III GENUS *PENAEUS* FABRICIUS 1798

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The Genus *Penaeus* has a world wide distribution and the various species belonging to it are found both in tropical and temporate latitudes. Practically all of them are marine although some are known to spend a part of their life in the brackish water and even in fresh water. Of the 28 valid species of the genus only 8 are represented in Indian waters, they being *Penaeus japonicus* Bate, *P. latisulcatus* Kishinouye, *P. canaliculatus* (Olivier), *P. monodon* Fabricius, *P. semisulcatus* de Haan, *P. indicus* H. Milne-Edwards, *P. merguiensis* de Man and *P. penicillatus* Alcock.

Most of the species belonging to this genus grow to large sizes and they support commercial fisheries in many parts of the world, accounting for over 50% of the total world production of prawns and shrimps. All the 8 species recorded from India are listed (Holothuis and Rosa, 1965) as prawns of economic value although some of them do not occur in commercial quantities in India.

1. *PENAEUS INDICUS* H. MILNE-EDWARDS, 1837

The distinguishing characteristics of the species (Fig. 3) are as follows:

Body completely glabrous. Rostrum slender, long with distinct double curve, $1^{1}/_{2}$ to 2 times in length of carapace in the juvenile stages, first five dorsal teeth close together, penultimate and distal teeth widely separated, position of latter variable. Rostrum becomes shorter with increasing size, equalling length carapace in prawns of 80 mm, almost straight and with higher blade. Rostrum extending beyond tip of antennular scale in large prawns, blade high but not forming a triangular crest. Adrostral groove shallow, decreasing in depth backwaters up to epigastric tooth. Eight to nine (sometimes seven) dorsal and four to

five ventral teeth on rostrum. Carapace glabrous, thin, sulci and carina feebly defined. Gastro-orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle. Orbitoantennal sulcus wide and ill-defined. Postantennular spine continued as an oblique ridge to the hepatic spine. Subhepatic ridge absent. Abdominal segments four to five keeled, keel on sixth segment ending acutely. Telson grooved, without lateral spines. Second and third joints of the first leg and second joint of the second leg provided with a spine.

Maxilliped III reaches to the second segment of the antennular peduncle. Dactyle of maxilliped III of adult male as long as the propodus. First, fourth and fifth pereopods reach the first segment of the antennular peduncle, the second limb extending to tip of antennular peduncle and third surpassing the same by half length of chela. Mandibular palp two segmented, last segement subrhombiodal, bluntly pointed at the apex, nearly twice as long as wide. Endopodite of maxillula segmented in two. Distal piece of appendix masculin a deltoid in outline with rounded apex fringed with thickly set setae. Sixth abdominal somite as long as telson.

Median lobe of petasma rounded at tip, projecting forward up to the apex of the lateral lobe which is covered with sparsely set fine setae on outer surface. Terminal portion of the distal margin serrated with 12 well- calcified teeth. Anterior median process of thelycum roughly semicircular and relatively small situated on sternite between fourth pereopods. There are minute apical spines on the anterior margin of this process. The two large lateral plates housing seminal receptacles occupy most part of the last thorasic sternite. The lateral plates meet each other in the median where the edges of the plates are up-curved to form an appearance of a valve (Fig. 3)

Cardiac plate has 21 to 23 equidistant spinules set on a longitudinal row. Zygocardiac ossicle has 8 to 13 conical teeth set in an arc shaped series. Prepyloric armed with about 10 pointed teeth which get successively larger towards tip. Hall (1962) has shown that variations in the number of spinules in the different components of the stomodial apparatus are more or less similar in *P. indicus* and *P. merguiensis*.

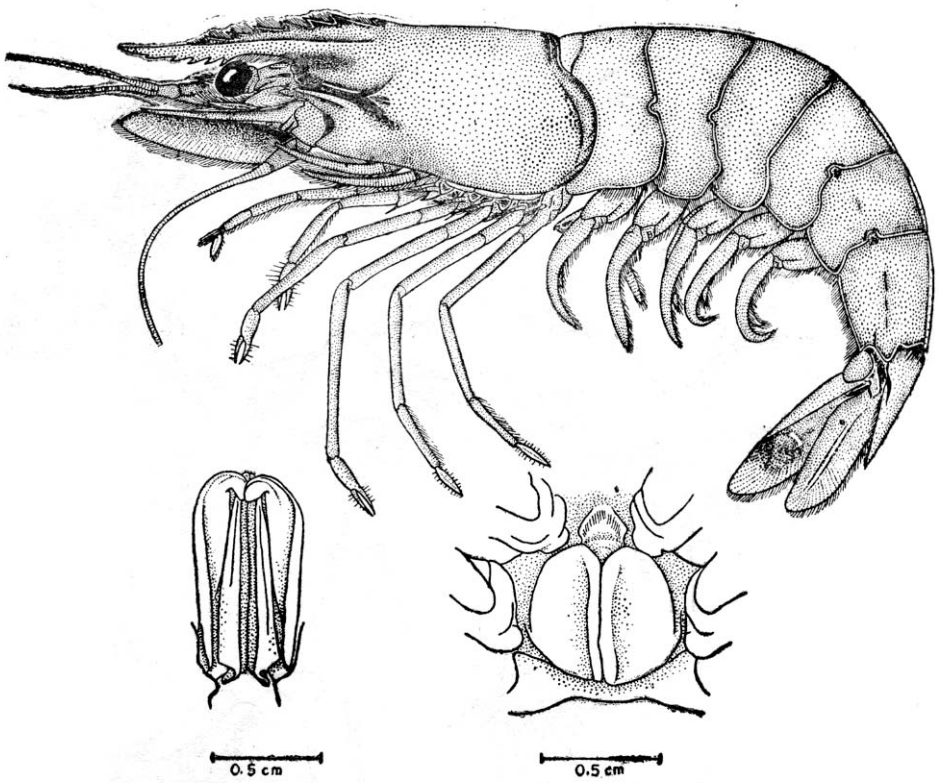

Fig. 3. ***Penaeus indicus*** H. Milne-Edwards.

