PRELIMINARY BIOLOGICAL INFORMATION OF SCYLLA SERRATA (FORSKÅL, 1775) (BRACHYURA, PORTUNIDAE) IN THE PERSIAN GULF AND GULF OF OMAN: A CONSERVATION PRIORITY

BY

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ABSTRACT

The status of the populations of the mud crab Scylla serrata (Forskål, 1775) is poorly known in the western Indian Ocean. Biological aspects of the species have been studied using 96 specimens collected between autumn 2009 and summer 2010 from the northwestern Gulf of Oman and 22 specimens collected in spring 2009 from the northeastern Persian Gulf. The population was found to be sparse in the northwestern Gulf of Oman (about 1 crab per hectare) and only one small population was recorded in the Persian Gulf. In total, 81.3% of the crabs in the Gulf of Oman were males, which may be a result of the breeding migration of females into offshore waters. The carapace width of the Gulf of Oman specimens ranged from 89.7 to 196.5 mm (males) and 91.7 to 170.1 mm (females). The smallest mature female measured was 12.4 cm in carapace width. The carapace width (CW)/weight (W) relationships in the crabs of the Gulf of Oman were calculated to be $W = 2 \times 10^{-5} CW^{3.48}$ and $W = 1.8 \times 10^{-3} CW^{2.52}$ for males and females, respectively. The gill chamber in many of the Gulf of Oman’s crabs was covered with the lepadomorph barnacles, Octolasmis cor (Aurivillius, 1892) and O. angulata (Aurivillius, 1894). Although, the reason of the low abundance of the crab in the Persian Gulf and the Gulf of Oman is still unknown, conservation programmes seem to be necessary.

RÉSUMÉ

Le statut des populations du crabe Scylla serrata (Forskål, 1775) est peu connu dans l’ouest de l’Océan Indien. Les aspects biologiques des cette espèce ont été étudiés à partir de 96 spécimens collectés entre l’automne 2009 et l’été 2010 dans la partie nord-ouest du Golfe d’Oman et de 22 spécimens collectés au printemps 2009 dans le nord-est du Golfe Persique. La population a été...
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trouvée clairsemée dans le nord-ouest du Golfe d’Oman (à peu près 1 crabe/hectare) et une seule petite population a été trouvée dans le Golfe Persique. Au total 81,3% des crabes du Golfe d’Oman étaient des mâles, ce qui est peut être le résultat de la migration reproductrice des femelles vers les eaux du large. La largeur de la carapace des spécimens du Golfe d’Oman s’échelonne entre 89,7 à 196,5 mm (mâles) et 91,7 à 170,1 mm (femelles). La plus petite femelle mature mesurée a été de 12,4 cm de largeur de carapace. La relation largeur de la carapace (CW)/ poids (W) chez les crabes du Golfe d’Oman a été calculée à \( W = 2 \times 10^{-5} \times CW^{3.48} \) et \( W = 1.8 \times 10^{-5} \times CW^{2.52} \) respectivement, pour les mâles et les femelles. La chambre branchiale de nombreux crabes du Golfe d’Oman était couverte de cirriphèdes lépadomorphes Octolasmis cor (Aurivillius, 1892) et O. angulata (Aurivillius, 1894). Bien que la raison de la faible abondance des crabes du Golfe Persique et du Golfe d’Oman soit encore inconnue, des programmes de conservation semblent nécessaires.

INTRODUCTION

Mud crabs (Scylla spp.) are large portunid crabs that are mangrove associated and distributed throughout the tropical and subtropical Indo-Pacific region (Keenan et al., 1998; Keenan, 1999). These crabs are commercially important and play an essential role in crustacean fishery and aquaculture due to their meat quality, large size and ability to survive out of water for up to five days, which makes possible their shipment to distant markets (Angell, 1992; Le Vay, 2001). The taxonomic composition of the genus Scylla was unclear until recently when Keenan et al. (1998) distinguished four species within the genus based on their allozyme, mitochondrial DNA and morphometric characters. The four species are Scylla serrata (Forskål, 1775), S. olivacea (Herbst, 1796), S. tranquebarica (Fabricius, 1798) and S. paramamosain (Estampador, 1949). Such a clear knowledge for discriminating the four species based on external characters is very helpful in understanding the biology, ecology and fishery management of these crabs (Le Vay, 2001). Scylla serrata is considered to be the largest portunid crab (around 200 mm in carapace width and 1.5 to 2 kg in weight; Apel & Spiridonov, 1998) and it is also the most widespread species of the genus, being distributed throughout the Indo-West Pacific, and is the only known mud crab species in the western Indian Ocean (Keenan et al., 1998; Le Vay, 2001). The preferred habitat of S. serrata is mangrove forest inundated by full salinity sea water during most of the year (Keenan et al., 1998).

