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# Monograph on the Planktonic Shrimps of the Genus *Lucifer* (Family Luciferidae) from the Indian E E Z



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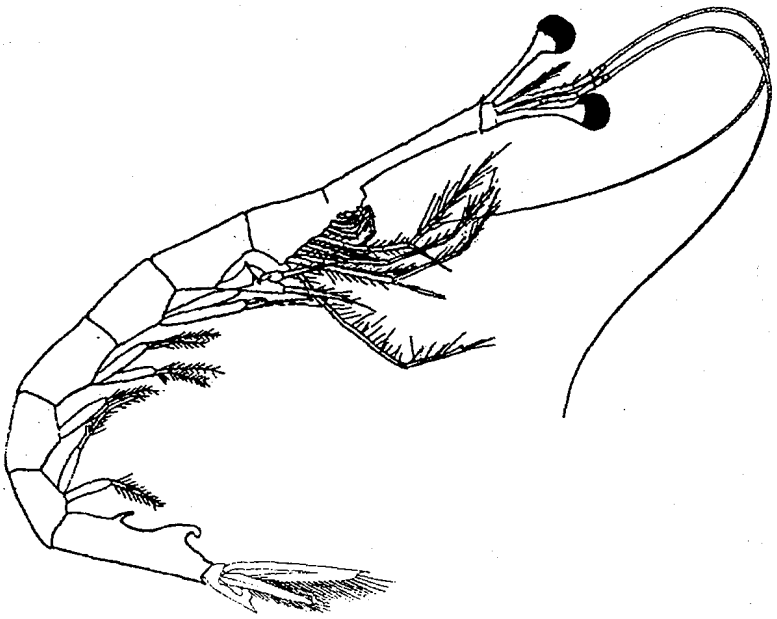
T.S. Naomi, Geetha Antony, Rani Mary George, S. Jasmine



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**Monograph on the Planktonic Shrimps of the Genus *Lucifer* (Family Luciferidae) from the Indian EEZ**

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***Lucifer typus*** H. Milne Edwards, 1837, Male TL 12 mm

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## FOREWORD

Since its inception in 1947 the Central Marine Fisheries Research Institute has been giving importance to the study of trophic level organisms and their role in the marine food web of the fishery environment. Studies were conducted extensively on the secondary producers from the estuarine, nearshore and the oceanic environments of the Indian coasts. Copepods, euphausiids, siphonophores, mysids, cladocerans, amphipods, chaetognaths, penaeid shrimps, fish eggs and larvae are some of the key groups of zooplankton that were investigated in detail. Taxonomy was the backbone of such fishery related studies besides highlighting the interrelationship between the prey and the predator. However, until now adequate attention is not focused on the taxonomic studies of the marine decapod zooplankton in India.

A great deal of information was generated on the zooplankton collected by FORV *Sagar Sampada* during her cruises in the Indian EEZ covering the Arabian Sea, Bay of Bengal, Lakshadweep islands and the Andaman-Nicobar island ecosystem since 1985. Based on such already available database in the Central Marine Fisheries Research Institute, it was thought appropriate to make taxonomic endeavours in the form of monographs for specifying the diagnostic characters and other relevant details of the widely known decapod families from the Indian EEZ. As a first step towards fulfilling this task, the study of the truly planktonic pelagic shrimps of the family Luciferidae from the Indian seas was conducted, as it remained the least studied group despite the fact that the larvae and adults of the family contribute to a sizable percentage of the zooplankton of the coastal seas around India. The database of this monograph from the Indian EEZ is based on the zooplankton collections made by FORV *Sagar Sampada* during her first 44 cruises (1985-1988) and also the coastal samples off Cochin by the mechanized vessel *Cadalmin* in 1992. Besides, species of this family are known to be the ideal prey items for the coastal fishes and large shrimps of India.

This monograph on the very common planktonic genus *Lucifer* from the Indian waters is the first output of the taxonomic efforts taken by the newly formed Marine Biodiversity Division in the Central Marine Fisheries Research Institute under its in-house Project *Taxonomy of Marine Zooplankton* (FEM/BIOD/01). The authors deserve all appreciation for bringing out this publication in time followed by the completion report of the project in June 2005. I hope that many more of such books will come out on related groups in future to help those who are keen to work on zooplankton of the Indian seas and their taxonomic features and placements.