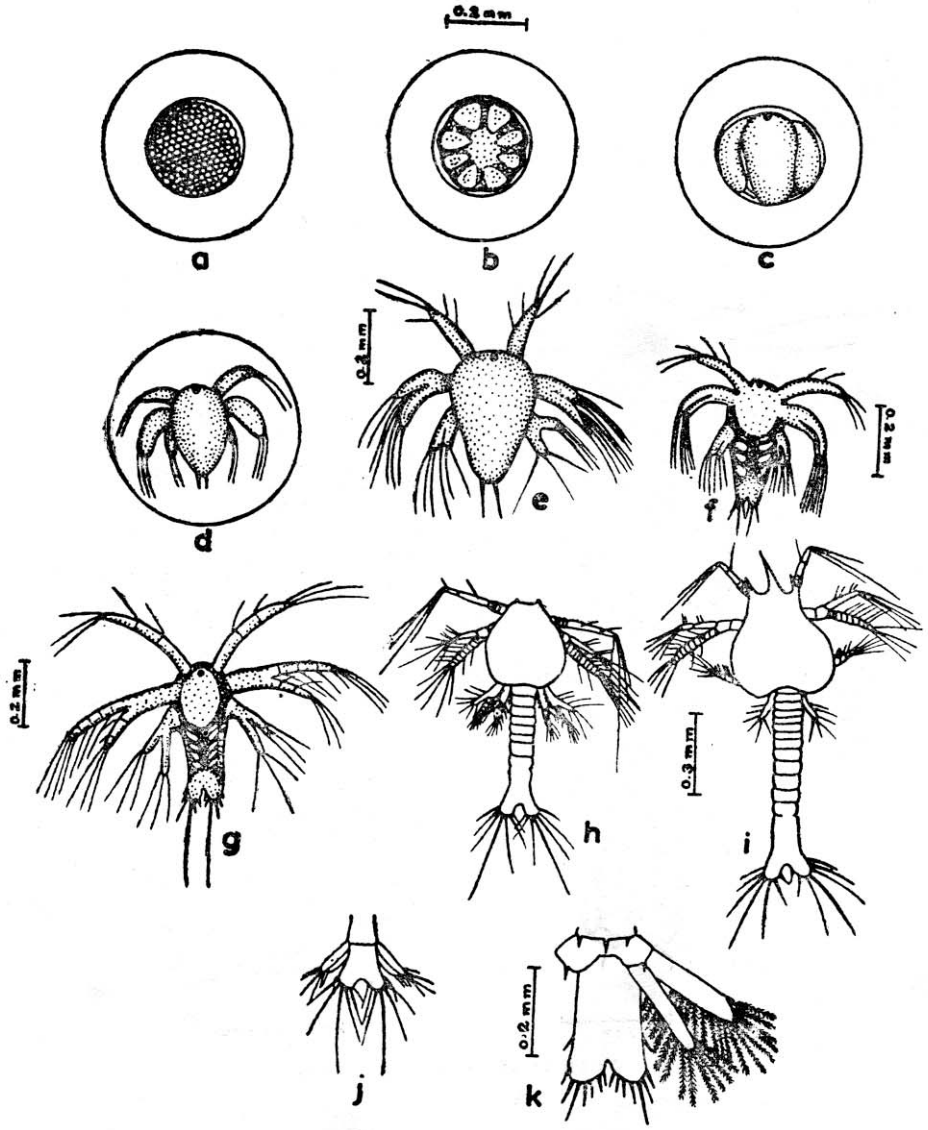

Fig. 4. Eggs and Larvae of *Penaeus indicus*.
a-d. Development stages of egg; e. Nauplius I; f. Nauplius II; g. Nauplius III (Subrahmanyam, 1965); h. Protozoea I; i. Protozoea II; j. Uropod and telson of Protozoea III; k. Uropod and telson of Schizopod I (Menon, 1937).

General colour of live specimens is translucent whitish, with numerous small brownish, greyish or greenish chromatophores scattered over the carapace and abdomen. The upper half of the rostrum, base of eyestalks, dorsal carina of the last three abdominal somites, telson and uropods are deeply pigmented with maroon and dull brown chromatophores. The antennae and the terminal portion of the exopods of the second and third maxillipeds are pinkish; the tips of both uropods and the external margins of the outer pair are pinkish-red with similarly coloured setae. The antennular flagella are lemon yellow, banded and dotted with maroon.

Distribution

The occurrence of *P. indicus* has been reported from New South Wales: off Broadwater; Queensland: Gulf of Carpentaria; New Guinea: Port Moresby; North Borneo: Labuan, Sandakan; Indonesia: Palembang, East Kalimantan, Java; Philippines: Manila Bay, St. Miguel Bay, Bulacan Province, Santa Cruz, Luzon; Singapore: Amoy, Andamans; East Pakistan; Gulf of Aden; east coast of Africa and Madagascar. The species is fairly widely distributed in the Indo-Pacific, ranging from coasts of India and Ceylon to the west through Gulf of Aden to east of Africa and Madagascar, to the east to Andamans, Malaya, Singapore and Indonesia. As a commercial fishery the species exists in India, Ceylon, Malaya, Singapore, Mosambique and Madagascar, but it is reported as of scattered distribution in Australia, New Guinea and the Philippines. It is considered rare in waters east and south-east of Borneo. In India the species supports commercial fisheries in both the marine and estuarine environmens on the east and west coasts.

Biology and Life-History

Eggs and larvae:- Eggs of *P. indicus* have been reported to occur in large numbers in subsuface plankton in Madras waters (Subrahmanyam, 1965). They were obtained from 3 metres below surface in February 1964. These eggs have been referred to this species purely on the basis of circumstantial evidence of simultaneous occurrence of adults in mature condition. Panikkar and Menon (1956) stated that the species preferred deeper waters for spawning, its eggs and larvae having been seldom obtained along with those of other pepaeids known to exist in the same area. Menon (1937)

recorded three stages of protozoea and one of schizopod (mysis) (Fig. 4 h to k) and Subrahmanyam (1965) described three stages of nauplius obtained by hatching the eggs collected from the Madras plankton (Fig. 4a to g). Menon's collections were from surface plankton, apparently indicating planktonic habits of the larvae. Collections made from areas near Cochin indicate that larger numbers of larval forms in advanced stages are present in the inshore subsurface waters particularly in the early hours of the morning.

Postlarval stages are well represented in the tow net collections taken from the estuaries near Cochin on the Southwest coast of India. George (1962) estimated the seasonal abundance of postlarvae of *P. indicus* (8 to 14 mm in total length) and studied the recruitment of these into the backwaters of Cochin. He observed that the postlarvae enter the Cochin backwaters in all the months except the period June to September and the peak recruitment having been observed in November-December and February-April. Hall (1962) observed that penaeid larvae and postlarvae (species not specified) formed only insignificant portion of the plankton collected from Singapore prawn ponds. He observed that more postlarvae were present in the inflowing waters than in the outflowing waters of the prawn ponds. It is possible that the post larvae settle down to the bottom of the prawn pond before the flow of tide reverses. Mohamed, Rao and George (1967) described the first post larva of the species and compared the distiguishing characteristics of the species with those of the co-existing species in Cochin backwaters. They found that the first postlarvae are fast swimmers performing rapid forward movement along the edges of the glass troughs in which they were placed.

Juvenile stages of *P. indicus* (30 to 120 mm total length) spend their life mostly in the estuaries and backwaters. On the southwest coast of India these juveniles support a good commercial fishery in the back waters and paddy fields where they live till they attain lengths of 100 to 120 mm, after which they go back in to the sea (Menon, 1954; Menon and Raman 1961; George, 1962). Recent observations made on the sizes of these prawns in the paddy fields at Edavanakkad, near Cochin showed that they grow even up to 160 mm in this enclosed environment. Hall (1962)

observed the maximum size of the species in the Singapore prawn ponds as 27 mm carapace length. This is about 113.4 mm total length as per the conversion rate given by him. The entire catch from the prawn ponds are therefore juveniles. The juveniles are bottom living and are obtained from the estuarine environment throughout the year.

Sexually mature adults occur only in the sea. They are associated with shallow coastal regions and muddy sea bottom which are subjected to changes due to the physical conditions of the coast line and the nutrients obtained from the land and rivers. De Bruin (1965) states that they prefer sand bottom and shallow waters of the sea within 2 to 6 fm (3.7 to 11 m). On the coasts of India the adults form part of the prawn fishery within 25 fathoms (45.8 m) in the sea. Its occurrence in the sea is subjected to seasonal fluctuations. George and Mohamed (1966) observed that the prawn fishery of Kanyakumari district (southern extremity of the west coast of India) is exclusively supported by large sized mature *P. indicus*.

