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DISTRIBUTION, HABITS AND HABITATS OF PALINURID LOBSTERS AND THEIR LARVAE

R. Raghu Prasad*♦
Central Marine Fisheries Research Institute

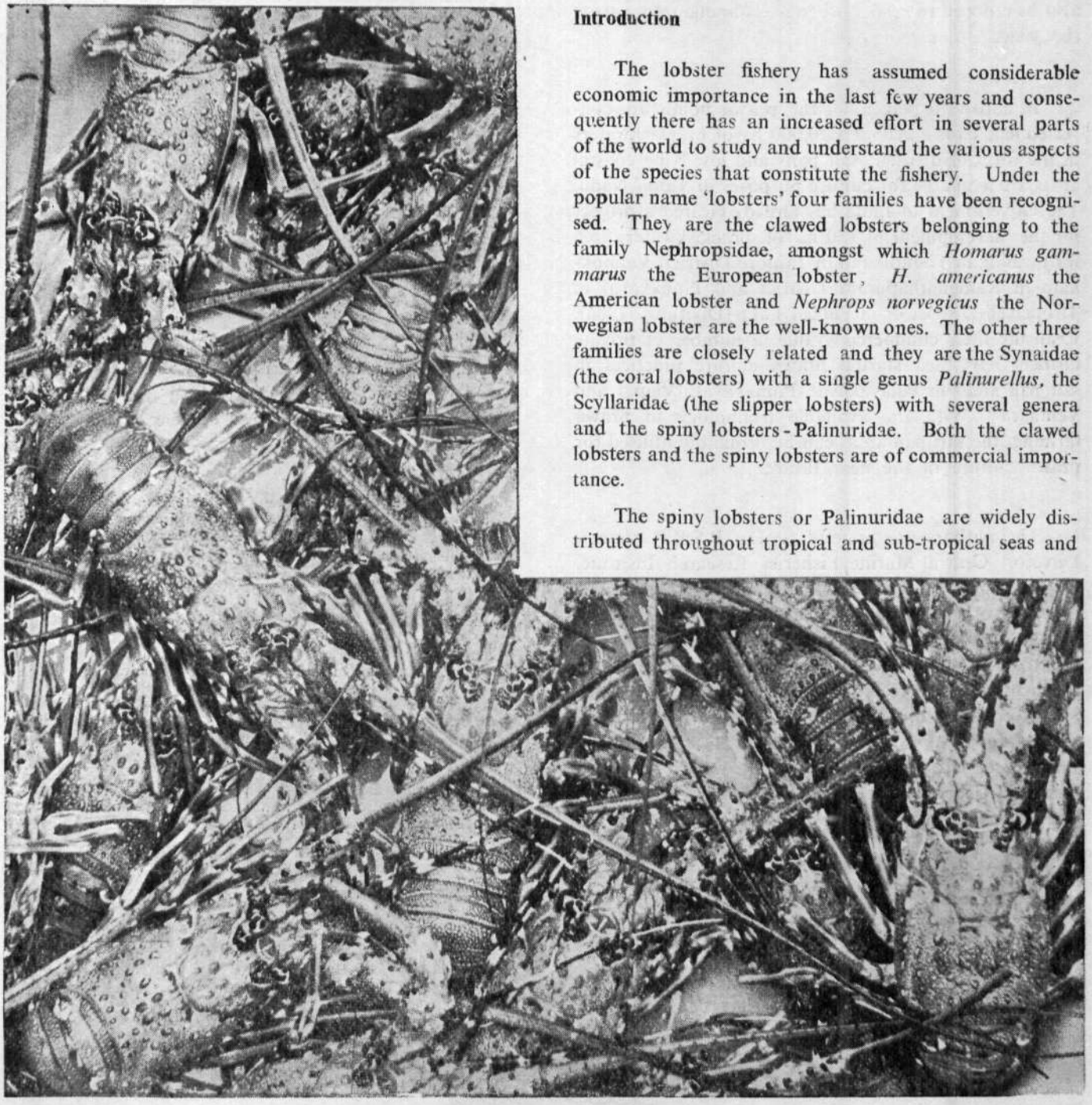

Photo courtesy: Mr. M. Kathirvel

Introduction

The lobster fishery has assumed considerable economic importance in the last few years and consequently there has an increased effort in several parts of the world to study and understand the various aspects of the species that constitute the fishery. Under the popular name 'lobsters' four families have been recognised. They are the clawed lobsters belonging to the family Nephropsidae, amongst which *Homarus gammarus* the European lobster, *H. americanus* the American lobster and *Nephrops norvegicus* the Norwegian lobster are the well-known ones. The other three families are closely related and they are the Synaidae (the coral lobsters) with a single genus *Palinurellus*, the Scyllaridae (the slipper lobsters) with several genera and the spiny lobsters - Palinuridae. Both the clawed lobsters and the spiny lobsters are of commercial importance.

