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SPAWNER — RECRUIT DISTRIBUTION OF *PENAEUS INDICUS* IN PARANGIPETTAI COASTAL ECOSYSTEM

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ABSTRACT

Tamil Nadu ranks third in marine prawn production in India. Prawn fishery in Parangipettai Coast is considered the best among the east coast of India. The Indian white prawn *Penaeus indicus* and Tiger prawn *Penaeus monodon* are the commercially valuable components harvested from both estuarine and marine environments. Present study gathered informations about population distribution and abundance of different stages of *P. indicus* both from marine and estuarine phases. Among marine prawn production *P. indicus* contributes 46.18% and 56.18% in the estuarine production. The adult *P. indicus* exhibited high fecundity. Naturally they spawn in open sea, far away from the shore, but within the continental shelf. The hatched out nauplius and protozoea are planktonic and marine in habitat. The mysis and postlarvae were migrated mainly during postmonsoon and summer seasons, to the inland brackishwater such as estuary, backwater and mangrove along with tidal currents, where they nourished for about 6-9 months as juveniles (upto 120 mm), while approaching maturity they migrated back to sea for breeding and spawning. From the manipulation of field data it was evident that about 14 months are required for a postlarvae to become a viable spawner. The peak value of mean '*Kn*' between 105 mm and 115 mm length group indicates the approaching maturity of *P. indicus* and other five peaks between 130 and 175 mm length group reveals five spawning activities and the declining of peaks reveals the subsequent senility. From the length-weight relationship it was evident that for a given carapace length, male prawns possessed a greater total length and weight than female counterparts.

INTRODUCTION

PRAWNS are widely distributed in the tropics and occupy an exalted position in the world marine food market. Tamil Nadu ranks third in prawn exploitation in India, the other two states being Maharastra and Kerala. Maharastra exploits mainly non-penaeid prawns (Sanjeeva Raj, 1973 ; Anon, 1979). *Penaeus indicus* and *P. monodon* are commercially exploited from both estuarine and marine environments. The penaeid prawns use the marine environment as their breeding and spawning site and the estuary as their nursery ground. Information on larval ingression of the penaeid prawns into the estuary will be of much use to assess the potential of the juvenile population in the adjoining inland waters.

Information is lacking on the pattern of seasonal migration of postlarval and juvenile *P. indicus* in Indian waters. Of date biologist have shown interest in correlating the postlarval, juvenile and adult in a wild population, which exhibit seasonal migration phenomenon. The present study in Parangipettai waters has made an endeavour to study the spawner—recruit distribution, composition and availability with particular reference to Indian white prawn *P. indicus*. This will provide necessary baseline information for future studies of this

nature and will aid the prediction on the availability of the resource.

Material and Methods

Investigations have been conducted to gather information on the abundance of all stages (both from estuarine and marine phases) in the life history of *P. indicus*. Collections of marine and estuarine prawn fishery data from March 1977 to February 1979 were made every week at the fish landing centre of Parangipettai. The basic morphometric measurements like total length (distance between the anterior tip of the rostrum and posterior tip of telson), carapace-length (distance between the post-orbital margin of the eye and the posterior margin of the carapace), tail-length (distance between the anterior median 1st abdominal segment and posterior tip of telson), total weight (animal with excess water removed) and tail weight (abdomen removed from the cephalothorax by the normal hand heading process) were taken in fresh condition. The ratio of total-weight and tail-weight is considered as recovery rate.

The materials for the present study consisted adults of 200 females and 250 males covering different sizes from catches obtained off Parangipettai Coast and 200 juveniles and sub-adults from estuarine habitat. The measurements of length and weight were taken in metric units to an accuracy of 0.5 mm and 0.1 gm respectively.

Catch observation made on aboard trawlers, the total catches for the days of observations were arrived at, from which average catch for the day was calculated, in the same way monthly catch was also assessed. Fortnightly surface zooplankton collections were made for 10 minutes with plankton net (mesh size 0.3 mm) from the Vellar Estuary to study the larval ingression. *P. indicus* larvae were sorted out using the larval characteristics described by Menon (1952) and Rao (1974). The juvenile *P. indicus* were collected in weekly interval using Velon screen dragnet in Vellar Estuary and its monthly mean population was utilised to derive the life cycle and migration by following the method of Staples (1979).

The relative condition factor '*Kn*' was calculated as derived by LeCren (1951) using the formula

$$Kn = w/\bar{w}$$

where w is the observed weight and $\bar{w}$ is the calculated weight. The product *Kn* was calculated without descriminating sex in the estuarine prawns and for both sexes of marine prawns.

