



Marine Science Center-University of Basrah

Mesopotamian Journal of Marine Sciences

Print ISSN: 2073-6428

E- ISSN: 2708-6097

www.mjms.uobasrah.edu.iq/index.php/mms



Study of reproductive performance and some biological characteristics of *Eriphia verrucosa* (Forsk., 1775) in Coast of Jableh, Syria

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Article info.

✓ Received: 15 July 2023

✓ Accepted: 8 November 2023

✓ Published: 29 December 2023

Key Words:

Crustaceans,
Decapods,
Eriphia verrucosa,
Fertility,
Reproductive Performance.

Abstract This study aimed to evaluate the reproductive performance of *Eriphia verrucosa* in Syrian waters for the first time. This study was conducted during the period between March 2021 and February 2022 in the coast of Jableh city, Syria. The total number of individuals collected was 110 individuals scattered between 50 females and 60 males, with a percentage of 45.4-54.5%, respectively. The results showed that spawning occurred during the period between March and July and a highest rate was during May. Fertility of *Eriphia verrucosa* ranged between 19512-116430 eggs/female, the width of the Carapace ranged between 3.5-6.4 cm, while the length of the Carapace ranged between 2.5-4.7 cm and the body weight ranged between 25.4-121.3 g.

دراسة كفاءة الخصوبة وبعض الصفات الحيوية
لنوع *Eriphia verrucosa* (Forsk., 1775) في شاطئ مدينة جبلة، سورية

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قسم علم الحيوان، كلية العلوم، جامعة تشرين، اللاذقية، سورية

المستخلص - هدفت هذه الدراسة إلى تقييم الأداء التناسلي عند النوع *Eriphia verrucosa* لأول مرة في المياه السورية. نفذت هذه الدراسة خلال الفترة الممتدة بين آذار 2021 وشباط 2022 في شاطئ مدينة جبلة، سورية، بلغ المجموع الكلي لعدد الأفراد التي جمعت 110 فرداً توزعت بين 50 أنثى و60 ذكر بنسبة 45.4% - 54.5% على التوالي. أظهرت نتائج هذه الدراسة أن الإباضة تحدث خلال الفترة الممتدة بين شهر آذار وتموز وكان المعدل الأعلى خلال شهر أيار. تراوحت الخصوبة عند النوع *Eriphia verrucosa* بين 19512-116430 بيضة/أنثى، وعرض الدرقة بين 3.5-6.4 سم وطول الدرقة بين 2.5-4.7 سم ووزن الجسم بين 25.4-121.3 غم.

الكلمات المفتاحية: القشريات، عشاريات الأرجل، *Eriphia verrucosa*، الخصوبة، الأداء التناسلي.

Introduction:

Eriphia verrucosa is distributed in Mediterranean Sea and Eastern Atlantic Ocean as well as it was reported from the Black Sea. In Syria, this species was collected from several locations of Syrian Coastal waters (Hasan, 2008). This species is inhabiting the stones and seaweeds along rocky coastlines of shallow waters down to depths of 15m (Rossi and Parisi, 1973) and later moving out to shallower waters of less than 1m and start reproduce during May to June (Dumitrache and Konsulova, 2009).

This species feeds mainly on bivalves, gastropods, hermit crabs, mollusks and polychaetes (Rossi and Parisi, 1973; Flores and Paula, 2001). This species plays an important role in its ecosystem as a food source of high percentage in protein, minerals and vitamins, in addition to containing a low percentage of fat and it is consider a seafood in several Mediterranean countries (Altinelataman and Dincer, 2007). Today, *E. verrucosa* is listed as an endangered species in the

Ukrainian Red Data Book due to eutrophication and pollution of Black sea, it has shown declining manner since 1980s regardless of being a dominant species in the past (Dumitrache and Konsulova, 2009).

Fecundity in crustaceans is generally defined as the number of eggs produced by a female, during a particular spawning season. It is an important population parameter for species of commercial value as it allows for estimates of the reproductive potential of the species (Rodrigues *et al.*, 2011). Fecundity is a key factor in the persistence of a fisheries stock and is used to evaluate the status of a population because it has direct effects on the recruitment of species in estuarine and marine environments (Begg and Waldman, 1999). The body size is the main sign for the fecundity of brachyuran crab's female (Hines, 1988).

