V. GENUS *PARAPENAEOPSIS* ALCOCK 1901

P. Vedavyasa Rao

Genus *Parapenaeopsis* comprising sixteen valid species enjoys a wide distribution. Majority of the species are restricted to tropical and warm temperate shallow seas, but a few of them are also recorded from brackish water regions. Most of the species are found in the Indo-Pacific region, from Persian Gulf and east coast of Africa to Japan and Australia. A couple of species also occur from Eastern Atlantic and Pacific America. Seven species are recorded from the Indian region so far. These are, 1. *Parapenaeopsis uncta* (Alcock), 2. *P. cornuta maxilipedo* Alcock, 3. *P. nana* (Alcock), 4. *P. acclivirostris* (Alcock), 5. *P. sculptilis* (Heller), 6. *P. hardwickii* (Miers) and 7. *P. stylifera* (H. Milne-Edwards).

Holthuis and Rosa (1965) have listed ten species as of economic value, but only five of them viz., *P. stylifera, P. sculptilis, P. hardwickii, P. hungerfordi* and *P. tenella* are abundant in various regions. In India, the first three species are commercially exploited and the salient features of their biology and fisheries are presented in the following chapters.

1. *PARAPENAEOPSIS STYLIFERA* (H. MILNE EDWARDS, 1837)

The species was first described by H. Milne-Edwards in 1837 in 'Histoire naturelle des Crustaces'. The diagnostic characters of the species are as follows.

Rostrum sigmoid with a proximal crest bearing 5-7 teeth + epigastric, the distal portion styliform and edentate, strongly upcurved, projecting much beyond the tip of anternnular peduncle. Adrostral carina ending about halfway between epigastric and penultimate tooth; sulcus shallow. Postrostral carina distinct almost extending to posterior border of carapace which is finely puncuate and with fine longitudinal suture running

from orbit to the gastric region, a similar short transverse suture extends across the branchiostegite at the level of the 3rd pair of legs (Fig. 16A).

orbital spine small, postocular sulcus moderately deep at angle 45^0 to rostrum. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent, antennal carina ending below hepatic spine. Hepatic sulcus pronounced, sinous attaining horizontal position in its anterior ; hepatic carina distinct only for lower $\frac{1}{2}$ sulcus commencing from below hepatic spine and reaching to the sharp pterygostomian angle.

Antennular flagella slightly longer than carapace in both sexes and subequal.

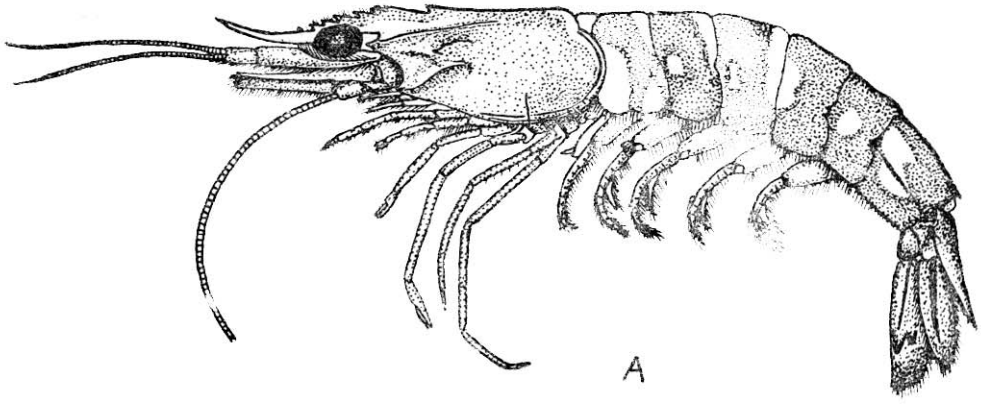
Third maxilliped surpassing carpocerite by dactyl; 1st pereopod reaching to the base of carpocerite, 2nd to tip of carpocerite; 3rd exceeding carpocerite by chela; 4th slightly exceeding carpocerite; 5th reaching almost tip of 2nd antennular segment. Mastigobranchiae and basial spines on first two pereopods.

Abdominal carination beginning from posterior 1.3 of 3rd somite, carina on 6th ending in a sharp spine. A pair of lateral cicatrices on 6th abdominal somite only. Telson with 2 or more than 2 pairs of conspicuous subapical fixed spines.

The perasma (Fig. 16B) symmetrical, simple and tubular; the distolateral projections slender, horn-like and straight, directed anterolaterally at 45^0 to petasmal axis, with ventral openings; distomedian projections small and curved ventrally. Proximal lateral enlargements of petasma of moderate size and evenly rounded.

The thelycum (Fig. 16C) consists of a large concave and square anterior median plate, posterior extension a slender stem-like process. Lateral plates smaller, fused posteriorly, each with an anteromedian indentation corresponding to a knob-like posterior process of the anterior lobe.

Colour:- The upper part of the body of the species is brownish green, the sides and the appendages are scarlet in life.



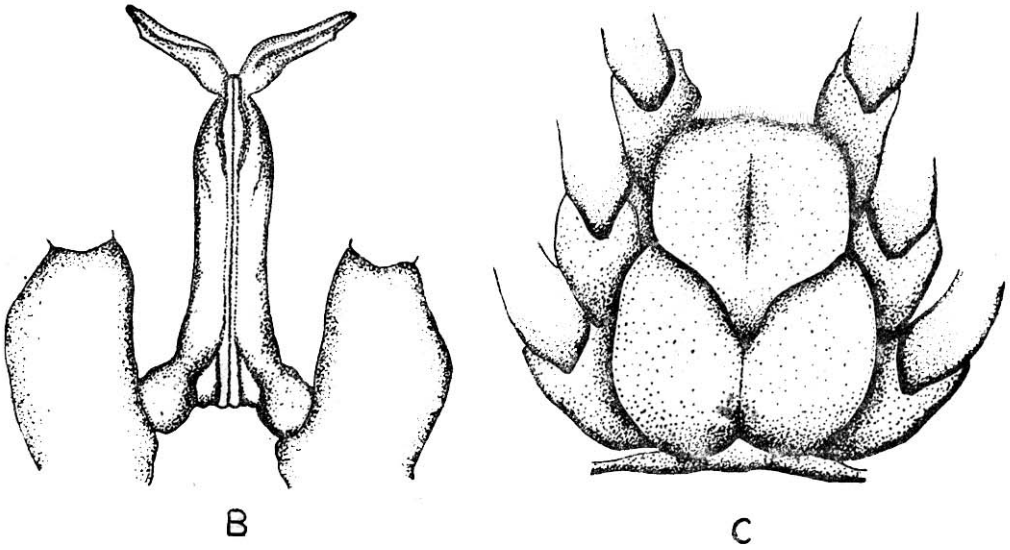


Fig. 16. ***Parapenaeopsis stylifera*** (H. Milne-Edwards)
A. An adult male, B. Petasma, C. Thelycum.

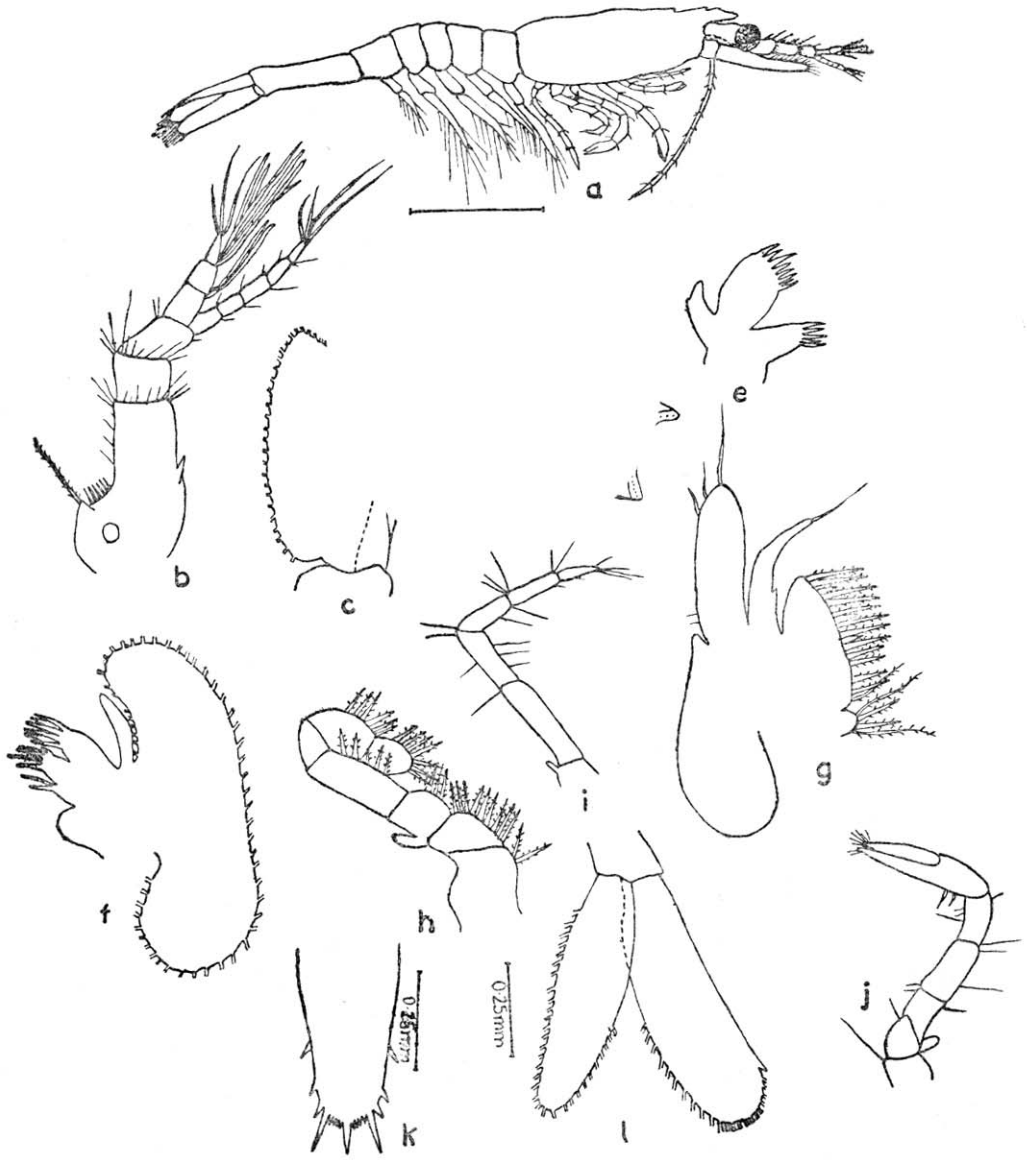


Fig. 17. *Parapenaeopsis stylifera* (H. Milne-Edwards), first postlarva.
a. Lateral view, b. antennule, c. Antenna, d. Mandible, e. Maxilla I, f. Maxilla II, g. Maxilliped I, h. Maxilliped II, i. Maxilliped III, j. First pereopod, k. Telson, 1. Uropod (Mohamed *et al.*, 1967)

Although the specific status of *P. stylifera* is well established, diverse opinion exist regarding the position of its variety, *P. s coromandelica* created by Alcock (1906). Thus, Hall (1962) considered the difference in telsonic armature of the variety from true *P. stylifera* as sufficient for specific discrimination and raised the variety to specific rank, while Racek and Dall (1965) disagreeing for this separation opined that these two forms represent distinct and geographically separated races and it is necessary to retain their taxonomic distinction at a infraspecific level. But, the extension of its geographical distribution to the west coast of India and their occurrence along with *P. stylifera* in appreciable numbers prompted George to synonymise the variety with *P. stylifera*.

