VII GENUS *MACROBRACHIUM* BATE 1868

By

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While distributed in most of the Indo-Pacific region the species belonging to this genus mostly inhabit freshwaters. Species like *Macrobrachium rosenbergii, M. malcolmsonii, M. idae, M. mirabile, M. rude* etc. however, are distributed in brackishwaters also. According to Tiwari (1955) there are altogether 34 species of this genus recorded from India. Among these, 14 are coastal species, several of which are known are to migrate to brackishwaters of the various river systems. Included in the first group are a few species which are commercially important, the most important of which are dealt with in detail below with reference to the existing knowledge about their biology and fishery.

1. *MACROBRACHIUM ROSENBERGII* (De MAN)

Common name

In Bengal it is commonly known as '*golda chingri*' or '*mocha chingri*'. On the south west coast in Kerala backwaters it is locally called 'aattu konju'. In Malaya it is known as 'Udang galah'. Vernacular name for this prawn in East Pakistan are Bharo, Chooda, golda, mocha, mora and shala chingri.

Diagnostic features (fig. 39).

Rostrum long and exceeds the antennal squame by nearly 1/5 its length, bent near the middle and upturned distally. The tooth formula 12 to 15 (most commonly 12 to 13) dorsally and 10 to 14 (most commonly 11 to 13) ventrally; 7th to 11th teeth are usually separated by wider intervals than others. The first 3 upper teeth, or rarely the first two, are on the carapace. In the female the rostrum is more strongly upturned distally and somewhat less deep.

The large chelipeds are subcylindrical and either equal or subequal; half as long again as the body; a longitudinal pale line traverses the upper and lower surfaces of the palm, carpus and sometimes the merus. The joints are beset with broad-based spines which are less strongly developed on the ischium and the immobile finger. The distal end of the carpus is about the same width as the palm, while the latter is of uniform width. The finger tips are strongly curved, more especially that of the mobile finger, which is stouter than the immobile finger and densely pubescent, a fact which causes it to look stouter than it really is. The tooth on the immobile finger is conical, while the crenation of the ridge situated posterior to this tooth is well pronounced; the proximal tooth of the mobile finger may, in some cases, be followed by a small tubercle. When the fingers are closed the tooth on the immobile one lies nearer the proximal than the distal tooth on the mobile finger. In the female these chelipeds are more than half the length of the body and beset with feebly developed spines. The palm is slightly compressed dorsoventrally, and is about the width of the distal end of the carpus. The mobile finger is stouter than the immobile, but not to the same extent as in males, nor is it so densely pubescent. When the fingers are closed the distal tooth of the immobile finger lies midway between the two teeth on the mobile fingers.

The telson tip is acutely pointed; the inner subterminal spinule on each side projects backwards beyond the outer one, but does not nearly reach the tip of the telson itself.

The whole surface of the body is conspicuously punctate, but this character is less marked on the carapace.

Colouration:- In fresh specimens, especially in males the large chelipeds are deep peacock blue, passing into green on the palm and fingers. This colouration is absent from the coxal and basal joints and is deeper on the upper than on the under surface. The ambulatory legs are pale blue. The spines on the legs are deep blue at the base and orange towards the apex. In general the body is flesh coloured. The abdominal segments have deep blue transverse bands which are broadest on the 4th, 5th and 6th segments.

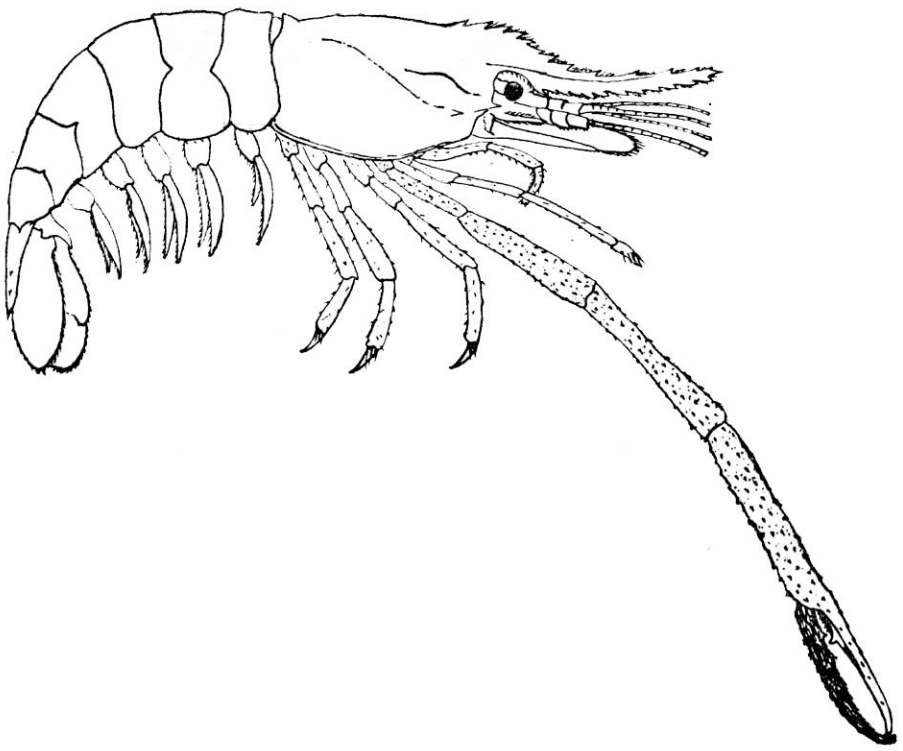

Fig. 39. ***Macrobrachium rosenbergii*** (de Man)

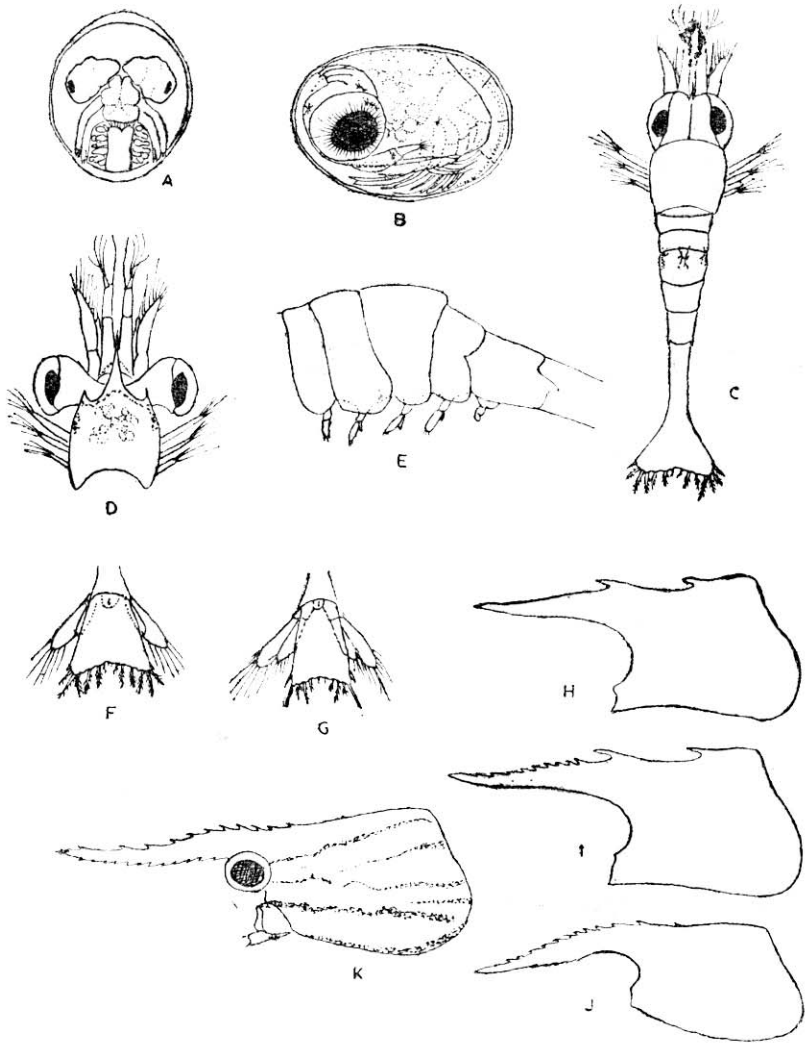

Fig. 40. Egg and larval stages of *M. rosenbergii*
A. B Well developed eggs. C. 1st stage larva
D. Head of 2nd stage larva. E. Body of 9th stage larva
F. 3rd stage larva–tail end
G. 4th stage larva–tail end
H. Carapace–30 days old larva
I. Carapace–12th stage larva
J, K. Carapace–juvenile prawns (Afthe Ling 1962)

Distribution

General distribution:- This species is confined to lower reaches of rivers, jheels etc. and widely distirbuted in Indo-Pacific zone, the western-most limit of distribution being the Indus delta. It does not extend beyond Indo-China in the Asian mainland. According to the water and land areas code given by Holthuis and Rosa (1965) the distribution of this species in land areas is in 423, 424, 431, 432, 433, 434, 435, 436, 437, 438, 611 and 621. In water areas it is distributed in the regions ISW and ISEW.

In Indian waters it is found to occur along both the coasts, on the west coast from Indus delta to Malabar coast and on the east coast from the south to Mahanadi delta and also in deltaic Bengals. In the backwaters and Pamba river system of Kerala and in the Hooghly estuarine system it supports good fisheries.

Differential distribution:- *M. rosenbsergii* form a considerable fishery in the freshwater zone of the Hooghly estuarine system. In the gradient zone it occurs in much lesser extent and only stray individuals of 0-year have been recorded in the marine zone. Smallest individuals (9mm to 30 mm total length) are found during May to July months in the upper reaches of Roopnarayan and Hooghly rivers. They occur mostly in shallow canals of the rivers.

In Cochin backwaters in summer months the juveniles are seen concentrating in the deeper areas of Pamba river near Pulikizh and such other places. They come down the river and enter the backwaters with the onset of the monsoon. During the breeding season adults are caught even from near the bar mouth. There are reports of stray specimens caught from the sea just outside the bar mouth.

