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A preliminary study on the traits of *Chamelea gallina* (Linnaeus, 1758) in the Gulf of Antalya, Mediterranean Coast of Turkey (Levantine Sea)

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Abstract

This study aimed to examine on some properties and to draw attention to why it cannot create an intensive stock amount of *Chamelea gallina (Linnaeus, 1758)* in the Gulf of Antalya in the Mediterranean coast of Turkey, Levantine Sea. Specimens of *C. gallina* displayed total shell legths of 6 to 32 mm, mean 14.5 mm and total weights of 0.1 to 11.44 g, mean 1.82 g. The total shell length and total weight relationship of *C. gallina* was calculated as TW =0.3333 * TSL 2.9894 (R^2 =0.9850). The mean meat yield was found as 12.10±0.9264%. A small number of *C. gallina* samples were collected. The majority of the collected striped venus were determined as empty shell. It was observed that the razorfish (*Xyrichtys novacula*) were fed with *C. gallina* during research. Finally, these results may draw attention the reasons why this species cannot form an intensive stock amount. It is thought that the empty shells of the striped venus can be caused from feeding of the razorfish (*X. novacula*) with *C. gallina* and environmental factor changes.

Keywords: Chamelea gallina; length; weight; meat yield; mediterranean

1. Introduction

Chamelea gallina (Linnaeus 1758) is the most produced and demanded bivalve species. *C. gallina* has a wide area of spread including the East Atlantic Ocean coasts, the British Isles, Norway, Portugal, Morocco, Canary Islands, the Adriatic Sea, the Black Sea and the Mediterranean (Fischer et al., 1987; Deval, 2001; Çolakoğlu and Tokaç, 2010; Biondi and Piero, 2012). This species is found intensively in the Western Black Sea and the Marmara Sea in Turkey (Dalgıç et al., 2006; Dalgıç and Karayücel, 2007; Dalgıç et al., 2009; Çolakoğlu and Tokaç, 2010). The production of mollusca was 5.988.076 tons in the world in 2016 (FAO, 2018). In 1999, the total production of *C. gallina* was reported to be 45.012 tons by FAO (FAO, 2019). It was began to be harvested for the first time in 1986 in Turkey coasts (Deval, 2001; Dalgıç et al., 2006). It was 34,941 tons in 2017, while the highest production of this species was in 2006 (49.610 tons) and in 2007 (48.549 tons) (BSGM, 2018). *C. gallina*, despite living in all the coasts of Turkey, the existing production is carried out from the Black Sea (Dalgıç et al., 2009; TUİK, 2016).

C. gallina is one of the important species of the Veneridae family (Çolakoğlu and Tokaç, 2010). It is a mass species on sandy shores up to 20 m in the Black Sea and Marmara Sea (Boltacheva and Mazlumyan, 2003; Dalgıç and Karayücel, 2007; Çolakoğlu and Tokaç, 2010; Todorova et al., 2015). But, *C. gallina* is usual, continual and few number in the eastern Mediterranean (Mutlu, 2013).

Since *C. gallina* is a benthic species, it has to be researched locally (Dalgıç et al., 2009). The growth of bivalves depends on the environmental conditions (nutrient, ground, depth, light, salinity) and reproduction status (Gaspar et al., 2004). Although various studies have been carried out on *C. gallina*, which is commercially cathed on the shores of the Black Sea and the Sea of Marmara of Turkey (Deval, 2001; Tunçer and Erdemir, 2002; Dalgıç et al., 2006; Dalgıç and Karayücel, 2007; Dalgıç et al., 2009; Çolakoğlu and Tokaç, 2010; Dalgıç and Ceylan, 2012; Kasapoğlu and Düzgüneş, 2014; Çolakoğlu and Tokaç, 2014), to date no research has been conducted on *C. gallina* in the Mediterranean coast of Turkey, Levantine Sea. In this study aimed to study on some properties and to draw attention to why it cannot create an intensive stock amount of *C. gallina* in the Gulf of Antalya in the Mediterranean coast of Turkey, Levantine Sea.

2. Materials and methods

2.1. Sampling

C. gallina samples were collected from sandy ground at a depth of 3 m with hand and hand dredge by scuba diving from the Gulf of Antalya (36^{0}52'N latitude; 30^{0}41'E longitude) on 07

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July, 17 July and 30 November 2018. In summer and autumn seasons, a small number of *C. gallina s*pecies could had been collected. *C. gallina* species could not had been collected because of moving sandy ground due to waves in winter. It was observed that the razorfish (*Xyrichtys novacula*) were fed with *C. gallina* during research.