Species Composition

Parangipettai prawn fishery was being constituted by 40 species of 4 families : Penaeidae, Palaemonidae, Sergestidae and Hippolytidae (Sriraman, 1978). Among these, *P. indicus*, *M. dobsoni*, *M. monoceros*, *P. semisulcatus*, *P. monodon*, *P. merguiensis* and *Parapenaeopsis stylifera* were the major components of the fishery.

Results

Prawn fishing was restricted to dawn of the day. The prawn fishing activity was spread through most part of the year except monsoon season (October to December). Fig. 1 gives catch per unit effort (catch/trawler/day) and the contribution of *P. indicus* to the total prawn catch. The annual prawn landing of I and II year were 460.4 and 431.9 tonnes respectively. During the study period *P. indicus* constituted 46.18% of the total marine prawn catch. The monthly prawn harvests during premonsoon and postmonsoon seasons showed a steady increase. However, the peak period of harvest and the maximum catch per unit effort were markedly discernible during postmonsoon season during both the year of study.

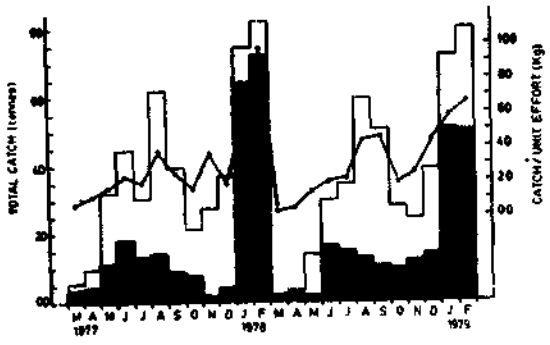

FIG. 1. Total marine prawn landings from Porto Novo Coast during March 1977 to February 1979. ▭ Total prawn catch; ▬ Total *P. indicus* catch and ·——· Catch/boat/day.

The total prawn catch in the estuary during I year was 33.1 tonnes and during II year it was 28.6 tonnes, of which *P. indicus* contribution was 58.22% and 54.14% respectively. The monthly fluctuations in the catches are given in Fig. 2.

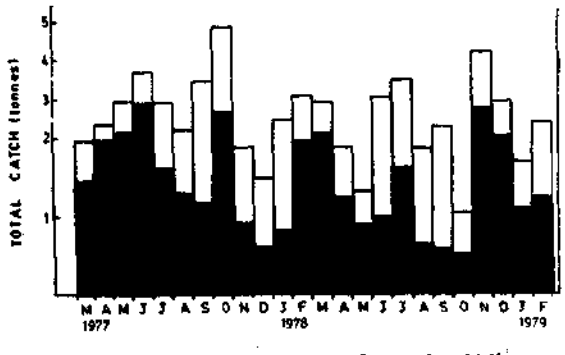

FIG. 2. Total prawn landings from the Vellar Estuary during March 1977 to February 1979. ▭ Total prawn catch and ▬ Total *P. indicus* catch.

More penaeid prawn postlarvae (pelagic) were available in downstream (near the mouth) than in the upstream. During I year, larval ingression was very high between March and September and, during II year this trend was seen between March and May and September and October months (Fig. 3).

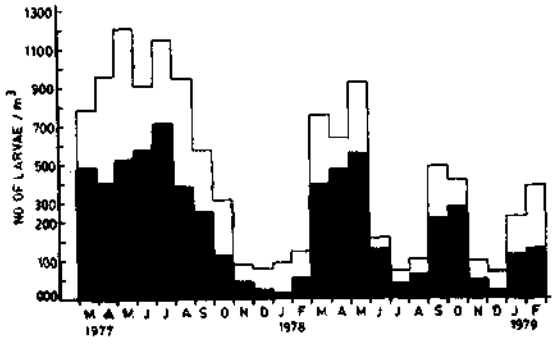

FIG. 3. The variation in abundance in the recruitment of planktonic prawn larvae during March 1977 to February 1979. ▭ Total prawn larvae and ▬ Total *P. indicus* larvae.

The monthly mean population density of juvenile penaeid prawns in Vellar Estuary is depicted in Fig. 5.

