



CHAPTER 33

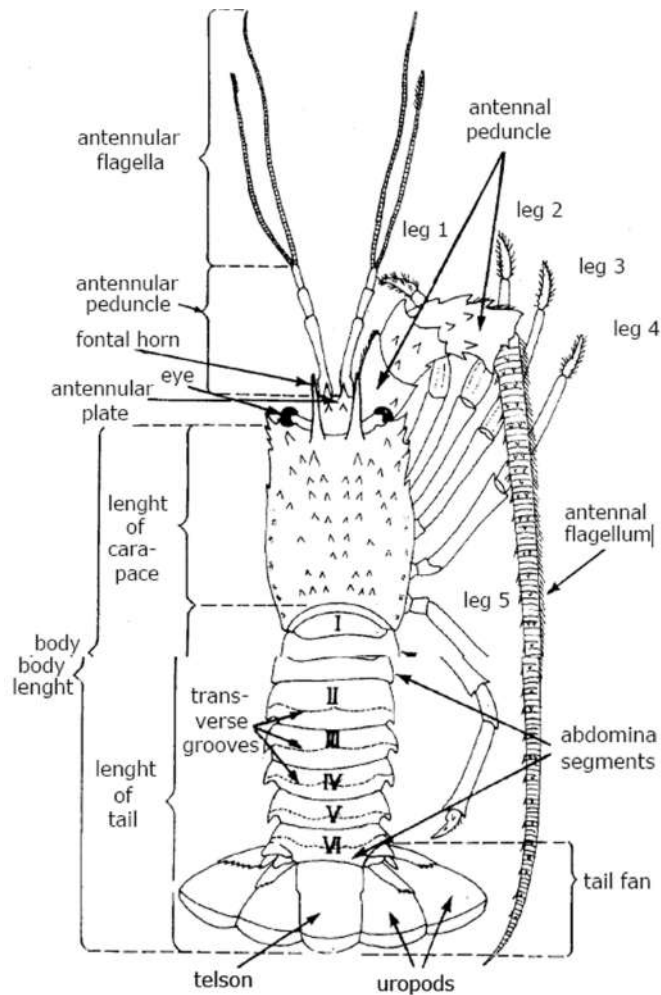
Deep Sea Crustacean Taxonomy

Taxonomy is the practice and science of classifying organisms. Taxonomy uses taxonomic units known as taxa. Conventional classic taxonomy mainly classifies the organism based on their morphological features whereas integrative taxonomy is based on the molecular techniques such as gene sequencing and DNA barcoding with classical morphological features.

The term ‘Systematics’ is often used in taxonomy. The systematic zoology is the science that discovers names, determines relationships, classifies and studies the evolution of living organisms. It is an important branch in biology and is considered to be one of the major subdivisions of biology having a broader base than genetics, biochemistry and physiology. Shellfish systematics is the most unique one in fisheries science in view of its importance and implications in diversity. The shellfish includes two highly diversified phyla i.e. phylum Arthropoda and phylum Mollusca. These two groups are named as shellfishes because of the presence of exoskeleton made of chitin in arthropods and shells made of calcium in molluscs. These two major phyla are invertebrates. They show enormous diversity in their morphology, in the habitats they occupy and in their biology. Phylum Arthropoda includes economically important groups such as lobsters, shrimps, and crabs. Taxonomical study reveals numerous interesting phenomena in shellfish phylogeny and the study is most indispensable for the correct identification of candidate species for conservation and management of our fishery resources and aquaculture practices. On the whole taxonomic study on shellfishes furnishes the urgently needed information about species and it cultivates a way of thinking and approach for all biological problems, which are much needed for the balance and well-being of shellfish biology as a whole.

