Size at Maturity in the Male Crab *Scylla serrata* as Determined by Chela Allometry and Gonad Condition*

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Sexual maturity in the male mud crab, *Scylla serrata* attains at the size range 81–90 mm carapace width (CW). At 97 mm CW 50% of males are mature. Highly significant ($P < 0.001$) relationships are obtained between chela allometry and carapace measurements. About 34% of male crabs harvested commercially from the Karwar area during December, 1984 and November, 1985 were immature.

Determination of size at maturity is an important tool in the studies of population dynamics and resource management. There have been many attempts to study maturity of a variety of crab species (Watson, 1970; Gangotri *et al.*, 1971; Brown & Powell, 1972; Hill, 1975; Fielding & Haley, 1976; Jacob, 1988). The mud crab *Scylla serrata* is largely an estuarine resident, but also reported in bays, slagoons and near shore waters all along Indo-Pacific range (Macnae, 1968). It is considered as one of the most commercially important edible crabs of India (Rao *et al.*, 1973) and also known to hold a key role in international crab trade (Alverson, 1971). Owing to its commercial importance, there are many efforts to study the breeding biology of *S. serrata* in Indian waters (Naidu, 1955; Chhapgar, 1956; Pillay & Nair, 1971; Shanmugam & Bensam, 1980). However, the reproduction aspects of male crabs are not yet described either from Indian waters or elsewhere and hence a study was initiated to describe the male size at maturity in *Scylla serrata* and the extent to which immature males are being commercially harvested in Karwar region.

Materials and Methods

The male crabs (with 'V' shaped abdomen) were procured from long lines operated in backwaters and gill nets and shore seines in inshore waters 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 thus collected were immediately brought to laboratory and were washed thoroughly to make free of slime, dirt and epizoic forms. The body weight was measured to the nearest gram and then gonadosomatic index (GSI) (drained gonad weight as percentage of total body weight) was calculated.

Gross examination of gonads indicated that the crabs below 80 mm size were immature, in which it was difficult to locate testes. Hence gonadal observation was restricted to only adult crabs ($<$ 90 mm carapace width). Classification of maturity stages of males was based on the colour of the gonads, GSI and size of the gonads with respect to space occupied inside the haemocoel (Edwards 1979; Shanmugam & Bensam, 1980). Size at maturity was determined by tabulating the percentage of crabs in different stages against size (Edwards, 1979).

* Formed part of Ph.D. thesis of the first author

Besides gonadal observations, certain morphological characters are also considered as secondary sexual characters to estimate the size at first maturity of male crabs (Watson, 1970; Hartnoll, 1968; Haley, 1973). These measurements as shown in Fig. 1 were made using dial calipers to determine whether there are any relations between morphology and maturity. Morphometric data were plotted and the regression lines were fitted by least square method assuming a model of $Y = a + b X$ where X = carapace width/or length as the case may be and Y the variable being measured. Correlation coefficients (r) were also employed to know the pattern of association of the parameters involved (Snedecor & Cochran, 1967).

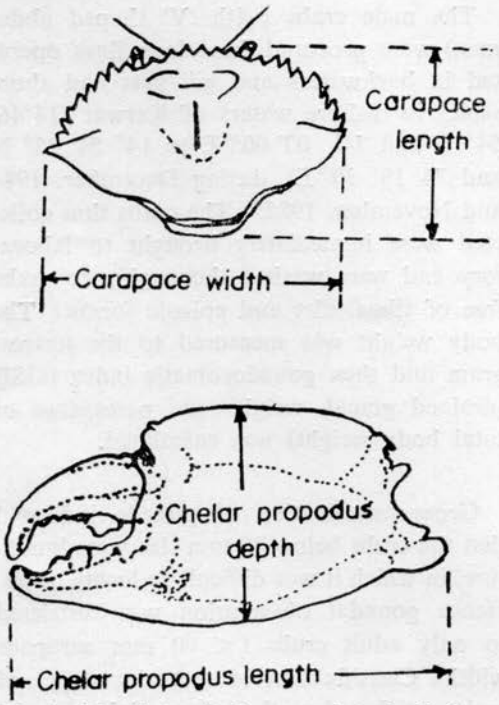

Fig. 1. Morphometric characters in male *S. Serrata*

Results and Discussion

Gross examination of gonads indicate that the *S. serrata* attained sexual maturity only after reaching 80 mm carapace width (CW). The percentage maturity increased with the size reaching cent percent in 131 mm CW and above (Table 1). Out of 1,134 adult male crabs (80 mm CW and above) examined 21.34% were immature with stage 1 testes and 13.93 and 64.73% were maturing (stage 2) and mature (stage 3) respectively. At 97 mm CW, 50% males were mature (Fig. 2).

The exponential coefficients (b) and correlation coefficients (r) along with degrees of freedom of morphometrical character are indicated in Table 2. In Fig. 3, the length and depth of chelar propodus are plotted against carapace width and carapace length. For each measurement, lines were fitted for immature and mature forms and maturity was determined by examination of vas deferens. A highly significant relationship was found ($P < 0.001$) between chela allometry and carapace measurements. The growth of the chela in both immature and mature crabs was however slower than the body (b values less than unity) indicating the negative allometric growth patterns. Gonadal observations (Table 1) and a clear transition between allometric growth of chela and carapace indicated in Fig. 3, suggest that the onset of maturity occurred at 81–90 mm CW range.

