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Crab fishery of the Calicut coast with some aspects of the population characteristics of *Portunus sanguinolentus, P. pelagicus* and *Charybdis cruciata*

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ABSTRACT

Annual crab landings by mechanised trawlers ranged between 9.0 t (1988-'89) and 64.0 t (1987-'88). During 1987-'91 period, *Portunus sanguinolentus* (94.2 %), *P. pelagicus* (3.0 %) and *Charybdis cruciata* (2.8 %) were the dominant species. The carapace length-body weight relationship were : $W = 0.01037\ L^{2.2177}$ for *P. sanguinolentus*, $W = 0.00374\ L^{2.5315.5}$ for *P. pelagicus* and $W = 0.00059\ L^{2.9515}$ for *C. cruciata*. The carapace width-body weight relationships of the respective species were : $W = 0.00013\ L^{2.8037}$, $W = 0.00024\ L^{2.7799}$ and $W = 0.00029\ L^{2.8287}$. The carapace length-carapace width relationships were W = 19.636+1.7218 L for *P. Sangninolentus*, W = 13.6133 + 1. 9549 L for *P. pelagicus* and W = 0.9874 + 1. 5473 L for C. Cruciata. The size varied from 26-175 mm carapace with (C W) in *P. sanguinolentus*, 66-115 mm C W in *P. pelagicus* and 51-120 mm C W in *C. cruciata*. In *P. sanguinolentus* a regular pattern of dominance of one sex over the other was absent. Maturity study indicated spawning throughout the year and the size at first maturity in female was 82.99 mm C.W. The L , K (annual) and t_o (annual) values were 172.9 mm C.W., 1.4939 and -0.0482 respectively in male. The respective values in female were 161.8 mm C.W., 1.574 and -0.0635.

Introduction

Almost the entire marine crab catch landed at Kozhikode is by trawlers. Among the crabs, *Portunus sanguinolentus* is commercially the most important followed by *P. pelagicus* and *Charybdis cruciata*. The studies on the fishery and biology of crabs from the Indian coast include that by Menon (1952) from Malabar on *P. sanguinolentus*, Sukumaran *et al.* (1986) from South Kanara, George and Nayak (1961) from Mangalore area, Prasad and Tampi (1952) on *P. pelagicus* from Mandapam, Lalithadevi (1985) from Kakinada region and Sukumaran and Neelakantan (1996, 1997) from Karnataka coast. Rao *et al.* (1973) gave a general account of the crab fishery of India. Thus these is

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no published account of the fishery from Kozhikode after Menon's account in 1952. Hence the fishery and biology of the commercially important crabs with detailed account of *P. sanguinolentus* exploited off Kozhikode as a by- catch in shrimp trawlers is dealt with in this paper based on the data collected for the period 1987-'91.

Material and Methods

Data of catch and effort were collected thrice a week from Puthiappa (Kozhikode) which is one of the major landing centres for trawlers. These data for the observation days were pooled and raised to the number of fishing days in a month to arrive at the monthly estimates. The yearly estimation was done from April to March. Random samples of crab were analysed in fresh condition twice a month for carapace width (C.W.), carapace length (C.L.), body weight, sex, maturity condition and impregnation. Maturity conditions were found out by examining the ovary after removing the carapace of each female crab. As in other crustaceans, 4 stages viz. immature, early maturing, late maturing and mature could be identified based on the gross structure of the ovary. Moreover as the ovary of the berried crabs are either in fully spent or partially spent condition, they are considered as spent ones. Hence they are also included in the maturity stages. Matured and spent (berried) crabs were taken together to find out the size at first maturity (Uduppa, 1986). Impregnated crabs were determined by examining the presence of the male sexual product in the seminal receptacle after opening the carapace (Ryan, 1967). The carapace length-body weight and carapace width-body weight relationships were derived using the formula $W=aL^b$, where W is the body weight in grams and L the carapace length (C.L), in mm, in the case of length-weight relationship and carapace width in mm (C.W) in the case of width-weight relationship. The regression equation for carapace length-carapace width was derived by using the allometric growth equation, $Y = a+bX$, where, Y = carapace width in mm, X, carapace length in mm (Pauly, 1984). The significance of the differences in regression between male and female was tested by analysis of co-variance. Since the number of *P. pelagicus* and *C. cruciata* in the catch was very low, the biological details are not given other than morphometric studies. The difference in sex ratio from the expected 1:1 ratio was also tested in *P. sanguinolentus* by Chi-square test (Snedecor and Cochran, 1973). L_∞ of *P. sanguinolentus* was found out by using Powell and Wetherall method separately for both males and females. Month-wise modal progression was traced from size-frequency data and K and t_0 were estimated by using Bertalanffy growth plot (Sparre *et al.*, 1992).

