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ESTUARINE PHASE IN THE LIFE-HISTORY OF THE COMMERCIAL PRAWNS OF THE WEST COAST OF INDIA

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ABSTRACT

32 species of prawns and shrimps are recorded from the Cochin Backwater. Among these, *Penaeus indicus* H. Milne-Edwards, *Metapenaeus monoceros* (Fabricius), *M. dobsoni* (Miers) and *M. affinis* (H. Milne-Edwards) belonging to Penaeidae and *Macrobrachium rosenbergii* (de Man) and *M. idella* (Hilgendorf) belonging to Palaemonidae are commercially important and their estuarine phase is studied. The minimum period of stay in the backwater and the size when they leave this ecosystem are estimated to be 5 months and 50 mm for *M. dobsoni*; 4 months and 40 mm for *M. affinis*; 10 months and 85 mm for *M. monoceros* and 6 months and 80 mm for *P. indicus*. From size frequency distribution of the juveniles in the estuary, the growth rate of each of these species is assessed and it is found that the average growth rate is highest in *M. dobsoni* (9.88 mm/month) and lowest in *M. monoceros* (6.72 mm/month). The freshwater prawn *M. rosenbergii*, is found to utilise the estuary for about 5 months. A general appraisal of the dynamics of each of the prawns is presented in the light of the data obtained from the three different ecological niches—estuarine areas, inshore and offshore regions of the sea. Prospects of utilisation of the estuarine areas for culturing different species of prawns and associated problems are discussed.

INTRODUCTION

THE ecosystem formed by the estuaries and backwaters plays a vital role in the biology and fishery of many aquatic living resources. Among these, crustaceans, particularly prawns are the most important group from the stand-point of commercial exploitation. Although, the importance of this ecosystem in the fishery and ecology of prawns has been realised, the recent encroachments of these areas by agro-industrial developments and engineering projects resulting in destruction of these areas and the living resources they harbour, has necessitated a fuller understanding of the inter-relationship between this environment and prawns. The present paper is therefore, aimed at elucidating various aspects of the estuarine phase of the life-history of prawns of the Cochin Backwater formed by the estuaries of the rivers Periyar and Pampa. The material for this paper is obtained from regular tow net collections for the larvæ and from try net (specially designed) collections for the juveniles taken from fixed stations during 1969.

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Hydrology of Cochin Backwater

The topography and general hydrological features of the Cochin Backwater are given by several workers (Ramamirtham and Jayaraman, 1963 ; George and Krishna Kartha, 1963 ; Cheriyan, 1963, 1967 ; Nair, 1964 and Qasim and Reddy, 1967). Due to the influence of the sea and the land drainage, the hydrological condition of the backwater, although highly dynamic, is typically estuarine, nevertheless, highly influenced by the southwest monsoon rains. Due to the openings of a number of small rivers, the southern part of the Vembanad Lake remains freshwater except during the summer (February to May) when the salinity varies from 10‰ to 18‰. In the northern part lying north of Cochin, the salinity of the water is generally higher and becomes fresh only for a short period during the floods of southwest monsoon. In the river Periyar, the tidal influence is felt up to about 30 km from the sea.

The hydrological features of the backwater near Cochin show a cyclical pattern (Table 1). During the monsoon period (June to September) the salinity and tem-

Table 1. *Maximum and minimum temperature, salinity, oxygen and absorbed phosphate of the surface water near Cochin for the period January to December* 1969

Month	Temperature (°C)		Salinity (‰)		Oxygen (ml/L)		Adsorbed phosphate (μg-at/L)	
	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.
January	29.9	27.2	32.41	25.11	4.61	3.11	3.26	0.42
February	30.5	28.6	33.88	27.28	5.23	3.85	1.65	0.30
March	30.9	29.9	34.20	30.96	5.21	1.70	3.40	0.54
April	32.0	29.5	34.50	30.40	5.62	2.76	1.08	0.54
May	31.0	29.0	34.78	30.42	4.80	2.51	2.52	0.16
June	30.5	27.2	30.41	3.01	4.03	2.60	1.02	0.42
July	28.8	27.0	2.68	0.37	7.25	4.05	1.50	0.30
August	29.9	25.7	24.27	1.52	7.92	3.14	1.14	0.30
September	30.0	27.2	29.44	2.25	4.66	3.50	1.98	0.30
October	30.3	29.1	22.22	0.75	5.90	2.88	3.20	0.33
November	30.0	28.5	31.50	1.81	5.70	2.80	1.08	0.48
December	30.3	29.0	30.17	19.19	4.75	3.42	2.40	0.41

