

OBSERVATION ON THE FISHERY AND BIOLOGY OF PENAEID PRAWNS FROM GODAVARI ESTUARY

S. LALITHA DEVI

Kakinada Research Centre of CMFRI, Kakinada - 533 002

ABSTRACT

The Godavari estuarine system of Andhra Pradesh supports a round the year penaeid prawn fishery. The annual average penaeid prawn landings at Matlapalem, B. V. Palem and P.G. Moga landing centres was 806.3 t, during 1979-'83 with peak catches during October-December. Twenty three species of penaeid prawns contribute to the fishery of which *M. monoceros*, *P. indicus*, *M. dobsoni*, *P. monodon*, *M. brevicornis*, *P. semisulcatus*, *P. merguensis* and *P. japonicus* are important in the order of abundance. Variations in the seasonal abundance of the constituent species between years and between the landing centres were noticed. Prawns in the length range of 40-100 mm (2-4 months old) formed bulk of the catch. A growth rate of 16-18 mm/month in *M. monoceros* 27.5-32.5 mm/month in *P. indicus* and 32.5-37.5 mm/month in *P. monodon* was discernible. In most of the species female dominated in almost all the months and also in the larger length groups. The species composition in the Godavari estuary during December and February-May was similar to that obtained in the marine catches landed at Kakinada Fisheries Harbour. This may be due to the existence of somewhat marine conditions (physico-chemical) in the estuary in those months.

INTRODUCTION

The Godavari estuarine system of Andhra Pradesh covering an area of 330 sq. km, supports a lucrative prawn fishery. Subrahmanyam (1965, 1967, 1973) and Ganapati and Subrahmanyam (1966) made preliminary study of the prawn fishery of this area. Rao (1975) dealt with the prawn fishery of the Kakinada backwaters based on the data collected from Boddu Venkatayapalem during 1968-'73. Except for the studies on biology of *Metapenaeus monoceros* and *Penaeus monodon* by Subrahmanyam (1973) and Subrahmanyam and Ganapati (1975) there is no information on the biology of the other penaeid prawns from this estuary. The results of a study conducted during 1979-'83 at Matlapalem and Pedagadimoga, and during 1979-'84 at Bodduvenkatayapalem landing centres are presented here.

MATERIAL AND METHODS

Weekly observations were made at Matlapalem, B.V. Palem and P. Gadimoga landing centres (Fig. 1). The craft and gear have been described by Ramamurthy and Muthu (1969). The data on effort, catch and species composition collected on each observation day based on random sampling of fishing units were raised to get the day's and the month's estimates. Total length (from tip of rostrum to the tip of telson) was measured to the nearest mm. The length data were grouped into 5 mm class intervals. The length composition and sex ratio of the species landed by different gears at the three landing centres were pooled, as there were no differences. For brevity, the data on the seasonal abundance of various species during different years were also pooled. Prawns in the length of 35 mm and above were considered for sex ratio and growth studies.

A total of 19912 specimens of *Metapenaeus monoceros*, 3396 *M. brevicornis*, 3511 *M. dobsoni*, 1507 *Penaeus japonicus*, 5094 *P. indicus*, 9023 *P. monodon*, 2621 *P. semisulcatus* and 2215 *P. merguensis* were studied for sex ratio.

Water samples were collected twice in a month during 1979-'80 from B.V. Palem to study salinity, temperature, dissolved oxygen content and pH. Salinity of the water was estimated by Mohr's titration method, dissolved oxygen by Winkler's method and pH by insitu pH meter.

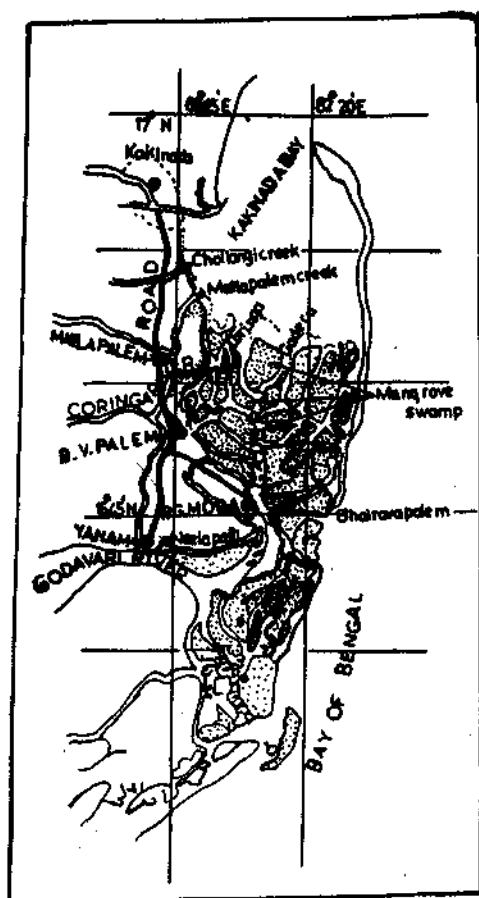


FIG. 1. Map showing the Godavari estuary.

THE ENVIRONMENT

Kakinada backwaters extend from lat. $16^{\circ} 45' - 55' N$ and longitude $82^{\circ} 15' - 21' E$; the entire area is full of mangrove mudflats, traversed by a network of tidal creeks which open into the Kakinada bay. The depth in most of these creeks is below 3 m; the sediment is muddy and rich in detritus and bottom fauna. Fishing is carried out in the lower reaches of these creeks. The ecology of the Godavari estuarine system (of which the Kakinada bay, the Coringa and Gaderu rivers form major components) has been studied by Ganapati and Ramasarma (1965), Ramasarma and Ganapati (1968 and 1971) and Rao *et al.* (1972). The description of the Kakinada backwaters has been given by Rao (1975).

