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Allometric relationship and meat yield of *Chama pacifica* broderip, 1835 from the Gulf of Antalya, Turkey

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Abstract

In this study, the allometric relationship and the meat yield of the large Pacific jewel-box *Chama pacifica* Broderip, 1835 were investigated. *C. pacifica* samples were by scuba diving at depths of 3-8 m in the Gulf of Antalya. The relationship of total shell length and total shell weight was determined as TW = $2.2693 \times TSL^{2.5327}$ ($R^2 = 0.69$). The mean flesh weight and mean meat yield were determined to be $11{,}07 \pm 0.445$ g and $6.84 \pm 0.18\%$, respectively. This research revealed the meat yield data of *C. pacifica* and its potential importance as a food source.

Keywords: Chama pacifica; Pacific jewel-box; flesh weight; meat yield; allometric relationship

1. Introduction

The Eastern Mediterranean Sea is prone to biological invasions because of its location between the Atlantic, Pontic and Erythrean regions, intensive marine traffic, and occurrence of abundant aquaculture activities in the coastal waters (Arvanitidis et al., 2006). The opening of the Suez Canal in 1869, allowing the introduction of the Indo-Pacific and the Red Sea originated species, was the main reason for biological invasion in the Mediterranean Sea (Galil, 2007; Zurel et al., 2011). A few of the Mediterranean species were partially or totally displaced by these invaders (Galil, 2007). One of these invaders was *Chama pacifica* Broderip, 1835 (Bivalvia: Chamidae), which was first recorded from Egypt in the Mediterranean Sea by Tillier and Bavay in 1905. This bivalve has settled in many locations of the south-eastern basin such as Israel, Lebanon, Turkey, Syria and Greece (Otero et al., 2013; Türkmen et al., 2005).

C. pacifica is a very peculiar species often taken into consideration as one of the most variable cosmopolitan chamids in the CIESM Atlas of Exotic Species in the Mediterranean Sea (Crocetta & Russo, 2013). *C. pacifica* was detected on the coast of Phalselis Ancient City in the Gulf of Antalya, where exotic species have been generally recorded in Turkey (Gökoğlu et al., 2017).

substrates of the continental shelf, where they are usually well concealed by overgrowing fouling organisms that extend equally over the natural rocks and shells (Zurel et al., 2011). *C. pacifica* is generally distributed on exposed areas from the tidal zone down to several meters, sometimes to 40 m depth. It can grow abundantly in port areas, but its tolerance to salinity changes is low (Otero et al., 2013). *C. pacifica* is a precious species for seashell collectors and has a low commercial market value (Otero et al., 2013; Katsanevakis et al., 2014).

Katsanevakis et al. (2014) reported that *C. pacifica* dominated benthic communities by outcompeting other sessile species for space or food, had positive impacts on climate regulation and lifecycle maintenance. It was also reported as a structural engineer due to its influence on increasing diversity and species richness. (Streftaris & Zenetos, 2006; Katsanevakis et al., 2014). Katsanevakis et al. (2014) have proposed it as one of the highly effective alien and cryptogenic marine species reported on ecosystem services or biodiversity.

Its shell has a strong irregular outline from suboval to subcircular, having longer or narrower forms as reported (Otero et al., 2013; Crocetta & Russo, 2013). The length and width of the shells can reach up to about 100 mm and it is considered to be quite large bivalve species. It has solid shells and the valves are of different sizes (Otero et al., 2013; Crocetta & Russo, 2013). The left lower valve is generally wider than the right valve, which is at the top and is generally flat. The outer colour changes in a wide range, from white to pinkish-red with pale-rose blotches around the shell boundary; the backbones are often white (Otero et al., 2013; Crocetta & Russo, 2013).

C. pacifica has separate sexes and fertilization is external (Otero et al., 2013). Spawning occurs once a year usually in spring and summer when the water temperature is more than 21 °C. This prolonged spawning period contributes in part to the

settlement success in the new surroundings (Zurel et al., 2011; Otero et al., 2013).

Knowledge on the meat yield, biology and growth of *C. pacifica* in the Gulf of Antalya is limited. In our study, we aimed to determine the allometric relationship and the meat yield of *C. pacifica* from the Gulf of Antalya in order to examine its potential usage as an important source of food for humans.

