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Growth parameters of the invasive blue swimming crab *Portunus segnis* (Forskål, 1775) (Crustacea) in the North-Eastern Mediterranean, Türkiye

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ABSTRACT

The blue swimming crab, *Portunus segnis*, is a Lessepsian and the most abundant and economically significant crab species on the Mediterranean Sea coast of Türkiye. However, there are a few studies on the growth of *P. segnis* in Türkiye. Our objective is to determine the allometry, and growth parameters of *P. segnis* in Iskenderun Bay, the Northeastern Mediterranean. Blue swimming crabs were sampled using a bottom trawl net from July 2014 to June 2015. Totally 320 specimens were caught. The carapace width (CW) varied from 38.1 to 163.17 mm (mean: 109.88±27.56 mm) and the total weight (TW) was measured at a minimum of 3.46 and a maximum of 324.36 g. The width (CW)- weight (TW) relationships of the crabs were estimated as log(TW)=2.9028CW-9.0664 (R^2=0.7452) for the females and log(TW)=2.9773CW-9.3842 (R^2=0.8433) for the males. The carapace width-weight relationships of both sexes indicated that the growth pattern is allometric ($p<0.05$). The von Bertalanffy growth parameters were computed as CW_∞=166.00 mm, K=1.2 year^{-1}, t_0=-1.62 years, C=0, WP=0.20, and Φ′=4.519 for all crabs. The von Bertalanffy growth parameters of *P. segnis* were determined on the coasts of Türkiye, for the first time.

Keywords: Crustacea, Decapoda, *Portunus segnis*, von Bertalanffy, Allometry

Introduction

Invasive species, prevalent in marine and estuarine ecosystems cause significant changes in the areas they invade (Havel et al., 2015). In such systems, invading species decrease the number of native species (Brenchley & Carlton, 1983). Lack of predators, parasites, and diseases are the most important reasons for the success of invasive species (Williamson & Fitter, 1996). In detail, a lack of predators gives the invasive species possibility of higher survival, higher growth, and lower mortality (Williamson, 1996). Thus, they cause ecological change and threats to biodiversity (Katsanavakis et al., 2014).

The blue swimming crab, *Portunus segnis* (Forskål, 1775) (Brachyura: Portunidae) is native to the West Indian Ocean and distributed from Pakistan to South Africa and to the Red Sea (Lai et al., 2010). It is one of the most successful invasive species in the Mediterranean (Klaoudatos & Kapiris 2014). The first record of *P. segnis* in the Mediterranean was on the coasts of Egypt, as *Neptunus (Portunus) pelagicus* (Fox, 1924). Lai et al., (2010) revised the Portunus species according to their morphometric, geographic, and genetic differences. Their research showed that in the Mediterranean ecosystem just *P. segnis* species is available. Gruvel (1928) reported the first record of *P. segnis* in Türkiye in Iskenderun Bay. *P. segnis* is distributed in the Sea of Marmara, the Aegean Sea, and the Levantine seacoasts of Türkiye (e.g. Ozcan, 2003; Bakır et al, 2014). In Iskenderun Bay, *P. segnis* is one of the most abundant crab species along with *Callinectes sapidus* and *Charybdis longicollis* (Ozcan et al., 2005). In addition, *P. segnis* is the second most economically significant Decapod Crustacean after *C. sapidus* (Tureli et al., 2000, Doğan et al., 2007). Also, it is a substantial nutrient source for humans with a high protein value and a low lipid ratio (Tureli et al., 2000).

Growth is an important model in understanding the ecology of the species, predicting the recruitment in fisheries, and regulating the stock assessment and management of the species in Crustaceans (Miller & Smith, 2003). Significant aspects of blue swimming crab growth were studied in its native range (e.g. Noori et al., 2015; Giraldes et al., 2016). Although the life history of the blue swimming crab in the endemic range has been investigated extensively, there is limited knowledge about it outside of the natural range (Tureli et al., 2016). In Türkiye, some research were carried out about *P. segnis* concerning meat composition and nutritional quality (e.g. Tureli et al., 2000; Gokoglu & Yerlikaya, 2003), heavy metal content (e.g. Olgunoglu & Olgunoglu, 2016), population biology (e.g. Inandi, 2015) and reproductive biology (Tureli & Yesilyurt, 2017).