During the southwest monsoon (July-September) the water level rises in all the regions of the estuary owing to the influx of freshwater from the upper reaches of the estuary.

SPECIES COMPOSITION

Twenty three species of penaeid prawns have been reported from the Godavari estuary (Muthu, 1969; Rao, 1975). Among them, nine species viz, *M. monoceros*, *M. dobsoni*, *M. brevicornis*, *M. affinis*, *P. indicus*, *P. monodon*, *P. merguensis*, *P. semisulcatus* and *P. japonicus* contribute to the fishery in commercial quantities. Other species viz, *Parapenaeopsis sculptilis*, *P. indica*, *P. cornuta*, *P. stylifera*, *P. probata*, *Solenocera crassicornis* and *Metapenaeopsis* sp. also occur in the catches, mostly during December and February-May.

FISHERY AND BIOLOGY

At the three landing centres, considerable monthly and annual variations in the total catch and species of penaeid prawns were observed. (Figs. 2 and 3, Tables 1-3).

Matlapalem: During the five year period, the penaeid prawn landings amounted to 536.3 t, accounting for 80.1% of the total

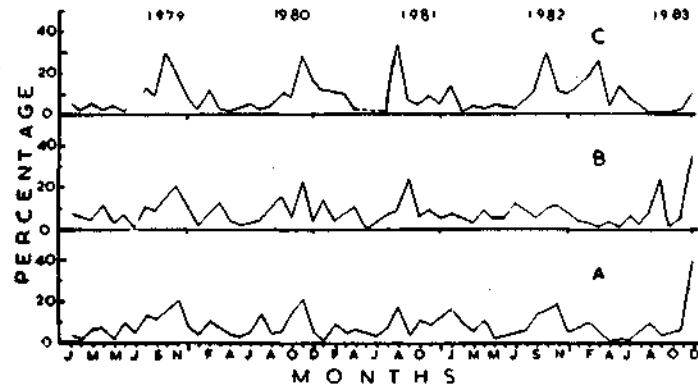


FIG. 2. Seasonal abundance of penaeid prawns at the three landing centres. a. Matlapalem, b. B.V. Palem, c. P. Gadimoga.

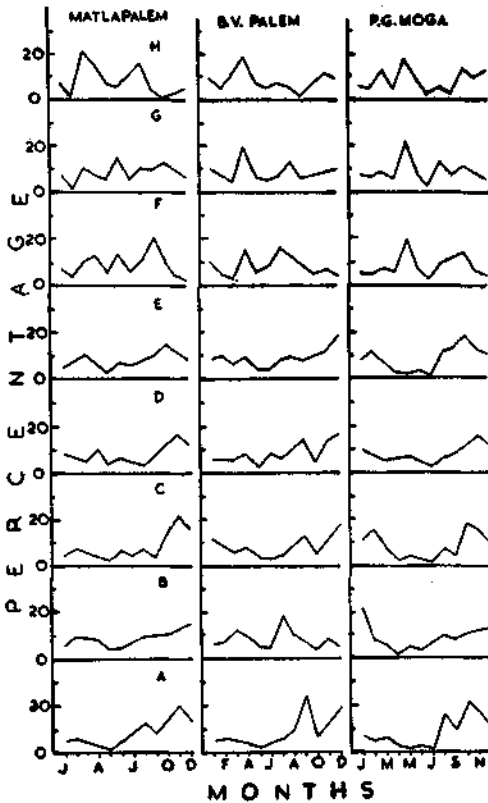


FIG. 3. Seasonal abundance of the species at the three landing centres. a. *M. monoceros*; b. *M. brevicornis*; c. *M. dobsoni*; d. *P. indicus*; e. *P. monodon*; f. *P. semisulcatus*; g. *P. merguensis*; h. *P. japonicus*.

prawn landings and 71.7% of the total fish landings (Table 1). The penaeid prawn catch per unit of dragnets and stakenets was 10.3 and 20.3 kg respectively.

In general, penaeid prawns were landed in fairly good quantities during October–December with peak in November. *M. monoceros* formed 66.5%, *P. indicus* 9.7%, *M. dobsoni* 8.3%, *P. monodon* 6.9%, *M. brevicornis* 2.4%, *M. lysianassa* 2.1%, *P. merguensis* 1.2%, *M. affinis* 1.1% and *P. semisulcatus* 0.8% of the penaeid prawn catch.

B.V. Palem: During 1979–84, a total of 2860.9 t of penaeid prawns were landed by dragnets and stakenets, accounting for 83.9% of the total prawn landings and 76.7% of the total fish landings. The catch rates of penaeid prawns by dragnets and stakenets are 12.8 kg and 24.2 kg per unit respectively (Table 2).

The landings were good during September–December with peak catches in September and December. *M. monoceros* formed 56.5%, *P. indicus* 10.9%, *P. monodon* 8.6%, *M. dobsoni* 8.5%, *M. brevicornis* 4.4%, *P. semisulcatus* 3.6%, *P. merguensis* 1.7%, *P. japonicus* 1.3%, *M. lysianassa* 1.2%, *M. affinis* 1.1% and *P. sculptilis* 0.8% in the penaeid prawn catch.