I am glad to place on record that the monograph has achieved its goal by forming itself a document for the correct identification of one of the common zooplankters thus resolving the existing taxonomy related issues on the group. Attempts have been made to ensure that the monograph is a user-friendly publication for the end-user and to build up a checklist wherever needed. Updated classification, easy to follow illustrations together with structures of taxonomic importance including the latest information on the dendrobranchiate crustaceans in general and the family Luciferidae in particular make this book an asset for plankton workers.

Cochin-18

Prof. (Dr.) Mohan Joseph Modayil
Director

## PREFACE

The Central Marine Fisheries Research Institute has been promoting taxonomic research that forms the basis of the science of biodiversity. The Institute started zooplankton research in India as early as the 1940s. The research on planktonology came to limelight with the arrival of FORV *Sagar Sampada* two decades back. Several taxa of zooplankton of the Indian EEZ were studied in detail for their distribution, ecology and biology. However, taxonomy, ecology and biology of the epiplanktonic shrimps of the genus *Lucifer* from the Indian EEZ were not specifically addressed. The present monograph is the outcome of a comprehensive study on taxonomy of the members of the genus *Lucifer*.

We take this opportunity to thank all those who had helped us to achieve the target of preparing a monograph. We express our deep sense of gratitude to Prof. (Dr.) Mohan Joseph Modayil, Director, Central Marine Fisheries Research Institute for providing facilities for undertaking this work and the keen interest evinced during the different stages of preparation without which it would not have been possible for us to complete the work.

We are extremely grateful to Dr. M. Rajagopalan, Head, Fishery Environment and Management Division for his constant encouragement and scientific support extended to us throughout the period of this work. We are immensely grateful to Dr. K.J. Mathew, Principal Scientist (Retired) and Emeritus Scientist who spared his time and professional expertise to review the manuscript and for offering valuable suggestions. We also remember with gratitude Dr. V.S.R. Murty, Former Head, Demersal Fisheries Division and Principal Scientist (Retired) of CMFRI for his encouragement and guidance on the Project *Taxonomy of Zooplankton*. We are much thankful to the referee for giving suggestions for improvement of the manuscript and the encouraging remarks.

We wish to record our gratitude and happiness to Mr. N.K. Sanil, Scientist (SG) of the Marine Biodiversity Division for the timely help rendered by patiently making the photomicrographs of the different species of the genus *Lucifer*. Our sincere thanks are also to Mr. V. Edwin Joseph, Library-in-Charge and his team for providing some of the very old and valuable references as well as for the latest publications on the family Luciferidae through electronic media. The assistance extended by our colleagues, Ms. Rekha J. Nair, Scientist, Mr. K. Balachandran, Technical Officer & Curator, Mr. V.J. Thomas, Senior Technical Assistant and Ms. P.K. Anitha, P.A. of the Division during the preparation of the monograph is gratefully acknowledged.

