



Length-Weight Relationships and Condition Factors of Five Crab Species (Decapoda) in the Black Sea

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ABSTRACT

This study determined the carapace length (CL)-weight relationships of the five *Decapoda* species (*Pachygrapsus marmoratus*, *Carcinus aestuarii*, *Liocarcinus depurator*, *Liocarcinus navigator*, and *Eriphia verrucosa*) living in the Black Sea. The crab samples were obtained between 2010 and 2016 by SCUBA, trawl, trammel net, and dredges at six locations (Kastamonu, Sinop, Samsun, Ordu, Giresun, and Trabzon). Total carapace length (CL) and weight (W) of each individual were recorded with an accuracy of 0.01 cm and 0.01 g, respectively. During the sampling period, a total of 5932 crab individuals belonging to five species were collected and measured. The minimum and the maximum “b” values of the length-weight relationship among these five species were estimated as 2.442 (for *L. navigator*) and 3.007 (for *P. marmoratus*), respectively. Growth was found as isometric for *P. marmoratus* and *C. aestuarii*, and as negative allometric for *L. depurator*, *L. navigator* and *E. verrucosa*.

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Key words

Length-weight, Relationship, Condition factor, Crab, Black Sea.

INTRODUCTION

The length-weight relationship (LWR) and condition factor are important in the biological study of crabs and their stock assessments. They are often used to calculate the standing stock biomass or condition indices and are also used in the analysis of ontogenetic changes and several other aspects of fish or crustacean population dynamics (Lagler, 1968).

Two hundred and twenty-four Decapod species have been reported in Turkish territorial waters (Ateş *et al.*, 2010), while 40 Decapod species have been reported in the Black Sea (Zaitsev and Mamaev, 1997). In studies carried out on the Black Sea's Turkish coasts, Holthuis (1961) detected seven crab species, Kocataş (1981) detected eight species, Kocataş and Katağan (2003) detected 11 species, Selimoğlu (1997) detected five crab species, Ateş (1997) six species, Gönlügür (2003) five species, Bilgin and Çelik (2004) 11 species and Aydın *et al.* (2013a) detected 12 crab species.

In this study, the length-weight relationship and condition factors were determined for five species (*Pachygrapsus marmoratus*, *Carcinus aestuarii*, *Liocarcinus depurator*, *Liocarcinus navigator* and *Eriphia verrucosa*) living in the Black Sea. Studies on the biology of these species have been conducted on the Black Sea's

Turkish coasts by Selimoğlu (1997), Düzgüneş *et al.* (1998), Aydın *et al.* (2012), (2013b), (2014), Aydın (2013), Karadurmuş and Aydın (2016) and Sümer *et al.* (2016). The present study aimed to determine the equations that best expressed the relationship of weight (W) and carapace length and condition factor for each species of Black Sea Decapods.

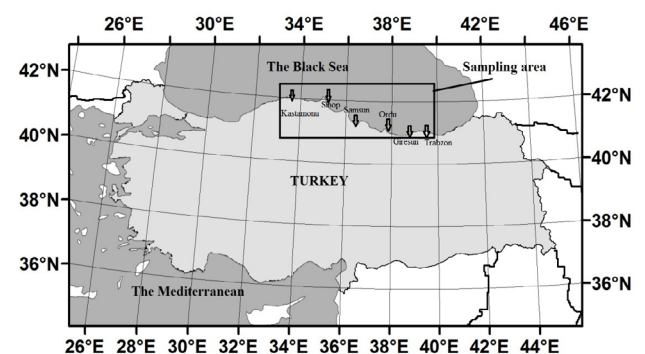


Fig. 1. Map of the Black Sea (North of Turkey).

MATERIALS AND METHODS

The crab samples were obtained between 2010 and 2016 by SCUBA, trawl, trammel net, and dredges at six main locations (Kastamonu, Sinop, Samsun, Ordu, Giresun, and Trabzon) (Fig. 1).

The specimens were transferred to the laboratory in a cooling box under motionless conditions. At the laboratory

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the species were identified according to studies by Zariquiey Álvarez (1968), Holthuis (1987), Fischer *et al.* (1987), Ingle (1993), Noël (1992), Ateş (1997), Düzgüneş *et al.* (1998), Kocataş and Katağan (2003), Bilgin and Çelik, (2004) and Aydın *et al.* (2013a).

Sex distinction was made by interpreting typical characteristic abdominal forms (Wenner, 1989; Metin and Aydın, 2017). Total carapace length (CL), carapace width (CW), and weight (W) of each individual were recorded with an accuracy of 0.01 cm and 0.01 g, respectively. The carapace width (CW) was measured from the tip of the left dorsal spine to the tip of the right dorsal spine and carapace length (CL) was measured with a Vernier caliper from the edge of the frontal region near the eye, to the base of the carapace back wall.