Life history

Eggs and larvae:- The early larval stages of species from Cochin backwaters have been described by Menon (1938), obtaining stages I and II in the larval development. In the Ist stage the length of the larva varies from 2.0 mm to 2.25 mm and the 2nd stage larva measures

about 2.5 mm in length. In stage I larva the carapace has a long, slender rostrum which is more than half of the antennular peduncle in length. The anterolateral angles of the carapace are drawn out into small pterygostomian spines. The posterior margin of the telson is slightly concave and bears 7 pairs of spines. The tips of the antennular peduncles and the oral region of the ventral side are beautiful pink in colour. A branching pink chromatophore is present on the dorsal side of the 3rd abdominal somite and another at the base of the telson on the ventral side. The appendages are almost identical with those of the 1st stage of *M. rude*. The antennular peduncle is unsegmented. Outer antennular flagellum is an unsegmented papilla bearing at its tip 4 aesthetes and a short plumose seta. Antennal peduncle bears a slender pointed spine opposite the base of the flagellum, which is finger-shaped, unsegmented and about 2/3 length of the scale and terminally with a long plumose seta and a spine. Scale is divided distally into four clearly marked joints. Mandible with incisor portion possessing 1 or 2 blunt teeth and molar portion 2 to 3 minute teeth. Proximal masticatory process of maxilla I narrow and armed ith 4 setae at the tip. Distal process has 4 teeth and a short seta. In maxilla II the proximal, larger of the three processes on the protopodite is armed with 4 setae and 3 setae on the others. Endopodite has a basal lobe carrying 2 setae and is tipped with a single seta. Scale has 5 plumose setae along its margin. Maxilliped I has the coxopodite reduced with 2 very short setae and basipodite slightly produced inwards and carrying 4 small setae. Endopodite has 3 terminal setae and a small one on the outer margin. Exopodite has 4 plumose setae terminally. In maxilliped II the coxopodite is unarmed and the basipodite has a single seta. Endopodite is 4 segmented with the last segment having 3 unequal setae terminally and a small one at the base of the outer margin. Endopodite has 6 setae, 4 large and 2 small. Maxilliped III is similar to maxilliped II, excepting for the presence of 2 setae on the third segment of the endopodite. Behind the maxillipeds there are large biramous rudiments of the first two pereopods.

The second stage is also similar to that of *M. rude*. In addition to the rostrum and pterygostomial spines the carapace bears a pair of supraorbital spines and a median papilla behind the rostrum.

5th abdominal somite has a pair of lateral spines. Posterior margin of telson with 8 pairs of spines, the innermost pair extremely small. Besides the chromatophores of the 1st stage the posterior side of the bases of the optic stalks and the protopodites of the first two pairs of maxillipeds are also coloured pink. 3rd abdominal segment has two large branching chromatophores on the dorsal side, each of which sends off a branch into the second segment. The base of the antennal preduncle also has a small chromatophore. All the chromatophores are pink in colour. In addition to the changes in the number of setae on most of the appendages, the first two pairs of pereopods are present with well developed exopodites and endopodites. The endopodite is 5-segmented. Behind the second pereopod there are rudiments of two of the remaining appendage.

Ling and Merican (1961) and Ling (1962) have described the larval development of the species from Malaya. Especially Ling (1962 and 1963) has traced the complete development in laboratory tanks. According to him the eggs (Fig. 40) are slightly oval in shape, measuring about 0.6 to 0.7 mm in its long axis and bright orange in colour. The female prawn carries the brood of eggs and takes care of them until they hatch. During the whole incubation period, which is about 19 days at room temperature, the pleopods beat back and forth intermittently to provide aeration for the eggs. Dead eggs and foreign material are carefully and cleverly removed from time to time by the sensitive and versatile first pair of thoracic legs. Starting from the 12th day of incubation the bright orange colour of the eggs gradually becomes lighter and in its place a light grey colour slowly developed. The light grey colour deepens gradually until the 18th day of incubation, when the larvae inside the eggs are fully developed and the colour becomes slate grey.

The process of hatching starts with slow but continuous vibration of the mouthparts of the larvae, accompanied by some stretching of its rolled up body, forcing the eggs to elongate gradually. Vibration of mouthparts becomes more and more vigorous, accompanied by further stretching of the body. About an hour later the thoracic appendages start to vibrate vigorously but intermittently for about 10 minutes with increasing length of period of vibration. The vibration then becomes very vigorous and continuous. The body continues to stretch and the telson

starts pushing outwards. Suddenly the egg shell breaks and the telson thrush out, followed by the head, and with a forceful flex and stretch of the body the entire larva springs out of the shell. In less than 5 minutes the newly hatched larva starts swimming around actively.

All larval stages are active and planktonic in habit. They swim actively all the time at a slightly oblique angle, with tail first and ventral side upwards. The characters of larval stages (Ling 1963) are:-

1st stage - (1st-2nd day after hatching) Eyes sessile; telson triangular, fan-shaped, carrying 7 pairs of spines; uropod absent.

2nd stage - (2nd-4th day) Eyes stalked; telson triangular, carrying 8 pairs of spines; uropods absent.

3rd stage - (4th-7th day) Uropods prensent, exopodite with 6 spines, endopodite bare.

4th stage - (7th-12th day) Telson oblong, almost rectangular, carrying 6 pairs of spines; uropods with spines on both exopodite and endopodite.

5th stage - (12th-16th day) Telson with posterior margin narrower than the base, number of spines on uropods increased; red, blue and yellowish chromatophores present on 2nd thoracic legs.

6th stage - (15th-21st day) Telson further elongated and narrowed; chromatophores on the 2nd thoracic legs very important.

7th stage - (18th-24th day) Buds of pleopods appear; chromatophore mass on mid-ventral abdominal region present.

8th stage - (22nd-28th day) Pleopods biramous but bare; chromatophore mass on mid-ventral abdominal region very prominent.

9th stage - (25th-31st day) Pleopods fully developed with setae.

10 th stage - (28th-33rd day) 1st and 2nd thoracic legs chelate.

11th stage - (31st-37th day) Rostrum with 2-3 small teeth on its distal upper margin.

12th stage - (35th-41st day) Rostrum toothed on half of its upper margin.

13th stage - (38th-45th day) Rostrum toothed on entire upper margin.

The larvae are fully grown at this stage and are ready to transform into juveniles.

Juveniles as soon as they are transformed lose all the larval pelagic characteristics, becomes crawlers and settle down to the bottom or cling to the side of the rearing tank or submerged objects. Raman (1967)

expressed the view that it is possible that the larvae after the early stages leave the planktonic habit and settles to the bottom. A nursery ground for the juveniles was located by him in the upper reaches of Pamba river and suggested the possibility of the existence of several such grounds in the upper reaches of the river system.

Nutrition and growth:- Several authors who studied the feeding habits of *M. rosenbergii* have described it as omnivorous. Mary John (1957) reported about the omnivorous food habit of the species and found that specimens from paddy fields and paddy grains in their stomachs. Raman (1967) observed it to be a bottom feeder and an omnivore. Few stomachs of drag net catches observed by him were found to contain bottom debris and mud with large quantities of decaying organic matter. Fish scales and remains of fish were also present in a few instances. Based on the examination of stomach contents of 396 specimens Rao (1967) is also of opinion that the animal is a bottom feeder and omnivorous. The principal items of food are debris, sand and crustacean remnants. Molluscan remains, filamentous algae, plant and animal tissues are other items of food. Earlier Rao (1965) observed in rearing experiments that the species relished a variety of food items of both animal and plant origin. He even noticed the cannibalistic tendency, eating its own moult and dead eggs. Seasonal variations in feed also was studied by him in 1967 and the data given is reproduced in table I.

TABLE I

Percentage prevalence of various items of food and condition of feed

Item	Jan. %	Feb. %	Mar. %	Apr. %	May %	June %	July %	Aug. %	Sep. %	Oct. %	Nov. %	Dec. %	All months pooled %
Debris	26.23	36.21	..	36.67	31.25	..	..	..	33.90	..	33.33	..	32.64
Sand	26.23	20.69	..	30.00	18.75	..	..	..	32.20	..	26.67	..	26.36
Molluscan remains	1.64	13.79	..	..	..	..	..	..	3.39	..	..	..	4.60
Crustacean remains	16.39	5.17	..	6.67	12.50	..	..	..	15.25	..	13.33	..	11.72
Filamentous algae	11.47	13.79	..	10.00	..	..	..	..	..	..	..	..	7.53
Diatoms	..	..	..	..	..	..	..	..	1.79	..	6.67	..	0.84
Fat globules	6.56	..	..	3.33	12.50	..	..	..	..	..	..	..	2.93

TABLE I (contd.)

Plant tissue	3.24	10.34	..	..	13.33	..	..	..	11.86	..	20.00	..	9.20
Fish remains	1.64	..	..	..	6.25	..	..	..	..	..	..	..	0.84
Animal tissue	1.64	..	..	..	12.50	..	..	..	1.70	..	..	..	1.67
Miscellaneous	4.92	..	..	..	6.25	..	..	..	..	..	..	..	1.67
Condition of feed	60.00	42.86	..	23.27	12.12	..	..	..	24.39	..	9.09	..	

The condition of feed was high during January to April and in September. The immature specimens were mostly found with empty stomachs.

Ling (1962) also considers the prawn omnivorous. Common items of food according to him include aquatic worms, aquatic insects and insect larvae, small molluscs and crustaceans, flesh and offals of fish and other animals, grains seeds, nuts, fruits, algae and tender leaves of stems of aquatic plants etc. When sufficiently hungry it may even become cannibalistic. Food materials are located by the sense of touch. Pieces of food are picked up and brought to its mouth by 1st and 2nd pairs of thoracic legs.

Among freshwater prawns this species grows to the largest size. As reviewed by Bhimachar (1965), Rajyalakshmi (1962) has investigated the age and growth of this species occuring in the hooghly estuary. According to them growth in the species is one of inverse exoponential pattern. Males have been estimated to attain lengths of 107.0 and 149.0 mm at the end of the first and second years of life and females 82.5, 130.5 and 168.5 mm at the end of 1st, 2nd and 3rd year respectively. Thus sexual dimorphism in growth is exhibited in this species. Initially the males grow faster than females, but the rate of growth between the 1st and 2nd year appears to be slightly faster in females than in males. At given ages the males are invariably longer than females. The data given by her for the males is shown in Table II.

TABLE II

Results of analysis of size frequency distributions
by the probability paper in *M. rosenbergii*

Age in years	0	I	II	III	IV
	79.5	107.5	149.0	..	..
1959	..	104.5	151.0	181.0	217.5
1960	..	111.5	142.7	176.1	204.5
1961	..	113.7	147.9	..	..
Average	79.5	109.18	147.65	178.55	211.0
Increment in length		38.4	30.9	32.5	

From the same estuarine system Rao (1967) studied the growth of the species by the same method and his results are tabulated below.

TABLE III
Results of analysis of size frequency distribution by the use of probability paper.