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Rani Mary George
S. Jasmine

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# ABSTRACT

The decapod dendrobranchiate shrimps of the family Luciferidae De Haan, 1849 under the superfamily Sergestoidea Dana, 1852 were studied comprehensively to prepare a taxonomic monograph and thus to record the taxonomic placement, diagnostic characters and the distribution of each species of the family in the seas around India. The zooplankton samples of the first 44 cruises of FORV *Sagar Sampada* in the Indian EEZ and the collections made from the coastal sea off Cochin for a period of one year constituted the database of this investigation. These holoplanktonic pelagic shrimps were chosen for a detailed taxonomic study due to its importance in the coastal food web and the abundance in planktonic state throughout the year exhibiting peak dominance during the southwest monsoon and immediate postmonsoon months. The study brought to light the presence of all the seven world species of the genus *Lucifer* in the Indian EEZ and thus added three more new records, namely, *L. chacei* Bowman, 1967; *L. intermedius* Hansen, 1919 and *L. orientalis* Hansen, 1919 to the already known four species from Indian waters, *viz.*, *L. typus* H.Milne Edwards, 1837; *L. hanseni* Nobili, 1905; *L. penicillifer* Hansen, 1919 and *L. faxoni* Borradaile1915. *L.penicillifer* Hansen, 1919 is the predominant species in the Arabian Sea and Bay of Bengal while *L.typus* H.Milne Edwards, 1837 in the island ecosystems. The neretic region of the Indian EEZ up to the 50 m depth support 51 % of these shrimps, mid shelf between 50 and 100m harbour 29%, whereas 12 % occur in the outer shelf between 100 and 200 m and 8 % in the deep zone beyond 200 m. In the fishery environment off Cochin up to 30 m depth zone *L.hanseni* is found to be the predominant species followed by three more species namely, *L.typus* H.Milne Edwards, 1837; *L.penicillifer* Hansen, 1919 and *L. chacei* Bowman, 1967 of which the last two are new records for the coastal area.

Keys of the family and species of the genus are given. Each species is treated in detail giving prime importance to its taxonomic placement, diagnostic characters and distribution supported by descriptions and adequate illustrations in a simple manner making the identification process an easy task. Comparisons are made wherever possible followed by references from the Indian authors and the world over. Schematic representations of a penaeid prawn and its appendages are adapted and given with a view to get familiarized with the usage of updated terminology. References included in this monograph are those of a review nature, relating to a new geographic area of occurrence of the species or giving a link to the diagnosis and distribution of the species.

The taxonomic placement of the family Luciferidae De Haan, 1849 under the superfamily Sergestoidea Dana, 1852 was under debate but Farfante & Kensley (1997) treated it as a separate family Luciferidae closely related to Sergestidae under the superfamily Sergestoidea and this pattern has been followed in this monograph.

# INTRODUCTION

The larval forms and adults of the epiplanktonic shrimps of the genus *Lucifer* constitute a sizable component of the zooplankton collections especially during the southwest monsoon and immediate post monsoon seasons along the coastal waters of India (Rajagopalan *et al.*, 1992). These decapod crustaceans are known to play a vital role in the food web of the warm neretic waters and estuaries, particularly in the dynamics of the ecosystem of the lagoons, reefs, sea grass beds and mangrove swamps of the lower latitudes constituting the forage of shore fishes and large shrimps and are thus designated as the indicators of nursery grounds of shrimps and fishes (Omori, 1977). Very little is known about the taxonomy, biology, ecology, growth, migration, swarming behaviour, feeding habits and fishery of the genus *Lucifer* from the waters of Indian subcontinent though there are several zooplankton papers and reports signifying their numerical abundance as larvae and adults in the estuaries and nearshore environments throughout the year.

Realising the importance of the genus *Lucifer* as an intermediary link in the coastal food web of the Indian waters and its possible utility as feed in culture systems, studies were conducted to prepare a monograph on the taxonomy of this common and important dendrobranchiate crustacean based on the collections made during the first 44 cruises of FORV *Sagar Sampada* from the Indian EEZ. Besides, zooplankton samples taken from the coastal waters off Cochin for a period of one year were also utilized for this purpose. Out of the 1,086 samples of the Indian EEZ collected from the eastern Arabian Sea, Bay of Bengal, Lakshadweep islands and the Andaman-Nicobar island ecosystem 910 were used for studying these planktonic shrimps. Antony *et al.*, (1989) suggested that there exists a close relationship between strong upwelling, abundance of *Lucifer* and the pelagic fishery resources along the southwest coast of India and on the east coast particularly at Madras, Vishakhapatnam and Orissa during the southwest monsoon.

Recently, Antony (1998) investigated on the population, distribution and abundance of the *Lucifer* spp. of the Indian EEZ based on the material collected from the FORV *Sagar Sampada* cruises. Her studies brought to light the presence of all the seven world species in the Indian waters and thus added three more new records namely, *L. chacei*, *L. intermedius* and *L.orientalis* to the already known four species of India, *viz.*, *L. typus*, *L. hanseni*, *L. penicillifer* and *L. faxoni*. In the coastal fishery environment off Cochin up to 30 m depth zone *L. hanseni* is the dominant species followed by three more species namely, *L. typus*, *L. penicillifer* and *L. chacei*, the latter two species are new records for the coastal sea off Cochin. She also conducted experiments on the biochemical composition of *L. hanseni* from the coastal sea off Cochin and observed the diurnal variations of *L.hanseni*, *L.typus*, *L.chacei* and *L.penicillifer* in the estuarine environment of Cochin.

