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Morphometric and biochemical composition of blue crabs (*Callinectes sapidus* Rathbun, 1896) collected from the Saros Bay (Çanakkale, Türkiye)

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Abstract

In this study, the morphometric characteristics, and biochemical composition of the blue crab (*Callinectes sapidus* Rathbun, 1896) population found in the Saros Bay (Çanakkale, Türkiye) were evaluated. Carapace width and length-weight relationships (CWiWR and CLWR), as well as protein, lipid, ash, and moisture contents, were examined in the sampled crabs. It was observed that female crabs (72%) predominated in the population. The average carapace width of female crabs was found to be greater than that of male individuals. In this study, carapace length-weight relationship (CLWR) and carapace width-weight relationship (CWiWR) in blue crab individuals demonstrated different growth patterns between sexes. Female crabs exhibited negative allometric growth in both CLWR (b=1.809) and CWiWR (b=1.773) relationships, indicating that body dimensions increased at a faster rate than body weight. In contrast, male crabs showed an isometric growth pattern in the CLWR relationship (b=3.008), suggesting a proportional increase between carapace length and body weight during growth. However, the CWiWR relationship in males (b=2.525) indicated negative allometric growth. In addition, the relatively higher b values observed in males compared to females suggest that males tend to gain more body mass during development. The blue crab is an important species in terms of nutritional value due to its high protein content. It is believed that the species' physiological characteristics, energy storage strategies, and reproductive cycle influence the variations in protein, lipid, and ash content among tissues.

Keywords: Carapace length/width-weight relationship, Meat yield, Biochemical composition

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1. Introduction

One of the most commonly caught crab species in the waters of Türkiye is *Callinectes sapidus*. The blue crab is native to the northwestern Atlantic (Yağlıoğlu et al., 2014; Bilgin, 2019). The blue crab, which can easily enter lagoons, river mouths, and occasionally rivers, has a high tolerance for salinity and temperature; it is known to be able to survive in both highly saline and very low-salinity waters (Mancinelli et al., 2017; Bilgin, 2019). It was first observed in Türkiye in the Gulf of Iskenderun (Hatay) (Holthuis, 1961). It has been reported to be distributed from the Gulf of Iskenderun throughout the entire Mediterranean coast and lagoons, extending as far as the Menderes Lagoon in the Aegean, and is also present in the Sea of Marmara (Enzenrob et al., 1997). Saros Bay constitutes an important habitat for numerous marine species due to its unique oceanographic characteristics, and high biological diversity (Öztürk & Öztürk, 1996). Furthermore, the extensive coastal lagoon systems, muddy-sandy substrate structure, and rich benthic organism diversity of Saros Bay provide suitable feeding, sheltering, and breeding grounds for blue crabs. These ecological characteristics may contribute significantly to the

growth performance, population structure, and physiological development of the species (Öztürk & Öztürk, 1996).

Information on the nutritional composition of blue crabs is necessary to simplify their processing, consumption, and marketing. Blue crabs have a wide dietary range consisting of both plant and animal organisms, whether live or dead. Although they are known as scavengers, they prefer live and fresh food. Their diet includes bivalves, fish, crustaceans, gastropods, and plant matter. They catch small fish and use their crushing chelipeds to consume young oysters and bivalves (Türeli, 1999).

Blue crabs, which are among luxury food products and have the potential to generate foreign exchange for our country through exports, are not currently farmed in Türkiye. There is also an imbalance in the quantities obtained through fishing. In this study, the aim was to evaluate the relationships between length-weight, meat yield, and biochemical composition of blue crabs.

2. Material and Method

2.1. Study area and sample preparation

In this study, blue crabs were collected in April 2022 from the Saros Bay (Çanakkale, Türkiye). The crab specimens brought to the laboratory were separated into female and male groups based on their sex (Figure 1). Their weights were measured using a scale with a precision (AND GF 6100) of 0.01 g. Morphological measurements were also carried out on 58 female and 22 male blue crabs (Figure 2). Carapace length, carapace depth, carapace width, cheliped length, cheliped width, and cheliped depth were measured to the nearest 0.01 cm using a vernier caliper (MITUTOYO 500-203-30). Carapace width (CWi) was defined as the linear distance between the apices of the posterior-most lateral carapace spines. Carapace length (CL) was measured dorsally along the median axis, extending from the frontal notch to the posterior edge of the carapace (Josileen, 2011). Subsequently, the basic statistical data of the measurement values were calculated, and the relationships among them were determined (Paul & Haefner, 1985; Türeli, 1999).