Calender year	Males				Females			
	Modal length (T.L.) in mm at years				Modal length (T.L.) in mm at years			
	I	II	III	IV	I	II	III	IV
1963	108.5	146.5	223.0	..	77.5	133.5	153.0	210.0
(s.d)	(26.63)	(18.43)	(42.10)		(15.87)	(15.74)	(18.50)	(5.78)
1964	123.5	142.5	..	..	89.0	129.5	161.0	220.5
(s.d)	(14.39)	(19.97)			(12.37)	(14.79)	(25.29)	(18.56)
1965	109.0	137.0	229.0	261.0	..	118.0	159.0	232.5
(s.d.)	(10.89)	(17.89)	(13.18)	(11.84)		(15.6)	(40.35)	(18.29)
Mean	113.67	142.0	226.0	261.0	83.25	127.0	157.67	221.0

He found 4 normal curves for both the sexes in the size frequency ditributions, first of which being 113.67 mm (total length) in males and 83.25 mm (total length) in females. Laboratory rearing experiments also showed more or less the same growth rate and length attained after growth for one year was found to be similar. So these modal lengths were assigned to age

one year. Subsequent modal lengths as shown in table III were disignated as of II, III and IV years respectively. Growth rates during the winter months November to February are slower compared to the other months, probably associated with low temperatures during the period. This rate of growth appears to be quite slow.

Raman (1967) studying the biology of the species from central Kerala waters during the years 1959- 63 records a much faster growth rate. Using length frequency data from various centres of observations along the Pamba river system he concluded that females attain 180-200 mm in one year. Males are found to grow slightly faster than females. Among females one- year classes are very rare whereas among males they are common. Females, are not usually found surviving far into the second year of life. In the case of males the modal size at 141-160 mm when the fishery commences in March at Ramankari moves to 161-180 mm by May, after which growth appears to be faster. From June to October the males grow about 80 mm, an average of 20 mm per month. But during the off season at the river centres the growth is comparatively slow. Dominant size groups at two observation centres for the year 1960-63 given by him are reproduced in Table III.

TABLE III

Dominant size groups of *M. rosenbergii* at Kumarakom and Ramankari for the years 1960-63.

Month	1960		1961		1962		1963	
	Male	Female	Male	Female	Male	Female	Male	Female
At Kumarakom								
June	221-240	161-180 & 221-240	181-200	141-160	..	..	..	..
July	201-220 &241-260	181-200	201-220 &541-260	181-200	261-280	181-200	201-220	181-200
August	221-240	201-220	221-240 &261-280	201-220	261-280	201-220	241-260	201-220
Sep.	..	..	261-280	201-220	281-300	..	221-240	221-240
Oct.	261-280	201-220	261-280	221-240	261-280	221-240	..	..
Nov.	..	..	..	..	281-300	221-240	..	..

TABLE III (Contd.)

At Ramankari								
March	..	..	141-160	101-120	..	..	..	..
April	..	..	141-160	121-140	..	..	121-140	141-160
May	201-220	161-180	161-180& 221-240	121-140	..	..	..	..
June	181-200	141-160	181-200	141-160	161-180 &201-220	181-200	201-220	141-160
July	201-220	161-180	201-220& 261-280	161-180	..	..	221-240	181-200
August	221-240	181-200	201-220& 241-260	181-200	..	..	221-240	181-200
Sep.	241-260	181-200	141-160& 261-280	221-240	..	..	241-260	201-220
Oct.	261-280	201-220	141-160& 261-280	201-220	261-280	221-240	..	..
Nov.	..	..	..	..	..	..	261-280	..

According to him a few males which probably remain upstream during the early monsoon season come down only in September-October. These are stunted in their growth because of their larger sojourn at the upper reaches of the river. The growth rate to a large extent appears to depend on area inhabited, being slow up the river and fast in the backwaters. During the monsoon the growth appears to be very fast in the backwaters and this may probably be due to the flooding of paddy fields and availability of good quantities of food.

Growth being accomplished by a series of moults in this prawn as in other Crustaceans, Ling (1962) has described the process of moulting in this species. Moulting periodicity was studied by Raman (1967) and he found that moulting takes place at irregular intervals, roughly one moult for every 10 mm of growth.

Fluctuations in condition factor 'Kn' was studied by Rao (1967). Based on the fact that a study of relative condition might give an idea of the average number of moultings taking place in a year he concluded that males moult 6 times and females 5 times in a year in the case of immature

prawns of total length above 30 mm. Sex dimorphism in growth rates involving higher growth for males may probably be due to 6 moults in a year for males and a lower growth in females as a consequence of 5 moults. In mature prawns both the sexes show the highest 'Kn' values during the months March to May which is the peak of the breeding season.

Behaviour and movements:- According to Rao (1969) the extreme limits of salinity tolerance for the species in the Hooghly estuary is 0 to 16.0 $^{0}/_{00}$. Spawning behaviour of the species was studied in the laboratory by Rao (1965). Various behaviour patterns in connection with mating and spawning are described by him. It is observed that courting behaviour in males is released only when a female which had just completed pre-spawning moult is available in the vicinity. The behaviour aspects of mating follow in a definite chronological order - fight for the establishment of territory, beconing, courtship, mounting, sex-arousal and copula - in a sequential stereotyped fashion. Ling (1963) is of opinion that soon after the pre-mating moult the female prawn secretes a certain kind of substance which strongly attracts the male. Sexual fighting between the males is a feature noticed in laboratory experiments. The victorious male chases the vanquished and protects the female by arresting it within the range of its long chelipeds. The male monts the female during copulation and extrusion of eggs on to the pleopods takes place generally 8 to 12 hours after mating. Homosexual behaviour was also noticed in males.

Mary John (1957) observed that when migration is obstructed the parent detaches the eggs from the brood pouch and eats them. However, no such observation was made by Rao in his studies. But detaching of eggs, though not of eating them, was observed when sudden fluctuations in salinity and oxygen take place or when the parent is handled by the observer.

M. rosenbergii performs an interesting spawning migration. Generally an inhabitant of freshwaters, this species migrates down to the estuarine regions and spawns in areas where salinity fluctuates between 5.0 to 20.0 $^{0}/_{00}$. After the young ones grow to a size of 2.0 to 3.0 they migrate up the estuary to the freshwater habitats. The spawning

periods being different in the Hooghly estuary and Kerala backwaters, these movements up and down the river systems and the brackishwater areas takes place at different times of the year in the two different places. A point of interest that emerges from studies at the two different places is that while migration of adults into backwaters in Kerala region takes place at a time when salinity is on the decrease in that area, in the Hooghly region actual migration occurs when the salinity is on the increase in the winter and summer months. The return migration of adults into freshwaters in Kerala coincides with the increase in salinity in backwaters, whereas in the Hooghly the return migration takes place during the monsoon months when salinity is on the decrease. The inward migration of young ones also takes place at different times in the two places.

According to Raman (1967) juveniles and large males seem to be quite at home at the river mouths adjacent to the backwater even when the salinity is nearly 18. 0 $^{0}/_{00}$ indicating that salinity alone is not the inducing factor for them to move up the river. Probably temperature is an important factor influencing their movements. Mary John (1957) observed the optimum temperature for its normal activity to be 29^{0} to 34^{0}C. At the height of the summer they are probably going up the rivers and remaining in deeper basins of the river system, where the bottom is slushy with plenty of organic detritus. When it rains occasionally during the dry months large numbers of them come down to the backwater regions.

Reprodution:- Male prawns are considerably larger than females, with a pair of extremely long and rather thick legs (2nd pereopods), a big head, a compact abdomen with very little space between its pleurae and with its genital pore at the base of the 5th pereopods. Females are in general smaller, with shorter and slender 2nd pereopods, a medium head, a spacious chamber (brood chamber) on the ventral aspect of the abdomen, formed by the pleurae and with the genital pores at the base of the 3rd pereopods.

The ovary in immature specimens appear as narrow, transparent or whitish strands. Along with maturation yellow dots gradually appear on the surface of the ovaries. In mature specimens the ovary is bright

orange in colour and more massive occupying a large part of the cephalothorax just behind the rostral base extending backwards even into the first abdominal segment and could be easily made out.

For maturation of ovary and spawning the species seem to congregate at the middle zone of the Hooghly estuary (Rajyalakshmi 1961). The gonad begins to mature from December-January, more frequently from early February. The posterior part assumes a little yellow colour and yolk granules appear in the oocytes. Gradually the ovary expands and begins to cover cavity underneath carapace. The colour becomes deeper. The immature or first stage ova are very transparent with a large nucleus in the centre. The ripe ova are very opaque. The ova-diameter frequency polygons are given by Rajyalakshmi (1961).

In Kerala estuary when the fishery commences in May-June practically all the females are either immature or maturing. Mature females generally begin to appear from July onwards. By October most of them are either mature or berried. In males the testes are well developed in most of the specimens at this time. Fully grown spermatozoea are observed in specimens measuring 150 mm and above. Mature males are able to mate at any time, while females are ready to respond only after the premating (puberty) moulting.

Mating can be induced under controlled conditions by introducing a matured male and a mature female which has just completed premating moult in an aquarium tank. For mating behaviour see Behaviour and movement, section. Courting behaviour is described by Ling (1963) also. The courting act continues for about 10 minutes to half an hour before the female is successfully won over. The male then holds the female between its long picer legs and at the same time actively cleaning the ventral portion of her thoracic shell with its other legs. This is followed by the final mating act which lasts only for a few seconds. Sperm ejected by the male is deposited in one mass on the female's ventral thoracic region between her thoracic legs, and is coated with a thin layer of gelatinous substance for protection.

The process of egg-laying may take place about 6-20 hours after mating. Unmated ripe female prawn would also lay eggs within 24 hours afte her permating moult, but the eggs would drop off in 2-3 days because they are not fertilized. During egg-laying the body of the female prawn bends forward far enough to have close contact with the ventral thoracic region, so that eggs are extruded through the female genital pores directly into the brood chamber. The eggs are held in bundles like grapes by some extremely thin and elastic membraneous substance. The eggs bundles are adhered tighly to the fine ovigerous setae of the first four pairs of pleopods.

Fecundity of the species has been studied by several authors and the results obtained by these different authors are summarised in Table IV.

TABLE IV

Fecundity in *Macrobrachium rosenbergii*

Author	Fecundity
Mary John (1957)	100,000 to 160,000 eggs
Rajyalakshmi (1961)	7,000 to 111,400 eggs Log F = 2.7949 + 3.3209 Log L.
Ling (1963)	70,000 to 120,000 eggs
Raman (1967)	139,600 to 503,000 eggs

The number of eggs in a fully mature ovary of a specimen measuring 241 mm was found by Raman (1967) to be 228, 850. Rajyalakshmi (1961) observed that the relationship between size (length) of the parent and the fecundity is exponential in the arithmetic form. The value of the exponent was estimated to be 3.3 indicating that fecundity increases more rapidly than body weight in relation to length.

Ling (1963) found that females kept in the laboratory were able to lay eggs twice within 5 months. In his opinion the species may be able to lay eggs 3 or 4 times in one year under natural conditions.