The southern part of Iran (north of the Persian Gulf and Gulf of Oman) is bounded with 1700 km of subtropical coastal area and is patchily covered with 15 000 ha of mangrove forests from the Mond Protected Area in the northwest of the Persian Gulf to northeast of the Gulf of Oman (Sheppard et al., 2010). Avicennia marina (Vierh.) is the dominant mangrove species throughout the southern Iranian mangrove stands, whereas Rhizophora mucronata (Lam.) occurs scarcely in the northwestern Gulf of Oman (Sheppard et al., 2010; Zahed et al., 2010). The southern Iranian mangrove reserve was designated as a Protected
Area, Ramsar Site and Biosphere Reserve in 1972, 1975 and 1976, respectively. Overexploitation of mangrove trees and oil pollution are considered as main threats for these areas (Zahed et al., 2010). It seems likely that populations of *S. serrata* are limited to the northern coast of the Persian Gulf and the Gulf of Oman (south coast of Iran) (Naderloo & Türkay, 2012; M. Rezaie-Atagholipour, pers. obs.), whereas on the south coast of the area specimens of the species have been recorded occasionally from the coastal waters of the United Arab Emirates in both the Persian Gulf and the Gulf of Oman (Apel & Spiridonov, 1998; Hogarth & Beech, 2001). There is a large number of studies on the biology and aquaculture of *S. serrata* within its geographical distribution range (BOBP, 1992), due to its importance in fisheries and aquaculture. However, there are no data available on the biological aspects of the species in the Persian Gulf and the Gulf of Oman. The aim of the study was to investigate biological aspects of *S. serrata* in a mangrove ecosystem in the Gulf of Oman, such as size distribution, carapace length/width-weight relationships, sex ratio and ovarian maturity. Further, these biological aspects were also investigated in the only known population in the Persian Gulf.

**MATERIAL AND METHODS**

The study sites were two mangrove ecosystems along the Iranian coast of the Persian Gulf and the Gulf of Oman (fig. 1). In total, 96 individuals (78 males and 18 females) were collected in monthly samplings from November 2009 to September 2010 from the mangrove ecosystem in northwestern Gulf of Oman (Hormozgan Province, west of the city of Jask, between 25°68′N and 26°68′N, and 57°77′E and 57°82′E). This area is a semi-enclosed muddy habitat with seasonal freshwater input and covered with mangrove trees (*Rhizophora mucronata*). Furthermore, 22 individuals were collected in April and May 2009 from a mangrove ecosystem in the northeastern Persian Gulf (Hormozgan Province, south coast of Qeshm Island, between 26°71′N and 26°72′N, and 55°90′E and 55°93′E). This area has a seawater channel running parallel to the coastal line, covered with planted mangroves (*Avicennia marina*) and has a wide muddy area towards its seaward fringe. There is no freshwater input into this mangrove ecosystem. The crabs were collected by hand on the site of the Persian Gulf and by hand and traps on the site of the Gulf of Oman.

In the laboratory, crabs were sexed, weighed and nine morphometric characters, proposed by Keenan et al. (1998), were examined. Because of the small sample size, data from the specimens of the Qeshm Island site were not calculated for all biological analyses. The specimens were dissected to determine ovarian maturation
Fig. 1. Map of the collection sites: A, south of Qeshm Island, northeast of the Persian Gulf; B, Jask city, northwest of the Gulf of Oman.

using external morphology and colour condition of the ovary, described by Quinitio et al. (2007).

The carapace length-weight and carapace width-weight relationships were calculated separately for both sexes using the equation: \( W = aL^b \), where \( W \) is the derived weight (g), \( L \) is the carapace length or width (mm), \( a \) is the intercept of the regression curve and \( b \) is the regression coefficient (slope) (Ikhwanuddin et al., 2011). Values are given as mean ± SE. All statistical and graphical analyses were performed using Microsoft Office Excel and PASW version 18 (IMB). All statistical tests were assumed significant at \( P \leq 0.05 \).

