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Maturity and breeding of the mud crab, *Scylla serrata* (Forskal) (Decapoda: Brachyura: Portunidae)

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Abstract. Females of *Scylla serrata* attained sexual maturity after reaching 80 mm carapace width and above. Fifty per cent of females at size range 91–100 mm carapace width were sexually mature. The growth rate of abdomen width or length with respect to either carapace width or length was generally at much higher side in mature females than in the immature specimens. A sharp transition at 80 mm carapace width indicated the morphological changes accompanied with the sexual maturity. The relationship between abdomen allometry and carapace measurements was highly significant ($P < 0{\cdot}001$). *Scylla serrata* although bred all through the year, exhibited two peaks of breeding, one in between December–March and another in September–November. The sex-ratio in two biotopes varied considerably with the breeding season and size of the female population. The females were found to be in berried state in inshore and off-shore waters of Karwar at 90 mm carapace width and above. Spawning of *Scylla serrata* was found to occur only in inshore and off-shore but not in backwaters.

Keywords. Maturity; breeding; mud crab; allometry; biotopes; berried.

1. Introduction

There are several studies on reproductive biology of portunids inhabiting Indian aquatic biotopes (Naidu 1955; Chhapgar 1956; Pillay and Nair 1968, 1971; Joel and Raj 1980) but the estuarine mud crab *Scylla serrata* remains as a topic of interest due to its unique spawnal migration. Throughout its occurrence in Indo-Pacific range, ovigerous females form a significant and regular components of the fishing catch (Arriola 1940). Incidental catches of ovigerous *S. serrata* are also reported by trawlers operating in deep waters of Malaysia (Ong 1966). Although the study of occurrence of ovigerous females in commercial fish catches forms a direct method to indicate the spawning seasons, detailed gonadal examination is necessary to depict various reproductive aspects.

The present work therefore is an attempt to obtain the knowledge of the breeding seasons and breeding grounds of *S. serrata* off Karwar. Stages of maturity, size at maturity and sex-ratio of *S. serrata* population are also dealt with.

2. Materials and methods

Crabs were collected from backwaters (from long lines) and inshore waters (gill-nets, shore-seines and trawlers) of Karwar (14° 46′ 54″ N and 74° 03′ 00″ E to 14° 54′ 25″ N and 74° 19′ 30″ E) during December 1984 and November 1985. The crabs were sexed and the live weight, adjusted whenever necessary for missing periopods, was measured to the nearest gram.

2.1 *Ovary examination*

To facilitate the removal of ovary, a cut was made in the carapace along and just ventral to the antero-lateral spines allowing the carapace easily to be lifted off exposing the ovary and other internal organs. The gonado-somatic index (GSI) (drained ovary weight as a percentage of total body weight) was then calculated for each crab.

2.2 *Maturity stages*

Colour changes in the ovary and oocyte diameter were taken into consideration to classify the maturity stages (Wild 1983). The size of the ovary with respect to space occupied in haemocoel (Shanmugam and Bensam 1980) and GSI were also considered (Haesman 1980) in the classification. The following 4 stages of development in the ovary were observed:

Stage I: The ovary is white, thin, transparent and thread like occupying 1/10th of the body cavity. There is no prominent seminal receptacle. The ova diameter ranges from 0·01–0·06 mm with a modal value of 0·05 mm. The GSI is very low and is up to 0·5.

Stage II: It shows the peripheral undulations for the formation of ovarioles. It represents the partial development of ovaries and occupying about 1/5th of the haemocoel. Colouration of the ovary ranges between yellowish to pinkish. The ova diameter varies from 0·10–0·30 mm with a modal value of 0·20 mm. The GSI ranges from 0·5–1·5.

Stage III: The stage denotes the maturing condition of the ovaries extending into anterolateral region of the carapace thereby occupying about half of the body cavity. The ovaries are orange in colour and the ova diameter ranges between 0·40 and 0·90 mm with a modal value of 0·80 mm. The GSI ranges from 2·5–8·0.

Stage IV: This stage shows the intensification of the colour (bright red) depicting the rapid maturation of the oocyte. There is a well defined seminal receptacle. The ovaries occupy approximately more than 3/4th of the haemocoel. The ova diameter ranges from 0·70–1·30 mm with a modal value of 1·15 mm. The GSI is as high as 15·85.

