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Aspects of biology of the deep-water pandalid shrimp *Plesionika martia* (A. Milne-Edwards, 1883) from Sığacık Bay (eastern Mediterranean)

Cengiz KOÇAK, Murat ÖZBEK*, Zafer TOSUNOĞLU
Faculty of Fisheries, Ege University, 35100 Bornova, İzmir - TURKEY

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Abstract: Some aspects concerning the reproduction, growth, and population dynamics of *Plesionika martia* were studied. Individuals were collected monthly between May 2008 and April 2009 during surveys conducted using a commercial trawl vessel. Samples were collected from Sığacık Bay (Aegean Sea, eastern Mediterranean) at depths ranging from 494 to 550 m. A total of 2110 individuals (766 males and 1344 females) were caught during these monthly surveys. The carapace length (CL) of the males ranged from 12.4 to 22.1 mm, and in females the CL ranged between 11.5 and 24.9 mm. The values of both CL and weight in females consistently exceeded that of males throughout the year. Although ovigerous females were observed throughout the year, the main reproductive period is suggested to be from May to December. In all groups examined, the values of allometric coefficient *b* were less than 3. Estimates of the Von Bertalanffy growth parameters were L_{∞} = 26.25 mm and k = 0.38 year^{-1} in females, and L_{∞} = 23.63 mm and k = 0.49 year^{-1} in males.

Key words: Biological aspects, *Plesionika martia*, Sığacık Bay, Aegean Sea, eastern Mediterranean

Sığacık Körfezi derin su pandalid karidesi *Plesionika martia* (A. Milne-Edwards, 1883)'nın biyolojik özellikleri

Özet: Bu çalışmada, Ege Denizi (Doğu Akdeniz)'de, *P. martia*'nın üreme, büyüme ve populasyon dinamikleri çalışıldı. Bireyler aylık olarak, Mayıs 2008 ve Nisan 2009 tarihleri arasında Sığacık Körfezi'nden 494-550 m derinlikler arasından toplandı. Araştırma sürecinde, toplam 2110 *P. martia* birey (766 erkek ve 1344 dişi) toplandı. Karapas boyu (CL), erkek bireyler için 12,4 mm ve 22,1 mm arasında, dişi bireyler için 11,5 mm ve 24,9 mm arasında ölçüldü. Yıl boyunca, dişilerin ortalama boy (CL) ve ağırlığı (W) erkeklerin ortalama boy ve ağırlığından sürekli olarak yüksek çıktı. Yumurtalı dişiler yıl boyunca gözlendi. Ana üreme periyodu mayıs ve aralık ayları arası olarak tespit edildi. İncelenen tüm gruplarda, allometrik katsayısı (*b*) 3'ten az bulundu. Von Bertalanffy büyüme parametreleri dişilerde L_{∞} = 26,25 mm, k = 0,38 year^{-1}, erkeklerde L_{∞} = 23,63 mm, k = 0,49 year^{-1} olarak hesaplandı.

Anahtar sözcükler: Biyolojik özellikler, *Plesionika martia*, Sığacık Körfezi, Ege Denizi, Doğu Akdeniz

* E-mail: ozbekm71@yahoo.com

Introduction

Golden shrimp *Plesionika martia* (A. Milne-Edwards, 1883) has a circumtropical distribution both in temperate and tropical waters (Holthuis, 1980). It occurs throughout the Mediterranean Sea at depths between 165 and 871 m (Company and Sarda, 2000) and is a significant by-catch of deep-water trawl fisheries in several Mediterranean regions (Company and Sarda, 1997, 2000; Campisi et al., 1998; Koukouras et al., 1998; Marsan et al., 2000; Politou et al., 2000; Maiorano et al., 2002; Chilari et al., 2005). In the Mediterranean Sea, *P. martia* is caught along the continental shelf edge and slope; it is more common in the western part than in the eastern and is absent in the northern and central Adriatic Sea (Relini et al., 1999).