Several studies have been conducted to determine the relationships between length–weight, biochemical composition and food resources of warty crab (Erkan *et al.*, 2008, 2010; Kaya *et al.*, 2009; Ulaş and Aydın, 2011; Fouda *et al.*, 2015; Dernekbaşı *et al.*, 2021). Due to importance of biological and reproduction of any species, Karadurmuş and Aydın (2016) conducted study in the black sea to determine some biological and reproduction characteristics of *E. verrucosa* in the Black sea. However, there is no such study for this species from Syrian marine waters, therefore this study aimed to deal with biological and reproduction of this species from Jableh coast, Syria.

Materials and Methods:

Collecting Samples:

Samples of *E. verrucosa* were collected monthly from March 2021 to February 2022 from the Jableh region, Syria (Fig. 1) using hand nets under stones during low tides.

Study Area:

The area of study consider relatively clean area into which the Rumaila River flows. It is characterized by a rocky landscape topped with deposits of small pebbles and coarse sand, interspersed with well-lit beach pools ending in a rocky slope that is exposed to waves, covered with abundant green algae such as *Ulva*.

Carapace Width, Body Weight Measurements and Sex Determination:

A total of 50 females and 60 males were collected. Carapace width (CW), carapace length (CL), body weight (BW) and sex were recorded for each crab sample. The CW and CL of each crab were measured to the nearest 0.01cm using a millimetric ruler. The BW of the crab was measured to the nearest 0.1 g using a digital balance.

Gonad and Ovarian Development:

The carapace of the crabs was opened to observe gonadal development. Each month, mature female ovaries were dissected and macroscopically examined to determine the maturity stages.

Five stages were used to classify females based on the reproductive staging criteria developed by Paul *et al.* (2021).

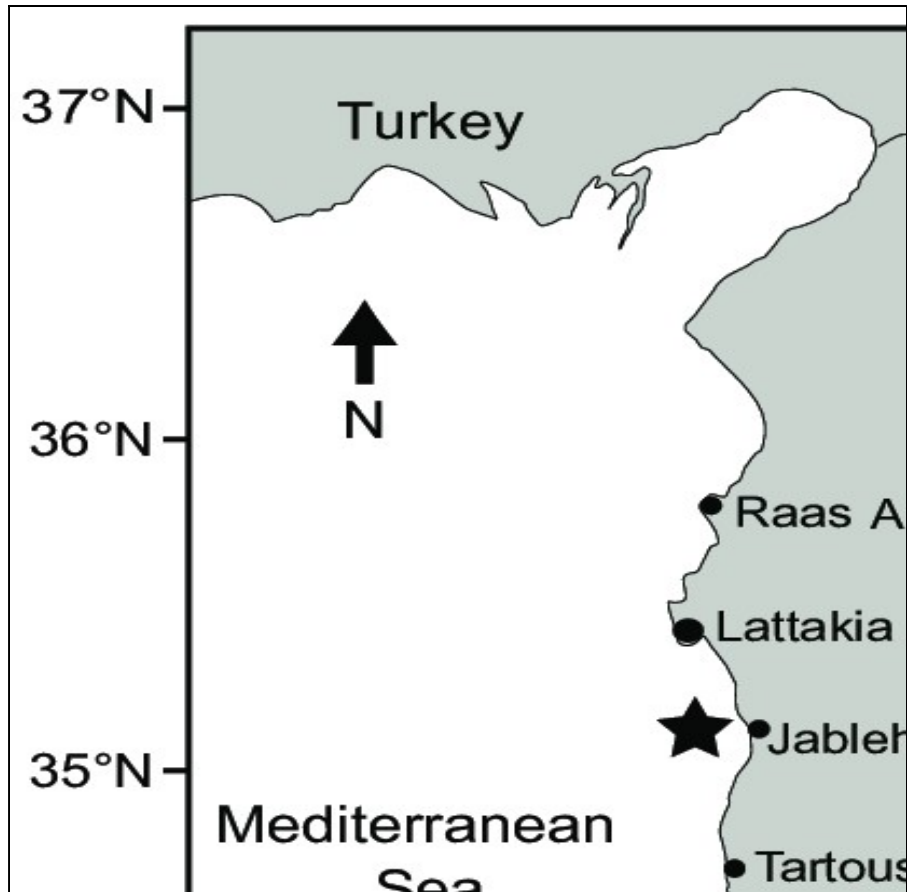


Figure 1. Site of the study in Jableh coast, Syria (Hasan, 2008).