The phylum, subphylum, class, subclass, superorder, order, suborder and superfamily are described briefly with a view to get a clear understanding on the taxonomic placement of the family Luciferidae under the superfamily Sergestoidea. Identification is made easier through illustrations and simple descriptions are given below the taxonomic placement of each species. The illustrations are mostly published figures from monographs and various journals; the source of each is quoted in the text under its respective species. The plates given are those of the preserved specimens of the seven species occurring in the Indian EEZ. The external characters and morphology of an adult prawn are depicted along with sketches of taxonomically important appendages (Farfante and Kensley, 1997) to gain acquaintance with the updated terminology used in classification. Further, morphological characters of the mature male and female of Lucifer, life history stages and significant diagnostic characters to be noted in species identification are given importance and reproduced.

Discussions leading to the relevance of the inclusion of the family Luciferidae under the superfamily Sergestoidea are given due importance from the taxonomic point of view. Literature is cited below each species from the Indian EEZ and other key areas from the world over in general. Care has been taken to limit only those references that are significant as either review papers, reports covering a new area of occurrence or papers emphasizing on the diagnosis, abundance and distribution of the constituent species in the Indian subcontinent and other sea areas.

# HISTORICAL BACKGROUND

The distinguished Danish carcinologist, H. J. Hansen in his monograph on 'The Sergestidae of the "*Siboga*" Expedition' had given an elaborate account of the genesis of the genus *Lucifer* and the evolvement of six recognized species from the *Siboga* collections in 1919. J. Vaughan Thompson first created the genus *Lucifer* in 1829 from the *Siboga* Expedition and the specimens observed were from the Atlantic Ocean. Thompson named the genus but not the species. However, Henri Milne Edwards named the shrimp as *Lucifer typus* in 1837, a species with long eye stalks and of extremely common occurrence in the Atlantic waters. The presence of this species was traced subsequently to several places in the Indian Ocean and Bay of Bengal.

Dana (1852) and Bate (1888) described five species under different names that were later dropped or replaced as these were found to be based on immature specimens and were of little value in differentiating one species from the other. Nobili (1905) described *L.hanseni* as a valid species from the Red Sea. Subsequently many species were published in 1914 by several authors. Borradaile (1915) described 11 species including 5 new species of which *L. faxoni* from the Atlantic Ocean was recognized as valid. Among the many species figured by several workers during this period Hansen (1919) reduced the number of species to three and found acceptance for *L. typus* M.-Edw., *L. Hanseni* Nobili and *L. Faxonii* Borrad., in his monograph published on the *Siboga* collections and those collected from the warmer temperate and tropical waters. He further added three more new species namely, *L.penicillifer* Hansen, *L.intermedius* Hansen and *L. orientalis* Hansen in the same year 1919. Descriptions and synonyms of these species including keys for identifcation characters of male and female of each of the six species were given in a comprehensive manner along with illustrations by Hansen (1919). Thomas E. Bowman (1967) subsequently redescribed, figured and established through comparative studies that *L. faxoni* Borradaile, a Pacific species, belonging to "Group B" (species with short eye stalks) as reported by Hansen (1919) and which closely resembled the coastal western Atlantic *L.faxoni,* was that of a new species found in the tropical waters of Pacific Ocean. He identified the new species and named it *L. chacei* from the Pacific. It shows also similarities with *L. hanseni* Nobili in having a slender, acutely ending processus ventralis just like *L. faxoni* Borradaile. Among the seven recognized species of the genus *Lucifer*, four were reported from the Indo-Pacific and the remaining three namely, *L. typus* H.Milne Edwards, *L. faxoni* Borradaile and *L. chacei* Bowman were from the Atlantic Ocean.

