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STUDIES ON THE REPRODUCTIVE BIOLOGY OF THE BROWN PRAWN *METAPENAEUS MONOCEROS* (FABRICIUS, 1798) ALONG THE KAKINADA COAST

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ABSTRACT

Five ovarian maturation stages are recognised in *Metapenaeus monoceros*. Males and females attain size at first maturity at 96 and 116 mm total length (TL) respectively. Each female spawns at least four times in its life time with an interval of about 2 months between successive spawnings. After attaining maturity, males are sexually active throughout their life. Spwaning season is prolonged extending from January to October. The following linear relationships are obtained between fecundity and total length/ total weight/ovary weight.

Fecundity (in thousands) = -507.1369 + 4.9593 x total length
Fecundity (in thousands) = -25.4832 + 9.7134 x total weight
Fecundity (in thousands) = -18.3825 + 96.6413 x ovary weight

Ovary weight is a better index of fecundity than either total length or total weight. Fecundity varies from 51,684 ova in female of 113 mm TL to 402, 378 ova in a female of 181 mm TL. The ratios of males to females vary from 1 : 3.21 to 1 : 0.29 in different months. These wide variations in the sex ratio are found to be associated with the sex-wise segregation in the fishing grounds. Annual sex ratio in the population is significantly different at P = 0.01 level from the usual 1:1 ratio.

INTRODUCTION

The reproductive biology of a number of penaeid species has been studied in varying detail by earlier workers namely Hudinaga (1942), King (1948), Menon (1951, 1953), Eldred (1958), Shaikhmahmud and Tembe (1958, 1960, 1961), Cummings (1961), Subrahmanyam (1963), Tuma (1967), Rao (1968), George and Rao (1968), Thomas (1974) and Perez - Farfante (1975) among others. But the work done on the reproductive biology of *M. monoceros* is very little and is restricted to a few observations on the spawning seasons (George, 1962); spawning grounds (George and George, 1964); hypomorphic ovaries (Nalini, 1975); and maturation and spawning (Nalini, 1976). All these works relate to the Cochin area. Information on the reproductive biology of *M. monoceros* from the other parts of the country is lacking. Therefore, detailed investigations on the reproductive biology including maturation, size at first maturity, spwaning seasons, spawning frequency, fecundity and sex ratio of *M. monoceros* along the Kakinada coast were undertaken during the years 1974 - '77.

MATERIAL AND METHODS

Material for this study was collected once a week from the trawler catches landed at the Kakinada fishing harbour. Since random sampling was adopted, the number of specimens observed in a month varied depending on the magnitude of the catches.

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Samples were sexed and biological characters noted. Total length was measured to the nearest mm and total weight was taken to nearest 0.1 g. Weight of the ovary was taken to the nearest 0.01 g. These data were collected from fresh specimens. Ovaries for ovadiameter and fecundity studies were fixed in 5% formaldehyde. Maturity stage noted in fresh condition was verified by microscopic examination. Colour and size of the ovary have been found to be useful in classifying ovaries in fresh condition.

A number of workers (Cummings, 1961; Rao, 1968; Caillouet, 1972; Martosubrato, 1974; Thomas, 1974 and Nalini, 1976) observed that the size of the ova in penaeids are similar in different parts of the ovary. Nevertheless, to maintain uniformity, a portion of the ovary on the right side of the first abdominal segment was examined for ova diameter and fecundity studies. Ova diameter measurements were taken to follow the maturation process in the ovaries. The ova being irregular in shape, measurement of every ovum was taken in the same parallel plane using mechanical stage of the microscope in order to avoid error due to distortion and subjective bias. For fecundity studies, an ovary segment of about 0.05 g was taken and weighed to the nearest 0.001 g accuracy. All mature ova contained in the sample were counted by using a counting slide. From this value the number of mature ova in the entire ovary was calculated based on the toal ovary weight.

Fecundity of penaeids has been studied by Anderson *et al* . (1949) in *P. setiferus;* Rao (1968) in *M. dobsoni, M. affinis, P. indicus* and *P. stylifera;* Liao *et al. (1969)* in *M. monoceros* (=*M. ensis);* Martosubrato (1974) in *P. duorarum* and Nalini (1976) in *M. monoceros* by estimating the number of ripe ova in mature as well as ripe ovaries. In the present study, fecundity was determined by estimating the number of mature ova in the ripe ovaries. Fecundity was estimated by examining 31 ripe ovaries in the total length range of 113-181 mm. The least squares method was applied to calculate regressions of fecundity (F) on total length (TL), body weight (TW) and ovary wieght (OW). In addition regression equation was also calculated between total weight and ovary weight.