The female prawn carries her brood of eggs and takes care of them until they hatch. Vigrous movements of pleopods back and forth to provide aeration for the eggs is noticed throughout the incubation period, which is 20-21 days according to Mary John (1957), about 19 days (Ling 1963) and 19-20 days (Rao 1965). Dead eggs and foreign material are carefully removed from time to time by the 1st pair of thoracic legs. Starting from 12th day of incubating the bright orange colour of the eggs gradually becomes lighter and becomes light grey. This light grey colour deepend gradually day by day until the 18th day of incubation when the larvae inside the eggs are fully developed and the colour becomes slate grey.

Fertilization takes place soon after the eggs are extruded. First division of nucleus occurs about 4 hours after fertilization. Subsequent division of nuclei takes place at about 1 to 2 hours intervals. Cleavage is completed within 24 hours. Ventral plate is formed at the end of the 2nd day. Buds of appendages are well formed during the 4th day. Optic vesicles are formed during the 7th day and eye pigments start appearing during the end of the 8the day. On the 10th day chromatophores are developed. The heart also is formed on this day and it starts beating. The embryo is well formed by the 12th day and almost ready for hatching by 16-17th day. Hatching takes place by the 19-20th day.

The process of hatching starts with slow but continuous vibration of the mouthparts of the larva, accompanied by some stretching of its rolled up body, forcing the eggs to elongate gradually. Vibration of mouthparts becomes more and more vigorous, accompanied by further stretching of the body. After that the thoracic legs start vibration, at first intermittantly and later continuous. The body continues to stretch and the telson starts pushing outward. Suddenly th egg shell breaks and the telson thrush out, followed by the head. With a forceful flex and stretch of the body the entire larva springs out of the shell. In less than 5 minutes the newly hatched larva starts swimming around actively.

The species has a restricted spawning season during the summer months December to July in the Hooghly estuary and according to Rajyalakshmi (1961 & 1964) peak spawning is durimng March to May. Rao (1967)

confirmed the observation on peak spawning period and observed that the physiological drive for maturity and spawning migration appears to stem form the rise in temperature and salinity during the season. In Kerala, according to Raman (1967) the breeding period is from August to December with a peak in October-November. In both places the breeding period follows the predominant season of the area.

Population and fishery

Sex ratio: - In general in the Pamba river system and adjoining backwaters when the fishery commences in May-June at the various centres males far outnumber the females (table V). From August onwards females predominate and continues so up to October. In November males once again become more numerous.

TABLE V

Sex ratio of the catches from Kumarakom and Ramankari
During 1960-63 (Raman 1967)

Months	1960 Male %	1961 Male %	1962 Male %	1963 Male %
Kumarakom				
June	69.2	80.0	..	..
July	69.9	68.0	62.5	53.3
August	48.4	46.1	40.7	49.5
September	..	29.5	66.7	29.7
October	16.7	21.6	28.6	..
November	53.3	..	50.0	..
December	44.9	..	..	..
Ramankari				
March	..	95.0	..	..
April	..	89.4	..	67.4
May	97.2	85.9	..	..
June	67.8	90.0	73.1	60.9
July	65.8	51.4	..	41.8
August	50.6	35.6	..	23.6
September	54.3	31.6	..	41.7
October	52.9	29.8	48.5	..
November	..	..	..	70.0

In the Hooghly estuarine system sex ratios of the species in percentages calculated for different ages of the population and tested on "null hypothesis" show that only O-year group conforms to the equiproportional ratio while higher age groups are significantly different, even at one percent level. The percentage of males are seen to be constantly on the decline as age advances while those of the females are on the increase, possibly denoting a higher rate of mortality in males than in females. At Nabadwip, an important landing centre situated at the entrance of the freshwater zone of the Hooghly estuary, differential proportion of sexes during different periods of the year are noticed. Males are predominant in February and again in September while females are dominant in February and again from september to January. This probably shows that there are discreet shoaling habits of sexes for purposes of spwaning. During the peak of the spawning season March to May almost only berried females are found. Percentages of immature males and females at the same centre also show a similar trend of differential migration, males appearing in the fishery early in January while females enter later during March-April months.

Instances of sex reversal has been reported by Rao (1967), in laboratory rearing experiments. Live berried females collected from the vicinity of Barrackpore during June 1965, after hatching out the larvae, on further rearing in the tanks were found to change into individuals showing male secondary sexual characters by September after passing through one to two post-spawning moults.

Age composition:- In the Pamba river system in kerala the O-year class approaching one year age is present in the catch as a mode at 141-160 mm in March, 161-180 mm in April and 181-200 mm in June at Ramankari. This shifts to 261-280 mm by October and even 281-300 mm in November in some years. On the assumption that they represent the early brood of last season it is apparent that they grow to about 200, 220 mm in one year. The large ones are the products of the previous years breeding and hence more than one year old, while those forming the mode at 261-280 mm found in July-August have already entered the second year. A good number of males survive into the second year while in the case of females the second year group is missing.

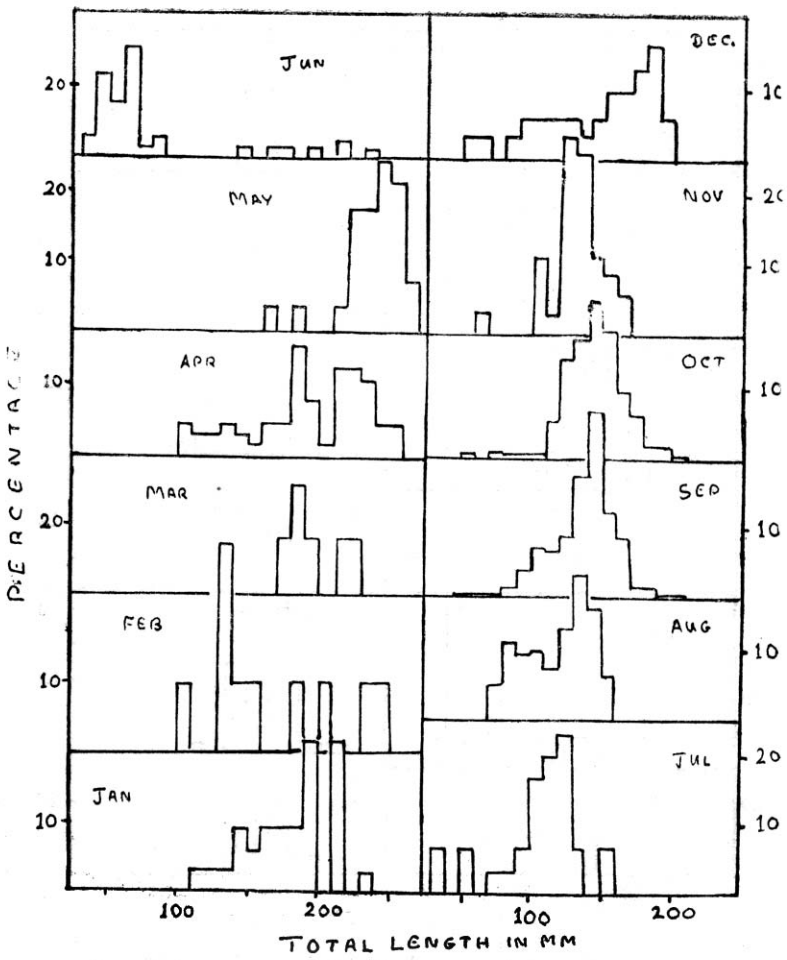

Fig 41. **Length frequency distribution of females during different months-data pooled for the years 1962 to 1965 (Rao, 1967)**

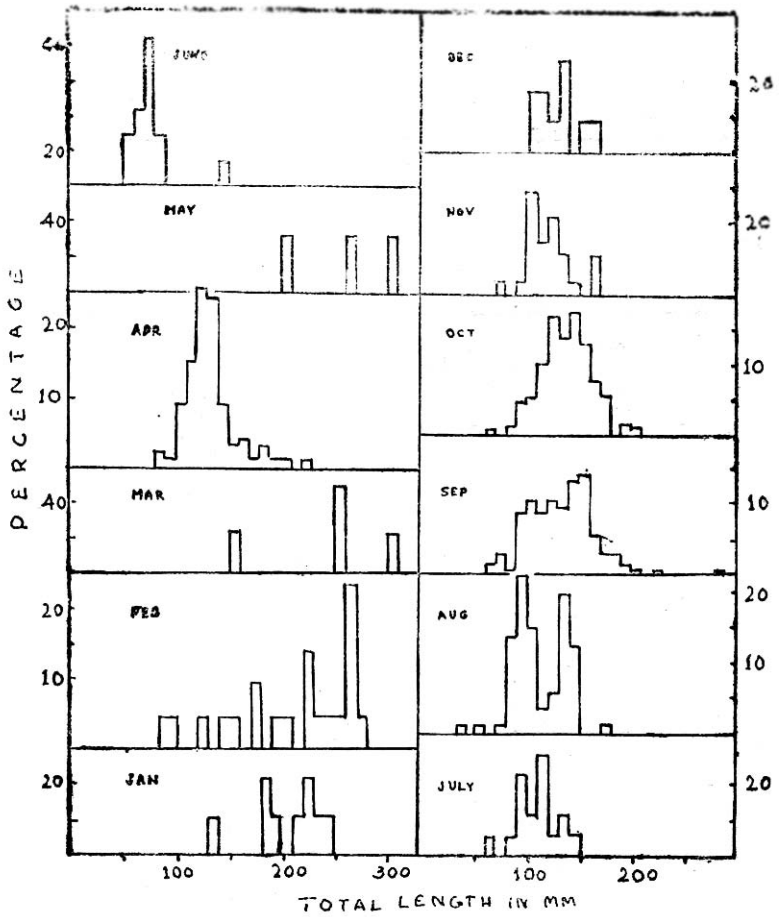

Fig. 42. **Length frequency distribution of male during different months-data pooled for the years 1962 to 1965 (Rao, 1967)**

By analysis of length frequency curves by the probability plot technique, Rao (1967) arrives at a different picture concerning age composition in the Hooghly estuarine system. He recongises 4 year classes in the fishery here,with lengths 113.67 mm. 142.0 mm 226.0 mm and 261.0 mm in the case of males and 83.25 mm, 127.0 mm 157.67 mm and 221.0 mm in females for the 4 years respectively. In the fresh water zone of the Hooghly river the maximum amout of fishery is constituted by I and II year groups followed by 0, III and other age groups. During the months January to April the fishery is constituted by all age groups except 0 year individuals, the dominant ages being II and III years. During May and June the fishery, though less, is mostly of III and IV years. Between the months June and December 0-year groups are available, the peak period being August to October, July to August months mostly comprise of I year age groups. During September to November the fishery is mainly of post-spawners consisting of II year and subsequent ages.