FISHERY AND BIOLOGY OF PENAEID PRAWNS

TABLE 1. *Penaeid* prawn landings for five years (1979-'83 and annual average) at Matlapalem (catch in tonnes, units in 1,000, effort in 1,000 hrs and CPUE in kg)

Species	Catch for 5 years			Annual average	
	Drag net	Stake net	Total	Drag net	Stake net
<i>M. monoceros</i>	196.8	159.8	356.6	39.4	32.0
<i>M. affinis</i>	3.9	1.9	5.8	0.8	0.4
<i>M. dobsoni</i>	22.9	21.9	44.8	4.6	4.4
<i>M. brevicornis</i>	7.8	4.9	12.7	1.6	1.0
<i>M. lysianassa</i>	5.9	5.4	11.3	1.2	1.1
<i>P. indicus</i>	31.9	19.7	51.6	6.4	3.9
<i>P. monodon</i>	24.7	12.3	37.0	5.0	2.5
<i>P. semisulcatus</i>	3.1	1.3	4.4	0.6	0.3
<i>P. merguensis</i>	4.0	2.6	6.6	0.8	0.5
<i>P. japonicus</i>	1.0	0.5	1.5	0.2	0.1
Other penaeid prawns	3.0	1.0	4.0	0.6	0.2
Total catch of penaeids	305.0	231.3	536.3	61.0	46.3
Total prawn catch	381.1	280.6	669.7	77.8	56.1
Total trawl catch	448.1	299.9	748.0	89.6	60.0
Units	29.6	11.4	41.0	5.9	2.3
Effort	353.1	74.7	427.8	70.6	14.9
CPUE of penaeids	10.3	20.3	13.1	—	—

TABLE 2. *Penaeid* prawn landings for six years (1979-'84 and annual average) at B.V. Palem (catch in tonnes, units in 1,000, effort in 1,000 hrs. and CPUE in kg)

Species	Catch for 6 years			Annual average	
	Drag net	Stake net	Total	Drag net	Stake net
<i>M. monoceros</i>	981.4	634.6	1,616.0	163.6	105.8
<i>M. affinis</i>	22.4	9.5	31.9	3.7	1.6
<i>M. dobsoni</i>	143.7	99.1	242.8	24.0	16.5
<i>M. brevicornis</i>	93.0	31.4	124.4	15.5	5.2
<i>M. lysianassa</i>	26.7	7.6	34.3	4.5	1.3
<i>P. indicus</i>	231.2	80.7	311.9	38.5	13.5
<i>P. monodon</i>	186.0	59.8	245.8	31.0	10.0
<i>P. semisulcatus</i>	78.6	25.6	104.2	13.1	4.3
<i>P. merguensis</i>	37.2	12.4	49.6	6.2	2.1
<i>P. japonicus</i>	27.2	9.3	36.5	4.5	1.6
Other penaeid prawns	45.4	18.1	63.5	7.6	3.0
Total catch of penaeids	1,872.8	988.1	2,860.9	312.1	164.7
Total prawn catch	2,294.0	1,117.3	3,411.3	382.3	186.2
Total trawl catch	2,533.3	1,196.5	3,729.8	422.2	199.4
Units	146.8	40.9	187.7	24.5	6.8
Effort	1,749.0	248.3	1,997.3	291.5	41.4
CPUE of penaeids	12.75	24.16	15.24	—	—

TABLE 3. *Penaeid prawn landings for five years (1979-'83 and annual average) at Padagadimoga (catch in tonnes, units in 1,000, effort in 1,000 hrs and CPUE in kg.)*

Species	Catch for 5 years			Annual average	
	Drag net	Stake net	Total	Drag net	Stake net
<i>M. monoceros</i>	468.0	252.9	720.9	93.6	50.6
<i>M. affinis</i>	8.9	2.8	11.7	1.8	0.6
<i>M. dobsoni</i>	49.8	36.8	86.6	10.0	7.4
<i>M. brevicornis</i>	11.9	5.3	17.2	2.4	1.1
<i>M. lysianassa</i>	23.7	6.2	29.9	4.7	1.2
<i>P. indicus</i>	75.8	26.9	102.7	15.2	5.4
<i>P. monodon</i>	61.7	20.6	82.3	12.3	4.1
<i>P. semisulcatus</i>	14.1	3.8	17.9	2.8	0.8
<i>P. merguensis</i>	17.3	5.4	22.7	3.5	1.1
<i>P. japonicus</i>	6.3	1.4	7.7	1.3	0.3
Other penaeid prawns	8.0	3.4	11.4	1.6	0.7
Total catch of penaeids	745.5	365.5	1,111.0	149.1	73.1
Total prawn catch	928.5	442.9	1,371.4	185.5	88.6
Total trawl catch	1,032.2	470.9	1,503.1	206.4	94.2
Units	55.9	18.8	74.7	11.2	3.8
Effort	694.0	112.3	806.3	138.8	22.5
CPUE of penaeids	13.33	19.44	14.87	—	—

Padagadimoga: A total of 1,111.0 t of penaeid prawns were landed accounting for 81.0% of total prawn landings and 73.9% of the total fish landings, with a catch rate of 13.3 kg per unit by dragnets and 19.4 kg by stakenets during 1979-'83 (Table 3).

The catches were considerable during August-January with a peak in October. The contribution by *M. monoceros*, was 64.9%, *P. indicus* 9.2%, *M. dobsoni* 7.8%, *P. monodon* 7.4%, *M. brevicornis* 2.7%, *P. merguensis* 2.0%, *P. semisulcatus* 1.6% and *M. lysianassa* 1.5%.

Species-wise details

M. monoceros: The landings amounted to 2,693.5 t, at the three landing centres, accounting for 59.7% of the penaeid prawn landings. In general, the landings were good during September-December, with a peak in September and December. The overall length ranged from 16-122 mm and that of males and females from 35-102 mm and 35-122 mm respectively. The bulk of the catch was in the length range of 42-72 mm.

Prawns measuring 16-25 mm occurred throughout the year, thereby indicating that this species spawns throughout the year, and that recruitment of juveniles into the backwaters is continuous.