2.2. Meat yield

The following formula were used to determine meat yield (*MY*) (Freeman, 1974).

$$MY = \frac{Wet\ meat\ weight\ (g)}{Total\ weight\ (g)} 100 \quad (1)$$

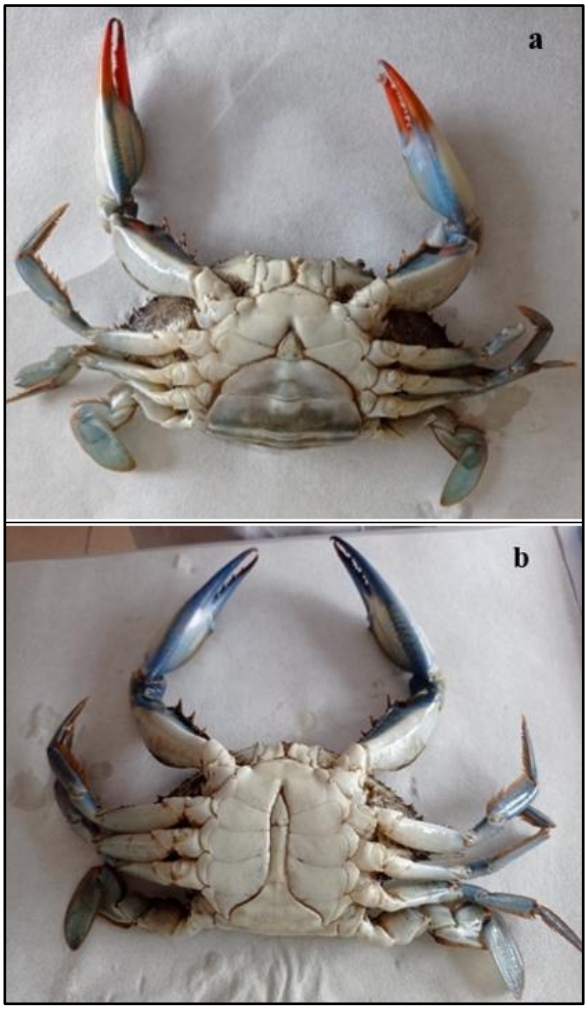

Figure 1. Ventral view of (a) female and (b) male blue crabs. In males, the tail flap is characterized by a narrow triangular apron, whereas in females it exhibits a comparatively broader morphology.

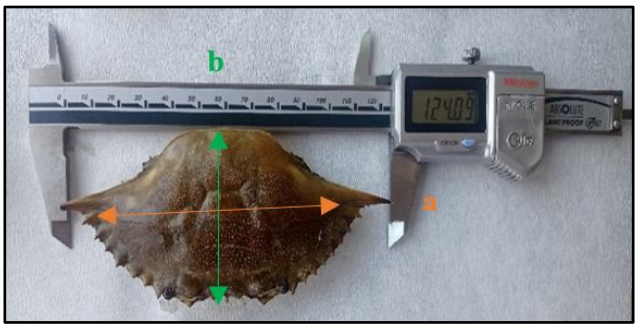

Figure 2. Morphometric measurements of blue crab (a: Carapace width, b: Carapace length)

2.3. Biochemical composition

Freeze-dried meat samples were analyzed to determine their proximate composition. Crude protein content (%) was measured using the Kjeldahl method with a nitrogen conversion factor of 6.25 (N×6.25). Total lipid content was determined by extraction with a chloroform–methanol mixture following the method of

Erickson (1993). Ash content was obtained by incineration in a muffle furnace according to AOAC (2000). Moisture content was determined gravimetrically in accordance with AOAC (2000). Carbohydrate content was calculated by difference as described by Çelik et al. (2014).