This study aimed to estimate the allometry and growth parameters of *P. segnis* in Iskenderun Bay (non-endemic range). Our results were compared with the growth estimations of *P. segnis* within its native region. Thus, it will form an idea about the status of the population of the alien species in Iskenderun Bay. It is thought that the results of this research will contribute to our knowledge about the population and management of non-indigenous species on the Mediterranean coasts of Türkiye.

Material and Methods

Study Area and Sampling Methods

Blue swimming crabs were caught between July 2014 and June 2015 monthly, except for February. Sample collection was done using a small bottom trawl net at 0-50 m depths towed for 45 minutes in Yumurtalik Cove, Iskenderun Bay (Northeastern Mediterranean) (Figure 1). Water quality parameters were quantified by a YSI 6600 multi-parameter probe. Carapace width (CW) (accurate to 0.01 mm) and total weight (TW) (accurate to 0.1 g) of all crabs were measured. The sexes of the crab specimens were recorded.

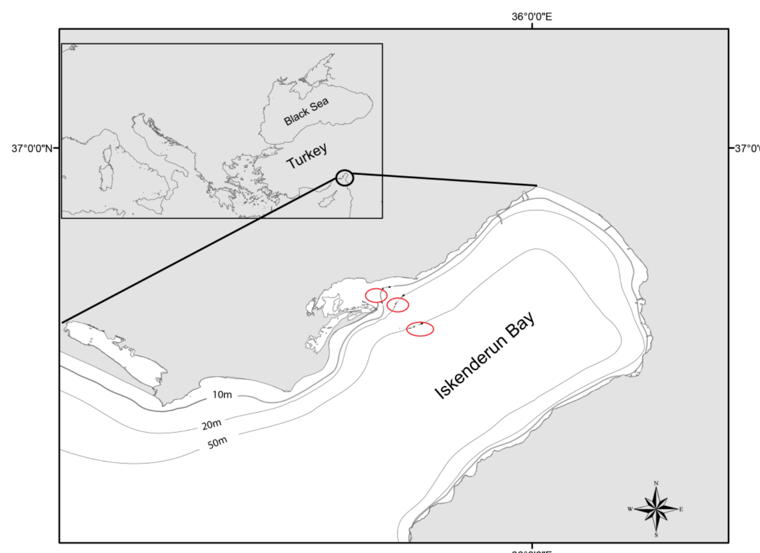

Figure 1. Yumurtalık Cove (Iskenderun Bay, Northeastern Mediterranean-Türkiye)

Data Analysis

To determine the growth was used to allometric $Y=a.x^b$ shaped growth equation. The logarithm of both sides of the allometric growth equation, which is curvilinear, is taken and converted into a linear relation equation in the form of $Log(W)=Log(a)+bLog(CW)$ for females and males. Where W is the total weight (g), CW is the carapace width (mm), a is the allometric constant, and b is the slope of the linear equation (Haefner, 1985).

Growth was estimated using the monthly length-frequency distributions. The crab size distributions were grouped into length classes at 10 mm intervals. Growth parameters were determined with the von Bertalanffy growth function. The FISAT software was used for data analysis (Gayanilo et al., 2005). The seasonal von Bertalanffy growth equation may be defined as:

$CW(t)=CW_{\infty}[1-\exp\{-K(t-t_0)-(CK/2\pi)(\sin 2\pi(t-t_s)-\sin 2\pi(t_0-t_s))\}]$

Where CW_{∞} is the asymptotic carapace width, K'= curving parameter of the growth equation (yr^{-1}), t_0= age at the carapace width is zero, t_s= the growth rate that is the highest during the year, C= size of the seasonal variation in growth, which ranges between 0 and 1 (i.e. when C values close to 0 no seasonal variation, when close to 1 the amplitude is maximal). The CW_{∞} and K growth parameters were calculated by ELEFAN, and t_0 was computed for growth fitting with Pauly's equation (1983):

$Log(-t_0)=-0.3922-0.2752*\log(CW\infty)-1.038*\log(K)$

Φ, the growth performance index, was measured as $\Phi'=\log(K)+2\log(CW\infty)$ (Pauly & Munro, 1984).

