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Sex ratio, fecundity and reproductive potential in two marine portunid crabs, *Portunus (Portunus) sanguinolentus* (Herbst) and *Portunus (Portunus) pelagicus* (Linnaeus) along the Karnataka coast

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Chi-square values for the pooled data were significant at a probability level of 0.05 indicating that there was significant variation in sex ratio in *P.(P.) sanguinolentus* and *P. (P.) pelagicus*. The fecundity increased with the size of the crab from 0.044 to 1.19 x 10^6 eggs in *P.(P.) sanguinolentus* and from 0.056 to 1.07 x 10^6 eggs in *P. (P.) pelagicus* and the correlation coefficient values were significant at $P \leq 0.001$ level between the parameters studied. The productivity was found to increase from a low of 0.1 in 80-90 mm to a maximum of 2.2 in 120-130 mm in the former and 130-140 mm in the latter species.

Notwithstanding the commercial importance of *Portunus (Portunus) sanguinolentus* and *P.(P.) pelagicus* in their distributional ranges, information on the spawning biology of these crabs is rather fragmentary and limited[1-7]. Most of these studies are only brief accounts on some aspects of relative growth, sexual maturity, maturity stages, sex ratio, mating behaviour, fecundity and spawning from various regions. In the present account, the sex ratio, fecundity and reproductive potential of *P.(P.) sanguinolentus* and *P. (P.) pelagicus* are dealt with from the Karnataka coast.

Materials and Methods

Portunus (P.) sanguinolentus and *P. (P.) pelagicus* caught by different type of gears like trawl, minitrawl and shore seine were sampled from Mangalore, Malpe and Karwar (Fig. 1) fish landing centres periodically during 1992-94. Crabs were classified as juvenile if the abdominal flap was firmly attached to the thorax[8]. Sex was differentiated by the abdominal shape. The abdomen is narrow and inverted V shaped in males, while it is triangular to semicircular in females. The sex ratio of the adult population (more than 80 mm CW) was studied as there was no apparent variation in the ratio in juvenile crabs. The overall sex ratios were tested using the chi-square. Fecundity studies were made on the basis of the extruded eggs on pleopods as suggested by Sukumaran *et al*[2].

The relationships between carapace width (CW) and egg mass weight/ fecundity, and crab weight and egg mass weight/ fecundity, and egg mass weight and fecundity were determined by regression analysis. Egg mass index was determined using the

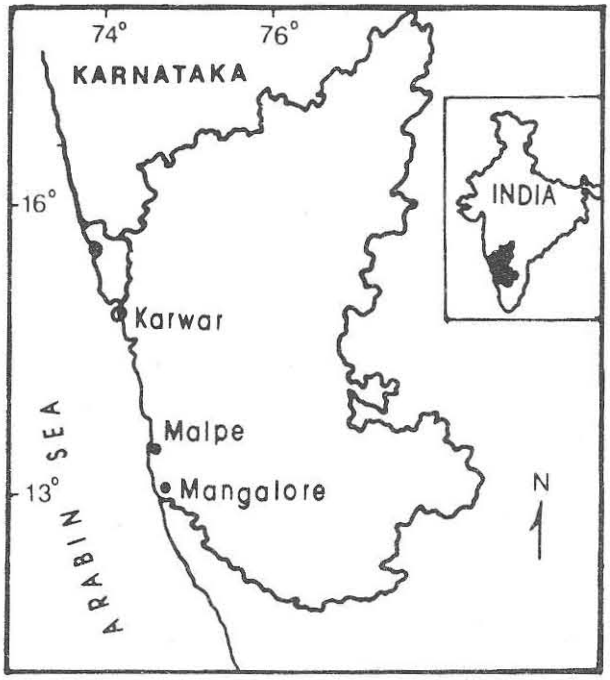

Fig 1—Map of Karnataka showing the centres of sampling.

following formula:

$$\frac{\text{Egg mass index}}{\text{Mean crab weight}} = \text{mean egg mass weight} \times 100$$

To estimate the reproductive potential for each size class, taking into consideration the variations observed with regard to the egg carrying capacity as well as the percentage of females in berry in different size groups, an index of class reproductive potential was determined based on the method suggested by Kanciruk & Herrnkind[9].

Results and Discussion

The incidence of males of *P. (P.) sanguinolentus* was more at Karwar with a male to female ratio of 1.29 : 1, whereas, at Mangalore, the ratio was 0.93 : 1. At Malpe, males and females were more or less equally distributed (1.06 :1) although there was variation during different months.