$$Moisture(\%) = \frac{wet\ meat\ weight(g) - dry\ meat\ weight(g)}{wet\ meat\ weight(g)} 100 \quad (2)$$

$$Carbohydrate(\%) = 100 - [Lipid(\%) + Protein(\%) + Ash(\%)] \quad (3)$$

2.4. Morphometric relationship

The morphometric measurements are expressed as mean ± standard deviation (SD). The carapace length–weight relationship (CLWR) and carapace width–weight relationship (CWiWR) were estimated using the following exponential equations (Ricker, 1975).

$$W = aL^b \quad (4)$$

$$W = aCWi^b \quad (5)$$

In these equations;
W: Total weight (g),
L: Carapace length (cm),
CWi: Carapace width (cm),
a: Intercept,
b: Slope of the regression curve.

The exponential equations were transformed to following logarithmic equations.

$$\log W = \log a + b \log L \quad (6)$$

$$\log W = \log a + b \log CWi \quad (7)$$

The statistical significance of the b value was evaluated using a t-test. Growth was considered isometric when b=3, positive allometric when b>3, and negative allometric when b<3 (Pauly, 1984). The significance level was determined as p<0.05. The Kolmogorov-Smirnov test was utilized to assess the normality of the data distribution. The relationship between the morphometric parameters and biochemical compositions of blue crabs was examined using Spearman correlation analysis. The SPSS 27 software for Windows was used to conduct all statistical analyses.

3. Results

A total of 80 blue crabs were collected. The population examined was found to consist of 28% male and 72% female individuals.

Morphometric measurements of female blue crabs are given in Table 1. The average carapace length, width, weight of female blue crabs was 6.42±0.8 cm, 14.57±2.06 cm, 142.77±38.95 g, respectively. Morphometric measurements of male blue crabs are given in Table 2. The weight of male blue crabs was measured at 158.98±49.06 g, and carapace length at 10.91±1.13 cm.

Table 1. Biometric characteristics of female blue crabs

	Weight (g)	Carapace Length (cm)	Carapace Depth (cm)	Carapace Width (cm)	Carapace Weight (g)	Carapace Meat Yield (%)
Min	57.36	8.08	2.53	9.82	38.51	12.70
Max	215.66	13.22	4.11	18	149.58	33.35
Mean±SD	142.77±38.95	11.12±1.21	3.53±0.34	14.57±2.06	95.47±26.99	25.09±4.75
	Right Cheliped Weight (g)	Right Cheliped Length (cm)	Right Cheliped Depth (cm)	Right Cheliped Width (cm)	Right Cheliped Meat Yield (%)	
Min	2.32	4.56	1.16	0.97	14.36	
Max	12.90	8.09	2.17	2.15	70.16	
Mean±SD	6.95±2.40	6.60±0.78	1.74±0.23	1.39±0.21	48.92±8.26	
	Left Cheliped Weight (g)	Left Cheliped Length (cm)	Left Cheliped Depth (cm)	Left Cheliped Width (cm)	Left Cheliped Meat Yield (%)	
Min	2.76	4.88	1.26	0.98	8.33	
Max	12.67	7.92	2.21	2.04	90.27	
Mean±SD	6.90±2.32	6.51±0.70	1.75±0.21	1.41±0.21	49.48±12.45	

