Proc. Indian natn. Sci. Acad. B.45 No. 1 pp 72–89 (1980)

Comparative Study of the Biology of the Freshwater Prawn, *Macrobrachium malcolmsonii*, of Godavari and Hooghly River Systems

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Presence of mature and berried females and their locality-wise and month-wise frequency of occurrence is used to determine the season and periodicity of breeding. In both Hooghly and Godavari, the breeding period corresponded to the monsoon season of their respective locations, with four peak months of spawning. A relationship between rainfall, temperature, dissolved oxygen and breeding is shown. The larvae hatch in fresh waters but have nursery grounds in estuaries being carried there by flood waters. Using sex-ratio, the pre-breeding, principal breeding and post-breeding periods have deen defined to indicate spawning.

Interpretation of age, using length frequency analysis, has been made making use of observations on maturity, breeding and recruitment also. The presence of several modes in some months, consistency of their occurrence year after year is also used to determine the age and growth. Three-year groups in males and two in females in Hooghly region and five-year groups in males and four in females in River Godavari, were noted.

Key Words: Comparative Biology, Maturity, Recruitment, Age Determination, *M. malcolmsonii*

Introduction

Macrobrachium malcolmsonii (H. Milne Edwards) is the most common freshwater prawn of India. The species is currently much in demand in freshwater aquaculture practices (Rajyalakshmi 1974). It forms a fishery of considerable magnitude in the river Godavari and (Ibrahim 1962, Rajyalakshmi & Ranadhir 1967) moderate fishery in the river Hooghly. The Godavari studies showed that these prawns live in freshwater and the larvae descend down to the estuary which perhaps constitutes the nursery ground.

Studies on the biological aspects like maturity and growth have been made for the first time in the river Hooghly and later, an opportunity occurred when the species could be studied in the river Godavari also. The Hooghly samples were meagre. From the reports of fishermen, the species forms a good fishery in the upper reaches of the

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river (Rajyalakshmi 1966). The region is outside the purview of the present study and sampling. The population sampled includes all size groups obtained from the downstream limit of its distribution in the estuarine regions of the river. In the river Godavari the species was sampled in its principal range of distribution.

Material and Methods

The sources of material were the fishermen's catches. Samples were collected from different sampling centres in arbitrarily determined zones—viz; 19 centres in five zones in the Hooghly estuarine system and 10 centres in three zones in the river Godavari (figures 1a and b) at intervals of 15 days. A system of stratified sampling was evolved to get equal representation of all the zones irrespective of the heaviness or otherwise of the catches in any area, during the different seasons. On the basis of the maturity scale developed earlier by the author (Rajyalakshmi 1961) five stages are determined depending on colour of the ovary, diameter of the ova, etc., as the criteria. Similarly embryonic development of the fertilized egg is also determined under four stages using criteria such as the size of yolk, development of various appendages, eyes, etc. Study of breeding behaviour is based on the seasonal and zonewise

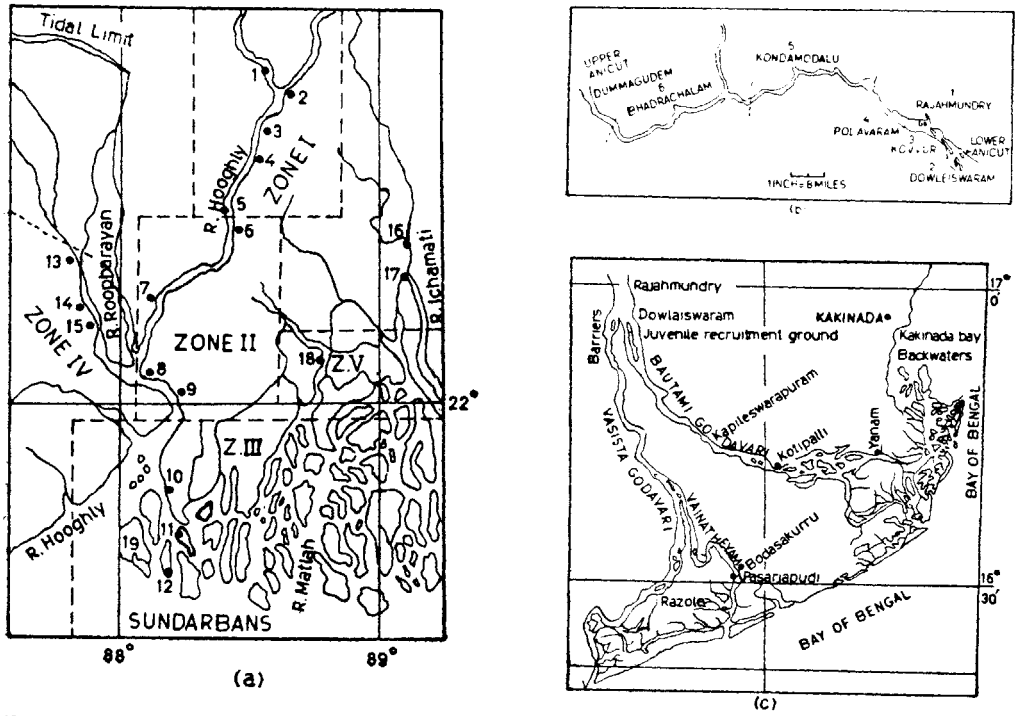

Figure 1 Map of River Hooghly (a) of River Godavari (b) and the estuarine regions of River Godavari (c) showing sampling centres.

1, Ghasighata; 2, Medgachi; 3, Khasbati; 4, Khishigoli; 5, Konnagar 6, Budge Bugge; 7, Fuleshwar-Uluberia region; 8, Nurpur; 9, Diamond Harbour; 10, Kakdwip; 11. Namkhana; 12, Frasergung; 13, Govindapur; 14, Kolaghat; 15, Anantapur; 16, Itindaghat; 17, Hasnabad; 18, Canning; 19, Bohkali; 20, Zamboodwip Tidal Limit: Nabadwip-Purbasthali area.

distribution of various stages of maturity and stages of embryonic development.

Length frequency analysis was used to determine the probable age and growth of the prawn taking into consideration the several drawbacks involved in this method. Differences in the habitat preferences of young and adults, prolonged and intermittent breeding are some of the drawbacks which mar the length frequency distributions for following the modal progression from month to month. The multiplicity of modes in younger size groups and overlapping in older size groups, selective properties of certain gear and the moulting character of prawns have also to be taken into consideration while analysing the age distribution.