The length-weight relationships were determined for all collected individuals by the expression $W = aCL^b$, where W is weight (g), CL is carapace length (cm), “a” is the intercept of the regression curve, and “b” is the slope or regression coefficients (Ricker, 1973).

Fulton’s coefficient of condition factor (K) was calculated by $K = 100W/CL^3$, where CL is carapace length

(cm) and W is weight (g) (Le Cren, 1951; Bagenal, 1968; Sparre and Venema, 1992).

The relationships among the variables were identified using the regression analysis. The best appropriate model was selected based on R² value (Ulaş and Aydın, 2011). The observed differences were evaluated statistically using SPSS 22.0 and Student’s t-test (Düzgüneş *et al.*, 1983).

RESULTS AND DISCUSSION

During the sampling period, a total of 5932 crab individuals belonging to five species was collected and measured. Mean carapace length, mean carapace width and weight, and sex ratio in five crab species from the Black Sea is summarized in Table I.

Sümer *et al.* (2016) in their study conducted in the same area with 237 individuals of *Pachygrapsus marmoratus*, calculated 3.5 cm average carapace length (CL) and 3.9 cm average carapace width (CW) values. In their study, Aydın *et al.* (2014) determined mean CL, CW, and weight as 2.55 cm, 2.90 cm, and 14.21 g, for all individuals, respectively.

Table I.- Carapace length (CL), carapace width (CW), weight (W) characteristics and female/male (F:M) sex ratio in five crabs from the Black Sea.

	n	CL (cm)		CW (cm)		W (g)		Sex ratio
		Mean±SE	Min-Max	Mean±SE	Min-Max	Mean±SE	Min-Max	
<i>P. marmoratus</i>	1884	2.54±0.71	0.80-4.30	2.89±0.78	1.05-4.80	14.22±10.67	0.58-52.16	1:0.94
<i>C. aestuarii</i>	870	5.04±0.93	1.00-7.10	6.43±1.12	1.25-9.20	76.89±37.98	0.76-172.00	1:0.98
<i>L. depurator</i>	365	2.98±0.36	1.50-3.60	3.73±0.47	1.90-4.50	13.83±4.32	1.75-25.00	1:0.19
<i>L. navigator</i>	950	1.72±0.17	1.20-2.22	2.13±0.21	1.4-2.82	2.95±0.79	1.08-6.23	1:4.58
<i>E. verrucosa</i>	1863	4.64±0.82	1.50-6.80	6.40±1.09	2.80-9.10	111.15±52.68	4.07-312.00	1:0.44

n, number of individuals; SE, standard error; Min, minimum; Max, maximum.

Table II.- CL, CW and W characteristics for the five crabs according to sex.

	Female				Male			
	n	CL (cm) Mean±SE (min-max)	CW (cm) Mean±SE (min-max)	W (g) Mean±SE (min-max)	n	CL (cm) Mean±SE (min-max)	CW (cm) Mean±SE (min-max)	W (g) Mean±SE (min-max)
<i>P. marmoratus</i>	917	2.41±0.61 (0.90-4.30)	2.75±0.67 (1.10-4.80)	11.25±7.70 (0.67-44.33)	967	2.66±0.77 (0.80-4.20)	3.02±0.85 (1.05-4.70)	17.04±12.22 (0.58-52.16)
<i>C. aestuarii</i>	432	4.81±0.99 (1.40-7.00)	6.17±1.01 (2.10-9.20)	64.23±29.97 (1.80-172.00)	438	5.28±0.99 (1.00-7.10)	6.69±1.19 (1.25-8.55)	89.41±40.93 (0.76-169.00)
<i>L. depurator</i>	60	2.79±0.54 (1.50-3.60)	3.50±0.68 (1.90-4.50)	12.74±6.09 (1.75-25)	305	3.01±0.30 (1.90-3.60)	3.77±0.39 (2.50-4.50)	14.05±3.85 (3.50-24.51)
<i>L. navigator</i>	780	1.72±0.17 (1.20-2.22)	2.13±0.21 (1.40-2.82)	2.93±0.77 (1.08-6.23)	170	1.74±0.18 (1.30-2.15)	2.15±0.23 (1.60-2.72)	3.04±0.86 (1.60-6.02)
<i>E. verrucosa</i>	571	4.00±0.66 (2.40-6.05)	5.57±0.90 (3.45-8.30)	68.93±32.28 (16.33-216.0)	1292	4.92±0.72 (1.50-6.80)	6.77±0.96 (2.80-9.10)	129.81±49.04 (4.07-312.0)

For abbreviations and statistical details, see Table I.

