Reproductive biology of the Suez Canal spider crab

Schizophrys aspera (H. Milne Edwards, 1834: Crustacea: Brachyura: Majidae)

Hamed A. El-Serehy a,b,*, Khaled A. Al-Rasheid b, Nesreen K. Ibrahim c, Fahad A. Al-Misned b

a Marine Science Department, Faculty of Science, Port Said University, Port Said, Egypt
b Zoology Department, College of Science, King Saud University, Riyadh 11451, Saudi Arabia
c Marine Science Department, Faculty of Science, Suez Canal University, Ismailia, Egypt

Received 10 March 2015; revised 20 June 2015; accepted 22 July 2015
Available online 29 July 2015

Abstract A reproductive biology study of the spider crab Schizophrys aspera (H. Milne Edwards, 1834) was conducted in the Suez Canal from July 2012 to June 2013. The annual sex ratio (Male:Female) of S. aspera was female biased with values of 1:1.25. Out of the four ovarian development stages of this crab, two stages were observed in the Suez Canal throughout the whole year. The ovigerous crab’s carapace width varied from 28 to 52 mm. This crab species can spawn during most of the year in the canal water, with a peak during late spring and early winter. The fecundity of ovigerous females ranged between 2349 and 13600 eggs with a mean of 5494 ± 1486 eggs. Female crabs that reached sexual maturity exhibited a minimum carapace width varying between 22 and 46 mm, and fifty percentage of all ovigerous females showed a carapace width of 36 mm.

© 2015 Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Crustaceans are the most dominant and successful aquatic group. They are usually represented by a large number of species, exhibiting a great array of life styles, and occupying quite dissimilar habitats. This diversity in the crustacean groups is a result of their life patterns and reproductive strategies (Sastry, 1983). Crustacean decapods form the major and important component of commercial fisheries in the region of the Suez Canal. Fishing for brachyuran crabs in the Suez Canal is mainly concentrated in the area of the eastern and western coasts of the Bitter Lakes in the southern sector of the canal, and is also dominated by a single family, Portunidae, and especially a single edible species, the blue swimming crab, Portunus pelagicus (Linnaeus, 1758). Catches in the canal, however, often contain specimens of a few of the twelve species of non-edible brachyuran crabs, principally the spider crab Schizophrys aspera (H. Milne Edwards, 1834) (El-Serehy et al., 2012). The spider crab is not edible but is common in the Suez Canal environment, and has a negative impact on fishing nets and the broader fishing industry.
The species is widely distributed, extending into the Red Sea (Griffin and Tranter, 1974), South Africa (Stebbing, 1910) the Seychelles Islands (Rathbun, 1911), Madagascar, Mauritius, Sri Lanka, Singapore, the Philippines (Griffin and Tranter, 1986), India (Chhippar, 1957), Pakistan (Tirmizi and Kazmi, 1991), Japan (Sakai, 1969), China (Dai et al., 1978) Taiwan (Lin, 1949) and America (Rathbun, 1925).

The study of the reproductive biology of these crabs, with particular reference to the seasons of their spawning and fecundity, is important in order to gain complete understanding of their population fluctuations and dynamics. This is vital in order to enable managers and policy makers to develop and establish regulatory measures to conserve the population of the edible and economically important brachyuran crabs in canal water and to help reduce the negative impact of the non-edible brachyuran crabs on the fisheries of the Suez Canal.

Although studying different biological aspects of the spider crabs from the Suez Canal attracted the attention of many authors (Ibrahim, 2012, 2014; Madkour et al., 2012; Ibrahim and Amin, 2013), there appears to be no published reproductive biology study for *S. aspera* in the Suez Canal, and this study is, therefore, an attempt to provide reproductive biology information. Particularly, aspects of the ratio of males and females (sex ratio), developmental stages of the gonads, season during which spawning occurs, size at first sexual maturation and size at 50 percentage maturation of ovigerous females were investigated, along with their fecundity.

### 2. Material and methods

#### 2.1. Collection and processing of crab samples

The study was undertaken in the Suez Canal from July 2012 to June 2013 at six localities. These locations represent the best known fishing sites along the Suez Canal: El-Qntra and El-Ferdan (on the Suez Canal proper); Ismailia on Timsah Lake; and three localities on the Bitter Lake: Deversoir, Fayed and Fanara (Fig. 1). The crabs were collected as discard products from artisanal fishery (gillnets, trammel nets, crab nets and beach seine), moreover few specimens were provided by scuba divers.

