0.0114	3.088	0.327	0.966	2.431-3.280
Lotidae	*Gaidropsarus mediterraneus*	21	18.04±3.269	10.8-27.1	42.54±37.890	5.62-181.19	0.0012	3.616	1.345	0.963	3.010-3.179
Centracanthidae	*Spicara smaris*	103	12.86±2.603	8.0-20.4	26.70±15.311	8.11-92.23	0.0223	2.722	0.183	0.938	2.594-3.572
Mullidae	*Mullus barbatus*	2693	10.50± 2.181	5.3-19.0	13.08±7.666	1.20-73.40	0.0074	3.123	0.026	0.962	2.508-3.380
	Mullus surmuletus	80	10.95±2.018	7.1-14.0	16.69±4.896	3.21-33.83	0.0042	3.400	0.260	0.957	2.669-3.512
Pleuronectidae	*Platichthys flesus*	16	16.69±5.329	15.7-32.7	127.00±56.362	35.59-390.02	0.0052	3.175	1.278	0.975	2.778-3.678
Pomatomidae	*Pomatomus saltatrix*	25	14.44±2.321	12.5-20.2	29.79±14.929	16.00-75.19	0.0092	3.005	0.415	0.865	2.509-3.336
Rajidae	*Raja clavata*	63	26.43±19.25	13.2-90.0	472.22±993.231	6.42-4364.00	0.0010	3.288	1.733	0.971	2.867-3.700
Scombridae	*Sarda sarda*	36	33.78±2.781	28.1-37.5	420.07±33.509	233.72-517.82	0.0502	2.562	0.762	0.891	3.100-3.180
Scorpaenidae	*Scorpaena porcus*	42	13.02±4.377	5.4-26.0	59.90±4.977	3.70-403.71	0.0210	2.982	1.351	0.973	2.590-3.343
Soleidae	*Solea nasuta*	91	9.559±5.249	3.4-22.6	14.05±5.679	0.25-55.86	0.0042	3.265	0.274	0.987	2.755-3.225
Syngnathidae	*Hippocampus guttulatus*	291	8.322±0.686	6.5-10.3	2.16±0.539	1.01-4.61	0.0044	2.898	0.027	0.819	2.470-3.276
Uranoscopidae	*Uranoscopus scaber*	155	12.41±4.694	5.2-23.4	47.61±51.595	2.79-243.40	0.0252	2.854	0.371	0.979	2.829-3.228
					Rare Species						
Atherinidae	*Atherina boyeri*	1	9.1		5.15						
Blennidae	*Parablennius tentacularis*	2	12.95±2.192	11.40-14.50	28.65±18.12	15.84-41.46					
Callionymidae	*Callionymus lyra*	1	12.3		13.03						
Clupeidae	*Sardina pilchardus*	1	16.2		33.93						
Labridae	*Symphodus ocellatus*	2	9.70±0.989	9.00-10.40	15.91±9.447	9.23-22.59					
Triglidae	*Trigla lyra*	1	13.4		24.48						
Acipenceridae	*Acipencer stellatus*	3	28.53±1.419	27.0-29.8	43.15±2.193	41.25-45.55					
Belonidae	*Belone belone*	4	24.23±5.962	15.5-28.8	14.66±7.879	4.09-23.12					
Gobiidae	*Mesogobius batrachocephalus*	3	25.37±6.600	18.8-32.0	189.12±113.302	91.84-161.99					
Ophidiidae	*Ophidion barbatum*	7	19.14±1.416	16.8-20.6	49.68±14.239	27.39-60.46					
Scophthalmidae	*Scophthalmus maeticus*	3	15.90±9.412	8.9-26.6	105.13±49.683	9.00-277.59					
Sparidae	*Diplodus annularis*	6	6.97±0.653	6.4-7.8	5.22±2.063	2.79-8.21					
Syngnathidae	*Syngnathus acus*	4	28.4±3.747	25.7-33.9	6.99±5.175	2.19-13.97					
Trachinidae	*Trachinusdraco*	6	18.85±2.758	16.0-23.5	46.57±25.522	25.65-95.28					
					Mollusks and Crustacean Species						
Cardiidae	*Cardium edule*	313	3.28±0.905	1.1-5.4	18.87±11.504	0.52-54.87	1.1570	2.260	0.101	0.885	
Cerithiidae	*Gourmya vulgata*	11	2.41±0.321	1.8-2.8	1.73±0.484	0.80-2.40	0.2130	2.349	0.207	0.922	
Crangonidae	*Crangon crangon*	21	7.22±0.734	5.4-8.3	2.88±0.769	1.45-4.59	0.0102	2.806	0.941	0.919	
Muricidae	*Rapana venosa*	506	3.73±1.028	2.0-9.8	11.59±11.207	1.68-111.33	0.2170	2.864	0.174	0.931	
Portunidae	*Liocarcinus vernalis*	56	3.61±2.763	1.4-12.9	16.90±6.441	1.89-117.70	1.2090	1.758	0.044	0.942	
Veneridae	*Chamelea gallina*	628	1.76±0.522	0.7-3.0	1.95±1.415	0.2-4.82	0.4520	2.365	0.173	0.954	
Ostreidae	*Ostrea edulis*	1	1.50		2.07						