Spent stage is indicated by a flacid, speckled appearance of ovaries resulting from aggregation of unspawned ova. Ova colour ranges from red to brown and distinguished with the fawn to grey shrunken ovarian lobules.

Among ovigerous females two stages in the development of eggs could be recognised, one in which the eggs attached to abdominal appendages are orange red in colour and the other are dark brown representing more advanced stage.

2.3 *Size at first maturity*

Size at first maturity was determined by tabulating the percentage of crabs in different stages against size (carapace width).

2.4 *Morphometric measurements*

Certain morphometric changes often accompany the pubertal moult in brachyuran crabs (Haley 1973; Hartnoll 1974). During the puberty the shape and dimensions of abdomen in female crabs are greatly changed and are modified. The morphometric characters were made using dial calipers to determine whether any relation existed between the morphology and sexual maturity.

2.5 *Breeding*

The gonadal observations were initially carried out on large number of *S. serrata* including all the moulting stages. Later, however, only 1519 intermoult (hard shelled) adult crabs (> 80 mm carapace width) were sacrificed to determine the breeding periodicity, as soft shelled and small sized crabs yielded very eratic information regarding the breeding state of the animal. Besides tabulating mean GSI every month, a periodic incidence of ovigerous females were recorded to know the status of breeding population. The breeding grounds were inferred from the place of incidence of sponge bearing crabs with dark brown eggs—a stage which is indicative of actual hatching time (Joel and Raj 1980).

2.6 *Sex-ratio*

Looking at the shape of the abdomen a total of 7953 crabs were sexed in the commercial catches, without sacrificing them, to throw some light on population structure.

2.7 *Statistical analysis*

Morphometric data were plotted and the regression equations were calculated by assuming an allometric growth equation $Y=a+bX$, where X = carapace width or carapace length as the case may be and Y the variable being measured (Snedecor and Cochran 1967).

3. Results

3.1 *Size at maturity*

In Karwar waters, females of *S. serrata* attained sexual maturity only after reaching 80 mm carapace width. The proportion of immature (stage I), maturing (stages II and III) and mature (stage IV) stages of ovary within each size range varied between backwaters and inshore waters. The percentage of maturity increased with the size till 141 mm but thereafter it was irregular and the crabs belonging to 181–190 mm size range were found to be sexually active indicating high percentage of maturity. In both backwaters and inshore waters 50% of female crabs at size range 91–100 mm were mature (figure 1).

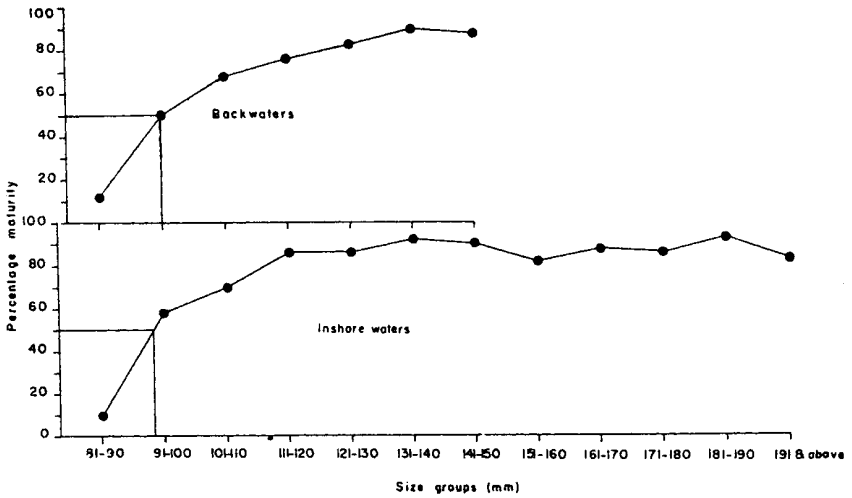

Figure 1. Percentage of maturity of females indicating 50% size at maturity.

3.2 *Morphometric characters*

The allometric growth equations of morphometric measurements along with correlation coefficient (r) values are indicated in figure 2.