Sex distribution in this crab in relation to size indicated that females were more pronounced in the smaller sizes, whereas, males dominated in the larger sizes as observed by Sumpton *et al.*[3] in this species from Australian waters. The abundance of females in the lower size groups might have resulted from the tendency of reproductively active females to postpone somatic growth thereby causing them to

Table 1—Monthly distribution of sex ratio in adult crabs of *P. (P.) sanguinolentus* in the inshore waters at Mangalore, Malpe and Karwar during 1992-94

Months	Total n	Males n	Sex ratio (M/F)	Chi-square	Remarks
Mangalore (Trawl)					
Nov. 92	123	51	0.71	3.58	NS
Dec.	490	35	0.92	0.81	NS
Jan. 93	331	174	1.11	0.87	NS
Feb.	225	83	0.58	15.47	S
Mar.	120	61	1.03	0.03	NS
Apr.	166	97	1.41	4.72	S
May	91	46	1.02	0.01	NS
Nov	4	4	-	4.00	S
Dec.	162	68	0.72	4.17	S
Jan. 94	243	135	1.25	3.00	NS
Feb.	13	4	0.44	1.92	NS
Mar.	124	56	0.82	1.16	NS
Apr.	44	18	0.69	1.45	NS
May	47	18	0.62	2.57	NS
Pooled	2183	1050	0.93	3.16	NS
Malpe (Trawl)					
Oct. 92	2	0	-	-	.
Nov.	90	58	1.81	7.51	S
Dec.	315	166	1.11	0.92	NS
Jan. 93	237	85	0.56	18.90	S
Feb.	228	127	1.26	2.96	NS
Mar.	269	154	1.34	5.65	S
Apr.	198	111	1.28	2.90	NS
May	133	81	1.56	6.32	S
Sep.	15	5	0.50	1.67	NS
Oct.	4	1	0.33	1.00	NS
Nov	107	53	0.98	0.01	NS
Dec.	145	70	0.93	0.17	NS
Jan. 94	138	61	0.79	1.86	NS
Feb.	146	67	0.85	0.98	NS
Mar.	11	5	0.83	0.09	NS
Apr.	123	62	1.02	0.01	NS
May	141	81	1.35	1.13	NS
Pooled	2302	1187	1.06	2.25	NS

Months	Total n	Males n	Sex ratio (M/F)	Chi-square	Remarks
Karwar (Trawl)					
Dec. 92	63	40	1.74	4.59	S
Jan. 93	83	42	1.02	0.01	NS
Feb.	55	33	1.50	2.20	NS
Mar.	109	58	1.14	0.45	NS
Apr.	168	106	1.71	11.52	S
May	70	43	1.59	3.65	NS
Dec.	109	57	1.10	0.23	NS
Jan. 94	123	64	1.08	0.20	NS
Feb.	28	10	0.56	2.28	NS
Mar.	11	2	0.22	4.45	S
Apr.	75	48	1.78	5.88	S
Pooled	894	503	1.29	14.03	S
Karwar (Shore seine)					
Nov. 92	10	7	2.33	1.60	NS
Jan. 93	5	2	0.67	0.20	NS
Feb	50	38	3.17	13.52	S
Mar	44	34	3.40	13.09	S
Apr.	1	0	-	-	
Jul.	12	6	1.00	0	
Dec.	14	3	0.27	4.57	S
Jan. 94	12	7	1.40	0.33	NS
Feb	22	12	1.20	0.17	NS
Mar.	56	34	1.54	2.57	NS
Apr.	32	23	2.56	6.12	S
Aug.	28	12	0.75	0.57	NS
Pooled	286	178	1.65	17.13	S
Trawl pooled	5379	2740	1.04	1.90	NS
All gears/ centres pooled	5665	2918	1.06	5.16	S

Crabs measuring 80 mm CW and above were considered as adults, S=significant at 5 % level; NS= not significant at 5 %level accumulate in these sizes as observed by Colby & Fonseca[10] in *Uca pugilator* in Southern Florida.

In *P. (P.) pelagicus*, the male to female ratio was 1:1 in the trawl catches at Mangalore, while it was nearly equal at Malpe (0.99 : 1) although there was month to month variation. At Karwar, on the otherhand, the proportion of males in the trawl catches was low, the ratio being 0.84 : 1, whereas, males outnumbered females in shore seine catches at this centre with a ratio of 1.26 : 1. Mini trawl catches from the estuary of Mangalore showed the preponderance of female (0.78 : 1).