Fig. 1: Sampling locations in the Black Sea (HYD: hydraulic dredge, TRWL: trawl net, PS: Purse seine net, GN: gillnet).

Values of 'b' ranged between 1.758±0.044 (*Liocarcinus vernalis*) and 3.616+1.345 (*Gaidropsarus mediterranues*). Most of the R^2 values were greater than 0.81 (Table 1). L-W relations per fishing gear were estimated for the most abundant fish species (Table 2). Comparison of the fishing gear estimates of the b values for the most abundant fish captures showed significant differences (ANCOVA: $p<0.05$) (Table 2). According to table 2, the *b* values, with the exception of *Engraulis encrasicolus* in the bottom trawl, ranged between 2.2 and 3.8.

Discussion

This study covers the recent information on the length-weight relationship of 25 species living in the Black Sea. For two of them (*Cardium edule* and *Gourmya vulgata*) these are the first data from the Turkish Black Sea area. "a" and "b" parameters for the rest of the species have been updated against ongoing environmental and ecological changes in the Black Sea. Table 3 shows comparisons of the LWR parameters of the species

Table 2. Length-weight relations per fishing gear for most abundant fish species caught in the Black Sea.

		TL (cm)			L-W relationships			
		n	Min	Max	a	b	SE_b	R^2
Engraulis encrasicolus	Purse Seine	1494	5.9	14.6	0.001	3	0.04	0.946
	Bottom Trawl	2	12	12.3	1.688	0.799	-	1
	Gillnet	92	9.4	15	0.013	2.679	0.11	0.949
Merlangius merlangus	Purse Seine	28	7.2	21.1	0.001	3.724	0.31	0.957
	Bottom Trawl	1325	5.9	22.2	0.005	3.162	0.05	0.923
	Gillnet	939	8.6	22.1	0.010	2.878	0.08	0.822
Mullus barbatus	Purse Seine	210	5.3	16.7	0.011	2.894	0.07	0.965
	Bottom Trawl	2192	5.7	19	0.007	3.111	0.03	0.962
	Gillnet	291	8.2	19	0.021	2.727	0.12	0.837
Trachurus mediterraneus	Purse Seine	476	6.2	19	0.006	3.104	0.07	0.978
	Bottom Trawl	9	13.2	17	0.0001	3.817	0.44	0.977
	Gillnet	139	9.7	19.5	0.006	3.145	0.10	0.951
Sprattus sprattus	Purse Seine	138	6.4	10.7	0.032	2.176	0.14	0.742
	Bottom Trawl	285	5.6	10.5	0.005	3.016	0.05	0.917
Chamelea gallina	Bottom Trawl	11	1.3	3	0.473	2.254	0.09	0.932
	Hydraulic dredge	617	0.8	2.8	0.422	2.324	0.07	0.944
Rapana venosa	Bottom Trawl	485	2	9.8	0.234	2.785	0.02	0.916
	Gillnet	21	3.1	5	0.460	2.618	0.13	0.885

Table 3. Length-weight relationship parameters of marine species estimated from the present study and other areas.

