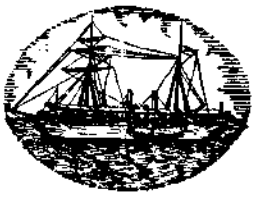
SYMPOSIUM ON CRUSTACEA

PART II



MARINE BIOLOGICAL ASSOCIATION OF INDIA

MARINE FISHERIES P.O., MANDAPAM CAMP

INDIA

PROCEEDINGS

OF THE

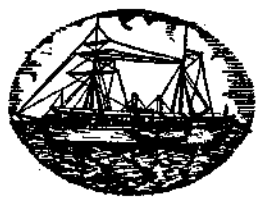
SYMPOSIUM ON CRUSTACEA

HELD AT

ERNAKULAM

FROM JANUARY 12 TO 15 1965

PART II



SYMPOSIUM SERIES 2

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MARINE FISHERIES P.O., MANDAPAM CAMP

INDIA

OBSERVATIONS ON THE FISHERY AND BIOLOGY OF THE GIANT FRESHWATER PRAWN *MACROBRACHIUM ROSENBERGII* DE MAN*

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ABSTRACT

Results of a study of the biology and fishery of the giant freshwater prawn *Macrobrachium rosenbergii* de Man in Central Kerala during the years 1959–1963 are reported.

The common methods of fishing, annual trends in production, effort and catch rate and monthly fluctuations in the fishery are discussed.

Using the length frequency data from the various centres, the age and growth of the two sexes contributing to the fishery have been studied. Males are found to grow slightly more than females. Among females, 1-year class are very rare, whereas among males they are common. Females are not usually found surviving far into the second year of life.

By following the maturity condition of the gonads and the abundance of berried and spent forms in the fishery the time and place of breeding have been fixed. Fecundity of the species was studied by estimating the number of extruded eggs. The seasonal migrations of the species are dealt with in the light of observations made along the course of the Pampa River.

The possibility of an over-fishing problem has been posed and certain conservation measures suggested.

INTRODUCTION

THE giant freshwater prawn, *Macrobrachium rosenbergii* de Man, supports a lucrative fishery in the rivers and backwaters of Central Kerala. The relatively large size of the species and its availability in fairly large numbers account for its popularity with the shrimp packing industry. This fishery was not of much significance until 1953 when the freezing and packing industry was established at Cochin essentially for the purpose of exporting prawns as a foreign exchange earning commodity. Encouraged by higher returns more and more people took to fishing for the species and various indigenous methods were adopted for catching them from all possible places. The fear of depletion, though available data do not confirm it, lead the industrialists to devote more attention to this species than to the other equally or more important marine prawns. Consequently the Standing Fisheries Research Committee appointed by the Government of India decided at its meeting early in 1959 that systematic investigations on the biology and fishery of this prawn should be taken up at the Central Inland and Marine Fisheries Research Institutes. The present account is based on the investigations carried out at the Central Marine Fisheries Research Sub-Station, Ernakulam.

Our knowledge of the biology and the fishery of this species is limited to the accounts given by Chopra (1943), Chacko (1955), Mary John (1957), Panikkar and Menon (1955) and Ling and Merican (1961). The early larval stages of this species from the Cochin backwaters have been described by Menon (1936). Rajyalakshmi (1961) studied the breeding and maturation of this species in the Hooghly river. But much of the life-history and bionomics remain unknown.

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M. rosenbergii is generally caught from the Vembanad and Kayamkulam lakes and the important rivers opening into them, *viz.*, Muvattupuzha, Meenachil, Pampa and Achankovil. The Periyar river, a branch of which opens into the Cochin backwaters, is not of any significance to this fishery since this species is seldom caught from this river. The Vembanad lake, which opens into the Arabian Sea at Cochin, is the largest body of backwater on the west coast of India extending for about 56 kilometres from Cochin to Alleppey. The widest part is the southern end where the Pampa, Meenachil and Achankovil rivers open. At this part the lake is about 15 kilometres wide and it gradually narrows towards the north. The rivers are comparatively short, narrow and fast flowing with mostly sandy bottoms. In the lower reaches, however, the river-bed is slushy and muddy. The bottom of the lake is muddy for the most part. The Muvattupuzha river opens near Vaikom at about the middle of the lake. The water in the southern part of the lake is almost fresh during the major part of the year. Salinity during the dry months, February to May, varies from 10 to 18‰. During the rest of the year the water is nearly fresh and especially so during the monsoon months—June to September. The tidal influence of the sea is more pronounced in the northern parts, where the water becomes fresh only during the monsoon months, and is felt up to a distance of 30 kilometres or more upstream. The salinity of the water in the lower reaches of the rivers also shows a slight increase during the dry months. At a point about 15 kilometres up the Pampa river mouth the highest salinity recorded is 3·50‰ during April. This may vary from month to month due to occasional rains. The water level in the river rises slightly during high tide even at places 60 or 70 kilometres above the river mouth. But the water never becomes saline beyond the village of Pulikizh about 30 kilometres up the river.

Methods and Materials

Regular fortnightly samples were obtained from commercial catches at Kumarakom and Ramankari (Fig. 1) during the fishing season and monthly experimental fishing was conducted with cast net and baits at five centres along the course of the Pampa river. From the river mouth upwards these centres are Pallathuruth, Ramankari, Pulikizh, Aranmula and Ranni roughly 15 kilometres apart. Experimental fishing was conducted with cast net and baits on the same lines as in commercial fishing. Surface plankton was taken by using a half-metre plankton net made of organdy and a specially designed bottom sledge trawl was used in the search for juveniles. An effort was also made to compare the catches obtained by the two commonly used gears, *ottal* nd cast net. The assessment of the total landings at both the regular centres was made from the figures of the purchasing agents who supply the prawns to the freezing companies. Annual production figures for the region were computed from the records of the freezing companies as the local consumption of the species was negligible due to the high prices offered by the companies.

Each sample was sorted out in the field itself and the sex ratio, total length (from tip of rostrum to tip of telson), carapace length and maturity were noted. In the case of berried specimens the nature of the eggs was also recorded. Size of the moulted specimens was specially noted. Ovarian eggs were examined in the laboratory and their size frequency recorded. This was carried out in the case of berried and spent specimens also. The number of extruded eggs was estimated by counting a weighed portion of the berry and computing the total.

Fishery

Fishing for *M. rosenbegii* is generally carried out by individual fishermen using *veechu vala* (cast net) or *ottal* (a conical contrivance open at both ends made of thin bamboo strips) with the help of a small dug-out 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 fishes. *Vatta vala* (a pouch net) and *anta vala* (a drag net) are used for catching the species from among submerged vegetation. While fishing with cast nets, baits are dropped in water and their position marked by poles.