Crab samples were randomly selected as they were being brought outside the lift nets. The selected samples were immediately kept in ice. In the laboratory crabs were transferred to a deep freezer and kept at \(-20^\circ C\) until analysis. A total of 3047 crabs of *S. aspera* were collected and preserved this way. Each crab’s sex was determined and its body weight and the width of its carapace were measured and recorded. The width of the carapace was measured to the nearest mm using a Vernier Calliper. Individual wet weights of the collected crabs were recorded to the nearest gram. The ovigerous females were counted, and their carapace width was recorded.

Four major parts of the reproductive biology of the Suez Canal spider crab *S. aspera* were studied as described below:

#### 2.2. Sex ratio

The analysis of *S. aspera* sex ratio was done using monthly data sets of the total number of female and male individuals. Chi-square \((x^2)\) test was applied to detect the significant differences between the ratios of male and female crabs.
season of this spider crab species was determined from the percentage of females in each month who were either at ovary stage III or stage IV.

2.4. Fecundity

For each ovigerous *S. aspera* female, carapace width was measured to the nearest mm and the eggs were weighed to the nearest 0.001 g. In order to calculate the total number of eggs carried externally by each ovigerous female, a sub-sample (5%) of the total egg weight was examined and counted under a Wild M40 inverted microscope. These data were used to calculate the total number of eggs carried by each ovigerous female Kumar et al. (2000).

2.5. Size at first sexual maturity and Lm50 percentage

During the present study, the minimum size class data obtained from 603 females were used to determine the size (Carapace width) at first sexual maturity of *S aspera* in the Suez Canal. The Lm50 percentage (i.e. the length at first reproduction) or the length at which fifty percentage of all females in the crab stock from the Suez Canal are ovigerous was estimated by using the formula given below (King, 1995):

\[ P = \frac{L}{1 + \exp(-r_m (L - L_{m50}))} \]

where, \( P \) is the probability of existing mature crabs, \( L \) is the mean carapace width (mm), \( r_m \) is the slope of the curve, and \( L_{m50} \) is the mean carapace width (mm) at sexual maturity.

3. Results

3.1. Sex ratio

During the present study a total of 3047 crabs of *S. aspera* were collected from the canal, with 1354 and 1693 individuals of males and females, respectively. Thus the overall ratio between male and female *S. aspera* in the Suez Canal during the whole year is not equal. Rather, females comprise 55.6% of the total. Moreover, the Chi square analysis (Table 1) confirmed that the overall sex ratio of the Suez Canal *S. aspera* differed significantly from unity (\( p < 0.05 \)).

3.2. Female maturity stages and spawning season

Monthly variations in the different maturity stages of female ovaries of *S. aspera* species are shown in Fig. 2. Eggs of the female crab have various colors of yellow, orange and brown depending on the stage of maturity. Four different stages of maturation were recognized: stage I (immature), white to ivory; stage II (maturing or developing), creamy; stage III (mature), yellow to orange; and stage IV (ripe), brown. Immature females were recorded in all months, but the highest percentage was in January. The proportion of maturing females increased during the winter months to reach a maximum in April. Mature females were observed during summer with the highest percentages occurring in August. Specimens at the spent stage (ovigerous females) appeared in considerable numbers for most of the year except between January and April. This indicates that *S. aspera* has a prolonged breeding season that commences in May and terminates in December.

3.3. Size at first sexual maturity and Lm50%

The size of female *S. aspera* at first sexual maturity was determined using the minimum size class data of 603 ovigerous females collected from the Suez Canal. During the present study, female *S. aspera* crabs attained maturation when their carapace width (CW) varied between 22 and 62 mm. The minimum carapace width of female *S. aspera* attaining maturation in the Suez Canal varied between 22 and 46 mm. The logistic curve fitting the estimation of carapace width at which 50 percentage of female *S. aspera* are sexually mature is shown in Fig. 3. Fifty percent maturity was attained at a female carapace width of 36 mm.