A few criteria are considered for identifying the modes, as given by other scientists (Iverson 1955 and 1956).

(i) Each mode must be separated from every other mode by deep troughs;

(ii) Each mode must be present in the data for at least two, not widely separated months;

(iii) The mode must be the centre group of a peak of the smoothed distribution or the entire group of two or more minor peaks.

Using the above criteria males and females are analyzed separately. The central tendency of the size groups was emphasized graphically by smoothening the monthly length frequencies with a moving average of 3 intervals (Taylor 1958 and 1965). Total lengths of the prawns were used for analysis.

Results

Maturity, spawning and breeding behaviour

The percentage increment in gonad weight from stage I to stage IV of maturity (figure 2) shows that the relative increase in the weight is greater between stages II & III and III & IV than between stage I & II. Rapid deposition of yolk and increase in ova size might be the reason for the relatively larger increase in weight between stages II & III and III & IV than between I & II. The spent ovary weight is similar between stages I A & B.

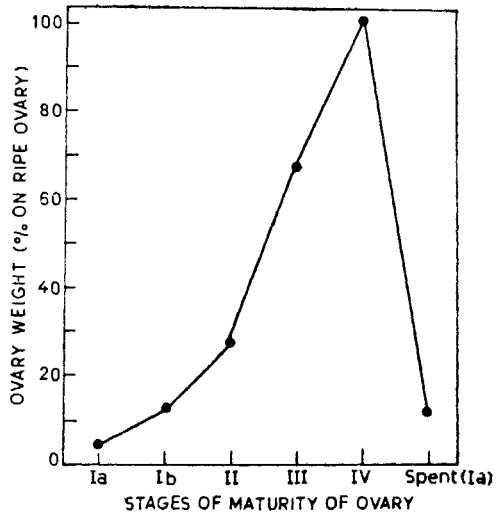

Figure 2 Percentage increment in weight of ovary of *M. malcolmsonii* from River Godavari

Maturity

Hooghly samples: The distribution of the different stages of intra-ovarian development and simultaneous embryonic development are noted separately (table 1). All the localities at which samples were available belong to zones I and II. The samples were rather scanty in other zones. Berried females begin to appear by the beginning of May. They continue to occur through June to August, a period corresponding to the monsoon season. By about the middle of June, about 78% of the females were berried. Later, in June and July, almost all females in the samples were either berried or the eggs had already hatched as evidenced by the deep pleura of the abdomen and ovigerous setae on the pleopods. Sometimes

Table 1 *Locality-wise and month-wise distribution of different stages of maturity and embryonic development in* M. malcolmsonii *collected from Hooghly estuary in 1959*

Zone	Locality month	Length range (mm)	Frequency at different stages of maturity					Frequency at different stages of embryonic development			
			I		II	III	IV	I	II	III	IV
			A	B							
I	Medgachi										
	May	76–95	10	22	—	—	1	1	—	—	—
	June	79–121	2	6	10	1	3	10	8	2	2
	Aug.	79–115	7	2	2	3	5	1	1	2	—
	Sept.	99–100	4	—	1	—	—	—	—	—	—
	Nov.	100	—	—	—	1	—	—	—	—	—
I	Khusigoli										
	June	92–98	1	2	—	—	—	2	1	—	—
	July	116	—	1	—	—	—	—	—	—	1
	Nov.	100	—	—	—	1	—	—	—	—	—
I	Khasbati										
	July	115	—	—	1	—	—	—	—	1	—
I	Chinsurah										
	June	86–90	4	—	4	—	—	—	2	—	—
I	Ghasighata										
	August	102–116	—	2	1	—	1	—	2	—	—
II	Fuleswar										
	July	47–104	8	6	1	1	2	2	—	—	—
IV	Gobindapur										
	Oct.	110	1	—	1	—	—	—	—	—	—
V	Canning										
	Apr.	31–80	14	25	12	2	—	—	—	—	—

the intra-ovarian eggs show ripeness along with deep pleura and ovigerous setae, which is an indication of imminent spawning.

It is rather difficult to assess the percent of females in berry at any given moment, as soon after the larvae (zoea I) hatch out, a fresh batch of eggs appear on the pleopods in a day or two after moulting (personal observations of the author in the laboratory rearing experiments), with other signs of active spawning (presence of ovigerous setae and deep pleura) still intact. Hence, though the prawns observed in July and August were active spawners, the percentage of berried forms among them was very low probably because of the absence of berried condition at the time of sampling. In Hooghly estuary *M. malcolmsonii* has thus a peak spawning during the period May to August.

Godavari samples: All the samples were collected from the Rajahmundry area during the period February to November of each year. The data for three years (1966-68) are presented in table 2 along with information on rainfall, water level, temperature, etc. Details regarding the frequency of different stages of maturity and embryonic development are presented in table 3. These

Table 2 *Maturing, mature and berried* M. malcolmsonii *in the fishing grounds of River Godavari during 1966-1968 along with information on hydrographic characters of the river*