A hypothetical scheme for the movement and migration of various stages of *P. indicus* in the life history has been worked out for Parangipettai waters (Fig. 4). In proposing this scheme, data of all available marine and estuarine fishery along with their juvenile

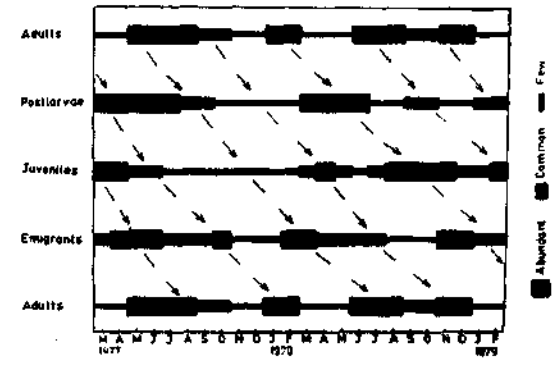

FIG. 4. Diagrammatic representation of the life history of *P. indicus* in Porto Novo coastal waters. The relative abundance of different stages is indicated by the horizontal bars. Arrow marks indicate the transition of stages and route/season of migration.

	Adults	*Postlarvae*	*Juveniles*	*Emigrants*
Abundant⇒	10,000 kg.	400/m³	250/100m²	1800 kg.
Common ⇐	10,000 kg.	400/m³	250/100m²	1800 kg.
Few ⇐	5,000 kg.	200/m³	175/100m²	900 kg.

population abundance and larval ingression are made use of. This is to ensure that the scheme should be valid, bringing in as near and proximal to natural events that take place in the population. Hence a large body of data was gathered.

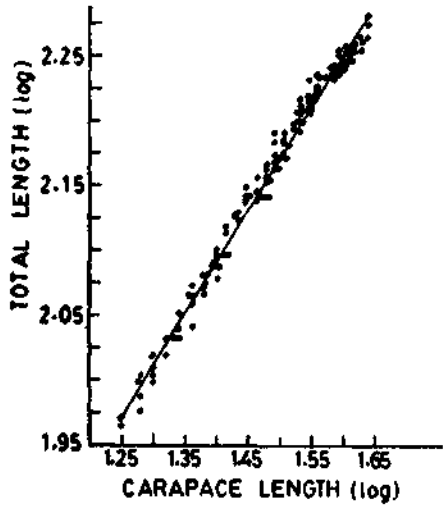

FIG. 5. Logarithmic relationship between carapace length and total length of male *P. indicus* (marine catch).

Length-weight relationship

A study of length-weight relationship is useful for interconversion and to calculate the condition factor (LeCren, 1951). Using the regression equation (Table 1) the relationship of carapace-length against total-length, tail-length, total-weight and tail-weight for the prawn *P. indicus* was derived, which was found significant at 5% level.

To derive the regression equation, the morphometric data of males and females of the sizes above 20 mm carapace-length were treated separately (mainly available in marine environment; the attainment of maturity reflects differences in relative condition factor between sexes). The prawns of less than 20 mm carapace length (normally available in the estuary, backwater and mangroves) were treated cumulatively, since no significant differences exist between length and weight in immature forms as already demonstrated by Prabakara Rao (1967) in species harvested from Chilka Lake.

The scatter of plots from the graphs of carapace-length against other morphometric

TABLE 1. *Regression equations for the conversion from carapace length (CL) to total length (TL), tail length (tl), total weight (TW) and tail weight (tw) of* P. indicus *collected in different habitats*

Habitat	Parameter	Regression equation		
Marine (male)	TL	Log TL 0.9551	0.8122	log CL
	tl	Log tl 0.5283	0.9407	log CL
	TW	Log TW —2.8787	2.8382	log CL
	tw	Log tw —3.2910	3.0106	log CL
Marine (female)	TL	Log TL 1.0691	0.7323	log CL
	tl	Log tl 0.7651	0.7742	log CL
	TW	Log TW —2.4989	2.5818	log CL
	tw	Log tw —2.6882	2.6049	log CL
Estuary (juvenile)	TL	Log TL 0.8746	0.8671	log CL
	tl	Log tl 0.6334	0.8397	log CL
	TW	Log TW —2.9247	2.8174	log CL
	tw	Log tw —3.2725	2.9422	log CL

parameters (Figs. 6 to 17) exhibits the existence of good relationship and also the suitability of fitting the exponential formula (parabolic equation) to the data *viz.* $W = aL^n$ where W is the weight, L the length and a and n are the constants.