Results

Catch, effort and CPUE

The effort expended during the period of study varied from 20,425 units in 1987-'88 to 12,423 units in 1989-'90 with an annual average of 16,046. There was a gradual reduction in the effort from 1987-'88 to 1989-'90 followed by a slight increase in 1990-'91 (Table 1). The annual landings showed wide fluctuations. From a maximum catch of 64 t in 1987-'88, it declined to a minimum of 9 t in the succeeding year. Thereafter it increased to 42.7 t in 1989-'90 and subsequently came down to 34.6 t in 1990-'91. The CPUE also showed almost the same pattern and it ranged between

TABLE 1. *Year-wise estimated catch and effort of* Portunus sanguinolentus, P. pelagicus *and* Charybdis cruciata *at Calicut during 1987/'88 - 1990/'91*

Year	Effort (Units in No.)	Catch (Kg)			Total	C/Effort	% in total
		P. sanguinolentus	*P. pelagicus*	*C. cruciata*			
1987–'88	20,425	63,906	169	–	64,075	3.1	1.3
1988–'89	15,233	3,941	3,438	1,658	9,037	0.6	0.3
1989–'90	12,423	40,219	–	2,523	42,742	3.4	1.9
1990–'91	16,113	33,654	946	–	34,600	2.2	1.2
Total	64,184	1,41,720	4,553	4,181	1,50,454	2.3	1.1
Average	16,046	35,430	1,138	1,045	37,613	2.3	1.4
%		94.2	3.0	2.8	3.2		

3.4 kg in 1989-'90 and 0.6 kg in 1988-'89. The total trawl landings on the other hand showed a pattern commensurating with the effort.

Seasonal variation

The monthly catch, effort and CPUE in different years and their average are shown in Fig. 1. It could be seen that the duration as well as the peak period of fishing varied in different years. In 1987-'88, the fishery was observed in all the months of operation whereas in 1988-'89, it occurred only for five months. In 1989-'90, the fishery lasted for six months but in 1990-'91, it was only for just three months. In the same way, the peak landing was observed in November and December in 1987-'88 and in the succeeding year, February accounted for the higher catches. January and February-March in 1989-'90 and 1990-'91 repectively were the peak periods. Nevertheless it could be seen that though the fishery occurred from October to May, better catches were obtained from November to March with a peak during January-February.

Species composition

The commercial crab landings were constituted by *Portunus sanguinolentus* (94.2 %) followed by *P. pelagicus* (3.0 %) and *Charybdis cruciata* (2.8 %). Of these, *P. sanguinolentus* alone

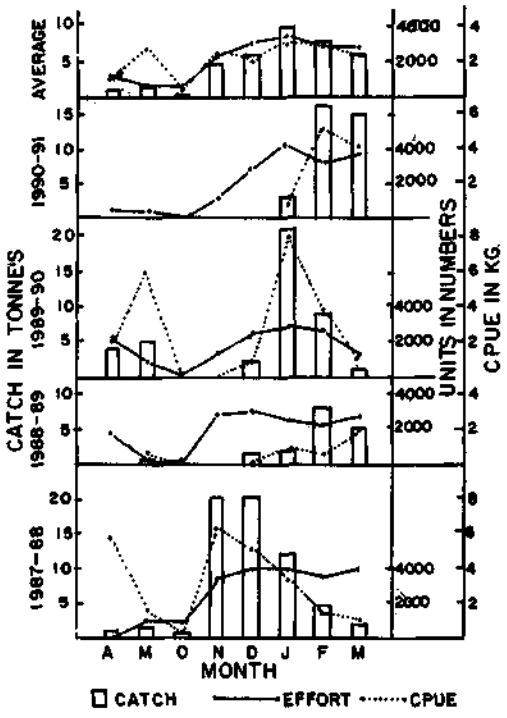

Fig. 1. Estimated month-wise catch, effort and CPUE.

occurred in all the months, *P. pelagicus* occurred during December-March and *C. cruciata* from March-May (Fig. 2). In 1987-'88 and 1990-'91, the catches were comprised by *P. sanguinolentus* and *P. pelagicus* whereas in 1989-'90, it was constituted by *P. sanguinolentus* and *C. cruciata*. In 1988-'89, all the three species were present in the catch (Table 1).