Sex ratio was studied from the numbers estimated to the catch of a given month, rather than from the actual numbers observed in the sample, to obtain a meaningful structure of the population. Data collected during the period 1974-'77 were used for this purpose. In sex ratio studies in which monthly values were analysed for sex ratio estimation, different monthly values may give different estimations of sex ratio. It is possible that either the sex ratios are distributed according to the binomial theory and the apparent differences in the monthly sex ratios are due to sampling fluctuations or the sex ratios are not distributed according to the binomial theory due to an actual segregation of the sexes. To test if the variation in the monthly sex ratios could be expected from binomial distribution or not, x^2 statistics given below were calculated:

$$x^2 = \frac{\Sigma\left[\frac{x_i^2}{n_i}\right] - \frac{(\Sigma x_i)^2}{\Sigma x_i}}{pq}$$

Where x_i is the number of males in the `i' th month, $n_i$ is total number of observations in the `i'th month, $p = x_i/n_i$ (Cochran, 1953) and $q = (1 - p)$. Significance test at a probability level of $p = 0.01$ was carried out.

Results

Maturity stages of the ovary

The development of the ovary in *M. monoceros* was divided into five stages fol-

lowing King (1948), depending on the size and colour of the ovaries and size of the ova viz., immature (Stage I), maturing (Stage II), mature (Stage III), ripe (Stage IV) and spent (Stage V).

Immature : Ovary is formed of developing anterior lobes which are confined to the posterior half of the cephalothorax and posterior lobes which are situated on the dorsal aspect of the abdomen, extending upto the middle of the sixth abdominal segment. It is thin, strand - like and whitish. Ova are small and spherical with clear cytoplasm and conspicuous nuclei. Ova diameter range was between 0.01 - 0.09 mm with majority of them measuring 0.03 to 0.05 mm (Fig. 1).

Maturing : Ovary increases in size, the anterior lobes further develop and extend forward into the cephalothorax, the middle lobes and the rudiments of their lobules develop. The posterior lobes increase in girth and minute brown pigments appear on the dorsal surface of the ovary. The general colour of the ovary is yellowish. The ovary now contains two groups of ova, an immature group and of developing ones. The developing ova are translucent due to accumulation of yolk in the cytoplasm. The nuclei are not clearly visible. The developing ova measure between 0.07 mm and 0.19 mm with majority of them between 0.09 and 0.15 mm (Fig. 1).

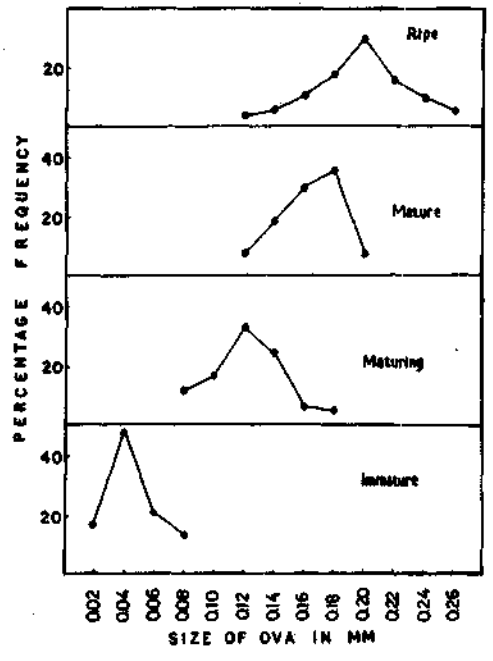

FIG. 1. Diameter-frequency distribution of developing ova in different stages of ovarian maturity in *M. monoceros*.

Mature : The ovary develops further, the anterior, middle and posterior lobes are fully formed. Yet, the anterior and middle lobes do not fill the cephalothorax completely. The ovary is generally light green, with branched brownish chromatophores distributed over the entire dorsal surface. It is now visible through the exoskeleton. The developing ova are opaque and the nuclei become completely invisible due to the accumulation of yolk. Size of the ova ranges between 0.11 and 0.21 mm with majority of them between 0.15 and 0.19 mm.

Ripe : The ovary is dark green or brownish green and is clearly visible through the exoskeleton. The anterior and middle lobes are fully formed and occupy the space available in the cephalothorax. Branched brownish pigments are densely distributed over the dorsal surface of the entire ovary. The posterior lobes develop extensions in the first abdominal segment region. Mature ova are opaque, fully yolked and measure between 0.11 and 0.27 mm with majority of them in 0.17-0.23 mm range.