Food and feeding:- Gopalakrishnan (1952) observed that the species does not show any significant difference in food habits in different months of the year. Analysis of the food of different sizes also showed no variations. Based on the periodic fluctuations of the various items of food consumed he observed that these prawns feed on whatever suitable material they come across. From laboratory observations he remarks that in the state of nature the species is partly predatory in habits and chase smaller creatures of a size which can be seized between the appendages. Larger crustaceans, fish and others are attacked only in dead condition. They usually prefer small particles of food, which are grasped by the chelae of the pereopods and passed on to the mouth. When bigger particles are taken up, more than one pereopod, with or without the assistance of third maxilliped, are used to catch hold of the prey. While capturing small ctenophores and medusae the pereopods hold the prey close to the mouth so that mouth parts can act on it.

Panikkar (1952) stated that the food of young penaeids consisted of organic detritus found in the mud, algal material and other extremely small organisms contained in the mud. Gopalakrishnan (1952) analysised

the gut contents of 380 specimens and found that vegetable matter and crustaceans formed the bulk of food consumed. Presence of other animal matter indicated omnivorous habits. The vegetable matter included diatoms like *Coscinodiscus, Pleurosigma, Rhizosolensia,* the planktonic alga *Trichodesmium* and cuttings of sea weeds. The Crustaceans included copepods, ostracods, amphipods, tiny decapods and their larval stages. Molluscan shell pieces, polychaetes, echinoderm larvae, hydroids, trematodes (living) and foraminifera were occasionally met with. Panikkar and Menon (1956) stated that the food of prawns (*Metpapenaeus dobsoni* and *P. indicus*) consists of detritus, both animal and plant, that accumulate at the bottom of their habitats which are usually areas with muddy bottom. They seem to consume large quantities of algal matter when available, some of the stomachs examined having been practically full of it. Small living creatures like molluscs and worms, living at the bottom may also be taken in. Hall (1962) found that the food of the juveniles of the species from Malayan prawn ponds consisted of crustacea (small and large), vegetable matter and polychaeta. Larger specimens took in more crustaceans including penaeids and brachyurans.

Growth:- Hall (1962) estmated a growth rate of 0.102 mm in carapace length per day in prawns caught from Malayan prawn ponds and he considers this as fast rate of growth since limiting factors such as extreme temperature and scarcity of food are non-existent in that habitat. While studying the offshore prawn fishery of Cochin, George, et al. (in press) stated that the modes seen in the size frequency distribution at 126-130 mm for males and 141-145 mm for females represent the first year class, those at 161-165 mm for males and 171-175 mm for females represent the second year class and those above 195 mm represent the third year class. By follwing the progression of modes they have also estimated a growth rate of 20 mm in males and 15 mm in females during four months between first and second year classes.

Hall (1962) has estimated the length weight relationship of the species as

$$W = 0.6918 \quad C^{2.922}$$

Where W is weight of prawn in grams and C is carapace length in cm.

Vast majority of this species caught from the estuaries doen not exceed 120 mm. Menon and Raman (1961) have stated that under the prevailing conditions in their brackish water habitat most of the prawns move out into the sea or are caught before they are about 100 mm in length., although the adults may reach double that size. The rate of growth is relatively high when they are in the estuaries and backwaters which act as a sort of nursery ground for the species. Crosnier (1965) observed that favourable temperature of the environment accelerates the growth rate.

Movements:- The life cycle of the species is completed after passing through two distinct environments - the sea and the estuary. The larval development takes place in the sea, and the migration into the estuaries, lakes and backwaters commence when they are in late mysis or early postlarval stages. According to Panikkar and Menon (1956) large numbers of young ones pass into the backwaters before they are 10 mm long and this process of migration is continuous throughout the breeding period. The size attained by the species in the backwaters does not exceed 120 mm. Kemp (1915) records the highest size observed by him in the Chilka Lake as 120 mm. The seaward migration begins after this size is attained. The seaward movement is described as a passive process as they are usually carried by the large influx of rain water flowing into the sea during the monsoon period. Further growth, attainment of sexual maturity and other life processes take place in the sea. Shaikhmahmud and Tembe (1960) record that the species moves into Bombay waters in September to December and February to June, and that these movements mostly take place after heavy rains.

Hall (1962) demonstrated the spawning ground of *P. indicus* about to 60 mi (80 to 96 km) from the Singapore prawn ponds and remarked that "migration of 40 to 50 n mi should be well within the capabilities of the mature *P. indicus*". Regarding the offshore prawn fishery of Cochin, George et al (in press) state that the females of the species belonging to the larger size groups move to still deeper waters or other areas for spawning activities and never return.

Maturation and reproduction:- *P. indicus* is heterosexual. Sexes can be distinguished by external characters such as presence of morophologically differentiated male and female sex organs. While the male sex

organ, is abdominal in position being the endopodite of the first pleopod; the female sex organ, thelycum, is a modification of the thoracic sternite. The presence of appendix masculina in the endopod of the second pair of pleopods is another male character. While the genital openings of the male are situated on the coxa of the fifth pair of walking legs those of the females are on the coxa of the third pair of walking legs. Females attain relatively larger size than males. Rao & George (1967) have traced the development of the external genital organs of the species from early stages to the adult form and found that over 50% of the individuals measuring 102.0 mm had their petasmal endopodites fused.

Menon (1957) reported that most of the mature individuals examined by him measured 150 mm and over, and hence he used this size as the limit to determine the proportion of mature and immature prawns in the samples. By observing the nature of the petasmal endopodites Hall (1962) observed that specimens below 23.4 mm carapace length were immature. Rao (1967) has studied the process of maturation of the species by ova diameter measurements and has statistically estimated the size of the females at first maturity as 130.2 mm. The smallest mature female actually observed by him was 134 mm in total length. The age of the species at first maturity has not been precisely estimated. George et al. (in press) have stated that females of 141 to 145 mm size group and males of 126 to 130 mm size group represent the first year class. It could therefore be assumed that the species attains sexual maturity at 130.2 mm, when about one year old.

The species is promiscous. During mating the sperm packs known as spermatheca are deposited by the male in the external genitalia of the female. The female carry the spermatheca and the sperms are dispensed at the time of spawning. Impregnated thelycum is not differently coloured. Fertilization is external. As the eggs are extruded from the genital opening of the female the sperms are dispensed from the spermatheca.

Rao (1967) has estimated fecundity as 68,000 in a female of 140 mm total length, to 731,000 eggs in a female 200 mm long. The relationship of gonad size and egg number is not determined but the estimated relatioship of body length to number of eggs is $\text{Log } F = -8.1277 + 6.0808 \text{ Log } L$, where F is the fecundity and L the total length of the prawn in

mm, with a regression coefficient of 0.9716.

Panikkar and Menon (1956) indicated the existence of two breeding periods namely October to November and May to June. Based on the occurrence of postlarvae of the species in the Cochin backwaters George (1962) recorded the spawning season as from October to May with two spawning periods in November to December and during February to April. Hall (1962) oberserved the spawning season of the species as February to April in Singapore waters. Subrahmanyam (1963) studied the gonad index of the species from Madras waters and observed that the breeding activity appeared to be pronounced in the months of May, July, August and September, and that there may be lesser breeding activity in March. George *et al*. (in press) stated that the species breeds throughout the fishing season with two peaks as observed earlier. Rao (1967) observed that *P. indicus* has a prolonged breeding period extending from October to April in Cochin waters. In Madagascar waters Crosnier (1965) found that the breeding period of the species is closely related to the water temperature. In Ambaro Bay the spawning is spread out with one or more intense periods in the warm season. By closely following the sizes of the spawners during the breeding season Rao (1967) concluded that individuals of *P. indicus* spawn five times during life time and that interval between two successive spawnings is about two months.