Size distribution

In *P. sanguinolentus* the size of female ranged from 36 to 155 mm C.W. and that of male from 26 to 175 mm C.W. with a preponderance of the size group 51-105 mm C.W. in the former and 51-130 mm C.W. in the latter. Fig. 3 (pooled for male and female) reveals that in most of the months the size frequency distribution depicted a multimodal pattern. Since there was not much variation in the modes and mean sizes of females and males, the data were pooled. In 1987, the dominant size groups during different months were 106-110 mm in May, 61-70 mm in October, 56-60 mm in November and 91-95 mm in December. In 1988, the main modes were 96-100 mm and 116-100

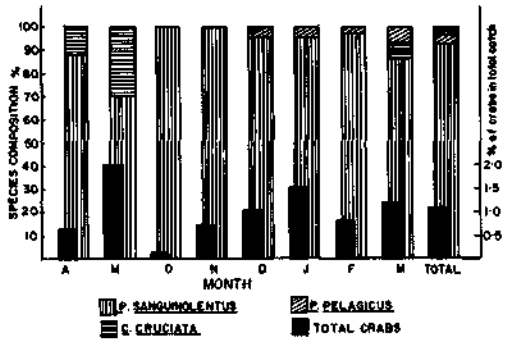

Fig. 2. Month-wise species composition of crabs and percentage of total crabs in total trawl landings.

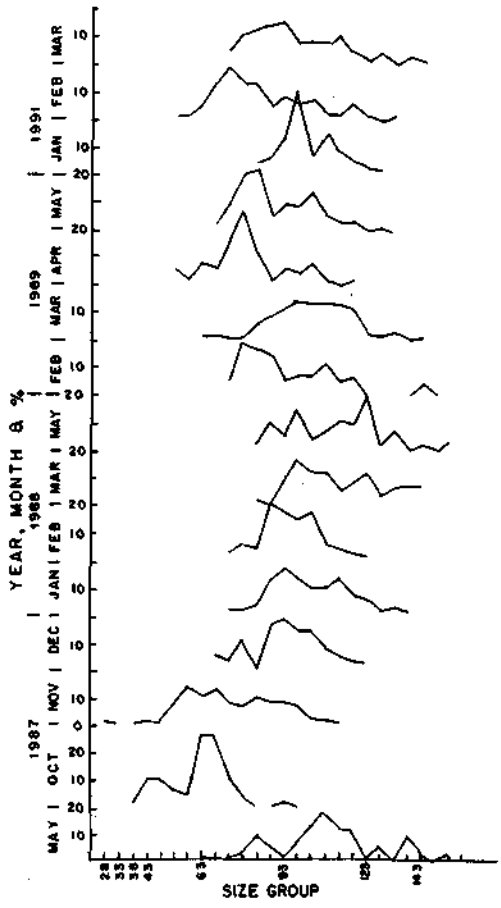

Fig. 3. Size distribution of *Portunus sanguinolentus*.

mm in January, 101-105 mm and 86-90 mm in February, 96-100 mm and 106-110 mm in March and 121-125 mm in May. In 1989, the dominant size groups in different months were 76-80 mm and 101-105 mm in February, 91-95 mm in April and 101-105 mm in May. In 1991, the main modal groups were 106-110 mm and 96-100 mm in January, 116-120 mm in February and 126-130 mm and 111-115 mm in March.

Size of *P. pelagicus* in general varied from 66-155 mm with a mode at 101-105

mm whereas in C. *cruciata* the size ranged from 51-120 mm with a mode at 71-75 mm.

Mean size

In 1987-'88, the mean size varied from 61.6 mm (October) to 113.86 mm (March) in 1988-'89, it ranged from 59 mm (December) to 11.2 mm (May), 79.4 mm (April) to 89.3 mm (May) in 1989-'90 and 88.6 mm (February) to 101.9 mm (January) in 1991 (Fig. 4). In October 1987 and December 1989, the mean size was low and this reduction might be due to peak recruitment of younger juveniles in these months.

Carapace length-body weight relationship

The relationship of each species is given below sex -wise (F = female, M = male, P = pooled). Since the difference in the regression of males and females was found to be not significant, a common equation for each species was calculated (Table 2). The weight (W) was in grams and the length (L) in millimeters.

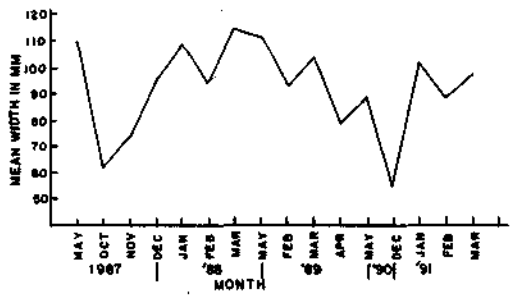

Fig. 4. Mean size of *Portunus sanguinolentus*.