The winter point (WP) was calculated as $WP=t_{w+}0.5$ shows the period of slowest growth. WP range between 0 and 1.

The von Bertalanffy growth parameters were calculated for all individuals (including females, males, and juveniles altogether) because the females and males numbers were insufficient for calculation separately.

The maximum age was estimated by using the formula: $t_{max}=3/K$. The age-length figure was drawn related to t_{max}.

Results and Discussion

The blue swimming crab *P. segnis* individuals were sampled in all sampling months during the study (except February). A total of 320 specimens (140 females, 110 males, and 70 juveniles) of *P. segnis* were caught. The carapace width and weight ranged from 38.10 to 163.17 mm (mean 109.88±SD 27.56 mm) (Table 1) and 3.46 to 324.36 g, respectively for all crabs. The dominant width interval was found between 110 and 120 mm for the females, 130 and 140 mm for the males, and 50 and 60 mm for the juveniles (Figure 2).

The carapace widths (CW) vary between 55.26 mm and 163.17 mm in females, while it varies between 48.77 mm and 154 mm in males (Table 1). Our results indicated that the carapace width of the females was significantly larger ($p=0.00$) than that of the males. Figure 3 showed the monthly length frequency of the females and males.

The CW-TW relationships of the specimens were Log TW=2.9028CW-9.0664 ($R^2=0.7452$) for the females and Log TW=2.9773CW-9.3842 ($R^2=0.8433$) for the males (Figures 4 and 5). The CW and TW relationships showed that, in both sexes, growth is allometric ($p<0.05$).

The seasonal von Bertalanffy growth function was measured using the length-frequency distribution analysis, for all samples, including juveniles (Table 2). All individuals had at least two cohorts during the studied period (Figure 6). Seasonality was not determined (C=0). The growth performance index (Φ´) was 4.519 for all specimens (Table 2).

Figure 7 showed that, in the first phase of life, the blue swimming crab had fast growth rates. In the second phase, the growth began to decline, but it did not become too slow. In the third phase of its life, the crab's growth was slow and stagnant until it reached its maximum size.

Table 1. The mean carapace width (mm), range in width for blue swimming crabs from Yumurtalik Cove sampled between July 2014-June 2015

Sex	n	Mean ±SD	Minimum CW	Maximum CW
Females	140	125.52 ±16.80	55.26	163.17
Males	110	111.65 ±23.11	48.77	154.00
Juvenile	70	75.82 ±20.54	38.10	117.45
All	320	109.88 ±27.56	38.10	163.17