RESULTS

The density of the population of *Scylla serrata* found in Qeshm Island was very low as only 22 specimens were collected during April and May 2009. The density of the population in the Gulf of Oman was also estimated to be low (up to 1 crab per hectare). The mean carapace width has been estimated to be 168.9 ± 4.1 mm and 153.8 ± 2.6 mm for populations of the Persian Gulf and the Gulf of Oman,
TABLE I
Seasonal sex ratio, size (carapace width), and weight of *Scylla serrata* (Forskål, 1775) in mangrove stands of the northeast of the Persian Gulf (Qeshm Island) and northwest of the Gulf of Oman (Jask city)

<table>
<thead>
<tr>
<th>Season</th>
<th>Sex (n)</th>
<th>Sex ratio</th>
<th>Weight (g)</th>
<th>Carapace width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>M : F</td>
<td>Mean ± SE</td>
<td>Range</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persian Gulf</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 2009</td>
<td>M (13)</td>
<td>59.1</td>
<td>1 : 0.69</td>
<td>649.2 ± 86.3</td>
</tr>
<tr>
<td>F (9)</td>
<td>40.9</td>
<td></td>
<td>789.8 ± 106</td>
<td>238-1424</td>
</tr>
<tr>
<td>Gulf of Oman</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 2010</td>
<td>M (18)</td>
<td>72</td>
<td>1 : 0.38</td>
<td>1132.2 ± 144</td>
</tr>
<tr>
<td>F (7)</td>
<td>28</td>
<td></td>
<td>435.4 ± 80.3</td>
<td>135.6-810</td>
</tr>
<tr>
<td>Summer 2010</td>
<td>M (13)</td>
<td>86.7</td>
<td>1 : 0.15</td>
<td>473.4 ± 37</td>
</tr>
<tr>
<td>F (2)</td>
<td>13.3</td>
<td></td>
<td>496.7 ± 62.9</td>
<td>231.9-999.8</td>
</tr>
<tr>
<td>Autumn 2010</td>
<td>M (23)</td>
<td>88.5</td>
<td>1 : 0.13</td>
<td>760 ± 71.3</td>
</tr>
<tr>
<td>F (3)</td>
<td>11.5</td>
<td></td>
<td>429.6 ± 73.8</td>
<td>286.3-532.1</td>
</tr>
<tr>
<td>Winter 2010</td>
<td>M (24)</td>
<td>80</td>
<td>1 : 0.25</td>
<td>1177.5 ± 64</td>
</tr>
<tr>
<td>F (6)</td>
<td>20</td>
<td></td>
<td>454.7 ± 46.5</td>
<td>383.3-681.9</td>
</tr>
<tr>
<td>Total 2010</td>
<td>M (78)</td>
<td>81.3</td>
<td>1 : 0.23</td>
<td>927.8 ± 52.9</td>
</tr>
<tr>
<td>F (18)</td>
<td>18.7</td>
<td></td>
<td>445.1 ± 35</td>
<td>135.6-810</td>
</tr>
</tbody>
</table>

Errors are given as standard error (SE).

respectively (table I). The results showed that the mean CW of 22 crabs (13 males and 9 females) collected in spring 2009 from the Persian Gulf was significantly larger than that of 23 crabs (16 males and 7 females) collected in spring 2010 from the Gulf of Oman (Student’s \( t = 1.46 \), df = 43 and \( P = 0.03 \)). The mean and range of weight and carapace width (CW) for both populations are shown in table I on a seasonal basis. The smallest specimen (CW = 89.7 mm and \( W = 122.7 \) g) and the largest specimen (CW = 196.5 mm and \( W = 1989.6 \) g) from the Gulf of Oman were two males, which were observed in April (winter) 2010 (table I). The most variable size frequency in this area was detected in spring 2010 (table I). Also, unimodal size distributions for both sexes were calculated as 170 mm for males \((n = 14, 2.06\% \) of males and 14.6% of all crabs) and 110 mm for females \((n = 5, 27.8\% \) of females and 5.2% of all crabs, see fig. 2). The carapace width-weight relationships for the population of the Gulf of Oman were analysed (fig. 3) and compared to other studies (table II). The regression coefficient values \((b)\) were 2.52 and 3.48 for females and males, respectively.