Panikkar and Aiyar (1937) observed that the species didn not attain sexual maturity in backwaters but their young ones were noticed in large numbers in the Adayar estuary when the bar was open to the sea. Panikkar and Menon (1956) stated that *P. indicus* seemed to prefer deeper waters for breeding, its eggs and larvae having been seldom obtained along with those of the other prawns of the area, which liberate their eggs in coastal waters not exceeding 10 to 12 fm (18.3 to 22 mm) in depth. Shaikhmahmud and Tembe (1960) found the species represented in the Bombay catches by immature specimens although they observed a few mature females in November to December. Subrahmanyam (1965) collected freshly spawned eggs and nauplii from very close inshore waters of Madras, on the basis of which he suggested that the species might be breeding in the inshore areas. It is, however, generally believed that the species breeds in the sea in relatively deeper waters and the postlarvae migrate into the estuaries and

backwaters for feeding and growth. Hall (1962) demarcated the possible spawning area of the species in the Malayn region east of Singapore in 10 to 20 fm (18.3 to 36.3 m) depth between Lat 01^0 21' N and 01^0 40' N Long. 104^0 20' and 104^0 30' E. Based on the observations made on occurrence of protozoea and the trawl catches in Madagascar waters Crosnier (1965) observed that the species probably breeds in shallow waters of the Bay of Ambaro without migration of the females taking place into the deeper sea.

The earliest developmental stages seen by Subrahmanyam (1965) was a blastula which was collected in the morning and he presumed that the spawning had taken place in the early hours of the morning. The eggs hatched out in the afernoon. On the basis of this the time taken for development is as follows:

12 (?) hrs. after spawning	..	hatch into	Nauplius I
20 hrs. after hatching	..	..	Nauplius II
44 hrs. after hatching	..	..	Nauplius III
66 hrs. after hatching	..	..	Protozoea I

Menon's (1937) collection of protozoea stages and first schizopod stage were obtained from plankton samples and hence the time required for development from one stage to the other is not given.

Fishery

Structure of the exploited population :- As a fishery the species is subjected to commercial exploitation at different stages of life from both estuarine and marine environments. George (1962) observed that the brood which comes into the backwaters in November to December reaches a size of 110 mm in September to October of the following year when they move out of the sea. He estimates a growth of 110 to 120 mm in the first year. Hall (1965) estimated that the species attains 27 mm carapace length (Ca. 113.4 mm total length) in 10 month in Singapore prawns ponds. Therefore the entire prawn pond and backwater fishery are constituted by 0 year class prawns. George *et al* (in press) obesrved that three year classes (0, 1 and 2) of this species are represented in the trawl fishery at Cochin.

In the backwater catches of Cochin the maximum size recorded is 140 mm. More than 80 percent of these catches were below 100 mm and the modal size groups were observed between 8 to 90 mm (Menon and Raman, 1961). In the inshore marine catches of Alleppey coast George (1961) observed its modal length shifting from 111-115 mm in July to 131-135 mm in October and at Chellanum from 111-115 mm to 126-130 mm from January to May and from 151-155 mm to 161-165 mm in September to December. At Narakkal the predominant size group was observed at 96-100 mm in January to February and at 131-135 and 141-145 mm in June, July and October. In the offshore trawl catches off Cochin 161-165 mm males and 171-175 mm females were found predominating the catches during early part of the season. Towards the close of the season the mode was seen at 146-150 mm for males and 156-160 mm for females. In Singapore prawn ponds the maximum size was 27 mm carapace length and the majority size was 10 to 20 mm carapace length (ca. 42 to 84 mm total length). In the commercial catches of Bombay, Shaikhmahmud and Tembe (1960) recorded 45 to 125 mm length range and 180-200 mm length range, the latter occurring only occasionally.

The sex ratio of the species obtained from the backwaters and from the inshore marine catches from Narakkal was studied in detail by Menon (1957). Data from Menon's work is reproduced in Tables I and II. His studies showed that the sexes were more or less equally distributed both in marine and in backwater environments. Shaikhmahmud and Tembe (1960) observed larger numbers of females in September and November in the commercial catches of Bombay. George and Rao (1965) found the distribution of sexes in the trawl catches of Cochin significantly different from what could be accounted for by the bionomial theory.

TABLE I

Sex ratio of *P. indicus* in Cochin waters (Menon, 1957)

Year	All size		Over 120 mm				Over 150 mm			
	Ratio		Ratio		% in total		Ratio		% in total	
	M	F	M	F	M	F	M	F	M	F
1952	41.6	58.4	41.4	58.6	82.9	83.5	36.5	63.5	29.9	37.2
1953	49.0	51.0	46.2	53.8	31.7	35.4	34.8	65.2	4.4	8.0
1954	51.0	49.0	51.0	49.0	77.0	77.0	49.4	50.6	29.0	30.9
1955	48.7	51.3	49.5	50.5	54.6	52.9	40.0	60.0	7.5	10.7
Average	49.0	51.0	48.8	51.2	59.8	60.2	44.6	55.4	16.5	19.7

TABLE II

Sex ratio of different sizes of *P. indicus* (Menon, 1957)

Size groups	Sex ratio		Percentage in total	
	M	F	M	F
Backwater catches				
Less than 120 mm	50.0	50.0	-	-
Sea catches				
Up to 120 mm	49.3	50.7	40.2	39.7
Between 120 and 150 mm	50.6	49.4	43.4	40.5
Over 150 mm	44.6	55.4	16.5	19.7
All sizes	49.0	51.0	-	-

M = Male; F = Female.

Fishing season :- In the backwaters of Kerala the species is fished almost throughout the year. The observations of Menon (1954) and Menon and Raman (1961) do not clearly indicate any seasonal preponderance of the species in the backwaters. The monthly percentage of the species in the paddy field catches and in the backwater catches are shown in Table III.

TABLE III

Showing the percentage of *P. indicus* in the commercial catches from the backwaters of Cochin (Data for 1952 and 1953 from Menon (1954) and for 1956 to 1968 from Menon and Raman (1961)

	1952	1953	1956	1957	1958
January	11.7	9.0	-	15.5	-
February	8.4	7.0	-	11.7	-
March	12.5	29.8	-	28.5	4.8
April	2.0	48.0	-	15.0	-
May	-	-	-	10.7	2.2
June	-	-	-	25.5	8.0
July	-	-	-	8.8	20.4
August	-	-	-	-	4.1
September	-	-	-	-	-
October	-	-	-	1.9	-
November	1.6	-	4.3	15.6	-
December	8.7	-	2.5	7.6	-

In the Singapore prawn ponds Hall (1962) observed two peaks in relative abundance, one in March to April and again in September. According to Panikkar and Menon (1956): "Though a few prawns may be caught throughout the year at various points along the west coast (of India), the marine fishey is largely seasonal. On the west coast the season generally coincides with the monsoon period, June to September, so far as the southern region is concerned". This is a general observation based on overall prawn catches and not concerning a particular species. Besides, the introduction of mechanisastion in the fishing industry in subsequent years has changed the pattern of succession of many a species in the fishery of this region. In the offshore catches of Cochin, George *et al.* (in press) found maximum abunadance of the species during January to April. Early in the season, during September to October period, the species was conspicuously rare in the offshore catches. In the commercial catches of Bombay Shaikhmahmud and Tembe (1960) found the species occurring throughout

the year except during the months of January, July and August. Mohamed (1965) oberved the species contributing substantially to the prawn landings at Sassoon Docks (Bombay) in certain months but there was no regularity in its appearance. Mohamed (1967) recorded the fishing season of the species in December to February in both the east and west coasts of India. George and Mohamed (1966) reported that P. indicus is commercially exploited in Kanyakumari District from May-June to September-October.