The spiny lobsters or Palinuridae are widely distributed throughout tropical and sub-tropical seas and

*Emeritus Scientist, ICAR.
♦Present Address: Ground Floor Flat, Saigeeth Apartments, 21 - Thirumurthy Street, T. Nagar, Madras-600 017.

by limiting the stocking density to about 70,000/ha. Improvements in flushing system, increase in the water depth, steady supply of nutritive food, provision of 'water blender' to avoid oxygen depletion are some of the suggestions for more effective implementation and higher production. The peak summer period may be avoided for stocking and the duration of culture can also be reduced to realise a better economic return from the yield.

In Japan 70 percent of the prawn ponds are converted salt pans. About 1,20,000 ha of brackishwaters in the form of disused salt pans and low lying coastal areas are available for culture purposes in Tamil Nadu. The Government of India has already cleared a project for the development of 150 ha of brackishwater area for farming in Thondikadu in Tanjore District, Valinokkam in Ramanathapuram District and Pinnakayal in Tirunelveli District or in Pulicat Lake (Dixitulu, 1986). Realising their commercial value, a number of private farmers have just started prawn culture practices in salt pan areas in Palayakayal, Pinnakayal, Vaipar and Vembar. With the available technology in prawn farming, the salt pan areas can be profitably utilised for prawn culture in the near future.

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References

DIXITULU, J.V.H. 1986. Tamil Nadu News letter. *Fishing Chimes*, **6**: 61.

MARICHAMY, R. 1986. Prawn farming in the tidal flat of Kallar estuary. *Nat. Symp. on Estuarine Biology*, Parangipettai, 26–28 October, 1986, Abstract No: 22.

MARICHAMY, R AND S. RAJAPACKIYAM 1982. The culture of milkfish, mullet and prawn in an experimental marine fish farm at Tuticorin. *Proc.Symp. Coastal Aquaculture*, **1**: 256-265.

MOHAMED, K. H., M. S. MUTHU AND R. MARICHAMY 1980. Laboratory bred prawns from Narakkal cultured in salt pan reservoirs at Tuticorin – a success story. *Mar. Fish. Infor. Serv.*, T & E Ser., No. **26**: 3–5.

MUTHU, M. S. 1980. Site selection and types of farms for coastal aquaculture of prawns. *Nat. Symp. Shrimp Farming, Bombay*, 16–18 August, 1978, pp. 97-106.

NAIR, R. V., P. BENSAM AND R. MARICHAMY 1974. Possibilities of marine fish culture in the salt pan areas of Tuticorin. *Indian J. Fish.*, **21**: 120-126.

RAO, G. SUDHAKARA AND K. A. NARASIMHAM 1978. Prawn culture in salt pans at Nellarevu in Andhra Pradesh in 1974. *Bull. CMFRI*, No. 28.

SHIGUENO, K. 1972. Problems of prawn culture in Japan. Coastal Aquaculture in the Indo-Pacific Region. FAO Fishing News (Books) Ltd. London, pp. 282-312.

SRIRAMAN, K. AND S. ANANTHANARAYANAN 1986. Culture of *Penaeus monodon* with different stocking densities. *Nat. Symp. on Estuarine Biology*, Parangipettai, 26–28 October, 1986, Abstract No. 16.

SULTAN, K.M.M., R. SOUNDARARAJAN AND T. FRANKLIN 1973. Shrimp culture made easy. *Proc. Seminar on mariculture and Mechanised Fishing, Madras*, 28–29 November, 1972, pp. 103-104.

SUSEELAN, C. 1975. The prawn culture practices in salt pan reservoirs at Manakudy near Cape Comorin. *Bull. Dept. Mar. Sci., Univ. Cochin*, 7 (3): 477-486.

UNNITHAN, K.A. 1985. Prawn seeds and stockings. A guide to prawn farming in Kerala. CMFRI Spl. Publication, **21**: 43-58.

VENKATESAN, V. AND VICTOR CHANDRA BOSE 1982. Observations on the culture of tiger prawn *Penaeus monodon* Fabricius in brackishwater ponds. *Proc. Symp. Coastal Aquaculture*, **1**: 146-150.