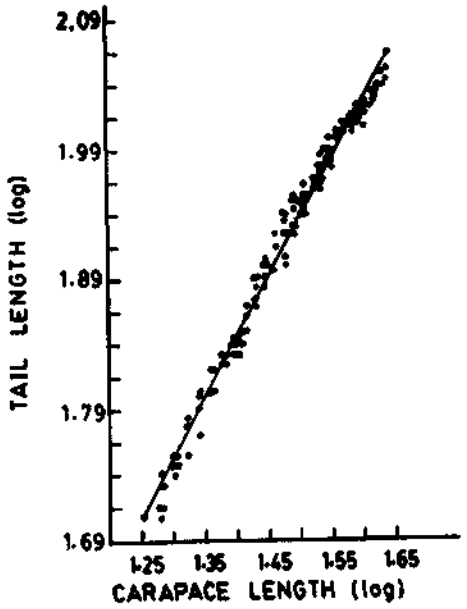

FIG. 6. Logarithmic relationship between carapace length and tail length of male *P. indicus* (marine catch).

Analysis of covariance (F) was employed to test whether the regression of carapace length, total length, tail length, total weight and tail weight were significantly different for the two sexes and juveniles. The results showed that the variation was significant at 1% level and reveals the existence of significant difference between the sexes and juveniles.

The regression formulae were used to calculate the entries presented in the Tables 2, 3 and 4. These Tables will provide a convenient reference for the conversion of length and weight for statistical purposes in future studies.

Relative condition factor

The mean value of *Kn* was plotted against size groups of estuarine (juveniles) (Fig. 18) and marine (Fig. 19) prawns. In the estuarine prawns the mean *Kn* value showed its peak at 27 mm size group, and attained a minimum value at 54 mm size group. It would appear from the graph that the fluctuation in relative condition of marine prawns with reference to length seems to be same in both sexes. The higher peak was between 105 to 115 mm total-length followed by a trough between 120 to 130 mm. The increasing trend after 130 mm was maintained upto 175 mm and then declined.

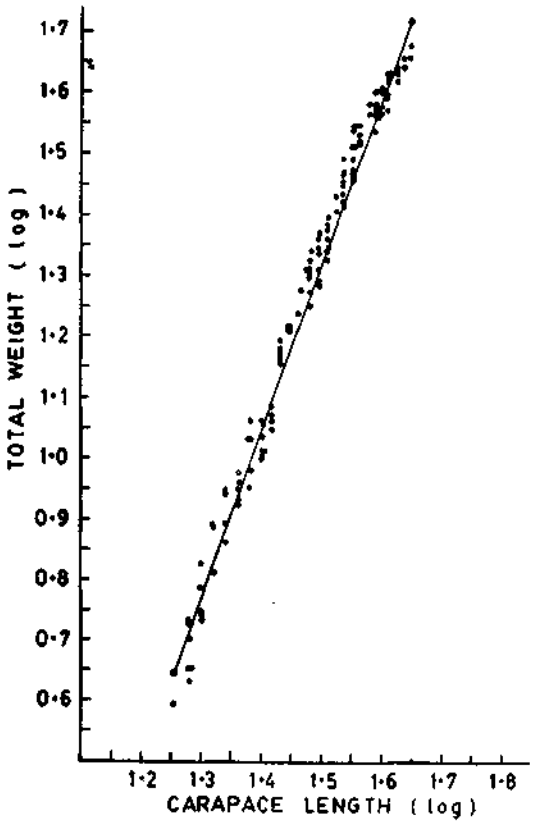

FIG. 7. Logarithmic relationship between carapace length and total weight of male *P. indicus* (marine catch).

Life cycle of P. indicus

The life-cycle of penaeid prawns involves usually both a marine and an estuarine phase. The adult *P. indicus* exhibited high fecundity,