P. sanguinolentus (Fig. 5)

F : W = 0.0144 L $^{2.1228}$ (r = 0.9284, n = 254)

M : W = 0.0092 L $^{2.2551}$ (r = 0.8845, n = 303)

P : W = 0.0104 L $^{2.2177}$ (r = 0.937, n = 557)

P. pelagicus (Fig. 6)

F : W = 0.0027 L $^{2.6158}$ (r = 0.956, n = 98)

M : W = 0.0016 L $^{2.7575}$ (r = 0.963, n = 70)

P : W = 0.0037 L $^{2.5315}$ (r = 0.943, n = 168)

C. cruciata (Fig. 7)

F : W = 0.00093 L $^{2.8327}$ (r = 0.904, n = 85)

M : W = 0.00045 L $^{3.0233}$ (r = 0.979, n = 89)

P : W = 0.00059 L $^{2.9619}$ (r = 0.968, n = 174)

TABLE 2. *ANOVA table for testing the identicality of regression lines in the carapace length-body weight relationship among males and females of* P. sanguinolentus, P. pelagicus *and* C. cruciata

Variation in species	DF	Sum of squares	Mean squares	Calculated F	Tabulated F	(5 %) Significance
P. sanguinolentus						
Sex	2	0.017	0.0085	1.23	19.5	Not significant
Error	553	5.8137	0.0105			
Total	555	5.8307				
P. pelagicus						
Sex	2	0.0049	0.00245	2.22	19.49	Not significant
Error	164	0.8902	0.00542			
Total	166	0.8951				
C. cruciata						
Sex	2	0.0069	0.00345	1.62	19.49	Not significant
Error	170	0.954	0.00561			
Total	172	0.9609				

Carapace width-body weight relationship

Here also the difference in regression between the sexes was not significant (Table 3). Hence a common equation was found out. The width was taken in millimeters and weight in grams.

P. sanguinolentus (Fig. 5)

F : W = 0.00012 width $^{2.7884}$ (r = 0.94, n = 512)

F : W = 0.00012 width $^{2.8155}$ (r = 0.895, n = 562)

P : W = 0.00013 width $^{2.8037}$ (r = 0.94, n = 1,074)

P. pelagicus (Fig. 6)

F : W = 0.000094 width $^{2.8778}$ (r = 0.98, n = 98)

M : W = 0.00043 width $^{2.7088881}$ (r = 0.98, n = 70)

P : W = 0.00015 width $^{2.779}$ (r = 0.96, n = 168)

C. cruciata (Fig. 7)

F : W = 0.00058 width $^{2.559}$ (r = 0.91, n = 85)

M : W = 0.00018 width $^{2.938}$ (r = 0.95, n = 91)

P : W = 0.00029 width $^{2.8287}$ (r = 0.94, n = 176)

Carapace length-carapace width relationship (Fig. 8)

Here also, the difference in regression between sexes was not significant (Table 4). The width (W) and length (L) were in millimeters

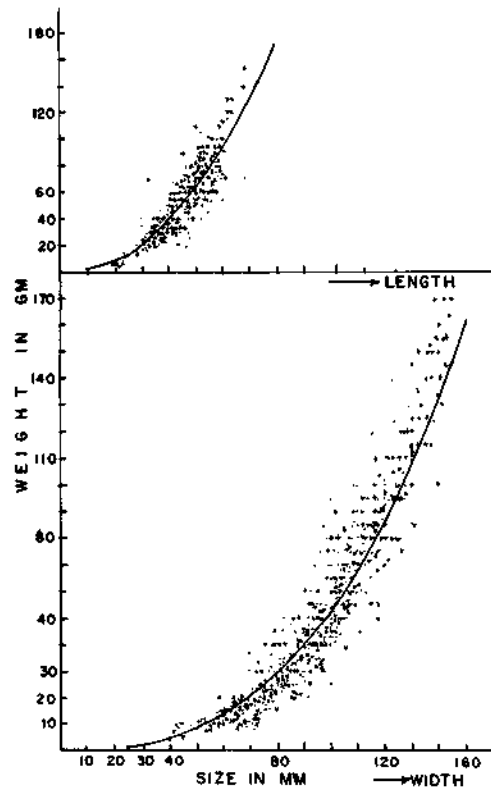

Fig. 5. Carapace length-body weight and carapace width-body weight relationships of *Portunus sanguinolentus*.