Depth ranges in which fishing is carried out:- The estuarine and backwater fishery for the juveniles of the species is carried out in very shallow waters not exceeding 10 m in depth. The depth of water in the paddy fields of Kerala, from where the species is fished in large quantities, and of the Singapore prawn ponds, is less than 1.5 metres. The commercial fishery for adults is generally carried out in the coastal waters up to a depth of 50 metres along the Indian coast. In Madagascar waters the species is generally fished from depths up to 10 metres.

Catches:- George (1961) has observed that the species formed 1 to 5 percent of the inshore marine catches at Alleppey, 10.3 to 75 percent at Chellanum and 3.5 to 33.3 percent at Narakkal, on the west coast of India. In the offshore fishery at Cochin George *et al*. (in press) recorded the highest value of 48 percent for the species in total catches. In Singapore prawn ponds Hall (1962) records *P. inducus* as forming 27.99 percent of the catches. Mohamed (1967) states that the species forms approximately 10 percent of the total marine prawn production of India. On the basis of this the total catch of this species per year in India is estiamated as 8,000 tonnes.

Fishing equipment:- In the backwaters the species is caught in large quanitities in stake nets, cast nets, drag nets, dip nets and small scoop nets. On Kerala coast there are conical sluice nets specially designed to catch all the prawns entering the paddy fields situated near the backwaters. All these nets are made of cotton twine. Some ingenious contraptions like ‘changala pachil’ (Panikkar, 1937), bamboo scree traps etc. are also in use in different parts of the estuaries and backwaters. In the inshore marine fishery the principal types of gear employed in the capture of prawns are the boat seines and the shore seines. In Gujarat

and Maharashtra States on the west coast of India large stake nets ('Dol net') are used in the inshore prawn fishery. Along the Kerala coast and on the southern end of the west coast of India east nets of various dimensions form an important gear for capture of prawns. From the deeper regions prawns are caught in trawls and stake nets only. In the mechanised vessels the gear in use are common 2 or 4 seam shrimp trawls having 13 to 18 metres headline. The mesh size of the various parts of the shrimp trawl are: the wings 76 mm, the belly 50 mm, the batings 38 mm and the cod end 25 mm. These nets are mostly made of cotton twine but in some cases synthetic fibres are also used. The bigger trawlers, however, use nets with longer headlines.

Small dug-out canoes (4 to 6 metres long) are the principal craft in use in the small backwaters. Larger dug-outs (6 to 10 metres long), canoes and catamarans are used in the inshore fishery in the west coast of India. On the east coast plank built canoes and catamarans are in use. The shrimp trawls are operated from 7 to 11 metre pablo type wooden hull boats powered by 10 to 30 hp diesel engines. A few larger steel built boats are also operating shrimp trawls.

Possibilities of culture:- Farming and culturing of the species, in the strict sense of those terms, is not reported from any part of the world. The time old method of trapping of the juveniles of this prawn, along with those of other species, is extensively practised in the paddy fields of Kerala (Panikkar, 1937 ; Menon, 1954; Gopinath, 1956; Panikkar and Menon, 1956; Kesteven and Job, 1957; George, Mohamed and Pillai, 1967). Soon after the rice cultivation is over in October the paddy fields lying close to the backwaters and connected canals are prepared for the trapping of prawns. These preparations include strengthening of the bunds and refixing the sluices which control the flow of water into the fields. The water is let in during the high tide and let out during the low tide. When the water is let out a bamboo screen is placed inside the sluice to prevent the prawns from escaping. During the night a petromax lamp (ca. 300 candle power) is kept over the mouth of the sluice in order to attract the prawns when the water is let in. Fishing is generally carried out during ebb tide at night when there is maximum tidal gradient due to the

spring tide. A conical net (sluice net) is fixed to the mouth of the sluice and the water from the field is let off virtually filtering through the net. The prawns are collected from the bag end of the net. The practice is described in detail by Menon (1954) and Gopinath (1956). Culturing in the strict sense is not involved in this practice as the prawns that enter the fields are neither tended nor do they remain there for significant length of time. But the recent studies made on this practice by George, Mohamed and and Pillai (1967) have proved that the prawns entering the field do remain in these fields for some time during which they feed and grow. They also found that thsese paddy fields are not merely a part of of the trapping mechanism but that they provide as active and suitable biological environment for the life and growth of these prawns. Therefore it would follow that introduction of modern culture techniques into this age old system of prawn trapping would be benificial and result in improvement in the quantum of catches as well as the size of the prawns caught.

2. *PENAUS SEMISULCATUS* DE HAAN, 1850

The distinguishing characteristics of the species (Fig. 5), are as follows :

Teeth on rostrum 6-7/2-3, almost staright with a uniformly convex blade, reaching tip of antennular peduncle. Postrostral carina distinctly sulcate, the sulcus slightly less or equal to 1/3 length of carapace. Adrostral carina and sulcus reaching 2/5 length of carapace from posterior edge. Postrostral carina almost reaching posterior border from carapace. Gastro-orbital carina occupying posterior 2/3 distance between cervical sulcus and anterior margin of carapace. Orbito-antennal sulcus posteriorly deep and with parallel sides. Antennal carine 2/5 length of carapace, exceeding orbito-antennal sulcus posteriorly and meeting hepatic sulcus 1/3 its length from posterior end. Hepatic carina inclined downwards to horizontal at angle of about 15^0 and 1/5 length in carapace cervical sulcus upcurved, shallow and 1/4 length in carapace.

Upper antennular flagellum larger than lower, exceeding 1/2 length of peduncle. Prostrostema, reaching 1/4 of second segment of antennular peduncle; stylocerite attaining 1/2 of first segment. Dactyl of maxilliped III 2/3 length of propodus (in male) which bears an apical tuft of setae as long as dactyl. Maxilliped III reaching tip of basal segment as antennular peduncle. Pereopod I exceeding carpocerite by half the entire dactyl, pereopod II reaching or exceeding tip of first, pereopod II exceeding third segment of antennular peduncle, pereopod IV exceeding carpocerite by half the entire dactyl, pereopod V very slightly exceeding fourth. Exopods on all pereopods, an ischial spine smaller than basial, on first.

Abdomen dorsally carinated from fourth somite. Fourth and fifth somites each with 2 and sixth with 3 cicatrices. Telson unarmed.

Median projection of petasma flattened dorsoventrally, slightly overhanging lateral lobes; latter with minute spical spines, minutely tuberculate internally and externally but without distinct rows or areas of spines. Anterior plate of thelycum obtusely angled apically, with deep V-shaped excavation; a posterior tongue inserted between flaps of seminal receptcale for 1/3 their length. Width of anterior plate 1/3 seminal receptacle at its widest point. Seminal receptacle as wide as long, flaps strongly reflected with transverse striae on everted lips and almost angular at their lateral extremities.

