Studies on taxonomy and ecology of Mysidacea from the EEZ of India

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IN MARINE SCIENCE
UNDER THE FACULTY OF MARINE SCIENCES

by

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Declaration

I here by declare that the thesis entitled **"Studies on taxonomy and ecology of Mysidacea from the EEZ of India"** submitted by me is an authentic record of research carried out by me, under the supervision of Dr. Saramma.U. Panampunnayil, Scientist, National Institute of Oceanography, Regional Centre, Cochin -18, in partial fulfillment of the requirement for the Ph. D degree of the Cochin University of Science and Technology in Marine Science and that no part of this thesis has been presented before for any other degree, diploma, or associateship in any university.

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Certificate

I here by certify that the thesis entitled "**Studies on taxonomy and ecology of Mysidacea from the EEZ of India**" submitted by Biu.A, Research Scholar (Reg.No.2734), National Institute of Oceanography, Regional Centre, Cochin-18, is an authentic record of research carried out by him, under my supervision in partial fulfillment of the requirement for the Ph. D degree of Cochin University of Science and Technology in Marine Science and that no part of this thesis has previously formed the basis for the award of any degree, diploma, or associate ship in any university.

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Acronyms and Abbreviations

ANOVA	Analysis of Variance
Chl	Chlorophyll
CMLRE	Centre for Marine Living Resources and Ecology
CTD	Conductivity-Temperature-Depth
DO	Dissolved oxygen
DOD	Department of Ocean development
E	East
ED	Female with eyed larvae
EEZ	Exclusive Economic Zone
EG	Female with egg
EL	Female with eyeless larvae
et al.	et alii (latin word meaning 'and others')
Fig.	Figure
FIM	Fall intermonsoon
FORV	Fishery Oceanographic Research Vessel
ICMAM	Integrated Coastal and Marine Area Management
IF	Immature male
IIOE	International Indian Ocean Expedition
IM	Immature female
IOBC	Indian Ocean Biological Centre
J	Juvenile
JGOFS	Joint Global Ocean Flux Studies
MLD	Mixed Layer Depth
mm	Millimeter
MM	Mature male
MR-LR	Marine Research - Living Resource
mya	Million years ago
N	North
NIO	National Institute of Oceanography
PCR	Polymerase Chain Reaction
psu	Practical Salinity Unit
SIM	Spring intermonsoon
SF	Spent female
SST	Sea surface temperature
SUM	Summer monsoon
TE	Tris.EDTA
TEN	Tris.EDTA.NaCl
UNCLOS	United Nations Conference on the Law of the Sea
UNESCO	United Nations Education, Scientific and Cultural Organization
WIM	Winter monsoon

Contents

Chapter 1. Introduction

1.1. General biology	1
1.2. Evolution of Mysidaeca	2
1.3. Mysids in the marine economy	2
1.4. General morphology	7
1.5. Classification	12
1.6. Historical resume	15
1.7. Review of literature on Indian Mysidacea	17
1.8. Scope and purpose of study	19

Chapter 2. Materials and Methods

2.1. Study area (Indian EEZ and adjoining area)	21
2.1.1. Indian EEZ	
2.1.2. Shallow coastal waters of northwest coast of India	
2.1.3. Cochin backwaters	
2.2. Sampling methodology	23
2.2.1. Physico- chemical parameters	
2.2.2. Zooplankton collection	
2.3. Analytical methods	30
2.4. DNA barcoding	33
2.5. Biochemical analysis	34
2.6. Statistical analysis	35

Chapter 3. Systematic account on Mysidacea

3.1. Introduction	37
3.2. Results	38
3.3. Discussion	107

Chapter 4. Ecology and zoogeography of mysids

4.1. Introduction	122
4.2. Results	123
4.2.1. Quantitative abundance	
4.2.2. Ecology and distribution	
4.3. Discussion	140

Chapter 5. Mysids from the northwest coast of India

5.1. Introduction	152
5.2. Study area	153
5.3. Results	163
5.4. Discussion	191

Chapter 6. Mysidacea of the Cochin backwaters
6.1. Introduction 196
6.2. Study area 198
6.2.1. Season design
6.3. Results 200
6.3.1. Physico-chemical parameters
6.3.2.Taxonomy, ecology and biology
6.3.3. Diel and tidal variations of mysids
6.3.4. Statistical analysis
6.4. Discussion 243

Chapter 7. DNA Barcoding and Biochemistry of mysids
7.1. DNA barcoding 255
7.1.1. Introduction
7.1.2. Results
7.1.3. Discussion
7.2. Biochemical composition 262
7.2.1. Introduction
7.2.2. Results
7.2.3. Statistical analysis
7.2.4. Discussion

Summary and Conclusion 273
References 279
Publications

Chapter 1

Introduction

1.1. GENERAL BIOLOGY

Members of the order Mysidacea are shrimp like crustaceans, commonly called "opossum shrimp", which refers to the presence of a brood pouch or marsupium in mature female. They inhabit all regions of the oceans to depths as great as 7210 m (Belyaev, 1966). Mysids are highly adaptive group and therefore also good invaders of new areas (Ketelaars *et al.*, 1999). There are many brackish water species and a few species occur in fresh water, some have become adapted to the specialized environments of caves and wells while yet others live symbiotically associated with animals such as sea anemones, sponges and hermit crabs (Clarke, 1955; O.S.Tattersall, 1962, 1967; Bowman, 1973; Vannini *et al.*, 1993; Price and Head, 2004). Some species burrow into the sediment, live just above it or migrate between bottom and surface waters, a few are strictly pelagic species and some live in shallow water in the littoral zone (Mauchline, 1980). Though mysids occur widely throughout the marine environment, the most marked concentration occur in coastal regions. Coastal and epipelagic forms are small, but deeper species are large in size (Mauchline, 1980; Brusca and Brusca, 2003).

Colour: Mysids in their natural surroundings exhibit a general tone of colour which is in harmonize with their environment. The colour changes are brought about by the expansion and contraction of large chromatophores distributed all over the body. Animals on a sandy shore will be almost transparent or greyish in tint while those living among weeds will be dark green or brown and the deep water forms will be deep red in colour. (Tattersall and Tattersall, 1951; Mauchline, 1980).

Breeding season: Some species breed throughout the year, some produce three or more generations per year, some produce two and some only one generation per year. The number of embryos carried in the pouch varies according to the species and is also affected by the size of the female, the time of the year and the temperature.

Fertilization and development: Fertilization is external. The male sheds the sperm directly into the brood pouch or near to its proximity and is carried to the marsupium by currents. The eggs are shed into the brood pouch where fertilization takes place. The larval development takes place entirely within the marsupium. The development within the marsupium can be divided into three stages as eggs, eyeless larvae and eyed larvae (Mauchline, 1971). All the larvae within a single marsupium are at the same stage of development. They are regularly oriented, their heads pointing posteriorly and closely packed together. The duration of marsupial development is related to ambient temperature and salinity and varies with species and ranges from 96 hrs at 25 - 29°C (Nair, 1939) to 150 - 270 days at 0.2 -10°C (Berril, 1971; Lasenby and Langford, 1972). In general in colder temperature the length of incubation period is greater than under warmer conditions.

Growth and life span: Increase in body size is associated with moulting and in many species growth continues after sexual maturity has attained and many characters may change and hence identification of the species under Mysidacea is rather difficult. The growth is accompanied by considerable changes in the proportions and armature of the body and appendages, so that smaller individuals differ considerably from larger ones. This disconcerting phenomenon has led to much confusion among the taxonomists in the past because a few specimens at their disposal have frequently led to creation of new species, which have subsequently proved to be different growth stages of species already described. The actual size of the animals is unfortunately not a reliable guide because those living in warmer waters mature more rapidly and undergoes the various growth stages at a much smaller size than those inhabiting in colder regions. The longevity of individuals also vary; in temperate waters length of life span is one year to eighteen months, in colder waters it will be about two years and in warmer waters mysids are mostly annuals.

Food and feeding: Mysids are omnivorous and capable of utilizing a wide variety of food source depending on availability. They are adapted to two types of feeding. Most coastal species utilize organic detritus and small planktonic organisms by filter feeding mechanism. Another method is to seize food masses by the thoracic endopods and consume as the animal swims away. Other than detritus, the food of mysids consists of small burrowing amphipods, cladocerans, cyclopoid copepods and diatoms.

Vertical migration: Mysids are primarily benthic in habit moving about during daytime just above the bottom, feeding on detritus. Many species perform a diel vertical migration, rising to the surface layers during night and returning to the deeper layers at daylight. Mysids generally avoid bright illumination; therefore light intensity appears to be the major factor controlling the vertical migration. Seasonal changes in the vertical migration have been found, to avoid seasonal extremes of temperature and salinity in littoral zone and brackish water environment.

Behaviour

(a) Aggregation: Many mysids show well marked aggregative behavior and aggregation within different population of mysids can be very different in origin, form and behavior. Various physiological and environmental factors

influence the formation and maintenance of mysid aggregation and based on the sociality and intrinsic biological processes, aggregation is classified under different terms like swarms, shoals or schools. (Mauchline, 1971; Wittmann, 1977). The process of aggregation aids in maintaining increased reproductive and feeding efficiency, sociality and protection from predators etc., (Emery, 1968; Clutter, 1969; Wittmann, 1977; O. 'Brien, 1988)

(b) Kin recognition and Adoption: Wittmann (1978) observed that ovigerous females capture and introduce prematurely liberated larvae of other females into their marsupia. Ovigerous females are capable of distinguishing intra and interspecific difference among larvae. In some species of mysid (*Tenagomysis tasmaniae*), females are capable of recognizing their own young (Johnston and Ritz, 2005).

(c) *Homing behavior*: Mysid swarms at benthic coral reef sites are found to disperse into the water column in the evening and reform at the exact same location the following morning, probably reflecting the homing behavior of individual mysids (Twining *et al.*, 2000). The ecological significance of homing is not known.

Parasites: A wide range of parasites has been reported in mysids, the most frequently described being the ellobiopsid protozoans, the choniostomatid copepods and the epicaridean isopods. All these are external parasites found on various parts of the surface of the body and appendages of the host and on the inner surface of the marsupial pouch. Many of these are probably only epizoic, merely using the mysid as a substratum for attachment. Others do penetrate the tissue of the host for nutritional purposes and so influence its growth and development. These parasites infest mysids belonging to specific species of a number of genera, but why they occur in one species of a genus and not all is unknown.

1.2. EVOLUTION OF MYSIDACEA

Fossil mysids have been dated as far back as the Triassic period, about 248 - 213 million years ago. A group of fossil crustaceans known as Pygocephalomorha, which includes a number of Paleozoic genera from that carboniferous and Permian periods (360 - 248 mya), is possibly related to the mysids.

1.3. MYSIDS IN THE MARINE ECONOMY.

As food for man: The biomass of littoral and sub littoral mysids are often large and the standing stock attain the order of 20-200 g/m^2 (Mauchline, 1980). Such swarms are exploited commercially, especially in the tropical and subtropical regions and the species harvested are often not known. Omori (1978) states that several species of mixed groups of mysids are fished in local region of China, Korea and south eastern Asian countries but no descriptions of these fisheries are available. The mysids are used to make shrimp paste and sauces. Some thousand of tonnes of *Neomysis* sp. are harvested in Japan each year. They are boiled, dried and marketed as preserved cooked food known as "*tsukundani*" (Mauchline, 1980). *Praunus flexuosus* is collected in the Channel Islands and made into a paste called "*cherve*" to use as bait for catching mullet. In Korea mysids are used to improve "*Kimchis*" flavor, a Korean side dish. In West Ireland, boiled mysids are used with toast. In Calcutta markets, *Mesopodopsis orientalis* mixed with the decapod *Acetes* are sold as "*Kada chingri*" (Mauchline, 1980). In the Chilka lake region the mysids are mixed with turmeric and boiled and eaten with rice. In Maharashtra, mysids locally called "*Kolim*" are exploited commercially on a small scale by the fishermen of Satpati and Alewadi villages in Thane district of the North Konkan coast (Patil and Sankolli, 1991).

As food for fishes: As food of fishes, mysids play a very important part in the economy of the sea. Most coastal species utilize organic detritus and are prey to the demersal fish and thus mysids are involved in a short food chain.

Organic detritus → Mysids → Fish

The records of mysids from the stomachs of marine fishes are numerous from all parts of the world. Several species are known to form shoals in the continental shelves and are consequently a potential food resources for a wide range of fish, as listed by Mauchline (1980).

Fresh water species of mysids have recently been introduced into lakes, rivers and reservoirs as food for the resident population of fish, and most of their introduction appears to have been successful (Sparrow *et al.*, 1964; Linn and Frantz, 1965; Hansen, 1966; Stringer, 1967; Zhuravel, 1959; Boroditch, 1973). Ogle and Price (1976) had successfully used mysids as food in prawn culture and had obtained good results.

As experimental organism: Mysids are good experimental organisms because they are large and durable and relatively easy to handle and remain in good condition in the laboratory. The estuarine species *Mysidopsis bahia* are cultured and tested for sensitivity to various concentrations of cadmium (Nimmo *et al.*, 1978a) and for toxicity of insecticide lindane (Schimmel *et al.*, 1977). The American society and U.S Environmental Pollution Agency (USEPA) use this species as a key- testing organism for coastal and estuarine monitoring. Consequently some species of estuarine mysids are extremely useful as bioassay test organisms in studies of the potential impact of various pollutants particularly in life cycle toxicity experiments. Their omnivorous feeding habits also make them potentially good species for food selection and prey switching over studies.

In wood pulp effluent plants: *Mysis stenolepis* was found to be able to utilize cellulose, probably through the presence of gut micro flora (Foulds and Mann, 1978). It assimilated sterile raw cellulose, with efficiencies of 30-50% efficiencies that are surprisingly high and could be of interest in the context of studies on effluents from wood pulp mills.

Nutrient recycling: Most of the coastal and estuarine species utilize organic detritus to a considerable extent. They are responsible for the remineralization of substantial portion of the detritus (Fockedey and Mees, 1999). Mysids can be largely omnivorous, with demonstrated capabilities to digest cellulose and diets spanning macrophyte detritus, large microalgae, and smaller animals and heterotrophic protists. They are abundant and significantly play an active role in the transport of sediment.

1.4. GENERAL MORPHOLOGY (Figs. 1.1 and 1.2)

Size - The mysids are shrimp-like forms ranging in length from 3 mm to 25 mm, the size of the species increase from the tropics to the poles and from shallow water to deep water.

General form - The body is divided into cephalon, thorax and abdomen. There are five cephalic, eight thoracic and six abdominal somites, each somite with a pair of appendages.

Integument -This is usually thin, soft and poorly calcified. In some species the integument is covered with minute up turned scales giving a hispid appearance while in some the body is armed with spines.

Carapace - In the majority of species it covers the thorax laterally but leaves the last one or two thoracic somites, dorsally exposed. There is a well marked groove, the cervical sulcus, running across the dorsal surface above the region of the mandibles. The anterior margin of the carapace is usually produced forward into a more or less well developed rostral plate, may be evenly acute with no trace of rostrum, or produced into very long pointed process; the posterior margin may be emarginate or straight. Both anterior and posterior margins may be furnished with out growths in the form of spines or upturned lappets or fine flexible prolongations but in the great majority of species the margins are entire and unadorned.

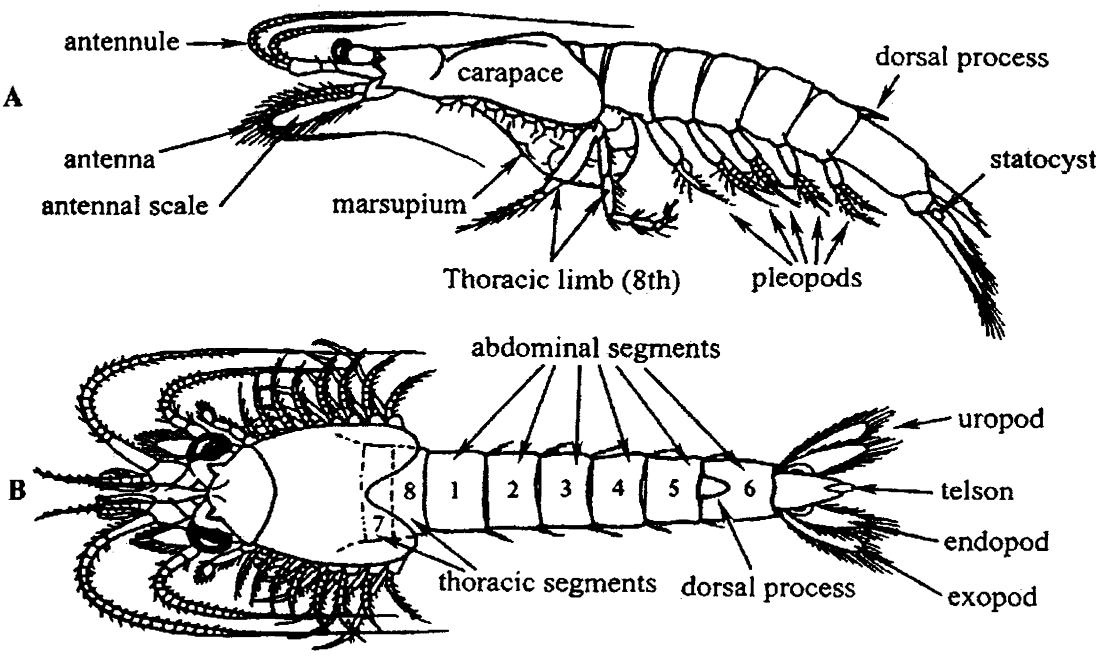


Figure 1. 1. The general morphology of mysids (A typical form). (Modified from Stuck *et al.*, 1979) A, Lateral view; B, Dorsal view.

Telson - The telson is not a true somite but represents the posterior unsegmented portion of the body. It does not bear appendages and varies in form and its characters form a valuable clue to the identification of species.

Eyes - The head bears a pair of well developed usually stalked movable eyes. The eyes may be semiglobular, dorso ventrally flattened or plate like. The cornea occupies the distal portion of the eyestalk and in some the cornea is divided into two parts and in some the cornea may be completely absent.

Labrum - Immediately anterior to the mouth there is an unpaired flat plate, which form the upper lip. This is somewhat broader than long and the anterior margin may be convexly rounded or produced into short or long spine.

Appendages

Antennules - These appendages consist of a three segmented peduncle and two flagella. The outer flagellum longer and larger than the inner, bearing near its base a number of sensory hairs. In the male it is much more robust than in female. In the Sub Order Mysida, there is a ventral conical lobe on the third segment of the peduncle of the male, which is densely covered with sensory hairs.

Antennae - This pair of appendages consist of a sympod and a well developed exopod and endopod. The sympod is made up of three parts which are closely fused and usually with a prominent spine on the outer distal corner. The exopod or scale is plate like, may be setose all round, or the outer margin may be entire or serrated ending in a strong spine. In some genera the scale is vestigial. The size and shape of the scale afford useful generic characters. The endopod is in the form of a many-segmented flagellum, the proximal three segments are much larger and stronger than the succeeding segments and is called the antennal peduncle.

Mandibles - This pair of appendages consist of a palp and a masticatory process. The palp of the mandible is three segmented, first segment short and inconspicuous; second and third segments with row of setae and bristles. The masticatory margin of mandibles is strong and chitinised and consist of an anterior serrated sharp incisor process, a movable lappet, the *lacinia mobilis*, and a posterior rounded finely ridged margin, the molar process. Between the *lacinia mobilis* and the molar part there is a concave part armed with row of short stiff spines, known as the spine row.

Maxillulae - These appendages are normally three segmented, with well marked lobes from the first and third segments. The lobe from the first segment is furnished with long and short plumose setae. The second segment is difficult to make out and without lobes. The lobe from the third segment is distally armed with two rows of short strong spines.

Maxillae - This pair of appendages consists of a three segmented sympod, and a well developed exopod and endopod. All the parts are flattened and fringed all round with close row of plumose setae.

Thoracic appendages - There are eight thoracic somites each with a pair of biramous appendages. The first two pairs are usually modified to assist in feeding and the remaining form the swimming legs. The endopod consists of six segments, pre ischium, ischium, merus, carpus, propodus (carpopropodus) and dactylus with or without nail. The exopod is natatory with a broad basal plate and many segmented flagellar part.

Marsupium - The Mysidacea have been called the 'Opossum shrimps' from the habit of females carrying the young in a brood pouch. The brood pouch or marsupium is formed of two to three pairs of lamellae, which are borne on the posterior pairs of the thoracic appendages on the ventral side of the body.

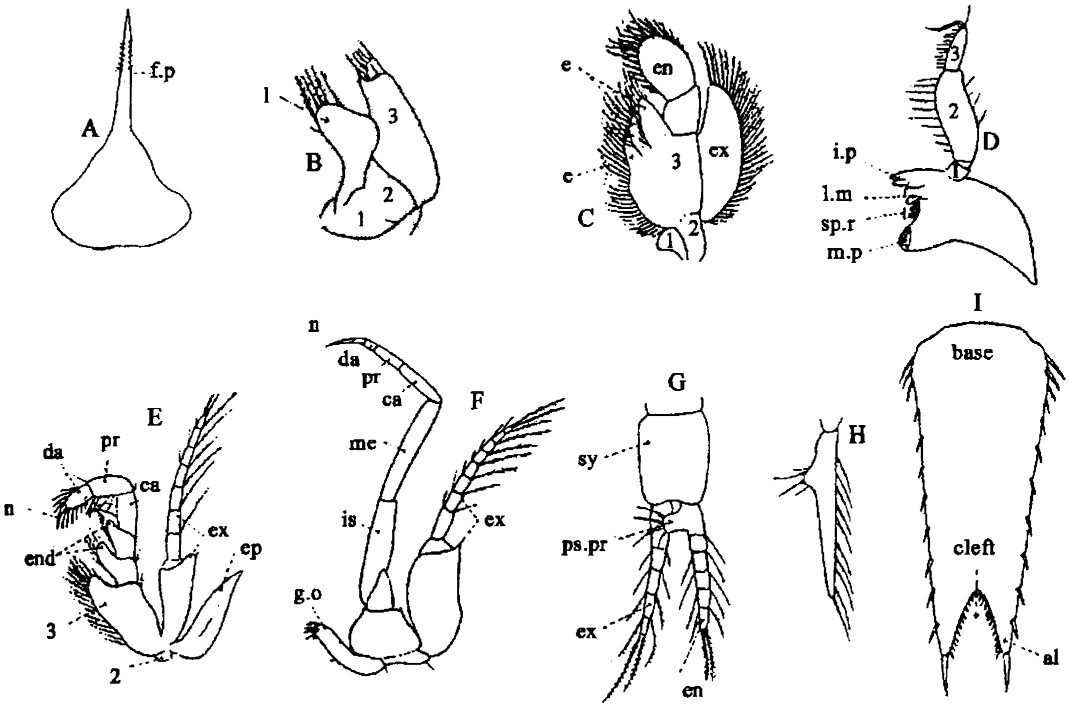


Figure 1. 2. **A,** Labrum; fp, frontal process. **B**, Mandible with three segmented palp; ip, incisor process; l.m, *lacinia mobilis*; sp.r, spine row; m.p, molar process. **C.** Maxillule composed of three segments 1, 2, 3; 1^1, lobes from first segment. **D**, Maxilla with three segments in sympod 1.2.3; $e^{2,}$ endite from second segment; $e^{3,}$ bifid endite from third segment; en, two segmented endopod or palp; ex, exopodite. **E**, Thoracic limb; 2, coax; 3, basis with its endite; end, endites from ischium and merus respectively; ca, carpus; pr, propodus da, dactylus; n, nail; ex, exopodite. **F**, Eight thoracic limb; 1, precoxa; 2, coax; 3, basis; 4, preischium; is, ishium; me, merus; ca, carpus; pr, propodus; da, dactylus; n, nail; g.o, genital organ. **G**, A typical male pleopod; sy, sympod; en, endopod; ps.pr, Pseudobrachial process. **H,** A typical reduced female pleopod. **I**, Telson showing base and cleft; a.l, apical lobe ending in a strong apical spine.

Pleopods - The abdomen is composed of six segments with a pair of appendages - the pleopods, on the first five segments. The pleopods of the female are reduced to simple unjointed setose plates. In the male the pleopods are well developed and natatory. In some one or two pleopods will be rudimentary as in the female and two pairs may become modified for sexual purposes. Near the base of the endopod of each pleopod of the male is an outgrowth of varying forms, the pseudobranchiae, which are supposed to have a respiratory function.

Uropods - These are the last pair of abdominal appendages and differ from pleopods. They are formed of large flattened lamellar exopod and endopod with or without spines and fringed with close set of regular plumose setae. At the proximal end of the endopod there is a large sense organ, the statocyst, or gravity receptors. The statocyst comprises a vesicle, inside which is a lith suspended on sensory hairs. It is an organ controlling the orientation of the animal in space and for detecting depth and pressure. The uropods with the telson form a powerful swimming organ.

Individual species are identified through differences in their external morphology especially the structure of thoracic legs, antennal scale, telson and uropods.

1.5. CLASSIFICATION

Class	-	Crustacea
Sub class	-	Malacostraca
Series	-	Eumalacostracca
Division	-	Peracarida
Order	-	Mysidacea

Sub-class MALACOSTRACA

Definition: Crustacea in which the carapace has a varied form. The trunk is typically composed of fourteen somites each of which bears a pair of appendages. The head region bears five pairs of appendages namely antennules, antennae, mandibles, maxillulae and maxillae. The trunk appendages are differentiated into thoracic consisting of eight and the abdominal of six pairs. Paired eyes are usually present and well developed, but they may be reduced or vestigial.

Division PERACARIDA

Definition: First thoracic somite always fused with the head region. Carapace when present fused with the head and anterior thoracic somites, leaving last four posterior thoracic somites free and distinct. Eggs and young carried by the female in a marsupium composed of brood lamellae or oostergites attached to the thoracic limbs. Development takes place in a marsupium, young liberated at a later stage and not as nauplii.

Order MYSIDACEA

Definition: Peracarida in which though the carapace covering most of the thorax, it does not coalese dorsally with more than the first three segments. Eyes when present, movably pedunculate, antennules biramous, antennae have scale like exopodite or squama. Thoracic limbs with many segmented exopods; first and some times second pairs modified as maxillipeds. Uropod with lamellar exopod and endopod forming a tail fan with the telson, a statocyst usually present on the endopod.

The order Mysidacea falls into two clearly distinct groups, which differ so profoundly from one another that, they have been given the status of suborders under the names Lophogastrida and Mysida.

Sub Order Lophogastrida

The Lophogastrida shows some primitive characters, which are absent in nearly all the Mysida. Large foliaceous gills present on the thoracic appendages. No statocyst on the endopod of the uropod. Pleopods of both sexes biamous, multiarticulate, natatory and unmodified. Marsupium composed of seven pairs of imbricating brood lamella. Well developed pleural plates present on the abdominal somites. A more or less well marked transverse groove encircling the last abdominal somite and marking the incomplete fusion of the sixth and seventh abdominal somites of the embryo. A pair of lateral teeth immediately in front of this groove marks the postero-ventral angle of the sixth abdominal somite of the fossil forms and of the embryo.

Many species in the Lophogastridae live in the deep oceanic environment and are large in body size ranging from 17-350 mm. The largest mysid known as *Gnathophausia ingens* has 351 mm length. Only very few Lophogastrids are recorded from the Indian waters and almost all of them are well known species having a very wide distribution.

As the present study deals exclusively with the sub order Mysida, Lophogastrids are omitted from the list.

Sub Order Mysida

Definition: Branchiae absent; carpopropodus of the endopods of the third to eighth thoracic limbs usually divided into a number of subsegments; marsupium generally of two or three and rarely seven pairs of lamellae; pleopods of the females rudimentary, rarely biramous, generally in the form of small unsegmented plates; pleopods of the male either well developed, biramous; natatory appendages or one or more pairs reduced as in the female and one or more pairs secondarily modified as accessory sexual appendages; statocyst usually present on the endopods of the uropods.

The sub order Mysida is divided into four families Lepidomysidae, Stigiomysidae, Petalophthalmidae and Mysidae. Species of Lepidomysidae and Stigiomysidae inhabit caves and wells, and that of Petalophthalmidae are mainly distributed in deep waters and all these species have no statocyst in the uropods and the marsupium consists of seven pairs of lamellae.

The family Mysidae is the most extensive group with seven sub families; Boreomysinae, Thalassomysinae, Siriellinae, Rhopalophthalminae, Gastrosaccinae, Mysinae and Mysidellinae.

1.6. HISTORICAL RESUME

The first published description of a mysid was given by Muller (1776) who described *Cancer flexuosus*, now known *as Praunus flexuosus*, a species abundant in the shores of British Isles. The first illustration of a mysid was published by Slabber (1775) in which a short description and a recognisable figure of what he called 'a shrimp like animal with trumpet like eyes' was given and later it was identified with *Podopsis slabberi* (Beneden, 1861) now known as *Mesopodopsis slabberi*, another species common in British waters. In 1780, Fabricius described two species from Greenland, *Cancer pedatus* and *Cancer oculatus* (*Mysis oculata*). Latriella (1802) instituted the first type genus of the order, *Mysis* to include the *Cancer* sp. He associated the Mysidacea with the Stomatopoda. In 1817, Latriella put forward a new classification and separated Mysida from the Stomatopoda and placed them in a separate group the Schizopoda, by which the group was known for nearly a century. Again in 1825, Latriella divided the Schizopoda into two groups, (1) with a tail fan and (2) with a caudal furca. In 1830 Milne-Edwarde described the first representative of euphausiid *Thysanopoda tricuspidata* and until 1904 euphausiids were included with the mysids in the Schizopoda. In 1831 Latriella drew up another classification in which he associated Schizopoda with the Stomatopoda and the term Schizopoda was abandoned. This classification was accepted as the standard by other writers till 1850 when Dana reintroduced the name Schizopoda in a synopsis of the genera of Mysidacea. Sars (1872-1927) published two monographs, (1) Mysidae of

Norway (2) Mysidae of the Mediterranean, which was an important landmark in the history of Mysidacea. The monograph of Mysidacea, published by Czerniavsky (1882 - 1883) added considerably to the knowledge of Mysidacea Fauna of the Black and Caspian seas, of the sea of Azor and of the eastern Mediterranean. Boas (1883) separated euphausiids and mysids into two distinct order of Malacostraca and the order Mysdiacea was further divided into two sub orders the Lophogastrida and the Mysida. Hansen (1893) adopted the suggestion made by Boas to abolish Schizopoda and considered that Euphausiacea were allied to the Decapoda and the Mysidacea to the Cumacea, Amphipoda, Isopoda and Tannidacea. In 1904 Calman formulated a new classification of the Malacostraca based on the scheme suggested by Hansen. The eupausiids and decapods were grouped together in one division called Eucarida and Mysidacea, Cumacea, Amphipoda, Isopoda and Tannidacea in another division named Peracarida. Thus the group Schizopoda ceased to exist and Calman's classification was generally adopted. The final form of classification as accepted today was drawn up by Hansen (1910).

Zimmer's two comprehensive works on the fauna of Northern waters 'The Fauna Arctica' (1904) and the 'Nordisches Plankton' (1909) form an invaluable guide to the study of the Mysidacea found in those regions. The celebrated work of Hansen (1910), a landmark in the study of Mysidacea, contains fully illustrated descriptions of Mysidacea collected during the Siboga Expedition.

In 1951, Tattersall and Tattersall published their monograph on British Mysidacea, which includes an excellent historical account and an accurate and clearly illustrated guide to the study of British species. Gordon (1957) published a bibliography of the order listing over 1100 references up to the end of 1955 and this detailed classification of the literature is extremely valuable to the workers in this field. The monograph by Ii (1964) is an invaluable guide to the Mysidacea of the Japanese waters.

The most valuable works on the taxonomy of Mysids for different geographical region are those of Tattersall and Tattersall (1951) for British and North Atlantic species; Tattersall (1951) for American species; Ii (1964) and Murano (1966-2006) for Japanese and Western Pacific species; Pillai (1957 - 1976) for Indian species and papers of Bacescu (1934 -1997), Nouvel (1937 - 1978), O.S. Tattersall (1952 - 1969), W.M.Tattersall (1906 -1951) Brattegard (1969 - 1988) and Panampunnayil (1977 - 2002) for species in regions specified in the titles of the papers. Access to many relevant literatures can be obtained through the references quoted by Mauchline and Murano (1977), which list broad geographical region of occurrence of all species.

1.7. REVIEW OF LITERATURE ON INDIAN MYSIDACEA

The earliest works on the Mysidacea of Indian waters are those of Woodmason and Alcock (1891), Alcock and Anderson (1894, 1899) and Anderson (1897). Their works dealt exclusively with the Lophogastrida dredged by the '*Investigator*' from deep waters in the Bay of Bengal and the Arabian Sea. Tattersall recorded the first Mysida *Siriella paulsoni* in 1906 from Ceylon and between 1908-1914 he described six other species of mysids from the brackish water of the Indian coast. Hansen (1910) recorded seven species collected from the Bay of Bengal during the Siboga Expedition. In 1915, Zimmer described the Mysidacea collected by Dr. Dunker during a voyage from Ceylon to New Guinea, but no exact locations were given. In 1922 Tattersall published a report on Mysidacea collected by S.W. Kemp from Kilakarai and Pamban in the Gulf of Mannar and Port Blair in the Andaman Islands and the total numbers of species were brought up to 53. Later in 1939 he described the Mysidacea of the John Murray Expedition in the Arabian Sea. Isolated records of Indian species were made by Colosi (1920), Nouvel (1954a) and O.S. Tattersall (1957). The next advance in the histroy of Indian Mysidacea took place from 1957 onwards with a series of publications by Pillai (1957, 1961, 1963a,b, 1964, 1965) who recorded the littoral mysids of the Kerala coast and the planktonic mysids from the west coast and the Maldive - Laccadive Islands in the Arabian Sea. The first comprehensive collection of zooplankton from Indian Ocean was that made by the International Indian Ocean Expedition (IIOE) during 1960-65. The first major account of the quantitative distribution of Mysidacea of the Indian Ocean was given in the plankton atlas (IOBC, 1972) based on the zooplankton collections of the IIOE. The real basis of our knowledge on the Indian Mysidacea was for the first time laid by Pillai (1973), when he published the Mysidacea of the Indian Ocean based on materials collected during IIOE that sampled the surface and subsurface waters down to 200 m. Taxonomy and distribution of 38 species had been dealt with, out of which 6 were recorded as new. Subsequently, Panampunnayil (1977-1999) made valuable additions to the Mysidacea of the Indian Ocean and recorded 20 new species from the south west coast of Australia between latitude 22°14'-34°16'S and longitude 114°28'-110°29'E and 10 new species from the east and west coasts of India. About 140 species of Mysidacea are now known from Indian waters. Other contributions on Mysidacea from the Indian waters include the works of Balasubramanyan (1964) Shyamasundari (1973), Taniguchi (1974) and Chandramohan (1983). Information on the distribution and abundance of mysids in general of the EEZ of India has been presented by Mathew *et al.*, (1989). Fifteen species of mysids were reported from the shallow waters of Andaman Sea (Panampunnayil, 2002). Mysidacea of the south eastern Andaman Sea was incorporated in the proceeding of workshop on Andaman Sea (Fukuoka and Murano, 2002). Biju *et al.*, (2006) studied mysids on the Minicoy lagoon (Lakshadweep) with description of a new species of *Anisomysis*. Panampunnayil and Biju (2006) reported four new species belonging to genus *Rhopalophthalmus* from northwest coast of India. In addition to these there are several other important studies dealing with reproduction, anatomy, distribution, ecology and economic aspects which include the works of Nair (1939); Nath (1972-74); Nath and Pillai (1971, 1972, 1976); Devasundaram and Roy (1954); Dutta *et al.* (1954); George (1958); Goswami *et al.* (1979); Gajbhiye *et al.* (1980); Varghese (1981); Goswami (1983); Gupta and Gupta (1984); Sarkar and Chowdhury (1986); Gowda *et al.*, (1988); Nair *et al.* (1989); Patil and Sankolli (1991); Achuthankutty *et al.* (1992); Shirgur and Deshmukh (1994, 95) and Neelam *et al.* (1996).

1.8. SCOPE AND PURPOSE OF STUDY: Mysids are omnivores and, they utilize diverse of food during their life cycle, which spans from few months to two years (Mauchline, 1980) and some species can switch from one feeding mode to another when food availability changes (Viitasalo and Rautio, 1998). Mysids are prey for many larger predators globally, such as for invertebrates, various fishes (Thiel, 1996; Hostens and Mees, 1999) birds and seals (Mauchline, 1980a), there by linking primary and secondary production to higher trophical level. They are responsible for the remineralization of a substantial proportion of the detritus and hence are important constituents of food webs from particulate matter to macroplankton. The works of Tattersall (1906-1939), Hansen (1910) and Pillai (1957-1973) provide much information on the taxonomy of mysids from the Indian Ocean. In addition to these, Panampunnayil studied the mysids from the shallow coastal waters of Maharashtra, Gujarat, Andaman Sea and eastern Indian Ocean (1977- 2000). The distribution and abundance of mysids in general from the selected areas of the EEZ of India have been presented by Mathew *et al.* (1989). Apart from these at present there is no information on the taxonomy and species diversity of this group from this area.

Considering the significant role of mysids in the productivity of tropical and coastal ecosystems, the present study has been undertaken to extend our knowledge on the systematics, species composition, distribution, abundance and ecology of mysid fauna of the Indian EEZ and adjoining areas. The present study therefore will undoubtedly furnish valuable information on Mysidacea of the Indian waters.

Chapter 2

Materials and methods

2.1. STUDY AREA

Materials for the present study were collected from Indian EEZ and adjoing areas (shallow waters of northwest coast of India and Cochin backwaters). Environmental parameters, zooplankton and water samples were collected from all areas.

2.1.1. Indian EEZ (Arabian Sea, Bay of Bengal and the Andaman sea)

The data used for this study is based on samples collected during 12 cruises carried out in the Arabian sea, Bay of Bengal and the Andaman Sea (Indian EEZ) by the research vessel, *FORV Sagar Sampada* (Plate 2.1) as part of a multidisciplinary project entitled "Marine Research- Living Resources (MR-LR) Assessment Programme" funded by Ministry of earth science (Formerly, Department of Ocean development), New Delhi. The project was designed to asses and evaluate the environmental parameters and the marine living resources (primary and secondary), of the Indian EEZ by the simultaneous collection of physical, chemical and biological oceanographic parameters from the Seas around India.

Seasons followed were inter monsoon spring (March - May), summer or southwest monsoon (June - September), inter monsoon fall (October) and winter or northeast monsoon (November - February) as per the Protocol under Joint Global Ocean Flux Studies (JGOFS, 1996). Hydrobiological samples were collected from pre fixed stations during 12 cruises from Arabian Sea - 4, Bay of Bengal - 4 and Andaman Sea - 4 cruises.

Plate 2.1. Research vessel *FORV Sagar Sampada*

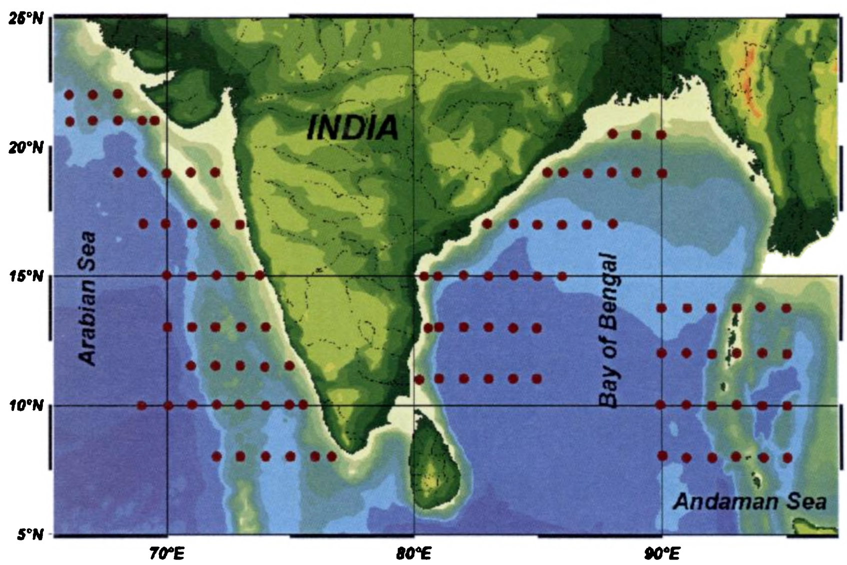


Figure 2. 1. Sampling locations in the Indian EEZ

From 105 stations, a total of 336 surface samples and 1325 stratified samples were analyzed. Station positions are shown in Fig. 2.1.

2.1.2. Shallow costal waters of northwest coast of India

Materials were collected during many biological and environmental investigations in and around coastal waters of Gujarat and Maharashtra carried out for the environmental impact assessment of marine ecosystem. Samples were collected from 10 areas (Fig .2.2).

2.1.3. Cochin backwaters

The material examined was collected as part of the studies on "Ecosystem modeling of Cochin backwaters" during March 2003 to February 2004, funded by ICMAM, Chennai. During the period of study, two types of sampling were done, weekly sampling from 3 stations (Thevara, WS1; Fort Cochin, WS2 and Bolghatty, WS3) for one year and two seasonal (premonsoon and postmonsoon) time series sampling (24 hour) from five stations (TS1, TS2 TS3, TS4 and TS5) (Fig. 2.3).

2. 2. SAMPLING METHODOLOGY

2.2.1. Physico-chemical parameters.

In the Arabian Sea, Bay of Bengal and Andaman Sea, surface temperature (SST) was measured using bucket thermometer. A Sea -Bird electronic CTD (SBE 911 Plus, USA) (Plate 2.2) was used to obtain the temperature and salinity profiles. Salinity values from the CTD were corrected using the values obtained from the Autosal (Guildline - Model 8400A) and the values are represented in psu (practical salinity unit). Mixed layer depth (MLD) was computed as the depth at which density rises by 0.2 units from the surfaces. This density difference is equivalent to a 1°C change in temperature, if salinity is constant.

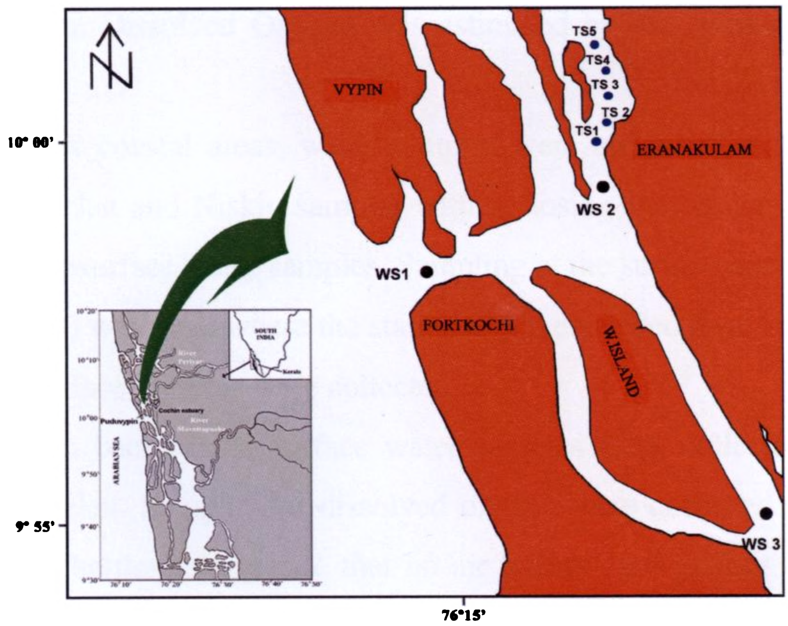


Figure 2. 3. Sampling locations in the Cochin backwaters

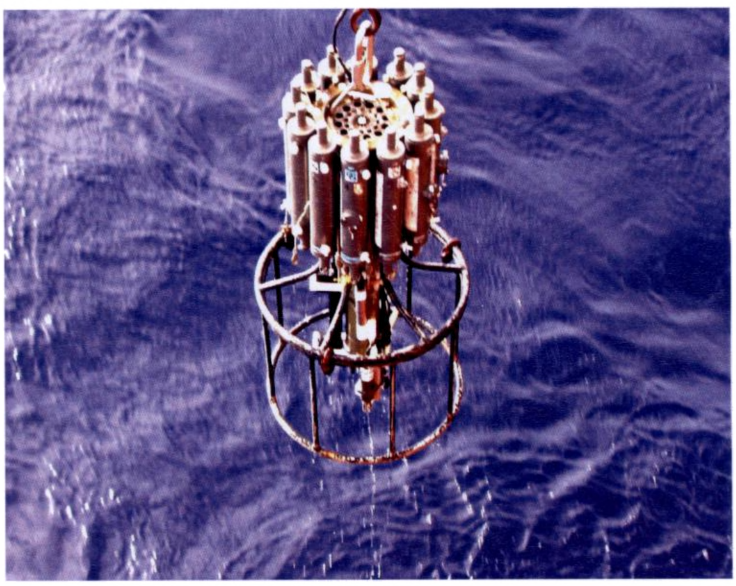


Plate 2. 2. CTD rosette with Niskin bottles

Water samples were collected for chemical analysis (dissolved oxygen and *p*H) from different depths (0, 10, 20, 30, 50, 75, 100, 150, 200, 300, 500, 750 and 1000 m. Dissolved Oxygen was estimated by the Winkler titration method.

In shallow coastal areas, water samples were collected using a clean polyethylene bucket and Niskin sampler with a closing mechanism was used for obtaining subsurface water samples. Sampling at the surface and bottom (1 m above the bed) was done where the station depth exceeded 5 m. For shallow regions, only surface samples were collected.

In Cochin backwaters, surface water samples were collected using a clean plastic bucket. Samples for dissolved oxygen were collected in 125 ml stoppered glass bottles taking care that no air bubbles are getting trapped in the sample. The samples were fixed immediately with manganous chloride solution (Winkler A) followed by alkaline potassium iodide (Winkler B) solution. Water samples for the analyses of salinity were collected in pre-cleaned polyethylene bottles. Temperature and *p*H of the water samples were measured in the field. For the estimation of Chl *a*, one litre of surface water was collected in clean plastic bottle.

2.2.2. Zooplankton collection

In oceanic waters, the zooplankton samples were collected from five different depth strata - surface to top of thermocline, top of thermocline to bottom of thermocline, bottom of thermocline to 300m, 300-500 m and 500-1000 m) using a Multiple plankton net (MPN) (Plate 2.3) (Hydrobios-mesh size 0.2 mm and mouth area 0.25 m^2) and surface samples using Bongo net (Hydrobios - mesh size 0.3 mm; filtering cone length 250 cm; ring diameter 60 cm) (Plate 2.4).

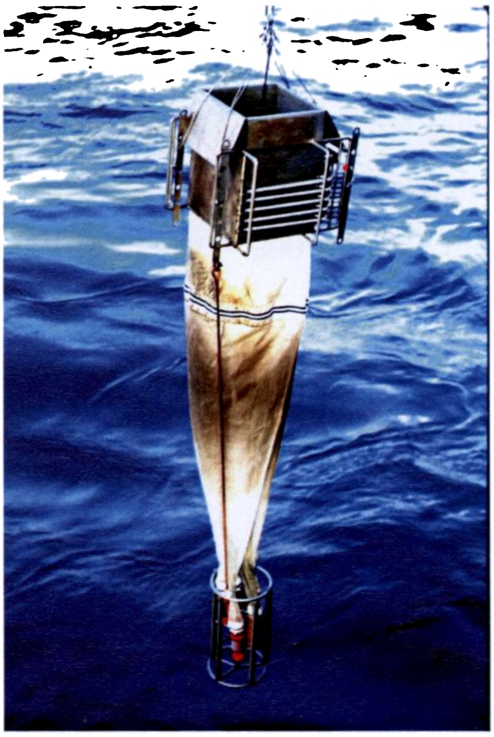


Plate 2. 3. Multiple plankton Net

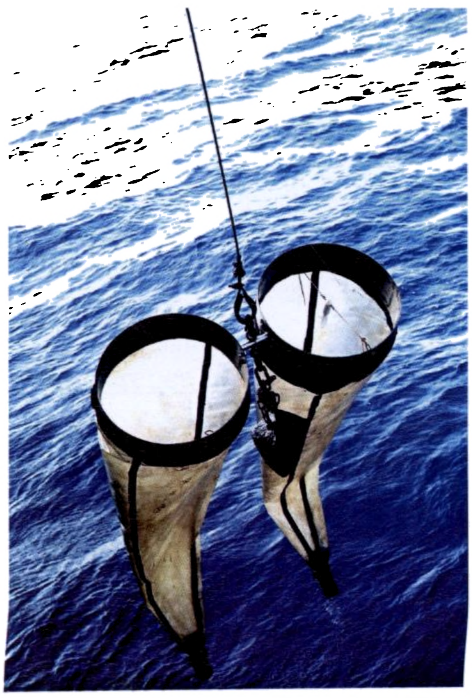


Plate 2.4. Bongo Net

The Multi Plankton Sampler has to be operated with an electrical connection (single or multi conductor cable) between Deck Command Unit and Underwater Unit. The net was hauled vertically with a speed of 1m/s.

The depths of hauls were fixed based on the thermocline besides two standard depths (1000 - 500 m, 500 - 300 m). The thermocline depths were 300 m - Base of thermocline (BT), Base of thermocline - Top of thermocline (BT-TT or thermocline layer), and Top of thermocline - surface (TT- 0 m or mixed layer). The depth of occurrence of the thermocline was taken as the depth where the temperature falls by 1°C from the surface and 15°C isotherm was considered as the bottom of the thermocline (Kesavadas, 1992). The number of strata sampled varies according to station depth and hydrographic conditions. At coastal stations two shallow depth intervals were invariably sampled. The volume of water filtered was calculated as the vertical distance (m) covered by the net's mouth area (0.25 m^2).

The Bongo net was towed horizontally for 10 minutes while the ship's speed was 2 knots.

Volume of water filtered was calculated using the following formula,

$$\text{Volume cubic meters} = 3.14 \times \frac{(\text{Net diameter})^2}{4} \times \text{Distance}$$

$$\text{Distance in meters} = \frac{\text{Difference in flow meter reading} \times \text{Rotor constant}}{999999}$$

$$\text{Rotor constant} = 26873$$

For the collection of zooplankton from coastal waters, a Heron Tranter Net (Plate 2.5) (Tranter *et al.*, 1972). The mouth area of the net is 0.25 m^2 and the total length is about 1.8 m (mesh size 0.33mm). Oblique hauls of 6 minutes duration were taken.

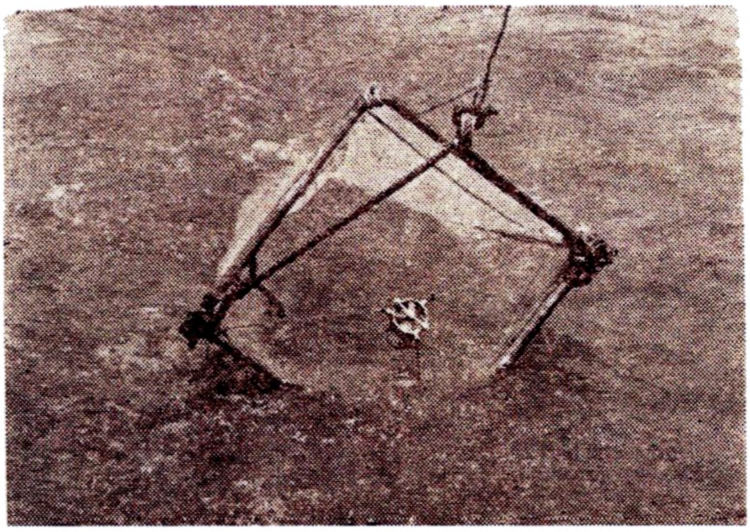


Plate 2.5. Heron Tranter Net

Plate 2.6. Working Party Net

Volume of water filtered (V) through the net was calculated by adopting the calibration formula provided with the flow-meter,

$$V=[(0.157XN) - 0.003] XA$$

Where, N-number of revolution, A= mouth area of net.

In Cochin backwaters, the surface zooplankton was collected using W.P net (Working Party net) mesh size 200μm and mouth area $0.6m^2$ (Plate 2.6).

2.3. ANALYTICAL METHODS

(a) Physico-chemical factors

Temperature

The temperature of water samples was measured by a good quality centigrade thermometer immediately after collection.

***p*H**

*p*H was measured using a digital *p*H meter (ECIL No. 5652) after standardizing with standard buffers of *p*H 4,7 and 9 just before the use.

Salinity

The estimation of salinity for the estuarine and coastal waters was carried out in the laboratory using precalibrated Salinometer (Digi Auto3G, accuracy ± 0.001)

Dissolved oxygen

Dissolved oxygen (DO) was determined by Winkler method (Grasshoff, 1976). Water samples were collected in 125 ml DO bottles without trapping air bubbles. Immediately the sample was fixed by adding 1 ml each of manganous sulphate solution (Winkler A) and alkaline iodine solution (Winkler B). The precipitate formed was dissolved in 1 ml concentrated sulphuric acid. The iodine liberated was estimated by titration using starch as indicator. Dissolved oxygen values are represented as µM.

Chlorophyll *a*

Collected water sample filtered under low vacuum through GF/F (normal pore size 0.7 m) filters, added one or two drops of magnesium carbonate solution and kept in refrigerator (Strickland and Parsons, 1972). The filter paper was extracted in 90% acetone, centrifuged and made up to 10ml using 90% acetone and the absorbance was measured using a spectrophotometer using 1cm cuvette against 90% acetone as blank at different wave lengths of 750, 664, 647, and 630nm. The amount of plant pigment in the water sample was calculated using the equation (SCOR/UNESCO).

$$\text{Chl-}\,a = 11.85E\,665 - 1.54E\,645 - 0.08E\,630$$

$$\text{mg Chlorophyll/m}^3 = C/V \times 10$$

Where, C = value obtained from the formula given

V= volume of water filtered in liters

10= volume of 90% acetone

b) Zooplankton

Zooplankton sampling and analysis were done following the standard method (UNSECO, 1968; IOBC, 1969). Samples were preserved in 5% buffered formalin.

The classification of Mysidacea adopted in the present work is that of Hansen (1910) in which the more primitive forms are considered first and the more complex ones later according to their degree of specialization.

Generic definitions have been adopted mainly from the monographs of Tattersall and Tattersall (1951), Hansen (1910) and Ii (1964) and specific identifications are mainly based on the literature by Tattersall (1908, 1914, 1915, 1922), Hansen (1910), O.S. Tattersall (1951) and Pillai (1957, 1961, 1964, 1973).

Mysids were divided mostly on the degree of development of the secondary sexual characteristics into the following classes (1) secondary sexual characteristics not developed - juveniles (2) immature male (3) mature male (4) females with marsupium developing but no eggs or young present yet - immature females (5) mature females, females with eggs or young present in the marsupium (Mauchline, 1971). Immature individuals were distinguished from juveniles by the presence of rudimentary oostegites (female) and longer fourth pleopod (male). Mature females were categorised according to the reproductive conditions. The eggs and larvae in the marsupium were enumerated and the developmental stages of the brood were determined. The development within the marsupium of ovigerous females which did not have a damaged or ruptured marsupium can be divided into three stages as eggs, eyeless larvae and eyed larvae.

All figures have been drawn with the aid of a Camera Lucida. Total length of all species has been measured from the tip of the rostral plate along the dorsal surface to the apex of the telson. The measurement have been made with an eye piece micrometer. Characteristics described refer to both sexes unless other wise stated. Holotypes of the new species and where possible paratypes and allotypes have been deposited in the Reference Collection of IOBC (RC, NIO, Cochin).

2.4. DNA BARCODING

DNA Isolation from Mysid

DNA from the mysid genome was extracted as per standard Proteinase k digestion method (Sambrook *et al.*, 1989). Sample tissues were first washed in 0.85% saline several times, then suspended in TEN buffer having 1% SDS. Proteinase-K was then added to a final concentration of 200 µg/ml and mixed gently. The suspension of lysed cells was incubated in a water bath for 3 hours at 50°C. The solution was cooled to room temperature and an equal volume of phenol equilibrated with 0.5M Tris-HCl (*p*H 8.0) was added and gently mixed by slowly turning over the tube for 10 minutes. The two phases were separated by centrifugation at 5,000rpm for 15 minutes at room temperature. The viscous aqueous phases were transferred to a clean centrifuge tube and the extraction with phenol was repeated twice. A third extraction with a 24:1 mixture of chloroform and iso-amyl alcohol was given to the sample and the aqueous phase was collected carefully. DNA samples in solution were precipitated after the addition of 0.1 volume of 3.0M Sodium acetate (*p*H 5.2) and 0.6 volumes of iso-propanol. The precipitated DNA was pelleted by centrifugation at 10,000 rpm for 15 minutes at room temperature. The excess salt was removed by washing the DNA pellets three times in 70% ethanol. The DNA samples were dried under vacuum and dissolved in 100 µl volume of TE.

Nucleic acid quantification

The DNA was quantified spectrophotometrically using a nanodrop spectrophotometer (ND1000) by measuring the optical density both at 260 and 280nm. The reading at 260 nm gives the concentration of the nucleic acid in the sample. The ratio between readings at 260 nm and 280 nm (OD_{260}/OD_{280}) provides an estimate of the purity of the nucleic acid. The integrity of DNA samples was estimated by visualizing samples on a 0.8% agarose gel stained with ethidium bromide (0.5μg/ml) and electrophoresing at 90 V for 60–90 min.

Polymerase chain reaction (PCR)

PCR was carried out on the extracted DNA from mysids. The universal primer designed by Folmer *et al.*, (1994) used for the amplification of COI gene of mysid.

HCO2198 TAAACTTCAGGGTGACCAAAAAATCA

LCO1490 GGTCAACAAATCATAAAGATATTGG

All the PCRs were performed in 50 μl of reaction volume consisting of 1x PCR buffer, 50 pico moles each of forward and reverse primers, 200 mM concentrations of each of dNTPs and 1 U of Taq polymerase (Bangalore Genei, Bangalore). 100 ng of DNA was used as template. The thermocycling conditions consisted of an initial denaturation at 94 °C for 5 min followed by 35 cycles of 30 s denaturation at 94 °C, 50 s annealing at 50°C and 2 min extension at 72 °C. The final extension of flush ends was carried out at 72 °C for 5 min. All PCRs were performed in a EPPENDORF thermocycler. The products of PCR were separated on a 1.8 % agarose gel, stained with ethidium bromide (0.5 g/ml) and photographed using gel documentation system (Kodak Gel logic1500 imaging system). PCR products were cleaned using QIAquick® PCR Purification Kit (QIAGEN, USA). The PCR product were sequenced using the same primers at Bangalore Genei, Bangalore, by an ABI Prism 3700 sequencer (Applied Biosystems).

2.5. BIOCHEMICAL COMPOSITION

Samples for biochemical studies were collected from Cochin backwater during premonsoon period at weekly basis (2nd march, 16th March and 31nd March, 2007) using Working Party net. After collecting zooplankton, samples were immediately taken to lab, the organisms were classified (*Mesopodopsis orientalis*, *Mesopodopsis zeylanica* and *Rhopalophthalmus indicus*) and separated into mature male, immature male, spent female, female with embryo (brooding female), immature female and juveniles then individual specimens rinsed briefly with small amount of chilled distilled water, blotted on filter paper. Samples from each group were lyophilized, weighed, and kept at -30°C.

Protein quantification was conducted according to the Folin- Phenol method described by Lowry *et al.*, (1951) using bovine albumin as standard. The quantification of total carbohydrate was performed according to the colorimetric method using phenol and sulphuric acid, described by Dubois *et al.*, (1956) using glucose as standard. Lipid extraction was carried out according to Bligh and Dyer (1959) by direct elution with chloroform and methanol (1:2 v:v). The extracted lipid were dried at 80°C (20min.) and determined spectrophotometrically after carbonization at 18° C in concentrated sulphuric acid according to Marsh and Weinstein (1966); tripalmitine solution were used as standard.

2.6. STATISTICAL ANALYSIS

Linear Multiple regression Analysis

Multiple regression analysis was employed to assess the predictability of mysid population density in relation to physicochemical variables in the Cochin backwaters.

The model used for the purpose was

$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$

Where y = population density, x_1= chlorophyll, x_2 = dissolved oxygen,

x_3 = salinity, x_4= *p*H, x_5 = water temperature.

The significance of the fitted regression was tested using ANOVA.

Two-factor ANOVA

To test whether there is significant difference between species and between stages with respect to protein carbohydrate and lipid, the experimental data were subjected to statistical analysis using Two-factor ANOVA. Wherever, the treatment effects were found to be significant, least significant difference at 5% level were worked out and significant treatment effects were separated.

Chapter 3

Systematic account on Mysidacea

(Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Sea)

3.1. INTRODUCTION

The Exclusive Economic Zone (EEZ) is defined as the region, which extends into the ocean up to 200 nautical miles from the coastline, including those of Island territories. The new regime for the ocean giving all maritime nations exclusive rights over economic activities in a region came in to force by the signing of the United Nations Conference on the Law of the Sea (UNCLOS), which came into force in 1994. The EEZ of India spans an area of 2.02 million square kilometers (1.015 x 10^6 km^2), representing two-thirds of Indian land mass (61%). Of the total areas of the EEZ, the continental shelf (0-200m) occupies 20.54%, the continental slope (200-500 m) covers 1.29%, and the oceanic region covers 78.17%. The EEZ section along west coast forms about 42.6%, on the east coast 27.8% and around Andaman & Nicobar Islands about 29.6% of the Indian EEZ. The non - conventional fishery resources distributed in the continental slope of the Indian EEZ offer a promising potential in the Indian fishery scenario, which can be further improved by knowledge of the exploitation of the fishery resources of the EEZ.

Taxonomy is the focal point and integrative basis of biological sciences devoted to the identification, naming, and classification of living things according to apparent common characteristics. It establishes the characteristics, relationships, range and identity of the components of biological systems. Biological systems can only be understood with the aid of taxonomy (an understanding of the variation both within and between species and communities). Taxonomy contributes to the recognition of the selective pressures affecting evolution and is the means by which diversity is measured d its causes understood. The classification of animals and plants is essential understand and catalogue the biodiversity of marine system. Systematic udy of biodiversity and flux of standing stock assess the tertiary production. he works of W.M. Tattersall (1906- 1939), Hansen (1910) and Pillai (1957-976) provide much information on the taxonomy of mysids from the Indian)cean. In 1973, Pillai published the Mysidacea of the Indian Ocean based on he materials collected during International Indian Ocean Expedition (IIOE). Panampunnayil (1999a) studied the mysids from the shallow costal waters of Maharashtra, Gujarat, and Andaman waters. Apart from these, at present there is no comprehensive taxonomic information about the mysids of the EEZ.

3.2. RESULTS

During this study period 336 surface samples and 1325 stratified samples were analyzed and mysids were present in 123 surface samples and 91 stratified samples. The collection represented 27 species of mysids belonging to 21 genera. Three species, *Boreomysis plebeja* (Bay of Bengal), *Anchialina media and Synerythrops intermedia* (Andaman Sea) are new records for Indian water. One species, *Pseuderythrops gracilis* is new record for Andaman waters and a further two species, *Rhopalophthalmus indicus* and *Euchaetomera glyphidophthalmica* are recorded for the first time from Bay of Bengal. Four immature species *Boreomysis plebeja, Rhopalophthalmus indicus, Anchialina grossa* and *Lycomysis spinicaudata* are represented by immature forms and are tentatively referred to adult stage.

Details of the mysids collected from Arabian Sea, Bay of Bengal and Andaman Sea are given in Table 3.1- 3.6.

and its causes understood. The classification of animals and plants is essential to understand and catalogue the biodiversity of marine system. Systematic study of biodiversity and flux of standing stock assess the tertiary production. The works of W.M. Tattersall (1906- 1939), Hansen (1910) and Pillai (1957-1976) provide much information on the taxonomy of mysids from the Indian Ocean. In 1973, Pillai published the Mysidacea of the Indian Ocean based on the materials collected during International Indian Ocean Expedition (IIOE). Panampunnayil (1999a) studied the mysids from the shallow costal waters of Maharashtra, Gujarat, and Andaman waters. Apart from these, at present there is no comprehensive taxonomic information about the mysids of the EEZ.

3. 2. RESULTS

During this study period 336 surface samples and 1325 stratified samples were analyzed and mysids were present in 123 surface samples and 91 stratified samples. The collection represented 27 species of mysids belonging to 21 genera. Three species, *Boreomysis plebeja* (Bay of Bengal), *Anchialina media and Synerythrops intermedia* (Andaman Sea) are new records for Indian water. One species, *Pseuderythrops gracilis* is new record for Andaman waters and a further two species, *Rhopalophthalmus indicus* and *Euchaetomera glyphidophthalmica* are recorded for the first time from Bay of Bengal. Four immature species *Boreomysis plebeja, Rhopalophthalmus indicus, Anchialina grossa* and *Lycomysis spinicaudata* are represented by immature forms and are tentatively referred to adult stage.

Details of the mysids collected from Arabian Sea, Bay of Bengal and Andaman Sea are given in Table 3.1- 3.6.

Taxonomic listing of the mysids

ORDER MYSIDACEA Boas, 1883

SUB ORDER MYSIDA Boas, 18823

Family Mysidae Dana, 1850

Sub family BOREOMYSINAE Holt and Tattersall, 1905

Genus *Boreomysis* G.O. Sars, 1869

Boreomysis plebeja Hansen, 1910

Sub family SIRIELLINAE Norman 1892

Tribe Siriellini Czerniavsky, 1882

Genus *Seriella* Dana, 1850

Siriella thompsoni (Milne -Edwards, 1837)

Siriella gracilis Dana, 1852

Siriella aequiremis Hansen, 1910

Genus *Hemisiriella* Hansen, 1910

Hemisiriella parva Hansen, 1910

Sub family RHOPALOPHTHALMINAE Hansen, 1910

Genus *Rhopalophthalmus* Illig, 1906

Rhopalophthalmus indicus Pillai, 1961

Sub family GASTROSACCINAE Norman, 1892

Genus *Gastrosaccus* Norman, 1868

Gastrosaccus dunckeri Zimmer, 1915

Genus *Haplostylus* Kossmann, 1880

Haplostylus pusillus Coifmann, 1936

Genus *Eurobowmaniella* Murano, 1995

Eurobowmaniella simulans W.M. Tattersall, 1915

Genus *Anchialina* Norman and Scott, 1906

Anchialina typica (Kroyer, 1861)

Anchialina grossa Hansen, 1910

Anchialina dentata Pillai, 1964

Anchialina media Ii, 1964

Genus *Pseudanchialina* Hansen, 1910

Pseudanchialina pusilla (G.O. Sars, 1883)

Pseudanchialina inermis (Illig, 1906)

Sub family MYSINAE Hansen, 1910

Tribe Erythropini Hansen, 1910

Genus *Pseuderythrops* Coifmann, 1936

Pseuderythrops gracilis Coifmann, 1936

Genus *Gibberythrops* (Illig, 1930)

Gibberythrops acanthura (Illig, 1906)

Genus *Pleurerythrops* Ii, 1964

Pleurerythrops inscita Ii, 1964

Genus *Euchaetomera* G.O. Sars, 1883

Euchaetomera glyphidophthalmica Illig, 1906

Genus *Synerythrops* Hansen, 1910

Synerythrops intermediata Hansen, 1910

Tribe Leptomysini Hansen, 1910

Genus *Dioptromysis* Zimmer, 1915

Dioptromysis perspicillata Zimmer, 1915

Genus *Afromysis* Zimmer, 1916

Afromysis dentisinus Pillai, 1957

Genus *Doxomysis* Hansen, 1912

Doxomysis longiura Pillai, 1963

Tribe Mysini Hansen, 1910

Genus *Mesopodopsis* Czerniavsky, 1882

Mesopodopsis orientalis W.M. Tattersall, 1908

Genus *Acanthomysis* Czerniavsky, 1882

Acanthomysis macrops Pillai, 1973

Genus *Lycomysis* Hansen, 1910

Lycomysis spinicauda Hansen, 1910

Genus *Anisomysis* Hansen, 1910

Anisomysis spinata Panampunnayil, 1993

Systematic discussion

Sub family BOREOMYSINAE Holt & Tattersall

Genus *Boreomysis* G.O. Sars

Boreomysis Sars, 1869, p.330; 1879a, p.8-10; 1885a, pp.177-178; Ortmann, 1894, pp.105-106 (key); Zimmer, 1904, pp. 429 - 430; 1909, p. 52; Hansen, 1910, p. 24; Illig, 1930, pp. 559-560 (key); Banner, 1948, pp. 361 - 62; W.M. Tattersall, 1951, p.45; O.S. Tattersal, 1955, pp. 66 - 68.

Diagnosis: Eyes well developed or rudimentary. Outer flagellum of antennule in both sexes swollen at the base and furnished with long sensory hairs; male appendages on the antennule short or small. Antennal scale with outer margin smooth and terminating into a spine; apex of scale truncate, small oblique distal suture present. Endopod of third to eighth thoracic limbs with sixth joint divided in to 2-3 sub joints by distinct articulation, of which the proximal one some times more or less oblique while the distal one always quite transverse. Pleopods of male well developed, biramous and natatory, endopod of the first pair rudimentary and unjointed; exopod of the second and third pairs more or less elongated; distal setae on the exopod of the third or both second and third pair some times very short and reduced. Telson cleft at the apex, the cleft armed with spines.

Remarks: The members of this genus are all deep-sea dwellers and a few species show rather wide distribution. Most of the species of this genus are rather similar with each other and are separated by only relatively minor characters. The close studies of W.M. Tattersall and O. S. Tattersall on the enormous species of this genus obtained by the *Albatross* or the *Discovery* proved that there are considerable variations in a single species according to sex or growth stages and they united several species to the older species as their synonyms respectively. The characters of the antennal scale, telson and uropod serve readily for the recognition of this genus. Although more than forty-five species are included in this genus, present collections contained only one species, *Boreomysis plebeja*.

Boreomysis plebeja Hansen

(Fig. 3.1 A-E)

Boreomysis plebeja Hansen, 1910, pp. 24-25, pl.2, figs 2a-d; Illig, 1930, pp. 414, 560; O.S. Tattersall, 1955, pp.68, 74, fig.11 A; Ii, 1964, pp.35, fig. 5 - 6.

Occurrence

Bay of Bengal: station 1351, 1 immature female.

Body length: immature female 6.2 mm

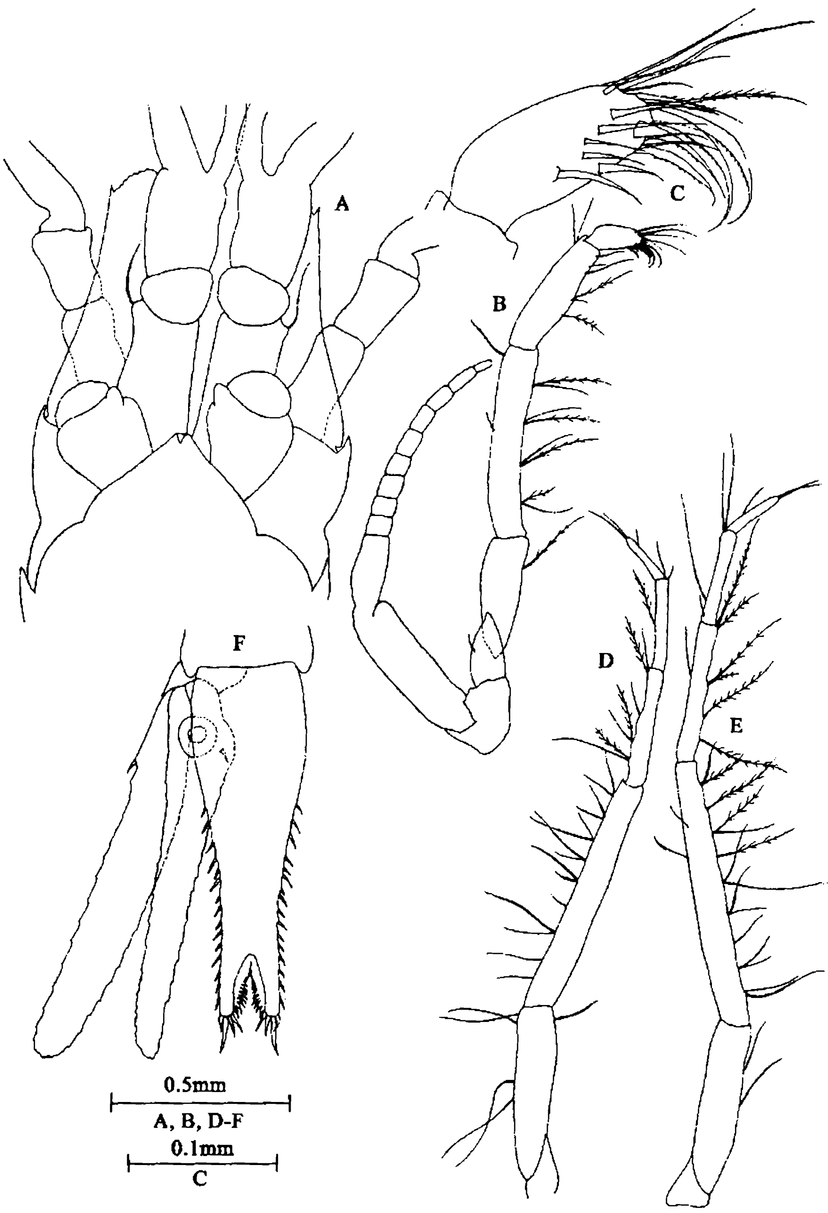


Figure 3.1. *Boreomysis plebeja* Hansen, Immature female. A, anterior part of body, B, Second thoracic limb, C, same, endopod tip enlarged; D, third thoracic endopod; E, seventh thoracic endopod.

Remarks: The present specimen is an immature female and agrees with Hansen's description of *Boreomysis plebeja,* especially in the lateral spinulation of telson and therefore referable to this species. *B. plebeja* was described in 1910 by Hansen from a single immature female captured by

Siboga Expedition. In 1930, Illig reported a single young female under this name from the Southern Atlantic Ocean, collected during *Valdivia Expedition* and Ii (1964) collected many immature females from Japan. In 1955, Tattersall obtained a single nearly adult male during *Discovery* collections but unfortunately its pleopods were badly damaged. The present specimen is closely related to *Boreomysis* sp. (Pillai, 1964) but is differentiated by the relative length of antennal scale and ocular papilla and the spinulation on the lateral border of telson. The present specimen well agrees with Hansen's type specimen except for some minor variations. In the present specimen antennal scale just reaches the tip of antennal peduncle while in type specimen and Ii's specimen antennal scale overreaches the antennal peduncle. In Ii's specimen two semiglobular protuberances are present on the dorsal median line at the posterior region of the carapace while in the present specimen, this protuberances are absent. Hansen also did not mention about this protuberances. In the present specimen ocular papillae is short as in type specimen whereas in Tattersall's immature male ocular papillae is long and extend beyond the anterior margin of the cornea. In type specimen, Hansen did not mention the spines on the uropod, whereas in present specimen there is a single spine on the endopod of uropod, just distal to the statosyst as in Ii's description, while in Tattersall's immature male specimen, endopod of uropod armed with two long delicate spines. The exopod of uropod is longer than endopod in Ii's specimen while in present specimen endopod and exopod is more or less same length. In the present specimen, third to eighth thoracic endopods are six segmented but in Ii's specimen, in third to eight endopod, sixth segment is divided to three sub joints by two articulations. These variations can be due to growth changes. The body length of type specimen is 8.2 mm, Tattersall's specimen, a nearly adult male measured 12.4 mm and the largest immature female was 14 mm while Ii's immature female measured 9 -

11 mm. This species is distinguished from allied species of this genus by the shape and spinulation of the telson.

Sub family SIRIELLINAE Norman

Tribe Siriellini

Genus *Siriella* Dana

Cynthia Thompson, 1828, p. 57.

Siriella Dana, 1850, p. 129.

Promysis Kroyer, 1861, p. 70.

Protosiriella Czerniavsky, 1882, p. 27.

Pseudosiriella Claus, 1884, p. 275.

Siriella Sars, 1885a, pp. 204-205; Zimmer, 1909, pp. 68-69; Hansen, 1910, pp. 27-31; Tattersall and Tattersall, 1951, pp. 141-144; Ii, 1964, p. 57; Pillai, 1965, p. 1987.

Diagnosis: Antennal scale with obliquely truncate and distally rounded apex, extending well beyond outer spine, outer margin naked except in *S. serrata* (Hansen, 1910) and *S. africana* Panampunnayil (1981). Eyes well developed. Labrum anteriorily produced into long spine except in *S. lingvura* (Ii, 1964), *S. jonesi* (Pillai, 1964) and *S. spinula* (Panampunnayil, 1995). Endopod of third to eighth thoracic limbs subsimilar, with carpus distinct and propdus sometimes with faint division; dactylus with large claw encircled by brush of stiff peculiarly serrated setae. Pleopods of male biramous with coiled or curved pseudobranchial lobes; exopod or endopod or both rami of third and fourth pleopods may or may not be modified. Pleopods of female reduced to simple plates; exopod of uropod divided by an obscure articulation; proximal segment externally spiny; inner margin of uropod spiny. Telson entire, linguiform, always armed at apex with three small spines except in *S. armata* (Milne- Edwards, 1837) and pair of plumose setae.

Remarks: Members of this genus show considerable variation with growth and many diagnostic characters undergo considerable changes which led to the formation of many new species which have later proved to be ill founded. This genus comprises a large number of species and about 69 species have hither to been recognized as distinct species. The females of this genus are often closely allied with each other and are hardly distinguishable while the character of the pleopods easily distinguishes the males.

Hansen (1910) divided the genus into four groups of species mainly by the combined character of telson, uropod and male pleopods. Later Ii (1964) formed six groups based on the modification of male pleopods, Thompsoni group - setae on the pleopods not modified; Aequiremis group- endopod of the fourth male pleopods with modified setae; Anomala group- endopod of third and fourth pleopods with modified setae; Dubia- group, endopod of both third and fourth pleopods with modified setae and proximal joint of outer uropod with both spines and setae on outer margin; Pacifica group - Both rami of both third and fourth male pleopods with modified setae, proximal joint of outer uropod normal and armed with spines only on outer margin; Inornata group - Terminal setae on both rami of the fourth male pleopods modified.

The genus at present is represented by 22 species in the Indian waters and the present collection contains only three species, *Siriella thompsoni* (Milne- Edwards), *S. gracilis* Dana and *S. aequiremis* Hansen.

Siriella thompsoni H.M.Edwards

(Fig.3.2 A-F)

Cynthia Thompsoni Milne-Edwards, 1837, p. 462.

Cynthia inermis Kroyer, 1861, p. 44, fig.6, a-g .

Siriella indica Czerniavsky, 1882, p. 103, figs. 1-6.

Siriella thompsoni G.O. Sars, 1885a, p. 205, pl .36, figs. 1-24; Thiele, 1905, pp. 447- 449, fig 7-9; Hansen, 1910, p.31; 1912, p. 192-193, Colosi, 1920, pp. 229-260; 1922, pp. 1-22; 1924, pp.1-7; Coifmann, 1936, pp. 21-23, fig. 12 a-e; W.M. Tattersall, 1923, p.280; 1926, p. 9; 1936a, p.145; 1939, p. 234; 1951, p. 60-61; O.S. Tattersall, 1955, p.84; 1962, pt 2, pp. 224- 225; Ii, 1964, p. 62, figs. 14-15; Pillai, 1973, p. 38, figs. 10-11; Panampunnayil, 2002, pp.371-390, fig. 1A-C.

Occurrence

Arabian Sea: station 1477, 1 immature female and 1 juvenile; station 1479, 1 mature male and 1 spent female; station 1481, 1 mature male, 1 immature female; station 1482, 2 mature males, 2 immature males, 2 spent females, 2 females with eyed larvae, 2 immature females and 2 juveniles; station 1489, 1 juvenile; station 1496, 1 immature female; station 1498, 2 immature females and 1 juvenile; station 1499, 1 mature male, 1 immature female, 1 immature male and 1 female with eyed larvae; station 1501, 1 immature male.

Bay of Bengal: station 1641, 1 spent female; 1642, 1 spent female; station 1657, 4 mature males, 3 spent females and 2 immature females; station 1665, 2 mature males and 1 spent female; station 1670, 1 mature male and 2 immature males.

Andaman Sea: station 1338, 1 female with eyed larvae; station 1340, 1 immature male, 1 spent female and 1 juvenile; station 1462, 1 mature male.

Body length: mature male 4.9 - 7.5 mm mature female 5.5 - 7.7 mm

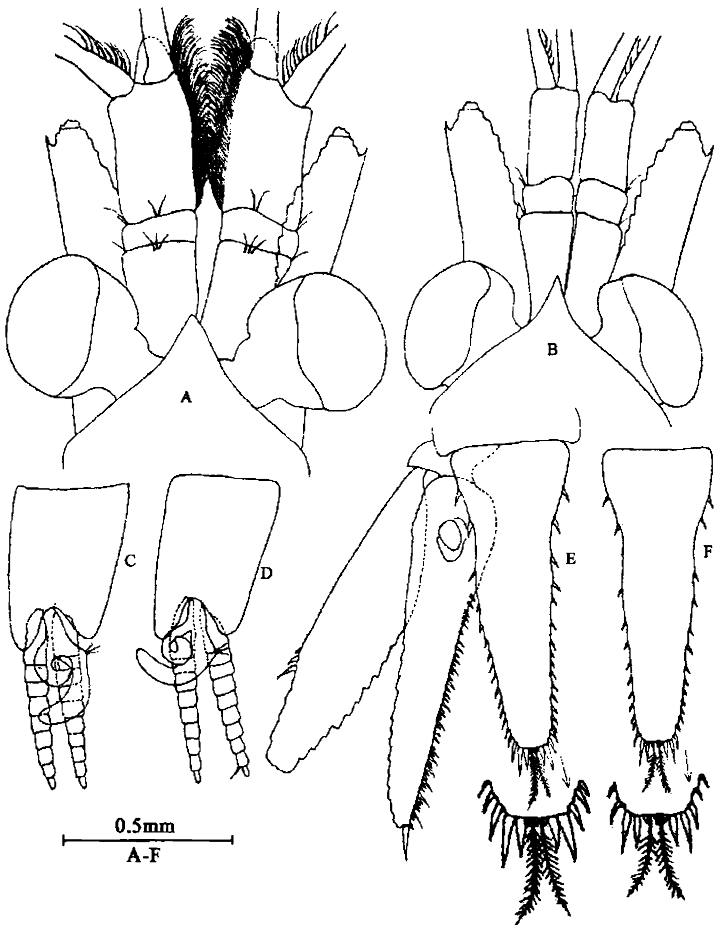


Figure 3.2. *Siriella thompsoni* (Milne-Edwards), Male. A, anterior part of body; B, anterior part of body of female; C, third pleopod; D, fourth pleopod; E, posterior part of body of female; F, telson of female.

Remarks: *S. thompsoni* belongs to the thompsoni group. This species can be easily distinguished by the sub-truncated apex of the telson, relative length and acuteness of rostral projection, the number of spines arming the outer margin of the outer uropod, the number of spines on the lateral margin of the telson.

The present specimens agree with the published descriptions and figures but show some variations in the following characters. In Ii's specimens, the rostrum is a narrow triangular plate extending to 1/3 of first segment of antennule and not covering the eyestalks. Pillai has shown it as low triangular apically pointed rostrum leaving the eye stalks completely uncovered in male and it is little more produced just covering the base of the eye stalks in female, while in the present specimen, it is more produced and extend to the middle of the first segment of the antennular peduncle covering the base of the eye stalks as described as Panampunnayil (2002). In the case of relative length of the apical spines in the telson, the present specimens agree with the description of Ii in having the outer pair of spines larger than the inner in both male and female, while in Panampunnayil's specimen, male inner pair is longest and in female outer pair is longest. In the present specimen, the exopod of uropod has three outer spines in both sexes, and in Pillai's material the male has four and female has two spines, as that of Panampunnayil's specimen. The body length of Sar's specimen is 10 mm, while Ii's, Pillai's and Panampunnayil's specimen have length of 5.5 - 9.5 mm, 5 - 6 mm, and 5 - 5.5 mm respectively.

Siriella gracilis Dana

(Fig.3.3 A-E)

Siriella gracilis Dana, 1852, p.655; Sars, 1885a, p.209, pl 36, figs.25-28; Hansen, 1910, p.31; Hansen, 1912, p.193; Colosi, 1918, p.6; 1920, p. 235; 1924, p 1-75; Illig, 1930, p 419; Coifmann, 1936, p.25 pl 10, figs. 14a-e, pl 11, fig 14; W.M. Tattersall, 1939, p.235; 1951, p. 62; O.S. Tattersall, 1955, p. 86; Ii. 1964, p. 72, fig. 16; Pillai, 1964, p. 6; 1973 p. 42, fig. 12; Bacescu, 1979a, p.128; Panampunnayil, 2002, p. 372.

Occurrence

Arabian Sea: stations, 1398, 1401, 1409, 1410, 1411, 1431,1453, 1476, 1477, 1479, 1481, 1482, 1487, 1488, 1489, 1490, 1494, 1495, 1496, 1498, 1499, 1501, 1504,1506, 1509, 1518, 1693, 1674, 1677, 1678, 1682, 1685, 1686, 1688, 1691, 1699 and 1703.

