SHORT COMMUNICATION   KISA **ARAŞTIRMA**

Length-weight relationships and reproduction characteristics of *Liocarcinus navigator* (Herbst, 1794)

Liocarcinus navigator (Herbst, 1794) yengecine ait boy ağırlık ilişkisi ve üreme özellikleri

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Özet: Bu araştırmada Orta Karadeniz Bölgesi'nde *Liocarcinus navigator* yengeç türünün karapaks boy/genişlik ile boy/ağırlık arasındaki ilişkiler ve üreme özellikleri araştırılmıştır. Araştırma boyunca ölçülen 637 adet yengecin 48 (%7,6) adeti erkek, 589 (%92,4) adeti dişi bireylerden oluşmaktadır. Karapaks boyları 1,7-2,22 cm arasında değişmekte olup, her iki cinsiyetinde ortalama karapaks boyu 1,73cm $\pm$ 0,17 olarak tespit edilmiştir. Yengeçlere ait minimum ve maksimum ağırlıklar 1,08-6,23 g ve ortalama ağırlıkları 2,91g$\pm$ 0,81 olarak hesaplanmıştır. Araştırmada incelenen bütün bireylerin karapaks boyu (L) / genişliği (CW) ve karapaks boyu (L) / ağırlığı (W) arasındaki ilişkiler W=0,7157 L^{2,526} (R^2=0,79) ve W=0,4433 CW^{2,4514} (R^2=0,78) olarak belirlenmiştir. Gözlenmiş yumurtalardan alınan örneklerde yapılan ölçümlerde yumurta çapları 229,4 - 447,3 µm arasında değişmekte olup ortalama 347,2 $\pm$14,7 µm olarak tespit edilmiştir.

Anahtar kelimeler: Boy-ağırlık ilişkisi, Üreme, *Liocarcinus navigator*, Karadeniz

Abstract: In this study, carapace length/width and length/weight relationships and reproduction characteristics of the crab species, *Liocarcinus navigator,* in the Middle Black Sea Region were determined. 637 individuals were sampled during the study whereas, 48 crabs were male and 589 crabs were female. While the carapace length of individuals varies between 1.7 and 2.22 cm, mean carapace length was determined as 1.73cm $\pm$ 0.17 for both sexes. In addition, minimum, maximum and mean weights of sampled individuals were calculated as 1.08, 6.23 and 2.91g $\pm$ 0.81, respectively. Relationships between carapace length (L) / width (CW) and weight were demonstrated as W=0.7157 L$^{2.526}$ (R^2=0.79) and W=0.4433 CW$^{2.4514}$ (R^2=0.78). Minimum, maximum and mean egg sizes of from sampled individuals were determined as 229.4 µm, 447.3 µm and 347.2 µm $\pm$ 14.7, respectively.

Keywords: Length-weight relationships, Reproduction, *Liocarcinus navigator*, Black Sea.

INTRODUCTION

Most of the studies on brown swimming crab (*Liocarcinus navigator*, Herbst, 1794) in Turkey so far have conducted with their fauna and there is a limited number of studies on its biology and reproduction characteristics. Furthermore, available studies on crab species have been more focused in the Marmara, Aegean and Mediterranean Seas of Turkey, but limitedly in the Black Sea. Dolgopolskaya (1969) determined 17 crab species in the Black Sea in the Northern Black Sea and Azov Sea. In another study, 20 crab species were reported by Stevcic and Galil (1994) in the Mediterranean Sea. First study conducted in the Turkish coasts of the Black Sea by Holthuis (1961), 7 crab species were determined, and then, 8 crab species were reported by Kocataş (1981). Ateş (1997) determined 6 crab species among 12 reported decapods while Gönlügür (2003) defined 5 crab species among 10 reported decapods around the coasts of Sinop province. In the study conducted by Kocataş and Katağan (2003), 11 crab species were reported along the Turkish coasts of the Black Sea and 11 crab species reported by Bilgin and Çelik (2004) along the coasts of Sinop province. Ateş *et al.* (2004) determined the decapods crustacean fauna