4. Fecundity

Table 2 shows the relationships between the width of the carapace, the egg size and the number of females’ eggs for *S. aspera* recorded during the period of this investigation. Determination of fecundity of the female *S. aspera* from the Suez Canal showed that each female with a carapace width ranging between 28 and 52 mm can produce a total number of eggs varying between 2349 and 13,600. During the present

| Year | Total (Observed) | Sex ratio | \( \chi^2 \) (p value) |
|------|-----------------|-----------|---------------------|
|      | Male | Female | Total | Male | Female |         |
| 2012 | Jul.  | 82    | 102   | 184 | 1     | 1.24   | 0.14   |
|      | Aug.  | 90    | 87    | 177 | 1     | 0.97   | 0.82   |
|      | Sep.  | 178   | 116   | 294 | 1     | 0.65   | 0.01   |
|      | Oct.  | 62    | 85    | 147 | 1     | 1.37   | 0.06   |
|      | Nov.  | 13    | 24    | 37  | 1     | 1.85   | 0.07   |
|      | Dec.  | 137   | 107   | 244 | 1     | 0.78   | 0.05   |
| 2013 | Jan.  | 64    | 90    | 154 | 1     | 1.04   | 0.04   |
|      | Feb.  | 53    | 90    | 143 | 1     | 1.47   | 0.01   |
|      | Mar.  | 27    | 56    | 83  | 1     | 1.02   | 0.01   |
|      | Apr.  | 302   | 318   | 620 | 1     | 0.76   | 0.52   |
|      | May   | 109   | 131   | 240 | 1     | 0.68   | 0.16   |
|      | Jun.  | 237   | 487   | 724 | 1     | 0.94   | 0.01   |
| Total| 1354 | 1693  | 3074  | 1    | 1.25  | 0.03   |
In the present study, the mean fecundity of *S. aspera* was 5494 ± 1486 eggs. In the Suez Canal, the smallest ovigerous female had a carapace width of 28 mm, 14.3 g total weight, 0.36 g gonad weight, a fecundity of 2349 eggs and an egg size of 890 μm. The largest ovigerous female, meanwhile, achieved a carapace width of 52 mm, 81.34 g total weight, 4.95 g gonad weight, a fecundity of 13,600 eggs and an egg size of 1263 μm.

5. Discussion

In the majority of brachyuran crab species, the sex ratio is usually close to unity (Hartnoll, 1978; Lawal-Are, 2010), however some variations between different populations and from one year to the other in the same population have been detected (Sastry, 1983; Varisco and Vinuesa, 2011). During the present study the overall sex ratio in *S. aspera* (with the values of M:F = 1:1.25) differed significantly from the expected 1:1 ratio, with most months revealing a higher number of females, i.e. the sex ratio of the Suez Canal spider crab *S. aspera* is female biased. An overall female bias in the sex has been recorded for many brachyuran crab species (Safaie et al., 2013; Chatterjee and Chakraborty, 2015). There are two main possible reasons for this difference from the expected 1:1 ratio between the two sexes. On the one hand, it may result from differences in habitat preferences and feeding behavior between male and female crabs. Mature crabs are known to display different habitat preferences between male and females. Generally, females migrate from inshore areas toward offshore to spawn (Weng, 1992). Moreover, most female crabs are
known to require a sandy substrate for successful egg extrusion (Kangas, 2000). Females of many crab species are more abundant in shallow water (Potter et al., 1983). All the six fishing localities of the Suez Canal exhibited sandy substrates, shallow water depths (5–25 m), and most of the fishing process occurred offshore. Alternatively, the unequal sex ratio of S. aspera in the Suez Canal could be attributed to the effects of fishing gear. Fishermen in the Suez Canal use a variety of gears such as gillnets, trammel nets, crab nets and beach seine. Gillnets and trammel nets usually operate in the deeper area, while crab nets and beach seine perform in shallow water. This difference in operating fishing gears produces unequal brachyuran sex ratio (Kangas, 2000; Lawal-Are, 2010; Safaie et al., 2013).

The immature stages of S. aspera were observed through 2012 and 2013, revealing that the mature stages occurred from May and extended to December (Fig. 2). This pattern of ovarian development from the Suez Canal indicates that the third and fourth stages of ovarian development is usually achieved in conjunction with rising sea water temperatures, which in their turn indicate that the development of ovaries and eggs in S. aspera is controlled by water temperatures. Brachyuran crab spawning takes place during the whole year in tropical and subtropical waters, while it appears to be more restricted to the warmer months in the temperate regions (Kangas, 2000; Lawal-Are, 2010; Safaie et al., 2013).