Aydın *et al.* (2012) calculated the average CL for *Liocarcinus navigator* as 1.73 cm and the average W as 2.91 g. Similar results were also obtained for CL and W in the present study.

Aydın's (2013) studied *Carcinus aestuarii* conducted in the same area analyzed 565 specimens and found that CW ranged from 1.25 to 8.55 cm in males and from 2.1 to 9.2 cm in females. CL oscillated from 1.0 to 6.6 cm in males and 1.4 to 7.0 cm in females. It is seen that the results obtained by Aydın (2013) are similar to those obtained in the present study.

Karadurmuş and Aydın (2016), in their study on *Eriphia verrucosa* found the mean CW as 6.76 cm (3.0-9.0) in males and as 5.57 cm (3.45 - 8.3) in females. The mean body weight of males and females was found as 129.3 g and

66.1 g, respectively. There is a close similarity between the length and weight data obtained in the study carried out by Karadurmuş and Aydın (2016) and in this study (Table II).

In the study carried out by Aydın *et al.* (2013b) on *L. depurator*; the average carapace length and width were determined as 21.6 mm and 26.6 mm for females, and 30.1 mm and 37.7 mm for males, respectively. The average weight of crabs was determined as 5.2 g for females and 13.95 g for males. Although the values of male individuals were similar in this study, female individuals were found to be larger (Table II). It is thought that this difference might be due to the method and the time of the sampling.

Figure 2 shows the relationship between length and weight of five different crab species sampled during the study, and the regression parameters are given in Table III.

Table III.- Regression parameters of the CL-W relationship ($W=aCL^b$) of the five crab species.

	Sex	n	a	b	±SE	Confidence limits (95%)		r ²	Pauly t-test	P
						Lower	Upper			
<i>P. marmoratus</i>	Total	1884	0.693	3.007	0.009	2.989	3.026	0.981	0.073	ns
	Female	917	0.708	2.950	0.014	2.922	2.979	0.978	3.14	< 0.05
	Male	967	0.700	3.024	0.012	3.000	3.048	0.984	1.964	< 0.05
<i>C. aestuarii</i>	Total	870	0.637	2.901	0.016	2.669	2.933	0.973	6.035	< 0.05
	Female	432	0.706	2.821	0.025	2.771	2.871	0.966	7.013	< 0.05
	Male	438	0.625	2.926	0.020	2.885	2.967	0.978	3.521	< 0.05
<i>L. depurator</i>	Total	365	0.614	2.817	0.004	2.732	2.902	0.921	4.220	< 0.05
	Female	60	0.596	2.885	0.064	2.755	3.015	0.971	1.756	< 0.05
	Male	305	0.604	2.824	0.059	2.706	2.942	0.880	2.937	< 0.05
<i>L. navigator</i>	Total	950	0.761	2.442	0.038	2.367	2.517	0.811	14.578	< 0.05
	Female	780	0.770	2.415	0.044	2.327	2.502	0.789	13.068	< 0.05
	Male	170	0.730	2.541	0.063	2.416	2.666	0.905	7.227	< 0.05
<i>E. verrucosa</i>	Total	1863	1.205	2.893	0.010	2.872	2.915	0.974	9.764	< 0.05
	Female	571	1.413	2.756	0.024	2.708	2.804	0.957	9.965	< 0.05
	Male	1292	1.300	2.854	0.013	2.827	2.881	0.970	10.449	< 0.05

Table IV.- Condition factors (K) by the carapace length (CL) for the five crab species in Black Sea.

	K=100W/CL ³					
	Total		Female		Male	
	n	Mean±SE (min-max)	n	Mean±SE (min-max)	n	Mean±SE (min-max)
<i>P. marmoratus</i>	1884	70.38±9.02 (42.72-126.95)	917	68.5±8.47 (42.7-106.1)	967	72.17±9.17 (44.1-127.0)
<i>C. aestuarii</i>	870	54.82±6.26 (41.8-87.5)	432	53.88±6.43 (41.8-81.5)	438	55.73±5.95 (42.5-87.5)
<i>L. depurator</i>	365	50.72±5.7 (33.66-71.23)	60	53.51±6.24 (42.0-71.2)	305	50.17±5.45 (33.7-66.1)
<i>L. navigator</i>	950	56.77±7.33 (37.84-81.01)	780	56.68±7.62 (37.8-81.0)	170	57.17±5.8 (43.4-77.4)
<i>E. verrucosa</i>	1863	103.06±9.56 (69.22-162.99)	571	101.72±11.1 (77.1-163.0)	1292	103.66±8.74 (69.2-154.0)