Year/ months	Stage of maturity						Total samples (Nos.)	Rainfall (mm)	Mean water level (ft)	Temperature °C	O_2 (ml/l)
	Maturing		Mature		Berried						
	Nos.	%	Nos.	%	Nos.	%					
1966											
Feb.	—	—	—	—	—	—	—	—	39.4	27.5	*
Mar.	65	100.0	—	—	—	—	65	—	32.5	30.2	
Apr.	277	99.0	1	0.4	—	—	278	1.0	38.0	31.8	
May	85	82.5	18	17.5	—	—	103	4.8	38.0	32.4	
June	20	54.1	17	45.9	8	21.6	37	8.6	39.0	31.3	
July	91	53.8	78	46.2	95	56.3	169	16.6	44.0	29.6	
Aug.	16	72.7	6	27.3	3	16.6	22	24.4	47.0	28.9	
Sept.	56	54.9	46	45.1	19	18.6	102	8.6	47.0	29.1	
Oct.	11	100.0	—	—	—	—	11	18.6	42.0	31.3	
Nov.	11	81.7	1	8.3	—	—	12	6.4	41.8	27.5	
1967											
Feb.	—	—	—	—	—	—	—	—	39.9	27.3	4.72
Mar.	27	100.0	—	—	—	—	27	18.6	38.5	28.6	4.45
Apr.	242	99.6	2	0.4	1	0.4	244	13.7	40.0	31.8	4.57
May	34	60.7	22	39.3	—	—	56	25.2	40.0	34.1	4.52
June	61	49.6	62	50.4	27	21.95	123	16.0	38.0	31.8	4.68
July	NR	—	—	—	—	—	—	19.9	45.0	28.3	5.65
Aug.	8	42.1	11	57.9	8	42.1	19	8.9	48.0	28.4	8.50
Sept.	53	42.4	72	57.6	63	50.5	125	15.5	43.0	29.3	8.45
Oct.	14	46.7	16	53.3	6	20.0	30	16.8	43.0	30.0	6.30
Nov.	—	—	—	—	—	—	—	—	44.8	29.1	5.00
1968											
Feb.	—	—	—	—	—	—	—	11.75	40.8	29.5	5.72
Mar.	72	96.0	3	4.0	—	—	75	—	41.0	29.3	5.43
Apr.	275	98.9	3	1.1	2	0.7	278	—	42.0	31.8	4.97
May	197	88.3	26	11.7	7	3.1	223	26.8	41.0	33.5	5.45
June	249	54.6	207	45.4	104	22.8	456	22.1	39.0	30.9	4.89
July	136	53.8	117	46.2	134	50.95	253	16.8	42.0	29.7	5.85
Aug.	10	43.5	13	56.5	1	4.3	23	—	46.0	29.7	7.75
Sept.	17	44.7	21	55.3	16	42.1	38	15.9	44.0	29.5	8.50
Oct.	NR	—	—	—	—	—	—	21.0	42.7	29.9	7.40
Nov.	—	—	—	—	—	—	—	12.9	42.0	27.5	5.85

* Data not available
NR, not recorded

Table 3 *Showing frequency of different stages of maturity/embryonic development in* M. malcolmsonii *(River Godavari) in different months, 1966-1968*

Year/ month	Frequency at different stages of maturity					Frequency at different stages of embryonic development				Total
	I		II	III	IV	I	II	III	IV	
	A	B								
1966										
Mar.	5	60	—	—	—	—	—	—	—	65
Apr.	—	277	1	—	—	—	—	—	—	278
May	—	85	14	1	3	—	—	—	—	103
June	4	16	7	7	—3	—	3	4	1	37
July	55	36	32	19	27	4	51	32	7	169
Aug.	4	12	1	3	2	—	1	2	—	22
Sept.	16	40	20	16	10	4	8	4	3	102
Oct.	—	11	—	—	—	—	—	—	—	11
Nov.	—	10	—	1	1	—	—	—	—	12
1967										
Mar.	—	27	—	—	—	—	—	—	—	27
Apr.	1	246	2	—	—	—	1	—	—	249
May	—	34	12	3	7	—	—	—	—	56
June	6	55	17	17	28	2	6	10	9	123
July*										
Aug.	8	—	2	4	5	2	2	3	1	19
Sept.	32	21	20	17	35	7	21	22	13	125
Oct.	4	10	1	6	9	—	2	—	4	30
1968										
Mar.	—	72	2	—	1	—	—	—	—	75
Apr.	2	273	3	—	—	1	—	1	—	278
May	7	190	12	12	2	1	5	1	—	223
June	72	177	90	82	35	15	38	43	8	456
July	70	66	42	38	37	22	37	48	26	263
Aug.	—	10	1	2	10	—	—	1	—	23
Sept.	11	6	3	10	8	1	8	3	4	38

*Samples not available

data suggest that mature and berried prawns constitute high percentages during the period June to August. Though the peak spawning months appear to be July and August, these mature individuals start appearing from March/April and stray numbers of mature prawns continue to appear up to October. Thus the spawing season in the Godavari region appears to extend from June to September.

The incidence of mature and maturing individuals at various lengths in Hooghly

estuary indicate that greater number of individuals are in the 76–90 mm size groups with an average size at 83 mm. It appears to be large probably because the population has been sampled from its downstream end of distribution in the Hooghly estuary.

In the case of the Godavari samples the average size at first maturity is at 68 mm which is smaller than that noticed for the Hooghly estuarine samples.

Sex Ratio and Spawning

Hooghly samples: For determination of sex ratio, the individuals could be broadly grouped as follows: Between 33 to 50 mm size, the proportion of males to females was 1 : 4 during winter and monsoon seasons and 1 : 1.5 in summer. Between 51 and 80 mm the ratio was more or less equal in summer, 1 : 1.5 in winter, while during the monsoon the proportion of males was higher, being 1 : 0.67. Beyond a length of 80 mm the proportion of famales progressively increases from winter through summer and monsoon showing a ratio of 1 : 2.4, 1 : 1.31 and 1 : 13.1 respectively between males and females. Above the size of 125 mm, females were not observed.

Godavari samples: The sex ratio in samples from river Godavari is clearly defined because the samples were obtained from the main habitat of the species viz., the riverine region.

The sex ratio of males : females during different periods of the breeding cycle which is arbitrarily divided into the pre-breeding months (February–April), breeding months (May–September) and post-breeding months (October–January) is given in table 4. In general, during the pre-breeding season the ratio of males to females does not much vary. During the breeding season the females constitute more than 70%, while during the post-breeding months the males predominate (more than 70%) in the catches. The exceptions to this are preponderance of females in April 1966, of males in February 1967 and February and March 1968 and of females in October-November 1968 and October-November 1969. During the statistical year 1968-69 a shift in the cycle by two months appears to have taken place. Thus in February-March 1968 males

Table 4 *Ratio of males to females in different periods of the breeding cycle in the principal-breeding ground in River Godavari, 1966–68*