In the present study, the range of the minimum carapace width (CW) of ovigerous female S. aspera was 22–46 mm, and the CW at which 50% of all females in the stock of that spider crab are ovigerous was 36 mm. According to Campbell and Fielder (1986), Sukumaran and Neelakantan (1996), and Sal-Moyano et al. (2014), the size at first sexual maturity differs with latitude and/or location and within individuals at any location.

The fecundity of brachyuran crabs is usually recognized to be an important parameter for measuring their reproductive output (Mantellatto and Fransozo, 1997). Determination of the fecundity of female S. aspera from the Suez Canal showed that each female with a carapace width varying from 28 to 52 mm can produce 2349–13,600 eggs. In the Suez Canal water, mean fecundity of S. aspera attained 5149 ± 1367 eggs. The spider crab S. aspera, therefore, seems to be a crab species with relatively low fecundity. Fecundity can vary among crab species from less than 5000 eggs, described for Aratus pisonii (H. Milne Edwards, 1837) in Jamaica (Warner, 1967) to more than 4,000,000 eggs, as reported by Haynes et al. (1976) for Chionoecetes opilio (Fabricius, 1788) in the Gulf of Saint Lawrence, Canada. Fecundity of female crabs is size dependent (Kumar et al., 2003), moreover fecundity is strongly correlated with body size of the crab species and weight within the species (Hartnoll, 1985). The analysis of the relationship between carapace width and fecundity for S. aspera in the Suez Canal with Fecundity = 2.2808 (CW)^2.09 indicates that the fecundity increases with an increase in carapace width (R^2 = 0.62). Thus, it can be stated that higher fecundity was found in larger female crabs due to the longer inter-molt period between population and egg extrusion. In other words, larger females usually have more time than the smaller ones in order to accumulate the energy reserves. The latter are usually required by female crabs (small and/or large) to produce their eggs. This difference might account for the higher number of eggs often produced by large sized females (De Lestang et al., 2003; Sal-Moyano et al., 2014). As discussed above, fecundity of crabs not only varies from one species to the other, but also varies within the same species. Many factors can affect fecundity in brachyuran crabs including: size, age, climatic regime, nourishment, and even ecological properties of the water body (Arshad et al., 2006; Safaie et al., 2013; Gonzalez-Pisani and Lopez-Greco, 2014).

In conclusion, the annual sex ratio (Male:Female) of S. aspera is not 1:1 but rather, 55.6% are females, i.e. the sex ratio in this species is biased toward females and differed significantly from the expected unity, with most months sustaining a higher female occurrence. The range of the minimum carapace width (CW) of ovigerous female S. aspera was 22–46 mm, and the carapace width at which 50% of all females in the stock of that spider crab are ovigerous was 36 mm. Despite having a low fecundity, S. aspera has a prolonged breeding season in the Suez Canal that commences in May and terminates in December.

Acknowledgment

The authors extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for funding this work through Research Group number (RG-1436-242).

References

Arshad, A., Efrizal Kamarudin, M.S., Saad, C.R., 2006. Study on Fecundity, Embryology and larval development of blue swimming crab Portunus pelagicus (Linnaeus, 1758) under laboratory conditions. Res. J. Fish. Hydrobiol. 1, 35–44.
Campbell, G.R., Fielder, D.R., 1986. Size at sexual maturity and occurrence of ovigerous females in three species of commercially
exploited portunid crabs in SE Queensland. Proc. R. Soc. Queensland 97, 79–87.

Chatterjee, S., Chakraborty, S.K., 2015. Population and reproductive biology of two species of brachyuran crabs (Family: Grapsidae) Sesarma (Chironomans) bidens and Metapogonops maculatus at coastal belt of Midnapore, West Bengal, India. Int. J. Aquat. Sci. 6, 15–36.

Chhapgar, B.F., 1957. On the marine crabs (Decapoda: Brachyura) Sarcopagis gregaria and S. splendida from the Gulf of St. Lawrence. J. Fish. Res. Board Can. 33, 2592–2595.

Ching, M., 1995. Fisheries Biology, Assessment and Management. Fishing News Books. Blakwell Science Ltd., Oxford, UK, pp. 342.