TABLE 3. *Morphometric data for* P. indicus *(female)*

Carapace length (mm)	Total length (mm)	Tail length (mm)	Total weight (gm)	Tail weight (gm)	No. of tail/kg	Recovery rate	No. of prawn/kg
20	105	59	7.2	5.0	200.0	0.69	138.8
21	108	61	8.2	5.7	175.4	0.69	121.9
22	112	63	9.3	6.4	156.3	0.69	107.5
23	116	65	10.4	7.2	138.8	0.69	96.1
24	120	68	11.6	8.1	123.5	0.70	86.2
25	124	70	12.9	9.0	111.1	0.70	77.5
26	128	72	14.3	9.9	101.0	0.69	69.9
27	134	74	15.7	11.0	90.0	0.70	63.7
28	138	76	17.3	12.1	82.6	0.70	57.8
29	142	78	18.9	13.2	75.8	0.70	52.9
30	145	80	20.6	14.4	69.4	0.70	48.5
31	149	82	22.5	15.7	63.7	0.70	44.4
32	152	84	24.4	17.1	58.5	0.70	41.0
33	155	86	26.4	18.5	54.1	0.70	37.9
34	159	88	28.5	20.0	50.0	0.70	35.1
35	163	90	30.7	21.6	46.3	0.70	32.6
36	165	92	33.1	23.2	43.1	0.70	30.2
37	168	94	35.5	24.9	40.2	0.70	28.2
38	171	96	37.9	26.7	37.5	0.70	26.4
39	174	98	40.6	28.6	35.1	0.70	24.6
40	176	100	43.4	30.5	32.8	0.70	23.0
41	178	102	46.2	32.6	30.7	0.71	21.6
42	182	104	49.2	34.7	28.8	0.71	20.3
43	185	106	52.3	36.9	27.1	0.71	19.1
44	187	108	55.5	39.1	25.6	0.70	18.0
45	189	109	58.8	41.5	24.1	0.71	17.0
46	191	111	62.2	43.9	22.8	0.71	16.1
47	193	113	65.8	46.5	21.5	0.71	15.2
48	196	115	69.5	49.1	20.4	0.71	14.4
49	199	117	73.3	51.8	19.3	0.71	13.6
50	202	119	77.2	54.6	18.3	0.71	12.9
51	204	120	81.2	57.5	17.4	0.71	12.3
52	207	122	85.4	60.5	16.5	0.71	11.7
53	210	124	89.7	63.6	15.7	0.71	11.1

TABLE 4. *Morphometric data for* P. indicus *(juvenile)*

Carapace length (mm)	Total length (mm)	Tail length (mm)	Total weight (gm)	Tail weight (gm)	No. of tail/kg	Recovery rate	No. of prawn/kg
3	19	11	0.026	0.014	71429.5	0.54	38461.5
4	25	14	0.059	0.032	31250.0	0.54	16949.1
5	30	17	0.111	0.061	16393.4	0.55	9009.0
6	35	19	0.185	0.104	9615.4	0.56	5405.4
7	40	22	0.286	0.164	6097.5	0.57	3496.5
8	45	25	0.416	0.242	4132.2	0.58	2403.8
9	50	27	0.580	0.343	2915.4	0.59	1724.1
10	55	30	0.781	0.467	2141.3	0.60	1280.4
11	60	32	1.022	0.619	1615.5	0.60	978.ç
12	65	35	1.305	0.799	1251.6	0.60	766.3
13	69	37	1.636	1.011	989.1	0.62	611.2
14	74	39	2.015	1.258	794.9	0.62	496.3
15	78	42	2.448	1.541	648.9	0.63	408.5
16	83	44	2.936	1.863	536.8	0.63	340.6
17	87	46	3.483	2.227	449.0	0.64	287.1
18	92	49	4.092	2.635	379.5	0.64	244.4
19	96	51	4.765	3.089	323.7	0.65	209.9
20	101	53	5.506	3.592	278.4	0.65	181.6

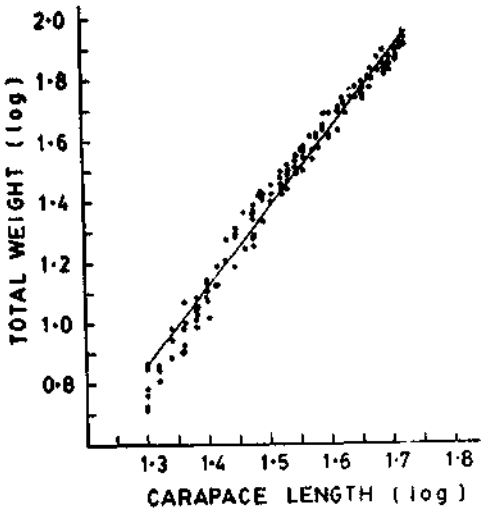

FIG. 11. Logarithmic relationship between carapace length and total weight of female *P. indicus* (marine catch).

DISCUSSION

Parangipettai coastal waters support substantial prawn fishery throughout the stretch of coastal fishing area (20 km). The normal fishing depth ranges from 10-30 m. Prawn fishery off this coast is considered the best among the east coast of India (Sriraman and Natarajan, 1975). The trawlers operate exclusively for prawns for most part of the year all along the coastline. Only during rainy season and festival time the fishing activity is suspended. The increase in fishing effort could be directly proportional to prawn catch. The very active fishery exists during premonsoon and postmonsoon seasons.