As the prawns remain in the backwaters for a short period, the modal progression from the length frequency data (Fig. 4) for any particular mode could not be traced for more than 4 months. By connecting various modes in different months, the monthly growth rate in females and males of 30-50 mm length was calculated at 15-18 mm and 16.0-17.5 mm respectively.

Females dominated throughout the period of observation (Fig. 5), except in July, and the overall female to male ratio was 1.95:1.0. The distribution of sexes in relation to length (Fig. 6) indicates that from 37-127 mm, females dominated except in 77 mm length group, in which the Chi-square value was non-significant at 1% level. Above 102 mm, males were not represented in the catches.

FISHERY AND BIOLOGY OF PENAEID PRAWNS

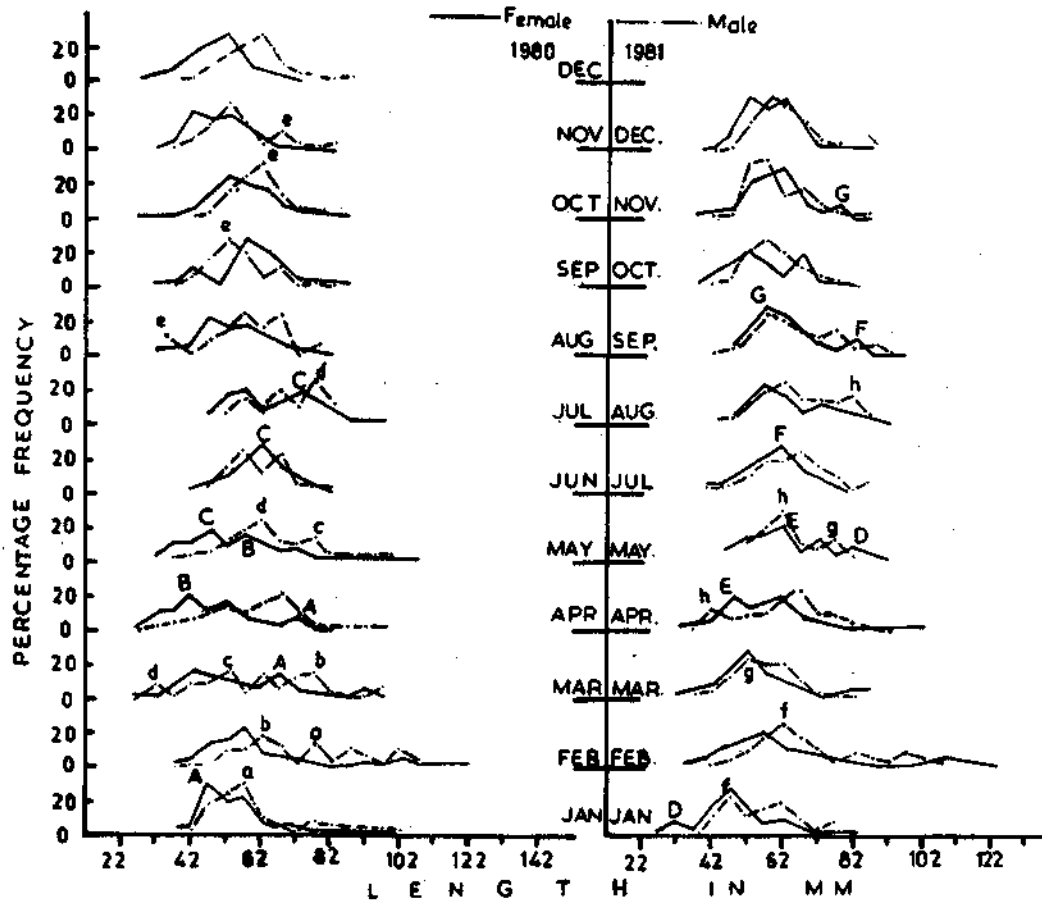


FIG. 4. Monthly length-frequency distribution of *M. monoceros* during 1980-'81.

M. brevicornis: A catch of 167.0 t was recorded which formed 3.7% of the penaeid prawn landings, with peak in July. The length ranged from 16-122 mm, that of females and males 35-122 and 35-92 mm respectively. Prawns in the length range of 47-92 mm formed the mainstay of the fishery.

Females dominated (Fig. 5) except in February and the female to male ratio was 2.9:1.0. Distribution of sexes in relation to length (Fig. 6) indicated the predominance of males in 72-77 mm group. In the 67 mm group the sexes were almost equal and above 92 mm, males were not represented in the catches.

M. dobsoni: This species accounted for 374.2 t, which formed 8.3% of the penaeid prawn landings. The landings were high in January-February and September-December, with peak in December. The length ranges of females and males were 35-79 and 35-82 mm respectively.

Females dominated except in August (Fig. 5). The female to male ratio was 2.4 to 1.0. Females dominated in the length range 37-62 mm, and above 77 mm females were not represented in the catches (Fig. 6).

Penaeus indicus: A total of 466.2 t was landed accounting for 10.34% of the total

penaeid prawn landings, with a peak in December. The length range of females and males was 35–141 mm and 42–132 mm respectively. Those in the length range 54–97 mm mainly contributed to the fishery.

Females dominated the catches (Fig. 5). The distribution of sexes in relation to length (Fig. 6) indicates the predominance of females in all the length groups, and males above 132 mm length were absent. The overall female to male ratio was 4.9:1.0.

P. monodon: With a catch of 365.1 t this species formed 8.1% in the penaeid prawn landings. In general *P. monodon* landings were in considerable quantities during

August, December and in February with a peak in December.

The length of females and males ranged from 35–239 and 35–209 mm respectively. Prawns of 89–159 mm length formed the bulk of the catch. Prawns above 200 mm were few in number and they occurred when fishing near the bay region during summer and the neap tides.