In total, 13 out of 22 crabs collected in April and May 2009 from the Persian Gulf were females (table I) and seven of them were mature, with one pair of crabs observed during mating. In contrast, 81.3% of crabs collected during a year in the Gulf of Oman were male (table I), and mature females were observed in winter
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Fig. 2. Size (carapace width) distribution of *Scylla serrata* (Forskål, 1775) in Jask mangrove stand, northwest of the Gulf of Oman. 

$(n = 4)$, spring $(n = 3)$ and summer $(n = 2)$. Unfortunately the spawning peak could not be determined in this study due to the small sample size. The smallest mature female in the Gulf of Oman measured 12.4 cm in CW, and also four out of eight mature females were in the CW size class 13 cm. All females with CW larger than 14.5 cm $(n = 5)$ were mature.

The acorn barnacles *Amphibalanus amphitrite* (Darwin, 1854) and *Chelonibia patula* (Ranzani, 1818) were commonly seen attached to the carapace, claws and walking legs of the many specimens collected from the Gulf of Oman. Further, *A. amphitrite* also was observed on the body of the Persian Gulf’s crabs. Two lepadomorph barnacles, *Octolasmis cor* (Aurivillius, 1892) and *O. angulata* (Aurivillius, 1894), were found together in the gill chamber of the mud crabs collected from the Gulf of Oman, but were not observed in the population from the Persian Gulf. The lepadomorph barnacle-bearing crabs were observed in winter and spring 2010 with mean CW $15.9 \pm 9.1$ cm, and all of them, but one, were male.

DISCUSSION

Distribution and density

Sampling at Qeshm Island was discontinued after two months due to the unstable condition of the population. The population of mud crabs at Qeshm Island was the first known and most probably is the only population of the species in the Persian Gulf (Naderloo & Türkay, 2012). Other reports of the species from the Gulf include the mention by Naderloo & Türkay (2012) from Bandar-Abbas (Iran) and
Fig. 3. A, Carapace width-weight; and, B, carapace length-weight relationships of *Scylla serrata* (Forskål, 1775) in Jask mangrove stand, northwest of the Gulf of Oman.

that of Hogarth & Beech (2001) from Ras al-Khaimah (United Arab Emirate), with each report based on a single specimen. *Scylla serrata* has been recorded as being abundant in the archaeological deposits along the coastal regions of the United Arab Emirates, but mangrove habitat fragmentation was considered as the most probable cause for loss of this species from this area (Beech & Hogarth, 2002).

Comparably, *S. serrata* has a stable population in the well-developed mangrove ecosystems occurring along the Iranian coast of the Gulf of Oman. However, the
### TABLE II

Overall sex ratio, size at maturity (CW50) and length-weight relationship of *Scylla serrata* (Forskål, 1775) through its geographical distribution range

<table>
<thead>
<tr>
<th>Sex</th>
<th>Overall sex ratio (%)</th>
<th>CW50 (cm)</th>
<th>CW-weight relationship</th>
<th>CL-weight relationship</th>
<th>Region</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>18.7</td>
<td>–</td>
<td>( W = 1.8 \times 10^{-3} \text{CW}^{2.52} )</td>
<td>( W = 4.2 \times 10^{-3} \text{CL}^{2.55} )</td>
<td>The Gulf of Oman, Iran</td>
<td>This study</td>
</tr>
<tr>
<td>Male</td>
<td>81.3</td>
<td>–</td>
<td>( W = 2 \times 10^{-5} \text{CW}^{3.48} )</td>
<td>( W = 8 \times 10^{-5} \text{CL}^{3.47} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>7.5</td>
<td>–</td>
<td>( W = 2.9 \times 10^{-3} \text{CL}^{2.59} )</td>
<td>Kenya, East Africa</td>
<td>Fondo et al. (2010)</td>
</tr>
<tr>
<td>Male</td>
<td>60</td>
<td>7</td>
<td>–</td>
<td>( W = 1 \times 10^{-4} \text{CL}^{3.38} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>48.4</td>
<td>–</td>
<td>( W = 5 \times 10^{-3} \text{CW}^{1.89} )</td>
<td>–</td>
<td>Khulna, Bangladesh</td>
<td>Ali et al. (2004)</td>
</tr>
<tr>
<td>Male</td>
<td>51.6</td>
<td>–</td>
<td>( W = 7.8 \times 10^{-3} \text{CW}^{3.06} )</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>45.3</td>
<td>8.6</td>
<td>( W = 4 \times 10^{-1} \text{CW}^{2.69} )</td>
<td>–</td>
<td>Ranong, Thailand</td>
<td>Tongdee (2001)</td>
</tr>
<tr>
<td>Male</td>
<td>54.7</td>
<td>–</td>
<td>( W = 1.2 \times 10^{-1} \text{CW}^{3.32} )</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>33</td>
<td>13-14</td>
<td>–</td>
<td>–</td>
<td>Cape, South Africa</td>
<td>Robertson (1996)</td>
</tr>
<tr>
<td>Male</td>
<td>67</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>Catch was not randomly</td>
<td>12</td>
<td>–</td>
<td>–</td>
<td>Nogombo, Sri Lanka</td>
<td>Jayamanna &amp; Jinadasa (1993)</td>
</tr>
<tr>
<td>Male</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>10.5</td>
<td>–</td>
<td>–</td>
<td>Papua, New Guinea</td>
<td>Quinn &amp; Kojis (1987)</td>
</tr>
<tr>
<td>Male</td>
<td>51</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile</td>
<td>9</td>
<td></td>
<td>–</td>
<td>–</td>
<td></td>
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</tr>
</tbody>
</table>
density of this population is low (up to 1 crab per hectare) compared with the
density of this species in other mangrove habitats in Indo-West Pacific region. For
instance, Hill (1979) reported 44-53 individuals per hectare and Robertson (1996)
reported 15-33 individuals per hectare along the South African estuaries. A low
density of the species (up to 2 crabs per hectare) was also recorded in Queensland,
Australia (Hill, 1979).