The chi-square values for the pooled data for trawl in respect of *P. (P.) sanguinolentus* and *P. (P.) pelagicus* were not significant (Tables 1, 2) . However, for *P.(P.) sanguinolentus*, this value was significant for shore seine (Karwar). In the case of *P. (P.) pelagicus*, the chi-square value was not significant for shore seine (Karwar) while it was significant for minitrawl (Mangalore). For the pooled data for all gears/ centres, the chi-square values were significant (at a probability level of 0.05) enough to reject the null hypothesis i.e., 1: 1 ratio for both the species.

Table 2—Monthly distribution of sex ratio in adult crabs of *P. (P.) pelagicus* in the inshore waters at Mangalore, Malpe and Karwar during 1992-94

Months	Total n	Males n	Sex ratio (M/F)	Chi-square	Remarks
Mangalore (Trawl).					
Feb.93	45	19	0.75	1.09	NS
Mar.	80	40	1.00	0	NS
Apr.	146	73	1.00	0	NS
May	293	147	1.01	0.01	NS
Dec.	12	0	-	-	
Jan. 94	83	34	0.69	2.71	NS
Feb.	129	66	1.05	0.06	NS
Mar.	218	130	1.48	8.09	S
Apr.	290	159	1.21	2.70	NS
May	143	52	0.57	10.64	S
Pooled	1439	720	1.00	0	NS
Mangalore (Mini trawl-esturine)					
Mar.93	40	19	0.90	0.10	NS
Apr.	132	72	1.20	1.09	NS
May	156	63	0.68	5.76	S
Jun.	31	10	0.48	3.90	S
Feb. 94	68	31	0.84	0.53	NS
Mar.	89	32	0.56	7.02	S
Apr.	52	29	1.26	0.69	NS
May	76	26	0.52	7.38	S
Pooled	644	282	0.78	9.94	S
Malpe (Trawl)-					
Sep. 92	34	12	0.55	2.94	NS
Oct. 92	26	3	0.13	15.38	NS
Nov.	1	1	-	1.00	NS
Dec.	6	3	1.00	0	NS
Jan. 93	9	5	1.25	0.11	NS
Feb.	90	51	1.31	1.60	NS
Mar.	143	66	0.86	0.85	NS
Apr.	108	52	0.93	0.15	NS
May	85	45	1.13	0.29	NS
Aug.	93	62	2.00	10.33	S
Sep.	78	50	1.79	6.20	S
Nov	2	0	-	-	
De.	18	3	0.20	8.00	S
Jan. 94	43	21	0.95	0.02	NS
Feb.	93	52	1.27	1.30	NS
Mar.	33	13	0.59	1.48	NS
Apr	95	48	1.02	0.01	NS
May	63	35	1.25	0.78	NS
Sep.	85	28	0.49	9.89	S
Pooled	1107	550	0.99	0.04	NS
Karwar (Trawl)					
Dec. 92	45	21	0.88	0.20	NS
Jan. 93	106	43	0.68	3.77	NS
Feb.	119	51	0.75	2.43	NS
Mar.	57	25	0.78	0.86	NS
Apr.	128	54	0.73	3.12	NS
May	77	36	0.88	0.32	NS
Jan. 94	188	67	0.53	15.51	S
Feb	73	47	1.81	6.04	S
Mar.	140	83	1.46	4.83	S
Apr.	58	26	0.81	0.62	NS
Pooled	991	453	0.84	7.29	S
Karwar (Shore seine)					
Nov. 92	6	1	0.20	2.67	NS.
Dec.	28	21	3.00	7.00	S
Jan. 93	57	43	3.07	14.75	S
Feb.	54	29	1.16	0.29	NS
Mar.	7	6	6.00	3.57	NS
Apr.	-	-	-		
Nov.*	18	2	0.13	10.89	S
Dec.	14	4	0.40	2.57	NS
Jan. 94	8	1	0.14	4.50	S
Feb	13	7	1.17	0.08	NS
Mar.	51	28	1.22	0.49	NS
Apr.	11	7	0.64	0.81	NS
Pooled	267	149	1.26	3.60	NS
Trawl pooled	3457	1723	0.99	0.04	NS
Indi. gears pooled	991	431	0.77	16.79	S
All centres/ gears pooled	4448	2154	0.94	4.41	S

Asterisk indicates gill net catch; crabs measuring 80 mm CW and above treated as adults
S-significant at 5% level; NS-not significant at 5% level

Sex distribution in relation to size in *P. (P.) pelagicus* did not show any clear pattern and the ratio varied in different size groups in various gears at all centres.