VICTOR CHANDRA BOSE, S. AND V. VENKATESAN 1982. Prawn and fish seed resources of Marakanam Estuary. *Proc. Symp. Coastal Aquaculture*, **1**: 196-201.

a few species occur in temperate waters also. The Family Palinuridae consists of nine genera and all these are represented in the Indian Ocean. Altogether eighteen species belonging to 9 genera have been recorded from the Indian Ocean. Of these, seven species *viz., Panulirus homarus, P. ornatus, P. versicolor, P. polyphagus, P. penicillatus, P. longipes* and *Puerulus sewelli* are common in the Indian waters. *P. sewelli* is known to occur in commercially exploitable quantities in the deeper waters especially off the coast of Kerala. The results of recent exploratory fishing conducted by the Integrated Fisheries Project have indicated the occurrence of large quantities of *Palinustus mossambicus* also in the deeper waters of the southwest coast of Kerala. The commercial possibilities of exploiting this species are, however, not known. This makes eight species of palinurids of commercial importance. Amongst the six species of Panulirus, all of which are inhabitants of shallow waters especially rocky areas or where there are extensive coral reefs which offer suitable retreats, only four species form the mainstay of the commercial fishery. These are *P. homarus, P.polyphagus, P.ornatus* and *P.versicolor* and details of the distribution of which are given together with the distribution of *Puerulus sewelli* and *Palinustus mossambicus* with the description of species at the end.

Habits and habitat

Habits

Spiny lobsters are shelter dwellers and include singular or multiple den residency and show definite homing patterns. Most of the species do not undertake extensive migrations. They are nocturnal foragers and generally begin to feed at dusk, are gregarious and return to their dens before dawn. According to Kanciruk (1980) "Interactions between environment (temperature, light, photoperiod, salinity *etc.*) and palinurid behaviour are complex, and evidence indicates that such environmental parameters strongly affect activity patterns, migratory movements, reproduction, growth and regional and local distribution. Based on current research, the most important of these factors seems to be light (controlling activity patterns) and temperature (influencing or triggering migratory behaviour and breeding activity)."

Habitat

Although these lobsters enjoy wide distribution, there are clear evidences to show that most species prefer particular regions or habitat. There is a great variation in the habitat preference of adult lobsters and it may vary from the intertidal zone to great depths of the ocean characterised by mud-ooze substrate and perpetual darkness. It is generally believed that the adult lobsters do not undertake long migrations. Studies carried out by Mohamed and George (1967) on the migration of *P. homarus* showed extremely limited movements. It is, however, reported that *P. ornatus* undergoes mass migration between habitats which explains the significant contrast between the habitats of the juveniles and adults of this species. "The most characteristic feature of the habitat of many of the palinurids is the residence area or den. Dens are not usually constructed by the Palinuridae but are opportunistically chosen from the surrounding habitat. The burrowing ability of most Palinuridae is usually assumed to be minimal." Except in a few regions, detailed studies on the habitat preferences of lobsters have not been carried out. Some of these studies have indicated that there are 'true home dens' to which individual lobsters will repeatedly return after their nocturnal foraging. The available information has been compiled by Kanciruk (1980). In regard to the four species, which contribute mainly to the lobster fishery of India, Prem Kumar and Daniel (1975) have given a detailed account of their distribution pattern in the Indian region.

P. ornatus: It occurs in appreciable quantities along the southeast coast of India where they constitute a good fishery. The species has been recorded from other regions also along the coast of India.

P. polyphagus: This species although recorded from both the coasts of India, is more common along the west coast particularly the northwest coast of India forming a good fishery. Chopra (1939) has, however, stated that this is the only species of lobster of commercial importance off Calcutta.

P. versicolor: Although this species also enjoys a fairly wide distribution along the coasts of India and the Andaman and Nicobar islands, it does not contribute significantly to the fishery and is the rarest commercial species.

P. homarus: Amongst the four species which contribute to the commercial fishery, this is the most important and forms a good fishery in several places along the coasts of India and the Andaman and Nicobar Islands. The bulk of the fishery is concentrated along the southwest coast of India. Berry (1971) has observed that along the East African coast *P. homarus rubellus* inhabits the surf zone and is most tolerant to surge and

turbulence. He also reported that the distribution is correlated to the occurrence of its main food which is the mussel *Perna perna*. It is interesting to mention here that large-scale settlement of the puerulus stage of *P. homarus* was noticed in the spat collectors kept off the coast of Kovalam (near Madras) for collecting the spat of *Perna viridis*. This may indicate that in this region also mussels constitute the main food of the puerulus as well as the adults of *P. homarus*.

Puerulus sewelli: This is known to occur in commercially harvestable quantities in the deeper waters off Kerala. So far no attempt has been made to fish them on a commercial basis.

Larval history

The eggs are attached to the endopodites of the pleopods of the female and no reliable information is available on the time taken for development and hatching of the larvae. In most cases hatching takes place at night. Generally the first larval stage is recognized as the phyllosoma. Some authors have, however, recorded stages earlier to the phyllosoma stage and these have been referred to as 'prenaupliosoma', 'naupliosoma' or 'prephyllosoma.' These, whenever present, last only for a few hours before moulting into the phyllosoma. Therefore, some believe that the "prenaupliosoma stage probably represents an embryonic form occurring as a result of premature rupturing of the eggs in most species, although the finding of prenaupliosoma of *P. argus* in the plankton by Sims (1965) shows this is not universal" (Phillips and Sastry, 1980). In regard to the species occurring in Indian waters the only record of a free larval stage prior to phyllosoma is that of Deshmukh (1968) who observed in *P. dasypus (= homarus)* a larval form different from the naupliosoma and phyllosoma and suggested the name 'prephyllosoma.'