Species	Present study			Black Sea				Marmara Sea				Aegean Sea				Mediterranean Sea				Other Seas			
	N	a	b	n	a	b	Source	N	a	b	Source	n	a	b	Source	N	a	b	Source	n	a	b	Source
Alosa fallax	68	0.0050	3.14	475	0.0027	3.34	1					32	0.0102	2.93	14					80	0.0013	3.55	24
Cardium edule	313	1.1570	2.26																				
Chameleagallina	628	0.4520	2.37	1332	0.0007	2.69	3	91	0.0004	2.97	10									695	0.0007	2.80	25
Crangon crangon	21	0.0102	2.81																	64	4.10^{-5}	2.65	26
Engraulis encrasicolus	1588	0.01294	2.71	575	0.0174	2.60	4					630	0.0037	3.18	16	392	0.0156	2.66	20	156	0.008	2.86	28
Gaidropsarus mediterraneus	21	0.0012	3.62					8	0.0068	3.01	11												
Gobius niger	112	0.0180	2.86	113	0.0113	3.00	5	286	0.0115	2.98	12	272	0.0047	3.39	16	225	0.0124	2.97	21	141	0.016	2.89	28
Gourmya vulgata	11	0.2130	2.35																				
Hippocampus guttulatus	291	0.0044	2.89													31	0.0025	2.91	21				
Liocarcinus vernalis	56	1.2090	1.76	672	0.00034	2.92	6																
Spicara smaris	103	0.0223	2.72																				
Merlangius merlangus	2292	0.0054	3.15	904	0.0067	3.03	4	166	0.0047	3.15	12	23	0.0102	2.99	17					17	0.0002	2.31	26
Mullusbarbatus	2693	0.0074	3.12	432	0.0051	3.24	5	99	0.0049	3.33	12	2021	0.0076	3.13	16	451	0.0032	3.06	20	512	0.012	3.00	28
Mullus surmuletus	80	0.0042	3.40					17	0.0045	3.39	11	120	0.0069	3.21	15					122	0.011	3.03	28
Neogobius melanostomus	172	0.0114	3.09	99	0.0047	3.39	5																
Platichthys flesus	16	0.0052	3.18	51	0.007	3.09	7													178	0.0087	3.09	
Pomatomus saltatrix	25	0.0092	3.01	143	0.0130	2.86	4	290	0.0325	2.53	12												
Raja clavata	63	0.0010	3.29	27	0.0019	3.24	5	24	0.0001	2.87	12	24	0.0335	2.89	18	77	0.0037	3.08	22	18	0.0024	3.20	27
Rapana venosa	506	0.2170	2.86		0.0004	2.77	8																
Sarda sarda	36	0.0502	2.56	411	0.001	3.84	9													5	0.0051	3.18	24
Scorpaena porcus	42	0.0210	2.98	470	0.0124	3.19	5	15	0.0067	3.34	12	86	0.0159	3.07	19	320	0.0167	3.02	23	231	0.0236	2.89	29
Solea lascaris	91	0.0042	3.27																				
Sprattus sprattus	423	0.0064	2.92	5087	0.0079	2.87	4														0.0021	3.47	23
Trachurus mediterraneus	624	0.0050	3.14	1432	0.005	3.17	9					45	0.0042	3.37	15	373	0.0128	2.81	20	232	0.0138	2.76	26
Uranoscopus scaber	155	0.0252	2.85	69	0.0150	3.05	5	82	0.0109	3.15	12	157	0.0100	3.19	19	92	0.0103	3.15	20	45	0.017	3.03	27