TABLE 3. *ANOVA table for testing the identicality of regression lines in the carapace width-body weight relationship among males and females of* P. sanguinolentus, P. pelagicus *and* C. cruciata

Variation in spices	D.F.	Sum of squares	Mean squares	Calculated F	Tabulated F	(5 %) Significance
P. sanguinolentus						
Sex	2	0.0017	0.00085	10.25	19.5	Not significant
Error	1070	9.3165	0.00871			
Total	1072	9.3182				
P. pelagicus						
Sex	2	0.0061	0.003	2.45	19.49	Not significant
Error	164	1.204	0.0073			
Total	166	1.21				
C. cruciata						
Sex	2	0.0155	0.00775	1.345	3.04	Not significant
Error	172	0.991	0.00576			
Total	174					

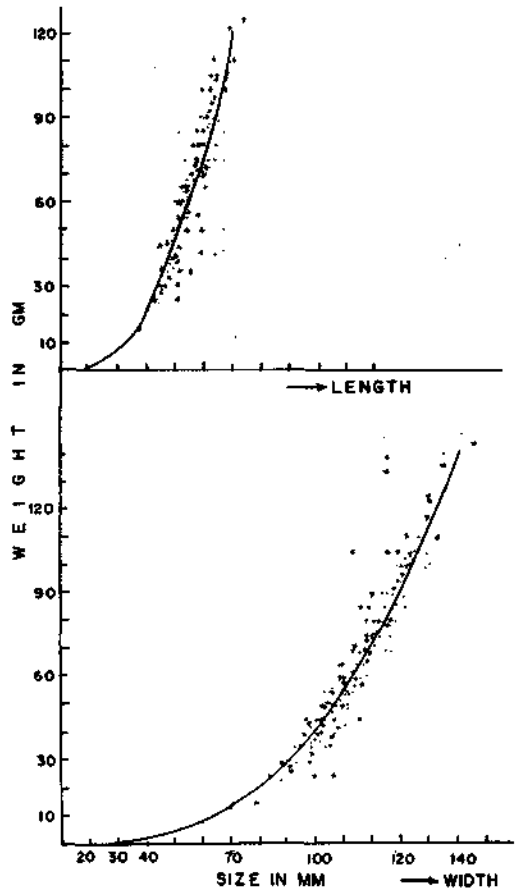

Fig. 6. Carapace length-body weight and carapace width-body weight relationships of *Charybdis cruciata*.

P. sanguinolentus

F : W = 21.9151 + 1.6584 L (r = 0.87, n = 254)

M : W = 18.4925 + 1.7545 L (r = 0.93, n = 303)

P : W = 19.636 + 1.7218 L (r = 0.92, n = 557)

P. pelagicus

F : W = 13.4242 + 1.9806 L (r=0.98, n=78)

M : W = 14.2323 + 1.911 L (r=0.99, n=70)

P : W = 13.6133 + 1.9549 L (r=0.98, n =168)

C. cruciata

F : W = –2.2929 + 1.5686 L (r = 0.97, n = 85)

M : W = 0.077 + 1.5308 L (r = 0.99, n= 89)

P : W = –0.9874 + 1.5473 L (r=0.99, n=174)

Sex ratio

In *Portunus sanguinolentus* a regular pattern of dominance of one sex over the other was absent. In 1987, males dominated in numbers whereas in 1988, females dominated except in February. In 1989 and 1991, there was a preponderance of males except in February, 1991. The female : male ratio for the pooled data of 1987-'91 was 48.2 : 51.8 (Fig. 9). The Chi-square test to find out the significance of the difference in sex ratio has shown that the same was not

TABLE 4. *ANOVA table for testing the identicality of regression lines in the carapace length-carapace width relationship among males and females of* P. sanguinolentus, P. pelagicus *and* C. cruciata

Variation in species	DF	Sum of squares	Mean squares	Calculated F	Tabulated F	(5 %) Significance
P. sanguinolentus						
Sex	2	91.94007	45.97	1.072	3.00	Not significant
Error	553	23710.31149	42.8758			
Total	555	23802.25156				
P. pelagicus						
Sex	2	15.1809	7.59045	3.19	19.49	Not significant
Error	164	3970.4063	24.2098			
Total	166	3985.5872				
C. cruciata						
Sex	2	4.253	2.1265	3.34	19.49	Not signigicant
Error	170	1388.6015	8.1682			
Total	172	1392.8545				