The length-frequency analysis (Fig. 7) showed a monthly growth rate of 30–32 mm in females of 35–95 mm length. In males of 45–115 mm length, an average growth of 32 mm/month was observed. Females dominated throughout, except in April, when the sexes were in equal proportion (Fig. 5). The distribution of sexes in relation to length shows (Fig. 6) the predominance of females in the 49–89 and 139–239 mm length groups. The sexes were almost in 1:1 ratio in the 39 and 99–109 mm length groups while males dominated in 119–129 mm group.

P. semisulcatus: This species formed 2.8% of the penaeid prawn landings, with a catch of 126.5 t, peak being in July and April. The length of females and males ranged from 35–179 mm and 35–139 mm respectively. Prawns in the length range 69–129 mm contributed in considerable quantities to the fishery.

Females dominated throughout (Fig. 5). The overall female to male ratio was 1.49:1.0. The distribution of sexes in relation to length (Fig. 6) showed the female dominance in all the length groups.

P. merguensis: This species amounted to 78.9 t, accounting for 1.8% of the penaeid prawn landings. The landings were good in April, May and August with a peak in April. The length of females and males ranged from 39–179 mm and 39–159 mm respectively. Prawns in the length range of 69–139 mm contributed to the bulk of the fishery.

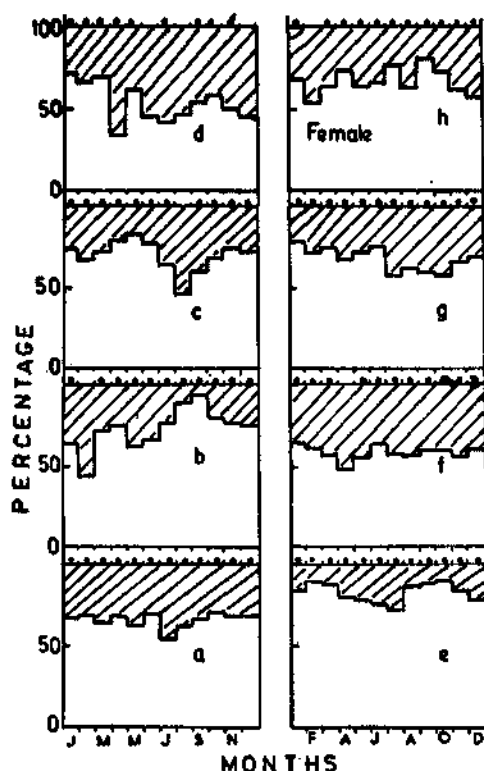


FIG. 5. Monthly sex ratio in a *M. monoceros* b. *M. brevicornis*; c. *M. dobsoni*; d. *P. japonicus*; e. *P. indicus*; f. *P. monodon*; g. *P. semisulcatus*; h. *P. merguensis*. Dot on the top indicates the Chi-square value to be significant at 1% probability level.