in the *Posidonia oceanica* communities in the Aegean Sea, and first record of *Liocarcinus navigator* species for Gökova Bay was also stated. In the study conducted by Bilgin and Çelik, (2004) along the coasts of Sinop, first record of *Liocarcinus navigator* species was given for the Black Sea. During the study, 26 individuals were determined with a deep interval of 5-30m. In a few studies conducted for the biological assessment of crab species in the Black Sea, Selimoğlu (1997) studied on biology of two crab species (*Liocarcinus vernalis* and *Pachygrapsus marmoratus*), Erkan *et al.* (2008) studied on reproduction of *Eriphia verrucosa,* and Düzgüneş *et al.* (1998) studied on growth of *Liocarcinus vernalis* and *Pachygrapsus marmoratus* species. Fauna research conducted by Bilgin and Çelik (2004), characteristics of *Liocarcinus navigator* species was defined as oval shaped carapace, longer width than length, slightly convex in width dorsal surface, narrow cleft on the ventral of the orbital side, and there are 5 spines on the anterio-lateral side of the carapace. The fourth spine underdeveloped. Besides, it was also stated that the carapace is dark brown and the pereiopods are more pale colored.

There is no scientific research on the biology of *L. navigator* species in the Turkish coasts. This study is also important in terms of being first study regarding the biology, morphometrics and reproduction dimensions of *L. navigator* species.

MATERIALS AND METHOD

This study was conducted along the Black Sea coasts from Sinop to Cide during the summer seasons of the years 2011 and 2012 (Figure 1). Samplings were made by hydraulic dredges which were actually used for striped venus clam (*Chamelea gallina*) capture in the depth intervals of 5 m, 10 m, 15 m, and 20 m.
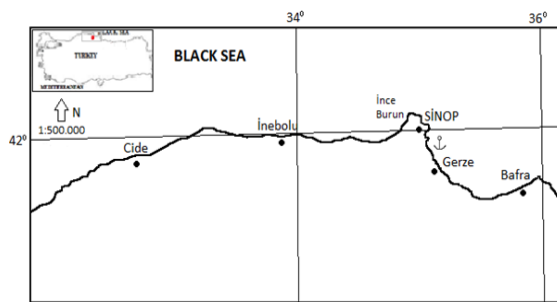

Figure 1. Study area

637 sampled *Liocarcinus navigator* crab species preserved in the alcohol were delivered to the laboratory.

Crabs were wet weighed in the laboratory with a digital scale (0.001g) and measured, the carapace length (CL) and carapace width (CW) with a digital caliper (1 mm) and sexes determined (Figure 2). Sex ratio of crabs was analyzed using Chi-square test ($\chi2$).

Figure 2. *Liocarcinus navigator*

The relationship between the carapace length and weight of crabs is usually expressed by the equation, $W=aL^b$. Where W is body weight (g), L is carapace length (cm), a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3 (Ricker, 1975). The parameters a and b in carapace length/width and length/weight relationship were estimated by regression analysis using the method of ordinary least squares. Fulton's condition factor was calculated from the expression (Ricker, 1975; Bagenal, 1978); $CF=(W / (L^3)) \times 100$. Sexual

differentiation was made visually by considering characteristic shapes of abdomen (Figure 3).

Figure 3. a) Female crab b) Male crab

Gonad maturation stages were determined by macroscopic observations (Wenner, 1989). In order to obtain the data related to reproductive biology, the pleopod eggs were removed from female and the total weight of eggs was measured by a balance with a sensitivity of 0.0001 g. Then, sub-samples were taken from different areas and weighed, and then the eggs were counted over a glass slide after dripping 30 % glycerin over the samples to separate the eggs. The number of eggs was calculated by gravimetric method via the equation $F=n^*(W_0/X)$, where F represents the number of eggs, X stands for sub-sample weight (g), W_0 denotes the weight of ovary and n represents the number of eggs in the sample. Moreover, diameters of randomly selected 50 eyed eggs were measured for each sample by an ocular micrometer under stereo microscope (Prager et al.,1990; Jones et al., 1990). In addition, the relationship between fecundity and carapace length was determined with the formula, $(F)= aL^b$ (Gunderson, 1993).