perature values decline considerably due to the heavy rainfall and the minimum values are obtained in the month of July. In the post-monsoon period (October to January), although wide fluctuations occur in the salinity values a salinity gradient is observed as the season advances. The temperature also exhibits an upward trend. In the premonsoon period (February to May), the hydrological conditions of the backwaters around Cochin is almost similar to that of the adjoining sea in having fairly uniform and high salinity and temperature. Maximum values are generally observed in the month of April.

Prawn and Shrimp Fauna

Faunistic and resources investigations carried out in this region (Henderson and Matthai, 1910 ; Panikkar, 1937 ; Nataraj, 1942 ; Menon, 1954 ; Panikkar and Menon, 1956 ; Gopinath, 1956 ; Menon and Raman, 1961, and George, 1964) have shown that a number of species inhabit this backwater and also contribute to valuable fishery. The prawn and shrimp fauna observed during the present investigations are listed below.

Family PENAEIDAE
Penaeus indicus H. Milne-Edwards
P. monodon Fabricius
P. semisulcatus de Haan
P. japonicus Bate
P. latisulcatus Kishinouye
P. canaliculatus (Olivier)
Metapenaeus monoceros (Fabricius)
M. affinis (H. Milne-Edwards)
M. dobsoni (Miers)
M. burkenroadi Kubo
Parapenaeopsis stylifera (H. Milne-Edwards)
P. sculptilis (Heller)
P. maxillipedo Alcock
P. acclivirostris (Alcock)

Family SERGESTIDAE
Acetes erythraeus Nobili
A. indicus H. Milne-Edwards
A. japonicus Kishinouye
A. cochinensis Rao

Family ATYIDAE
Caridina gracilirostris de Man

Family PALAEMONIDAE
Macrobrachium rosenbergii (de Man)
M. idella (Hilgendrof)
M. scabriculum (Heller)
M. rude (Heller)
M. equidens (Dana)
Palaemon styliferus H. Milne-Edwards
P. tenuipes (Henderson)
Leandrites celebensis (de Man)

Family HIPPOLYTIDAE
Hippolysmata ensirostris Kemp

Family ALPHEIDAE
Ogyrides striaticauda Kemp
Alpheus malabaricus Kemp
A. palaudicola Kemp
A. rapax Fabricius

Of the 32 species of prawns and shrimps recorded here, only six species viz., *P. indicus*, *M. monoceros*, *M. dobsoni*, *M. affinis*, *M. rosenbergii* and *M. idella* are commercially important.

Extent of Dependence on Estuarine Ecosystem

Based on their natural habitat, the commercial species of prawns can be broadly classified into three groups—(i) purely marine forms, (ii) marine forms entering estuaries, and (iii) freshwater forms entering estuaries. Those of the first category are generally restricted to deeper waters, while most of the littoral forms enter the estuaries in the early stages. Some of the fresh water forms occur as adults in estuaries. On the basis of existing knowledge on the life-history of prawns, the extent of their utilisation of estuaries is shown in Fig. 1. It would appear that 39 species of prawns use to varying degrees the estuaries at some stage or other of their life-history.