Year/ months	Breeding cycle	Males		Females	
		Frequency	%	Frequency	%
Feb. 66	Pre-breeding	70	54.7	58	45.3
Mar.		84	55.3	68	44.7
Apr.		59	17.9	270	82.1
May	Principal breeding	22	17.6	103	82.4
June		4	8.9	41	91.1
July		80	11.0	650	89.0
Aug.		7	23.3	23	76.7
Sept.		61	41.8	85	58.2
Oct.	Post-breeding	20	64.5	11	35.5
Nov.		106	72.1	41	27.9
Dec.		36	85.7	6	14.3
Jan. 67		138	82.1	30	17.9
Feb. 67	Pre-breeding	770	72.6	291	27.4
Mar.		1127	59.1	780	40.9
Apr.		631	51.0	607	49.0
May	Principal breeding	468	29.1	1143	70.9
June		198	22.9	665	77.1
July		88	22.4	305	77.6
Aug.		143	31.2	315	68.8
Sept.		133	30.7	400	69.3
Oct.	Post-breeding	29	27.1	78	72.9
Nov.		—	—	—	—
Dec.		76	69.1	34	30.9
Jan. 68		273	76.7	83	23.3
Feb. 68	Pre-breeding	635	80.1	158	19.9
Mar.		803	71.7	317	28.3
Apr.		552	56.2	431	43.8
May	Principal breeding	336	53.2	295	46.8
June		125	19.1	530	80.9
July		249	39.3	385	60.7
Aug.		106	43.1	140	56.9
Sept.		52	22.0	154	78.0
Oct.	Post-breeding	43	20.0	172	80.0
Nov.		53	32.7	109	67.3
Dec.		51	82.3	11	17.7
Jan. 69		—	—	—	—

predominate, in April-May 1968, both sexes are in equal proportions and the predominance of females in the next phase continues up to October-November 1968, unlike the previous years. It shows that the sex ratio as well as the consequent breeding behaviour of the prawn vary with changes in environmental conditions from year to year as shown below.

Relationship between Rainfall, Temperature and Breeding

Annual variations in the breeding cycle appear to be related to rainfall. In the Godavari region during 1966 high rainfall was confined to July–August months (vide table 2). In 1967 high rainfall commenced early in March and continued up to July. In 1968, May–October was the period of high rainfall. The shift in the commencement of high rainfall in 1968 (May) compared to that of 1967 (March) appears to have profoundly affected the cycle of sex ratio of the prawns in the statistical year 1968–69 as seen in the shift by two months of each phase of sex ratio cycle compared to that of 1967–68.

The relationship between breeding and rainfall is due to a chain of events. Rainfall in the upper reaches results in freshets and consequent rise in water level and a fall in temperature. The fall in temperature at the onset of rainfall and freshets in the river result in an increase of dissolved oxygen content of the water. All the factors together favour early breeding. With the commencement of rainfall and consequent flood, the water level at the barrier rises and this helps in the transport of the larvae to their nursery grounds in the estuaries where further moulting and growth of the larvae take place.

The presence of prawns in an advanced stage of maturity in the Rajahmundry area above the anicut suggests that the eggs hatch out in freshwaters. This phenomenon of hatching in freshwaters is further confirmed by townet collections of plankton in the river and laboratory studies. Survey of estuarine areas (vide figure 1c) showed the presence of post-larvae (total length 4–7 mm; carapace length 0.75 to 1.5) and juveniles. The salinity conditions in the estuary during the breeding season (June–August) are such that the bottom salinity ranged from 0.6‰ to 2.7‰. This indicates that waters of low salinity are congenial for the development and growth of larvae beyond the zoaea stage besides the other favourable conditions like availability of food etc., in the estuaries. On the other hand flowing waters saturated with higher concentrations of dissolved oxygen appear to favour the onset of breeding.

Length-frequency Analysis

Length distribution of *M. malcolmsonii* is closely associated with the breeding behaviour of the prawn. It was shown earlier that there is a marked difference in the sex ratio in the different months of the annual breeding cycle. This is to a large extent reflected in the length frequency distributions and the analysis of the data for growth studies has to be made in the light of this feature. It is carried out separately for the males and females in the Hooghly and Godavari regions.

Hooghly samples: In Hooghly the samples are meagre compared to the Godavari samples. Males constitute a lower percentage of the prawn population from September to January. During the other months they are equal in proportion to the famales in the prawn catches but both are poorly represented in some months. However an attempt has been made to follow the progression of modes to the extent possible. It is seen that two broods enter the fishing grounds (figure 3). This is clearly seen in the case of

females but rather erratic in the case of males.

Females: The two age groups that enter the catches are designated as A and B for the purpose of analysis. The group A enters the fishing in November when a mode is observed at 28 mm and this increases to 33 mm by December. The same age group is observed in January at 38 mm length. In February and March the group is present but not clearly defined as a mode. By April the mode is again seen at 55.5 mm length. From April there is a marked increase in the length of the group with the mode at 83.0 mm by May. In June the mode is observed to have progressed to 93.0 mm and in July it is at 97.5 mm and by August it progressed to 108.0 mm length. The size group represented by this mode was not observed in the samples from the fishing ground from August onwards. The progression of modes shows that there is an increase of 85 mm over a period of 9 months.

In the month of June a new group B enters the prawn population with a mode at 33.0 mm which remains dominant from August to October. During August to October period only the modal values of the group are clearly defined. The modal value of the group in October is 68.0 mm. It shows an increase of 35 mm over a period of 4 months.

The two groups belong to two different age groups of 6 months difference. Though the period of spawning in the estuary is for four months only (beginning of May to end of August) it is possible that the larger prawns continue to breed in the rivers above the estuary for another two months. The complete absence of the larger mature prawns from the estuary proper from September onwards renders the new recruits which entered in November to gain prominence. The appearance of another brood of young recruits in June shows that spawning was continuous and that the spawning activity is very intense in the beginning and again at the end of the spawning period, the latter confined to the freshwater zone only. Besides these two groups which form prominent modes in the size distribution there are other groups which form minor peaks in the different months without showing any regular progression of modes.

Males: The progression of modes in the males is not as clear as in the females. From July to November there is a backward shift in the modes which is indicative of the constant movement of the larger sized males out of the estuarine fishing ground. The smallest mode in December is at 38.0 mm (as compared to 33.0 mm of females in the same month). The position of the same group in the month of January is at 43.0 mm which shifts to 63.0 mm by February but in the subsequent months this group is not clearly defined. Later, in the months of April to July continuity of one group is observed which has got modal values of 48.0, 48.0, 60.5 and 78.0 mm respectively, in the months of April, May, June and July. It shows an increase of 30.0 mm over a period of three months which shows that the growth in the males is slightly faster than that of the females for a corresponding age (as seen in the case of the B group of females during June to October).