The growth rate of abdomen width with respect to carapace width was lesser ($b = 0{\cdot}6870$) in mature specimens than that of immature ones ($b = 0{\cdot}7350$). The growth rate of abdomen width or length was generally at higher side in mature crabs than in the immature specimens. The sharp break or transition at about 80 mm size indicated the occurrence of morphological changes associated with maturity (figure 2). The morphological relationships in both immature and mature crabs were highly significant at $P < 0{\cdot}001$.

3.3 *Breeding*

Monthly observations of gonadal development depicted the prolific breeding nature of *S. serrata* possessing all maturity stages throughout the year but with a considerable seasonal variation. Mean GSI values exhibited two peaks—one between December–March and another between September–November (figure 3). Correspondingly the observations confirmed the maximum incidence of ovigerous females during the same period (figure 4). Hence these seasons were considered as the actual breeding seasons. Environmental parameters such as salinity and temperature during the period of study indicated that high GSI and incidence of mature stages (IV) in female crab population coincided with fairly moderate salinity and temperature (figure 5).

The analysis of sex-ratio of crabs from backwaters and inshore waters showed that although there was near equal proportion of males and females in both the biotopes, the sex-ratio varied considerably with the season and size of female population (Prasad 1987). The proportion of females particularly adults dropped considerably in the backwaters during peak breeding seasons (October–December) and the same had increased in the inshore water population. This drop was

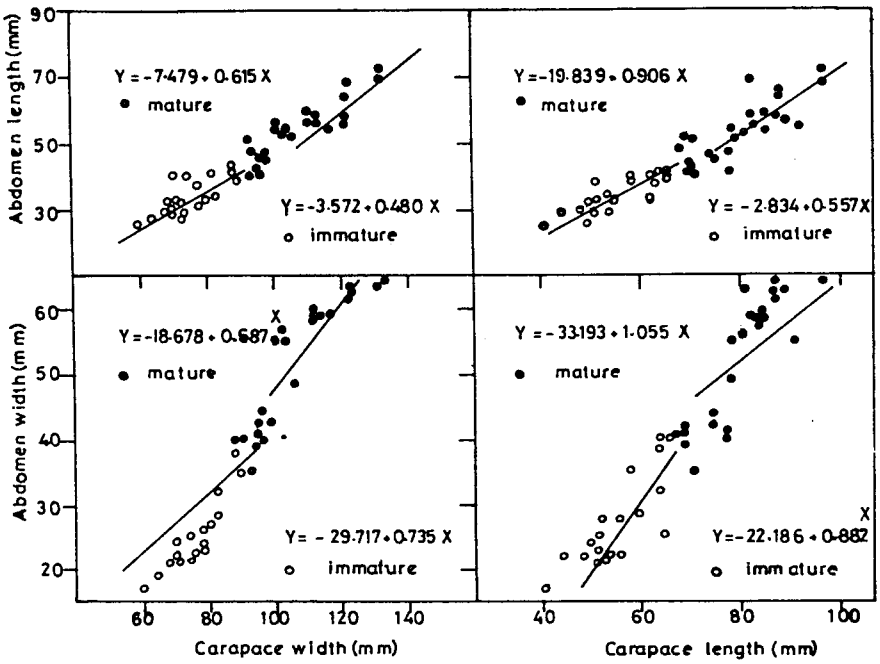

Figure 2. Relationship between abdomen allometry and carapace measurements.

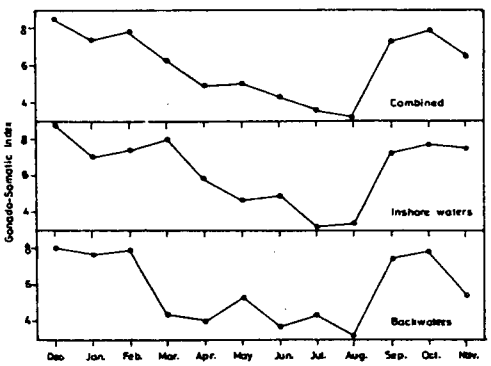

Figure 3. Monthly variation in GSI values in female crabs during Dec. 1984 and Nov. 1985.