Size composition: Monthly size frequencuy histograms of males and females in the catches from 3 centres in the Pamba river system and adjoining backwaters during the year 1961. (Raman 1967) and in the catches of Hooghly estuarine system for the years 1962 to 1965 (Rao 1967) are shown in figures 41 to 44.

The maximum length of the sepcies according to Patwardhan (1937) is more than a foot (3 feet from tip of telson to tip of extended 2nd leg). In the studies of Hooghly estuary the maximum lengths observed are 310 mm total length (80.78 mm carapace length) for males and 267.0 mm total length (68. 14 mm carapace length) for females. According to Rajyalakshmi (1961) the largest theoretical size (100) estimated to be attained by the species is 396 mm and the largest size recorded by her is 310 mm. Raman (1967) records a maximum size of 320 mm in the case of males.

The maximum size at maturity for females given by Rajyalakshmi (1961) is 136 mm, aged 2 years. According to Rao (1967) the mean sizes of maturity for females and males respectively as indicated by 50 percent levels are 155 mm and 175 mm.

Based on 873 observations of length range from 30 mm to 305 mm, Rao (*op. cit.*) found that the lengths and weights were related to each other linearly conforming to the formula :-

$$\text{Log } W = 5.52748 + 3.19346 \log L \text{ or}$$

$$W = 0.00007222 \times L^{3.19346}$$

Rajyalakshmi (1962) had earlier arrived at the formula

$$\text{Log } W = 5.5837 + 3.2276 \log L$$

The total length – carapace length relationship was worked out by Rao (1967) and the formula obtained by him were

$$\text{Log. C.L.} = 0.92760 + 1.3787 \log \text{T.L. and}$$

$$\text{Log T.L.} = + 0.88675 + 0.83088 \log \text{C.L.}$$

Raman (1967) also found that these body measurements have a linear relationhip. The formula given by him are :-

$$\left.\begin{aligned} \text{C.L.} &= 0.32281\ \text{T.L.} - 10.81851 \\ \text{T.L.} &= 3.06401\ \text{C.L.} - 35.08947 \end{aligned}\right\} \text{ Males}$$

and

$$\left.\begin{aligned} \text{C.L.} &= 0.27892\ \text{T.L.} - 5.67957 \\ \text{T.L.} &= 3.58076\ \text{C.L.} - 20.53643 \end{aligned}\right\} \text{ Females}$$

Abundance and density :- The estimated annual production figures from 1957 to 1962 (Table VI) from the Kerala backwaters given by Raman (1967) shows that the catches of the species remained more or less steady around 300 m. tons till 1961. Maximum of 429 m. tones was recorded in 1960 while 1962 shows the lowest.

Table VI
Estimated production of *M. rosenbergii* for the years 1957-62.

Year	1957	1958	1959	1960	1961	1962
Total production in m. tons	356	296	378	429	307	189

The monthly catches at two centres Ramankari and Kumarakom are also given by him.

The relative abundance of the species in the Hooghly estuary

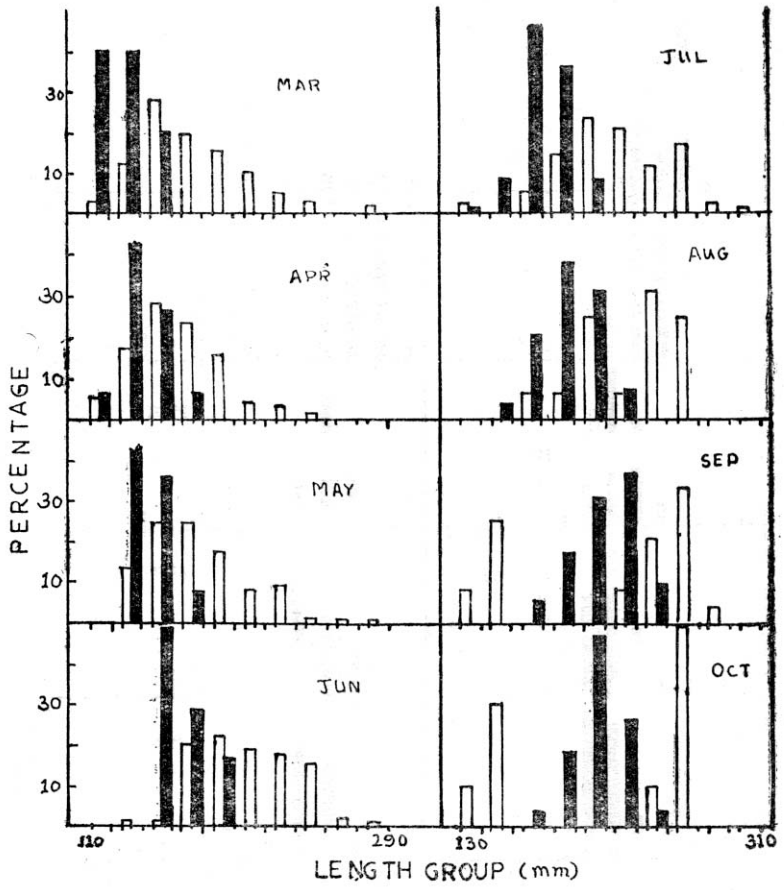

Fig. 43. Monthly frequency histograms of *M. rosenbergii* from Ramankari during 1961. Females shaded. (Raman, 1967)

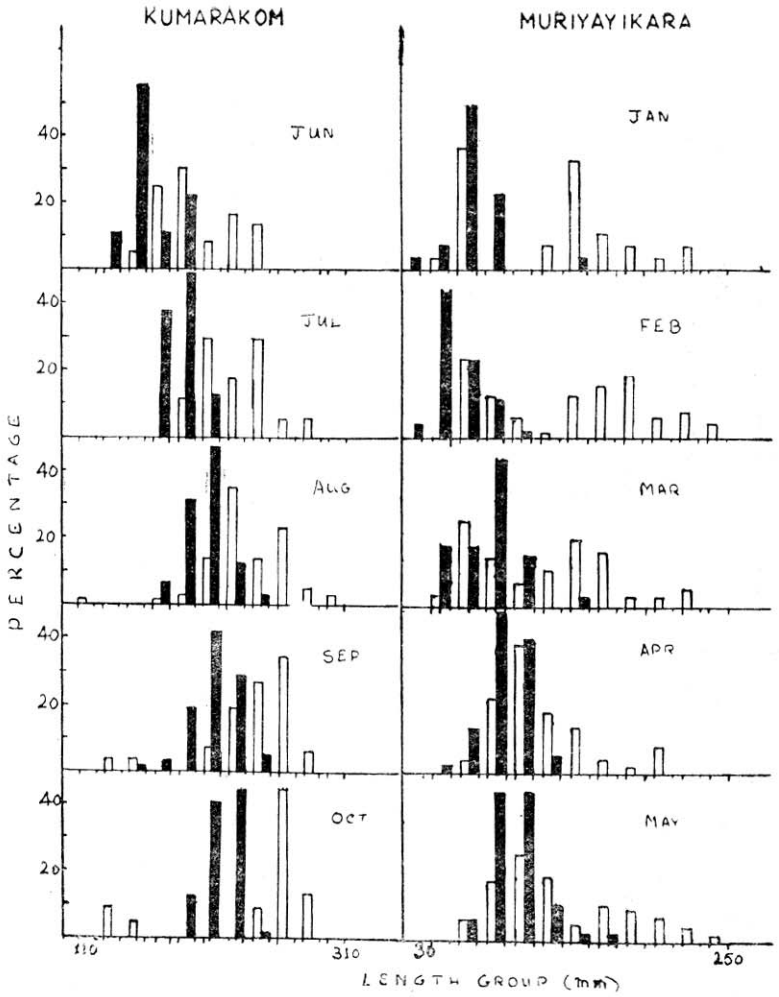

Fig. 4 . Monthly frequency histograms of *M. rosenbergii* from Kumarakom and Muriyayikara during 1961. Females shaded. (Raman, 1967)

fishery is discussed by rao (1969). The composition of species in the catches of the estuary in different years from 1962 to 1966 given by him are shown in table VII.

TABLE VII

Composition of *M. rosenbergii* in the catches of two zones of the Hooghly estuary during different seasons from 1962 to 1966

Zone	% of pro-of occur-rence	1962-63 Land-ings in ton-nes	%	1963-64 Land-ings ton-nes	%	1964-65 Land-ings ton-nes	%	1965-66 Land-ings ton-nes	%	Mean of all Land ings ton-nes	%
Fresh water zone	91.16	1.072	3.81	5.093	2.2	1.006	0.63	1.098	0.56	2.068	1.35
Middle zone (Sal: 0.10-12.68 $^{0}/_{00}$)	4.62	0.043	0.14	0.106	0.15	0.231	0.69	0.039	0.15	0.105	0.26
Roopnarayan river (Sal: 0.0-5.72$^{0}/_{00}$)	4.22	..	..	0.383	0.63	..	..	..	..	0.096	0.15

Natality and recruitment: In the Pamba river system in Kerala from September onwards good numbers of the larvae of the species are seen in surface plankton hauls taken from places like Pallathuruthu and Kumarakom, the backwater centres, but are very rare in collections from places in the upper areas. In late October and November they are obtained from the Cochin backwaters also in large numbers. After they complete the larvel life in the backwaters the juveniles go up the river by December or early January. In February also fresh recruits arrive at the upper reaches of the Pamba river. As reported by Raman (1964) during the summer months the juveniles are seen concerntrating in the deeper zones of the river near Pulikizh so that the place can be considered as a nursery ground. They come down the river and get recruited into the backwaters with the onset of the monsoon.

In the Hooghly estuary recruitment of the juveniles and different age groups to the fresh water as well as gradiant zones of the river takes

place the different seasons. In the freshwater zone the 0-year groups get recruited in the period June to December with the peak period between August and October. 1st year groups are mostly recruited in July-August. During September to November the fishery is mainly of post-spawners consisting of II year and subsequent ages. In the gradiant zone females in berry and of advanced stages of maturity are recruited from February to July.

Mortality:- Rao (1967) found that when the ratios in percentages were plotted for each sex against the ages, the ratios in males have been on constant decline while those of females were on the increase. This according to him denoted a higher rate of mortality in males than in females.