Size at first maturity

In males attainment of first maturity is closely associated with the joining of the

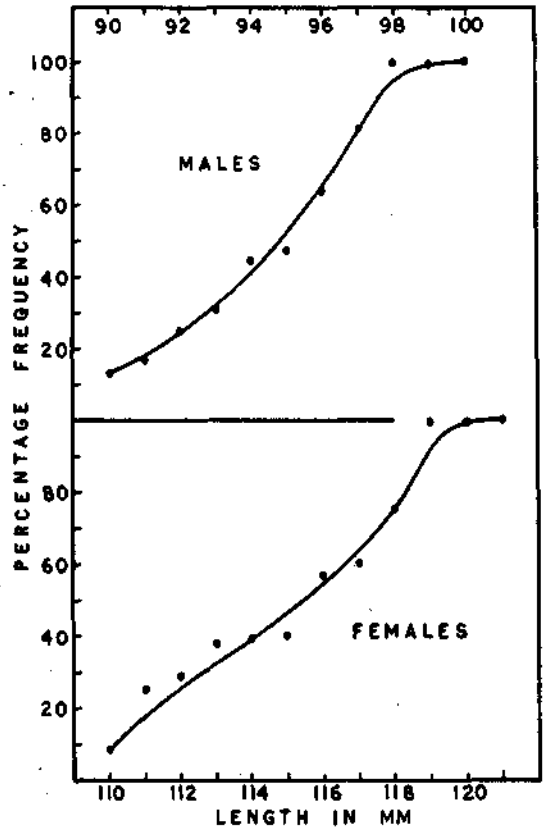

FIG. 2. Determination of size at first maturity in *M. monoceros*.

endopodites of the first pair of pleopods i.e., the petasmal endopodites (Eldred *et al.*, 1961; Tuma, 1967). Males at different stages of joining of petasmal endopodites were observed beyond a length of 85 mm. The smallest male with completely joined petasma was observed at a length of 89 mm. This male had completely developed spermatophores in the terminal ampoules. Males with completely joined petasmal endopodites and clearly visible spermatophores in the terminal ampoules at the base of fifth periopods were considered as mature. On the basis of these criteria, the size at first maturity was determined by examining 105 males in the length range of 89-100 mm. The frequency distribution of mature males at different length shows that 50% of the males attain maturity at 95/96 mm total length (Fig. 2). By the time they reach a length of 98 mm, all the males are mature. Hence, in this study, all the males measuring 96 mm or more are considered as mature. From the age data (Rao, 1985), it may be stated that males attain first maturity in the seventh month of their life. After attaining maturity all the males are sexually active throughout the year without any seasonal changes.

To determine the size at first maturity in females, at which 50% of the population attains first maturity, immature and maturing were grouped together as 'immature' while mature ripe and spent were classifed as 'mature'. It was observed (Tables 1-4) that the smallest mature female was observed in the 106-110 mm size group (Table 4). Hence about 133 females in the length range of 106-120 mm examined in 1974 were analysed with 1 mm grouping to determine the size at first maturity. It was observed that the smallest mature female measured 110 mm in total length and the percentage of mature females gradually increased from that length onwards till 50% of the females were mature by the time they are 115 - 116 mm in length (Fig. 2). By the time they reached 119 mm total length, 100% of the females were mature. From the age data (Rao, 1985), it may be stated that in females also first maturity is attained in the seventh month of their life.

Spawning population

The length-wise distribution of females in different stages of ovarian maturity during the years 1974-'77 is given in Tables 1-4. Ripe females were encountered only after a length of 108 mm. However, most females of 113-178 mm length range form the spawning population and contribute to the major

TABLE 1. *Percentage occurrence of females of* M. monoceros *in different stages of maturity in various size groups during 1974*

Stage/size groups in mm	Maturity stages					No.of prawns obser-ved
	Immature	Maturing	Mature	Ripe	Spent	
53	100.00					3
58	100.00					12
63	100.00					14
68	100.00					19
73	100.00					17
78	100.00					23
83	100.00					40
88	100.00					47
93	100.00					38
98	97.88	2.12				46
103	83.33	16.67				60
108	74.51	21.57	3.92			51
113	13.04	78.26	4.35	4.35		46
118	-	44.83	41.38	10.34	3.45	29
123	-	28.57	24.49	42.86	4.08	49
128	-	18.52	25.93	37.04	18.52	54
133	-	17.91	29.85	40.30	11.94	67
138	-	25.53	17.65	51.18	7.65	68
143	-	13.73	17.65	47.06	21.57	102
148	-	14.08	15.49	56.34	14.08	71
153	-	19.28	25.30	43.37	12.05	83
158	-	13.89	12.50	59.72	13.89	72
163	-	30.65	19.35	40.32	9.68	62
168	-	23.26	13.95	39.53	23.26	43
173	-	26.67	10.00	43.33	20.00	30
178	-	12.50	-	75.00	12.50	16
183	-	26.67	13.33	33.33	26.67	15
188	-	-	50.00	-	50.00	4

TABLE 2. *Percentage occurrence of females of* M. monoceros *in different stages of maturity in various size groups during 1975*