Estuarine Phase of Penaeid Prawns

The penaeid prawns spawn in the sea, the only exception being the Australian species, *Metapenaeus bennettae* which is reported to breed in the coastal lakes of New South Wales (Dakin, 1946 ; Morris and Bennett, 1951). The general pattern is that the eggs that are spawned in the relatively deeper waters of the sea (deeper

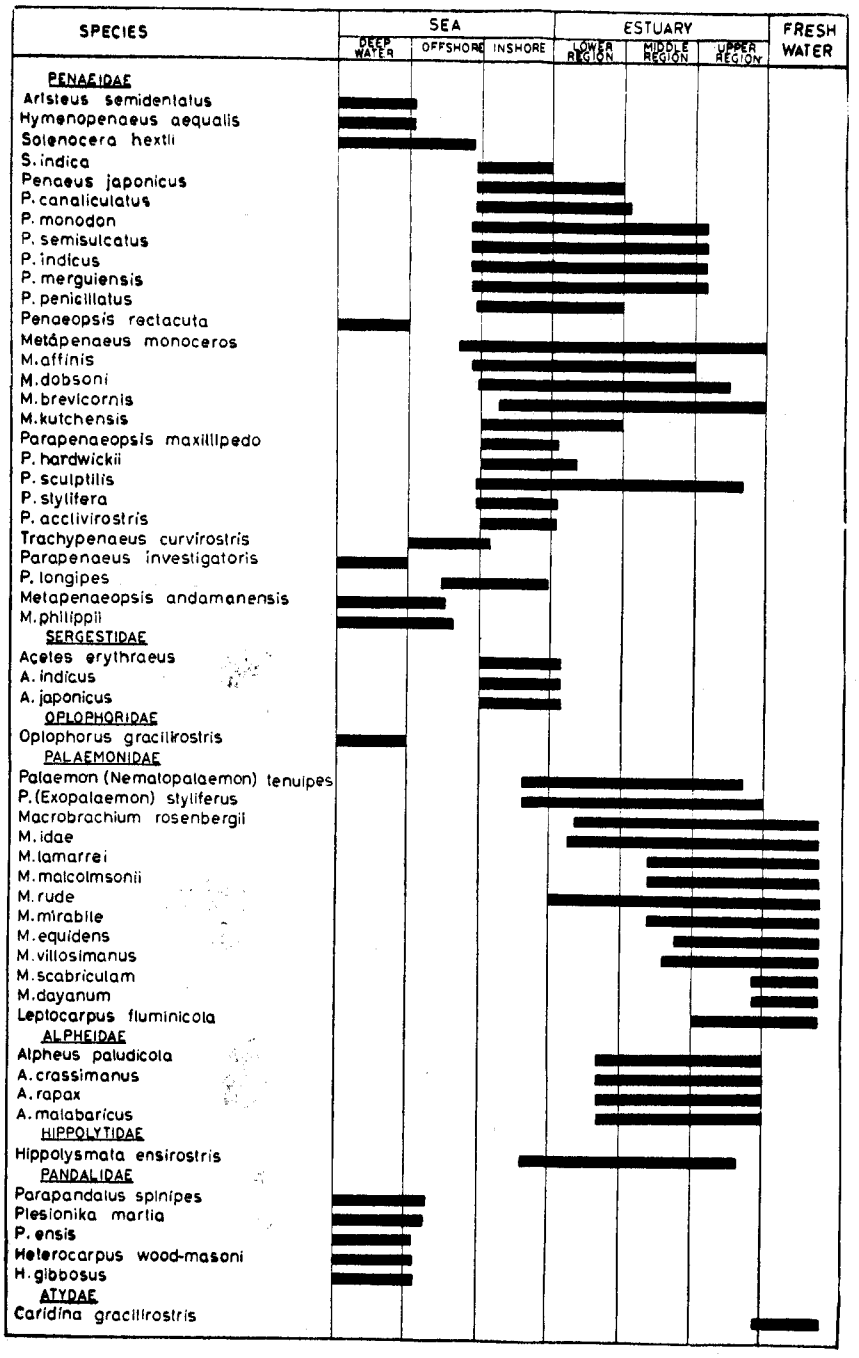

FIG. 1 Distribution pattern of commercial prawns of India in different environments.

in relation to the area of normal existence of adult prawns) hatch out into tiny napulii which pass through a number of stages in the course of their development. The early developmental stages are confined largely to the sea, but they migrate towards the shallow inshore and estuarine regions as they attain advanced stages within two or three weeks from the time of spawning. As they enter the estuaries, the pelagic postlarvae settle down to the bottom and adapt to the benthic habitat. While the recruitment to the estuaries takes place at this stage in almost all the commercial species their further growth follows specific characteristics.