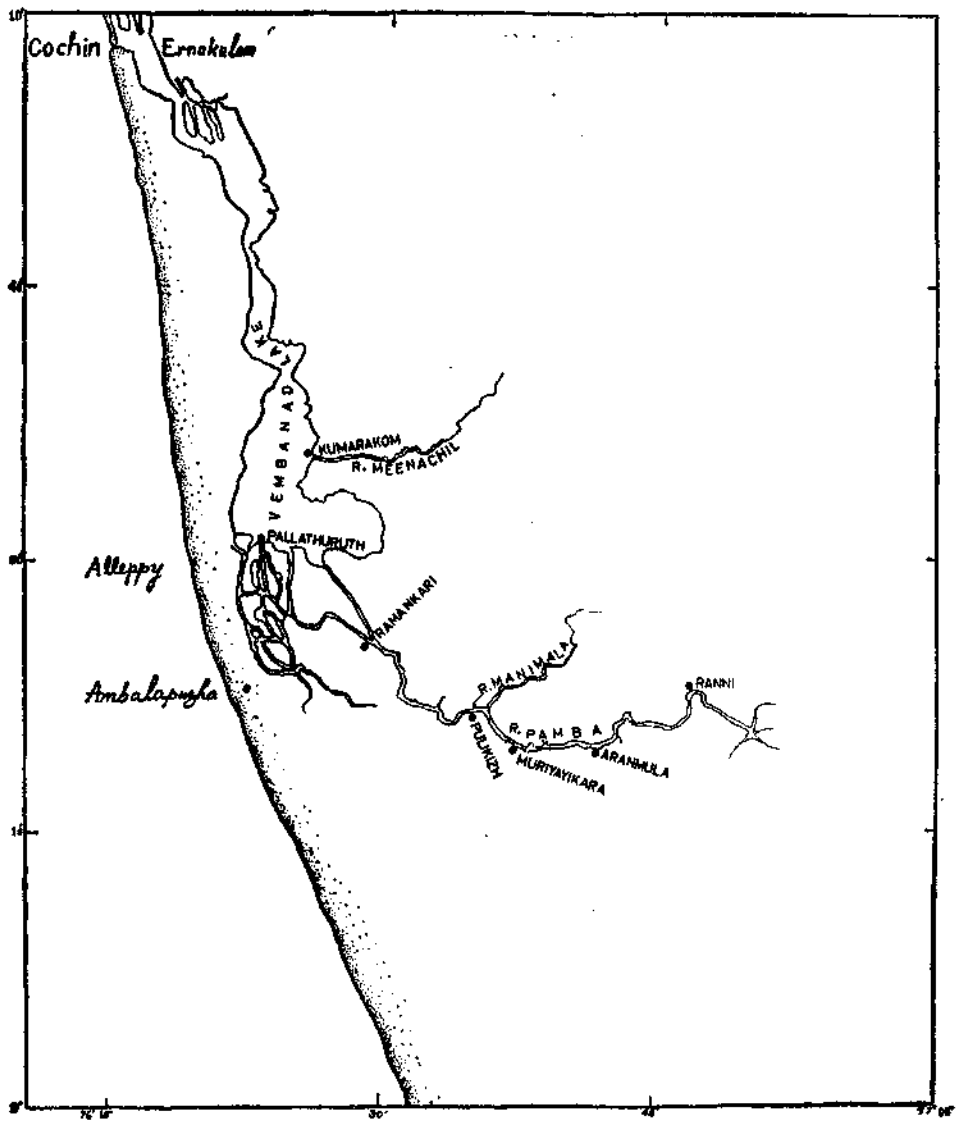

FIG. 1. Showing the Vembanad lake with Pampa river and the observation centres.

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 are collected with bare hands. *Vadi vala* is used for fishing in the shallow parts of the rivers and backwaters and *M. rosenbergii* occasionally occur in their catches also.

In some places the species is also taken with hook and line while fishing for other fishes. This is common in the northern parts of the Vembanad lake between Vaikom and Cochin.

The fishery started in May at Ramankari and in June at Kumarakom during 1960. The landings increased during July and reached a peak in August (Table I). In september there was a slight fall in the catch at both the centres and in October again it improved. In the following months the landings gradually dwindled. In the next season there was only a single peak in September and in the next three months the landings gradually decreased. At Ramankari the fishery in 1961 started very early in March and at Kumarakom as usual in June.

TABLE I

The estimated monthly landings of the two observation centres for the seasons 1960 *and* 1961

Months	1960		1961	
	Kumarakom (kg.)	Ramankari (kg.)	Kumarakom (kg.)	Ramankari (kg.)
March ..	...	..	..	680·25
April ..	...	..	..	1,000·00
May ..	..	1,360·77	..	1,200·00
June ..	4,085·00	3,630·00	2,500·00	1,500·00
July ..	9,075·00	4,540·00	9,200·00	2,200·00
August ..	15,880·00	6,805·00	13,525·00	3,000·00
September ..	8,950·00	2,217·00	14,220·00	2,000·00
October ..	11,283·00	3,642·00	11,750·00	1,100·00
November ..	3,122·00	200·00	4,000·00	200·00
December ..	300·00	..	..	..
Total ..	52,695·00	22,394·77	55,195·00	12,880·00

The estimated annual production figures from 1957 to 1962 (Table II) shows that the catches of the species remained more or less steady around 300 m. tons till 1961. The maximum production of the species—429 m. tons—was recorded in 1960 while 1962 production was the lowest recorded (189 m. tons).

TABLE II

The estimated annual production for the years 1957–1962

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

Catch effort data collected from the two observation centres are presented in Table III. Unit of fishing effort (unit per day) is computed on the basis of one individual working with a craft and gear.

TABLE III

Total effort, total catch and catch per unit of effort at the two observation centres

	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 the years, for which data are available for Ramankari, 1960 seems to be the most productive as shown by the highest catch per unit of effort (2·076 kg./unit/day) and 1962 the least productive (1·177 kg./unit/day). In 1959 both effort and catch rate showed increase from the previous year. In 1960 and 1961 the effort is less. The minimum of effort expended is recorded in 1962 which was a poor season and the reduction in total effort is an outcome of this poor yield. But the effort in 1963 shows a threefold increase and the catch rate is also high. This catch per unit of effort is better than those of 1958, 1959 and 1961. At Kumarakom also 1962 is a very poor season with the lowest effort and catch rate among the three years for which data are available. Here also the catch rate has shown a slight improvement in 1963.

AGE AND GROWTH

In Table IV size ranges and dominant size groups among males and females from the two centres for the years 1960–63 are indicated. The length data for the years 1960–61 from the two centres are grouped into 20 mm. groups and monthly length frequency histograms drawn for the two sexes separately for following up the growth rate. When the regular fishery starts at Ramankari in June 1960 the mode among males is at 181–200 mm. (Fig. 2). This shifts gradually to 261–280 mm. by October thereby showing a growth of about 80 mm. in four months. At Kumarakom the fishery starts in June with a mode at 221–240 mm. (Fig. 3) which moves over to 261–80 mm. by August. A lesser mode at 201–220 mm. is present in the cast net sample in July at this centre. This corresponds to the regular mode at Ramankari. In August this moves over to 221–240 mm. and by October to 261–280 mm. indicating identical growth rate. In the succeeding season also the same trend is noticed (Figs. 4 and 5). However, the mode at 181–200 mm. appears in June itself at Kumarakom and shifts to 221–240 mm. by August as in the previous year. The usual mode of June (221–240 mm.) shifts to 261–280 mm. by August as usual. The modal size in September and October is at 261–280 mm. After reaching this size the growth seems to be very slow and the modal group of August (221–240 mm.) may also be growing and contributing to this larger mode by October. Some of them seem to be returning to the rivers as is evidenced by the presence of such specimens at the upper reaches of the Pampa river from December onwards. An increase in the number of males towards the end of the season at the river centre (Ramankari) may also be taken as an additional evidence indicating their return. Towards the end of the season