*C. gallina s*pecies (Fig. 1) were collected in July (108 individuals) and in November (10 individuals) by scuba diving.

Figure 1. The striped venus (*chamelea gallina*) from the gulf of antalya.

The collected striped venus were empty shell. Only length measurements of these samples were made. These measurements were used in length calculations. *C. gallina s*pecies collected in July (117 individuals) and in November (18 individuals) were brought to the laboratory. Weights using 0.01 g precision scales (the total weight (TW), the flesh weight (FW) and the shell weight (SW) and the lengths with 0.1 mm precision caliper (the total shell length (TSL) (the maximum length along the anterior-posterior axis), the shell height (SH) (maximum distance on the dorsal-ventral axis), the shell width (W) (maximum distance on the lateral axis) and shell thickness (ST) (the middle of each valve) were measured. For flesh and shell weight measurements, all specimens were opened using a knife and the flesh removed with a scalpel.

2.2. Determination of allometric relationships, statistical analyses and biometric relationships

Shell lengths and weights relationships were calculated according to the allometric equation: *Weight =a * size^b* (Pauly, 1984; Berik et al., 2017; Acarlı and Vural, 2018) using the least square regression analysis of Microsoft Excel.

The exponential relationship can be shown by a linear equation because weight is a strong function of length. This equation can be explained by the linearized form log *Weight =log a + b log size* (Pauly, 1984; Berik et al., 2017)

The weight was related to TW, FW and SW. L was also related to size such as TSL, W and SH. The intercept (the first growth coefficient) is a, while b is the slope (relative changeable growth rate) (Pauly, 1984; Berik et al., 2017). Allometric relationships were analized one-way ANOVA were used with the software STATIST 7.1. All statistical analyzes were evaluated at the P<0.05 levels (SPPS 15.0) (Watts et al., 1998). Meat yield (MY) equation was used as:

MY = [Meat weight (g)/Total weight (g)] x 100 (Acarlı et al., 2011; Berik et al., 2017).

Shell component index (SCI) = [Shell wet weight (g)/Total weight (g)] x 100 (Gaikwad and Kamble, 2014).

3. Result and discussion

3.1. Shell dimensions and allometric relations

Specimens of *C. gallina* displayed total shell legths of 6 to 32 mm, mean 14.5 mm and total weights of 0.1 to 11.44 g, mean 1.82 g in the material collected (Table 1).

Table 1
Descriptive statistics of *Chamelea gallina* from the Gulf of Antalya.

Mesurements	N	Minimum	Maximum	Mean (SE)
TSL	253	6	32	14.5±0.030
SH	253	6	28	13±0.027
W	253	4	18	8.1±0.016
ST	253	0.5	2	1.1±0.002
TW	140	0.1	11.44	1.82±0.154
SW	137	0.08	5.71	1.16±0.092
FW	138	0.01	1.36	0.22±0.022

TSL, Total shell length (mm); SH, Shell height (mm); W, Shell Width (mm); ST, Shell Thickness (mm); TW, Total Weight (g); SW, Shell Weight (g); FW, Flesh weight of C. gallina (without shell) (g).

It was determined that this species had the maximum length/maximum mean length and the maximum weight/maximum mean weight values in the Western Marmara Sea (Table 2). The minimum length and minimum weight values were found in Marmara North Sea (Table 2). The minimum of mean length and minimum mean weight values were detected in the Mediterranean coast of Turkey, Levantine Sea (Table 2).

Table 2
Length-weight measurement values determined by other investigators of *Chamelea gallina.*

Area	Latitude (°)	L mean±Std.(mm), (min.-max.), N	TW mean±Std. (g), (min.-max.), N	Researchers
North Marmara Sea	40	20.09 (3.6-34.5) N: 2887	3.1 (0.01-12.1) N: 2887	Deval, 1995; Deval, 2001
West Marmara Sea	40	28 (21.1-36.9) N: 91	6.84 (2.47-15.41) N: 91	Tunçer and Erdemir, 2002
West Black Sea	41	19.56 (6.3-31.5) N:424	2.46 (0.08-8.67) N:424	Dalgıç et al., 2006; Dalgıç et al., 2009
Middle Black Sea	42	18.45 (6.5-28.7) N:1432	2.34 (0.09-6.26) N:1432	Dalgıç et al., 2006; Dalgıç et al., 2009
Middle Black Sea	41	18.48 (7.4-29.1) N:596	2.16 (0.13-8.43) N:596	Dalgıç et al., 2006; Dalgıç et al., 2009
Eastern Black Sea	41	17.96 (6.4-30) N:1332	1.88 (0.09-57) N:1332	Dalgıç and Karayücel, 2007
West Marmara Sea	40	23.9 (7-39) N:3325	4.85 (0.3-21.05) N:3325	Çolakoğlu and Tokaç, 2010
East and Middle Black Sea	41	17.6 (7-30) N:628	1.95 (0.2-4.82) N:628	Kasapoğlu and Düzgüneş, 2013
Monfalcone	45	26.85, N:40		Gizzi et al., 2016
Chioggia	45	26.14, N:40	-	Gizzi et al., 2016
Goro	44	26.06, N:40	-	Gizzi et al., 2016
Cesenatico	44	26.52, N:40	-	Gizzi et al., 2016
San Benedetto	43	26.39, N:40	-	Gizzi et al., 2016
Capoiale	41	26.40, N:40	-	Gizzi et al., 2016
Gulf of Antalya, Mediterranean	36	14.5±0.030 (6-32), N:253	1.82±0.154 (0.1-11.44), N:140	In this study