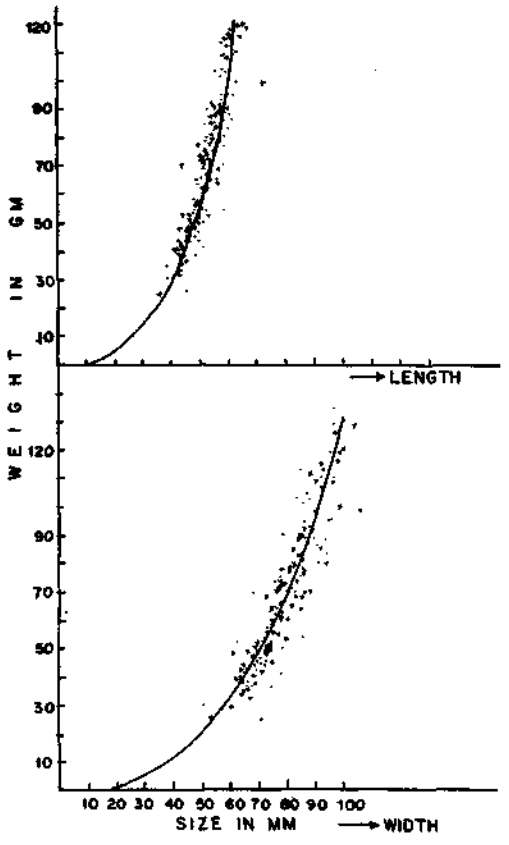

Fig. 7. Carapace length-body weight and carapace width-body weight relationships of *Charybdis cruciata*.

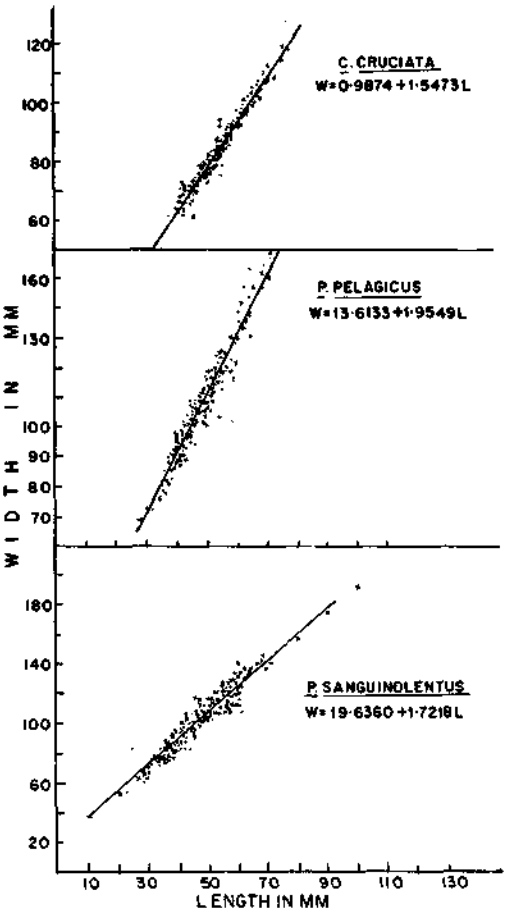

Fig. 8. Carapace length-carapace width relationship of *Portunus sanguinolentus, P. pelagicus* and *Charybdis cruciata*.

significant either year-wise or on pooled (Table 5).

Maturity stages

From the pooled data of *P. sanguinolentus* for the period 1987–'91 it was found that among females immature formed 58.8 % followed by 16.3 % of berried, 8.3 % each of early maturing, and matured, and 5.9 % of late maturing. Month-wise data showed the dominace of immature in October to December, February and April; early maturing in January and March and matured and berried in January, March and May (Fig. 10).

Impregnated females

Among the total females, 55.5 % were found to be impregnated. Of these, 55 % were in immature stage, 15. 7 % in early maturing, 8.9 % in late maturing, 14.1 % in matured and 6.3 % in berried stage (Fig. 11). Maximum

TABLE 5. *Chi-square test for the significance of sex ratio of* Portunus sanguinolentus

Year	No. of females	probability	DF	Chi-square estimated	Value tabulated	5 % significance
1987-'88	240	0.4829	6	7.8752	12.592	Not significant
1988-'89	119	0.4938	2	5.6033	5.991	Not significant
1989-'90	68	0.4928	1	0.4649	3.841	Not significant
1990-'91	127	0.4652	3	7.4948	7.815	Not significant
Total	554	0.4822	15	23.3388	24.996	Not significant

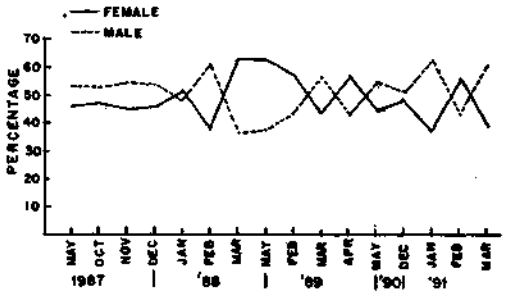

Fig. 9. Sex ratio of *Portunus sanguinolentus* in percentage.

number of impregnated females were found in February (65.9 %).