Gonad Development:

The present study investigated the ovarian development stages of *E. verrucosa* based on internal observation. Internal observation occurred through dissection of the species. The process of maturation of ovaries was classified into five phases (stages): immature (stage I; color: creamy white), underdeveloped (stage II; color: yellow), early maturing (stage III; color: orange), late maturing (stage IV; color: brown), and mature (stage V; color: dark purple). The classification was carried out based on the external characteristics and observed color of the ovaries through dissection of the crab. Figure (3) shows the stages of ovary development in *E. verrucosa*, which were as follows: immature, under-developed, early developed, late developed and mature.

The Gonadosomatic Index (GSI) (Fig. 4):

Gonadosomatic index was calculated monthly during the collection of *E. verrucosa* samples. It was calculated using the formula $GSI = 100 \times (GW / W)$, where GW is gonad weight and W is crab weight (Lawal-Are, 2010).

Fertility:

Fertility and egg size were evaluated from ovigerous of 7 females. The egg number was determined using the following $F = n \times (W0 / X)$, where F represents the number of eggs, X stands for subsample weight (g), W0 denotes the weight of the ovary (g), and n represents the number of eggs in the sample (Kumar *et al.*, 2003).

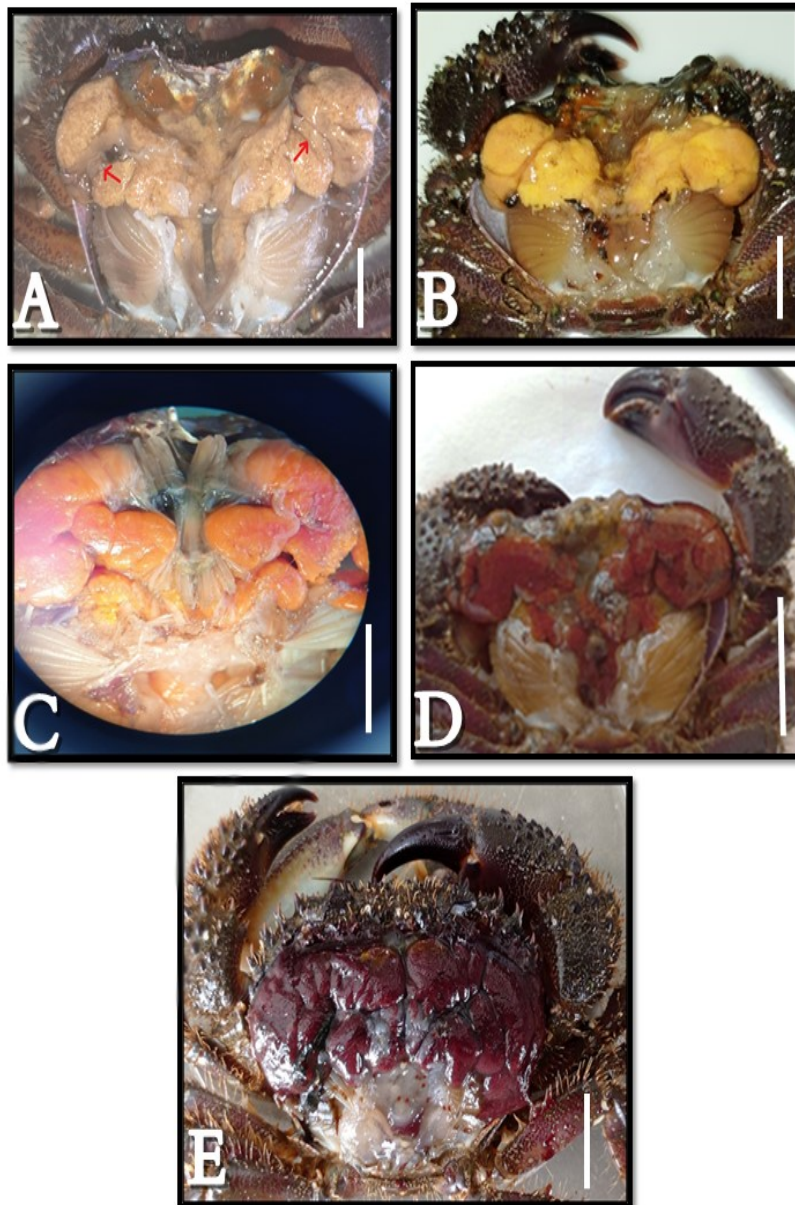


Figure. 3. Ovarian development stages of *E. verrucosa* collected from Jableh coast, Syria; (A) immature stage, (B) under-developed stage, (C) early developed stage, (D) late developed stage, (E) mature stage (scale bar 1cm).