Phyllosoma larvae, as the name indicates have flat and leaf-like body. They are transparent, have long legs and protuberant eyes and have orange-red chromatophores particularly on the coxal segments of the pereopods and between the base of the first and second antennae. The first stage of phyllosoma (Fig. 1) measures from 1.1 to 2.3 mm in body length (from the tip of the abdomen to the tip of the forebody between the eyes) depending on the species. The eyes are thick stalked but unsegmented and are about as long as the first antenna. The first antenna is about one and a half times the length of the second antenna and both are unsegmented. The first maxilliped may be present or absent and the second maxilliped is segmented. The third maxilliped is biramous with setose exopodite. There are three pereopods of which the first two are biramous with setose exopodites. The abdomen is

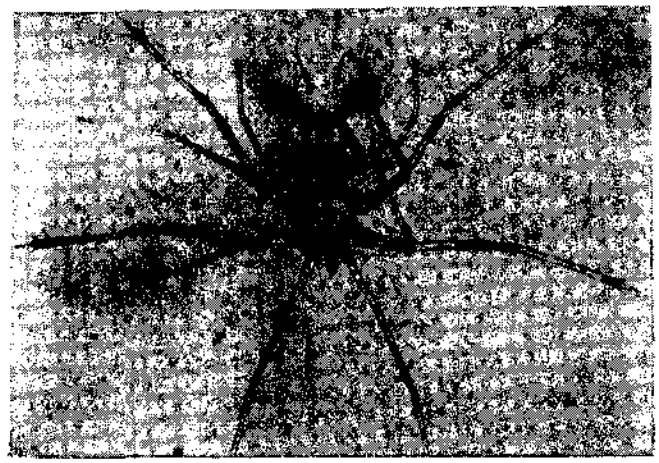

Fig. 1. First stage phyllosoma larva of *Panulirus homarus* (Linn.) (Photo courtesy: Mr. M. Kathirvel).

unsegmented. The shape of the cephalic shield varies from species to species. Differences have been observed by many workers between the larvae reared in the laboratory and those obtained from plankton.

The specific identification of the phyllosoma larvae has been a major problem especially in regions where there are several species of lobsters co-existing. The identification in most cases therefore, has been based on circumstantial evidence relating to the intensity of larval population and the abundance of particular species. Positive species identification is possible either through laboratory hatched larvae or from the last stage of phyllosoma metamorphosed into the puerulus stage

Fig. 2. A group of advanced phyllosoma larvae of *Scyllarus* sp. (Photo courtesy: Mr. M. Kathirvel).

in the laboratory whose specific identity could be determined. Out of the different species of lobsters recorded from the Indian Ocean, the first phyllosoma of only six *viz., P. homarus, P. ornatus, P.polyphagus, P. longipes, P. japonicus* and *Puerulus sewelli* are correctly known. These are based on laboratory hatched larvae. Rearing of these larvae in the laboratory through successive stages has met with relatively little success. The phyllosomas pass through a series of moults and with each moult the larvae increase in size. Each moult, however, does not necessarily mean that there is a concurrent change in the stage of development because laboratory experiments have shown that there may be several moults between successive stages. Different workers have assigned varying number of stages through which the phyllosoma larvae pass from the newly hatched to the time they metamorphose into the puerulus stage when they start assuming some of the characters of the adults. At this stage they generally change from a planktonic to a settled life and moults into the juvenile stage and assume the morphological features of the adults.

It is believed that in the case of the Indian species there are about 10 or 12 stages of phyllosoma and that the larval life in different species ranges from 3 to about 6 or 7 months. Depending on the species, the last phyllosoma stage varies in length between 30 and 43 mm. In the final stage all the pereopods are fully developed, the pleopods have become biramous and so also the uropod is fully developed. This last stage of phyllosoma metamorphoses into the puerulus and Gurney (1942) describes this as "the most profound transformation at a single moult known among Decapoda."