L: Lenght, TW: Total weight, N: Number of individuals

In this study, the mean shell width and the mean shell height were found as 8.1±0.016 mm (min. 4 mm-mak. 18 mm) and 13±0.027 mm (min. 6 mm-mak. 28 mm), respectively (Table 1). The maximum mean shell width in the Western Marmara Sea and the minimum mean shell width in Capoiale were determined as 28 mm and 6.13 mm, respectively (Table 2).

It was detected that the maximum mean shell height in the West Marmara Sea was 21.8 mm (Table 2) and the minimum mean shell height in the Mediterranean coast of Turkey, Levantine Sea was 13 mm (Table 1). These results showed that the maximum mean shell width and the maximum mean shell height were in the Western Marmara Sea (Table 2), the minimum mean shell width was in Capoiale (Table 2) and the minimum mean shell height was in the Mediterranean coast of Turkey, Levantine Sea (Table 1). In this study, the mean shell thickness was detected as 1.1 (0.002) mm (Table 1). It was found that the mean shell thickness (1.06 mm) was lower in Capoiale (Table 2).

In this study, the TSL-TW relationship was calculated as *TW* =0.3333 * *TSL* 2.9894 (R^2 =0.9850). Length and weight relationship results demonstrated that this species showed allometric growth in the sampling area. All the allometric relationships between shell mesurements and weight were given in Table 3.

It was found that this species had a negative allometric growth in the North Marmara Sea, West Marmara Sea, Eastern Black Sea, East and Middle Black Sea and Marmara Sea (Table 4). In this study, all the slopes of the regression lines were significantly different from zero. The TSL, the SH and the W all showed a strong correlation with the TW, the FW and the SW. However, while the ST was in a small relationship with the TSL and the FW, the TW was slightly better for *C. gallina* in the Mediterranean coast of Turkey, Levantine Sea (Table 3).

A strong relationship was found between the regression analysis of the shell length (TSL, W and SH) and weight (TW, FW and SW) in the North Marmara Sea, West Marmara Sea, Eastern Black Sea and Marmara Sea (Table 4).

Table 3
Allometric relationships of *Chamelea gallina* between body measurements (total shell length, height, width and thickness) and weight in the Gulf of Antalya.

Relationship	n	a	b	R^2	P
Total weight (TW)					
TW on TSL	140	1.4454	0.3294	0.9850	P ≤ 0.005
TW on SH	140	1.2964	0.3308	0.9723	P ≤ 0.005
TW on W	140	0.8043	0.3229	0.9722	P ≤ 0.005
TW on ST	140	0.1102	0.2856	0.6907	P ≤ 0.005
TW on SW	137	0.6784	1.0085	0.9908	P ≤ 0.005
TW on FW	138	0.1018	1.1650	0.8602	P ≤ 0.005
Flesh weight (FW)					
FW on TSL	138	2.5285	2.2416	0.8400	P ≤ 0.005
FW on SH	138	2.2802	0.2439	0.8341	P ≤ 0.005
FW on W	138	1.3921	0.2373	0.8372	P ≤ 0.005
FW on ST	138	0.1779	0.2077	0.5877	P ≤ 0.005
FW on TW	138	5.5322	0.7383	0.8602	P ≤ 0.005
FW on SW	135	3.6550	0.7307	0.8496	P ≤ 0.005
Total shell Lenght (TSL)					
TSL on SH	253	0.8905	1.0090	0.9704	P ≤ 0.005
TSL on W	253	0.5727	0.9327	0.9591	P ≤ 0.005
TSL on ST	253	0.0863	0.7137	0.5583	P ≤ 0.005
TSL on TW	140	0.3333	2.9894	0.9850	P ≤ 0.005
TSL on SW	137	0.2248	3.0024	0.9742	P ≤ 0.005
TSL on FW	138	0.0284	3.4768	0.8400	P ≤ 0.005

TSL, Total shell length; W, Shell width; SH, Shell height; ST, Shell thickness; TW, total weight; SW, Shell Weight; FW, flesh weight

Table 4
Parameters of allometric relationships of *Chamelea gallina* between body measurements by others resaershers determined.