Metapanaeus dobsoni

The species breeds almost throughout the year with two peak periods, June to August and October to December (George, 1962a ; Rao, 1968). Examination of the tow net collections shows that the larval stages from protozoea onwards occur in fairly large numbers in all the months of the year with peak periods coinciding with breeding. The sizes of these larvae vary from 1.0 mm to 3.5 mm and they are pelagic. Advanced postlarvae above 3.5 mm in size are not obtained in the surface collections and it would appear that they have, by this time, settled to the bottom.

Monthly size frequency distribution of the species obtained from the try net operations from Cochin Backwater is shown in Fig. 2. The size range varies from 10 mm to 90 mm. Two widely separated modes are observed in the size frequency distribution of most of the months ; the smaller mode representing the immigrating juveniles and the larger mode the emigrating prawns. This inward and outward movement is observed throughout the year.

Although, the estimation of growth rate by following the progression of modes in length frequency curves is rendered difficult due to the continuous immigration and emigration of juveniles to and fro from the estuary it is clear from the quick progression of modal sizes seen during some months that the juvenile prawns grow rapidly in this ecosystem. The progression of modes in the size frequency distribution is summarised in table 2.

TABLE 2. *Progression of size modes and rate of growth in* Metapenaeus dobsoni

Serial No.	*Progression of modes*				Period	Growth increment (mm)	Average rate of growth/ month (mm)
	Month	Initial mode (mm)	Month	Final mode (mm)			
1.	March	17	May	47	3	30	10
2.	April	32	June	56	3	24	8
3.	May	23	August	65	4	42	10.5
4.	July	23	September	56	3	33	11.0
5.	September	17	December	56	4	39	9.75
Total					17	168	9.88

It would appear that the species at this stage grows at an average rate of about 10 mm per month. Menon (1951) found an average growth rate of 8.34 mm per month by rearing the postlarvae and juveniles in glass containers in the laboratory.