Godavari samples: Juvenile length frequency distribution : The length frequency distribution of juvenile size groups sampled at the barrier across river Godavari is shown in figure 4. The size ranged over 9 mm to 32 mm generally ,and a few measured up to 41 mm. In 1966-67 and 1967-68 the modal length was at 19 mm during the entire period October to January. It shifted to

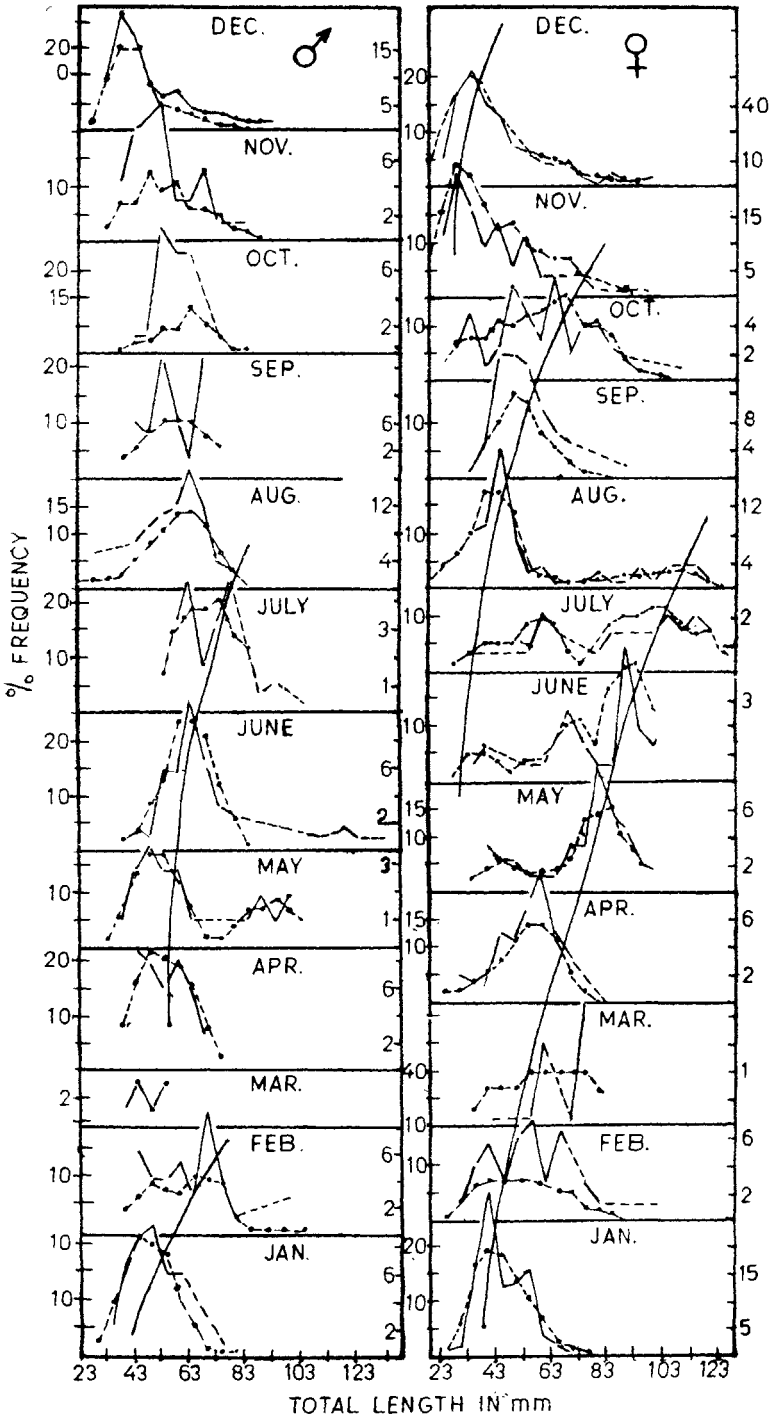

Figure 3 Length frequency distribution of males and females of *M. malcolmsonii* from river Hooghly during different months

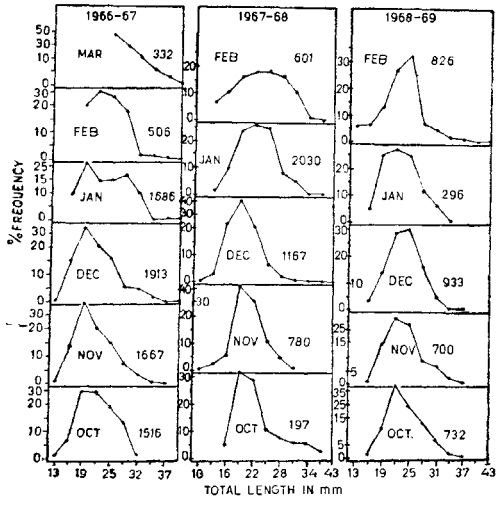

Figure 4 Length frequency distribution of juveniles of *M. malcolmsonii* from river Godavari sampled at the barrier

22 mm in February in both the years. In 1968-69 in a corresponding period the length was at 22 mm which shifted to 25 mm in February 1969. The absence of any progression indicated continuous recruitment of the group over the five months.

Length-Frequency Distribution of Samples from Commercial Catches (Godavari)

It has been possible to collect a large number of *M. malcolmsonii* from the river Godavari above the barrier. The season for the fishery is from January to October with a peak from February to June. The samples include the large sized prawns also, particularly during July-September.

The length-frequency distributions (figures 5, 6 & 7) have not revealed any regular progression of the modes. The prominent modes in each month have been noted taking into consideration either the original frequencies or the smoothed curve (table 5).

Table 5 *Prominent modes in the length frequency distribution of* M. malcolmsonii *of river Godavari, 1966-68*

Years	1966		1967		1968	
Month Sex	Males (size in mm)	Females (size in mm)	Males (size in mm)	Females (size in mm)	Males (size in mm)	Females (size in mm)
Jan.	63,93	68	63,98	—	58,98	63,73,93
Feb.	78,98	68	103	78	108	73,88
Mar.	78,103,128	73	103	78	98	75.5
Apr.	48,78,113	63	103	73	98	73
May	—	68	98	78	108	65.5
June	—	68	48,108	68	108	68
July	68,103	73	63,93,118 143,178	88	53,88,123 178	68
Aug.	—	—	63,98,128 158,198	58,98,153	48,98,128	68,98
Sept.	48,93,163	98	63,108	63,103	93,123	73,103,138
Oct.	—	—	—	83,118	—	88,133
Nov.	68,103	43	103	90.5	—	73,93,128
Dec.	98	—	—	—	83,108,133	—