This prawn is locally called in Malayalam as 'Karikadi Chemmeen' on the southwest coast of India and in West Pakistan as 'Kiddi'.

Distribution

Unlike a number of other penaeids that migrate into estuarine regions when quite young *P. stylifera* is purely a marine species spending all its life in sea. The general distribution of the species is from West Pakistan, coasts of India, East Pakistan through Malaysian waters to Indonesia. It inhabits comparatively shallow coastal waters up to 30-40 metres depth. The commercial concentration of the species outside the Indian region has been reported from the sea off Mutwal, Negombo and Chilaw (Ceylon) at depths of 7 to 10 metres (De Bruin, 1965); Alor Star area (Northwestern Malaysian coast) Penang (Hall, 1962); Tjilatjap (Java), Padang (Sumatra) and Eastern Borneo (Kalimantan) (Racek and Dall, 1965). A study of their relative abundance of distribution through the coastal regions of India shows striking difference. They are most abundant from Veraval to Trivandrum Coast, but moderately available in the Sind, Mekran and Kutch areas. In the southern most part of west coast of India and in the east coast they are found only in lesser numbers. It occurs all the year round in the west coast of India, but abounds the shallow inshore waters from January to June and deeper waters in September-October. Their occurrence in the marine region and their relative abundance during warmer months seems to be due to their inability to tolerate lesser salinity.

Life history

Eggs and larvae:- Very little information is available on the distribution of eggs and larval stages. Menon (1953) believes that the eggs are liberated in the shallow waters at a depth of 18.23 metres and the larvae occur from October to March in the Malabar coast. The eggs of the species were also collected from the inshore waters of Cochin and the early larval stages like protozoea and zoea occur throughout the year except during June to September. The first postlarval stage (Fig. 17) measures from 4.25 to 4.75 mm in total length and 1.290 to 1.315 mm in carapce length. The larva is characterised by having a small rostrum reaching middle of eye with 2 dorsal and one epigastric teeth; carapce with antennal, hepatic and branchiostegal spines; inner branch of distal segment of antennular peduncle 5 jointed with 6 setae at tip, outer branch 3 jointed; antennal flagellum 10 joined and the scale with 39 setae; mandibular palp jointed; 2nd maxilla with 4 endites and the scaphognathite bearing 54-55 seatae; abdominal segments without median dorsal spines and the telson with 3 pairs of lateral and 11 posterior spines, the median posterior spine being very large and about equal in length to the large outermost pair of posterior spines, the margin of telson tapering between posterolateral spines. The larva has light brownish pigments at the tip of antennular peduncle, but the eye stalks are yellowish. A few branched brownish chromatophores are present in the middle region of the carapace. Abdomen appears yellowish and the posterior portion of the 6th abdominal segment and the basal portion of uropod are tinged with yellowish and brownish pigments. Tip of telson light brown in colour (Mohamed *et al*. 1967).

The swimming behaviour of the larva observed in the laboratory has shown that the larva swims straight forward without any jerk and rests horizontally at the edges of the container.

A study of the distribution and abundance of these larval stages in the inshore and backwater regions of Cochin has revealed that these larvae do not enter the backwaters and the scarcity of postlarvae in the inshore waters appears to be due to their preference of more saline deeper waters.

Food and feeding:- Generally penaeid prawns feed at the bottom. Available information on the food and feeding habits of the species is restricted to a study of the kinds of food items observed from the gut contents of dead specimens. Very little work has been done on the nutritional aspects of the food or the selectivity and food preference of these prawns. Menon (*op. cit*.) examined the stomach contents of prawns varying in size from 45 to 105 mm. The species feeds mainly on crustaceans belonging to various orders like copepods, cirripeds (Cypris larvae), mysids, amphipods and larval decapods. Minute gastropods, bivalves and foraminifera are also recorded in the stomach content frequently. An interesting feature is that unlike in the associated penaeid prawns of the locality, vegetable matter other than the diatoms has been noticed rarely. Since they feed at bottom considerable amount of sand and mud are also present in the stomach content.

Hall (1962) examined the stomach content of 30 specimens of his '*P. coramandelica*' taken from the Alor Star fishery and ranging in carapace length of 1.0 to 2.1 cm. Most of the stomachs were full. The important food items in the diet were as follows.

Item	Predominant	Residual	Total
Polychaeta	-	2	2
Small crustacea	14	14	28
Large crustacea	3	-	3
Mollusca	8	5	13
Pisces	-	2	2
Vegetable	5	13	18

Small crustacean material consisting of Calanoid and Harpacticoid copepods was present in considerable numbers. Antennal debris formed the bulk of large crustaceans. The molluscan material appeared to consist of mainly a protobranch lamellibranch having a thin iridescent shell. All the vegetable material was angiosperm tissue. Detritus formed only a very small part of the stomach contents, but the diatom, *Coscinodiscus* (? Concinnus) was relatively numerous in the stomachs of this species.

Penaeids in general are considered as detritus feeders (Panikkar and Menon, 1956) taking both animal and plant that accumulate at the bottom of their habitat. But Hall (1962) observes that detritus can be

considered only as a minor item of diet and many penaeids appear to feed on that which is most readily available and some species even select the food. Thus he classified the species embraced in his studies into 6 groups based on their feeding habits, and his '*P. coramandelica*' was included in that group of species which feed mainly on small crustaceans.

Growth:- As in other crustaceans, the growth takes place by resorting to periodical ecodysis. The estimation of growth becomes difficult due to this phenomenon and the absence of any hard parts in the body. All the studies made so far ragarding the growth of these prawns were based on tracing the progression of modes in size frequency distribution. Menon (op. cit.) studying the growth process of the species from Malabar coast observed that the postlarval prawns ranging in size from 10 to 20 mm were present in all months from December to June. In November and December most of the prawns were measuring above 60 mm. (Fig. 18) and he believed that the juveniles caught during the latter month were belonging to the generation produced in two preceding months. The frequency curve showed two generations the one year class at a modal length of 80-90 mm and 0 year group without any well defined modes. The subsequent growth of 0 year group was estimated from the frequency curve of the succeeding months. The rapidly growing 0 year group attained 70-80 mm by March and the one year class prawns were dwindling due to fishery and by June the large sized prawns disappear from the inshore waters probably due to migration to deeper waters at the commencement of southwest monsoon. From these observations he concluded that the prawns born probably towards close of October or early in November grow to a length of 70-80 mm and they grow faster during this period. The subsequent growth from April to October becomes slow and one year prawn attain and average length of 90-100 mm.

In the trawl fishery of Cochin (George, *et al*., in press) the dominant mode of the species in November was 81-85 mm in males and 86-90 mm in females. These modes shifted gradually to 96-100 and 106-110 mm respectively by middle of the season in February-March. The growth in the intervening period of 4 months works out to 15 mm for males and 20 mm for females.

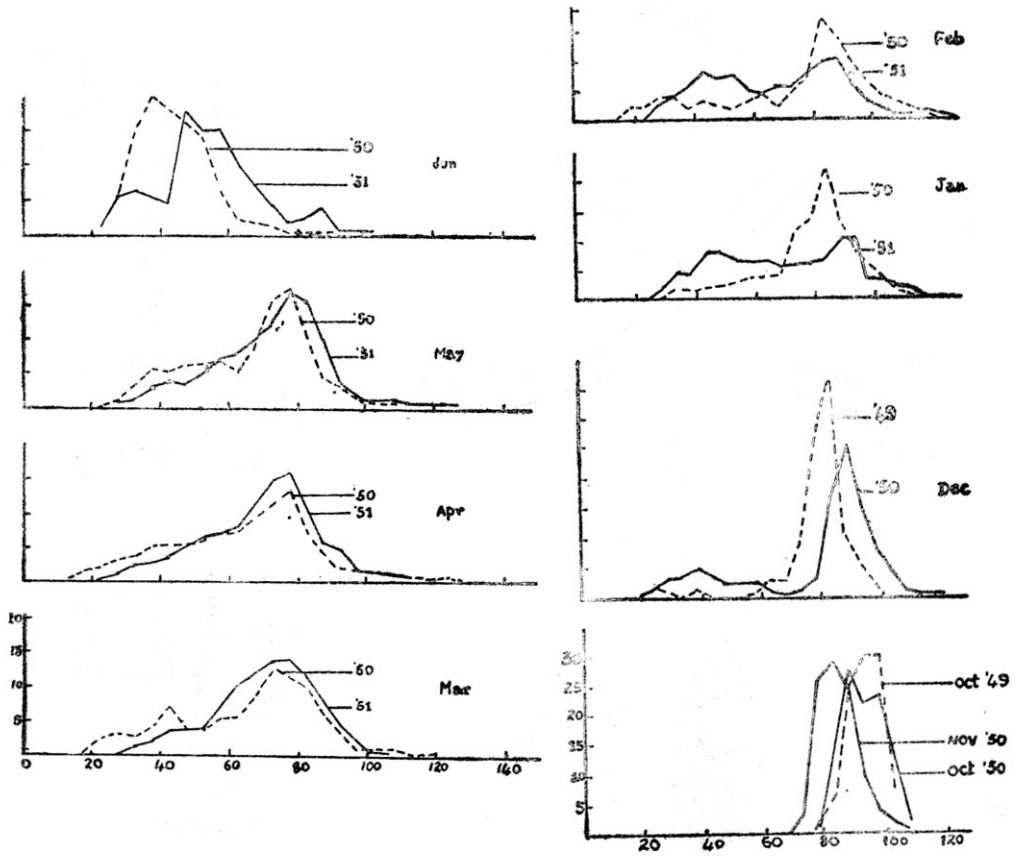


Fig. 18. *Parapenaeopsis stylifera* (H. Milne-Edwards), Length frequency distribution (of both sexes) (Menon, 1953)