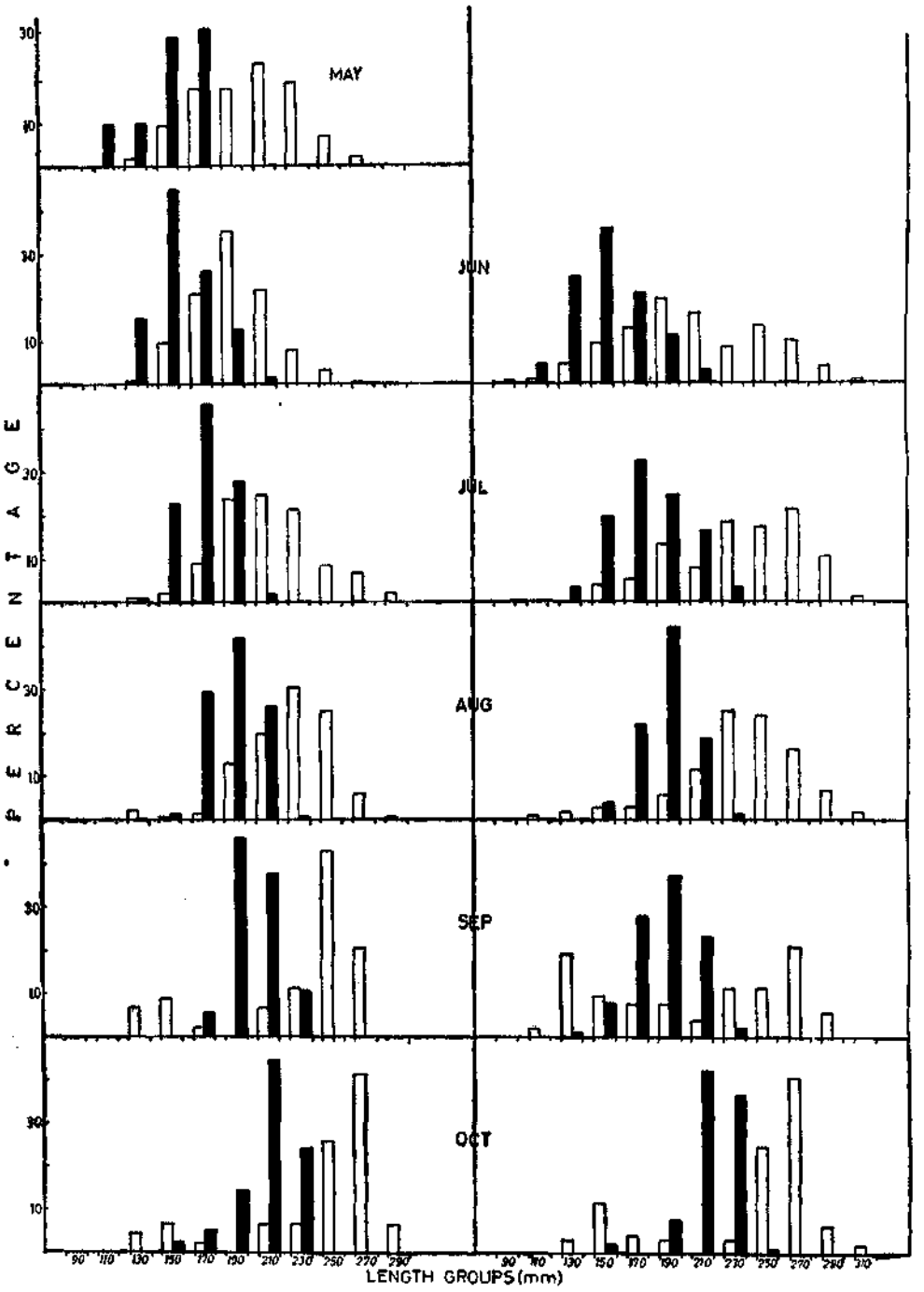

FIG. 2. Monthly percentage of *M. rosenbergii* from the landings of two gears—*Ottal* (left side) and cast net for Ramankari during 1960. Females shaded.

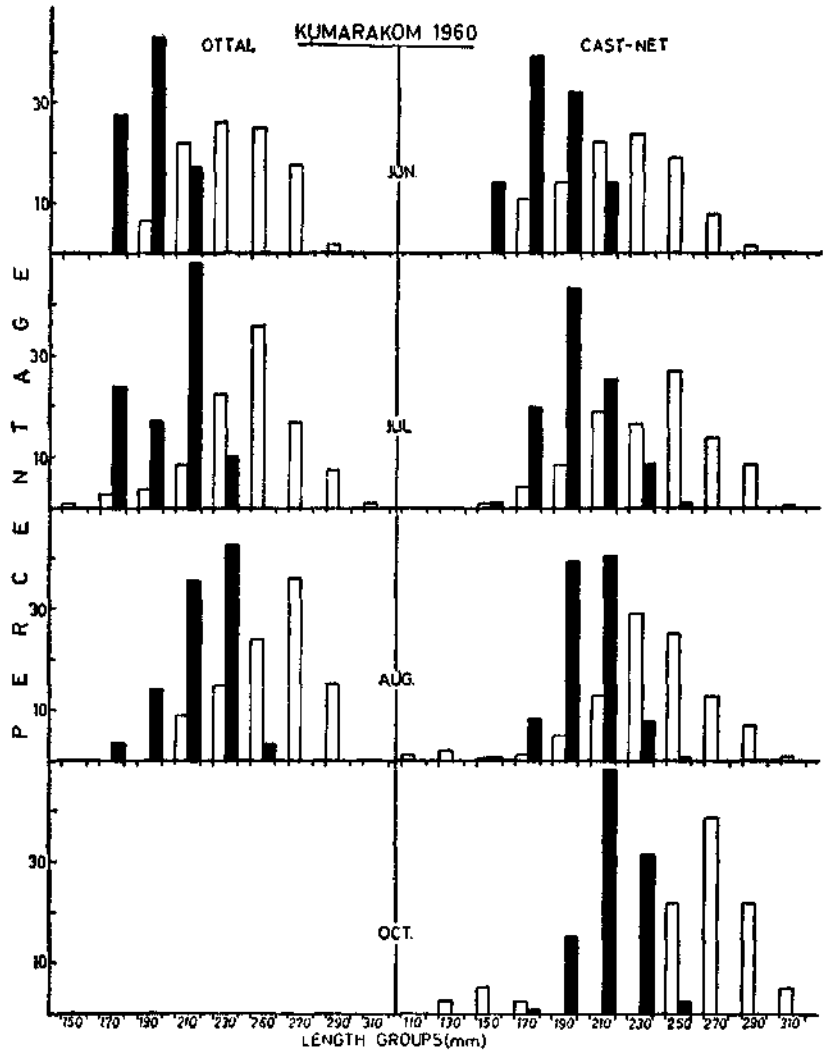

FIG. 3. Monthly size frequency of *M. rosenbergii* taken from *Ottal* and cast net during 1960. Females shaded.

a dominant size group appears at both the centres at 121–140 mm. or 141–160 mm. They also seem to return to the rivers after November.

In January when the regular fishery is over younger specimens of both sexes are caught from Pampa river around Muriyayikara, a fish-landing centre in the river east of Pulikizh (Fig. 1). The males with a larger size range show two dominant size groups—at 61–80 mm. and 141–160 mm. (Fig. 6). These two groups may be considered as the later and earlier broods of the same period just ended. There is also a minor mode 221–240 mm. which is continued through February and March. The smallest mode (61–80 mm.) is present in February and March also probably due to fresh recruitment. The mode at 141–160 mm. is also present in March and moves over to 161–180 mm. by May. The 61–80 mm. group present up to March moves over to 101–120 mm. in April and continues in May also. A mode present at 181–200 mm. in February shifts to 201–