2. Materials and methods

2.1. Sampling

A total of 92 *C. pacifica* samples were by scuba diving at depths of 3-8 m in the Gulf of Antalya (between 36^{0}52'54.49'N 30^{0}41'37.67'E) on April 21st of 2018 (Figure 1).
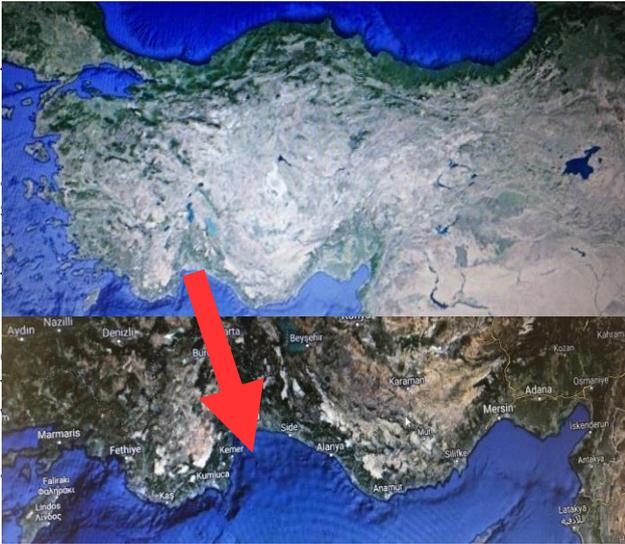

Figure 1. Sampling area of *C. pacifica*; the Gulf of Antalya, Turkey (photos taken from Google Earth, 2018).

2.2. Determination of allometric relationships

Samples of *C. pacifica* were transported to the laboratory and fouling organisms attached to their shells were removed (Figure 2). Total shell length (TSL) (the maximum length along the anterior-posterior axis), total shell width (TSW) (maximum distance on the lateral axis) and total shell height (TSH) (from the umbone area to the opposing valve margin) of the *C. pacifica* were measured by a caliper to the nearest 0.1 mm. The total weight and flesh weight were determined by using a digital balance with an accuracy of 0.01g. For flesh weight measurements, all specimens were opened using a hammer and the flesh removed.

Shell length and weight relationship was calculated according to the allometric equation: Weight= a* size^b using the least square regression analysis of Microsoft Excel software. The exponential relationship can be shown by a linear equation as follows; log Weight = log a + b log size.

The term "weight" referred to the total weight (TW) and total flesh weight (FW). L was also related to size such as TSL, TSW and TSH where "a" is the intercept and "b" is the slope of the function. T-test was used to determine the significance of b values (Pauly, 1984; Berik et al., 2017).

Figure 2. The large Pacific jewel-box (*Chama pacifica*) from the Gulf of Antalya

2.3. Sex ratio

Sex of the samples was determined with naked eye and by stereo microscope. Total numbers of males and females were used to calculate the sex ratio (Zurel et al. 2011).

2.4. Specifying of meat yield

Parts of *C. pacifica* for meat yield calculation were shown in Figure 3. Meat yield was determined by the following equation; Meat Yield= [Meat weight (g) / Total weight (g)] x 100 (Yıldız et al., 2011; Çelik et al., 2012; Berik et al., 2017).
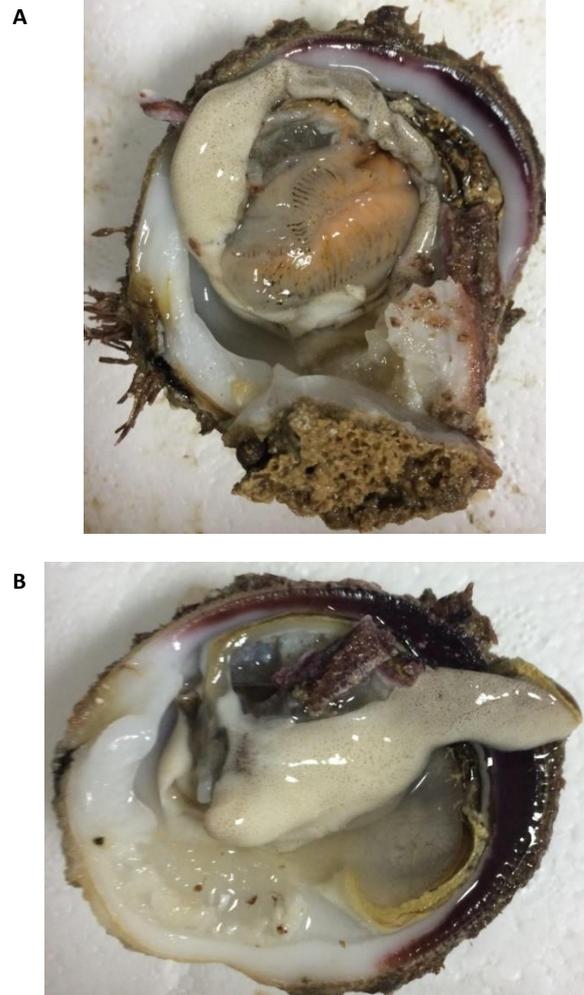