Size distribution

The probable reason for a higher mean CW in the Qeshm Island area population
compared to the Gulf of Oman population (in the same season) may be lower mud
crab exploitation rates in the Persian Gulf compared to the Gulf of Oman (Rezaie-
Atagholipour, pers. obs.).

From the mean CW values in both sites of the present study (table I) it appears
that specimens of the populations in the southern Iran are approximately larger
compared to other regions in the Indo-Pacific. Further, the modal size classes in the
Gulf of Oman (170 mm for males and 110 mm for females) were higher compared
given values in other geographical ranges of the species, such as Kenya in East
Africa (75 mm for males and 81 mm for females, Fondo et al., 2010), Bangladesh
(81-90 mm for males, Ali et al., 2004) and New Guinea (100-110 mm for males
and 115-120 for females, Quinn & Kojis, 1987).

There are many benefits to estimating the length-weight relationships in crabs,
including the possibility of ontogenetic analyses in studies of population dynamics,
calculating the crab biomass and the possibility to convert weight to length, due
to the fact that the extremities of the crab can be broken easily and measuring
may be difficult (Ikhwanuddin et al., 2011). Results of length-weight relationships
in the present study (table II) suggest that males may be heavier than females
for a given CW, but this phenomenon was only observed in large crabs (fig. 3).
In other words, in large crabs, the ratio of body weight to CW in males was
higher than in females, but in the small crabs, this ratio in males and females
was relatively equal (fig. 3). This result for S. serrata has also been recorded
from other habitats such as Thailand (Tongdee, 2001), Bangladesh (Ali et al.,
2004) and East Africa (Fondo et al., 2010; table II). It seems likely that the
higher body weight of males compared to females in large crabs is a result of
the enlargement of the male claw through sexual maturation, which has also been
observed for S. olivacea and S. paramamosain in Thailand (Tongdee, 2001), and
for S. serrata and S. tranquebarica in India (Mohapatra, 2010). Thirunavukkarasu
& Shanmugam (2011) observed similar sexual dimorphism in the body weight
of S. tranquebarica however they suggested different foraging behaviours and
metabolic rate of both sexes, rather than enlargement of the claw of males as the
reason. Sexual dimorphism in body weight has been reported in other portunid crabs like \textit{Portunus pelagicus} (Linnaeus, 1758) and \textit{P. sanguinolentus} (Herbst, 1783) (cf. Sukumaran & Neelakantan, 1997).

Because of sexual dimorphism in \textit{S. serrata}, the crossing point of lines for male and female CW and CL against weight can roughly indicate the size at onset maturity, which in this study was about 120 mm and 80 mm in CW and CL, respectively (fig. 3). This observation was supported by data on gonad classification as the smallest mature female at the Gulf of Oman was measured to be 124 mm in CW.