RESULTS

Over the study period, a total of 637 crabs were caught, 48 (7.6%) of which were males and 589 (92.4%) females. The observed sex ratio was significantly higher in favor of for the female ($\chi2 = 459.5$; d.f. =1; p <0.05). Majority of L. navigator crabs (90 %) were caught from the depths of 15 m to 20 m. Mean, maximum and minimum weights, carapace lengths and widths determined during the measurements by sexes are shown in Table 1.

Table 1. Mean length for each sexes of *L. navigator*. N: sample size, L: Carapace length (cm), W: Carapace weight (g), Min: minimum, Max: maximum, SE: standard error

Sex	Number	Parameters		
		L_{mean} (cm) (L_{min}-L_{max})	CW_{mean} (cm) (CW_{min}-CW_{max})	W_{mean} (cm) (W_{min}-W_{max})
Female	589	1.72 ± 0.17 (1.2 – 2.22)	2.13 ±0.21 (1.5 – 2.82)	2.9± 0.81 (1.08 – 6.23)
Male	48	1.77 ± 0.15 (1.45 – 2.15)	2.21 ± 0.2 (1.8 – 2.72)	3.11 ± 0.85 (1.7 – 6.02)
Male and Female	637	1.73 ± 0.17 (1.2 – 2.22)	2.13 ± 0.21 (1.5 – 2.82)	2.91± 0.81 (1.08 – 6.23)

Considering mean carapace length and weight of female and male individuals of the samples (1.73 cm±0.17 and 2.91 g±0.81, respectively), *L. navigator* species can be evaluated as a small crab species compared to the other crab species in the Black Sea.

There is no statistically difference between carapace lengths and weights of male and female individuals (P<0.05). The parameters of the regression analysis between carapace length/width and weight and carapace length and width by calculating growth parameters, and the degrees of relationships were given with a and b values in the Table 2.

Table 2. Parameters of the relationship among W and L, W and CW, L and CW of each sex for *L. navigator* was describe

		W=a L^b			W=a CW^b			L=b CW+a		
	N	a	b	R^2	a	b	R^2	a	b	R^2
Male	48	0.513	3.1	0.93	0.312	2.87	0.90	-0.07	1.28	0.95
Female	589	0.73	2.49	0.78	0.45	2.43	0.77	0.02	1.22	0.94
Combine	637	0.176	2.52	0.79	0.44	2.45	0.78	0.014	1.23	0.94

The b value of carapace lengths/weights of male (3.1), female (2.49) and combine (2.52) were found no significant (P>0.05). The relationships between the carapace length/width and weight are given in Figure 4 and 5.
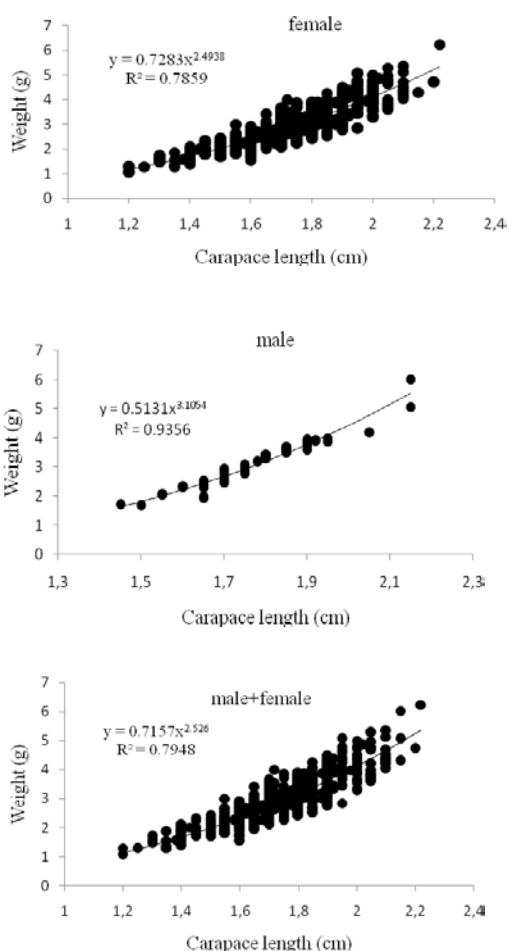