The biological knowledge of *P. martia* is mainly focused on the western and central Mediterranean Sea (Cartes, 1993a, 1993b; Company and Sarda, 1997; Campisi et al., 1998; Company and Sarda, 2000; Marsan et al., 2000; Maiorano et al., 2002; Company et al., 2003). With regard to the eastern part of the Mediterranean Sea, knowledge generally centers on presence, depth distribution, and abundance (Katağan et al., 1988; Koukouras et al., 1998; Politou et al., 1998, 2000; Kallianiotis et al., 2000; D'Onghia et al., 2003). Recently, Chilari et al. (2005) provided information on the species' population structure, growth, sex ratio, reproduction, size at sexual maturity, and fecundity in the eastern Ionian Sea.

In the present study, fishery studies were carried out with the goal of assessing select biological aspects of *P. martia* (population characteristics, growth, sex ratio, and reproduction) in Sığacık Bay (Aegean Sea, eastern Mediterranean) in Turkey.

Materials and methods

Monthly sampling surveys were carried out between May 2008 and April 2009 in Sığacık Bay, Aegean Sea (from 38°05′13″N, 26°35′08″E to 37°59′27″N, 26°54′47″E) (Figure 1). These surveys were conducted using a commercially used bottom trawl (44-mm nominal mesh size, PE netting at the cod-end). The trawling speed fluctuated from 2.3 to 2.7 knots, depending on the nature of the substrate.

A total of 36 hauls were taken at depths ranging from 128 to 550 m. All hauls were carried out in daylight. A total of 2110 specimens of *P. martia* were caught between depths of 494 and 550 m in 12 hauls. The specimens were frozen in order to preserve them for further analysis in the laboratory. For each defrosted, undamaged specimen, the carapace length (CL) was measured with a digital caliper to the nearest 0.01 mm from the posterior margin of the orbit to the posterior dorsal margin of the carapace. In order to provide linear relationships between the CL and the weight of the specimens, the wet mass (not blotted with filter paper) of the specimens was determined using a digital balance with a precision of

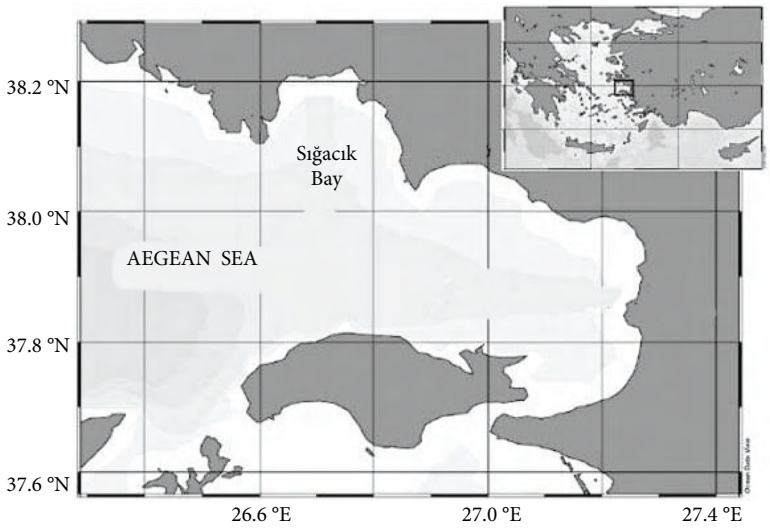

Figure 1. Location of Sığacık Bay.

0.01 g. Ovigerous females were weighed after removal of the eggs. No occurrence of parasites was observed in the specimens.

Sex was determined under a stereomicroscope based on the presence or absence of the male appendix masculina on the endopod of the second pair of pleopods (Zariquiey Alvarez, 1968) and the sex ratio was determined according the formula F/F + M, where F indicates female specimens and M indicates males. Females were examined for the presence of external eggs and the stage of egg maturation was assigned according to the following 3-stage scale (Company and Sarda, 1997):

1) Early stage: eggs of recent spawning with intense sky-blue color and no visible embryonic pigmentation;

2) Middle stage: pale green-colored eggs with slight embryonic eye pigmentation;

(3) Late stage: colorless eggs with clearly visible embryonic eye pigmentation and well-developed embryo.

The relationship between CL and body weight (BW) was computed according to the exponential curve function BW = aCLb, where a is the intersect and b is the allometric coefficient (or slope). This was calculated for females (nonovigerous and ovigerous) and for males.