The two years landing data showed similarity in annual pattern of prawn catch. The peak landing during postmonsoon (January and

February) was mainly because of large number of prawn juvenile and subadults (80-120 mm size group) that normally would occur in the

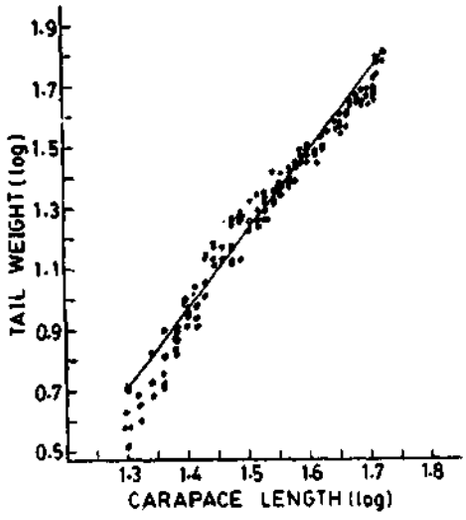

FIG. 12. Logarithmic relationship between carapace length and tail weight of female *P. indicus* (marine catch).

estuary and mangrove backwater, which were carried to the sea as a result of drainage through the estuary by heavy monsoonal flood.

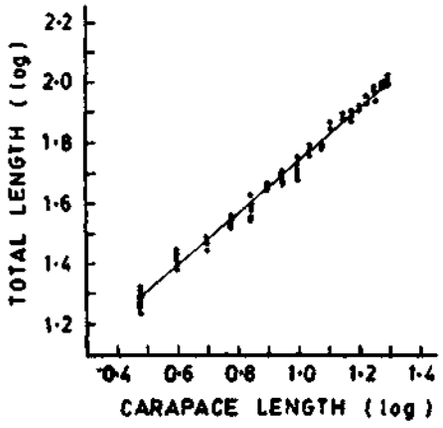

FIG. 13. Logarithmic relationship between carapace length and total length of juvenile *P. indicus* (estuarine catch).

Usually large numbers of small-sized prawns were found during monsoon and postmonsoon seasons and big-sized prawns were observed during summer and premonsoon seasons. Likewise positive correlation between rainfall and commercial prawn catches has been reported from Mississippi waters (Gunter and

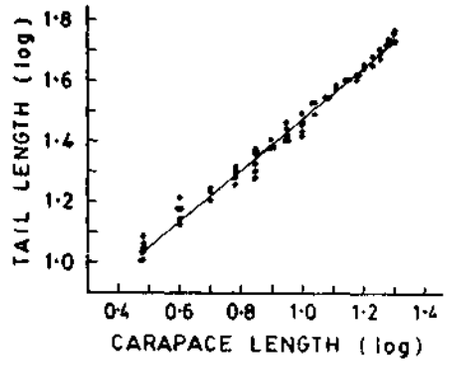

FIG. 14. Logarithmic relationship between carapace length and tail length of juvenile *P. indicus* (estuarine catch).

Edwards, 1969) and from Australian waters (Ruello, 1973). Furthermore, it has been observed that the prawn catch was not only related to the annual rainfall, but was also

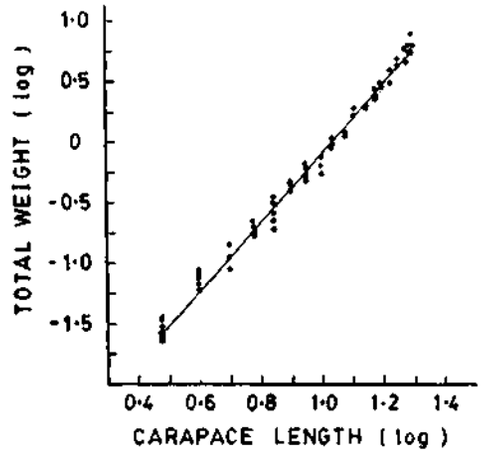

FIG. 15. Logarithmic relationship between carapace length and total weight of juvenile *P. indicus* (estuarine catch).

related to the combined rainfall effect of the preceeding one or two years (Staples, 1980). The observation in the present study seem to support his views. Hence, apart from an

immediate effect of rainfall on the emigration of juvenile prawns from the estuary, the cumulative effect of the annual rainfall should also be borne in mind. The onset and duration of the prawns' reproductive season, success of broods, recruitments of postlarvae, their growth and survival and latter migration and recruitment to their marine home would be related to annual rainfall, a deciding factor for determining the optimum productivity of marine prawn stock.

The data of the International Indian Ocean Expedition (1960-1965) reveals that the maximum numbers of penaeid prawn larvae (more than 50%) were found along the coastline of Tamil Nadu, in the Bay of Bengal (Paulinose and George, 1976). The present investigation showed that penaeid prawns were the major components of the coastal fishery (Figs. 1 and 2).