Distribution and abundance of phyllosoma larvae

Distribution

The distribution of phyllosoma is determined by several factors particularly in view of its prolonged larval life and the influence excerted by the prevailing water movements. Most of the studies, however, have shown a greater concentration of phyllosoma along the coast or near islands. This is to be expected owing to the fact that majority of the species of adult lobsters inhabit coastal regions, around islands and coral reefs. It is also generally believed that these larvae are seldom found beyond the geographical limits of the adult populations. In spite of extended planktonic life, during which period they are subjected to varying influence of water movements, it is interesting that the larvae still remain concentrated in certain restricted areas thereby facilitating the restocking of these regions. Tampi and George (1975) while studying the International Indian Ocean Expedition collections have remarked that "one of the strange features worthy of notice is the lack of larval specimens in any appreciable numbers along the coastal regions of India and Ceylon. While adults of the palinurids are present in large numbers around Ceylon, southwest and southeast coasts of India contributing to commercial fishery (De Bruin, 1960; 1962; George, 1968), the absence of larvae from this region in the collections covering a period of 5 years excepting for a single specimen from the Lakshadweep area is quite intriguing." Attempts have been made to study the mechanisms of larval transport and dispersal, and different explanations have been given for the peculiar features of distribution, but still these are not fully understood. The problem has to be viewed from the methods of collection, time and area of sampling and more detailed analysis of the larval transport in relation to the hydrological factors of the regions particularly the water movements are required. Phillips and Sastry (1980) have stated that "The overall direction of the phyllosoma larvae during the larval movements seems to be fortuitous, and there is no suggestion that the larvae actually seek to travel in a particular direction. Under this assumption the presence of larvae in a water mass has been used by oceanographers as indications of the origins of that particular water mass (Murano, 1957; Johnson and Brinton, 1963). Larvae released in shallow inshore areas are typically described as being carried offshore in the particular watermass in which they are released. Thus, while the mechanisms of the return of the larvae back to the coast are not fully understood, their return can be taken as indicating the presence of water movements. The data on the early phyllosoma larvae of *P. cygnus* show that these larvae are transported offshore by the action of surface wind drift, passing over the top and moving contrary to the direction of the described major circulation of the area. This suggests that caution should be used in the interpretation of the movements of the larvae in relation to water circulation features, although the basic truth of the statement is unchanged." Phillips (1981) has, however, remarked in the case of phyllosomas of *P. cygnus* that most of them complete their planktonic period without re-entering the continental shelf waters and that concentrations of the late stage of the larvae have been found in the waters near the edge of the continental shelf.

It is believed by some investigators that the larvae which are carried farthest from the coast and which cannot return to the same area and consequently considered lost may be the source of recruitment to other

areas. This has been observed in the South Florida waters, Australia-New Zealand region and the Madagascar-Southeast Africa region. The ability of the phyllosoma larvae to postpone their metamorphosis into the puerulus stage until they are in the neighbourhood of a suitable benthic habitat has also been mentioned in the literature as a possibility. This may be an inbuilt control mechanism for self preservation.

In the pattern of vertical distribution these larvae show some interesting features. The larvae collected from the Indian Ocean by the DANA Expedition which constitute numerically the best collection, show the quantitative vertical distribution of these larvae. Contrary to the expectations, the maximum number of larvae is found at about 50 m with very few near the surface. They were fairly abundant at 100 m. Their number decreased with increasing depth although fairly large numbers were obtained at 200, 300, 500 and 600 m. The occurrence of the I stage phyllosoma of *P. ornatus* at 2,000 m is difficult to explain and that of IX and XII stages of *P. penicillatus* as far down as 3,500 m is rather interesting. With the available data it is not possible to explain precisely the vertical distribution pattern and the factors influencing this. In general, it could be stated that the majority of the larvae obtained from deeper waters were fairly advanced stages. The study of the oceanographical conditions suggests that the greater concentration of the larvae in the upper 100 m is closely related to the distribution of the pycnocline which acts as an effective barrier for the vertical movements of the larvae. It is also known that intensity of light plays a vital role in the vertical distribution of these larvae, the early stages of which are reported to show a strong photopositive reaction to dim light. In the case of the phyllosoma larvae of *P. cygnus* recent investigations have shown that they perform daily diurnal migrations, rising to the surface at night and descending to lower depths during day time. Therefore, light appears to be an important factor in influencing the vertical distribution.

Abundance

In spite of increasing attention being paid to the study of the phyllosoma larvae, no serious attempt seems to have been made to study the abundance and quantitative distribution of these larvae. A large number of species of adults have been recorded from Indian waters but the paucity of their larvae in the regular plankton collections made even in regions where the adults are known to inhabit is somewhat puzzling. This could partly be attributed to the type of net used, method and time of collection. Ritz (1972) observed that the densities of the early stages of phyllosoma of *P. cygnus* are apparently independent of the plankton biomass but in the case of late stages a correlation between the larval density and the plankton biomass was noticed. Tampi (1973), however, reported that generally "the areas of poor phyllosoma catch coincide with regions of low zooplankton biomass and especially the decapod larvae."