Figure 3. Parts of *C. pacifica* used in meat yield calculation A: Meat part of female *C. pacifica*, B: Meat part of male *C. pacifica*

3.   Result and discussion

3.1.   Shell dimensions and allometric relations

Total shell lengths of *C. pacifica* ranged from 3.2 to 6.7 cm and total weights from 42.99 to 323.75 g (Table 1).

Table 1
Descriptive statistics of *Chama pacifica* from the Gulf of Antalya.

Mesurements	N	Minimum	Maximum	Mean (SE)
TSL	92	3,2	6,7	5,31±0,071
TW	92	42,99	323,75	164,51±6,251
TSW	92	2,5	7,8	4,39±0,087
TSH	92	4,2	8	6,51±0,085
FW	92	2,45	22,04	11,07±0,445

TSL, Total Shell Length (cm); TW, Total Weight (g); TSW, Total Shell Width (cm); TSH, Total Shell Height (cm); FW, Flesh weight of *C. pacifica* (without shell) (g).

The TSL-TW relationship was calculated as TW = 2.2693*$TSL^{2.5327}$ (R^2= 0.69) (Figure 4). The TSL frequency distribution was given in Figure 5.
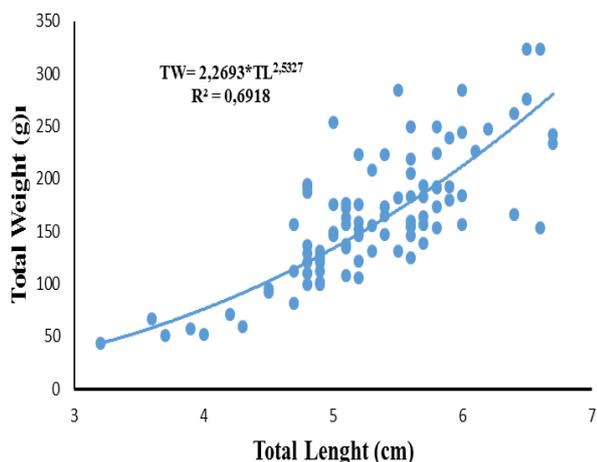

$$TW = 2,2693*TL^{2,5327}$$
$$R^2 = 0,6918$$

Figure 4. The TSL-TW relationship of *Chama pacifica* collected from the Gulf of Antalya.
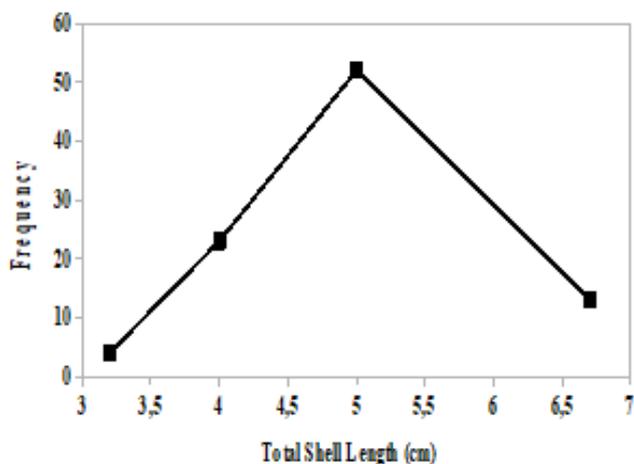

Figure 5. TSL frequency distribution of *Chama pacifica* from the Gulf of Antalya.