P. indicus supports a viable commercial fishery on both marine and estuarine fronts on the east and west coasts of India (Mohammed, 1967). It forms 10.1% (18,165 tonnes) of the total marine prawn production of India during 1978 (Anon., 1979). Observations of the local prawn landings showed uniformly good catch pattern for the study period (I year 460.4 tonnes and II year 431.9 tonnes). Though the II year catch was slightly lesser than I year, the difference was not great. However, in the present study, the landings of big-size prawns were unusually poor during postmonsoon season which could be attributed to the over abundant recruitment of lower age groups. The secondary peak in prawn landing between July and September consisted mainly of large sized prawns. Generally the decline in some seasons in prawn landing could be due to the overfishing as well as due to exploitation by injudicious fishing of prawn juveniles in the inland nursery area irrespective of seasons.

The fisheries of the estuary, backwater and mangroves were constituted by juveniles of the same species of penaeid prawns that occur in the adjoining neritic province of Bay of Bengal along with *Macrobrachium* spp. The estuarine prawn fishery substitutes for the marine prawn catch demand and usually satiates the day to day requirement of the local people. Banerji (1969) observed that over 50% of the total prawn production of India come from backwaters. In the present study, estuarine prawn landing was lower during II year (28.6 tonnes) than I year (33.1 tonnes). The fall in catch during II year was due to decline in the growth and relative paucity of algae, seaweeds etc. (inside the marine zone of the estuary) used as food and for shelter by these prawns. The algal vegetation consisted of *Halodule uninervis, Halophila ovalis, Enteromorpha clathrata, E. compressa, Chetomorpha brachygonia* etc. These algal flora would start their growing phase with the onset of postmonsoon and formed thick meadows during the succeeding seasons of summer and premonsoon. During monsoon season and onset of postmonsoon season the estuarine fishery was dominated by *Macrobrachium* spp.

From the analysis of length-weight for a given carapace length, male prawns possessed a greater total-length and greater weight than female. Parallel findings were reported on the 'brown tiger prawn' *Penaeus esculentus* and the 'western king prawn' *P. latisulcatus* of Western Australia (Penn and Hall, 1974). However, in the 'field' the maximum size *P. indicus* (210 mm) was observed among females only, whereas among males the maximum size was 188 mm. Generally the male prawns would appear to have higher '*b*' value while the female have lower '*b*' value. The results indicate that the relationship between carapace length against total length, tail length, total weight and tail weight was more relevant for male prawns. Similar observations were made on *P. latisulcatus* and *P. esculentus* from Western Australia (Penn and Hall, 1974). Thus the relevance was least in females since in

females the length-weight relationship fluctuated widely during attainment of maturity and at different stages of ovary development. The 'raw' as well as logarithmic values of observed carapace length and corresponding morphometrics were plotted and the regression line fitted to the data showed a linear relationship between these variables as shown in Fig. 6 to 17.

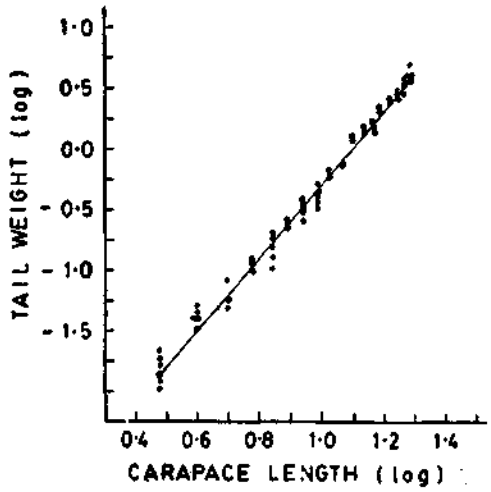

FIG. 16. Logarithmic relationship between carapace length and tail weight of juvenile *P. indicus* (estuarine catch).

In the 'relative condition factor' (relative well-being and health of shrimp) the peak *Kn* between 105 and 115 mm indicates the increase in 'condition' (*Kn*) when the prawn was approaching maturity. The subsequent peaks represented the cyclic gonadial development and spawning. Similar changes in relative condition factor have been observed by Rao (1967) in *Macrobrachium rosenbergii* and Thomas (1975) in *Penaeus semisulcatus*. Studies in the food and feeding habits of prawns have shown that the weight of food ingested by the prawn was negligible in comparison with the body weight (Thomas, 1975). Hence it appears that the food in the gut does not affect the '*Kn*' value.