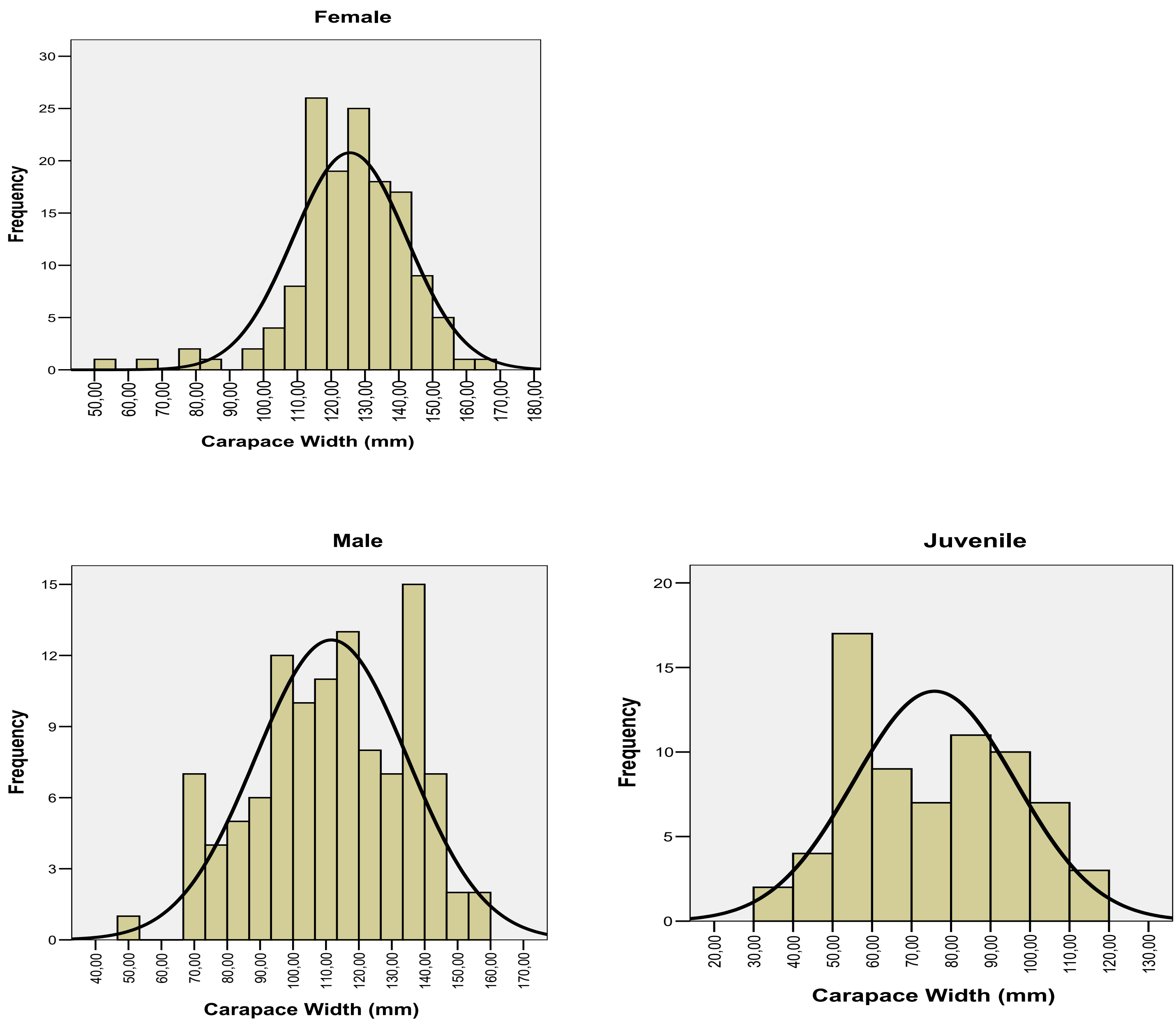

Figure 2. Length-frequency distribution of females, males and juvenile of blue swimming crab between July 2014-June 2015 in Yumurtalik Cove

Figure 3. Monthly length- frequency distribution of female, male and all blue swimming crabs