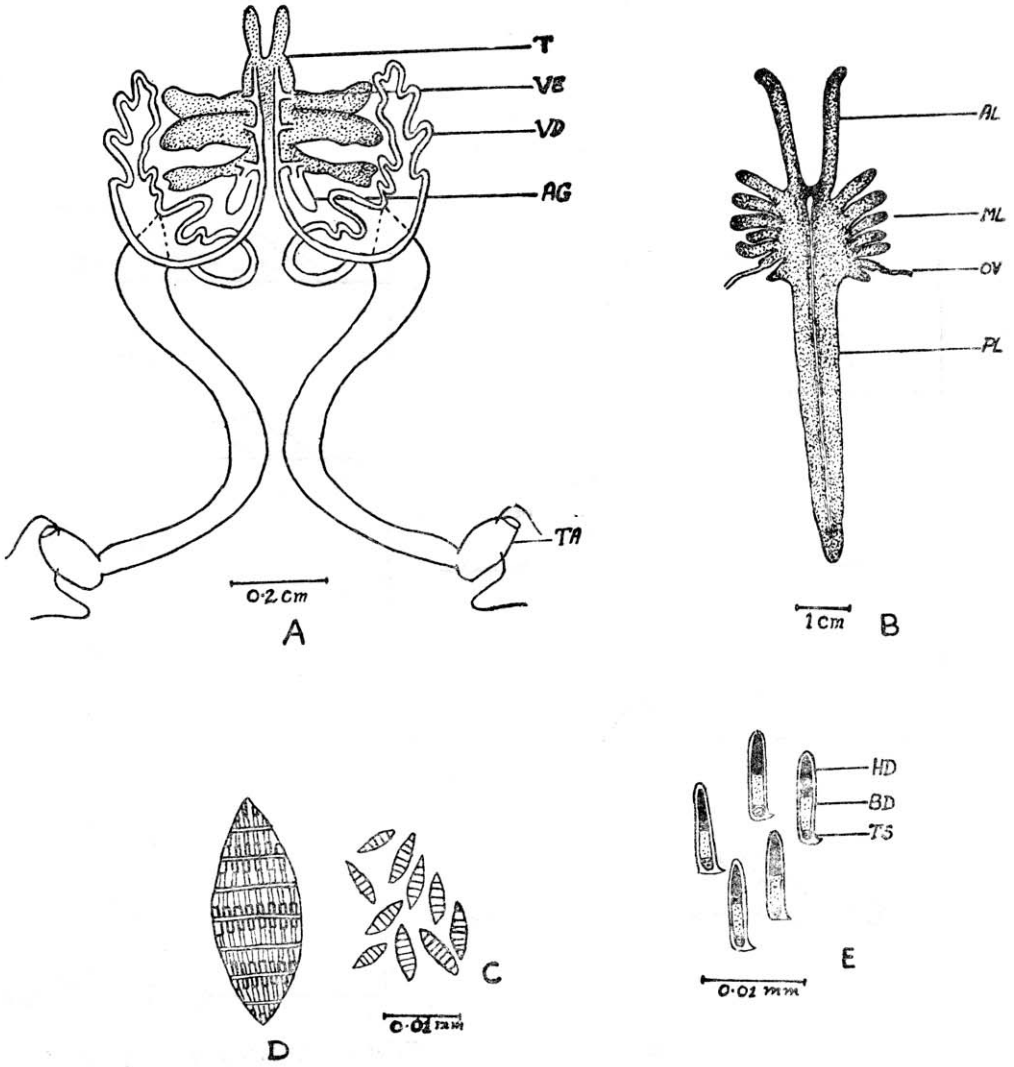


Fig. 19. *Parapenaeopsis stylifera* (H. Milne-Edwards) Reproductive systems. A. Male reproductive system, B. Female reproductive system. C. & D. Spermatophore; E. Spermatozoa; T. Testis; VE. Vas-efferens; VD. Vas-deferns; AG. Accessory gland; TA. Terminal ampoule; Al. Anterior lob; ML. Middle lobe; OV. Oviduct; PL. Posterior lobe; HD. Head piece; BD. Body and TS. Tail piece. (Shaikhmahamud and Tembe, 1958)

In Bombay waters (Mohamed, 1967a) the species appears to grow a little faster. In November 1957, the modes representing the youngest individuals were seen at 51-55 mm for males and 61-65 mm for females. These modes progressively shifted to 81-85 mm and 91-95 mm in February, showing a growth of 30 mm in three months. The monthly growth rate is therefore about 10 mm. He observed that the smaller prawns recruited in November might have been born in May or June and they would have completed 5-6 months of life.

From the above observations it is clear that the growth rates of the species vary from place to place and the difference in growth rates may be due to the environmental conditions of the particular locality. However, since these prawns breed almost throughout the year, the interpretation of modes for determining the growth would be difficult and more improved techniques such as tagging or staining methods should be employed to confirm the above conclusions. Thsese studies as well as that of Hall (*op. cit*.) thus suggest that *P. stylifera* may live for more than two years.

Differential growth of sexes:- As in other commercial penaeids of this coast, *P. stylifera* also exhibits difference in the growth rate of sexes. It has been shown that the females grow faster than males after attaining maturity. George *et al*. (in press) and Mohamed (1967a) studying the offshore fishery of Cochin and Bombay respectively come to the same conclusions.

Length-weight relationship:- The relationship between the weight and carapace length is expressed by the formula : $W = 6194\ C^{2.820}$ (Hall, *op. cit*.). Since the value of prawn as food is greater with the increased weight of a prawn for any particular carapace length, Hall concludes '....species of *Parapenaeopsis* are of less food value than *Penaeus indicus*, *P. merguiensis* and species of *Metapenaeus*'. But the species constitutes a considerable percentage of the total prawn catches of India, its economic value cannot be underrated.

Movement:- As mentioned earlier, this is a non-migratory species in the sense that it does not enter into estuaries during early phase of life as in other penaeids. But in the sea it performs annual migration to

and from inshore waters. The shoreward movements commences in October. Towards the end of May at the commencement of southwest monsoon, it moves into deeper waters. The large sized prawns leave the inshore waters first and these are followed by younger ones. It has also been observed that a good number of females do not return to the coastal waters after the rains have stopped, but takes varying periods of time extending to even an year. The males do not share this habit of staying in deeper waters for longer time (Menon, *op. cit*.). George and Rao (1967) have shown that the females segregate together at the breeding period during October-December.

Reproduction:- *P. stylifera* is heterosexual. The two sexes can be distiguished by a number of external characters. The male is generally smaller in size and brighter in colour than the females; the endopodites of the first pair of pleopods are modified to form the copulatory organ called petasma and the endopod of the second pleopod also bears an accessory structure called appendix masculina. In the female, the sternal plates in between the last three pairs of thoracic legs are modified to form thelycum. The male genital openings are paired, each aperture is situated on the coxa of last pair of pereopods. The female genital opening is also paired and are present on the bases of the coxa of third pair of walking legs.

Shaikhmahmud and Tembe (1958) have made a detailed study of the anatomy and histology of the reproductive organs of *P. stylifera*. The male reproductive system (Fig. 19A) consists of a pair of testes, a pair of terminal ampoules and a petasma. The testes are situated in the thoracic region lying above the posterior half of the dorsal surface of the heptopancreas and beneath the pericardinal sinus and the heart. They are irregular in shape and each consists of three lobes, the anterior, the middle and the posterior lobes. The anterior lobe is joined in the middle with its fellow of the opposite side. Just below and behind the posterior lobe is situated an accessory gland. The vas efferens arises from each of the testes lobes and joins into the proximal part of the vasdeferens which is a thin delicate tube running downwards and backwards. In its course it receives ducts from the lobe of the testes as well as from the accessory gland. The tidal part of the vasdeferens is thicker and has a wider lumen.

On the coxa of the last pair of thoracic legs, the vasdeferens gets dilated and ends in a distal terminal ampoule. It is a sac like structure with thick muscular coat and contains spermatophores and a white thickly fluid. Histologically, the testes has two different regions, one with bigger germ cells and the other with smaller glandular cells. In the mature testes, the contents of the cells of the germinal portion are in the form of spermatids and the sperm.

Sperm:- The spermatophores are oval transparent sac-like structure measuring about 0.0576 mm in breadth and 0.288 mm in length (Fig. 19C). In each spermatophore, the sperms are arranged in a transverse compact rows varying from 6 to 8 in number. The sperm is elongated and cylindrical in shape with a very short tail. The head piece is slightly smaller than the body and the whole spermatozoon appears to be enclosed in a thin transparent membrane. The body is followed by a tail piece. The membrane at the tail end is produced into a thin spine like process (Fig. 19, E).

The female reproductive system consists of a paired ovaries, oviducts (Fig. 19B) and a single thelycum. The ovaries are bilaterally symmetrical, extending in the mature condition from the level of epigastric tooth to the tip of last abdominal segment. Each side of the ovary consists of three lobes, the anterior, the middle and the posterior lobes. The middle lobe is formed by 6 to 7 finger-like lateral lobules. The thin oviducts start from the tips of penultimate lobule of the middle lobe on either side and run downwards to external openings placed in the coxae of third pereopods. Histologically, the ovary is surrounded by a thin membrane called capsule. This is followed by a thick layer of connective tissue and an inner layer of germinal epithelium, which is distributed on certain well defined areas called 'zone of proliferation'. The ramaining area is the follicular region containing immature ova. These ova are found is the centre, while the mature ones are at the perephery. At the time of spawning the follicular cells undergo degeneration.

Maturity stages of females:- Based on the external changes in colour, size, texture and microscopical examination of the ovary Shaikhmahmud and Tembe (1961) and Rao (1967) have distinguished five maturiry stages (Fig. 20) and they may be distinguished on the following points.

Immature stage:- The ovaries of immature prawns are thin, translucent, unpigmented and confined to the abdomen. They measure 30 to 68 mm in length and 0.65 to 1.5 mm in breadth. They contain oocytes and small spherical ova with clear cytoplasm and conspicuous nuclei. The diameter of the ova is less than 0.08 mm.

Early maturing stage:- The ovary is increasing in size and the anterior and middle lobes are developing. The dorsal surface is light yellow to yellowish, green. The length and breadth of the ovary varies from 43 to 84 mm and 1.5 to 2.0 mm respectively. Opaque yolk granules are formed in the cytoplasm and partly obscure the nuclei. The developing ova are larger than the immature stock. The majority of ova measure between 0.10 mm and 0.19 mm.

Late maturing stage:- The ovary is light green and visible through exoskeleton. The anterior and middle lobles are fully developed. It measures from 51 to 92 mm in length and 1.9 to 2.8 mm in breadth. The maturing ova are opaque due to the accumulation of more yolk and 90% of ova measure between 0.14 mm and 0.27 mm.

Mature stage:- The ovary is dark green and clearly visible through exoskeleton. They occupy all the available space in cephalothorax and abdomen. They measure 49 mm to 119 mm length and 2.9 to 4.0 mm in breadth. The ova are larger than in the preceding stage and the perepheral region becomes transparent. Most of ova measure from 0.21 mm to 0.35 mm in diameter.

Spent-recovering stage:- The ovaries are greatly reduced in size and are flaccid with dirty yellow or whitish in colour. It is probable that after extrusion of eggs, the gonad reverts almost immediately to the immature condition. Therefore, this stage is distinguishable from that of immature virgin females only on the size of prawn. However, Shaikhmahmud and Tembe (*op. cit*.) have distinguished between spent and regenerating stages also. The ova are microscopic with clear cytoplasm and conspicuous nuclei and measure below 0.096 mm.

P. stylifera attains maturity in the first year of its life. The smallest size at which the male becomes mature is 65.0 mm. The statistical

minimum size of maturation for female is 63.2 mm, but most of the females are observed to attain maturity by 70 mm size.

Mating:- There is no observation on the actual mating of these prawns. But it is believed that prawns mate freely and mating is not confined to any particular months, but probably throughout the year (Menon, op. cit.).