Table 2. Biometric characteristics of male blue crabs

	Weight (g)	Carapace Length (cm)	Carapace Depth (cm)	Carapace Width (cm)	Carapace Weight (g)	Carapace Meat Yield (%)
Min	80.08	8.59	2.86	10.36	53.52	24.65
Max	236.25	12.62	3.95	16.14	141.20	44.97
Mean±SD	158.98±49.06	10.91±1.13	3.53±0.31	13.43±1.58	93.45±25.82	32.79±4.37
	Right Cheliped Weight (g)	Right Cheliped Length (cm)	Right Cheliped Depth (cm)	Right Cheliped Width (cm)	Right Cheliped Meat Yield (%)	
Min	4.45	5.69	1.55	1.06	22.70	
Max	17.58	8.91	2.31	1.94	55.87	
Mean±SD	10.92±3.90	7.59±0.99	1.98±0.24	1.62±0.24	46.13±8.35	
	Left Cheliped Weight (g)	Left Cheliped Length (cm)	Left Cheliped Depth (cm)	Left Cheliped Width (cm)	Left Cheliped Meat Yield (%)	
Min	4.15	5.66	1.46	1.15	33.44	
Max	16.3	9.23	2.30	1.99	57.11	
Mean±SD	9.96±3.96	7.56±1.03	1.90±0.25	1.58±0.24	47.88±5.88	

Table 3. Allometric relationships of blue crab between morphometric components (carapace length and carapace width) and total weight

Relationship	Sex	*N*	*a*	*b*	R^2	Relationship (*t*-test)
CLWR	Female	58	0.682	1.809	0.657	- allometry
	Male	22	-0.281	3.008	0.918	isometry
CWiWR	Female	58	0.082	1.773	0.777	- allometry
	Male	22	-0.660	2.525	0.857	- allometry

Statistical description of the parameters including sample size (*N*) (number of specimens observed), length-weight relationship parameters '*a*' and '*b*' with 95% confidence limits, and coefficient of determination (R^2) for blue crabs are shown in Table 3.

When analyzing the nutritional composition of blue crabs, in female blue crabs, protein content was highest in the carapace meat (77.39±1.88%), followed by the right cheliped, left cheliped, gonad, carapace shell, right cheliped shell, and left cheliped shell; lipid content was highest in the gonad (23.83±1.75%); carbohydrate content was highest in the carapace shell (30.54±5.42%); moisture content was highest in the carapace meat (80.45±3.47%); and ash content was highest in the right cheliped shell (70.18±1.70%). In male blue crabs, similar to females, the highest protein content was found in carapace meat (78.89±3.24%), lipids in sperm (15.33±1.15%), carbohydrates in carapace shell (25.34±2.85%), and moisture in carapace meat (80.90±3.25%). However, the highest ash content was observed in the left cheliped shell (70.53±1.07%) (Table 4).

According to the Spearman correlation analysis (Table 5), significant relationships were identified among the biochemical parameters of the blue crab. Protein content showed strong positive correlations with lipid (r=0.702, p<0.01) and moisture content (r=0.947, p<0.01), whereas significant negative correlations were observed with carbohydrate (r=-0.662, p<0.01), ash (r=-0.693, p<0.01), and tissue type (r=-0.898, p<0.01). These findings indicate that protein-rich tissues are also characterized by high moisture content, while containing lower levels of carbohydrates and mineral substances. Lipid content was positively correlated with moisture (r=0.787, p<0.01) and negatively correlated with ash content and tissue type, suggesting that lipid accumulation is greater in softer edible tissues than in mineralized structures. Carbohydrate content exhibited positive correlations with ash (r=0.578, p<0.01) and tissue type (r=0.741, p<0.01), indicating that carbohydrates are relatively more abundant in mineral-rich shell tissues. In addition, the negative correlation detected between moisture and ash content (r=-0.624, p<0.01) suggests that increasing water content is associated with reduced mineral density. No significant correlations were found between sex and the examined biochemical parameters, indicating that biochemical composition is influenced primarily by tissue type rather than sex. Overall, these results demonstrate that the biochemical composition of blue crab varies substantially according to the physiological and structural characteristics of different tissues.