In this study, allometric relationships between body measurements (TSL, TSH and TSW) and weight were examined in the Gulf of Antalya. TSL-TW relationship was calculated and b value was determined to be less than three. This result reveals

that this species shows negative allometric growth in the sampling area. Nonetheless, b values may be affected by seasonal nutrient availability and reproduction activity (Lagade et al., 2015; Berik et al., 2017). All of the allometric relationships between shell measurements and total weight are given in Table 2. Lack of data on allometric relations for *C. pacifica* obstruct us to make a scientific comparision.

Table 2
Allometric relationships of *Chama pacifica* between body measurements (total shell length, height and width) and weight in the Gulf of Antalya.

Relationship	a	b	R^2	p
TSL on TW	2.27	2.53	0.69	$P \leq 0,05$
TSL on TSW	0.84	0.99	0.48	$P \leq 0,05$
TSL on TSH	1.77	0.78	0.61	$P \leq 0,05$
TSL on FW	0.12	2.69	0.62	$P \leq 0,05$
TW on FW	0.10	0.92	0.68	$P \leq 0,05$
TSW on TSH	2.99	0.53	0.56	$P \leq 0,05$

TSL, Total shell length (cm); TW, total weight (g); TSW, Total shell width (cm); TSH, Total shell height (cm); FW, flesh weight of *C. pacifica* (without shell) (g).

3.2.   Meat yield

In this study, mean meat weight and mean meat yield of *C. pacifica* was determined to be 11,07±0.445 g and 6.84±0.18%, respectively. Unfortunately, no data is available in order to compare these results. But, according to Çelik *at al.* (2012), mean meat yield of *Mytilus galloprovincialis* in Sinop, South of the Black Sea (Turkey) was determined as 9.98±0.73%. Furthermore, mean meat yield of *Flexopecten glaber* caught from Çardak Lagoon in Çanakkale, Turkey was reported to be 34.14%, 37.63%, 39.69%, 29.96% in autumn, winter, spring and summer respectively, while mean meat weight of *F. glaber* was determined as 10.12 ±0.280 (g) (Berik et al., 2017). These results show that mean meat weight of *C. pacifica* was higher than that of *F. glaber.* In bivalves, meat yield is dependent on the environment, breeding season, feeding regime and species (Çelik et al., 2012; Lagade et al., 2015; Berik et al., 2017).

3.3.   Sex ratio

While 45 individuals of *C. pacifica* were males, 44 of them were females and sex of 3 individuals couldn't be assigned. The sex ratio was determined to be 51% to 49%. Zurel et al. (2011) notified the male/female ratio approximately 1:1.5. In bivalves, exogenous steroids, temperature, food availability and pollutants were reported to have influence on the sex ratio (Breton et al., 2017).

4.   Conclusion

C. pacifica is one of the highly effective alien and cryptogenic marine species reported on ecosystem services or biodiversity (Katsanevakis et al., 2014). Scientific informations on the meat yield, biology and growth characteristics are missing for the surrounding waters of Turkey and Mediterranean. In our study, we examined the allometric relationship and the meat yield of *C. pacifica* from the Gulf of Antalya in order to determine its potential usage as an important food source for balanced nutrition. Moreover, intense population of *C. pacifica* in the Gulf of Antalya was observed on hard substrates (Figure 6). Although the species is not consumed as a food source in Turkey yet, the mean meat weight of *C. pacifica* was found to be higher than that of *F. glaber* in

Turkey. *F. glaber* is one of the most high market valued species for the seafood sector in Mediterranean (Berik et al., 2017). The total marine catch was decreased in Turkey and the world (FAO, 2018; The Ministry of Agriculture and Forestry, 2019). These show that *C. pacifica* has an important potential not only to be a suitable food source, but also creates profit for fishermen.

Figure 6. *Chama pacifica* on the rock in the Gulf of Antalya.

Acknowledgments

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