Fecundity:- Mature specimens may produce an average of 39,500 eggs at 70.0 mm and 2,36,000 eggs at 120.0 mm total length. The number of eggs produced is dependant on the length of the prawn and the relationship between fecundity and total length is expressed by the formula

F = -1.5746 + 3.3437 Log L, where F is the fecundity and L the total length.

Spawning:- Spawning takes place in comparatively shallow coastal waters not more than 18-23 metres depth and in areas of soft mud and rich plankton. Since the eggs of the species are generally obtained in tow net collections made in early mornings, it is probable that the spawning takes place in the night time. The species breeds throughout the year, but the peak spawning season varies from place to place and from year to year. At Bombay, the peak period has been observed from December to May (Shaikhmahmud & Tembe, 1961; Mohamed, 1967a); along the Malabar coast, from November to December (Menon, *op. cit.*) and at Cochin (Fig. 21) from November to January and April (George *et. al*., in press; Rao, 1967).

Multiple spawning of the species during its lifetime has been pointed out by Chopra (1943) and Menon (1953). The latter suggests the possibility of the species breeding 2 or 3 times during its lifetime of 2-3 years. Spawning more than once in an year has also been pointed out by Shaikhmahmud and Tembe (1960). Recently, utilising the data of monthly distribution of late maturing and mature females in 10 mm group, Rao (1967) has shown that the species breeds 3 times during its growth from 91-100 to 111-120 mm. Since the females attain maturity at 70.0 mm, it is quite probable that it may spawn twice before growing to 91-10 mm thus the species spawns five times during its lifetime. It has been observed that there is a gap of 2 months between the successive spawnings and during which period the immature stock of ova grows to final stage of maturity and ready for consequent spawning.

Parasites:- A bopyrid parasite belonging to the Genus Epipenaeon has been frequently found infesting the branchial chamber of prawns. A study of the gonads and external sexual organs of the parasitised prawns has revealed that these organs are imperfectly developed or remain rudimentary even in larger specimens measuring over 100.0 mm. Thus the parasites produce marked inhibitory effect on the development of sexual organs of the host.

Population

Sex ratio:- The distribution of the sex ratio of the species in the inshore fishery has been studied by Menon (1957). The following tables give the sex ratio, percentage for the two length groups representing the first and second year classes.

TABLE I

Sex ratio and percentages in total of each group

Year	All size				Over 80 mm				Over 100 mm	
	Ratio		Ratio		Percentage		Ratio		Percentage	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1952	58.6	41.4	46.5	53.5	34.6	56.2	9.3	90.7	1.3	18.0
1953	52.7	47.3	49.6	40.4	53.4	60.2	4.5	95.5	0.6	14.9
1954	50.7	49.3	44.4	55.6	58.3	74.9	1.5	98.5	0.5	34.5
1955	59.6	40.4	50.0	50.0	29.1	43.5	3.8	96.2	0.5	18.7

TABLE II

Sex ratio and percentage for all four years together

	All size		Over 80 mm		Over 100 mm	
	Male	Female	Male	Female	Male	Female
Number	2215	1753	929	997	17	327
Ratio	55.8	44.2	48.2	51.5	5.0	95.0
Percentage in total	..	..	41.9	56.9	0.8	18.7

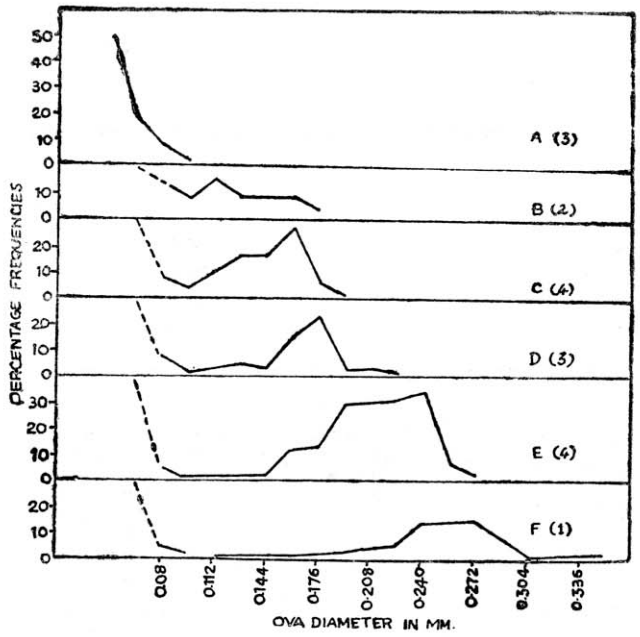


Fig 20. ***Parapenaeopsis stylifera*** (H. Milne Edwards) Size-frequency distribution of developing ova. A Immature, B and C Early maturing, D and E Late maturing, F Mature.

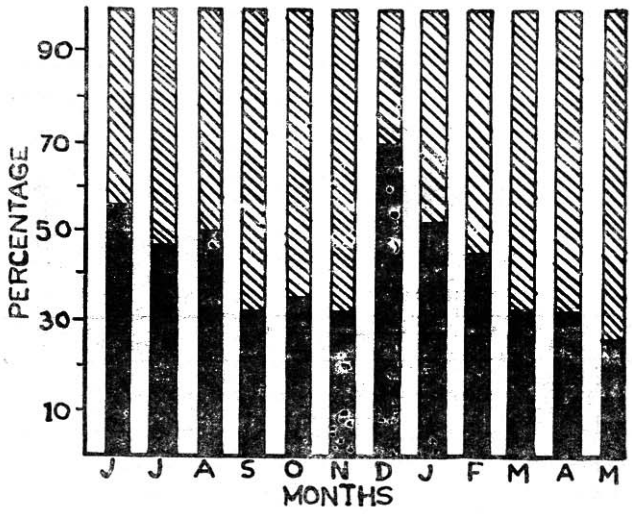


Fig. 21. *Parapenaeopsis stylifera* (H. Milne Edwards) Monthly percentage of prawns with ovaries in spawning and non-spawning condition.

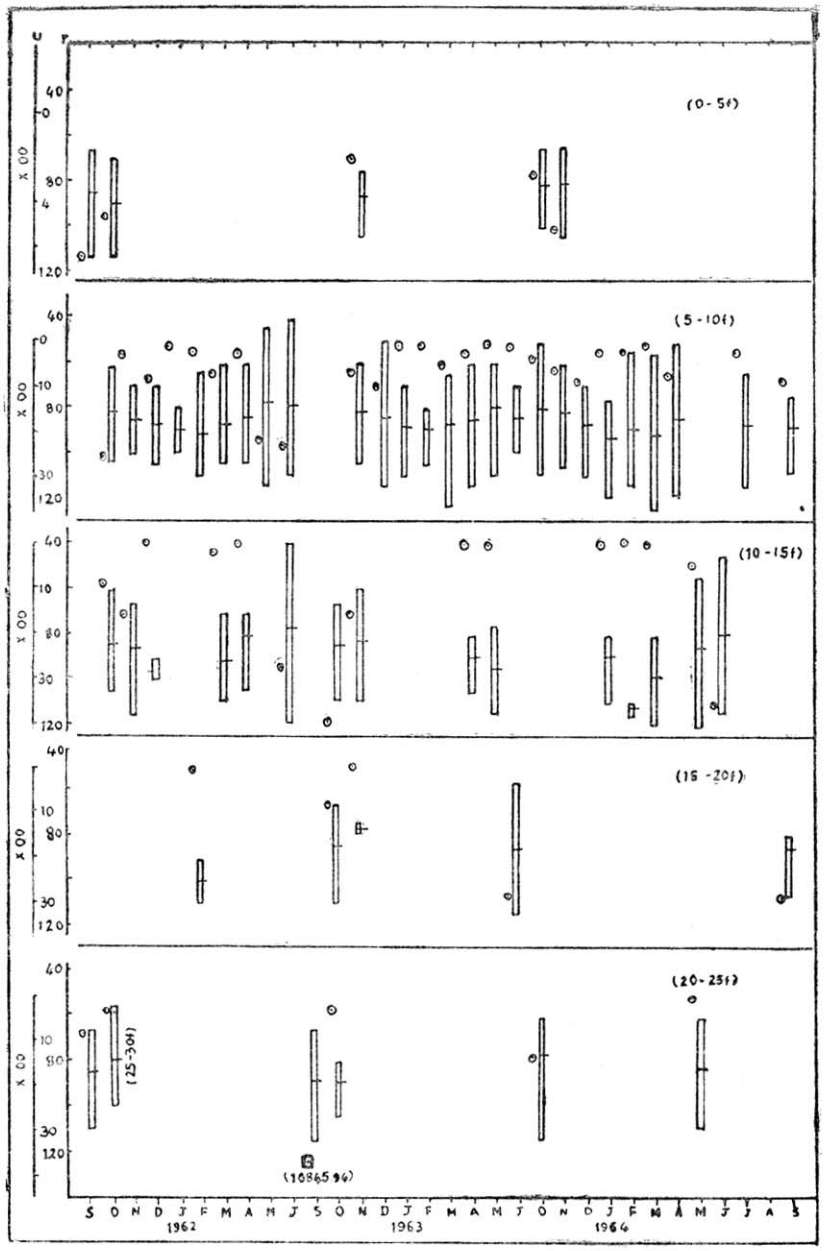


Fig. 22. Abundance and size of *Parapenaeopsis stylifera* (H. Milne Edwards) during 1961-62 to 1963-64. Vertical column represents size range (r) and the horizontal line on it the mean size in mm. Abandance (u) in number per trawling hour (After George *et. al*, 1967)

The male : female ratio for the prawns measuring up to 80.0 mm (0 year group) was 63 : 37; for the prawns measuring between 80.0 and 100.0 mm (first year class) 57.6 : 42.4 and for those measuring above 100.0 mm (Second year class) was 5.0 : 95.0. The estimation of the average percentage contributed by these groups to the annual fishery was 58.1 : 43.1, 41.2 : 38.2 and 0.8 : 18.7 respectively. From these observations it is concluded that males predominate over females noticeably both in the population and catch in the smaller groups (less than 100.0 mm size). The females become excess of males in larger size groups.

Shaikhmahmud and Tembe (1960) studying the variations in the sex ratios of the species in Bombay waters point out that females are predominant for six months from Jaunary to June and it coincides with the peak of their breeding season.

The distribution of sex ratio of the species in the trawl fishery off Cochin is shown in table III.

TABLE III
Showing the sex ratios of *P. stylifera* in the trawl fishery of Cochin for the years 1962 and 1963

Months	1962			1963		
	Sample size	Males	Ratio	Sample size	Males	Ratio
Janunary	33	9	0.27	41	17	0.41
February	43	8	0.19	29	16	0.55
March	108	47	0.43	141	65	0.46
April	49	25	0.51	251	32	0.13
May	401	174	0.43	31	13	0.42
June	818	423	0.52	24	10	0.42
September	515	238	0.46	--	--	--
October	778	419	0.54	125	80	0.64
November	574	348	0.61	177	118	0.67
December	326	170	0.52	18	14	0.78

The statistical analysis of the sex ratio has revealed that it is significantly different from what could be accounted for by binomial theory. The male ratio is less in the exploited ground from October to December (George and Rao, 1967).