Numerous contributions on distribution and abundance of the species of the genus *Lucifer* were made from the world oceans. *L. faxoni* was reported in large numbers from the coastal waters along the Atlantic coast of the United States of America by Hay and Shores (1918), Burkenroad (1934), Holthuis (1959) and many others. Investigations on *L. faxoni* were undertaken by Edmondson (1925) and Hiatt (1947) from the Hawaiian waters, Seguin (1966) from the Bay of Dakar, French West Africa and Williams (1984) from the Gulf of Mexico.

In the Hawaiian waters *L. typus* was first observed by Bate (1888). Cecchini (1933) reported on *L. typus*, *L. faxoni* and *L. orientalis* from the Red Sea. Bowman and McCain (1967), Troost (1975), Hendrickx and Estrada (1994) studied the distribution of *L. typus* from the north and South American coasts while Stebbing (1913), Hayashi and Tsumura (1981) from the African waters. Froglia and Giannini (1984) recorded *L.typus* from the Adriatic Sea.

In the eastern Atlanto-Mediterranean coast, Robert Gurney (1924, 1927) reported the adults and larvae of *L. hanseni* in different stages of development from the Suez Canal. Dakin and Colefax (1940) recorded the occurrence of *Lucifer hanseni* and *L. typus* in the Australian waters off New South Wales. Khan (1976) registered *L. orientalis* from the northern Arabian Sea off Pakistan. Cai (1986) made observations on the size and sex ratio of *L. hanseni* from Xiamen Harbour, China while Michel *et al.*, (1986) on *L. hanseni* and *L. penicillifer* from the Arabian Sea. Grabe and Lee (1992) found *L.hanseni* as the dominant species in Kuwait Bay.

Barnard (1950) conducted studies on *L. penicillifer* and Kensley (1971) on *L. penicillifer, L. chacei, L. typus* and *L. orientalis* from the east coast of Africa.

Omori (1977) reviewed the distribution pattern of the seven species of the genus *Lucifer* from the world oceans. Numerical abundance shows that *Lucifer* spp. are found to be more in the Indo-west Pacific region rather than in other seas and the greatest number was recorded in the Malay Archipelago, South China Sea region. Later Omori (1992) redescribed *L.typus* and *L.orientalis* from the eastern central Pacific. Gordon (1956) made detailed investigations on *L. penicillifer* and *L. typus* from the Great Barrier Reef area.

Huang and Jinchuan (1987) monitored the distribution of *L. intermedius* in relation to temperature, salinity and the pelagic fishery in Taiwan Strait. Ma Zhaodang (1992) identified *L. intermedius, L. typus, L. penicillifer* and *L. orientalis* from the Kuroshio region of the east China Sea and published the quantitative distribution of the species in relation to ecology of the region.

Investigations on the genus *Lucifer* from Indian waters date back to 1933 when Menon observed the abundance of *L. hanseni* from the Madras coast. Each paper on zooplankton from the Indian region reported on the distribution and fluctuations of the species of *Lucifer* in relation to environmental parameters. Only a few are reviewed here on the basis of location. Prasad *et al.*, (1952) and Prasad (1954) observed *L. hanseni* and *L. typus* in the Gulf of Mannar and Prasad (1958) in the Palk Bay. Ganapathy and Ramanamurthy (1975) investigated on the distribution and seasonal abundance of *Lucifer penicillifer, L. hanseni* and *L. typus* off Vishakhapatnam. Nair *et al.*, (1981) recorded *L. typus, L. hanseni, L. faxoni* and *L. penicillifer* from 22 stations along the east coast of India. Around Andaman and Nicobar Islands Madhupratap *et al.*, (1981) observed *L. typus, L. penicillifer* and *L. hanseni*. Goswami (1983) studied the seasonal occurrence of *L. typus* in the lagoon and the sea around Kavaratti atoll. Sarkar *et al.*, (1986) reported on the seasonal variations of *L. hanseni* in the Hooghly estuary.