Bay of Bengal: stations, 1238, 1239, 1241, 1243, 1247, 1249, 1257, 1356, 1357, 1367, 1642, 1647, 1648, 1649, 1650, 1653, 1655, 1656, 1657, 1665, 1670, 1671, 1909, 1897, 1819,1902, 1996, 1907, 1905 and 1908.

Andaman Sea: station 1201, 1203, 1204, 1206, 1207, 1208, 1209, 1211, 1212, 1213, 1214, 1338, 1340, 1442, 1447, 1448, 1462, 1474, 1524, 1530, 1532, 1535, 1538, 1541 and 1542.

Body length: mature male 5.5-7 mm, mature female 4.5-5.8 mm

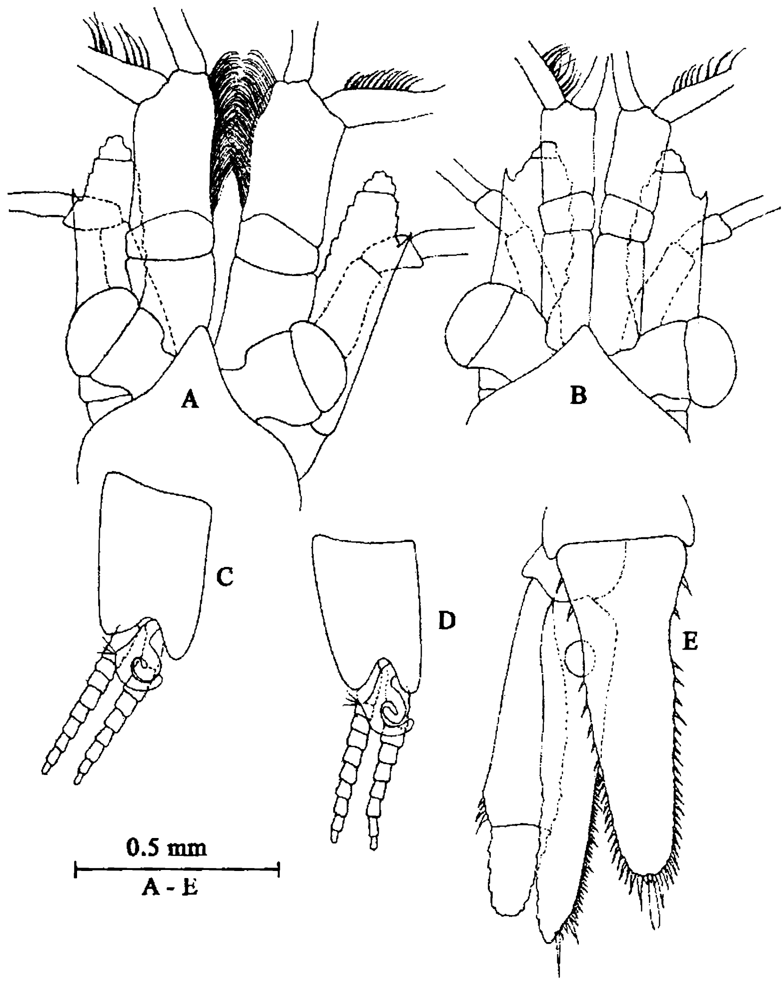


Figure 3.3. *Siriella gracilis* Dana, Male. A, Anterior part of body; B, anterior part of body of female; C, third pleopod; D, fourth pleopod; E, posterior part of body of female.

Remarks: The present specimens very well agree with Pillai's (1973) description, except that the rostrum in male is more produced and extending to 1/3 of the base of the first antennular segment while in Pillai's specimen, the rostrum in male is low and does not over reach the base of the antennular peduncle. In this aspect, the present specimens agree with the Panampunnayil's description (Panampunnayil, 2002). The largest specimen recorded by Panampunnayil have a length of 7.4 mm. Ii's (1964) and Pillai's (1964) specimens measured 7 mm.

Siriella aequiremis Hansen

(Fig.3.4 A-E)

Siriella aequiremis Hansen, 1910, p 41, p 13, figs. 4a-c, pl 4, figs. 1a-1; 1912, p. 194; Colosi, 1918, p. 6; 1920, p. 236, pl 18, fig. 19; Illig, 1930, p. 562; Coifmann, 1937, p. 3; W.M.Tattersall, 1951, p. 78; O.S. Tattersall, 1955, p. 86; Ii, 1964, p. 135, fig. 36-37; Pillai, 1973, p. 47, fig.15-16. Panampunnayil, 2002, p. 374, fig. 2A, B.

Occurrence

Arabian Sea: station 1479, 1 mature male, 4 immature males and 3 juveniles; station 1481, 1 mature male and 2 immature females; station 1482, 2 mature males, 2 spent females and 1 immature female; station 1489, 1 mature male, 1 immature female and 5 juveniles; station 1496, 1 immature female; station 1501, 1 immature female.

Andaman sea: stations 1442, 1 immature male; 1447 1 immature male; 1457 1 female with eye less larvae; station 1524, 1immature female; station 1530, 1 female with eyeless and 1 mature male; station 1538, 1 juvenile; station 1542, 1 immature female and 1 juvenile.

Body length: mature male and female 8 - 9.7 mm

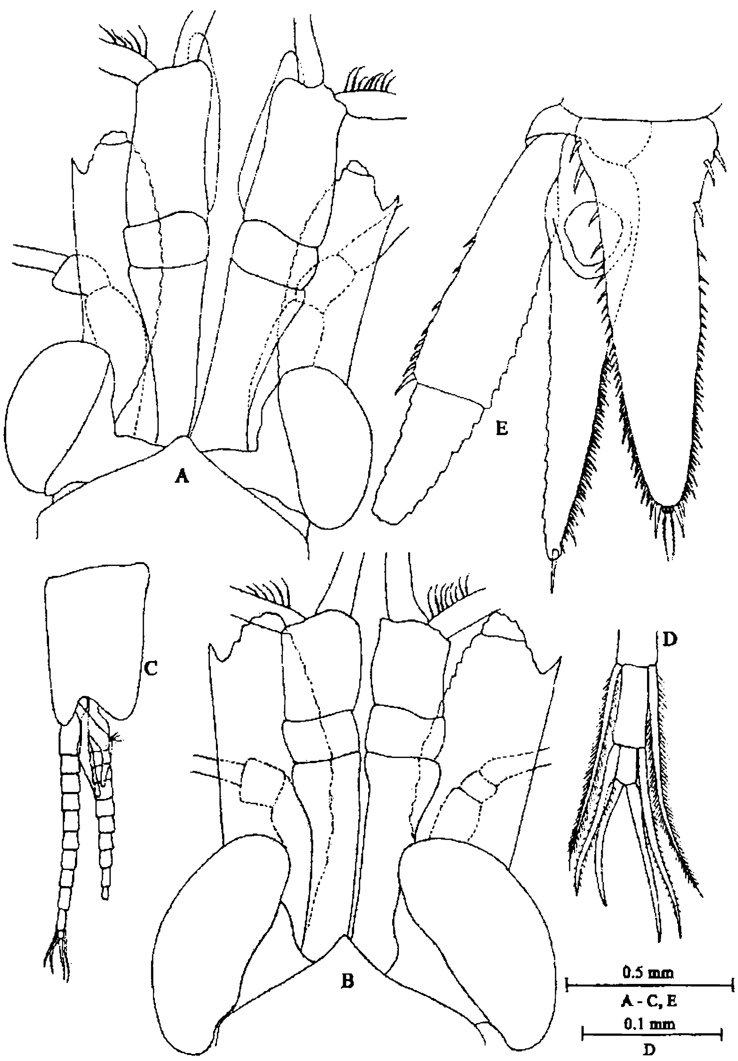


Figure 3. 4. *Siriella aequiremis* Hansen, Male. A, anterior part of body; B, anterior part of body of female; C, fourth pleopod; D, same, tip of exopod; E, posterior part of body of female

Remarks: This species can be readily recognized by the robust body, characteristically modified setae of the fourth pleopod of the male, and the spinulation of the telson and uropods. The present specimens agree with the published descriptions except for some minor variation. In the present specimens the modified setae on the penultimate segment of the endopod of the fourth pleopod of male are secondarily armed with fine hairs and spinules while setae on the ultimate segment is naked. In Pillai's specimen all the modified setae are naked, while in Panampunnayil's specimens all setae secondarily armed with fine hairs and spinules. This species is one of the largest species of *Siriella* and is widely distributed in the oceanic waters, adult measuring between 8 - 11.6 mm.

Genus *Hemisiriella* Hansen

Hansen, 1910, p. 45; Ii, 1964, p. 149; Pillai, 1965, p. 1987.

Diagnosis: Carapace short. Antennal scale shorter than antennal peduncle. Endopod of third thoracic limb extremely elongated, sixth joint divided into two sub-joints, dactylus rudimentary. Endopod of fourth to eight thoracic limbs as in genus *Siriella*. Pseudobranchial lobes on second to fourth pleopods spirally twisted, none of the setae modified. Telson and uropods nearly as in *Siriella*.

Remarks: This genus includes four species, *H. abbreviata* (Hansen, 1912) *H. gardineri* (W.M. Tattersall, 1912) *H. purva and H. pulchra*, of which *H. parva and H. pulchra* are represented in the Indian waters. The present collection contains only *H. parva*.

Hemisiriella parva Hansen.

(Fig. 3.5 A-F)

Hemisiriella parva Hansen, 1910, p.47, pl. 6, figs. 2a-e; Zimmer, 1918, p. 16, figs. 5-7; Colosi, 1918, p. 6; 1920, p. 236, pl. 18, fig. 2a; W.M. Tattersal, 1922, p. 456; 1936, p. 147; 1951, p. 80; Delsman, 1939, p. 167; Ii, 1964, p. 161, figs. 42-43; Pillai, 1964, p. 13, fig. 7; 1973, p. 53, figs. 22-23. Panampunnayil, 2002, p. 374.

Occurrence

Arabian Sea: station 1678, 1 juvenile; station 1485, 1 mature male.

Bay of Bengal: station 1650, 1 immature male and 1 female with eyed larvae.

Andaman Sea: station 1201, 1mature male, 1 spent female and 1 juvenile; station 1209, 1 mature male; station 1460, 1 juvenile; station 1535, 1 immature male; station 1538, 1 mature male and 1immature female.

Body length: mature male 5.8 - 7.1 mm, mature female 4.5 - 6 mm

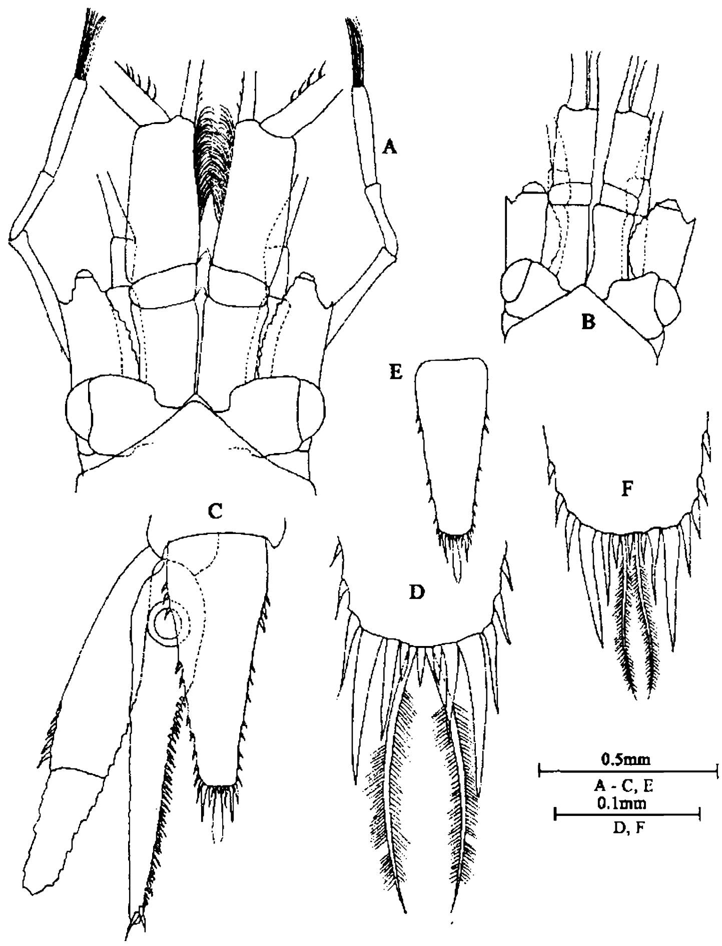


Figure 3.5. *Hemisiriella parva* Hansen, Male. A; anterior part of body; B, anterior part of body of female; C, posterior part of body of female; D, tip of telson; E, telson of female; F, same, tip enlarged.

Remarks: This species can be readily distinguished from other Indian species, *H. pulchra* by the following points. In *H. parva* the endopod of the uropod clearly overreaches the exopod while in *H. pulchra* the endopod is as long as or slightly shorter than the exopod. In *H. parva* the telson lack waist and steadily narrows towards the apex and the apex is armed with three pair of large spines and three pair of small spines. In *H. pulchra* telson has a marked constriction at the basal one fourth and the apex of the telson is armed with only two pairs of large spines and three pairs of small spines. The present specimens closely resemble those described by Pillai (1973). In Panampunnayil's specimens, in female the outer and middle pair of spines on the apex of telson are nearly equal in size while in the present specimen middle pair is long as in Pilla's specimen. The present specimen is the largest recorded from the Indian Ocean (7.1 mm).

Sub family RHOPALOPHTHALMINAE Hansen

Genus *Rhopalophthalmus* Illig

Rhopalophthalmus Illig, 1906, p. 207; Hansen, 1910, p. 48; O.S. Tattersall, 1957, pp. 86; Ii, 1964, p. 166; Pillai, 1967, p. 1694.

Diagnosis: Carapace short with a pair of postorbital spines continued backwards as dorsal keels, a pair of dorso median nodules may be present. Antennal scale long and narrow, outer margin naked with strong outer distal spine, sympod armed with two or more spines, triangular fleshy out-growth present on the dorsal surface covering adjacent halves of base of scale and peduncle. Thoracic endopods three to seven with varying number of carpopropodal segments, eighth endopod reduced in size showing pronounced sexual dimorphism. First abdominal segment in male with small rounded pleura. Pleopods in male all biramous and multiarticulate, second pair with exopod greatly elongated and armed at distal end with modified setae; endopod normal, pseudobranchiae in the form of large lobed plates. Pleopods in female unsegmented, simple and rod like. Rami of uropods two segmented, endopod with single stout spine below statocyst. Telson linguiform, entire with lateral margin armed distally with row of six to seventeen strong spines regularly increasing in length, distal border armed with two pairs of long barbed spines.

Remarks: The genus *Rhopalophthalmus* was instituted by Illig (1906) for the reception of type species *R. flagellipes* captured by the S.S. *Valdivia* off Banana in the Congo Estuary. Of the twenty species which have up to the present been referred to this genus, only nine species - *R. chilkensis* (W.M. Tattersall, 1951), *R. kempi* (W.M. Tattersall 1957), *R. tattersallae* (Pillai, 1957), *R. indicus* (Pillai, 1961), *R. macropsis* (Pillai, 1964), *R. mumbayensis*, *R. murudana*, *R. vijayii* and *R. anishii* (Panampunnayil and Biju, 2006) have been recorded from the Indian waters and the present collections contain only one species. The species of this genus are distinguished from each other by the number of spines on antennal sympod, carpoprodal segments in the thoracic endopod and number of lateral spines on the telson.

Rhopalophthalmus indicus Pillai

(Fig.3.6 A-F)

Rhopalophthalmus indicus Pillai, 1961, p. 20.

Occurrence

Bay of Bengal: station 1665, 2 immature males.

Body length: immature male 5.7 mm

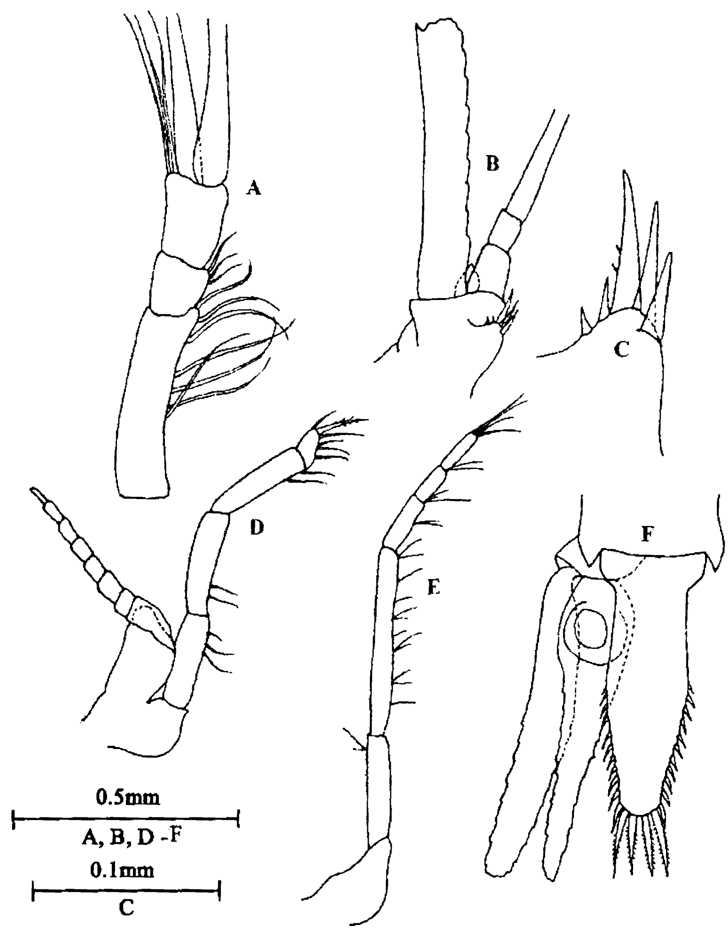


Figure 3.6. *Rhopalophthalmus indicus* Pillai. Immature female. A, antennule; B, antenna; C, antennal sympodial spines; D, second thoracic limb; E, seventh thoracic endopod; F, posterior part of body.

Remarks: This species is easily identified from the other species of this genus by the presence of five spines on the antennal sympod (except *R. phyllodus* (Murano, 1986a) 4 - 5 propodal segments of thoracic endopods 3-7, relative length of the eighth thoracic endopod of male and female and relative length of the apical spines of the telson. Though the present specimen is an immature female, it is referable to *R. indicus* in having five spines in the antennal sympod. In the case of number sympodial spine this species resembles *R. phyllodus* have also 5 spines in the antennal sympod, but this species is distinguished from *R. indicus* by the sharply pointed subsidiary teeth in the apical spines of the telson and body length. Body length of *R. phyllode* is 9.2-11.6 mm while *R. indicus* is the largest species of this genus with body length of 15 -17 mm. In present specimen largest sympodial spine is secondarly armed with two small spines in the outer margin, the lateral margin of the telson has only 11 spines while in adult it is 14. In the case of carpoprodal segments, the present specimens have only 3 in seventh endopod while in adult it is 5-6. The above difference from the type specimen may be due to the immaturity of the present specimen.

Subfamily GASTROSACCINAE

Genus *Gastrosaccus* Norman

Gastrosaccus Norman, 1868, p. 438.

Haplostylus Kossmann, 1880, p. 95.

Gastrosaccus Tattersall and Tattersall, 1951, p. 160.

Diagnosis: General form slender. Hind border of carapace deeply emarginate, with filaments, or reflected lappets or entire; rostral plate generally small and triangular. Eyes small and cylindrical. Antennal scale short, outer margin without setae and terminating in strong spine. Labrum produced anteriorly into long spine. Sixth joint of endopod of third to eighth thoracic limbs multisegmented. First abdominal segment of female with expanded pleural plates forming part of marsupium. Pleopods in male biramous, exopod of third pair elongated and multisegmented. First pair of pleopods in female biramous or uniramous, remaining pairs simple unsegmented plates. Telson long, quadrangular with apical cleft, lateral margin and cleft through out armed with spines. Exopod of uropod externally armed with spines, inner border of endopod with sharp spines.

Remarks: Norman (1868) instituted the genus *Gastrosaccus* for those forms in which the pleural plates of the first abdominal somite in female are produced to form part of the brood pouch. The peculiar lobes on the hind border of the carapace in some species were regarded as being quite constant and Kossmann (1880) instituted a new genus *Haplostylus* for those in which they did not occur. It has since been found that this character is not constant and the genus *Haplostylus* was abolished (Tattersall and Tattersall, 1951) and all the species with or without lobes on the hind border of the carapace were included in the genus *Gastrosaccus*. Bacescu (1973a) reinstated the generic name *Haplostylus* to accept those species in which the endopod of the third pleopod of the male was uniarticulate and transferred all the species having this character to the above genus. In 1995, Murano instituted another genus, *Eurobowmaniella*, for those species having complicated copulatory organ in the exopod of third male pleopod and labrum with subsidiary spines in addition to a median long process and transferred *G. muticus* and *G. simulans* to this genus.

The genus *Gastrosaccus* now includes only those species in which the endopod of the third pleopod of male is multiarticulated and *G. dunckeri* (Zimmer, 1915) is the only Indian species.

Gastrosaccus dunckeri Zimmer

(Fig.3.7 A-B)

Gastrosaccus dunckeri Zimmer, 1915, p. 165, figs 13-18; W.M. Tattersall, 1922, p. 459; Pillai, 1957, p. 7, fig. 111, 1-7; O. S. Tattersall, 1960, p. 170, figs, 2 A - N; Pillai, 1961, p. 25, pl 111, figs. K - N; 1964 p. 17, fig. 9; 1973 p. 61- 64, figs. 28-29; Ii, 1964, p. 235 and 580, fig. 59.

Occurrence

Arabian sea: station1504, 2 mature males.

Body length: mature male 8.2 - 8.6 mm

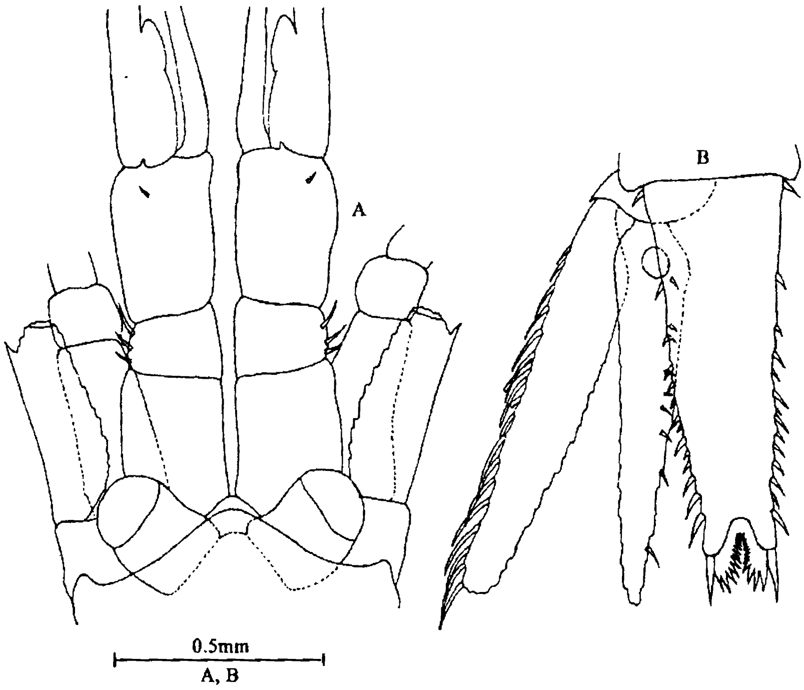


Figure 3.7. *Gastrosaccus dunckeri* Zimmer, Male. A, anterior part of the body; B, posterior part of the body.

Remarks: This species was created by Zimmer (1915) for specimens collected from an unspecified locality in Indian Ocean between Ceylon and New Guinea. The present specimens closely resemble the published description and figures of *G. dunckeri* by Panampunnayil (1999a).

According to Pillai (1973) *G. dunckeri* collected from the inshore waters of Kerala have a different type of telson in which the spines arming the telsonic sinus are very long and the distal ones are bent towards the median line. The shape and armature of the telson and the spinulation of the inner uropod easily distinguishes this species from all the other species of the genus.

Genus *Haplostylus* Kossmann

Haplostylus Kossmann, 1880, p. 95; Bacescu, 1973a, p.321; Hatzakis, 1977, 271-273; Fenton, 1990, p. 443- 445.

Diagnosis: Carapace with small triangular rostrum, hind border of carapace deeply emarginated with or without reflected lappets. Antennal scale short, outer margin terminating in spine. Labrum anteriorly produced into spine. Thoracic endopods three to eight with several carpopropdal segments. First abdominal segment in female with expanded pleural plates. Pleopod one in female biramous, others simple unsegmented plates. Pleopods 1, 4^{th} and 5^{th} in male with unsegmented endopod and multisegmented exopod. Exopod of third pleopod long and many segmented, endopod rudimentary reduced to mere lobe. Telson long with armed apical cleft, lateral border throughout armed. Exopod of uropod externally armed with spines; inner border of endopod with sharp spines.

Remarks: The genus *Haplostylus* was established by Kossmann (1880) and included all those species that lacked lobes on the posterior margin of the carapace. This was later found to be a poor character and all the species were placed in the closely allied genus *Gastrosaccus* and *Haplostylus* was abandoned. Later in 1973, the generic name *Haplostylus* reinstated by Bacescu to accept those species in which the endopod of the third male pleopod was uniarticulate. Since then this classification has been followed and many of the *Gastrosaccus* species having this character was transferred to the genus *Haplostylus*.

At present this genus includes 26 species. The present collections contain only one species, *Haplostylus pusillus*.

Haplostylus pusillus Coifmann

(Fig.3.8 A-F)

Gastrosaccus pusillus Coifmann, 1936, p. 30, fig. 19; Pillai, 1973, p. 64. figs. 30, 31.

Haplostylus pusillus Hatzakis, 1977, p. 284; Bacescu, 1979a, p.128, fig. 1A; Panampunnayil, 2002, p. 377, figs. 4 A-I.

Occurrence

Andaman Sea: station 1532, 1 spent female; station 1533, 1 spent female; station 1448, 4 mature males.

Body length: mature male 5.1-7.2 mm, mature female 5.8 mm

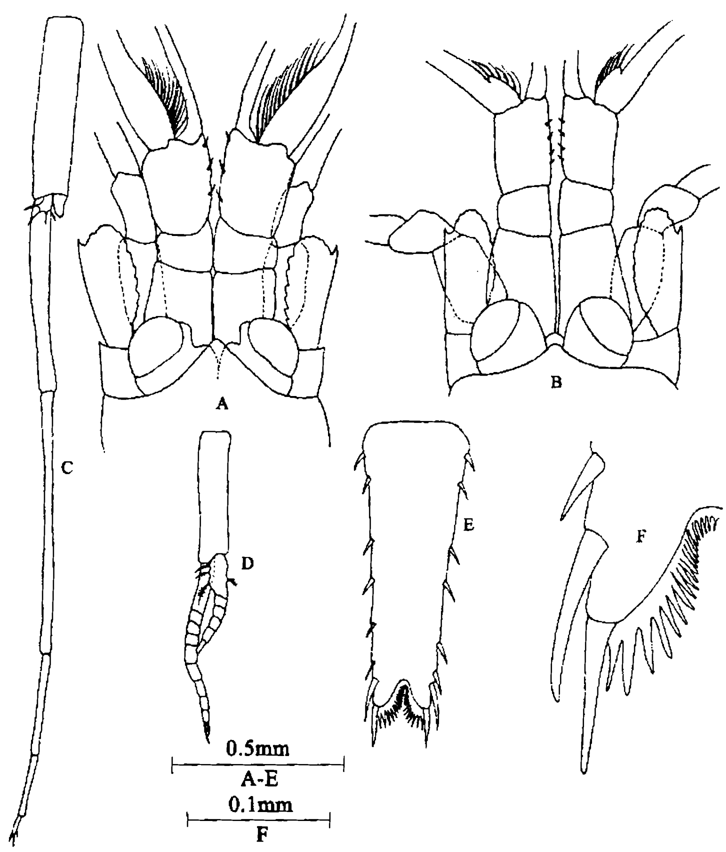


Figure 3.8. *Haplostylus pusillus* Coifmann, Male. A, anterior part of body; B, anterior part of body of female; C, second pleopod; D, Third pleopod; E, telson of male; F, same, tip enlarged.

Remarks: This species was originally briefly described by Coifmann for specimen collected in the Red Sea. Later Pillai (1973) published a detailed fully illustrated description based on a single adult male collected in the Andaman Sea pointing out certain difference observed. Though the present specimens very well agree with description given by Pillai, they show some variations in some of the characters. In the present specimens the antennal scale overreaches the second segment of the antennal peduncle. In Pillai's specimen, the antennal scale stops short of the distal end of the second segment of antennal peduncle. The endopod of the second pleopod of male is six segmented. According to Pillai, it is eight segmented. The second segment of the exopod of the third pleopod is 1.3 times longer than the first segment. In Pillai's specimen the second segment is as long as the first segment. In the above aspect, present specimens agree with Panampunnayil's description. In the present specimens telsonic cleft is armed with 15 pairs of spines while in Pillai's and Panapunnayil's specimens these are 10 and 17-20 pairs respectively.

Genus: *Eurobowmaniella* Murano

Eurobowmaniella Murano, I995, p. 21; 1996, p. 65.

Diagnosis: Carapace produced anteriorly into triangular rostrum, postereodorsal margin emarginated with 6-10 filaments. Antennular peduncle with second segment armed with spines. Labrum with median strong process and pair of subsidiary spines on frontal margin. Third to eighth thoracic endopods with 7-11 carpoprodal segments. Pleopods in male biramous, first, fourth and fifth endopod unsegmented, and exopod multisegmented. Second and third pleopod with multisegmented endopod and exopod. Third exopod extremely elongated, modified as complicated organ. Pleopods in female with first pair biramous and second to fifth pairs uniramous. Telson distally cleft, lateral margin with spines. Exopod of uropod with spines on entire outer border, endopod with four spines on inner margin.

Remarks: This genus was instituted by Murano (1995a). This genus is closely related with *Bowmaniella*, but is easily distinguished by the presence of complicated copulatory organ in the exopod of third male pleopod and labrum with subsidiary spines in addition to the median long process. The name *Eurobowmaniella* is derived from "Euro" means eastern, and " bowmaniella" the most related genus Bowmaniella.

In the Indian water this genus is represented by two species *E. muticus* and *E. simulans,* and the present collection contains only *E. simulans.*

Eurobowmaniella simulans Tattersall

(Fig. 3. 9 A-G)

Gastrosaccus simulans W.M. Tattersall, 1915, p. 155, fig.1c; 1922, p. 460; Pillai, 1957, p. 6, fig. II 6-8; 1961, p. 24, pl. 3, figs. I, J; 1965, fig. 29; Muller, 1993, p.81.

Erobowmaniella simulans phuketensis Murano, 1995a, 22, figs.1-3.

Erobowmaniella simulans Murano, 1996, p. 65.

Occurrence

Arabian Sea: station 1684, 4 mature male, 2 immature male, 4 females with eyed larvae, 2 females with eyeless, 6 females with egg, 4 immature female, larvae, and 2 juveniles; station 1707, 3 mature male, 4 immature males, 1spent female, 2 female with eyed larvae, 1 female with eyeless larvae, 3 female with egg, 3 immature females and 7 juveniles.

Body length: mature male 7 -7.5 mm, mature female 7- 8.4 mm.

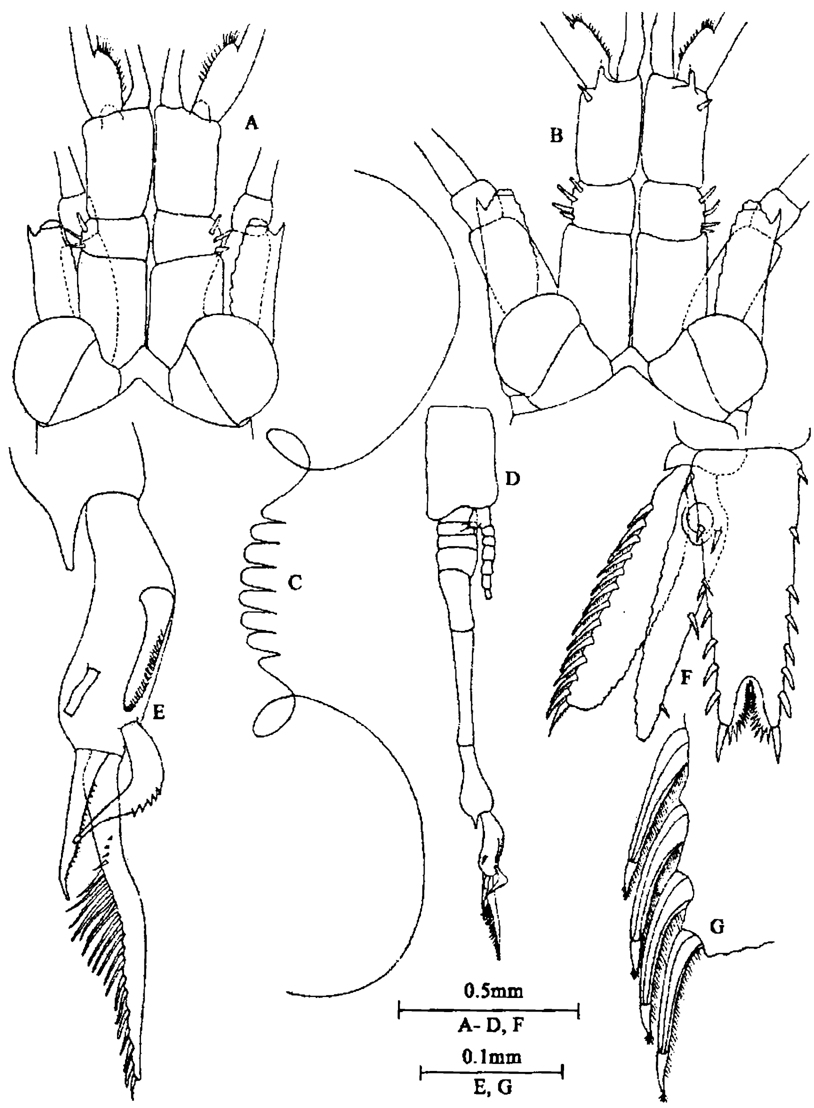


Figure 3.9. *Eurobowmaniella simulans* W.M Tattersall, Male. A, anterior part of body; B, anterior part of body of female; C, hind border of carapace; D, third pleopod; E, same, tip of endopod enlarged; F, posterior part of body; G, same, tip of exopod of uropod enlarged.

Remarks: This species can be easily distinguished from *E. muticus* by the following points. In *E. simulans* the hind border of carapace with 6 to 8 filaments while in *E. muticus* hind border with 8 to 10 filaments. In *E. simulans* exopod of third pleopods of male is eight segmented while in *E. muticus* it is five segmented. In *E. simulans* lateral border of telson has 8 pines on against 10 -15 in *E. muticus* lateral border of telson has 10 to 15 pines.

Genus *Anchialina* Norman and Scott

Anchialus Kroyer, 1861, p. 53; Sars, 1885a p.192.

Anchialina Norman and Scott, 1906, p.24; Hansen, 1910, pp. 50-51; Illig, 1930, p.564; Tattersall and Tattersall, 1951, pp. 179-180; Ii, 1964, p.186-188; Pillai 1965; Wang and Liu, 1987, p. 218; Jo and Murano, 1992, p.1

Diagnosis: Body short, robust. Hind border of carapace nearly straight, base of outer flagellum in male swollen. Antennal scale short; outer margin terminating in small spine. Mandible with *laciniae mobilis*, spine row and molar tubercle. First pair of thoracic limbs with strong claw. Second thoracic endopod in female simple; in male fifth segment internally expanded; sixth joint of endopod tree to eight with few sub segments. First abdominal segment with pair of lateral plates. Pleopods in female rudimentary; in male well developed, exopod of third pleopod modified. Exopod of uropod shorter than endopod, outer margin armed with small spines; endopod with long and short spines. Telson large, deeply cleft, lateral margin and cleft armed with spines.

Remarks: The identification of the genus *Anchialina* is most reliably done based on modifications of the exopod of the third male pleopod, except in *A. agilis* and *A. oculata*, where the identification is based on presence or absence of a lamella on the ocular peduncle. The genus *Anchialina* is divided into two groups based on the structure of the third male pleopod. The *typica* group has an exopod without lobiform processes among the distal modification and the *grossa* group has more or less distinct lobiform processes. Of the 19 species which have up to the present been referred to this genus, 4 species, *A. dentata*, *A. grossa, A. typica,* and *A. media* have been recorded from Indian waters and the present collections contain all the four species.

Anchialina typica Kroyer

(Fig.3.10 A-G)

Anchialina typicus Kroyer, 1861, p. 53, pl, 2 figs. 7a-1; Sars, 1885a, pp. 193-197, pl. 34, figs. 4-24.

Anchialina typica Hansen, 1910, pp. 52-59, pl. figs. 2a-1c; 1912, p. 196; 1925, fig.6a; Colosi, 1918, p.7; W.M. Tattersall, 1922, p. 445; 1926, p. 9; 1936, p.148; Delsman, 1939, p.166, fig. 18; Illig, 1930, p. 565; Nouvel, 1943, p.70, figs.109- 110; W.M. Tattersall, 1951, P. 100; Banner, 1954, p.580; O.S. Tattersall, 1955, P. 89, fig. 25, A-M; 1960, p. 175; 1962, p.230; 1965, p. 82; Ii, 1964, p. 188, figs. 48 A-L; Pillai, 1964, p. 18, fig. 10 a-i; 1965, P. 1700, figs. 32-34; 1973, p.69-70, fig. 32. Brattegard, 1970a, p. 24, figs. 6A-D; 1973, p. 16; Bacescu and Ortiz, 1984, p.16, fig. 1B; Wang and Liu, 1987, p. 222, fig.9, 1-14; Panampunnayil, 2002, p. 377.

Occurrence

Arabian Sea: station 1504, 10 mature males, 2 immature females, 5 immature males, 1 female with eyed larvae, 1 female with eye less larvae (13 larvae) and 2 juveniles; station 1515, 1 immature female and 3 juveniles; station 1688, 2 immature female and 1 juveniles.

Bay of Bengal: station 1257, 1 spent female, 2 females with eye less larvae and 4 juveniles; station 1646, 1 immature male; station 1904, 1 female with eyed larvae; station 1905, 1 female with eyeless larvae.

Andaman Sea: station 1542, 3 mature males, 1 spent female, 1 immature female and 2 juveniles.

Body length: mature male 5.2 - 5.4 mm, mature female 5.5 - 5.7

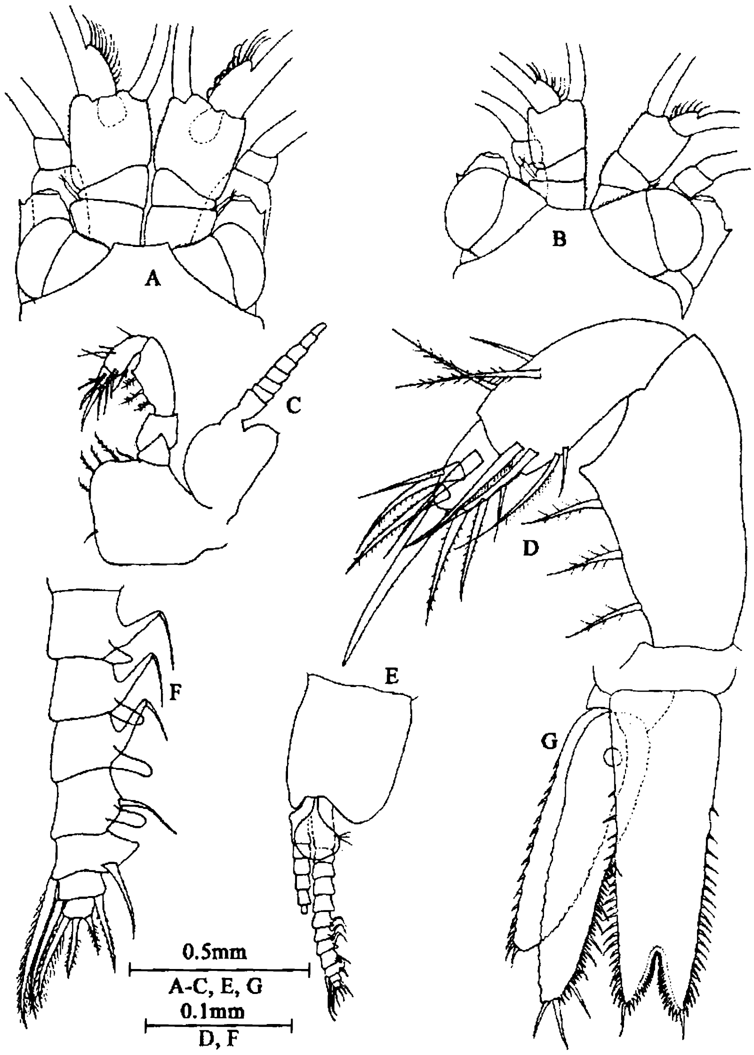


Figure 3.10. *Anchialina typica* Kroyer, Male. A, anterior part of body; B, anterior part of body of female; C, second thoracic endopod; D, same, distal part enlarged; E, third pleopod; F, same, tip enlarged; G, posterior part of body.

Remarks: This species belongs to the *typica* group and can be easily distinguished from other species by the shape of the rostrum, the modified setae on the third thoracic endopod of male and the armature of the third pleopod. The largest size for the present specimen is 5.7 mm. Kroyer's (1861) type specimen and Pillai's (1973) specimen measured 7 mm and Ii's (1964) was 5 mm and Hansen's (1910) largest male measured 6 mm.

Anchialina grossa Hansen.

(Fig. 3.11 A-B)

Anchialina grossa Hansen, 1910, P. 54, pl. 7 fig. 3; 1912, p. 96.

Anchialina frontalis Zimmer, 1915, p. 159, figs. 1-6.

Anchialina grossa W.M. Tattersall, 1922, p.458, fig. 6; 1936, p.148; 1951, p. 102; Ii, 1964, pp. 202 - 204, figs. 53K-M; Pillai, 1965, p.1701, figs.35 - 38; Wang and Liu, 1987, p. 218, figs. 7, 1-12; Panampunnayil, 1999a, p.173, fig 6.9.

Occurrence

Andaman Sea: station 1532, 1 immature male; station 1532, 1 immature female.

Body length: immature male 3.4 mm, immature female 3.4 mm

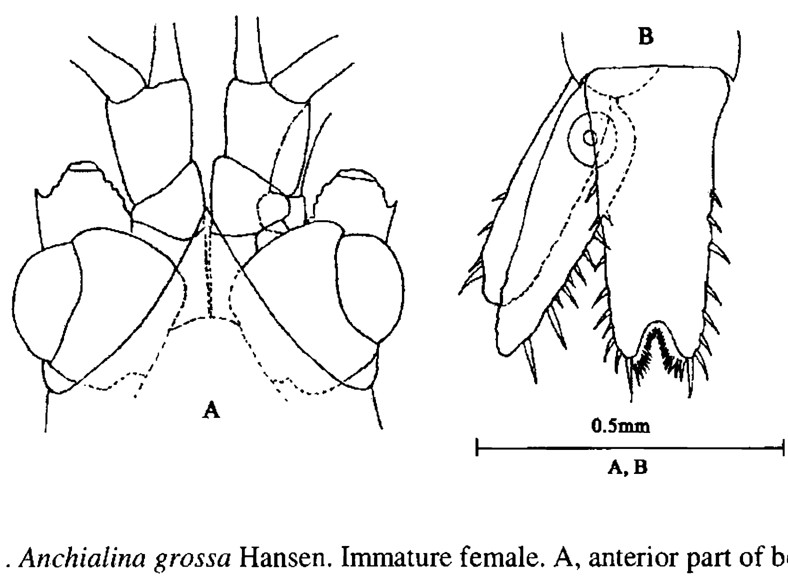


Figure 3.11. *Anchialina grossa* Hansen. Immature female. A, anterior part of body; B, anterior part of body.

Remarks: The specimens are too immature to be identified with any species. The species of *Anchialina* are identified based on the shape of the third pleopod of the male. In the present specimen is immature female and the only reliable character is the large triangular acuminated rostrum. Such type of rostrum has been recorded for species like *A. grossa* (Hansen, 1910), *A. obtusifrons* (Hansen, 1912), *A. sanzoi* (Coifman, 1936), *A. media* (Ii, 1964) and *A. pillaii* (Jo and Murano, 1992) Among these *A. grossa* has been recorded from the present area by earlier workers and based on the geographical range present immature specimens are tentatively referred to *A. grossa.*

A. grossa is distinguished by allied species by typical lamellar process of the exopod of the third pleopod in the male, triangular pointed rostrum in both sexes and the length of the endopod of the uropod

Anchialina dentata Pillai

(Fig. 3.12 A-G)

Anchialina dentata Pillai, 1964, p. 19; fig. 11.

Anchialina purva Ii, 1964, 196-201, figs. 50-51; O.S. Tattersall, 1965, P.83.

Anchialina dentata Pillai, 1973, 70 -72, figs. 33-34; Murano, 1990a p. 195; Panampunnayil, 2002, p. 378, figs. 5 A-D.

Occurrence

Arabian Sea: station 1490, 2 mature males, 4 immature females, 4 spent female, 1 female with eyeless larvae, 1 female with egg and 1 juveniles; station 1504, 2 mature males, 1 immature female and spent females.

Body length: mature male 6 - 7 mm, mature female 5.7 - 6.2 mm

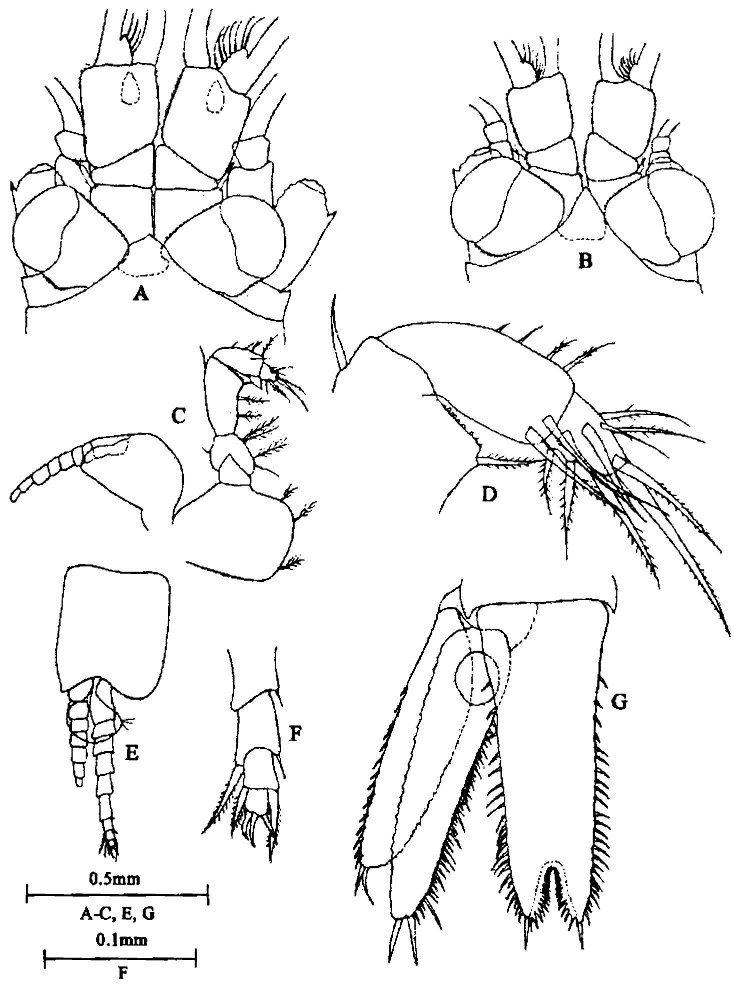


Figure 3.12. *Anchialina dentata* Pillai, Male. A, anterior part of body; B, anterior part of body of female; C, second thoracic limb; D, same, distal portion of endopod enlarged; E, third pleopod; F, same, tip enlarged; G, posterior part of body.

Remarks: This species belongs to the *typica* group and can be readily distinguished from other allied species by short triangular rostral plate, saw like distal border of the merus of the second thoracic endopod and the modification of the third pleopod of male. The present specimens fully agree with those described by Panampunnayil (2002), except that the merus of the second thoracic endopod in male cut into 18 sharp spines whereas in present specimens there are only 9, as recorded by Pillai (1973).

Anchialina media **Ii**

(Fig.3.13 A, A-G; 13B, A-F)

Anchialina media Ii, 1964, 204 figs. 52A-Q, 53A-J, 54A-P.

Occurrence

Andaman Sea: station 1532, 11 mature males, 4 immature males and 6 juveniles.

Body length: mature male 8 - 8.2 mm

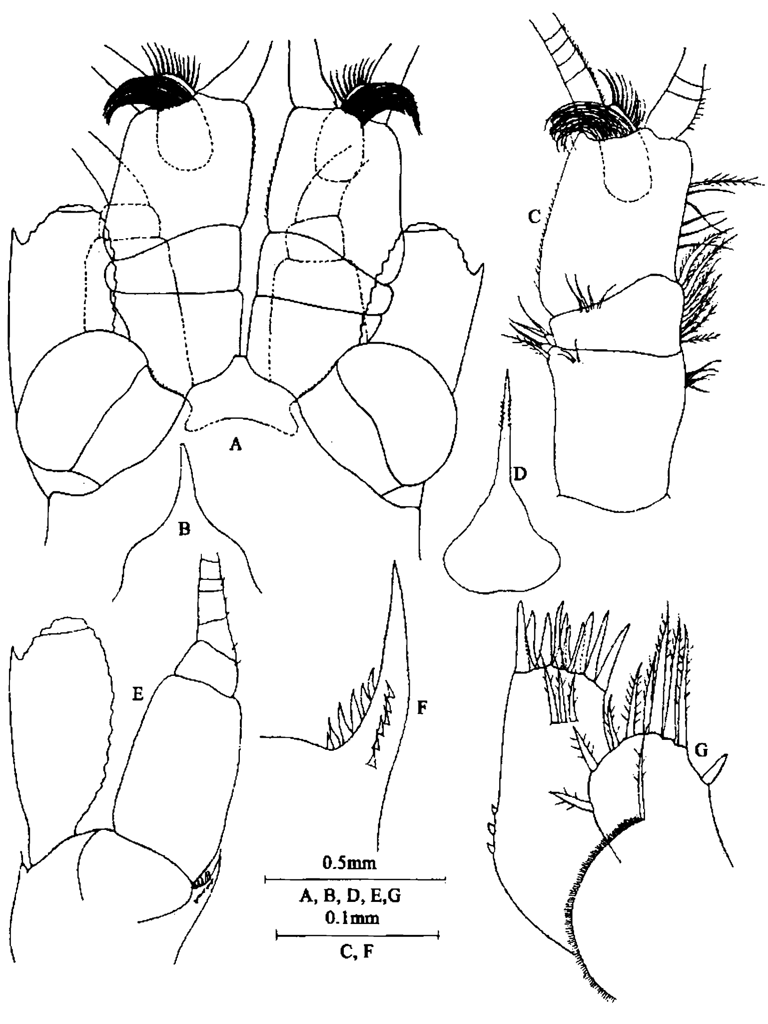


Figure 3.13A. *Anchialina media* Ii, Male. A, anterior part of body; B, rostrum; C, antennule; D, labrum; E, antenna F, same, sympodial spine enlarged; G, maxillule.

Remarks: This species is easily distinguished from other species of *Anchialina* by the modified setae on the third segment of the mandibular palp and the modification of the exopod of the third pleopod of the male. The present species belongs to the *grossa* group in having lobiform process among the distal modification of the third pleopod of the male. Compared to Ii's descriptions the following variations were observed.

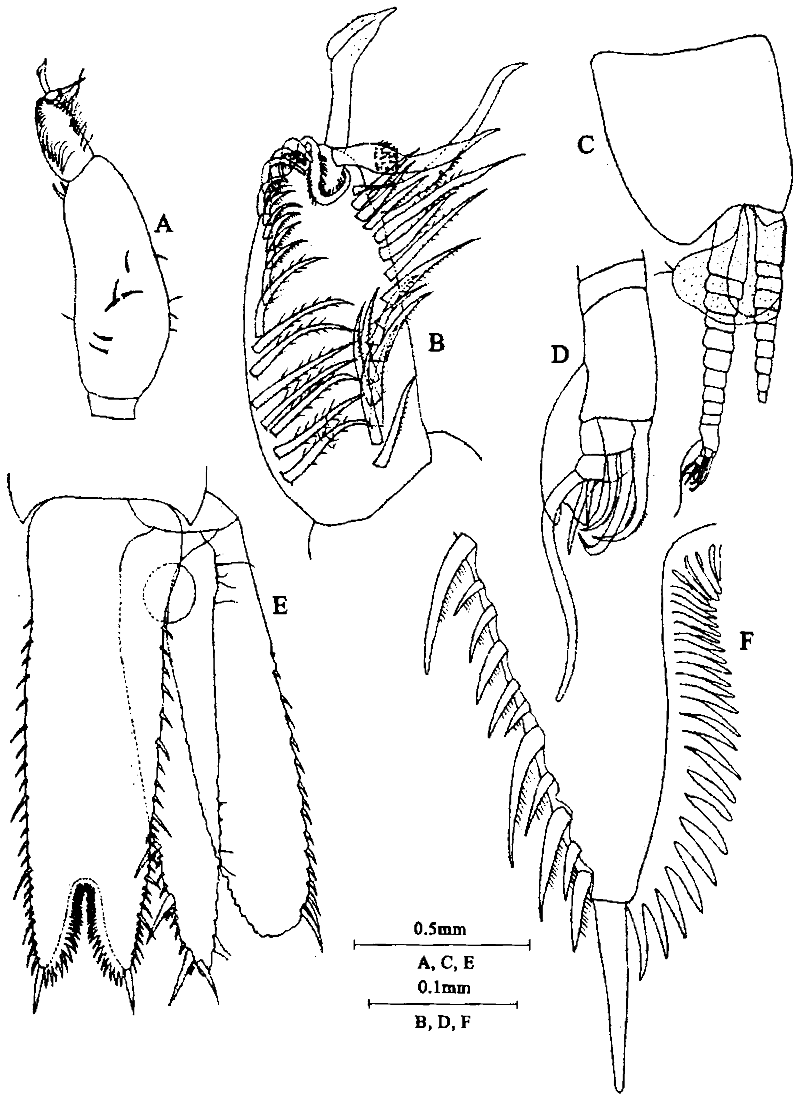


Figure 3.13B. *Anchialina media* Ii, Male. A, mandibular palp; B, Same, tip enlarged; C, third pleopod; D, same, tip of exopod enlarged; E, posterior part of body; F, tip of telson enlarged.

In Ii's specimen the antennal scale is a little more than twice as broad while in present specimens, it is little more than two and half times as long as broad. In Ii's second segment of the antennal peduncle 4 times as long as the third and sympodial spines with only one row of spines.

In present specimens second segment of the antennal peduncle broad and little more than five times as long as third and sympodial spines with two rows of spines. In the present specimens, labrum with long median process armed with six pair of teeth like structure on dorsal surface, Ii does not mention the number of teeth in median process. Second segment of the mandibular palp 3 times as long as third in the present specimens, while in Ii's specimens it is 2/5 times as long as third. In the present specimens, inner lobe of the maxillule with a plumose setae, outer lobe with 10 -11 spines, but Ii did not mention the number of spines. In the present specimens, exopod of the third pleopod is 13-14 segmented, while in Ii's specimens it is 16 segmented. In lateral margin and cleft of telson armed with 24-26 and 26-27 respectively, while in Ii's specimen these are 35 and 38 respectively. Exopod of uropod has 16-17 spines as against 17-19 in Ii's specimens. Present specimens have a length of 8 - 8.1 mm (male) while Ii's specimen measured 7 mm.

Genus *Pseudanchialina* Hansen

Pseudanchialina Hansen, 1910, p. 59; Ii, 1964, p.215; Pillai, 1967, p. 1702.

Diagnosis: Carapace covering the whole of thorax, frontal plate large, hind border feebly concave. Eyes well developed. Antennular peduncle of male thicker than in female. Antennal scale small, rapidly broadening distal wards, outer distal spine long, terminal suture present, and setae very long. Labrum anteriorly produced into a spine. Endopod of thoracic limbs slender, sixth segment divided into few subsegments. First abdominal segment in female with lateral wings, sixth segment longer than combined length of two previous segments. Pleopods in female simple, third pair in male as in *Gastrosaccus,* with long peduncle. Uropods slender, with long setae, exopod not longer than endopod, outer margin naked, with subapical spine. Telson as long as or longer than uropod, with few evenly spaced lateral spines, apex incised, with two rows of spines, extreme lateral spines very long.

Remarks: At present this genus includes four species, *P. erythraea* (Nouvel, 1944) *P. siboga* (Nouvel, 1944) *P. pusilla* (Sars, 1883a) and *P. inermis* (Illig, 1906). *P. pusilla* and *P. inermis* are widely distributed in the Indian and Pacific Oceans and these two species were contained in the present collection.

***Pseudanchialina pusilla* G.O. Sars**

(Fig. 3.14 A-F)

Promysis pusilla Sars, 1883a, p. 42.

Achialus pusillus, Sars, 1885a, p. 200, pl. 35, figs. 19-20.

Pseudanchialina pusilla, Hansen, 1910, p. 60, pl. 8, figs. 41-c, pl. 9, figs, 1a-k; W.M. Tattersall, 1936, p. 149; Pillai, 1957, p. 9, fig. 4; O.S. Tattersall, 1960, P. 176, fig. 4; Ii, 1964, p. 217; Pillai, 1964, p. 21, fig. 12; 1973, p. 73, fig. 36; Panampunnayil, 2002, p.379.

Occurrence

Arabian Sea: stations 1401, 1405, 1419, 1422, 1430, 1431, 1477, 1478, 1479, 1480, 1482, 1483, 1487, 1488, 1489, 1494, 1496,1498, 1499, 1504, 1674, 1677, 1678, 1679, 1680, 1682, 1685, 1686, 1688, 1691, 1693, 1699, 1703, 1504, 1508, 1883, 1897, 1881, 1902, 1895, 1900, 1904, 1887, 1905 and 1908.

Bay of Bengal: stations 1232, 1236, 1239, 1241, 1243, 1247, 1244,1248, 1249, 1254, 1257, 1259, 1261, 1344, 1348, 1350, 1352, 1353, 1354, 1365, 1357, 1641, 1642, 1645, 1646, 1648, 1649, 1650, 1651, 1653, 1654, 1654, 1655, 1657, 1658, 1669, 1670, 1671, 1912, 1917 and 1921.

Andaman Sea: stations 1201, 1204, 1206, 1207, 1208, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1217, 1334, 1338, 1340, 1442, 1443, 1444, 1447, 1460, 1462, 1467, 1468, 1474, 1470, 1474, 1475, 1524, 1530, 1531, 1532, 1535 and 1538.

Body length: mature male 4.9 -7.5 mm, mature female 5.5 -7.7 mm

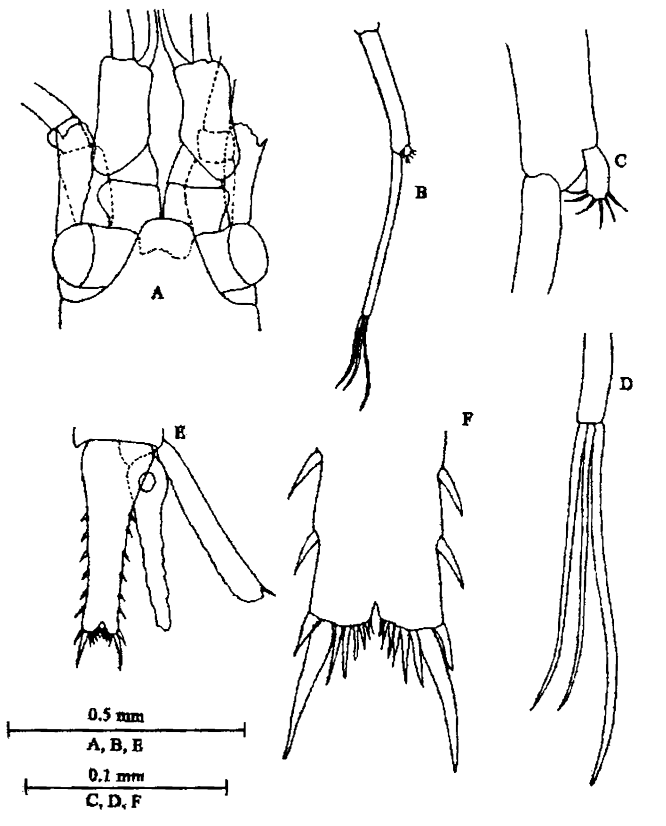


Figure 3.14. *Pseudanchialina pusilla* G.O. Sars, Male. A, anterior part of body; B, third pleopod; C, same, tip of exopod enlarged; D, same, tip of endopod enlarged; E, posterior part of body; F, tip of telson.

Remarks: This species can be easily distinguished from its allied species by the number of lateral spines on the telson and apically subtruncate rostral process. The maximum size recorded for this species is 3.1 mm (Pillai, 1973). In present specimens telsonic sinus is armed with 6 pair of spines while in Pillai and Panampunnayil recorded 8 pair of spines.

Pseudanchialina inermis **(Illig)**

(Fig. 3.15 A-B)

Chlamedopleon inermis Illig, 1906, p. 209, fig. 16.

Pseudanchialina inermis Hansen, 1910, p. 61, pl. 9, figs. 2a-d; Illig, 1930, p. 422-423; Coifmann, 1936, p.31-32.

Pseudanchialina sibogae Nouvel, 1944, p. 267; 1959, p. 222.

Pseudanchialina inermis Pillai, 1973, p. 75-77; Valbonesi and Murano, 1980, p, 213-215.

Occurrence

Arabian Sea: station 1405, 1 spent female.

Body length: mature female 3.3 mm

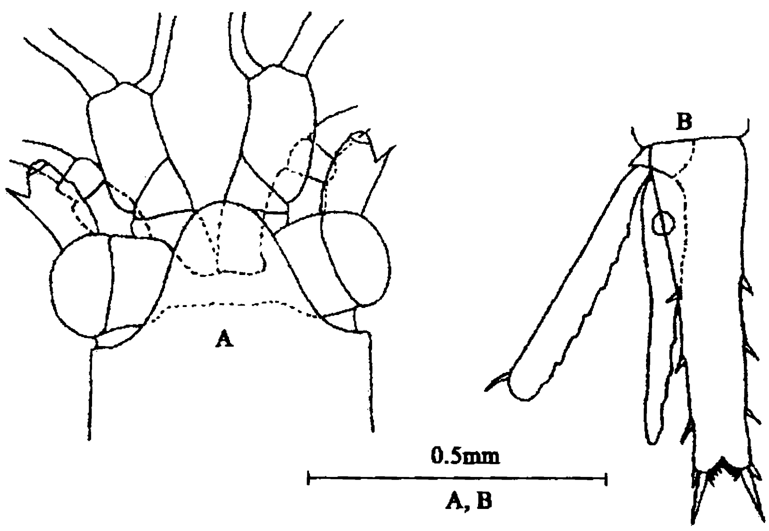


Figure 3.15. *Pseudanchialina inermis* (Illig), Female. A, Anterior part of body; B, Posterior part of body.

Remarks: *P. inermis* differs from the only other species of the genus *P. pusilla* in having 4 to 5 pair of spines along the lateral border of the telson as against 6-9 spines in the latter. The rostrum is broader and shorter in the Indian specimens (Pillai, 1973) and is shorter in the specimens from Timor (Hansen, 1910) and Japan (Valbonesi and Murano, 1980) and is somewhat triangular in shape with narrowly rounded apex in the specimen from Japan. This is the largest specimen collected from the Indian waters. *P. inermis* collected from Akajima Island (Murano,1990) measured 2.3 - 2.6 mm, from Tansbe Bay, measured 2.2 - 2.3 mm (Valbonesi and Murano,1980) and from Micronesia, measured 2.7- 3 mm (Murano, 1983).

Sub family MYSINAE

Tribe Erythropini

Genus: *Pseuderythrops* Coifmann

Pseuderythrops Coifmann, 1936, p.83; 1937, p. 35-36; Nouvel, 1959, p. 233-234.

Diagnosis: Body slender. Anterior margin of carapace broadly rounded. Carapace with deep depression on lateral borders just behind buccal mass region. Eyes large and globular. Antennal peduncle relatively slender, first segment with outer corner not produced and armed with several setae, two of which grow laterally and then anteriorly; second segment shortest, with small lobe provided with bristles on anterior margin. Antennal scale with long apical lobe, spine of outer margin developed; peduncle consisting of 3 sub equal segments. Mandibular palp with second segment narrow and bend in proximal portion. Endopod of third thoracic limb more robust than those of succeeding limbs, with distal sub- segment of propodus armed with characteristic setae along inner margin. Endopods of fourth to eight of thoracic limb long and slender, eight endopod shorter than preceding ones. Fourth pleopod of male with exopod longer than or equal to endopod, provided with modified setae on distal segments. Telson elongate, triangular, with spines on distal half of lateral margins and apex Uropods longer than telson, endopod with swollen base enclosing large statocyst. Marsupium composed of 2 pair of oostegites.

Remarks: This genus is easily distinguished from allied genera by the carapace without a definite rostral projection, the characteristic shape of mandibular palp, the shape and armature of the telson and the modification of exopod of the fourth pleopod. In 1964, Ii stated that this genus might be a synonym of the genus *Metamblyops,* but Pillai (1973) recognized it as a valid genus.

This genus contains only two species, *P. megalops* (Murano, 1998a) and *P. gracilis* (Coifmann, 1936) were and latter is represented in the present collection.

***Pseuderythrops gracilis* Coifmann**

(Fig. 3.16 A-C)

Pseuderythrops gracilis Coifmann, 1936, p. 83, fig.1; 1937, p. 36, pl. 19, figs. 23a-c; Nouvel, 1959, p. 233-234, figs. 119-137; Pillai, 1964, p.25, figs. 15; 1973, p.91-94, figs 48-49.

Metamblyops gracilis Ii, 1964, p. 346 (Part).

Pseuderythrops gracilis Murano, 1998a, p. 231-238.

Occurrence

***Andaman Sea*:** station 1524, 1 immature male, 2 spent females and 2 immature females.

Body length: mature female 8.5 mm

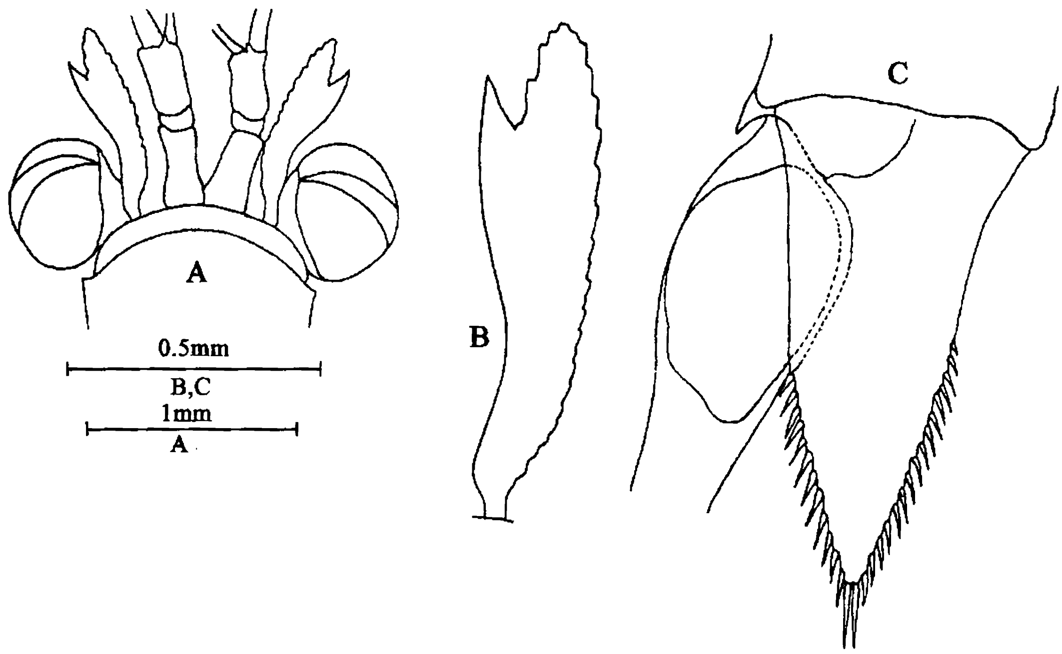


Figure 3.16. *Pseuderythrops gracilis* Coifmann, Female. A, anterior part of body; B, antennal scale; C, telson with statosyst.

Remarks: This species can be easily distinguished by long fully exposed eyestalks, the virtual absence of a frontal plate for the carapace, graceful curve of the antennal scale and enormous size of the statocyst. Only one female specimen was collected in the present survey. The original description and illustrations given by Coifmann (1936) were brief but later, Nouvel (1959) and Pillai (1964, 1973) gave a detailed redescription with good illustrations. Murano (1998a) add some variable characters to this species, while the present specimen agrees well with Pillai's descriptions except for some minor variations. In all the specimens examined the cornea is divided into two by an oblique partition. This partition has not been recorded by earlier workers.

Genus: *Gibberythrops* (Illig)

Parerythrops Illig, 1906

Gibberythrops Illig, 1930

Diagnosis: Eyes normal, not depressed dorsoventrally. Thorax without sternal processes between pair of thoracic legs. Telson elongate, triangular, armed on narrow apex with pair of long spines and pair of median setae. Lateral margin of telson with small spines on distal half of margin. Pseudobranchial processes on endopods of male pleopod slender.

Remarks: In 1930, the genus *Gibberythrops* was created by Illig for the reception of already known species *Parerythrops acanthura,* In 1936, Coifmann transferred this species from to *Erythrops*, though the name *Gibberythrops* was retained as a subgenus In 1939, this genus was again referred to *Gibberythrops* by Tattersall for the character of thorax without sternal processes and difference in shape of eye and telson.

Four species, *G. acanthura* (Illig, 1906), *G. longicauda* (Bravo and Murano, 1977), *G. stephensoni* (W.M.Tattersall, 1936) and *G. typicus* (Murano, 1969) are referred to this genus. Only *G. acanthura* is represented in the present collection.

***Gibberythrops acanthura* (Illig)**

(Fig. 3.17 A-B)

Parerythrops acanthura Illig, 1906, p. 197

Gibberythrops acanthura Illig, 1930, p. 431; W.M.Tattersall, 1951, p.122

Occurrence

Arabian Sea: station 1673, 5 immature males and 3 juveniles; station 1674, 3 mature males, 1 immature male, 3 spent females and 2 juveniles.

Body length: mature male 4.5 - 5.2 mm, mature female 6.3 mm

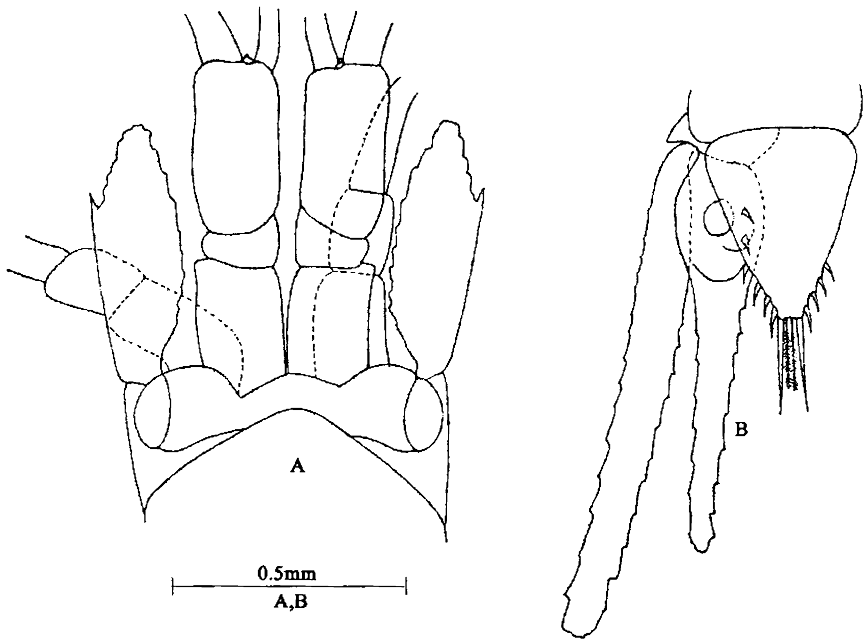


Figure 3.17. *Gibberythrops acanthura* (Illig), Female. A, anterior part of body; B, posterior part of body.

Remarks: This species can be easily distinguished from allied species by the following points. Apex of antennal scale not extending beyond spinous process terminating naked outer margin, cornea as wide as eyestalk. Telson armed with 4 or 5 spines on distal 1/3 of lateral; margin. Telson of this species resembles that of *G. typicus* but the eye and antennal scale is considerably different. The present specimens well agree with the published descriptions.

Genus: *Pleurerythrops* Ii

Pleurerythrops Ii, 1964, p. 323.

Diagnosis: General form short and robust. Cephalothorax wider than abdomen, conspicuous waist between thorax and abdomen present. Anterior margin of carapace produced in front into broad sub-truncate rostral plate. Eyes small, set wide apart. Antennal scale small, outer margin straight and naked, ending in strong spine, distal lobe large. Dactylus of second thoracic endopod with strong deeply bifid nail. Thoracic endopods three to eight, slender, carpopropodus three segmented, nail long. Pleopods in male biramous and natatory; endopod of fifth pleopod with long barbed seta on ultimate and penultimate segments. Telson sub-triangular, lateral margin smooth, straight and converging, distal margin narrowly truncate and armed with median pair of plumose setae and two pairs of spines, inner pair long, stout and blade shaped and five times longer than outer pair. Uropods longer than telson, endopod with row of 14-19 sharp closely set spines on inner margin.

Remarks: The genus *Pleurerythrops* was created by Ii (1964) to describe *P. inscita* collected from latitude 2°15' N longitude 108°20' E (Malacca Strait). This genus is easily distinguished from other genera of the *Erythropini* in having modified setae on the fifth pleopod of the male, presence of a deep constriction between the thorax and abdomen and the apical armature of the telson. At present this genus includes *P. inscita* (Ii, 1964), *P. secunda* (Murano, 1970a), *P. constricta* (Panampunnayil, 1977), *P. monospinosa* (Liu and Wang, 1986), *P. americana* (Zoppi de Roa and Delyado, 1989), of which *P. constricta and P. inscita are* recorded from Indian waters. In the present collection only latter is present.

Pleurerythrops inscita Ii

(Fig.3.18 A-B)

Pleurerythrops inscita Ii, 1964 p. 323; Panampunnayil, 1998, pp. 624-628, figs. 23-48.

Occurrence

Arabian Sea: station 1427, 1 mature male; station 1430, 1 immature male.

Body length: mature male 3.1 mm.

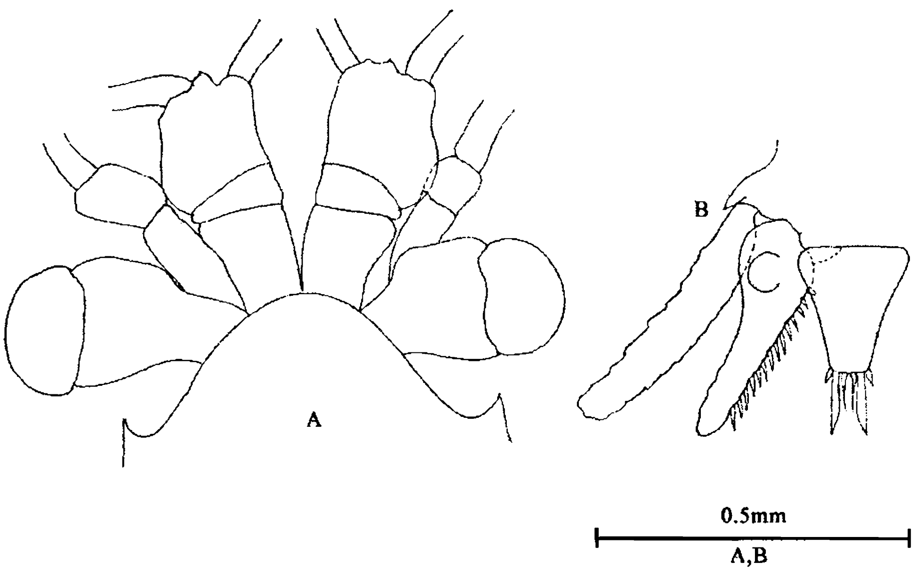


Figure 3.18. *Pleurerythrops inscita* Ii, Male. A, anterior part of body; B, posterior part of body.

Remarks: This species is easily identified from its allied species, *P. constricta* Panampunnayil by the obtusely rounded or subtruncate rostrum, presence of bifid nail of the second thoracic endopod furnished with subsidiary spinules and presence of sternal process. The present specimens fully agree with those described by Panampunnayil (1998) except the description of anterior part of the carapace. In the present specimen, the anterior margin of the carapace is broadly rounded as described by Ii (1964), while in Panampunnayil specimen, it is subtruncate. In Indian water this species was first recorded by Panampunnayil (1998) from latitude 7°45'. 2" N, longitude 77°22'. 5" E. The present record is the second report from Indian waters.

Genus: *Euchaetomera* G.O. Sars

Euchaetomera Sars, 1884, 13, p. 211; Hansen, 1910, pp.65-66; Tattersall and Tattersall, 1951, p. 273; Ii. 1964 p. 360; Murano, 1977a, p. 141

Diagnosis: Rostrum small, rounded or pointed. Eyes large with cornea divided into two parts, anterior and posterolateral areas. Antennal scale slender, outer margin terminating in prominent spine. Uropods long and slender with prominent statocyst. Telson short, Lateral margin convex, apex truncate, armed with one to two pairs of small spines and pair of long plumose setae; lateral margin may be armed or unarmed.

Remarks: Ten species, *E. intermedia* (Nouvel, 1942), *E. oculata*, (Hansen, 1910), *E. plebeja* (Hansen, 1912), *E. richardi* (Nouvel, 1945a), *E. tenuis* (Sars, 1884), *E. zurstrasseni* (Illig, 1906) and two unnamed species, one from the middle of the Bay of Bengal by Pillai (1973) and other from the tropical region of the central Pacific by Murano (1977a) are included in this genus.

This genus at present is represented by 4 species in the Indian Ocean, of which only one species, *Euchaetomera glyphidophthalmica* is present in the collection. This genus is easily identified by the presence of short telson and its spinulation.

Euchaetomera glyphidophthalmica Illig

(Fig.3.19 A-G)

Euchaetomera glyphidophthalmica Illig, 1930, p. 445, figs, 84-87; W.M. Tattersall, 1939, p. 243; O.S. Tattersall, 1955, p.131; Pillai, 1964, p. 227, fig. 16; Murano, 1977a; pp. 146-147, fig. 3. Panampunnayil, 2002, p. 379, fig. 6A-H.

Occurrence

Arabian Sea: station 1483, 1 mature male1.

Bay of Bengal: station 1237, 1 spent female.

Andaman Sea: station 1530, 1 immature male.

Body length: mature male 5.8 mm, mature female 6.3 mm

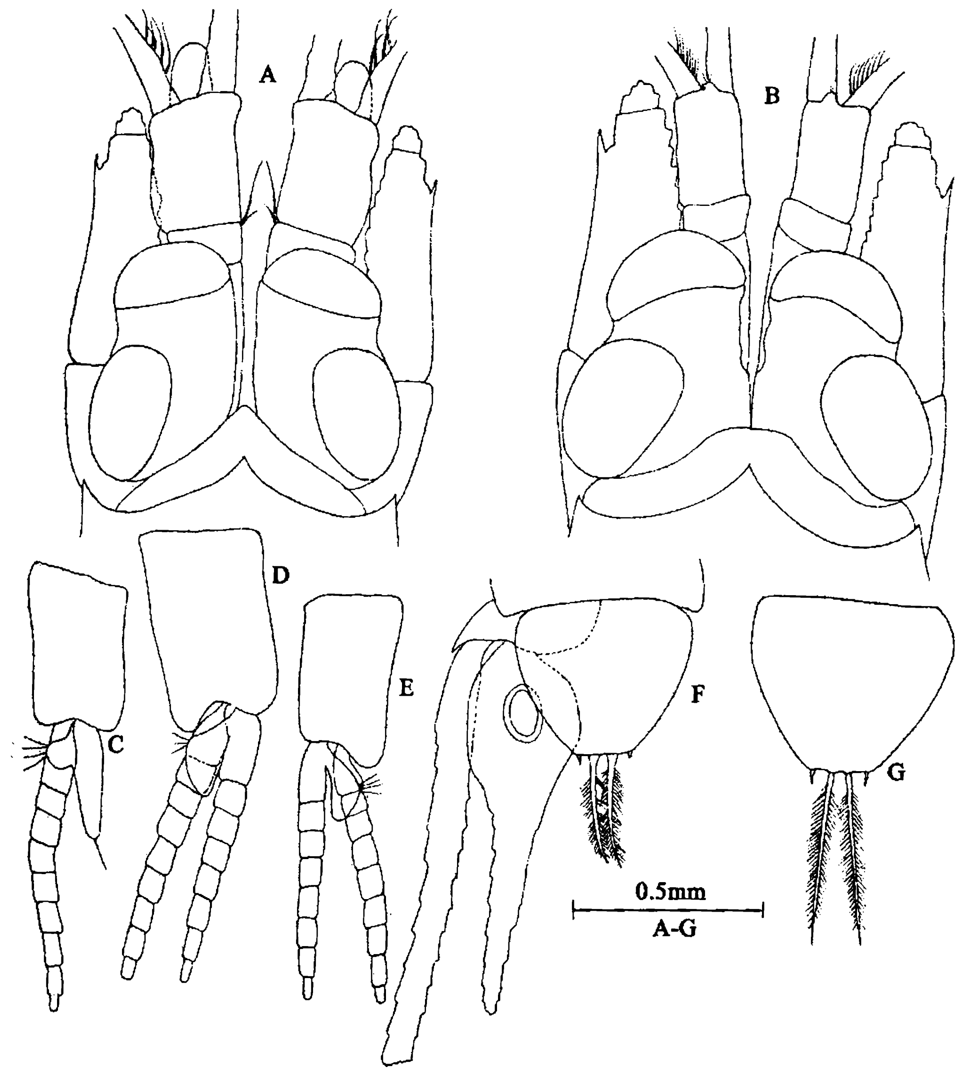


Figure 3.19. *Euchaetomera glyphidophthalmica* Illig, Male. A, anterior part of body; B, anterior part of body of female; C, first pleopod; D, third pleopod; E, fifth pleopod; F, posterior part of body; G, telson of female.

Remarks: This species is distinguished from other species of the genus by the small narrow acute rostral plate, the larger lateral cornea and the naked lateral margin of the telson. Illig (1906) described that the telson is armed with two pairs of spines on the distal margin, while O.S. Tattersall (1955) and Pillai (1964) noted that it is armed with only one spine at each corner of the distal margin. In the present specimens the later case was observed. Pillai reported the length of adult female as 9.4 mm that is the maximum size observed.

Genus: *Synerythrops* Hansen

Synerythrops Hansen, 1910, 34 p. 64; Illig, 1930, 22, p. 570. Murano, 1975, 12, p. 90.

Diagnosis: Rostral plate triangular anteriorly produced between eyes. Eyes well developed and globular; ocular papilla may or may not be present. Antennal peduncle slender, its second segment connected with ventral side of basal part of third segment. Antennal scale large, much longer than antennal peduncle. Terminal joint of mandibular palp broad and expanded. Distal segment of endopod of maxilla short, about as long as broad. Endopod of the first thoracic limbs with lobe on the second and third joints. Sixth joints of endopod of the third to eight thoracic limbs divided in to 3 sub joints. In male pseudobranchial process of pleopod is elongated into long narrow lobe. Telson short triangular, about as long as broad with rather broadly rounded apex; armed with a few lateral spines mostly confined to the distal part of the lateral margins; apex armed with a pair of long spines and a pair of median plumose setae, but without a pair of median small spines. Inner uropod may or may not have spines.

Remarks: This genus was established in 1910 by Hansen for the reception of *S. intermedia* represented by only a single immature female, so that he was not able to establish the character of male pleopods in this genus. Later, W.M.

Tattersall (1939) described the interesting feature of pseudobranchial process of the male pleopods.

This genus was closely allied to both *Hypererythrops* Holt and Tattersall and *Gibberythrops* Illig, while the pseudobranchial process on the male pleopods is most helpful for their distinction. The process in the present genus is elongated in to long narrow lobe, while it is short in *Gibberythrops* or rounded in *Hypererythrops.* In present specimen pseudobranchial process shows some variations, pseudobranchial process of 2-5 pleopods are somewhat bended.

The present genus is easily distinguishable in the three characteristics, maxilla with short distal segment of endopod, unusual connection between second and third segment of antennal peduncle, elongated pseudobranchial process on the male pleopods and short telson.

At present this genus contains following three species, *S. intermedia* (Hansen, 1910) *S. cruciata* (W.M. Tattersall, 1951) and *S. truncata* (Murano, 1975). The present collections represent only *S. intermedia.*

Synerythrops intermedia Hansen

(Fig. 3.20 A-E)

Synerythrops intermedia Hansen, 1910: 64-65; Illig, 1930, pp.64-65, pl.9, fig. 5a-e,pl.10 fig.1a- c; W.M. Tattersall, 1939, pp. 237-238, Ii, 1964, p. 342; Murano, 1975, 12, p.90.