The average carapace width, average weight of the crab, egg mass weight, average fecundity per brood and egg mass index for the two species are shown in Table 3. Present study indicated that there is an increase in the number of eggs carried with the increase in size of crab, although there was some variation at certain sizes (Table 3). The fecundity varied from 0.044 to 1.19 x 10^6 eggs in *P. (P.) sanguinolentus*, and from 0.056 to 1.07 x 10^6 eggs in *P.(P.) pelagicus*.

The statistical relationships between fecundity and egg mass in relation to carapace width in respect of *P. (P.) sanguinolentus* and *P. (P.) pelagicus* suggest an exponential relation between the variables in both these species (Table 4). It is also noted that there was a direct relationship between

Table 3-Average carapace width, average weight, egg mass weight, average fecundity per brood and egg mass index in *P. (P.) sanguinolentus* and *P. (P.) pelagicus*

Size groups (mm)	n	Carapace width (mm)	Average weight (g)	Egg mass weight (g)	Total no. of eggs	Egg mass index
			P.(P.) sanguinolentus			
80-90	4	86.5±3.11	41.15±9.41	4.87±1.18	2,88,162	11.83
90-100	9	94.3±1.42	48.63±7.11	5.26±2.32	3,36,926	10.82
100-110	8	103.6±3.12	67.43±13.78	10.25±3.55	4,88,528	15.20
110-120	17	114.7±2.84	81.42±11.41	10.71±4.67	4,83,789	13.40
120-130	8	123.2±2.40	112.35±8.10	14.22±4.46	7,42,477	12.66
130-140	6	133.8±3.11	146.0±19.98	17.99±5.56	7,37,886	12.32
140-150	3	145.0±3.40	153.74±15.20	18.83±1.73	4,67,880	12.24
150-160	2	154.0±1.41	228.77±16.06	19.58±1.72	9,20,510	8.56
			P.(P.) pelagicus			
80-90	2	88.3±1.06	37.01±2.38	1.99±0.22	66,950	5.37
90-100	2	96.2±1.04	52.88±2.31	5.84±0.58	1,90,017	11.05
100-110	6	103.7±3.39	85.99±13.10	8.15±3.59	1,46,515	9.47
110-120	8	114.1±2.95	92.91±11.41	9.67±4.18	3,24,218	10.41
120-130	6	123.7±3.08	132.12±11.94	14.43±4.42	4,76,273	10.84
130-140	5	133.6±3.36	198.16±29.59	23.40±13.26	6,46,412	11.81
140-150	8	141.3±2.69	196.58±20.21	17.97±7.32	5,41,610	9.14
150-160	5	154.4±4.28	262.77±57.23	22.83±8.98	6,23,206	8.69
160-170	2	164.0±1.41	353.56±2.21	23.27±1.19	8,62,825	6.58
170-180	2	173.5±3.54	375.32±9.64	25.29±1.30	9,04,370	6.72

Table 4—Statistical relationships between carapace width and eggmass weight/fecundity, crab weight and eggmass weight/ fecundity and eggmass weight and fecundity in *P. (P.) sanguinolentus* and *P. (P.) pelagicus*

Variables X	Variables Y	Least square regression	r'	n
		P. (P.) sanguinolentus		
C.width	Eggmass wt.	$Y=0.00000889 \times ^{2.9467}$	0.7509	57
C.width	Fecundity	$Y=94795\times ^{1.7888}$	0.4162	57
Crab wt.	Eggmass wt.	$Y=0.14118 \times ^{0.9527}$	0.7748	57
Crab wt.	Fecundity	$Y=29516 \times ^{0.6077}$	0.4511	57
Eggmass wt.	Fecundity	$Y=108041 \times ^{0.6166}$	0.5628	57
		P. (P.) pelagicus		
C.width	Eggmass wt.	$Y=0.00000507 \times ^{3.0425}$	0.7727	46
C.width	Fecundity	$Y=122583 \times ^{2.6091}$	0.6332	46
Crab wt.	Eggmass wt.	$Y=0.050748 \times ^{1.1144}$	0.9908	46
Crab wt.	Fecundity	$Y=3769.433 \times ^{0.9307}$	0.7875	46
Eggmass wt.	Fecundity	$Y=46904.55 \times ^{0.8225}$	0.7875	46