The richest collection of panulirid phyllosomas from the Indian Ocean appears to be the one made by the DANA Expedition during 1928–1930 and described by Prasad, Tampi and George (1975). The larvae have been assigned to 10 species belonging to 4 genera, whereas adults of 10 species belonging to 3 genera have been recorded from Indian waters. It is interesting to note that in the DANA collections as well as the International Indian Ocean Expedition collections studied by Tampi and George (1975) the maximum number of larvae was that of *P. versicolor* although this species does not contribute substantially to the commercial fishery along the Indian coast.

Despite the considerable amount of information that has been gathered on the distribution of the adult lobsters and many workers have been studying the larval history, much more remains to be done to have a complete picture of the life history of this group of crustaceans which have great economic value. Specific identity of the larval stages of most of the species is unknown, the distribution pattern in space and time and the effects of environmental factors on this, their mortality rates and number of stages through which the larval phase is completed, their food and feeding habits and conditions necessary for the phyllosomas to metamorphose into the puerulus stage thereby changing from a planktonic to a benthic life are some of the aspects which require detailed study. It would also be interesting to conduct some experiments to find out whether the normal lengthy larval period could be abridged so that when a complete culture system is evolved considerable time could be saved in producing marketable size lobsters. These data together with the information on the ecology and biology of the adults are essential for the management of this valuable resource.

Description of the species

The following is a brief description of the important distinguishing characters of the different species of palinurids occurring in the Indian waters.

Panulirus homarus* (Linnaeus)

Synonyms
Locusta marina Rumphius
Locusta marina indica Rumphius
Cancer homarus Linnaeus
Astacus homarus Fabricius
Palinurus homarus Fabricius
Palinurus burgeri De Haan
Palinurus (Panulirus) dasypus Heller
Palinurus femoristiga De Man
Panulirus burgeri Bouvier

The antennular plate has four principal spines, the anterior pair being larger than the posterior. In between them there is a group of spinules. The median and lateral spines of the fused coxicerites of the antennae are small and placed almost in a line. One to three spinules may be present in between the median and lateral spines. The exopod of the second maxilliped is with or without a flagellum which if present may vary in its number of segments. The third maxilliped is without an exopod. The abdominal somites have an interrupted or uninterrupted transverse groove, the anterior margin of which is crenulated and with setae.

The colouration is generally bluish grey with numerous minute white dots. A row of six or seven large white spots are present on either side of the carapace. Each abdominal somite has a conspicuous white spot on either side and the walking legs have irregular yellowish-white spots.

Panulirus ornatus* (Fabricius)

Synonyms
Cancer (Astacus) homarus Herbst
Palinurus ornatus Fabricius
Palinurus sulcatus H. Milne Edwards
Panulirus sulcatus White
Panulirus ornatus Stimpson
Palinurus (Senex) brevipes Pfeffer
Palinurus (Senex) sulcatus Pfeffer
Palinurus homarus Pfeffer
Panulirus polyphagus Borradaile

Four principal spines, the anterior pair being larger than the posterior, are present on the antennular plate. Small spinules may be present in between the two pairs of spines. The median spine of the fused coxicerites of the antennae is larger than the lateral spine and the three spines are situated almost on the same line. There are no spinules. The second maxilliped has an exopod without a flagellum but with a tuft of setae, whereas the third maxilliped is without an exopod. Abdominal somites without a transverse groove.

Bluish green in colour, the carapace has pale cream verniculate lines and bright orange spots. Each abdominal somite has a dark blue transverse band with one or two cream coloured oblique spots on the sides. Walking legs alternately banded or marbled with cream and maroon.

Panulirus penicillatus* (Olivier)

Synonyms
Astacus penicillatus Olivier
Palinurus penicillatus Olivier
Panulirus penicillatus White

The antennular plate has four principal spines united at the base, the anterior pair being smaller than the posterior. Rest of the antennular plate is unarmed. The median spine of the fused coxicerites of the antennae is larger than the lateral spines and there are one or two spinules in between the median and lateral spines. The second maxilliped has an exopod with many jointed flagellum while the exopod of the third maxilliped is without a flagellum. The abdominal somites have an uninterrupted transverse groove, the anterior margin of which is non-crenulated and without setae.

Dark brownish green or brownish pink in colour with numerous orange yellow spots. The entire abdomen is speckled with minute white spots and on top of the 'plate D' a conspicuous white spot is present. There are pale yellow straight or wavy lines along the length of the walking legs.

Panulirus polyphagus* (Herbst)

Synonyms
Cancer (Astacus) polyphagus Herbst
Palinurus fasciatus Fabricius
Panulirus fasciatus Milne-Edwards
Panulirus polyphagus Nobili

The antennular plate with two principal spines situated far anteriorly and the rest of the plate is unarmed. The median spine of the fused coxicerites of the antennae is large and situated in front of the lateral spines. There are no spinules. The exopod of the second maxilliped has a many jointed flagellum, whereas the third maxilliped is without an exopod. The abdominal somites are without transverse groove.