Occurrence

Bay of Bengal: station 1248, 1 mature male.

Body length: mature male 12.3 mm

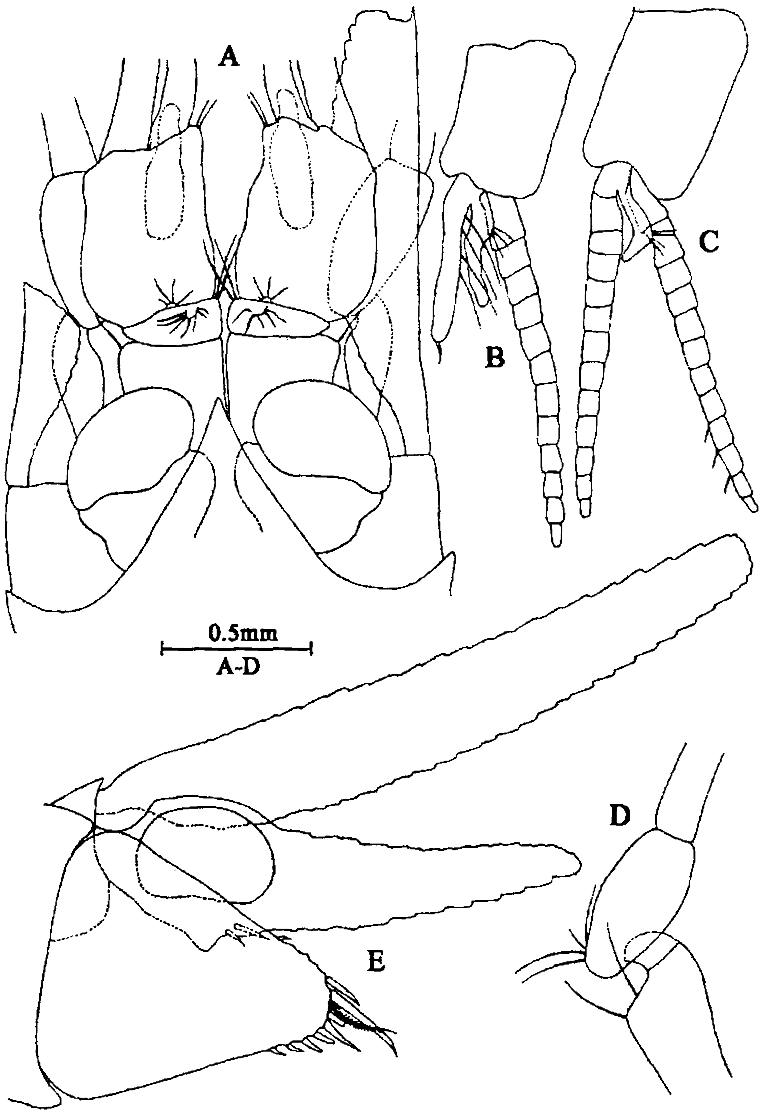


Figure 3.20. *Synerythrops intermedia* Hansen, Male. A, anterior part of the body; B, first pleopods; C, third pleopods; D, joint of antennal peduncle; E, posterior part of the body.

Remarks: The present species was established in 1910 by Hansen for the reception of a single immature female of 7.2mm long collected during Siboga-Expedition. In 1939, W.M. Tattersall reported 4 badly damaged specimens collected from Great Barrier Reef Expedition and identified them with *S. intermedia* though he had some doubt. Tattersall made the third record of the present species in 1939 for a single male from the Gulf of Aden. In his paper he reported the presence of a small ocular papilla and long narrow pseudobranchial process on endopod of pleopods. Murano (1975) reported the largest specimen (15.4 mm) from Japan.

The present occurrence of this species is the first record from the Indian waters. The present specimen showed some variation from the earlier descriptions. Rostrum in present specimen is obtusely rounded. In type specimen it is moderately rounded while obtusely pointed in Murano`s specimen. Rostral plate somewhat short, not extending to distal margin of eye in the specimens of Tattersal W.M. (1939) and Murano (1975), while in present specimen rostral plate extends to distal margin of the eye. In Tattersall`s and Murano's specimens distal suture is present in antennal scale while in the present specimen distal suture is absent. In the present specimen eyes are small, do not extend laterally beyond lateral line of anterior part of the body, while in Murano`s specimen, eyes are large and extend laterally beyond lateral line of anterior part of body. In Tattersall`s male specimen, pseudobranchial process of first pleopod is as long as endopod, and endopod bears 13 segments. While in present specimen, pseudobranchial process smaller than endopod and endopod has 12 segments. In earlier descriptions pseudobranchial process in the pleopods are straight but in present specimen pseudobranchial processes are somewhat bended. In the present specimen telson is armed with 6 spines while Murano recorded 8 spines.

This species is distinguished from other members of this genus, by the shorter rostral plate, large eyes, absence of ocular papilla and the smaller number of lateral spines on the telson.

Tribe Leptomysini

Genus : *Dioptromysis* Zimmer

Dioptromysis Zimmer, 1915.

Diagnosis: Body rather strongly built. Carapace produced into short apically blunt rostrum. Eyes large, cornea with large lens on distal lower part. Antennal scale setose all round, over reaching antennular peduncle. Labrum without frontal process. Thoracic endopods three to eight with three carpopropodal segments. Exopod of fourth pleopod of male seven segmented, seventh segment with long barbed spine and short seta. Telson more than twice as long as broad, apical cleft deep, one fourth total length, lateral border armed with eleven to thirteen sharp spines, more or less regularly distributed, last spine large, cleft armed with single pair of spines and pair of plumose setae. Endopod of uropod armed with row of seventeen sharp spines.

Remarks: This genus was created by Zimmer (1915) to describe a single female collected by Dr. Duncker during a voyage from Ceylon to New Guinea. At present this genus includes 5 species, *D. paucispinosa* Brattegard, 1969, *D. perspicillata* (Zimmer, 1915), *D. proxima* (Nouvel, 1964a), *D. spinosa* (Brattegard, 1969) and *D. djiboutiensis* (Bacescu, 1969). Only *D. perspicillata* occurred in the present collection.

Dioptromysis perspicillata Zimmer

(Fig. 3.21 A-B)

Dioptromysis perspicillata Zimmer, 1915, p. 168, fig. 20-22; W.M. Tattersall, 1922, p. 477; Pillai, 1963a, pp. 9-14.

Occurrence

Arabian Sea: station 1392, 1 spent female and 2 juveniles.

Body length: mature female 5.2 mm

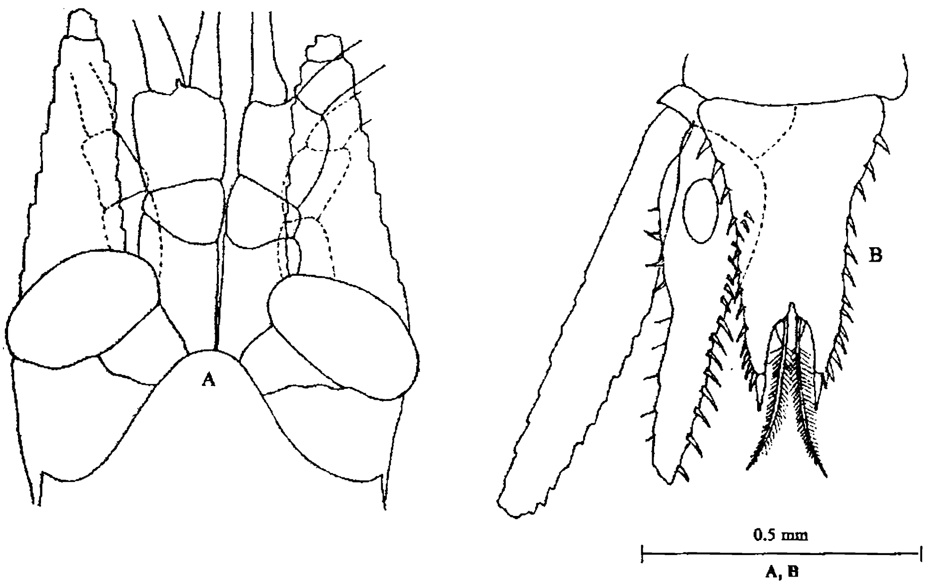


Figure 3.21. *Dioptromysis perspicillata* Zimmer, Female. A, anterior part of body; B, posterior part of body.

Remarks: Present report of *Dioptromysis perspicillata* is the third record from the Indian waters. The present specimens well agrees with the description of Pillai (1963a) but shows some minor variations. In the present specimen cornea is broader than the peduncle while in Pillai's description it is not broader than the peduncle. Pillai observed 17 spines on the inner border of the endopod of the uropod but I was able to find only 16. In the present specimen, lateral margin of telson is armed with 14 spines, while in Pillai's descriptions, it is 11-13.

Pillai measured 3.8 - 4.3 mm mature specimens and W.M. Tattersall (1922) 3.5 - 5 mm length while present female specimen is 5.2 mm in length.

Genus *Afromysis* Zimmer

Afromysis Zimmer, 1916, p. 62 ; Pillai, 1957, p. 1715.

Diagnosis: Frontal plate conical and apically blunt. Antennal scale lanceolate with distal suture. Second segment of palp of maxilla considerably produced, its inner border armed with closely packed row of long and short spines. Thoracic endopods with two propodal segments. Exopod of fourth pleopod of male longer than endopod, armed with two to three spiny setae. Inner border of endopod of uropod throughout armed with spines grouped into irregular series. Telson distally cleft, lateral border of telson generally with two groups of spines separated by a gap, cleft with a pair of setae and with or without spines.

Remarks: This genus was instituted by Zimmer 1916, for the reception of *Afromysis hanseni.* At present this genus includes 6 species, *A. hanseni* (Zimmer, 1916), *A. macropsis*, (W.M. Tattersall, 1922), *A. bainbridgei* (O.S. Tattersall, 1957), *A. ornata* (O.S. Tattersall. 1957), *A. dentisinus* (Pillai, 1957), *A. guinesis* (Bacescu, 1968a). In the Indian waters this genus is represented by two species *A. macropsis* Tattersall and *A. dentisinus* Pillai and the material under study includes A. *dentisinus* only.

Afromysis dentisinus Pillai

(Fig. 3.22 A-F)

Afromysis dentisinus Pillai, 1957, p. 11, fig. 1-7; 1964, p. 28, fig. 17; 1967; p. 1716, fig. 75; 1973, p. 100, fig. 54.

Occurrence

Arabian Sea: station 1392, 4 mature males, 5 immature males, 2 spent females and 1 immature female.

Body length: mature male 8.5 mm, mature female 9 mm

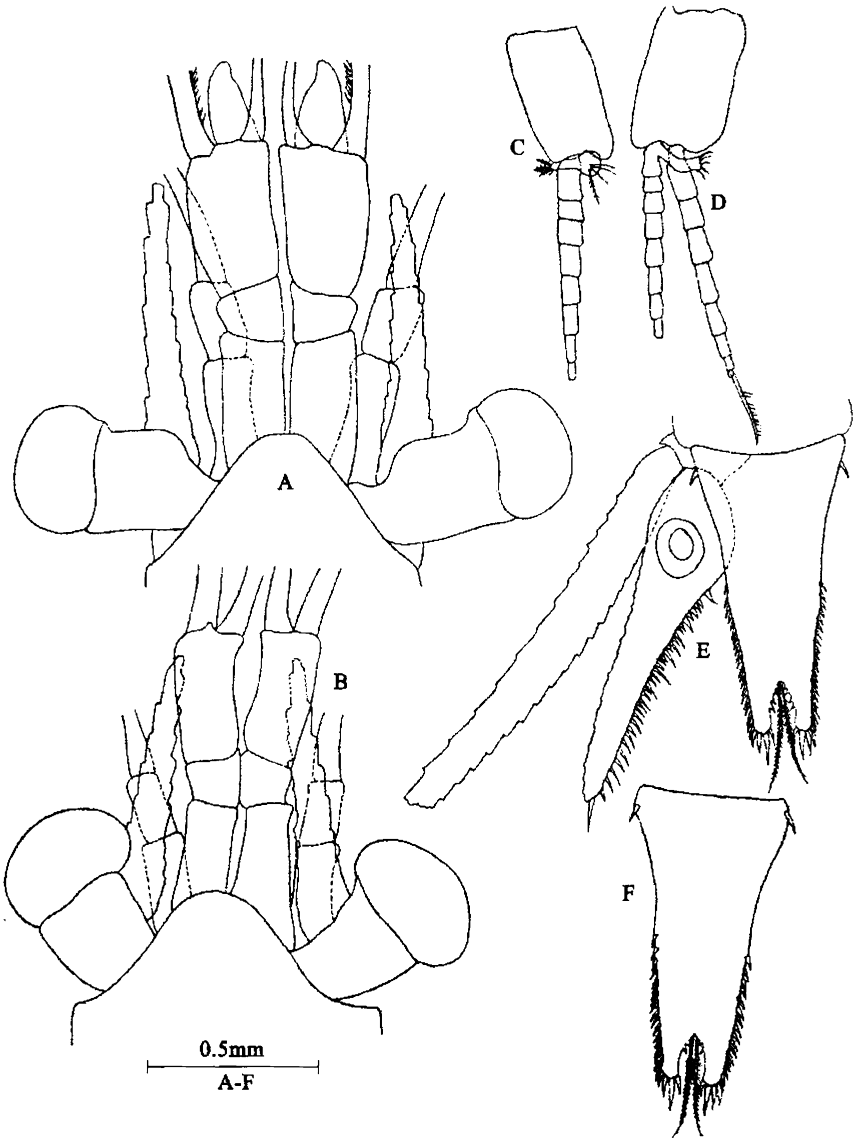


Figure 3.22. *Afromysis dentisinus* Pillai, Male. A, anterior part of body; B, anterior part of body of female; C, first pleopod; D, fourth pleopod; E, posterior part of body; F, telson of female.

Remarks: This species was established by Pillai (1957) for specimens collected from the inshore waters of Kerala and this can be readily distinguished from the only other Indian species of the genus *A. macropsis* W.M. Tattersall (1922) by the following points In *A. macropsis* there are 3 spines on the widened basal part of the telson and the spines on the distal margin are blunt. In *A. dentisinus* there is only one spine on the basal part of he telson, and the spines on the distal margin are pointed. In *A. macropsis* there are three modified setae on the exopod of the fourth pleopod of the male while *A. dentisinus* there is only one modified seta. The present specimens agree with the description given by Pillai (1964). But some variations were observed in the segmentation of pleopods. In the present specimens first pleopod has eight segmented exopod, fourth pleopod with 8 segmented endopod and seven segmented exopod while in Pilla's and Panampunnayil's specimens first pleopod has seven segment exopod and fourth pleopod is with seven segmented endopod and eight segmented exopod. In the present specimen, modified setae on the exopod of fourth pleopod of the male is barbed on one side, as described as Pillai. While Panampunnayil's specimens it is barbed on both sides. In the present specimens, telsonic cleft is armed with four pairs of denticles in male and 1-2 pair in female and also some females were without denticle, while Pillai and Panampunnayil recorded 3 pairs in male and one pair in female.

Genus: *Doxomysis* Hansen

Doxomysis Hansen, 1912, p. 205; Ii, 1964, p. 380; Pillai, 1957, p. 1716.

Diagnosis: Body smooth or spiny. Frontal plate short and triangular. Eyes large with short stalks. Antennal scale setose all round. Labrum without spiniform process. Terminal segment of palp of second maxilla expanded with stout spines, broader than long. Carpopropodus of thoracic endopods three segmented. Pleopods of male well developed; exopod of fourth pleopod with modified setae. Telson with deep apical cleft armed with small teeth and pair of setae, lateral border of telson fully or partly armed. Endopod of uropod with row of spines extending from statocyst to distal end.

marks: Hansen established this genus in 1912 for the species *Doxomysis lagica*, captured from the Galapagos Island. This genus is very closely lated to *Afromysis* and *Tenagomysis* but can be distinguished by the shape of e terminal joint of the endopod of second maxilla which is broader than ng. Shape of labrum is also a distinguishing character between *Doxomysis* nd *Tenagomysis*.

At present this genus includes 16 species. In the Indian waters this enus is represented by five species, *D. quadrispinosa* (Illig, 1906), *D. littoralis*, *D. anomala* (Tattersall, 1922), *D. longiura* (Pillai, 1964) and *D. nicobaricus* Panampunnayil (2002). In the present collection this genus is represented by a single species, *D. longiura*.

Doxomysis longiura Pillai

(Fig. 3.23 A-H)

Doxomysis sp. W.M. Tattersall, 1922, p. 480, fig.18.

Doxomysis littoralis, W. M. Tattersall, 1936a, p.154 (in part). Pillai, 1957, p. 258, figs. 1-19.

Doxomysis longiura Pillai, 1963b, p.12, fig. Vll, 1-2; 1964, p. 30, fig.18; 1965, p. 1717, fig. 79; 1973, p.105-109, fig. 58.

Occurrence

Arabian Sea: station 1392, 9 mature males, 6 immature males, 9 immature females, 2 females with eye less larvae and 22 juveniles; station 1503, 1 immature female.

Body length: mature male 5.8 - 6.9 mm, mature female 5.7 - 5.9 mm.

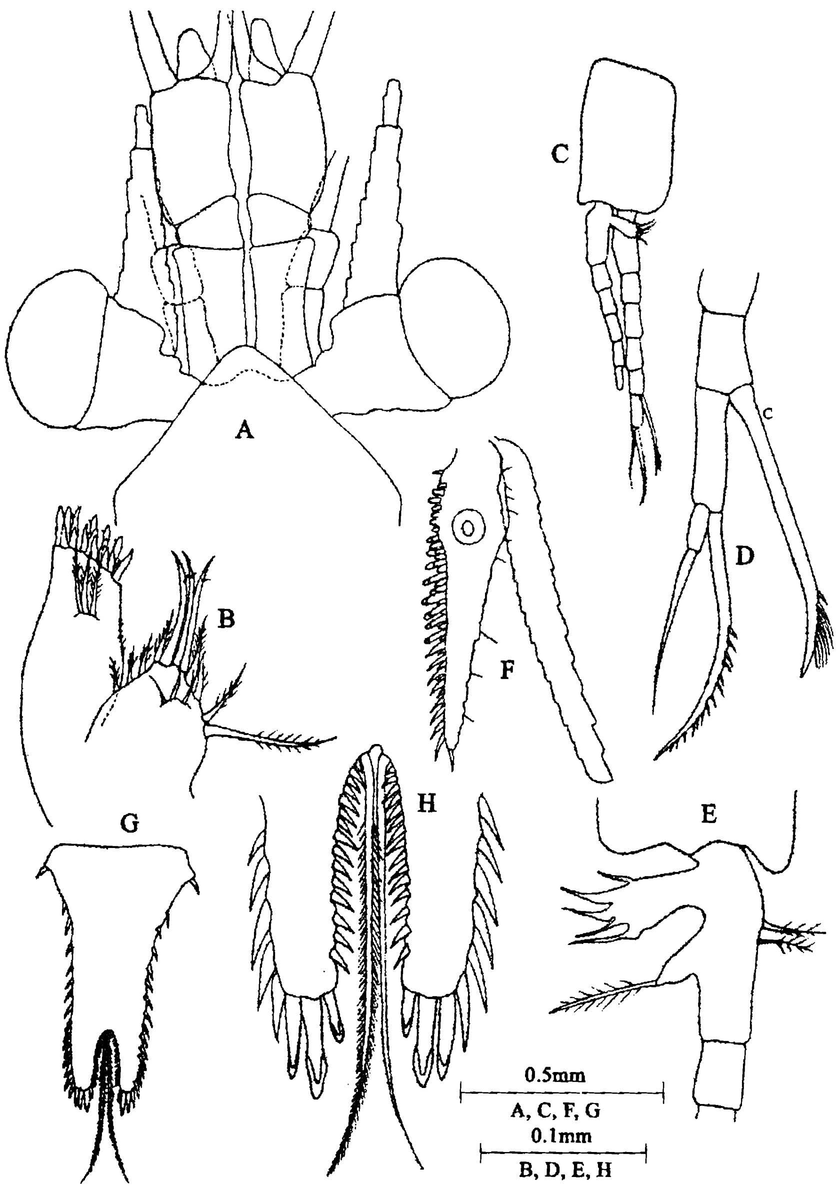


Figure 3.23. *Doxomysis longiura* Pillai. Male. A, anterior part of body; B, fourth pleopod; C, same, tip of exopod enlarged; D, maxillule; E, fifth pleopod basal part of endopod; F, endopod and exopod of uropod; G, telson; H, same, tip enlarged.

Remarks: This well-known and widely distributed species is readily recognized by the hispid body, relative length of the antennal scale and endopod of uropod and modifications of exopod of fourth pleopod. The present specimens agree with the published descriptions but show some variations in some of the characters. In the present specimen outer lobe of the axillule carries 14 short spines, while in Pillai's specimen, there are only 10. the present specimen telsonic sinus is broader and armed with 15 pairs of rong spines as against 11 in Pillai's specimens.

Tribe Mysini

Genus *Mesopodopsis* Czerniavsky

Podopsis Van Beneden, 1861, p. 17.

Macropsis Sars, 1877, p. 35.

Mesopodopsis Czerniavsky, 1882, p. 145, W.M. Tattersall, 1922, p. 482; Tattersall and Tattersall, 1951, p. 392: Pillai, 1961, p. 28; 1968, p. 7; Ii, 1964, p. 583; Wittmann, 1992, p. 72.

Diagnosis: Body long and slender. Frontal plate broad and semicircular. Eyes with long cylindrical stalks. Antennular peduncle slender and long; in male inner distal corner of third segment produced into long process tipped with coiled seta and slender spine like process. Antennal scale setose and round. Endopod of thoracic limbs without nail. Pleopods one, two and four rudimentary, third small and biramous; fourth with small endopod, exopod long and three segmented, third segment with two spine setae. Telson short, lateral margin ending in pair of strong spines and region beyond these spines abruptly constricted and armed with comb of spines.

Remarks: This genus could be easily distinguished by the extra flagellum of the antennule of male and the peculiar shape of the telson. The genus now includes seven species and can be distinguished into two groups, Euro African species with a spine below the statocyst and Indo Australian species without a spine (Wittmann, 1992). All the species are brackish water forms and very much alike.

T411

In the Indian waters this genus is represented by two species *M. orientalis* (W.M. Tattersall, 1908) and *M. zeylanica* (Nouvel, 1954) and only the former species occurred in the present collection.

Mesopodopsis orientalis Tattersall

(Fig. 3.24 A-B)

Macropsis orientalis, W.M. Tattersall, 1908, p. 236

Mesopodopsis orientalis, W.M. Tattersall, 1922, p. 482; Nair, 1939, p. 175; Nouvel, 1957a, p. 323; O.S. Tattersall, 1960, p. 180; 1965; Pillai, 1968, p. 6; Murano, 1986a, p. 2. Panampunnayil, 1999a, p.132, fig. 5.29

Occurrence

Arabian Sea: station 1392, 1 spent female and 1 immature female.

Body length: mature female 10 mm

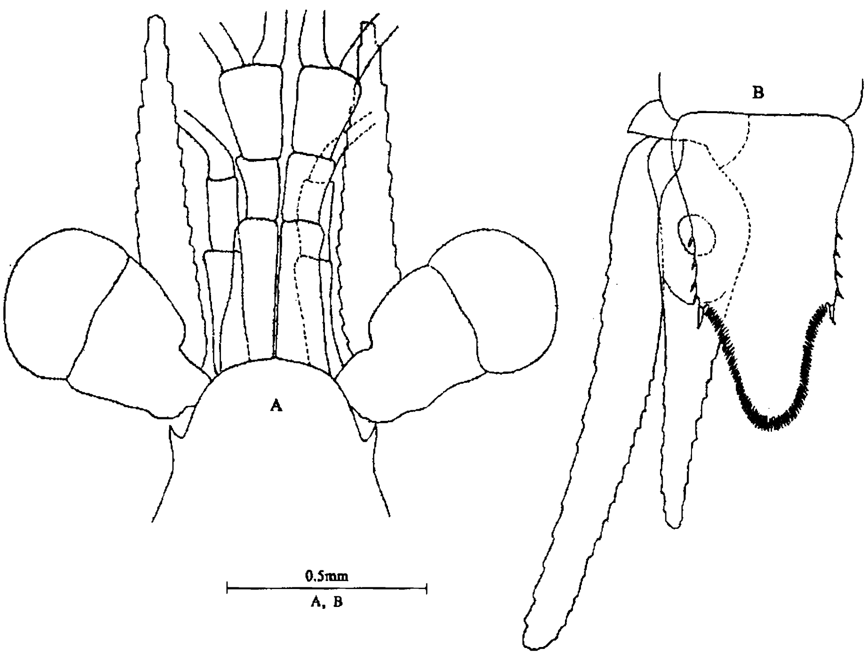


Figure 3.24. *Mesopodopsis orientalis* Tattersall, Male. A, anterior part of body; B, posterior part of body.

Remarks: This species was created by Tattersall (1908) for specimens collected from the brackish water of Bengal. *M. orientalis* is easily distinguished from other Indian species *M. zeylanica* Nouvel (1954) by the following points. In *M. orientalis* the frontal plate is semicircular. The endopod of fourth pleopod is longer than first segment of exopod, exopod three segmented and outer apical setae unsegmented and the distal part of telson armed with 30 to 36 pair of short spines. In *M. zeylanica* the frontal plate is triangular, the endopod of the fourth pleopod is shorter than the first segment of exopod, the exopod is five segmented, outer apical setae of the exopod is sub divided and distal part of telson armed with 50-55 teeth.

Genus *Acanthomysis* Czerniavsky

Acanthomysis Czerniavsky, 1882, p. 58, 64, 134.

Dasymysis Holt and Beaumont, 1900, pp. 25-26.

Metamysis Nakazawa, 1910, p. 250.

Orientomysis Derzhavin, 1913, p. 200.

Neomysis W.M. Tattersall, 1922, p. 483; 1932, p. 317.

Acanthomysis Ii, 1936, p. 588; W.M. Tattersall, 1951, p. 203; Tattersall and Tattersall, 1951, p. 409; Ii, 1964, pp. 464; Pillai, 1967, p. 1721.

Diagnosis: Antennal scale setose all round, long and narrow with rounded apex. Carpopropodus of thoracic endopods three to eight three segmented. Pleopods in female rudimentary unsegmented plates; in male pleopods one to three and five as in female, fourth with unsegmented endopod, exopod long, and two to three segmented, terminating in two long barbed setae. Teslon sub triangular, elongate, apex entire, lateral margins with small number of proximal spines and large number of distal ones, arranged regularly or in distinct series, apex of telson with long spines, endopod of uropod with spines in region of statocyst.

Remarks: This genus was instituted by Czerniavsky (1882) to include forms very closely allied to genus *Neomysis*, but which had the apex of the antennal scale rounded instead of ending in a long spine. In 1915 Zimmer on account of the very close similarity of the form of the fourth pleopod of the male regarded the genus as synonym of *Neomysis*. So many new species have been added to the genus *Neomysis* and as suggested by W.M. Tattersall (1922). Ii (1936) resintated the genus *Acanthomysis* to include those species in which the antennal scale has a rounded apex. This genus also closely related with *Paracanthomysis* Ii and *Proneomysis* Tattersall, but this genus easily distinguished by the structure of fourth pleopod.

Of the 14 species, which have up to the present been referred to this genus, only 5 species are known from Indian waters, they are *A. indica* (W.M. Tattersall, 1922), *A. pelagica* (Pillai, 1957), *A. anomala* (Pillai, 1961), *A. platycauda* (Pillai, 1964) and *A. macrops* (Pillai, 1973). The present materials contain only one species, *Acanthomysis macrops.*

Acanthomysis macrops Pillai

(Fig. 3.25 A-F)

Acanthomysis macrops Pillai, 1973, p. 110, fig. 61; Panampunnayil, 1999a, pp. 122 -124 fig. 5.

Occurrence

Arabian Sea: station 1392, 1 mature male, 4 immature females and 1 spent female.

Body length: mature male and female 6 mm.

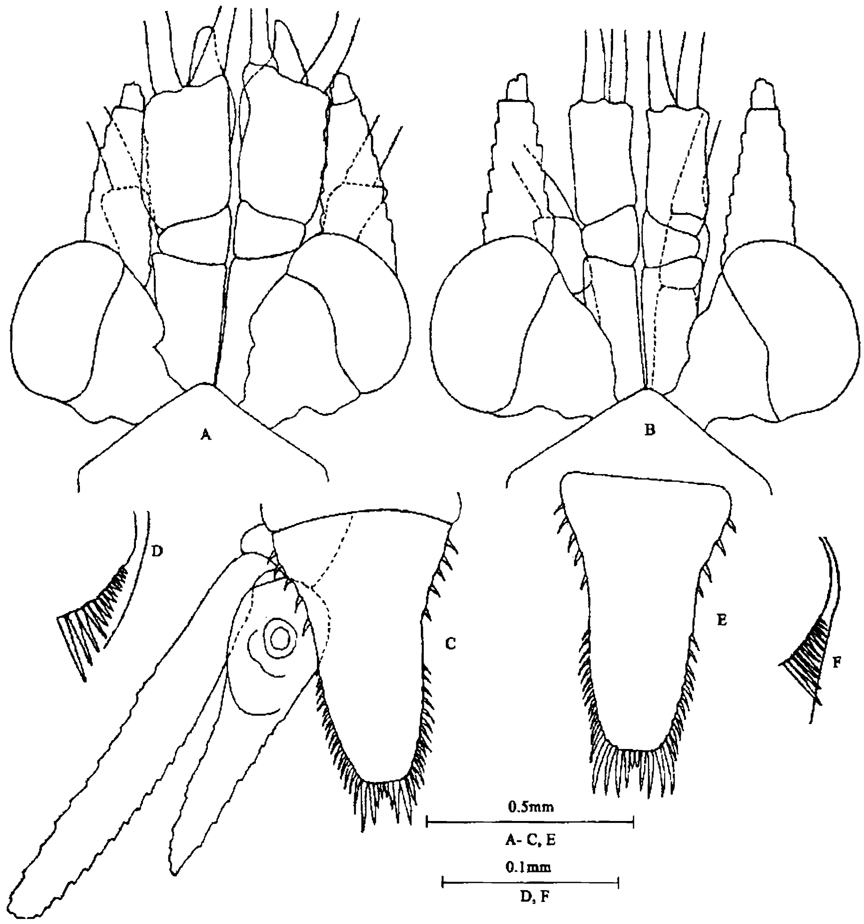


Figure 3.25. *Acanthomysis macrops* Pillai, Male. A, anterior part of body; B, anterior part of body of female; C, posterior part of body; D, spines on enopod of uropod; E, telson of female; F, spines on enopodof uropod.

Remarks: This species was created by Pillai (1973) based on material collected from the Arabian Sea during the IIOE. The present material very well agrees with the descriptions and figures published by Pillai except some minor variations. In the present specimen, lateral border of the distal half of the telson carry 13 pairs of spines, while in Pillai's specimen there are only 10 pairs. The telson showed clear dimorphism. In the present specimen in male, telson base is broad and apex proper carry only four pairs of spines and the outer two pairs are long and sub equal and inner most pair is the shortest in male while in female outer two are large and more or less same length. In Pilla's specimen, 4 pair is regularly increases in length towards the middle. In ecimen collected from the northern Arabian Sea (Panampunnayil, 1999a), ater two pairs are long and sub equal and the innermost pair is shortest.

Genus *Lycomysis* Hansen

Lycomysis Hansen, 1910, 37, pp.75-77.

Lycomysis Zimmer, 1915, p.216.

Lycomysis Ii, 1964, p. 543.

Diagnosis: Frontal plate short. Eye large. Antennal scale lanceolate and setose all around with distal partition. Labrum with long spiniform frontal process. Mandibular palp normal or armed with row of teeth along the inner margin of the second segment. Propodus of the thoracic endopods three to eight divided into three sub segments, claws setiform. Pleopods one to three and five of male simple unjointed plate with prominent side lobe, fourth with exopod three- jointed and terminating in a very long seta. Endopod of uropod with or without few spines in the region of statosyst. Telson with two rows of spines, a dorsal marginal row of long spines and ventral row of small spines.

Remarks: This genus was established in 1910 by Hansen for *L. spinicauda* , obtained by the *Siboga* Expedition. At present this genus includes 3 species, *L. spinicauda* Hansen (1910), *L. bispina* (Ii, 1940) and *L. platycauda* (Pillai, 1961). In the Indian waters this genus is represented by two species, *L. spinicauda* Hansen and *L. platycauda* Pillai. In the present collection this genus is represented by *L. spinicauda* and is the second record in the Indian water.

This genus is easily distinguished from others by the presence of 'saw' like structure on the mandibular palp and two rows of spines at each side of telson.

Lycomysis spinicauda Hansen

(Fig. 3.26 A-C)

Lycomysis spinicauda, Hansen, 1910, p. 77, pl.xi, figs. 3a-f, pl. xii, figs.2a-h.

Lycomysis spinicauda Colosi, 1916, p.1964, figs.1a-d; 1918, p.10; 1920, p. 251, pl.xx.figs.10a-g.

Lycomysis pusilla, Zimmer, 1915, p.175, figs. 30-37.

Lycomysis spinicauda W. M. Tattersall, 1922, p. 492, figs, 25;

Occurrence

Andaman Sea: station 1532, 1 immature female and 2 juveniles

Body length: immature female, 4.2 mm.

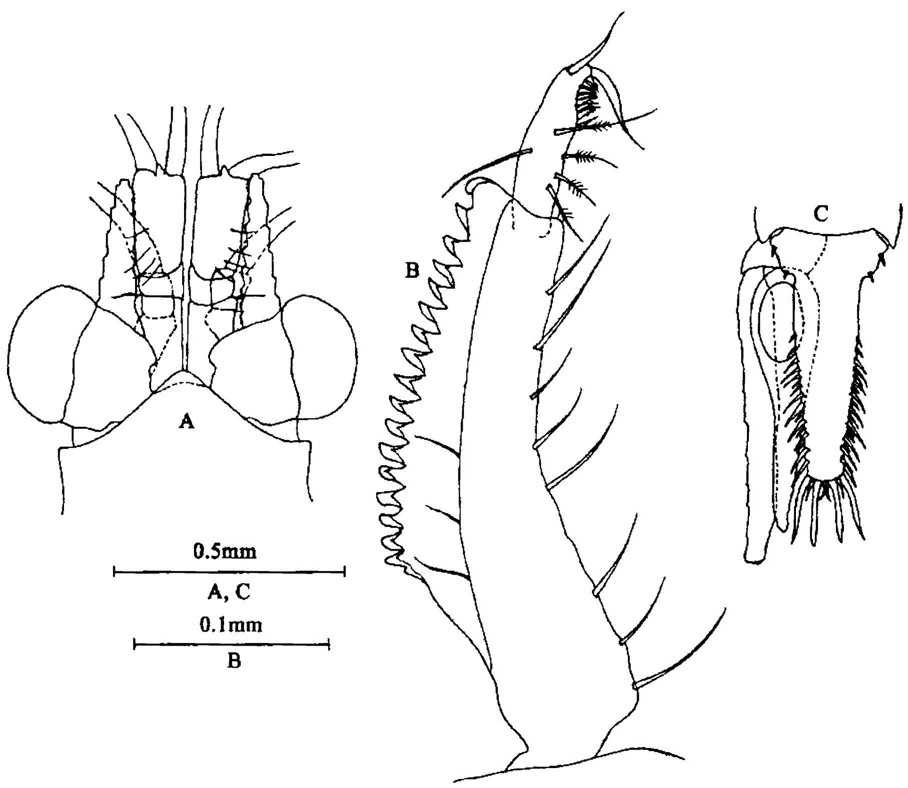


Figure 3.26. *Lycomysis spinicauda* Hansen, Immature female .A, anterior part of body; C, mandibular palp; D, posterior part of body.

Remarks: Eventhough the present materials are in immature, they are easily identified as *Lycomysis* by the structure of mandibular palp and telson. The present specimens distinguished *L. platycauda* by the following points. In the present specimens, apex of telson is subtrucate, with two pairs of long spines and two pairs of very short spines and the endopod of uropod without spines. In *L. platycauda* apex of telson is rounded, with five pairs of long spines, with median small spines and endopod of uropod with four spines below the statocyst.

Genus *Anisomysis* Hansen

Anisomysis Hansen, 1910, p. 74; Nagazawa, 1910, p. 252.

Cryptomysis Hansen, 1912, p. 203.

Kreagromysis Illig, 1913, p. 6; 1930, p. 580.

Anisomysis Illig, 1930, p. 592; Ii, 1964, p. 548; Bacescu, 1973a, p. 176; Pillai, 1976, p. 65.

Diagnosis: Slender body and large eyes with single or double cornea. Carapace with obtuse rostral prolongation. Antennal scale narrow, setose all round and with small distal joint. Second segment of mandibular palp with normal setae or small denticles with setae. First thoracic endopod with well-developed lobe from second joint. Sixth joint of thoracic endopod 3-8 usually divided into sub segments. Pleopods in both sexes except fourth in male rudimentary; endopod of fourth pair of male small, exopod very long three segmented terminating into two stout often armed spines. Telson short, with or without distal sinus. Uropods with rami setose all round, sub equal in length.

Remarks: The genus *Anisomysis* comprises more than forty species. Bacescu (1973a) divided the Genus *Anisomysis* into two subgenera based on the structure of the mandibular palp; subgenus *Paranisomysis* with prominent flagellate denticles along the inner margin of the second segment of the mandibular palp and subgenus *Anisomysis* with out such denticles. One species of the subgenus *Anisomysis* are represented in the present collection.

Anisomysis spinata Panampunnayil

(Fig. 3.27 A-B)

Anisomysis spinata, Panampunnayil, 1993, pp.114-1145, figs 1-19; 2002, pp. 188-189, fig 6-15.

Occurrence

Andaman Sea: station 1334, 1 mature male.

Body length: mature male, 4 mm

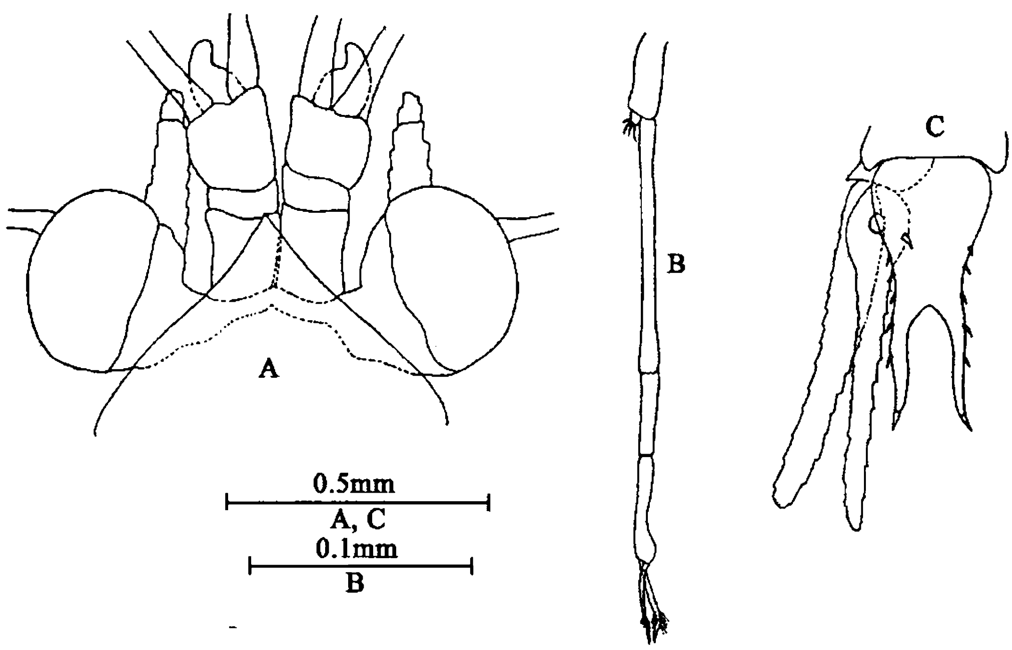


Figure 3.27. *Anisomysis spinata* Panampunnayil, Male. A, anterior part of the body; B, fourth pleopods; C, posterior part of the body

Remarks: The shape and armature of the telson and the presence of a spine on the endopod of the uropod distinguishes this species. The present specimen very well agree with the type specimen expect for the following minor pionts. The rostrum is narrower covering only the basal part of the eyestalks where as in the type specimen the rostrum is broader covering proximal half of eyestalks. In the present specimen the third segment of the exopod of the fourth pleopod is longer than the second segment while in the type specimen the third segment is shorter than the second segment. In the present species the lateral border of telson carry only 5 spines as against 6 in the type specimen.

3.3. DISCUSSION

The present study extends our knowledge on the Mysidacea on the Indian EEZ of Arabian Sea, Bay of Bengal and Andaman Sea. Twenty seven species belonging to 21 genera were recorded and the Genus *Anchialina* is represented by maximum number of species (4), followed by *Siriella* (3) and *Pseudanchialina* (2). All other genera are represented by single species. Through this study, three species, *Boreomysis plebeja, Anchialina media* and *Synerythrops intermedia* are added to the species list of mysids in the Indian waters. In Indian waters, *Rhopalophthalmus indicus* and *Euchaetomera glyphidophthalmica* are confined to west coast while the present study extends its distribution to east coast. *Pseuderythrops gracilis* is also a new record from Andaman Water.

During IIOE collection, 38 species were recorded from Indian Ocean by Pillai (1973). Thirteen species recorded during the present study, *Boreomysis plebeja, Rhopalophthalmus indicus, Eurobowmanilla simulans, Anchialina grossa, A. media, Euchaetomera glyphidophthalmica, Synerythrops intermedia, Pleurerythrops inscita, Giberythrops acanthura, Dioaptromysis perspicillata, Mesopodopsis orientalis, Lycomysis spinicauda,* and *Anisomysis spinata* were not represented in the IIOE collection.

Mysids recorded from the IIOE and the present collections are the following.

Species	IIOE	Present study
Lophogaster typicus	+	-
Lophogaster affinis	+	-
Paralophogaster indicus	+	-
Petalophthalmus oculatus	+	-
Boreomysis kistnae	+	-
Boreomysis plebeja	-	+
Siriella thomposoni	+	+
Siriella gracilis	+	+
Siriella dubia	+	-
Siriella aequiremis	+	+
Siriella jonesi	+	-
Hemisiriella parva	+	+
Hemisiriella pulchra	+	-
Rhopalophthalmus macropsis	+	-
Rhopalophthalmus kempi	+	-
Rhopalophthalmus indicus	-	+
Gastrosaccus dunckeri	+	+
Haplostylus bengalensis	+	-
Haplostylus pusillus	+	+
Eurobowmaniella simulans	-	+
Anchialia typica	+	+
Anchialina dentata	+	+
Anchialina sp.	+	-
Anchialina grossa	-	+
Anchialina media	-	+
Pseudanchialina pusilla	+	+
Pseudanchialina inermis	+	+
Erythrops minuta	+	-
Euchaetomera typica	+	-
Euchaetomera sp.	+	-
Euchaetomera glyphydophthalmica	-	+
Pleurethrops inscita	-	+
Synerythrops intermediata	-	+
Arachnomysis leuckartii	+	-
Longithroax similerythrops	+	-
Gymnerythrops macrops	+	-
Pseuderythrops gracilis	+	+
Gibbererythrops acanthura	-	+
Leptomysis capensis	+	-
Promysis orientalis	+	-
Afromysis dentisinus	+	+
Doxomysis quadrispinosa	+	-
Doxomysis longiura	+	+
Dioptromysis perspicillata	-	+
Acanthomysis platycauda	+	-
Acanthomysis macrops	+	+
Acanthomysis sp.	+	-
Mesopodopsis orientalis	-	+
Lycomysis spinicauda	-	+
Anisomysis hispida	+	-
Anisomysis tattersallae	+	-
Anisomysis spinata	-	+

+ present, - absent

The absence of some of the species of mysids in the present collections ay be due to the difference in the sampling depths and station location in the dian waters. The absence of species like *Boreomysis plebeja, Giberythrops canthura* and *Synerythrops intermedia* in the IIOE collection was mainly due the sampling depth; the above species are deep-water forms. In IIOE ollections, the sampling was restricted to 200 m where as the present ollections covers deeper depth as well.

Table 3.1. 'Sagar sampada' stations where mysids were collected from surface waters of the Arabian Sea

Station numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids ($1000m^3$)
	Latitude (N)		Longitude (E)					
1392	08°	00'	76°	27'	167	14-9-03	08.50	561
1393	08°	00'	76°	00'	1476	14-9-03	1745	-
1394	08°	00'	75°	00'	2766	15-9-03	0710	-
1395	08°	00'	74°	00'	2767	15-9-03	1632	-
1396	08°	00'	73°	00'	1291	16-9-03	0815	-
1397	08°	00'	72°	00'	1325	16-9-03	1728	-
1398	10°	00'	69°	00'	4518	18-9-03	1826	99
1399	10°	00'	70°	00'	4526	19-9-03	0215	-
1400	10°	00'	71°	00'	3631	19-9-03	1227	-
1401	10°	00'	72°	00'	2231	19-9-03	2154	28
1402	10°	00'	73°	00'	1980	20-9-03	0810	-
1403	10°	00'	74°	00'	2374	20-9-03	1900	-
1404	10°	00'	75°	00'	2218	21-9-03	1956	-
1405	10°	00'	75°	26'	130	21-9-03	0141	21
1406	11°	30'	75°	00'	205	22-9-03	2015	-
1407	11°	30'	74°	00'	2070	23-9-03	0550	-
1408	11°	30'	73°	00'	1579	23-9-03	1532	-
1409	11°	30'	72°	00'	1730	24-9-03	2030	90
1410	11°	30'	71°	00'	2887	24-9-03	1200	10
1411	13°	00'	70°	00'	4235	25-9-03	0235	50
1412	13°	00'	71°	00'	2441	25-9-03	0753	-
1413	13°	00'	72°	00'	1338	26-9-03	1839	-
1414	13°	00'	73°	00'	1954	27-9-03	0600	-
1415	13°	00'	74°	00'	170	28-9-03	0934	-
1417	15°	00'	73°	00'	218	5-10-03	1829	-
1418	15°	00'	72°	00'	2051	6-10-03	0249	-
1419	15°	00'	71°	00'	2601	6-10-03	1257	32
1420	15°	00'	70°	00'	3476	7-10-03	0033	-
1421	17°	00'	69°	00'	2622	8-10-03	1625	-
1422	17°	00'	70°	00'	3470	9-10-03	0228	1000
1423	17°	00'	71°	00'	2434	10-10-03	0320	-
1424	17°	00'	73°	00'	210	10-10-03	1335	-
1426	19°	00'	72°	00'	74	12-10-03	1155	-
1427	19°	00'	71°	00'	82	12-10-03	0659	-
1428	19°	00	70°	27'	198	13-10-03	0458	-
1429	19°	00'	69°	00'	2814	14-10-03	1824	-

- Not present

Table 3.1. (contd.)

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m^3
	Latitude (N)		Longitude (E)					
1430	19°	00'	68°	00'	3219	15-10-03	1544	1428
1432	21°	00'	67°	00'	2417	16-10-03	1642	-
1433	21°	00'	68°	00'	2679	17-10-03	0222	-
1435	21°	00'	69°	00'	1000	18-10-03	1143	-
1476	08°	00'	76°	17'	1085	19-3-04	1945	4846
1477	08°	00'	76°	00'	1400	20-3-04	0525	1682
1478	08°	00	75°	00'	2873	20-3-04	1330	-
1479	08°	00'	74°	00'	2120	21-3-04	0.50	20827
1480	08°	00'	73°	00'	1800	21-3-04	1400	-
1481	08°	00'	72°	00'	2800	22-3-04	1942	17301
1482	08°	00'	71°	00'	4900	24-3-04	1815	11470
1483	10°	00'	70°	00'	4526	25-3-04	0450	1205
1484	10°	00'	71°	00'	3410	25-3-04	1300	-
1485	10°	00'	72°	00'	1987	26-3-04	1130	-
1486	10°	00'	73°	00	1917	26-3-04	1000	-
1487	10°	00'	74°	00	2370	26-3-04	0700	-
1488	10°	00'	75°	00'	1022	27-3-04	1815	-
1489	10°	00'	75°	17'	1700	27-3-04	2230	48750
1490	10°	40'	75°	00'	1300	28-3-04	0915	1034
1491	11°	09'	74°	00'	1300	28-3-04	0720	-
1492	11°	09'	73°	00'	1700	29-3-04	0445	-
1493	11°	09'	71°	15'	1325	30-3-04	0635	-
1494	11°	09'	72°	00'	1500	31-3-04	0235	1800
1495	13°	00'	74°	00'	216	1-4-04	0635	661
1496	13°	00'	73°	00'	1900	2-4-04	0140	-
1497	13°	00'	72°	00'	1100	2-4-04	0110	-
1498	13°	00'	71°	00'	1100	2-4-04	2045	7266
1499	13°	00'	70°	00'	4437	3-4-04	08.0	596
1500	15°	00'	70°	00'	4378	5-4-04	1820	-
1501	15°	00'	71°	00'	2561	6-4-04	0400	2317
1502	15°	00'	72°	00'	2019	6-4-04	1445	-
1503	15°	00'	73°	00'	215	7-4-04	0700	36
1504	15°	00'	73°	30'	60	7-4-04	1000	4607
1505	17°	00'	69°	00'	2588	13-4-04	1110	-
1506	17°	00'	70°	00'	2588	13-4-04	2135	392
1507	17°	00'	71°	00'	2540	15-4-04	0645	-

- Not present

Table 3.1. (contd.)

Station numbers	Positions Latitude (N)		Longitude (E)		Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
1508	17°	00'	72°	00'	110	16-4-04	0845	402
1509	17°	00'	73°	00'	57	15-4-04	2115	-
1510	18°	23'	72°	00'	73	18-4-04	0001	-
1511	19°	00'	71°	00'	78	17-4-04	1705	-
1512	19°	00'	70°	00'	185	17°	00'	-
1513	19°	00'	69°	00'	2700	21-4-04	0355	-
1514	19°	00'	67°	00'	3500	27-4-04	0345	-
1515	21°	00'	69°	15'	62	22-4-04	0028	1429
1516	21°	00'	70°	00'	550	22-4-04	1800	-
1517	21°	00'	67°	00'	2500	23-4-04	0640	-
1519	21°	00'	65°	00'	2700	24-4-04	0600	-
1520	22°	00'	66°	00'	2500	25-4.04	0530	-
1521	22°	00'	67°	00'	1800	26-4-04	0060	-
1522	22°	00'	68°	00'	121	26-4-05	1530	-
1518	21°	00'	66°	00'	2700	23-4-04	1801	179
1509	17°	00'	73°	00'	57	15-4-04	2115	434
1672	08°	00''	76°	34'	5002	27-5-05	1830	-
1673	08°	00'	76°	00'	1527	28-5-05	1245	-
1674	08°	00'	75°	00'	2837	28-5-05	0930	161
1675	08°	00'	74°	00'	2839	28-5-05	0615	-
1676	08°	00'	73°	00'	2096	29-5-05	1810	882
1677	08°	00'	72°	00'	2876	30-5-05	0430	1126
1678	10°	00'	71°	00'	3752	30-5-05	2215	3291
1679	10°	00'	70°	00'	3600	31-5-05	1735	-
1680	10°	00'	72°	00'	1900	1-6.05	0810	-
1681	10°	00'	73°	00'	2032	1-6-05	1610	-
1682	10°	00'	74°	00'	2435	1-6-05	0045	14137
1683	10°	00'	75°	00'	2261	2-6-05	0855	-
1684	10°	00'	75°	34'	235	2-6-05	1230	12352
1685	11°	00'	74°	38'	555	4-6-05	1740	1000
1686	11°	00'	74°	00'	2121	5-6-05	2300	2608
1687	11°	00'	73°	00'	1688	5-6-05	2300	-
1688	11°	00'	72°	00'	1740	5-6-05	2210	3194
1689	11°	00'	71°	00'	2500	6-6-05	0800	-
1690	13°	00'	70°	00'	4500	7-6-05	1850	-
1691	13°	00'	71°	00'	2481	7-6-05	0110	4316

- Not present

able 3.1. (contd.)

ation mbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m^3)
	Latitude (N)		Longitude (E)					
1692	13°	00'	72°	00'	1676	8-6-05	0945	-
1693	13°	00'	73°	00'	1812	8-6-05	1930	8604
1694	13°	00'	74°	00'	210	9-6-05	1830	-
1695	15°	00'	72°	00'	2110	10-6-05	1430	-
1696	15°	00'	73°	00'	570	10-6-05	1850	-
1697	15°	00'	73°	00'	231	13-6-05	0815	-
1698	17°	00'	72°	06'	196	14-6-05	0640	-
1699	17°	00'	71°	00'	2450	14-6-05	0400	1176
1700	17°	00'	70°	00'	3555	15-6-05	1235	-
1701	17°	00'	69°	00'	2485	15-6-05	2132	-
1702	19°	00'	68°	00'	3382	17-6-05	1850	-
1703	19°	00'	69°	00'	2918	18-6-05	0000	1053
1704	19°	00'	70°	00'	400	18-6-05	1835	-
1705	19°	00'	71°	00'	84	19-6-05	0250	-
1706	19°	00'	72°	00'	72	19-06-05	0650	-
1707	17°	00'	73°	00'	52	19-06-05	2240	2051
1910	15°	00'	73°	30'	1410	30-11-06	0609	-
1911	15°	00'	73°	00'	1830	30-11-06	0212	-
1912	15°	00'	72°	00'	130	2-12-06	2047	86
1913	15°	00'	71°	00'	2608	2-12-06	0920	110
1914	15°	00'	70°	00'	3442	2-12-06	1815	-
1915	17°	00'	69°	00'	2549	4-12-06	1120	-
1916	17°	00'	70°	00'	3457	4-12-06	1850	-
1917	17°	00'	71°	00'	2375	6-12-06	0330	267
1918	17°	00'	72°	00'	175	7-12-06	1830	-
1919	17°	00'	73°	00'	5071	6-12-06	0143	-
1920	19°	00'	72°	00'	86	12-12-06	0435	-
1921	19°	00'	71°	00'	200	10-12-06	1910	147
1922	19°	00'	70°	00'	200	10-12-06	1134	-
1923	19°	00'	69°	00'	2808	10-12-06	0330	-
1924	19°	00'	68°	00'	3500	9-12-06	0850	-
1925	21°	00'	69°	30'	66	14-12-06	1215	-
1926	21°	00'	69°	00'	490	14-12-06	0900	-
1927	21°	00'	68°	00'	2652	14-12-06	1720	-[
1928	21°	00'	67°	00'	2407	15-12-06	1800	132
1929	21°	00'	66°	00'	2405	16-12-06	0100	-

- Not present

structure of the mandibular palp; subgenus *Paranisomysis* with prominent flagellate denticles along the inner margin of the second segment of the mandibular palp and subgenus *Anisomysis* with out such denticles. One species of the subgenus *Anisomysis* are represented in the present collection.

Anisomysis spinata Panampunnayil

(Fig. 3.27 A-B)

Anisomysis spinata, Panampunnayil, 1993, pp.114-1145, figs 1-19; 2002, pp. 188-189, fig 6-15.

Occurrence

Andaman Sea: station 1334, 1 mature male.

Body length: mature male, 4 mm

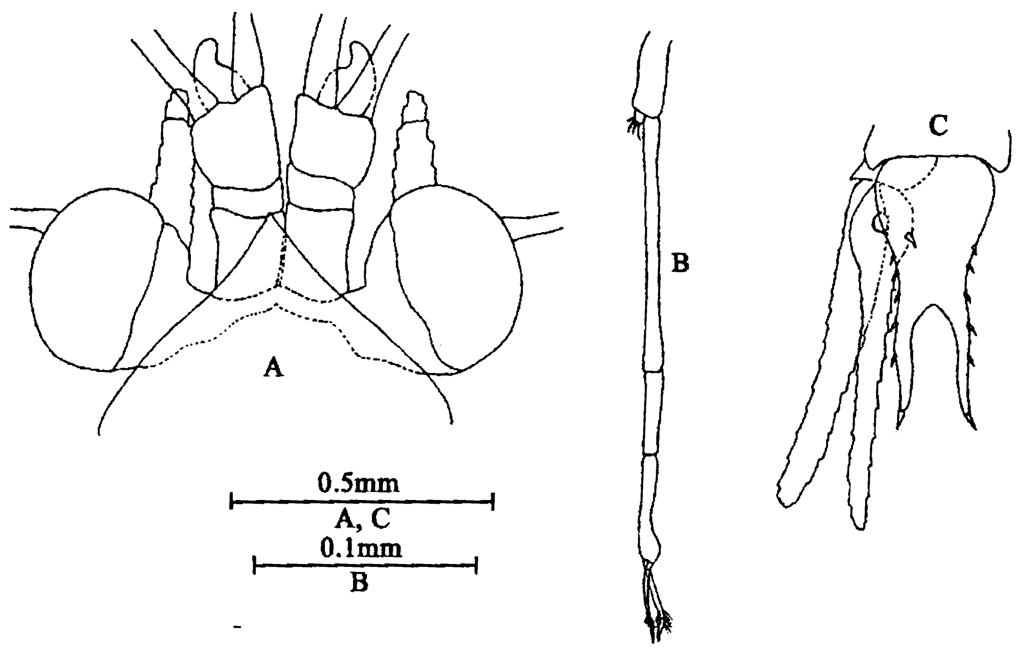


Figure 3.27. *Anisomysis spinata* Panampunnayil, Male. A, anterior part of the body; B, fourth pleopods; C, posterior part of the body

Remarks: The shape and armature of the telson and the presence of a spine on the endopod of the uropod distinguishes this species. The present specimen very well agree with the type specimen expect for the following minor pionts. The rostrum is narrower covering only the basal part of the eyestalks where as in the type specimen the rostrum is broader covering proximal half of eyestalks. In the present specimen the third segment of the exopod of the fourth pleopod is longer than the second segment while in the type specimen the third segment is shorter than the second segment. In the present species the lateral border of telson carry only 5 spines as against 6 in the type specimen.

3.3. DISCUSSION

The present study extends our knowledge on the Mysidacea on the Indian EEZ of Arabian Sea, Bay of Bengal and Andaman Sea. Twenty seven species belonging to 21 genera were recorded and the Genus *Anchialina* is represented by maximum number of species (4), followed by *Siriella* (3) and *Pseudanchialina* (2). All other genera are represented by single species. Through this study, three species, *Boreomysis plebeja, Anchialina media* and *Synerythrops intermedia* are added to the species list of mysids in the Indian waters. In Indian waters, *Rhopalophthalmus indicus* and *Euchaetomera glyphidophthalmica* are confined to west coast while the present study extends its distribution to east coast. *Pseuderythrops gracilis* is also a new record from Andaman Water.

During IIOE collection, 38 species were recorded from Indian Ocean by Pillai (1973). Thirteen species recorded during the present study, *Boreomysis plebeja, Rhopalophthalmus indicus, Eurobowmanilla simulans, Anchialina grossa, A. media, Euchaetomera glyphidophthalmica, Synerythrops intermedia, Pleurerythrops inscita, Giberythrops acanthura, Dioaptromysis perspicillata, Mesopodopsis orientalis, Lycomysis spinicauda,* and *Anisomysis spinata* were not represented in the IIOE collection.

The absence of some of the species of mysids in the present collections may be due to the difference in the sampling depths and station location in the Indian waters. The absence of species like *Boreomysis plebeja, Giberythrops acanthura* and *Synerythrops intermedia* in the IIOE collection was mainly due to the sampling depth; the above species are deep-water forms. In IIOE collections, the sampling was restricted to 200 m where as the present collections covers deeper depth as well.

Table 3.1. (contd.)

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m^3
	Latitude (N)		Longitude (E)					
1430	19°	00'	68°	00'	3219	15-10-03	1544	1428
1432	21°	00'	67°	00'	2417	16-10-03	1642	-
1433	21°	00'	68°	00'	2679	17-10-03	0222	-
1435	21°	00'	69°	00'	1000	18-10-03	1143	-
1476	08°	00'	76°	17'	1085	19-3-04	1945	4846
1477	08°	00'	76°	00'	1400	20-3-04	0525	1682
1478	08°	00	75°	00'	2873	20-3-04	1330	-
1479	08°	00'	74°	00'	2120	21-3-04	0.50	20827
1480	08°	00'	73°	00'	1800	21-3-04	1400	-
1481	08°	00'	72°	00'	2800	22-3-04	1942	17301
1482	08°	00'	71°	00'	4900	24-3-04	1815	11470
1483	10°	00'	70°	00'	4526	25-3-04	0450	1205
1484	10°	00'	71°	00'	3410	25-3-04	1300	-
1485	10°	00'	72°	00'	1987	26-3-04	1130	-
1486	10°	00'	73°	00	1917	26-3-04	1000	-
1487	10°	00'	74°	00	2370	26-3-04	0700	-
1488	10°	00'	75°	00'	1022	27-3-04	1815	-
1489	10°	00'	75°	17'	1700	27-3-04	2230	48750
1490	10°	40'	75°	00'	1300	28-3-04	0915	1034
1491	11°	09'	74°	00'	1300	28-3-04	0720	-
1492	11°	09'	73°	00'	1700	29-3-04	0445	-
1493	11°	09'	71°	15'	1325	30-3-04	0635	-
1494	11°	09'	72°	00'	1500	31-3-04	0235	1800
1495	13°	00'	74°	00'	216	1-4-04	0635	661
1496	13°	00'	73°	00'	1900	2-4-04	0140	-
1497	13°	00'	72°	00'	1100	2-4-04	0110	-
1498	13°	00'	71°	00'	1100	2-4-04	2045	7266
1499	13°	00'	70°	00'	4437	3-4-04	08.0	596
1500	15°	00'	70°	00'	4378	5-4-04	1820	-
1501	15°	00'	71°	00'	2561	6-4-04	0400	2317
1502	15°	00'	72°	00'	2019	6-4-04	1445	-
1503	15°	00'	73°	00'	215	7-4-04	0700	36
1504	15°	00'	73°	30'	60	7-4-04	1000	4607
1505	17°	00'	69°	00'	2588	13-4-04	1110	-
1506	17°	00'	70°	00'	2588	13-4-04	2135	392
1507	17°	00'	71°	00'	2540	15-4-04	0645	-

- Not present

Table 3.1. (contd.)

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1508	17°	00'	72°	00'	110	16-4-04	0845	402
1509	17°	00'	73°	00'	57	15-4-04	2115	-
1510	18°	23'	72°	00'	73	18-4-04	0001	-
1511	19°	00'	71°	00'	78	17-4-04	1705	-
1512	19°	00'	70°	00'	185	17°	00'	-
1513	19°	00'	69°	00'	2700	21-4-04	0355	-
1514	19°	00'	67°	00'	3500	27-4-04	0345	-
1515	21°	00'	69°	15'	62	22-4-04	0028	1429
1516	21°	00'	70°	00'	550	22-4-04	1800	-
1517	21°	00'	67°	00'	2500	23-4-04	0640	-
1519	21°	00'	65°	00'	2700	24-4-04	0600	-
1520	22°	00'	66°	00'	2500	25-4.04	0530	-
1521	22°	00'	67°	00'	1800	26-4-04	0060	-
1522	22°	00'	68°	00'	121	26-4-05	1530	-
1518	21°	00'	66°	00'	2700	23-4-04	1801	179
1509	17°	00'	73°	00'	57	15-4-04	2115	434
1672	08°	00''	76°	34'	5002	27-5-05	1830	-
1673	08°	00'	76°	00'	1527	28-5-05	1245	-
1674	08°	00'	75°	00'	2837	28-5-05	0930	161
1675	08°	00'	74°	00'	2839	28-5-05	0615	-
1676	08°	00'	73°	00'	2096	29-5-05	1810	882
1677	08°	00'	72°	00'	2876	30-5-05	0430	1126
1678	10°	00'	71°	00'	3752	30-5-05	2215	3291
1679	10°	00'	70°	00'	3600	31-5-05	1735	-
1680	10°	00'	72°	00'	1900	1-6.05	0810	-
1681	10°	00'	73°	00'	2032	1-6-05	1610	-
1682	10°	00'	74°	00'	2435	1-6-05	0045	14137
1683	10°	00'	75°	00'	2261	2-6-05	0855	-
1684	10°	00'	75°	34'	235	2-6-05	1230	12352
1685	11°	00'	74°	38'	555	4-6-05	1740	1000
1686	11°	00'	74°	00'	2121	5-6-05	2300	2608
1687	11°	00'	73°	00'	1688	5-6-05	2300	-
1688	11°	00'	72°	00'	1740	5-6-05	2210	3194
1689	11°	00'	71°	00'	2500	6-6-05	0800	-
1690	13°	00'	70°	00'	4500	7-6-05	1850	-
1691	13°	00'	71°	00'	2481	7-6-05	0110	4316

- Not present

Table 3.1. (contd.)

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1692	13°	00'	72°	00'	1676	8-6-05	0945	-
1693	13°	00'	73°	00'	1812	8-6-05	1930	8604
1694	13°	00'	74°	00'	210	9-6-05	1830	-
1695	15°	00'	72°	00'	2110	10-6-05	1430	-
1696	15°	00'	73°	00'	570	10-6-05	1850	-
1697	15°	00'	73°	00'	231	13-6-05	0815	-
1698	17°	00'	72°	06'	196	14-6-05	0640	-
1699	17°	00'	71°	00'	2450	14-6-05	0400	1176
1700	17°	00'	70°	00'	3555	15-6-05	1235	-
1701	17°	00'	69°	00'	2485	15-6-05	2132	-
1702	19°	00'	68°	00'	3382	17-6-05	1850	-
1703	19°	00'	69°	00'	2918	18-6-05	0000	1053
1704	19°	00'	70°	00'	400	18-6-05	1835	-
1705	19°	00'	71°	00'	84	19-6-05	0250	-
1706	19°	00'	72°	00'	72	19-06-05	0650	-
1707	17°	00'	73°	00'	52	19-06-05	2240	2051
1910	15°	00'	73°	30'	1410	30-11-06	0609	-
1911	15°	00'	73°	00'	1830	30-11-06	0212	-
1912	15°	00'	72°	00'	130	2-12-06	2047	86
1913	15°	00'	71°	00'	2608	2-12-06	0920	110
1914	15°	00'	70°	00'	3442	2-12-06	1815	-
1915	17°	00'	69°	00'	2549	4-12-06	1120	-
1916	17°	00'	70°	00'	3457	4-12-06	1850	-
1917	17°	00'	71°	00'	2375	6-12-06	0330	267
1918	17°	00'	72°	00'	175	7-12-06	1830	-
1919	17°	00'	73°	00'	5071	6-12-06	0143	-
1920	19°	00'	72°	00'	86	12-12-06	0435	-
1921	19°	00'	71°	00'	200	10-12-06	1910	147
1922	19°	00'	70°	00'	200	10-12-06	1134	-
1923	19°	00'	69°	00'	2808	10-12-06	0330	-
1924	19°	00'	68°	00'	3500	9-12-06	0850	-
1925	21°	00'	69°	30'	66	14-12-06	1215	-
1926	21°	00'	69°	00'	490	14-12-06	0900	-
1927	21°	00'	68°	00'	2652	14-12-06	1720	-[
1928	21°	00'	67°	00'	2407	15-12-06	1800	132
1929	21°	00'	66°	00'	2405	16-12-06	0100	-

- Not present

Table 3.2. 'Sagar sampada' stations where mysids were collected from surface waters of the Bay of Bengal

tion mber	Positions				Depth of Stations in meters	Date	Time in hours	Total Number of Mysids ($1000m^3$)
	Latitude (N)		Longitude (E)					
230	19°	00'	84°	40'	54.9	11-11-02	0109	-
231	19°	00'	85°	12'	175	11-11-02	0905	-
232	17°	00'	82°	32'	55	12-11-02	1610	69
233	17°	00'	83°	00'	219	12-11-02	2030	-
234	17°	00'	84°	00'	800	13-11-02	0615	-
235	17°	00'	85°	00'	2755	13-11-02	1625	-
236	17°	00'	86°	00'	2700	14-11-02	0010	602
237	17°	00	87°	00'	2564	14-11-02	1245	-
238	19°	00'	87°	00'	1965	15-11-02	0510	7
239	19°	00'	87°	25'	2180	15-11-02	2245	60
240	19°	00'	88°	00'	2204	16-11-02	0730	-
241	19°	00'	89°	00'	1771	16-11-02	19.15	3357
242	20°	23'	89°	07'	1173	17-11-02	1400	-
243	20°	00'	88°	00'	130	17-11-02	0974	138
1244	20°	00'	87°	30'	62.5	18-11-02	0526	669
1245	19°	00'	86°	00'	190.3	1911-02	0035	-
1246	15°	00'	80°	17'	67.3	23-11-02	1905	111
1247	15°	00'	80°	25'	1011	23-11-02	2224	371
1248	15°	00'	81°	00'	2551	24-11-02	1000	17
1249	15°	00'	82°	00'	2845	24-11-02	1880	76
1250	15°	00'	83°	00'	3152	25-11-02	1130	-
1251	13°	00'	84°	00'	3314	26-11-02	1100	-
1252	13°	00'	83°	00'	3365	26-11-02	2215	259
1253	13°	00'	82°	00'	3448	27-11-02	0919	-
1254	13°	00'	81°	00'	3389	27-11-02	1212	593
1255	13°	00'	80°	34'	184.2	28-11-02	0705	-
1256	13°	00'	80°	22'	44	28-11-02	1135	-
1257	10°	00'	80°	00'	57	29-11-02	0243	152
1258	10°	00'	80°	12'	153	29-11-02	0718	-
1259	10°	00'	81°	00'	3374	29-11-02	1435	288
1260	11°	00'	82°	00'	3607	30-11-02	1010	-
1261	11°	00'	83°	00'	3542	30-11-02	2320	16
1342	11°	28'	79°	00'	71.2	10-7-03	1034	-
1343	11°	28'	79°	00'	248	10-7-03	1155	-
1344	11°	28'	81°	00'	3241	10-7-03	2024	227
1345	11°	28'	82°	00'	3559	11-7-03	0870	-
1346	11°	28'	83°	00'	3443	11-7-03	1726	-
1347	11°	28'	84°	00'	3463	12-7-03	04.32	-
1348	13°	28	85°	00'	3177	13-7-03	1930	182
1349	13°	28'	84°	00'	3257	14-7-03	1012	-
1350	13°	28'	83°	00'	3339	14-7-03	2311	348

\- Not present

Table 3.2. (contd.)

Station number	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1351	13°	28'	82°	00'	3383	15-7-03	0727	-
1352	13°	28'	81°	00'	3245	15-7-03	1890	132
1353	13°	30'	80°	32'	2626	16-7-03	1236	62
1354	13°	27'	80°	25'	69.1	16-7-03	0250	201
1355	15°	32'	80°	35'	59	17-7-03	1516	-
1356	15°	28'	80°	38'	229	17-7-03	1758	27
1357	15°	28'	81°	00'	1283	18-7-03	2121	86
1358	15°	24'	82°	00'	2532	19-7-03	1135	-
1359	15°	30'	83°	00'	2985	19-7-03	1750	-
1360	15°	30'	84°	00'	3067	20-7-03	0933	-
1361	15°	30'	85°	00'	2961	20-70-3	1730	-
1362	15°	31'	86°	00'	2869	21-7-03	1230	-
1363	17°	30'	83°	18'	5.07	25-7-03	2100	-
1365	17°	30'	85°	00'	2603	27-7-03	1820	78
1364	17°	30'	84°	00'	2551	28-7-03	1915	-
1366	17°	28'	86°	00	2561	29-7-03	0850	-
1367	17°	28'	87°	00'	2454	29-7-03	1900	31
1368	17°	30	88°	00'	2379	30-7-03	0530	-
1369	15°	30'	87°	00'	2800	1-8-03	0855	-
1640	20°	30'	88°	00'	106	21-2-05	1030	-
1641	20°	30'	89°	00'	260	21-2-05	1718	23
1642	20°	23'	90°	00'	124	21-2-05	2333	19
1643	19°	00'	90°	00'	1906	22-2-05	1045	-
1644	19°	00'	89°	00'	1806	22-2-05	1748	-
1645	19°	00'	88°	00'	2260	23-2-05	0038	1092
1646	19°	00'	87°	00'	2034	24-2-05	0900	33
1647	19°	00'	86°	00'	1955	24-2-06	1755	26
1648	19°	00'	85°	00'	369	25-2-05	0015	471
1649	17°	00'	83°	00'	208	26-2-05	2225	997
1650	17°	00'	84°	00'	2079	27-2-05	2330	439
1651	17°	00'	85°	00'	2817	28-2-05	0702	21
1652	17°	00'	86°	00'	2867	28-2-05	1441	-
1653	17°	00'	87°	00'	2631	28-2-05	2226	330
1654	17°	00'	88°	00	2575	2-3-05	0215	486
1655	15°	00'	86°	00'	3005	2-3-05	1918	32
1656	15°	00'	85°	00'	3107	3-3-05	1825	11.9
1657	15°	00'	84°	00'	3180	3-3-05	2255	1681
1658	15°	00'	83°	00'	3024	4-3-05	0734	28
1659	15°	00'	82°	00'	2909	4-3-05	0343	-
1660	15°	47'	80°	00'	180	5-3-05	0359	-
1661	15°	00'	81°	00'	2592	6-3-05	0315	-

\- Not present

Table 3.2. (contd.)

Station Number	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1662	13°	00'	80°	41'	219	6-3-05	2311	-
1663	13°	00'	81°	00'	3476	8-3-05	0120	-
1664	13°	00'	82°	00'	3410	8-3-05	0945	-
1665	13°	00'	83°	00'	3275	8-3-05	1754	42
1666	13°	00'	84°	00'	3396	9-3-05	0245	-
1667	11°	00'	84°	00'	3586	10-3-05	2244	-
1668	11°	00'	83°	00'	3638	11-3-05	0245	15
1669	11°	00'	82°	00'	3704	11-3-05	1020	-
1670	11°	00'	81°	00'	3330	11-3-05	1736	1142
1671	11°	00'	80°	00'	300	12-3-05	2340	52
1875	20°	00'	90°	00'	1200	119-9-06	7000	-
1879	19°	30'	85°	39'	197	22-9-06	1800	-
1880	19°	00'	86°	00'	1888	24-9-06	0001	131
1881	19°	00'	87°	00'	1972	24-9-06	1032	-
1882	19°	00'	88°	00'	2190	24-9-06	1712	-
1883	19°	00'	89°	00'	1683	25-9-06	2145	2151
1884	19°	00'	90°	00'	1848	26-9-06	0455	-
1885	17°	0'	88°	00'	2505	27-9-06	0720	-
1886	17°	00'	87°	00'	2554	28-9-06	1025	-
1887	17°	0'	86°	00'	2692	28-9-06	1940	3866
1888	17°	00'	85°	00'	2758	29-9-06	0545	-
1889	17°	00'	84°	00'	2740	29-9-06	1530	-
1890	17°	00'	83°	00'	192.56	29-9-06	2400	-
1891	15°	00'	80°	00'	148	7-10-06	1900	1698
1892	15°	00'	81°	00'	2504	7-10-06	0800	-
1893	15°	00'	82°	00'	2828	8-10-06	0545	-
1894	15°	00'	83°	00'	3142	8-10-06	1200	-
1895	15°	00'	84°	00'	3104	8-10-06	0910	9696
1896	15°	00'	85°	00'	3014	9-10-06	0645	-
1897	15°	00'	86°	00'	2919	9-10-06	2210	793
1898	13°	00'	85°	00'	3197	10-10-06	1340	-
1899	13°	00'	84°	00'	3299	11-10-06	1700	-
1900	13°	00'	83°	00'	3356	12-10-06	0130	4431
1901	13°	00'	82°	00'	3229	12-10-06	0090	-
1902	13°	00'	81°	00"	3374	12-10-06	1630	1235
1903	13°	00	80°	00	197	13-10-06	1700	-
1904	11°	00'	80°	00'	206	14-10-06	1825	1707
1905	11°	00'	81°	00'	3360	15-10-06	0135	4791
1906	11°	00'	81°	37'	3594	15-10-06	0900	357
1907	11°	19'	83°	00'	3496	15-10-06	2010	-
1908	11°	00'	84°	00'	3490	16-10-06	1810	4285

- Not present

Table 3.3. 'Sagar sampada' stations where mysids were collected from surface waters of the Andaman Sea

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1201	07°	00'	90°	00'	2637	16-9-02	0225	1184
1202	07°	00'	91°	00'	4068	17-9-02	0915	-
1203	07°	00'	94°	00'	900	18-9-02	0415	53
1204	07°	00'	94°	45'	1975	18-9-02	1215	137
1205	10°	00'	95°	00'	1817	20-9-02	0081	-
1206	10°	00'	94°	00'	1546	20-9-02	0223	90
1207	10°	00'	92°	00'	1836	21-09-02	0022	461
1208	10°	00'	90°	00'	3312	22-9-02	0020	494
1209	13°	00'	95°	00'	1255	28-9-02	1810	252
1210	13°	00'	94°	00'	1333	30-9-02	0010	27
1211	13°	00'	92°	00'	1976	30-9-02	2045	646
1212	13°	00'	90°	00'	1026	1-10-02	1305	87
1213	15°	00'	91°	00'	1058	3-10-02	0005	863
1214	15°	00'	90°	00'	2701	4-10-02	0430	183
1215	15°	00'	90°	00'	2815	5-10-02	0015	33
1326	07°	00'	90°	00'	2644	31-3-03	0730	-
1327	07°	00'	91°	00'	3025	31-3-03	2015	-
1328	07°	00'	92°	00'	4065	1-4-03	0745	-
1329	07°	00'	93°	00'	1425	1-4-03	2015	-
1330	07°	00'	94°	00'	420	2-4-03	0080	-
1331	07°	00'	94°	19'	3250	2-4-03	1530	-
1332	10°	00'	94°	00'	1565	3-4-03	1800	-
1333	11°	40'	92°	30'	119	5-4-03	1830	-
1334	13°	00'	92°	00'	1998	6-4-03	1345	87
1335	13°	00'	91°	00'	2983	6-4-03	0045	-
1336	13°	00'	90°	00'	2975	7-4-03	0930	-
1337	13°	00'	89°	00'	3043	7-4-03	1930	-
1338	10°	00'	92°	00'	1814	9-4-03	0730	32
1339	10°	00'	91°	00'	3473	9-4-03	1845	-
1340	10°	00'	90°	00'	3308	10-4-03	0415	862
1341	10°	00'	89°	00'	3373	10-4-03	1510	-
1436	08°	00'	90°	00'	3271	23-12-03	1443	-
1437	08°	00'	91°	00'	3490	24-12-03	0220	-
1438	08°	00'	92°	00'	3197	24-12-03	1520	-

- Not present

Table 3.3. (contd.)

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Total number of mysids (1000m³)
	Latitude (N)		Longitude (E)					
1439	08°	00'	93°	00'	717	25-12-03	0030	-
1440	08°	00'	94°	00'	1588	25-12-03	1541	-
1441	08°	00'	95°	00'	2744	26-12-03	0303	-
1442	10°	00'	95°	00'	1697	27-12-03	2327	2317
1443	10°	00'	94°	00'	1660	27-12-03	1102	-
1444	10°	00'	93°	00'	1350	27-12-03	2040	1184
1445	10°	00'	92°	00'	1240	28-12-03	0750	-
1447	12°	00'	95°	00'	2170	29-12-03	2105	1733
1448	12°	00'	94°	00'	1916	30-12-03	0825	909
1454	12°	00'	93°	00'	1341	31-12-03	1540	-
1457	13°	44'	95°	00'	1160	5-1-04	2030	256
1458	13°	44'	96°	00'	1350	6-1-04	0825	-
1459	13°	44'	93°	00'	600	6-1-04	1450	784
1460	13°	44'	92°	00'	1450	7-1-04	0025	6923
1461	13°	44'	91°	00'	3000	7-1-04	1203	-
1462	13°	44'	90°	00'	3800	7-1-04	2154	23802
1468	12°	00'	90°	00'	3000	9-1-04	2219	9166
1469	12°	00'	91°	00'	3000	10-1-04	1128	-
1470	12°	00'	92°	00'	12500	10-1-04	2324	12211
1474	10°	00'	91°	00'	2500	11-1-04	0301	6184
1475	10°	00'	90°	00'	3250	11-1-04	1430	98
1524	12°	00'	93°	20'	1458	11-6-04	1050	1963
1530	13°	45'	95°	00'	1000	14-6-04	2200	4615
1531	13°	44'	94°	00'	1380	14-6-04	1514	264
1532	13°	45'	93°	00'	40	15-6-04	0400	977
1533	13°	45'	92°	40'	196	15-6-04	1123	-
1534	12°	00'	95°	00'	1500	15-6-04	1430	-
1534	12°	00'	95°	00'	1500	15-6-04	1325	344
1535	12°	00'	94°	00'	1300	17-6-04	0150	2840
1538	10°	00'	95°	00'	2000	19-6-04	0034	1940
1539	10°	00'	94°	00'	3000	19-6-04	2015	-
1540	10°	00'	93°	00'	1420	20-6-04	1120	-
1541	10°	00'	92°	00'	1300	21-06-04	0527	76
1542	08°	00'	94°	30'	2300	26-6-04	0425	280

- Not present

Table 3.4. Mysids collected from different depth strata of the Arabian Sea (Stations wherever mysids observed) in Sagar Sampada collections

tion nbers	Positions				Depth of Stations in meters	Date	Time in hours	Depth of Plankton haul in meters	Total number of mysids (1000m³)
	Latitude (N)'		Longitude (E)						
405	10°	00'	75°	26'	130	21-9-03	0141	16-0	250
410	11°	30'	71°	00'	2887	24-9-03	1305	72-194	32
1410	11°	30'	71°	00'	2887	24-9-03	1305	194-300	75
1418	15°	00'	72°	00'	2051	6-10-03	0448	17-0	1647
1427	19°	00'	71°	00'	82	12-10-03	1057	76-34	95
1427	19°	00'	71°	00'	82	12-10-03	1057	34-0	117
1430	19°	00'	68°	00'	3219	15-10-03	1644	0-45	88
1431	21°	00'	66°	00'	2511	15-10-03	1150	0-42	95
1478	08°	00'	75°	00'	2873	20-3-04	1405	28-168	800
1478	08°	00'	75°	00'	2873	20-3-04	1405	168-300	151
1482	08°	00'	71°	00'	4900	24-3-04	1700	184-48	117
1482	08°	00'	71°°	00'	4900	24-3-04	1700	184-300	172
1483	10°	00'	70°	00'	4526	25-3-04	0350	218-70	27
1485	10°	00'	72°	00'	1987	26-3-04	1230	34-0	823
1487	10°	00'	74°	00'	2370	26-3-04	2000	204-19	64
1488	10°	00'	75°	00'	1022	27-3-04	1230	0-50	80
1488	10°	00'	75°	00'	1022	27-3-04	1230	194-50	111
1490	10°	40'	75°	00'	1300	28-3-04	1830	166-37	155
1494	11°	09'	72°	00'	1500	31-3-04	1345	225-33	62
1499	13°	00'	70°	00'	4437	3-4-04	0200	218-43	46
1503	15°	00'	73°	00'	215	7-4-04	1830	31-0	516
1504	15°	00'	73°	30'	60	7-4-04	0945	50-35	5066
1506	17°	00'	70°	00'	2588	13-4-04	2330	300-500	20
1506	17°	00'	70°	00'	2588	13-4-04	2330	26-0	769
1515	21°	00'	69°	15'	62	22-4-04	00.28	62-0	129
1673	08°	00'	76°	00'	1527	28-5-05	1215	100-500	64
1674	08°	00'	75°	00'	2837	28-5-05	0945	163-26	29
1674	08°	00'	75°	00'	2837	28-5-05	0945	300-500	160
1679	10°	00'	70°	00'	3600	31-5-05	07.40	39-0	717
1680	10°	00'	72°	00'	1900	1-6-05	0700	192-300	185
1682	10°	00'	74°	00'	2435	1-6-05	0000	150-53	204
1686	11°	00'	74°	00'	2121	5-6-05	2325	300-173	63
1688	11°	00'	72°	00'	1740	5-6-05	2110	36-0	3000
1693	13°	00'	73°	00'	1812	8-6-05	2015	179-33	328
1910	15°	00'	73°	30'	1510	11-30-06	0615	36-50	1142
1921	19°	00'	71°	00'	200	12-10-06	0727	40-0	500

Table 3.5. Mysids collected from different depth strata of the Bay of Bengal (wherever mysids observed) in Sagar Sampada collections

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Depth of Plankton haul in meters	Total number of mysids ($1000m^3$)
	Latitude (N)		Longitude (E)						
1234	17°	00'	84°	00'	800	13-11-02	0800	161-45	69
1248	15°	00'	81°	00'	2551	24-11-03	0830	300-186	350
1343	11°	30'	80°	00'	248	10-7-03	1255	31-180	27
1351	13°	28'	82°	00'	3383	15-7-04	0800	1000-500	8
1365	17°	30'	85°	00'	2603	27-7-03	1840	38-0	842
1642	20°	23'	90°	00'	124	21-2-05	2355	0-12	666
1646	19°	00'	87°	00'	2034	24-2-05	1020	174-17	305
1647	19°	00'	86°	00'	1955	24-2-06	1904	19-0	421
1648	19°	00'	85°	00'	369	25-2-05	0645	159-12	245
1649	17°	00'	83°	00'	208	26-2-05	2310	163-12	132
1650	17°	00'	84°	00'	2079	27-2-05	0035	201-11	21
1652	17°	00'	86°	00'	2867	28-2-05	1542	179-19	175
1653	17°	00'	87°	00'	2631	28-2-05	0655	13-0	923
1653	17°	00'	87°	00'	2631	28-2-05	0655	208-13	307
1656	15°	00'	85°	00'	3107	3-3-05	18.40	300-172	31
1656	15°	00'	85°	00'	3107	3-3-05	1840	19-0	424
1656	15°	00'	85°	00'	3107	3-3-05	1840	300-500	100
1658	15°	00'	83°	00'	3024	4-3-05	0825	60-0	200
1660	15°	47'	80°	00'	180	5-3-05	1205	127-25	196
1662	13°	00'	80°	41'	219	6-3-05	1746	33-0	121
1662	13°	00'	80°	41'	219	6-3-05	1746	138-33	380
1665	13°	00'	83°	00'	3275	8-3-05	1754	26-0	160
1666	13°	00'	84°	00'	3396	9-3-05	0415	300-223	207
1667	11°	00'	84°	00'	3586	10-3-05	1215	214-26	106
1668	11°	00'	83°	00'	3638	11-3-05	0344	40-0	1400
1669	11°	00'	82°	00'	3704	11-3-05	0112	300-210	1168
1875	20°	00'	90°	00'	1625	19-906	0735	139-13	117
1881	19°	00'	87°	00'	1972	24-9-06	0932	134-15	134
1882	19°	00'	88°	00'	2190	24-9-06	1800	13-0	1230
1883	19°	00'	89°	00'	1683	25-9-06	0330	144-23	9777
1884	19°	00'	90°	00'	1848	29-9-06	0400	159-13	328
1887	17°	00'	86°	00'	2692	28-9-06	1830	14-0	3692
1891	15°	00'	80°	00'	148	7-10-06	1100	159-10	26
1891	15°	00'	80°	00'	148	7-10-06	1100	0-10	1600
1894	15°	00'	83	00'	3142	8-10-06	1315	167-8	201
1894	15°	00'	83°	00'	3142	8-10-06	1315	0-8	500
1896	15°	00'	85°	00'	3014	9-10-06	0550	300-187	141
1896	15°	00'	85°	00'	3014	9-10-06	0550	187-9	269
1896	15°	00'	85°	00'	3014	9-10-06	0550	0-9	3555
1896	15°	00'	85°	00'	3014	9-10-06	0550	500-300	20
1907	11°	19'	83°	00'	3496	15-10-06	2100	161-18	28

Table 3.6. Mysids collected from different depth strata of the Andaman Sea (stations wherever mysids observed) in Sagar Sampada collections

Station Numbers	Positions				Depth of Stations in meters	Date	Time in hours	Depth of Plankton haul in meters	Total number of mysids ($1000m^3$)
	Latitude (N)		Longitude (E)						
1202	07°	00'	92°	00'	4068	17-9-02	1130	300-500	60
1209	13°	00'	95°	00'	1255	28-9-02	2020	179-30	107
1212	13°	00'	90°	00'	1026	1-10-02	1530	181-300	202
1333	11°	40'	92 °	40'	119	5-4-03	1930	23-0	173
1334	13°	00'	92°	00'	1998	6-4-03	1400	22-0	182
1442	10°	00'	95°	00'	1697	27-12-03	0030	97-0	122
1443	10°	00'	94°	00'	1660	27-12-03	1250	181-47	89
1462	13°	44'	90°	00'	3800	7-1-04	2310	37-177	143
1474	10°	00'	91°	00'	2500	11-1-04	1530	175-83	43
1524	11°	00'	93°	20'	1458	11-6-04	2355	300-199	40
1530	13°	45'	95°	00'	1000	14-6-04	0510	96-0	42
1530	13°	45'	95°	00'	1000	14-6-04	0510	216-96	33
1531	13°	44'	94°	00'	1380	14-6-04	1800	300-500	40
1534	12°	00'	95°	00'	1500	15-6-04	13.25	184-300	344

Chapter 4

Ecology and zoogeography of mysids

(Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Sea)

4.1. INTRODUCTION

Effective utilization of marine resources depends upon accurate knowledge of their occurrence, relative abundance and distribution. Without an accurate knowledge of exact species composition and their incidence it will not be possible to assess the potential resource of an area. Woodmason and Alock (1891) reported six deep Sea and bathypelagic species of Lophogastrida from Andaman water. Hansen (1910) also reported the distribution of 7 species of mysids collected from Bay of Bengal during the Siboga Expedition. Later in 1939, W.M. Tattersall described the Mysidacea of John Murray Expedition in the Arabian Sea. Ganapati and Syamasundari (1962) gave an account of the seasonal occurrence of mysids off Waltair coast (Andaman). It was in sixties some major studies were carried out on mysids of the Indian Ocean especially that of the Arabian sea and the Bay of Bengal based on samples collected during IIOE (Pillai, 1964, 1965, 1973) that sampled the surface and surface waters down to 200 m only. Balasubrahmanyan (1964) gave an account about the distribution of eight species of mysids in Bay of Bengal. In addition to these, Panampunnayil (2002) studied the ecology and taxonomy of 15 species from Andaman waters. Eventhough the Mysidacea has been studied in some detail for its quantitative geographical distribution and abundance in some of the world oceans (reviewed by Mauchline, 1980), the same of the Indian Ocean has been least investigated. The distribution and abundance of mysids in general in the EEZ of India have been presented by Mathew *et al.* (1989). Apart from these at present there is no information about the ecology and seasonal distribution of mysids in the Indian EEZ. Considering the limited information on the mysids of the Indian EEZ, the present study was under taken to evaluate the abundance of the species composition and diversity in relation to environmental parameters.