Fishing gear:- In the Hooghly easturine system, though the species is caught in every kind of net in stray cases, normally they are captured in traps (*bithi* and *duarbithi*), bush (*kumor*) and light fishing and cast nets, which are generally meant for prawns in the freshwater zone of the estuary. Operations involving hauling are done during the low tides because of the bottom feeding habits of the species. Traps are located all along the river in the freshwater zone on the banks. These are kept in the highest high tide and the prawns are taken out during the low tides. In bush fishing twigs and branches of trees are planted on the banks of the river in a cluster, where water depths are not more than 2 fathoms, and the leaves are allowed to decay for a fortnight. Then, during the low tides *Kumor jal*, a drag net of 30 to 40 feet in length with ½" to 1" mesh size with earthern sinkers is encircled around the bush. While the branches are being taken out, the bottom of the net is gradually scooped centripetally and ultimately joined by two or three fishermen and finally the net hauled. The cast nets, *khapla*, are generally operated during the low tides in knee-deep waters by fishermen where the bottom is uneven and rough. In the gradiant zone of the Hooghly the species is generally caught in the bag nets, *thor* and *been jals* and cast nets. Purely prawn nets like '*morjals*' and '*sitkijals*' are also operated near the shore in some areas.

In the Pamba river system and adjoining backwaters, fishing for the species is generally carried out by individual fishermen using

mainly '*veechu vala*' (cast net) or '*ottal*' (a conical contrivance open at both ends, made of thin bamboo strips) with the help of a small dugout canoe. Occasionally various types of drag nets such as *vadi vala*, *koru vala* and *peru vala* also catch small numbers of this prawn along with other fishes. *Vatta vala* (a pouch net) and *anta vala* (drag net) are used to catch these prawns from among submerged vegetation. While fishing with cast nets, baits are dropped in water and their position marked by poles. After allowing some time for the prawns to approach the bait the cast net is operated over the baits. This type of fishing is usually carried out at night in depths varying from 3 to 6 metres. *Ottal* is used in shallow areas 1-2 metres deep. Same type of baits attached to small floats are dropped in the fields and when the float is found moving the ottal is plunged above it and the prawns collected with bear hands. Vadi vala is used for fishing in the shallow parts of the river and backwaters. In some places in the northern parts of the Vembanad lake between Vaikom and Cochin the prawn is also caught with hook and line.

Fishing boats:- Most of the fishing operations for the species being in shallow waters and near the banks, boats are not generally employed in the fishery. However, in the operation of the gears like veechu vala small dug-out canoes operated by single persons are made use of.

Fishing areas:- *M. rosenbergii* supports a lucrative fishery in the Pamba river system and the adjoining backwaters of central Kerala. It is mostly caught from the southern regions of the Vembanad lake as well as the Kayamkulam lake and the important rivers opening into them, namely, Moovattupuzha, Meenachil, Pamba and Achankoil rivers.

In the Hooghly estuarine system the species forms considerable fishery in the freshwater zones of the Hooghly river, the Roopnarayan and Ichamati rivers. In the gradiant zones of these rivers also it forms a fishery to a lesser extent. The species also contributes to the prawn fishery in *bheris* in Bengal.

Fishing season:- In Kerala backwaters the fishery commences in May-June, reaches the peak in July-August and September months and then decline, lasting usually upto November.

In the freshwater zone of the Hooghly river, although the fishery is active throughout the year, the main season lasts from May-June to December, with the peak period August to November. In the gradiant zone of the same, the fishery mostly confined to the Ulubaria-Fuleswar region lasts from February to July, mostly contributed by females in berry and advanced maturity stages. According to Rao (1969) also the peak season for the species here is during the monsoon.

Fishing operation and reslults:- Catch-effort data collected from the two observation centres given by Raman (1967) are reproduced in table VIII. The unit of fishing effort (unit per day) is computed on the basis of one fisherman working with one craft and gear.

TABLE VIII

Total effort, total catch and catch per unit of effort
at two observation centres during 1958 to 1963

	1958	1959	1960	1961	1962	1963
I. Ramankari						
Fishing effort (Unit/day)	2081	3622	2807	1428	415	1427
Total catch (kg)	2987.3	5584.4	5826.6	2621.1	488.4	2778.4
Catch per unit of effort (kg)	1.436	1.542	2.076	1.835	1.177	1.947
II. Kumarakom						
Fishing effort (Unit/day)	..	..	..	1869	715	1045
Total catch (kg)	..	..	..	4944.1	1064.2	1596.1
Catch per unit of effort (kg)	..	..	..	2.644	1.488	1.527

Of all these years at Ramankari 1960 seems to be the most productive as shown in the table and 1962 the least productive. In 1959 both effort and catch rate showed increase from the previous year. In 1961 the effort is less. The minimum of effort is recorded in 1962 which was a poor season. At Kumarakom also 1962 was a very poor season with the lowest effort and catch rate along the three years. Here also the catch improved slightly in 1963.

Prawn culture:- Being a fast growing species *M. rosenbergii* is an ideal prawn for culture. The possibilities of culturing this prawn has been suggested by several authors. Possibilities of establishing artificial hatcheries also were suggested by several including Naidu (1939)

and Mary John (1957). Raman (1964) reported about a nursery ground of the species near Pulikizh from where juveniles could be collected for purposes of culture. The best time for collection of juveniles from this area according to him is January and February months. He also suggested the possibility of the existence of similar nursery areas with similar ecological conditions in the river systems associated with Vembanad lake.

In connection with culture of the species and stocking young ones in the Hooghly estuarine system, Rao (1967) reported about several centres from where postlarvae could be collected. The postlarvae and youngest juveniles are found in shallow canals of rivers, of about 1 metre deep and are fished by local fishermen with fine meshed cloth and small bag nets 1 metre diameter at the mouth and 2 to 3 metres length, the mouth end being exposed above the water level during operation in very slow currents of water.

Ling's studies in Malaya were aimed at making rearing of the species a profitable proposition. He (1962 and 1963) after successfully breeding and rearing the larvae in laboratory tanks describes the techniques for culturing these prawns. Details concerning facilities and material required, larval food and techniques and procedure of rearing are given by him.

Protection and Management:- In the Keral backwaters apprehension concerning depletionary tendencies in the production of this giant prawn has been prevalent for some time. Since the species is subjected to fishery at different stages of its life, there is likelihood of the stock being depleted at some time or other. Mary John (1957) pointed out this possibility and emphasised the need for the protection of the breeders. Studying the fishery up to 1963 Raman (1967) was of opinion that no alarming tendency of depletion was evident till that time. A self-imposed close season during October-November 1963 by the freezing industy was welcome trial. But it was discontinued in later years. However, Raman (*op. cit*.) observed that the indiscriminate destruction of fry by fishing with small mesh nets like *peru vala* and *koru vala* in the upper reaches of the rivers during the summer months might adversely affect the prawn stocks in the long run. He also feared that the use of copper

sulphate for catching the riverine fishes by poisoning in the same areas which area the nursery grounds of the prawn was killing good numbers of the juveniles of the prawn. So he suggested that a closed season tried along with some measures for protecting the nursery areas during summer months might be useful in getting a sustained yield from the fishery. So far no such measures have been taken in the case of this prawn fishery. It is reported that the fishery for this giant prawn in the Pamba river system and Vembanad lake has been a complete failure during 1968 season. It remains to be seen whether there would be survival of the fishery in the 1969 season.

2. *MACROBRACHIUM MALCOLMSONII* (H. MILNE EDWARDS)

Common name

It is one of the "chingris" on the east coast of India.

Diagonostic features (Fig. 45).

Rostrum projects beyond the antennular peduncle for about 1/5 of its length. Dorsally the proximal portion is highly convex and the distal part more or less straight and much shorter, carrying one or two teeth near the apex. The proximal portion is relatively deep and the distal portion much narrower. The tooth formula is 9 to 11 + 1 or 2 (most commonly 10 to 11 + 1) and ventrally 5 to 7 (most commonly 6). As in *M. rosenbergii* the first 3 upper teeth or rarely the first 2 are on the carapace.

The large chelipeds are subequal in length and resemble those of *M. rosenbergii*, but the spinules are not so strongly developed, and are more closely set; the movable finger is somewhat less pubescent; a groove traverses both the upper and lower surfaces of the palm and carpus, recalling the longitudinal lines present in *M. rosenbergii*. The chelipeds are less than double the body length. The ischium and fingers are comparitively shorter than in adult males of *M. rosenbergii*. In females these chelipeds are scabrous and two-thirds the length of the body. The palm

is slightly compressed dorsoventrally and of uniform width; it is as wide as or slightly wider than the distal end of the carpus. The mobile finger is not pubescent. The grooves on the carpus and palm, characteristic of males are absent in the female.

In the male the anterior surface of the carpace, the posteroventral regions of the first five abdominal epimera, the anterior region of the second abdominal epimeron and sometimes of the first, fifth and sixth abdominal serga and the upper surface of the telson are scambrous. The thoracic legs with the exception of their dactyli are provided with very numerous closely set spinules. In the female the body is smooth and exhibits none of the roughness characteristic of males.

The telson tips as in *M. rosenbergii* is acutely pointed. The inner subterminal spinule on each side projects backwards beyond the outer one, but does not nearly reach the telson tip.

In specimens under 110 mm in total length the rostrum may be slightly upturned distally and may extend a little beyond the distal margin of the antennal squame.

Distribution

General distribution:- The species inhabits fresh and salt waters. It is known only from the eastern parts of India and Burma. According to the land and water areas code given by Holthuis and Rosa (1965) the distribution of this species in land areas is in 421 (w), 423 and 431. In water areas it is distributed in the region ISW.

In India the species is common in the Chilka Lake and penisular rivers that drain into the Bay of Bengal and Deltaic Bengal. The fresh water prawn fishery of the river Godavari is constituted mainly by this species.

Differential distribution:- As the species show some migration to brackish waters for breeding in the Hooghly estuarine system, a certain amount of differential distribution of stages in the life history is noticed here. But in Godavari river no such differential distribution is noticed by Ibrahim (1962).

Life history

Eggs and larvae:- The early embryonic development from fertilized egg to gastrulation of the species is described by Ibrahim (1962) (Fig. 46 a-f). The egg immediately after extrusion measure on an average 0.52 mm in length and are either spherical or elliptical in shape with a thin egg membrane provided with a coating of transparent adhesive secretion. The stellate island of protoplasm containing the nucleus is discerned in the centre of the egg. Commencement of cleavage is rather slow. Within 4.45 hours after fertilization the nucleus divides into two. The second nuclear division followed by the first appearance of cleavage furrows takes place by 9.45 hours. 8 blastmere stage is reached 2 hours later. Up to this stage the nucleus of each blastomere is distinctly seen. After 12.45 hours 16-celled stage is attained. Gastrulation commences 32.15 hours after fertilization. In a region of the egg which is destined to develop ventral aspect of the embryo, certain cells get detached from the egg membrane resulting in the formation of some space between the egg membrane and yolk cells. Consequently the blastoderm develops as a thin plate between the egg membrane and the yolk cells. Just before hatching the egg measures 0.629 mm. Hatching takes place on the 12th day after fertilization, much earlier than in *M. rosenbergii*. An account of the later embryonic development, hatching and the first stage larva is given by Rajyalakshmi (1960). The figure of the larva given by her is shown in fig. 46.