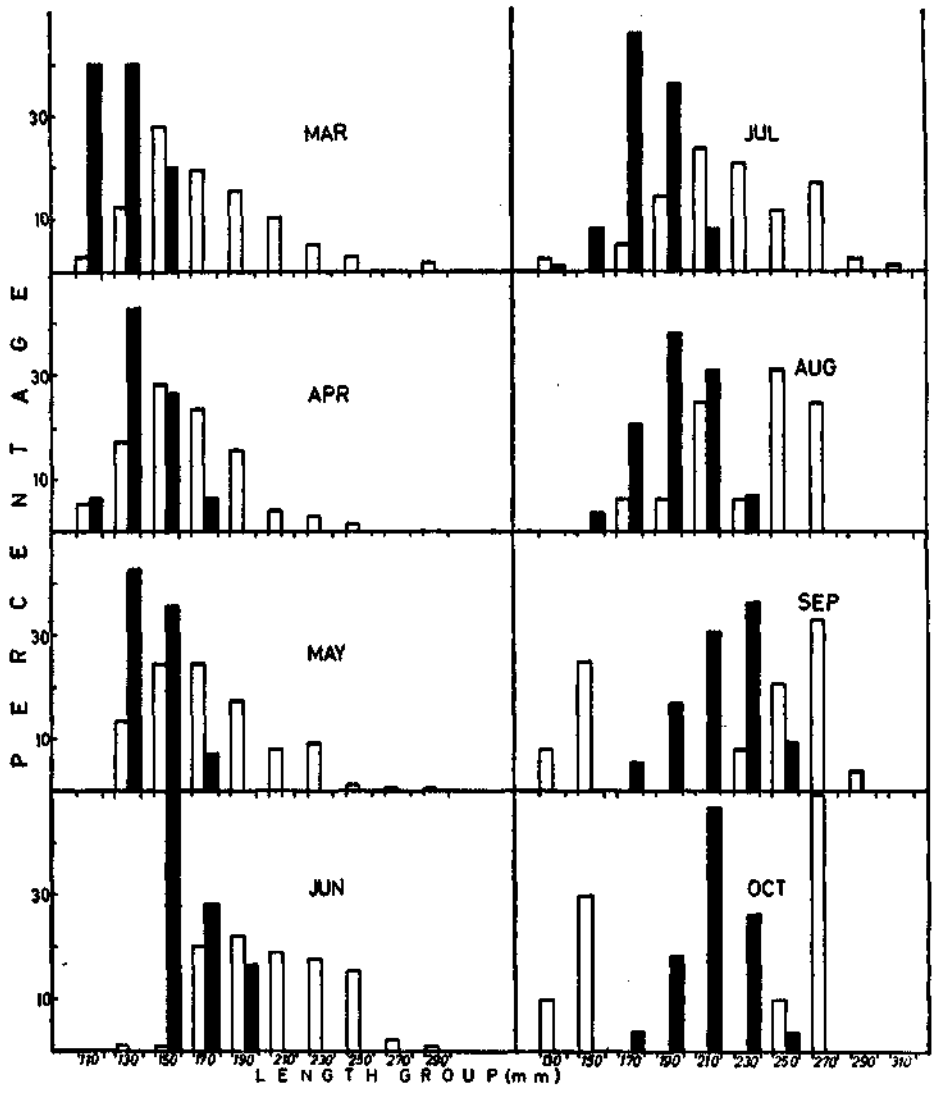

FIG. 4. Monthly frequency histograms of *M. rosenbergii* from Ramankari during 1961. Females shaded.

229 mm by April. This and the minor mode referred to above (221-240 mm) are the previous years' brood, perhaps the products of late and early breeding. They are the bigger modal groups at the lower centres like Ramankari and Kumarakom in May and June. As growth advances, the two groups merge and appear as a single mode in the catches of the next season—221–240 mm. mode of May and 261–280 mm. mode of July 1961 at Ramankari, 221-240 mm. mode in June at Kumarakom. The earlier brood of 1960—the 161–180 mm. group of Muriyayikara and Ramankari in May 1961 and the modal group of 181-200 mm. of June at Kumarakom and Ramankari—seem also to merge with the larger mode referred to above by the end of the season. Some of them also move up the river after August.

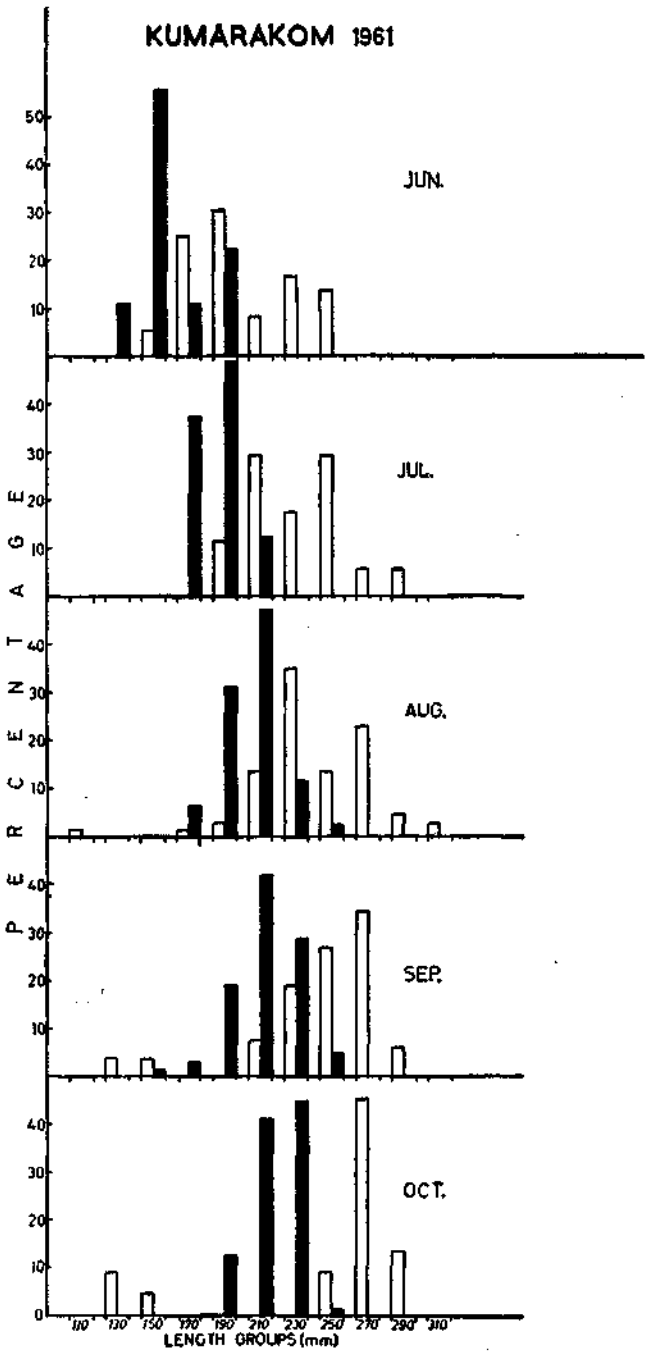

FIG. 5. Monthly frequency histograms of *M. rosenbergii* from Kumarakom during 1961. Females shaded.

TABLE IV

*Size range and dominant size groups * at Kumarakom and Ramankari for the years* 1960–1963

Months	1960		1961		1962		1963	
	Size range and (dominant size) in mm.		Size range and (dominant size) in mm.		Size range and (dominant size) in mm.		Size range and (dominant size) in mm.	
	♂	♀	♂	♀	♂	♀	♂	♀
At Kumarakom								
June ..	161–300 (221–240)	151–220 (161–180)	141–260 (181–200) and (221–240)	131–200 (141–160)	..	..	..	..
July ..	151–320 (201–220) and (241–260)	171–250 (181–200)	181–290 (201–220) and (241–260)	161–210 (181–200)	161–300 (261–280)	161–240 (181–200)	155–310 (201–260)	132–229 (181–200)
August ..	101–320 (221–240)	91–250 (201–220)	111–310 (221–240) and (261–280)	161–260 (201–220)	181–290 (261–280)	181–240 (201–220)	201–309 (241–260)	161–224 (201–220)
September ..	..	..	131–290 (261–280)	151–260 (201–220)	241–310 (281–300)	201–261 ..	195–304 (221–240)	191–250 (221–240)
October ..	121–320 (261–280)	171–260 (201–220)	131–300 (261–280)	191–250 (221–240)	131–310 (261–280)	201–262 (221–240)	..	..
November ..	..	..	..	..	261–310 (281–300)	221–260 (221–240)	..	..
At Ramankari								
March ..	..	..	101–300 (141–160)	111–150 (101–120)	..	..	..	..
April ...	..	..	111–200 (141–160)	111–170 (121–140)	..	...	91–260 (121–140)	91–180 (101–120)
May	121–280 (201–220)	111–180 (161–180)	131–290 (141–160, 161–180 and 221–240)	121–170 (121–140)	...	...	...	..
June ...	121–270 (181–200)	121–220 (141–160)	151–290 (181–200)	141–190 (141–160)	161–270 (161–180 and 201–220)	161–200 (181–200)	131–280 (201–220)	111–160 (141–160)
July ..	131–300 (201–220)	131–220 (161–180)	161–290 (201–220 and 261–280)	141–210 (161–180)	..	..	171–280 (221–240)	131–240 (181–200)
August ..	131–290 (221–240)	151–230 (181–200)	171–280 (201–220 and 241–260)	151–230 (181–200)	..	..	171–280 (221–240)	131–240 (181–200)
September ..	121–280 (241–260)	171–230 (181–200)	121–290 (141–160 and 261–280)	171–260 (221–240)	..	..	131–280 (241–260)	201–260 (201–220)
October ..	131–300 (261–280)	141–240 (201–220)	131–280 (141–160 and 261–280)	171–240 (201–220)	141–290 (261–280)	181–261 (221–240)	..	..
November ..	..	..	..	..	..	..	256–301 (261–280)	170–225

* Figure in parenthesis denote dominant size groups.