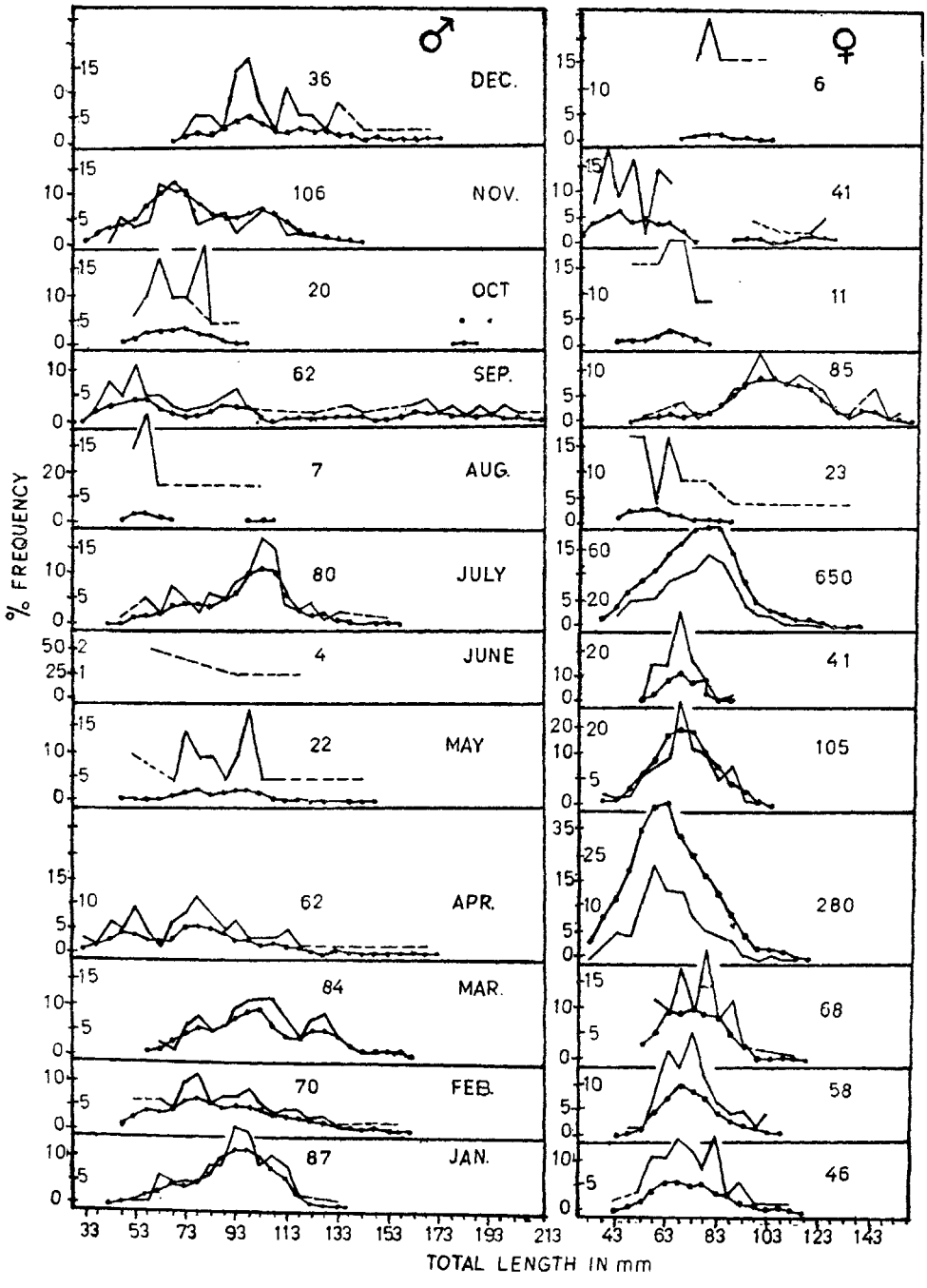

Figure 5 Length frequency distribution of males and females of *M. malcolmsonii* from river Godavari (1966)