George (1958) observed *L. hanseni* from Narakkal, Kerala. George and Paulinose (1973) recorded *L. typus* for the first time from the coastal waters of Arabian Sea. Rani Mary *et al.*, (1981), Naomi (1986) and Rajagopalan *et al.*, (1992) reported on the seasonal fluctuations of *L.hanseni* and *L.typus* off the west coast of India from different sea areas. Antony (2005) studied the occurrence of all the seven species of the genus *Lucifer* in the Indian EEZ.

The contributions made by Thompson (1829), Dana (1852), Semper (1861), Dohrn (1871), Brooks (1882), Bate (1888), Rosenstadt (1896), Gerstaecker and Ortmann (1901), Gurney (1924, 1927), Kishinouye (1928), Menon (1933), Balss (1944), Bowman (1967) and Nasima and Wali (1971) greatly enhanced our knowledge on the morphological characters and anatomy of the species of the genus *Lucifer*. Histological studies conducted by Hartnoll (1968) on *L. typus* collected from the Mediterranean Sea off Israel were also helpful in clarifying certain points.

Literature compiled mainly from Hansen (1919), Dakin and Colefax (1940), Bowman (1967), Kensley (1971), Hayashi and Tsumura (1981) and Farfante & Kensley (1997) were useful in comparing and assessing the diagnostic features of the seven known world species of the genus *Lucifer*.

# TAXONOMIC PLACEMENT

**Kingdom : Animalia**

**Phylum : Arthropoda**

Arthropods are distinctly segmented animals with jointed appendages. The cuticle in arthropods forms a rigid exoskeleton, composed mainly of chitin which is periodically shed as the animal grows. A presegmental section - the acron supports compound or simple eyes and a postsegmental part – the telson. Each segment at least primitively supports a pair of appendages. The appendages are used for feeding, sensory reception, defense and locomotion. The arthropod body has a coelom that is reduced to a tiny cavity around the reproductive and excretory organs. The body cavity is a hemocoel, filled with hemolymph that bathes the organs directly.

**Subphylum : Crustacea** Brünnich, 1772

The subphylum Crustacea is a large group with more than 55,000 species. Crustaceans have three distinct body parts: head, thorax and abdomen. They have two pairs of antennae on the head, compound eyes, three pairs of mouthparts and a telson. Crustaceans typically have a thick carapace on the dorsal side of their body. Their appendages are typically biramous including the second pair of antennae. Smaller crustaceans respire through their body surface by diffusion and larger crustaceans respire with gills.

**Class : Malacostraca** Latreille, 1802

Class Malacostraca is the largest subgroup of crustaceans including the decapods. The classification of crustaceans is under debate and some authors regard Malacostraca as a class while others consider it as a subclass. Malacostraca comprises more than 21,000 species worldwide. Malacostracan characteristics are five pairs of walking legs - the first pair is often modified to form pincers; cephalothorax covered by carapace followed by abdomen; appendages near the mouth called maxillipeds; two-chambered stomach and a centralised nervous system. Great majority of malacostracans are marine.

**Subclass : Eumalacostraca** Grobben, 1893

The largest group of malacostracans, includes three superorders: Syncarida, Peracarida and Eucarida. Malacostracans are of highly variable morphology with five-segmented cephalon, eight-segmented thorax and six-segmented abdomen plus telson; zero to three thoracic somites fused with head, appendages usually maxillipeds; antennules and antennae primitively biramous; antennae often with scale-like exopod; most with well developed carapace, gills primitively as thoracic epipods; tail fan composed of telson plus paired uropods; abdomen typically long and muscular, but greatly reduced, shortened and little visible dorsally in brachyura.

**Superorder : Eucarida** Calman, 1904

Eucarida – The highly developed eumalocostracans; carapace fused dorsally with all thoracic somites; compound eyes located on movable stalks; protopodite of antenna consisting of 2 segments; adults without lacinia mobilis on mandibles; 0, 1 or 3 pairs of maxillipeds; telson without caudal rami; eggs usually attached to abdominal appendages, young typically developing with metamorphosis, free-swimming nauplius stage in primitive forms. The group includes the orders Euphausiacea (krill), the monotypic Amphionidacea, and the Decapoda (shrimps, lobsters, crabs, and allies). Eucarids inhabit almost all environments from the poles to the tropics and from freshwaters to marine abyssal depths.