Lobster Resources

Lobsters are among the most prized of fisheries resources and of significant commercial interest in many countries. Because of their high value and esteemed culinary worth, much attention has been paid to lobsters in biological, fisheries, and systematic literature. They have a great demand in the domestic market as a delicacy and is a foreign exchange earner for the country.



general shape (dorsal view) of a spiny lobster
(*Panulirus* sp. Xno rostrum, no pincers)

Key to species of *Panulirus* recorded off the Indian coast and the island groups, Andaman Nicobar Island and the Lakshadweep Islands

1. Margin of transverse abdominal grooves with squamae varying from well-developed and even in size to minute and irregular in size. Overall colour ranges from brownish-red in specimens with large squamae to olive green in specimens with minute squamae*P.homarus*
2. Antennular plate (between the stridulating organs) with 2pairs (4) of subequal principle spines, fused at their bases. Supraorbital horns rounded in cross section. Overall colour olive-black.....*P.pencilatus*
3. Antennular plate with 1 pair (2) of equal principle spines; supraorbital horns flattened bilaterally. Overall colour purplish-red with abdomen covered with conspicuous white spots.....*P.longipes*
4. Antennular plate with 1 pair of equal spines; white bands on each abdominal segment. Legs with white spots. Colour Olive green.....*P.polyphagus*

5. Conspicuous transverse white band posteriorly on each abdominal segment. Legs with longitudinal white stripes, juveniles have white antennae. Overall colour black and green.....*P.versicolor*
6. No transverse white band on abdominal segments but above each pleural spur is a conspicuous white spots. Legs with irregular transverse mottling, no longitudinal stripes. Overall colour bluish green.....*P.ornatus*

***Panulirus homarus homarus* (Linnaeus, 1758)**

Biology: Maximum total length 31cm, carapace length 12cm. Average total length 20 to 25cm Major fisheries are on the southeast and southwest coast of India. The commercial fishery at Muttom, Kanyakumari district was found to be largely supported by 1st and 2nd year animals. At a given carapace length females are heavier than males. Females attain functional maturity at a carapace length (CL) of 55mm. Males attain maturity at 63mm CL on the basis of allometric growth of III walking leg. Peak breeding season is from November to December.

Genus *Puerulus* Ortmann, 1897

Key to species (after Berry, 1969)

1. Two teeth between frontal horns and the cervical groove
 - 1a. Median keel of carapace with 5 post-cervical and 2 or 3 intestinal teeth. Fifth pereopod of male not chelate..... *P.sewelli*

Biology: Maximum total body length 20cm, maximum carapace length about 8cm. Average total length about 15 cm. The species was commercially exploited along the southwest and southeast coast of India. A catch rate of 200-300kg/hr was reported from vessels opening off Mandapam. January to April is the peak period of abundance. During 1998-2000, 524t were landed at Sakthikulangara, Kollam, and Kerala. The sizes of *P.sewelli* ranged from 76-80mm to 176-180 TL in Males and from 81-85mm to 176-180mm in females. 26% of females were found in mature/berried stage. Due to coincidence of peak breeding and the fishery, the breeding population has been heavily exploited. The species has been overexploited and the current landing is around 2 tonnes/annum from Quilon Bank.

Family: Scyllaridae Latreille, 1825

Key to Identification of the family

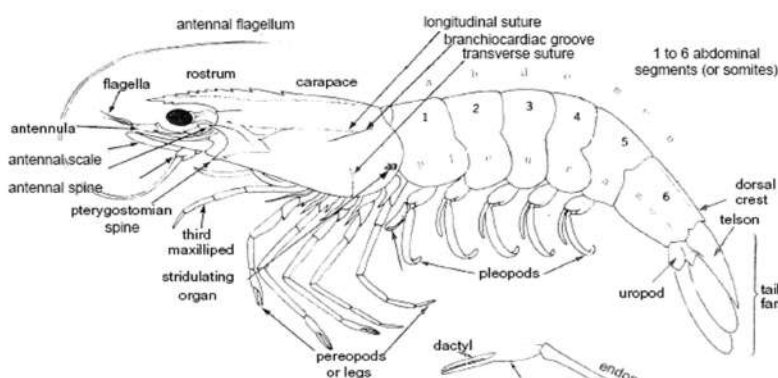
Antennal flagellum reduced to a single, flat plate which forms the sixth and final segment of the antenna. The shovel-like appearance of the antennae is responsible for the name shovel-nosed lobster