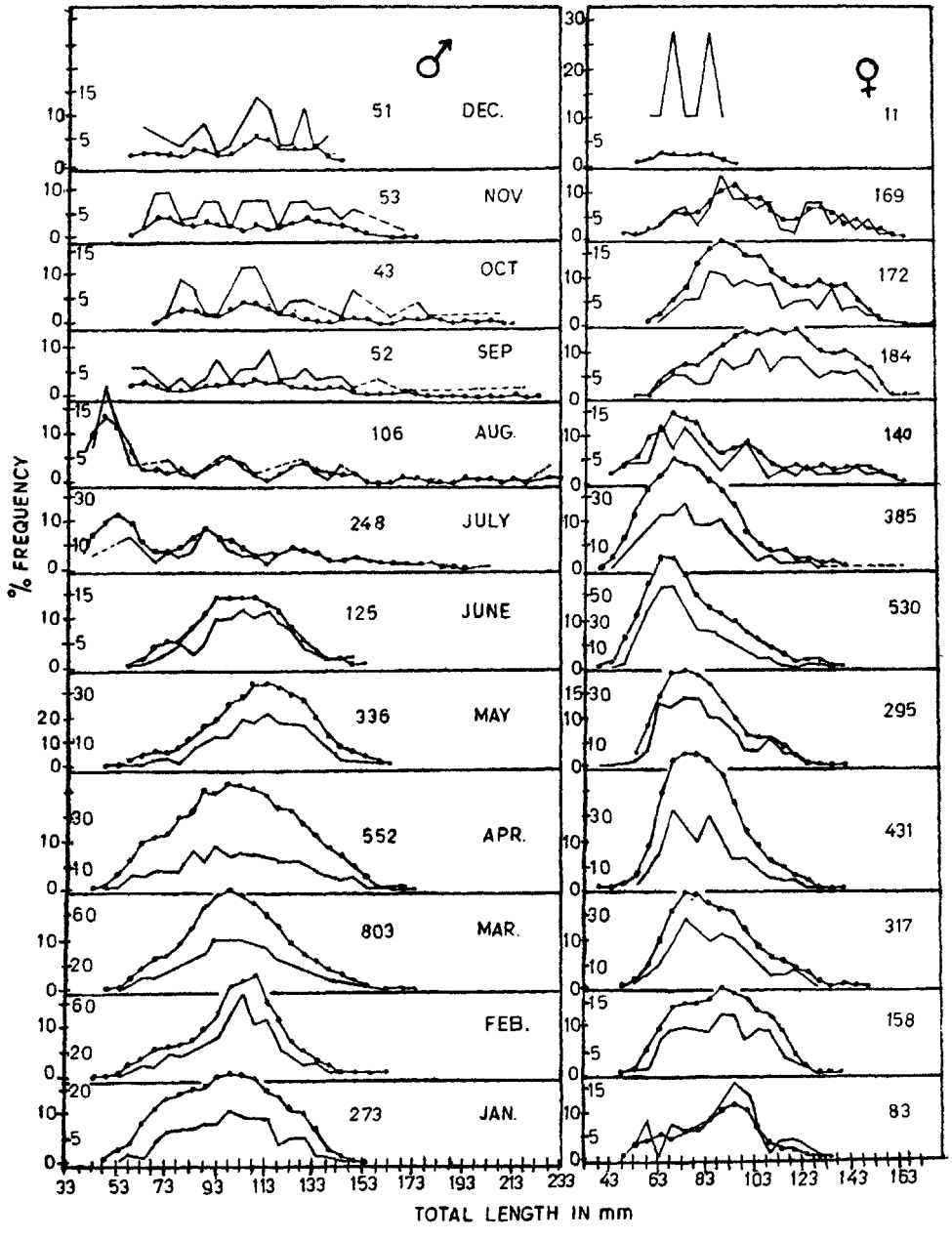

Figure 6 Length frequency distribution of males and females of *M. malcolmsonii* of river Godavari (1967)

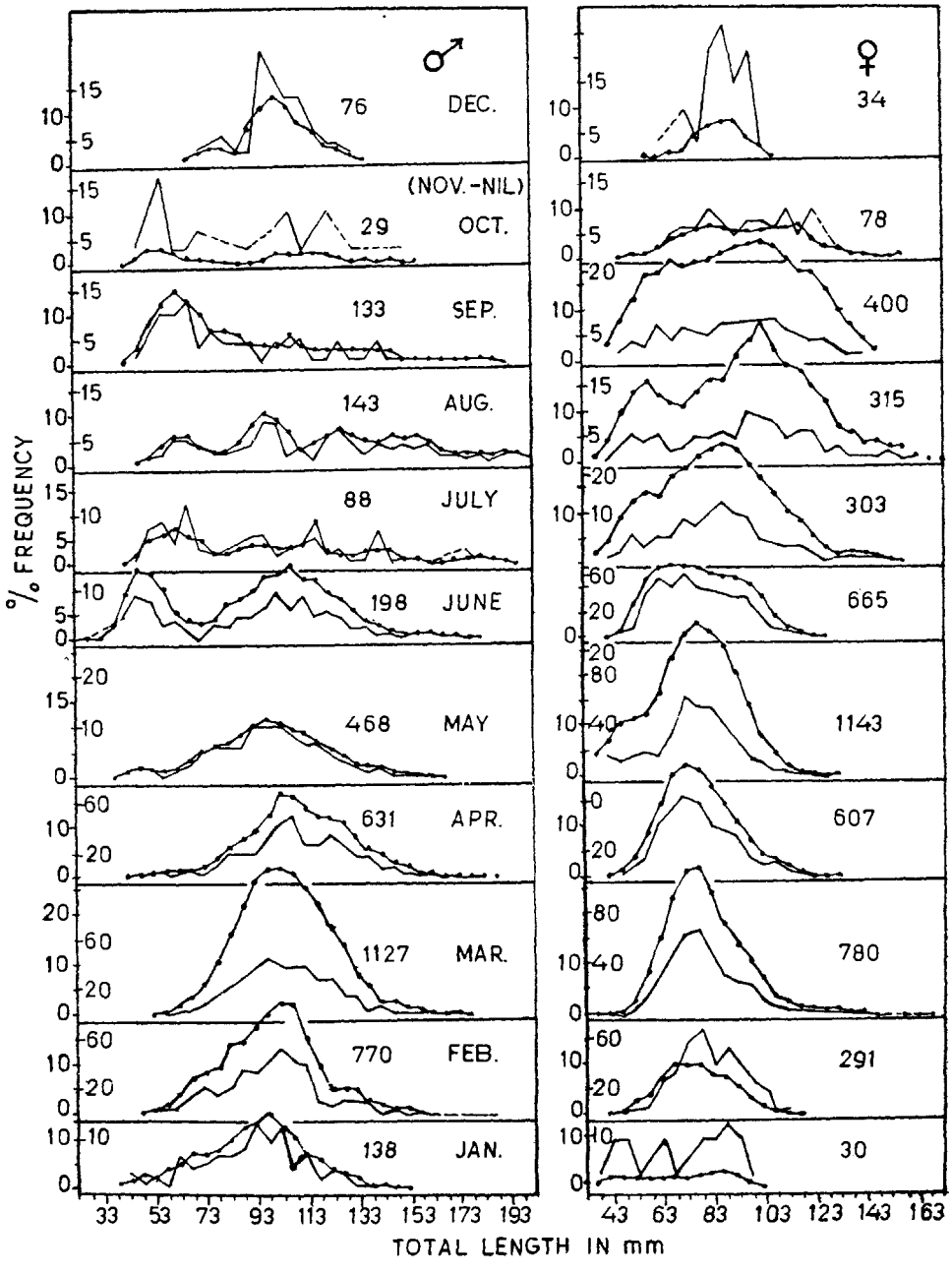

Figure 7 Length frequency distribution of males and females of *M. malcolmsonii* from river Godavari (1968)

The table shows the stationary position of the modes at certain lengths over long periods. Thus from February to April 1966 there is a mode at 78 mm and in 1967 at 63 mm and 103 mm from July to September and February to April respectively. During 1968 a mode is seen around 98–108 mm from January to August in the case of males. Similarly in the case of females from January–July the modes are around 63–73 mm in 1966, 68–78 mm in 1967 and 63–73 mm in 1968. It shows a migratory tendency of both males and females belonging to a particular age group. Depending on the time of onset of spawning and environmental factors influencing growth, the size in the different months varies from year to year. This migratory tendency hampered the study of growth from month to month.

The frequency of occurrence of the different modes is shown separately for males and females (table 6).

It is seen that smaller size groups measuring 48 mm are very common among males but not in females. These are observed during April to September. The next frequent one in males is the 63–68 mm size group. Corresponding to this in the females a high frequency is noticed around 68–73 mm.

In the next stage the males showed a high frequency around 98 mm and the females around 93 mm.