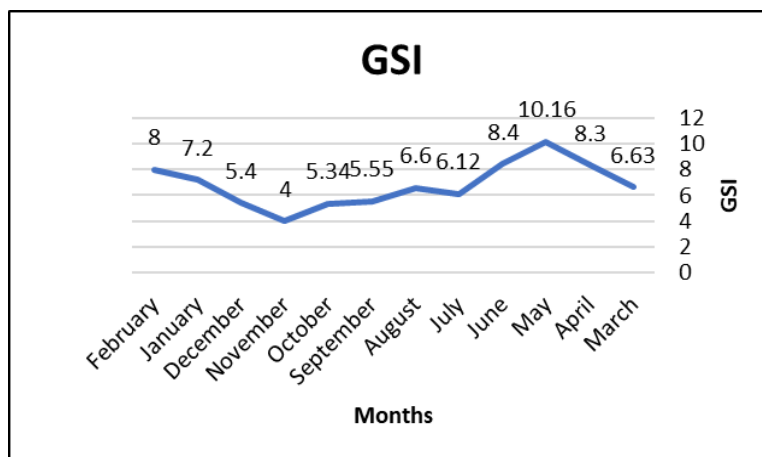


Figure.4: Gonadosomatic index of female *E. verrucosa*

Sex Ratio:

The ratio of males to females was estimated monthly using the relationship (Sarah *et al.*, 2016)

$$\text{Male Sex Ratio} = \frac{\text{number of males}}{\text{total number}} \times 100$$

$$\text{Female Sex Ratio} = \frac{\text{number of females}}{\text{total number}} \times 100$$

Statistical Analysis:

Statistical analyses were performed using SPSS® 10.1 and using excel to draw graphs. Statistical tests involved the use of Pearson correlation. All statistical effects were considered significant when $p < 0.01$.

Results:

A total of 110 crabs of *E. verrucosa*, 50 females (7 ovigerous females), 60 males were caught. Carapace width ranged between 2.3-6.4 cm in females and 2.9-7.2 cm in males, body weight ranged between 19-121.3 g in females and 12.94-140 g in males (Table 1).

Table 1. The total number, carapace width (CW) and body weight (BW) between different sexes of *E. verrucosa* in Jableh coast, Syria.

Sex	Number	CW (mm)	BW (g)
Males	60	2.9-7.2 (5±1.2)	12.94-140 (69.17±38)
Females	50	2.3-6.4 (4.4±1)	19-121.30 (45.40±20.8)
Ovigerous female	7	3.5-6.4 (4.9±1)	25.4-121.30 (60.5±33)

Note: Numbers in parenthesis refers to mean ±SD.

Sex Ratio:

The sex ratio was 54.5% male and 45.4% female. Male of *E. verrucosa* crabs have a V-shaped abdomen while the female have a wider U-shaped abdomen. This ratio was different from the expected 1:1 ratio (Table 2).

Table 2. Monthly variation of total number, males, females and sex ratio of *E. verrucosa* during period March 2021 to February 2022 in Jableh coast, Syria.

Month	Total number	Males	Females	Sex Ratio (M:F)
20/3/2021	6	3	3	1:1
24/4/2021	9	4	5	0.8:1
17/5/2021	11	5	6	0.83:1
20/6/2021	12	6	6	1:1
15/7/2021	11	6	5	1:0.83
11/8/2021	15	8	7	1:0.87
15/9/2021	16	9	7	1:0.77
20/10/2021	12	8	4	1:0.5
16/11/2021	6	2	4	0.5:1
26/12/2021	3	2	1	1:0.5
22/1/2022	4	3	1	1:0.33
17/2/2022	5	4	1	1:0.25
Total	110	60	50	1:0.83

Discussion:

The overall sex ratio of all individuals was calculated as males: females 1:0.83—with a significant deviation from the expected 1:1 ratio, the difference may result from its migration and water temperature. In Karaburun South West Black sea (Erkan *et al.*, 2008); and in the South Black Sea (Turkey).

Karadurmuş and Aydın (2016) found a sex ratio of M:F=1:0.43, M:F=1:0.42, respectively. The crabs were found throughout the year and were abundant from May to October (Table. 2). The reason for that is possibly due to the fact that from May to October mean water temperature (mean, 27.3 °C) and salinities (mean, 37.8‰) were higher than during the other months (Karadurmuş and Aydın, 2016).