Nutrition and growth:- As in the case of other prawns this species is also found to be omnivorous. The percentages of various items of food in the stomach contents given by Ibrahim (1962), based on analysis of stomachs of 407 specimens are shown in table IX.

Generally mud, sand grains and debris constituted the major part of the stomach contents, forming 65.7% and 35.9% in adults and juveniles respectively. Apart from this the adults and juveniles show differences in the food items as can be seen in the table. In the stomachs of juveniles the percentage of diatoms are much more than in adults suggesting that juveniles at times resort to surface feeding also.

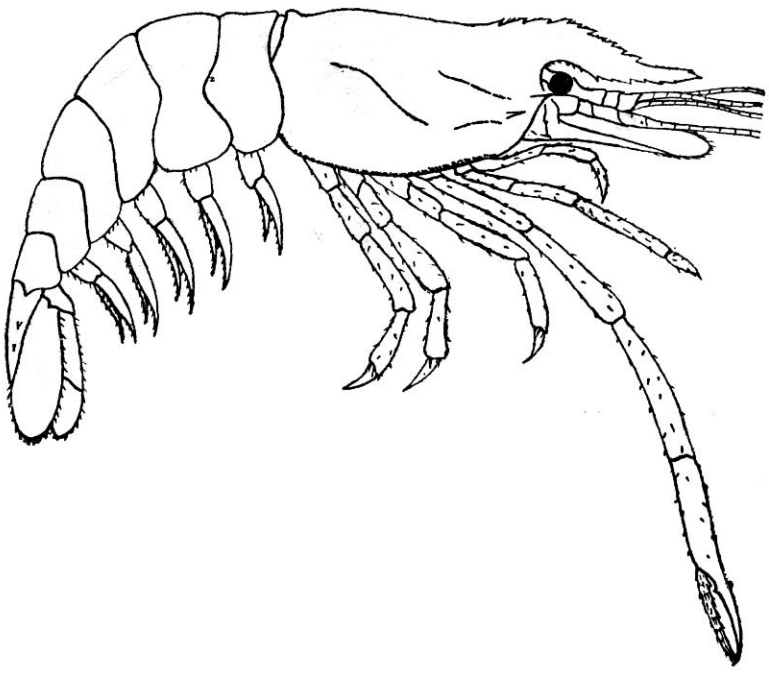

Fig. 45. *Macrobrachium malcolmsonii* (H. Milne Edwards)

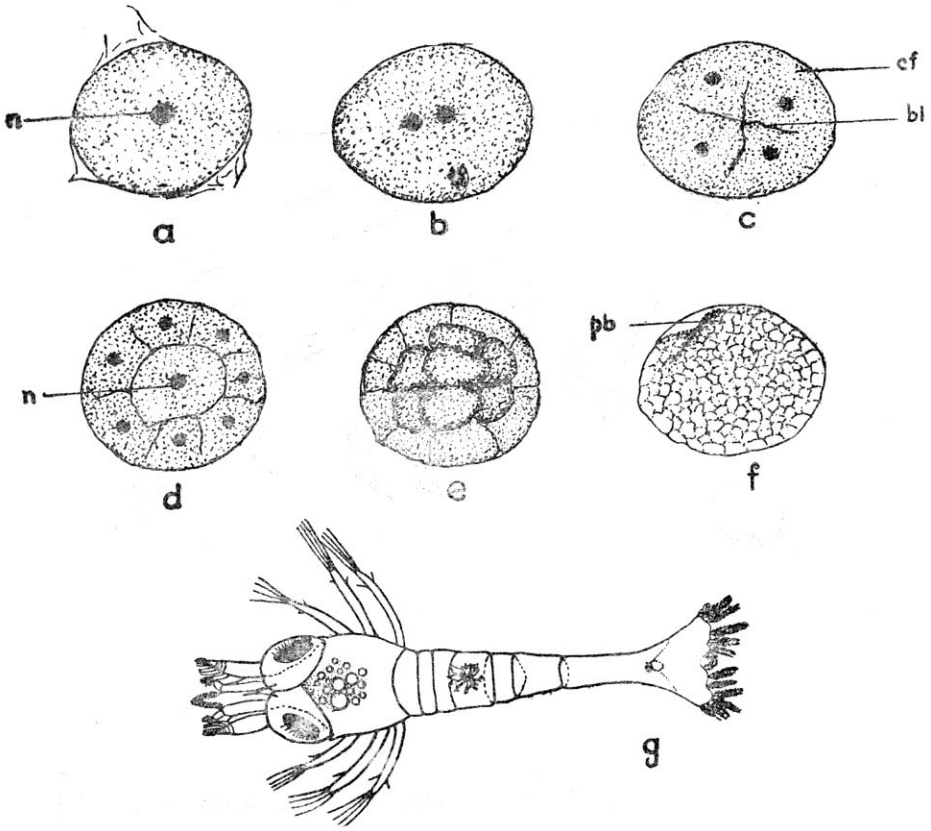

Fig. 46. Nuclear divisions, cleaveges and gastrulation in egg of *M. malcolmsonii* (a to f). bl-Blastomere, cf-cleavage furrow, n-nucleus. pb-problastopore (After Ibrahim, 1962) g-First stage larva of *M. malcolmsonii* (After Rajyalakshmi, 1960)

TABLE IX

Percentage of food items in the gut of juveniles and adults of *M. malcolmsonii*

Gut contents	Juvenile (T. L. 19.0-35.0 mm)	adults (above 35.0 mm)
Debris	19.8	41.7
Mud and sand grains	16.1	24.0
Diptera larvae (Chironomid)	4.3	5.1
Insect parts	3.6	5.4
Cladocera	0.2	0.6
Copepoda	0.8	0.3
Crustacean appendages & fragments	4.1	5.8
Diatoms (*Stauroneis*, *Navicula*, *Frustulia*)	33.7	2.2
Desmids (*Cosmarium* sp.)	2.4	0.2
Filamentous algae (*Spirogyra*)	3.0	2.9
Macrovegetation (plant parts; pieces of leaves etc.)	6.6	7.6
Fish scales	2.8	1.2
Miscellaneous	2.6	3.0

In the matter of growth, Ibrahim (1962) studying the prawns in the Godavari river and Rajyalakshmi (1964) from Hooghly estuary arrive at different conclusions, using the same method of probability plot. Their results are given in tables X and XI. While in the Godavari the males of the species have been estimated to grow 80.0, 63.5 and 50.0 mm during the first, second and third years of life and females 74.5, 39.0 and 35.0 mm in these years respectively, in the Hooghly estuary the postulated growths are much slower. There the males register and growth of 58.0, 32.5 and 28.0 mm in the first, second and third years respectively and females 56.0 and 37.5 mm in the first and second years. The disparity observed in growth rates of the species in the two estuaries could probably be attributed either to environmental factors or to differences in population abundance, if not to inaccuracies in interpretation.

TABLE X

Results of analysis of percentage length frequency distribution of *M. malcolmsonii* by probability plot method for 1960-62 (Ibrahim 1962)

Year	Age in Years	Males			Age in years	Females		
		Modal length (mm)	Standard deviation (mm)	Increment in length (mm)		Modal length (mm)	Standard deviation (mm)	Increment in length (mm)
1960-61	0	44.0	± 5.2419		0	44.5	± 6.85	
	I	62.0	± 14.3010		I	65.0	± 8.33	
		98.0	± 11.6935			84.5	± 7.66	
				63.5				39.5
	II	129.5	± 10.8870		II	105.5	± 6.82	
		158.0	± 12.5000			122.5	± 6.04	
				50.0				35.0
	III	183.0	± 10.2150		III	139.5	± 6.04	
		204.0	± 5.7451			158.5	± 8.87	
1961-62	0	43.0	± 5.1075		0	42.0	± 4.9731	
	I	61.0	± 11.0215		I	62.0	± 7.3924	
		89.0	± 8.3876			79.0	± 8.6021	
				50.0				40.5
	II	112.0	± 7.7957		II	101.0	± 6.6982	
		137.0	± 8.1187			121.5	± 6.8548	
				50.0				24.5
	III	162.0	± 9.6774		III	135.5	± 10.6182	
		187.0	± 11.9623			..	..	

TABLE XI

Results of analysis of size frequency distribution by the use of probability paper in *M. malcolmsonii* for the years 1959 through 1961 (Rajyalakshmi 1964)

Age in years		Mean length (mm)	Standard deviation (mm)	Increment in length (mm)
Male	0	40.0	± 4.301	18.0
	I	58.0	± 9.543	32.5
	II	90.5	± 8.333	28.0
	III	118.5	± 11.156	
Female	0	36.5	± 5.242	19.5
	I	56.0	± 10.887	37.5
	II	93.5	± 9.409	

Ibrahim (1962) found several of this prawn in the Godavari river parasitised by the bopyrid *Palaegyge alcocki*. Parasitisation was observed to cause retardation of overall growth as well as sexual development. In the case of infected prawns growth increments of only 27.0 mm and 26.5 mm during 1960 and 1961 respectively (Table XII) are evident between first and second year groups. In comparison with normal growth rate this is much slow.

TABLE XII

Analysis of length frequency in parasitised prawn by the probability plot method (Ibrahim 1962)

Year	Age in years	Modal length (mm)	Standard deviation (mm)	Increment in length (mm)
1960	0	43.5	± 3.763	..
	I	54.0	± 5.376	..
		72.0	± 8.199	27.0
	II	84.0	± 6.182	
		96.0	± 3.763	
	III	..	..	..
1961	0	..	..	..
	I	53.5	± 4.301	..
		64.0	± 5.846	..
				26.5
	II	81.0	± 4.838	..
		89.5	± 5.511	..
	III	..	..	..

The absence of any parasitesed prawn above 115.0 mm length possibly indicates that only those that are not attacked by the parasite grow beyond that size. Again parasitised prawns were never observed to carry eggs and their gonads were in a degenerate condition, indicating a retarded sexual development due to parasitisation.

Behaviour and movements:- In this prawn a simple behaviour of movement to shallow waters at dusk and during night is noticed in river Godavari and also in Chilka lake. Extreme limits of salinity tolerence for the species in the Hooghly estuary according to Rao (1969) is 0.0 to 90.0 $^{00}/_{00}$. In the Godavari river in this speices there appear to be no breeding migration towards the lower areas. In the monsoon season when

the whole stretch of the river up to the mouth show freshwater conditions intensive breeding takes place throughout the areas. However, an interesting upstream movement of juveniles is noticed here. Juveniles are found to move to upstream over the first anicut of the river at Dowleishwaram. The movement of these young prawns from the lower region of the anicut to the upper region was practically negligible during daytime but very intensive in the night. They were observed to move along the sloping cement pavement of the anicut alongside the descending water. It was observed that during January and February when the iron sills of the anicut were raised the young prawns moved vertically up these sills and the walls. This upstream movement recorded in August continued till February when the flow of water over the anicut ceased and was resumed in June when the overflow over the anicut commenced again. During December-January this movement becomes so intensive that the local fishermen collect large quantities of the juveniles which are sold fresh or dried. Length frequency analysis of samples from these upward moving juveniles show their size ranging from 13.0 mm to 60.0 mm with the major portion ranging in size from 21.0 to 36.0 mm (mode 30.0 mm).