Stage/size groups in mm	Maturity stages					No.of prawns observed
	Immature	Maturing	Mature	Ripe	Spent	
73	100.00					1
78	100.00					4
83	100.00					11
88	100.00					11
93	95.65	4.35				23
98	94.44	5.56				36
103	95.12	4.88				41
108	76.19	16.67	7.14			42
113	51.61	25.80	12.90	9.68		31
118	4.17	41.67	16.67	33.33	4.17	48
123	-	39.03	17.07	39.02	4.88	41
128	-	32.76	20.69	34.48	12.07	58
133	-	26.39	18.06	37.50	18.06	72
138	-	23.17	25.61	35.37	15.85	82
143	-	11.29	14.52	47.56	11.29	62
148	-	15.22	17.39	58.70	8.70	46
153	-	18.18	9.09	54.55	18.18	22
158	-	18.75	37.50	43.75	-	16
163	-	36.36	18.18	36.36	9.09	11
168	-	-	50.00	50.00	-	2
173	-	50.00	-	50.00	-	2
178	-	50.00	-	50.00	-	2
183	-	-	100.00	-	-	1

component of the population harvested by the trawlers from inshore waters. It is possible that they form aggregations during spawning and become vulnerable to capture. Similar schooling pattern was observed in *P. setiferus* (Hildebrand, 1954), *P. duorarum* (Costello and Allen, 1970) and *P. merguiensis* (Munro, 1975).

Spawning frequency

Tables 1-4 show that the distribution of ripe females indicated 4-5 modes at different length groups. In 1974, modes were observed at 123, 138, 148 and 158 mm for ripe females. From this it may be interpreted that individual prawn may attain ripe stage at about these lengths in its life time. There is also a possibility of the prawn spawning yet once more btween 158-178 mm length range. Hence, it may be inferred that an individual prawn attains ripe stage at least 5 times in its life time. The analysis of data of 1975-'77 also vindicated this inference. Taking age of these sizes as 7-15 months (length 116-178 mm) it

TABLE 3. *Percentage occurrence of females of* M. monoceros *in different stages of maturity in various size groups during 1976*

Stage/size groups in mm	Maturity stages					No.of prawns observed
	Immature	Maturing	Mature	Ripe	Spent	
53	100.00					5
58	100.00					13
63	100.00					15
68	100.00					46
73	100.00					63
78	100.00					53
83	100.00					44
88	100.00					42
93	100.00					38
98	100.00					27
103	91.67	8.33				24
108	93.10	6.90				29
113	50.00	30.00	7.50	12.50	-	40
118	-	44.45	27.78	19.44	8.33	36
123	-	36.17	21.28	17.02	25.53	47
128	-	7.89	44.74	23.68	23.68	38
133	-	15.94	47.83	26.09	10.14	69
138	-	25.35	40.85	23.94	9.86	71
143	-	18.03	31.15	40.98	9.84	61
148	-	15.07	32.88	39.73	12.32	73
153	-	18.46	33.85	38.46	9.23	65
158	-	28.57	25.00	42.86	3.57	56
163	-	26.09	28.26	34.78	10.87	46
168	-	34.48	31.03	27.59	6.90	29
173	-	30.77	42.31	23.08	3.84	26
178	-	8.33	41.67	41.67	8.33	12
183	-	14.29	14.29	42.86	28.56	7
188	-	75.00	-	25.00	-	4

may be said that each prawn spawns once in two months. If it survives, it may spawn even after this age also.

Spawning seasons

Maturity distribution of females in different months of the four year period is given in Tables 5 and 6. It was observed that all the maturity stages were represented in most of the months. In 1974, females showing all the stages of ovarian maturity were observed throughout the January-October period. Only juveniles were represented in the catch of November and December. The percentage

TABLE 4. *Percentage occurrence of females of* M. monoceros *in different stages of maturity in various size groups during 1977*

Stage/size groups in mm	Maturity stages					No.of prawns observed
	Immature	Maturing	Mature	Ripe	Spent	
53	100.00					2
58	100.00					5
63	100.00					9
68	100.00					15
73	100.00					29
78	100.00					50
83	100.00					61
88	100.00					72
93	100.00					57
98	100.00					57
103	100.00					56
108	91.03	7.69	-	1.28	-	78
113	71.93	19.30	8.77	-	-	57
118	4.94	40.74	20.99	1.23	32.10	81
123	-	58.21	23.88	5.97	11.94	67
128	-	39.13	30.43	15.94	14.49	69
133	-	33.33	26.39	19.44	20.83	72
138	-	23.17	29.27	28.05	19.51	82
143	-	26.56	21.88	25.00	26.56	64
148	-	20.31	34.38	28.12	17.19	64
153	-	28.81	30.51	23.73	16.95	59
158	-	25.00	31.25	31.25	12.50	32
163	-	17.65	29.41	29.41	23.53	17
168	-	8.33	33.33	33.33	25.00	12
173	-	20.00	10.00	50.00	20.00	10
178	-	-	50.00	50.00	-	4
183	-	-	71.43	14.29	14.29	7
188	-	33.33	-	66.67	-	3
193	-	-	-	100.00	-	1

composition of the ripe females varied from 6.38 in September to 50.57 in May (Fig. 3). January-August period formed the main spawning season as evidenced by the higher proportion of ripe females in the catches. In 1975, two peak periods - March, May and August were observed while in 1976 spawning activity was better during April-August. The spawning activity was poor in 1977 when compared to the previous years. Ripe females were represented in appreciable numbers only during March, April, June and September in 1977.