In the current study, carapace width (CW) of *E. verrucosa* was 2.9-7.2 cm in males and 2.3-6.4 cm in females, and weight 12.94-140 g for males, 19-121.30 g for females (Table 1). In the South Black Sea (Turkey), the CW ranged from 3 to 9 cm in males, from 3.45 to 8.3 in nonovigerous females, and 3.55 to 7.85 cm in ovigerous females, and the minimum recorded crab weight was 4.07 g (Karadurmuş and Aydın, 2016). In the Aegean Sea the minimum recorded crab weight was 74.6 g for *E. verrucosa* (Ulaş and Aydın, 2011). These differences between the studies could

be due to the variations of sampling methods, total number of examined specimens and sampling regions. Ovigerous females were observed only between March and June. The decrease in gonadosomatic index between May (10.17%) and November (4%) suggests that spawning takes place between these months.

In our research, the fertility of *E. verrucosa* varied from 19512 to 116430 egg for CW ranging from 3.5 to 6.4 cm and body weight from 25.4 to 121.30 g (Table 1). The mean number of eggs was 49285.46 ± 3931 (SD) for a female with a mean CW of 4.9 ± 1 (SD) cm and with a mean body weight 60.5 ± 33 g. In the South Black Sea (Turkey), Karadurmuş and Aydın (2016) was $89,129 \pm 8005$ eggs (range: 15,228 to 224,165 eggs). The CW/ fertility relationship found $F = 81.521CW^{2.650}$, indicating that fertility increases with an increase of CW ($R^2 = 0.357$). Our results also showed that fertility increases with an increase of CW ($R^2 = 0.902$) (Fig. 5).

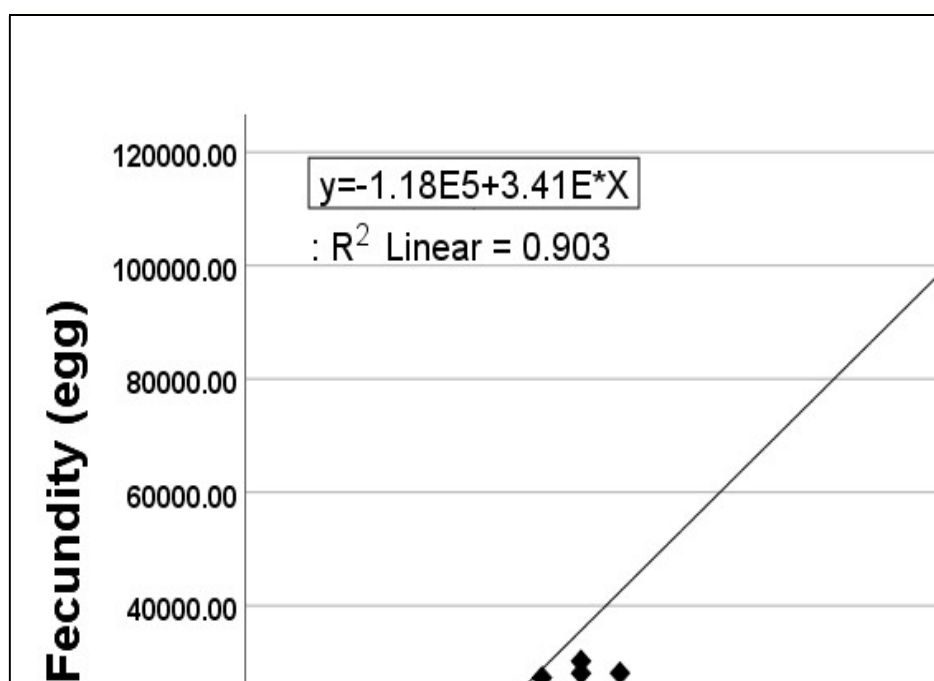


Figure 5. Relationship between carapace width and fecundity of seven females of *E. verrucosa*

The classification of ovarian development stages was carried out based on the external characteristics and observed color of the ovaries through dissection of the crab (Fahimi *et al.*, 2017; Paul *et al.*, 2021). This color variation may happen due to the diet intake of the crab (Quinitio *et al.*, 2007), and may occur due to the accumulation of lipid in the form of yolks in the oocytes (Ikhwanuddin *et al.*, 2014). Finally, our results were compared with a few studies, due to the lack of studies that dealt with the reproductive biology of *E. verrucosa*. However, further studies are required to assess the reproductive biology of warty crabs in other locations of Syrian coast.

Acknowledgements:

We would like to thank the Department of Zoology, Faculty of Science, Tishreen University, Lattakia, Syria, for providing the necessary facilities for work.

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