***Thenus unimaculatus* Burton & Davie, 2007**

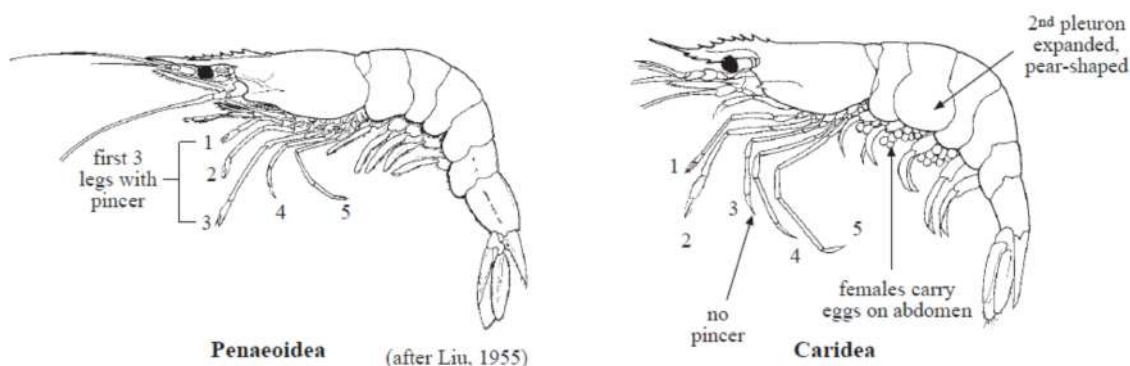
Biology: Maximum total body length about 25cm; often appears as bycatch in trawl; also caught in gillnets. At Kollam, Kerala peak fishery was observed from November to February. Total length varied between 61-230 mm in males and 46-250mm in females. Length at recruitment (Lr) was 48mm. Absolute fecundity varied from 14750 to 33250 mature eggs (Radhakrishnan *et al.*, 2013).

Shrimp Resources

Shrimp resources are available both from inshore and from offshore waters. As the fish resource from inshore waters remained static during the last two decades, fishing pattern underwent several changes in the previous decade, leading to the exploitation of deep sea resources either with deployment of large sized vessels or modified medium/small sized vessels. Deepwater shrimps appear to have a world-wide distribution in tropical waters. They have been caught in surveys using baited traps in depths between 200 m and 800 m off continents and at 200- 500 m depth in the Indian Ocean.



Deep sea decapod crustaceans constitute one of the dominant high price groups of invertebrates in the marine fishery sector of Kerala although the structure and organization of their community are not well known as that of coastal penaeid prawns. In view of the increasingly prominent role played by deep sea prawns and prawn products in the economy of the country, the taxonomic identity of various species exploited from the deep sea fishing grounds off Kerala is an essential prerequisite for the sustainable development and management of deep sea prawn wealth of Kerala. The deep sea prawns landed at various harbours of Kerala is an assemblage of wide array of species representing various families, the prominent being *Pandalidae*, *Aristeidae*, *Solenoceridae* and *Penaeidae* while family *Oplophoridae* contributes to only a minor portion of the deep sea trawl catches in Kerala.



Penaeid shrimps

Aristeus alcocki Ramadan 1938

Diagnostic characters: Large size red abdominal rings. Rostrum in female long and slender upper margin curved downwards till distal end of 2nd segment of antennular peduncle. Rostrum in males much shorter and seldom surpassing tip of antennular peduncle, armed with three teeth above orbit; **and no teeth on ventral side, lacks hepatic spine, upper antennular flagellum very short, Eyestalk with a tubercle.** Petasma simple, membranous, right and left halves united with each other along the whole length of dorsomedian with a papilla-like projection directed posteromedially. Thelycum represented by a shield shaped plate directed anteroventrally bordered by an oblique ridge on either side.

Colour: Pink with reddish bands on the posterior border of all abdominal segments.

Fishery & Biology: The catches were mainly composed of females and their size ranged from 78 mm to 188 mm in total length. The size distribution showed unimodal pattern with majority in size groups 146-165 mm. The males, which were very poorly represented in the catches were relatively smaller in size and their total length varied from 67 mm to 110 mm.