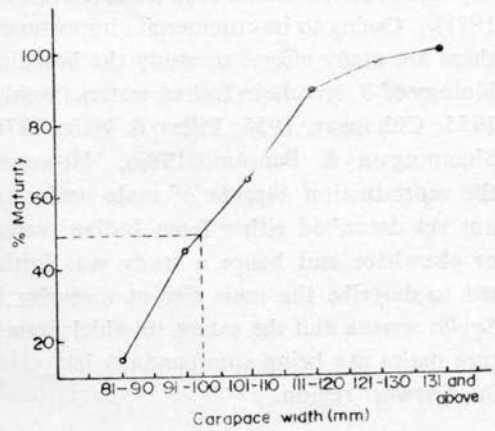

Fig. 2. Percentage of mature males in different size groups.

From the chela measurements and maturity condition results, the proportion of mature crabs was estimated, To obtain information on size structure of males in the total commercial catch, 3,669 crabs, in the landings of longlines, gill nets and shore seines during December, 1984 and Novem-

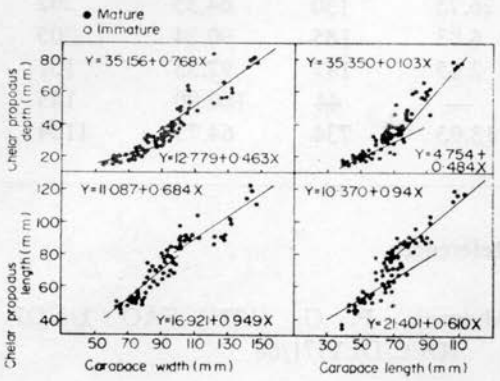

Fig. 3. Relationship between chela allometry and carapace measurements.

ber, 1985 were observed. Using maturity and size frequency data the proportion of immature crabs within each size category interpolated. From these data it was estimated that 33.64% of the male crabs of *S. serrata* harvested commercially from the Karwar area during 1984-1985 were immature (Fig. 4).

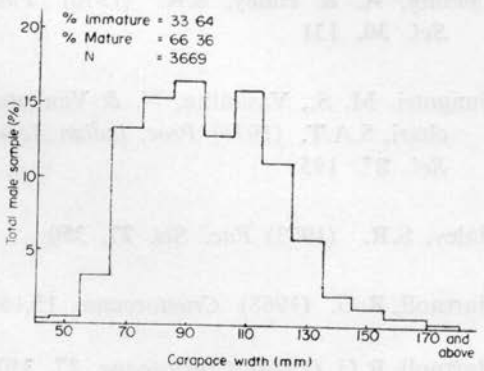

Fig. 4. Size frequency analysis in male crabs collected during December, 1984 and November, 1985.

According to Hartnoll (1974) the growth rate of any organ usually changes during ontogeny and the growth constant is specific within each phase of the growth. Many investigations have encompassed one prepuberty and another post-puberty phase in decapod crustaceans (Watson, 1970; Brown & Powell, 1972; Hartnoll, 1974). In an intensive review of existing literature on variations in growth patterns of morphometric characters in crabs, Hartnoll (1974) observed a transition from the prepuberty to the post-puberty phase thereby bringing about abnormal changes in certain morphological characters such as chela measurements in male crabs at pubertal moult. It is evident from the present study that the abnormal increment in chela allometry may have occurred at 81–90 mm CW in male *S. serrata* depicting a precise transition or break up in the above said parameters (Fig. 3) and was also further corresponded with the incidence of mature (stage 3) gonads in 81–90 mm CW range (Table 1). This unusual increment of chela allometry at puberty however seems to have an adapative significance in mate selection and/or aggressive interactions involving competition for food and/or space (Hartnoll, 1974). Although it appeared that the pubertal moult was indispensable to initiate the gonadal development, unlike that of tanner crabs *Chinoecestes bairdi* (Brown & Powell, 1972), further moulting after puberty in *S. serrata* did not seem to affect the state of maturity, as all the adult crabs examined, irrespective of moult state, had maturing and mature gonads.

S. serrata is known to be the largest edible crabs of India (Rao et al., 1973) and in Karwar waters the maximum sizes were recorded around 230 mm CW weighing about 1.8 to 2.4 kg (Prasad, 1987). The contribution (10.67%) of larger crabs (121–170 mm CW and above) to total commercial catches of male crabs was comparatively very less (Fig. 4). The size structure of male *S. serrata*

Table 1. *Proportion of immature (stage 1), maturing (stage 2) and mature (stage 3) male crabs in different size groups*

Size groups mm	Immature		Maturing		Mature		Total
	n	%	n	%	n	%	
81–90	135	63.08	50	23.36	29	13.55	214
91–100	83	38.07	36	16.51	99	45.41	218
101–110	18	8.91	54	26.73	130	64.35	202
111–120	6	2.93	14	6.83	185	90.24	205
121–130	—	—	4	2.65	147	97.35	151
131 and above	—	—	—	—	44	100.00	144
Total & %	242	21.34	158	13.93	734	64.73	1134

also indicate an indiscriminate catching of immature ones which is estimated to be about 33.64% to total commercial landings of male crabs. Hence exploitation of male crabs which are below 80 mm CW should be discouraged in order to conserve the resources of male crab population.

Table 2. *Allometry levels (b), correlation coefficients (r) and degrees of freedom in the morphological characters of male S. serrata*

Category	X	Y	'b'	'r'**	df
Immature					
1	C.W	Ch.L	0.949	0.899	41
2	C.W	Ch.D	0.463	0.859	41
3	C.L	Ch.L	0.610	0.544	41
4	C.L	Ch.D	0.480	0.847	41
Mature					
1	C.W	Ch.L	0.684	0.868	39
2	C.W	Ch.D	0.768	0.934	39
3	C.L	Ch.L	0.940	0.893	39
4	C.L	Ch.D	1.023	0.930	39

X = Independent variable; Y = dependent variable; C.W = carapace width; Ch.L = chelar propodus length; C.L = carapace length; Ch.D = chelar propodus depth; ** highly significant ($P < 0.001$)

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