Figure 4. The relationship between carapace length and weight for *L. navigator*
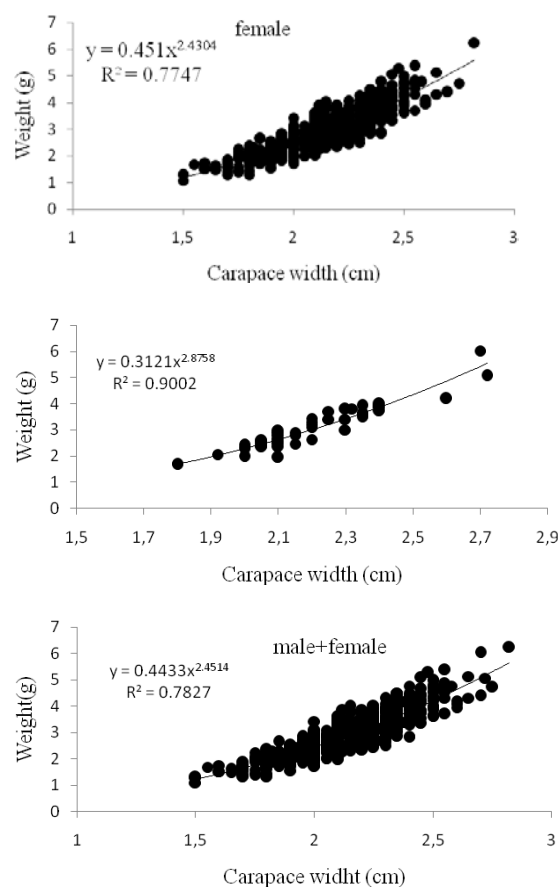

Figure 5. The relationship between carapace width and weight for *L. navigator*

A strong relationship was determined between carapace length and carapace width of the sampled individuals (R^2=0.94) (Figure 6).
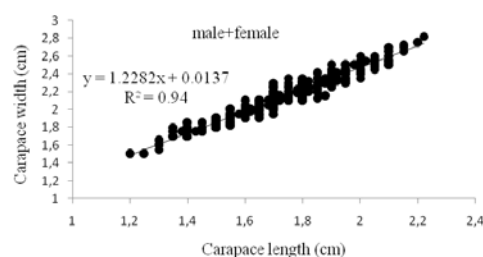

Figure 6. The relationship between carapace length and carapace width for *L. navigator*

393 (66.72%) individuals of all the 589 sampled females had eggs. Moreover, 99 individuals sampled in July had eyed eggs. The total number of 99 individuals which have eyed eggs were used for the determination of the number of eggs and the egg sizes. The number of individuals and the total number of eggs in 1 g eggs of sampled crabs which have eyed eggs were given in Table 3.

Table 3: Fecundities of 99 berried females crabs *L. navigator,* with their respective carapace width (CW), carapace length (L), body weight (W), Eggs numbers /1g

Number of crabs	Carapace mean length (L) (cm)	Carapace mean width (CW) (cm)	Body mean weight (W) (g)	Mean Eggs numbers/1g
1	1.25	1.45	1.28	10000000
5	1.33	1.64	1.64	8434718
2	1.45	1.7	2.05	8733766
12	1.55	1.89	2.27	7763868
21	1.62	2.01	2.71	7228830
24	1.72	2.14	3.27	5837033
13	1.82	2.25	3.53	6069837
16	1.92	2.37	4.13	6284221
4	2.0	2.45	4.56	7646464
1	2.2	2.63	6.23	6833333

Minimum, maximum and mean egg sizes during the study period were 229.4 µm, 447.3 µm and 347.2 µm + 14.7, respectively. Relationships between carapace sizes/gonad weights and egg sizes were given in Table 4.