Colour in life dark green with indistinct darker crossbands on the abdomen ; antennal scales eyestalks, pleopods and uropods dull red, the latter with a brownish fringe; pereopods with yellow and reddish bands, antennae banded (adapted from Dall, 1957).

Distribution

This is also a widely distributed species in the Indo-Pacific region as the other two species discussed. It is reported from Australia: Queensland, Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Repurse Bay; New Guinea: Kinikini Bay, Hercules Bay, Oyster Bay, Daru I., Yule I.; Indonesia: Java, East Borneo, Sumatra, Sulawesi, Lesser Sunda I., Mollucas, Halmahera I.; Philippines: Manila Bay; Japan: Seto Inland Sea;

Taiwan: South China Sea; Malaysia: Singapore, Malacca straight; East Pakistan, Coasts of India and Ceylon, West Pakistan, Red Sea, East coast of Africa: Durban Bay, St. Lucia estuary, off Zululand coast, Richards Bay, Delagoa Bay; Madagascar: Cape St. Sebastian and Mangokay estuary.

Fishery and biology

Although the species is reported as forming part of the prawn fishery from many countries of the Indo-Pacific region, detailed information on its fishery and biology is scanty. The species is of commercial importance in certain areas of the Seto Inland Sea of Japan. Yasuda (1956) observed that the juveniles of the species measuring 3.2 mm to 17.0 mm in carapace length spend their life from late August to middle of October in areas of the sea where *Zostera marina* are growing. After middle of October the species seems to be fished only from the offshore areas where the bottom is muddy. It is also oberved that the young prawns groups continuously and rapidly to adult size and then grow at a much reduced rate.

Hall (1962) found that *P. Semisulcatus* formed 0.07 percent of the prawn catches (numerically) of the Singapore prawn ponds. He examined the stomach contents of 14 specimens and found the following food items:

Food item	Predominant	Residual	Total
Polychaeta	2	1	3
Small Crustacea	-	3	3
Large Crustacea	1	3	4
Pisces	1	1	2
Vegetable	-	2	2

Based on these observations he grouped the species among prawns with 'general carnivorous diet'. Weight length relationship of this species was expressed by the formula.

$$W = 1.0069\ C^{2.727}$$

where W is weight in gms. and C is carapace length in cm. In Singapore Straits the species probably breeds in the same breeding grounds of *P. indicus* in February - April (Hall, 1962).

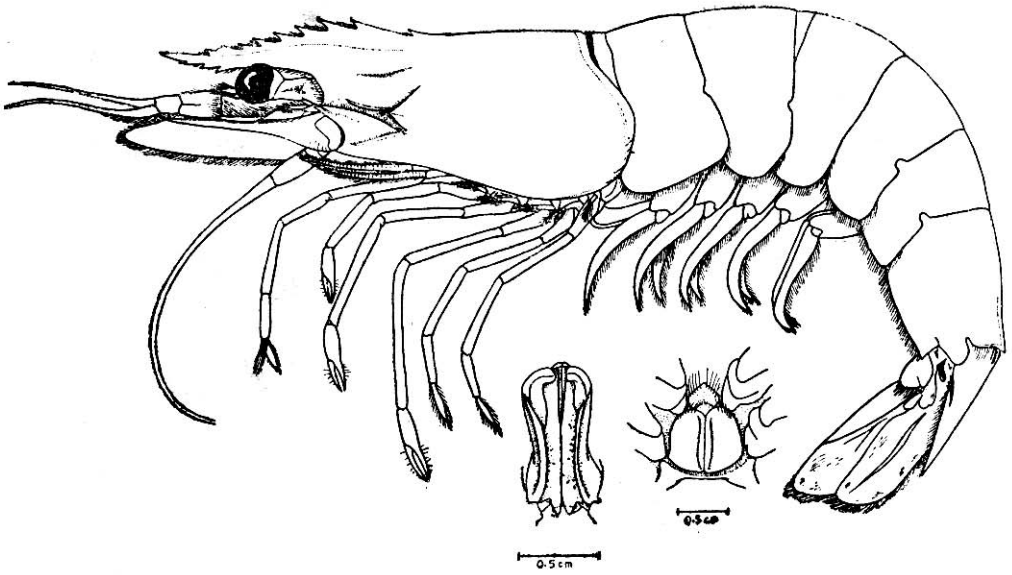

Fig. 5. *Penaeus semisulcatus* (Olivier)

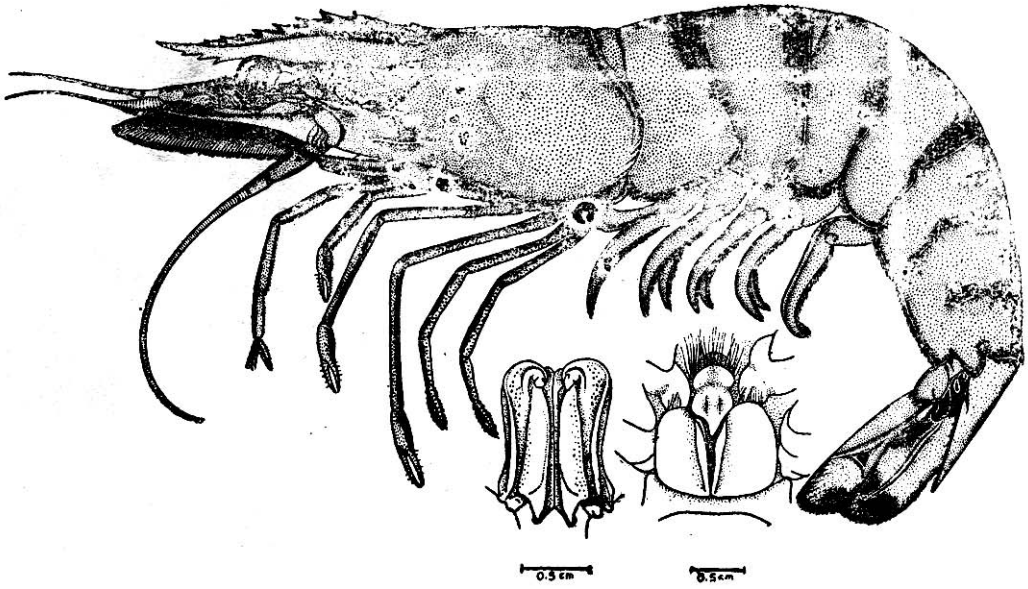

Fig. 6. *Penaeus monodon* Fabricius.

In India, *P. semisulcatus* is caught along with other prawns only occasionally. It is not known to contribute any significant portion of the marine catches. However, the species is often well represented in the brackishwater fishery of the west coast of India by juveniles measuring up to 150 mm. In the marine catches the size composition varies from 150 to 180 mm although the largest recorded size is 222 mm. From the general pattern of occurrence it would appear that this species also follows the same pattern of life cycle as that of the other penaeids of the area - sea to estuary and back to the sea.

Pillay (1954) observed the species forming significant portions of the prawn catches of the 'Bheris' (Brackish water areas) of West Bengal. He found that the larvae and the young are brought into the 'bheris' along with the tide during the winter months. They bury themselves in the muddy water of the ponds and grow very rapidly feeding on the food resources of the iliotrophic layer. A length of 3 to 5 inches (76 mm to 127 mm) is attained by the end of the season when most of them are caught and marketed.