**Order : Decapoda** Latreille, 1802

Decapoda are the most diverse eucarid malacostracans including prawns, shrimps, lobsters and crabs. All decapods have ten legs; these are the last five of the eight pairs of thoracic appendages, characteristic of crustaceans. The front three pairs function as mouthparts termed generally *maxillipeds,* the remaining five pairs walking legs or *pereiopods* used in locomotion. In many decapods, usually one or more pairs of pereiopods terminating in enlarged pincers; the claws are called *chelae* and those legs are termed *chelipeds.* Pereiopods are mostly without exopods in adults, but these may be present in larvae. Head and thoracic segments fused dorsally with the carapace overhanging laterally to enclose gills in lateral branchial chambers. Abdomen may be well developed, elongate, and end in a tail fan formed by telson and uropods. It may be reduced and flattened

and ultimately folded under the thorax with tailfan lost. Abdomen bearing paired ventral pleopods that may be lost or reduced to varying degrees; males often with first one or two pairs modified for copulation (gonopods). Order Decapoda is divided into two suborders, Dendrobranchiata and Pleocyemata. In natant taxa, pleopods are used for locomotion. In the suborder Pleocyemata female pleopods are used for egg-attachment, the eggs hatch as zoea; in the suborder Dendrobranchiata the eggs not carried by female, hatch as nauplii.

**Suborder : Dendrobranchiata** Bate, 1888 .

Dendrobranchiata is the name coined by Martin Burkenroad in 1963 for the suborder of decapod crustaceans containing prawns. They are distinguished from the superficially similar shrimp by the gill structure that is branching in prawns (hence the name, dendro="tree"; branchia="gill"), but is lamellar in shrimp. This suborder comprises less than 500 shrimp species worldwide, falling into two superfamilies: the Penaeoidea (Aristeidae, Benthesicymidae, Penaeidae, Sicyoniidae, Solenoceridae), and the Sergestoidea (Sergestidae, Luciferidae). These groups are united by the unique synapomorphy of dendrobranchiate gills (two principle branches off the main axis, each of which is divided into multiple secondary branches). Among a number of other characters separating dendrobranchiate shrimps from the pleocyemate shrimps, is the possession of chelae on the first three pairs of pereiopods versus the first two pairs in the Caridea.

Carapace laterally compressed or cylindrical. Eyes stalked, compound; rarely reduced. Antennules biramous; with stylocerite. Antennae with 5-segmented peduncle and scaphocerite. Mandibles with palp. Maxillulae with segmented endopodal palp. Maxillae biramous; with two bilobed endites. Endopods of first maxillipeds with five segments; without *crista dentata.* First three pairs of pereiopods chelate; sometimes without exopods. Abdomen with biramous pleopods; usually with petasma, sometimes also with appendix masculina; without appendix interna. Telson together with broad biramous uropods forms tailfan. Eight thoracic appendages consisting of 3 maxillipeds + 5 pereiopods (fourth and fifth sometimes reduced or absent). Abdomen 6-segmented (excluding telson). Gills dendrobranchiate. Sexes separate; gonopores on coxae of third pereiopods of female, fifth of males; male with petasma, female with thelycum. Eggs not carried by female, hatch as nauplii.

## Superfamily : Sergestoidea Dana, 1852

### Distinguishing characters of the family

**Sergestoidea** Dana, 1852a, *Proc. Acad. nat. Sci. Philad.*, 6: 18 [as Sergestidae, name translated to superfamilial status by Holthuis in Glaessner, 1969, *Treatise Invert. Paleo.*, R. Arthropoda 4(2): R446, R450]. Burkenroad, 1983, *Crust. Issues*, 1: 280, 281, 284. Williams, 1984, *Shr. Lob. Crabs Atl. Coast U.S.*,: 50.