probably be due to migration of female crabs out of backwaters of Kali estuary into the sea. The mating processes however appeared to take place both in backwaters and inshore waters as the mating pairs (soft shelled female and hard shelled male) were caught in both the biotopes. Nevertheless the females were found to get into berried state only in the sea. The berried females were never caught by long lines in backwaters during the entire duration of the study. Further majority (52·05%) of the berried crabs caught belonged to trawl catch which came from nearshore and offshore waters of Karwar. Although female crabs tended to get into berried form at 90–100 mm size itself, it was actually 120–130 mm group found to be active contributing a larger share (31·58%) to the berried females caught in Karwar

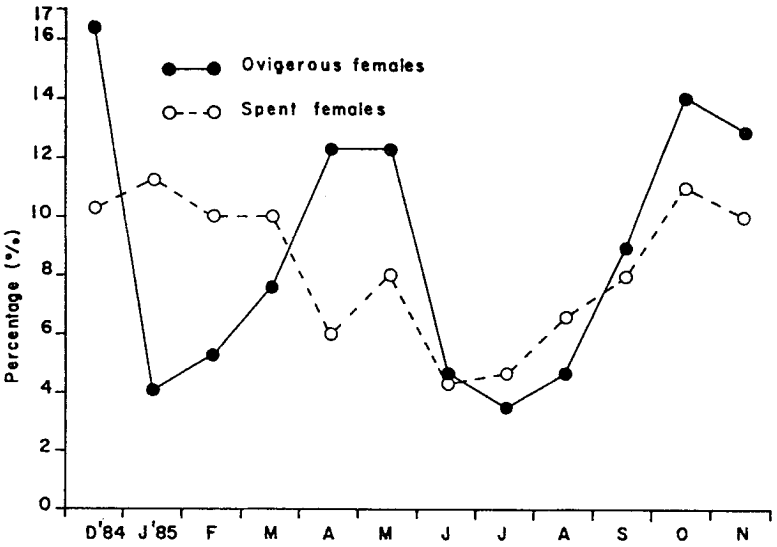

Figure 4. Incidence of ovigerous and spent females of *S. serrata* in Karwar waters.

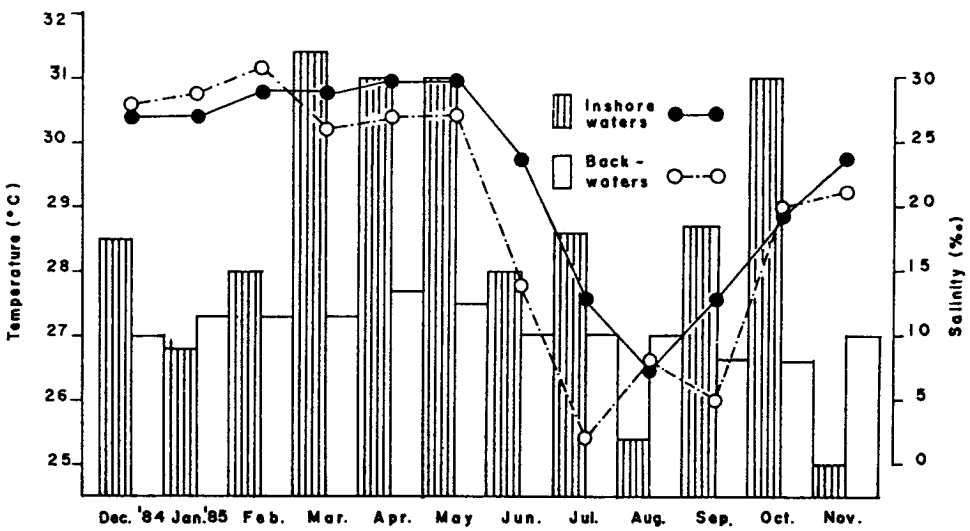

Figure 5. Seasonal variation of salinity and temperature in Karwar waters.

waters. Out of 1519 adult females examined, 19·81% (N = 301) of crabs were identified as spent females but majority (N = 219) of them were caught by gill-nets and shore-seines in inshore waters.

4. Discussion

4.1 *Size at maturity*

It is reported that the fresh water female crab *Barytelphusa cunicularis* becomes

sexually mature on attaining a carapace width of about 44 mm (Diwan 1973) while in the case of *B. guarini* it was about 40 mm carapace width (Gangotri *et al* 1971). From the gonadal study it is evident that although *S. serrata* attains sexual maturity (with stage IV ovary) in 81–90 mm size range itself, the animals were found to be sexually active only with size range of 120–180 mm. Moreover, unlike that of males (Prasad 1987) the female crabs never attained absolute (100%) maturity at any given size range. The reproductive activity seemed to decline in older animals with a carapace width of 190 mm and above.