Age composition:- The population is composed of 0, first and second year class prawns. In Bombay coast, the fishery is mainly supported by 0 year group prawns (Mohamed, 1967a), while at Karwar and Mangalore 1st year class prawns dominate the catch throughout the year. In the Malaber coast, the fishery is contributed by 0 year and one year class prawns. The former group enters the fishery by March, while the latter persists from October to December-January. Along Cochin and Alleppey coasts also, the fishery is contributed to 0 year and 1st year classes. In the offshore catches of Cochin, smaller groups come to the fishery in April and from November to March larger groups predominate.

Recruitment:- At Bombay the recruitment of younger specimens takes place in the month of September-November and these prawns grow in the fishing groud contributing to the fishery of the season. At Cochin and Alleppey coasts, the recruitment of small sized prawns takes place twice in an year, during April and September.

Size composition:- The recorded size range of the population as a whole is from 10.0 mm to 145.0 mm.

At Veraval, the size range of the prawns is from 60.0 mm to 130.0 mm. In October, 71-85 mm prawns dominate the catch, while in November and December slightly larger prawns measuring 90-100 mm for females and 80-90 mm for males occur in the catches. In March, 101-115 mm prawns dominate the catch.

In Bombay, smaller size groups (51-65 mm) are observed in September-November period. This group progressively attains 81-95 mm by February. At Karwar, from January to May larger females (101-120 mm) dominate and in November-December and in June slightly smaller sized females form the majority of the catches. In most of the months, males of 86-90 mm size are observed in the catches.

At Mangalore, dominant size for males and females in July is 81-90 mm and 91-105 mm and at Cannanore during the peak fishery season in December-February measuring between 76-80 mm and 91-95 mm dominate.

At Cochin coast, the females measuring 96-100 mm and males 81-85 mm dominate from January to March. In April and May both the smaller as well as larger groups are present. Soon after the rainy season, when the fishery commence in September, 91-100 mm size prawns are caught and in the succeeding months up to December 71-95 mm prawns are found in abundance. The depth-wise size distribution of the species in the fishing ground off Cochin was studied by George *et al*. (1967). In 9-18 meter area the size of the prawn increases gradually to reach the mean size of 90-95 mm by January-February and then it declines. In 18-27 meter zone mean size of 111.0 mm was recorded in February. In the deeper zones of beyond 27 m. the size was comparatively low varying from 77-90 mm.

Abundance:- Estimation of the population size is not available. In the inshore water, the species is abundant up to 22 m., especially from the depth ranges of 12-15 m and 15-20 m.

At Veraval, the species supports a good fishery during October-December period. In Bombay, the species is caught throughout the year, but forms the significant portion of the catch when the fishery commences in September. The same trend is maintained in the next month also. In November its proportion slightly declines. During January-February the species again contributes to the fishery and in April-May also their catch is comparatively high.

At Karwar, the species ranks second in the prawn catches landed by trawlers. It is abundantly caught in the inshore fishery during April, July and August. At Mangalore, the peak season is from January to April, while at Cannanore, it is from December to February. In the Malabar coast, the species is most abundant in the catches during summer months, from February to May. In the southwest coast of India, the species stands next to *Metapenaeus dobsoni* in abundance and the peak of the fishery season is September-October, January-February and in some years in April.

Their depth-wise abundance was studied by George *et al*. (1967). In 1961-62 season, the species was comparatively low in shallow waters (0 to 9 m) during the beginning of the season. But their abundance ranged from 124.14 to 2608.56 (catch in numbers per trawl hour) in the depth zone 9 to 18 m with maximum in October and minimum in January. In the area of

18-27 m deep, their abundance varied from 10.99 in December to 2844.53 in June and high abundance was recorded in September-October in the deeper zone (27-45 m). In 1962-63 season, a maximum abundance of 1035.88 was recorded in December and the minimum of 75.51 in May in zone 9-18 m. In 18-27 m area high values of abundance were obtained in October and November. In the deeper areas maximum abundance was in September and June. In 1963-64 season, high abundance was noticed from December to May in 9-18 m area and in June in the next deeper zone. As in the previous years, the catch was good in the 27-45 m. depth zone in October. From these studies it is concluded that the species is scarce in the lower depths during the beginning of the season after the southwest monsoon, but are found in abundance in the deeper waters beyond 27 m depth. From November to February-May the species is generally encountered at a depth varying between 9 and 27 m. (Fig 22).

Fishing methods:- In Bombay area, the indigenous gear, 'Dol' or bag net is the gear used for catching prawns. This net is made of either cotton yarn or hemp. The small nets vary in size from 35' to 50' in length with a mesh size from $\frac{1}{2}$" to 2" and are known as 'Bokshi', while the larger 'Dol' nets vary from 130' to 150' in length. The details of the dol nets and their operation have been described by Setna (1949). In the North Kanara coast, the prawns are caught by shore seines (*Yendi bale*) the details of which are given by Pradhan (1956). In the southwest coast of India, various types of boat seines, shore seines, drag nets and cast nets are used. The mechanised fishing for prawns has been introduced recently and various sizes of shrimp trawls are used. The most common shrimp trawl is 2 to 4 seam trawl varying from 13 to 18 m in head rope length and with mesh sizes of 76 mm, 50 mm, 38 mm and 25 mm for wing, body, throat and cod end respectively.

The indigenous gears are mainly operated by dug-out canoes and plank-built boats with out-rigger. The mechanised fishing vessels are generally the medium sized 7-11 m. pablo boats having 10-30 b.h.p. engines.

Fishing areas:- There is a regular commercial exploitation of the species in West Pakistan, west coast of India and in lesser extent on the east coast of India. It is found in large shoals in the shallow waters

and forms an important species both in the inshore and offshore fishery. The general fishing ground has a muddy bottom and the species seems to prefer soft mud. As mentioned earlier, it cannot tolerate low salinity. The hydrological features of the sea water at Alleppey and Narakkal during the peak of the fishing season has shown that the dissolved oxygen varies from 3.25 to 4.82 c.c./ litre, salinity from 28.09 $^{0}/_{00}$ to 34.06 $^{0}/_{00}$, surface temperature 27.8^{0} C to 29.5^{0} C and pH 8.30 to 8.38 (George, 1961).

Fishing season:- Although the species occurs all the year round in the west coast of India, it abounds the inshore waters from November-December to May-June and offshore waters in September-October. At Veraval, the species supports a good fishery in October-December. In Bombay coast, the fishery starts in September and the peak months are September, October, January to April-May. At Karwar, April, July and August are the main seasons for the fishery. At Mangalore, the peak season is from January to April, while on the Malabar coast, the fishery commences in October and reaches the peak in February-May. Along Cochin coast, the fishery starts from September-October and the maximum catch was observed during December-January and April-May.

Catch:- The species contributes approximately 18.0% of the annual prawn catch of the Country, which varied from 62,768 m. tons to 94,895 m. tons during the period 1958-65. Wide fluctuations in the percentage composition of the species in the total estimated landings of Bombay is observed. During 1952-53 and 1954-55 season, it formed 26.4% of the total prawn catch landed at Sassoon Dock, while it is only 6.31% for the years 1959 to 1963. At Karwar, the species forms about 8 to 10% of the annual prawn catch, while in Mangalore it is as high as 31.5% of the total estimated landings. At Cochin waters, the percentage of *P. stylifera* varies in different months from 2.8 to 40.2, and the annual catch per hour of trawling for the seasons 1957-'58 to 1962-'63 were 52.1, 60.5, 41.6, 39.8, 64.4 and 43.2 kg respectively (George *et al*., in press).

2. *PARAPENAEOPSIS SCULPTILIS* (HELLER, 1862)

This is another species of economic importance, although it does not contribute to the extent of that of *P. stylifera*. Heller in 1862 first described the species and the diagnostic characters are as follows:

Rostrum-Teeth 6-8+epigastric, latter always feeble, often represented by a barely perceptible depression in male. Apparently sexually dismorphic in male measuring 70.0 mm and above, unarmed portion absent, rostrum curving downwards, reaching to 2nd segment of antennular peduncle; in female rostrum is long, strongly sigmoidal, unarmed distal ½ strongly upcurved and reaching beyond tip of antennular peduncle. Epigastric tooth 1/5 carapace, 1st tooth at or slightly behind anterior margin of carapace. Postrostral carina low, of uniform height, ending 1/20 length of carapace from posterior end; feebly sulcate, sometimes merely flat-topped throughout its length and narrowing slightly about the middle. Adrostral carina ending mid-way between 1st and 2nd teeth. Carapace-orbital angle small. Longitudinal suture reaching 3/4 length of carapace from postorbital margin and reaching level of transverse suture. Orbito-antennal sulcus absent. Antennal spine large, the carina reaching ½ distance between spine and hepatic spine. Cervical sulcus straight, feeble, wide, its upper end indistinct. Hepatic sulcus pronounced 1/3-½ length of carapace inclined downwards at angle of 15^0 to horizontal, sinous, posterior end indistinct and curving upwards, ending at ½ carapace at level of hepatic spine; hepatic carina distinct only for lower $\frac{1}{2}$ sulcus, starting below hepatic spine and running towards sharp pterygostomidal angle. Feeble indication of branchiocardiac sulcus usually present. Antennules-Flagella subequal; prosartema reaching tip of junction of peduncle of eye with cornea; stylocerite attaining ½ basal segment. Thoracic appendages - Third maxillipeds reaching from 3/4 to slightly exceeding carpocerite. 1st pereopod reaching from pterogostomial angle to base of carpocerite; 2nd reaching from base to ½ carpocerite; 3rd reaching from tip to exceeding carpocerite by dactyl; 4th reaching base of, 5th reaching tip of carpocerite. Mastigobranchiae on 1st and 2nd pereopods, ischial spines absent,

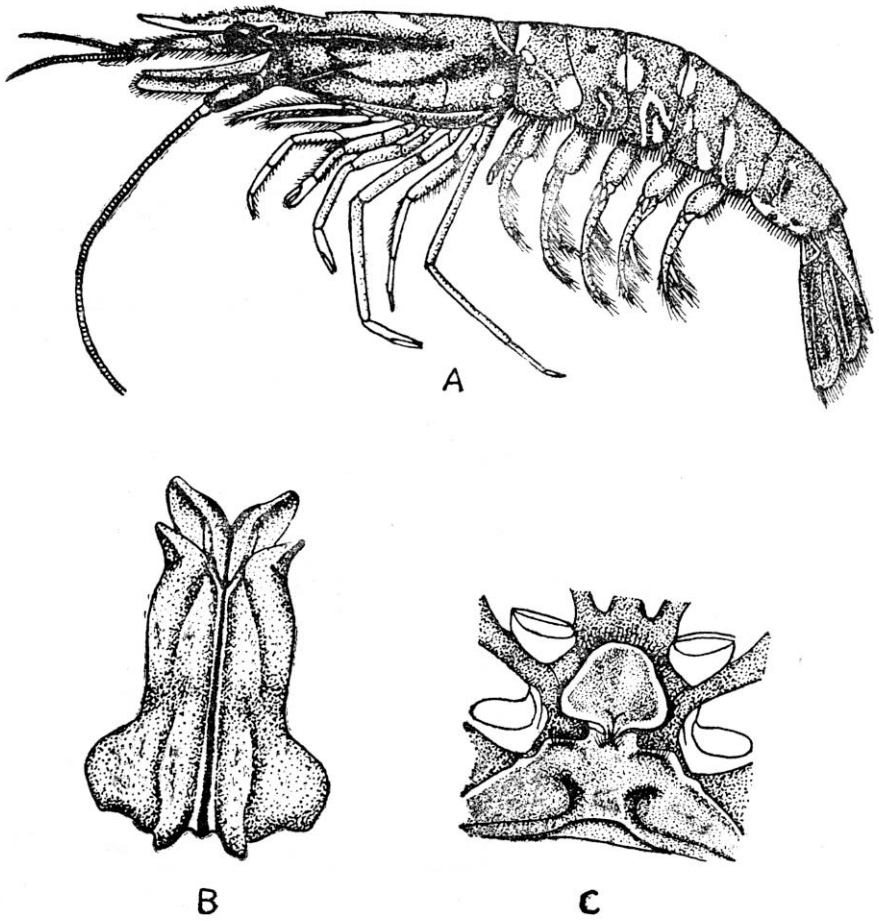


Fig. 23. ***Parapenaeopsis sculptilis*** (Heller), A. An adult male, B. Petasma; C. Thelycum.