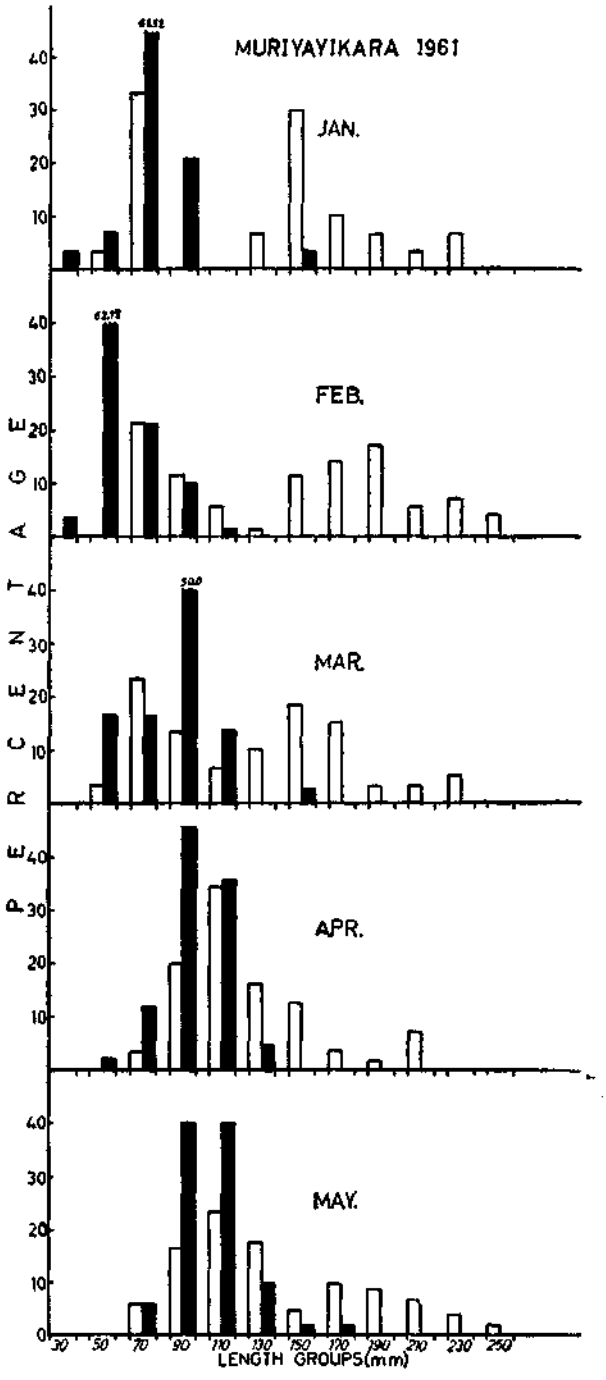

FIG. 6. Monthly frequency histogarms of *M. rosenbergii* from Muriyayikara during January–May 1961. Females shaded.

TABLE V

Percentage of various stages of maturity in males and females during the seasons 1960–1963, *at Ramankari*

Month	Male		Female				
	Immature	Mature	Immature	Maturing	Mature	Berried	Spent
1960							
May ..	3·7	96·3	90·0	10·0	..	Nil	Nil
June ..	5·3	94·7	42·7	54·6	2·7	,,	,,
July ..	2·0	98·0	23·6	55·1	21·3	,,	,,
August ..	3·4	96·6	10·3	67·0	22·7	,,	,,
September ..	14·6	85·4	16·3	35·0	30·9	17·9	,,
October ..	2·9	97·1	Nil	1·6	19·5	78·9	,,
1961							
March ..	21·9	78·1	100·0	Nil	Nil	Nil	,,
April ..	28·6	71·4	92·9	7·1	,,	,,	,,
May ..	17·0	83·0	92·9	7·1	,,	,,	,,
June ..	2·2	97·8	80·0	20·0	,,	,,	,,
July	2·6	97·4	54·2	44·4	1·4	,,	,,
August ..	Nil	100·0	24·1	37·9	37·9	,,	,,
September ..	8·3	91·7	Nil	11·5	46·2	42·3	,,
October ..	24·0	76·0	,,	Nil	40·8	59·2	,,
1962							
June ..	6·8	93·2	92·6	7·4	Nil	Nil	,,
October ..	3·0	97·0	Nil	Nil	22·8	77·1	,,
1963							
April ..	60·6	39·4	100·0	,,	Nil	Nil	,,
June ..	13·7	86·3	97·8	2·2	,,	,,	,,
July ..	Nil	100·0	36·1	59·0	4·8	,,	,,
August ..	,,	100·0	6·2	71·6	22·2	,,	,,
September ..	3·3	86·7	Nil	33·3	66·7	,,	,,
November ..	Nil	100·0	,,	Nil	Nil	100·0	,,

The males entering the fishery consist of a number of groups moving down the river in several batches beginning from March. As seen in the samples from Muriyayikara (Fig. 6) they are (1) the early brood of 1960 season (141–160 mm. mode of January), (2) the later brood of 1960 (61–80 mm. group of January) and (3) those which survived from the previous year's brood (181–200 mm. group of February and 201–220 mm. group of April and 221–240 mm. group of January, February and March). The former may be traced back to the mode at 121–140 mm. or 151–160 mm. seen at the fishing centres during the close of the fishing season and the latter is a continuation of the size groups similar to the 201–220 mm. mode of August 1961 at Ramankari. The minor mode appearing at 121–140 mm. or 141–160 mm. during September–November at the centres are to be traced back to the 101–120 mm. group of May at Muriyayikara (Fig. 6). Some of them are perhaps remaining upstream and probably coming down only late in the season by August–September. The growth during the time June to August seems to be rather slow (30 mm. in 3–4 months). Later in December a modal group appears at 161–180 mm. at Pulikizh (Table VIII). 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

TABLE VI

Percentage of various stages of maturity in males and females during the seasons 1960–1963 *at Kumarakom*

Month	Male		Female				
	Immature	Mature	Immature	Maturing	Mature	Berried	Spent
1960							
June	.. ..	100·0	52·8	41·4	5·8	..	..
July	.. 0·9	99·1	21·8	50·4	27·7	..	..
August	.. 3·9	96·1	3·1	51·6	44·3	1·0	..
October	.. 5·6	94·4	1·1	1·7	14·5	58·7	24·0
November	.. ..	100·0	..	..	..	100·0	..
1961							
June	1·5	98·5	64·3	35·7	..	..	..
July	.. ..	100·0	27·3	67·3	5·5	..	..
August	.. 1·5	98·5	13·2	31·6	52·6	2·6	..
September	.. 7·7	92·3	..	12·9	58·1	17·7	11·3
October	.. 13·6	86·4	..	..	11·3	76·3	12·5
November	.. 5·3	94·7	..	..	..	42·0	58·0
1962							
July	.. ..	100·0	40·7	51·9	7·4	..	..
August	.. ..	100·0	6·3	56·3	37·5	..	..
September	.. ..	100·0	..	20·0	80·0	..	..
October	.. 5·9	94·1	..	..	0·7	70·8	28·5
November	.. ..	100·0	..	..	..	72·7	27·3
1963							
July	.. 5·1	94·9	45·9	41·4	32·7	..	..
August	.. 1·2	98·8	4·3	29·2	66·2	..	..
September	.. ..	100·0	..	..	70·0	25·0	5·0

quantities of food. Mary John (*op. cit*). observed large quantities of paddy in the stomachs of the species during this time.