1: Ozdamar, 1996; 2: Polat *et al.*, 2009; 3: Dalgic & Karayucel, 2007; 4: Kalaycı *et al.*, 2007; 5: Demirhan & Can, 2007; 6: Duzgunes *et al.*, 1998; 7: Ak *et al.*, 2009; 8: Duzgunes *et al.*, 1992; 9: Yankova *et al.*, 2011; 10: Tuncer & Erdemir, 2002; 11: Keskin & Gaygusuz, 2010; 12: Bok *et al.*, 2011; 13: Ozen *et al.*, 2009; 14: Karakulak *et al.*, 2006; 15: Ceyhan *et al.*, 2009; 16: Cicek *et al.*, 2006; 17: İsmen *et al.*, 2007; 18: İlkyaz *et al.*, 2008; 19: Ozaydın *et al.*, 2007;20: Sangun *et al.*, 2007;21:Verdiell- Cubedo *et al.*, 2006; 22: Yeldan & Avsar, 2007; 23:Valle *et al.*, 2003; 24: Coull *et al.*, 1989; 25: Gaspar *et al.*, 2001; 26: Robinson *et al.*, 2010; 27: Merella *et al.*, 1997; 28: Abdallah, 2002; 29: Moutopoulos & Stergiou, 2002.

covered by this study and of the values obtained from the literature (various sources) regarding the research studies carried out in seas surrounding Turkey and other seas in the world. According to the results of the study, the 'a' values ranged from 0.0010 to 1.2090 while the 'b' parameter varied between 1.758 and 3.616 (Table 3). The most abundant species in the samples were red mullet followed by whiting, anchovy, baby clam, rapa whelk, Mediterranean horse mackerel and sprat. Parameter 'b' for red mullet in this study was lower than the one obtained from the Sea of Marmara (Bok *et al*., 2011) and the Aegean Sea (Cicek *et al*., 2006) but slightly higher than from the Mediterranean Sea (Sangun *et al*., 2007). The 'b' coefficient value obtained for whiting was found to be similar to the values of the same species studied for the Sea of Marmara (Bok *et al*., 2011) and slightly higher than for the Aegean Sea (Ismen *et al*., 2007). Regression coefficient 'b' for anchovy was found to be lower than the findings obtained in the Aegean Sea (Cicek *et al*., 2006) but higher than in the other seas (Cicek *et al*., 2006; Sangun *et al*., 2007). There are very limited studies on the growth of baby clam in Turkey. The value of 'b' was found to be lower than in the other studies carried out in the Black Sea (Dalgic & Karayucel, 2007) and the Sea of Marmara (Tuncer & Erdemir, 2002). This may be attributed to the ecological differences because the Back Sea has lower salinity and overfished baby clam stocks due to intensive use of hydraulic dredges in the Black Sea. Rapa whelk's 'b' value is higher than in the previous study carried out in the Black Sea (Duzgunes *et al.*, 1992). Sprat is the only species with an under fished stock in the Turkish EEZ of the Black Sea, due to the fact that sprat fishing is performed by a limited amount of license allocations and at that time of the year no other fishing activity is performed. Therefore, the 'b' values estimated by this study were found to be higher than by the study carried out by Kalayci *et al*. (2007). Horse mackerel is the second commercially important pelagic fish species in the Black Sea. The regression value of 'b' found in this research is lower than for the Aegean Sea (Ceyhan *et al*., 2009) but higher than in the value for the Mediterranean Sea (Sangun *et al*., 2007) (Table 3).

The findings of this study are useful for comparing the results of other studies carried out at different times and places. Additionally, it is very important to provide recent input data for stock assessments and surplus production models.

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