4.2. RESULTS

4.2.1. Quantitative abundance

Mysids enjoyed wide spread distribution during all seasons in the areas investigated. Average abundance of mysids in the entire area (surface waters) investigated has been estimated to be 882.86/1000m^3. Surface collections and stratified collections showed clear variation in mysids population density. Surface collection constituted 90.7% and stratified collection constituted only 9.9% of mysids.

The EEZ of the Bay of Bengal appeared to be more productive (37.6%) than other areas (Fig. 4.1); spring intermonsoon showed maximum population density of mysids (43.1%) in the Bay of Bengal, followed by winter monsoon. Fall intermonsoon and summer monsoon constituted 29.3%, 15.2% and 12.5% of mysids respectively.

The EEZ of the Arabian Sea constituted 29.3% of the total mysid population; spring intermonsoon showed clear dominance of mysids than other seasons (67.6%). Winter monsoon had minimum of mysids (1%). During summer and fall intermonsoon mysids constituted 22% and 9.4% respectively.

The Andaman Sea constituted 33.1% of the total mysids, of which fall intermonsoon contributed maximum (41.6%) and sprig Intermonsoon contributed minimum (7.8%). Summer monsoon and winter monsoon constituted 16% and 34.6% of mysids in the Andaman Sea (Fig. 4.2).

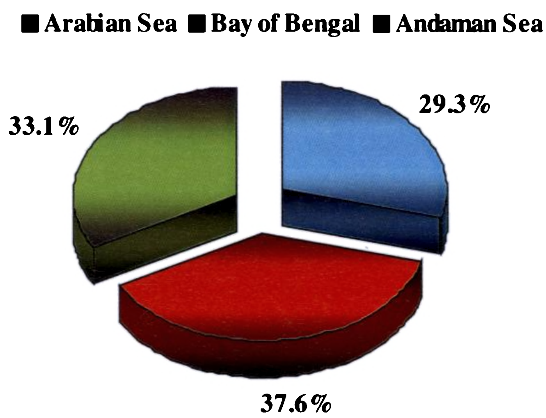
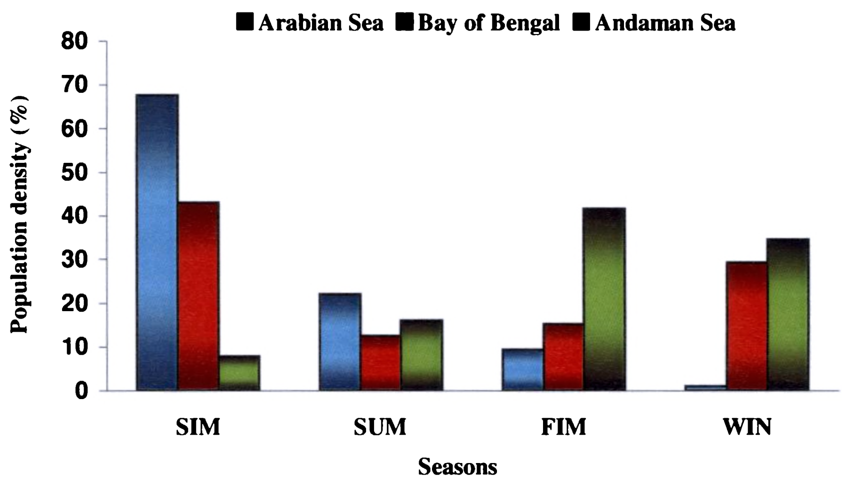


Figure 4. 1. Percentage contribution of mysid population in the Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Seas.



SPR-spring intermonsoon, SUM- summer monsoon, FIM-fall intermonsoon, WIN-winter monsoon

Figure 4. 2. Seasonal percentage of mysid population in the Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Sea.

Maximum specie of mysids recorded during summer monsoon (15), followed by spring intermonsoon (12), fall intermonsoon (11) and winter monsoon (8) (Table 4.1).

Table 4. 1. Seasonal distributions of mysids in the Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Seas.

Species	Spring	Summer	Fall	Winter
Boreomysis plebeja	-	+	-	-
Siriella thompsoni	+	-	-	-
Siriella gracilis	+	+	+	+
Siriella aequiremis	+	+		+
Hemisiriella parva	+	+	+	+
Rhopalophthalmus indicus	+	-	-	-
Gasrosaccus dunckeri	-	+	-	-
Haplostylus pusillus	-	+	-	+
Eurobowmaniella simulans	-	+	-	-
Anchialina typica	+	+	+	+
Anchialina grossa	+	+	-	-
Anchialina dentata	+	-	-	-
Anchialina media	-	+	-	-
Pseudanchialina pusilla	+	+	+	+
Pseudanchialina inermis	-	-	+	-
Pseuderythrops gracilis	-	+	-	-
Gibberythrops acanthura	-	+	-	-
Pleurerythrops inscita	-	-	+	-
Euchaetomera glyphidophthalmica	+	+	-	+
Synerythrops intermedia	-	-	-	+
Dioptromysis perspicillata	-	-	+	-
Afromysis dentisinus	-	-	+	-
Doxomysis longiura	+	-	+	-
Mesopodopsis orientalis	-	-	+	-
Acanthomysis macrops	-	-	+	-
Lycomysis spinicauda	-	+	-	-
Anisomysis spinata	+	-	-	-

Although maximum population density of mysids were observed from the Bay of Bengal, maximum species diversity were encountered in the Arabian Sea, (17), followed by the Andaman Sea (12) and the Bay of Bengal (9) (Table 4.2).

Table 4. 2. Species diversity in the EEZ of the Arabian Sea, Bay of Bengal and the Andaman Seas

Species	Arabian Sea	Bay of Bengal	Andaman Sea
Boreomysis plebeja	-	+	-
Siriella thompsoni	+	+	+
Siriella gracilis	+	+	+
Siriella aequiremis	+	-	+
Hemisiriella parva	+	+	+
Rhopalophthalmus indicus	-	+	-
Gasrosaccus dunckeri	+	-	-
Haplostylus pusillus	-	-	+
Eurobowmaniella simulans	+	-	-
Anchialina typica	+	+	-
Anchialina grossa	-	-	+
Anchialina dentata	+	-	-
Anchialina media	-	-	+
Pseudanchialina pusilla	+	+	+
Pseudanchialina inermis	-	-	+
Pseuderythrops gracilis	-	-	+
Gibberythrops acanthura	+	-	-
Pleurerythrops inscita	+	-	-
Euchaetomera glyphidophthalmica	+	+	+
Synerythrops intermedia	-	+	-
Dioptromysis perspicillata	+	-	-
Afromysis dentisinus	+	-	-
Doxomysis longiura	+	-	-
Mesopodopsis orientalis	+	-	-
Acanthomysis macrops	+	-	-
Lycomysis spinicauda	-	-	+
Anisomysis spinata	-	-	+

Day and night variations

Mysids from surface samples showed clear day and night variations (Fig.4.3A-C), there was an increase by 84.2% in the night samples over the day samples and their average occurrence during day was only $743/1000m^3$, whereas during night it was $3967/1000m^3$. Seasonal day and night variations showed in Fig. 4.4. In the Arabian Sea day collections accounted 78.3% of mysids and during night it was 21.7%. In this area, all seasons except fall intermonsoon, showed clear night dominance of mysids. In fall intermonsoon day collections contributed 77.3% of mysids while during night only 22.7% of mysids recorded. During spring intermonsoon day and night collections contributed 17.4% and 82.7% of mysids respectively. Day collections during summer monsoon and winter monsoon contribute 10% and 16.7% respectively, while during night it was 90% and 83.3% respectively.

In the Bay of Bengal day collections contributed only 20.06% and during night it was 79.9%. In this area, night collections mysids dominated in compared with the day collections. During spring intermonsoon night collection contributed 78.1% and 21.9% in day collections. Day and night collections during summer monsoon contributed 14.1% and 85.9% respectively. In fall intermonsoon and winter monsoon night collection contributed 60.3% and 83.6% respectively while in day collections it was 39.7% and 13.4% respectively.

In the Andaman Sea, day collections provided 6.7% and night collections contributed 93.3% of mysids. This area also showed clear night dominance in all seasons. The day and night contribution during spring intermonsoon and summer monsoon were 12%, 87.9% and 15.8%, 84.2% respectively. Night collections in fall intermonsoon and winter monsoon contributed 94.6% and 96.1% respectively, while in day it was 5.4% and 3.9% respectively.

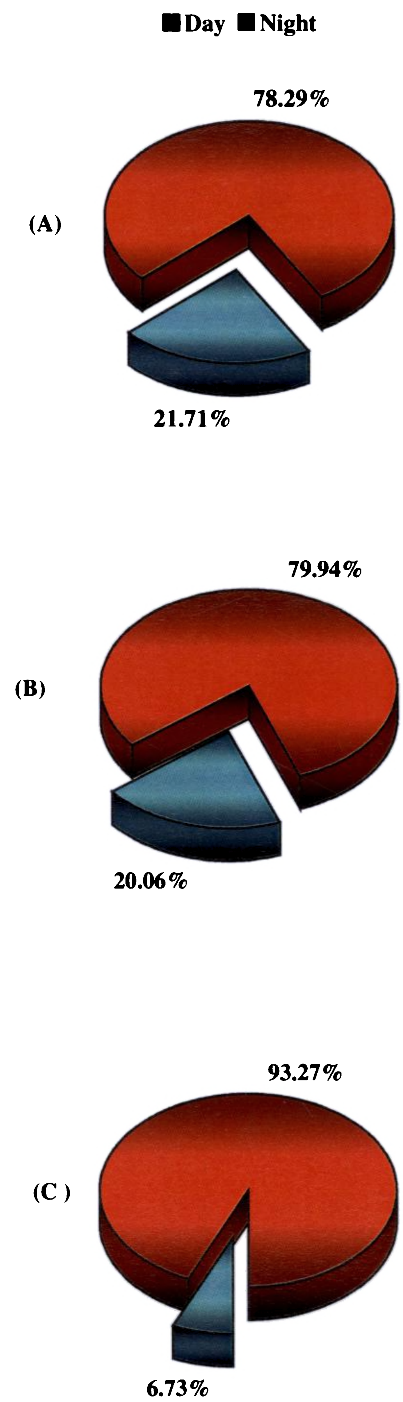
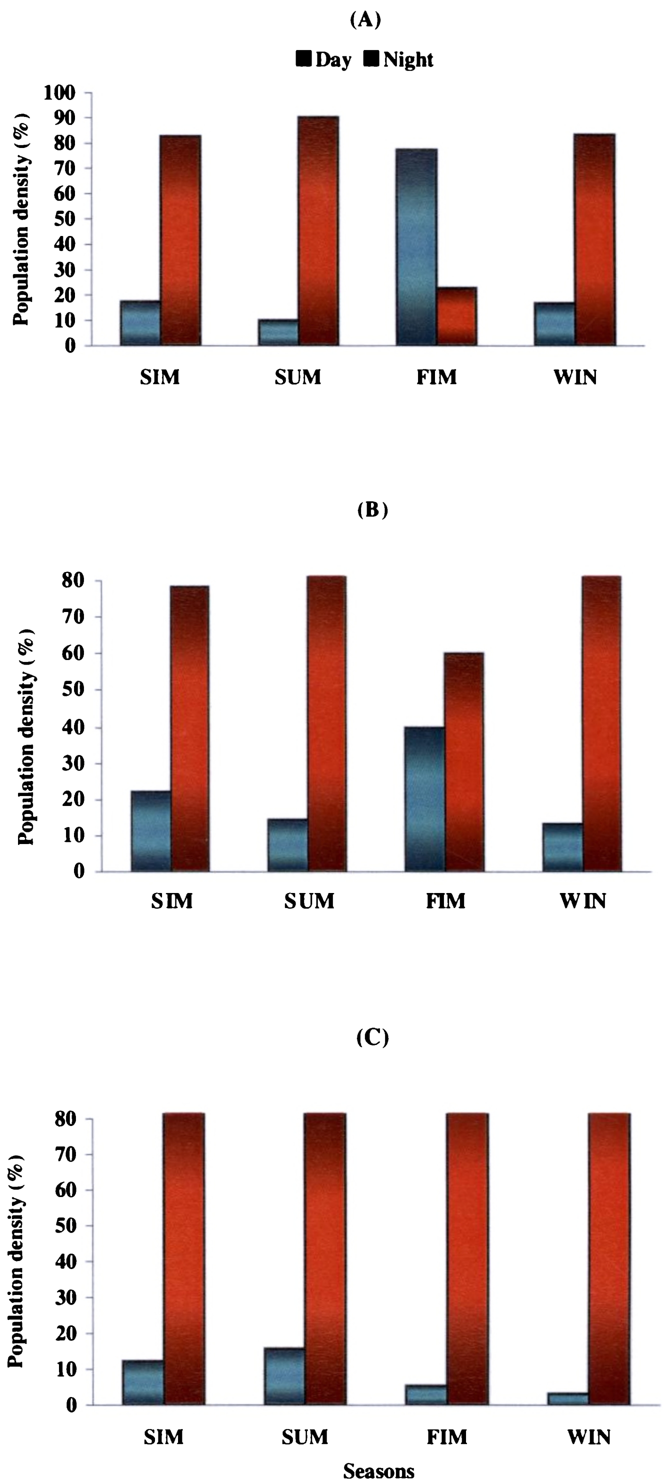


Figure 4. 3. Percentage compositions of mysids during day and night in (A) Arabian Sea, (B) Bay of Bengal and (C) Andaman Sea.



SPR-spring intermonsoon, SUM- summermonsoon, FIM-fall intermonsoon, WIN-winter monsoon

Figure 4. 4. Seasonal percentage compositions of mysids during day and night in (A) Arabian Sea, (B) Bay of Bengal and (C) Andaman Sea.

Vertical distribution

Most of the studied mysids are surface dwellers. Twelve species of mysids were observed only in surface waters. Above the thermocline a total of sixteen species were recorded. Below the thermocline four species (*Boreomysis plebeja, Pseudanchialina pusilla, Pseuderythrops gracilis* and *Gibberythrops acanthura*) noted while below 500 m depth only two species, (*B. plebeja* and *G. acanthura*) were observed (Table 4.3).

Table 4. 3. Vertical distribution of mysids in Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Sea

Species	Surface	MLD	TT-BT	BT-300	300-500	500-1000
Boreomysis plebeja	-	-	-	-	-	+
Siriella thompsoni	+	-	-	-	-	-
Siriella gracilis	+	+	+	-	-	-
Siriella aequiremis	+	-	-	-	-	-
Hemisiriella parva	+	+	+	-	-	-
Rhopalophthalmus indicus	-	+	-	-	-	-
Gastrosaccus dunkeri	+	-	-	-	-	-
Haplostylus pusillus	+	-	+	-	-	-
Eurobowmaniella simulans	+	-	-	-	-	-
Anchialina typica	+	+	-	-	-	-
Anchialina grossa	+	+	-	-	-	-
Anchialina dentata	+	-	-	-	-	-
Anchialina media	+	-	-	-	-	-
Pseudanchialina pusilla	+	+	+	+	+	-
Pseudanchialina inermis	-	+	-	-	-	-
Pseuderythrops gracilis	-	-	-	+	-	-
Gibberythrops acanthura	-	-	+	-	+	+
Pleurerythrops incita	+	-	-	-	-	-
Euchaetomera glyphidophthalmica	-	+	+	-	-	-
Synerythrops intermedia	-	-	-	+	-	-
Dioptromysis perspicillata	+	-	-	-	-	-
Afromysis dentisinus	+	+	-	-	-	-
Doxomysis longiura	+	-	-	-	-	-
Mesopodopsis orientalis	+	-	-	-	-	-
Acanthomysis macrops	+	-	-	-	-	-
Lycomysis spinicauda	+	-	-	-	-	-
Anisomysis spinata	+	-	-	-	-	-

Six species of mysids, *S. thompsoni, S. gracilis, Hemisiriella parva, Anchialina typica, Pseudanchialina pusilla* and *Euchaetomera glyphidophthalmica* were distributed through out the study area (Arabian Sea, Bay of Bengal and Andaman Sea). Distribution of different species of mysids are given in figure 4.5A-D).

4. 2. 2. Ecology and distribution.

Tolerance of mysids with physico-chemical factors are shows in figure 4.6 and 4.7.

Boreomysis plebeja Hansen

During the study period this species was collected only from the Bay of Bengal during summer monsoon from depths of 1000-500 m where low oxygen levels are noted (16.88- 58.17µM). This species was observed in temperature and salinity ranged from 9.67- 6.29°C and 35-34.90 psu respectively.

Siriella thompsoni (Milne- Edwards)

The range in temperature, salinity, *p*H, and dissolved oxygen in which this species occurred were 25.35 to 30.24°C, 29.58 to 35.44 psu, 8.02 to 8.44 and 197.2 to 236.5µM respectively. During the study period this species was collected only in surface waters of the entire study area during spring intermonsoon. In the Arabian Sea they contributed 1.9%, in Bay of Bengal 1.3% and the Andaman Sea 0.2%. They accounted only 0.9% of the total mysids collected from the study area and this species coexisted along with *Siriella gracilis, S. aequiremis and Pseudanchialina pusilla.* Females were found to carry 4 -7 eggs in their marsupium.

Siriella gracilis Dana

It is a widely distributed species and are abundant in the surface waters. About 98.9% of this species occurred in the surface waters. In the present collection many adults and young ones of both the sexes were collected suggesting that they breed throughout the year. This species was the second most abundant species and can tolerate wide range of salinity and temperature (3.36 to 30.75 psu and 30.1 to 36.96°C respectively). The Arabian Sea had major representation of this species (48%) followed by Andaman Sea (28.7%) and the Bay of Bengal (11.4%). Eventhough they are mostly concentrated in the surface waters, this species was frequently collected from below the mixed layer up to 500 m.

Siriella aequiremis Hansen

It is an oceanic species. In the present collection usually not more than two or three were present in collections from surface and subsurface waters (0-150m) and contributed only 0.5% of the total mysids. This species was recorded in the Andaman Sea during winter monsoon and summer monsoon and in the Arabian Sea during spring intermonsoon. They are found to tolerated variation in temperature 27.81 - 30.24°C, salinity 31.66 - 35.51 psu, *p*H of 7.98 - 8.44 and dissolved oxygen 197.2 - 257.04µM.

Hemisiriella parva Hansen

It is truly an oceanic species, abundant in surface waters (87%). This species occurred in all the seasons and are collected from depths up to 234 m. They tolerate temperature of 12.99 to 36.26°C, salinity of 26.58 to 35.12 psu, *p*H of 7.72 to 8.34 and dissolved oxygen of 4.65 to 230µM and occurred along with *Siriella gracilis, S. aequiremis and Pseudanchialina pusilla.* Their brood size is 8.

Rhopalophthalmus indicus Pillai

This species were occurred in spring inter monsoon from the Bay of Bengal in the mixed layer (0-26 m). They tolerate a temperature range of 20.3 to 28.2°C, salinity of 33.42 psu, *p*H of 8.25 to 8.30 and dissolved oxygen of 229.19 to 230µM.

Gastrosaccus dunckeri Zimmer

In this collection *G.dunckeri* were collected from, coastal surface waters of Arabian Sea during intermonsoon spring and occurred in temperature of 30.9°C, salinity of 34.58 psu, *p*H of 8.43 and dissolved oxygen of 204.84µM. This species occurred along with *Siriella gracilis, Anchilana typica, A. dentata and Pseudanchialina pusilla.*

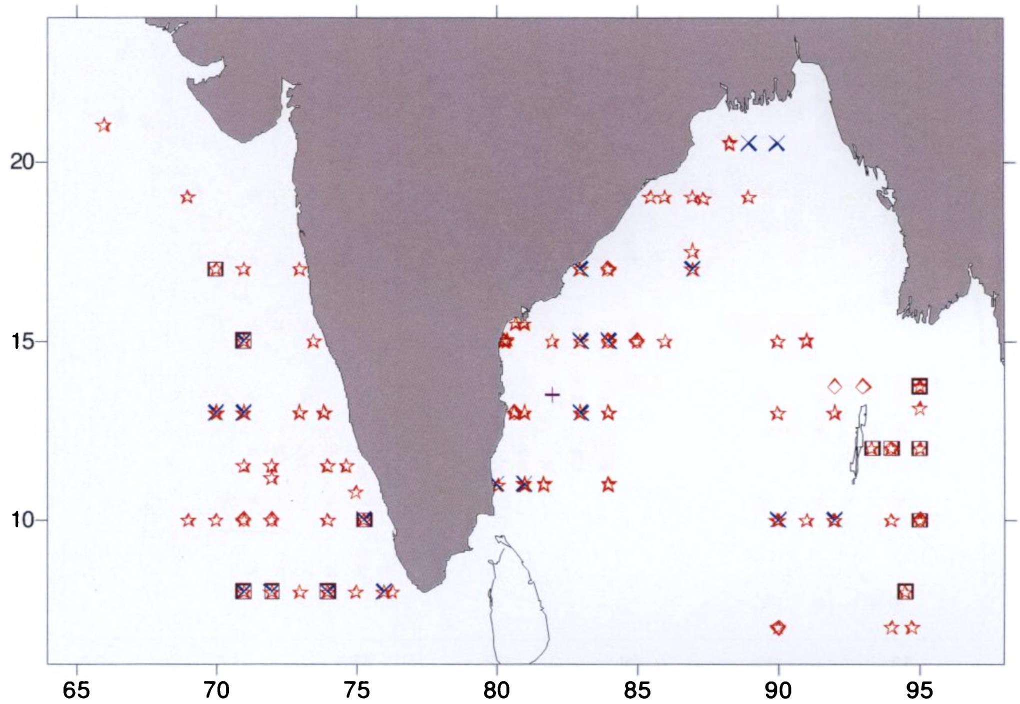
Haplostylus pusillus Coifmann

The range in temperature, salinity, *p*H and dissolved oxygen in which *H. pusillus* occurred were 27.2 to 34.47°C, 33.28 to 33.42 psu, 8.25 to 8.30 and 229.19 to 230µM respectively. This species occurred only in fall intermonsoon and winter monsoon at Andaman waters. They were common in surface waters up to bottom of thermocline (170 m), along with *Siriella gracilis, Pseudanchialina pusilla, Anchilana grossa, A. media and Lycomysis spinicauda.*

Eurobowmaniella simulans Tattersall

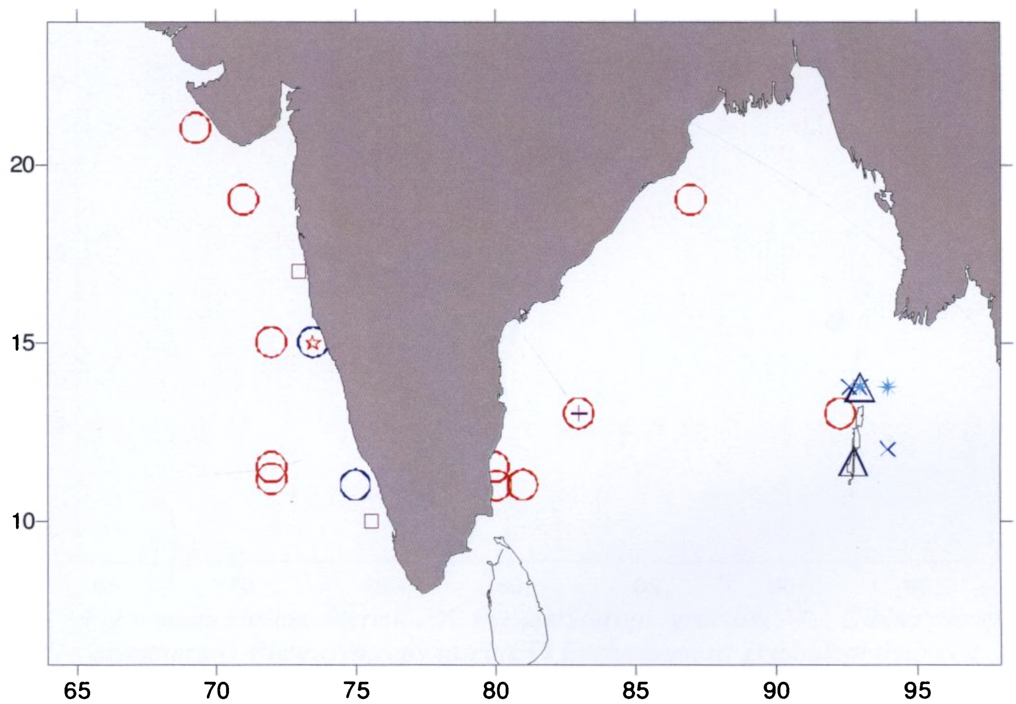
This species occurred only in surface waters at two coastal stations in the Arabian Sea during summer monsoon and formed 3.4% of the total mysids present in the Arabian Sea and 0.87% of the entire study area. They tolerate temperature and salinity range of 29.2 to 31.10°C and 32.5 to 35 psu. This species was found to have the highest brood size (37 eyed larvae present in the marsupium of female) with 8.4 mm length.

(A)



+ *Boreomysis plebeja*, × *Siriella thompsoni*, ☆ *S. gracilis*, □ *S. aequiremis*
◇ *Hemisiriella parva*

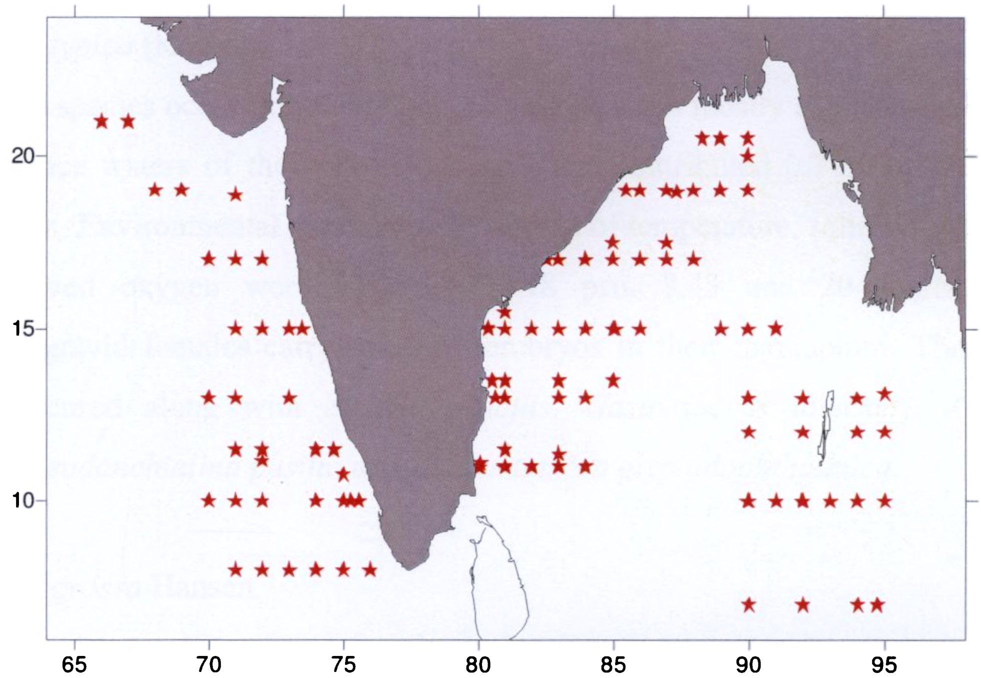
(B)



+ *Rhopalophthalmus indicus*, ☆ *Gastrosaccus dunckeri*, × *Haplostylus pusillus*
□ *Eurobowmaniella simulans*, ○ *Anchialina typica*, △ *A. grossa*, ○ *A.dentata* ✳ *A. media*

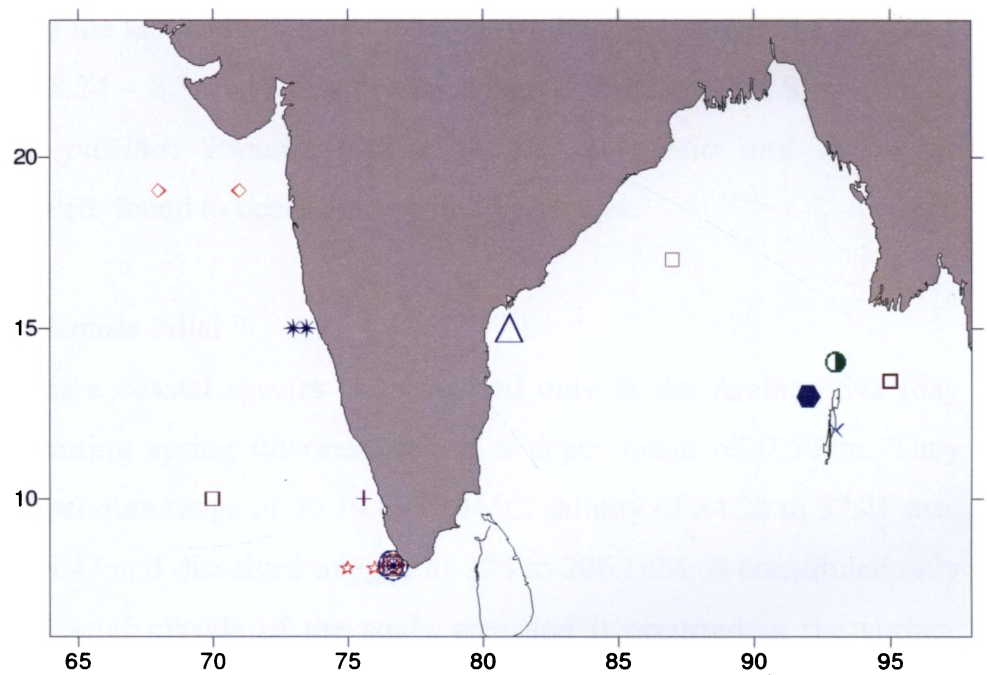
Figure 4. 5 A, B. Distribution of different species of mysids in the Indian EEZ of Arabian Sea, Bay of Bengal and Andaman Sea.

(C)



★ *Pseudanchialina pusilla*

(D)



+ *Pseudanchialina inermi* , × *Pseuderythrops gracilis*, ☆ *Gibberythrops acanthura* ◇ *Pleurerythrops inscita*, □ *Euchaetomera glyphidophthalmica*, △ *Synerythrops intermediata*, ⌑ *Dioptromysis perspicillata*, ◯ *Afromysis dentisinus*, ✳ *Doxomysis longiura*, ◎ *Mesopdopsis orientalis*, ⬡ *Acanthomysis macrops* , ◑ *Lycomysis spinicauda*, ⬢ *Anisomysis spinata..*

Figure 4. 5 C, D. Distribution of different species of mysids in the Indian EEZ of Arabian Sea, Bay of Bengal and Andaman Sea.

Anchialina typica (Kroyer)

This species occurred throughout the year and was mostly concentrated in the surface waters of the entire study area and contributed 0.71% of the total mysids. Environmental parameters in respect of temperature, salinity, *p*H and dissolved oxygen were 34.28°C, 30.18 psu, 8.43 and 204.84µM. Reporting gravid females carrying 12-14 embryos in their marsupium. This species occured along with *Siriella gracilis, Gastrosaccus dunckeri, A. dentata, Pseudanchialina pusilla* and *Euchaetomera glyphidophthalmica.*

Anchialina grossa Hansen.

One damaged immature female during intermonsoon spring and one immature male during summer monsoon were collected from the Andaman waters where the temperature range from 28.1 - 29.47°C, salinity of 32 - 32.1 psu, *p*H of 8.24 - 8.36 and dissolved oxygen 220 - 195µM. Species like, *Haplostylus pusillus, Pseudanchialina pusilla, A. media and Lycomysis spinicauda* were found to occur along with this species.

Anchialina dentata Pillai

This is a coastal species and occurred only in the Arabian Sea (day collection) during spring intermonsoon at a depth range of 0-50 m. They tolerate temperature range of 30.19 to 30.46°C, salinity of 34.28 to 37.71 psu, *p*H of 8.21-8.43 and dissolved oxygen of 204 to 206.1µM. It constituted only 0.4% of the total mysids of the study area and it occurred in the surface waters.

Anchialina media Ii

This is the first record of *A. media* for the Indian waters. In the present study this species was collected at one station from Andaman waters during summer monsoon with a population density of 927/1000m^3 and it contributed

1.22% of the total mysids collected from Andaman waters. The temperature, salinity, *p*H and dissolved oxygen in which *A. media* occurred were 28.9°C, 32.3 psu, 8.12 and 254.17µM respectively. This specie occurred along with *Haplostylus pusillus, Pseudanchialina pusilla and Lycomysis spinicauda.*

Pseudanchialina pusilla (G.O. Sars)

This species occurred through out the year and was the most abundant species in the samples. It occurred in 120 stations and constituted the 64.77% of the total mysid population of which 12.13% from stratified samples and rest of them from surface samples. Eventhough they have affinity to surface waters, their occurrence was frequently up to 500 m depths. Brooding females and juveniles noted in all seasons. In Bay of Bengal majority of *P. pusilla* (49.3%) was observed, followed by Andaman Sea (34.2%) and the Arabian Sea (16.27%). They tolerate wide range of environmental factors. Their tolerance of temperature ranged from 3.24 to 31.22°C, salinity of 30.1- 36.96 psu, *p*H of 7.98 to 8.64 and dissolved oxygen of 11.7 to 278µM. Brood size is 8 - 9.

Pseudanchialina inermis (Illig)

This species occurred only at one station in the Andaman Sea during fall intermonsoon in mixed layer (16-0 m). The hydrographic features of the station were, temperature 29.10 to 29.20°C, salinity 32.62 psu, *p*H 8.16 to 8.18 and dissolved oxygen 203.35 to 211µM.

Pseuderythrops gracilis Coifmann

Only a single specimen of *P. gracilis* was obtained from the thermocline layer (190 - 300 m) in the Andaman waters during summer monsoon and occurred in an area where the temperature ranged from 12 to

19.89°C, salinity 34.53 to 35 psu, *p*H 7.52 to 7.57 and dissolved oxygen 33.85 to 44.94µM.

Gibberythrops acanthura (Illig)

This species was rare in the present samples. Only 17 specimens were collected from the Arabian Sea during summer monsoon. All specimens were collected from below the mixed layer up to 1000 m depth. This species contributed 8.54% of the total population of Arabian Sea. They occurred in the temperature range of 7.215 -15.07°C, salinity 35 - 35.1 psu, *p*H range 7.55 to 7.71 and dissolved oxygen 14.27 to 20.17µM.

Pleurerythrops inscita Ii

This species occurred only in two stations in the Arabian Sea during fall intermonsoon and it is the second record from the Indian waters. Their tolerance to temperature, salinity, *p*H, and dissolved oxygen were 24.22 to 29.27°C, 35.16 to 36.52 psu, 8.06 to 8.35 and 149.34 to 200µM respectively.

Euchaetomera glyphidophthalmica Illig

They were collected from the Arabian Sea during spring intermonsoon and Bay of Bengal during winter monsoon and the Andaman Sea during summer monsoon. The present occurrence of *E. glyphidophthalmica* from the Bay of Bengal is the first record for this area. This species is an oceanic form and mostly occurred in stratified samplings. They tolerate a temperature range of 15 to 29.34°C, salinity of 33.72 to 36.01 psu, *p*H of 7.74 to 8.28 and dissolved oxygen of 12.49 to 242µM.

Synerythrops intermedia Hansen

In the Indian waters, the occurrence of this species is a new record. This species occurred only in the Bay of Bengal during winter monsoon and tolerate a temperature of 11.12 -15.28°C, salinity of 34.93 - 35.02 psu, *p*H of 7.67-7.86 and dissolved oxygen of 7.23 -12.4µM

Dioptromysis perspicillata Zimmer

This species was rare in the present samples, only 3 specimens were recorded at the surface waters from the Arabian Sea during fall intermonsoon. They tolerate a temperature of 24.2°C, salinity 35.2 psu, *p*H 8.1 and dissolved oxygen of 149.3µM respectively. This species was recorded along with *Acanthomysis macrops, Mesopodopsis orientalis, Doxomysis longiura* and *Afromysis dentisinus.*

Afromysis dentisinus Pillai

This species also occurred only in the Arabian Sea during fall intermonsoon and mostly in coastal surface waters. The range of temperature, salinity, *p*H and dissolved oxygen in which *A. dentisinus* occurred were 23.1 to 24.64°C, 35.16 to 35.8 psu, 8.06 to 8.26 and 149.3 to 205µM respectively.

Doxomysis longiura Pillai

This species was collected from the Arabian Sea only during fall intermonsoon and inter monsoon spring and were more abundant in the day collections during fall intermonsoon. They tolerate wide range of temperature, salinity, *p*H, and dissolved oxygen of 24.22 to 29.27°C, 35.16 to 36.52 psu, 8.06 to 8.35 and 149.34 to 200µM respectively. This species constituted 1.1% of the total population of the study area, mostly from (98.2%) surface samples.

Mesopodopsis orientalis Tattersall

Two specimens were collected from a coastal station of the Arabian Sea during fall intermonsoon where the temperature (24.22°C), salinity (35.16 psu) *p*H (8.06) and dissolved oxygen (149.34µM) were moderately high.

Acanthomysis macrops Pillai

Only six specimens were collected from the surface coastal waters of the Arabian Sea during fall intermonsoon. Hydrobiological parameters in respect of water temperature, salinity, *p*H and dissolved oxygen were 24.2°C, 35.16 psu, 8.06 and 149.34µM respectively.

Lycomysis spinicauda Hansen

This species occurred only in the Andaman waters only in one station during spring intermonsoon along with *Anchialina grossa, A. media* and *Haplostylus pusillus*. They occurred in temperature of 28.9°C, salinity 32.2 psu, *p*H 8.1 and dissolved oxygen 254.2µM respectively.

Anisomysis spinata Panampunnayil

This species was collected only from the Andaman waters during intermonsoon spring at a depth range of 0-30 m. It was found to tolerate temperature of 29.46 to 30.01°C, salinity of 32.66 to 32.64 psu, *p*H of 8.4 to 8.3 and dissolved oxygen of 207 to194µM.

4.3. DISCUSSION

The mysids were found to enjoy a wide distribution in the area investigated. According to Mathew *et al.* (1989) earlier Arabian Sea had higher population density of mysids whereas the present study reveals higher abundance of mysids in the Bay of Bengal. Eventhough Bay of Bengal showed more population density, the species diversity is more in Arabian Sea. Abundance of *Pseudanchialina pusilla* and *Siriella gracilis* may be the reason of increased population density in the Bay of Bengal, these species were also dominant in the collections of the IIOE (Pillai, 1973) and the Andaman Sea (Panampunnayil, 2002). It is highly possible that low species diversity observed in the Bay of Bengal may be due to the discharches of large amount of fresh water into it from perennial rivers, which prevent the survival of high saline mysid species.

The difference in population density in the study area might be due to good invading capacity of mysids in new areas and change in their reproductive strategy. As in the case of other zooplankton, the mysids also showed significant variation in day and night samples. Mathew *et al.* (1989) reported, 62% of mysids in the night sampling and 38% in the day samples from the Indian EEZ, which indicates strong diurnal vertical migration of mysids. The present study also showed same trend. In the Arabian Sea during fall intermonsoon, mysids in day collections were more, compared to that of night, might be due to the high density of *Doxomysis lingura* and *Afromysis dentisinus.*

Ecology and distribution

During the study, 27 species of mysids were recorded from the study area. Most of the species were surface dwellers and 17 species were recorded from the Arabian Sea, 9 from Bay of Bengal and 13 from the Andaman water. Among the 27 species, most of them were represented by few specimens. Below thermocline mysids population and their diversity were low. In the present study only two species, *Boreomysis plebeja* and *Gibberythrops acanthura* were found to occur below 500 m depths.

The genus *Boreomysis* was represented by only one species, *Boreomysis plebeja.* The type specimen was taken from south -east of Halmahera (East Indies). Illig (1930) recorded a single immature female from the Benguela current to the north west of Cape Town (Southern Atlantic). O.S. Tattersall (1955), were also taken in the Benguela current from west of the Orange River estuary and from west of Walvis Bay. Ii (1964) recorded this species in the pacific as north as Japan (Tokyo Bay and Suruga Bay). Hansen's type specimen was captured by vertical net towed from 1000m to surface, and Illig's specimen was obtained from the depth of 3000m. The present specimen was collected from 500-1000 m depth. This species is cosmopolitan and the present distribution in the Indian waters extent its distribution eastwards.

The collection contains three species of *Siriella* namely, *Siriella. thompsoni, S, gracilis and S. aequirmis.*

Siriella thompsoni has been previously recorded from all the oceans and is a typical oceanic form inhabiting the surface waters and tolerate wide range of environmental factors. This species is widely distributed in the upper warm temperate waters of the Indian and the Atlantic Oceans. It has been recoded from the Mediterranean. It has been collected in good numbers at or near the surface during day and night in horizontal, vertical or oblique hauls from about 150 m to the surface (Panampunnayil, 2002). Though widely distributed, in the present study it was recorded from 17 stations, each haul containing 2 - 3 specimens. There are records of these species having been collected from 2500 m to surface (Illig, 1930) but Ii observed that all these collections were made with open nets and it is likely that the specimen were actually taken from surface waters. W.M. Tattersall (1936a) observed the occurrence of this species with other neritic forms in the Great Barrier Reef lagoon and suggests that its occurrence form an evidence of incursion of Oceanic species in to the lagoons.

Siriella gracilis is another widely distributed species, usually coexisting with *S. thompsoni* (Pillai, 1973) but it has not hitherto been recorded from the Atlantic Ocean. This species was the second most abundant species and they tolerate wide range of temperature and salinity. Studies on mysids in the Andaman waters have yielded same fruitful results (Panampunnayil, 2002). *S. gracilis* is a warm water species confined to the tropical and subtropical waters of the Indian and Pacific Oceans. In present collection, this species occurred in 92 stations represented by many adults and young ones of the both sexes. Like *S. thomsoni* this species also breed through out the year.

Siriella aequirmis is a rare species and is an oceanic form having a very extensive distribution in tropical parts of the Pacific and Indian Oceans (Pillai, 1973) and has been recorded from the east coast of Central America (Hansen, 1912), East India (Hansen, 1910), Philippine Islands (W.M. Tattersall, 1951), South China Sea (Ii, 1964), Bay of Bengal (Pillai, 1965), Andaman Sea (Panampunnayil, 2002), Red sea (Coifmann, 1937) and Enewetak lagoon, Micronesia (Murano, 1983). It is absent in the Atlantic. It has never been found in large numbers, usually not more than two or three in a collection. In the present study this species occurred at 13 stations. During IIOE this species was collected from 18 stations. W.M. Tattersall and Ii observed that this species breeds through out the year in the Pacific Ocean.

Hemisiriella parva is a truly oceanic planktonic species abundant in surface waters. It is not usually found in inshore waters unless there is some unusual incursion of oceanic waters into the inshore region. Till now this species has been recorded from East Indies (Hansen, 1910), Malaya (Colosi, 1920), Bay of Bengal (W.M. Tattersall, 1922), Great Barrier Reef (W.M. Tattersall, 1936), Java (Delsman, 1939), Philippines (W.M. Tattersall, 1951) and Arabian Sea and Bay of Bengal (Pillai, 1964, 1973). Andaman Sea (W.M. Tattersall, 1922; Panampunnayil, 2002), South China Sea (Ii, 1964). Apparently it is widely distributed in the warmer region of both Pacific and Indian Oceans. In the present study this species was encountered only in 8 stations and was represented by very few specimens, suggesting that inspite of its wide distribution it does not appear to be an abundant form. The other species of the genus *H. pulchra* which usually occur along with *H. parva* did not occur in the present collection though it has been recorded by Pillai in collections from this area during the IIOE.

Genus Rhopalophthalmus is represented by only one species, *R. indicus* Pillai. In the IIOE collections this species was not recorded. *Rhopalophthalmus indicus* has been known only from Indian waters. First record was from Kayamkulam lake, Kerala (Pillai, 1961), and second from Godavary estuary where salinity was 20.02 psu (Chandramohan, 1983). The biology and ecology of *R. indicus* collected from Cochin estuary is dealt with in chapter 6. According to Pillai (1973) the species of *Rhopalophthalmus* are coastal in habit and when present occur in swarms eventhough, the present collection contains only two specimens. The present collection extends its distribution in Bay of Bengal.

The genus *Gastrosaccus* is represented by *G. dunckeri* only and it is a coastal form but occasionally captured in offshore waters. Panampunnayil (1999) recorded this species from shallow coastal waters of Mumabi (India) where temperature and salinity ranged from 26.6-29.3°C and 24 - 41 psu respectively. This species has been recorded from several localities in the Indian and Pacific Oceans namely Ceylon (Zimmer, 1915), Orissa, India (W.M. Tatterrsall, 1922), Singapore (O.S. Tatterrsall, 1960), South China Sea (Ii, 1964) and Arabian Sea, (Pillai, 1973).

Hitherto, *Haplostylus pusillus* has been known from three localities, Red sea (Coifmann, 1936; Almeida prao-por, 1980; Bacescu, 1979), Andaman Sea (Pillai, 1973; Panampunnayil, 2002) and Irimote Island, Japan (Kouki and Murano, 1997). Coifmann (1936) created *Haplostylus pusillus* to describe specimens collected from the Red Sea and this species remained not recorded until Pillai recorded a single adult male from the Andaman waters in 1973 (11° 23N 93° 31E) during IIOE. In 1979, Bacescu recorded adult males, females and many juveniles from Red Sea and his Specimens are closer to the description of Pillai. The present material was collected from 2 stations in the Andaman Sea and this species appears to be endemic in the Indian Ocean. From the biogeographical viewpoint, it is interesting to note that the distribution area of the species extends from Red Sea in the west to Andaman Sea in the East. The occurrences of the species at two extremes of hydrographical regimes of the Indian Ocean suggest that it must obviously be widely distributed in the Indian Ocean.

In the present collection, the genus *Eurobowmaniella* is represented by *Eurobowmaniella simulans*. According to Pillai (1957), this species was fairly common along the Kerala coast during March to October, appearing in swarms in June and July. Dexter (1996) reported that, this species is ranked as one of the abundant species in the intertidal animal community of open sandy beaches on the west coast of Phuket Island and it occur in abundance during the southwest monsoon (Murano, 1995a). Panampunnayil (1999) recorded this species from the shallow coastal waters of Mumbai (Bassien Creak) at depths of 5.8 m where the range of temperature and salinity were 24-26°C and 32-35 psu respectively. In the present study this species has from the coastal waters of the Arabian Sea during summer monsoon (June-September). Murano (1995a) collected this species from intertidal zone of the sandy beaches during June to November and in a lesser degree during December to May. Sujoy (2005) has successfully reared this species in the laboratory. According to him the brood size of adult female ranged from 14 - 44, had an incubation period of 2-5 days and the juveniles reached sexual maturity in 24-28 days. Presently this species is distributed in the Coast of Orissa, Goa (W.M. Tattersall, 1922), Kerala (Pillai, 1957, 1961; Sujoy, 2005), sandy beaches of Phuket Island (Murano, 1995a; Dexter, 1996), and Penisular Malaysia (Hanamura *et al.*, 2007)

Members of the genus *Anchialina* are generally oceanic forms and in the present collections 4 species namely *A. typica*, *A. dentate, A. grossa* and *A. media* were recorded . *A. typica* is truly oceanic species widely distributed in the Indian, Pacific and Atlantic Oceans. Though this is a true oceanic species W.M. Tattersal (1922) had recorded it from the shallow waters of Port Blair.

In the Barrier Reef Bay, W.M. Tattersal (1936a) had observed it as a regular species from May to October and suggests that it migrate inshore during this season of the year for breeding purpose, moving out to deeper water again in the non-breeding seasons. It has been recorded from tropical Atlantic (Kroyer, 1861), Hawai Islands (Ortmann, 1905), English channel (Gough, 1905), West Indies, Gulf of Saim, East Indies (Hansen, 1910), Gilbert Islands (Hansen, 1912), Carribian Sea (Colosi, 1920), Andaman Island and Gulf of Mannar (W.M. Tattersall, 1922), Great Barrier Reef (W.M. Tattersall, 1936a), Western Atlantic near Bermuda and Bahama (W.M. Tattersall, 1936b), Philippine Islands (W.M. Tattersall, 1951), Mid-Atlantic and Benguela Current (O.S. Tattersall, 1955), Singapore (O.S. Tattersall, 1960), South Africa (O.S. Tattersall, 1962), Japan (Ii, 1964), Northern region of Malacca Strait (O.S. Tattersall, 1965), North West Madagascar, Nosy-be (Nouvel, 1971), Arabian Sea and Bay of Bengal (Pillai, 1964, 1973), Western Cuban shelf waters (Bacescu and Ortiz, 1984) and Gulf of Mexico (Modlin, 1984; Price *et al.*, 1986; Escobar and Soto, 1991). Though it enjoys a wide distribution, it is comparatively rare in the present collections, not more than four or five specimens in each collection.

Anchialina grossa is a neritic form and has been recorded from East Indies, Bay of Bengal Gulf of Siam, South China Sea (Hansen, 1910), Gilbert Islands (Hansen, 1912), Ceylon (Zimmer, 1915), Andaman Island (W.M. Tattersall, 1922; Panampunnayil, 1999), Great Barrier Reef and Philippine Island (W.M. Tattersall, 1936a). During IIOE collection this species are not recorded.

Anchialina dentata is also a neritic form and has been recorded from Arabian Sea (Pillai, 1964, 1973), South of China Sea (Ii, 1964), South of Java (Pillai, 1973) and South West of Japan (Murana, 1990a) and Andaman Sea (Panampunnayil, 1999). The present occurrence in the Andaman Sea is the second record of the species from this area. *A. dentata* is a comparatively rare species and its records from widely distant places indicates that it has an extensive distribution in the topical and sub tropical parts of the Indo-pacific waters.

Anchialina media is an oceanic gregarious form. This species is previously recorded only from South China Sea (Ii, 1964) and the present record in the Indian EEZ (Andaman waters), extends its distribution towards east.

In the present collections *Pseudanchialina pusilla* was the most abundant. It has been recorded from Celebes Sea (Sars, 1885a), East Indies and Bay of Bengal (Hansen, 1910), Great Barrier Reef (W.M. Tattersall, 1936a), Arabian Sea (Pillai, 1957, 1973) Andaman Sea (Panampunnayil, 1999), The South China Sea (Wang and Liu, 1987) and Malacca Strait (O.S. Tattersall, 1960). This is the most abundant mysid of the Indian Ocean (Pillai, 1973), is an oceanic surface dwelling form and extensively distributed in the tropical and sub tropical parts of the Indian and Pacific Oceans. In the present collection it occurred at 125 stations and formed the bulk of the material. They tolerate wide range of salinity and temperature. Because of its abundance must obviously play an important role in the economy of the Indian Ocean and their small size compensated by their abundance (Pillai, 1973).

According to Pillai (1973) *Pseudanchialina inermis* is comparatively rare and occur along with *P. pusilla.* In the present collections, this species was recorded from only one station. This species has been previously known from the Indian Ocean (Illig, 1906, 1930; Pillai 1973), the Bay of Bengal (Hansen, 1910), the Suiz Canal (W.M. Tattersall, 1927), Tanzania (Nouvel, 1944), Malacca strait (O.S. Tattersall, 1965) Tanabic Bay, Japan (Valbonesi and Murano, 1980), Enewetak lagoon, Micronesia, (Murano, 1983), the South China Sea (Wang and Liu, 1994) and Akajima Island, Japan (Murano, 1990a). It is an Indo- Pacific species.

According to Pillai, *Psuderythrops gracilis* is an oceanic surface dwelling form but Murano (1998a) described the species as hyper benthic form in depth of about 300m. In the present collections this species was observe in the depth range of 190-300 m. During the IIOE collection this species was recorded from Arabian Sea and Bay of Bengal and its present occurrence in the Andaman water is the first record from this area. Hitherto, this species has been recorded from Red Sea (Coifmann, 1936, 1937; Nouvel, 1959) the Arabian Sea (Pillai, 1964, 1973) Sulu and Timor Seas (eastward) (Murano, 1998a). Thus its distribution extends north of the equator to eastward.

Gibberythrops acanthura is a deep-water form. Pillai (1964) collected this species from 388-1000 m depths from the Arabian Sea. It has been recorded from Arabian Sea (W.M. Tattersall, 1939; Pillai, 1964), Srilanka (Illig, 1930) Red Sea (Coifmann, 1936), Gulf of Aden (Bacescu, 1979), Philippines (W.M. Tattersall, 1951), South east of Durben, south of Cape Guardafui and north east of Seychelles (O.S. Tattersall, 1955).

Pleurerythrops inscita was first recorded by Ii from the surface waters of west of Borneo (2° 15' N, 108° 20' E). From Indian waters, this species was first recorded by Panampunnayil (1998) from 50 - 0 m depths and the present occurrence is the second record. This species has been previously recorded from Malacca Strait (Ii, 1964; O.S. Tattersall, 1965) and the northern South China Sea (Liu and Wang, 1986).

Euchaetomera glyphidophthalmica is a mesopelagic form having a wide geographical range and has been recorded from the tropical and temperate regions of the Atlantic Ocean (Zimmer, 1914; Illig, 1930; W.M. Tattersall, 1943; O.S. Tattersall, 1955), the Mediterranean Sea (Zimmer, 1915; Colosi, 1929) the Pacific Ocean (Murano, 1977a) from the Gulf of Aden (W.M. Tattersall, 1939) and from the Arabian Sea (Pillai, 1964). There were only three previous records of this species from the Indian Ocean; first by

W.M. Tattersall (1939) from Gulf of Aden, second by Pillai (1964) from the Arabian Sea and third by Panampunnayil (2002) from the Andaman waters. During IIOE this species was not recorded and hence the present collections from the Bay of Bengal forms a new record. Though it is widely distributed species, most of the hauls contained only one or two specimens. Its distribution was mostly found in between 100 to 200m depths (Murano, 1977a).

Synerythrops intermedia is a deep sea form. This species was originally recorded from Indian waters; widely distributed in the Indian and the Western Pacific Oceans. They are distributed in Manipa Strait of Indonesia (Hansen, 1910). Out side Trinity opening of Great Barrier Reef and Gulf of Aden (W.M. Tattersall, 1936a) and Suruga Bay of central Japan (Murano, 1975).

Dioptromysis perspicillata appears to be a surface dwelling coastal form. This species is monotypic (Pillai, 1963). At first, a single female specimen was taken by Zimmer (1915) from a voyage from Cylon to New Guinea. The exact locality where the collection was made is not known. According to Pillai, it is presumed to be some where in the Indian waters. Their distribution extends Port Blair (Andaman Island) and Gulf of Mannar (W.M. Tattersall, 1922) and Arabian Sea (Pillai, 1963).

The genus *Afromysis* is represented by a single species, *Afromysis dentisinus* and it was originally recorded from the inshore waters of Kerala (Pillai, 1957) and subsequently from the off shore waters in the Arabian Sea (Pillai, 1964, 1973; Panampunnayil, 1999). The present recorded extends its distribution northwardly and this species seems to be confined to the coastal waters of The Arabian Sea. This is a littoral form living close to the coast in shallow waters. Though this species had been found to occur in swarms in the inshore waters of Kerala, in the study area it was very poorly represented. Panampunnayil, (1999) reported this species in temperature and salinity of 22.8-28.5^{o} C and 35.9-37 psu respectively.

Doxomysis longura is a coastal form and it was recorded from Andaman Island (W.M. Tattersall, 1922), Great Barrier Reef (W.M. Tattersall, 1936a) and Kerala coast (Pillai, 1957).

Eventhough, *Mesopodopsis orientalis* recorded only one station in present study, it is the most widespread and abundant mysids in the, back waters and estuaries of both east and west coasts of India (Panikker and Aiyar, 1937). The present occurrence in the Arabian Sea, confirm its presence in the coastal waters. They tolerate wide range of salinity and temperature. It has been recorded from the brackish waters and estuaries throughout the year (W.M. Tattersall, 1914; Panikkar and Aiyar, 1937; George, 1958; Gupta and Gupta, 1984; Chandramohan, 1983; Sarkar and Chowdhury, 1986) and also from the fresh waters of Orissa, Midnapur, Calcutta and Adayar (W.M. Tattersall, 1915) and from the fish and prawn culture ponds in Java (Nouvel, 1957), Singapore (O.S. Tattersall, 1960), Malaysia (O.S. Tattersall, 1965; Hanamura *et al.*, 2008) and Thailand (Murano, 1986a). This species has been also recorded from Saltpan of Mumbai (Panampunnayil, 1999). The ecology and reproduction of this species dealt with chapter 6.

Acanthomysis macrops is a rare species and has so far been recorded from the Arabian Sea (Pillai, 1973; Panampunnayil, 1999). This is the third record of *A. macrops* from the Indian waters. It is also an endemic form in the Arabian Sea.

Lycomysis spinicauda is a surface dwelling oceanic form, hitherto known from the Indian Ocean and in the Western Pacific. The present record of *L. spinicauda* is the second record from the Indian waters. It has been previously recorded from Buton Strait (Hansen, 1910); China Sea (Colosi, 1916), Between Ceylon to Dampier Strait (Zimmer, 1916); Andaman Island (W.M. Tattersal, 1922).

Anisomysis spinata is a rare and endemic in the Indian waters. Its occurrence was reported in Lakshadweep waters (Panampunnayil, 1993),and

Andaman waters (Panumpunnayil, 1999). It is the third record of *A. spinata* from the Indian waters.

Most of the species have very wide range of distribution in the tropical and sub tropical Indo Pacific waters and they may contribute a substantial part of food of surface feeding fishes. A peculiar feature in the present study is the closer affinity between the Indian and Pacific mysids than between those of Indian and Atlantic mysids. Such predominance of tropical Indo-pacific fauna is due to the large-scale interchange of water between Pacific and Indian Ocean through the Indonesian Archipelago, which helps to maintain a wide distribution of warm water species (Pillai, 1973).

Indian Ocean	**Indian & Pacific**	**Indian, Pacific& Atlantic**
Rhopalophthalmus indicus	*Siriella gracilis*	*Boreomysis plebeja*
Haplostylus pusillus	*Siriella aequiremis*	*Siriella thompsoni*
Eurobowmaniella simulans	*Hemisiriella parva*	*Anchialina typica*
Pleurerythrops inscita	*Gastrosaccus dunkeri*	*Euchaetomera glyphidophthalmica*
Afromysis dentisinus	*Anchialina grossa*	
Doxomysis longiura	*Anchialina dentata*	
Dioptromysis perspicillata	*Anchialina media*	
Acanthomysis macrops	*Pseudanchialina pusilla*	
Mesopodopsis orientalis	*Pseudanchialina inermis*	
Anisomysis spinata	*Pseuderythrops gracilis*	
	Gibberythrops acanthura	
	Synerythrops intermedia	
	Lycomysis spinicauda	

The widely distributed Indo-Pacific species like *Siriella gracilis, Hemisiriella parva* and *Pseudanchialina pusilla*, have been never recorded from the Atlantic Ocean, perhaps because these stenothermic warm water species are unable to tolerate the cold waters around the southern tip of the African continent and enter the Atlantic (Pillai, 1973). The two narrow man made connections to the Atlantic Ocean, namely, the Suez and Panama canals are apparently inadequate to facilitate migration into the Atlantic.

Chapter 5

Mysids from the northwest coast of India

5.1. INTRODUCTION

The northwest coast of India extends from 16°N to 24°N comprising the maritime states of Gujarat and Maharashtra and Union territory of Daman and Diu. The length of the coastline is 2,347 km and the continental shelf area is 27,600 km^2.

The habitat of marine zooplankton is delineated into two major realms, the neritic province covering the shelf areas and the oceanic province covering the areas off the shelf edges deeper than 200 m. Each province is characterized by unique physical, chemical and ecological proportion. The neritic area is characterized by high plankton production with relatively low diversity while the oceanic area supports a diverse plankton community. The shallow waters of the coastal zone is a complex region as this part is greatly affected by the monsoons, river run off, currents, tides and land based activities including waste water discharges. This narrow inshore strip of the coastal waters eventhough occupies a very small area of the Indian Ocean, contributes significantly to the over all production potential. The rivers opening into the near shore waters enhance the availability of nutrients that triggers the biological productivity. The productivity of the coastal waters is nearly five times greater than that of the open ocean (Mann, 1968). The coastal areas are sheltered environment, having pockets of localized fertile zones, which form an ideal nursery ground for a wide variety of fish and shellfish including many species of commercial importance.

Several species of mysids form an important component of the zooplankton in the near shore waters. They feed mainly on detritus and diatoms and play an important role in nutrient regeneration. Though they are not very abundant in the plankton, the low population density is compensated by their comparatively large size and occasional incidence in swarms.

The shallow water mysids of the Indian region are rich and diverse and our knowledge on them is limited to the works of W.M. Tattersall, Pillai and Panampunnayil. In a series of papers, W.M. Tattersall (1906, 1908, 1914, 1915, 1922) described the mysids collected mainly from the brackish waters of the east coast of India. Pillai (1957, 1961, 1964) studied the littoral mysids of the Kerala coast, Gajbhiye *et al.* (1980) reported some mysid distribution from near shore waters off Mumbai and Panampunnayil (1999a) reported mysids in the coastal waters of Maharastra and Gujarat, since then no further additions have been made to the species list. Hence an extended knowledge of the Mysidacea of the northwest coast is desirable and requires more systematic investigation.

5.2. STUDY AREA

Zooplankton samples collected from 10 localities were considered for the present study.

1. Mundra (Fig. 5. 1).

The coastal stretches off Mundra in general, has a variegated topography with vast intertidal mud flats criss-crossed by numerous creeks, the prominent creeks in the vicinity of the study area being Bocha, Navinal and Baradi Mata creeks. Occurrence of a large number of creeks has created a number of islands including Navinal and Bocha islands. These islands and the intertidal area of the creek sustain vast stretches of mangroves. The region is swept by significantly strong tides with spring and neap tidal ranges of 5.07 and 3.8 m respectively at the Mundra port (Bocha creek). The currents of Mundra and associated creeks are largely tide induced and excursions are mostly bimodal reversing in direction with the change in the tidal phases. The circulation of the coast is generally elliptical with the major axis parallel to the shoreline.

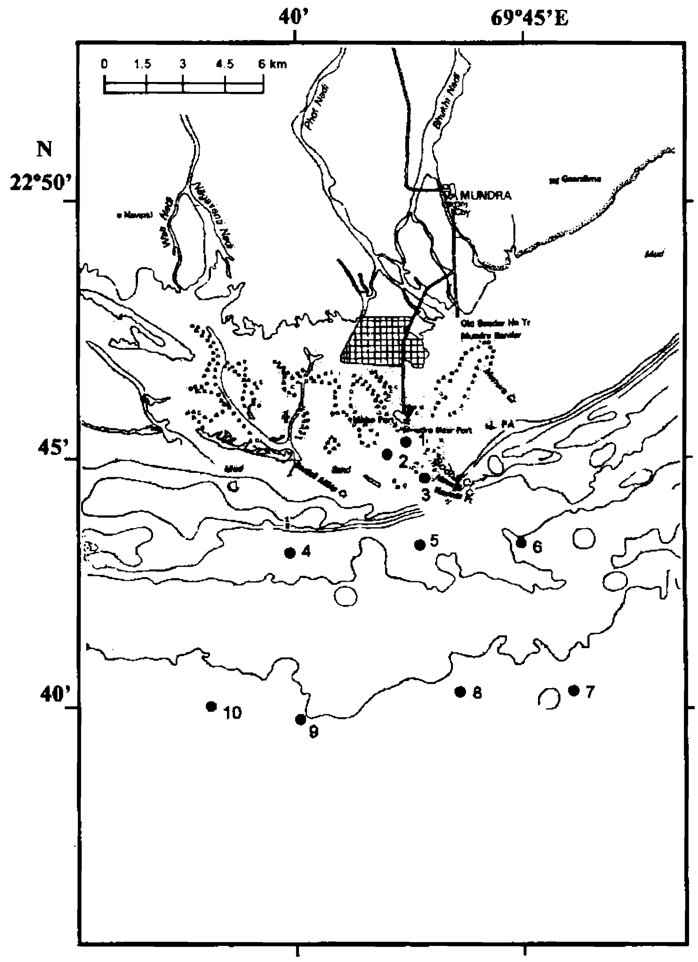


Figure 5. 1. Location of stations in Mundra

2. Kandla (Fig. 5. 2).

Kandla is on the interior most part of Gulf of Kachchh on the western side, north of Nakti. This part of the Gulf is also well known for its high biodiversity. The mouth of Kandla creek is prone to heavy siltation. The nature of circulation in the area favours the formation of oblong shaped shoals alternating with strand flows at the mouth of Kandla creek. Kandla creek is a tidal stream (width 1 km) of about 12 km long connecting the Gulf and Phang - Sara creeks. Due to the large tidal variation (mean spring tide ranges of 5.86

m), the creek is subjected to strong tidal currents exceeding 1 m/s. The banks of the creek are flat and mainly characterized by silty clay while the bed mostly consists of coarse sand.

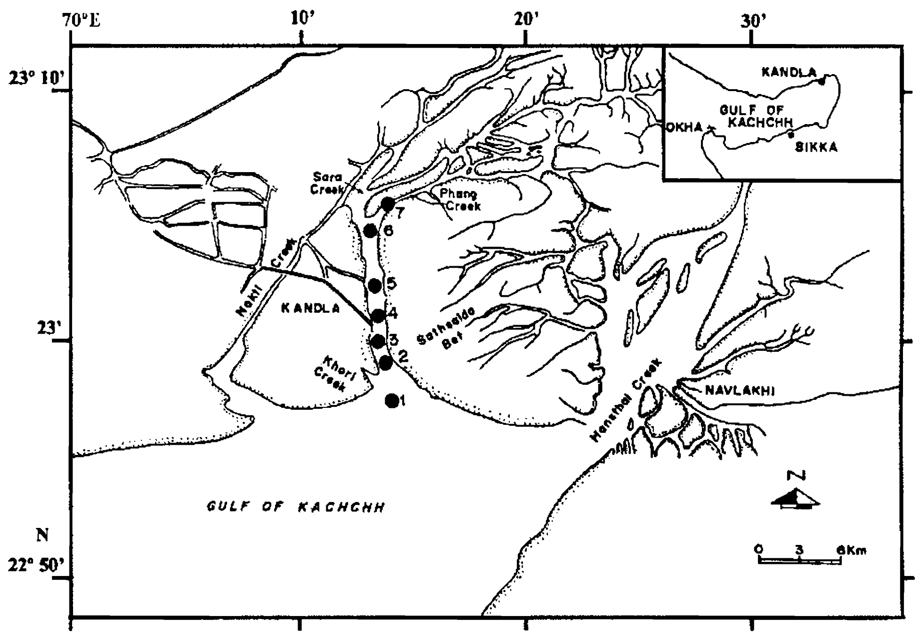


Figure 5. 2. Location of stations in Kandla

3.Vadinar (Fig. 5. 3).

Vadinar is located in the Gulf of Kachchh at the north central east coast of the Gulf, north of Salaya. The biological characteristics of the coastal zone of Vadinar is in confirmity with the marine wealth of the Gulf (NIO, 1997). The high tidal influence generates strong currents rendering the water mass well mixed. The salinity which is higher than that of typical sea water is characteristic of the Gulf and results from excessive evaporation and seepages from exposed intertidal areas during low tides. The sub tidal region along the Vadinar coast harbour a variety of algae, crabs, prawns, fishes etc. The high biodiversity and biodensity of life in the region is due to the availability of different habitats like sandy, muddy, rocky and coral beds.

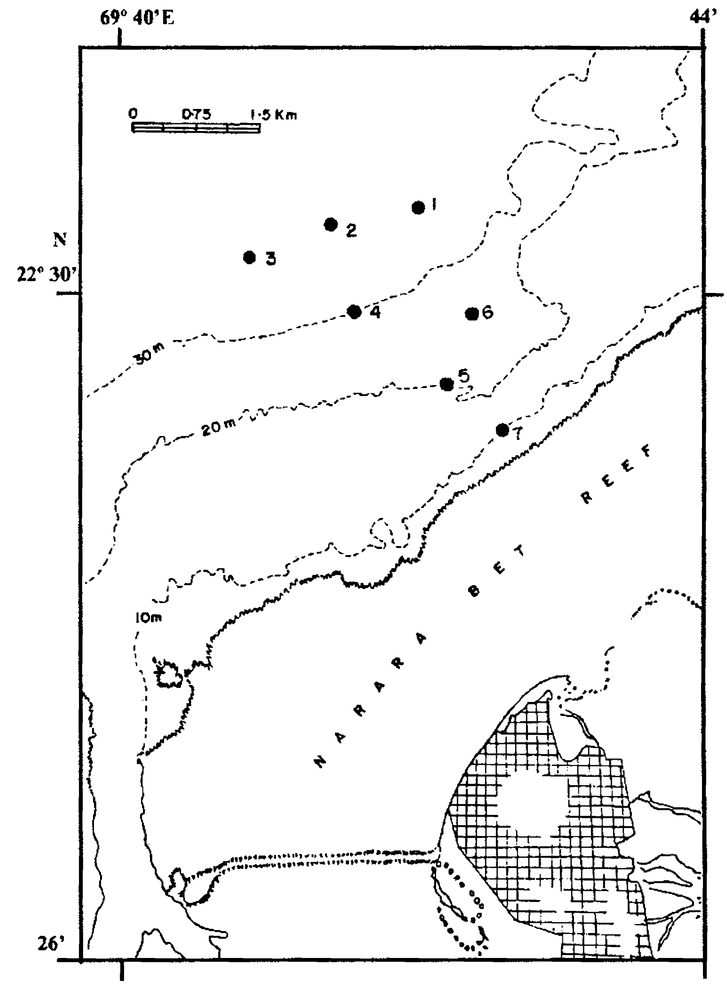


Figure 5. 3. Location of stations in Vadinar

4. Mithapur (Fig. 5.4)

Mithapur is located about 10km from Okha port at the head of Okhamandal peninsula. The region forms a part of the semi arid coastal belt. The fertility of the coastal belt is affected by salinity ingress due to excess withdrawal of ground water not compensated by the recharge of aquifers. The coastal environment of Mithapur forms an internal part of the Gulf of Kachchh.

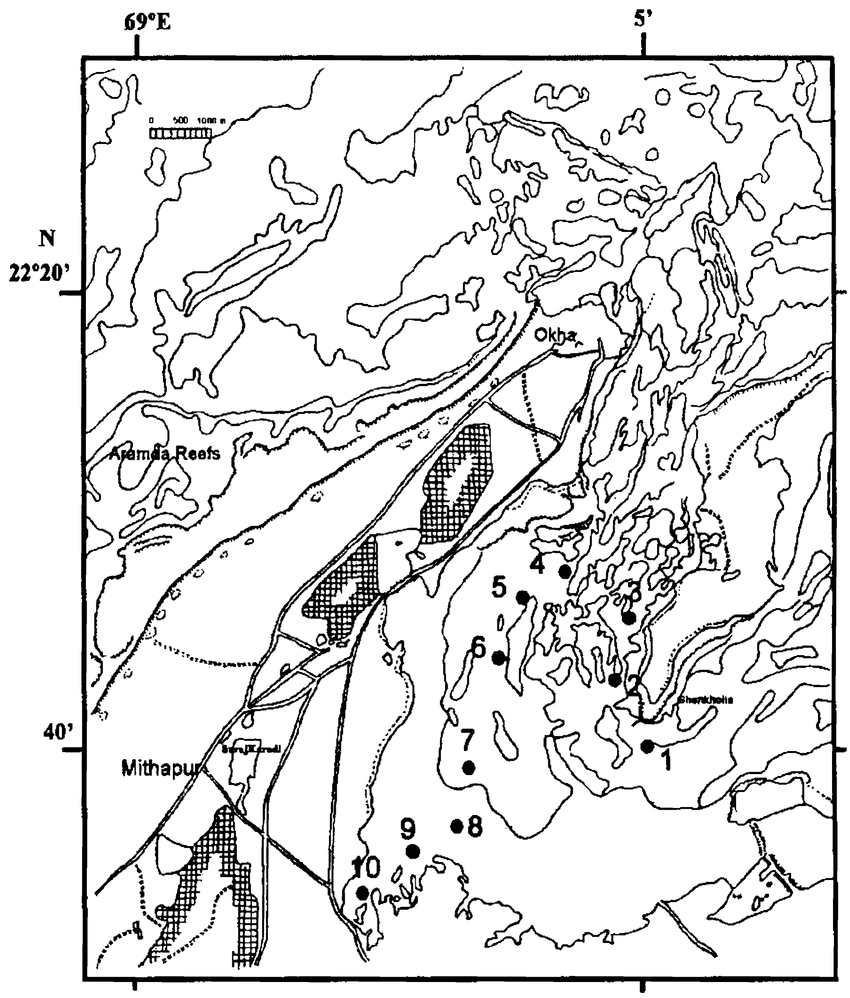


Figure 5. 4. Location of stations in Mithapur

5. Veravel (Fig. 5. 5)

The Veraval-Diu coast forms straight coastline revealing a vivid manifestation of the interaction of marine, aeolian and fluvial processes that have resulted in a number of important geomorphic landforms. The near shore zone is characterized by the formation of recent alluvium deposits, sand bars, mud flats, mangrove swamps, beach and littoral sands, oyster beds and sands dunes. The inland zone consists of lithophyte beach, beach rocks and milliolitic limestone of marine and aeolian origin. The white to pale brown limestone strata has thickness of 30-45.

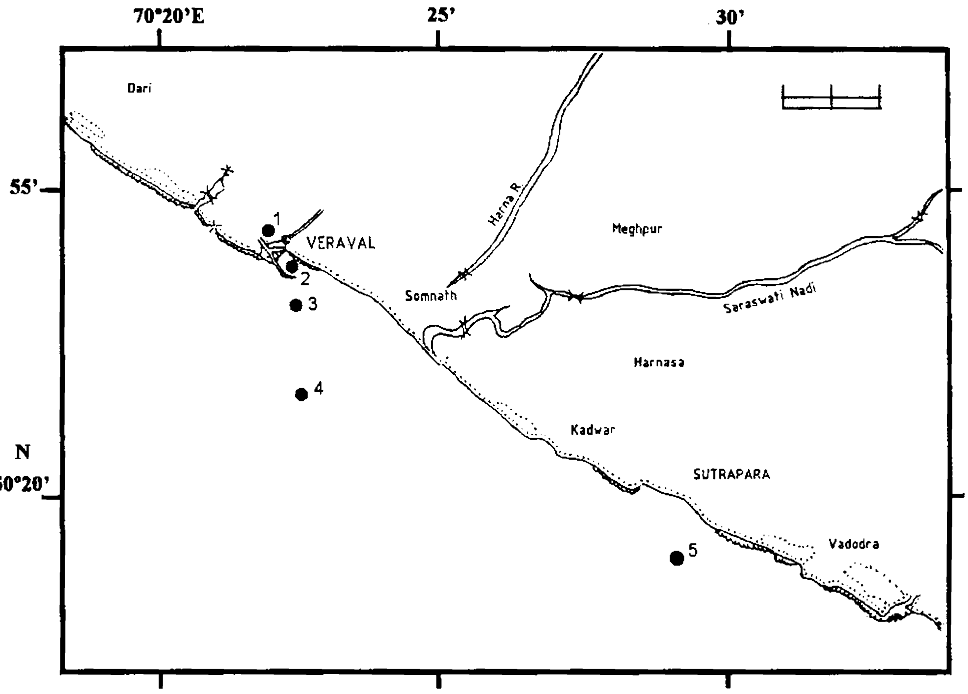


Figure 5. 5. Location of stations at Veraval

6. Bhavnagar (Fig. 5.6)

The study area is bordered by Bhavnagar creek to the south, Sonari khadi to the north and the Gulf of Kham bhat to the east.

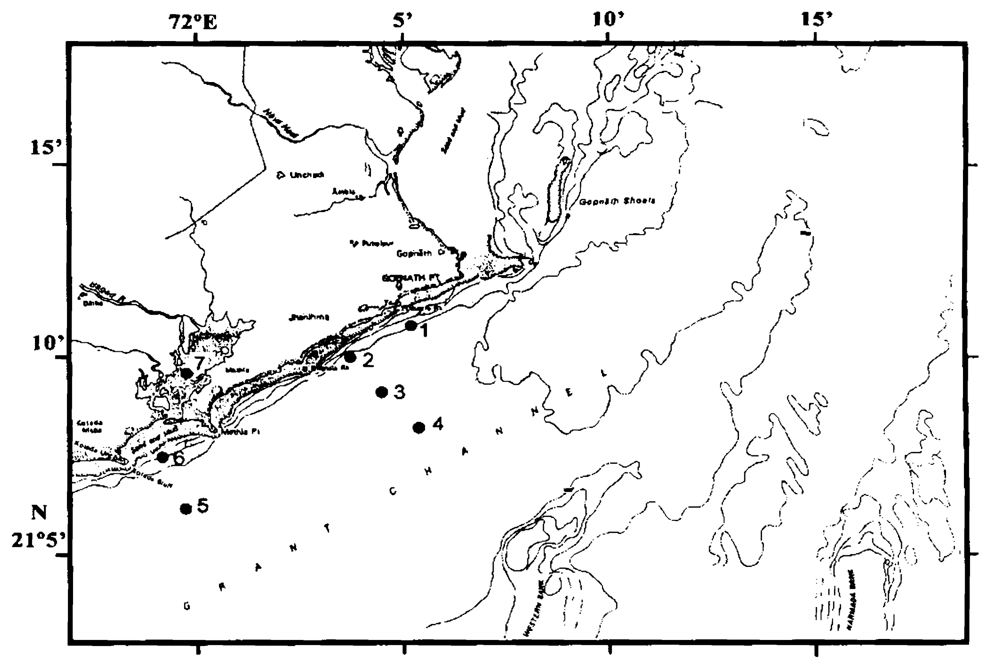


Figure 5. 6. Location of stations at Bhavnagar

7. Hazira (Fig. 5. 7)

The area of study is at the mouth of estuarine zone of Tapi estuary. The near shore area of Hazira exhibits typical character of south Gujarat coast with vast intertidal regions composed of poorly sorted sediment made up of sand, silt and clay with isolated rocky out crops, gently slopping continental shelf with uneven seafloor often strewn with sand bars. The area experiences high tidal influence due to the proximity to the Gulf of Khambhat. Water is highly muddy by virtue of high-suspended solids (290-810 mg/l). Under the influence of estuarine discharges the salinity of the open shore waters varies over a wide range of 14 to 34%.

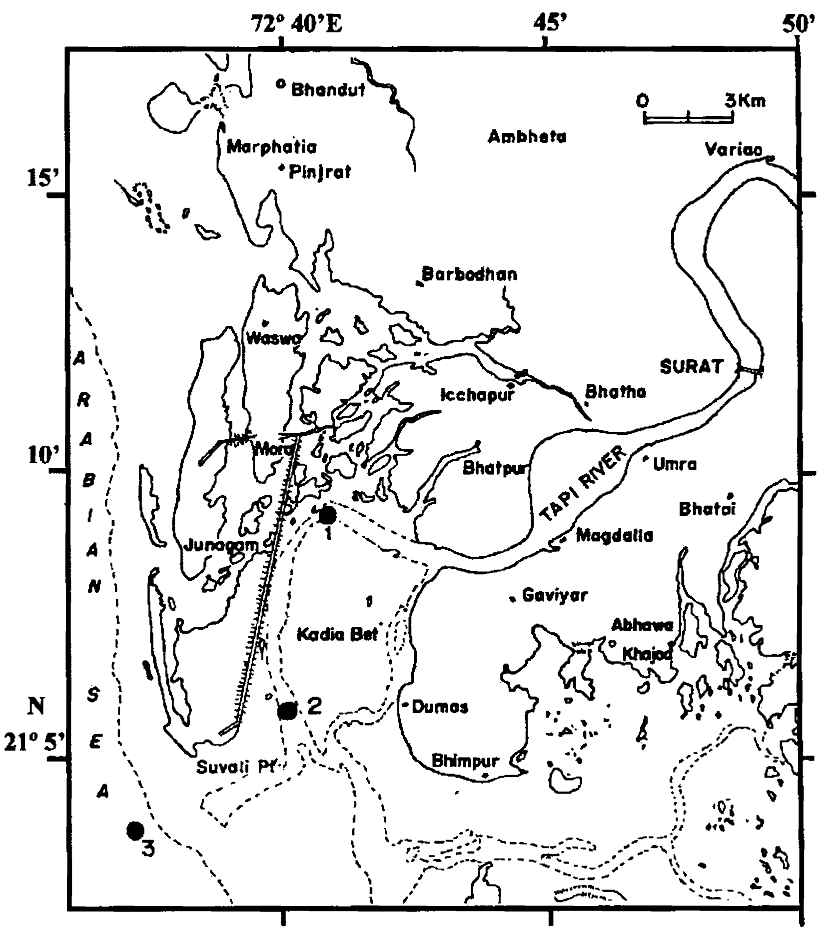


Figure 5. 7. Location of stations in Hazira

8. Dahanu (Fig. 5.8)

Dahanu, located 120 km north of Mumbai, is one of the last green belt along the heavily industrial west coast of India. Dahanu's coast is a unique combination of large intertidal zone, rock shelf and mangroves (Dewan and Chawla, 1998; Menon, 1998a, 1998b). The intertidal zone is known to be critical to the biological productivity and richness of offshore marine areas. The Dahanu coast is considered to be one of the richest fishing grounds in the Gulf of Cambay (an area between Mumbai and Diu). The intertidal zone is known to be critical to the biological productivity and richness. Dahanu's coastline of 35km is considered to be the least disturbed among the entire north -western coast of India. The combination of mangroves and rock shelf at Dahanu provide an important nursery for developing crustacean, molluscan and fish larvae, including commercially important species.