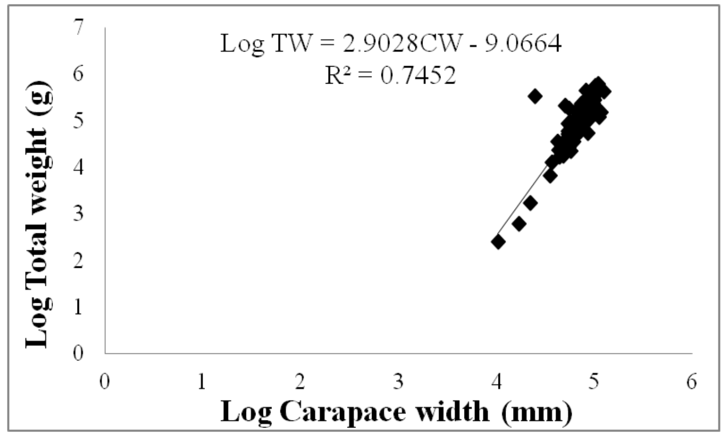

Figure 4. Carapace width- total weight relationship of *P. segnis* females

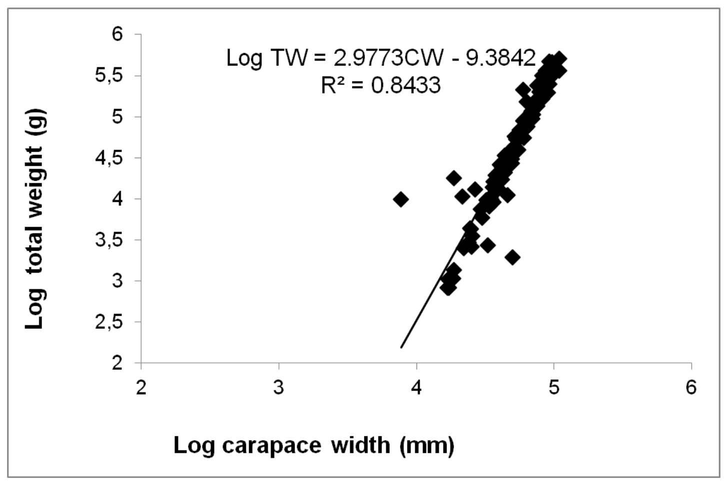

Figure 5. Carapace width- total weight relationship of *P. segnis* males

Table 2. von Bertalanffy growth parameters for *P. segnis*

CW_∞ (mm)	K (year-1)	t_0	C	WP	Φ'	Rn
166.00	1.2	-1.62	0	0.20	4.519	0.270

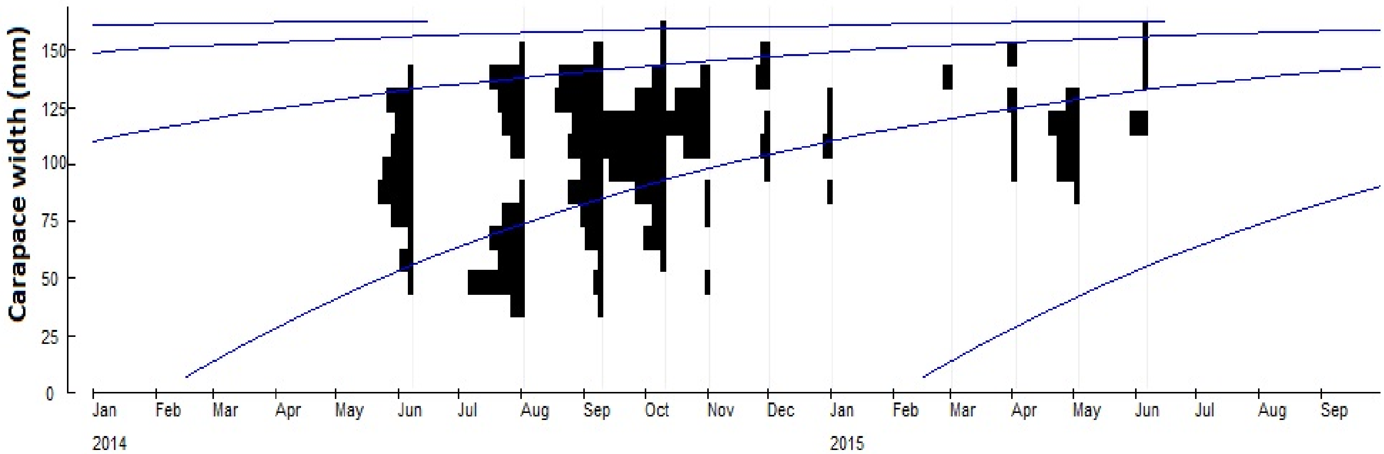

Figure 6. Length-Frequency distribution with seasonal von Bertalanffy growth curves for both sexes of *P. segnis*