A small percentage of immature ovaries even in the crabs belonging to 120 mm and above further indicate that even larger crabs also had to be impregnated more than once for the development of ovary. The moulting stage, presence of seminal products in spermatheca (Ezhirarasi and Subramoniam 1980) and certain neurosecretory factors (John and Sivadas 1979) are of prime importance to initiate the development of ovaries. The photoperiod and nutrient reserves have also been attributed to the rate of development of ovaries in *S. serrata* (Nagabhushanam and Farooqui 1980).

4.2 *Morphometric characters*

It can be seen from figure 2 that morphometric measurements indicate differential post maturity growth pattern in females. However these growth patterns were of negative allometry showing the exponential values (b) less than the unity. It is generally agreed that although a sudden increment of these secondary sexual characters takes place at pubertal moult, majority of the female portunids showed negative allometry as the frequency of moulting decreases after puberty (Watson 1970; Hartnoll 1974). What is finally evident from the results is that the pubertal moult in female *S. serrata* occurs at 80 mm carapace width and above thereby bringing an abnormal increase in certain morphometric characters such as abdomen dimensions. The same is illustrated in figure 2 with a clear transition at puberty and gonadal observations corresponding with the fact that the females attain puberty only after reaching 80 mm carapace width. These morphometric characteristics may have some adoptive significance while providing sufficient space for fertilized eggs thereby creating a congenial incubation chamber.

4.3 *Breeding*

Chandran (1968) while working on breeding of marine crabs of Indian coast hypothesised that the salinity, temperature and ample supply of food material are some of the important factors which trigger the breeding mechanisms. Although the mud crab breeds continuously throughout the year in Karwar waters, it had two distinct peaks one in December–March and another in September–November when the salinity and temperature were neither high nor low (figure 5). These conditions seemed to be ideal for successful incubation and larval development.

Haesman *et al* (1985) while presenting a review of general trends of spawning activity of *S. serrata* has concluded that the length of the spawning period increases with the decreasing latitude. One of the reasons accounted was the availability of food in differential amounts in different seasons. For Indian waters Pillay and Nair

(1968) drew attention to the possible influence of post monsoonal upwelling on the peaks of spawning during November–January in southwest coastal waters.

The available information on spawning migrations of *S. serrata* has been reviewed by Hill (1975). It was noticed that spawning migrations usually followed lunar cycle and also salinity changes. Several reports reveal that *S. serrata* spawns in the sea and the young ones migrate either to inshore waters or backwaters. Distance travelled in the spawning migrations however greatly vary in accordance with topographical features and prevailing hydrological conditions. Ovigerous females in shallow (1–15 m) lagoons, bays, inlets and coastal waters have been generally captured in Philippines (Arriola 1940), Hawaii (Brick 1974) and India (Naidu 1955). Joel and Raj (1980) have noticed the berried females of *S. serrata* in brackish water zones of Pulicat lake mouth adjacent to sea. The incidence of sponge bearing females in Karwar waters indicated that spawning grounds of *S. serrata* are located in both inshore and off-shore up to 20–25 km. Majority of the ovigerous females (52·05%) were caught in trawlers which were operated off the shore and as near as 8–25 km from the backwaters of Kali estuary. Interestingly out of 1915 female crabs examined in backwaters none of them was with a 'berry'. Such absence of ovigerous females in the backwaters could be primarily due to seaward spawnal migration of mature females. This view has been strengthened with high sex-ratio (males/females) during the peak breeding season. Secondly ovigerous females, if any, may not have been accessible for 'long lines' a major gear employed in backwaters, for catching *S. serrata*, by the simple fact that the intensity of feeding in crabs decline during berried state (Edwards 1979; Haesman *et al* 1985). Thirdly it could also be due to timidity or protective behaviour towards the eggs. In conclusion therefore it may be said that the recruitment of *S. serrata* population in Karwar waters takes place from the spawning grounds located in the inshore and off-shore waters of Karwar.

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