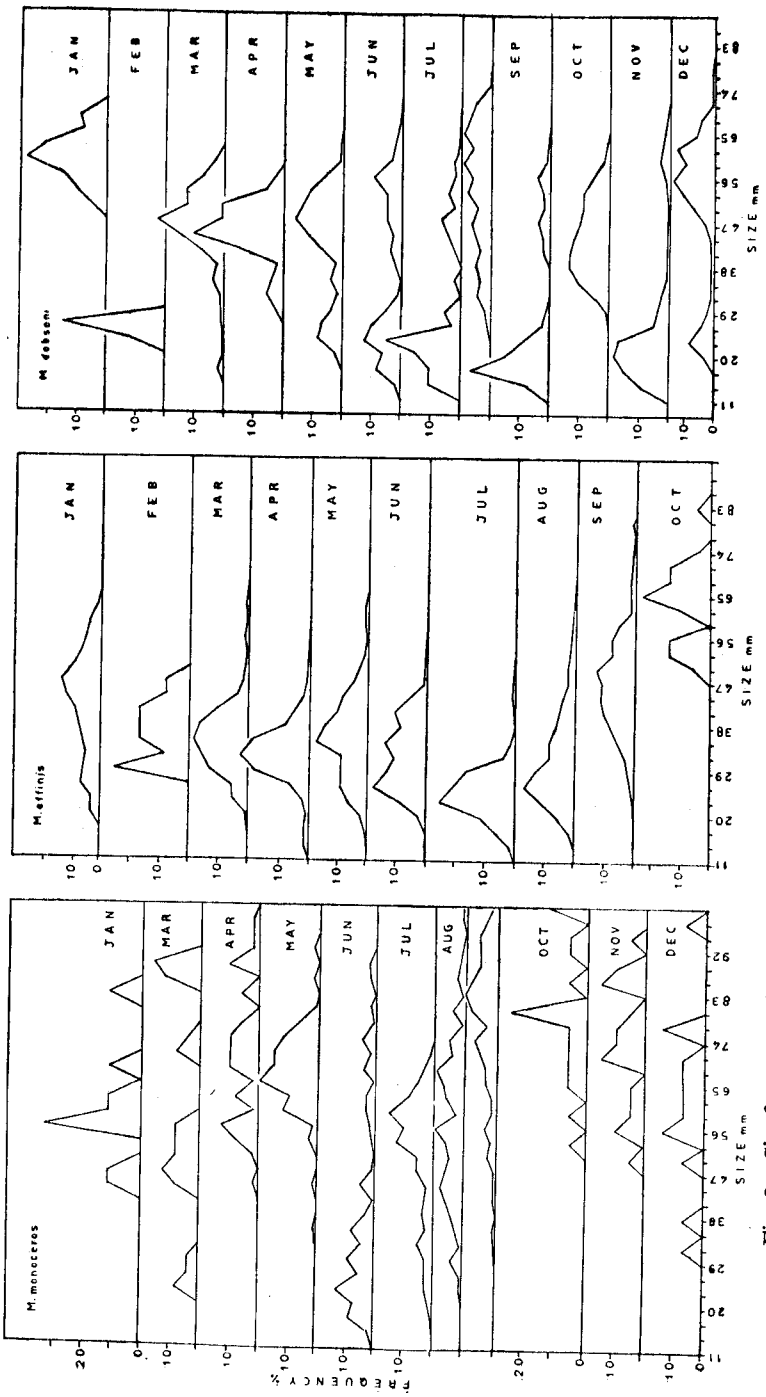

Fig. 2. Size frequency distribution of juvenile prawns of the genus *Metapenaeus* in Cochin Backwater in 1969

The higher growth rate assessed during the present observations could only have been due to the faster growth taking place in the natural habitat.

In the average size frequency distribution of the species in estuaries (Fig. 3) the decrease in the population is noticed from 50 mm onwards and this can be considered as the minimum size at which the emigration commences. Taking into consideration the relatively faster rate of growth in the earlier stages and the observed rate of growth, the emigration of this species from this environment seems to commence when they are about 4 months old, although they may remain in the backwater till they are about 5 months old.

Metapenaeus affinis

This species has a prolonged breeding season extending from October to March (Rao, 1968) and the larvae enter the estuaries in the late mysis stage onwards, when they measure 3.0 mm. The larvae of this species do not occur in large numbers in the estuary and the peak season of their abundance is found during October-December and June-July. The size range of the juvenile population from the try net collections (Fig. 2) is from 10 mm to 93 mm. Smaller juveniles are obtained in all the months except in October indicating more or less continuous recruitment. The modal sizes fluctuate between 23 mm and 65 mm but those between 25 mm and 60 mm dominate the catch in most of the months. The size distribution is of a unimodal nature and satisfactory progression of modes could be traced only from July-October. The modal group seen at 23 mm in July shifts gradually to 56 mm by October, thereby showing a growth rate of 8.25 mm per month. In the average size distribution of the species in the estuaries, however, decrease in the estuarine population is noticed from 40 mm onwards (Fig. 3), and at the time of emigration they are about 4 months old.

Metapenaeus monoceros

George (1962a) observed year round breeding with two peaks identical with those of *M. dobsoni* for this species, and the presence of larval stages in the inshore and estuarine areas almost throughout the year supports this finding. The species enters the estuaries in the late mysis stage (size about 3.0 mm) and soon settles to the bottom.

In the estuarine catches a wide size range from 10 mm to 102 mm occurs. The size distribution (Fig. 2) shows multiple modes, indicating continuous recruitment to the estuarine areas. Following the progression of modes, the rate of growth of the species is estimated (Table 3).