Size at first maturity

The carapace width at first maturity in females has been found to be 82.99 mm (SE ± 0.00814). The smallest matured and berried females were recorded under the size group 81-85 mm C.W. The immature females were recorded up to 115 mm C.W. and the early maturing females were noticed from 66-70 mm C.W.

L_∞, K and t_0 of P. sanguinolentus

The L_∞ value of female was 161.8 mm (C.W) and that of male 172.9 mm (C.W.). The L_{max} of females and males were 155 and 172 mm (C.W.) respectively. In females K and t_0 were 1.574

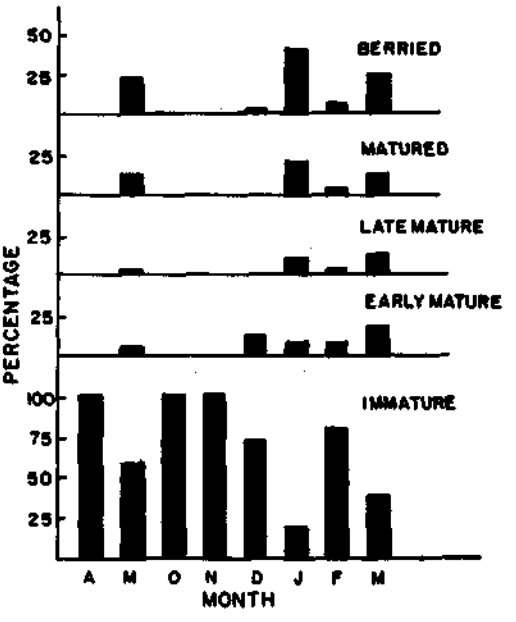

Fig. 10. Maturity condition of *Portunus sanguinolentus* in percentage.

and –0.0635 and in males they were 1.4939 and –0.0482 in that order (Table 6).

The sizes at different ages were found out by von Bertalanffy's growth equation and accordingly female attains a size (C.W.) of 131.5 mm in first year, 155.5 mm in second year and 160.5 mm in third year whereas male attains a size of 136.8 mm in first year, 164.8 mm in second year and 171.1 mm (C.W.) in third year.

TABLE 6. *Input data and regression for the von Bertalanffy plot* (Portunus sanguinolentus)

Female			Male		
t (age in years) (X)	L (t) (mm)	$-\ln (1-L(t) / L_\infty)$ (Y)	t (age in years) (X)	L (t) (mm)	$-\ln (1-L(t) / L_\infty)$ (Y)
0.17	48.0	0.352	0.33	75.3	0.572
0.25	63.5	0.498	0.42	86.3	0.691
0.33	77.5	0.652	0.50	97.2	0.826
0.42	85.4	0.750	0.58	105.1	0.936
0.50	94.7	0.880	0.67	112.7	1.005
0.58	102.3	1.000	0.75	121.3	1.209
0.67	111.3	1.164	0.83	126.3	1.311

Female : a = 0.0999, b = K = 1.574, t_0 = -a/b = -0.0635
Male : a = 0.07212, b = 1.4939, t_0 = –0.0482

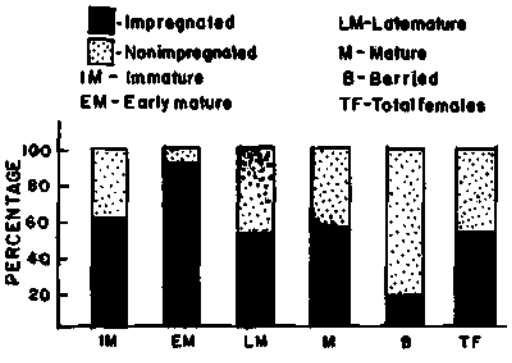

Fig. 11. Percentage of impregnated females in different maturity stages of *Portunus sanguinolentus*.