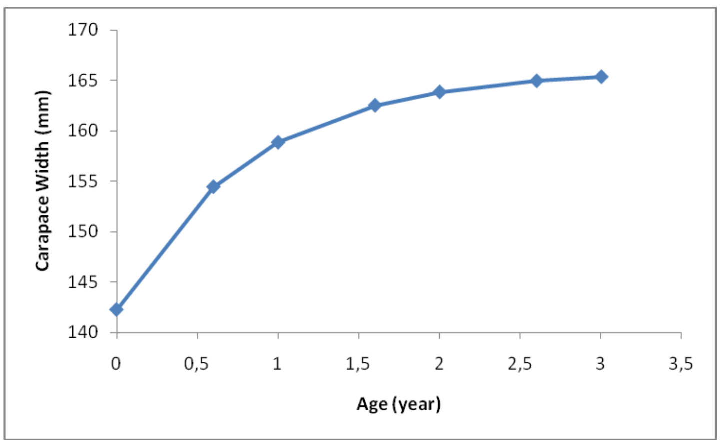

Figure 7. Growth curve of blue swimming crab, *P. segnis*

The growth parameters for blue swimming crabs were estimated in the Eastern Mediterranean, in its non-native range. In this study, CW was measured with a minimum of 55 and a maximum of 163 mm in females and a minimum of 48 and a maximum of 154 mm in males (Table 1). In Iskenderun Bay, the largest male and female sizes were determined as 170 mm CW and 171.5 mm CW, respectively, by Inandi (2015). The smallest male and female sizes were measured as 47.2 mm CW and 51.3 mm CW, respectively. Likewise, Ozcan & Akyurt (2006) proved that the CW frequency of males ranged between 40 and 169.9 mm, and the CW frequency of females ranged between 40 and 182.2 mm in Iskenderun Bay. As seen, our results on the CW range were found lower than those notified in earlier research in the same area. In the Gulf of Gabes, the minimum CW was lower than that in our study for males and females but in the Persian Gulf, the minimum CW was larger than that in our study for males and females (Hosseini et al., 2014a; b; Noori et al., 2015). In some of these previous studies, the maximum CW was larger than that in our study for males and females (Hosseini et al., 2014b), while in others, it was similar to those of females in our study (Hosseini et al., 2014a; Noori et al., 2015).

Our results indicated the carapace width of the females was larger than that of the males, and the difference was found to be statistically significant ($p=0.00$). Moreover, in Iskenderun Bay, Inandi (2015) reported similar data, but the difference was not statistically significant. In another study in the Gulf of Gabes, in the species' nonnative area, Hajjej et al., (2016) found that the mean carapace width of males was significantly bigger than that of females ($p<0.05$), same as those in the Persian Gulf, in its native area (Hosseini et al., 2014a; b).

On the Mediterranean Sea coast of Türkiye, a negative allometric growth pattern was found between the carapace width and weight in both males and females (Pauly's t-test $P<0.05$) (Figures 3 and 4, Table 3). In accordance with the morphology of the species, it can be said that the increase in weight is slower than the increase in carapace width. In Türkiye, there had been no data on the carapace width-total weight relationship of *P. segnis*. So, the results of this study were compared to those of earlier research from the native and other non-native ranges of *P. segnis*. Some other studies in native regions also provided similar results (Kamrani et al., 2010; Hosseini et al., 2014a; Giraldes et al., 2016), but Safaie et al., (2013) and Noori et al., (2015) found that growth is a positive allometric in both sexes and in males, respectively. In a non-native area of the species, the Gulf of Gabes (Tunisia), one study showed similar results (Hajjej et al., 2016). On the other hand, Ben Abdallah-Ben Hadj Hamida et al., (2019) indicated different results (Table 3).

In this study, for the first time, the von Bertalanffy growth parameters of *P. segnis* were determined on the coasts of Türkiye. The data of growth studies of blue swimming crab in its native range were summarized in Table 4. Findings of these researches in its native region showed a difference from our results. The value of CW_∞ of the males and females was found to be lower than those reported from the Persian Gulf (Kamrani et al., 2010; Safaie et al., 2013). The value of K for both sexes for the reported estimates in the native region (in the Persian Gulf) (Kamrani et al., 2010) was 0.98 yr^{-1}, whereas, for the North-Eastern Mediterranean, it was 1.2 yr^{-1}. The seawater temperature is high throughout the year in İskenderun Bay (between 16˚C -28˚C). At higher temperatures, growth rates increase. So our findings were normal. It can be said that results compatible with the high growth rate of invasive species are obtained. (Table 4). The growth performance index Φ′ calculated from our research was smaller than those reported from the Gulf of Oman, Iran (male: 11.04, female: 10.91) (Safaie et al., 2013). But, in the Gulf of Gabes (Tunisia), in a non-native area, similar results were reported (Hajjej et al. 2016; Ben Abdallah-Ben Hadj Hamida et al., 2019).