Reproduction:- In the studies in the fishery of Godavari river, it is found that the gonads begin to ripen from April and more frequently from June onwards. Percentage of mature females increase from 11.3 in May to 37.8 and 38.7 in August and September respectively. The average weight of ovary per gram body weight of prawn ranged from 0.036 g (for size group 57.0 – 61.0 mm) to 0.067 g (for size group 77.0 – 81.0 mm). The weight of ovary was comparatively less among the 0 and III year classes but higher among I and II year groups. The size at first maturity was found to be 41.0 mm, aged 1 year.

The breeding period of the species in Godavari river extends nearly to 8 months from April to November with at least two peaks, once in June and again in August-October (Table XIII).

Intensive breeding commences immediately after the heavy rains. There are evidences to show that individuals beginning to breed for the first time become berried first. During the breeding season the one-year class constituted the predominant group in the catches.

TABLE XIII

Percentage of berried females of *M. malcolmsonii* in the commercial catches during 1960 and 1961

Month	1960		1961	
	% of berried females in total	% of berried individuals among females	% of berried females in total	% of berried individuals among females
April	..	..	0.83	..
May	0.75	..	8.38	11.33
June	22.41	28.53	23.93	29.58
July	9.39	14.35	15.04	21.80
August	7.25	29.26	18.79	37.85
September	15.49	24.62	27.11	38.78
October	17.05	37.85	9.70	20.20
November	0.24	..	0.70	01.70

The spawning period of the species in Hooghly river is, however, shorter during the months May to August (Rajyalakshmi 1964). According to Patwardhan (1937) the breeding season is still shorter, during May, June and July.

Fecundity studies on Godavari prawns indicate that the number of eggs in the berry ranged from 3,465 to 63,080 in specimens ranging from 54.0 mm to 164.0 mm respectively in size.

Hatchlings of 2.0 to 3.0 mm size range are found in plankton tows made at Rajamundry.

Population and fishery

Sex ratio:- Identification of sex is mainly based on the secondary sex characters. The appendix masculina being clearly visible at advanced stages, sex differentiation is possible only in specimens of 30.0 mm and above. In the Godavari river catches among the size groups 37.0 to 52.0 mm the proportion of males was considerably more than that of females and in sizes ranging between 57.0 to 77.0 mm (sizes breeding for the first time) females dominated. After this stage, however, males again predominate in

the catches up to 237.0 mm. Females were recorded only up to 197.0 mm and beyond this they were absent in commercial catches. X^2 test on sex ratio indicated that there are highly significant variations in sex ratio among different length groups. Larger number of males of larger sizes were observed by Rajyalakshmi (1964) and Bhimachar (1965) also.

Monthly analysis of sex ratio changes indicated that in the months May-June and September only females dominated while in all the other months males were predominant in the Godavari fishery. On pooling the sex ratios showed marked fluctuations during different seasons, more of females in the monsoon (June to September) and summer (March to May) and more of males in winter (October to February).

Age composition:- Observations on the fishery of this prawn in Godavari river during 1960 and 1961 indicated that among males the 0-year class contributed 13.0%, 1-year class 69.4%, 2-year class 16.3%, and 3-year class 1.2%. Among females 0-year class formed 9.1%, 1-year class 75.3%, 2-year class 14.1% and 3-year class 1.4%. Thus the bulk of the commercial catch among both the sexes was constituted by 1-year and 2-year groups.

In Hooghly the fishery is constituted by 0, I, II and III year classes in males and only 0, I, and II year class in the case of females.

Size composition:- In Godavari catches the size of males ranged from 30.0 mm to 237.0 mm while females ranged in size from 30.0 mm to 197.0 mm. The sizes of the different age groups are given in table X.

In the Hooghly river the smallest sized individuals (25.0 mm modal value) appear in commercial catches by November-December. For sizes of different age groups constituting the fishery see Table XI. Modal lengths of the species in the fishery in different months are given by Rajyalakshmi (1964).

Minimum size at first maturity in female is 41.0 mm according to Ibrahim (1962). But Rajyalakshmi (1964) records a much higher size of 79.0 mm.

Henderson and Mathai (1910) records maximum sizes of 230 mm in males and 133 mm in females. Patwardhan (1937) mentions a maximum length of 15 inches (380 mm) from telson tip to the tip of the long legs. Ibrahim (1962) got specimens up to 237.0 mm and 197.0 mm in males and females respectively from Godavari. Rajyalakshmi (1964) estimated the asymptotic length in *M. malcolmsonii* as Loo = 246 mm and the maximum size of the species recorded by her in Hooghly river was 135 mm only.

Based on 1502 observations on length and weight Ibrahim (1962) observed that the increase in weight in the species was slightly higher than the cube of its length, conforming to the formula

$W = 0.000001815485\ L^{3.38788}$ Males

$W = 0.000002728978\ L^{3.82041}$ Females

Abundance and density:- The total annual prawn landing at Rajahamundry for the year 1959 to 1961 from a stretch of about 16-24 km given by Ibrahim (1962) are given in Table XIV.

TABLE XIV

Total landings of prawns at Rajahmundry for three years 1959-61.

Year	Landings in tonnes	Percentage in total fish landings	Value in rupees
1959	20.36*	14.32	43,650
1960	36.66	14.49	78,410
1961 x	35.76	19.53	76,670

* Data for only 10 months

Over 16.0% of the total fishery of the river Godavari is contributed by *M. malcolmsonii*. The relative abundance of the species in the Hooghly estuarine fishery was discussed by Rao (1969). The composition of the species in the total catches of Hooghly in different years (Table XV) are given by him.

TABLE XV

Composition of *M. malcolmsonii* in the catches of two zones of the Hooghly estuary during 1962-1966

Zone	%of proportion of occurrence	1962-63 Landings in tonnes	%	1963-64 Landings in tonnes	%	1964-65 Landings in tonnes	%	1965-66 Landings in tonnes	%	Mean of all Landings in tonnes	%
Fresh water zone	82.27	0.408	1.45	9.306	4.02	2.411	1.51	4.892	2.50	4.254	2.77
Middle zone (Sal: 0.10-12.68 $^{0}/_{00}$)	1.43	..	..	..	..	0.103	0.31	0.186	0.72	0.072	0.18
Roopnarayan river (Sal: up to 5.72 $^{0}/_{00}$)	14.30	..	..	0.517	0.85	0.336	0.68	2.034	2.84	0.722	1.14

Natality and recruitment:- In Hooghly the species breeds during the months May to August and the smallest sized individuals (with mean modal length 25.0 mm) get recruited in the commercial fishery by November-December, approximately 5-6 months later).

The heavy commercial fishery for this prawn in the Godavari river stretch between Dowleishwaram and Dummugudem, especially near Rajahmundry is substantially contributed by heavy recruitment of juveniles. Breeding taking place throughout the course of the river, the hatchlings that are washed down by the flood currents as well as those of the local breeders in the lower reaches of the river make a concerted slow migratory movement upstream as the salinity at the lower areas increases and these juveniles are recruited in the commercial fishery later in Rajahmundry area. The maximum recruitment and thereby maximum exploitation of the higher size groups occur in the summer months from March to June.

Fishing gear:- In Godavari river major landings of the speicies along with other prawns are by cast nets. The meshes of the net range from 7.0 to 26.0 mm. Drag nets with mesh range 7.0 to 20.0 mm are also used occasionally. Fishing by baiting with a mixture of rice, rice bran and oil cake is a common practice. Though prawn fishing is carried out both in day time and night large quantities of prawn are caught in the nights from the shallow regions of the river near the banks as well as around the exposed sand heaps in midstream.

In Hooghly estuary the prawn is caught along with other in traps (*bithi* and *dwarbithi*), bush (*kumor*) and light fishing and cast nets. Bag nets like *thor* and *been jals* and shore seines are also operated.

Fishing boats:- Most of the fishery for these prawns being done from shore and banks of the river, boats are not much employed in the fishry. However, in some operations small dug-out canoes are used.

Fishing areas:- In the Godavari river exploitation of this prawn extends up to about 800 km upstream of Rajahmundry, but is maily confined to 1) Rajahmundry (Andhra Pradesh) at a distance of 80 km from sea, 2) Sironcha, 450 km from sea and 3) Nander, 800 km from sea (the latter two in Maharashtra) in a discontinuous manner.

In Hooghly the fishery is mostly confined to the fresh water and gradiant zones of the river.

Fishing season:- The fishery for prawns mostly contributed by this species at Rajahmundry has a peak season in the summer months from March to June. During the period July to December the catches are generally low. However, the fishery improves by February onwards. In the Hooghly estuary, in the upper zone the peak season is December to February (Rao 1969). There is another peak during monsoon also. In the middle zone and in Roopnarayan river the peak is during monsoon.

Fishing operation and results:- Details regarding the cast net fishery for this prawn at Rajahmundry area are given by Ibrahim (1962). During the months February to June about 38-90 fishermen families at Rajahmundry subsist on this prawn fishing, catching about 1.49 to 3.08 kg of

prawns per day per individual fisherman.

Prawn culture:- Culture of fresh water prawns in inland waters is not practiced much in India at present. Since *M. malcolmsonii* is one of the species that grows to large size it is worthwhile attempting culturing it inland waters such as large reservoirs and tanks. Collecting large sized sexually mature males and females and getting them spawn in laboratory tanks was found to be not very difficult by Ibrahim (1962). He found several berried specimens with eggs in advanced stages of development collected from Godavari river and kept in aquaria as well as small temporary pits hatching out their eggs successfully. He also observed repeated spawning of a female in the laboratory conditions. From the point of view of seed production this is quite important. The production of hatchling and prawn seed could be augmented by properly tapping the source of the upstream migrating juveniles over the first anicut of the river Godavari as a prawn seed collection centre.

Protection and management:- The heavy commercial prawn fishery in the river Godavari in the area between the two anicuts Dowleishwaram and Dummugudem, and in particular in the areas near Rajahmundry is substantially contributed by the heavy recruitment of juveniles. This is mainly due to the successful negotiation of the anicut by the juveniles. In the absence of fish passes, strict enforcement of conservancy measures on all the adjoining sides of the anicut during night, prohibiting the destruction of this valuable prawn fishery potential, will help in the further improvement of this fishery of the river.