Relationship	N	a	b	r^2	Researcher
SH on TSL	536	0.69	1.024	0.998	Deval, 2001
W on TSL	232	0.303	1.005	0.984	
SW on TSL	322	3.544	2.900	0.992	
FW on TSL	42	4.771	3.265	0.770	
TW on TSL	536	3.383	2.902	0.993	
SW on TW	367	0.137	0.976	0.995	
FW on TW	42	1.039	1.180	0.807	
TSL on TW	91	0.0004	2.9669	0.95	Tuncer and Erdemir, 2002
TSL on SW	91	0.0004	2.9083	0.95	
TSL on FW	91	5E.05	3.1814	0.94	
TSL on W	91	0.8942	5.4158	0.89	
TW on TSL	1332	-3.1408	2.6918	0.968	Dalgıç and Karayücel, 2007
SH on TSL	1332	-0.0479	1.0080	0.998	
W on TSL	1332	-0.3680	1.0267	0.973	
FW on TSL	1332	-4.2724	2.7123	0.932	
TW on TSL	628	0.4520	2.365	0,954	Kasapoğlu and Düzgüneş, 2013
TSL on TW	2462	0.3539	2.8908	0.98	Çolakoğlu and Tokaç, 2014
SH on TW	2587	0.4888	2.7973	0.97	
W on TW	2561	2.6892	2.4167	0.94	
TSL on SH	2616	-0.0711	0.9495	0.99	
TSL on W	2607	-0.1418	0.5746	0.96	

TSL, Total shell length; W, Shell width; SH, Shell height; ST, Shell thickness; TW, total weight; SW, Shell Weight; FW, flesh weight

3.2. *Meat yield*

In this study, it was found that mean FW of *C. gallina* was 0.22±0.022 g (min.0.01 g-mak.1.36 g, N:138), mean MY was 12.10±0.9264% (min.2.17%-mak.85.36%, N:138), the mean SW was 1.16±0.092 g (min.0.08 g-mak.5.71 g, N:137) and the mean SCI was 68.17±0.5192% (min.46.66%-mak.99.52%, N:137). It was determined that the mean meat weight of *C. gallina* (N: 1655) was 0.66±0.01 g (min.0.09 g-mak.2.53 g) and the mean meat yield was 19.10±0.43% (min.0.78%-mak.85.60%) in the West Sea of Marmara (Çolakoğlu and Tokaç, 2014). It was determined that the mean meat weight of *C. gallina* (N: 1332) was 0.15±0.01 g (min. 0.01 g-0.46 g), the mean meat yield was 8.04% and the mean shell weight was 1.22±0.04 g (min. 0.03 g-mak.4.01 g) in the Eastern Black Sea (Dalgıç and Karayücel, 2007).

When these studies were evaluated, the mean FW and the mean MY in the West Sea of Marmara and the mean SW in the Eastern Black Sea were observed to be maximum. The minimum mean FW and the minimum MY were determined in the Eastern Black Sea and the minimum mean SW was found in the Mediterranean coast of Turkey, Levantine Sea. In Bivalves, MY varies according to environmental conditions, breeding season, nutritional status and species (Acarlı et al., 2011; Berik et al., 2017).

Latitude is the main factor affecting solar radiation and water temperature change (Caroselli et al., 2016). It is widely used as monitoring and control parameter in ecological studies (Caroselli et al., 2016; Gizzi et al., 2016). It has a notable effect for organism biology (Caroselli et al., 2016). The shell morphology of the molluscs is particularly sensitive to environmental conditions (depth, discharge, wave exposure, bottom structure, sediment, pH and temperature changes) (Gizzi et al., 2016). Water temperature in the crustal growth of *C. gallina* has a dominant role. Shell growth slows down strongly at temperatures below 10°C. Energy absorption decreases at temperatures above 28-27°C and energy spending increases with respiratory tract. Thus, the shell growth stops (Deval, 2001; Gizzi et al., 2016). High temperature affects calcification by affecting the presence of nutrients that play a key role in the growth of the molluscs (Gizzi et al., 2016). *C. gallina* has a relatively low tolerance to high temperature compared to other bivalve species (Moschino and Marin, 2006; Gizzi et al., 2016). Several studies showed that changes in the abiotic environmental factors such as temperature, salinity and oxygen affected the immune parameters by making *C. gallina* more susceptible to diseases and infections (Gizzi et al., 2016; Matozzo and Marin, 2011). It was observed that the salinity and temperature as the first component and the chlorophyll-a concentration as the second affected the growth of *C. gallina*. This species had the lowest growth rate in the Black Sea, which had low temperature, salinity and chlorophyll-a values, whereas it showed the highest growth rate in the Gulf of Cadiz, which was more hot, salty and chlorophyll-a (Delgado et al., 2015).