The seasonal length-frequency distributions (0.5-mm size classes) for each sex of the whole sampled population were calculated. Growth was treated as a continuous function (Garcia and Le Reste, 1981). The Von Bertalanffy growth parameters were estimated separately for females and males using ELEFAN in the FiSAT program (Gayanilo et al., 1995). The comparison of growth performances between sexes was done using the growth performance index of Pauly and Munro (1984).

Results

In general, the number of females sampled in each month during the study was higher than that of males. Thus, the sex ratio was slightly in favor of females for the entire dataset (Figure 2). The highest value of the sex ratio was observed in July (0.953), while the minimum value was observed in December (0.519).

Length and weight-frequency distributions for both sexes of *P. martia* for the whole study period are presented in Figure 3. The average CL values were 19.03 ± 1.40 mm for females and 18.39 ± 1.29 mm for males. Similarly, the average weight values were calculated as 5.46 ± 1.07 g for females and 4.82 ± 0.85 g for males.

Seasonal size distributions showed a size predominance of females over males, although there was not a statistically significant difference among the seasonal median sizes of the length values of both sexes at the 95% confidence level (Figure 3).

Ovigerous females were observed throughout the year (Figure 4). The lowest percentage of ovigerous females was observed in the period from December to April, while the highest was seen from May to

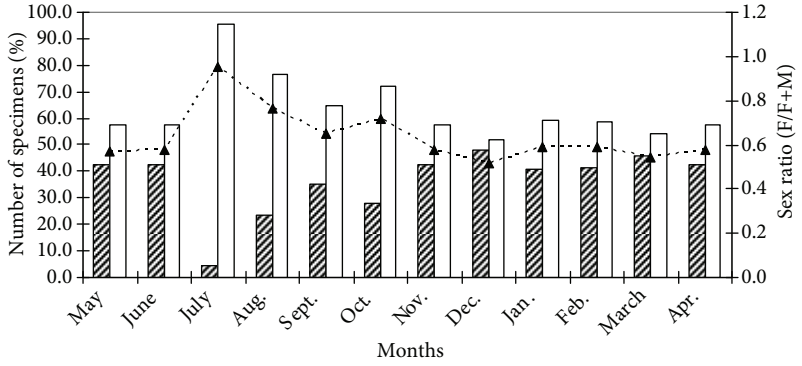

Figure 2. Sex ratio (F/F + M) and numbers of sampled specimens (n) of *Plesionika martia* (A. Milne-Edwards, 1883) collected per month (striped bar: male; empty bar: female; dashed line: sex ratio).

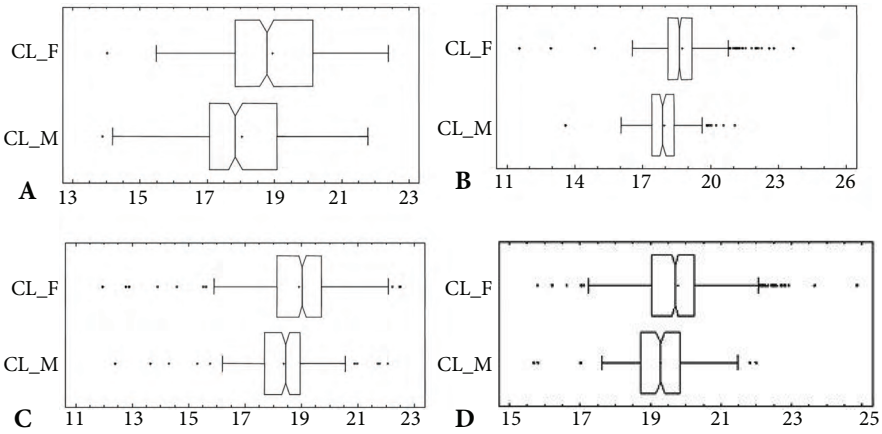

Figure 3. Seasonal size (CL, in mm) and weight (W, in g) distributions of females and males of *P. martia*: A) spring, B) summer, C) autumn, D) winter.