Greenish grey or muddy brown in colour with numerous indistinct white spots. A row of six large white spots are present on either side of the carapace. There is a large oblique patch on either side of the first abdominal somite. The hind margin of each abdominal somite has a brown band with a white line in the middle. Yellowish white spots are present on the walking legs.

Panulirus versicolor* (Latreille)

Synonyms
Palinurus versicolor Latreille
Palinurus taeniatus Lamark
Palinurus fasciatus Von Siebold
Palinurus (Panulirus) ornatus var. *decoratus* Heller
Panulirus dasypus Ortmann
Panulirus demani Borradaile
Puer spiniger Bouvier
Puerulus spiniger Calman
Panulirus versicolor Calman
Panulirus versicolor Borradaile
Palinurus ornatus Rathbun
Panulirus ornatus Rathbun
Palinurus fasciatus Musgrave
Panulirus versicolor De Man

The antennular plate has four principal spines, the anterior pair equal to or larger than the posterior one. Rest of the antennular plate is unarmed. The median and lateral spines of the fused coxicerites of the antennae are large and subequal, the former being in advance of the latter. No spinules are present. The exopod of the second maxilliped has usually a single jointed flagellum. The third maxilliped is without an exopod. The abdominal somites have transverse furrows in the juveniles while these are absent in the adults.

In colouration they are usually bright green with a bluish tinge. The carapace has almost symmetrical dark bluish-black patches and flecks bordered by cream lines. Patches are present at the sides with cream coloured wavy lines inside. Hind margin of each abdominal somite has a dark bluish-black band with a white line in the middle. Walking legs have white lines along their entire length.

Panulirus longipes* (A. Milne Edwards)

Synonyms
Palinurus longipes A. Milne Edwards
Palinurus guttatus Hoffmann
Palinurus (Panilurus) longipes Miers
Palinurus longitarsus Lenz and Richters
Panulirus japonicus Gruve
Panulirus japonicus longipes De Man
Panulirus longipes George and Rao
Panulirus longipes longipes George and Holthuis

The species *longipes* occurring along the Indian coasts is considered to be a distinct sub-species and is called *P. longipes longipes*. The distinguishing characters are that the antennular plate has two principal spines in addition to three to five spinules in front and four to eight behind. The median spine of the fused coxicerites of the antennae is equal to or slightly larger than the lateral ones. There are three to four small spinnules in between the median and lateral spines. The second and the third maxillipeds have a distinct flagellum. The abdominal somites have an interrupted or uninterrupted transverse groove, the anterior margin of which is non-crenulate and with setae.

The colouration varies from dark brown to reddish brown with a violaceous tinge and there are numerous bright and dull white spots. A conspicuous white spot on top of the 'plate D'. A similar spot on either side in addition to a pair on the dorsal side of the abdominal somites II to VI. Walking legs have conspicuous white spots.

Puerulus sewelli Ramadan @

Synonyms
Panulirus angulatus Alcock
Puerulus angulatus Calman

The lateral margins of the carapace are cut into three teeth which decrease in length posteriorly. The posterior tooth is not far in advance of the cervical groove. The infra-orbital spine is large and has below and anterior to it a prominence which is half as long as the spine and cut into two teeth and behind this there are two other teeth. The abdominal somites are carinated, the carina of the sixth segment being double. The second to fifth somites are transversely grooved near the posterior edge. The antennular peduncle is more than half as long as carapace and the basal segment is longer than the second and third joints together. The antennal peduncle is spinose on its outer margin in adult specimens. The external maxillipeds reach the middle of the second segment of the antennular peduncle, its exopodite reaches the middle of the carpus.

* Descriptions of the six species of *Panulirus* have been taken from Nair *et al.* (1973).
@ Description from Ramadan (1938).

Palinustus mossambicus Barnard

Synonym
Palinustus mossambicus Barnard

Carapace prismatic, covered with tubercles which are fringed with stiff setae. The anterior margin of the carapace between the supraorbital processes is straight and provided with 4 to 6 spinules of different size and stronger median spines are absent. Each orbit is fringed by the supraocular process, three forwardly directed strong spines and by some small spinules. Cervical groove distinct and behind this groove a posteriorly converging double row of three or four small spinules are present in the median region of the carapace. The first abdominal segment has an uninterrupted transverse groove which has a row of setae along the anterior margin. The second to fifth abdominal segments are provided with uninterrupted anterior transverse groove and a posterior groove which is interrupted in the middle by a short longitudinal carina. Antennular segments with four spines in the median part anteriorly tapering and the antennal peduncles have about five longitudinal rows of strong spines. All the three maxillipeds have an exopod with a flagellum in the first and second maxillipeds.