TABLE 3. *Progression of size modes and rate of growth in* Metapenaeus monoceros

Serial No.	Progression of modes				Period	Growth increment (mm)	Average rate of growth month (mm)
	Month	Initial mode (mm)	Month	Final mode (mm)			
1.	January	68	April	89	4	21	5.25
2.	March	47	October	101	8	54	6.75
3.	June	23	December	77	7	54	7.71
4.	July	59	December	98	6	39	6.50
Total					25	168	6.72

In relation to the other two species of the genus, *M. monoceros* shows a lower growth rate, the average estimated at 6.72 mm per month within the above size range. By rearing the postlarvae in the laboratory, George (1959) observed a growth rate of 7.98 mm per month in the lower size ranges of 3.0 mm to 60.0 mm. In the paddy fields adjoining Cochin Backwater, however, he recorded only 5 mm growth per month in the higher size ranges between 55 mm and 120 mm. In the corresponding size ranges, the rate of growth estimated here is higher than the previous observation.

Owing to the multimodal nature of the size distribution of the species in the estuaries, the minimum size at which they leave this habitat is not clear, while it is apparent that the size groups above 85 mm are relatively scarce. In the average size frequency distribution of the species (Fig. 3) the decrease in the estuarine popu-

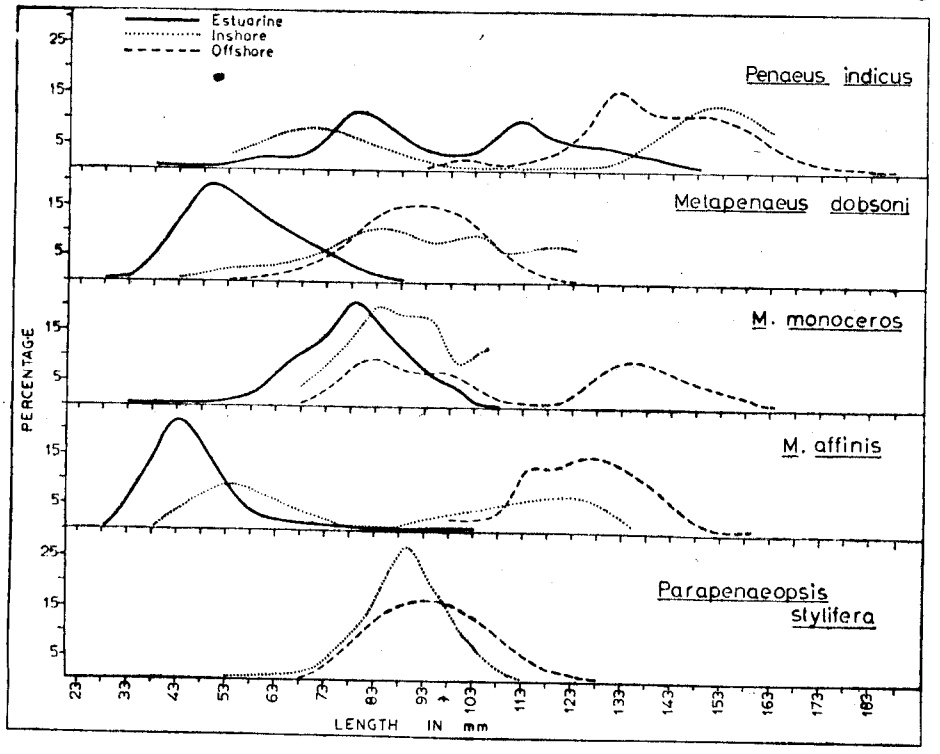

Fig. 3. Average size frequency distribution of commercially important prawns in different environments at Cochin.

lation begins from about this size and their seaward migration possibly commences at this relatively advanced stage. The species, therefore, remains in this ecosystem for a protracted period of nearly 10 months.

Penaeus indicus

The seasonal distribution of mature females in the inshore waters at Cochin indicates that the species has a prolonged breeding period with greatest breeding activity between October and May (George, 1962a ; Rao, 1968). Although wide fluctuations are observed in the occurrence and abundance of larvae in the estuarine

areas, two peaks—one in February-April and another in November-December—are noticed. Recruitment of the species to the estuaries takes place in relatively advanced postlarval stages when they measure 7.00 mm in total length. Normally the postlarvae of the species are poorly represented in the tow net collections. As the species contributes to a significant fishery in the backwaters, the lower numbers of postlarvae found in the tow net collections indicates that they have already acquired the benthic habit at the time of entry to the estuaries.