TABLE 5. *Monthly percentage occurrence of females of* M. monoceros *in different stages of maturity during years 1974 and 1975*

Year/ month	Maturity stages					No.of prawns obser-ved
	Immature	Maturing	Mature	Ripe	Spent	
1974						
January	10.48	34.68	14.52	30.65	9.68	124
February	19.15	18.09	9.57	39.36	13.83	94
March	23.01	8.85	12.39	29.20	26.55	113
April	12.86	10.00	21.43	40.00	15.71	70
May	10.34	12.64	19.54	50.57	6.90	87
June	20.00	20.00	17.89	36.84	5.26	95
July	30.41	21.65	16.49	26.80	4.64	194
August	22.31	21.49	19.01	28.10	9.09	121
September	72.34	10.64	7.09	6.38	3.55	141
October	28.00	25.00	7.00	26.00	14.00	100
November	100.00					16
December	100.00					27
1975						
January	52.46	18.03	8.20	14.75	6.56	61
February	38.10	31.75	12.70	14.29	3.17	63
March	2.05	17.81	14.38	54.79	10.96	146
April	22.22	15.20	16.37	33.33	12.87	171
May	1.43	17.14	28.57	42.86	10.00	70
June *	-	-	-	-	-	-
July	6.82	68.18	18.18	2.27	4.55	44
August	35.00	15.00	5.00	45.00	-	40
September	81.43	11.43	5.71	1.43	-	70
October *	-	-	-	-	-	-
November	100.00					12
December	100.00					32

* No data due to poor catch.

The foregoing analysis shows that *M. monoceros* spawns throughout the January-October period along the Kakinada coast with peaks varying in different years. Also, a reduction in the spawning population was observed from 1974 to 1977 as a result of fishing pressure on the spawning stock.

Fecundity

Fecundity was estimated by examining 31 ripe females in the legnth range of 113-181 mm. The fecundity varied from 53,684 ova in a female of 113 mm length to 416,273 ova in a female of 181 mm length (Table 7).

TABLE 6. *Monthly percentage occurrence of females of* M. monoceros *in different stages of maturity during 1976 and 1977*

Year/ month	Maturity stages					No. of prawns obser-ved
	Immature	Maturing	Mature	Ripe	Spent	
1976						
January	40.26	10.40	24.68	5.19	19.48	77
February	35.56	23.33	12.22	16.67	12.22	90
March *	-	-	-	-	-	-
April	25.45	7.27	29.09	30.91	7.27	165
May	48.94	17.02	8.51	17.02	8.51	47
June	22.41	24.14	15.52	32.76	5.17	58
July	5.13	14.10	37.18	41.03	2.56	156
August	14.42	23.08	30.77	27.88	3.85	104
September	62.44	19.25	10.80	1.41	6.10	213
October	100.00	-	-	-	-	28
November	100.00	-	-	-	-	22
December	6.89	9.24	9.24	10.92	1.68	119
1977						
January	41.18	24.71	15.29	7.06	11.76	85
February	38.78	14.29	15.31	9.18	22.45	98
March	23.17	28.05	24.39	15.85	8.54	246
April	41.64	18.09	16.04	15.36	8.87	293
May	100.00	-	-	-	-	10
June	21.10	23.85	22.02	18.35	14.68	109
July	100.00	-	-	-	-	35
August	59.65	28.07	1.75	-	10.53	57
September	57.14	12.38	13.33	12.38	4.76	105
October	100.00	-	-	-	-	47
November	81.48	16.67	-	-	1.85	54
December	100.00	-	-	-	-	53

* No catch.

Relationship between fecundity (F) and total length (TL)

The relationship between fecundity and total length is linear (Fig. 4) indicating that the fecundity increases in direct proportion with total length. The equation derived is :

F (in thousands) = - 507.1369 + 4.9593 TL; (r=0.99).

The scatter points of observed values fall close to the calculated line indicating a good

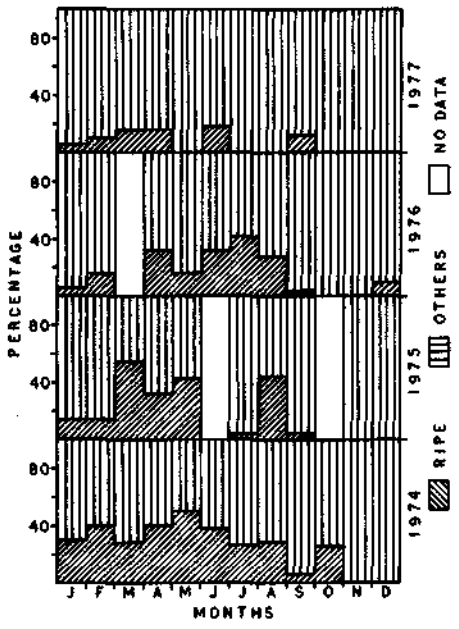

FIG. 3. Month-wise percentage of females of *M. monoceros* in ripe stage and other stages during the years 1974 to 1977.

fit. The minimum and maximum values of fecundity estimated from the equation are 53,264 to 390,490 ova for 113 and 181 mm long prawns respectively. The rate of increase is 4,959 ova per 1 mm increase in total length. These are in close conformity with the observed values.