Distribution: Indian Ocean; Arabian Sea and Bay of Bengal, at depth of 350-450 m off Quillon and Alleppey.

Solenocera hextii Wood-Mason & Alcock, 1891

Family : Solenoceridae

Diagnostic characters: Flatnened rostrum with 7 teeth on dorsal side and no teeth on ventral side of the rostrum. Postrostral carina sharp but not laminose. Antennular flagella with red and white bands. The spines on the cervical groove situated ventral to the posteriormost rostral tooth which is well developed. The characteristic 'L' shaped groove on either side of the branchiostegal region is also clearly defined.

Colour: Pink to red

Distribution: Found all along the east and west coast of India at depths between 250 to 547 m.

Metapenaeopsis andamanensis (Wood-Mason, 1891)

Family: *Penaeidae*

Diagnostic characters: Rostrum more or less horizontal and straight with 6 to 7 teeth on dorsal side and no teeth on the ventral side. Lower antennular flagellum longer than the upper, much longer than the entire antennular peduncle but 0.7 times the carapace length. 3rd pereopod surpass the rostrum by the length of the entire chela. Assymetrical petasma. 3rd maxilliped and 1st pereopod with a basal spine, distal fixed pair of spines on telson.

Colour: Pale pink to red

Fishery & Biology: The total length of males varied from 67 mm to 115 mm and that of females from 68 mm to 130 mm.

Distribution: A penaeid prawn commonly encountered in the trawl catches at all depths ranges upto 400 m and was obtained from all areas.

Penaeopsis jeryii Perez Farfante, 1979

Family: *Penaeidae*

Diagnostic characters: Dagger shaped rostrum with teeth on dorsal side of the rostrum. Specimen appears to be pale red in color with white bands on the body. Cervical groove very prominent, antennal scale as long as rostrum. Thelycum trilobed and sub elliptical in structure.

Fishery & Biology: Size range of female specimens ranged from 74-115 mm and males ranged from 70-110 mm.

Distribution: All along the southwest coast of India particularly off Cochin, Quillon and Alleppey at depth of 275-350 m

Caridean / Non-Penaeid shrimps

Heterocarpus woodmasoni Alcock, 1901

Family : *Pandalidae*

Diagnostic characters: Carapace with 2 longitudinal crests on each side, extending over full length of carapace – post antennal crest and branchiostegal crest. A conspicuous elevated, sharp tooth at middle of dorsal crest of 3rd abdominal segment, telson bears 5 pairs of dorsolateral spinules besides those at the tip.

Fishery & biology: Size in the catches ranged from 72 to 135 mm in total length but dominated by 111-120 mm size groups in both the sexes. The fertilized eggs on the pleopods and the head-roe are light orange and this colour stands out in contrast with the pink colour of the prawn. The berry becomes greyish in advanced stages of development.

Distribution: Andamans, Southwest of India off Cochin and Alleppey at depths of 250-400 m

Heterocarpus chani Li, 2006

Diagnostic characters: The teeth on the dorsal crest and the rostrum together vary from 8 to 10. Teeth on the rostrum proper varying from 2 to 4 and 13-15 on ventral side. The dactyli of the 3 posterior legs short, median carination of the 3rd abdominal tergum is quite prominent. Carapace with 2 longitudinal crests on each side, extending over full length of carapace- post-ocular crest and branchiostegal crest. Post antennal crest very short.

Fishery & biology: The size of the individual prawn varied from 67 to 140 mm in total length and the catches were represented by all groups of the females. Males are mostly in 90-100 mm size groups. The colour of the berry is light **orange** and turns dirty grey as embryo develops.

Distribution: Southeast and Southwest coast off Cochin, off Alleppey at depths of 250-400 m. immature specimens were found in greater numbers in shallow waters while the bigger prawns seemed to prefer deeper grounds beyond 350 m.