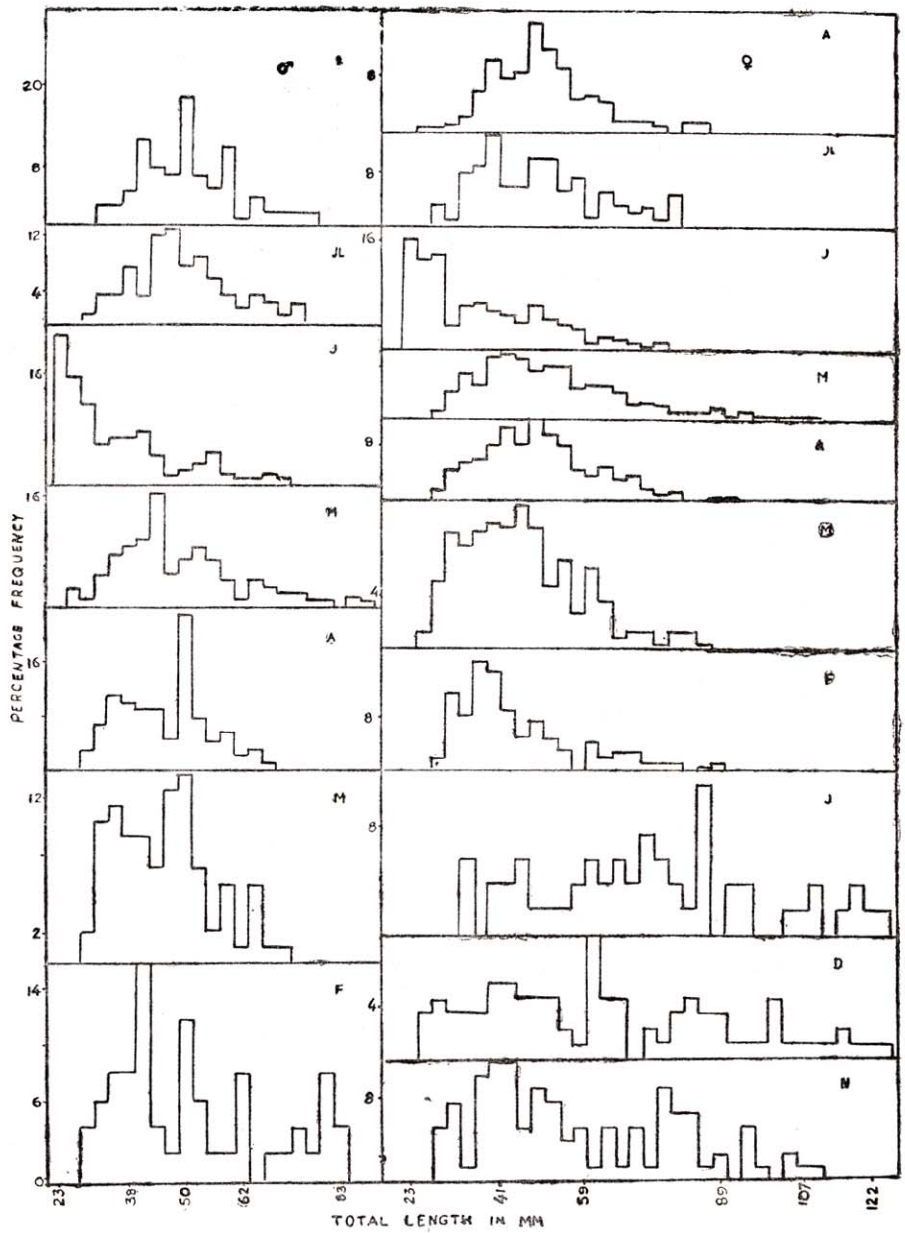


Fig. 24. *Parapenaeopsis sculptilis* (Heller) Percentage length frequency distribution from month to month in males and females (After Rajyalakshmi, 1966)

Abdomen - Dorsally carinated from middle of 4th somite, carinae of 4th and 5th ending in angular, sometimes very minutely spinuous projections, that of 6th ending in a large spine. The third and anterior 4th somite with feeble dorsal sulcus or flat topped strip indicating its position, often present on 1st and 2nd somites also. 4th somite with 1, 5th with 1 and 6th with 3 pairs of faint lateral cicatrices. Telson unarmed (Fig. 23, A). Petasma (Fig. 23, B) - Reaching basis of 4th pereopod, with pair apical spout like projections directed anterolaterally and opening ventrally, distance between their apices almost equal that of distolateral projections, which is 2/5 total length of petasma. Petasma constricted at 0.7 its length, a pair of very large prominent lateral proximal projections, slightly curved distally, ending posteriorly in knob-like processes. Appendix masculina - Distal piece with expanded, flattened distolateral region inclined at 45^0 to longitudinal axis and ½ length basal piece. Thelycum (Fig. 23C) - Anterior plate slightly concave, length 0.7-0.8 width; with 2 low tubercles on posterior edge separated by shallow median depression and articulating with corresponding pair of tubercles on rectangular posterior sternal plate, latter with tubercle bearing tuft of setae.

Colour - Four wide whitish transverse bands evenly spaced along carapace and abdomen, edged with narrow pink bands, region between white and pink bands light to dark brown; appendages pink to red.

Although, the species is well established, Hall (1962) claims that this species in fact is *Penaeus affinis* Milne-Edwards, 1837. But Burkenroad (1963a and 1963b), Racek and Dall (1965) and Kirkegaard and Walker (1967) do not uphold this view.

Alcock (1906) created a variety, *P. sculptilis* var. *cultirostris* for 18 males which possess straight rostra which are nearly horizontal and do not reach further than the middle of the 2nd joint of antennular peduncle, but have a peculiar dagger shape. Kubo (1949) raised this variety to specific rank. Dal (1957) synonymised both Alcock's variety and Kubo's species, *P. cultirostris* with *P. sculptilis*, pointing to the fact that cultrate condition of the rostrum is invariably found in males of the latter species after copulation. The position of epigastric tooth, sulcation of postrostral carina and first and second abdominal somites are variable and therefore not valid for creating a distinct species.

However, Hall (*op. cit*) disagrees with Dall's view and suggests that although there are similarities between the rostra of adult male *P. sculptilis* and the variety *cultirostris*, the precise form of *cultirostris* rostrum is shown in the Malaysian form by the adult male of *P. hardwickii* and it is with this species that the variety *cultirostris* is to be synonimised. Recently, Racek and Dall (*op. cit*.) pointed out that the cultrate condition of the rostra in the males of *P. sculptilis* and *P. hardwickii* display close affinities and in view of these similarities they suggest that it is possible that Alcock's material of *P. s. cultirostris* may consist of both species, eventhough, they could readily by distinguished from each other by their secondary sexual characters. Thus, the status of this variety is still unsettled.

P. sculptilis is known by the standard name - 'Rain bow prawn' and locally in Australia it is also called 'Coral prawn'. In New Guinea, it is known by a variety of vernacular names such as 'Brown coral prawn', 'Tiger prawn', 'Long beaked prawn' and 'Short beaked prawn'.

Distribution

This is a widely distributed tropical species, found from west and east coasts of India to Hongkong through Malaysian waters and Indonesia to tropical Australia and New Guinea. The northern and southern limits of this species lie just inside the tropics of Cancer and Capricorn and within these limits its distribution could be considered as Indo-West Pacific. Its abundance in commercial quantities has been reported from Penang, Singapore (Malaysia), Java (Indonesia) and from Queensland, east coast (Australia). It is also forms a good portion of the prawn fishery in Keppel Bay (Dall, 1957) and at Papua.

In India, commercial exploitation of the species is done at Kutch, Bombay in the west coast and in the Hooghly estuarine system in the east coast. It is also reported from the Godavari river system almost throughout the year.

Life history

No information is available on the eggs and nauplial stages. Kirkegaard and Walker (1967) have recorded a series of small larvae of the

species with 8+8 telson spines in the plankton samples taken from the Norman river (Australia). Protozoea were found in June when the salinity of the river was between 30% and 32%, mysis stages in water below 22% and juveniles up-river in water below 5%. The juveniles have also been recorded from the Hooghly estuarine system in June, November, March and May (Rajyalakshmi, 1966). According to Hall (1962) the juveniles of his *P. affinis* (*P. sculptilis*) occupy the tidal flats for 2 or 3 months and then they migrate to deeper waters.

Food and feeding:- No observation on the stomach contents of the species has been made from the Indian region. However, Hall (*op. cit*.) examined the stomach content of 21 specimens and grouped it under those prawns with a general carnivorous diet mainly feeding on polychaets, crustaceans and molluscs. The specimens studied by him measured from 1.3 to 3.8 cm carapace and were from the 'Ambai' fishery of Penang. The stomachs were on the average about half full and he gave the following table for the composition of stomach contents of the species studied.

Item	Predominant	Residual	Total
Polychaeta	4	5	9
Small crustacea (Organisms ingested as whole)	-	7	7
Large crustacea (Those organisms of which only parts are ingested)	3	7	10
Mollusca	11	6	17
Pisces	-	2	2
Vegetable	-	2	2

He further observes "The only items of small crustacean debris which were identifiable were of Herpacticoid copepod. The large crustacean material, apart from two records of gammarid amphipods, appeared to consist of portions of decapods. Both the records of fish debris included vertebrae. All the molluscan material appeared to be of a single species of protobranchiata and although this item was by far the most important found in the stomachs of *P. affinis*, there was one record of a 'split bolus' in which protobranch material formed the posterior one-third of the

volume while decapod crustacean material formed the more recently ingested anterior two-thirds.

Detritus formed but a very small portion of the contents of the stomach.