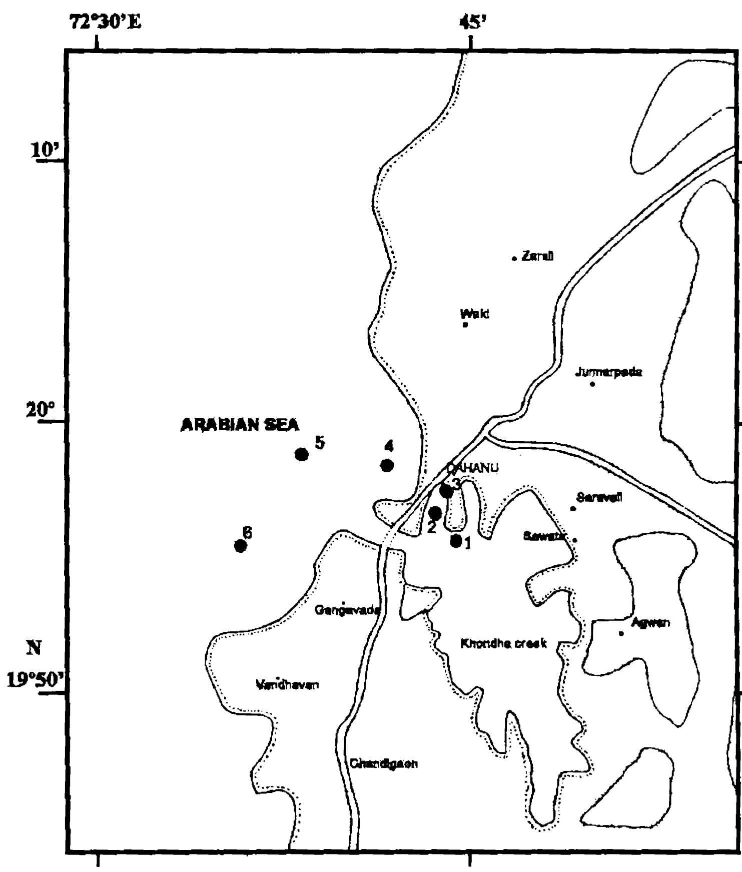


Figure 5. 8. Location of stations in Dahanu

9. Bassein (Fig. 5. 9).

Bassein creek is the northern extremity of Thane creek. The Bassein creek joins the Arabian Sea north of Dongri and the interior part of this complex creek system is fringed by rich mangrove vegetation and the land around is used for cultivation and as saltpans. Bassein creak transport variety of anthropogenic contaminants to the coastal waters and hence the area exhibits low oxygen and high concentration of nutrients which increase towards interior segment. Bassein creek receives about 35mld of industrial effluent and 10 mild of sewage through the Ulhas River and Mumbai creek.

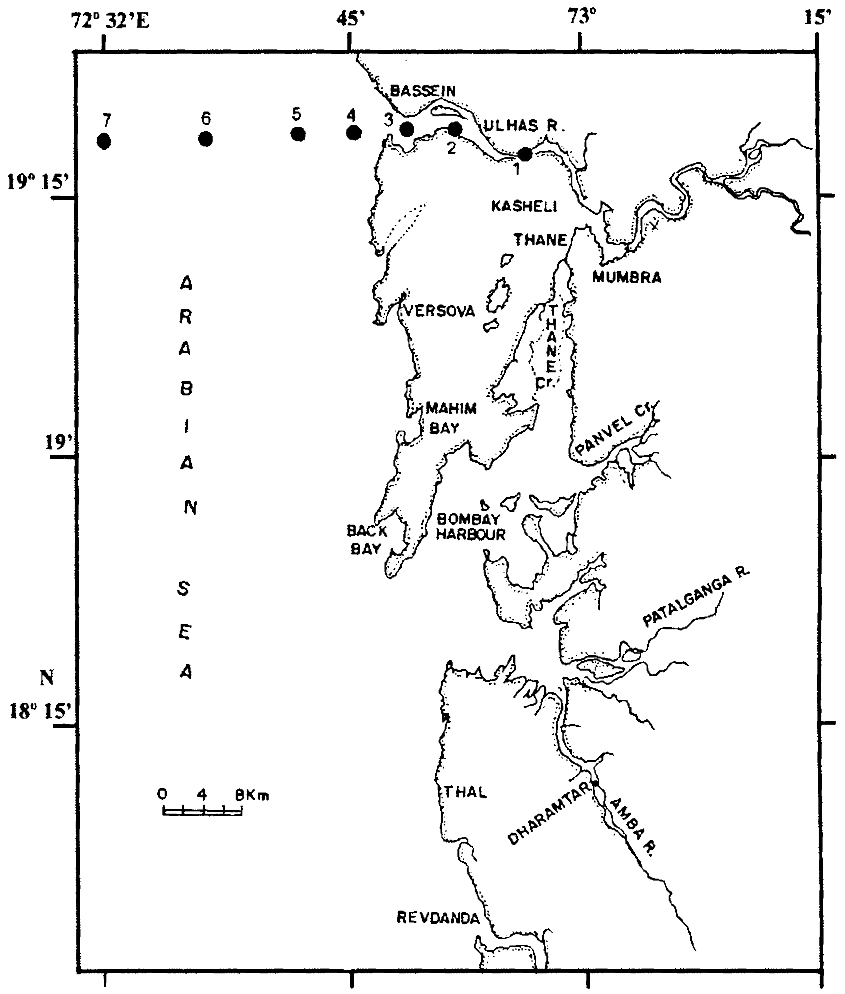


Figure 5. 9. Location of stations in Bassein

10. Amba river estuary (Fig. 5. 10)

Amba River, which originates in the Western Ghats follows a narrow and meandering course along her length of over 140km before opening into Mumbai Harbor. The catchments area of the river basin receives on an average of 2100mm of annual rainfall, 95% of which occurs during southwest monsoon (June - September). The lower reaches of the river often refereed to as Dharamtar creek. A Konkan type bandhara constructed across the river at Nagothane (about 50km up stream from the mouth). The region down stream of bandhara is subjected to significant seawater incursion during dry season.

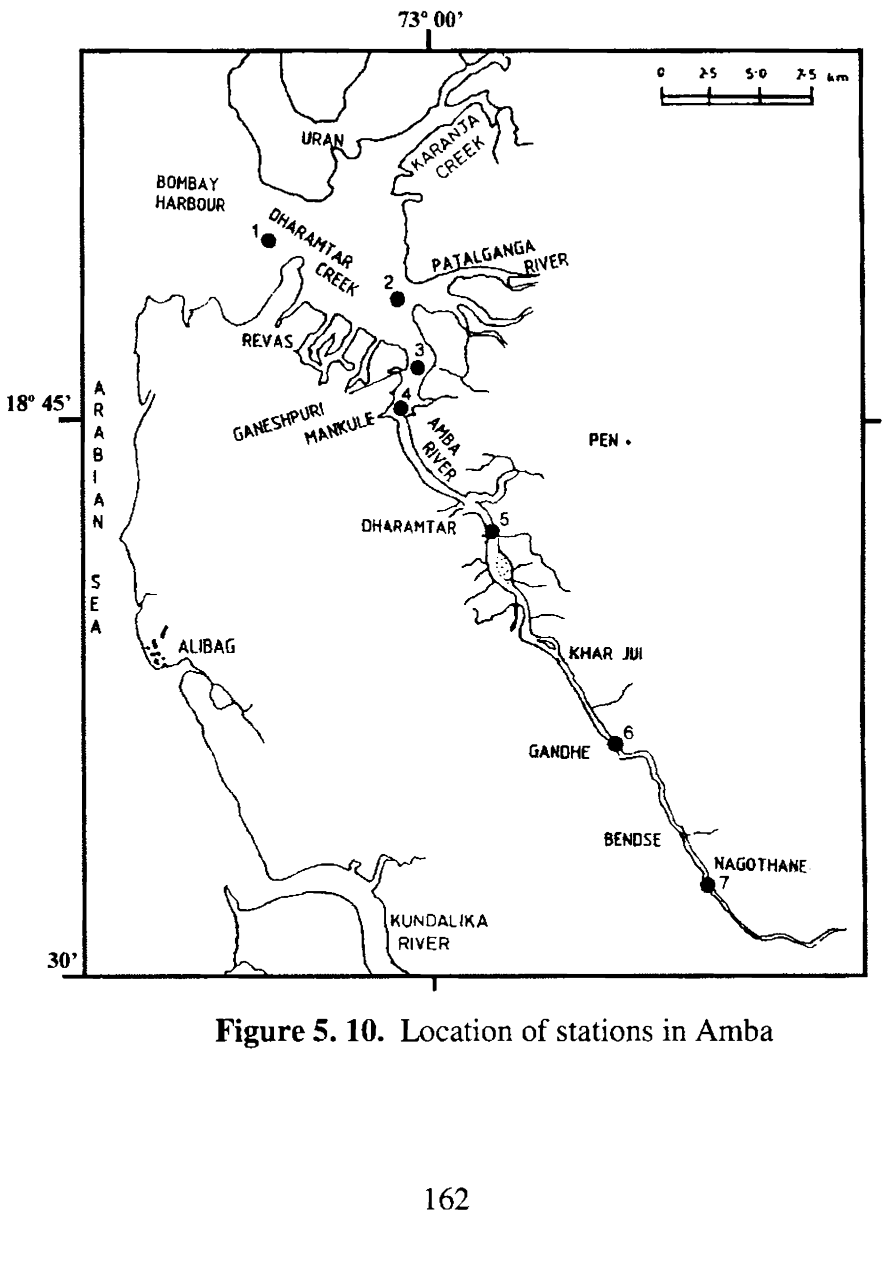


Figure 5. 10. Location of stations in Amba

Location and sampling frequency

The number of stations sampled at each locality and month and year are given below

Mundra	10 stations	April 2007 and May 2007
Kandla	7 stations	December 2006
Vadinar	7 stations	November 2005
Mithapur	10 stations	December 2003, April 2004, and May 2004
Veravel	5 stations	September 1999
Bhavnagar	7 stations	March 2007 and November 2007
Hazira	3 stations	December 2005 and May 2006
Dahanu	6 stations	February 2007
Bassein	7 stations	January 2006, May 2006, and October 2006
Amba	7 stations	May 2005, 2006 and 2007

5.3. RESULTS

Of the 10 localities, mysids occurred at all areas except at Veravel. Maximum density ($8792/100m^3$) was found at Dahanu and was constituted by a single species *Mesopodopsis orientalis.* Twelve species of mysids belonging to eight genera of four-sub families were identified, of which three species, *Siriella hanseni, Erythrops minuta, Acanthomysis anomala* are first reports from this area. *Mesopodopsis orientalis* is the most abundantly caught species and occurred in aggregations at Bassein, Dahanu and Mithapur. *Indomysis annandalei* was the next in abundance ($2117/100m^3$) eventhough they occurred only in Mithapur. *Rhopalophthalmus vijayi* was the abundant mysid at Bhavnagar, contributed 80.4% of the total population of this area and occurred in small aggregations. All other species were either moderately or sparsely represented. The percentage composition of different mysid species encountered at different localities is shown in Table 5.1.

Table 5.1. Percentage composition of different species of mysids at different locations

	Siriella dubia	*Siriella hanseni*	*Siriella jonesi*	*Rhopaloph-thalmus mumba-yensis*	*Rhopaloph-thalmus anishi*	*Rhopaloph-Thalamus vijayi*	*Gastro-saccus dunckeri*	*Eurobow-maniella muticus*	*Erythrops minuta*	*Acantho-mysis anomala*	*Mesopo-dopsis orientalis*	*Indo-mysis annadalei*
Mundra	-	-	-	-	-	-	0.1	-	-	-	99.9	-
Kandla	-	-	-	-	-	-	-	-	-	14.29	85.71	-
Vadinar	0.62	-	7.79	-	-	-	91.59	-	-	-	-	-
Mithapur	-	0.08	-	-	-	-	1.3	-	-	-	42.01	56.6
Veravel	-	-	-	-	-	-	-	-	-	-	-	-
Bhavnagar	-	-	-	6.63	3.51	80.36	1.56	-	0.52	-	7.41	-
Hazira	2.2	-	-	-	-	-	0.44	-	-	-	97.36	-
Dahanu	-	-	-	-	-	-	-	-	0.03	-	99.96	-
Bassein	-	-	0.76	0.33	1.41	-	3.63	0.13	0.19	-	93.54	-
Amba	-	-	-	4.25	-	-	-	-	-	-	95.75	-

Taxonomic listing of the mysids

SUB ORDER MYSIDA BOAS, 1883

Family MYSIDAE Dana, 1850

Sub family SIRIELLINAE Norman, 1892

Tribe Siriellini Czerniavsky, 1882

Genus *Siriella* Dana, 1850

Siriella dubia Hansen, 1910

S. hanseni W.M.Tattersall, 1922

S. jonesi Pillai, 1964

Sub family RHOPALOPHTHALMINAE Hansen, 1910

Genus *Rhopalophthalmus* Illig, 1906

R. mumbayensis Panampunnayil and Biju, 2006

R. anishi Panampunnayil and Biju, 2006

R. vijayi Panampunnayil and Biju, 2006

Sub family GASTROSACCINAE Norman, 1892

Genus *Gastrosaccus* Norman, 1868

Gastrosaccus dunckeri Zimmer, 1915

Genus *Eeurobowmanialla* Murano, 1995

Eeurobowmanialla muticus W.M.Tattersall, 1915

Sub family MYSINAE Hansen, 1910

Tribe Erythropini Hansen, 1910

Genus *Erythrops* G.O. Sars, 1869

Erythrops minuta Hansen, 1910

Tribe Mysini, Hansen, 1910

Genus *Acanthomysis* Czerniavsky, 1882

Acanthomysis anomala Pillai, 1961

Genus *Mesopodopsis* Czerniavsky, 1882

Mesopodopsis orientalis W.M. Tattersall, 1908

Genus *Indomysis* W.M. Tattersall, 1914

Indomysis annandalei W.M. Tattersall, 1914

Taxonomic account

Sub family SIRIELLINAE Norman

Tribe Siriellini

Genus *Siriella* Dana

***Siriella dubia* Hansen**

(Fig. 5.11A-E)

Siriella dubia Hansen, 1910. P. 44, pl. 5, figs. 4a-e; W.M. Tattersall, 1922, p. 455, figs. 5a-b; 1936, p. 146, fig. 1; 1951, p. 80; Illig, 1930, p. 560; Ii, 1964, p. 131, fig. 35; Pillai, 1964, p. 7, fig. 2; 1973, p. 42, fig. 13-14. Panampunnayil, 1999a. p. 79, fig. 5.16.

Occurrence

Vadinar	**November 2005**
Station 5:	1 immature female
Station 7:	1 female with egg

Body length: mature female 7.8 mm

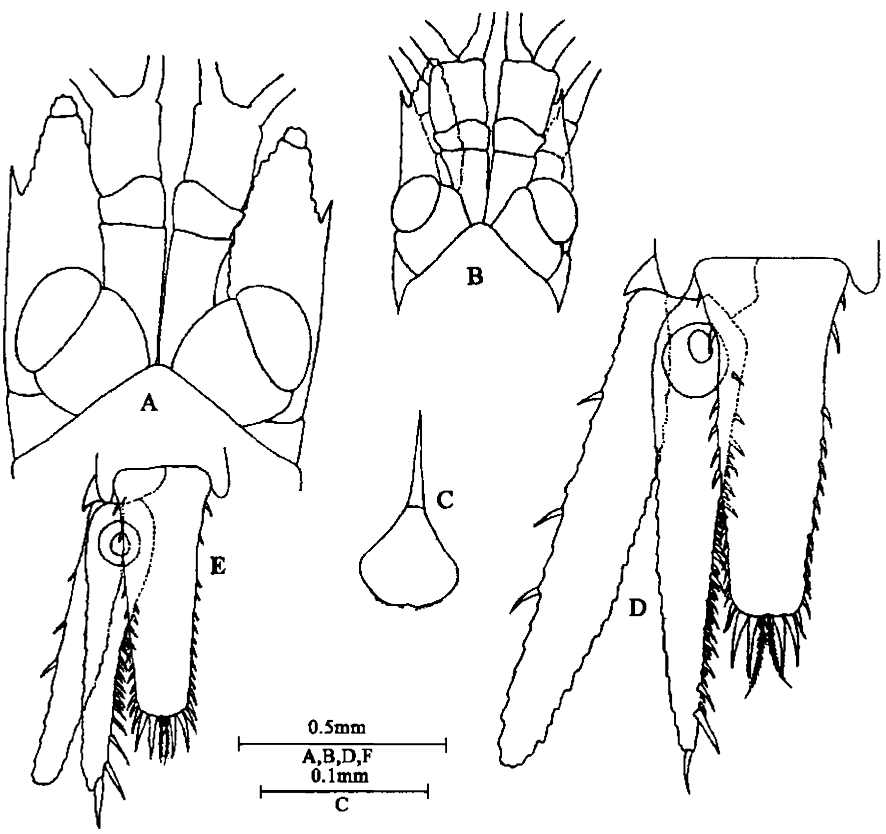


Figure 5. 11. *Siriella dubia* Hansen, Female. A, anterior part of the body; B, anterior part of the body of immature male; C, labrum; D, Posterior part of immature female; E, Posterior part of immature male.

Remarks: This species was first described by Hansen (1910) and the type specimen was a single adult female taken in the Siboga Expedition. In 1922, W.M. Tattersall obtained more specimens from Port Blair which supplemented Hansen's description. W.M. Tattersall (1936a) obtained further material from the Great Barrier Reef and amended his earlier description of male pleopods. Since then this species has been dealt with by li (1964), Pillai (1964, 1973) and Panampunnayil (1999a).

This species is unique in having the outer border of the proximal segment of the exopod of the uropod setose and also in having three to four equidistant spines in the outer border of the exopod of uropd and anteriorly produced long sharp spine on the labrum. The present specimens agree with the published description and figures but show some variations. According to the description published by Hansen and Ii, the apex of the telson is armed with four pairs of long spines successively increasing in length. In the present material the apex is armed with only three pairs of spines and the inner pair of spines are the longest in both sexes. Pillai (1973) found the inner pair of spines slightly shorter than middle pair in female and just the reverse in male. In earlier descriptions outer border of exopod of uropod having four equidistant spines spread along the entire border while the present specimens have only 3 spines in the exopod of uropod. In earlier descriptions, lateral margin of the telson has 11-13 spines while in present specimens 14 spines were observed. Body length of this species from different areas has some variations. Hansen's specimen from East Indies measured 6.6 mm, Ii's specimens from Japan 6.5 mm, Tattersall's specimens from Andaman Sea 8 mm and Pillai's from Arabian Sea 7.2 mm and the largest specimen (8.5 mm) was collected from the coastal waters of Mumbai (Panampunnayil, 1999a).

Distribution: *Siriella dubia* is a widely distributed species in Indian and Pacific Oceans. Hitherto this species has been recorded from East Indies (Hansen, 1910), Andaman Island, Great Barrier Reef, Philippine island (W.M. Tattersall, 1922, 1936a, 1951), Arabian Sea (Pillai, 1964, 1973, Panamapunnayil, 1999a), South China Sea (Ii, 1964) and Malacca strait (O.S. Tattersall, 1965). The present distribution does not extent its distribution.

Ecological note: This species is a shallow water form and was collected from 9 - 0 m depth and occurred in temperature of 28°C and salinity 35 psu. This species occurred along with *Siriella jonesi* and *Gastrosaccus dunckeri* at Vadinar. Adult female obtained carried only11 eggs in their brood pouch.

Siriella hanseni W.M.Tattersall

(Fig.5.12 A, B)

Siriella hanseni, W.M. Tattersall, 1922, p. 448, figs. 1-2.

Occurrence

Mithapur	**April 2004 and May 2004**
Station 3:	1 immature male, 1 immature female

Body length: Immature male 4.7 mm, immature female 4.5 mm

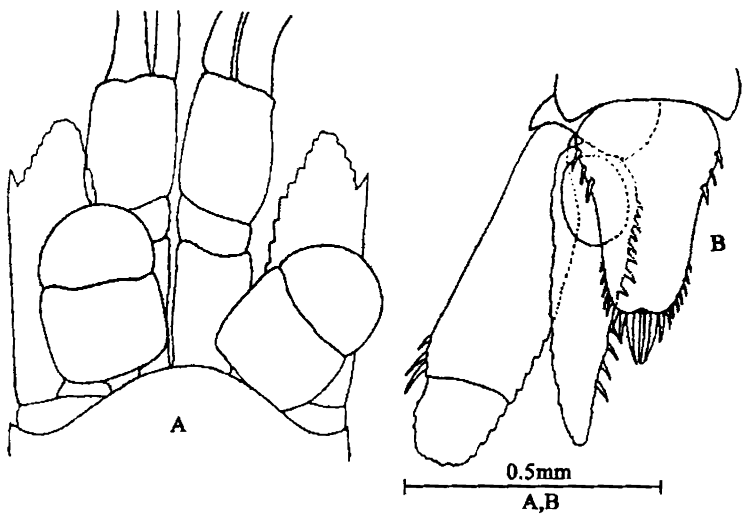


Figure 5. 12. *Siriella hanseni* W.M. Tattersall. Immature male. A, Anterior part of the body; B, posterior part of the body.

Remarks: This species is distinguished by the rounded rostral projection, the unjointed tarsus of the thoracic limbs, unmodified pleopods, linguiform telson and the number of spines present on the exopod of uropod. Eventhough the present specimens are immature, they are very well agreeing with the previous descriptions, except for some minor variations. In the present specimens, distal border of the telson bears 8 - 9 spines while in earlier descriptions it was 12. In previous descriptions the endopod of the uropod bears only 10 spines while in the present specimen, endopod of the uropod has 13 spines. These variations may be due to the immaturity of the specimens.

Distribution: Pamban, Gulf of Mannar (India) (W.M. Tattersall, 1922), Arabian Gulf (Murano, 1998b), Singapore (O.S. Tattersall, 1960) and North East Australia (Bacescu, 1986a). The present record is the first report of this species from the northwest coast of India

Ecology: This species is sparsely represented at Mithapur and occurred in temperature and salinity of 27.2°C and 33 psu respectively.

Siriella jonesi Pillai

(Fig. 5.13 A-H)

Siriella jonesi Pillai, 1964, p. II, figs. 5-6; 1973, p. 46, figs. 17-18. Panampunnayil, 1999a, p. 83, fig. 5.17.

Occurrence

Vadinar	**November 2005**
Station 7:	15 mature males, 5 immature males, 7 immature females, 15 juveniles
Hazira	**December 2005, May 2006**
Station 2:	1 immature male
Station 3:	2 immature males, 1 female with egg, 1 juvenile
Bassien	**January 2006, May 2006, October 2006**
Station 2:	1 mature male
Station 3:	4 mature males, 1 immature male, 5 juveniles

Body length: mature male 7.7- 8 mm, mature female 6.7 mm

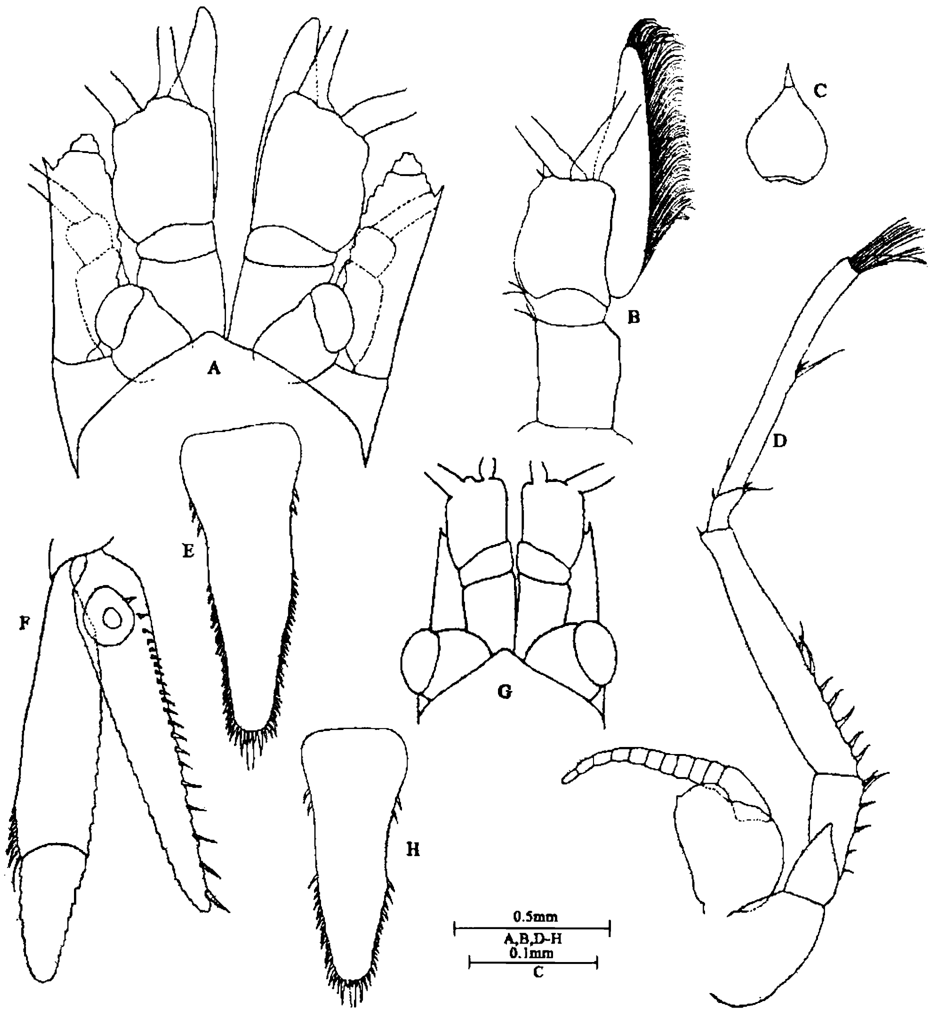


Figure 5.13. *Siriella jonesi* Pillai, Male. A, anterior part of body; B antennule; C, labrum; D, fifth thoracic limb; E, telson; F, exopod and endopod of uropod; G, anterior part of body; H, telson of female.

Remarks: This species belongs to the Thompsoni group (Hansen, 1910) of the genus in which none of the male pleopods have modified setae and the pseudobranchial lobes on the second to fourth pleopods are spirally coiled. There are only three previous records of this species (Pillai, 1964, 1973; Panampunnayil, 1999a). The original description was based on an immature male (5.6 mm) collected from the Arabian Sea (20°20'N 72°00'E). A second report on an adult male (8.8 mm) collected during IIOE (20°19'N 72°28'E) was made in 1973. Panampunnayil (1999a) gave first detailed description of female and juvenile. Since then this species has not been recorded from anywhere else. In the present collection, large number of adult and young males, females and juveniles are well represented.

Compared to the earlier descriptions the present specimens show some differences. In Pillai's specimen, the carapace is produced into a very low rostrum and does not over reach the base of the eyestalks. In the present specimens the rostrum is more produced reaching the base of the antennular peduncle and covers the basal part of the eyestalk as described by Panampunnayil. In the present specimens the first segment of the antennular peduncle in male is shorter than the third segment while in Pillai's specimen the first segment is longer than the third segment. The antennal scale is only three times as long as broad while in Pillai's specimen it is four times as long as broad. The largest adult specimen in the present material measured only 8 mm, but Pilla's specimen measured 8.8 mm and Panampunnayil's specimen measured 7mm. A prominent character of this species, which has not been noticed by Pillai, is the short frontal spine of the labrum. In all the species of *Siriella* except in *S. linguvura* (Ii, 1964) and *S. spinulata* (Panampunnayil, 1995), the labrum is anteriorly produced into a very long spine, usually as long as or longer than the lip proper. In having extremely elongated fifth thoracic endopod, this species resembles *S. nodosa* (Hansen, 1910). But in *S. nodosa* the rostrum is narrow and more produced, the thoracic endopods are devoid of spines, sixth joint of the thoracic endopod is undivided, widened basal part of the telson has only single pair of spines, spines on the lateral margin of telson are not arranged in series and in male the spines on the inner uropod are arranged in series.

Distribution: From the available information it appears that this species has a restricted distribution and is confined to the Arabian Sea. The three earlier records of this species are from the Arabian Sea and the present record is also from the same area.

Ecological note: In Vadinar, this species occurred along with *Siriella jonesi* and *S. dubia*, and in Hazira and Bassein, along with *G. dunckeri*. This is a littoral form living close to the coast in shallow waters. It has been found to occurred in temperature and salinity ranging from 24.5-33°C and 31.3-37 psu respectively.

Sub family RHOPALOPHTHALMINAE Hansen

Genus *Rhopalophthalmus* Illig

***Rhopalophthalmus mumbayensis* Panampunnayil and Biju**

(Fig. 5.14 A, B)

Rhopalophthalmus mumbayensis Panampunnayil and Biju, 2006, p.1331, figs. 1-27.

Occurrence

Bhavnagar	**March 2007 and November 2007**
Station 1:	5 mature males, 5 immature males, 9 spent females, 7 immature females, 4 juveniles
Station 3:	1 immature male
Station 7:	3 mature males, 8 immature females
Amba	**May 2005, 2006 and 2007**
Station 4:	2 mature males, 4 immature females, 6 juveniles
Station 5:	8 mature males, 3 immature males, 12 spent females, 1 female with eyed larvae, 9 immature females
Bassein	**January 2006, May 2006 and October 2006**
Station 5:	3 mature males, 1 immature male, 1 juvenile

Body length: mature male 8.5 - 10.8 mm, mature female 10.4 - 12 mm

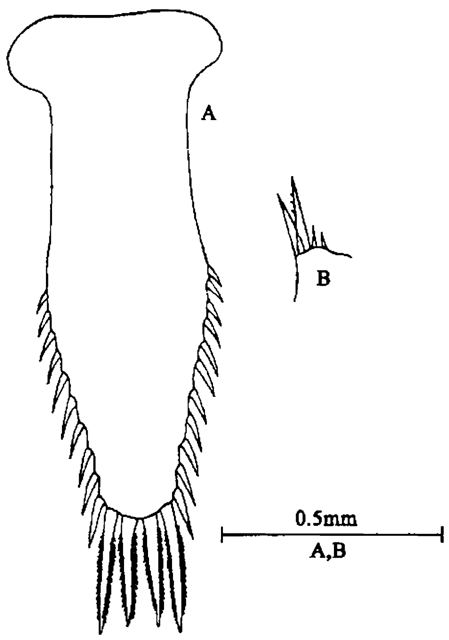


Figure 5.14. *Rhopalophthalmus mumbayensis* Panampunnayil and Biju. Male, A, telson; B, spines on antennal sympod.

Remarks: *R. mumbayensis* is related to *R. kempi* (W.M. Tattersall, 1957), *R. tattersallae* (Pillai, 1961), *R. orientalis* (W.M. Tattersall, 1957), *R. macropsis* (Pillai, 1964) and *R. longipes* (Ii, 1964) in having two long and two short spines on the antennal sympod, but differ in the following points. In *R. kempi* there are only three carpopropodal segments in the third to seventh thoracic endopods and vestigial endopod of the eighth thoracic limb is longer than the basal plate of the exopod. In *R. tattersallae* one of the long spines on the antennal sympod is barbed; thoracic endopods three to seven have only four carpopropodal segments and the inner pair of apical spines of the telson are longer than the outer pair. In *R. macropsis* and *R. longipes* the carpopropodus is four segmented and the telson is long and narrow. In *R. orientalis* there are four carpopropodal segments the telson has 15-16 lateral spines and the apical pairs of spines are equal in length. The combinations of characters afforded by the spines on the antennal sympod, the carpopropodal segments of the thoracic endopods and the armature of the telson will serve to identify this species. The present materials have some minor variations from previous descriptions. In type specimen, spines on antennal sympod do not have any secondary spines, while in the present specimens middle long spine bears secondary spines.

Distribution: The present report of this species from Bhavnagar, Bassein and Amba estuary is the second record of this species from the Indian waters. Panampunnayil and Biju (2006) reported this species from Dharamtar, Thane and Bassein.

Ecological note: *Rhopalophthalmus mumbayensis* is littoral in habitat and mostly a gregarious form. In the present collection this species was observed along with *R. anishi* and *Gastrosaccus dunckeri*. The temperature and salinity recorded ranged from 26 - 34°C and 31 - 36.4 psu respectively. Adult female carry 20 eggs in their marsupium.

Rhopalophthalmus anishi Panampunnayil and Biju

(Fig. 5.15 A-E)

Rhopalophthalmus anishi Panampunnayil and Biju, 2006, p. 1336, figs. 28-40.

Occurrence

Bhavnagar	**March 2007, November 2007**
Station 1:	8 mature males, 5 immature males, 2 females with egg, 15 juveniles.
Bassein	**January 2006 and October 2006**
Station 4:	2 mature males

Station 6: 3 mature males, 11 spent females, 2 immature males
1 immature female, 3 juveniles

Body length: mature male 10.3 - 11.4 mm, mature female 9.8 - 11.8 mm

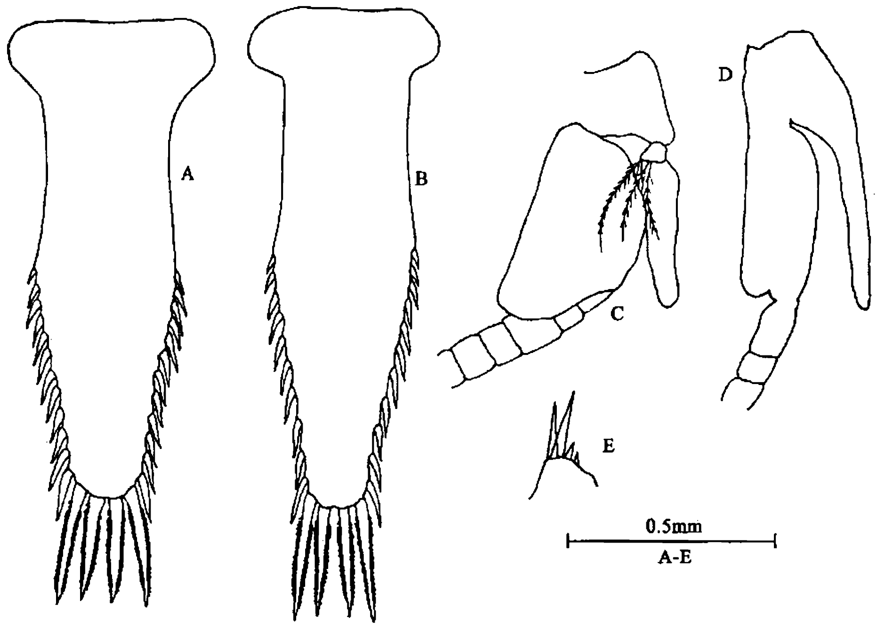


Figure 5. 15. *Rhopalophthalmus anishi* Panampunnayil and Biju. Male, A, telson; B, telson of female; C, eight thoracic limb; D, eighth thoracic limb of female E, spines on antennal sympod.

Remarks: The present occurrence of *Rhopalophthalmus anishi* is the second record. Thepresent materials fully agree with the description of Panampunnayil and Biju (2006) except for some minor variations. In type specimen endopod of eighth thoracic limb in female is longer than the basal segment, while in some specimens in the present collection, endopod of eighth thoracic limb in female is as long as the basal segment. In type specimens, largest adult male have 11 mm and female have 11.7 mm length while in the present specimen, largest adult have 11.4mm and female have 11.8mm length.

This species can be readily distinguished by the thoracic endopods with three to five capopropodal segments, vestigial endopod of eighth thoracic limb in female longer than or as long as the basal segment of the exopod and the spines on the distal border of the telson are sharply pointed and the outer pair of spines are distinctly longer than the inner pair. *R. kempi* is the only other species in which the endopod of the eighth thoracic limb in both sexes are longer than the basal segment of exopod, is distinguished from *R. anishi* in having shorter antennal scale, only 3 carpopropodal segments and in the arrangement of distal spines on the telson.

Distribution: In the present collection this species is taken from Bhavnagar and Bassien. Its previous record is from the Kasheli, which is at the interior part of Bassein creek.

Ecological note: It is a shallow water form and occurred along with *R. mumbayensis*, *Gastrosaccus dunckeri* and *Mesopodopsis orientalis*. It has been found in temperature and salinity of 27 - 27.5°C and 30 -33 psu respectively. Brood size was 9 -13.

Rhopalophthalmus vijayai Panampunnayil and Biju

(Fig. 5.16 A- D)

Rhopalophthalmus vijayi Panampunnayil and Biju, 2006, p. 1402, figs. 52-64

Occurrence

Bhavnagar	**March 2007 and November 2007**
Station 1:	12 matured males, 15 immature males, 8 spent females, 14 immature females, 15 juveniles
Station 4:	20 mature males, 28 immature males, 4 spent females, 4 females with eyed larvae, 6 females with eyeless larvae, 18 females with egg, 75 immature females, 52 juveniles

Station 5: 19 mature males, 5 immature males, 20 spent females, 1 female with egg, 23 immature females, 73 juveniles,

Station 6: 12 mature males, 11immature males, 2 females with eyeless larvae, 4 females with egg, 56 immature females, 93 juveniles,

Station 7: 9 matured males, 7 spent females, 6 juveniles

Body length: mature male 8.5 - 8.8 mm, mature female 8.9 -10.5 mm

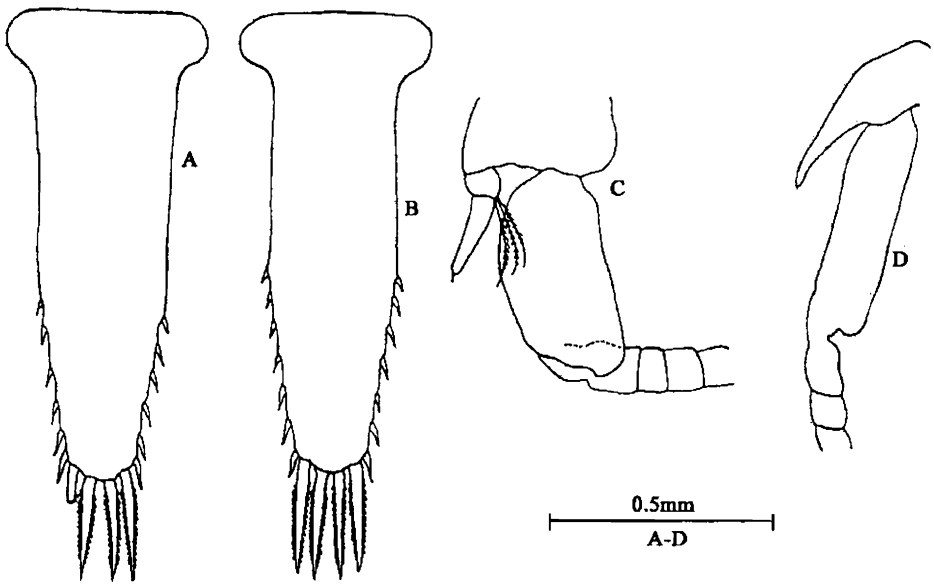


Figure 5. 16. *Rhopalophthalmus vijayai* Panampunnayil and Biju, Male. A, telson; B, telson of female; C, eight thoracic limb; D, eighth thoracic limb of female.

Remarks: This species may be easily distinguished from all the other species of the genus except *R. africana* (O.S. Tattersall, 1957) by its slender form and in having fewer number of spines on the lateral border of the telson. *R. africana* differs from it in having only two spines on the antennal sympod, four carpopopropodal segments in third to seventh thoracic endopods and in its more robust form.

This species show some variations from type specimens. In type specimen lateral margin of telson has only seven spines, while in the present specimens, there are six to nine spines are present. In the present specimen great variations are observed in the relative length of apical spines of telson. In some specimen, the apical spines are sub equal while in others the inner pair are longer than outer pair or vice versa. In type form apical spines are sub equal. Type specimen measured 6.6 - 8.6 mm only while the present specimens are larger and measured 8.5 - 10.5 mm in length.

Distribution: This species has been collected from Bhavnagar only and the present record is the second record of this species. Its distribution is confirmed to Arabian Sea and the previous record has been from Dhahej (Panampunnayil and Biju, 2006).

Ecological note: At Bhavnagar this species alone contributes 80.36% of the total population. In most of the stations, this species observed along with *Gastrsaccus dunckeri, Erythrops minuta and Mesopodopsis orientalis* and occurred in temperature and salinity ranging from 28.4 to 30.0°C and 24.2 to 34 psu respectively. Female carry 7 - 18 eggs in their marsupium.

Subfamily GASTROSACCINAE Norman

Genus *Gastrosaccus* Norman

Gastrosaccus dunckeri Zimmer

Gastrosaccus dunckeri Zimmer, 1915, p. 165, figs. 13-18; W.M. Tattersall, 1922, p. 459; Pillai, 1957, p. 7, fig. 111, 1-7; O.S. Tattersall, 1960, p. 170, figs, 2 A - N; Pillai, 1961, p. 25, pl 111, figs. K - N; 1964 p. 17, fig. 9; 1973 p. 61-64, figs. 28-29; Ii, 1964, p. 235 and 580, fig. 59; Panampunnayil, 1999a, p. 105, fig. 5.22.

Occurrence

Mundra	**April 2007**
Station 9:	1 immature female
Vadinar	**November 2005**
Station 7:	38 mature males, 22 immature males, 29 spent females, 2 females with eyeless larvae,7 females with egg, 37 immature females, 159 juveniles
Mithapur	**December 2003, April 2004 and May 2004**
Station 2:	8 mature males, 5 immature males, 2 spent females, 1 female with eyed larvae, 5 immature females, 7 juveniles
Bhavnagar	**March and November 2007**
Station 5	1 matured male, 2 immature males, 2 Juveniles,
Station 6:	2 matured males, 2 spent females
Station 7:	2 mature males, 1 juvenile
Hazira	**May 2006**
Station 3:	1 spent female
Bassein	**January 2006, May 2006, October 2006**
Station 2:	8 immature males, 1 mature female, 1 spent female, 9 immature females, 9 juveniles
Station 3:	3 mature males, 6 immature males, 3 spent females, 4 immature females, 11 juveniles
Station 6:	1 damaged spent female

Body length: matured male 7.3 - 8.2 mm, mature female 6.2 - 8.8 mm

Remarks: The shape and armature of the telson and the spinulation of the inner uropod easily distinguishes this species from all the other species of the genus. The present specimens well agree with the description of Panampunnayil (1999a).

Distribution: This species are cosmopolitan in distribution and have been recorded from Indian and Pacific Oceans. In Indian waters, this species has been recorded from different localities, Orissa (W.M. Tattersall, 1922), Coastal waters of Kerala (Pillai, 1957, 1961), Arabian Sea (Pillai, 1973) and shallow coastal waters of Gujarat and Mumbai (Panampunnayil, 1999a).

Ecological note: It is a coastal form and were moderately represented at Vadinar, Mithapur and Bassein and sparsely distributed at Hazira, Bhavnagar and Mundra. This species occurred along with *Siriella jonesi, Rhopalophthalmus mumbayensis, R. anishi, R. vijai* and *Indomysis annandelai.* They occurred in the temperature range of 24 - 30.4°C and salinity of 27.3 - 40 psu. Brood size was 6 - 9.

Genus *Eurobowmaniella* Murano

***Eurobowmaniella muticus* Tattersall**

(Fig. 5.17 A-F)

Gastrosaccus muticus W.M. Tattersall, 1915, p. 512, fig. 1; 1922, p. 459; Pillai, 1957, p. 4, figs. 1-5; 1961, p. 24, pl. 3, figs. C-H; Shyamasundari, 1973, p. 392, figs. 12-16. Panampunnayil, 1999a, p.110, fig. 5.23.
Eurobowmaniella muticus Murano, 1996, p. 28.

Occurrence

Bassein	**January 2006**
Station 5:	2 mature males

Body length: mature male 7.7 mm

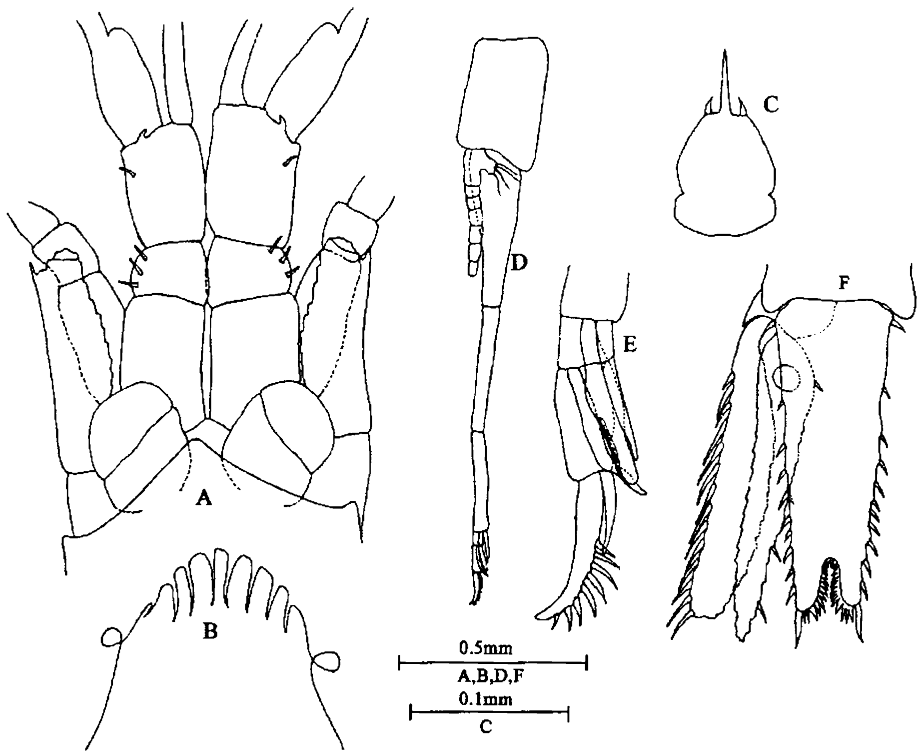


Figure 5. 17. *Eurobowmaniella muticus* Tattersall, Male. A, anterior part of the body; B, posterior part of the carapace; C, labrum; D third pleopod; E, same, tip of exopod enlarged; F, posterior part of the body

Remarks: This species had been earlier referred to the genus *Gastrosaccus* (W.M. Tattersall, 1915; Pillai, 1957, 1961; Panampunnayil, 1999a) and in 1996, Murano transferred this species to the genus *Eurobowmaniella*, based on the character of labrum and the distal modification of the third pleopod of male. The present materials well agreed with the previous descriptions, except for some minor variations. In all the present specimens, the anterior end is bluntly rounded as described by Panampunnayil. In Pillai's specimens, the anterior margin of the carapace is produced into a small acute spine. There is a pseudorostral process which lie anterior to the true rostrum and it is possible that Pillai mistook this for the true rostrum.

In third pleopod, exopod is five segmented and on detailed examination it has been found that the last three segments carry modified spines as that of

Panampunnayil's specimens. The antipenultimate segment has one stout spine and one flattened process with grooves, on the distal border. The penultimate segment carry one stout distal spine and the ultimate segment terminate in two stout spines, the inner one short and the outer one longer stouter and strongly barbed. Pillai's mature male and female are 10 and 13 mm in length while the Panampunnayils specimens are only 7.6 and 8.4 mm and the present specimens measured only 7.7 mm.

This species can be readily distinguished from the other species of the genus by the character of the labrum and distal modification of the exopod of the third pleopod of the male.

Distribution: This is a shallow water coastal form and endemic in the Indian Ocean. It has been recorded from Chilka Lake, Orissa, Gangetic delta (W.M. Tattersall, 1915, 1922), Kerala coast (Kurian, 1954; Pillai, 1957, 1961) and Waltair coast (Shyamasundari, 1973).

Ecological note: During the study, this species was represented at Bassein only and in company with *Rhopalophthalmus mumbayensis* and *Mesopodopsis orientalis*. They occurred in the temperature and salinity of 32.5°C and 30.3 psu respectively.

Genus *Erythrops* G.O. Sars

Nematopus G.O. Sars, 1863, p. 233, pt.3.

Erythrops G.O. Sars, 1869, pt. 325, 1870, pp. 11-24; Zimmer, 1904 pp. 445- 446; 1909, p.76; Illig, 1930, p. 570 (key); W.M. Tattersall and O.S. Tattersall, 1951, p.187; Ii, 1964, p. 357.

Diagnosis: Body slender and delicate, Antennule robust in male, outer distal corner of basal segment of peduncle forming a hirsute lobe, Antennal scale with outer margin entire or serrate, terminating in a trong spine. Eye short, flattened, cornea reniform. Thoracic endopods three to eight long and slender, carpus separated from propodus by oblique partition, propodus two segmented. Pleopods two to five of male, biramous, endopod of first one segmented. Inner margin of endopod of uropod smooth or spiny. Telson very short, trapeziform, lateral margins naked or finely serrate, apex truncate. Armed with two pairs of stout spines and a pair of plumose setae.

Remarks: In the Indian waters only two species were identified, *E. nana* (W.M.Tattersall, 1922) and *E. minuta* (Hansen, 1910). In the present collection later is represented.

Erythrops minuta Hansen

(Fig. 5.18 A-E)

Erythrops minuta Hansen, 1910, p. 63; W.M. Tattersall, 1922, p.445; Illig, 1930, p. 576; O.S. Tattersall, 1960, p.178; Ii, 1964, p. 352, fig. 582.

Erythrops sp. Pillai, 1964, p. 22, fig. 13.

Occurrence

Bhavnagar	**March 2007 and November 2007**
Station 5:	2 mature male, 1 female with egg, 1 immature female
Dahanu	**February 2007**
Station 3:	2 mature male
Bassein	**January 2006, May 2006**
Station 6:	1 mature male, 2 spent female

Body length: mature male 3.8 mm; mature female 3.4 mm

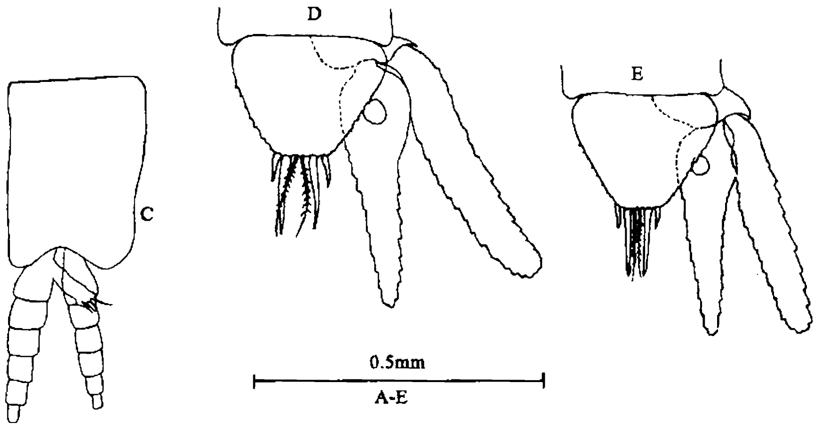


Figure 5. 18. *Erythrops minuta* Hansen, Male. A, anterior part of the body; B, anterior part of the body of female; C, fourth pleopod; D, posterior part of the body; E, posterior part of the body of female.

Remarks: This species was first established in 1910 by Hansen. The spinulation on the lateral border of the telson and three equally spaced teeth on the outer border of antennal scale identify this species easily from other species of this genus. The present materials agree with the published descriptions but for some minor variations.

In the present specimens, antennal scale has a distinct lobe overreaching the outer apical spine where as in Pillai's specimens, this lobe is absent and its outer distal spine is very prominent and projects well beyond the almost obsolete distal lobe. Another conspicuous character in the Pilla's specimen is the spinulation of the surface of the body and appendages. While in the present specimen, there is no spinulation. Ii (1964) and Hansen (1910) does not mention about this spinulation. In Ii's and Pillai's specimens, front margin of the carapace exposes the eyestalk, while in the present specimens anterior part of the carapace fully covers the eyestalks. In the present specimen cornea is not clearly developed and eye is depressed. In Pilla's female specimens, spinulation is present on the inner border of the endopod of the uropod, while in the present specimens these spinulations are not observed. Ii (1964) found only two spines on the outer margin of the antennal scale but as in Hansen's and Pilla's material there are three spines in the present specimens. In Ii's specimen, spines on the telson occurred only at the distal third of the lateral border, while in the present specimens whole border except a very short area near the base is spiny like that of Pilla's specimens. According to Ii, fourth pleopod of male has some modifications but in the present specimens it is unmodified. Hansen's specimens measured 2.6 - 2.9 mm, Tattersall's 3 mm, and Ii's 3.6 mm. The present material is 3.8 mm and the largest hitherto recorded.

Distribution: *Erythrops minuta* has been previously recorded from the Gulf of Siam (Hansen, 1910), Gulf of Mannar (W.M. Tattersall, 1922), Singapore Strait (O.S. Tattersall, 1960), Formosa (Ii, 1964), Arabian Sea (Pillai, 1964, 1973), Malacca strait (O.S. Tattersall, 1965), Andaman Sea (Shyamasundari, 1973). Bahrain waters (Grabe *et al.*, 2004) *E. minuta* obviously has a restricted distribution in the Pacific and Indian Ocean. The present collection is from the Arabian Sea and does not extend its known distribution.

Ecological note: *Erythrops minuta* is a coastal form, probably living amidst the littoral algae. In the present collection this species occurred along with *Rhopalophthalmus anishi, R. vijayi, Gastrosaccus dunckeri* and *Mesopodopsis orientalis* and the temperature and salinity of 32.5 - 33°C and 30 - 34.8 psu respectively. Brood size was 7.

Tribe Mysini Hansen

Genus *Acanthomysis* Czerniavsky

Acanthomysis anomala Pillai

(Fig. 5.19 A.B)

Acanthomysis anomala, Pillai, 1961, p.26, pl.4, figs. A-L

Occurrence

Kandla	**December 2006**
Station 7	1 immature female

Body length: immature female 3.9 mm

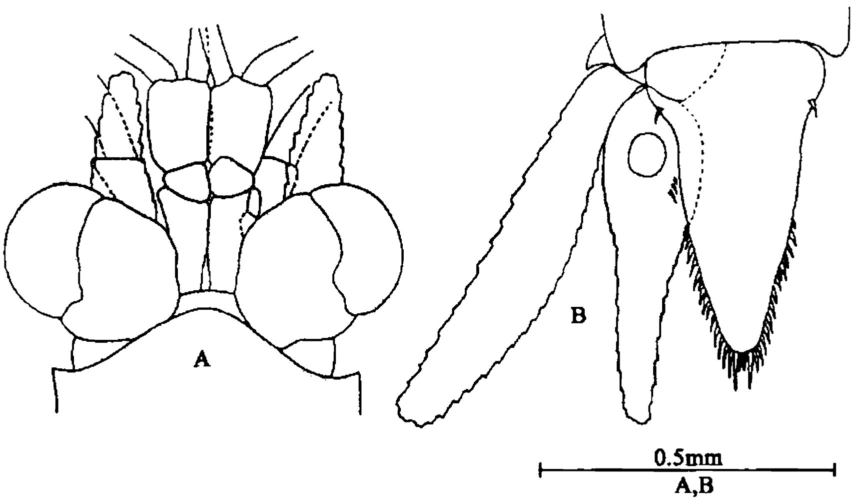


Figure 5. 19. *Acanthomysis anomala* Pillai. Immature female. A, anterior part of the body; B, posterior part of the body.

Remarks: This species is easily distinguished from other members of the genus *Acanthomysis* by the spinulation of telson. The present specimen is immature and tentatively referred to *Acanthomysis anomala* in having 15-16 lateral distal spines and one spine on the proximal portion of the telson. In genus *Acanthomysis*, this type of spinulation occurs only in *Acanthomysis anomala*. The present specimen is closely related to *A. pelagica* (Pillai, 1957). The difference between these two species are, in *A. pelagica* there are 16-21 lateral spines on the distal part and four spines on proximal part of the telson, while in *A. anomala*, there are only 15-16 spines on distal part and 1 to 2 spines on the proximal part of the telson. In type specimen only 15 spines are present in the distal lateral border of the telson while the present specimen has 16 spines.

Distribution: This species was previously recorded only from South west coast of India (Pillai, 1961) and the present occurrence extends its distribution to north.

Ecological note: In the present collection, *A. anomala* occurred only at Kandala along with *M. orientalis*. They occurred in the temperature and salinity of 23°C and 37 psu respectively.

Genus *Mesopodopsis* Tattersall

Mesopodopsis orientalis Tattersall

Macropsis orientalis W.M. Tattersall, 1908, p. 236

Mesopodopsis orientalis W.M. Tattersall, 1922, p. 482; Nair, 1939, p. 175; Nouvel, 1957a, p. 323; O.S. Tattersall, 1960, p. 180; 1965; Pillai, 1968, p. 6; Murano, 1986a, p. 2; Panampunnayil, 1999a, p. 132.

Occurrence: Swarms/ aggregations of this species were encountered at Mundra, Kandla, Mithapur, Bhavnagar, Hazira, Bassein, Dahanu and Amba.

Body length: mature male 5.4 - 8.5 mm, mature female 5.7-9.2 mm.

Remarks: The present specimens well agrees with the descriptions of Panampunnayil (1999a).

Distribution: *Mesopodopsis orientalis* is widely distributed through out the northwest and south west coast of India and endemic in Indian Ocean.

Ecological note: In the present study *M. orientalis* was the dominant species and occurred at 8 stations. It is a gregarious form and observed along with *Rhopalophthalmus mumbayensis, R. vijayi, Eeurobowmanialla muticus, Erythrops minuta, Acanthomysis anomala* and *Indomysis annandelai.* They tolerate wide range of salinity and temperature. It usually lives in swarms/shoals/aggregations. In the present study a sample of swarm taken at Dahanu. (Station 4), consisted of 32.42% mature males, 16% immature males 14.13% immature females, 16.7% brooding females, 11.32% spent females and 9.43% juveniles. Brood size was 9 (8.3mm) - 30 (9.7mm).

Genus *Indomysis* Tattersall

Indomysis W.M. Tattersall, 1914, p. 77; Pillai, 1965, p. 1720.

Diagnosis: Body slender, Eyes well developed. Rostral plate absent, anterolateral parts of carapace acutely produced. Antennular peduncle in male without hirsute lobe. Antennal scale narrowly oval in shape, setose all round, with distinct distal joint. Pleopods in female simple, unjointed. Pleopods 1-3 in male as in female, fourth biramous, exopod long and unsegmented terminating in single long barbed seta. Fifth pair elongated single segmented with long plumose setae. Telson short, entire, quadrangular in shape, lateral margin armed with four short spines, apex truncate, armed with row of small teeth, distal lateral corner with pair of long spines.

Remarks: This genus was created by W.M. Tattersall (1914) for specimens collected from a brackish water creek at Panvel near Mumbai. In the form of the telson this genus resembles *Potamomysis* Czerniavskly (W.M. Tattersall,

1908) but can be easily distinguished by the shape of the antennal scale and the different form of the pleopods.

Indomysis annandalei Tattersall

(Fig. 5.20 A-F)

Indomysis annandalei Tattersall, 1914, p. 78, pl. 12, figs. 1-15, pl.13, figs. 6-13; Murano, 1998b, p. 50, fig. 5. Panampunnayil, 1999a, P.139.

Occurrence

Mithapur **December 2003, April 2004 and May 2004**

Moderately distributed in most of the stations

Body length: mature male 5.4 - 8.5 mm, mature female 5.7 - 9.2 mm

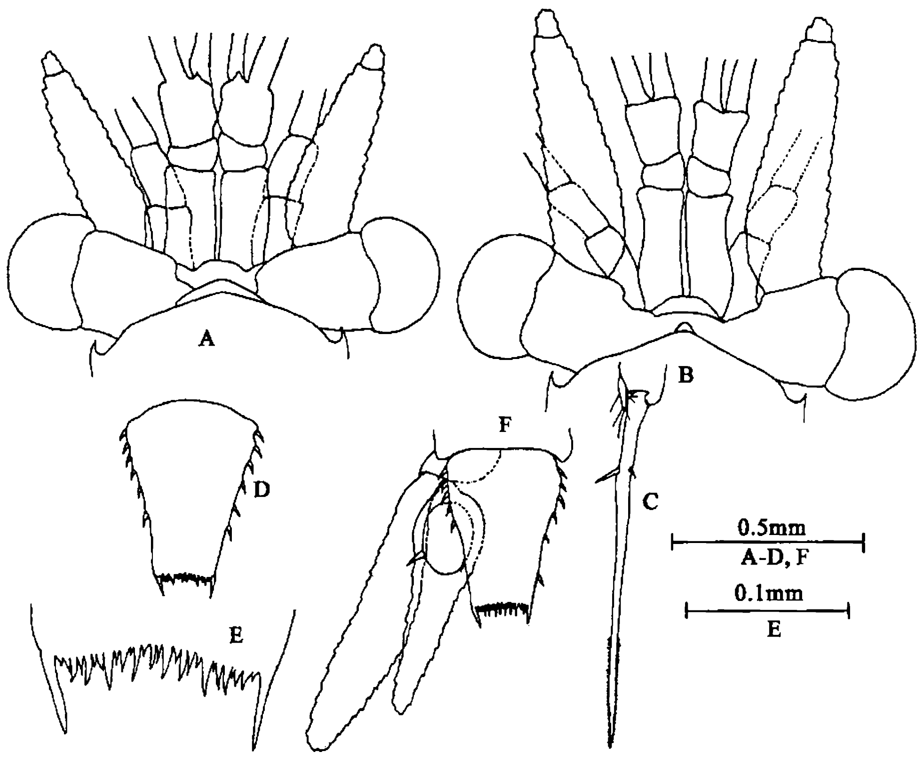


Figure 5. 20. *Indomysis annandalei* Tattersall, Male. A, anterior part of the body; B, anterior part of the body of female; C, fourth pleopod; D, telson; E, telson, tip enlarged. F, posterior part of the body of female.

Remarks: W.M. Tattersall (1914) created this species and was redescribed by Panampunnayil (1999a). The present specimens well agree with the description of Panampunnayil except in the shape of the carapace. According Panampunnayil the carapace is broadly rounded while in the present specimens, it is somewhat conical. In the type material the frontal plate is low and the eyestalks are completely exposed. In the present specimens frontal plate is more developed, slightly overlapping the eyestalks. Antennal scale has distinct distal septum. In the type form there is no distal septum.

In the present specimens, the usual number of spines on the lateral border of the telson is 5-6 but it may go up to 8. Tattersall has stated that the lateral borders of the telson carry 4-7 spines. It has been found that the number of spines on the two sides of the same telson may vary and seldom have the same number on both sides of the single telson. In the present specimens there is a single spine on the dorsal inner margin of the endopod in the region of the statocyst while in type specimen there is no spine on the endopod. This species can readily be distinguished by the form of the thoracic endopods six to eight, by the form and armature of the telson and the form of the fourth pleopods of the male.

Distribution: This species have been recorded from the salt pans around Bombay - Panvel (W.M. Tattersall, 1915), Mulund (Deshmukh, 1989), Thane and Bhayander (Mustafa, 1995). Kazmi and Timizi (1995) recorded this species from the saltpans of Karachi, Murano (1998b) from Tarut Bay, Saudi Arabia, Panampunnayil (1999a) reported this species from salt pans of Thane and Bhayander and Grabe *et al.* (2004) collected this species from Bahrain waters.

Ecological note: This species is a shallow water form inhabiting the saltpans and the adjacent creeks where the salinity and temperature undergo marked fluctuations. This species is tolerant to a wide range of salinity and temperature and can actively breed in salinity as low as 10.5 psu and as high as 80.3 psu. The temperature in which it occurred ranged from 26.5 to 36°C. The number of broods carried by the females vary from 9-13.

5.4. DISCUSSION

The present study extends our knowledge on the Mysidacea into the northwest coast of India. Mysids were encountered at all localities except at Veravel. A total of eight genera and twelve species are represented in the collection. *Mesopodopsis orientalis* was the most common and dominant mysid and occurred at 8 localities with relatively high concentration at Mundra, Bassein and Dahanu. *Indomysis annandalei* was the second abundant species. All the other species were either moderately or sparsely represented.

Genus *Siriella* is represented by three species, *S. dubia, S. jonesi* and S. *hanseni*. In the Indian Ocean *S. dubia* has so far been recorded from the Andaman and Arabian Sea only. Pillai (1973) had stated that this is a rare species and has a restricted distribution and is confined to the area north of 10°N in the Indian Ocean and western part of the Pacific Ocean. It does not occur in the Atlantic Ocean. In the present collection it occurred at Vadinar.

Siriella jonesi occurred in moderate numbers at Vadinar, Hazira and Bassien and judging from the available information it is a coastal form and is confined to the Arabian Sea.

Earlier studies reveals that *Siriella hanseni* is distributed in the Indian and Pacific Oceans. In the present collection this species occurred only at Mithapur.

The genus *Rhopalophthalmus* is represented by nine species in the Indian waters, three of them, viz. *R. mumbayensis, R. anishi,* and *R. vijayi* was represented in the study area. In general, species of *Rhopalophthalmus* are neritic in habitat and when present occur in swarms (Pillai, 1973). *R. vijayi* occurred in small aggregations and is definitely a gregarious form; the other two species were only sparsely represented. *R. mumbayensis and R. anishi* were found at Bhavnagar and Bassein, while *R. vijayi* was confined to a particular locality at Bhavnagar. All the three species are endemic in the Indian waters.

The genus *Gastrosaccus* is represented by three species in the Indian waters and the present material contains only one species, *G. dunckeri*. This species is common along the coastal waters of India. In the present collection this species were encountered in moderate numbers at Mundra, Vadinar, Mithapur, Bhavnagar, Hazira and Bassein. *G. dunckeri* has been recorded from several localities in the Indian and Pacific Oceans.

Genus *Eeurobowmanialla* is represented by two species; *E. simulans* and *E. muticus* in the Indian waters and the present material contain *E. muticus* only. This species occurred at Bassein and earlier records reveals that this species is confined to Indian waters.

In the present collection genus *Erythrops* is represented by *Erythrops minuta* and occurred sparsely at Bhavnagar, Bassein and Dahanu. This species was found to along with *Rhopalophthalmus vijayi, Gastrosaccus dunckeri* and *Mesopodopsis orientalis.* Present record is the first report of *E. minuta* from the study area. This species is distributed in Indian and Pacific Oceans.

The genus *Acanthomysis* includes 14 species and are distributed in the Indian, Pacific and Atlantic Oceans. Murano (1984) reported this as the most abundant mysid in the neritic waters of Japan and had been abundantly found in the stomach of soles and penaeid shrimps. So far only five species are known from India. In the present collections the genus is represented by only one species, *A. anomala.* The present record is the first report of this species from the present study areas and is an endemic form in the Arabian Sea.

Mesopodopsis orientalis is the most abundantly caught species and occurred in aggregations at Dahanu (February), shows the breeding intensity during the premonsoon periods. But aggregations of this species is mostly monospecific and consisted of individuals of different age groups and do not mingle with other species. Bhattacharya and Kewalremani (1972) reported the occurrence of large numbers of juveniles of *M. orientalis* in the coastal waters of Bombay during May-June and November-January, suggested that the adults from estuary and back waters migrate to the coastal waters and breed there, as the juveniles may not be able to survive in estuaries and backwaters where the salinity will be very low in the rainy seasons.

These mysids locally called '*Kolim*' are exploited commercially on a small scale by the fishermen of Satpati and Alewadi villages of Thane district (Patel and Sankolli, 1991). The fishery is seasonal from March to May in Satpati while it is October to December in Alewadi. The fishing method adopted is simple and fetches fairly good returns of about Rs.10/ kg. The fish *Thrissocles mystax* called '*Kanti*' in Marathi is supposed to feed on "*Kolim*" and is considered as a possible indicator species of "*Kolim*". Patel and Sankolli conclued that since this resource forms a cheap dietary protein for the poor tribal adivasi population of these areas, it must be preserved judiciously and more studies are needed in this direction.

In the present study *Indomysis annandalei*, characteristic of salt pans (Panampunnayil, 1999a) was encountered at Mithapur and was present in moderate numbers. This high saline species is endemic in the Indian Ocean. Kasmi and Tirmizi (1995) reported it from salinities of 37- 45 in Karachi waters. The ecology and fishery potential of the salt pan reservoirs around Mumbai were extensively studied by Shirgur and Deshmukh (1994) and they stated that the reservoirs of the salt pans, which support dense growth of micro and macro zooplankton, especially mysids, can contribute extensively for aquaculture.

Indomysis annandalei occurring in large numbers can sustain the economically important fishes such as *Oredromis mossambicus* (Tilapia) *Macrones seenghala, Boleophthalmus dussumeri, Lates calcarifer* and others (Shirgur and Deshmukh, 1994).

Maximum number of species (7) was recorded from Bassein while lowest (1) was observed at Vadinar. *Siriella dubia, S. jonesi, Rhopalophthalmus mumbayensis, R. anishi, R. vijayi, Gastrosaccus dunckeri, Eurobowmaniaella muticus, Mesopodopsis orientalis* and *Indomysis annandalei* were previously known from around the study area, all the other species are first records from the respective areas of their collection.

Based on the distribution range of the species, mysids can be segregated into the following groups.

Indian EEZ	Indian Ocean	Indian and Pacific Ocean
Siriella jonesi	*M. orientalis*	*Siriella dubia*
Rhopalophthalmus mumbayensis	*Indomysis annandalei*	*Siriella hanseni*
R. anishi		*Gastrosaccus dunckeri*
R. vijayi		*Erythrops minuta*
Eurobowmaniaella muticus		
Acanthomysis anomala		

The shallow water mysids are of immense economic value because of their ability to multiply rapidly. They form an important component of zooplankton, feeding mainly on detritus and diatoms. The mysids in turn are eaten by fishes like *Megalops cyprinoides, Polynemus tetradactylus, Etroplus suratensis* and the prawn *Parapenaeopsis stylifera* (Rao, 1970; Varghese 1981; Jhingran, 1975). Hence by adopting suitable methodology, *Mesopodopsis orientalis* and other brackish water mysids can be made to form a nourishing natural source of food in fish culture ponds.

List of mysid species so far recorded from the northwest coast of India.

Species	Gajbhiye *et al.* (1980)	Panampunnayil (1999a)	Present study
Siriella dubia	-	+	+
Siriella jonesi	-	+	+
Siriella hanseni	-	-	+
Siriella sp.	+	-	-
Rhopalophthalmus macropsis	+	-	-
Rhopalophthalmus mumbayensis	-	+	+
Rhopalophthalmus murudi	-	+	-
Rhopalophthalmus vijayi	-	+	+
Rhopalophthalmus anishi	-	+	+
Gastrosaccus dunckeri	-	+	+
Gastrosaccus muticus	-	+	+
Erythrops minuta	-	-	+
Acanthomysis pelagica	-	+	-
Acanthomysis platycauda	+	+	-
Acanthomysis macrops	-	+	-
Acanthomysis microps	-	+	-
Acanthomysis anomala	-	-	+
Afromysis dentisinus	-	+	-
Mesopodopsis orientalis	-	+	+
Mesopodopsis zeylanica	+	-	-
Indomysis annandalei	-	+	+

Mesopodopsis orientalis and *Indomysis annandalei* which occur in large numbers and tolerate wide range of environmental parameters, are capable of completing life cycle in a few days may be suitable for bioassay tests to determine the potential impacts of various pollutants on all life stages.

Chapter 6

Mysidacea of the Cochin Backwaters

6.1. INTRODUCTION

The Cochin Backwater system, a large basin of brackish water (area about 250 km^2, is one of the largest estuaries in India. It forms a complex system of shallow estuarine network running parallel to the coastline of Kerala. The backwater system is a bar-built estuary with two permanent openings to the Arabian Sea, one at Cochin (renamed as Kochi) and other at Azhikode, north of Cochin. Six rivers (Achankovil, Pumba, Manimala, Meenachil, Muvattupuzha and Periyar) with their tributaries along with several canals bring large volume of fresh water in to the backwater system. Variation in the river discharge inducing a strong salinity gradient and is responsible for the diverse biotopes of peculiar plankton communities in the Cochin backwaters (Nair and Tranter, 1972; Madhu *et al.*, 2007).

Tidal incursion from the Arabian Sea contributes a regular flow of salt water, which diminishes considerably towards the head of the Cochin estuary (Madhupratap, 1987). In this micro-tidal estuary, seasonal effects of fresh water are readily visible in the prevailing salinities, which play an important role in the ecobiology of the system (Madhupratap, 1987).

The region receives about 320 cm rainfall annually, of which nearly 75% occurs during summer monsoon period (Qasim, 2003). The onset of summer monsoon and its duration may vary from year to year. Normally, it occurs from June to September. During the peak of summer monsoon period (July/ August), heavy rain occurs in the region (40-50 cm rain fall can occur in few hours) (Qasim, 2003). During postmonsoon period (October-January), the river discharge gradually diminishes and tidal influence gains momentum as the estuarine conditions change to a partially mixed type, weakening stratification (Menon *et al.*, 2000). During pre monsoon period (February - May), fresh water input to Cochin backwater is minimum due to low rainfall over the resulting a gradient of salinity from the mouth to the head of the estuary (Madhupratap, 1987; Menon *et al.*, 2000; Jyothibabu *et al.*, 2006). Being a tropical system it experience limited fluctuations in temperature (Nair and Tranter, 1972). Water temperature varies from about 28°C in summer monsoon period and 30°C in premonsoon (Madhupratap, 1987; Jyothibabu *et al.*, 2006).

Cochin backwater, a tropical micro-tidal estuary with high biological production, provide an ideal breeding ground for many economically important fin fishes and shell fishes (Qasim, 2003; Madhu *et.al.,* 2007). Variation in salinity gradient in the Cochin backwaters leads to a complex ecosystem and supports diverse species of flora and fauna depending on their capacity to tolerate oligohaline, mesohaline or marine conditions.

Importance of mysids in the estuary

Mysid crustacean occupy a wide variety of aquatic environment and are ubiquitous member of the estuarine ecosystem. The importance of mysids in the tropical estuaries and backwaters is generally thought to be significant since these habitats play an important role in completing the life cycle of many commercially important fishes and prawns (George, 1958, 1962; Muhamed, 1970; Rao, 1970, Jhingran, 1975; Bhattacharya, 1982). They are also important as major producers and consumers in estuarine food webs (Mauchline, 1980). Their ecological importance particularly their role in food chains as a link between the benthic and pelagic system, is becoming increasingly apparent. Mysids are opportunistic omnivores capable of utilizing phytoplankton, zooplankton, bottom detritus and organic materials in suspension (Mauchline, 1971; Grossnickle, 1982; Lasenby *et al.*, 1986;

Rudstam and Hansson, 1990). They form important link in estuarine food chains between microbial producers (eg: bacteria) and secondary consumers (fishes) (Webb, 1973), and therefore play a critical role in the cycling of energy within the system through the detrital path way. Mysids are selective feeders, has potential for structuring zooplankton communities (Fulton, 1982), and for influencing the structure of phytoplankton and meiofaunal communites (Mees and Jones, 1997). Due to their high densities in estuaries, mysids serve as a potential food source for coastal fishes. These crustaceans have been recorded in the diet of many marine and estuarine fish (Darnell, 1958, 1961; Stickney *et al.*, 1974; Mauchline, 1980) as well as birds (Moffat, 1996). Mysids are known as important link in the energy transfer to higher trophic levels of estuaries (Mees *et al.*, 1994). Their trophic role as a converter of energy into forms which can be used by higher organisms, especially fishes, coupled with the ubiquity and abundance of mysids in estuaries indicate their significance in the productivity of such ecosystem, which has been greatly underestimated.

Despite this universally recognized role in the ecology of estuaries, mysids have been little studied in Indian estuaries. This is the first report on the taxonomy, seasonal abundance, distribution, ecology, reproductive biology, diel and tidal variations of mysids from the Cochin backwaters.

6.2. STUDY AREA

The Cochin backwater is part of a long chain of lakes and canals, parallel to the coast, extending between 9° 40' 12" and 10° 10' 46" N and 76° 09' 52" and 76° 23' 57" E. The total area of the backwater is about 157 sq. km. with depth ranging from 2 to 14 m.

Two types of sampling were done, (1) weekly collection for one year at three stations for studying the seasonal distribution and reproductive biology of mysids (2) seasonal (Premonsoon- March and postmonsoon- October) time series collections at five stations for studying the diel and tidal variations of mysids in the Cochin backwaters.

Fort Cochin (WS 1, Lat 09° 58.24' and Long 076° 14.35'). This station is located near the bar mouth and experiences maximum tidal effect. The water remains low saline for one or two months during the monsoon season and marine condition prevails during the remaining part of the year. Depth ranges from 11 to 14 m.

Bolghatty (WS 2, Lat 09° 59.00' and Long 076° 16.15'). This station is situated towards the northern limb of the Cochin estuary, free from the influence of much variations and maintain more or less estuarine conditions through out the year. Depth varies from 2.3 to 4 m

Thevara (WS 3, Lat 09° 57.18' and Long 076° 17.02'). It is situated on the southern branch of the Cochin estuary having a depth range of 2.5 to 4 m. Next to bar mouth, this station experiences the maximum tidal influence due to the navigation channel. This area also receives fresh water from Chitrapuzha.

The five time series stations (TS1, TS2, TS3, TS4 and TS5) were selected along the northern limb of the Cochin estuary. Each station was 1km apart from each other.

6.2.1. Season design

Seasons are classified in to three, ie., Premonsoon (February to May), Summer monsoon (monsoon) (June to September) and Postmonsoon (October to January).

6.3. RESULTS

6.3.1. Physico- chemical parameters

Temperature

At all stations seasonal fluctuations in surface temperature showed comparable pattern (Fig. 6.1). Maximum and minimum temperatures were recorded in April and June respectively at Bolghatty station. The annual average temperature experienced was 29.3 ± 0.48°C.

At Fort Cochin, temperature fluctuated from 27.3°C to 32.8°C in August and April respectively. In premonsoon period temperature ranged from 29.9 to 32.8 °C with an average of 31.2 ± 0.95. In monsoon and postmonsoon period, temperature fluctuated from 31.7 - 27.2°C (av. 21.9 ± 1.16) and 30.9 - 28.8°C (av. 30 ± 0.58) respectively.

Maximum temperature at Bolghatty was recorded during March (33.5°C) and lowest of 27.2°C during June. The seasonal values of temperature fluctuated from 30.6 - 33.5°C during premonsoon, 27.2 - 33.5°C in monsoon and 28.9 - 30.9 °C for postmonsoon period.

At Thevara, maximum temperature of 32.5 °C was noticed during April and minimum of 27.7°C during August. The seasonal values in temperature ranged from 30.7 to 32.5°C (av. 31.4 ± 0.54) during premonsoon, 27.7 to 31.2°C (av. 29.59 ± 1.2) for monsoon and 29.4 to 31.7°C (av. 30.26 ± 0.68) during postmonsoon.

Salinity

Salinity shows well defined seasonal variation, highest values were observed in premonsoon period and lowest during monsoon period (Fig. 6.2).

At Fort Cochin salinity fluctuated from 0.79 - 34.5 psu, lowest value was recorded during July and highest in May. The salinity range at Fort

Cochin during premonsoon, monsoon and postmonsoon were 18.3 to 34.5 (av. 26.2 ± 6.7), 0.7 to 29.8 (av.11.3 ± 11.5) and 3.8 to 34.2 (av. 23.8 ± 11.7).

At Bolghatty, maximum value observed during January (29.23) and minimum value (0) during June and August. Salinity variation was 8.5 to 29.16 psu (av. 23.18 ± 6.26) in premonsoon, 0 to 25.5 psu (av. 5.01 ± 7.17) in monsoon 1.02 to 29.2 psu (av. 17.3 ± 10.5) in postmonsoon period.

At Thevara, the annual variation in salinity was from 0 to 34.7 psu, the lowest value recorded during July and August and highest during March. The salinity variation during premonsoon, monsoon and postmonsoon were 16.8 to 34.7 psu (av. 26.38 ± 5.08), 0 to 29.3 psu (av. 5.63 ± 8.99) and 0.56 to 31.92 psu (av. 19.23 ±11.86) respectively.

*p*H

Seasonal variation in *p*H were limited (Fig 6.3). The annual average of pH was 7.5 ± 0.19. The average for three stations showed marginal difference between seasons, values being 7.6, 7.2 and 7.9 during premonsoon, monsoon and postmonsoon respectively.

At Fort Cochin, 8.3 was the highest *p*H recorded during January and lowest (6.8) during July. Seasonal average recorded for premonsoon, monsoon and postmonsoon were 7.5 ± 0.4, 7.4 ± 0.4 and 8 ± 0.3 respectively.

At Bolghatty station highest *p*H value recorded during October (8.72) and lowest value observed during September. Seasonal average *p*H in premonsoon, monsoon and postmonsoon were 7.6 ± 0.3, 7.11 ± 0.5 and 7.8 ± 0.5 respectively.

Highest *p*H value at Thevara was recorded during November (8.72) and lowest value (6.3) observed during September. Seasonal average *p*H in premonsoon, monsoon and postmonsoon were 7.6 ± 0.4, 7.2 ± 0.4 and 7.9 ± 0.4 respectively.

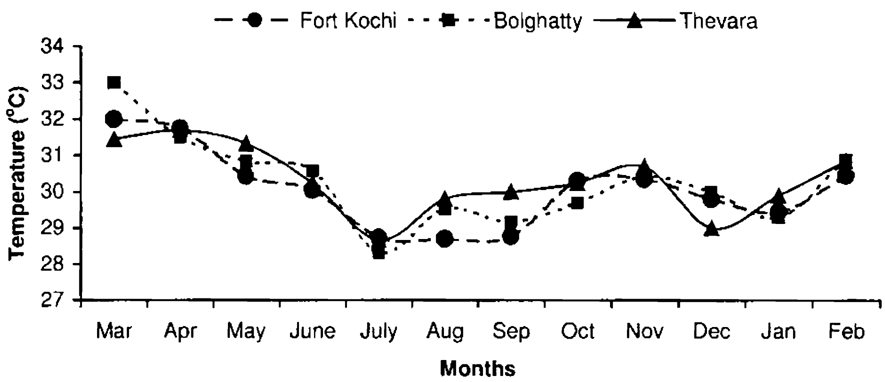


Figure 6. 1. Seasonal variations of temperature at three stations in Cochin backwaters

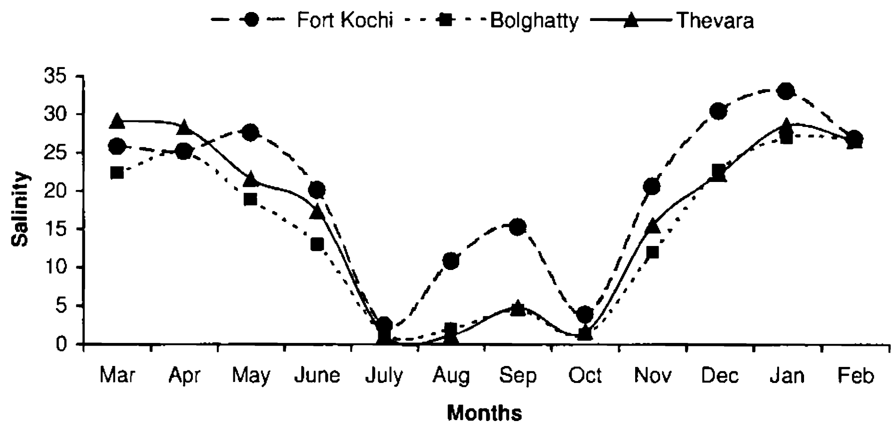


Figure 6. 2. Seasonal variations of salinity at three stations in Cochin backwaters

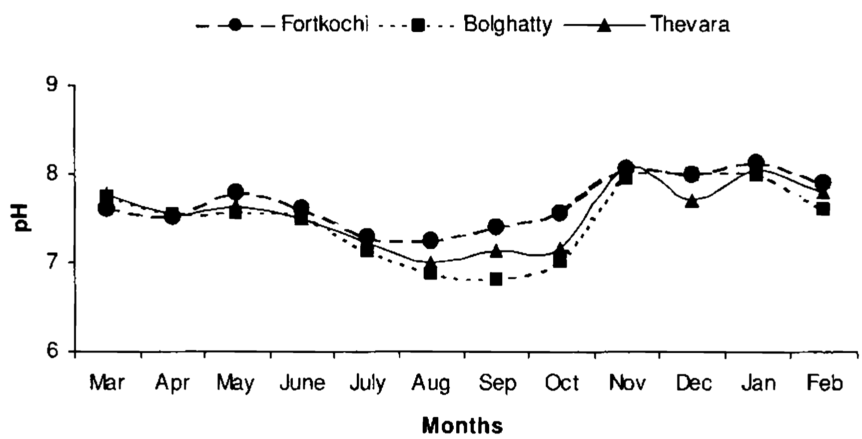


Figure 6. 3. Seasonal variations of *p*H at three stations in Cochin backwaters

Dissolved oxygen (DO)

Highest average value was observed in postmonsoon period (Fig. 6.4). The annual average of dissolved oxygen was 262.6 ± 11.1 μM .