Among the large size groups there is greater frequency of males in the 128–133 mm size groups. The females are also common in the size group but not so common as males. The females are very scanty in the still higher size groups but the males continued to form modes of a small magnitude around 158–178 mm and 198 mm and these large sized males are available from July to September only.

The above study shows that the males only are available in stray numbers for capture in the fishing grounds at a smaller size (48 mm) compared to the females. They are seen first in April. These are probably the offspring of late spawners which spawned in October in which case they are 6 months old. The 63–68 mm size group in the case of males and 68–73 mm size group in the case of females appear from January onwards. If these are considered as the offspring of the spawners during the peak period of spawning, they are also 6–7 months old. Compared to the offspring of late spawners they seem to be growing at a faster rate.

The peak around 93 mm in the case of males and 73 mm in the case of females shows a merger of all the spawning broods when they are about one year old and also shows that the males grow slightly faster than the females. Probably the growth of the females in length slackens after attaining maturity around 60–65 mm. Further the females do not seem to survive in large numbers into the higher size groups though the males continue to live beyond the 1st year of their life. Thus the frequent modes observed in the case of males around 158 mm are probably representative of two year old prawns, around 178 mm are 3 year old prawns and around 198 mm are 4 year old prawns.

Observations on Age and Growth

Taking July as the peak breeding month when all the size groups would be represented in the distribution, at least 5 size groups of males and 3 size groups of females of the following ages could be made out.

With some minor variations similar modes were noted in July-August of 1968 and 1967 although in 1967 the general representation in samples was poor.

(Length in mm)

Age group	*River Godavari*		*River Hooghly*	
	Males	Females	Males	Females
0 year	48	63	—	—
	98	73	98	75
end of I year	128	98	123	93
end of II year	158	123	133	—
end of III year	178	143	Not de-fined	No repre-sentation
end of IV year	198	—	—	—

Taking the 1st modal length as that of last batch of larvae to be released in a breeding season viz., in October and the next mode as that of larvae released in early batch i.e., in July, the first two modal lengths are then taken to represent 0-year group. As stated earlier this pattern of bimodality of each age group becomes obscure with progression in age and only one modal length is seen at the end of I and II years in both sexes and III and IV years also in the case of males.

Even at a length of 70 mm, sexual distinction in growth rate is evident, the males being larger in length and the 2nd pair of periopods also becoming larger. The weight distribution also shows this distinction in sexes at this size. This differentiation is carried out through rest of their life. Maximum sized males are observed at 228 mm while females rarely attain a length of 168 mm.

A comparison of probable size at ages in the samples from the two river systems shown above indicates that in the 0-group only one modal length is evident in the Hooghly samples, unlike the bimodality observed in the Godavari samples, possibly due to the inadequate samples in the former. In males also the age groups above II year are not fully representative in the Hooghly samples. However, in the 0-and I-year group there is close correspondence in the age-length relationship of the two regions.

Table 6 *Frequency of occurrence of different modes in length frequency distribution in males and females*

Modal length (mm)	Frequency of occurrence	
	Males	Females
43	0	1
48	4	0
53	1	0
58	1	1
63	5	3
68	2	8
73	0	9
78	3	3
83	1	1
88	1	3
93	4	3
98	9	3
103	7	2
108	6	0
113	2	0
118	1	1
123	1	0
128	3	1
133	1	1
138	0	1
143	1	0
148	—	—
153	—	1
158	1	0
163	1	0
168	—	—
173	—	—
178	2	0
183	—	—
188	—	—
193	—	—
198	1	0

Length, Weight and Total Length-Carapace Length Relationship

	Hooghly samples	Godavari samples
Males	Log W= −5.1022+2.9976 Log L (350 observations; L=35–135 mm; Wt=0.3–34.5 g)	Log W= −5.0909+3.0790 Log L (408 observations; L=45–230 mm; Wt=1–162 g)
Females	Log W= −5.3727+3.1054 Log L (655 observations; L=28–125 mm; Wt=0.1–17.2 g)	Log W= −5.6549+3.3085 Log L (322 observations; L=37–165 mm; Wt=0.46–44 g)
Berried females	Log W= −4.8912+2.9421 Log L (24 observations; L=79–122 mm; Wt=4.3–16.0 g)	Log W= −6.8409+3.5598 Log L (261 observations; L=50–145 mm; Wt=0.7–35 g)

Where L=Total length range; Wt=weight range, Log L=Log of total length, Log W=log of weight

It can be observed that the values are high in berried individuals and in females of Godavari samples unlike those of the Hooghly estuary, probably because of the inclusion of larger size groups in the Godavari samples.

The relationship of total length to carapace length is expressed in the formulae:

Males : Carapace length=−7.0573+ 0.3256 total length (in 424 specimens in total length range of 39–143 mm)

Females : Carapace length=−5.3195+ 0.2995 total length (in 431 specimens in total length range of 39–153 mm)

Juveniles : Carapace length=−0.2966+ 0.2046 total length (in 161 specimens in total length range of 8–38 mm)

Discussion

The size at first maturity is smaller in the Godavari individuals. It appears probable that the larger size in the Hooghly is because of the differential migration of larger individuals to the estuarine zone.

The growth rates as observed in Godavari by earlier workers (e.g. Ibrahim 1962) appear to differ to a certain extent from the growth rates observed in the species from the Hooghly estuary. The Godavari fishery is much more extensive and abundant and made up of prawns of larger sizes viz., 220 mm (males) and 200 mm (females). The maximum observed size in Hooghly is 135 mm only. Besides these differences it must be noted that the Hooghly species is sampled in its sojourn in the lower limits of the distribution, i.e., in the estuarine region while the Godavari form was observed in the purely freshwater habitat. Thus, basic differences both in the habitat from which samples have been collected seem to account partly for the observed differences. However, in the present studies in the 0 and I year groups there does not seem to be any appreciable difference in growth in the samples from the two areas.

It is commonly believed that males reach the breeding ground in advance of females and this might account for the early predominance of males. In the pre-breeding season males predominate but during breeding season females are far in excess of males. This is probably due to fertilization

and attachment of spermatophores on to the females in the two months prior to spawning.

In the Hooghly estuary the distribution of *M. malcolmsonii* seems to be associated with the availability of low saline waters which are favourable for the prawn. To some extent the absence of the prawn from Matlah river system which is closed at the upper end and consequently has waters of higher salinity, reflects the adversity of higher salinity on the distribution in the adult phase of *M. malcolmsonii*.

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