Relationship between facundity (F) and total weight (TW)

The linear relationship between fecundity and total weight (Fig. 5) shows that fecundity increases in direct proportion to total weight, with the rate of increase being about 9,713 ova per gram body weight, the equation being :

F (in thousands) = - 25.4832 + 9.7134 TW; ($r \approx 0.99$)

The minimum and maximum values of of the estimated fecundity are 73,302 and

TABLE 7. *Fecundity data of* M. monoceros

S.No.	Total length (mm)	Total weight (g)	Ovary weight (g)	Fecundity (No. of ova) (g)
1.	113	10.17	0.72	53684
2.	117	11.32	0.89	60132
3.	118	11.78	0.94	72398
4.	121	12.97	0.99	67132
5.	123	14.32	1.58	127067
6.	129	15.70	1.53	128008
7.	127	16.27	1.70	132099
8.	129	17.03	1.75	149225
9.	130	15.80	1.55	125913
10.	132	18.19	1.93	158332
11.	133	18.15	1.96	167503
12.	134	17.30	1.85	147088
13.	136	20.51	2.09	178727
14.	142	20.74	2.23	182282
15.	144	23.12	2.27	199640
16.	140	21.64	2.32	193125
17.	142	21.80	2.38	196296
18.	143	21.91	2.47	226022
19.	149	26.21	2.62	225994
20.	145	23.35	2.65	222198
21.	150	26.32	2.71	230191
22.	152	25.85	2.73	238107
23.	148	26.83	2.82	232526
24.	156	30.22	2.91	260895
25.	159	30.93	3.22	270152
26.	162	34.02	3.48	304368
27.	165	35.28	3.52	307515
28.	168	35.37	3.55	310423
29.	171	36.88	3.68	326395
30.	175	41.07	4.21	358378
31.	181	45.55	4.56	416273

4,16, 962 ova for 10.17 g and 45.55 g heavy prawns respectively. Similar observation was made by Martosubrato (1974) for *p. duorarum.*

Relationship between fecundity (F) and ovary weight (OW)

The relationship between fecundity and ovary weight is linear (Fig. 6). Fecundity increases at the rate of about 96,641 ova per gram of ovary weight, the equation being:

F (in thousands) = -18.3825 + 96.6413 OW; (r = 0.99).

Minimum and maximum fecundities estimated from the equation are 51,199 and 422,302 obtained from 0.72 and 4.56 g ovaries. From the scatter points and the calculated line it is seen that ovary weight is a better index of fecundity than total weight.

Relationship between ovary weight and total body weight

The linear relationship shows (Fig. 7) that ovary weight increases by 0.1 for each

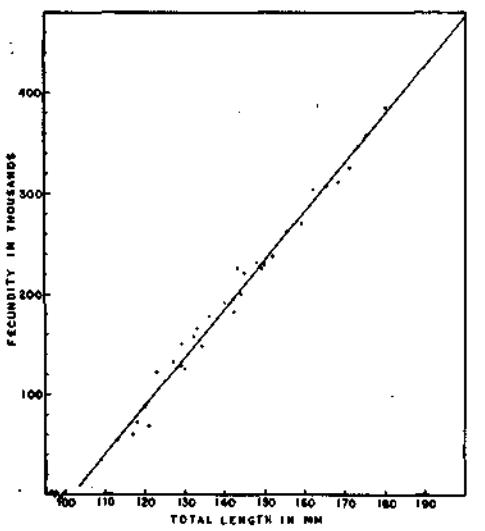

FIG. 4. Relationship between fecundity and total length in *M. monoceros.*

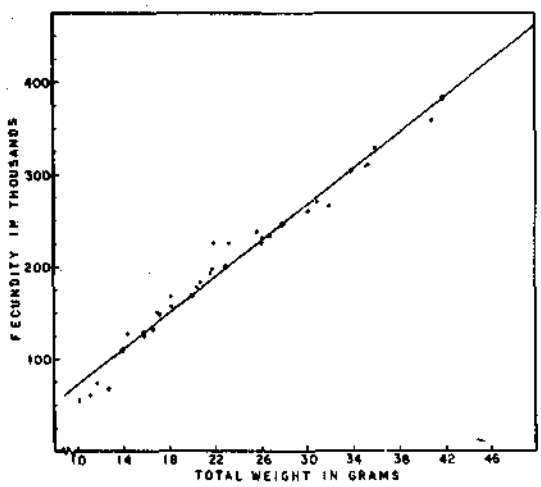

FIG. 5. Relationship between fecundity and total weight in *M. monoceros.*

one gram increase in body weight the equation being:

OW = - 0.0712 + 0.1046 TW; (r = 0.99).