In the try net collections, the species appears only sporadically and hence the growth of the species cannot be properly traced from the monthly size frequency distribution. However, the size of the species in the estuarine population ranges from 36 mm to 150 mm and majority of the prawns are seen between 60 mm and 115 mm. George (1962b) found that the species attains 110-120 mm in the first year and that it migrates back to the sea from the estuaries after this length is attained. Hall (1962) observed a growth rate of 12.852 mm per month in the species in the prawn ponds in Singapore and he stated that the majority of prawns left the ponds on attainment of 85 mm size. Subrahmanyam (1968) recorded an average growth rate of 14.36 to 16.0 mm per month within a size range of 42 to 148 mm in the land locked *P. indicus* population of Ennur and Adyar estuaries.

The average size frequency distribution of the species in estuaries (Fig. 3) showed bimodal distribution, a lower mode at 80 mm and a higher one at 115 mm. Besides this, smaller sizes are also well represented in the inshore population. In view of these, it is difficult to state the exact nature of their movement and the size at which they leave the estuaries. It is possible that some of the juveniles after attaining a length of 80 mm leave the estuaries as evidenced by the decrease in the population represented by the first mode and others leave after reaching 115 mm as shown by the second mode. Another possibility is that those leaving at smaller sizes return to the estuary and contribute to the second mode. Fair representation of the smaller sizes in the inshore population suggests probability of their completing the life cycle in the sea itself. From the existing knowledge of the fisheries and biology of the species, the first interpretation seems most plausible. Taking into consideration, the average value of the different growth rates expressed by the previous workers, 80 mm size is probably attained by the species in about 6 months time.

Estuarine Phase of Palaemonid Prawns

The palaemonid prawns are the denizens of rivers, lakes and ponds, and they move out into the estuaries for the purpose of breeding. After spawning, the adults as well as the young ones return to their natural habitat.

Macrobrachium rosenbergii

This is one of the important commercial freshwater prawns occurring in all the major rivers and estuarine systems in the country. In Cochin Backwater, it is generally caught from the Vembanad Lake and from the rivers joining it. In Periyar river system, they are scarce and are caught in insignificant numbers.

The biology and fisheries of this species have been dealt with by many workers (Chopra, 1943 ; Chacko, 1955 ; Panikkar and Menon, 1956 ; Mary John, 1957 ; Ling and Merican, 1961 ; Rajyalakshmi, 1961, 1964 ; Raman, 1964, 1967 and Rao, 1965, 1968 & 1969). The species migrates from the rivers to the estuarine regions of the backwaters where the salinity fluctuates between 6‰ to 17.5‰ when its breed-

ing period is approached in August-December. Breeding takes place in this region and the freshly hatched larvae get distributed in the estuaries. Studies made on the plankton collections obtained from the backwater and on the rearing of the larvae show that only the first zoeal stage is planktonic and as it transforms into the second zoeal stage, the larvae sink to the bottom. Thereafter, it grows rapidly to a size of about 20-30 mm before ascending the rivers by December or early January. They remain in fresh water from January to May and again migrate to the backwaters with the onset of the monsoon (Raman, 1967). The species spends approximately 5 months in the estuarine environment.

In the Hooghly estuary, Rajyalakshmi (1961) and Rao (1968) found that the species spawns from March to May and the breeding migration of the adults into the estuary seen from December onwards occurs when the salinity is on the increase. The return migration of the adults takes place during monsoon, but the young ones start upward migration from September to October after the monsoon floods. This movement seen in the Hooghly estuary is not in agreement with what is observed in Cochin Backwater.

Macrobrachium idella

This species supports a subsistence fishery of some importance in Cochin Backwater and the canal systems associated with it. It occurs in large numbers from June to December and its main spawning season is observed from September to November. The females commence their migration down to the estuarine region by July-August for spawning. As in *M. rosenbergii*, the first zoeal stage is planktonic and from the second zoea onwards they become benthic. They grow fast till January and then start migrating towards freshwater. Both juveniles and adults are generally absent in the brackishwater environment from March when there is a steep rise in salinity. The general pattern of movement of this species is similar to that of *M. rosenbergii*.