The variation at Fort Cochin was from 92.8 - 342 μM, highest value observed during December and lowest in March. The seasonal DO values ranged from 269.2 to 92.8 μM (av. 201.8 ± 47 μM), 297.4 to 138.3 μM (av. 244.4 ± 44.6 μM) and 342 to 264.3 μM (av. 295 ± 20.7 μM) were premonsoon, monsoon and postmonsoon respectively.

At Bolghatty, highest value (406 μM) was recorded during November and lowest value (158.97 μM) observed during May. Average seasonal values were, 214 ± 53.3 μM during premonsoon 254.24 ± 47.69 μM in monsoon and 298 ± 41.35 μM during postmonsoon respectively.

At Thevara, the highest value of 313.9 μM was recorded during November and lowest of 148.2 μM during April. The fluctuation of dissolved oxygen values were 148.2 to 323.7 μM in premonsoon, 200.7 to 324 μM in monsoon and 215.27 to 402.47 μM in postmonsoon with an average of 214 ± 53.28, 272.1 ± 36.47 and 311.9 ± 47.58 μM for premonsoon, monsoon and postmonsoon respectively.

Chlorophyll *a* (Chl *a*)

In general chlorophyll values were very high in monsoon period compared to premonsoon and postmonsoon periods (Fig. 6.5). The average annual Chl *a* was 18.4 ± 6.6 mg m^{-3}. At Fort Cochin, the minimum values observed was 7.5 and maximum 95.7 mg m^{-3} during May and August respectively. In premonsoon Chl *a* value varied from 7.5 to 26.6 mg m^{-3} (av. 14.3 to 5.9 mg m^{-3}); in monsoon, 10.3 to 95.7 (av. 31.6 ± 24 mg m^{-3}) and in postmonsoon, 9.3 to 16.9 mg m^{-3} (av. 11.1 ± 4.1 mg m^{-3}).

At Bolghatty, both highest (75.9 mg m^{-3}) and lowest (7.9 mg m^{-3}) values were observed during monsoon periods. Seasonal average of chlorophyll for premonsoon, monsoon and postmonsoon were respectively 19.5 ± 12.18, 23.90 ± 17.04 and 14.2 ± 3.8 mg m^{-3}.

At Thevara, highest value of 58.3 mg m^{-3} observed during June and lowest value (7.0) during April. Seasonal variation was 25.5 to 7.0 (av. 13.18 ± 5.3), 8.0 to 58.3 (av. 20.8 ± 17.6) and 7.7 to 19.3 (av. 11.5 ± 3.6) for premonsoon, monsoon and postmonsoon respectively.

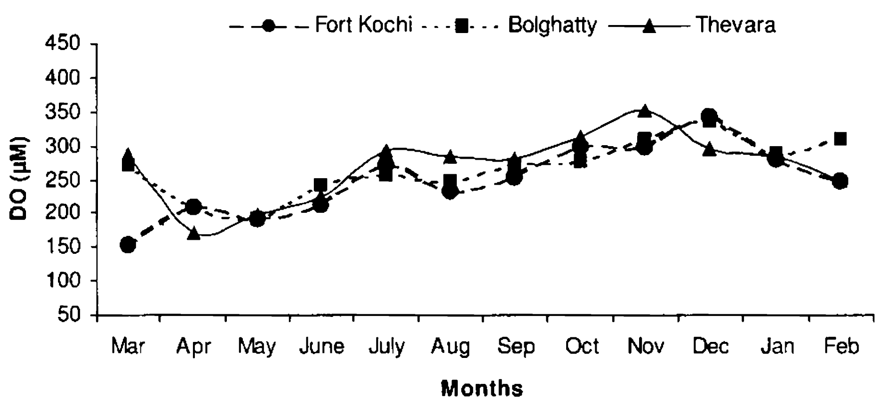


Figure 6. 4. Seasonal variations of dissolved oxygen at three stations in Cochin backwaters

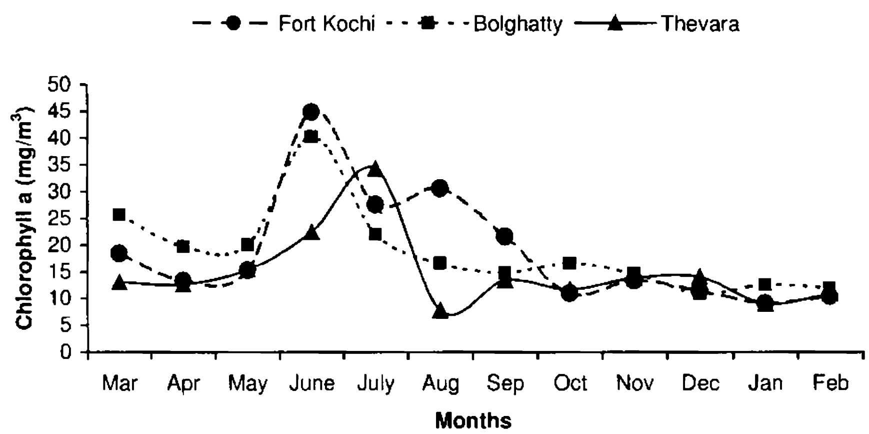


Figure 6.5. Seasonal variations of chlorophyll *a* at three stations in Cochin backwaters

6.3.2. Taxonomy, ecology and biology

Four species of mysids belonging to three genera, *Mesopodopsis orientalis* Tattersal, *Mesopodopsis zeylanica* Nouvel, *Rhopalophthalmus indicus* Pillai, and a new species *Kochimysis Pillaii* belonging to a new genus *Kochimysis* were observed in the Cochin backwaters. Population densities of mysids in the backwater were highly inconsistent. The density fluctuation did not show a fully synchronous pattern between the sampling stations, this probably indicates a heterogenous distribution of the mysid. All the four species of mysids were present at Bolghatty stations. Three species *M. orientalis, M. zeylanica* and *R. indicus*, were found at Thevara while at Fort Cochin, two species (*M. orientalis* and *M. zeylanica*) were observed. Marked seasonal variations in population density and distribution were observed during the period of observation. Invariably numerical abundance of all species was high in Bolghatty followed by Thevara and Fort Cochin.

Sub family MYSINAE Hansen

Tribe Mysini

Genus *Mesopodopsis* Tattersall

***Mesopodopsis orientalis* Tattersall**

(Fig. 6.6 A-E)

Macropsis orientalis W.M. Tattersall, 1908, p. 236

Mesopodopsis orientalis, W.M Tattersall, 1922, p. 482; Nair, 1939, p. 175; Nouvel, 1957a, p. 323; O.S. Tattersall, 1960, p. 180; 1965; Pillai, 1968, p. 6; Murano, 1986a, p. 2. Panampunnayil, 1999a, p.132, fig. 5.29

Occurrence: Stations; WS1, WS2, WS3, TS1, TS2, TS3, TS4 and TS5

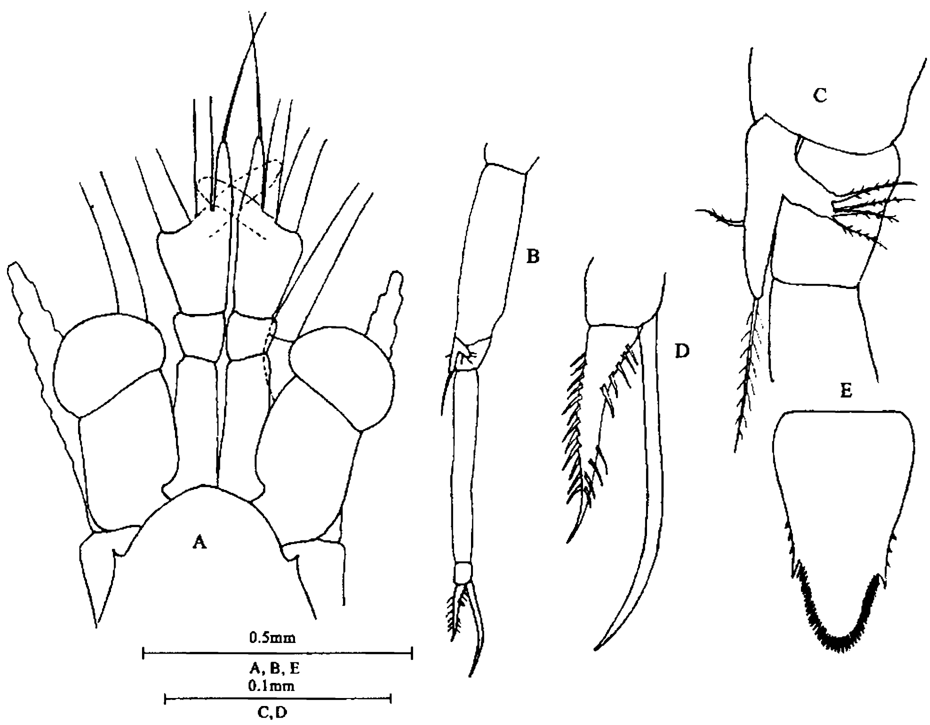


Figure 6. 6. *Mesopodopsis orientalis* Tattersall, Male. A, anterior part of the body; B, fourth pleopod; C, same, tip; D, same, endopod enlarged; E, telson

Remarks: *M. orientalis* is easily distinguished from other Indian species *M. zeylanica* by semicircular frontal plate, endopod of fourth pleopod is longer than first segment of exopod, exopod three segmented and outer apical setae unsegmented and the distal part of telson armed with 30 to 36 pair of short spines. The present specimens well agree with the description of Panampunnayil (1999a).

Seasonal distribution, reproductive biology and ecology

M. orientalis occurred through out the study period and contributed 27.07% of the total population. At Fort Cochin, Bolghatty and Thevara, they contributed 34.5%, 22% and 35.6% respectively. Seasonal distribution of *M. orientalis* is shown in Fig. 6.7 and percentage composition of different age groups were plotted in Fig. 6.8 A-C.

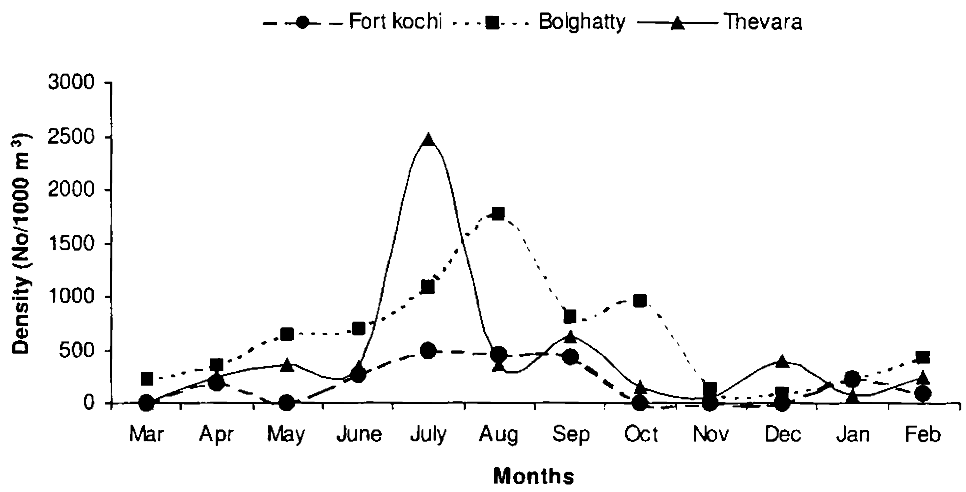


Figure 6. 7. Seasonal abundance of *M. orientalis* in the Cochin backwaters

Premonsoon

M. orientalis occurred during pre monsoon period (18.8%) with an average population of 25.3 ± 59.7/1000m^3 at Fort Cochin 151.2 ± 217.7/1000m^3 at Bolghatty and 78.4 ± 122.8/1000m^3 at Thevara station, constituted by 13.2% immature males 16% mature males, 2.9% spent females, 6.1% females with eyed larvae, 2.4% females with eyeless larvae, 2.3% females with eggs, 19.3% immature females and 37.9% juveniles.

Eventhough brooding females were absent during March and April, 7% immature males, 10% mature males, 14.6% immature females and 18% juveniles were present during March and 41.7% of juveniles were observed during April. May contributed, 16.3% brooding females, 21.7% juveniles and 14.7% immature females.

In premonsoon period, Fort Cochin, contributed 13.1% of *M. orientalis,* constituted by 21.5% immature males, 22.6% mature males, 22.6% immature females and 33.3% juveniles. During this season spent females and ovigerous females were completely absent in this station.

At Bolghatty, *M. orientalis* contributed 22.4% of the total population and constituted by 8.9% immature males 15.6% mature males, 5.7% spent females, 7.6% females with eyed larvae, 1.8% female with eggs, 17.8% immature females and 42.6% juveniles. During this season, female with eyeless larvae were absent in this station.

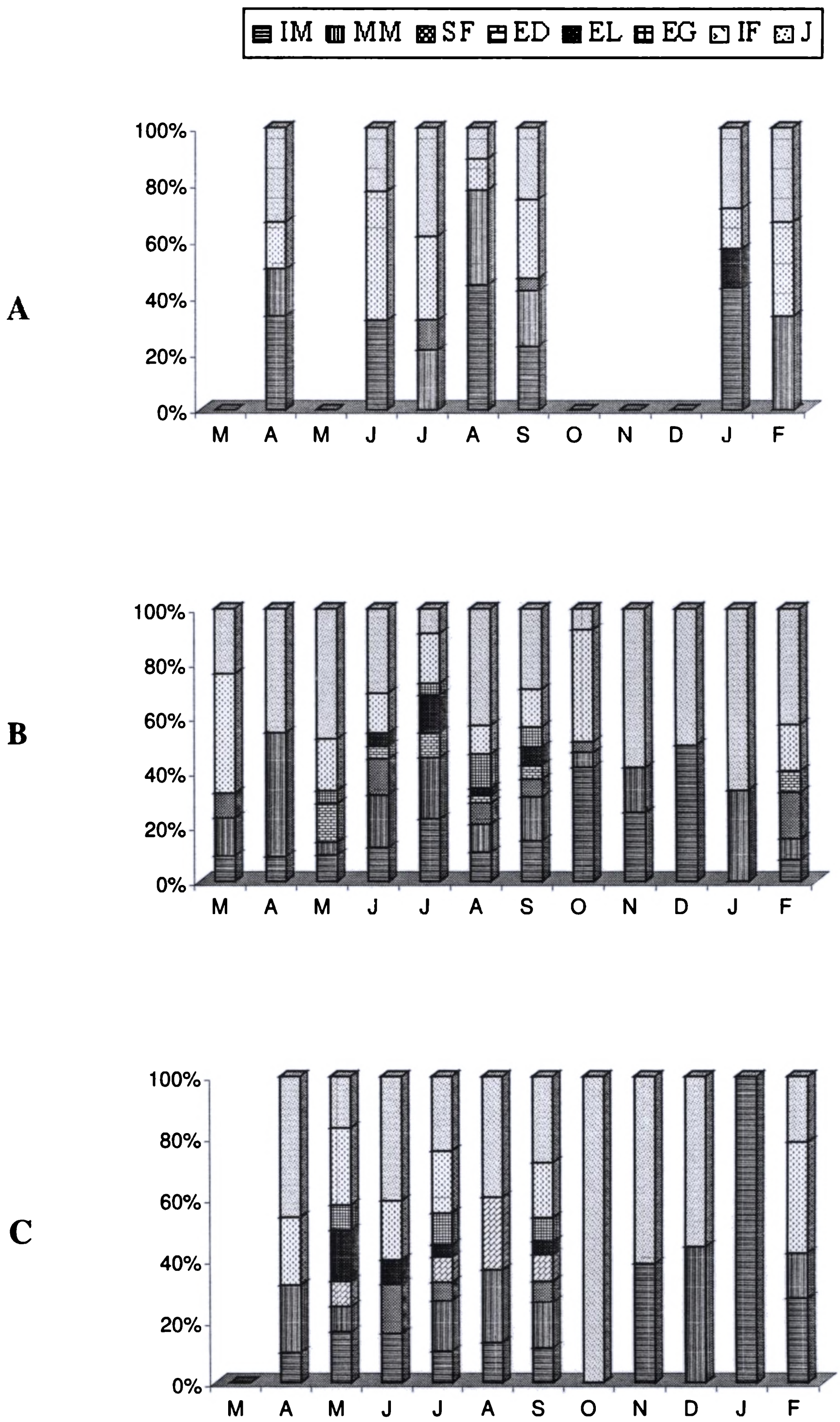
At Thevara, *M. orientalis* contributed 16.33% of the total population and constituted 17.9% immature males 14% mature males, 3.5% females with eyed larvae, 7.1% females with eyeless larvae, 3.5% females with eggs, 27.5 % immature female and 26.6 % juveniles.

Monsoon

M. orientalis was more abundant in the monsoon period and formed 66% of the total mysid population and contributed 13.7% immature male 16.7% mature male, 6.6% spent females, 5.3% females with eyed larvae, 3.66% females with eyeless larvae, 5.4% females with eggs, 16.2% immature females and 32.6% juveniles. All the stages of *M. orientalis* were observed during June to September with comparatively high density. Juveniles dominated in all these months.

At Fort Cochin, *M. orientalis* contributed 76.2% in monsoon period with an average density of 161 ± $231.4/1000m^3$. During this period, the population was constituted by 19.4% immature male, 25% mature males, 3.2% spent females, 3.8% females with eyed larvae, 25.4% immature females and 24.2% juveniles.

At Bolghatty, *M. orientalis* contributed 58.9% with an average density of 312.5 ± $422.3/1000m^3$ and constituted by 13.3% immature males, 16.23% mature males, 6% spent females, 4.1% females with eyed larvae, 5.3% females with eyeless larvae, 6.3% females with eggs, 13.1% immature females and 35.9% juveniles.



IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles.

Figure 6. 8. Percentage composition of different age group of *Mesopodopsis orientalis*. (A- premonsoon; B- monsoon; C - postmonsoon)

Postmonsoon

At Thevara, *M. orientalis* contributed 72.1% of the total population with an average density of 237.8 ± 387.9/ 1000m^3 and contributed 11.7% immature male, 13.6% mature males, 8.9% spent females, 7.6% females with eyed larvae, 3.4% females with eyeless larvae, 6.7% females with eggs, 15.7% immature females and 32.5 % juveniles.

M. orientalis observed in postmonsoon period was 14.5% and constituted by 29.2% immature male 14.3% mature males, 1.7% spent females, 1.5% females with eyeless larvae, 20.2% immature females and 32.9% juveniles. During this season females with eyed larvae and female with eggs were completely absent in all stations.

In October, only spent females were represented (12.29%) while in November only immature males (5.5%), mature males (32%), and juveniles (39.8%) were present. At Fort Cochin, *M. orientalis* contribute 10.7% of the total population with an average density of 20.6 ± 68.4/1000m^3, and they constituted by 243.6% immature males, 14.1% females with eyeless larvae, 32% immature females and 65% juveniles. Mature males, spent females, females with eyed larvae, with eyeless larvae and with eggs were absent at Fort Cochin station.

At Bolghatty, *M. orientalis* contribute 18.76 % of the total population with an average density of 116.2 ± 221/ 1000m^3 and were constituted of 35.9% immature males, 9.2% mature males, 2.7% spent females, 28.3% immature females and 24.3% juveniles. Brooding females were not observed at this station during postmonsoon.

At Thevara, *M. orientalis* contribute 11.57 % of the total population with an average density of 52.7 ± 112.5/1000m^3 constituting 12.1% immature males, 28.8% mature males and 59.4% juveniles. Brooding females and immature females were completely absent in this station.

Ecology: This species occurred in wide range of salinity (0 - 34.6 psu) and temperature (27.2 - 32.8°C). Dissolved oxygen and *p*H ranged between 138.4336.6 µM and 6.8 - 8.3 respectively. It is a euryhaline species and some time occurred in swarms/aggregations. During the study period one swarm of *M. orientalis* (Plate 6.1) was observed at station TS5 on March 2004 at 6 am. This swarm was constituted by 10.3% immature males, 18% mature males, 3.9% spent females, 3.4% of females with eyeless larvae, 5.6% of females with eyed larvae, 6.5% of females with eggs, 25.6% of immature females and 26.7% of juveniles.

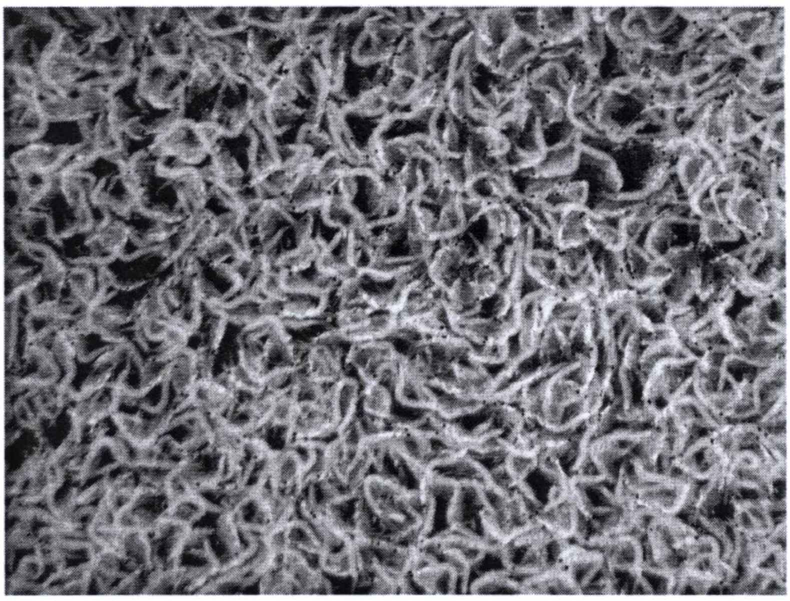


Plate 6. 1. Swarm of *Mesopodopsis orientalis*

Body lengths

Males and females mature at 5.2 - 6.4mm and 4.5 - 6.4 mm length respectively (Table 6.1). They attained maximum body size during September (8.3 mm). The total length of immature male and female ranged from 4.2 to 5.8 mm and 4.3 to 6.5 mm respectively. The largest immature male was collected in December, while immature female in April (Table 6.2). The appearance of eggs in the marsupium occurred, when it attains a body length of 4.7 to 6.4 mm and the eyed and eyeless larvae occurred at a length range of 5.3 to 7.4 mm and 4.5 to 6.3 mm respectively. In some females measuring 6.5 mm, secondary sexual characters were not yet visible, while in some measuring 4.5 mm, secondary sexual characteristics could be noticed. Length of juveniles ranged from 1.2 to 4.6 mm.

Brood characteristics

The number of embryos or larvae in the marsupium of females of different size at different times of the year were examined and the number of young carried by females of different body lengths as shown in Table.6.3. The brood size was positively correlated ($P<0.05$) with female length (Fig. 6.9). The minimum number of brood recorded was 8 in 4.5 mm females and the maximum was 12 in 6.3 - 7.4 mm females. The egg size (early embryo) varied between 0.39-0.47 mm, with no correlation with the length of female. The size difference of eggs was also observed in the same brood.

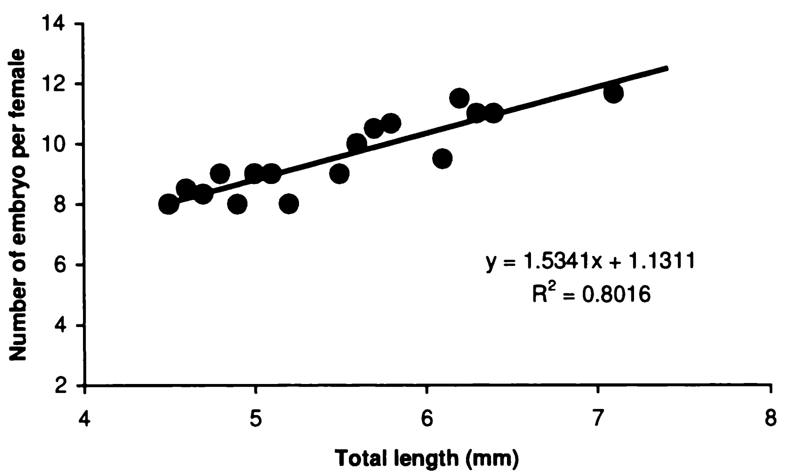


Figure 6. 9. Relationship between female length and brood size of *Mesopodopsis orientalis.*

Table 6. 1. Length variations (min-max) among different stages of the *M. orientalis.*

Different stages		Length range (min-max) (mm)
	Juveniles	1.2-4.6
Male	Immature	4.2-5.8
	Mature	5.2-7.6
Female	Immature	4.3-6.5
	with eggs	4.7-6.4
	with eyeless larvae	4.5-6.3
	with eyed larvae	5.3-7.4
	Spent	4.9-8.3

Table 6. 2. Variation in length (mm) of different age groups of *M. orientalis* in different months

Months	IM	MM	SF	ED	EL	EG	IF	J
March '03	4.5-4.9	5.6 -6	5.2-5.8	-	-	-	5.4	2.2-3.2
April	4.9-5	5.7-5.8	-	-	-	-	5-6.5	3-3.6
May	5.2	6-7.6	-	5.4-5.9	5.9-6.2	5.7-6.1	5.3-6.3	1.2-3.9
June	4-4.9	5.2-6.2	4.9-7.2	7.2	4.5	-	4.8-5.4	2.7-3
July	4.7-5	5.2-6.3	7.1-7.3	6.2-6.4	5.2-6	4.7-6.2	5.1-6.2	1.7-3.3
August	5.1-5.3	5.7-5.9	5.7-5.8	5.3-6.3	6.3	5.2-5.8	6-6.2	3.2-4.6
September	5.3-5.5	6.2	6.7-8.3	6.1	5.9-6.1	6.1-6.4	4.3-6.2	2.1-3.7
October	4.9-5.4	6	7.6-7.7	-	-	-	4.7-5.8	1.9-3.4
November	5.2-5.3	5.8	-	-	-	-	-	1.8-3.2
December	5.2-5.8	5.3-5.9	-	-	-	-	-	2.1-3.5
January '04	4.2-5	6-6.3	-	-	5.8	-	5.2-6.2	2.4-3.5
February	5.1-5.3	6.1-6.3	5.7-6	7.4	-	-	5-6.1	2.3 -4

IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with s, IF- immature females, J- juveniles

Table 6. 3. Number of young ones carried by females of different size classes of *M. orientalis* in the Cochin backwaters in different months.

Size class	M	A	M	J	J	A	S	O	N	D	J	F
4- 4.5	-	-	-	8	-	-	-	-	-	-	-	-
4.6- 5	-	-	-	-	8,9	-	-	-	-	-	-	-
5.1- 5.5	-	-	8		10	10	-	-	-	-	-	-
5.6- 6	-	-	9,11	10	11	9,10	9,11	-	-	-	-	-
6.1- 6.5	-	-	10	-	9,11	12	11	-	-	-	-	-
6.6- 7	-	-	-	-	-	-	-	-	-	-	-	-
7.1- 7.5	-	-	-	12	-	-	-	-	-	-	-	10

Mesopodopsis zeylanica Nouvel

(Fig. 6.10A-E)

Mesopodopsis zeylanica Nouvel, 1954a, P. 33, figs. 1-16.

Mesopodopsis zeylanica Pillai, 1961, P. 28; 1968, P.21

Occurrence: Stations; WS1, WS2, WS3, TS1, TS2, TS3, TS4 and TS5

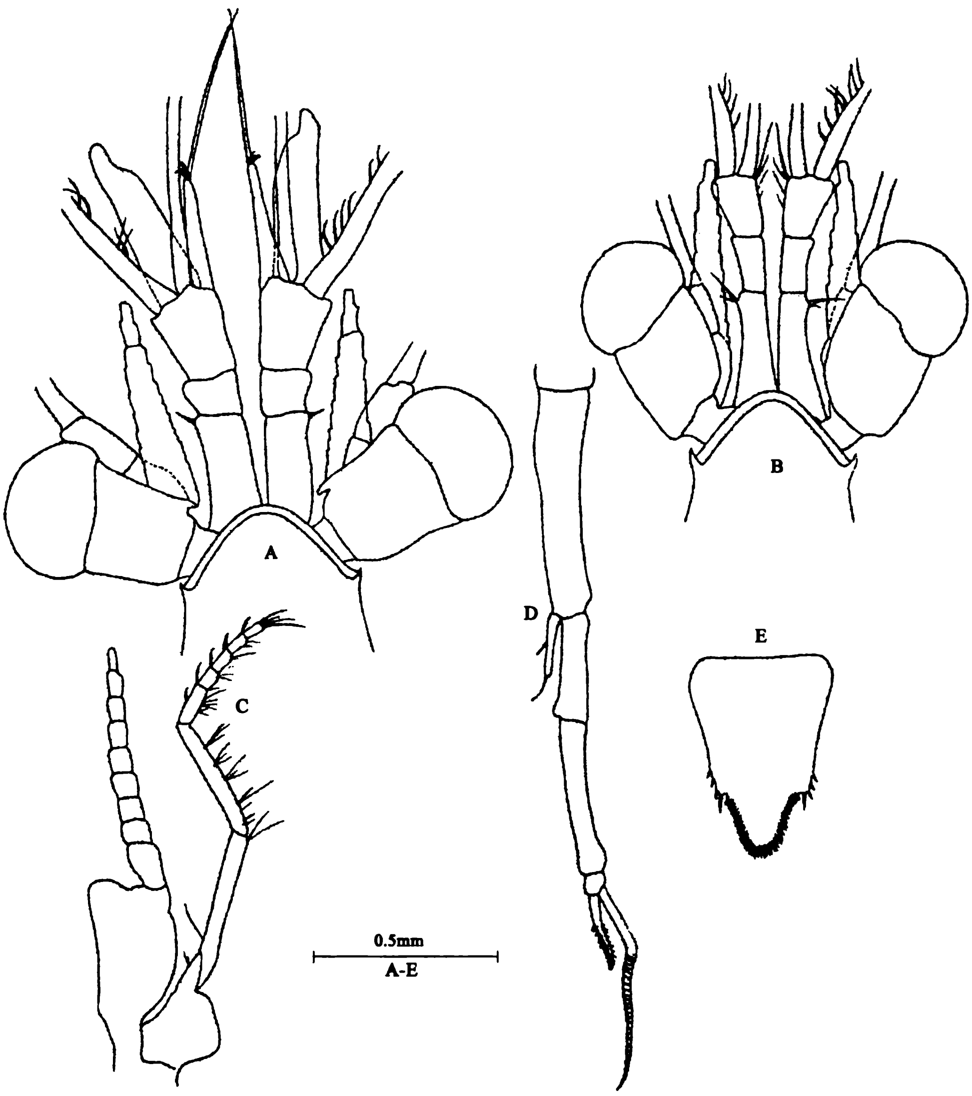


Figure 6. 10. *Mesopodopsis zeylanica* Nouvel, Male. A, anterior part of the body; B, anterior part of the body of female; C, eighth thoracic endopod; D, fourth pleopod; E, telson.

Remarks: *M. zeylanica* is easily distinguished from other Indian species *M. orientalis* by the following points. In *M. zeylanica* the frontal plate is triangular, the endopod of the fourth pleopod is shorter than the first segment of exopod, the exopod is five segmented, outer apical setae of the exopod is sub divided and distal part of telson armed with 50-55 teeth In *M. orientalis* the frontal plate is semicircular. The endopod of fourth pleopod is longer than first segment of exopod, exopod three segmented and outer apical setae unsegmented and the distal part of telson armed with 30 to 36 pair of short spines.

Seasonal distribution, reproductive biology and ecology

M. zeylanica occurred through out the study period at all stations and was the dominant species. During the study period it contributed 46.4% of the total mysid population. In Fort Cochin Bolghatty and Thevara, they contributed 65.5%, 39.3% and 55.7% respectively. Seasonal distribution of *M. zeylanica* plotted in Fig. 6.11 and percentage composition of different age groups were plotted in Fig. 6.12A-C.

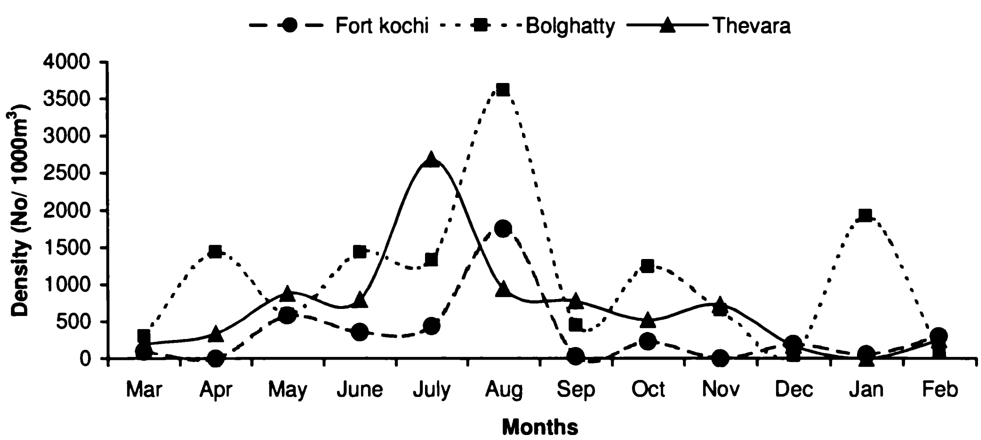


Figure 6. 11. Seasonal abundance of *M.zeylanica* in the Cochin backwaters

Premonsoon

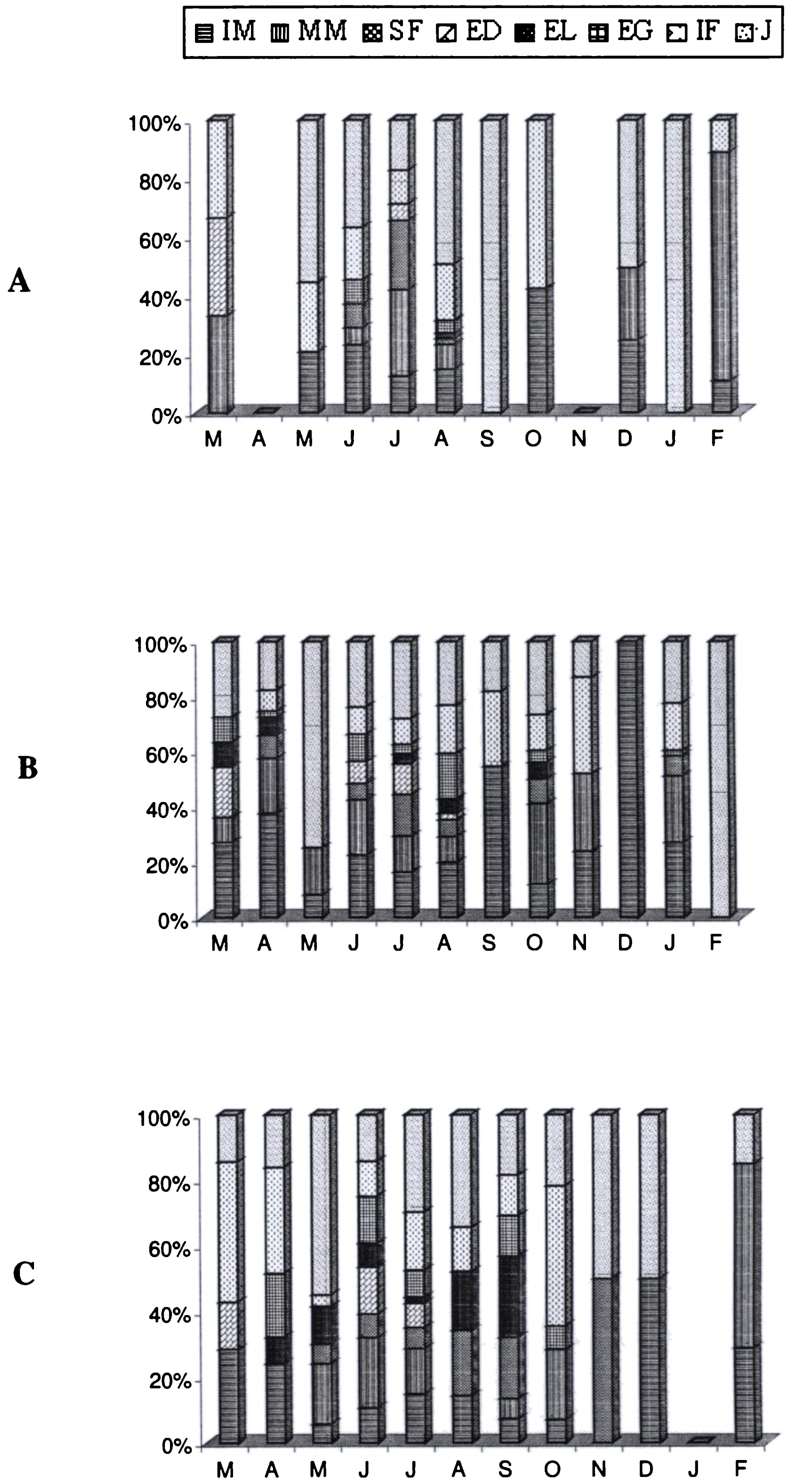
During premonsoon period 19.9% *M. zeylanica* was observed with an average density of 89 ± 168.3/1000m^3 at Fort Cochin, 220 ± 309.7/1000m^3 at Bolghatty and 150 ± 221/1000m^3 at Thevara station. The population was constituted by 21.55% immature males 19.4% mature males, 3.4% spent females, 2.3% females with eyed larvae, 5% females with eyeless larvae, 2.5% female with eggs, 10.5% immature females and 35.3% juveniles.

In February, ovigerous females (spent female, female with eyed larva, with eyeless larvae, with eggs) were completely absent. Mature males dominated during this month (44.6%) and juveniles contributed 38.4% of the monthly population. In March and April, densities of ovigerous females were very low and juveniles contributed 13.9% and 11.4% respectively, while in May, juveniles showed high density (61.7%).

At Fort Cochin, *M. zeylanica* contributed 24.2% of the total population with a composition of 15.8% immature males, 27.1% mature males, 3.3% females with eyed larvae, 20.8% immature females and 33% juveniles. Spent females, females with eyeless larva and females with eggs were completely absent during this period.

At Bolghatty, *M.zeylanica* contributed 18.5% of the total population with 27.9% immature males 17.3% mature males, 4.9% spent females, 2.3% females with eyed larvae, 5.8% females with eyeless larvae, 2.5% females with egg, 4.5% immature female and 35.6% juveniles.

At Thevara, *M. zeylanica* contributed 20% of the total population of which 15.6% were immature males 18.1% mature males, 3.1% spent females, 1.7% females with eyed larvae, 7.7% females with eyeless larvae, 3.9% females with eggs, 13.42% immature females and 36.3% juveniles.



IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles.

Figure 6. 12. Percentage composition of different age groups of *Mesopodopsis zeylanica.* (A- premonsoom ; B- monsoon; C - postmonsoon).

Monsoon

Compared to other seasons *M. zeylanica* was more abundant during the monsoon period and contributed 57.4% to the total population and constituted 17.7% of immature males, 11.6 % mature males, 8.5% spent females, 4.7% females with eyed larvae, 5.1% females with eyeless larvae, 9% females with eggs, 15.47% immature females and 28% juveniles.

However spent females were absent in September, all life stages of *M. zeylanica* were observed during this period. Maximum average density of *M.zeylanica* was observed in August ($2105 \pm 1375/1000m^3$).

During monsoon period *M. zeylanica* was the dominant at Fort Cochin (63.8%) with an average density of $161 \pm 231.4/1000m^3$ and composed of 15.4% immature males, 11.7% mature male, 6.6% spent females, 0.9% females with eyed larvae, 1.4% females with eyeless larvae, 3.9% females with eggs, 17.5% immature females and 42.5% juveniles.

At Bolghatty, *M. zeylanica* contributed 52.1% of the total population with an average density of $427.8 \pm 502/1000m^3$ and it was contributed by 22.1% immature males, 11.7% mature males, 7.4% spent females, 5.1% females with eyed larvae, 3.5% females with eyeless larvae, 11.5% females with eggs, 15% immature females and 23.8% juveniles.

At Thevara, *M. zeylanica* contributed 62.9% of the total population with an average density of $325.1 \pm 349/1000m^3$ and consisted of 13% immature males, 11.3% mature males, 10.8% spent females, 5.9% females with eyed larvae, 9% females with eyeless larvae, 8.3% females with eggs, 15.1% immature females and 26.5% juveniles.

Postmonsoon

During postmonsoon period *M. zeylanica* contributed 22.69% to the total population and constituted 19.8% immature males 20.4% mature males, 10.6% spent females, 1.3% females with eyeless larvae, 2.2% females with eggs, 18.7% immature females and 27% juveniles.

Immature females contributed 37.7% of the monthly population in October and in December immature males contributed 58.3%. The densities of ovigerous females became very less or absent during October to December.

At Fort Cochin, *M. zeylanica* contributed 12% of the total population with an average density of 43.9 ± 85.8 and constituted 30.4% immature males, 10.1% mature males, 27.3% immature females and 32.1% juveniles.

At Bolghatty, *M. zeylanica* contributed 29.48% of the total population with an average density of 323.1 ± 264.4/1000m^3 and constituted by 22.5% immature males, 26.2% mature males, 6.4% spent females, 1.9% females with eyeless larvae, 2.3% females with eggs, 18.7% immature females and 21.79% juveniles.

At Thevara, *M. zeylanica* contributed 17.1% of the total population with an average density of 118.2 ± 231.6/1000m^3 and constituted 8.7% immature males, 7.8% mature males, 25.5% spent female, 2.6% females with egg, 15.7% immature females and 39.63% juveniles.

Ecology: In the present study, *Mesopodopsis zeylanica* mostly occurred along with *R. indicus* and *M. orientalis.* This species is a euryhaline (0 - 32.47) and eurythermal species (27.2 - 33.5 °C). The dissolved oxygen and *p*H in which *M. zeylanica* occurred were 138.4 to 379 µM and 6.3 to 8.7 respectively.

Body lengths

The total length of smallest free-swimming individual was 1.4 mm. Juveniles attained a length range of 1.4-to 4.9 mm. Total length of adult males ranged from 5.2 to 7.3 mm (Table 6.4). The length of largest immature male was 5.7, collected during June, December and February. The sexes were usually distinguishable when the lengths is longer than 4.2 mm in males and 4 mm in females and males were having larger fourth pleopod and female having small developing marsupium. The largest immature female (6.6 mm) was collected in February. The smallest breeding female was 4.8 mm. The largest female (spent) measured 7.4 mm in length collected during April (Table 6.5).

Brood characteristics

The number of embryos or larvae in the marsupium of females of different sizes at different times of the year were examined and the number of young ones carried by females of different body length is shown in Table 6.6. The minimum number of brood recorded was 7 (4.5 mm females) and the maximum was 11 (6 to 7 mm females). The egg (early embryo) size varied from 0.38 to 0.43 mm. The brood size was positively correlated (P>0.05) with female length. (Fig. 6.13).

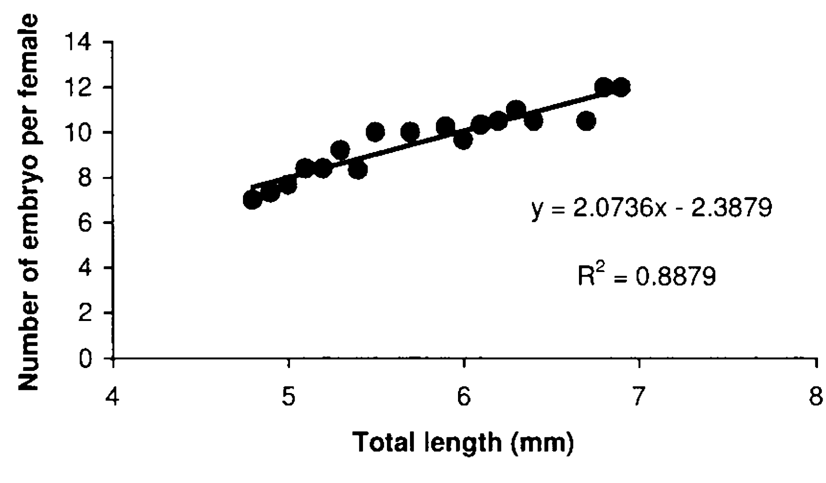


Figure 6. 13. Relationship between female body length and brood size of *M. zeylanica.*

Table 6. 4. Length variations (min-max) among different stages of the *M. zeylanica*

Different stages		Length range (min-max) (mm)
	Juveniles	1.4- 4.9
Male	Immature	4.2- 5.7
	Mature	5.2- 7.3
Female	Immature	4- 6.6
	with eggs	4.8- 6.6
	with eyeless larvae	4.9- 6.9
	with eyed larvae	5.6- 7.2
	Spent	5.3- 7.4

Table 6. 5. Variation in length (mm) of age groups of *M. zeylanica in* different months

Months	IM	MM	SF	ED	EL	EG	IF	J
March '03	4.4-5.3	5.2-6.4	-	6.2-7.2	5.2-6.7	5.4-6.6	4.2- 6	1.4-2.8
April	5-5.4	6-6.2	6.4-7.4	-	5.6-5.8	5.7-5.9	4.7-5.8	3.2-4.2
May	4.2-5.2	5.7-5.8	5.7-7	-	6.2-6.9	-	5-5.3	1.5-4.9
June	5-5.7	6.2	6.2-6.7	5.6-5.8	6-6.7	4.8-6.6	4.5- 6.5	2.7-3.5
July	4.2-4.9	5.2-5.8	5.3-7	6.2-6.7	5.2-5.7	6-6.4	4- 6.3	3.3
August	5.1-5.3	5.7-6.6	5.7-5.9	-	4.9-6.2	5.2-6.2	5-5.2	1.9-3.5
September	4.7-5	6.2-6.3	6.5-6.9	-	5.2-5.4	6.5	4.7-5.7	2.1-3.2
October	4.8-5.6	5.2-7.3	6.2	-	6.2-6.7	6	5.6-6.2	2.5-4.2
November	4.2-5.4	6-6.4	5.9-6.8	-	-	-	4.7-5	2.2-3.8
December	5.5-5.7	5.7-6.2	-	-	-	-	-	2.7-4.2
January '04	4.3-5	5.4-5.5	6.5-7.2	-	-	5.3	4.3-5.9	2.3-3.2
February	5.5-5.7	5.2-6.2	-	-	-	-	6.6	4.4

IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles

Table 6. 6. Number of young carried by females of different size classes of *M. zeylanica* in the Cochin backwaters in different months

Size class	M	A	M	J	J	A	S	O	N	D	J	F
4.5- 5	-	-	-	7,8		8		-	-	-	-	-
5.1- 5.5	-	-	-	-	7	7,8	9,10	-	-	-	9	-
5.6- 6	-	9,10,11	-	8,10	9,11	-	-	-	-	-	-	-
6.1- 6.5	11	-	10	12	11	9,11	9	9	-	-	-	-
6.6- 7	-	-	12	11	9,12	-	-	10,12	-	-	-	-
7.1-7.5	12	-	-	-	-	-	-	-	-	-	-	-

Sub family RHOPALOPHTHALMINAE Hansen

Genus *Rhopalophthalmus* Illig

Rhopalophthalmus indicus Pillai

(Fig. 6.14A-E)

Rhopalophthalmus indicus Pillai, 1961, p.20

Occurrence: WS1, WS2, WS3, TS1, TS2, TS3, TS4 and TS5

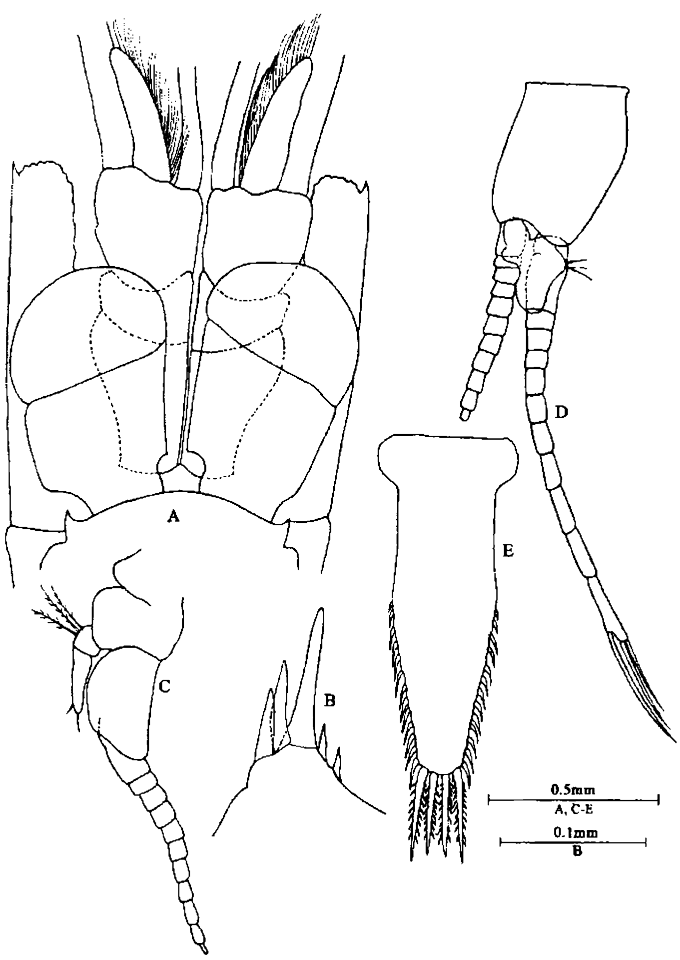


Figure 6. 14. *Rhopalophthalmus indicus* Pillai, Male. A, anterior part of the body; B, antennal sympodial spines; C, eighth thoracic endopod; D, third pleopod; E, telson.

Remarks: The present specimens agree with description of type specimen except some minor variation. In the present specimen lateral border of telson carries 13-17 slender spines, while in Pillai's specimen 14 spines are present. In type specimen, eighth thoracic endopod of male as long as the basal segment of exopod, while in the present specimens endopod is shorter than basal segment of exopod. This species is distinguished from others by the number of spines on the antennal sympod, number of carpopropodal segments of thoracic endopods 3-7, relative length of the 8^{th} thoracic endopod of male and female and relative length of the apical spines of the telson.

Seasonal distribution reproductive biology and ecology

Rhopalophthalmus indicus occurred through out the study period and contributed 26% of the total mysid population, eventhough they were completely absent at Fort Cochin. It showed clear seasonal variation in its abundance. At Bolghatty it showed an average density of 293/1000m^3, while at Thevara, the average density was 38/1000m^3 and it contributed 38.61% at Bolghatty and 8.2% at Thevara. Seasonal distribution of *R.indicus* was shown in Fig. 6.15 while percentage composition of different age groups are given in Fig. 6.16A,B.

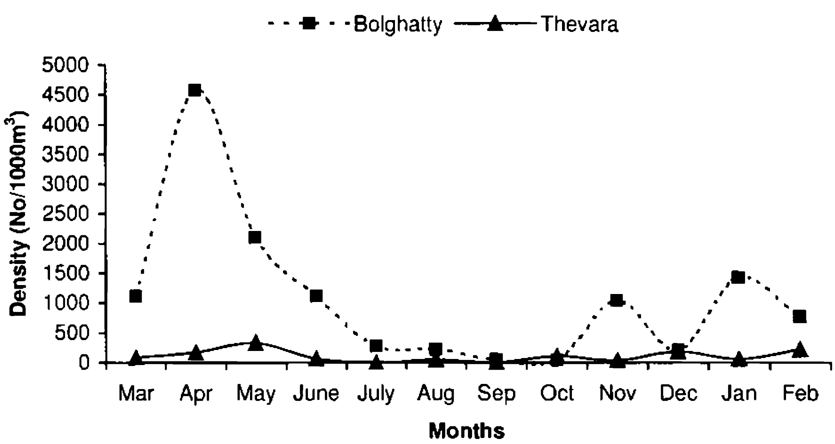


Figure 6. 15. Seasonal abundance of *R. indicus* in the Cochin backwaters.

Premonsoon

During the premonsoon period 65.9% of the *R.indicus* were found with an average density of 779.6 ± 552.5/1000m^3 at Bolghatty and 73.64 ± 97.2/1000m^3 at Thevara stations. During this period they constituted 13.4% immature males 19.3% mature males, 9.2% spent females, 16.1% females with eyed larvae, 5.4% females with eyeless larvae, 8.78% females with eggs, 7.4% immature females and 20.6% juveniles. All the developmental stages were observed from February to May, except spent females in February collection.

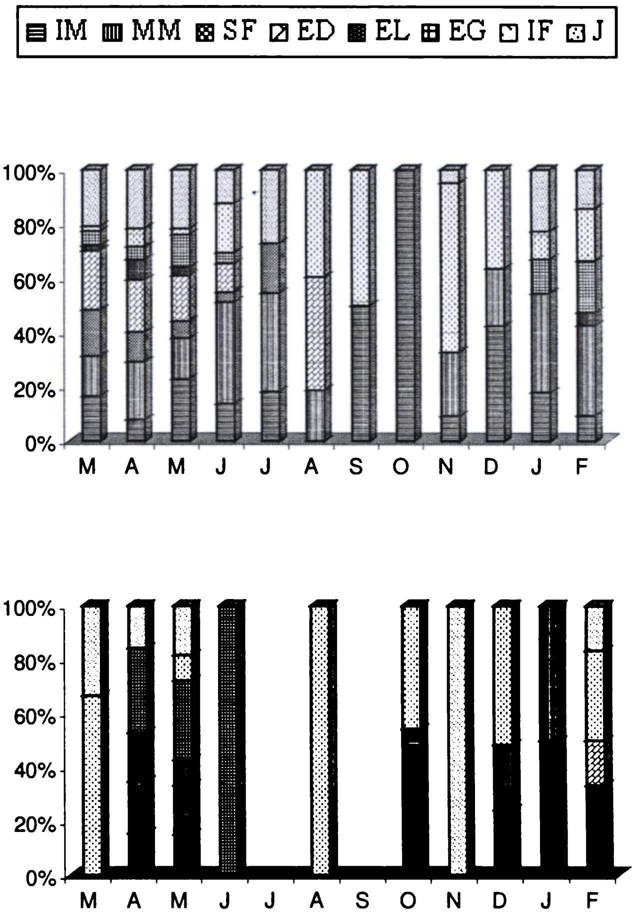
At Bolghatty, *R. indicus* contributed 65.8% of the total population and was constituted by 12.9% immature males 20% mature males, 9.7% spent females, 17.5% females with eyed larvae, 5.41% females with eyeless larvae, 7.8% females with eggs, 6.2% immature females and 20.7% of juveniles.

At Thevara, *R. indicus* contributed 61.8% of the total population constituting 18.6% of immature males 11.6% mature males, 3.8% spent females, 4.56% females with eyed larvae, 3.8% females with eyeless larvae, 18.8% females with eggs, 19.9% immature female and 18.9 % of juveniles.

Monsoon

During this period *R. indicus* contributed 12.4% of the total population with 12.8% immature males, 31.8% mature males, 5.2% spent females, 11.7% females with eyed larvae, 6.39% females with eggs, 20.3% immature females and 11.9 % juveniles.

With the onset summer monsoon, a clear decrease in density was observed. During July - September, ovigerous females and juveniles disappeared or decreased in density whereas immature females, mature males and immature females were observed in high density.



IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL- females with eyeless larvae, EG- female with eggs ,IF- immature females, J- juveniles.

Figures 5. 16. Percentage composition of different age groups of *Rhopalophthalmus indicus* (A- pre monsoon; B- monsoon; C- postmonsoon).

Table 5. 7. Number of broods in different size class of incubating females and developmental stages of *R. indicus* (number of female examined in parenthesis).

Size grouping (mm)	Egg	Eyeless larvae				Eyed larvae			
	S1	S2	S3	S4	S5	S6	S7	S8	S9
8-8.5	(4) 6,7	(1) 7	(3) 6,7	-	-	-	-	-	-
8.6-9	(1) 7	(3) 6,8	(1) 7	(2) 7	-	-	-	-	-
9.1-9.5	(1) 8	(2) 7,8	(2) 7	-	(1) 8	-	-	(2) 8,9	(2) 8
9.6-10	(2) 8,9	(1) 11	(2) 7,8	-	(1) 9	-	(2) 10	-	-
10.1-10.5	(1) 10	(1) 9	(1) 9	(1) 12	(3) 9	(1) 11	-	(1) 9	(3) 9,11
10.6-11	-	-	-	-	-	(3) 9,11	(1) 9	-	(3) 8,13

At Bolghatty, *R. indicus* contributed 13.7% of the total population with an average density of 103.3 ± 188.2/1000m^3 of that 13.7% were immature males, 33.8% mature males, 5.7%, spent females, 12.5% females with eyed larvae, 2.8% females with eggs, 18.8% immature females and 12.8% juveniles.

At Thevara, *R.indicus* contributed 8.7% of the total population with an average density of 7.1 ± 19.8/ 1000m^3 and constituted by 58.8% females with eggs, and 41.2% immature females. Immature males, mature males, spent females, females with eyed and eyeless larvae and juveniles were absent in this station.

Postmonsoon

21.7% of *R. indicus* was obtained during postmonsoon period, constituted by 19.9% immature males 28.8% mature males, 5.8% females with egg, 32.9% immature females and 13.2% juveniles. Spent females, females with eyed larvae and females with eyeless larvae were absent in this season.

October to December months showed more or less similar pattern of distribution of *R. indicus.*

At Bolghatty, *R. indicus* contributed 20.5% of the total population with an average density of 224.8 ± 252.4/1000m^3 and they constituted 17.6% of immature males, 30.1% mature males and 6.6% females with eggs, 32% immature females and 13.7% juveniles. Spent females, females with eyed larvae and with eyeless larvae were absent in this station.

At Thevara, *R.indicus* contributed 29.4% of the total population with an average density of 32.2 ± 58.3/1000m^3 and contributed 35.6% of immature males, 19.7% mature males, 38.9% immature females and 9.32 % juveniles. Spent females, females with eyed larvae, females with eyeless larvae and females with eggs were absent in this station.

Ecology: This species is observed in temperature and salinity range of 28 - 33.5°C and 1.84 - 29.16 psu respectively. A significant correlation ($P<0.05$) was observed between population density of *R. indicus* and salinity (Fig. 6.17). Polyspecific /monospecific swarms or grouping of *R. indicus* (Plate 6.2) were observed at the time series sampling stations. Swarming was observed 8 times, of which three were at TS1, three swarms at station TS2 and two at station TS5. In polyspecific swarms *R. indicus* was the dominant species accounting 60 to 96% of number of individual in the swarm and *M. zeylanica* and *M. orientalis* were concomitant species.

Station 1 (TS1)

A sample of swarm taken at station 1 on 9-3-04 at 00hr consisted of 98286/1000m^3individuals of *R. indicus* constituted by 15.1% of mature males, 21.89% immature males, 2.28% spent females, 87% females with eyed larvae, 1% females with eyeless larva, 1.1% females with eggs, 19.2% immature females and 38.5% juveniles. These swarm was comprised of 6571/1000m^3 individuals of *M. zeylanica*, constituted by 12% of mature males, 13% immature males, 2% spent females, 7% females with eyed larvae, 8% females with eyeless larva, 2% females with eggs, 4% immature females and 52% juveniles. *M. orientalis* co-existed with this swarm contributing 1.2% to the total population, constituted by 17% mature male, 7% of immature males, 7% spent females, 4% female with eyed larvae, larva, 37% immature females and 30% juveniles.

Another sample taken on 9-3-04 at 0600hr at the same place had only a single species, (*R. indicus*) with a density of 12191/1000m^3 constituted by 35.9% of mature males, 9.7% immature males, 3.7% spent females, 9.7% females with eyeless larva, and 41% juveniles.

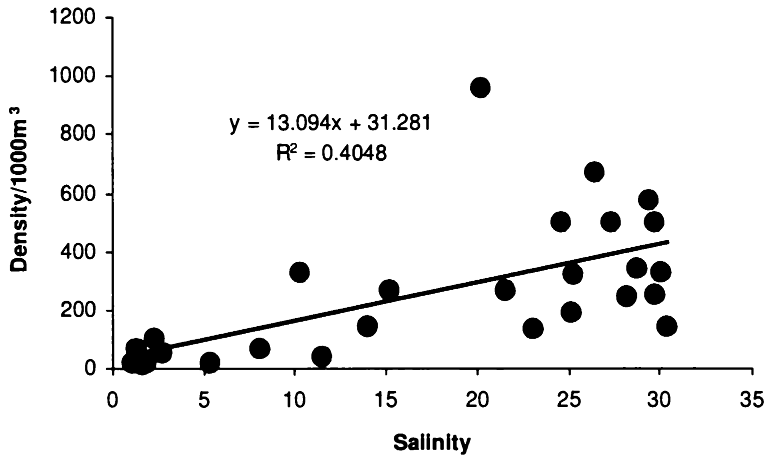


Figure 6. 17. Relationship between salinity and *R. indicus* in the Cochin backwaters.

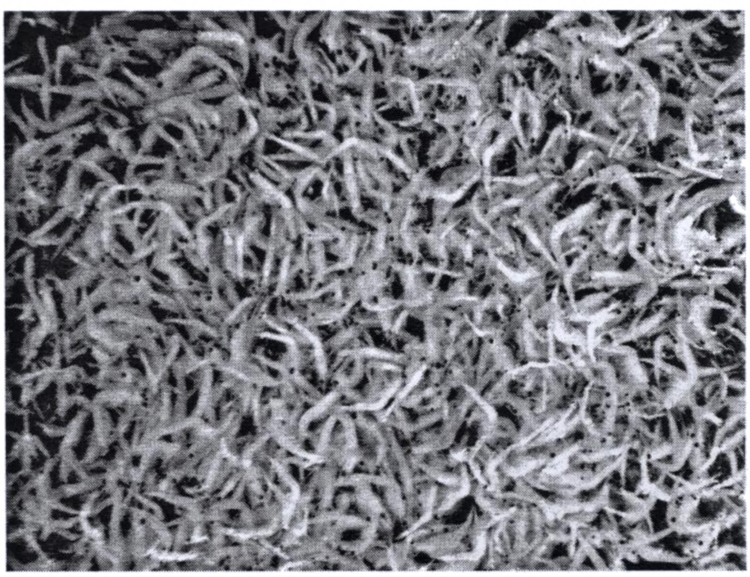


Plate 6. 2. A swarm of *Rhopalophthalmus indicus.*

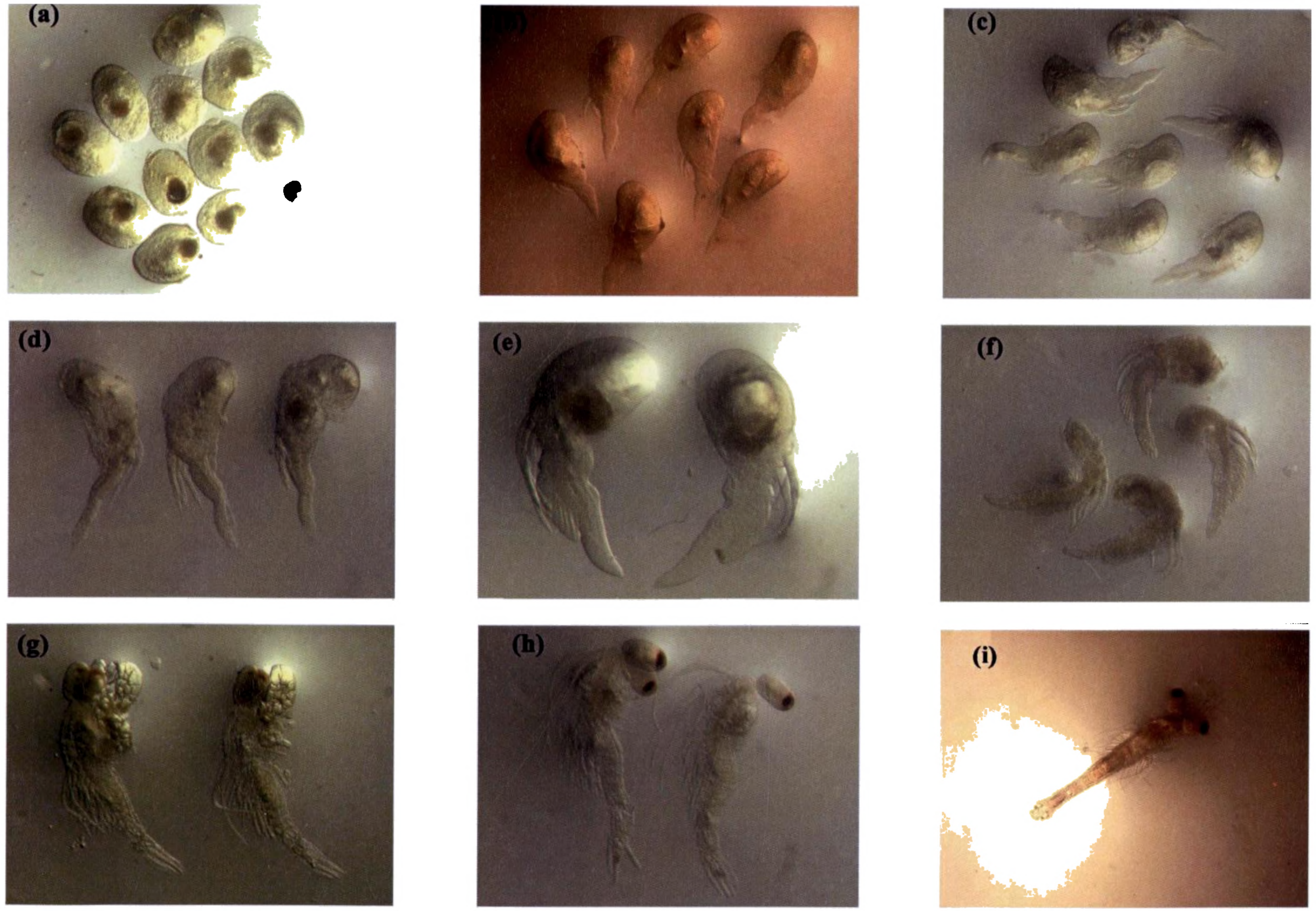


Plate 6. 3. Different life stages during larval development of *R. indicus* Pillai

salinity ranging from 25.02 to 32.47°C and 30 to 32.5 psu respectively. This species was observed along with *R. indicus*.

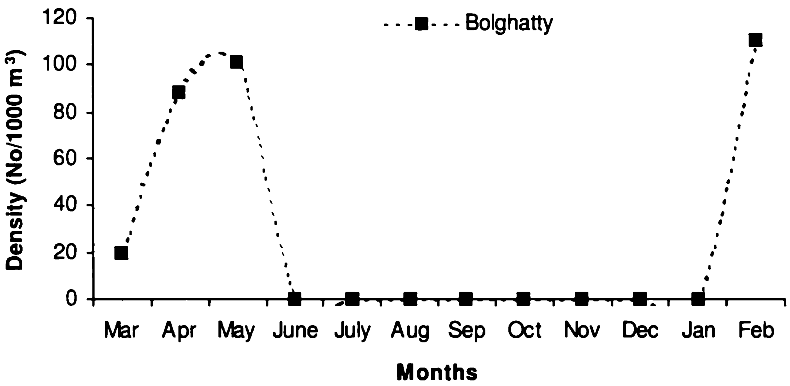
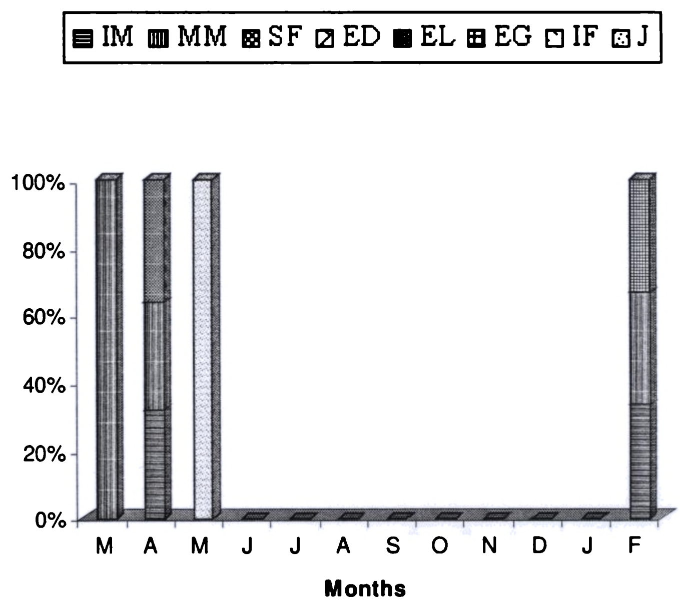


Figure 6. 19. Seasonal variation of *K. pillaii* in Cochin backwaters.



IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles

Figure 6. 20. Percentage composition of different age groups of *K. pillaii* in Cochin backwaters.

others were observed except *K. pillaii*. In general, day and night variation in the population density of mysids was well defined. All species were more abundant at night hours. During October collection, 85.4% of mysids were observed in the night samples and 14.6% occurred in day collections. In March collection 95.2% of the population was found in night samples and rest confined in the day collections.

Mixed semidiurnal tides were observed during March (Fig. 6.21) and in October, weak predominantly diurnal tides (Fig. 6.22) were noticed. During the present study, the density distribution of mysids was closely associated with that of tidal characteristics. Compared to that of October collection, high densities of mysids were observed during March and *M. zeylanica* and *R. indicus* were significantly abundant during night flood tides (Table 6.12), while *M.orientalis* showed more or less similar density distribution for flood as well as ebb tides. They also followed similar pattern of distribution in the during night ebb and flood period (235 ± 212.7/1000m^3 and 296 ± 254/1000m^3 respectively). *Kochimysis pillaii,* occurred only during night ebb tides, though their density was very low. In October, all species showed more or less similar pattern of distribution during both phase of tides (ebb/flood) (Table 6.13)

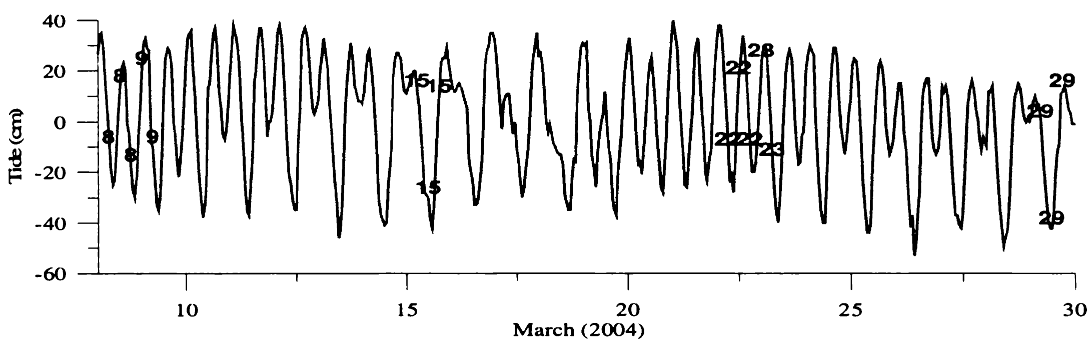


Figure 6. 21. Tidal observation in the month of March (2004) showing the periods of zooplankton sampling.

Another sample taken from the same area (station 1) on 23-3-04 at 0600hr again had only *R. indicus* with a density of 24430/1000m^3 individuals, constituted by 9.1% of mature males, 7.7% immature males, 0.8% females with eyed larvae, 4.1% females with eyeless larva, 2.5% females with eggs, 14.3% immature females and 61.5% juveniles.

Station 2 (TS2)

At station 2, a sample of swarm taken on 9-3-04 at 00hr consisted of 127229/1000m^3 individuals of *R. indicus*, 4880/1000m^3 individuals of *M. zeylanica* and 180/1000m^3 of *M. orientalis*. The dominant species *R. indicus* was constituted by 3.03% of mature males, 12.5% immature males, 0.7% spent females, 1.2% females with eyed larvae, 0.7% females with eyeless larva, 2.98% females with egg, 26.6% immature females and 52.17% juveniles. *M. zeylanica* contributed 3.68% of the swarm and was constituted by 20% of mature males, 10% immature males, 4% spent females, 4% females with eyed larvae, 9% females with eyeless larva, 6% females with eggs, 21% immature females and 27% juveniles. *M. orientalis* contributed only 0.14% of the total population represented exclusively by mature males.

Another sample taken on 23-3-04 at 0600hr at the same station (station 2) had 16396/1000m^3 individuals of *R. indicus* constituted by 7.7% of mature males, 6% immature males, 3.3% spent females, 1.1% female with eyed larvae, 3.8% females with eyeless larva, 7.1% females with eggs, 23.6% immature females and 47.3% juveniles.

On 22-3-04 at 0600hr, another swarm taken at same place, with a density of 11389/1000m^3 individuals of *R. indicus* constituted by 8.8% of mature males, 5.9% immature males, 3.9% spent females, 1% female with eyed larvae, 1% females with eyeless larva, 2.9% females with eggs, 19% immature females and 57.6% juveniles. *M. zeylanica* was absent in this swarm and *M. orientalis* contributed 3.75% to the total population constituted by 25%

of immature males 13% spent females, 13% females with eggs, and 50% juveniles.

Station 5 (TS5)

At station 5, a swarm was noticed with a numerical density of 21376/1000m^3 on 9-3-04 at 00hr, constituted by *R. indicus* 60.5% and *M. zeylanica* 39.4%. *R. indicus* population constituted by 4.1% of mature male, 1.7% immatures male, 16.9% spent females, 8.5% females with eggs, 8.5% immature females and 60.3% juveniles. *M. zeylanica* comprised of 26.6% mature males, 19% immature males, 1.3% spent females, 1.3.8% females with eyed larvae, 15.2% immature females and 34.2% juveniles.

Another swarm with a density of 48197/1000m^3 was noticed on 9-3-04 at 0600hr at the same station comprised by *R. indicus* (79.41%), *M.zeylanica* (17.23%) and *M. orientalis* (3.32%). The dominant *R. indicus* represented by 5.5% of mature males, 6% immature males, 1.6% spent females, 2.6% females with eyed larvae, 5% females with eyeless larva, 1.8% females with eggs, 31.7% immature females and 45.8% juveniles. *M.zeylanica* was constituted by 26.6% of mature males, 19% immature males, 1.3% spent females, 3.8% females with eyed larvae, 15.2% immature females and 34.2% juveniles. The density of *M. orientalis* in this swarm was 1600/1000m^3 individuals and constituted by 6.3% of mature males, 6.3% immature male, 6.3% spent females, 6.3% immature females and 75% juveniles.

Brood characteristics

The numbers of embryos or larvae in the marsupium of different size groups of females during different periods of the year were examined. Brood number in relation to size of incubating female and developmental stage for *Rhopalophthalmus indicus* is shown in Table 6.7. The number of young ones carried by females within a range of body lengths are shown in (Table 6.8).

The brood size was positively correlated with female body length ($P<0.05$) (Fig. 6.18). The minimum number of brood recorded was six in 8.3 mm females and maximum was 13 in 10.7 mm females. The eggs (early embryo) had size variation ranging from 0.42 to 0.47 mm, irrespective of female length. The maximum number of brood observed is thirteen.

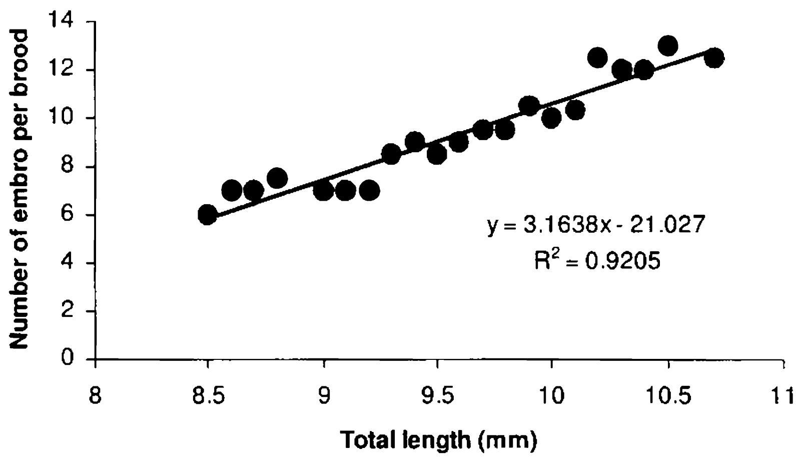


Figure 6. 18. Relationship between female length and brood size of *R. indicus*.

Marsupial development

The complete larval development of mysids takes place within the brood pouch of females and can be divided into three phases; egg, eyeless larvae and eyed larvae (Mauchline, 1980). The eggs cannot be called eggs in the strict sense since they are already fertilized before they reach the marsupium (Quddusi and Nasima, 1995). They are actually stage 1 larvae or early embryos.

Various workers used different terminology for these phases and in the present study has adopted the description of Mauchline (1980), namely eggs or early embryos (Stage-1), eyeless larvae (Stages 2-6) and eyed larvae (Stages 7-9).

Sub divisions for the above mentioned last two phases were particularly on the basis of morphological changes, on which basis 9 stages can be recognized in the marsupial development (Plate 6.3a-i). From the examination of 52 - berried females, 17% females with eggs (early embryo), 52.8% with eyeless larvae and 30.2% eyed larvae were obtained.

Stage 1

Fertilized eggs and embryos ranged from 0.5 - 0.6 mm in diameter. These egg-bearing females had a length range of 8.5 to 10.2 mm. The yolk globules were more or less spherical or somewhat polygonal.

Stage 2

During hatching (out of the egg membrane) the embryo presumably shoots out abdomen first, in which the abdomen was seen protruding from the egg. In this stage, larvae look like a "comma" and has only1 to 1.2 mm length. Four tube like or conical structures appear in the middle of the body.

Stage 3

Yolk mass markedly concentrated towards the anterior region of the larvae. Length of tube like structures were found to be increase (rudimentary antenna and antennules). Posterior end became more pointed and size of the larva ranged between 1.3 to 1.5 mm.

Stage 4

The anterior part of the larval body clearly go to bend inwards. Posterior part of the abdomen becomes narrow. Marking of the thoracic appendages appeared. At this larval stages had 1.5 to 1.7 mm length.

Stage 5

The posterior part of the abdomen becomes narrower. The size of the anterior region was markedly reduced. Rudiments of thoracic appendages became clearer and the body segmentation go to started. At this stage larvae were 1.6 to 1.8 mm in length and eyeless.

Stage 6

The thoracic appendages were free. Length of antennae and antennules were increased. Yolk was fully concentrated in the anterior region, as segmentation progressed. Formation of exopod and endopod started in the uropod. Posterior pointed end of the body became some what rounded. In this stage the length ranged from 1.8 to 1.9 mm.

Stage 7

Development of eyestalk with a patch of cornea on its tip was observed. Antennae and antennules became clearer and have more length. Body segmentation became clear. The anterio dorsal region had a very prominent bulge of yolk. Endopod and exopod were separated from uropod with setae on the posterior regions. Setae also occurred on the tips of the thoracic appendages. Telson appeared without spines. In this stage, the body length ranged between 2 to 2.2 mm.

Stage 8

Eyestalk was more developed, cornea become more thickened and clear. Body became more or less straight. Antennae and antennules were clearly observed. The amount of yolk present in the anterior part got reduced markedly. The length of thoracic appendages increased. The abdominal region becomes quite clear, the eyes were clearly pigmented and segmentation was completed. Pair of small bud like structures (rudimentary pleopod) occurred in the abdominal segments. Length remains same as that of stage 7.

Stage 9

The size of the individuals increased and yolk got completely encircled in the digestive tract. Statocyst also appeared in this stage. The appendages were quite developed and larvae become miniature of the adult, which is ready to be liberated. The longest larva measured were 2.5mm from the base of the eye to the posterior margin of the telson.

Post-marsupial development

Total length of the smallest free swimming individual was2.5mm and the largest juvenile measured 5.6 mm (Table 6.9). Immature stages exists in the length range of 5.8 to 9.2 mm, eventhough males mature at 8.6 mm and can be easily distinguished by the absence of setae on masculins in antennules. Immature females had length range of 5.4 to 8.6 mm, formation of marsupium started in this stage and the oostegites present as four separate lamellae (anterior and posterior) but did not joined ventrally. As body size increases, the oostegites become larger and fringed with setae, posterior pair of lamellae tightly over lapping anterior pair to form a compact pouch. The appearance of eggs in the marsupium was observed, when the body attained length of 8.5 to 10.2 mm. The eyeless and eyed larvae occurred in the length range 8.3 to 10.4 mm and 9.3 to 10.7 mm respectively. Spent females appeared in the length range of 10 to 10.8 mm. Females were larger than males. Both sexes attain their longest size during premonsoon period (Table 6.10), female ranging up to 10.8 mm and male up to 10.3 mm in total length.

Table 6. 8. Number of young ones carried by females of different size classes of *R. indicus* in the Cochin backwaters in different months

Size class	M	A	M	J	J	A	S	O	N	D	J	F
8- 8.5	6,7	-	7,8		-	-	-	-	-	-	-	-
8.6- 9	7	6,8	7		-	-	-	-	-	-	-	6
9.1- 9.5	-	7,8	9	8,9	-	-	-	-	-	-	9	7
9.6- 10	9	10	7,9	9	-	-	-	-	-	-	8,9	10,11
10.1- 10.5	13	12,13	-	-	-	-	-	-	-	-	-	-

Table 6. 9. Length variations (min-max) among different stages of the *R. indicus.*

Different stages		Length range (min-max) (mm)
	Juveniles	2.5- 5.6
Male	Immature	4.2- 9.2
	Mature	8.6- 10.3
Female	Immature	5.4- 8.6
	with egg	8.5-10.2
	with eyeless larvae	8.3-10.4
	with eyed larvae	9.3-10.7
	Spent	10-10.8

Table 6. 10. Variation in length (mm) of different age groups of *R. indicus* in different months.

Month	IM	MM	SF	ED	EL	EG	IF	J
March ' 03	6.5-8.9	6.6-8.9	10-10.5	10.3-10.7	8.5-9.5	8.5-10	7.4-7.8	3.2-4.3
April	7.5-9	9.8-10.3	10.2-10.8	9.3-10.2	9-9.2	8.8-10.2	5.7-8.2	3-5.2
May	7.2-8.4	9.3-9.5	10-10.3	9.8-10	8.3-9.2	8.6-9.9	5.8-8	2.5-4.7
June	6.3-8	9.7-9.8	-	9-9.4	-	9-9.7	6-7.2	3-5.6
July	6.3-9	9.2-10	-	-	-	-	5.9-6.7	4.2-5
August	-	8.8-9.7	-	-	-	-	5.4-5.9	-
September	-	-	-	-	-	-	-	-
October	6.9-8.7	-	-	-	-	-	-	-
November	5.8-8.6	9-9.4	-	-	-	-	5.8-6.7	3.2-5
December	6.8-8.2	8.6-10.3	-	-	-	-	6.3-8.4	3.4-4.8
January '04	6.9-7.8	8.8-10.2	-	-	-	9.2-9.6	8.2-8.6	2.5-5.2
February	6.7-9.2	9-9.2	-	-	9.2-10.4	8.9-9.7	5.6-8.3	3.4-4

IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles

Subfamily HETEROMYSINI Hansen

Genus *Kochimysis* Panampunnayil and Biju

Kochimysis pillaii Panampunnayil and Biju

Occurrence: Stations WS2 and TS2

A new genus and species of *Kochimysis pillaii* is recorded during the present study and the taxonomic details have already been published (Panampunnayil and Biju 2007) and hence are not dealt with here.

Seasonal distribution reproductive biology and ecology

Kochimysis pillaii contributed only 0.59% to the total population and was observed only at Bolghatty station during pre monsoon period. In this season, they contributed 1.5% with an average density of 29.1± 42.1/1000m^3, constituted by 20.3% immature males, 26. 6% mature males 10% spent females 11.6% females with eggs and 31.6% juveniles. Seasonal distribution plotted in Fig. 6.19 and percentage compositions are shows in Fig. 6.20.

In February, *K. pillaii* was constituted by 33.3% immature males, 33.3% mature males and 33.3% females with eggs. Mature males were present only in March. In April, it was constituted 31.8% immature males, 31.8% mature males and 36.4% spent females. While in May, only juveniles were present.

Body length and brood characteristics

The length of smallest free-swimming larvae had only 1.3 mm and total length of the mature males ranged from 3.3-3.5 mm. (Table 6.11) They started to carrying eggs at a length of 3.3 mm and spent females had the same length. Longest mature male occurred during March and April (Table 6.12). It carried 5 eggs (size of 0.3 mm) in their marsupium and preferred temperature and

Table 6. 11. Length variations (min-max) among different stages of the *K. pillaii.*

Different stages		Length range (min-max)\ (mm)
	Juveniles	1.3
Male	Immature	2.6
	Mature	3.3- 3.5
Female	Immature	-
	with eggs	3.3
	with eyeless larvae	-
	with eyed larvae	-
	Spent	3.3

Table 6. 10. Variation in length (mm) of different age groups of *K. pillaii* in different months.