From the equation it is estimated that females weighing 10.17 and 45.55 g would have ovaries weighing 0.99 and 4.69 g respectively.

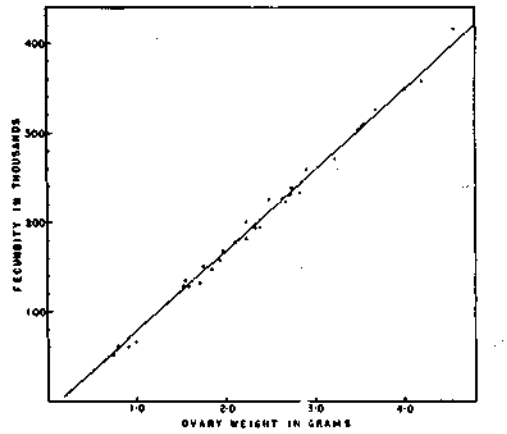

FIG. 6. Relationship between fecundity and ovary weight in *M. monoceros.*

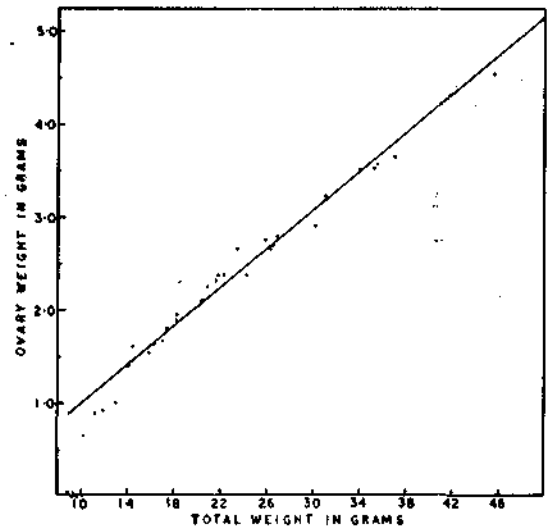

Fig. 7. Relationship between total weight and ovary weight in *M. monoceros*.

Sex ratio

Monthly sex ratio for the years 1974-'77 indicated random fluctuations in different years without any seasonal trend (Fig. 8). The percentage composition of males in the catches of 1974 varied from 41.85 in August to 55.14 in July, while it varied from 23.75 (January) to 52.81 (October) in 1975. The percentage composition of males in 1976 varied from 33.58 (July) to 77.78 (November), and from 28.57 (May) to 56.77 (January) in 1977. Annual sex ratio indicated that in 1974 both sexes were represented in more or less equal numbers but there was a drastic fall in the proportion of males in the catches subsequently in 1975. In 1976 and 1977 males were more in the catches than females.

The x^2 test showed that at $p = 0.01$ level, the distribution of sexes in the catches in different months was significantly different from the binomial distribution (Table 8). It is possible that these monthly variations in sexes are due to size-wise segregation of *M. monoceros* in the fishing grounds. It was not possible to relate it to any other biological phenomena of the species.

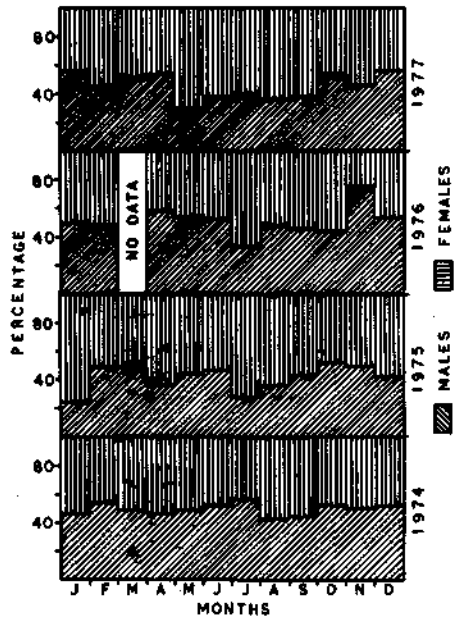

Fig. 8. Month-wise sex ratio of *M. monoceros* in trawler landings at Kakinada during the years 1974 to 1977.

Table 8. *X^2 values of sex ratios for the years 1974-77.*

Year	Degrees of freedom	Value of x^2	Test at P=0.01
1974	11	231620	Significant
1975	11	49078	Significant
1976	10	339192	Significant
1977	11	514406	Significant

Discussion

In the present study it was observed that the ova measured 0.01 - 0.09 mm, 0.07-0.19 mm, 0.11-0.21 mm and 0.11-0.27 mm with modes at 0.04 mm, 0.12 mm, 0.18 mm and 0.20 mm in immature, maturing, mature and ripe

stages of ovarian maturity respectively. Also Stage II to Stage IV ovaries contained only two groups of ova, representing the immature and mature stock. Nalini (1976) observed the ova diameter range of *M. monoceros* as 0.01-0.08 mm, 0.08-0.16 mm, 0.11-0.23 mm and 0.19-0.32 mm for immature, maturing, mature and ripe stages respectively.