P. indicus postlarvae were abundantly recruised to the estuary along with tidal current during March to September of I year and during March to June and during September-October months of II year. Its abundance in Cochin waters was reported during September and January and May to July, 1967 (Rao, 1973). The size of the recruits was less than 10 mm total length (Panikkar and Menon, 1956).

The works of Hughes (1969 a, b) provide some explanation for the postlarvae were active in the water column after acclimation to a given salinity. If the salinity decreased, the postlarvae would change their rheotactic responses in a rhythm corresponding to tidal cycle. This biological rhythm was maintained even after the shrimps were removed from their natural environment and kept in the laboratory.

In the present study, the ingressed postlarval population seems to be responsible for the correspondingly good marine catch obtained during the postmonsoon of next year (after 7 to 9 months). But the correlation coefficients between recruited *P. indicus* larval population and juveniles, sub-adults and adult population were not at significant level. This could be due to movements of population from one place to another in search of new pastures and due to currents. Similar findings were observed in Gulf of Mexico (Neal, 1975).

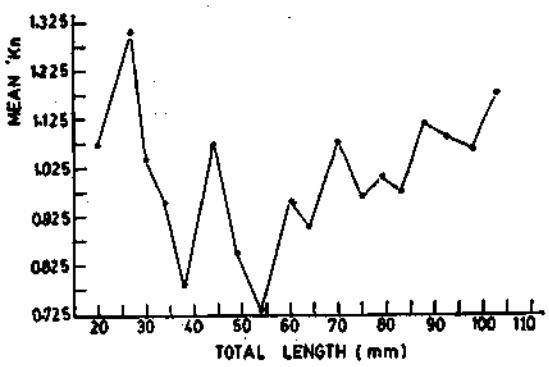

FIG. 17. The relative condition factor (mean *Kn*) (varying total length) of *P. indicus* juveniles (estuarine catch).

There are many factors which affect the success of spawning, the recruitment of larvae to the nursery areas and the migration of juveniles to the adult marine stock. In addition extrinsic factors like vagaries of annual rainfall, rate of predation, mortality of juvenile entangled in nets as they operate upon to catch larger fish and prawns in the inland brackish-water nursery areas, pose threats. The normal

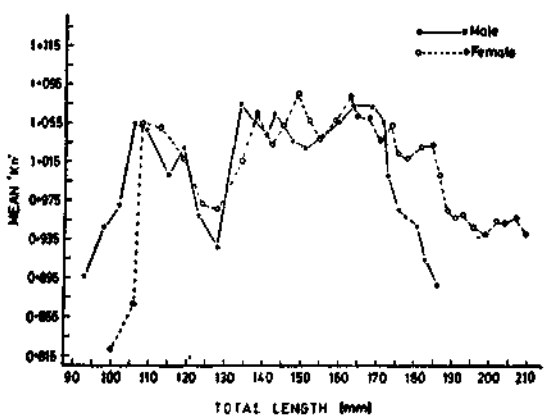

FIG. 18. The relative condition factor (mean *Kn*) (varying total length) of *P. indicus* (marine catch).

sequence of events in the life cycle of prawns, thus, passes through many vicissitudes. Besides, overfishing also limits the spawner-recruit relationship. Due to these varied and complex influence, the number of juveniles recruited to an adult population woud not always reflect the nature of the adult population (Walker, 1975). However, a knowledge of composition and census of juveniles leaving a nursery area will help to forecast the likely size of that adult population as they grow up (Walker, 1975). Similarly, information on the abundance of ingressed postlarvae coupled with a knowledge on their growth rate will be useful to predict the nature of the forthcoming harvestable prawn crop and will also help assess the practical prospects of cultivating a known amenable species of prawns (Bearden 1961; Baxter, 1963; Subrahmanyam and Janardhana Rao, 1968).

From the diagramatic representation (Fig. 4) of life cycle of the prawn *P. indicus* in the Vellar Estuary and Bay of Bengal, it was evident that a total duration of about 14 months was needed for a young one to become a viable spawner. The larvae ingressed into inland areas such as estuaries, backwaters and mangroves, where they spend anywhere between 7 and 9 months. While approaching maturity they migrate back to the sea, where they grow well, attain maturity and become capable of spawning wihtin 4 or 5 months and never return to inland waters. Thus the total duration works to 14 months. The life span of *P. indicus* was estimated as 3 years (Sriraman, 1978). During its life-span, *P. indicus* would spawn five times and the interval between two successive spawnings being about two months (Rao, 1968). In the present study area also *P. indicus* would seem to show similar features. The observations support that the life-span was about 3 years and would spawn more than once in a year.

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