All the prawns which had a high proportion of mollusca were obtained from the 'Ambai' fishery on Batu Maung flat, Penang and this flat is mainly of mud and bivalves inhabit the surface of the mud. It appears that the molluscan material was taken by these prawns in proportion with its availability and they do not select the food material.

Growth:- By employing the probability plot method, Rajyalakshmi (1966) has shown that the juveniles of the species grow approximately 12-15 mm per month in the very early months after hatching. This rate declines later and by the end of first year males attain length of 45.0 mm to 59.0 mm and females 50.0 mm to 65.0 mm. The growth rate maintains a constant proportion during later years and the increments in length attained by males during second year is 30 mm and by females 25.5 mm to 29.0 mm. The females appear of live one more year than the males and in the third year of the life the increment in growth is approximately 25.0 to 29.0 mm. Faster rate of growth is observed in females indicating a sexual difference in the rate of growth (Figs. 24&25).

Hall (1962) based on the length frequency distribution of males and females obtained from the 'Ambai' fishery, fitted growth curves to the data for the period October to February. The curves indicate an increase in carapace length from below 0.5 cm to 2.0 cm for males and 2.25 cm for females in that four month period.

Length-weight relationship:- This aspect has been studied by Hall (1962) and Bhimachar (1963). The relationship is expressed by the following formula :

$$W = 0.4954\ C^{2.944}$$ (Hall, *op. cit*.)

$$W = -5.1272 + 2.9580 \log L$$ (Bhimachar, *op. cit*.).

where 'W' is the weight, 'L' is the total length and 'C' the carapace length.

Movement:- The speceis does not appear to have extensive migration and according to Kirkegaard and Walker (*op. cit*.) it does not move far from the river mouths. The larvae and juveniles migrate upstream; 0-1 year group contributing to the fishery of less saline areas. The larger specimens (adults) move out of the less saline areas and are generally caught in tidal marine zones or in the inshore marine regions. On the Batu Maung flats of Penang, Hall (1962) found that the juveniles move into the flats in November-December and after 2 or 3 months disperse into deeper waters. He explains this movement is mainly due to the shallow nature of flats and certain areas getting dried up during low tides and apparently unsuitable for juveniles.

Reproduction:- *P. sculptilis* is heterosexual and sexually dimorphic. The males are distinguished by smaller sizes, lack of anterior edentate portion of rostrum extending beyond last rostral tooth to beyond tip of antennular peduncle in specimens measuring above 70 mm and the secondary sexual characters like the petasma and appendix masculina. In the females the presence of thelycum and the anterior edentate portion of rostrum extending to the tip of antennular peduncle are characteristic.

No detailed study on the maturaion process of the gonads has been made. Bhimachar (*op. cit*.) gives the sizes of males at sexual maturity as 75.0 mm and the females also attain maturity at this size according to Rajyalakshmi.

There is no information on mating, fecundity or fertilisation. However, it is likely that the mating is promiscous and fertilisation takes place externally as in other penaeid prawns.

Spawning takes place in the inshore waters extending from December to April-May with peaks in December-January (Rajyalakshmi, 1966). In Bombay waters, although the females with ripe ovary occur throughout the year, intensive breeding activity as indicated by the occurrence of mature females is observed during December-February.

Population

Sex-ratio:- Studies on the sex ratio of the species in the fishery of Hooghly estuarine system have indicated that the ratio changes generally with the size and the season. In younger individuals (23 mm to 26 mm size range) the sex ratio is equal, but in the slightly higher sizes of 29 mm to 69 mm the male to female ratio is 1:3.24. In prawns measuring above 89.0 mm only females are found. Sex-wise length frequency distribution has indicated that generally females grow to bigger sizes and greater ages. The equality seen in the sex ratio of younger individuals and the disparity in the large sized prawns might indicate either a higher rate of mortality in males or segregated movement of one sex after certain sizes.

In the Bombay fishery, the females are found to dominate over the males.

Size composition:- The maximum size recorded so far is 152.0 mm total length. However, Filewood (1964) gives a variable measurement of 6-7 inches. Small sized males of 23.5 mm modal size occur in June, while females are encountered in November (29.7 mm), December (27.8 mm), March (29.4 mm), May (30.5 mm) and in June (24.2 mm) in the estuarine catches of Hooghly river system. Higher age classes have a bimodal length frequency distribution for each year group and this might be due to the prolonged spawning season.

At Bombay, during 1959-60 season, more than 15% of the prawns were within 55 to 105 size range in September-November period. A gradual increase of size from 75 mm in September to 135 mm in March was also observed. Juveniles measuring 25.0 mm appeared in January.

Munro (1966) gives a range of sizes in terms of whole count per pound of a particular specimen or sample and observes that counts per pound ranged from 20-173 and throughout the season individuals were distributed throughout this full size range.

Age composition:- Smaller individuals belonging to 0-1 year age groups contribute to the fishery of less saline areas and the larger specimens (2nd and 3rd years) support the inshore fishery. Thus the fishery depends on populations with a dominance of certain year groups.

In the Queensland fishery, the year groups are well mixed in the 1 to 3 fathom depth zone, while the 'Ambai' fishery of Penang shows a fairly uniform mixing of age groups but with an influx of juveniles in October-December period.

Abundance:- In the Gulf of Kutch area, the species occurs regularly and at Modhwa it forms about 18.8% of the total prawn catch during September-January period.

In Bombay coast, the species occurs throughout the year, but available in commercial quantities from October-November to May with peaks in December-February. At Sassoon Docks and Arnala, the fishrey is quite considerable contributing 42.23% and 34.10% respectively of the total annual landings of prawns. It was found to be the second most important fishery at Arnala. Though, the fishery was observed to be relatively less important at Versova, the landings of the centre were comparable with that at Sassoon Docks in the month January (Kunju, 1967).

In the Hooghly estuarine systems, the species is dominant in the winter and monsoon months.

Weather appears to cause changes in abundance, although, the total population size may not be altered. In Penang, this species is relatively abundant on four occasions, one during each steady southwest monsoon and at the beginning and end of the northeast monsoon (Hall, 1962).

Munro (1966) states that *P. sculptilis* is mainly confined to the fringes of the coast out to the four fathom contour in the Gulf of Carpentaria, but may be found as deep as 7 fathoms. The greatest concentrations were found around river mouths in depths of less than 3 fathoms. In Bombay, large numbers are caught at a depth range of 2 to 8 fathoms.

Seasonal variations are also observed by Munro who state "Occurrence is seasonal but it is likely that the species occurs in rivers throughout the year.....this species moves into coastal waters during monsoon season. Although small numbers were observed as early as August and as late as May, the main period of abundance coincides with the wet season and immediately prior to it, namely November to March".

The species seems to inhabit the bottom of different types such as sand, mud, mud flats, mud with fine shell particles, fine sloppy alluvial silt and clean sand mixed with coarse shell and gravel (Hall, 1962; Ramamurthy, 1963 and Munro, 1966). In the Gulf of Kutch area, Ramamurthy (*op. cit*.) found that an increase in percentage in the catches taken over sandy bottoms instead of muddy bottom.

Fishing methods:- In India three types of gears, viz., stake nets (bag nets), boat seines and trawl nets are used for catching these prawns. The former two types of gears are generally employed in shallow inshore waters of Bombay and in the estuarine regions of Hooghly and Godavary. The details of the structure and operations of these nets are described by Setna (1949) and Rajyalakshmi (1966). The trawl nets are used in the deeper waters.

The shrimp fishery of Singapore emplyos a push net known locally as the "Sondong". This is a net hung on two poles 10 to 15' long which cross about 2 feet from the thicker ends and have shoes fitted to the other ends. The net is made up as a scoop and pushed along in shallow water by the operator. Periodically the net is lifted and the catch taken back to the operator. The hauling seine used in Singapore is known as the "Pukat Tarek" which has a roughly cone shaped bag about 36' deep with wings 500' long tapering to a depth of 9'. Ratton leads 2500' long are for hauling. Cotton twine in three sizes is used to make up the net and the mesh size tapers from $2^{1}/_{2}$" in the extremiteis of the wings to $1^{1}/_{4}$" at the mouth of the bag. It is handed as a beach seine by up to 16 men from a row boat (Kirkegaard and Walker, 1967).

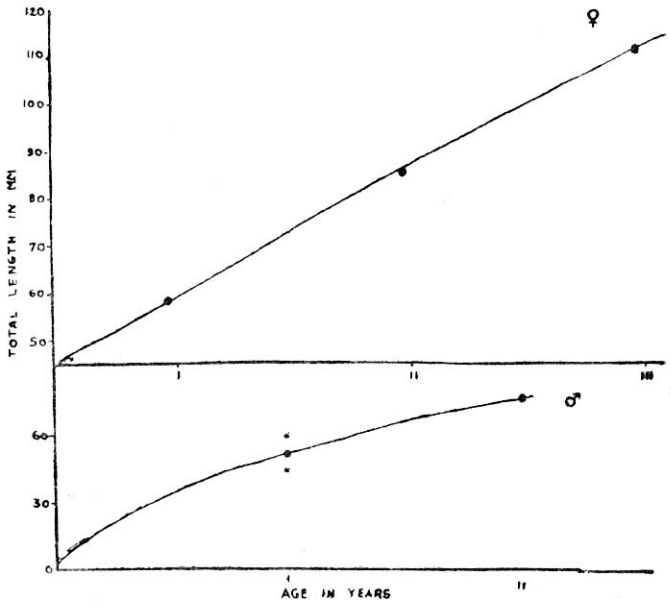
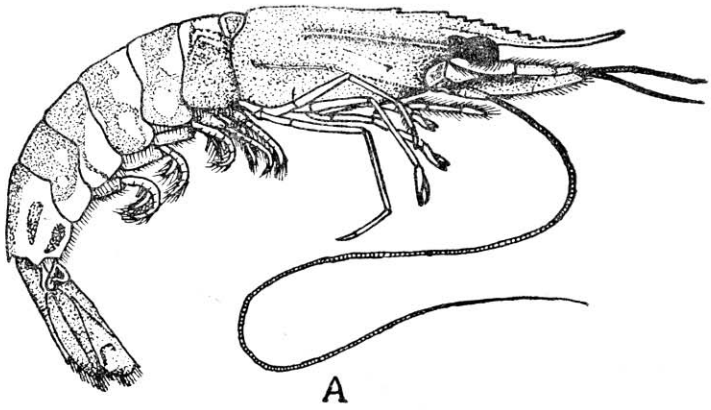
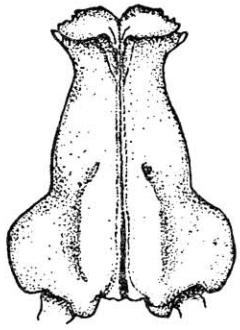


Fig. 25. *Parapenaeopsis sculptilis* (Heller) Approximate growth rate curve in males and females (After Rajyalakshmi, 1966)





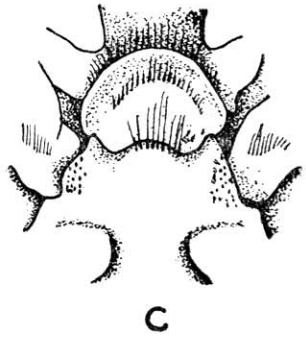


Fig. 26. *Parapenaeopsis hardwickii* (Miers) A. An adult male, B Petasma; C. Thelycum.