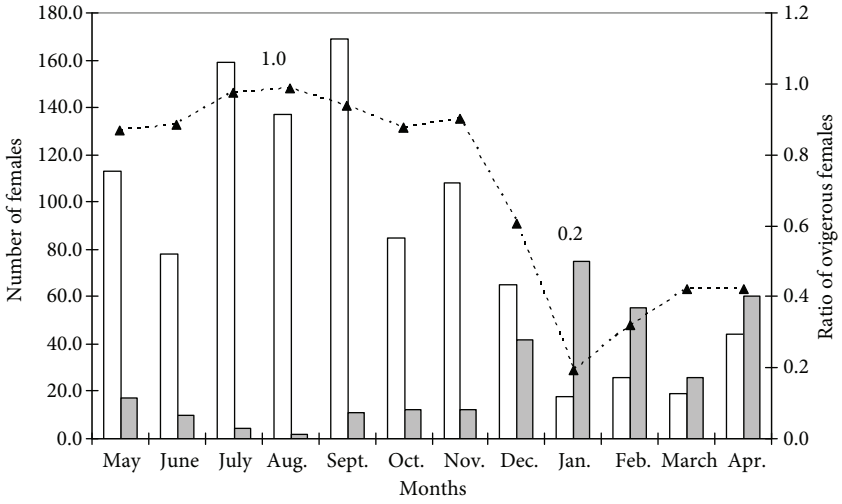

Figure 4. Monthly distribution of ovigerous females (white) and nonovigerous females (grey) and the ratio of ovigerous females (ovigerous females to total females; line).

November. The rate of ovigerous females (percentage of the female population) showed a peak (98.6%) in August. In contrast to this, the minimum value was observed in January (19.4%). The smallest and largest ovigerous females of *P. martia* had a CL of 12.9 mm and 24.9 mm, respectively, and were found in September 2008 and March 2009.

According to the presence of the ovigerous females, it seems possible that the main reproductive period could be defined as May to November (Figure 4). The ratio of the egg mass to body weight (the weight of egg mass/body weight) ranged between 0.068% and 17.541%, with an average value of 5.121% (n = 500).

The CL-weight relationships for the different groups (ovigerous females, nonovigerous females, and males) are presented in Figure 5. In all of the groups examined, the values of allometric coefficient *b* were statistically lower than 3 at the 95% significance level, indicating a negative allometry. The slope of the size-weight relationship suggests the existence of negative allometry in the growth of *P. martia* for all 3 groups of individuals (ovigerous females, nonovigerous females, and males).

The Von Bertalanffy growth parameter estimates were as follows:

• Females: L_{∞} = 26.25 mm, k = 0.38 year^{-1}; Rn = 0.411.

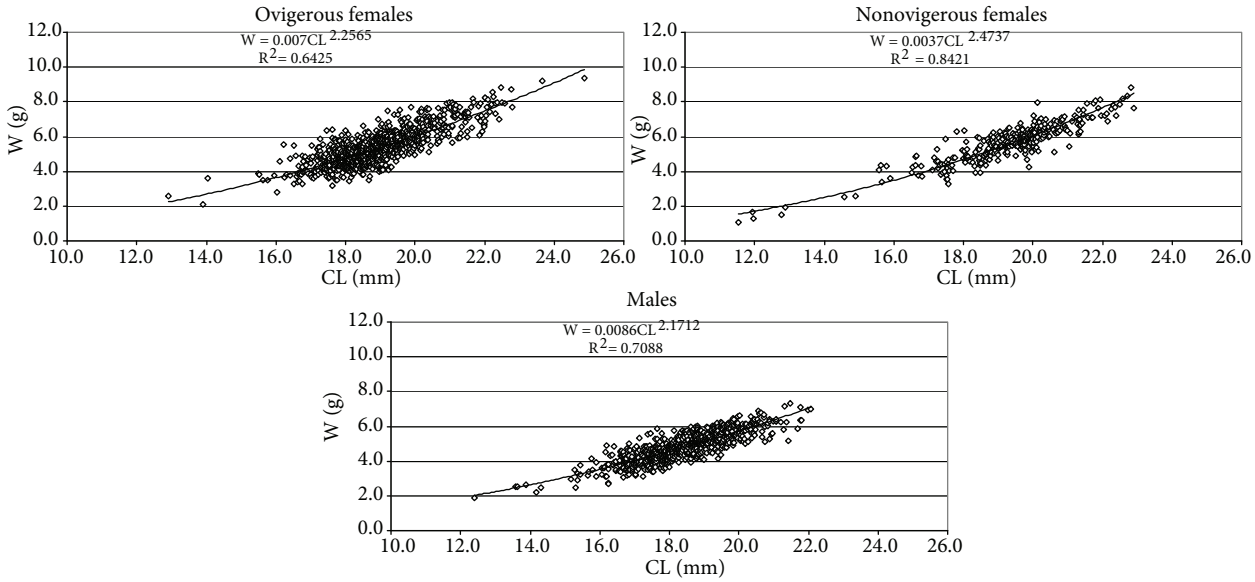

Figure 5. Carapace length-weight relationships for the different groups (males, females, nonovigerous females, and ovigerous females).