Plesionika quasigrandis (Bate, 1888)

Pandalidae

Diagnostic characters: Rostrum upturned at the tip. Rostrum is armed with 46 teeth on the dorsal side and 31 teeth on the ventral side., very long slender legs, Telson is double the length of the 5th abdominal somite. Lower antennular flagellum longer than the upper and about 5.4 times the carapace length. 3rd maxilliped extends beyond the antennal scale by the length of its dactylus. Second pereopod exceeds the tip of antennal scale by its chela and 1/8 length of carpus. Minute tubercle on the dorsal surface of the carapace at about 1/6th of its length from the hinder edge which corresponds in position to the small blunt median spine which is present in all the specimens.

Colour: Body pale red in colour

Fishery & biology: The size of this prawn in the catches ranged from 63 to 125 mm but the size groups 95-110 mm in both sexes predominated. Berry is greenish-blue in colour with ovoid shape of fertilized eggs.

Distribution: In Indian waters this species is known to occur in south-east and south-west coast of India abundantly noticed from Quilon and Mangalore regions from the depth of 250-400 m.

***Plesionika semilaevis* Spence Bate, 1888**

Diagnostic characters: Rostrum very long pointed with 7-9 dorsal teeth including 2-5 teeth on carapace posterior to the level of orbital margin while ventral margin of the rostrum is armed with 34-56 teeth.

Fishery & biology: The size of this prawn in the catches ranged from 71 to 120 mm in males and 80 to 130 mm in females. The modal lengths for males and females were at 90-95 mm and 96-100 mm respectively. Berry is deep blue in colour in the early stages and to light grey in advances stages of development.

Distribution: In Indian waters this species is known to occur along the south-west coast particularly throughout the Kerala coast abundantly noticed from Quilon and Alleppey regions from the depth of 200-450 m.

Family : Ophlophoridae

***Ophlophorus gracilirostris* Alcock, 1901**

Diagnostic characters: Carapace with dorsal carina extending to the posterior margin. Rostrum very long almost equal in length to the carapace. Branchiostegal spine quite distinct, with a well-defined keel, spine on the 3rd abdominal tergum very much longer than those on the 4th and 5th. In the male the anterior border of the first abdominal somite is bilobed with the posterior lobe more pronounced and angular.

Distribution: Arabian Sea, Bay of Bengal, Andaman Sea and Hawaii Islands, Southwest of Cochin, off Alleppey 300-450 m

***Acanthephyra fimbriate* Alcock & Anderson, 1894**

Diagnostic Characters: The carapace is without a straight ridge or carina running on the entire length of the lateral surface i.e., from the hind margin of the orbit to the posterior edge of the carapace. Rostrum long, upcurved with 5 to 6 teeth on the dorsal side and only one tooth on the ventral side of rostrum. Dorsal carina of 3rd to 6th abdominal somites ending in pointed spines. Sometimes the posterior spine on the sixth somite may be absent. Telson generally more or less truncated at the tip and laterally it is armed with spines. Eyes are well pigmented. Incisor process of the mandible is provided with teeth throughout the entire length of its cutting edge. Pereopods are not abnormally broad and flattened. Exopods of the third maxilliped and all pereopods are neither foliaceous nor rigid.

Distribution: Southeast and Southwest coast of India

***Acanthephyra sanguinea* Wood-Mason, 1892**

Diagnostic Characters: Rostrum longer than carapace with 7 dorsal and 5 ventral teeth, extending much beyond the tip of the antennal scale. Branchiostegal spine small, forming a small projection on frontal border of carapace and without a carina. Surface of carapace finely pitted as in all the species of the purpurea group. Dorsal carinae of 3rd to 6th abdominal somites ending in pointed spines, that of 3rd somite the longest and of 4th and 5th of equal size and smallest. Four pairs of dorsolateral spines present on the telson.