Table 4. Biochemical composition of blue crab freeze-dried tissue (meat, gonad, sperm) and shell (%) (Mean±SD)

	Sex	Protein	Lipid	Carbohydrate	Moisture	Ash
Carapace Meat	Female	77.39±1.88	12.67±2.31	2.71±0.15	80.45±3.47	7.23±1.06
	Male	78.89±3.24	14.00±2.00	3.15±2.81	80.90 ±3.25	3.96±1.71
Right Cheliped Meat	Female	75.52±0.49	11.33±3.06	5.22±2.90	80.71±5.55	7.92±1.04
	Male	76.26±4.40	12.00±2.00	3.76±2.38	79.96±10.99	7.98±1.03
Left Cheliped Meat	Female	77.15±0.39	10.67±1.15	5.08±0.73	80.15±10.52	7.10±2.03
	Male	79.11±0.65	10.67±4.16	3.93±2.62	82.10±6.06	6.30±2.88
Gonad	Female	54.43±0.83	23.83±1.75	19.09±1.95	71.76±6.50	2.65±2.30
Sperm	Male	70.79±1.20	15.33±1.15	7.60±2.00	71.76±6.50	6.27±1.15
Carapace Shell	Female	13.00±0.62	2.97±0.96	30.54±5.42	37.55±4.77	53.49±4.09
	Male	13.26±0.35	3.32±2.32	25.34±2.85	35.06±4.76	58.08±0.70
Right Cheliped Shell	Female	10.42±0.99	2.00±0.00	17.40±2.65	26.44±8.71	70.18±1.70
	Male	9.43±0.80	4.60±1.11	15.77±1.32	26.43±8.50	70.20±1.00
Left Cheliped Shell	Female	9.44±0.28	3.31±1.13	18.07±1.31	26.09±6.59	69.18±0.37
	Male	9.30±0.08	2.00±3.46	18.17±4.07	25.37±7.41	70.53±1.07

Table 5. Spearman correlation of protein, lipid, carbohydrate, moisture, ash, sex (female and male) and tissue (Carapace meat, right cheliped meat, left cheliped meat, gonad, sperm, carapace shell, right cheliped shell and left cheliped shell)

Spearman	Protein	Lipid	Carbohydrate	Moisture	Ash	Sex	Tissue
Protein	1						
Lipid	0.702*	1					
Carbohydrate	-0.662*	-0.439*	1				
Moisture	0.947*	0.787*	-0.566*	1			
Ash	-0.693*	-0.735*	0.578*	-0.624*	1		
Sex	0.051	0.049	-0.132	-0.002	0.033	1	
Tissue	-0.898*	-0.688*	0.741*	-0.863*	0.764*	0.018	1

**Correlation is significant at the 0.01 level.*

4. Discussion

In the present study, the proportion of female blue crabs (72%) was found to be considerably higher than that of males (28%). It is well established that sex ratios in crab populations are not constant and may vary depending on sampling period, environmental conditions, migration behavior, and reproductive cycles (Permatahati et al., 2025). Similarly, Türeli (1999) reported that females constituted 68.8% of the blue crab population in the Gulf of Iskenderun. This pattern may be explained by the tendency of females to aggregate in specific habitats during reproductive periods, whereas males generally exhibit a broader spatial distribution (Permatahati et al., 2025).

Morphometric analyses revealed that the mean carapace width of female individuals was greater than that of males. This finding may be associated with reproductive adaptations related to egg-carrying capacity in females. However, several studies have reported that male crabs may attain larger body sizes (Iveša et al., 2025). Türeli (1999) reported a mean carapace width of 12.69±2.33 cm in adult females, while Enzenrob et al. (1997) documented carapace widths ranging between 10.8 and 15.1 cm. In addition, Prager et al. (1990) reported an average carapace width of 14.7 cm in ovigerous females. These findings indicate that the morphometric values obtained in the present study are generally consistent with the existing literature.

Regression analyses of the length–weight relationships demonstrated distinct growth patterns between female and male individuals. In the CLWR, females exhibited negative allometric growth (b=1.809), whereas males showed an isometric growth pattern, with the b value being very close to 3 (b=3.008). This result indicates that body weight increased proportionally with carapace length in males. In contrast, the predominance of length increase over weight gain in females may be associated with energy allocation toward reproductive activities

and metabolic processes (Hartnoll, 1983; Atar & Seçer, 2003).