Months	IM	MM	SF	ED	EL	EG	IF	J
March '03	-	3.5	-	-	-	-	-	-
April	2.6	3.5	3.3	-	-	-	-	-
May	-	-	-	-	-	-	-	1.3
June	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-
January '04	-	-	-	-	-	-	-	-
February	2.6	3.3	-	-	-	3.3	-	-

IM- immature males, MM- mature males, SF- spent females, ED- females with eyed larvae, EL-females with eyeless larvae, EG- females with eggs, IF- immature females, J- juveniles

6.3.3. Diel and tidal variations of mysids

A total of four mysid species, *R. indicus* Pillai, *M. zeylanica* Nouvel, *M. orientalis* Tattersall and *K. pillaii* Panampunnayil and Biju were recorded during the time series (24hr.) sampling period in March, while in October all

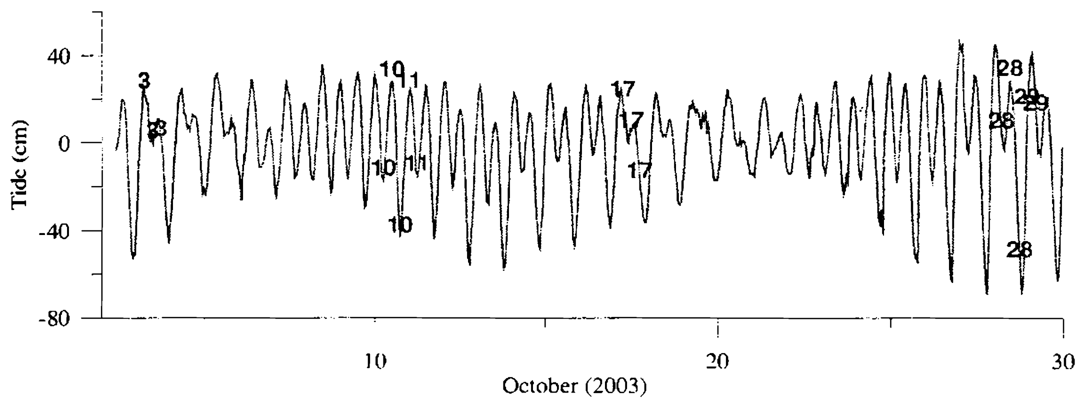


Figure 6. 22. Tidal observation in the month of October (2003) showing the periods of zooplankton sampling.

Table 6.12. Average population density (No/1000m^3) of mysids in the flood and ebb tides during March 2004

Tides	*M. orientalis*	*M. zeylanica*	*R. indicus*	*K.pillaii*
Night flood	296.6 (± 254.8)	1462.2 (± 1966.7)	13082.8 (± 24069.3)	-
Night ebb	235.8 (± 212.7)	694.1 (± 659.3)	5717.9 (± 6262.4)	14.4 (± 28.8)
Day flood	96.3 (± 119)	160.5 (± 165.9)	32.9 (± 40.5)	-
Day ebb	65.0 (± 43.1)	107.5 (± 148.7)	622.6 (± 1075.2)	-

Table 6. 13. Average population density (No/1000 m^3) of mysids in the flood and ebb tides during October 2003

Tides	***M. orientalis***	***M. zeylanica***	***R. indicus***	***K.pillaii***
Night flood	194.73 (± 178.6)	481.24 (± 721)	59.31 (± 61.8)	-
Night ebb	215.27 (± 281.9)	637.27 (± 955.4)	58.95 (± 111.7)	-
Day flood	98.70 (± 136.1)	83.66 (± 83.5)	2.17 (± 83.7)	-
Day ebb	24.88 (± 43.1)	19.76 (± 36)	51.50 (± 63.9)	-

6.3.4. Statistical analysis

Mesopodopsis orientalis

The fitted multiple regression model for the data is $y = 1309.398 - 25.678x_1 - 3.525x_2 - 41.648\,x_3 - 13.128x_4 + 1.269x_5$

In this regression model, the variables, dissolved oxygen, salinity, *p*H and water temperature are having negative impact on population density of *M. orientalis*. Only chlorophyll is having positive impact. The fitted regression model for the data is significant and it could be seen from the ANOVA. Eventhough the fitted regression is significant (Table 6.14) it explains only 13.5% of the variability in the data.

Table 6. 14. ANOVA for environmental parameters with population density of *M. orientalis*

Source	SS	df	MS	F	P- value
Regression	995742	5	199148.451	3.473	$p < 0.01$
Residual	6364132	111	29.62		
Total	7359874	116			

Mesopodopsis zeylanica

The regression equation of best fit for the data is $y = 607.04 - 6.435\,x_1 - 6.530\,x_2 - 30.562\,x_3 + 16.515\,x_4 + 1.121\,x_5$.

The fitted regression is significant as it could be seen from the Table.6.15. The only significant variable in the regression is salinity ($p>0.05$), which is having negative impact on population density.

Only 12.6% of the variability in the data is explained by the fitted model.

Table 6. 15. ANOVA for environmental parameters with population density of *M. zeylanica.*

Source	SS	df	MS	F	P- value
Regression	1439178	5	287835.593	3.211	$p < 0.05$
Residual	9950431	111	89643.525		
Total	11389609	116			

Rhopalophthalmus indicus

The regression model, $y = -1322.681 + 63.631\ x_1 + 6.856\ x_2 - 135.959\ x_3 + 56.304\ x_4 + 0.644 x_5$ fitted to the data is significant ($P<0.001$) (Table 6.16).

The fitted regression explains 48.2% of the variability in the data. Significant variables in the prediction model were pH followed by water temperature, salinity and dissolved oxygen. Water temperature, salinity and dissolved oxygen are having positive impact in the prediction model and *p*H is having negative impact.

Table 6. 16. ANOVA for environmental parameters with population density of *R. indicus.*

Source	SS	df	MS	F	P- value
Regression	4933374	5	986674.872	20.69	$p < 0.001$
Residual	5293379	111	47688.095		
Total	1022673	116			

Kochimysis pillaii

The fitted model for the data is $y = -4.629 + 0.684\ x_1 + 0.302\ x_2 - 3.937\ x_3 + 1.681\ x_4 - 0.00649\ x_5$. The fitted model is significant (P<0.01) as it is evident from the Table. 6.17. The fitted regression only addresses 16.2% of variability in the data. Significant variations in the prediction equations were *p*H and salinity. *p*H is having negative impact while sanity is having a positive impact.

Table 6. 17. ANOVA for environmental parameters with population density of *K. pillaii.*

Source	SS	df	MS	F	P- value
Regression	4256.534	5	851.307	4.305	$p < 0.01$
Residual	21950.252	111	197.750		
Total	26206.786	116			

6.4. DISCUSSION

Physico- chemical parameters

The study of hydrographraphical parameters of the estuarine environment is of great importance to characterize the general features, distribution pattern and relative abundance of nutrients. The hydrographical condition in an estuary mainly depends on the intrusion of seawater and influx of fresh water from rivers.

Temperature is a factor of prime importance in the physical environment of organisms. This has a universal influence controlling the activities and distribution of animals. The temperature of estuaries affects the physical properties of waters. Density, vapour pressure, surface tension, viscosity, solubility, diffusion of gases etc. and temperature variations often cause stratification of water. The distribution of temperature in estuarine region depends on the flow of fresh water from rivers (Sankaranarayanan and Qasim, 1969), the mixing of tidally influenced sea water (Ramamirthan and Jayaraman, 1963) and process like exchange of heat from atmosphere and other localized phenomena.

However, tropical estuaries experiences only limited fluctuation in temperature, comparatively low temperature was observed in Fort Cochin due to the intrusion of comparatively cooler water from the open ocean due to the tidal cycle. Compared to that of other stations, Fort Cochin is subjected to the maximum tidal effect. The influence of fresh water in to the estuarine system is not the sole factor influencing the water temperature in the estuary but the influx of cold water from the sea may be also a significant factor (Sankaranarayanan and Qasim, 1969). The seasonal average was high during premonsoon compared to monsoon and postmonsoon. Many workers (Nair and Tranter, 1972; Kumaran and Rao, 1975; Balakrishnan and Shynamma, 1976; Joseph, 1988; Sivadasan, 1996 and Sheeba, 2000) have reported high water temperature during premonsoon in the Cochin estuary.

Salinity is considered as an important parameter in an estuarine habitat and the environment remains vigorous because of extreme changes in salinity. Wide fluctuation in salinity values was observed in estuaries from almost marine conditions to strictly fresh water conditions. Salinity in the estuaries usually depends on the intrusion of seawater through bar mouth, discharges of fresh water from rivers, isolated rainfall and evaporation etc.

A distinct seasonal pattern was observed for salinity distribution. The extreme drop in salinity near to fresh water conditions was observed during monsoon due to the dilution by large amount of fresh water influx. High salinity at Fort Cochin during monsoon seasons compared to that of other stations may be due to the intrusion of seawater during the tidal cycles. Nair *et al.* (1988) observed very large spatial variations of salinity in the three areas of study in Cochin backwaters ranging from 0.24 to 31 X 10^{-3} controlled by tidal and monsoonal flow and shallowness of the area.

Many of the life process depend on the hydrogen ion concentration in the surrounding medium. The pH of the medium depends on factors like photosynthetic activity, discharge of industrial effluents, nature of dissolved materials, rainfall etc. Variation in pH due to the chemical and other industrial discharges renders a stream unsuitable not only for recreational purpose but also for rearing of fish and other aquatic life (Webb, 1982).

The industrial effluence discharged in to the aquatic system may significantly lower or elevate the *p*H of water depending on the nature of the effluents (Sheeba, 2000). The low variation in the *p*H in the Fort Cochin stations may be due to the influence of seawater intrusion and wide range of fluctuations in the Bolghatty and Thevara may be due to the intermittent discharge of industrial effluents.

Dissolved oxygen content of water is a vital water quality parameter and is linked with the health of aquatic life. The amount of dissolved oxygen in natural water depends up on temperature, salinity, turbulence of water and atmospheric pressure. Johannassen and Dahl (1996) have reported decline in dissolved oxygen as a result of increased nutrient load. The low oxygen may be due to the decomposition of organic matter present in the bottom. Dissolved oxygen content of the present study showed wide fluctuations with tide and with varying rate of tidal flow. The decomposition of organic waste and oxidation of inorganic waste may reduce the dissolved oxygen to extremely low levels (Sheeba, 2000). In the present study, low level of DO were observed in premonsoon period due to decomposition of organic waste present at the bottom brought in to the system during monsoon and postmonsoon.

Chl *a* is the green pigment in plants that provides most of the plants colour and supports photosynthetic pigments. Chl *a* can be considered to estimate phytoplankton productivity and biomass. The standing crop of phytoplankton indicates the availability of food for animals at the primary level. Seasonal distribution of Chl *a* shows high values during monsoon periods, which may be due to the nitrogenous input that comes through monsoonal river flow.

Seasonal distribution and reproductive biology

Mesopodopsis orientalis

M. orientalis is a euryhaline and eurythermal form, commonly found in the backwaters and estuaries of both east and west coasts of India (Panikkar & Aiyar, 1937; Devasundarum and Roy, 1954; George, 1958; Pillai, 1968). This species is also recorded from the prawn ponds of Singapore Island and the fish rearing lagoons of Java (Ii, 1964). Panampunnayil (1999a) recorded this species from saltpan of Mumbai (India) on salinity and temperature of 1.2-63.6 psu and 23.5-37°C respectively. This species also reported from the inner reaches of rivers where the water is almost fresh (Panikker and Aiyyer, 1937; George, 1958). Belyaev (1949), Remane and Schlieper (1958), McLusky and Heard (1971) revealed that euryhaline species are well adapted to live in an environment with wide fluctuation in salinity by their capacity to prevent excessive changes in their internal environment by maintaining its blood concentration hyper/hypo osmotic to the medium. A series of experiments were carried out by Battacharya and Kewalremani (1972) and Battacharya (1982) to ascertain the reaction of the adult and juveniles of *M. orientalis* to varying salinities at different temperatures. The salinity toleràance range of this species in the backwaters (0- 34.25) is more or less similar to laboratory data (1.75-35).

Although *M. orientalis* have been found through out the year in back waters and estuaries ((Panikkar and Aiyar, 1937; George, 1958), peak period of abundance synchronize with period of low salinity (George, 1958); large number of ovigerous females and juveniles were observed during this period. It has two reasons, one is related to reproduction. Second is coinciding with less predation. Estuaries are the breeding ground of many fishes and prawns (George, 1958; Rao, 1970; Jhingran, 1975). During monsoon periods these animals migrate to coastal waters from estuaries and breed there because the juveniles may not be able to survive in estuaries, where the salinity is less in rainy season. Adults and juveniles of *M. orientalis* occurred in great abundance during monsoon period and also occurred in premonsoon and post monsoon periods, but was less abundant (Bhattacharya and Kewalrami, 1972). Presence of juveniles *M. orientalis* through out the year suggests that breeding is continuous and can survive and reproduce at a wide range of salinity (0-34.25 psu). The failure to collect brooding females all months may be due to the low densities and migratory nature or it may be due to predation.

An analysis of the population structure of *M. orientalis* demonstrates the difference in length composition of population and reproductive condition of the species. In male the secondary sexual characters start to develop at a length range of 4.2 mm and attain sexual maturity at a total length of 5.2 mm, where as in female the secondary sexual characters starts to develop at a length of 4.3 mm and sexual maturity is attained at total length of 4.5 mm. Some immature female collected in May was larger than the ovigerous female collected in the same month indicating that total length does not determine maturity.

Eventhough large females carried more young ones, the number of young carried by female of equal body length also varied. The number of brood carried by females ranged from 7 to 12 and the brood was in different stages of development. Hanamura *et al.* (2008) reported 8 embryos in *M. orientalis* collected from Mebok estuary. Nair (1939) recoded the number of eggs carried by female as 8-10, while Panampunnayil (1999a) recorded 6-29 eggs or larvae in *M. orientalis* collected from coastal regions of Mumbai. These observations indicate that there is a variation in the number of broods carried by *M. orientalis* of different population. Hanamura *et al.* (2008) reported that estuarine population bears large sized and smaller number of eggs, while those of the coastal waters showed vice versa. Nair (1939) has described in detail the formation and extrusion of eggs in *M. orientalis.* The incubation period is not more than 96 hours at 25-29°C and the female then molts and immediately lays eggs again. In mysids shortest duration (4 days) of marsupial development is reported for *M. orientalis* while *Mysis relicta* the cold-water species has the longest (150-170 days) reported developmental time. The pattern of reproduction and succession of generation vary between different species and between populations of the same species at different latitude. The dependence of species on the environment may provided mechanism for generating environmental dependent adaptive strategies, namely changing the reproductive patterns, which would allow a species to cope with seasonal variations in its environment (Johnston and Northcote, 1989; Lehtonen, 1996).

Since in *M. orientalis,* breeding goes on all the year round many brood must be produced by a single female as instanced by the presence of 2-3 size classes of juveniles in most of the collections, which suggests the occurrence of two (biovoltinism) or three (trivoltinism) generations per year, but how long a single individual lives is not known. The population consists of mixed age groups due to continuous reproduction and hence makes it impossible to trace the development of a particular group through maturity due to the overlapping of generations. It may be that the life of such a female is shorter than that of the more slowly breeding cold-water forms (Mauchiline, 1980).

Mesopodopsis zeylanica

During the study period, *M. zeylanica* was the dominant species. This species is common along the west coast of India (Pillai, 1961). The presence of breeding female and juveniles through out the year indicate that this species breeds through out the year, but there is a seasonal variation in the intensity of breeding. Although reproduction and recruitment were continuous through out the year, main peak was observed in monsoon period. A minor peak was also recorded in premonsoon period. Such recruitment pattern suggests the occurrence of two (bivoltinism) or three (trivoltinism) generation per year. The percentages composition indicated the dominance of juveniles in most of the samples.

The size range for all specimens measured was 1.4 -7.4 mm. The largest gravid female occurred in March (7.2 mm) and the smallest in June. In other words the fully-grown species reach a length of 7.4 mm, though sexual maturity attained even at a smaller size (4.8 mm) indicating that growth continues even after attaining sexual maturity.

In male, secondary sexual characters start to develop at a length of 4.2 mm and attain sexual maturity at a total length of 5.2 mm. Whereas in female the secondary sexual characters start to develop at a length of 4 mm and generally attain sexual maturity at a total length of 4.8 mm.

The number of brood, carried by females varied between 7 to 11 mm.. Though larger females carried more young ones, the number of young ones carried by females of equal body length also varied.

Rhopalophthalmus indicus

The presence of different size class and maturity groups, especially, large percentage of brooding females and normal marsupial developments indicate that *R. indicus* has adapted to exist in the estuarine water through out its life cycle. The abundance of *R indicus* is positively correlated with salinity. According to Daly and Damker (1986), salinity is often the single most important physical factors affecting the population abundance of mysids in the estuary. Mesozooplankton biomass showed a clear seasonal variation due to their osmoregulatory behaviors, with minimum during summer monsoon increasing progressively with salinity to peak during premonsoon (Madhupratap, 1987).

The abundance of brooding females during high saline premonsoon period indicates that salinity plays an important role in the development of its marsupium. The occurrence of juveniles and immature stages from premonsoon and postmonsoon period reveals that, it has two alternate generations.

In male, the secondary sexual characters started to develop at a length range of 5.8 to 9.2 mm and sexual maturity attained at a total length of 8.6 mm. Where as in females the secondary sexual characters starts to develop at a length of 7.3 mm and sexual maturity at a total length of 8.5 mm. Mauchline (1980) reported, the egg number is highly related with body size and seasons in mysids, although other factors are important, as evidenced by the present results. The embryos with in a brood were at the same stage of development although individual broods were often at different stages of development, indicating synchrony with in a brood, but asynchronous development in the population. According to Mauchline (1973), the ratio in which larvae occur among this brood should reflect the length of time that the larvae take to pass through each stage, if the brooding females have been fairly sampled. Thus, the present data suggests that the eyeless larvae taken longest duration in the developmental stages.

Kochimysis pillaii

K. pillaii occurred only during premonsoon period and was found only at Bolghatty. Presence of all life stages during this period suggests that high saline period is suitable for their breeding. Eggs are formed in the marsupium at a length of 2.6 mm and their brood size was 5.

Species abundance

The fitted regression equation is significant for the data, it explains only little amount of variability in the data except for *R. indicus*. This may be due to the fact that there are other important variables, which control the population density of mysids in the Cochin Backwaters. Between three stations, the population density has some considerable variations. This may be coinciding with the geographical conditions of particular stations. According to Heubauch (1969) reproduction was the principal factor affecting the seasonal and geographical abundance. But the present data reveals that, in addition to reproduction other factors play an important role in species abundance. Breeding peak of *R. indicus* occurred in premonsoon seasons. Its total absence in the Fort Cochin station during premonsoon is a matter of concern. This may be due the effect of tidal current of that particular area. Fort Cochin (bar mouth) is one of the highest tidal effect area of the Cochin backwaters. Many workers described the influence of tidal current on the distribution of zooplankton and mysids. (Heubach, 1969; Wooldridge and Erasmus, 1980; Wooldridge and Bailey, 1982; Hill, 1991; Hough and Naylor, 1991; 1992; Moffat and Jones, 1993; Rost *et al.,* 1998). The abundance of *M. zeylanica* and *M. orientalis* of Fort Cochin station was very low when compared to that of other two stations.

Diel and tidal variations of mysids

Time series study reveals that mysid density was more during night hours. Many reports (Zaret and Suffern, 1976; Ohman *et al.,* 1983; Gliwicz and Pijanowska, 1988, Lalli and Parsons, 1997, Mauchline, 1980; Murano, 1999a; Grossnickle, 1979; Webb and Wooldrige, 1988; Takahashi and Kawaguchi, 1997, 1998) show that, mysid species are more active at night. In October the percentage of mysids during day collection (14.2%) was more compared to day collection of March (4.8%), may be due to the high intensity of light during premonsoon periods. Most of the mysids undergo circadian changes of their position in the water column, usually migrating from above (or within) the sediment during the day to surface waters during the night (Mauchline, 1980; Murano, 1999a). Most mysid species are planktivorous feeders, with a clear rhythm of activity that has its maximum during night hours (Grossnickle, 1979; Webb and Wooldrige, 1988; Takahashi and Kawaguchi; 1997, 1998).

The night time abundance is closely associated with the vertical migration of mysids. Many mysids follow clear circadian rhythms of occurrence in the water column. Circadian rhythms in pelagic organisms are usually related to the combined benefits of feeding in shallow eutrophic layer and evading predators in deep and dark environments (Zaret and Suffern, 1976, Ohman *et. al.,* 1983; Gliwicz and Pijanowska, 1988; Lalli and Parsons, 1997). According to Takahashi and Kawaguchi (1998), vertical migration of mysids has been associated with circadian feeding rhythms, predator avoidance and inter/ intraspecific competition reduction. In shallow environment, mysids do not have the possibility to hide in dark layers during day time, but burrowing into the sediments may be one way out to escape predators (Danilo *et al.,* 2001). These observations imply that nocturnal swimming and feeding may represent a trade between food in take and mortality by predation. Large number of *M. zeylanica* were observed in the gut of *Etroplus suratensis* (fish) (Varghes, 1981) and *M.orientalis* are known to be a food item for estuarine fishes like *Megalops cyprinoids*, *Polynemus tetradactylus* and the prawn *Parapenaeopsis stylifera* (Rao, 1970; Jhingran, 1975).

Eventhough variation in the population density of mysids during the seasons are related to breeding of mysids, tidal phases (ebb and flood) very much influence the diel distribution pattern of mysids in the Cochin backwaters. Compared to that of October collection, March showed high density due the active breeding of mysids, but their abundance during day and night very much influenced by tidal characters/phase in those months. Changes in the density of different mysids with respect to the direction of tidal flow suggest some variation in the distribution of various mysid species. The variation in abundance of *R. indicus* and *M. zeylanica* during ebb and flood tides, suggesting that their distribution may extent in to marine environments with high density. Limited difference in the density drifting of *M. orientalis* with respect to ebb or flood tides suggests that the species is evenly distributed between marine and estuarine environment of the system. Such a pattern is consistent with previous studies, which showed *M. orientalis* to be widely distributed through out the shallow coastal waters of Mumbai (Panampunnayil, 1999a). Pillai (1961) reported that high abundance of *M. orientalis* occurred in east coast, while the common species along the west coast is *M. zeylanica*. Water exchange at the mouth of estuaries may favor significant migration between mysid populations inhabiting the coastal area and those living in the estuary (Danilo *et al.*, 2001). In studying populations from this type of environments is important to assess the degree of interaction between the population under study and those of adjacent areas in order to distinguish real from apparent increases in its numbers (Mauchline, 1980); real increase result from breeding and population of young while apparent increases can result from immigration. Migration of coastal population of mysids into and out from the estuary take place according to the characteristics of prevailing water masses (Danilo *et al.*, 2001).

The phases and the character of tides very much influence the population distribution pattern of mysids. These confirm the data sets of March and October. In March, the mysid density follows the trend of mixed semidiurnal tides. While in October, weak mixed predominantly semidiurnal tides decrease the variation of mysid density in ebb and flood tides because high density of mysids not entering from adjacent coastal areas of estuary due to weak tides. According to Menon *et al.*, (2000), during postmonsoon period (October to January), the river run off gradually diminishes and tidal influences gains momentum as the estuarine conditions change to partially mixed type. This is clearly evident in the ebb and flood collection in October, during which *R. indicus* and *M. zeylanica* occurred in more or less similar density In short, mysids abundance clearly depend upon phase of tides (ebb/flood), character of tides (semidiurnal / diurnal), vertical migration (day and night variation), breeding activity etc.

In the present study *Mesopodopsis orientalis* and *Rhopalophthalmus indicus* showed swarming behavior. Mauchline (1980) suggests a number of advantages associated with swarming behavior including protection of individuals and population against predators and facilitation of breeding. Mysids decrease predation risk by forming swarms. Mysids in swarm have not been observed to be consumed by fish (Emery, 1968; Hahn and Itzkowitz, 1986). Whereas those removed by a net and artificially displaced from their swarm have been attacked and eaten by predator (Hahn and Itzkowitz, 1986). Modline (1990) reported that swarming by itself might deter predation. According to Ritz *et al.* (2001), the swarm represents a strategy for conserving energy and maximize food capture, his work clearly confirms the energetic benefits of being a larger social group rather than a smaller one or remaining solitary. Most of the swarms were observed during night. In general, mysids are attracted to weak source of light but avoid bright light. Bright light often inhibits the swarming behavior (Steven, 1961) and may damage their large sensitive eyes (Lindstrom, 2000).

Chapter 7

DNA barcoding and Biochemistry of mysids

7.1. DNA BARCODING

7.1.1. Introduction

Taxonomy, the science of naming and classifying organisms is the foundation of biology. Good taxonomy with correct identification of the species along with its ecological and evolutionary interpretation plays an important role in integrated pest control programs, and the conservation of biodiversity (Godfray *et al.*, 2004; Samper, 2004). DNA (Deoxyribonucleic Acid) barcoding is based on the premise that sequence diversity within a standardized segment of the genome can provide a "biological barcode" that enables identification at species level (Marshall, 2005). With the development of this technology for the production of molecular sequences, DNA taxonomy and barcoding arose as a new tool for evolutionary biology. DNA barcodes are particularly useful in studies of zooplankton, because the organisms are frequently rare, fragile, small and scattered throughout the pelagic realm (Bucklin *et al.*, 2007). DNA barcoding provides an efficient method for species level identification and as such, will contribute powerfully to taxonomic and biodiversity research (Hajibabaei *et al.*, 2007). The term, DNA barcoding is used to describe efforts to use the mitochondrial cytochrome *c* oxidase subunit I (mtCOI) gene as a molecular marker to allow easier and more efficient identification of specimens of known and unknown species. The mtCOI is sufficiently variable to be useful to identify and discriminate the most closely related species, and also detect genetic divergence of conspecific populations associated with geographic isolation and cryptic speciation (Bucklin *et al.*, 2007). The barcoding organizations may note that taxonomists have identified only about 15 percent of all living species over the past 250 years, and the rapid loss of biodiversity worldwide adds urgency to their task. DNA sequencing is becoming a reliable tool to confirm species identifications for taxonomic, ecological and evolutionary studies. It helps to uncover the phylogenetic affiliations among different taxa. The result obtained from DNA barcoding can also help to identify species that are good target for more detailed genetic analysis. At present the traditional taxonomist are very rare and substituting new expert will take many years of training. Traditionally, the identifications of larval forms require an experienced taxonomist, and involve detailed examination of samples under a microscope to identify species based on specific characteristics. Most of the larval forms show developmental variability. Phenotypic plasticity (Hebert, 2002) is a common phenomenon and many larvae are easily damaged during collection, leading to a large degree of uncertainty in identification. Erroneous identification could mislead our views of speciation, diversity, niche partitioning, and many other features of ecosystems. In this case, molecular taxonomy is expected to provide a 'universal key' that will allow identification of species by running unknown DNA sequencing through a DNA barcode database.

A 650 bp segment of the mtCOI gene has been adopted as the DNA barcoding system for animal life (Folmer *et al.*, 1994) and has been particularly used for species identification and some times classification of diverse taxa (Hebert *et al.*, 2003). As a result of declining cost and increasing ease of DNA sequencing, the development of a barcode library promises to create a system for the rapid identification of animal life. In taxonomy, DNA barcoding can be used for routine identification of specimens; and it can also flag typical specimens for comprehensive taxonomic investigation (Hajibabaei *et al.*, 2007). The use of mtCOI sequences as DNA barcodes has proven useful for marine animal species, especially crustaceans (Quan *et al.*, 2001; Vainola *et al.*, 2001; Porter *et al.*, 2005).

7.1.2. Results

The mitochondrial gene, cytochrome oxidace subunit I of the two mysids species *Mesopodopsis orientalis* and *Rhopalophthalmus indicus*, collected from tropical estuarine environment were amplified using the Universal COI primers. These fragments were completely sequenced and aligned with sequencher 4.8 software and deposited in NCBI database (*http://www.ncbi.nlm.nih.gov*) (Accession number: EU717686 and EU717687 respectively). PCR products obtained from mitochondrial control region of mysids were approximately 680bp (Fig. 7.1.1). DNA sequences of *M. orientalis* and *R. indicus* are shown in figure 7.1.2 and 7.1.3.

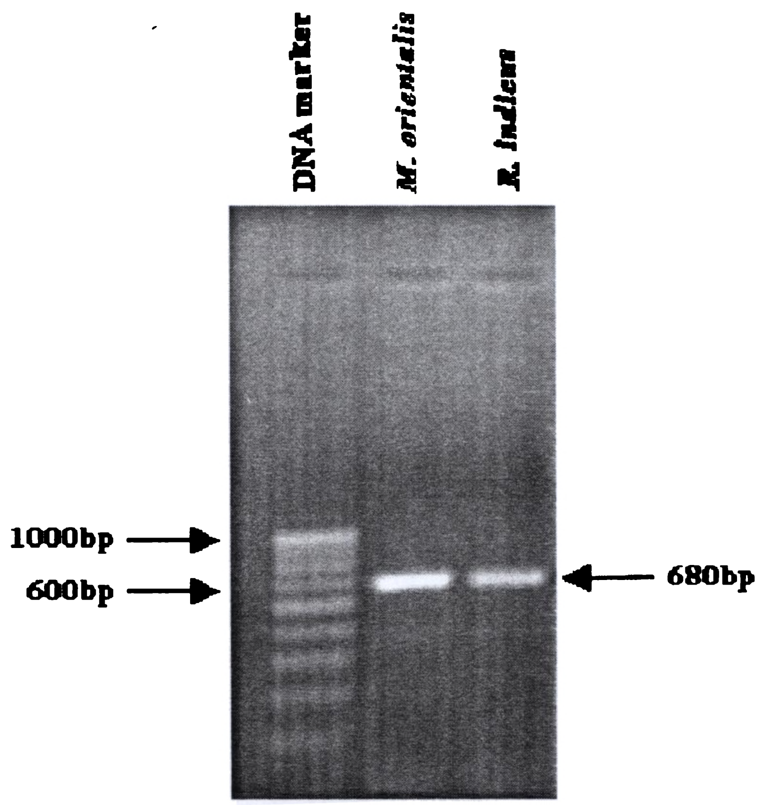


Figure 7.1.1. PCR products obtained from the amplification of the mitochondrial control region of mysids.

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  1 gaacacttat ttattcctgt gctgagctgg atgttgtact tctttaagcc
 51 atcttggaat tatttagagc ttgggcagcc agggtctcta attggagacg
101 atcagatcta caatgtagtt gtcactgcgc atgcttttat tataattttt
151 tttatggtaa tgcctgctat aattggtggg tttgggaact gacttgtacc
201 gattatattg ggtgcacctg acatggcttt tcctcgtatg aataatataa
251 ggttctggct cctcccccct tctcttaggt tacttttact tagggggata
301 gtggagagag gggtaggtac tgggtgaacg gtttatcctc ccctttcttc
351 taatttgtct catgctgggt ctgctgtaga tatgggtatt ttctccttac
401 atctggctgg ggtttcttct attttagggg ctgtaaactt tatttcaacc
451 gtgattaaca tacggtcttg tgacataact tttgatacta ttcctttgtt
501 cgtgtggtct gtttttatta ctgcagtact tttactttta aggttgccag
551 tgctagctgg agctattaca atgcttttga cagatcgaaa tattaatact
601 tctttttgat cctgttggag gggtgaccc tattttatac cagacttgtt
651 t
```

Figure 7. 1. 2. DNA sequence of *Mesopodopasis orientalis.*

(*http://www.ncbi.nlm.nih.gov,* Accession number: EU717686)