The 0-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 to 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 larger 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.

When the fishery starts in March in 1961 at Ramankari the modal size among females is at 101–120 mm. This moves over to 141–160 mm. by June. At Kumarakom the mode is at 141–160 mm. when the fishery starts in June. This shifts to 201–220 mm. by September–October at both the centres. In November when samples could be obtained this mode is found at 221–240 mm. Thus in one year the females grow to a size of about 180–200 mm. The maximum sizes noted are in the 241–260 mm. group, but very rarely above 260 mm. The latter may probably be more than one year old. So it is evident that as far as the females are concerned the fishery is based largely on the first year group only. The small females do not remain upstream as in the case of males and

so there is no minor mode at a smaller size in September–November. Perhaps, no female returns upstream after the breeding season for completing a second year of life.

TABLE VII

Size range and dominant size groups in mm. at the five points along the Pampa river where experimental fishing was conducted during December–May*

Month	Pallathuruth		Ramankari		Pulikizh		Aranmula		Ranni	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
December	141–307	177–227	Nil	Nil	166–295 (161–180)	Nil	Nil	Nil	114–212 (161–180)	Nil
January	Nil	Nil	194–204	Nil	148–281	Nil	141–200 (141–160)	Nil	168–200	Nil
February	Nil	Nil	106–242	Nil	150–259 (161–180)	79– 90	Nil	Nil	Nil	Nil
March	Nil	Nil	126–231	Nil	86–240 (161–180)	97	Nil	Nil	146–196 (161–180)	Nil
April	141–218	Nil	Nil	Nil	100–232 (121–140 and 161–180)	73–132 (101–120)	Nil	Nil	185	Nil
May	74	87–105	Nil	Nil	121–214	96–145 (121–140) (121–140)	156–218 (201–220) (161–180)	143 and	143–216 (161–180) (201–220)	156
	Sex Ratio (numbers)									
December	12	3	..	..	7	Nil	...	...	12	Nil
January	..	..	2	Nil	7	Nil	9	Nil	2	Nil
February	..	..	10	Nil	33	2	...	...	...	..
March	..	..	12	Nil	30	1	...	..	6	Nil
April	..	2	Nil	..	..	28	14	...	...	1	Nil
May	..	1	3	..	..	10	8	5	1	13	1

* Figures in parenthesis denote dominant size groups.

The females occurring at the fishing centre east of Pulikizh in January range between 21 and 90 mm. with a mode at 61–80 mm. In February a new modal group appears at 41–60 mm. evidently due to fresh recruitment. In March however, there is only one mode at 81–100 mm. From February onwards there seems to be a movement among females. Those reaching 100 mm. or above are moving away from these areas. The evidence is more in favour of a movement down to the backwaters where they seem to grow faster. At Muriyayikara for instance the mode at 81–100 mm. in March continues through May, but at Pulincunnu a centre down the river near the Vembanad lake in April the mode among females was at 121–140 mm. showing a downward migration of larger specimens and faster growth in brackish water. During the same month a sample from Pulikizh shows the modal size as 101–120 mm. (Table VIII) showing a downward migration of larger females. The continuation of the mode at 81–100 mm. in April and May at Muriyayikara may probably be due to growth among the smaller groups and migration of larger ones away from the area. It is due to this migration that the earlier broods of the season are not seen among females

TABLE VIII

Size frequency distribution (numbers) of samples obtained during experimental fishing

Size groups	Pulikizh											Ranni						
	Nov.	Dec.	Jan.	Feb.		Mar.		Apr.		May		Dec.	Jan.	Feb.	Mar.	Apr.	May	
	♂	♂	♂	♂	♀	♂	♀	♂	♀	♂	♀	♂	♂	♂	♂	♂	♂	♀
71–80	..	..		..	1			..	1	..								
81–100	..	..		..	1	1	1	1	2	..	1							
101–120	..	..		..	..	4	..	3	7	..	2	2	..	..	..	..	..	..
121–140	..	..		..	..	6	..	8	2	3	3	1	..	..	..	..	..	..
141–160	..	..	2	2	..	6	..	5	..	..	2	2	..	..	3	..	2	1
161–180	1	4	1	10	..	11	..	6	..	3	..	6	1	..	2	..	7	..
181–200	1	1	2	9	..	1	..	3	..	..	..	..	1	..	1	1	2	..
201–220	..	1	..	8	..	1	..	1	..	4	..	1	..	..	..	..	2	..
221–240	..	1	..	2	..	1	..	1	..	..	..							
241–260	1	..	1	2	..	..	..	..	..	..	..							
261–280	..	..	..	..	..	..	..	..	..	..	..							
281–300	..	..	1	..	..	..	..	..	..	..	..							

at Muriyayikara. However, a very small group at 141–160 mm. found in January and March probably belong to this group. Down the river and in the backwater these two groups grow side by side and by the time they enter the fishery they seem to merge so that there is only one mode in the frequency histogram.

MATURITY AND BREEDING

The ovaries of most of the specimens are narrow transparent or whitish strands when the fishery starts in June–July. In August they begin to develop gradually when yellow dots 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 even without removing the carapace. Just before the extrusion of the eggs the mature individuals are easily recognisable by their bulging abdominal pleura and the development of feathery hairs on the basipodites of the pleopods. The eggs when extruded get attached to them with the help of a sticky substance. The fringes of the pleopods are blue or violet in colour during this period. Spent specimens are seen with mud-coated pleopods and hairs with remnants of egg membranes. In most of the berried and spent specimens ovaries are found to regenerate and in some spent specimens mature and maturing ovaries are observed thereby showing the possibility of breeding more than once in the same season. This is in agreement with the laboratory observations of Ling and Merican (*op. cit.*). Eggs are bright orange in colour when they are first noticed on the pleopods turning grey as the development advances. In grey eggs the developing embryo could be easily made out.

When the fishery starts in May–June practically all the females obtained are either immature or maturing. Mature females generally begin to appear in the catches from July onwards (Tables V and VI). Thereafter their percentage increases and by October most of them are either mature

or berried. The testes are well developed in most of the specimens. Fully grown sperimatozoa are observed in specimens measuring 150 mm. The percentage of mature males is never less than 85 in any month (Tables V and VI).

Although berried specimens are caught in the fishery sporadically from various centres in late July and early August in some years they become common only in September when about 20% of the females are berried. Their percentage increases in October and November. In December also berried ones are caught, but the total number of females with or without eggs becomes much reduced during this month. Spent specimens occur in September, their percentage being about 10. This also increases in the subsequent months. It is thus evident that the breeding period extends from August to December with a peak in October–November. Spent specimens are seen only at the backwater centre—Kumarakom—but they are very rare at Ramankari which is a river centre. At a point near the opening of the Pampa river into the backwater (Pallathuruth) the same phenomenon has been noticed. The species therefore seem to prefer backwaters for hatching of eggs. This conclusion is also supported by the presence of large numbers of larvae in the backwaters during the breeding period. Grey coloured berries are very common at Kumarakom and other backwater centres, whereas the berries of almost all caught from the freshwater centres along the Pampa river are orange-coloured. It is therefore clear that later stages of development leading to hatching are passed through only in brackish-water environment. This is in agreement with the observations of Mary John (*op. cit.*).