Table 4. Mean carapace length, gonad weight and egg diameter

Mean carapace length (L) (cm)	Mean gonad weight (g)	Number of crabs	Mean egg diameter (µm) +STD	Minimum egg diameter (µm)	Maximum egg diameter (µm)
1.25	0.16	1	320.2 + 3.4	318.5	345.2
1.33	0.32	5	319.4 +11.8	292.4	362.8
1.45	0.43	2	330.9 +15.1	290.4	383.9
1.55	0.42	12	341.4 +14.7	257.6	393.9
1.62	0.56	21	341.1 +14.4	229.4	447.3
1.72	0.65	24	349.4 +15.8	265.0	416.5
1.82	0.66	13	345.6 +13.5	287.1	400.1
1.92	0.87	16	352.6 +15.0	305.0	436.8
2.00	0.95	4	348.4 +15.7	282.0	376.2
2.20	1.45	1	358.2 +15.8	300.1	388.7

A strong linear relationship was found between mean carapace length and mean gonad weight (R^2=0.93). Likewise, such a linear relationship was also determined between mean carapace lengths and egg sizes (R^2=0.87) (Figure 7).
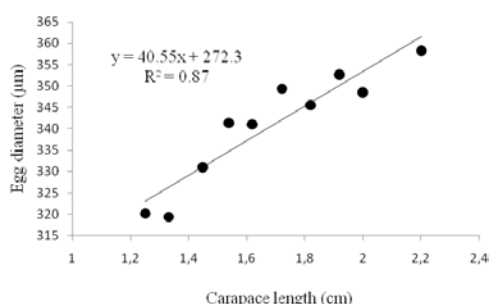
Figure 7. Relationship with mean carapace length and mean egg diameter

DISCUSSION

In this study which is conducted along the Black Sea coasts from Sinop to Cide in the years 2011 and 2012, biological parameters of *L. navigator* crab species were determined. There is no scientific research on biological assessment of this species in the literature.

According to the observations during the samplings, it was seen that *L. navigator* species had a higher population density in deeper waters (15-20 m) than *Liocarcinus depurator,* a species which lives on the firm and sandy bottoms as opposed to the former. Bilgin and Çelik, (2004) reported that *L. navigator* crab species were sampled same dept (between 5-30m) in central Black Sea Coast.

The finding of percentages of 7.6 % and 92.4 % for males and females of the total 637 sampled *L. navigator* species indicates that there is a higher female density in the study site. Similar results were found by Gülşahin and Erdem, (2009) for *Callinectes sapidus* in the Köyceğiz Lagoon, although Özcan et al., (2009) reported that male proportion was higher than females for *Carcinus aestuarii* in the Aegean Sea.

Although there is no statistically difference between carapace lengths and weights of male and female individuals (P<0.05), mean carapace length (1.73 cm± 0.17) and weights (2.9 g± 0.81) of female individuals, and mean carapace length (1.77 cm± 0.15) and weights (3.11 g± 0.85) of male individuals points that male individuals have greater than females. Can et al., (2007) and Kocak et al., (2011) stated that male crabs bigger than females for *Carcinus aestuarii*.

According to the results from the carapace length and weight relationship, growth parameter *b* was found as 3.1 for males and 2.49 was found for females and R^2 = 0.93 was found for males, R^2 = 0.78 was found for females (Table 2). Low b and R^2 values for females is thought to be a result of sampled 393 female individuals with eggs from the total 589 sampled individuals. Although, there was no data belonging to the whole year, the high number of individuals with eggs in July may suggest that this species spawns intensively in July. It was determined that 99 of the total sampled individuals have eyed eggs.

Only the individuals in the phase of eyed egg were evaluated for determination of the number of eggs and egg diameters, and it was determined that there are 6 048 519 pieces of eggs in 1 g with an average egg diameter of 347.2 µm (Table 4). This is the first record about the fecundity and egg diameters of this species.

Future studies should be on biology and ecology of crab species in the Black Sea. Such scientific studies should be conducted to support sustainability of marine biodiversity in Turkey. The first biological study on *L. navigator* crab species is supposed to be a case study for future studies.

ACKNOWLEDGEMENTS

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