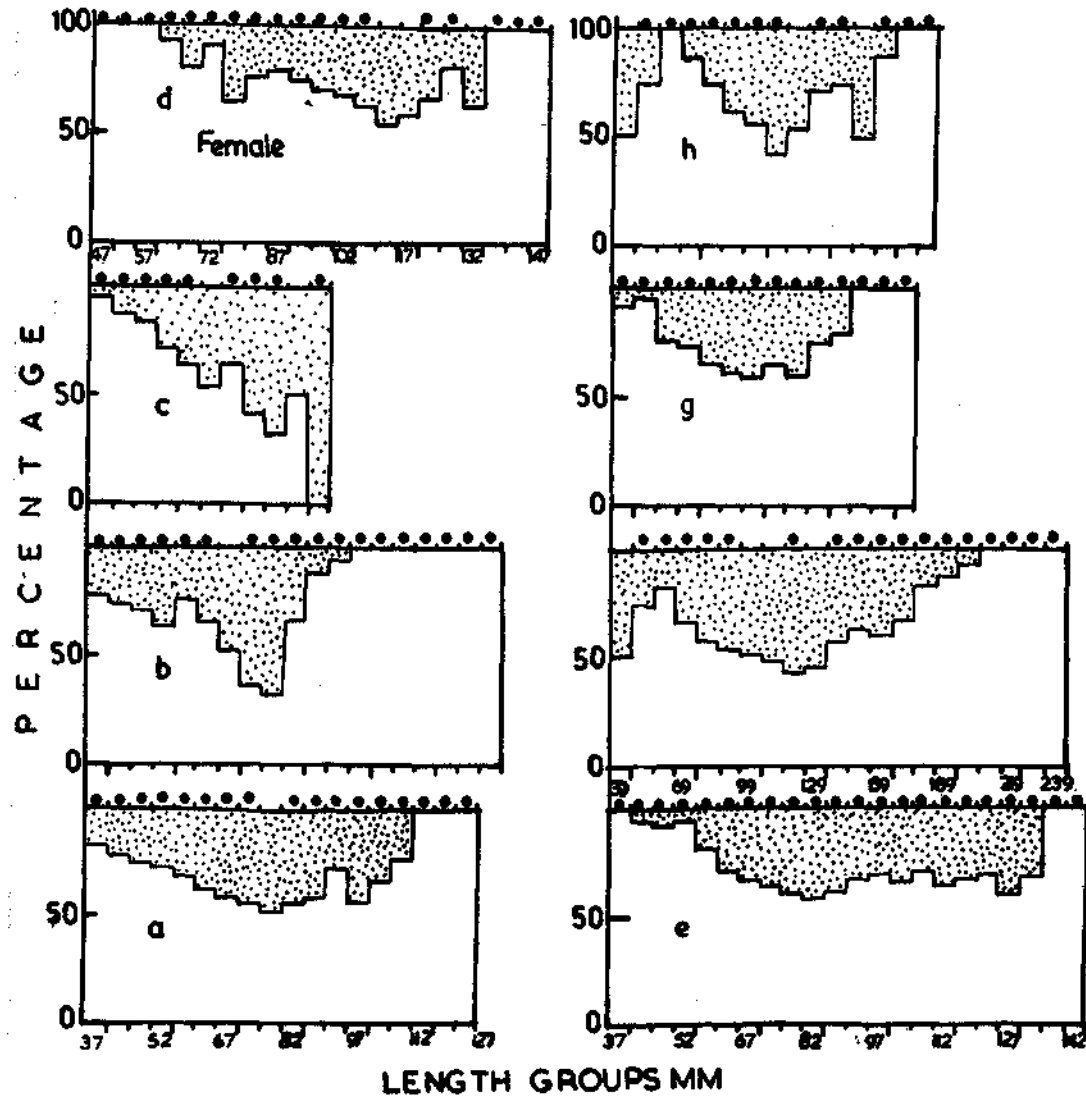


FIG. 6. Sex ratio in different length groups: a. *M. monoceros*; b. *M. brevicornis*; c. *M. dobsoni*; d. *P. japonicus*; e. *P. indicus*; f. *P. monodon*; g. *P. semisulcatus*; h. *P. merguensis*. Dot on the top indicates that the Chi-square value is significant at 1% level.

Females dominated throughout, but in February the Chi-square value was not significant (Fig. 5). Female to male ratio was 1.16:1.0. The distribution of sexes in relation to length showed the predominance of females in the 49–99 mm, 119–139 mm and above 159 mm length groups (Fig. 6).

P. japonicus: This species contributed 45.7 t and formed 1.0% of the penaeid prawn landings. The catches were considerable during March–May, November and December with peak in April. The length of females and males ranged from 47–147 mm and 62–132 mm respectively. The 77–122 mm

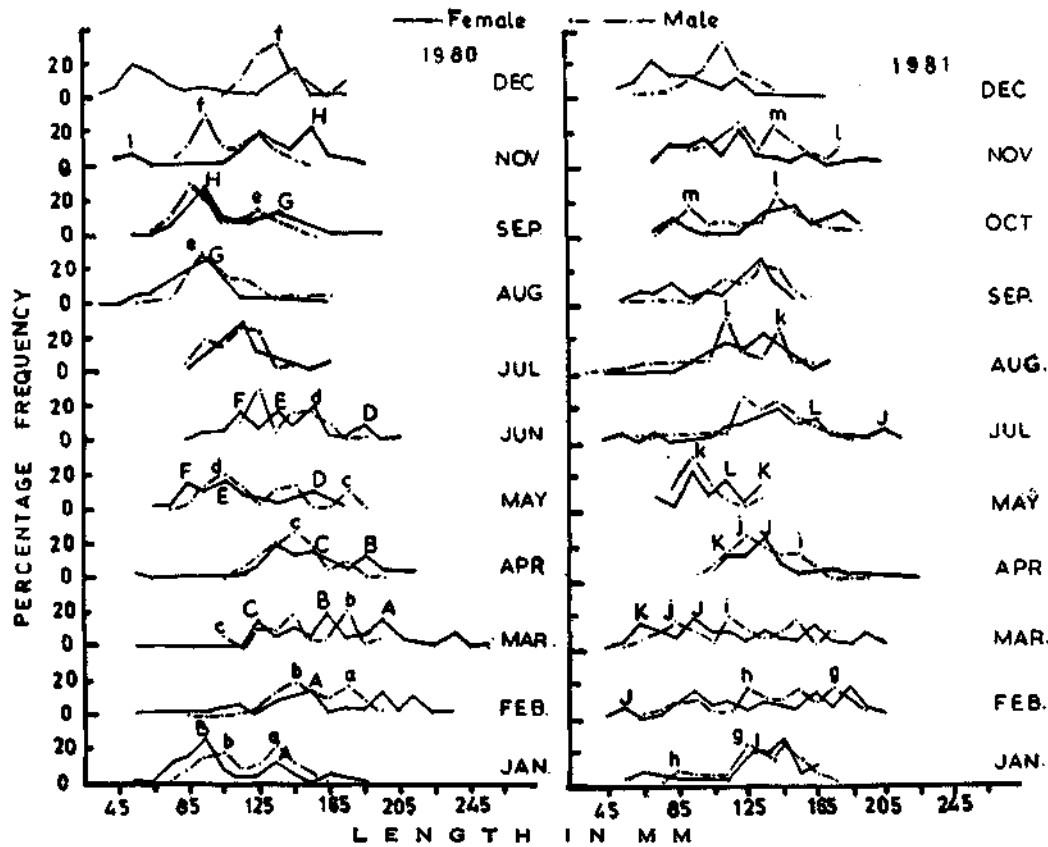


FIG. 7. Monthly length-frequency distribution of *P. monodon* during 1980-81.

group accounted for bulk of the prawn catches. Males dominated in April, June-August and December (Fig. 5). The length-wise sex ratio indicated the predominance of females in all the length groups, except in the 102-117 mm group; however, in this group the Chi-square values were not significant at 1% level (Fig. 6).

Rainfall and prawn fishery

The rainfall, total prawn catch and the catch per unit effort (standardised in terms of stakenet units) of prawns are shown in Fig. 8. Prawn landings are more or less directly related to the rainfall. Following the rainfall maximum which occurs during the southwest monsoon period of July-September, prawn landings were high during October to December.