Discussion

During the period of observation (April 1987 to March 1991), the operations of trawlers were suspended from June to September. During the months of operation, though the crab fishery showed wide fluctuations in different years the season was in general from October to May. George and Nayak (1961) also reported wide fluctuations in the fishery from year to year at Mangalore. According to Menon (1952) the fishery starts only in January or February and ends in May at Calicut. Sukumaran *et al.* (1986) have observed that the fishery lasts from December to May along South Kanara coast.

In the present study the morphometric relationships such as carapace width-body weight, carapace length-body weight and carapace length-carapace width did not show significant differences between sexes in all the species. Hence common equations were found out for males and females. Lalitha Devi (1985) has also studied the length-width (carapace) and width-weight relationships of *P. sanguinolentus* and *P. pelagicus*, and the results agree with the present study. But Sukumaran *et al.* (1986) observed significant variation (at 5 % level) between sexes in width-weight relationship of *P. sanguinolentus*.

The chi-square test for *P. sanguinolentus* showed that the dominance of males in the year-wise landings was not significant and the population has a sex ratio of 1:1 which agrees with the results of Lalitha Devi (1985) and Sukumaran *et al.* (1986).

Occurrence of berried *P. sanguinolentus* from December to may in the trawl catches as well as the availability of matured and berried females during July-August (indigenous gear) clearly indicates its spawning almost throughout the year. The occurrence of younger juveniles (26-50 mm C.W.) from October to December from the sea and during December-May from Korapuzha estuary (16-60 mm C.W. with a mode at 26-30 mm C.W.) further support this spawning nature. This observation agrees with that of Chhapgar (1950), Ryan (1967), Sukumaran *et al.* (1986) and Lalitha Devi (1985). But according to Menon (1952), the spawning period along the Malabar coast is February-April. The area as well as the mode of fishing would have been the main reasons for this as during that period the fishing was never done beyond 16 m depth and the gear were cast net, gill net and boat seine.

The size at first maturity in the present study (in *P. sanguinolentus)* was 82.99 mm C.W. in females. Menon (1952) reported a size of 78 mm C.W. in female *P. sanguinolentus*. According to Lalithadevi (1985) females attain maturity at the size of 57 mm C.W. and the smallest ovigerous female recorded was 122 mm C.W. In the present study the smallest matured and berried female were recorded under the size group 81-85 mm. Sukumaran *et al.* (1986) recorded 78 mm C.W. for the smallest berried female. Sukumaran and Neelakantan (1996) opined that the pubertal moult in *P. sanguinolentus* occurs at a carapace width of 80-90 mm in females.

In this study, the observed L_∞ of *P. sanguinolentus* as 172.9 mm C.W. in males and 161.8 mm C.W. in females supports the values obtained by Sukumaran *et al.* (1986) as 173 mm C.W. for males and 163 mm C.W. for females. Sukumaran and Neelakantan (1996) estimated different L_∞ values by using different methods. But considering the maximum size of the crab (169 mm for male and 166 mm for female) the value obtained (172 mm for male; 175 mm for female) by ELEFAN-I method is more nearer to L_{max}. The K value (annual) calculated in the present study was 1.574 for females and 1.494 for males. The t_0 (annual) was –0.0635 in females and 1.494 for male. Sukumaran *et al.* (1986) obtained the K value (monthly) as 0.288 ($e^{-K} = 0.75$) in both female and male. Sukumaran and Neelakantan (1996) estimated K (annual) around 1.0 in male and 0.8 in female. The t_0 (annual) was calculated as –0.0132 in male and –0.0975 in female.

In the present study *P. sanguinolentus* was found to reach a size of 132 mm C.W. (female) and 136.8 C.W (male) during the first year and 156 C.W. (female), 164.8 mm C. W. (male) during the second year. According to Sukumaran *et al.* (1986) male and female reach a size of 168 mm and 158 mm C.W. respectively in the first year. Sukumaran and Neelakantan (1996) estimated a growth rate in *P. sanguinolentus* as 112 mm (female), 124 mm C.W. (male) at the end of first year and 155 mm (female) and 168 mm (male) C.W. at the end of second year (values of von Bertalanffy plot).

The present study indicated that *P. sanguinolentus* exploited by trawlers comprised mainly 0-year class (98 %) and half of the females caught were below the size at first maturity. The landings of berried crab in substantial

quantity are also bound to affect the population adversely. Considering the growing demand for crab meat, there is every possibility of increasing the effort to harvest them beyond the optimum level. *C. cruciata* is a typical example for this. Earlier this species was thrown back into the sea but now the entire catch is brought to the shore as it fetches good price.

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