Discussion

That most of the commercial marine prawns of India generally spend their juvenile life in the estuaries is a well established fact, but the extent of their dependence on that ecosystem for completing the life cycle is still imperfectly understood. Some workers opine that these prawns can complete their life cycle in the sea without having to migrate into estuaries, but this view is largely based on inadequate knowledge of the ecology of prawn larvae. With the exception of *Parapenaeopsis stylifera*, the larvae and juveniles of all other commercially important species are represented in the catches from the estuaries. Still characteristic is that in all these prawns the smaller sizes are not encountered in the inshore and offshore catches, but only in the estuaries. This is strong evidence to suggest that the estuarine phase is a necessity in the life cycle of these prawns. Since the life cycle is completed in two distinct biotopes, and recruitment takes place from the estuaries it is natural to expect a relationship between the abundance of the larval and juvenile populations of the estuary and the adult population of the sea.

The natural imigration of the larvae into the estuaries suggest that congenial conditions are present in this habitat to live and grow. Moreover, factors such as food and protection are also important. The organic productivity of the Cochin Backwater is relatively high (Qasim *et al.*, 1969) and so also the availability of the principal food of juveniles—phytoplankton, small animals and detritus. In the

matter of predators also the estuaries apparently offer them better refuge than the marine environment and serve also as a nursery, particularly for the juveniles.

The growth rate and the period of minimum stay of each of the species in this environment vary from species to species (Table 4). This period of stay is highest in

TABLE 4. *Estuarine phase of commercially important penaeid prawns in Cochin Backwater*

Species	Size in mm and stage at entry into backwater	Minimum size in mm when leaving back-water	Minimum period of stay in backwater (in months)	Mean growth rate month in mm
M. dobsoni	1.0 Protozoea	50	5	9.88
M. affinis	3.0 Late mysis]	40	4	8.25
M. monoceros	3.0 Late mysis	85	10	6.72
P. indicus	7.0 Postlarva	80	6	13.3*

*Average value of the growth rates recorded by George (1962b), Hall (1962) and Subrahmanyam (1968).

M. monoceros and lowest in *M. affinis* and on attainment of the specific minimum size (Table 4) all these prawns commence their movement towards the sea.

Discussing the probable reason of the emigration of these juvenile prawns from the estuaries, Panikkar and Menon (1956) state that they are practically flushed out of the estuaries by the flood waters. The continuous nature of the commercial prawn catches from these estuaries does not seem to be in agreement with this. Since fully mature female prawns are totally absent in the estuaries and as their spawning is so far recorded only from the sea, it is obvious that their seaward movement is activated by sex instinct. The general agreement of the minimum size at maturity of these prawns (64.1 mm, 88.6 mm 130.2 mm) respectively for *M. dobsoni*, *M. affinis* and *P. indicus* (Rao, 1968) with the comencement of their size frequency distribution in the offshore spawning areas lend support to this view.

Marine prawns are cultivated in enclosed waters in many Asian countries. Different methods of cultivation are in existence. In Philippines the young prawns called 'Sugpo' (*Penaeus monodon*) are collected from brackishwater areas and stocked in ponds when they attain market size in 5 months to 1 year (Caces Borja and Rasalan, 1968). In India and Singapore the young of different species of marine prawns brought in by the tidal current are trapped and cultivated in the enclosed fields (George, Mohamed and Pillai, 1968 ; Tham Ah Kow, 1968). The Japanese 'Kuruma ebi' (*Penaeus japonicus*) is commercially cultured under controlled conditions from artificially spawned stock to marketable size (Fujinaga, 1969). Most of our commercial prawns can be considered as potential species for farming as they are evolved with a natural life cycle which is preadapted for the estuarine life in the younger stages and they could also withstand wider range of environmental changes. With directed research it would be possible to evolve suitable methods of culture for the Indian species of prawns and this would bring

into productive use the vast stretches of brackishwater areas which are now lying unutilised.

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