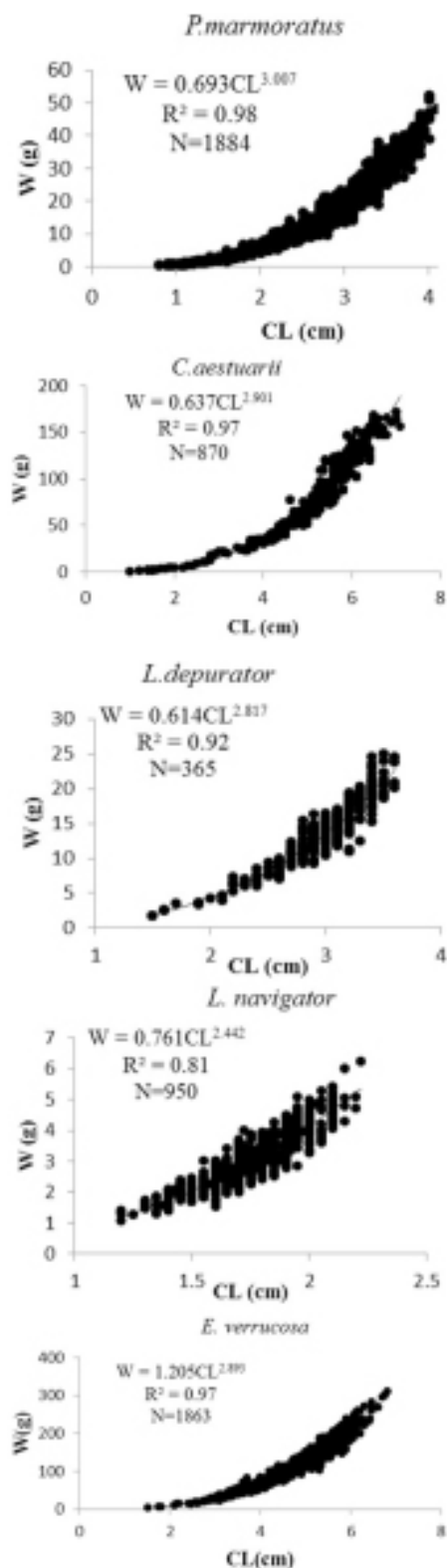


Fig. 2. Length-weight relationships of five crab species collected in the Black Sea.

Sümer *et al.* (2016) determined the “b” value for *P. marmoratus* as 2.33 for males and 2.37 for females. Selimoğlu (1997) obtained similar results for “b” values with females (2.63) and males (2.87) with CW. Aydın *et al.* (2014) reported “b” values of CW and W for male and female crabs were 3.1 and 3.06, respectively. Sümer *et al.* (2016), have reported that the “b” values obtained in their study were low with negative allometric growth. It was determined that the “b” values of the other two studies and the present study were similar.

Aydın’s (2013) study on *C. aestuarii*, found the “b” value in the relationship between CL and W as 2.95. This value is similar to the “b” value obtained in the present study. Karadurmuş and Aydın (2016), found the “b” value in *E. verrucosa* as 2.9 for males, 2.77 for females, and 2.91 for all individuals. As shown in Table III, the “b” values are similar to those obtained in the present study. Aydın *et al.* (2012) found the “b” value for the relationship between CL and W in *L. navigator* as 2.52. Similarly, the “b” value was calculated as 2.54 in the present study.

Sümer *et al.* (2016) determined the average condition factor for *P. marmoratus* as 45.6. Aydın *et al.* (2014) reported the mean K as 49.03 for males and 45.79 for females. Compared to the other two studies, the K value obtained in this study was higher.

Karadurmuş and Aydın (2016) calculated the mean K values for *E. verrucosa* as 39.7 for males and 37.3 for females. In this study, the mean K values were calculated as 103.6 for males and 101.7 for females (Table III).

The K values obtained in the other studies were lower than those obtained in this study as the K values were obtained using CW. If there is a substantial length difference between CW and CL in species, the difference in K values is large. There is not much difference between CW and CL in species with square-like carapace structure, therefore the same results are obtained no matter which length is used in calculating K values.

CONCLUSIONS

Length-weight relationships may vary among individuals in different species depending on many factors, such as genetic structure, body shape, condition factor, etc. The sample size, size-weight distributions, sampling time, the length used, and ecological conditions can cause differences in length-weight relationships. In crabs, length-weight relation and condition factor are not constant. It can vary depending on factors such as nutritional adequacy, nutritional ratio, gonad development, and breeding period. Continuous monitoring of natural stocks for sustainable ecosystem management is crucial in terms of fisheries’ biology and management. Therefore, it is thought that these

studies should be carried out to monitor crab stocks in the region. In addition, the findings of this study will constitute an important database for future studies of crab species.

Statement of conflict of interest

Authors have declared no conflict of interest.

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