Rajyalakshmi (*op. cit.*) has observed the breeding period of the species in the river Hooghly as December to July with a peak in March–May. This period follows the north-east monsoon which exerts pronounced influence on the physical features of the area. It is interesting to note that the breeding period of the same species observed during the present study also follows the predominant monsoon of the area, *viz.*, south-west monsoon. The number of eggs carried by a berried individual varies with length. In the present study it varied from 5,03,000 in a specimen measureing 181 mm. to 1,39,600 in one of 229 mm. However, fully mature ovary of a larger specimen (241 mm.) was found to contain 2,28,850 eggs. According to Chacko (*op. cit.*) the number of eggs extruded at a time varies from 1,00,000 to 1,60,000 depending on the size of the female and Rajyalakshmi (*op. cit.*) has estimated the maximum number of eggs extruded by a female as 1,11,400 at 200 mm. total length and the minimum 7,000 eggs at 136 mm. total length.

Larvae and Juveniles

From September onwards good numbers of the larvae of the species are seen in surface plankton hauls taken from Pallathuruth and Kumarakom, the backwater centres, but are very rare in collections from Ramankari. In late October and November they are obtained from the Cochin backwaters also in large numbers. Berried and spent specimens are also caught from this area. The plankton collections made during the course of the present investigations seem to indicate that only the first larval stage described (Menon, *op. cit.*) is a surface dweller. The second stage is only very rarely noticed in the plankton. Does it imply that after the first stage the larvae abandon their planktonic habit and sink? The present author has observed while rearing the first larval stage in the laboratory that after the first moult and transformation into the second stage the larvae sink to the bottom of the container and continue to swim about there. The above inference seems to be justified in the light of this observation. At this stage the larva is found to be very voracious eating its own moult and even other larvae. Attempts to collect the later larval stages from the surface or bottom have not succeeded. Rearing experiments were also unsuccessful since the second stage did not survive long enough to moult into the next. It has however been reported from Singapore (Ling and Merican, *op. cit.*) that the larvae thrive well in a mixture of sea-water and fresh water. This probably shows that the larvae stay on in the backwaters until they reach about 10 or 15 mm. length. The smallest juvenile caught from up the Pampa river in February measured 21 mm. So after completing the larval 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 Pampa. The specially designed sledge trawl when operated did not catch any juvenile of this species although other prawns of the same size were caught. The juveniles of *M. rosenbergii* are caught mostly in the *peru vala* a sort of shore seine operated in the rivers, which are dragged along from the middle of the stream and is hauled up towards the shore. In April 1960 one specimen of the species measureing 34 mm. was obtained in an improvised bottom net operated in a narrow channel east of Ramankari. It would therefore appear that the juveniles prefer to remain close to the banks of the rivers and channels hiding in holes and crevices and among submerged plants and seldom come to the middle of the stream. This is confirmed by actual observation on several occasions in such places from where they were caught with the help of a piece of cloth or with bare hands. As has already been reported (Raman, 1964) during the summer months the juveniles are seen concentrating in the deeper areas of the river near Pulikizh. They come down the river and enter the backwaters with the onset of the monsoon.

Sex Ratio

When the fishery starts in May or June at the various centres the males far outnumber the females. In 1961 when the fishery commenced early in March at Ramankari the females were in a minority up to June–July (Table IX). From August onwards females predominated and this condition prevailed in September and October as well. In November males once again become more numerous at this centre. At Kumarakom also the same trend was observed with the difference that the preponderance of males at the end of the season was not observed here.

Table IX

Sex ratio of the catches from Kumarakom and Ramankari during 1960–1963

Months	1960		1961		1962		1963	
	♂	♀	♂	♀	♂	♀	♂	♀
Kumarakom								
June	69·2	30·8	80·0	20·0	...	...	...	...
July	69·9	30·1	68·0	32·0	62·5	37·5	53·3	46·7
August	48·4	51·6	46·1	53·9	40·7	59·3	49·5	50·5
September	..	..	29·5	70·5	66·7	33·3	29·7	70·3
October	16·7	83·3	21·6	78·4	28·6	71·4	..	..
November	53·3	46·7	..	..	50·0	50·0	..	..
December	44·9	55·1	..	..	..	..	..	..
Ramankari								
March	..	..	95·0	5·0	...	...	...	...
April	..	..	89·4	10·6	...	...	67·4	32·6
May	97·2	2·8	85·9	14·1	...	..	..	..
June	67·8	32·2	90·0	10·0	73·1	26·9	60·9	39·1
July	65·8	34·2	51·4	48·6	...	..	41·8	58·2
August	50·6	49·4	35·6	64·4	...	...	23·6	76·4
September	54·3	45·7	31·6	68·4	...	...	41·7	58·3
October	52·9	47·1	29·8	70·2	48·5	51·5	..	..
November	..	..	..	..	...	...	70·0	30·0

Movements

The second dominance of males at Ramankari may be the result of the downward migration of females to the backwaters. The continued dominance of females at the backwater centres even in November and December indicate this. From September onwards males belonging to size groups between 150 and 250 mm. become very rare at the backwater centres. This may be partly due to the effect of continued fishing and partly due to a movement up the river. These sizes are caught from the centres up the river from November-December onwards (Table VII). During the monsoon months and up to September the species seems to be absent from all the centres above Pulikizh. At Pulikizh during the monsoon time also specimens are available. They are caught during experimental fishing in September and October. From November onwards some of the males belonging to the previous year's brood seem to be slowly moving upstream and by December they are available at all the centres in the upper reaches of the river. A few are usually caught from Pulikizh and Ranni in almost all the off-season months (Table VIII). It may be seen that the 150 mm. and 210 mm. groups among males which are moving up the river are represented in the catches of both these centres. Both sexes of the 0-year class are obtained at Pulikizh, but at Ranni males alone are met with. The latter sex seems to be more erratic in their movements and have a wider distribution. Perhaps, they are able to tolerate a wider range of ecological variations. They are present at all points along the Pampa during December to February. In March when the salinity goes up (even up to 18‰) some specimens are caught from the backwater centre at the river mouth. From April, however, they become very rare at the lowest centres. Later, in May with the first monsoon showers they are again available at these centres, most of the males caught ranging between 100 mm. and 160 mm.

The females on the other hand go up the river at the early juvenile stage and there seems to be a return movement from February onwards. Until then they are available only near Pulikizh. After reaching about 100 mm. they seem to be moving away from this area and are caught along with male specimens during March and April from certain centres in the river nearer to the backwaters. In May very few females are caught from the eastern centres Aranmula and Ranni. This was immediately after the first pre-monsoon showers. Perhaps, some of them may be going further up beyond Pulikizh area. With the onset of the monsoon all these are swept down into the extensive paddy fields and canals of Kuttanad and thence to the Vembanad lake.

Food and Feeding

M. rosenbergii is a bottom feeder and an omnivore. Detailed analysis of stomach contents was not attempted because all the specimens from the commercial fishery being caught with baits had stomachs filled with tapioca or coconut as the case may be. However, a few stomachs from the drag net catches were examined and were found to contain bottom debris and mud with large quantities of decaying organic matter. Fish scales and remnants of fish were met with in a few instances. The former may be accidentally swallowed along with the detritus from the bottom but the latter shows that the species eats fish and other organisms if obtained. Mary John (*op. cit.*) has also reported an omnivorous food habit for the species.

Moulting

To follow the moulting periodicity, the method used by Menon (1952) and George (1959) was tried. It is found that moulting takes place at irregular intervals—roughly one moulting for every 10 mm. of growth. The size frequency of soft individuals also supports this. Many of the freshly berried individuals are found to have just moulted. Perhaps, they are moulting prior to the extrusion of eggs as observed by Allen (1960) in the case of *Crangon allmani* Kinahan.

TOTAL LENGTH-CARAPACE LENGTH RELATIONSHIP

The total lengths (X) and carapace lengths (Y) of the two sexes were plotted to find out their relationships (Fig. 7). It is found that these body measurements have a straight line relationship.