In Turkey, sea water temperatures were identified as the mean 5.2 °C (min.13.8 °C- mak.16.4 °C) in the Black Sea, the mean of 15.5 °C (min.14.4 °C-mak.17.2 °C) in the Sea of Marmara, the mean of 18.5 °C (min.17.7 °C-mak.19.4 °C) in the Aegean Sea, the mean 22.04 °C (min.20.6 °C-mak.22.3 °C) in the Mediterranean (MGM, 2018). The total mean radiation intensity of Turkey was found 1.120 kWh m²-year in the Black Sea, 1.168 kWh m²-year in the Sea of Marmara, 1.304 kWh m²-year in the Aegean Sea, 1.390 kWh m²-year in the Mediterranean (BAKA, 2011). Turkey has four regions with the sea coast. The latitude value of the Central and Eastern Black Sea Region is large and humid. For this reason, the least radiation area is the area. Marmara and North Aegean Region have a slightly better radiation than the Black Sea. Southern Aegean and Western Mediterranean Regions receive moderate radiation. Eastern Mediterranean Region is a region with good radiation values (Aksungur et al., 2019).

The chlorophyll-a concentrations in the surface layer (0-10 m mean) were determined in the Aegean Sea (0-20 µgL) (CBD, 2018a) , (0-12 µgL) in the Marmara Sea (CBS, 2018c), (0-4 µgL) in the Black Sea (CBS, 2018b) and (0-1.2 µgL) in the Mediterranean (CBS, 2018d) between the years 2014-2017 in Turkey. The dissolved oxygen values for 2017 were detected 5-10 mg L at 0-70 m in the Black Sea (CBS, 2018b), 0-12 mg L for about 0-50 m in Marmara Sea (CBS, 2018c), 4.4-8.5 mg L approximately 0-100 m in the Aegean Sea (CBS, 2018a), surface water oxygen saturation level 97-112% and concentration values 5.74-6.7 mg L at 0-10 m in the Mediterranean (CBS, 2018d). The salinity values were found 17-18‰ in surface waters of the Black Sea (0-40 m), 22‰ in surface waters (0-20 m) of the Marmara Sea, 36.1-39.2‰ in surface waters of the Aegean Sea (0-50 m) and approx. 38.5-39.0‰ in surface waters of the Mediterranean (0-300 m) (Soydemir, 2004).

When these studies were evaluated, it was found that the sea water temperature, the radiation intensity and the salinity value were determined as the highest while the chlorophyll-a concentrations and dissolved oxygen values were found as the lowest in the Mediterranean coast of Turkey, Levantine Sea. In this study, a small number of *C. gallina* samples were could had been collected. Mutlu (2013) reported that *C. gallina* had few numbers with 17 samples collected using the epibentic sledge at a depth of 5-10 m between February 2000 and April 2002 monthly in the eastern Mediterranean. In this study, the majority of the collected striped venus were determined as empty shell. It was found a large amount of empty striped venus in the Eastern Black Sea of Turkey (Dalgıç and Karayücel, 2007). Similar incidents had also been reported from Italy (Angioni et al., 2010). Oxygen deficiency and other natural events were considered to be the cause (Dalgıç and Karayücel, 2007; Angioni et al., 2010). It was observed that the razorfish (*Xyrichtys novacula*) were fed with *C. gallina* during research. It was reported that the razorfish was fed with bivalves in the Gulf of Antalya (Üstüner et al., 2018) and *C. gallina* in the Strait of Sicily in the Mediterranean (Beltrano et al., 2006). Finally, these results may draw attention the reasons why this species cannot form an intensive stock amount. It is thought that the empty shells of the striped venus can be caused from feeding of the razorfish (*X. novacula*) with *C. gallina* and environmental factor changes (temperature, salinity, oxygen and chlorophyll-a).

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