Table 5—Index of reproductive potential in *P. (P.) sanguinolentus* and *P. (P.) pelagicus*

		Size class of female (cw in mm)								
		80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160-170
					P. sanguinolentus (n=2882)					
A	% of total females	24.8	22.3	18.3	16.1	10.5	5.9	1.8	0.3	-
B	% berry	1.9	12.6	19.7	30.3	21.8	10.9	2.2	0.5	-
C	Mean fecundity (×100,000)	2.9	3.4	4.9	4.8	7.4	7.4	4.7	9.2	-
D	IRP (27.2)	28.7	200.7	371.1	491.9	355.9	100.0	3.9	0.3	-
E	% of total egg production	1.8	12.9	23.9	31.7	22.9	6.4	0.3	0.0	-
F	E/A (Productivity)	0.1	0.6	1.3	2.0	2.2	1.1	0.2	0.0	-
					P. pelagicus (n=2387)					
A	% of total females	22.6	22.2	18.5	10.9	7.3	7.1	5.2	5.9	0.8
B	% berry	3.0	14.6	21.7	15.0	11.6	11.2	9.7	9.0	4.1
C	Mean fecundity (× 100,000)	0.7	1.9	1.5	3.2	4.8	6.5	5.4	6.2	8.6
D	IRP (47.6)	17.4	226.4	221.4	192.4	149.4	190.0	100.0	121.0	10.4
E	% of total egg production	1.4	18.4	18.0	15.7	12.2	15.5	8.1	9.9	0.8
F	E/A (Productivity)	0.1	0.8	1.0	1.4	1.7	2.2	1.6	1.7	1.0

egg mass weight and fecundity. Highly significant positive correlation ($P \leq 0.001$) was observed in all relationships studied.

The egg bearing propensity (percentage of females in a given size class with eggs), egg carrying capacity, contribution of each size class to total egg production in respect of *P. (P.) sanguinolentus* and *P. (P.) pelagicus* are given in Table 5. Eventhough the percentage of females in berry vary among different size groups, it is observed that the larger females had a larger egg carrying capacity. In *P. (P.) sanguinolentus*, the size class 120-130 mm CW represented only 10.5 % of all females (80 mm CW and above), yet contributed 22.9 % of the estimated egg production of all females with a "productivity" rating of 2.2 which is found to be the maximum for this species. The newly matured females in the size class of 80-90 mm CW represented 24.8% of all females (80 mm and above), yet produced only 1.8 % of the estimated total egg production (productivity = 0.1), making them 22 times less productive than 120-130 mm size group. The crabs measuring 130 mm and above produced an estimated 6.7 % of the total egg production (productivity = 1.1 and less). The productivity in crabs was found to increase from a low of 0.1 in 80-90 mm size group to a maximum of 2.2 in 120-130 mm size group. Thereafter it showed a steep fall.

In *P. (P.) pelagicus*, although the females in the size group 130-140 mm CW, represented only 7.1 % of all females measuring 80 mm and above, produced 15.5 % of the estimated total egg production of all females (productivity = 2.2).The newly mature females of this species in the size group of 80-90 mm CW represented 22.6 % of all females, yet produced only 1.4 % of the estimated egg production (productivity = 0.1) making them 22 times less productive than the 130-140 mm size class. It is seen that the productivity increased from 0.1 in 80-90 mm size group to 2.2 in 130-140 mm size group. Then it registered a fall in the rest of the size groups.

There has been considerable variation in the results obtained by various workers who studied sex ratio / fecundity of these portunids from different regions[11, 12]. Differential growth rate between the sexes is an important factor for the variation in sex ratio reported.

Considerable variation has been reported with respect to fecundity also[6,11]. While studying the fecundity in *Scylla serrata*, Prasad & Neelakantan[13] noted that the egg mass weight and carapace width are better indices for estimation of the reproductive potential than the weight of the crab. Shields *et al.*[14] found that the fecundity in rock crab, *Cancer anthonyi* varied seasonally. Several factors such as salinity, temperature, photoperiod, abundance of food in the environment and intrinsic state of the animal have been attributed to both interspecific and intraspecific variability of fecundity (Giese & Pearse.[15]).

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