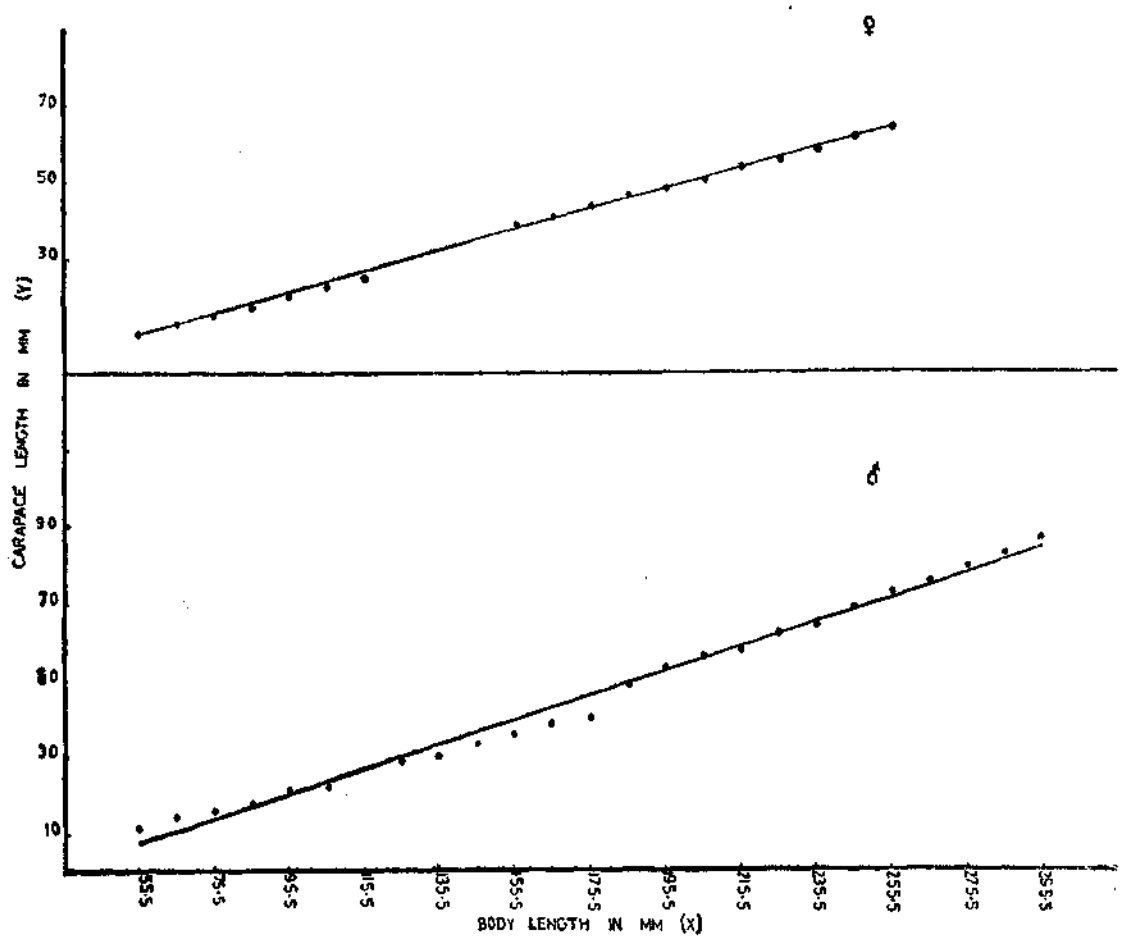

FIG. 7. Body length (X), carapace length (Y) relationship of male and female
——— Calculated line. . . . . Observed values.

The regression lines fitted by the method of least squares are as follows:

$$\left.\begin{aligned} Y &= 0{\cdot}32281\,X - 10{\cdot}81851 \\ X &= 3{\cdot}06401\,Y - 35{\cdot}08947 \end{aligned}\right\} \text{ Males}$$

$$\left.\begin{aligned} Y &= 0{\cdot}27892\,X - 5{\cdot}67957 \\ X &= 3{\cdot}58076\,Y - 20{\cdot}53643 \end{aligned}\right\} \text{ Females}$$

The coefficients of correlation "r" between the two lengths were found to be 0·99483 and 0·99983 for males and females respectively indicating the high relationship between the two quantities.

Discussion

The observations recorded indicate the probability of this species having a rather long breeding period extending over 6 months from July to December. The peak of the breeding activity is observed in October–November. Berried specimens are caught from Ramankari and Pulikizh during these months. All of them had orange-coloured eggs and it seems that they all come down to the brackish-water areas by the time the eggs turn grey and hatch out. Towards the end of the season even very small females are found to be berried. After spawning once at the peak of the breeding period for earlier those that are left uncaught are likely to remain in the backwaters and spawn again. There are indications of this in a second peak of availability of berried specimens in November in certain years. Fresh recruitments of juveniles arriving at the upper reaches even up to February–March also seem to support this view. Moreover spent and berried specimens are found to have well-developed ovaries even in November. Ling and Merican (*op. cit.*) suggest the possibility of two or more spawnings in the same season.

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‰ indicating that increased salinity alone is not the inducing factor for them to move up the river. Probably temperature may be an important factor influencing their movements. Mary John (*op. cit.*) has observed that the optimum temperature for its normal activity is from 29° to 34° C. When summer heat increases they are perhaps going up the rivers and remaining in deeper basins of the river systems. At these places the bottom is slushy with plenty of organic detritus which is their favourite food. When it rains occasionally during the dry months large numbers of them come down to the backwater regions. These up and down migrations of the species could be studied with more accuracy only by conducting mark recovery experiments.

The species is a fast growing one, females attaining 180–200 mm. in one year. In the case of males the modal size at 141–160 mm. when the fishery starts in March at Ramankari moves to 161–180 mm. by May after which the 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 and a few males which probably remain upstream during the early monsoon months come down only in September–October. They are stunted in their growth because of their longer sojourn at the upper river centres. These and a few of the others before reaching 270 mm. (modal group at the end of the season) return to the rivers by November and come down along with the next year's brood. They show modes at 230 mm. in May, 250 mm. in June and 270 mm. in July at Ramankari. Thus a good number of males are surviving for a second year, whereas in the case of females such a second year group is missing. Early in the season at all centres and towards the end of the season at the upper centres males are more in the catches. In the total fishery also the males are in a majority as could be expected from the presence of one and two-year old specimens among them. As mentioned in a previous section a part of the variations in sex ratio would seem to be related to these movements.

M. rosenbergii is a comparatively slow-moving species. Since it is being subjected to fishing at different stages of its life there is a likelihood of the stock becoming depleted at some time or other. Mary John (*op. cit.*) has pointed out this possibility and emphasised the need for the protection of the breeders. Though such an alarming tendency is not observed at present as shown by the catch per unit of effort data, it is quite essential to keep a close watch on the fishery in the years to come. A self-imposed closed season during October—November 1963 by the freezing industry is a welcome trial the results of which could be assessed in later years only.

It is feared that destruction of fry by small meshed nets like *peru vala* and *koru vala* in the upper reaches of the rivers during the summer months might adversely affect the prawn stocks at least in the long run. Gunter (1956) has stressed the need for protecting nursery areas.

It is also reported that while using copper sulphate for catching the riverine fishes by poisoning in the upper reaches of the rivers, good numbers of small prawns are also seen dying. A number of them might also be the juveniles of *M. rosenbergii*. Hence a closed season tried along with some measures for protecting the nursery areas during summer months may bring about the desired effect on the fishery.

Being a fast-growing species *M. rosenbergii* is an ideal prawn for culture. Naidu (1939) in a report on a survey of the fisheries of Bengal has stressed the importance of the freshwater lobster (*Palaemon*) and suggested that artificial hatcheries of the species may be of great value in augmenting the fisheries. Mary John (*op. cit.*) has suggested the establishment of hatcheries or sanctuaries for protecting berried females and young ones for conserving and developing the fisheries. Ling's studies in Malaya are aimed at making rearing of the species a profitable proposition. Further detailed studies would be necessary before undertaking culture of these prawns on a commercial basis.

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