LITERATURE CITED

BERRY, P. F. 1971. The spiny lobster (Palinuridae) of the east coast of Southern Africa. Distribution and ecological notes. *Oceanogr. Res. Inst. Invest. Rep.*, **27**: 1-23.

CHOPRA, B. N. 1939. Some food prawns and crabs of India and their fisheries. *J. Bombay nat. Hist. Soc.*, **41**: 221-234.

DE BRUIN, G.P.H. 1960. Lobster fishing in Ceylon. *Fish. Res. Stat. Dept. Fish. Ceylon*, Bull. No. **9**: 1-18.

DE BRUIN, G.P.H. 1962. Spiny lobsters of Ceylon. *Ibid.*, Bull. **No. 14: 1-28.**

DESHMUKH, S. K. 1968. On the first phyllosomae of the Bombay spiny lobsters *(Panulirus)* with a note on the unidentified first *Panulirus* phyllosomae from India (Palinuridae). *Crustaceana* Suppl., **2**: 47-58.

GEORGE, M. J. 1968. The lobster fishery resources of India. *Proc. Symp. Living Resources of Seas around India, ICAR, CMFRI*, 7-10 *December*, 1968: 570-580.

GURNEY, R. 1942. *Larvae of Decapod Crustacea.* Ray Society Monographs, London: 1-306.

HOLTHUIS, L. B. 1946. The decapoda macrura of the *Snellius* Expedition. I. The Stenopodidae, Nephropridae, Scyllaridae and Palinuridae. *Biol. Res., Snellius Expdn. XIV. Temminckia*, **7**: 1-178.

JOHNSON, M. W. AND E. BRINTON 1963. Biological species, water masses, and currents, In "The Sea: Ideas and Observations on Progress in the Study of the Seas" (M.N. Hill, ed.) **2**: 381-414. Wiley (Interscience), New York.

KANCIRUK, P. 1980. Ecology of juvenile and adult Palinuridae (spiny lobsters). In "The biology and Management of Lobsters", **2**: Ecology and Management, Chapter 2, 59-96. Academic Press. Inc., New York.

MOHAMED, K.H. AND M. J. GEORGE 1967. Results of tagging experiments on the Indian spiny lobster *Panulirus homarus* (Linn.) – movement and growth. Australian/New Zealand Meeting on Decapod Crustacea, C.S.I.R.O., Australia, 24–28 October, 1967, ANZDC, 67/2/19 : 1-10.

MURANO, R. 1957. Plankton as indicators of water masses and ocean currents. *Oceanogr. Mag.*, **9**: 53-63.

NAIR, R. V., R. SOUNDARARAJAN AND K. DORAIRAJ 1973. On the occurrence of *Panulirus longipes longipes, Panulirus penicillatus* and *Panulirus polyphagus* in the Gulf of Mannar with notes on the lobster fishery around Mandapam. *Indian J. Fish.*, **20**: 333-350.

PHILLIPS, B. F. 1981. The circulation of the southeastern Indian Ocean and the planktonic life of the western rock lobster. *Oceanogr. Mar. Biol., Ann. Rev.*, **19**: 11-39.

PHILLIPS, B. F. AND A. N. SASTRY 1980. Larval Ecology. In "The biology and management of lobsters", **2**: Ecology and Management, Chapter I, 11-57. Academic Press. Inc., New York.

PRASAD, R. R., P. R. S.TAMPI AND M. J GEORGE 1975. Phyllosoma larvae from the Indian Ocean collected by the DANA Expedition 1928–1930. *J. mar. biol. Ass. India*, **17**: 56-107.

PREM KUMAR, V. K. AND A. DANIEL 1975. Dstribution pattern of the economically important spiny lobsers of the Genus *Panulirus* White, in the Indian Ocean. *Ibid.*, **17**: 36-40.

RAMADAN, M. 1938. The Astacura and Palinura. *John Murray Exped.*, 1933–34, *Sci. Repts.*, **5**: 123-145.

RITZ, D. A. 1972. Factors affecting the distribution of rock lobster larvae *(Panulirus longipes cygnus)*, with reference to variability of plankton net catches. *Mar. Biol.*, **13**: 309-317.

SIMS, H. W., JR. 1965. Notes on the occurrence of prenauplisoma larvae of spiny lobsters in the plankton. *Bull. Mar Sci., Gulf and Carib.*, **15**: 223-227.

TAMPI, P.R.S. 1973. The phyllosoma larvae of the Indian Ocean. *J. mar. biol. Ass. India*, **15**: 560-565.

TAMPI, P.R.S. AND M. J. GEORGE 1975. Phyllosoma larvae in the IIOE (1960–65) collections –systematics. *Mahasagar - Bull. natn. Inst. Oceanogr.* **8**: 15-44.