Sex ratio and ovarian maturity

In the Gulf of Oman there were always fewer females than males (table I). Fewer females than males of \textit{S. serrata} in mangrove habitats have been observed in many previous studies, which are listed in table II. Le Vay (2001) reviewed many studies and discussed the spawning migration of the female mud crabs to offshore waters. Therefore, the higher abundance of males than females in the Gulf of Oman may be a result of the spawning migration of females out of the mangrove area, which have been also suggested by previous studies on mud crabs in other mangrove habitats (Tongdee, 2001; Jirapunpipat, 2008; Ikhwanuddin et al., 2011).

Except during the autumn, mature females were observed in all seasons in the Gulf of Oman. Spawning through most or all of the year has been considered by previous studies on the mud crabs (Le Vay, 2001). We cannot convincingly define a spawning season in this study.

Epizoic cirripedes

\textit{Amphibalanus amphitrite} is a dominant biofouling organism in the warm waters of the world (Desai et al., 2006); thus, it is not surprising that this species was found on the body of many specimens of \textit{S. serrata} from both sites. Furthermore, \textit{Chelonibia patula} has also been recorded on the carapace of portunid crabs in the Western Indian Ocean such as \textit{Portunus segnis} (Forskål, 1775) on the Iranian coast of the Persian Gulf and the Gulf of Oman (Shahdadi, 2007), and \textit{P. segnis} and \textit{Charybdis helleri} (A. Milne-Edwards, 1867) in the coastal waters of Pakistan (Javed & Mustaquim, 1994). The two lepadomorph barnacles, \textit{O. cor} and \textit{O. angulata}, are frequently reported from the gill chamber of \textit{S. serrata} and can affect the respiratory capacity of the mud crabs (Voris et al., 1994). These two lepadomorph barnacle species also have been previously recorded from the Arabian Sea and the Persian Gulf (Nilsson-Cantell, 1938). Voris et al. (1994) mentioned that the abundance of these two lepadomorph barnacles is significantly higher in mud crabs larger than 70 mm in southern Thailand.
Conservation priority

*Scylla serrata* is widely distributed throughout the mangroves of the Indo-Pacific region and is the only representative of the genus in the western Indian Ocean (Le Vay, 2001). Therefore, it is difficult to understand why the populations of *S. serrata* are small in the Gulf of Oman and the Persian Gulf, in spite of having extensive mangrove forests which are favoured by the species. Harsh environmental conditions (e.g., high salinity and low temperature in winter) of the Persian Gulf have always been considered as the main factor for impoverished Gulf biodiversity (Sheppard et al., 2010). The high salinity has been attributed to defining the distribution of the intertidal brachyuran crab (Apel & Türkay, 1999; Naderloo et al., 2011). Salinity may not be such a problem with *S. serrata* as they are also found in the Red Sea where salinities can reach 44 ppt. The most southern distribution of mud crabs in Australia and South Africa suggests that they cannot survive in water temperatures below 14°C (C. P. Keenan, pers. obs.). The water temperature in the northern Gulf of Oman mangroves reaches 22.6°C in winter, so this may not influence their distribution. Overexploitation through fishing, which is seen in the Gulf of Oman mangroves, could also be the limiting factor. To substantiate each of these claims additional studies seems to be essential. Management programs, such as protecting the mangroves areas and preventing the catching of mature and female crabs, have been mentioned as being effective to conserve mud crab populations (Bonine et al., 2008; Ikhwanuddin et al., 2011). Such management programs seem necessary for these mud crab populations in the Western Indian Ocean; although detailed environmental and biological data should be provided by additional studies on these populations of *S. serrata*.

Conclusion

Biological information of the mud crab *S. serrata* is provided from the mangrove habitats of the Persian Gulf and Gulf of Oman, southern Iran. One population of the species was known in the Persian Gulf, which seemed very unstable and was restricted to a planted mangrove area along the southern coast of Qeshm Island in Iran. A relatively stable population, however with a low density (up to 1 crab per hectare), occurs in the well developed mangrove ecosystems along the Iranian coast of the Gulf of Oman. Mature females have been observed in this population in spring, summer and winter. Further, our observations at monthly intervals in the Gulf of Oman showed that the number of females was always lower than that of the males, which may be the result of breeding migration of the females out of the mangrove habitat. The population of the species was found to be scarce in the Gulf of Oman. Although, harsh conditions in the area and overexploitation of this crab may be the reasons of this scarcity, there are no data addressing each of these
claims. We suggest that the populations of *S. serrata* are vulnerable in the Persian Gulf and Gulf of Oman, which made the priority of conservation programmes in the area.

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