```
  1 aaagatattg gaacaatgta ttttattttt ggtgcgtgga caggtattgt
 51 tggtacatca ttaagagctt taattcgatt agaattgagt cagtctggaa
101 cttttattgg aaatagccaa ctttataatg ttattgttac tgcacatgca
151 tttattatga ttttttttat agttatacct attatgattg gagggtttgg
201 taattgacta cttcctttaa taattggttc tcctgatata gcatttcctc
251 gaataaataa tataaggttt tgattattag ttccttcatt tattttatta
301 ctaataaggg gggctgttga gagtggagtt ggtacgggtt gaactgttta
351 tcctccttta gcttcaggat caggccatcc gggggcttct gttgatcttg
401 gtattttttc attacattta gcaggggttt cttctatttt aggggcaact
451 aattttattt ctactgtttt aaatactcga acatatggtc ttagaataga
501 taatatatct ttatttggtt gatctgtttt tattacggca attttattgc
551 ttttctcttt accggtgttt gctggggcta ttactatatt attaactgat
601 cgtaatttaa atacttcttt ctttgatcca gcaggaggag gggatcctat
651 tttataccag cattaa
```

Figure 7. 1. 3. DNA sequence of *Rhopalophthalmus indicus.*

(*http://www.ncbi.nlm.nih.gov,* Accession number: EU717687)

7.1.3. Discussion

In Indian waters, molecular taxonomic study of zooplankton is very rare. Only one Cheatognath, *Sagitta bedoti* Beraneck, 1895 (mtCOI gene) (Accession No.EU407234) collected from Cochin backwaters and one species of mysids, *Eurobowmaniella simulans* Tattersall, (18S) collected from Goa (Meland and Willassen, 2007), were subjected to molecular taxonomic study (Accession No. AM422486). Apart from this, there is no approach on molecular study on zooplankton in the Indian waters. The present study is the first attempt on the DNA sequencing of mysids in the Indian waters.

Analyzed the DNA sequence of two species, *Mesopodopsis orientalis* and *Rhoplalophthalmus indicus* belonging to the family Mysidae, collected from a tropical environment (Cochin backwater). Both these are highly abundant species in the Indian waters and play significant ecological role in the ecosystems. *M. orientalis* is a common mysid in the backwaters and estuaries of both east and west coast of India (Panikkar and Aiyar, 1937). At present the genus *Mesopodopsis* Czerniavsky contains 7 species, belonging to two morphogeographic groups, Indo-Australasian and Euro-African species. *M. orientalis* includes in former group. At present, two species of *Mesopodopsis*, *M. slabberi* and *M. wooldridgei* collected from Western Europe were analyzed at molecular level (Remerie *et al.*, 2006). *Rhopalophthalmus indicus* is also a common mysid in the backwaters and estuaries of west coast of India and endemic in the Indian waters. In the genus *Rhopalophthalnus* Illig, a total of 23 species were recorded worldwide, of which 9 species were recorded from the Indian waters. At present there is no information about the DNA barcoding of the members of *Rhopalophthalmus*, while Meland and Willssen (2007) analyzed 18s of one species *Rhopalophthalmus* (Accession No. AM 422488) collected from South Africa, but they did not give clear species name.

In the present sudy, along with our sequences, a total of 76 COI mtDNA sequences *M. slabberi* and 2 sequence of *M. wooldrigei* were taken for analysis, sequence were downloaded from NCBI; accession numbers of the sequences are AM158327, AJ966900, AJ966978, AJ966977, AJ966976, AJ966975, AJ966974, AJ966973, AJ966972, AJ966971, AJ966970, AJ966969, AJ966968, AJ966967, AJ966966, AJ966965, AJ966964, AJ96696, AJ966962, AJ966961, AJ966960, AJ966958, AJ966957, AJ966959, AJ966956, AJ966955, AJ966954, AJ966953, AJ966952, AJ966951, AJ966950, AJ966949, AJ966948, AJ966947, AJ966946, AJ966945, AJ966944, AJ966943, AJ966942, AJ966941, AJ966940, AJ966939, AJ966938, AJ966937, AJ966936, AJ966935, AJ966934, AJ966932, AJ966931, AJ966930, AJ966929, AJ966928, AJ966927, AJ966926, AJ966925, AJ966924, AJ966923, AJ966922, AJ966921, AJ966920, AJ966919, AJ966918, AJ96691, AJ966916, AJ966915, AJ966913, AJ966912, AJ966911, AJ966910, AJ966909, AJ966908, AJ966907, AJ966906, AJ966905, AJ966904, AJ966903, AJ96690 and AJ966901. The sequences were aligned using CLUSTAL X package (Thompson *et al.*, 1997) and phylogenetic analysis done by the neighbor-joining (NJ) method using MEGA (Kumar *et al.*, 2004).

Analysis of the mitochondrial COI genes sequences deposited in GENBANK revealed high levels of genetic divergence between morphologically distinguishable *M. orientalis* and *Rhaphalothalamus indicus*. These species were paired on a distinct branch in all analysis may be due to they belonging to different genus. Analysis also shows that closer affinity of *M. orietalis* with other members of the genus *Mesopodopsis* (*M. slabberi, M. wooldridgei*) (Fig. 7.1.4). Eventhough some species of the *Mesopodopsis* shows high intraspecific variations in mtCOI gene, the interspecific variations of species was very low. Remerie *et al.*, (2006) reported the high molecular diversity within the different mtCOI clades of *M. slabberi* due to habitat preference and their physiological tolerance. Low levels of mtCOI sequence difference within species were also reported in euphausiid species (Bucklin *et al.*, 1997, 2002; Papetti *et al.*, 2005).

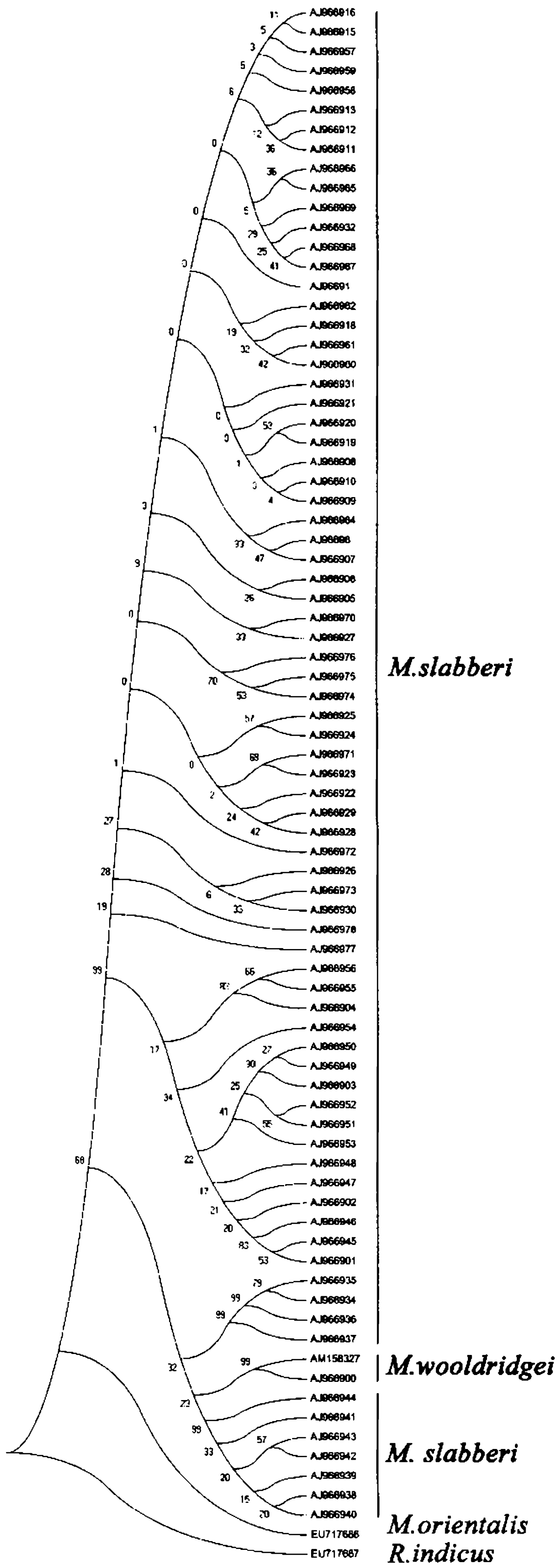


Figure 7. 1. 4. Relationships of mysid species, based on the mitochondrial sequence for each species. Tree was reconstructed by neighbor joining using Tamura-Nei gamma distances, a=0.05 (Swofford, 1998), using only transversion substitutions.

The consistent pattern of variation suggested that mtCOI sequence variation will be suitable for molecular systematic applications at several levels; populations (e.g. evaluation of the taxonomic significance of geographic within species), species (e.g. identification of sibling and cryptic species), and genus (e.g. reconstruction of speciation patterns). Mitochondrial COI is sufficiently variable to be useful to identify and discriminate even the most closely related species of mysids, and also likely to detect genetic divergence of conspecific populations associated with geographic isolation and cryptic speciation. According to Hudson and Coyne (2002) mitochondrial DNA evidence alone should not justify taxonomic decisions, evidence from unlinked molecular marker genes 16s and 18s and ITS (intra trans spacer) might be appropriate before drawing further taxonomic conclusions. In the future, barcodes may provide rapid, automatable protocols for zooplankton species identification and comprehensive DNA sequence databases and fabrication of DNA microarrays or "chips" will allow molecularly based recognition of known species. However, new or unknown species will require analysis by an expert taxonomist, who is able to identify and/or describe the species using morphological characters (Bucklin *et al.*, 2007).

7.2. BIOCHEMICAL COMPOSITION

7.2.1. Introduction

The need for biochemical studies on zooplankton is widely accepted in view of their nutritive value and flow of energy at different trophic levels. Biochemical composition and energetics in zooplankton is important for understanding the nutritional value and flow of energy at different energy level (Goswami *et al.*, 1981). Whether marine or brackish, they form food for fishes and crustaceans (Mauchline, 1980; George, 1958; Rao, 1970; Jhingran, 1975; Bhattacharya and Kewalremani, 1972). Raymond *et al.* (1964, 1966, 1968) emphasized the importance of investigating single species of zooplankton. Also live zooplankton species are being used as food in culture for several aquatic species to ensure a significant supply of proteins, lipids with essential fatty acids, carbohydrates, vitamins and minerals. In this context, significance of mysids in aquaculture as well as their role in ecosystem need to be evaluated. In most commercial hatcheries *Artemia* is used as live feed for fish and crustaceans. However, lack of availability of sufficient quantity of the feed as well as high cost of *Artemia* cysts (Lavens and Sorgeloos, 2000; Mihelakakis *et al.*, 2004) led to the choice of alternative food sources. Several mysids species have been cultured in the laboratory (Reitsema and Neff, 1980; McKenney, 1987; Ward, 1991; Domingues *et al.*, 1999; 2000) and tested as live feed for marine fish and crustaceans (Gomez, 1984; Guevara *et al.*, 2005) as well as for toxicity studies (Nimmo *et al.*, 1978b; Nimmo and Hamaker, 1982). Recently, live mysids are frequently used as food in early life stages of cephalopods (Forsythe and Hanlon, 1980; Turk *et al.*, 1986).

Report on biochemical composition of zooplankton from Cochin backwaters (Nair *et al.*, 1975; Gopalakrishnan *et al.*, 1977; Madhupratap *et al.*, 1979) deal mainly with total zooplankton or individual groups. Information on biochemical constituents of an individual or species especially mysids from Indian waters is meager. The present study is the first report on biochemical composition of mysids species from the Cochin backwaters.

7.2.2. Results

The biochemical composition (expressed as % dry weight) of different developmental stages viz, mature males, immature males, spent females, brooding females, immature females and juveniles of three species of mysids, *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophthalmus indicus*, collected from cochin backwaters during premonsoon periods are represented in Tables 7.2.1 to 7.2.3.

Table 7.2.1. Biochemical composition (%dry wt) different stages of *Mesopodopsis orientalis.*

Developmental stages	Protein	Carbohydrate	Lipid
Mature male (MM)	71.73±1.37	3.59±3.28	15.23±1.92
Immature male (IM)	65.83±1.76	4.27±2.15	16.80±2.69
Spent female (SF)	74.75±1.12	4.62±2.31	18.09±3.38
Brooding female (BF)	73.41±1.41	3.12±2.36	20.10±3.21
Immature female (IF)	66.97±1.82	4.94±1.20	18.11±4.37
Juveniles (JS)	65.60±1.40	4.32±1.58	15.03±2.55

Table 7.2.2. Biochemical composition (%dry wt) of different stages *Mesopodopsis zeylanica.*

Developmental stages	Protein	Carbohydrate	Lipid
Mature male (MM)	59.80±2.55	4.39±1.37	12.90±3.01
Immature male (IM)	55.10±2.21	4.74±3.64	10.59±2.25
Spent female (SF)	60.50±2.29	3.61±0.86	13.26±1.82
Brooding female (BF)	63.49±2.27	3.57±1.26	15.69±1.51
Immature female (IF)	53.53±2.16	4.43±1.01	13.10±1.30
Juveniles (JS)	51.97±2.59	3.44±1.16	15.13±2.53

Table 7.2.3. Biochemical composition (%dry wt) of different life stages of *Rhopalophthalmus indicus.*

Developmental stages	Protein	Carbohydrate	Lipid
Mature male (MM)	73.01±1.32	6.64±0.77	13.65±2.39
Immature male (IM)	72.38±1.52	8.00±4.41	13.73±1.97
Spent female (SF)	73.68±1.15	5.44±1.90	15.37±3.29
Brooding female (BF)	73.23±1.37	6.27±1.47	17.48±1.64
Immature female (IF)	71.83±1.46	6.76±0.98	16.79±2.35
Juveniles (JS)	70.64±1.24	5.93±2.77	14.65±3.22

Protein

Results show the importance of protein content in different stages (Fig. 7.2.1), which was the primary body component in all developmental stages constituting on an average more than half of the dry weight. The protein content in immature individuals was lower than adult male and females of *M. orientals* and *M. zeylanica* with relatively low variation in *R. indicus*. Protein contents (% of dry weight) of different life stages varied from 65.6%- 74.8% in *M. orientalis*, 52% - 63.5% in *M. zeylanica* and 70.6% - 73.7% in *R. indicus*. *R. indicus* showed high protein content (avg.72.46 ± 1), while in *M. orientalis* and *M. zeylanica* the average protein content was 69.72 ± 1.48, and 58.40 ± 2.35 respectively.

Carbohydrates

The amount of total carbohydrate was exceedingly low (Fig. 7.2.2). Immature males and females as well as juveniles consistently showed higher carbohydrate levels than other developmental stages. In *M. orientalis*, *M. zeylanica* and *R. indicus*, the average carbohydrate content was 4.14 ± 2.15, 4.03 ± 1.55 and 6.51 ± 2.05 respectively. Carbohydrate contents (% of dry weight) of different life stages varied from 3.1% - 4.9 % in *M. orientalis*, 3.4% - 4.7% in *M. zeylanica* and 5.9 % - 8 % in *R. indicus*.

Total Lipids

As that of protein, the present study strongly suggests that lipid fraction is most variable. High lipid contents were recorded in females especially, in brooding females (Fig. 7.3). High total lipid concentration was observed in *M. orientalis* (avg.17.23 ± 3.02 %) followed by *R. indicus* (avg.15.28 ± 2.48 %) and *M. zeylanica* (avg.13.44 ± 2.07). Lipid contents (% of dry weight) of different developmental stages varied from 15.2% - 20.1% in *M. orientalis*, 11% - 15.7% in *M. zeylanica* and 13.7% - 17.5% in *R. indicus*

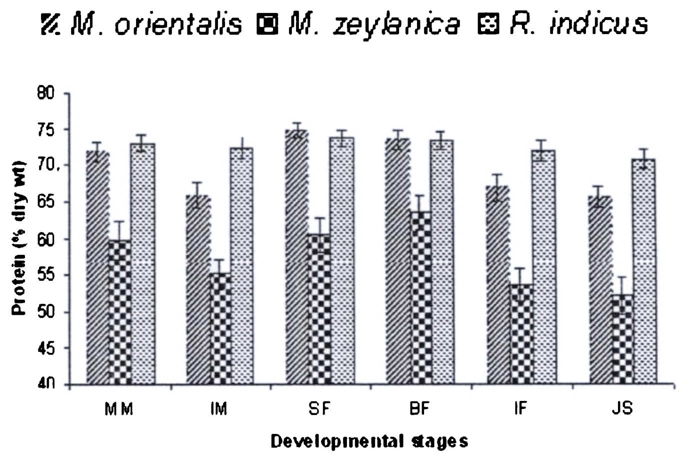


Figure 7.2.1. Difference in mean protein values between different stages of three species of mysids.

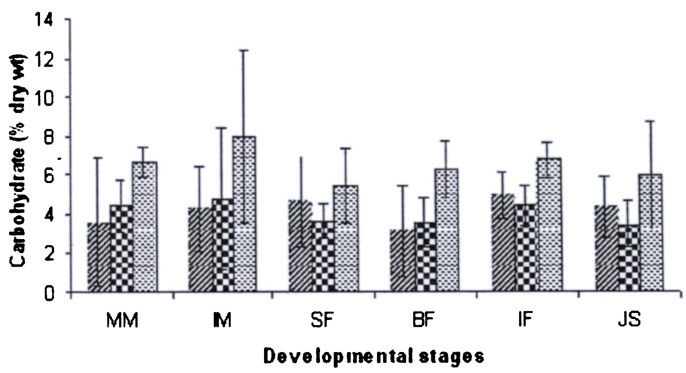
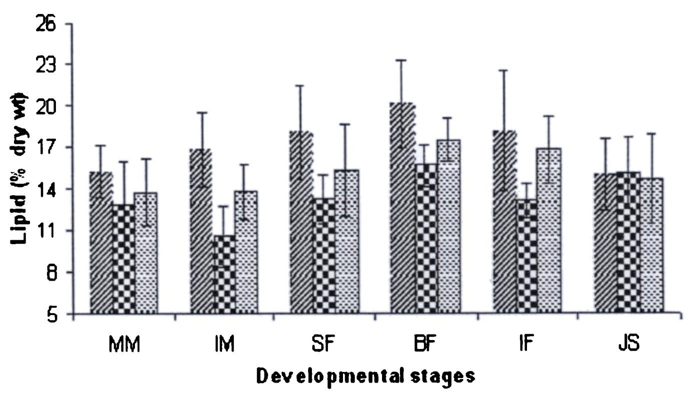


Figure 7. 2. 2. Difference in mean carbohydrate values between different stages of three species of mysids.



MM-mature males, IM-immature males SF-spent females, BF-Brooding females- IF-immature females, JS-juveniles

Figure 7. 2. 3. Difference in mean lipid values between different stages of three species of mysids.

7.2.3. Statistical analysis

Table 7.4 to 7.7 represents the results of ANOVA for biochemical composition of three mysid species.

Protein

. There is a significant difference in protein fraction between species (P<0.001) and between stages (p<0.01) (Table 7.2.1). The least significant difference observed between species and between stages was 2.60 and 3.68 respectively. Significantly higher amount of protein is observed in *R. indicus* and *M. orientalis*. Comparatively higher amount of protein was observed in mature males (MM), spent females (SF) and brooding females (BF) than other developmental stages.

Carbohydrates

Significant differences in carbohydrate concentration between species (P<0.001) and between stages (P<0.05) were observed (Table 7.2.2). The least significant difference worked out for species and stages were 0.643 and 0.909 respectively. Carbohydrate showed significantly higher values in *R. indicus* compared to other species. Among stages, IF and IM showed significantly high amount of carbohydrate compared to BF and SF stages.

Lipid

It could be seen that there is significant difference in lipid fractions (Table 7.2.3) between species (P<0.001) and between stages (P<0.05). The least significant difference between species is 1.510 and between stages 2.113. *M. orientalis* recorded significantly high amount of lipid content compared to *R. indicus* and *M. zeylanica*. Between stages, comparitively high lipid content was observed in SF, IF, and BF than IM and MM.

Table 7.2.1. Results of ANOVA for protein in *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophthalmus indicus*.

Source	SS	df	MS	F	P -value
Species	772.5	2	386.25	90.336	$P < 0.001$
Stages	148.1	5	29.62	6.927	$P < 0.01$
Error	42.8	10	4.28		
Total	963.4	17			

Table 7.2.2. Results of ANOVA for carbohydrate in *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophthalmus indicus*.

Source	SS	df	MS	F	P -value
Species	23.483	2	11.742	44.91	$P < 0.001$
Stages	5.019	5	1.004	3.84	$P < 0.05$
Error	2.615	10	0.261		
Total	31.117	17			

Table 7.2.3. Results of ANOVA for lipid in *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophthalmus indicus*.

Source	SS	df	MS	F	P -value
Species	42.912	2	21.456	14.94	$P < 0.001$
Stages	33.497	5	6.699	4.66	$P < 0.05$
Error	14.361	10	1.436		
Total	90.770	17			

7.2.4. Discussion

In the present study, *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophathalmus indicus* showed significant variations in their biochemical composition during different developmental stages. Protein, carbohydrate and lipid content in three species showed more or less similar pattern in their respective life stages. Results are basically consistent with the reported volume of protein, carbohydrate and lipid. Earlier studies on biochemical composition of other invertebrates especially zooplankton and mysids indicates that protein constitute the major fraction in terms of dry weight (Raymont *et al.*, 1964; Reev *et al.*, 1970; Raymont, 1971). The present results were also consistent with other reports obtained for mysids (Nair *et al.*, 1975) and zooplankton (Gopalakrishnan *et al.*, 1977) collected from Cochin backwater. Difference in biochemical composition between species and different developmental stages suggests that their diets / or physiological requirement needed to adapt to the varying environmental conditions.

Compared with that of carbohydrate and lipid, large amount of protein observed in our study, suggest that protein is the main metabolic reserve in mysids and it is largely used (deamination) during starvation (Verslycke and Janssen, 2002). Raymont *et al.* (1968) reported that mysids being relatively small aquatic animals should experience no great difficulty in eliminating ammonia arising from deamination. Bhat and Wagh (1992) also reported the potential use of protein as a metabolic reserve in marine zooplankton. Table 7.2.3, reviews earlier studies on biochemical composition in different species of mysids, which are comparable to the present study. In the amphipod *Jassa fulcata* a similar trend of high protein and low carbohydrate has been noticed by Nair and Anger (1980). Some variations in protein content were observed between mysids species. High variability of protein content was also reported in copepods (Mayzaud and Martin, 1975; Orr, 1934; Nakai, 1955). Krishnakumari and Achuthankutty (1989) recorded variability in protein content between oceanic zooplankton (avg. 38.1%) and coastal zooplankton (44.49%). Variations in protein values of zooplankton were explained on the basis of seasonal variations in *Meganyctiphanes norvegica* (Raymont *et al.*, 1969) and *Sagitta hispida* (Reeve *et al.*, 1970), utility as metabolic substrate (Conover, 1964) and difference in environmental salinity (Raymont, 1972). In the present study each species showed variation in protein content in their developmental stages. This may be either due to its utilization as a metabolic substrate or seasonal changes, life stage at the time of collection and salinity (Raymont, 1972). Studies of Moss and Lawrence (1972) and Ortego *et al.* (1984), suggests that fluctuations in protein content are related to the tissue water content. Fluctuations in the hydration level of tissues in different life stages quantify protein content in particular stages. Comparatively high values of protein in mature males and females may be due to the presence of highly developed exoskeleton. Verslycke and Janssen (2002) studied the effect of ecdysis on the protein metabolism in mysids. They assumed that, the exoskeleton of mysids contains large amounts of protein.

Low carbohydrate values in zooplankton have been reported both from temperate and tropical waters (Krishnakumari and Achuthankutty, 1989; Stephen *et al.*, 1979). The analysis of total carbohydrate in oceanic decapods showed as 2-3% of dry body weight (Raymont *et al.*, 1967). Raymont and Conover (1961) reported similar trend in three euphausids, *Meganyctiphanes*, *Thysanoessa* and *Nematoscelis* from tropical waters. It suggests that carbohydrate content in different stages of zooplankton is low irrespective of habitats and geographical regimes (Raymont *et al.*, 1969). Similar observations have been reported in mysids also and are identical with earlier studies (Raymont *et al.*, 1964, 1966; Raymont and Linford, 1966; Vinogradove, 1964; Goswami *et al.*, 1981; Azeitero *et al.*, 2001, 2003). It implies that the main energy storage in mysids is not in the form of carbohydrate chains, which might not contribute substantially towards the body reserve and energy flow.

Carbohydrate cannot be considered as a metabolic reserve since they constitute only a very small fraction in most planktonic organisms (Anger and Nair, 1979). Although protein and lipid utilization is variable in crustaceans generally, carbohydrate is more preferred for metabolic process than protein and lipid (Garret and Grisham, 1995; Morris, 1999). Glucose delivers fast energy in the form of ATP via the process of glycolysis and oxidative phosphorylation and is the major circulating carbohydrate in crustaceans (Morris, 1999). High carbohydrate content in immature male and females than matured ones may be due to comparatively high storage of glycogen.

Table 7. 2. 3. A comparison of the biochemical constituents in different species of mysids from different habitat (values are of % dry weight).

Mysid species	Protein	Carbo-hydrate	Lipid	Habitat	Reference
Mysids	52	13	27	Marine	Vinogradova, 1964
Neomysis integer	71	2	13	Marine	Raymont *et al.*, 1964
Leptomysis lingvura	70	3	11	Marinc	Raymont and Linford, 1966
Praunus valgaris	72	3	13	Marinc	Seguin, 1968
Mysids (Total)	57.9	2.7	19.4	Backwater	Nair *et al.*, 1975
Siriella sp.	45.92	4.2	10.5	Marine	Goswami *et al.*, 1981
Mesopodopsis slabberi	69.11	9.82	15.4	Estuary	Azeiteiro *et al.*, 2003
Mesopodopsis orientalis	69.72	4.14	17.23	Backwater	Present study
Mesopodopsis zeylanica	57.40	4.03	13.44	Backwater	Present study
Rhopalophthalmus indicus	72.46	6.51	15.28	Backwater	Present study

Lipid content was comparatively poor compared to reported values from colder regions (Raymont *et al.*, 1969; Conover, 1962; Vinogradova, 1964). In warm water environments the rate of primary production far exceeds the rate of consumption by zooplankton (Qasim, 1977). The continuous supply of phytoplankton food would render lipid reserve unnecessary, which might account for low lipid content in the tropical zooplankton (Goswami *et al.*, 1981). Lipid variation is a fluctuation of metabolism and reproductive strategy depending upon the species life cycle (Pastorinho *et al.*, 2003). In fact, many life span traits of aquatic invertebrates depend on deposit of lipids (Lehtonen, 1996; Ohman, 1997). During the present study all females especially brooding females showed high lipid content. The production of egg is related to the lipid content of individuals (Lehtonen, 1996). The egg of mysids contains high amounts of lipids and the lipid metabolism of ovigerous female can be assumed to be different from males (Linford, 1965; Verslycke and Janssen, 2002). The variation in lipid metabolism observed in various stages may be partially caused by a sex specific lipid metabolism (Verslycke and Janssen, 2002). Adult females may also show high lipid content because of its reproductive development (Raymont *et al.*, 1969). There is a wide view that lipid forms major food reserve for many zooplankton species. Lipid accumulation is the most widespread long-term energy storage strategy in aquatic crustaceans and their reproductive potential is largely dictated by lipid content (Sargent and Henderson, 1986; Gatten *et al.*, 1980).

As in other crustaceans, biochemical changes in developmental stages of mysids apparently resulted from metabolic needs in relation to the nutritional cycle and synthesis of reproductive products. Therefore environmental, trophic conditions as well as reproduction play an important role in determining changes in biochemical composition. As all the three species are very common in Cochin backwaters, culturing them under laboratory condition will be comparatively easier than oceanic spices. In conclusion, the evaluation of the nutritional composition of *Mesopodopsis orientalis*, *M. zeylanica* and *Rhopalophathalmus indicus* shows that these species have great potential use in aquaculture because their biochemical composition can satisfy the nutritious needs of a wide variety of fishes and crustaceans. These species also complies with the recommendations of FAO (1989), indicating the food sources used for aquaculture.

Summary and Conclusion

Members of the order Mysidacea are important component in marine and estuarine plankton inhabiting all regions of the oceans. There are many brackish water species and few species occur in fresh water, some have become adapted to the specialized environments of caves and wells. They are omnivores, responsible for remineralisation of a substantial portion of the detritus in the water column. They form an important link in the food chain (between microbial producers and secondary consumers) and therefore play a major role in the cycling of energy within the aquatic ecosystem. In tropical and subtropical waters, swarms of mysids are exploited commercially and marketed as preserved cooked food. Mysids have been used in fish farming as live feed resource. They are also excellent experimental organism, extremely useful in the studies of potential impact of various pollutants in the aquatic environment. Mysids are also used in wood pulp effluent plants.

Considerable work had been done on the taxonomy of Mysids in the Indian Ocean since 1900 (Tattersall, 1906-1939, Hansen, 1910, Pillai, 1957-1969, 1973; Panampunnayil, 1977-2000) and in 1987, Mathew *et al.* carried out a study on the distribution and abundance of mysids from the Indian EEZ. However, none of these accounts appears to give combined information on the taxonomy, ecology, species abundance and their distribution in the Indian waters in relation to the different environmental variables.

Despite their overwhelming ecological significance in ecosystems, very little work has been done on mysids in the Indian waters. Considering the significant role of mysids in the productivity of tropical ecosystem, the present study has been undertaken to extend our knowledge on the systematic, life history, distribution, abundance and DNA analysis and biochemical composition of readily available species.

The material for the present study have been collected from the Indian EEZ of the Arabian Sea, Bay of Bengal and the Andaman Sea, shallow coastal waters of northwest coast of India and Cochin backwaters.

Mysids in the Arabian Sea, Bay of Bengal and the Andaman Sea

Information on the systematics and ecology of Mysidacea of the Indian EEZ is very limited. In the present study, species composition and diversity of this group is evaluated based on 1325 stratified samples and 336 surface samples. Total 27 species of mysids belonging to 21 genera were recorded. *Boreomysis plebeja* (Bay of Bengal), *Anchialina media and Synerythrops intermedia* (Andaman Sea) are new records from the Indian waters. *Pseuderythrops gracilis* is a new record for the Andaman waters. *Euchaetomera glyphidophthalmica* and *Rhopalophthalmus indicus* are first records for Bay of Bengal.

Most of the mysids are surface dwellers, surface collection constituted 90.71% and stratified collection constituted only 9.92% of the total catch. Population density of mysids in the Bay of Bengal was higher (37.59%) than that of the Arabian Sea (29.29%) and Andaman Sea (33.1%). Dominant species like, *Siriella gracilis, Hemiseriella parva*, *Anchialina typica* and *Pseudanchialina pusilla* occurred through out the year. *Pseudanchialina pusilla* was the most abundant species (64.77%) and *Siriella gracillis* was the second dominant species (28.1%). Species diversity is more in Arabian Sea (17) as compared to Bay of Bengal (9) and Andaman Sea (14). Below 500m, only two species *Gibberythrops acanthura* and *Boreomysis plebeja* were recorded. Out of the twenty-seven species, four are common to Indian, Pacific and Atlantic oceans, 13 are confined to the Indo-pacific and 10 are restricted to the Indian Ocean, of which 4 are endemic in the Indian waters.

North westcoast of India

The majority of mysids species are divided into two broad categories. The first consists of species occurring in offshore, deep neritic, epipelagic, mesopelagic and bathypelagic environments. The second comprises shallow neritic, coastal, littoral and estuarine species, many of which have extremely localized distribution. The shallow water Mysidacea of the Indian region is rich and varied. Our knowledge on the taxonomy, ecology and distribution of many of these species is incomplete.

Zooplankton samples were studied from 10 locations. Mysids found in all areas except at Veravel. Maximum density ($8792/100m^3$) was found at Dahanu constituted by a single species *Mesopodopsis orientalis.* A total of 8 genera and 12 species were represented in the collection. Three species, *Siriella hanseni*, *Erythrops minuta* and *Acanthomysis anomala* are first records from the area. The mysid fauna of the shallow water is dominated by a single species, *Mesopodopsis orientalis. Indomysis annandelai* was the second in abundance. *Rhopalophthalmus vijayi* also occurred in small aggregations. All the other species are either moderately or sparsely represented.

Of the 12 species, 3 are common to Indo-Pacific waters, 9 are confined to the Indian Ocean of which 5 are endemic in the Indian waters.

Cochin backwaters

Cochin backwater is one of the largest estuaries in India. The importance of mysids in the tropical estuaries is generally thought to be significant since these habitats play an important role in completing the life cycle of many of the commercially important fishes and prawns. Ecological importance of mysids, particularly their role in food chains as a link between the benthic and pelagic system is becoming increasingly apparent. Their trophic role as a converter of energy into forms which can be used by higher organisms especially fishes coupled with ubiquity and abundance of mysids in the estuaries indicates that their significance in the productivity of such ecosystem has been greatly under estimated.

Present study is the first report of mysids from the Cochin backwaters. Four species of mysids belonging to 3 genera were recorded from Cochin backwaters, of which *Kochimysis pillaii* is a new genus and new species. In *M. orientalis* and *M. zeylanica*, reproduction and recruitment were continuous through out the year, main peak being associated with low salinity. Male and female of *M. orientalis* and *M. zeylanica* attained sexual maturity at a length of 5- 5.2 and 4.5- 4.8 mm respectively. The brood size in *M. orientalis*, *M. zeylanica* and *R. indicus*, was related to the size of the incubating females. *R. indicus* attained sexual maturity at a length of 8.6 mm in male and 8.5 mm in females. High abundance of gravid females of *R. indicus* during high saline premonsoon period suggests that salinity plays an important role in the development of marsupium and broods. In *M. orientalis*, brood size was 8 to 12, where as that of *M. zeylanica* and *R. indicus* are 7 to 11 and 6 to 13 respectively. Mysid abundance clearly depends upon the phases of tides (flood /ebb), character of tides (semidiurnal and diurnal) vertical migration (day and night variation) and breeding activity. Mysids undergo circadian changes of their position in the water column.

DNA barcoding

This is the first attempt to analyze DNA sequence of Indian mysids. DNA barcoding provides an efficient method for species level identification and is a powerful tool to taxonomic and biodiversity studies. The consistent pattern of variations in the mtCOI sequence will be suitable for evaluation of the taxonomic significance of geographic variation within species, identification of sibling and cryptic species and genus.

Biochemical composition

Biochemical analysis of three mysids, *Mesopodopsis orientalis, M. zeylanica* and *Rhopalophthalmus indicus* showed significant variations in their biochemical composition. Protein is the primary body component in all-developmental stages. In all species, matured males and females had higher protein content than in other stages. Carbohydrate content is high in the immature stages and lipid content was more in brooding females.

The present study extends our knowledge on the little known mysid fauna of the Indian waters. The main conclusions are the following.

A total of 39 species of mysids representing 26 genera were encountered in the collections, of which 4 species are cosmopolitan, 15 are Indo- pacific and 20 restricted to Indian Ocean, of which 10 species are endemic in the Indian waters. A new genus and a new species *Kochimysis pillaii* have been recorded from the Cochin backwaters. From the present study, three species of mysids, *Boreomysis plebeja*, *Anchialina media* and *Synerythrops intermedia* are added to the species list of Mysidacea in the Indian waters. *Euchaetomera glyphidophthalmica* and *Rhopalophthalmus indicus* from Bay of Bengal, *Pseuderythrops gracilis* from Andaman waters and *Seriella hanseni, Erythrops minuta* and *Acanthomysis anomala* from coastal waters of northwest coast of India are first report from the respective areas. Population density of mysids was high in the Bay of Bengal whereas species diversity was more in the Arabian Sea. Salinity plays an important role in the development of marsupium in *Rhopalophthalmus indicus* and brooding females occurred in larger numbers during the high saline pre-monsoon period. In the future, DNA barcodes may provide rapid, automatable protocols for zooplankton species identification and comprehensive DNA sequence databases and fabrication of DNA microarrays or "chips" which will allow molecularly based recognition of known species. However, new or unknown species will require analysis by an expert taxonomist, who is able to identify and/or describe the species using morphological characters. Biochemical analysis of three species of mysids, *Mesopodopsis orientalis, M. zeylanica* and *Rhopalophthalmus indicus* showed significant variations in their biochemical composition. Protein was the principle component in all development stages.

Species diversity is low in coastal and estuarine waters whereas it is high in Oceanic waters and reverses is the trend in the case of population density of mysids. Due to short life cycle and their abundance, *Mesopodopsis orientalis, Mesopodopsis zeylanica* and *Rhopalophthalmus indicus* is suitable tool for environmental assay experiments. Analysis of biochemical composition also suggests possible utilization of these species as an alternate live feed due to its nutritive value, which may partially meets the demands of fodder for wide variety of cultivated fishes and crustaceans.

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ORIGINAL ARTICLE

Mysidacea (Crustacea) from the Minicoy lagoon (Lakshadweep, India) with description of a new species of *Anisomysis*

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Abstract

Four species of mysids collected from the Minicoy lagoon are reported. *Anisomysis minicoyensis* sp. nov. is distinguished from the related species by the shape of the rostrum, the relative length of the antennal scale and the short protuberances on the second segment of the mandibular palp. The other three species recorded are *Siriella australiensis*, *Anisomysis truncata* and unidentified species of subfamily Gastrosaccinae.

Key words: *Anisomysis, India, Lakshadweep, Minicoy lagoon, Mysidacea, new species*

Introduction

During the investigations on the fauna of the sea grass ecosystem, several mysids were collected from the Minicoy lagoon (8°17′N 73°04′E) of the Lakshadweep Archipelago in the Arabian Sea. Four species of mysids were represented. *Anisomysis minicoyensis* is described as new to science and *Siriella australiensis* is recorded first from Indian waters. Part of two young females of *A. truncata* and many juveniles of an unidentified species of subfamily Gastrosaccinae were collected. All the specimens were collected from among thick vegetation of *Thalassia* and *Syringodium* from 1 m depth with a WP plankton net at night in September 2002. The type specimens of the new species are stored in the reference collections of the Indian Ocean Biological Centre, Regional Centre, National Institute of Oceanography, Kochi, India.

Genus *Siriella* Dana

Siriella australiensis Panampunnayil, 1995
Siriella australiensis Panampunnayil 1995: 1939, 1949, Figures 1–23.

Materials. One adult male (8.3 mm), two young males and one adult female (9.4 mm).

Remarks. The specimens are identified as *S. australiensis* by the modified setae on the exopod of the third pleopod and the exopod and endopod of the fourth pleopod of the male and the shape and armature of the telson (Figures 2–5). The present specimens closely resemble the type specimens except for the shape of the rostrum. The carapace is produced into a low triangular rostrum not extending beyond the base of the antennular peduncle (Figure 1), whereas in the type specimens the rostrum overreaches the base of the antennular peduncle and covers the basal part of the eyestalks.

Distribution. This species has been known only from the type locality, southwest Australia. The present occurrence extends the distribution range of this species several thousand kilometres northwestwards.

Subfamily Gastrosaccinae

(genus unknown)

Material. A large number of juveniles.

Remarks. From the character of the antennule, the antennal scale, the telson and the uropods, these juveniles are identified as members of the subfamily Gastrosaccinae but cannot be referred to any genus due to the very immature stage (Figures 6 and 7).

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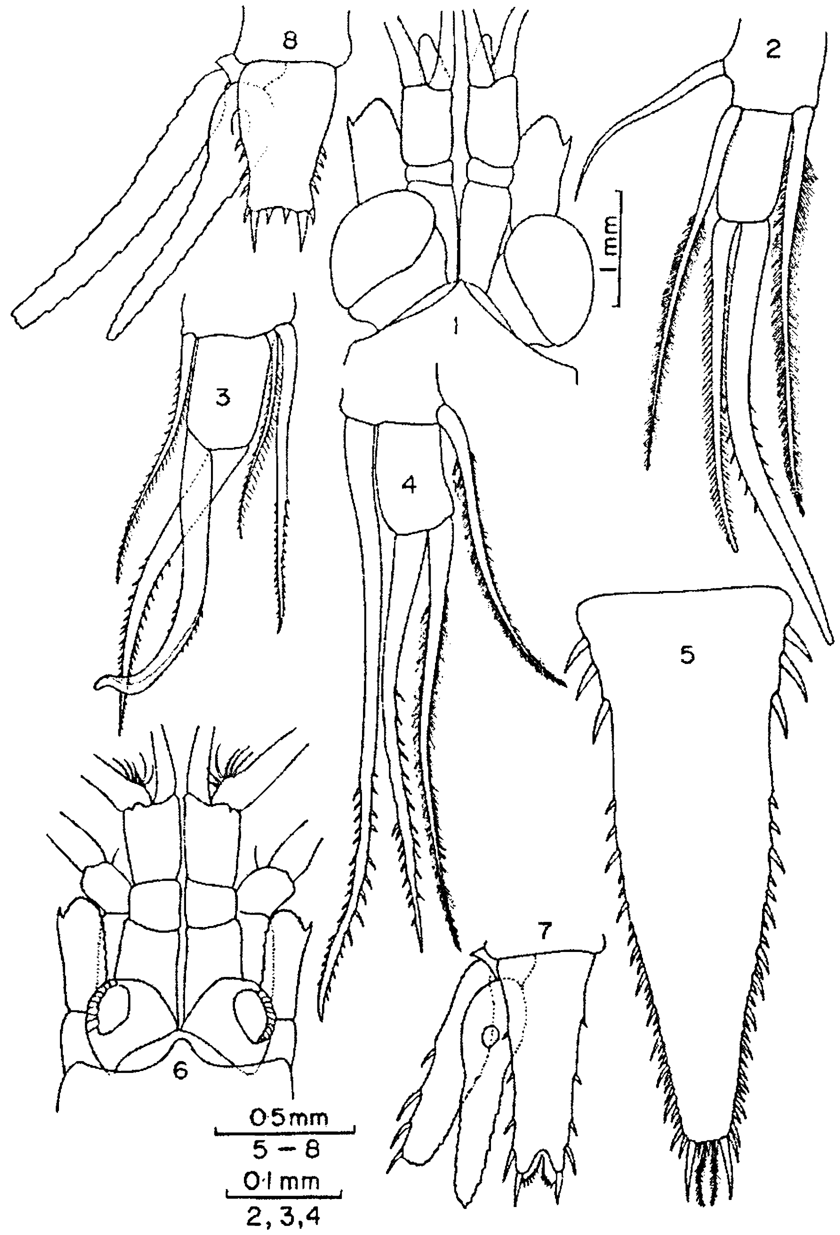

Figures 1–5. *Siriella australiensis* Panampunnayil, 1995 (female). 1, Anterior part of body; 2, distal part of exopod of third pleopod; 3, distal part of exopod of fourth pleopod; 4, distal part of endopod of fourth pleopod; 5, telson.
Figures 6, 7. Subfamily Gastrosaccinae, genus unknown (juvenile). 6, Anterior part of body; 7, telson and uropod.
Figure 8. *Anisomysis truncata* Panampunnayil, 1993 (female). Telson and uropod.

Genus *Anisomysis* Hansen

Anisomysis truncata Panampunnayil, 1993
Anisomysis truncata Panampunnayil 1993: 1145, 1148, Figures 20–34.

Material. The posterior part of two young females.

Remarks. These two specimens are referred to *A. truncata* based on the shape and armature of the telson (Figure 8).

Distribution. This species is known only from Minicoy lagoon.

***Anisomysis minicoyensis* sp. nov.**

Material. Holotype, adult male (IOBC-0509-10-50-2004). Allotype, adult female (IOBC-0509A-10-50-2004). Other materials: 25 adult males, 40 adult females and many juveniles.

Description. Anterior margin of carapace produced into triangular rostrum with obtusely pointed apex, extending to middle of first antennular segment and covering basal part of eye stalks in male (Figure 9); anterolateral corners of carapace rounded. Rostrum of female short, overreaching base of antennular peduncle (Figure 10). Eyes large,

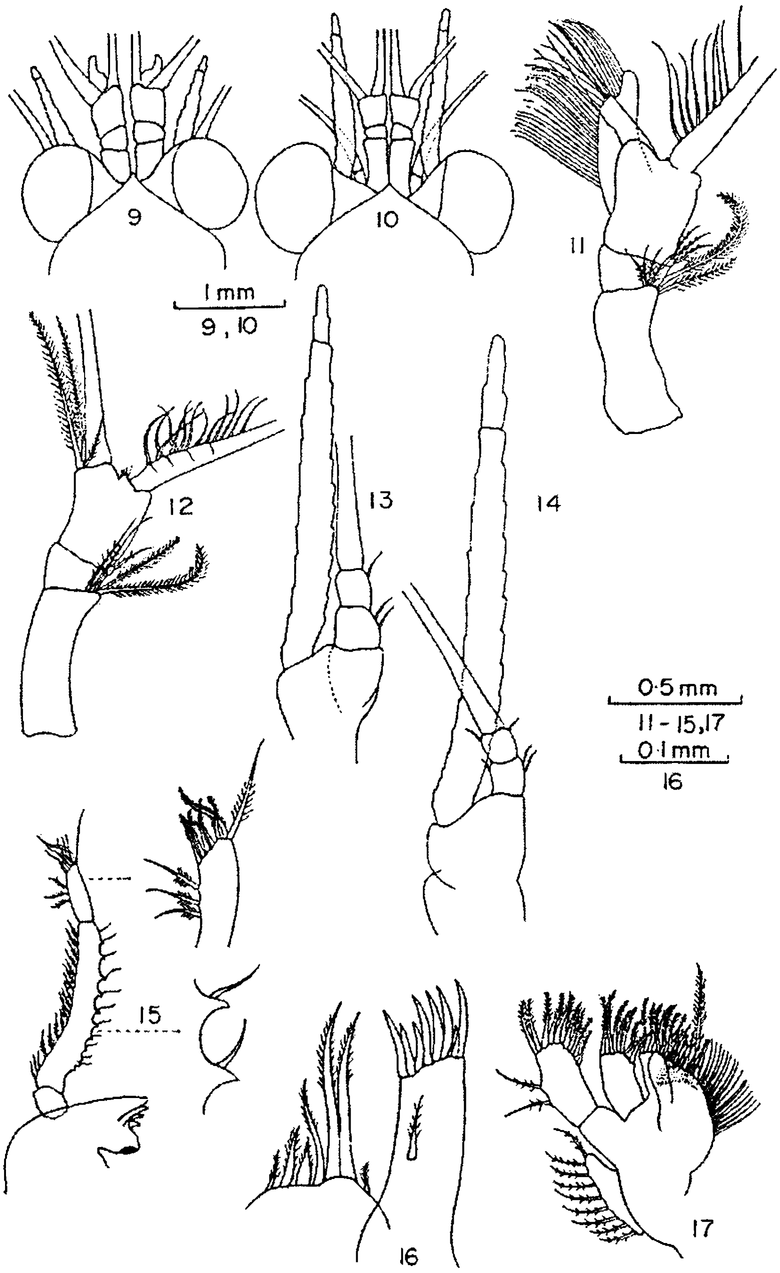

Figure 9–17. *Anisomysis minicoyensis* sp. nov. 9, Anterior part of body of male; 10, anterior part of body of female; 11, antennule of male; 12, antennule of female; 13, antennal scale of male; 14, antennal scale of female; 15, mandible of male; 16, maxillule of male; 17, maxilla of male.

cornea globular, wider than stalk. Antennular peduncle of male more robust than that of female; first segment as long as rest of peduncle with distal dorsal lobe tipped with one stout long plumose seta and three or four slender setae; second segment stout with distal lobe tipped with few setae; third segment broad, male lobe large and thickly hirsute (Figure 11). In female, antennular peduncle slender, first segment longer than rest of peduncle (Figure 12). Antennal scale of male 9.7 times as long as broad, overreaching antennular peduncle by one-third its length, extending to apex of male lobe, with distal suture; peduncle short, one-quarter length of scale (Figure 13). In female, antennal scale 10.7 times as long as broad, overreaching antennular peduncle by half its length (Figure 14).

Second segment of mandibular palp with 10–11 flagellated short denticles on inner margin, outer margin setose throughout; third segment one-third of second segment in length, distally armed with setae (Figure 15). Maxillule with comparatively large inner lobe armed with five short and two long plumose setae, outer lobe distally armed with strong teeth (Figure 16). Maxilla with well-developed lobes from second and third joints, exopod small and narrow (Figure 17).

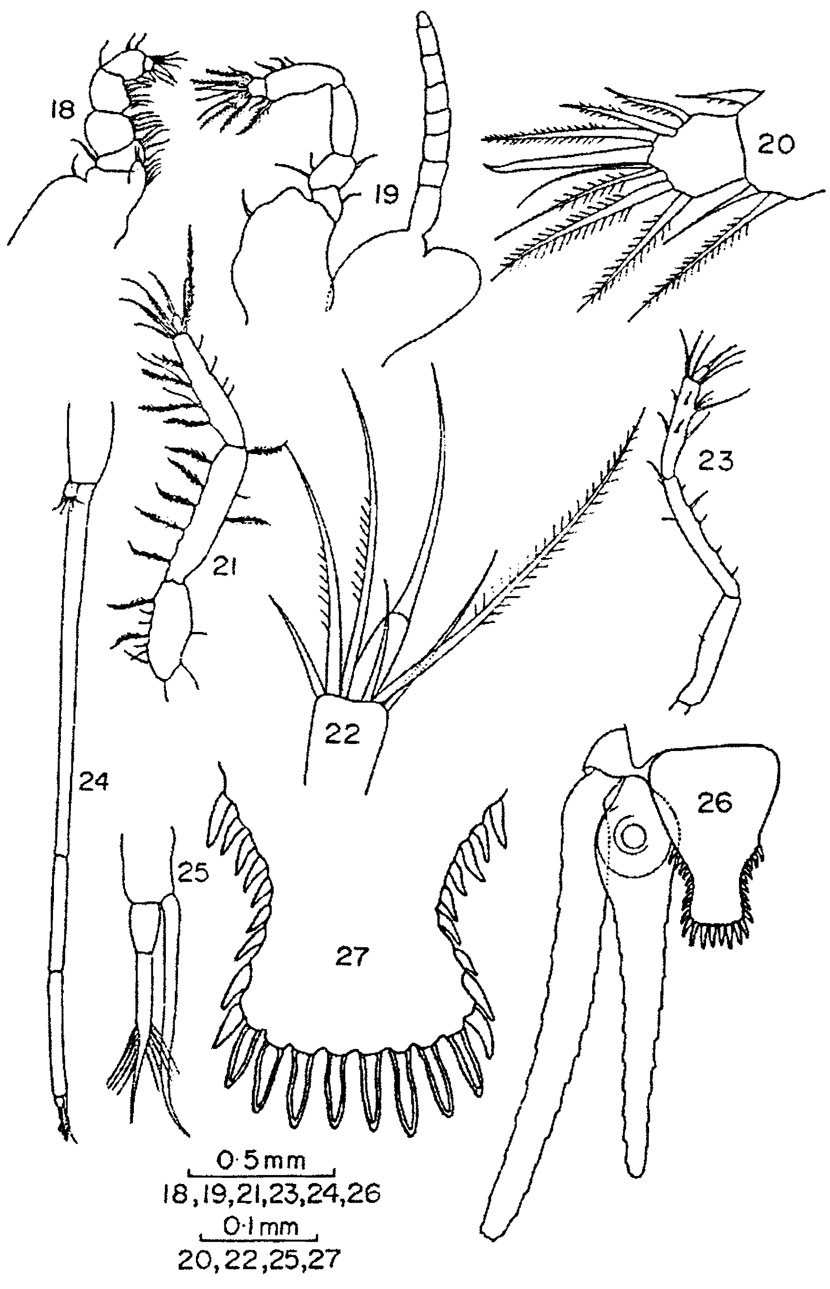

Figure 18–27. *Anisomysis minicoyensis* sp. nov. (male). 18, First thoracic endopod; 19, second thoracic limb; 20, tip of second thoracic endopod; 21, fourth thoracic endopod; 22, tip of fourth thoracic endopod; 23, eighth thoracic endopod; 24, fourth pleopod; 25, distal end of exopod of the fourth pleopod; 26, telson and uropod; 27, distal part of telson.

First and second thoracic limbs as usual for the genus (Figures 18–20). Third to eighth thoracic endopods slender, carpo-propodus undivided, dactylus with long slender nail; exopod nine-segmented (Figures 21–23).

Pleopods in male reduced to short unsegmented simple lobe except fourth pair. Fourth pleopod biramous, endopod short and unsegmented; exopod long, three-segmented, extending to middle of telson; first segment 1.5 times longer than rest, second segment slightly shorter than third; third segment terminating in two spines, one slender and naked, the other stout and barbed in middle (Figures 24, 25).

Telson medal-shaped, 1.4 times as long as broad at base, constricted at distal quarter, narrowest part one-third as wide as base; distal two-fifths of lateral margin armed with nine to ten spines, distal margin truncate with eight stout spines, innermost pair shortest, distal margin two-fifths of maximum basal width (Figures 26, 27).

Uropods long and narrow, setose all round and without spines, exopod longer than endopod; statocyst prominent (Figure 26).

Length. Adult male 5.3 -6.2 mm, adult female 5.6–6.3 mm.

Etymology. This species is named after the locality.

Remarks. The present species belongs to the subgenus *Paranisomysis*, in having the mandibular palp with flagellate denticles on the inner margin of the second segment and a medal-shaped telson with a lateral constriction. In the shape and armature of the telson, this species is closely related to *A. ohtsukai* Murano, 1994 from Japan, but differs from it in the following points.

1. In *A. minicoyensis*, the rostrum extends to the middle of the first segment of the antennular peduncle and covers the basal part of the eye stalks. In *A. ohtsukai*, the rostrum does not extend to the base of the antennular peduncle and leaves the eye stalks exposed.
2. In *A. minicoyensis*, the antennal scale is 9.7 times as long as broad in the male and 10.7 times as long in the female, whereas in *A. ohtsukai* it is only 7.5 times as long as broad.
3. In *A. minicoyensis*, all flagellated denticles on the second segment of the mandibular palp are small and the third segment is one-third of the second segment in length. In *A. ohtsukai*, the denticles in the middle are large and prominent and the third segment is two-fifths of the second segment.
4. The exopod of the fourth pleopod of the male reaches the middle of the telson in *A. minicoyensis*, whereas in *A. ohtsukai* it reaches the distal end of the telson.
5. The body length of the adult male and female of *A. minicoyensis* is 5.3–6.2 and 5.5–6.3 mm, respectively, whereas that of *A. ohtsukai* is 3.6–4.1 and 3.8–4.5 mm, respectively.

In having the mandibular palp with denticles and the telson with a lateral constriction and a truncate apex, the new species is also related to *A. lamellicauda* Hansen, 1912 and *A. marisrubri* Bacescu, 1973. *Anisomysis lamellicauda* differs from *A. minicoyensis* in having a very acuminated rostrum, a shorter antennal scale, 13 denticles on the second segment of the mandibular palp, nine spines on the lateral and nine spines on the distal margin of the telson. *Anisomysis marisrubri* differs from *A. minicoyensis* in having a shorter antennal scale, eight to ten denticles on the second segment of the mandibular palp, 11–13 spines on the lateral and 10–12 spines on the distal margin of the telson.

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Four new species of the genus *Rhopalophthalmus* (Mysidacea: Crustacea) from the northwest coast of India

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Abstract
Four species belonging to the genus *Rhopalophthalmus*—*R. mumbayensis*, *R. anishi*, *R. murudana*, and *R. vijayai*—are described as new to science. All four species are distinguishable from each other and from other related species by the combination of characters afforded by the number of spines on the antennal sympod, number of carpopropodal segments of the thoracic endopods, relative length of the vestigial endopod of the eighth thoracic limb, number of lateral spines on the telson, and the relative length of the distal spines.

Keywords: *Crustacea, India, Mysidacea, new species,* Rhopalophthalmus, *taxonomy*

Introduction

The genus *Rhopalophthalmus* was instituted by Illig (1906) for the reception of type species *R. flagellipes* captured by the S.S. *Valdivia* off Banana in the Congo Estuary. Of the 18 species which have up to the present been referred to this genus, only five species—*R. chilkensis* Tattersall, 1957, *R. kempi* Tattersall, 1957, *R. tattersallae* Pillai, 1961, *R. indicus* Pillai, 1961 and *R. macropsis* Pillai, 1964—have been recorded from Indian waters. By the present work four more species, *R. mumbayensis*, *R. anishi*, *R. murudana*, and *R. vijayai*, have been added to the list, which are all new to science. The study area included coastal waters off Murud, Daman, Dahej and creeks around Mumbai (Dharamtar, Thane, Bassein, Kasheli). Currents within the creek system are almost entirely due to the tidal ebb and flow and the temporal and spatial variations in salinity are governed by the quantum of sea water influx and the riverine fresh water flow. The interior part of this complex creek system is fringed by rich mangrove vegetation and salt marsh and receives large quantities of waste water, thereby enhancing the nutrient level which in turn supports high plankton production. Kasheli, the area of study, is the mid-estuarine zone of Ulhas estuary. The materials were collected with a Heron Tranter Net (Tranter et al. 1972) having a mouth area of 0.25 m^2 and a mesh size of 0.33 mm. The common and specific characteristics of the known species of *Rhopalophthalmus* from the coastal waters of India are given in Table I. All the type specimens are stored in the reference collection of the Indian Ocean Biological

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Table I. Common and specific characteristics of species of *Rhopalophthalmus* from the coastal waters of India.

	R. chilkensis	*R. kempi*	*R. indicus*	*R. tattersallae*	*R. macropsis*	*R. mumbayensis* sp. nov.	*R. anishi* sp. nov.	*R. murudana* sp. nov.	*R. vijayai* sp. nov.
Presence of nodules on carapace	–	–	+	+	+	+	+	+	+
Spines on antennal sympod	3 Subsimilar	4 Two long and two short	5 Dissimilar arranged like a cone	4 Two long and two short. Third spine with strong barbs	4 Two long and two short	4 Two long and two short	4 Two long and two short	4 Two long and two short	4 Two long and two short
Propodal segments of thoracic endopods 3–7	3–5	2	4–5	3	4	4–6	2–4	2–3	3–5
Eighth thoracic endopod of male	Longer than basal segment of exopod	Longer than basal segment of exopod	Shorter than basal segment of exopod	Shorter than basal segment of exopod	Shorter than basal segment of exopod	Shorter than basal segment of exopod	As long as basal segment of exopod	Shorter than basal segment of exopod	Shorter than basal segment of exopod
Eighth thoracic endopod of female	Shorter than basal segment of expod	Longer than basal segment of exopod	As long as	Shorter	Shorter	Shorter	Longer	Shorter	Shorter
Number of spines on lateral margin of telson	15–16	14	14	13	12	11–12	11	15–16	7
Apical spines of telson	Inner pair long	Inner pair long	Outer pair long	Inner pair long	Outer pair long	Outer pair long	Outer pair long	Inner pair long	Sub-equal
Length of adult (mm)	9–11.4	10.2	15–17	13.3	7.8	8–12	9.6–11.7	8.5–9.3	6.6–8.6

Centre (RC, NIO, Kochi). The descriptive terminology employed follows to a great extent Pillai (1973).

Genus *Rhopalophthalmus* Illig, 1906
Rhopalophthalmus mumbayensis sp. nov.
(Figures 1–27)

Material

Holotype: adult male (IOBC-0503-10-50-1999). Allotype: adult female (IOBC-0503 A-10-50-1999). Paratypes: five adult males and five adult females (IOBC-0503 B-10-50-1999).

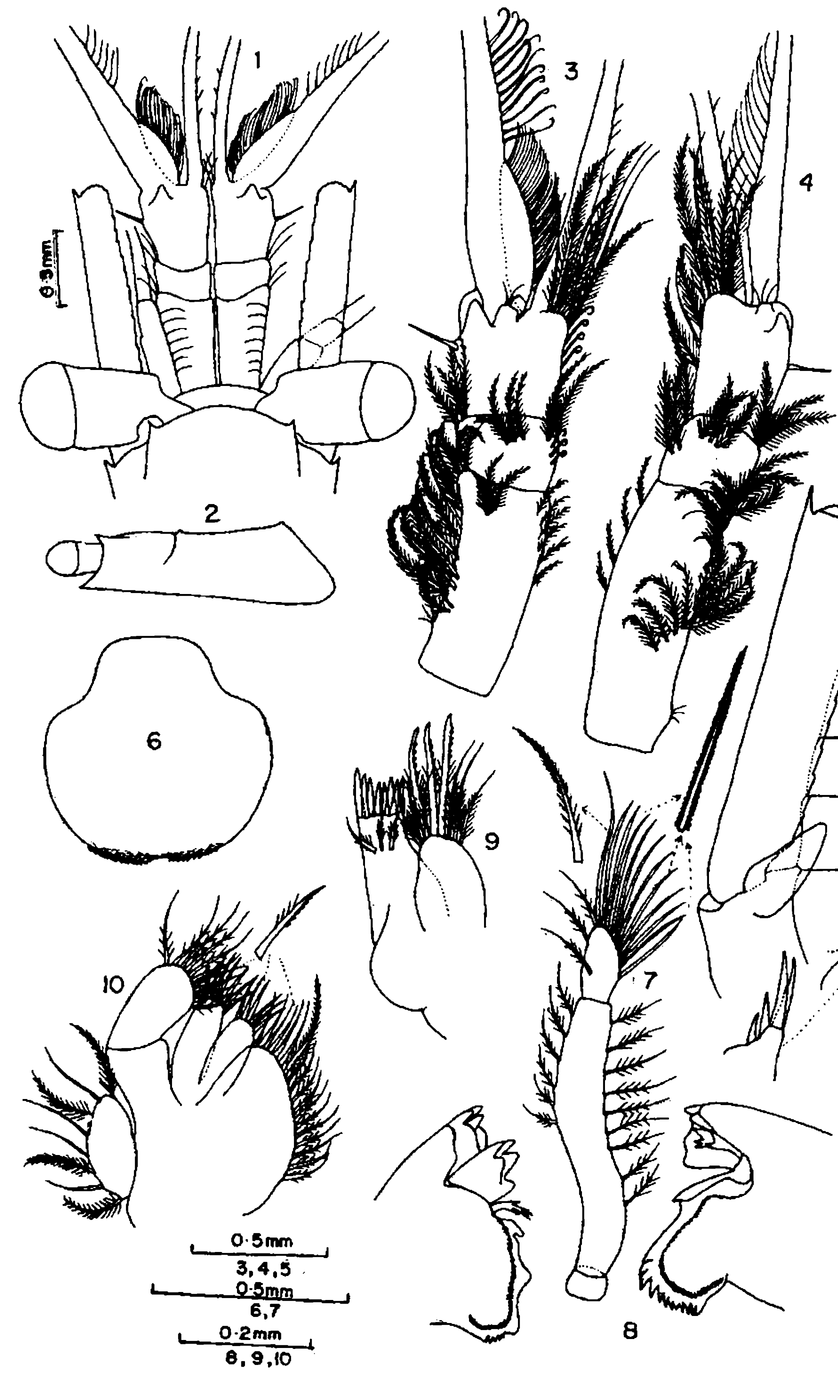
Dharamtar: (18°42.00'N, 73°01.80'E); October to November 1984, 34 adult males, 46 adult females, 12 immature males, 24 immature females, and eight juveniles. Thane: (19°11.20'N, 72°59.20'E); March 1990, four adult males, one adult female, and two immature females. Bassein: (19°18.80'–19°19.20'N, 72°44.70'–72°51.20'E); April 1989, January 1990. Large number of males and females of all stages. Daman: (20°24.70'N, 72°50.11'E); February 1990, 32 adult males, seven immature males, 46 adult females, and four immature females.

Description

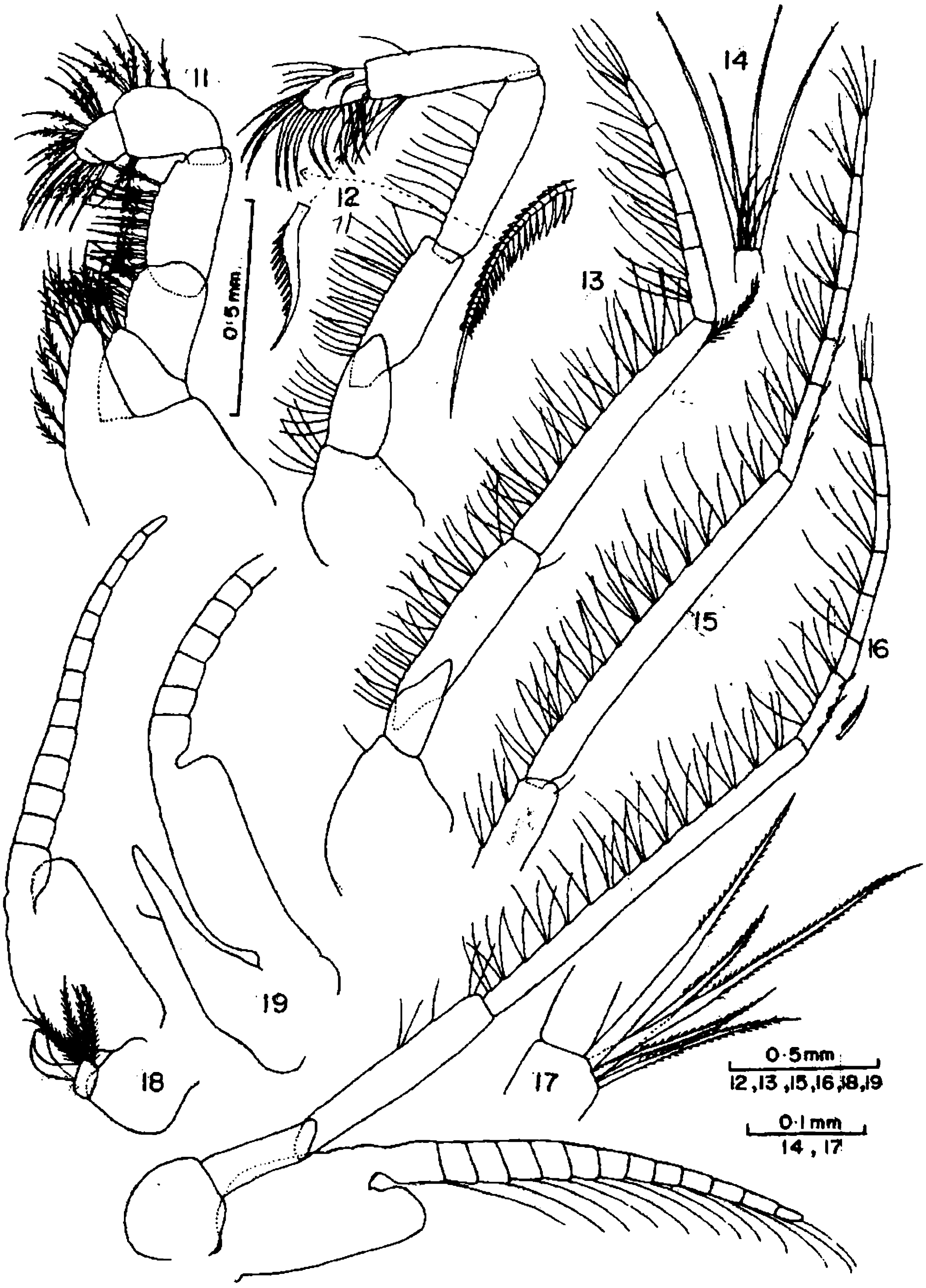
Body robust and strongly built. Carapace with dorso-median nodules; anterior margin lacking rostrum, postorbital spines prominent, keels prominent, cheeks sinuous. Eyes stout, extending to distal end of first segment of antennule, cornea occupying little more than half of eye and wider than stalk (Figures 1, 2).

Antennule more robust in male, first segment longer than rest of peduncle, outer distal angle drawn out and armed with few stout plumose setae, outer margin armed with row of 10 long curved plumose setae, inner margin with five to six short slender plumose setae; second segment short and armed with two long and three short hooked setae on inner distal angle, four setae on outer distal angle and three setae on dorsal margin; third segment broader and armed with one spinous seta on outer margin, and four hooked setae and group of seven long plumose setae on inner distal margin; mid-dorsal lobe between flagella present, base of outer flagellum swollen and thickly hirsute (Figure 3). In female antennular peduncle longer, first segment with row of 13 long curved plumose setae along outer margin; second segment with setae on outer and inner distal angles and on mid-dorsal margin; third segment with group of long plumose setae extending from inner distal angle to inner middle margin, hooked setae absent (Figure 4). Antennal scale slightly over-reaching antennular peduncle, nearly five times as long as broad, outer margin straight and terminating in strong spine extending beyond rounded apex; antennal peduncle short, less than half of scale; inner distal angle of sympod armed with two long and two short spines, second spine longest (Figure 5). In young and immature specimens one or two secondary spinules present on second longest spine.

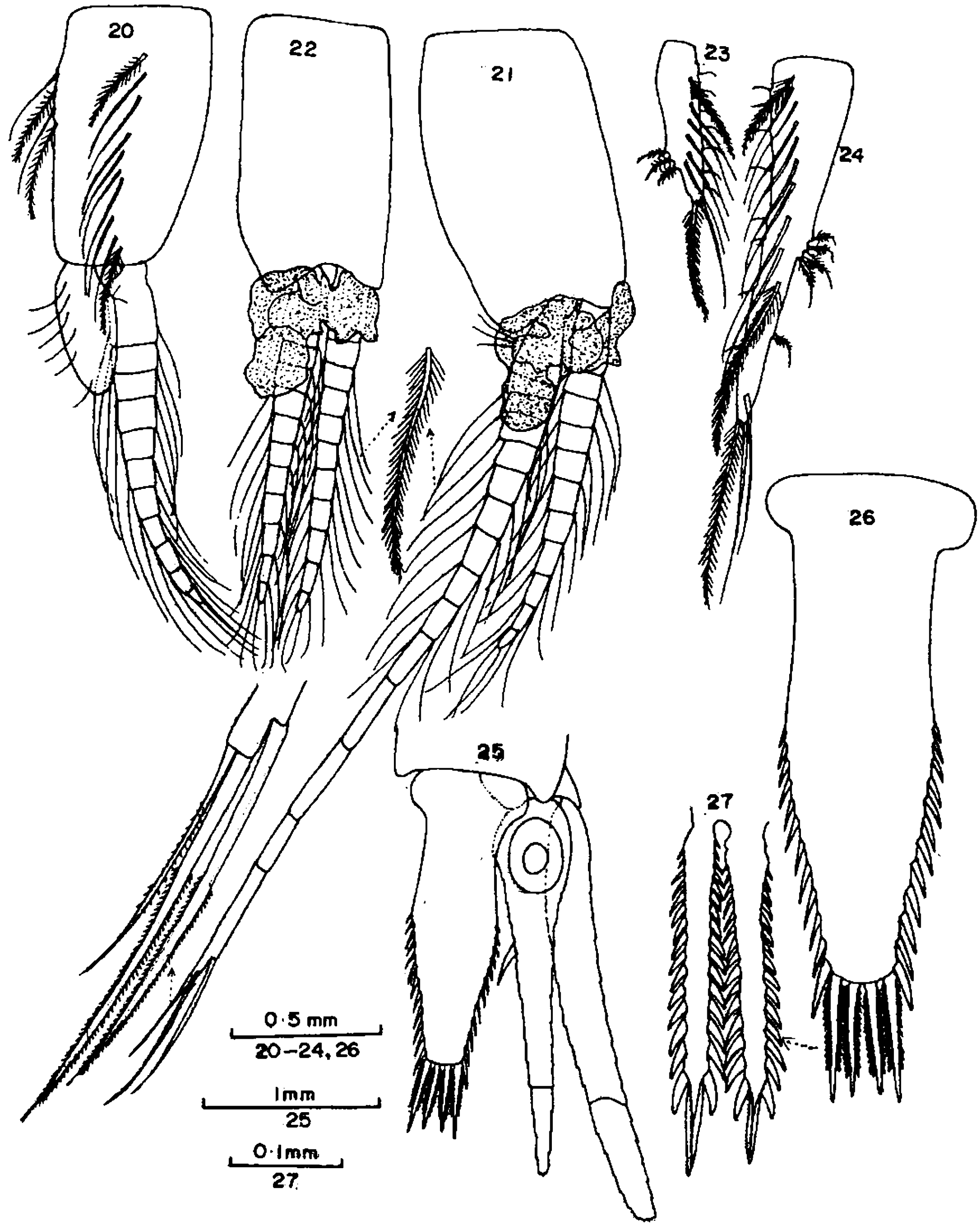
Labrum wider than long with transverse anterior margin and without any process in front (Figure 6). Mandibular palp slender, second segment four times as long as third and with row of barbed setae; third segment armed with group of modified setae on distal border



Figures 1–10. *Rhopalophthalmus mumbayensis* sp. nov. (male, unless indicated). (1) Anterior part of body. (2) Carapace, lateral view. (3) Antennule. (4) Antennule of female. (5) Antenna. (6) Labrum. (7, 8) Mandible. (9) Maxillule. (10) Maxilla.



Figures 11–19. *Rhopalophthalmus mumbayensis* sp. nov. (male, unless indicated). (11) First thoracic endopod. (12) Second thoracic endopod. (13) Third thoracic endopod. (14) Same, tip of endopod. (15) Fifth thoracic endopod. (16) Seventh thoracic endopod. (17) Same, one propodal segment. (18) Eighth thoracic limb. (19) Eighth thoracic limb of female.



Figures 20–27. *Rhopalophthalmus mumbayensis* sp. nov. (male, unless indicated). (20) First pleopod. (21) Second pleopod. (22) Third pleopod. (23) First pleopod of female. (24) Fifth pleopod of female. (25) Posterior part of body. (26) Telson. (27) Apical spines of telson.

(Figures 7, 8). Inner lobe of maxillule with five plumose setae and three stout barbed spines, outer lobe with nine strong spines on distal border (Figure 9). Maxilla with large basal lobe and deeply cleft distal lobe; exopod relatively small (Figure 10).

Basis of first thoracic endopod with prominent lobe, claw present (Figure 11) second; thoracic endopod stout, dactylus armed with strong peculiarly barbed spiniform setae (Figure 12). Endopods of third to seventh thoracic limbs slender, becoming longer in posterior pairs; third and fourth endopods with three to four, fifth endopod with four to five, and sixth and seventh endopods with five to six propodal segments (Figures 13–16). All endopods profusely setose, setae on seventh endopod spinulose (Figure 17); outer distal corner of basal plate of exopod rounded, flagelliform part 11–14-segmented. Endopod of eighth limb three-segmented, second segment short with five long plumose setae on inner margin, third segment long and bent, shorter than basal segment of exopod lacking setae (Figure 18). In female, endopod unsegmented, tapering, shorter than basal plate of exopod and armed with short simple seta on inner margin (Figure 19).

In male first abdominal segment with semicircular pleural plates. Pleopods biramous; first pleopod with 11-segmented exopod, and unsegmented endopod (Figure 20); second pleopod with 11-segmented endopod and 15-segmented exopod, first 10 segments with usual pair of plumose setae, distal five segments without setae, terminal segment longest and armed with three long barbed setae (Figure 21). Third and fourth pleopods with 11-segmented and fifth with 10-segmented rami (Figure 22).

In female, pleopods simple, rod-like, becoming longer towards posterior and with row of plumose setae (Figures 23, 24).

Telson broad, 1.3 times longer than last abdominal segment, 2.3 times as long as basal width, abruptly constricted near base to form waist, slightly broadening towards middle and gradually narrowing towards broadly rounded apex; lateral margins armed along distal half with 11–12 stout spines in male, gradually increasing in length towards posterior, apex with two pairs of long stout spines, outer pair slightly longer than inner pair and nearly one-quarter length of telson, each spine with row of bilaterally arranged subsidiary teeth progressively more flattened towards tip of spine (Figures 26, 27). In female, lateral margin of telson armed with 12–14 pairs of spines.

Uropods longer than telson, two-segmented and setose all round; endopod with stout spine near middle on inner margin; exopod longer than endopod (Figure 25).

Length: adult male 8.3–11 mm, adult female 9–12 mm.

Etymology

This species was collected from areas around Mumbai and hence the species name *mumbayensis*.

Remarks

Rhopalophthalmus mumbayensis sp. nov. is related to *R. kempi* O. Tattersall, 1951, *R. orientalis* O. Tattersall, 1957, *R. tattersallae* Pillai, 1961, *R. macropsis* Pillai, 1964, and *R. longipes* Ii, 1964 in having two long and two short spines on the antennal sympod, but they differ from the new species in the following points. In *R. kempi*, there are only three carpopropodal segments in the third to seventh thoracic endopods, and the vestigial endopod of the eighth thoracic limb of both sexes is longer than the basal plate of the exopod. In *R. tattersallae*, one of the long spines on the antennal sympod is barbed; thoracic endopods three to seven have only four carpopropodal segments and the inner pair of apical spines of the telson are longer than the outer pair. In *R. macropsis* and *R. longipes*, the carpopropodus is four-segmented and the telson is long and narrow. In *R. orientalis* there are four carpopropodal segments, and the telson has 15–16 lateral spines and the apical pairs of the telson spines are equal in length. The combination of characters afforded by the spines on the antennal sympod, the carpopropodal segments of the thoracic endopods, and the armature of the telson will serve to identify this species.

Ecological note

At Bassein, this species occurred in large numbers during April. Ninety-five per cent of the samples were constituted by adult males and females, and 80% of the females were carrying 6–20 eggs or larvae in the brood pouch. It occurred at 5–10 m depth, where the bottom sediment was sandy or silty clay. The temperature and salinity recorded ranged from 21 to 33°C and from 29.4 to 38.0 psu, respectively. Its occurrence at 5–10 m depth proves it is a littoral species, and the large number of specimens in the samples indicate that this species is a gregarious form.

Rhopalophthalmus anishi sp. nov.
(Figures 28–40)

Material

Holotype: adult male (IOBC-0504-10-50-1999). Allotype: adult female (IOBC-0504 A-10-50-1999). Paratypes: two adult males and two adult females (IOBC-0504 B-10-50-1999).

Kashelli: (19°14.30′N, 73°00.20′E), December 1996, 13 adult males, 13 adult females, eight immature males, seven immature females, and 33 juveniles.

Description

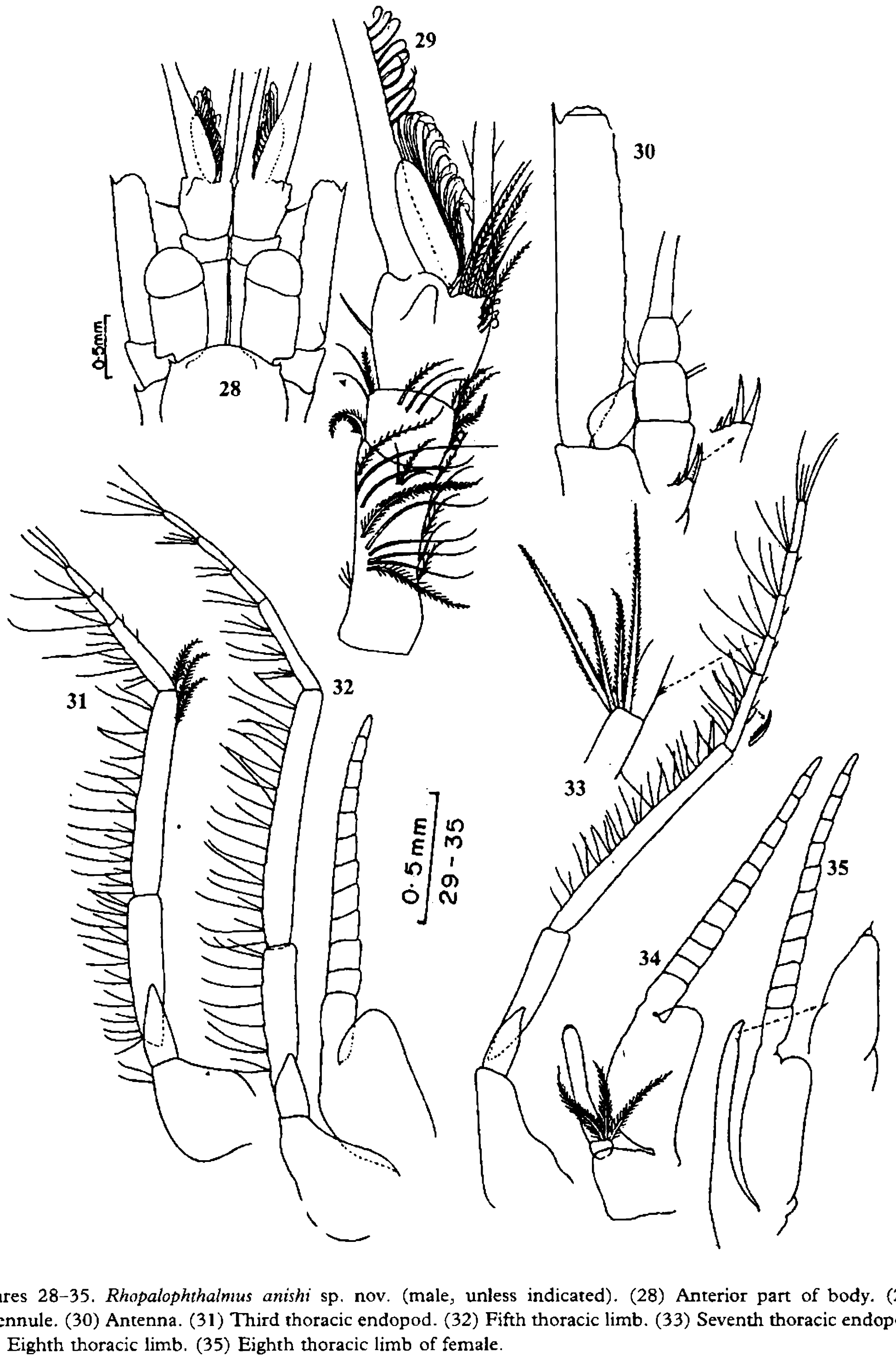
General form slender. Carapace broadly rounded in front, covering basal part of antennules, post-orbital spines small, continuing backward into faint keels; antero-lateral angles produced into strong spines; cheeks sinuous. Eyes stout, reaching beyond first antennular segment; cornea as broad as stalk and occupying distal third of eye (Figure 28).

Basal segment of antennule in male as long as rest of peduncle, third segment short and stout, but short basal part of outer flagellum swollen and hirsute (Figure 29). In female, basal segment much longer than rest of peduncle. Antennal scale long and narrow reaching clearly beyond antennular peduncle, five times as long as broad; antennal peduncle short, less than half length of scale; sympod with two long and two short spines (Figure 30).

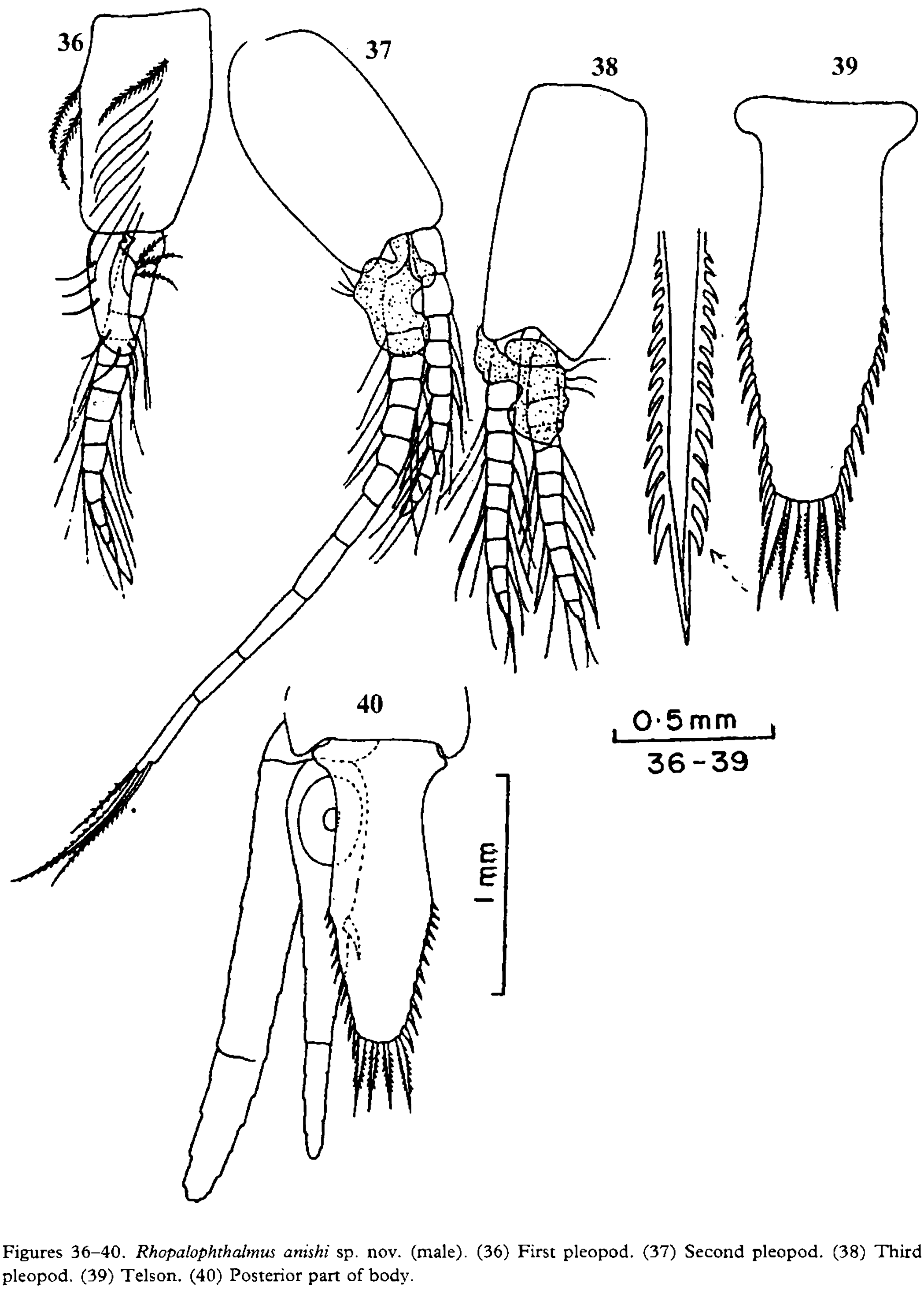
Mouthparts and first and second thoracic endopods as in *R. mumbayensis* sp. nov.

Thoracic endopods three to seven with three to five carpopropodal segments (Figures 31–33). Vestigial endopod of male eighth thoracic limb straight, three-segmented, almost as long as basal segment of exopod, second segment with three to four plumose setae on outer distal corner, apex broadly rounded (Figure 34). In female, eighth endopod longer than basal segment of exopod, slender, straight and unsegmented, distal end produced at apex into minute cusp with short seta (Figure 35).

Pleopods in male biramous, first pleopod with unsegmented endopod and 10-segmented exopod (Figure 36); second pleopod with 10-segmented endopod and 12-segmented exopod, distal segment of exopod with third long barbed setae (Figure 37); third, fourth, and fifth pleopods similar with 10-segmented exopod and endopod (Figure 38).



Figures 28–35. *Rhopalophthalmus anishi* sp. nov. (male, unless indicated). (28) Anterior part of body. (29) Antennule. (30) Antenna. (31) Third thoracic endopod. (32) Fifth thoracic limb. (33) Seventh thoracic endopod. (34) Eighth thoracic limb. (35) Eighth thoracic limb of female.



Figures 36–40. *Rhopalophthalmus anishi* sp. nov. (male). (36) First pleopod. (37) Second pleopod. (38) Third pleopod. (39) Telson. (40) Posterior part of body.

Telson moderately broad, longer than last abdominal segment, about twice as long as broad at base, distal half armed with 11 pairs of graduated spines, spines on distal border long and sharply pointed, outer pair distinctly longer than inner pair, subsidiary teeth sharp (Figure 39).

Uropods longer than telson, two-segmented, endopod with single stout spine on middle inner margin; exopod longer than endopod (Figure 40).

Length: adult male 9.7–11 mm; adult female 9.6–11.7 mm.

Etymology

This species is named after the first author's son, Anish.

Remarks

This species can be readily distinguished by the combinations of the following characters: (1) thoracic endopods have three to five carpopropodal segments; (2) vestigial endopod of eighth thoracic limb is longer than the basal segment of the exopod in female and in male almost as long as the basal segment of exopod and (3) spines on the distal border of the telson are sharply pointed and the outer pair of spines are distinctly longer than the inner pair.

Rhopalophthalmus kempi O. Tattersall, 1957 is the only other species of the genus in which the endopod of the eighth thoracic limb in both sexes is longer than the basal segment of the exopod. But *R. kempi* differs from the new species in having a shorter antennal scale, only three carpopropodal segments and the inner pair of distal spines on the telson are longer than the outer pair.

Ecological note

The new species is a shallow-water form and the temperature and salinity recorded at the time of collection were 25.4°C and 16.4 psu, respectively.

Rhopalophthalmus murudana sp. nov.

(Figures 41–52)

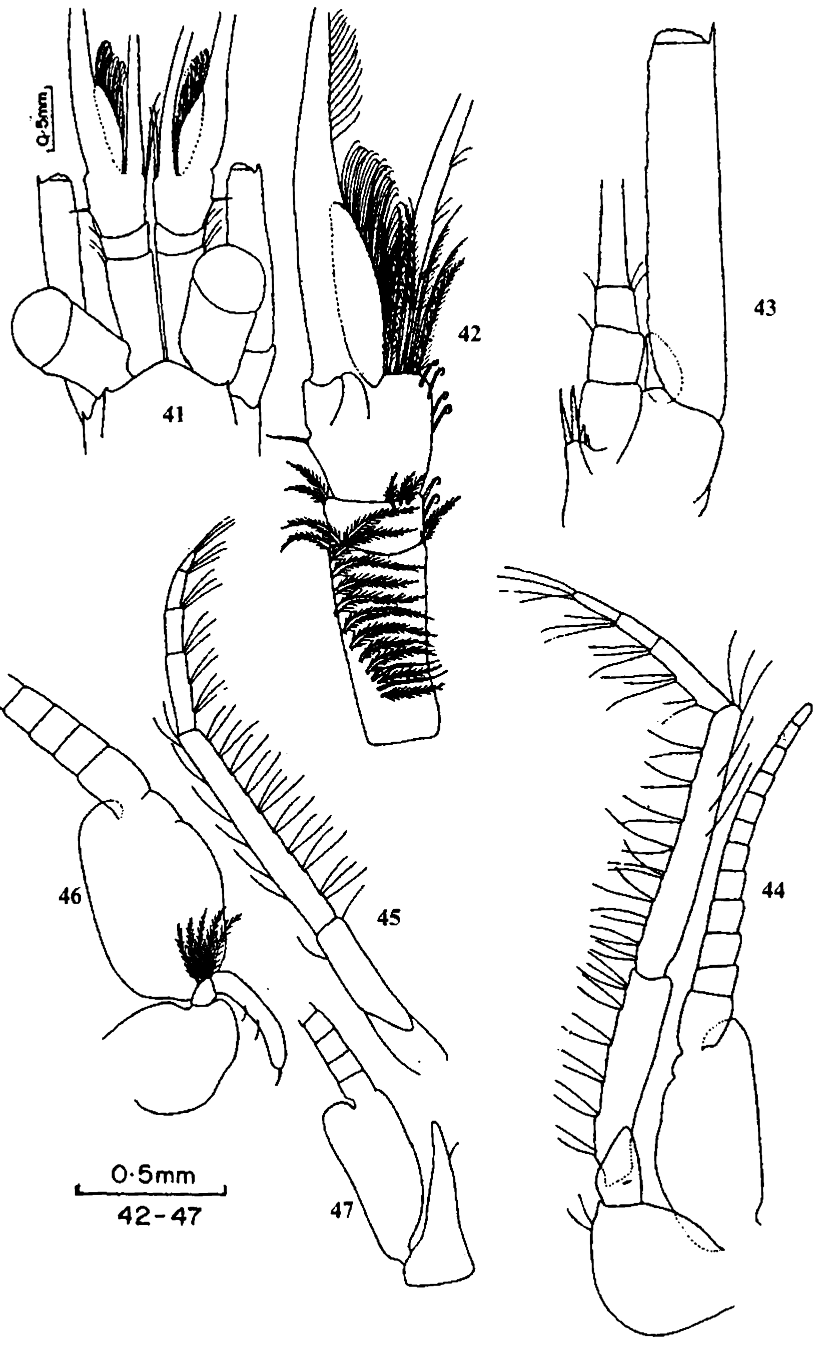
Material

Holotype: adult male (IOBC-0505-10-50-1999). Allotype: adult female (IOBC-0505 A-10-50-1999).

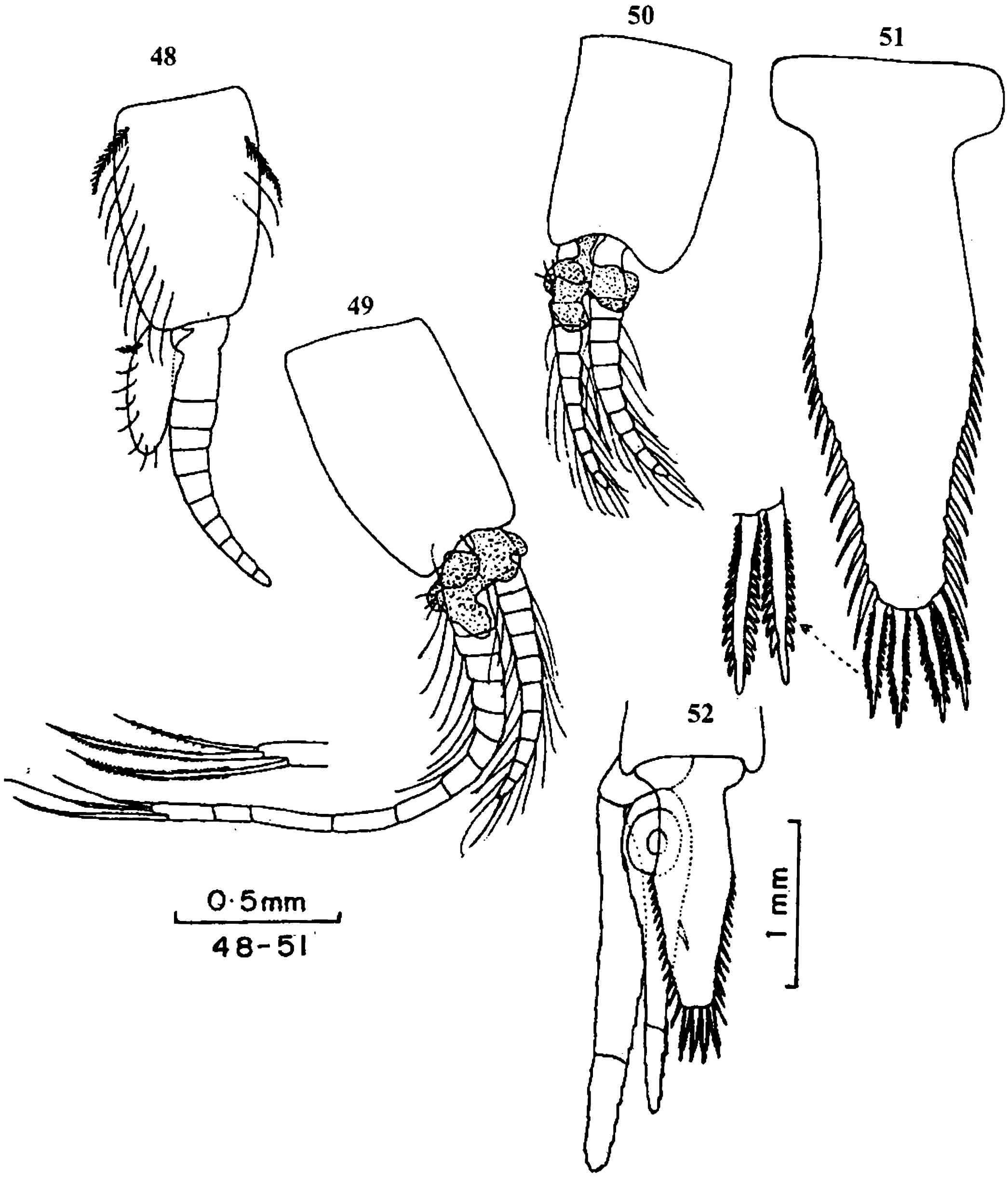
Murud: (18°16.39′–18°18.30′N, 72°55.28′–72°59.72′E); March 1990, six adult males, eight adult females, 13 immature males, six immature females, and nine juveniles.

Description

General form robust. Carapace anteriorly produced into broad triangular rostrum covering basal part of eye stalks; dorsal median nodules present. Eyes stout, as long as first antennular segment, cornea wider than stalk (Figure 41). First segment of male antennule little longer than rest of peduncle, base of outer flagellum swollen and hirsute and all segments furnished with long plumose setae (Figure 42). In female, peduncle longer and



Figures 41–47. *Rhopalophthalmus murudana* sp. nov. (male, unless indicated). (41) Anterior part of body. (42) Antennule. (43) Antenna. (44) Third thoracic endopod. (45) Seventh thoracic endopod, distal part. (46) Eighth thoracic limb. (47) Eighth thoracic limb of female.



Figures 48–52. *Rhopalophthalmus murudana* sp. nov. (male). (48) First pleopod. (49) Second pleopod. (50) Third pleopod. (51) Telson. (52) Posterior part of body.

more slender than male, first segment 1.5 times longer than rest of peduncle. Antennal scale as long as antennular peduncle, five times as long as broad; antennal peduncle one-third length of scale; antennal sympod with two long and two short spines (Figure 43).

Mouthparts and first and second thoracic endopods as in *R. mumbayensis*. Third to seventh endopods slender, third with two, and fourth to seventh with three propodal segments (Figures 44, 45). Eighth endopod three-segmented; second segment short with five long plumose setae on outer distal margin; third segment cylindrical and bent at right angle, with one stout seta at tip and two on inner margin, when straightened shorter than basal segment of exopod (Figure 46). Eighth endopod in female unsegmented, straight, shorter than basal segment of exopod (Figure 47).

Pleopods in male biramous, first pleopod with unsegmented endopod and 10-segmented exopod (Figure 48). Endopod of second pleopod 11-segmented; exopod long and 12-segmented, segments becoming longer posteriorly, distal segment with three long barbed setae (Figure 49). Pleopods three to five with 10-segmented exopod and endopod (Figure 50). In female, pleopods simple, unsegmented and rod-shaped becoming longer in posterior pairs.

Telson 1.5 times longer than last abdominal somite, 2.7 times as long as broad at base, more than distal half of lateral margin armed with 15–16 slender spines gradually increasing in length distally, first two spines very small; inner pair of distal spines slightly longer than outer pair, subsidiary teeth becoming flattened distally (Figure 51).

Uropods longer than telson, two-segmented, endopod with stout spine on inner margin, exopod longer than endopod (Figure 52).

Length: adult male and female 8.5–9.3 mm.

Etymology

This species is named after the type locality.

Remarks

This species closely resembles *R. orientalis*, O. Tattersall. The vestigial endopod of the eighth thoracic limb, the number of carpopropodal segments of third to seventh thoracic endopods, and the spines on the telson are very similar in the two species. But in *R. orientalis* the rostrum is relatively low, eyes are longer, and the subsidiary teeth on the telson are broader and truncate. This species also resembles *R. mumbayensis* sp. nov. but differs in having fewer carpopropodal segments, spines on the lateral border of the telson are more slender and more in number, and the inner pair of distal spines on the telson are longer than the outer pair.

Ecological note

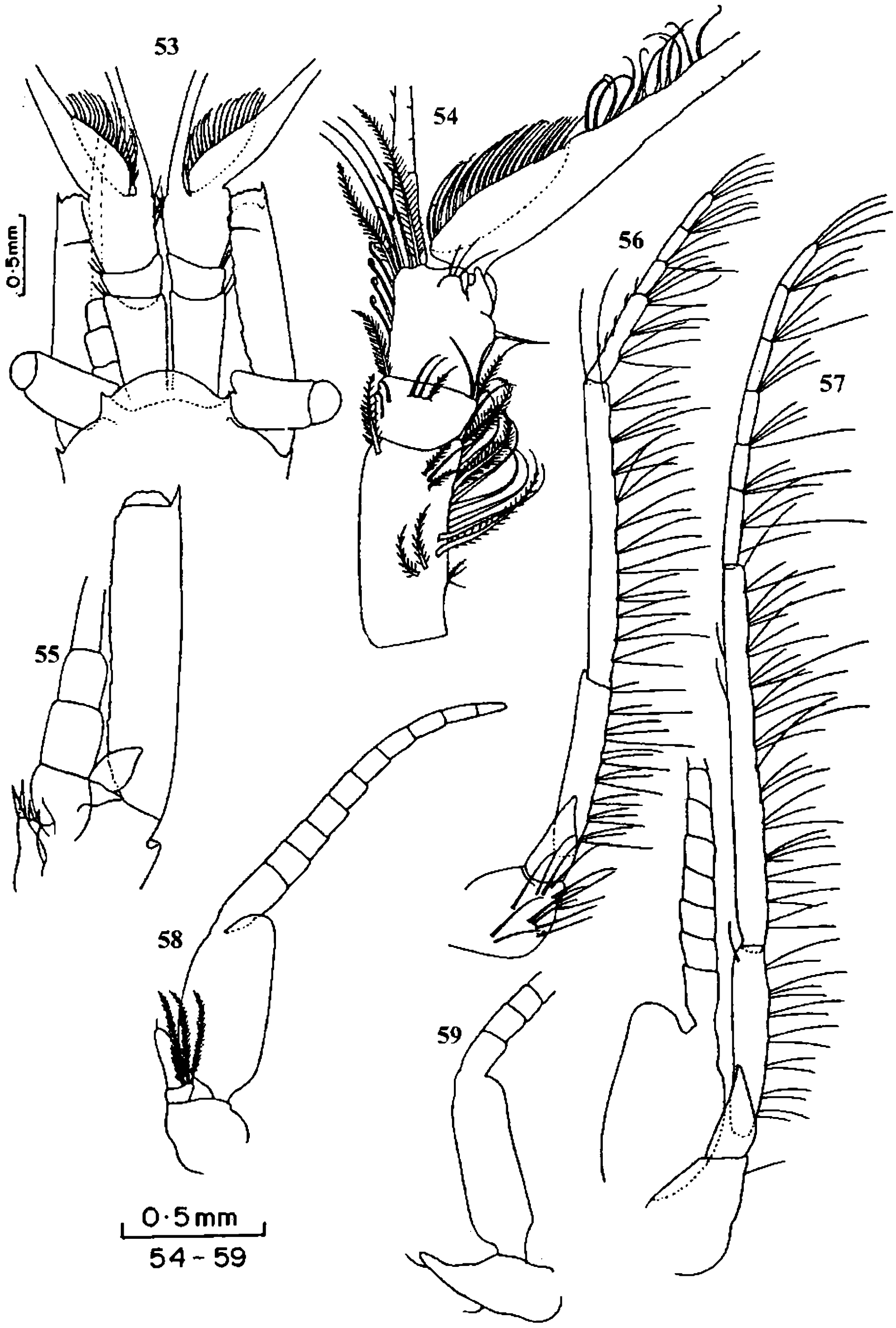
This species occurred in temperatures and salinity of 25.2–28.5°C and 35.7–36.3 psu, respectively, and was collected from 5 to 9 m depth where the bottom was clayey silt.

Rhopalophthalmus vijayai sp. nov.
(Figures 53–64)

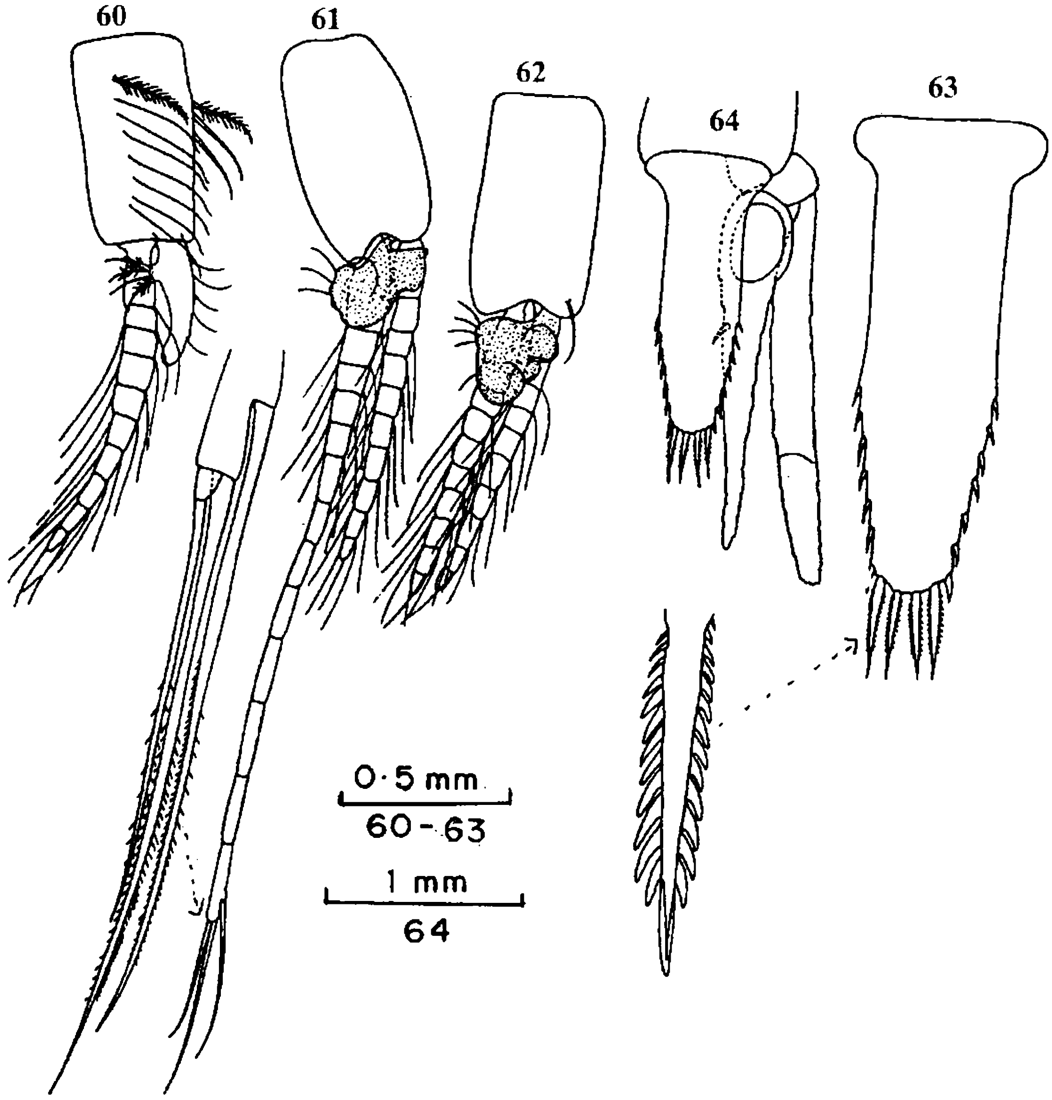
Material

Holotype: adult male (IOBC-0506-10-50-1999). Allotype: adult female (IOBC-0506 A-10-50-1999).

Dahej: (21°40.00′–21°43.30′N, 72°29.45′–72°32.00′E); November 1996, nine adult males, 30 adult females, three immature males, nine immature females, and 478 juveniles.



Figures 53–59. *Rhopalophthalmus vijayai* sp. nov. (male, unless indicated). (53) Anterior part of body. (54) Antennule. (55) Antenna. (56) Third thoracic endopod. (57) Fifth thoracic limb. (58) Eighth thoracic limb. (59) Eighth thoracic limb of female.



Figures 60–64. *Rhopalophthalmus vijayai* sp. nov. (male). (60) First pleopod. (61) Second pleopod. (62) Third pleopod. (63) Telson. (64) Posterior part of body.

Description

General form slender. Carapace short, leaving last three thoracic somites exposed; anteriorly produced into broadly rounded rostrum covering basal one-quarter of antennular peduncle and basal part of eyestalks; two small dorso-median nodules present, postorbital spines small, cheeks sinuous. Eyes extending to distal end of first antennular segment, cornea occupying one-quarter of eye and little narrower than stalk (Figure 53).

Antennule robust in male, first segment as long as distal two segments combined and with row of 9–10 plumose setae on outer margin, outer distal corner produced and tipped with few setae; second segment short with two hooked setae on inner margin, outer distal corner produced and tipped with setae; third segment broad with one spinous seta on outer margin, four hooked setae on inner margin and five to six long plumose setae on inner distal angle; dorsal lobe tipped with few setae; base of outer flagellum swollen and densely hirsute (Figure 54). In female antennular peduncle slender and longer, first segment longer than other two segments combined, hooked setae absent; third segment with seven long plumose setae on inner distal angle and four setae on inner margin. Antennal scale as long as antennular peduncle, 4.6 times as long as broad, outer margin straight, terminating in spine projecting beyond rounded apex, inner margin setose; antennal peduncle extending to middle of scale; antennal sympod with two long and two short spines on inner distal corner (Figure 55).

Mouthparts and first and second thoracic endopods as in *R. mumbayensis.*

Endopods of third to seventh thoracic limbs slender, increasing in length posteriorly; propodus three-segmented in third and five-segmented in fourth to seventh endopods (Figures 56, 57). Eighth endopod in male three-segmented, shorter than proximal segment of exopod, second segment short with three long plumose setae on outer distal corner, second segment long and finger-like with single simple seta at tip (Figure 58). In female eighth endopod unsegmented with two simple setae and shorter than proximal segment (Figure 59).

Pleopods biramous and natatory. First pleopod with 10-segmented exopod; endopod unsegmented and short, sympod with three plumose setae on inner distal margin and row of long plumose setae along mid-dorsal line (Figure 60). Second pleopod with 10-segmented endopod; exopod 13-segmented, segments increasing in length posteriorly, first five segments with usual pair of plumose setae, distal eight segments without setae, terminal segment ending in three long barbed setae, two at tip, one slightly away from tip (Figure 61). Third to fifth pleopods in male similar, endopod and exopod 10-segmented. Pleopods in female simple, unsegmented and rod-shaped, distal pairs progressively increasing in length (Figure 62).

Telson 1.4 times longer than last abdominal somite, 2.3 times as long as maximum width at base, abruptly narrowing near base to form waist, lateral margins almost parallel up to distal half and gradually narrowing towards rounded apex and armed along distal half with seven slender subequal spines, distal margin with two pairs of long sub-equal spines, inner pair of spines with 12 and outer pair with 10 pairs of closely set subsidiary teeth, proximal teeth spiniform and distal teeth broader (Figure 63).

Uropods: exopod and endopod two-segmented, setose all round and longer than telson. Endopod with one strong spine on inner margin (Figure 64).

Length: adult male 6.6 mm, adult female 8.6 mm.

Etymology

This species is named in honour of Dr Vijayalakshmi R. Nair, Scientist (retired), NIO.

Remarks

This species can be easily distinguished from all the other species of the genus except *R. africana* O. Tattersall, 1957 by its slender form and in having fewer spines on the lateral border of the telson. In *R. africana*, the lateral margin of the telson is armed with six to eight spines only, but differs from the new species in having only two large spines on the antennal sympod, four carpopropodal segments in third to seventh thoracic endopods and in its more robust form. The largest male and female of *R. africana* measured is 10 and 10.2 mm, respectively, whereas the maximum size of the present species is only 8.6 mm.

Ecological note

The specimens were collected from depths between 8 and 25 m, where the bottom was silty sand, and occurred in temperatures and salinity ranging from 26.9 to 29.0°C and from 23.1 to 29.8 psu, respectively.

Acknowledgements

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A new genus and species of Heteromysini (Crustacea-Mysidacea) from the backwater of Kochi (Kerala, India)

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Abstract
Kochimysis pillaii, a new genus and species of Heteromysini collected from the backwater of Kochi, is described. The new genus is closely related to the genus *Deltamysis* but is distinguishable from the latter by the following characters: antennules of male have a small setiferous lobe; antennal scale is without distal suture; second segment of mandibular palp broad; endopodite segments of maxilla subequal in length; in male carpus and propodus of second thoracic endopod with notches on outer margin; outer pair of apical spines on telson longer than the inner pair.

Keywords: *Kochi backwater,* Kochimysis, *Mysida, new genus, taxonomy*

Introduction

The Kochi backwater is part of a long chain of lakes and canals, parallel to the coast, extending between 9°40′12″ and 10°10′46″N and 76°09′52″ and 76°23′57″E. The total area of the backwater is about 157 km^2 with depth ranging from 2 to 8 m. A large number of rivers discharge into it and it opens into the Arabian Sea through one major and several minor inlets. The water is saline (5–32 psu) during the dry season and almost fresh water during the monsoon (May to October). The salinity gradient in the Kochi backwater supports diverse species of flora and fauna depending on their capacity to tolerate oligohaline, mesohaline, or marine conditions. The material examined was collected as part of the studies on "Ecosystem modelling of Cochin backwaters" during 2003–2004. Although there has been continuous sampling for zooplankton in the estuary, *Kochimysis* was collected in March and April 2003 and March 2004 only. The material was collected with a W.P. net (Working Party net; mesh size 200 µm, mouth area 0.6 m^2) from the surface and occurred at one station only (Figure 1). The salinity and temperature ranged from 25.02 to 32.47 psu and 30.0 to 32.5°C, respectively. Type specimens are deposited in the reference collection of the Indian Ocean Biological Center (IOBC), National Institute of Oceanography, Regional Center, Kochi.

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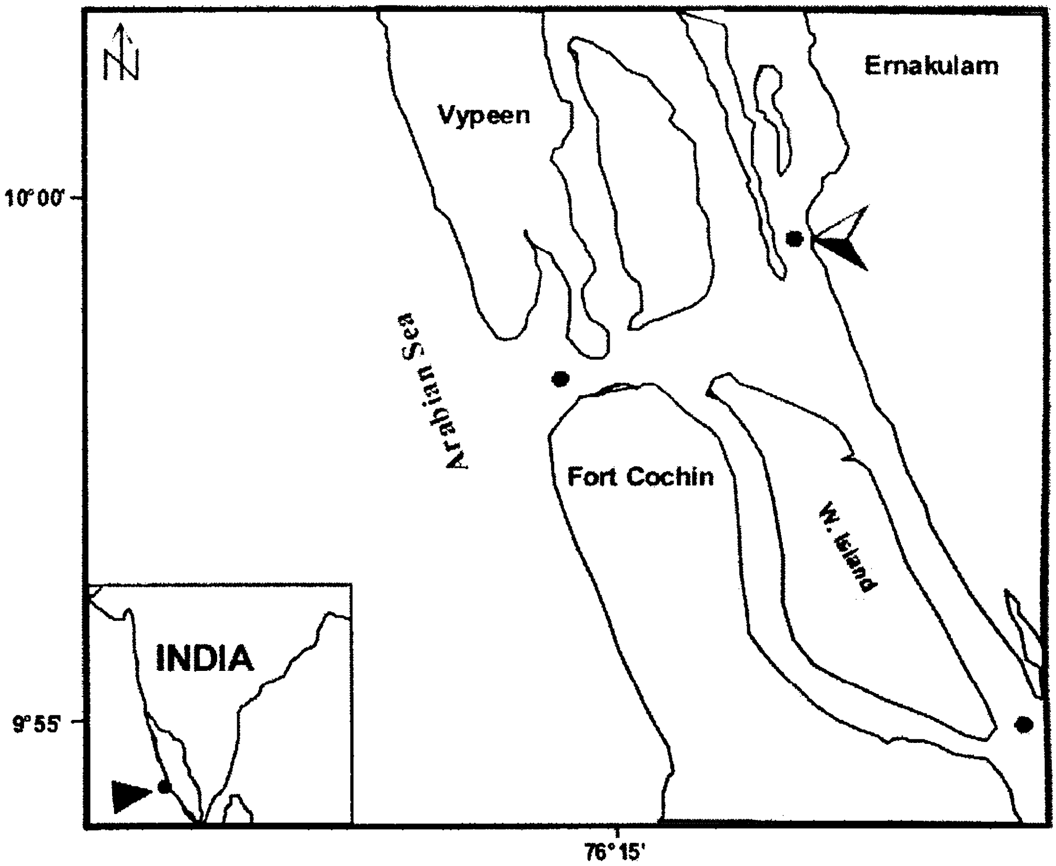

Figure 1. Location of station (arrowhead indicates the occurrence of *Kochimysis pillai*).

Genus *Kochimysis* gen. nov.

Diagnosis

General form small and slender. Carapace broadly triangular in front. Eyes normal. Male lobe of antennule reduced to small setiferous lobe; antennal scale oval with rounded apex, setose all round, distal articulation absent. Second segment of mandibular palp broad; *lacinia mobilis* and molar processes well developed. Labrum rounded in front without any spines. Maxilla with segments of endopod subequal in length, second segment oval. Second thoracic limb with carpus and propodus segments in female simple, in male with notches on outer margin; third thoracic endopod not stouter; remaining endopods with carpus and propodus fused and divided into number of subsegments; pleopods rudimentary in both sexes; telson entire, apex with two pairs of spines, outer pair longer than inner. Uropods without spines. Females with marsupium formed of two pairs of lamellae.

Type species. Kochimysis pillaii.

Etymology

The genus is named after the locality, Kochi.

Remarks

According to the emended diagnosis of the tribe Heteromysini by Bowman and Orsi (1992), the diagnostic characters of the tribe are as follows: the male lobe of antennules usually reduced, antennal scale setose all round, carpus and propodus of thoracic limbs 4–8 fused and divided into subsegments, all pleopods rudimentary in both sexes, telson with or without apical cleft, and third thoracic endopod sometimes enlarged and robust. The new genus *Kochimysis* clearly belongs to the tribe Heteromysini based on these characters. The tribe at present contains 10 genera. In all the genera except *Deltamysis* Bowman and Orsi 1992, some species of *Pseudomysidetes* Tattersall, 1936, and *Heteromysoides* Bacescu, 1968, the telson has an apical cleft. The new genus shows similarities to *Deltamysis* in the form and armature of the telson. However, the two genera are distinguished as follows: (1) in the new genus a small rounded setiferous male lobe is present on the third segment of the antennule, whereas in *Deltamysis* the lobe is not developed and the brush of setae are inserted directly on the ventral surface; (2) in the new genus the antennal scale does not have a distal articulation, whereas in *Deltamysis* the antennal scale has a transverse suture; (3) in the new genus both the mandibles have a *lacinia mobilis* and the second segment of the mandibular palp is broad. In *Deltamysis* the right mandible has no *lacinia mobilis* and the second segment of the mandibular palp is narrow; (4) in the new genus the endopodite segments of the maxilla are subequal in length and the distal segment is ovate. In *Deltamysis* the proximal segment is less than one-quarter of the distal segment and the latter is elongate and quadrangular.

Kochimysis pillaii sp. nov.

(Figures 2–5)

Material

Holotype: IOBC-0507-10-50-2006, adult male, 3.5 mm. Allotype: IOBC-0507 A-10-50-2006, female with embryos, 3.3 mm.

Other material. Two adult males, one adult female, two immature males, two immature females, and two juveniles.

Description

Body short and smooth. Anterior margin of carapace broadly triangular, rostrum inconspicuous, antero-lateral corners rounded, posterior margin emarginate leaving last three thoracic somites dorsally exposed (Figure 2A). In female frontal border of carapace scarcely produced (Figure 2B). Eyes well developed, closely set together, globular; eyestalks short and thick, cornea narrower than stalk. Antennular peduncle short and stout, first segment longer than distal segment, outer distal corner with finger-like lobe bearing two

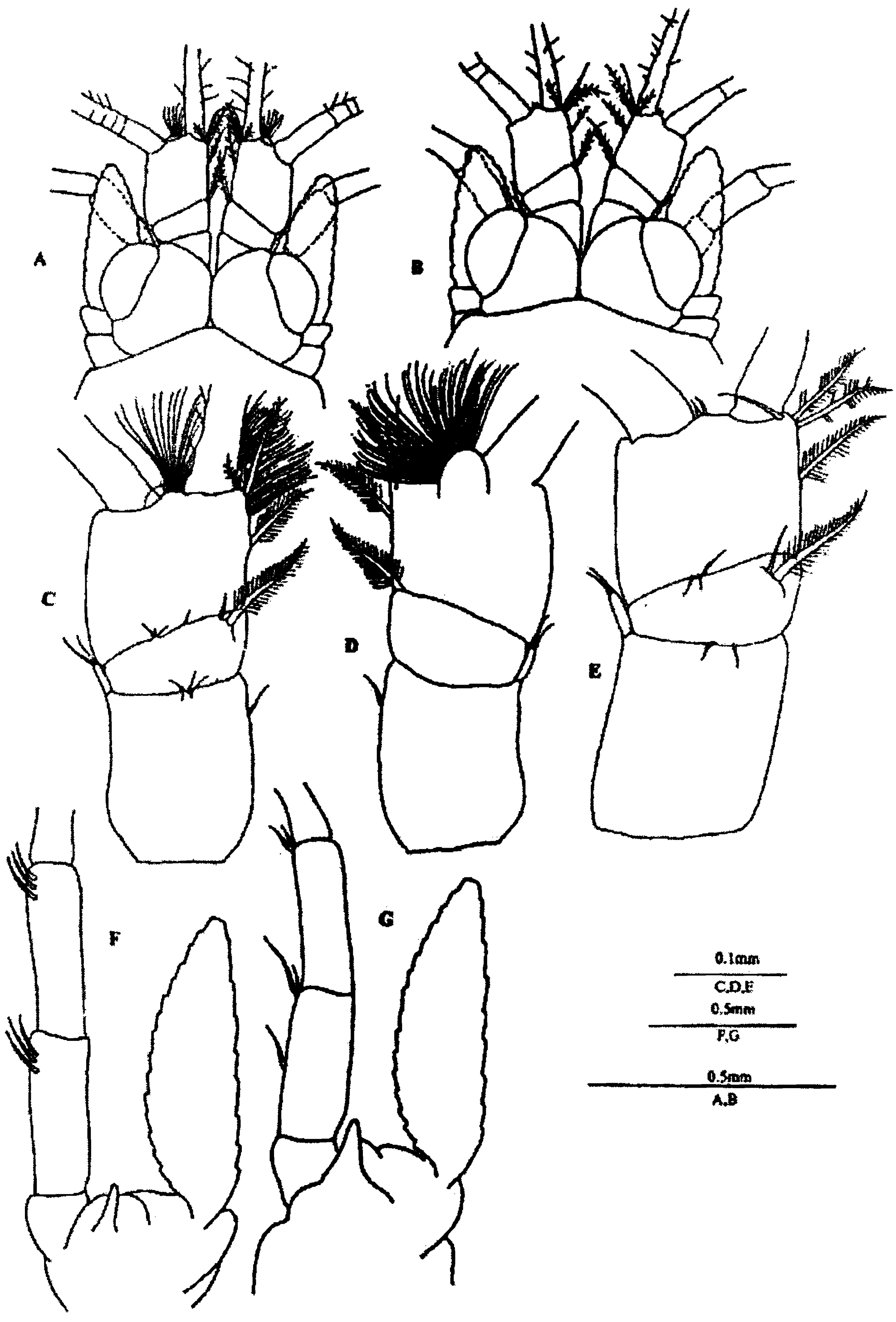

Figure 2. *Kochimysis pillai* sp. nov. (male, unless otherwise specified). (A) Anterior end of adult; (B) anterior end of adult female; (C) antennule; (D) antennule, ventral view; (E) antennule of female; (F) antenna; (G) antenna of female.

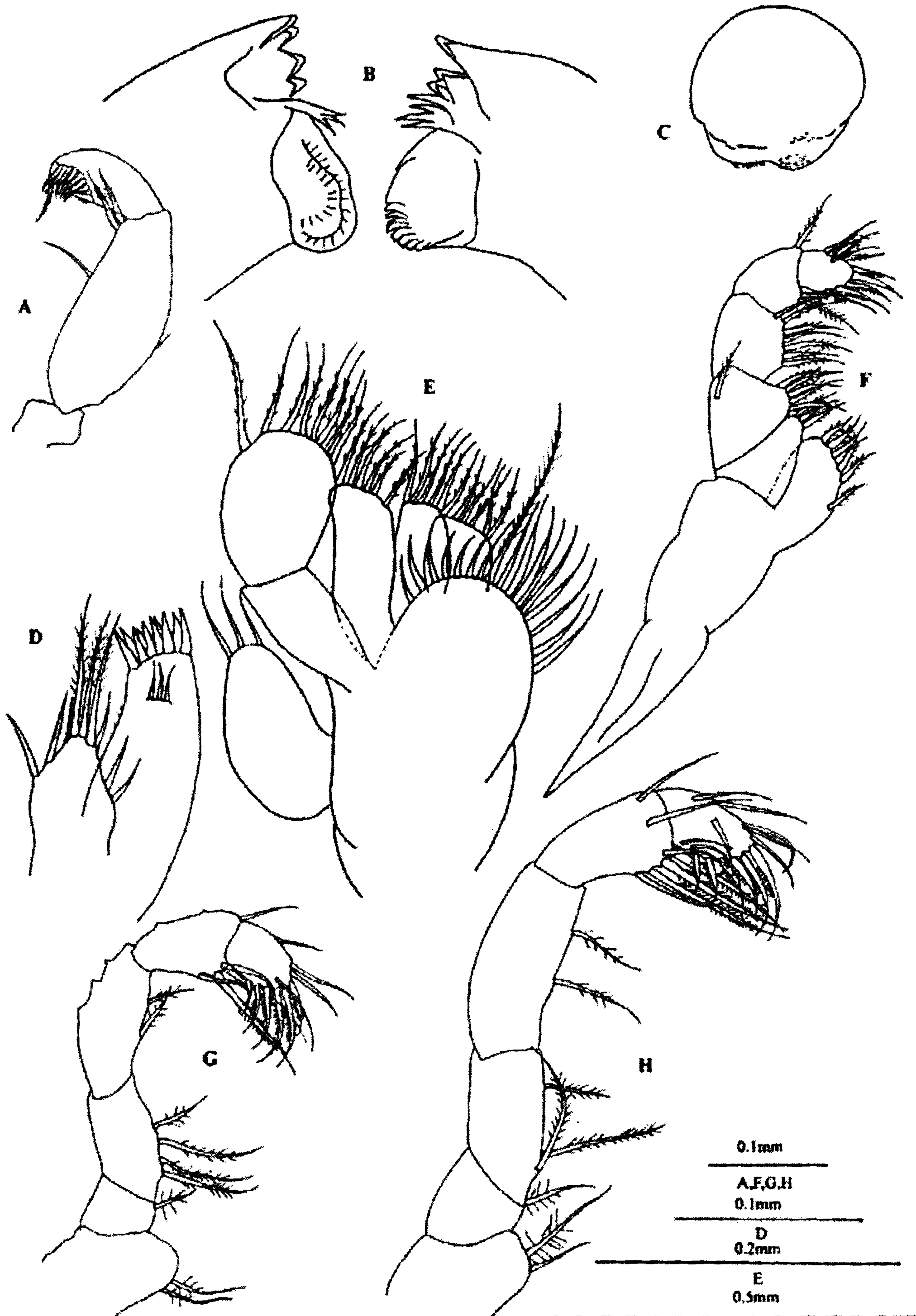

Figure 3. *Kochimysis pillai* sp. nov. (male). (A) Mandibular palp; (B) mandibles; (C) labrum; (D) maxillule; (E) maxilla; (F) first thoracic endopod; (G) second thoracic endopod; (H) second thoracic endopod.

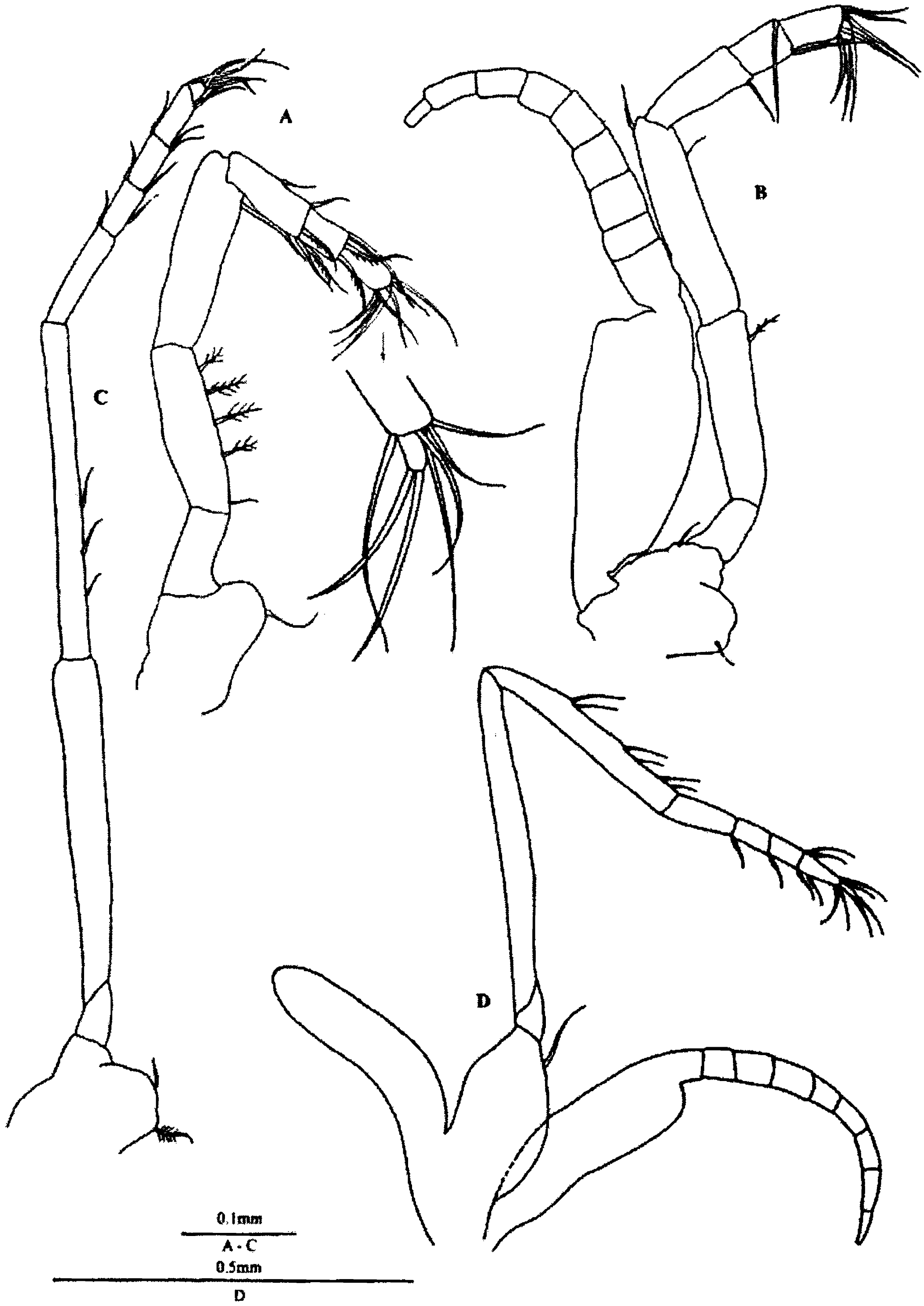

Figure 4. *Kochimysis pillai* sp. nov. (male). (A) Third thoracic endopod; (B) fourth thoracic limb; (C) fifth thoracic endopod; (D) eighth thoracic limb.

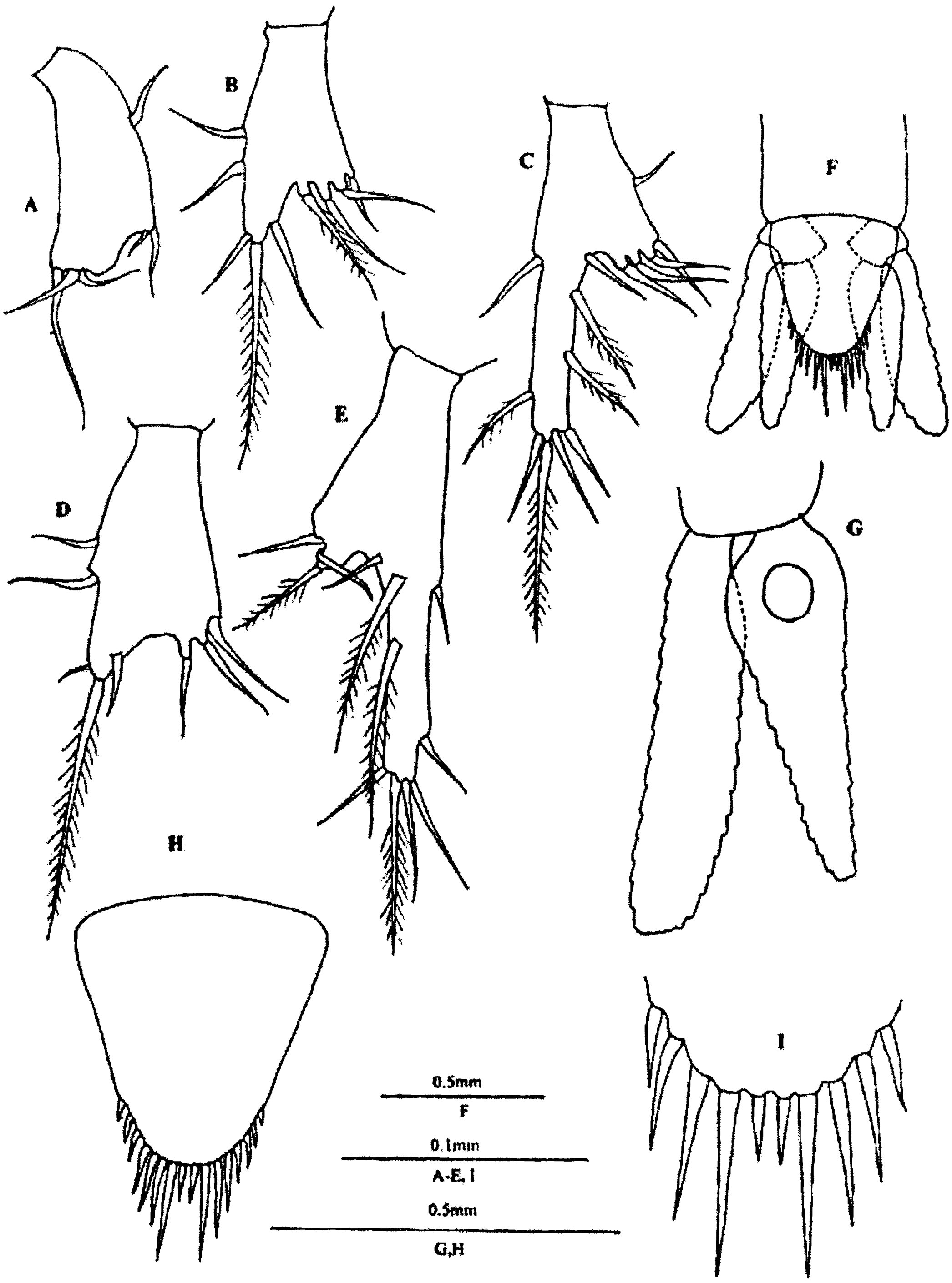

Figure 5. *Kochimysis pillai* sp. nov. (male, unless otherwise specified). (A) First pleopod; (B) third pleopod; (C) fifth pleopod; (D) second pleopod of female; (E) fifth pleopod of female; (F) posterior end; (G) uropod; (H) telson; (I) distal part of telson.

setae, second segment short with one stout plumose seta on inner distal corner; third segment with three setae on inner distal angle and one seta on inner margin, male lobe small, rounded and hirsute (Figure 2C, D). Antennule of female as in male except for absence of male lobe (Figure 2E).

Antennal scale oval, 3.5 times as long as broad, setose all round, shorter than antennular peduncle, distal suture absent; antennal peduncle longer than scale, three-segmented, second and third segments long and subequal in length; antennal sympod with finger-like process between peduncle and scale (Figure 2F, G).

Labrum with rounded anterior margin, posterior border bilobed (Figure 3C). Mandibles with well-developed *lacinia mobilis*, incisor, and molar processes; spine row of left with four strong spines and right with three spines (Figure 3B); palp three-segmented, first segment short, second segment broad and elongate bearing two setae on outer distal corner, third segment half length of second with oblique distal margin armed with row of pectinate setae and one long terminal seta (Figure 3A). Inner lobe of maxillule with three long and six short plumose setae, outer lobe distally armed with 10 spines and three subterminal setae (Figure 3D). Maxilla with large basal lobe, distal lobe deeply bifid, second segment of endopod oval, segments subequal in length; exopod with three setae at apex (Figure 3E).

First thoracic appendage with exopod and epipod; basis of endopod with prominent gnathobasic lobe, ischium and merus moderately produced inwards, all segments with setae on inner margin, dactylus with nail and group of pectinate setae (Figure 3F). Second thoracic endopod with carpus and propodus with notched outer margin (Figure 3G); in female carpus and propodus simple (Figure 3H); basis produced inwards; dactylus with group of pectinate setae, nail absent. Third and fourth thoracic endopods (Figure 4A, B) with carpopropodus divided into three subsegments; remaining endopods (Figure 4C, D) becoming longer posteriorly, carpopropodus divided into four subsegments; dactylus ending in two small setae. Basal segment of exopod rounded, flagelliform part nine segmented. In male eighth thoracic limb with small tubular genital organ (Figure 4D).

Pleopods in both sexes uniramous, reduced to unsegmented setose plates, becoming longer posteriorly (Figure 5A–E).

Uropods broad, longer than telson (Figure 5F), both rami oval, setose all round and without spines (Figure 5G), exopod longer than endopod.

Telson entire, longer than last abdominal segment, slightly longer than broad at base, lateral margins nearly straight, distal third armed with six progressively longer spines, apex broadly rounded with two pairs of spines, outer pair almost three times as long as inner pair (Figure 5H, I).

Etymology

This species is named after Dr N. Krishna Pillai in recognition of his valuable contributions to knowledge of Mysidacea of the Indian waters.

Remarks

This species resembles *Deltamysis holmquistae*, Bowman and Orsi, 1992, the monotype of the genus, in the form and armature of the telson, and the morphological differences are as stated in the remarks of the genus. Other differences observed are: (1) in *K. pillaii* the cornea of the eye is narrower than the eyestalks, whereas in *D. holmquistae* the cornea is as wide as the stalk; (2) in *K. pillaii* the antennal peduncle is much longer than the antennal scale and the distal two segments of the peduncle are subequal in length. In *D. holmquistae* the antennal peduncle is only as long as the scale and the third segment is longer than the second segment; (3) in *K. pillaii* the spine row of the mandible consists of three to four spines as against eight in *D. holmquistae*; (4) in *K. pillaii* the outer pair of apical spines of the telson are nearly three times as long as the inner pair, whereas in *D. holmquistae* the outer spines are only less than twice as long as the inner pair. The male of this species can be easily distinguished by the presence of notches on the second thoracic endopod.

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