On the east coast of Africa *P. semisulcatus* is found in large numbers in Durban Bay (Joubert, 1965). In the winter months (June - August) when there is a good growth of eel grass (*Zostera capensis*) on the central banks in the Bay large numbers of *P. semisulcatus* are found living in it. She found that the species was relatively scarce when the growth of eel grass was poor.

Based on the observations made in Java, Indonesia and India, Kesteven and Job (1957) considered the species as important for brackishwater farming.

3. *PENAEUS MONODON* FABRICIUS, 1798

The largest of the marine prawns, this species (Fig. 6) is known as "Jumbo Tiger Prawn" in most of the countries of the Indo-Pacific region. The identity of this species was the subject matter of protracted discussions among carcinologists for over a century. This controversy has been finally resolved when Holthuis (1949) designated a neotype in the place of the lost real type of Fabricius. Description of the species is as follows :

Rostrum with 7-8/2-3 teeth, usually 7/3, exceeding tip of antennular peduncle and sigmoid in shape in juveniles and adults. Adrostral carina reaching almost to epigastric tooth, Postrostral carina often more or less flat with feeble indications of a sulcus, carina reaching almost posterior edge of carapce. Gastro-orbital carina occupying posterior 1/3 to 1/2 distance between postorbital margin of carapace and hepatic spine. Hepatic carina prominent, anterior half horizontal, the posterior often diverging very slightly below horizontal axis; distinctly separated from base of antennal carina which ends above middle of hepatic carina. Hepatic sulcus ill-defined. Cervical sulcus often with upper 1/3 indistinct, 1/5 to 1/7 length of carapace. Antennular flagella subequal or slightly longer than peduncle. Prosartema reaching to or barely exceeding tip, stylocerite attaining 1/2 basal segment. Endopod of maxilliped III reaching tip of antennular peduncle in females and juvenile males. Dactyl almost length of propodus in males, inserted at 1/5 length of propodus, the distal end of latter bearing a tuft of setae as long as dactyl. Dactyle, 1/2 to 2/3 length of propodus in female and inserted apically. First pereopod reaching distal end of or slightly exceeding carpocerite, second reaching distal end of basal segment of antennular peduncle, third reaching to, or exceeding tip of peduncle by dactyl, fourth reaching as far as first, fifth exceeding fourth by dactyle. Ichial spine on first pereopod; no exopod on fifth leg.

Abdomen dorsally carinated from anterior 1/3 of fourth somite. Carina curving downwards fairly strongly towards posterior end of sixth somite. Fourth and fifth somites each with a small cicatrice, sixth with three cicatrices. Telson unarmed. Cardiac plate with 18-24 spinules, usually 20 to 24, zygocardiac ossicle principle +9 to 12 conical teeth, usually 9 to 10, followed by several smaller teeth and a cluster of minute teeth; prepyloric acute with 6 to 8 large teeth, sometimes with 2 to 3 smaller teeth on lateral margin. Petasma symmetrical, median anterior lobe small, separated from lateral by a shallow notch, not projecting as far as lateral lobes. Lateral lobes without distal setae, with distolateral irregular group of ossicles greatly variable in number. Distal piece of appendix masculina 1.6 to 1.7 times longer than width, anterior rounded portion concave, posterior bluntly pointed inserted between flaps of seminal receptacles for 2/5 of their length. Seminal receptacles circular, flaps forming tumid reflected lips on mid line with smooth inner edges in impregnated females (Dall, 1957).

Colour of fresh specimens dark blue to black, carapace and abdomen transversely banded, a pair of broad dark bands on each abdominal somite. Pleopods fringed with bright red setae. Pleopods and uropods tipped with light blue. Pattern of colour variable.

Vernacular name of the species in India :

Calcutta	. .	Bagda chingdi
Madras	. .	Yera
Kerala	. .	Kara chemmeen
Mysore	. .	Shetli, Shingde
Bombay	. .	Jinga

Greatest recorded size is 337 mm.

Distribution

The species is fairly widely distributed throughout the greater part of the Indo-Pacific region. It is reported from Australia: New South Wales, Queensland, Western Australia; South of New Guinea, Philippine Islands, Celebes, Amoy, Formosa, Taiwan, Southern Japan, Malaya, Singapore, Mergui, East and west coast of India and Ceylon, Pakistan, east coast of Africa, Durban Bay, Mauritius, Madagascar. Distribution, therefore, ranges from South Africa to Southern Japan and from Karachi to New South Wales. The species apparently prefers warm water habitats. It is recorded

from seas, rivers, estuaries, backwaters and even from freshwater.

Life history

Information regarding the eggs and larvae of the species is scanty. Panikkar and Aiyar (1939) report that the larvae enter Adayar backwaters (Madras) along with postlarvae during all the months that the bar ramains open. Occurrence of postlarvae has been reported from the Chilka lake and Ennur backwaters by Kemp (1915). They are pelagic and are reported to live among weeds. Large numbers of them settle in weed pools and backwaters of the Gangetic delta, situated many miles away from the sea. Delmendo and Rabanal (1956) observed that the fry of the species are carried out to the shallow coastal areas, tidal rivers and estuaries by the incoming tide. They also enter fish ponds through the coarse screen of the water control gates of the fish ponds. In the Philippines the fry are collected from these areas during May to October; peak occurrence being noted in August and September.

Kemp (1915) observed that the species is migratory in habit, the adults migrating out to sea during the breeding season. Throughout the Indian coasts the species occurs both in the sea and in the backwaters in smaller quantities in relation to other commercial species of prawns. In the trawler catches of Kerala it is seen that the larger sized prawns are obtained from the deeper waters. In Bombay the catches mostly consist of immature specimens. Hall (1962) records the species among the catches of the Singapore prawn ponds.

Food and Feeding :- Hall (1962) found the following food material in the stomachs of the specimens of *P. monodon* examined by him :

Food item	Predominant	Residual	Total
Polychaeta	2	2	4
Small Crustacea	-	3	3
Large Crustacea	14	4	18
Insecta	-	1	1
Mollusca	1	5	6
Pisces	1	-	1
Vegetable	3	5	8

Small crustacean material was found only in the stomachs of prawns obtained from prawn ponds and mostly consisted of harpacticoid copepods.

Large crustacean food items were mostly of brachyuran origin. He observed three specimens having their food bolus divided into three parts, each having different food items. Based on this he observed that the species had been engaged in ingesting material of secondary choice when no opportunity was presented for ingesting preferential crustacean material. According to him the presence of split bolus was not indicative of varying feeding behaviour during different periods of the day. Food of the fry of the species observed in the Philippine prawn cultivating ponds (Caces-Borja and Rasalan, 1968) consisted of 'lab-lab', a biological association of minute plants and animals growing on the mud floor of the fish ponds. Different types of fungi, bacteria, diatoms, algae and small animals together constituted what is known as 'lab-lab'. It is also observed that these fry take raw, balnched or powdered fish flesh and rice bran when fed arteficially.

Growth:- From the available literature it is fairly clear that the species migrates into the estuaries and backwaters early in life. No information is available on its growth in the sea. The average growth observed by Delmendo and Rabanal (1956) in the Philippine nursery ponds where the species in cultured is given in Table IV. They further observed that the growth rate may be still faster and that the largest one-year olds may measure as long as 250.0 mm and weight 120 gms while the smallest may be only 180 mm in length and 50 mm in weight. A kilogram of one year old 'sugpo' may contain 8 to 20 individuals.