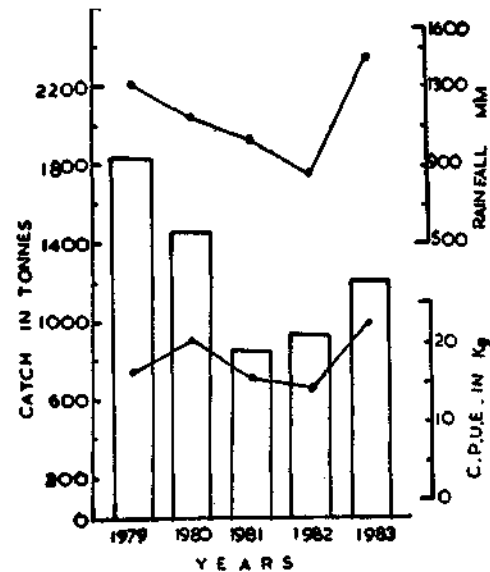


FIG. 8. Relation between the total prawn catch, catch per standard unit and the rainfall.

Age composition of the catch

Based on the growth and age studies of the penaeid prawns of this region made earlier (Lalitha Devi, 1986; Lalitha Devi, MSS) and the present study, the age of the penaeid prawns in the backwaters has been estimated as 2-4 months.

DISCUSSION

The observations on the length range of the important species contributing to the bulk of the fishery in the present study are in agreement with those of Menon (1957), Menon and Raman (1961), George (1959, 1962 a, 1962 b), Ramamurthy (1967, 1972), Gopalakrishnan (1971), Mohamed and Rao (1971), Rao and Kathirvel (1971), Rajyalakshmi (1961 and 1972), Rao (1975), Suseelan (1977), and Suseelan and Kathirvel (1979, 1983).

Considerable variations were observed among the species with regard to their peak abundance which in turn are related to their peak breeding season (Lalitha Devi, MS). For majority of the species, the peak seasons of occurrence in the Godavary estuary were January-April and August-December.

The monthly growth rates reported in *M. monoceros* ranged from 6.72-13 mm (Mohamed and Rao, 1971; George, 1969 and Subrahmanyam, 1973). At Kakinada the males and females of *M. monoceros* grow at a faster rate, the average being 16.8-17.5 mm per month. The growth rates observed in *P. indicus* (Lalitha Devi, 1986) are in agreement with those of Suseelan (1975) and Anonymous (1982). Subrahmanyam and Ganapati (1975) reported a growth rate of 11.67-15 mm per month in *P. monodon*. In this study higher growth rate of 30-35 mm/month was observed. From the foregoing observations, it is found that the growth of *M. monoceros* and *P. monodon* in the Godavary estuary is faster than hitherto reported.

According to Subrahmanyam (1973) the over all sex ratio between the males and females of *M. monoceros* is almost equal in the Godavary estuary (Valenathya). George

(1969) and Suseelan (1975) observed a slight predominance of females and males respectively. In this study the females outnumbered the males. In *M. dobsoni*, Menon (1957) observed the sex ratio to be 1:1. Suseelan (1975) noted a slight predominance of females and Ramamurthy (1972) observed more males during August-November. In the present study, females dominated throughout, except in August. In *P. indicus*, Menon (1955) and Suseelan (1975) reported the sexes as almost equally represented in the catches. In the present study, females dominated throughout the period of observation. In *P. monodon*, Subrahmanyam and Ganapati (1975) observed a slight predominance of females over males and the distribution of sexes in relation to length showed that their proportionality was more or less equal for all size groups. Suseelan (1975) observed slight predominance of males. In the present study females predominated. The observed female dominance in most of the months and also in the larger length groups of the eight species studied here may be due to differential growth between the sexes and migration of males to the sea at a smaller length than the females.

Availability of various prawn species beyond 120 mm length and the occurrence of *P. stylifera* in good quantities in the estuary during February-May may be due to the prevalence of marine conditions in these months.

Gunter and Hildebrand (1954) and Subrahmanyam (1964) related the prawn fishery to the intensity of rainfall. Menon and Raman (1961) reported on a direct relationship between rainfall and the prawn catches of the same year. Ramamurthy (1972) observed the peak prawn landings only during the months following the peak rainfall. Present observations are in corroboration with those of Menon and Raman (1961) and Ramamurthy (1972).

ACKNOWLEDGEMENTS

The author expresses her gratitude to Dr. S. Ramamurthy and Dr. K.A. Narasimham,

Scientists of CMFRI for kindly going through the manuscript critically.