Distribution: Southeast and Southwest coast of India

INTEGRATIVE TAXONOMY- A NOVEL APPROACH TO BIOLOGICAL STUDIES

A multisource approach that takes advantage of complementarity among disciplines, i.e., fields of study, has been called combined, multidisciplinary, multidimensional, collaborative, or integrative taxonomy mainly focusing on the species level. Integrative taxonomy does not replace traditional taxonomy. Rather, it compresses the traditional but slow taxonomic routine of visiting a taxonomic problem repeatedly into one procedure by coordinating the findings of different disciplines under the procedure. By doing so, integrative taxonomy improves rigor, more confidence in taxonomic information and consequently provides taxonomic stability.

DNA barcoding, a new method for the quick identification of any species based on extracting a DNA sequence from a tiny tissue sample of any organism, is now being applied to taxa across the tree of life. As a research tool for taxonomists, DNA barcoding assists in identification by expanding the ability to diagnose species by including all life history stages of an organism. As a biodiversity discovery tool, DNA barcoding helps to flag species that are potentially new to science. As a biological tool, DNA barcoding is being used to address fundamental ecological and evolutionary questions, such as how species in plant communities are assembled. The process of DNA barcoding entails two basic steps: (1) building the DNA barcode library of known species and (2) matching the barcode sequence of the unknown sample against the barcode library for identification. Although DNA barcoding as a methodology has been in use for less than a decade, it has grown exponentially in terms of the number of sequences generated as barcodes as well as its applications. Detailed species and larval level identification forms the pre-requisite for the proper conservation and management of the declining deep water shrimp resource of the country. DNA barcoding has been successfully used for species identification and discovery of new species, utilizing 650 base pair fragment of the mitochondrial gene, cytochrome oxidase subunit I (COI). COI was effectively used for the discrimination of closely related species and detection of cryptic species as well as for the identification of fish products. Mitochondrial DNA (Mt-DNA) sequence information has been used as an accurate and automated species identification tool for carrying out studies in a wide range of animal taxa, due to the presence of a significant amount of information.

Materials and methods

2.1. Sample collection

- (a) Proper disposable or easily sterilized tools. (b) Proper individual storage containers for the organisms and tissues. (c) Data collection tools to handle specimens, tissues.
- (d) Photo documentation materials (digital camera with appropriate lens(es), memory cards, backup hard drives).

2.2. Storage buffers

- (a) Dry ice and cooler. (b) Salt solution. (c) EtOH—95% (nondenatured). (d) Formalin or other voucher specimen preservation solution(s)

2.3. Extraction components

- (a) Lysis buffer for extraction method. (b) Proper plates, tubes or storage vessels. (c) When possible, on-site portable DNA extractor.

2.4. PCR components

- (a) PCR reaction ingredients and primers. (b) Positive control 16S or 18S and COI

2.5. Sequencing, data QC, and analysis.

Data analysis

Molecular sequences were checked and confirmed using ABI SeqEditor v.1.0. Protein coding gene sequences (COI and Cytb) were translated into amino acids using Transeq (EMBOSS online tool) to avoid the inclusion of pseudogenes. All the sequences were blasted to report GenBank data to verify the potential contamination and the nucleotide sequences were aligned using the Clustal W algorithm. The aligned data was edited using bioedit V.7.0.5.2, gaps of sequences treated as missing data. All the sequences were submitted to GenBank. The pairwise genetic distance was calculated using MEGA 6.0.

Morphological analysis

In case of deep sea penaeoid shrimps ancestral state reconstruction (ASR) was used to evaluate character evolutions. Fifty-two morphological characters (24 binary, 27 multistate and one non-informative) were chosen and considered for phylogenetic analyses based on the original taxonomic works of Ramadan (1938), Crosnier (1978; 1985), Pérez-Farfante (1997) and Dall (1999). All these major characters were re-examined carefully. The data matrix was analyzed with maximum parsimony using combinations of programs: Mesquite v.3.01 (Maddison and Maddison 2015) and PAUP v.4.0 (Swofford 2002). These characters were given equal weightage and unordered, the code given for each state (i.e., 0, 1, 2, 3, and 4). Branch support was assessed using 1000 bootstrap replicates without any outgroups. Results acquired from both morphological and molecular tools was combinely assessed before deriving to any conclusion of a particular species, which is nothing but integrative taxonomy.

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