• Males: L_{∞} = 23.63 mm, k = 0.49 year^{-1}; Rn = 0.371.

The growth performance index, ø′, was 2.418 for females and 2.437 for males. As expected, this result confirmed a slightly higher growth rate in males than in females.

Discussion

P. martia and *P. heterocarpus* represent the most abundant pandalids in the eastern Mediterranean basin and, in some cases, the most abundant by-catch species of commercial trawl fishing conducted at depths of between 350 and 550 m (Chilari et al., 2005). The depth patterns of the maximum abundance of these species has been well studied in the western Mediterranean basin (Company and Sarda, 1997, 2000; Campisi et al., 1998; Carbonell and Abello, 1998; Cuccu et al., 1998), but there are few studies from the eastern part of the same basin (Maiorano et al., 2002; Chilari et al., 2005) and no data from the seas of Turkey.

The minimum sizes of the sexes reported in this study were slightly larger than those reported from the eastern Ionian Sea (Chilari et al., 2005). As reported for most of the pandalid species (Company and Sarda, 1997; Maiorano et al., 2002; Chilari et al., 2005), females showed a size predominance of seasonal size distribution over males. The results observed in this study on the size predominance of females are in accordance with those reported from Sardinian waters (Campisi et al., 1998; Cuccu et al., 1998), from the Albanian waters of the southern Adriatic Sea (Marsan et al., 2000), and from some Spanish areas (Carbonell and Abello, 1998). The maximum values of the sex ratio were observed during the late summer-early autumn period (July to October 2008), and these values were found to be distinctly higher than those reported by Chilari et al. (2005) from the eastern Ionian Sea.

Ovigerous females were found throughout the sampling period, making it difficult to indicate the exact spawning period of the species in this study area. Because the May-to-November (2008) period showed the highest ratio of ovigerous females, it could be suggested that this is the main spawning period. A detailed study focusing on gonadal maturity could undoubtedly confirm this hypothesis. On the other hand, the lower number of the females caught in the period between December and April could present a problem in determining the exact spawning period. Chilari et al. (2005) reported that the period from April to October could be the main spawning season of the species in the eastern Ionian Sea, but also remarked on the difficulty of determining the exact spawning period because of the year-round presence of ovigerous females. When the phases of

the eggs were taken into consideration, the ratio of ovigerous females with eggs in the late maturity stage (stage 3) changed throughout the year, but 2 distinct periods (June to August and November to January) could be indicated as spawning seasons. Previously, both Company and Sarda (1997) and Maiorano et al. (2002) mentioned the possibility of more than one spawning season during the year.

Company and Sarda (2000) reported that the estimated slope (*b*) values of the relationship between CL and weight were around 3 for both sexes of *P. martia* in the western Mediterranean, but those researchers did not compute the size-weight relationship for ovigerous females only. Similarly, Maiorano et al. (2002) and Chilari et al. (2005) reported negative allometry for *P. martia* specimens (ovigerous females, nonovigerous females, and males) collected from the eastern and western Ionian Sea, respectively.

A comparison of the growth parameters estimated in the present study with those reported from the neighboring eastern and western Ionian Sea showed that the $L_{¥}$ lengths estimated in the present study were slightly lower than those reported from the neighboring areas for both males and females (Maiorano et al., 2002; Chilari et al., 2005). This could be attributed to the fact that the present study was conducted at a depth range between 350 m to 550 m, which was much shallower than that of the above studies.-

In conclusion, *P. martia* from Sığacık Bay seem to conform to previous studies carried out in other Mediterranean regions with regard to the major life-history traits, with the exception of $L_{¥}$ lengths. The authors suggest that similar studies are very important for understanding the biological characteristics and the life cycle of *P. martia*, especially in the eastern Mediterranean.

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