REFERENCES

- ANONYMOUS 1982. Newlight on the migration of the Indian white prawn *Penaeus indicus*. *Mar. Fish. Infor. Serv., T & E. Ser., No. 45*: 1-9.
- GANAPATI, P.N. AND D.V. RAMASARMA 1965. Mixing and circulation in Godavari estuary. *Curr. Sci.*, 34 (22): 631.
- GANAPATI, P.N. AND M. SUBRAHMANYAM 1966. The prawn fishery in Godavari estuary. *J. Zool. Soc. India*, 16: 11-120.
- GEORGE, M.J. 1959. Notes on the bionomics of the prawn *Metapenaeus monoceros* Fabricius. *Indian J. Fish.*, 6 (2): 268-277.
- GEORGE, M.J. 1962a. On the breeding of penaeids and recruitment of post larvae into the backwaters of Cochin. *Indian J. Fish.*, 9 (1): 110-116.
- GEORGE, M.J. 1962b. Observations on the size groups of *Penaeus indicus* (Milne Edwards) in the commercial catches of different nets from the backwaters of Cochin. *Ibid.*, 9 (2): 468-475.
- GOPALAKRISHNAN, V. 1971. The biology of the Hooghly-Matlah estuarine system (West Bengal, India) with special reference to its fisheries. *J. mar. biol. Ass. India*, 13(2): 182-194.
- GUNTER, G. AND HILDEBRAND, H.H. 1954. The relation of total rainfall of the state and catch of marine shrimps (*Penaeus setiferus*) in Texas waters. *Bull. Mar. Sci. Gulf Carib.*, 4: 95-103.
- LALITHADEVI, S. 1986. Growth and population dynamics of the Indian white prawn *Penaeus indicus* H.M. Edwards from Kakinada. *Proceedings. Ind. Acad. Sci.*, 96 (5): 529-639.
- LALITHADEVI, S. 1986. On the growth and population dynamics of some penaeid prawns from the private trawlers operated off Kakinada (MS).
- LALITHADEVI, S. Fishery and biology of some penaeid prawns from the commercial trawlers off Kakinada (MS).
- LALITHADEVI, S. Fishery and population dynamics of *Metapenaeus affinis*, *M. brevicornis* and *P. stylifera* from Kakinada (MS).
- MENON, M.K. 1957. Contributions to the biology of penaeid prawns of the southwest coast of India. Sex ratio and movements. *Indian J. Fish.*, 4 (1): 62.
- MENON, M.K. AND K. RAMAN 1961. Observations on the prawn fishery of the Cochin backwaters with special reference to the stakenet catches. *Indian J. Fish.*, 8 (1): 1-23.
- MOHAMED, K.H. AND P.V. RAO 1971. Estuarine phase in the life history of the commercially important prawns of the west coast of India. *J. mar. biol. Ass. India*, 13 (2): 149-161.
- MUTHU, M.S. 1969. *Parapenaeopsis indica* sp. nov. (Decapoda Penaeidae) from the Indian waters. *Indian J. Fish.*, 16: 174-180.
- NARASIMHAM, K.A. 1985. Ecology of the clam bed in the Kakinada Bay. *J. mar. biol. Ass. India.*, 27 (in press).
- RAJYALAKSHMI, T. 1961. Observations on the biology and fishery of *Metapenaeus brevicornis* (M. Edwards) in the Hooghly estuarine systems. *Indian J. Fish.*, 8 (2): 385-402.
- RAJYALAKSHMI, T. 1972. The prawn and shrimp nursery areas in the estuaries and lakes on the east coast of India a review and discussion. *Proc. Seminar on Mariculture and Mechanised Fishing, Madras*, pp. 42-47.
- RAMAMURTHY, S. 1967. Studies on the prawn fishery of Kutch. *Proc. Symp. on Crustacea*, Marine biological Association of India, Ernakulam, January, 1965, 4: 1424-1436.
- RAMAMURTHY, S. 1972. Observations on the prawn fishery of the Mangalore estuary on the south-west coast of India. *Indian J. Fish.*, 19 (1 & 2): 143-155.
- RAMAMURTHY, S. AND M. S. MUTHU 1969. Prawn fishing methods. Central Marine Fisheries Research Institute, *Bulletin*, No. 14: 235-258.
- RAMASARMA, D.V. AND P. N. GANAPATI 1968. Hydrography of the Kakinada Bay. *Proc. Symp. on Indian Ocean*, New Delhi, 1967., *Bulletin, Nat. Inst. Sci., India*, 38 (2): 49-79.
- RAO, T.A., A.R.K. SASTRY AND P.G. SHANWARE 1972. Analysis of the basic pattern of an estuarine shore in the vicinity of the Coringa Bay, Andhra Pradesh, India. *Proc. Indian. Acad. Sci.*, 70 (1) Sec. B. 40-50.
- RAO, G. SUDHAKARA, 1975. Prawn fishery of the Kakinada back waters. *Bull. Dept. Mar. Sci. Univ. Cochin*, 7 (2): 427-446.
- RAO, P. VEDAVYASA AND M. KATHIRVEL 1971. On the seasonal occurrence of *Penaeus semisulcatus* de Haan, *Panulirus polyphagus* (Herbs) and *Portunus* (P) *pelagicus* (Linn) in the Cochin Backwaters. *Indian J. Fish.*, 18 (1 & 2): 129-134.
- SUBRAHMANYAM, M. 1964. Fluctuations in prawn landings in the Godavari estuarine system, *Proc. Indo-Pac., Fish. Council.*, 11 (2), 44-51.

FISHERY AND BIOLOGY OF PENAEID PRAWNS

- SUBRAHMANYAM, M. 1965. Lunar, diurnal and tidal periodicity in relation to the prawn abundance and migration on the Godavary estuarine systems. *Fishery Technology*, 2: 26-41.
- SUBRAHMANYAM, M. 1967. Further observations on lunar periodicity in relation to the prawn abundance in the Godavary estuarine systems. *J. mar. biol. Ass. India*, 9: 111-115.
- SUBRAHMANYAM, M. 1973. Fishery and biology of *Metapenaeus monoceros* Fabricius from the Godavary estuarine systems. *Indian J. Fish.* 20 (1): 95-107.
- SUBRAHMANYAM, M. AND GANAPATI, P.N. 1975. The biology of the prawn, *Penaeus monodon* Fabricius from the Godavari estuarine system. *Bull. Dept. Mar. Sci. Univ. Cochin*, 7 (3) 653-670.
- SUSELAN, C. 1977. Resource and exploitation of Juvenile penaeid prawns from Manakkudy estuary. *Indian J. Fish.*, 27 (1 & 2): 96-106.
- SUSELAN, C. AND M. KATHIRVEL 1979. A good nursery ground for tiger prawns located in Kerala. *Mari. Fish. Infor. Serv., T & E. Ser.*, 12, 8-9.
- SUSELAN, C. AND M. KATHIRVEL 1983. A study on the prawns of Ashtamudi backwaters in Kerala with special reference to penaeids. *Indian J. Fish.*, 29 (1 & 2): 71-78.