The CWiWR revealed negative allometric growth in both sexes. Nevertheless, the relatively higher b value and high coefficient of determination (R^2=0.857) observed in males indicated that body weight increased more rapidly with increasing carapace width. This pattern may be related to enhanced muscle development and pronounced cheliped enlargement in males. In brachyuran crabs, chelipeds are functionally important structures involved in prey capture, defense, territorial competition, and mate acquisition, and they are generally more developed in males (Lee & Seed, 1992; Mariappan et al., 2000). In the present study, the larger right cheliped measurements observed in males support the existence of functional asymmetry associated with dominant claw usage. Similarly, the relatively larger right cheliped measurements in females suggest that bilateral morphological asymmetry may also occur in female individuals.

In length–weight analyses, *b* values lower than 3 indicate negative allometric growth, suggesting that body dimensions increase at a faster rate than body weight. Negative allometric growth is generally associated with food limitation, population density, environmental stress, and developmental stages of individuals (Sahu et al., 2026). Furthermore, length–weight relationships are influenced by several biological factors including sex, sexual maturity, molting stage, and carapace morphology (Olmi & Bishop, 1983). Therefore, the growth differences identified in this study may be associated with the environmental conditions and population structure of Saros Bay (Çanakkale, Türkiye).

The high R^2 values obtained from the regression analyses demonstrated strong relationships between carapace measurements and body weight, indicating that the models explained the variability in the data to a considerable extent. These findings suggest that both carapace length and carapace width are reliable morphometric parameters for biomass estimation and population assessments. Similarly, Atar and Seçer (2003) reported that width/length–weight relationships exhibit high correlation and provide a reliable method for population evaluation.

Biochemical analyses revealed that blue crab represents an important nutritional resource due to its high protein content. The protein values determined in this study were generally consistent with those reported in the literature, indicating that the nutritional quality of the species may exhibit similar characteristics across different geographical regions. The biochemical composition of different body parts varied considerably depending on tissue type and sex. The highest protein content was detected in the carapace meat of male individuals (78.89±3.24%), while similarly high protein levels were also recorded in the carapace and cheliped meat of females. Lipid content was particularly high in gonadal tissues (23.83±1.75%), indicating substantial energy storage associated with reproductive activity. Carbohydrate levels were generally low in all tissues, although relatively higher values were observed in shell tissues. Moisture content ranged between 71% and 81% in edible tissues, confirming the high water content characteristic of blue crab meat. In contrast, ash content was markedly higher in shell tissues (53–70%), reflecting their mineral-rich composition.

The generally higher protein levels observed in males may be associated with stronger muscle development and increased metabolic activity. Türeli et al. (2000) reported 18.93% protein, 22.43% moisture, and 2.34% crude ash in the carapace meat of male blue crabs and emphasized that blue crab meat constitutes a protein-rich food source. Furthermore, biochemical composition is influenced not only by species-specific characteristics but also by tissue type and seasonal variation. Türeli et al. (2002) reported that the distribution of protein, lipid, and ash in cheliped and carapace meat varies according to seasonal changes.

5. Conclusion

The findings of this study revealed that female individuals were dominant in the studied population and that the sex ratio could vary depending on environmental and biological factors.

Morphometric analyses revealed that female individuals had a larger carapace width than male individuals, and negative allometric growth was detected in the length-weight relationship. This indicates that height increase occurs faster than weight increase, and that the growth pattern can be influenced by environmental conditions. Furthermore, the strong correlation between carapace measurements and weight demonstrates that these parameters are reliable indicators in population analyses.

Biochemical analyses have revealed that the blue crab is a highly nutritious species with a high protein content. The variation in protein, lipid, and ash components among tissues is thought to be related to the species' physiological structure, energy storage strategies, and reproductive processes. This suggests that biochemical composition can vary not only depending on species characteristics but also on environmental conditions and seasonal changes.

Overall, the blue crab population in this area has been determined to have significant potential in terms of both

morphometric and biochemical aspects. However, due to the sensitivity of its growth characteristics and population structure to environmental factors, regular monitoring studies, seasonal assessments, and the development of appropriate fishing strategies are of great importance for the sustainable management of the species.

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Conflict of interest

The authors declare that there is not any conflict of interest regarding the publication of this manuscript.

Ethical Approval

This article does not require ethics committee approval.

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