The largest intraovarian egg measuring 0.27 mm in the present study is in agreement with the observation made by Mohamed *et al.* (1978). Liao *et al.* (1969) report the size of viable eggs obtained by artificial spawning as 0.22 mm while Mohamed *et al.* (1978) reported the size of eggs obtained by artificial spawning as 0.28 mm. Raje and Ranade (1972) reported the size of the spawned egg as 0.35 mm. It is well known that the size of ripe eggs of the same species occurring in different habitats and localities varies considerably (Gurney, 1942).

In *M. monoceros* the size at first maturity was 96 mm for males and 116 mm for females. George (1959) gave indirect evidence that females do not mature before attaining a length of 120 mm. Nalini (1976) recorded that the size at first maturity as 118 mm in females. The present study more or less confirms the results of these workers.

In the present study it was observed that stages II to IV contain only two groups of ova, representing immature and mature stocks. Moreover, these two groups are sharply separated from each other in size. Since the mature ova are well differentiated from the immature, spawning of individual prawn is probably restricted to a short and definite period. As the ovaries of spent recovering females contain only small, transparent, yolkless immature ova of less than 0.09 mm, it is possible that all the mature ova present in the ovary are liberated in a single spawning act within a short time. Heldt (1938) and Hudinaga (1942) observed that spawning takes place within 2 to 3 minutes in penaeids. This has been confirmed by the recent works of Thomas *et al.* on *M. dobsoni* (1974a) and *M. affinis* (1974b). Laboratory experiments on the spawning of *M. brevicornis* by the author (Rao, 1978) also support their view.

In the present study it was observed that *M. monoceros* spawns throughout January-October with active spawning during January-August. According to George (1959) the spawning season of the species in the Cochin waters is from October to December. However, George (1962) studying the postlarval abundance of the species in the Cochin backwaters, recorded that the species breeds throughout the year with two peaks, the first in July-August and the second in November - December. Nalini (1976) recorded the peak spawning season of the species as October - April from the same region. The present study is at variance with either of these observations.

It is observed that an individual female spawns at least five times in its life as evidenced by the occurrence of prawns with ripe stage at different lengths. Lindner and Anderson (1956) speculated that a single prawn could spawn as many as 4 times in a spawning season and indicated that a few females probably survived to spawn during a second season. Rao (1968) expressed that *M. dobsoni*, *P. indicus* and *P. stylifera* spawn at least five times in their life. This is more or less in conformity with the present observation. Burukovski (1970), studied *P. duorarum notialis* from the eastern Atlantic and estimated that it has the potential to spawn four times during its life span, with an interval of 2-3 months between successive spawnings. The results of these workers are supported by the present observations on *M. monoceros*.

The fecundity values of the present study are quite in conformity with those recorded by Rao (1968) for *M. dobsoni, P. stylifera, M.affinis* and *P. indicus;* by Martosubrato (1974) for *P. duorarum* and by Nalini (1976) for *M. monoceros.* However, Rao (1968) for *M. dobsoni, M. affinis* and *P. stylifera* and Martosubrato (1974) for *P. duorarum* found that fecundity increased approximately as the cube of total length. Nalini (1976) observed that fecundity in *M. monoceros* was porportional to 4.3509 power of total length deviating far away from the cubic relationship. Similarly Rao (1968) observed that fecundity in *P. indicus* was porportional to the sixth power of total length. The present study disagrees with these results since it was found that the fecundity increased in direct proportion to the total length.

A perusal of Figures 4 - 6 and the scatter points along the calculated lines show that ovary weight is a better index of fecundity than either total length or total weight. This agrees well with observations of Martosubrato (1974) on *P. duorarum* off Florida.

Sex ratio in different years deviated far from the binomial distribution. The only explanation for such unequal distribution is that there is sex-wise segregation in the fishing grounds. Menon (1957) studying the inshore prawn fishery of Cochin area opined that the variations in the sex ratio of *M. dobsoni, M. affinis, P. indicus,* and *P. stylifera* were due to inshore and offshore movements of these species. George and Rao (1967) ascribed the variation in sex ratios of *P. indicus, M. dobsoni* and *P. sylifera* to the movement of females out of the fishing grounds to deeper waters for spawning. Ramamurthy *et al.* (1978) attributed the variations in sex ratio of *M. dobsoni* to breeding movements. The author (Rao, 1979) also observed similar phenomena in the case of *M. brevicornis* off Kakinada. The present study on *M. monoceros* subscribes to the view of the earlier authors that there is sex-wise segregation in the grounds. In the case of *M. monoceros* there is evidence to say that breeding grounds and fishing grounds are one and the same and hence the probability of females moving out of the fishing grounds does not arise.

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