Kumar M.S., Ferguson G., Xiao Y., Hooper G., Venema S., 2000. Studies on Reproductive Biology and distribution of blue swimmer crab (Portunus pelagicus) in South Australian Waters. SARDI Research Report Series No 47.

Kumar, M.S., Xiao, Y., Hooper, G., Venema, S., 2003. Reproductive cycle of the blue swimmer crab, Portunus pelagicus, off southern Australia. J. Mar. Biol. Assoc. UK 83, 983–994.

Lawal-Are, A.O., 2010. Reproductive biology of the blue crab, Callinectes sapidus (De Rochebrune) in the Lagos Lagoon, Nigeria. Turk. J. Fish. Aquat. Sci. 10, 1–7.

Lin, C.C., 1949. A catalogue of brachyurous Crustacea of Taiwan. Quart. J. Taiwan Mus. 2, 10–33.

Madkour, F.F., Sallam, W.S., Wicksten, M.K., 2012. Epibiota of the spider crab Schizophrys dahlahk (Brachyura: Majidae) from the Suez Canal with special reference to epizoic diatoms. Mar. Biodivers. Rec. 5, 64–70.

Mantellatto, F.L.M., Fransozo, A., 1997. Fecondity of the crab Callinectes ornatus Ordway, 1863 (Decapoda, Brachyura, Portunidae) from the Ubatuba region, Sào Paulo, Brazil. Crustaceana 70, 214–226.

Potter, I.C., Chrystal, P.J., Lonergan, N.R., 1983. The biology of the blue manna crab P. pelagicus in an Australian Estuary. Mar. Biol. 78, 75–85.

Rathbun, M.J., 1911. Marine Brachyura. The Percy Sladen Trust Expedition to the Indian Ocean in 1905. under the leadership of Mr. J. Stanley Gardiner. Volume 3, number 11. Trans. Linn. Soc. Lond. 14, 191–261.

Rathbun, M.J., 1925. The spider crabs of America. Bull. U.S. Nat. Mus. 129 (i–xx), 1–613.

Safaie, M., Pazooki, J., Kiabi, B., Shokri, M.R., 2013. Reproductive biology of the blue swimming crab, Portunus similis (Forskal, 1775) in coastal waters of Persian Gulf and Oman Sea, Iran. Iran. J. Fish. Sci. 12, 430–444.

Sakai, T., 1969. Two new genera and twenty-two new species of crabs from Japan. Proc. Biol. Soc. Wash. 82, 243–280.

Sal-Moyano, M.P., Lagos-Tobias, A.M., Felder, D.L., Mantelatto, F.L.M., 2014. Reproductive growth and reproductive parameters in a population of Microphrys bicornutus (Brachyura, Majoidea) from Bocas Del Toro, Caribbean Sea, Panama. Rev. Biol. Mar. Oceanogr. 49, 81–90.

Sastrı, A.N., 1983. Ecological aspects of reproduction. In: Vernberg, F.J., Vernberg, W.B. (Eds.), The Biology of Crustacea. Academic Press, New York, pp. 179–270.

Stebbing, T.R.R., 1910. Scientific results of the trawling Expedition of H.M.C.S. “Thetis” Crustacea Part V. Amphipoda of Australia. Mem. Aust. Mus. 4, 567–658.

Sukumaran, K.K., Neelakantan, B., 1996. Relative growth and sexual maturity in the marine crabs, Portunus sanguinolentus (Herbst) and Portunus pelagicus (Linnaeus) along the south-west coast of India. Ind. J. Fish. 43, 215–223.

Tirmizi, N.M., Kazmi Q.B., 1991. Marine fauna of Pakistan: 4. Crustacea: Brachura (Dromiacea, Archaeobrachyura, Oxystomatia, Oxyrhyncha). Univ Karachi BCCI (Bank Credit Commr Int) Foundation Chair, Publication No. 1, pp. 1–244.

Varisco, M., Vinuesa, J., 2011. Reproductive biology of the spider crab Leucippa pentagona (Decapoda: Epialtidae), in Bustamante Bay, Argentina. Rev. Invest. Mar. 39, 471–480.

Warner, G.F., 1967. The life history of mangrove tree crab, Aratus pisonii. J. Zool. 153, 321–335.

Weng, H.T., 1992. The sand crab Portunus pelagicus (Linnaeus) populations of two different environments in Queensland. Fish. Res. 13, 407–422.