Tablo 3. The carapace width (CW)- weight (TW) relationship parameters for *P. segnis* in other studies

Sex	Sample number	CW (mm)	TW-CW relationship	R^2	Location	Distribution	Researcher
M	424	-	$TW = 0.0002CW^{2.757}$	0.93	Northern Persian Gulf	Native	Kamrani et al. 2010
F	348	-	$TW = 0.0002CW^{2.748}$	0.88			
T	772	23-173	$TW = 0.0002CW^{2.762}$	0.91			
M	1839	-	$TW = 0.00003CW^{3.214}$	0.96	Persian Gulf and Gulf of Oman	Native	Safaie et al. 2013
F	1769	-	$TW = 0.00001CW^{3.299}$	0.84			
T		-	$TW = 0.00002CW^{3.232}$	0.89			
M	418	75-175	$\text{Log } TW = -16.532 + 2.334 \log CW$		Persian Gulf	Native	Hosseini et al. 2014a
F	448	70-165	$\text{Log } TW = -15.278 + 2.554 \log CW$				
M	148	80.75-148.96	$\text{Ln } TW = 3.45 \text{ Ln}CW-11.64$	0.96	Persian Gulf	Native	Noori et al. 2015
F	154	84.54-163.42	$\text{Ln } TW = 3.03 \text{ Ln}CW-9.72$	0.93			
M	40	-	$TW=0.36*CW^{2.567}$	0.95	Western Arabian Gulf	Native	Giraldes et al. 2016
F	27	-	$TW=0.26*CW^{2.665}$	0.93			
M	335	39.26-155.5	$\text{Log } TW = 3.1444CW-10.181$	0.96	Gulf of Gabes	Non-native	Hajjej et al. 2016
F	299	34.27-148.5	$\text{Log } TW = 2.7433CW-8.4617$	0.93			
T			$\text{Log } TW = 2.9796CW-9.47$	0.94			
M	1552	45-168	$\text{Log } TW=-10.287+3.1870 \text{Log } CW$	0.97	Gulf of Gabes	Non-native	Ben Abdallah- Ben Hadj Hamida et al. 2019
F	1392	50-159	$\text{Log } TW=-9.1512+2.9198 \text{Log } CW$	0.96			
T	2944	-	$\text{Log } TW=-9.8910+3.0931 \text{Log } CW$	0.96			
M	110	48.77-154	$\text{Log } TW = 2.9773CW-9.3842$	0.84	Mediterranean of Türkiye	Non-native	This study
F	140	55.26-163.17	$\text{Log } TW = 2.9028CW-9.0664$	0.74			

Table 4. Published von Bertalanffy growth coefficients for *P. segnis*

Location	k (yr^{-1})	CW_∞ (mm)	t_0 (yr)	Source
Northern Persian Gulf	♂ 1.2 ♀ 1.1 B: 0.98	♂ 168 ♀ 177.9 B: 172.5	- - -	Kamrani et al., 2010
Persian Gulf and Gulf of Oman	♂ 1.7 ♀ 1.6	♂ 191 ♀ 185	♂ -0.055 ♀ -0.059	Safaie et al., 2013
Gulf of Gabes	♂ 1.34 ♀ 1.42 B: 1.02	♂ 206.48 ♀ 183.89 B: 190.60	♂ -0.130 ♀ -0.127 B: -0.177	Ben Abdallah- Ben Hadj Hamida et al., 2019
Mediterranean of Türkiye	B: 1.2	B: 166	B: -1.62	Present study

B: both

Growth was observed to be relatively constant throughout the year. As for the water temperature, the lowest mean value was measured as 16.60±0.24˚C, and the highest mean value was measured as 28.55±0.52˚C. The salinity change during the study was between 37.40±0.65‰ and 38.61±0.78‰ in Iskenderun Bay. This supported our interpretation of the data regarding the continuity of growth throughout the year.

Conclusion

The present research findings provided new information which is morphometric characters, growth patterns and population status of *P. segnis* on Turkish coasts. Blue swimming crab is commercially significant at local restaurants in Mersin and Iskenderun Bay. Also, it will be formed the basis for future research which is fisheries' biology and management, *P. segnis* population dynamics, stocks assessment, and impact on ecological systems of the Northeastern Mediterranean, Türkiye.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

Ethics committee approval: Ethics committee approval is not required for this study.

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Disclosure: -

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