Nakano's experiments made in Taiwan, Formosa (Kubo, 1956) showed that *P. monodon* grew to 2.6 - 3.15 cm from 1.25-1.50 cm in 26 days when water temperature was 19^0 - 29^0 C. The prawns were fed once a day on the meat of atyid shrimp *Neocaridina denticulata*, oyster and small fishes. In another experiment he cultured the prawn in a pond together with *Chanos chanos* for 182 days feeding them with sardine meat. The water temperature was 29^0 - 35.4^0 C. The prawns increased in body length from 3.3 cm to 11.67 cm.

Weight length relationship of *P. monodon* was estimated by Hall (1962) as

$$W = 1.0000\ C^{2.640}$$

where W is the weight of prawn in gms and C is the carapace length in cm.

TABLE IV

Average rate of growth of *P. monodon* under cultivation

(Delmendo & Rabanal, 1955)

Duration of culture	Total length in mm	Body depth in mm	Weight in grams
Fry	15.3	1.6	0.025
One week	21.5	2.5	0.06
Two weeks	28.2	3.6	0.08
Three weeks	38.8	4.5	0.02
Four weeks	45.3	5.7	0.78
Five weeks	57.1	7.8	1.63
Six weeks	60.3	9.7	3.30
Seven weeks	69.5	10.9	4.36
Two months	79.0	9.8	4.34
Three months	94.7	11.1	6.88
Four months	120.0	15.3	14.5
Five months	Incomplete		
Six months	141.9	18.3	22.3
Seven months	152.6	16.4	25.1
Eight months	Incomplete		
Nine months	178.0	27.8	57.3
Ten months	211.6	30.2	62.8
Eleven months	223.0	32.0	70.7
One year	229.8	32.0	95.1

Note:- The data for the ninth to twelfth months are for the 1951-52 season only and are therefore not strictly comparable with averages for the earlier periods.

Movements:- That the young ones of the species take shelter under weeds in the estuaries is reported by Kemp (1915), Domantay (1956) and Delmendo and Rabanal (1956). Kemp noticed that the young of the species ascends estuaries and makes its way to water of low salinity only in those seasons in which it is not breeding. The pelagic stages of larvae and postlarvae are apparently carried by tide well up into the Gangetic delta. According to him the adults annually resort to sea in the breeding season. Delmendo and Rabanal (1956) stated that it is probable that the

'sugpo', spawn in the sea not far from the coast and that the young are carried to shallow coastal waters, tidal rivers and estuaries by the incoming tide. They also enter fish ponds where they constitute a welcome and gratuitous addition to the cultivated fish crop. From the available information about this species, as well as others of the genus, it is quite clear that the pattern of movement seen in most of the penaeid prawns, sea to estuary and back, is followed by this species also.

Maturation and Reproduction :- *P. monodon* is also hetero-sexual. The sexes can be differentiated by the same characters as pointed out for *P. indicus*. Very little information is available about the spawning and reproduction of this species. Hall (1962) indicated the possibility of the species breeding in the same grounds as *P. indicus*, outside the Singapore waters, during the months February to April. It is quite possible that this species also breeds in the sea, in relatively deeper waters, from where alone large mature sized specimens are ever collected.

Information on the early larval history of the species is wanting. Kemp (1915) observed 10 mm long postlarvae in Chilka lake and Ennur. They are pelagic and transparent with a crimson streak running along the ventral surface, involving the whole of antennules and telson, but not other appendage, except to a slight extent on the uropods. They possess two pairs of lateral spines on the telson and the rostrum; the latter in the youngest individuals is without inferior teeth, and extends a little beyond the eyes. Caces-Borja and Rasalan (1968) report the occurrence of 'Sugpo' fry (postlarvae (?) of *P. monodon*) as small as 8 mm (usually between 10 and 15.2 mm) in length along the shores of Manila Bay from May to October. They are easily distinguishable by the dark brown pigment running through their transparent bodies, making them appear like small pieces of broken stick or debris. According to Kemp, larger postlarval specimens are still slender, but are deeply mottled with dark grey and dull green. Panikkar and Aiyar (1939) found the larval and postlarval stages of the species entering the backwaters of Madras and state that they grow for about a year, after which they go back to the sea to breed.

Habits:- *P. monodon* is extremely euryhaline in character and is capable of withstanding wide range of salinity. Panikkar and Menon (1956) observed the species even in the fresh water regions of Collair lake. To some extent they are eurythermal as evidenced by the wide gradient of temperature of the natural habitat of the species.

Fishery

Structrure of the exploited population:- As in the case of *P. indicus* this species is also subjected to commercial exploitation at different stages of life from both estuarine and marine environments. On the basis of the growth rate observed by Delmendo and Rabanal (1956) it is clear that the entire backwater fishery and the prawn pond fishery are constituted by 0-year class prawns. On the same basis the species occurring in the trawl catches from both the coasts of India would come under late 0-year class or early 1-year class. In a general study Srivastava (1953) obesrved that the Gulf of Kutch prawns (which includes this species also) have only one year span of life and perhaps die soon after spawning. Panikkar and Menon (1956) record 10 to 11 in. (25.4 to 27.9 cm) as its largest size in the marine catches off the coast of India. Present observations indicate that specimens over 300 mm in total length are common in the trawler catches landed from relatively deeper waters of the west coast. Shaikhmahmud and Tembe (1960) observed the species being represented in the stake net catches of Bombay with a size range of 100 to 150 mm.

Fishing season:- In the Kerala backwater fishery the species is caught throughout the season in small numbers. In the Gautami estuary on the east coast of India *P. monodon* is caught in all the months but the intense fishery is from November to early January (Subrahmanyam, 1966). In Bombay they are found in the commercial catches from August to October. Year to year variation in the fishing season is generally not evident.

Catches:- There is no reliable estimate of the quantity of the catches of this species in the commercial fishery. Mohamed (1967) gave a rough estiamte of the contribution of the species in the overall prawn fishery of the country as 0.9 percent. Subrahmanyam (1966) estimated the

production of the species from the Gautami estuary as 500 tonnes in 1960-61 season. He also observed wide fluctuations in the yearly catches in the subsequent years.

Fishing equipment:- Same as that of *P. indicus*.

Possibilities of culture:- *P. monodon* is probably the most suitable prawn for culturing in confined waters under controlled conditions. The culture of this species is extensively practiced in Philippines and Formosa (Delmendo and Rabanal, 1956; Kesteven and Job, 1957; Caces-Borja and Rasalan, 1968). In the Philippines the 'sugpo' fry' (advanced post larvae) are collected, reared, trasplanted and grown in culture ponds. The 'sugpo fry' are collected from the natural waters of the tidal creeks by using 'bon-bon' lures made of a bunch of water grass and are transplanted to the nursery ponds. After attaining some growth the small prawns are collected from the nursery ponds and are stocked in rearing ponds, either by themselves or along with *Chanos chanos*. Best results are obtained when prawn are stocked alone as true culture. They are harvested twice - once at the time of transplantation to the rearing ponds and a second time at the final harvesting. They attain marketable size within six months to one year. The growth attained by the species during different periods is shown in Table IV. Delmendo and Rabanal (1956) record the following three factors which exercise some kind of limitations to this extremely lucrative practice :

1. Harvesting of the crop is rendered difficult due to the nongregarious habits of the prawn.

2. Rate of survival of the fry is poor, estimated at 10 to 50 percent.

3. Season for 'sugpo fry' collection varies from year to year and the supply fluctuates considerably.

IV GENUS METAPENAEUS WOOD-MASON & ALCOCK 1891

By

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