In Penang, the 'Ambai', a device made up with the rows of stakes set in a linked set of 'V' shapes with bag nets at apices is used. This can be operated to a particular tide or both the phase of tide.

Beam or otter board trawls are used in the Queensland fishery. Mesh size is from 1 to 1¾ inches in the cod end, width varies from 6 to 10 feet wide (beam trawl) to 8 fathoms (otter trawl). The beam trawl is also used in estuaries and otter trawls both in estuaries and outside river mouths.

The beam trawl fishery in the estuaries of Australia use small boats of 20 feet long with 5 to 20 b.h.p. inboard motors. The details of these vessels and their design are given by Wright (1966) and Kirkegaard and Walker (*op. cit.*).

Fishing season:- In India, the inshore fishing seasons extend from October to May and in the river systems during monsoon. In Queensland, this is fished from the coastal waters in November-December. At Penang, the species is available in large quantities from October to December-January.

Catches:- The species forms about 0.8% of the annual prawn catches of India (Mohamed, 1967b). In the Gulf of Kutch where 60% of annual average marine fish production of 1250 tonnes consists of prawns, of which this species forms about 6% of the annual catch. The average annual catches at Versova, Sassoon Dock and Arnala were 71.171, 127.052 and 102.587 m. tonnes respectively, forming 2.24, 5.90 and 10.41 percentages.

3. *PARAPENAEOPSIS HARDWICKII* (MIERS, 1878)

This species ranks third among the commercially exploited species of the genus *Parapenaeopsis* in the Indian region. It is popularly known as 'Hard spear prawn' in Hong Kong (Cheung, 1960). *P. hardwickii* is closely related to *P. sculptilis*, but can be distinguished from it by the characters given below.

Rostrum sigmoidal, distal half or more styliform and edentate, strongly upcurved; in female at least ¼ of rostrum extending beyond tip of antennular peduncle; rostrum in mature male often cultrate and not exceeding beyond 2nd antennular segment; dorsally armed with 7-8 teeth+epigastric. Adrostral carina ending about half way between epigastric and penultimate tooth, sulcus shallow. Postrostral carina distinct, almost reaching posterior margin of carapace, with a broadly open sulcus.

Orbital spine not much more than a sharp angle, postocular sulcus moderately deep, at angle 40^0 to rostrum. Longitudinal suture reaching about 8/10 carapace, distinct in the entire length. Cervical sulcus shallow and short. not quite reaching longitudinal suture. Antennal spine prominent antennal carina reaching to 2/3 distance between hepatic and antennal spines. Hepatic sulcus pronounced, some what more than 1/3 length of carapace, slightly sinuous; hepatic carina distinct only for lower half sulcus, commencing from base of hepatic spine, and reaching to the vicinity of the sharp pterygostomian angle. Branchiocardiac sulcus barely perceptible (Fig. 26,A).

Antennular flagella not sexually dimorphic, slightly longer than their peduncle, which is 0.6 length of carapace.

Third maxilliped surpassing carpocerite by dactyl; 1st pereopod not quite reaching to base of carpocerite, 2nd surpassing it by dactyl; 3rd as long as outer maxillipeds, 4th reaching to base of carpocerite, 5th attaining anterior margin of conrnea. Mastigobranchiae and slender basial spines on 1st and 2nd pereopods.

Abdominal carination beginning from anterior 8/10 of 3rd somite, carina on 6th ending in a sharp spine; dorsal sulcus absent. Two lateral

cicatrices on 4th and 5th somites, 3 on 6th somite. Telson armed with 3-5 usually 4 pairs of mobile spines, of which the apical set is the largest.

In the petasma (Fig. 26,B) the distomedian projections not extending beyond tips of distolateral projections, about as long as wide, their anterolateral margins distinctly crenulated; distolateral projections pointing laterally; proximal lateral enlargements of petasma very large and rounded.

In the thelycum (Fig. 26,C) the anterior plate is slightly concave, wider than long, anteriorly and posterolaterally rounded; sternal plate between 5th pereopods flat, with a pair of anterolateral tooth-like process directed anteriorly, and a concave anteromedian margin bearing a transverse row of long setae.

Distribution

The general distribution of the species is from the coasts of India through Malaysia to Southern China. Although, the species occurs on both the coasts of India, it supports a good fishery only in Bombay and in lesser magnitude in Andhra coast. Its commercial exploitation has also been reported from Penang in Singapore (Hall, 1962).

Life-history

Eggs and larvae:- No information is available on the eggs and larval stages of the species. But Hall (*op. cit*.) believes that the species breeds in deeper waters and the young ones migrate to shallow inshore waters, where a portion of their life is spent.

Food and feeding:- The only observation on the food of the species was that of Hall (*op. cit*.) who studied 28 specimens ranging in carapace length from 1.0 cm to 1.7 cm, from the Penang 'Ambai' fishery. Nine of the stomachs examined by him were less than half full, but the remainder were full. The important food items ingested by the species are given below.

Item	Predominant	Residual	Total
Polychaeta	1	6	7
Small crustacea	1	13	14
Large crustacea	9	11	20
Molluscs	21	6	27
Pisces	-	7	7
Vegetable	-	1	1

He further commented that among the small crustacean debris were recognised to be composed of harpacticoid and calanoid copepods, ostracods and one cumacea. The one occasion on which the small crustacea formed the predominating feature of the stomach content was when harpacticoid copepods and ostracods were present together. The only large crustacea which were identified from the stomach of this species were Mysidacea. By far, the mass of molluscan material consisted of debris of protobranch lamellibranchs, but little gastropod debris was also observed. Although, the detritus was found in almost every stomach the amount was very small.

As *P. sculptilis*, this species has also been placed in a group of species with a general carnivorous diet.

Growth:- Hall (*op. cit.*) studied the size-frequency distribution of males and females of *P. hardwickii* from the 'Ambai' fishery, and fitted the growth curve to the data. The curves indicate an increase in carapace length from below 0.5 cm to about 1.25 cm in males and about 1.275 cm in females during four months from October to January. Since the juveniles of *P. hardwickii* of 0.4 cm to 0.5 cm carapace length are observed in October, he estimated that this size has been attained in about 4 to 5 weeks from spawning which takes place in September. Length-weight relationship has been given by: $W = 0.5808\ C^{2.824}$.

Reproduction:- *P. hardwickii* is heterosexual, distinguished externally by the secondary sexual characters like petasma and appendix masculina in male and the thelycum in female. No observation has so far been done on the maturation process, spawning behaviour and on the

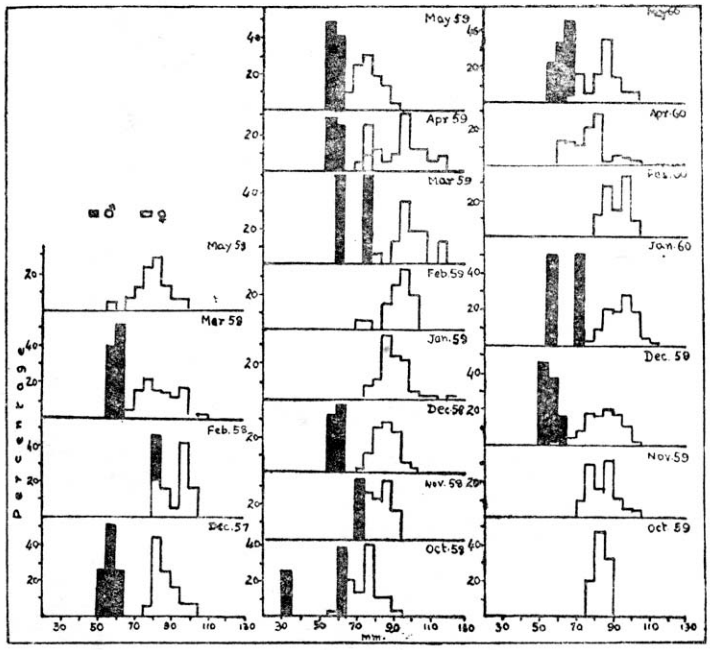


Fig. 27 *Parapenaeopsis hardwickii* (Miers) size frequency distribution in the commercial catches at Versova from 1957–58 to 1959-60 (After Mohamed, 1967)

fecundity of the species. Based on the analysis of samples obtained from Singapore Strait, Hall (*op. cit*.) remarked that the species probably spawns in deeper waters of Singapore Strait in about 40 fathom area possibly twice each year by inference, although, individuals no doubt spawns only once at the end of first year of life or six months later.

In Bombay waters, the breeding period appears to be protracted extending throughout the winter, from October to February with maximum intensity in December and January (Mohamed, 1967a).

Population

Sex ratio:- In Bombay fishery, generally the females dominate over the males. The sex-wise size distribution of the species for the years 1957-58 to 1959-60 is given by Mohamed (*op. cit*.). Wide disparity of sizes of males and females is seen. The females are recorded to a size of 125.0 mm, while the largest size of males seen is only 85.0 mm. In the distribution of sizes, it is also seen that the size range of females begin from the point where the size range of males end, giving a more or less continuous picture when both the sexes are considered together.

Size composition:- The greatest length recorded for the species is 130.0 mm. In the 'Ambai' fishery at Penang, small specimens measuring below 0.5 cm carapace length are obtained from October to middle of January. Large sized prawns appear in July and the majority of the catches of the 'Ambai' fishery are in the size range of 0.5 cm to 2.0 cm carapace length.

In Bombay area (Fig. 27) the males are generally smaller in size and in most of the months specimens measuring between 55-65 mm are caught. The small sized female are scarce in the fishery and the majority of females landed during November-January measure 80-90 mm, while in February-April, slightly larger females measuring 90-100 mm predominate.

Recruitment:- In 'Ambai' fishery of Penang, smaller sized prawns enter the fishery in October.

Abundance:- In Bombay area, the species forms 6.97%, 2.75% and 3.93% at Versova, Sassoon Dock and Arnala respectively. According to Hall (*op. cit*.) the species appear to prefer deeper waters in the Singapore Strait. In the Ambai fishery, this is the most important species accounting for 42.1% of the total numbers.

Fishing methods:- Some types of gears used for *P. sculptilis* are employed for this species.

Fishing season:- In Bombay area, the fishery starts in November and continues upto May, the peak season being November-January. At Sassoon Dock, its peak of abundance is in October-November and at Arnala it is from March to May.

In the 'Ambai' fishery of Penang, the maximum catches are obtained from mid September to end of November and from Mid July to early October.

Catch:- The species forms about 0.6% of the annual prawn landings of India (Mohamed, 1967b). The average annual catch at Versova, Sassoon Dock and Arnala are 221. 243, 59.218 and 38.769 m. tons. respectively.

VI GENERA *SOLENOCERA* LUCAS 1850, ATYPOPENAEUS ALCOCK 1905, *HYPPOLYSMATA* STIMPSON 1860, *PALAEMON* WEBER 1795 and *ACETES* M. EDWARDS 1830

By

M. Mydeen Kunju
(*Central Marine Fisheries Research Institute, Mandapam Camp*)