Integument thin, often very soft, in two genera bearing photophores. Carapace moderately to extremely compressed; rostrum shorter than eye stalks, often small to rudimentary; supra-orbital spine and hepatic spine present in some species of some genera; antennal, branchiostegal, and pterygostomian spines absent; cervical sulcus well marked, weak, or absent. Ventral antennular flagellum modified in male to form clasping organ or absent. Antennal flagellum bipartite, consisting of stiff proximal portion and more flexible distal portion. Mandibular palp of three articles. First maxilliped with exopod and epipod; second maxilliped with epipod; second and third maxillipeds and all pereiopods lack exopods. Second and third pereiopods with minute chela *(Sergestes pectinatus* lack chela on third pereiopod). Fourth and fifth pereiopods reduced (except in *Sicyonella)* or absent. Branchiae present. First to fifth abdominal somites rounded dorsally, sixth somite weakly carinate. Telson with not more than three pairs or lacking, lateral movable spines. Petasma variously composed of lobus accessorius, lobus armatus, lobus connectens, lobus inermis, lobus terminalis, processus ventralis, processus uncifer; lobes often bearing hooks. Appendix masculina unilamellate. Thelycum with sternite XII and sometimes sternite XIII and coxae of third pereiopod modified; seminal receptacles present, small, varying from simple shallow pockets to sac-like invaginations situated submesially at base of third pereiopods.

### Diagnosis and key of the two closely related families Sergestidae and Luciferidae under superfamily Sergestoidea Dana, 1852

Two families, Luciferidae and Sergestidae, represent the superfamily Sergestoidea Dana, 1852. The rostrum is shorter than the eye stalk in adults. In Luciferidae the body is strongly laterally compressed and branchiae are absent and antennule lack ventral flagellum. Carapace anteriorly elongated. In Sergestidae the body is moderately compressed and branchiae are present. Further, antennule with ventral flagellum modified or absent. Pereiopods 4 and 5 reduced or absent (except in *Sicyonella).* Pleurobranchia absent. Never more than two branchiae per thoracic somite on each side. Not more than seven or eight well developed branchiae on each side.

The small family Luciferidae de Haan, 1849 comprises a single genus, *Lucifer,* and only seven species worldwide. The phylogenetic position of the family has been a matter of some debate, but Perez Farfante & Kensley (1997) treated it as a close relative of the Sergestidae in the superfamily Sergestoidea Dana, 1852.

### Key to the families under the superfamily Sergestoidea Dana, 1852

Branchiae absent; body strongly compressed – Luciferidae de Haan, 1849

Branchiae present; body moderately compressed – Sergestidae Dana, 1852

## Distinguishing characters of the family: Luciferidae De Haan, 1849

**Luciferidae** De Haan, 1849, *Fauna Jap., Crust.*, 242. Dana, 1850, *Am. J. Sci.Arts*, (2) 9: 1852, U. S. *Expl. Exped.*, 13(1): 639; 1853, *Class. Geog. Distrib. Crust.*, 1435. Crosnier and Forest, 1973, *Faune Trop.*, 19: 345. Burkenroad, 1983, *Crust. Issues*, 1: 281, 283. Williams, 1984, *Shr. Lob. Crabs Atl. Coast U.S.*, 52. Squires, 1990, *Can. Bull. Fish. Aquat. Sci.*, 221: 57.

Placed on the Official List of Family-Group Names in Zoology, *International Commission on Zoological Nomenclature*, 1969, Opinion 864, *Bull. Zool. Nom.*, 25(4/5): 141. [In the Official List, the author of the name Luciferidae is incorrectly given as Dana, 1850. The correct author of Luciferidae is De Haan, 1849].

**Luciferinae** Bate, 1888, *Rep. scient. Res. Voy. Challenger*, 24: 443. Ortmann, 1893, *Ergebn. Plankton Exped. Humboldt-Stift.*, 2: 29. Hansen, 1922, *Result. Camp. scient. Prince Albert I*, 64: 10, 198. Cecchini, 1933, *Mem. R. Com. Talas. Ital.*, 200: 12. Burkenroad, 1934b, *Bull. Am. Mus. nat. Hist.*, 68:132. Gordon, 1956, *Sci. Rep. Great Barrier Reef Exped.*, 6(5): 324.

**Leuciferinae** Ortmann, 1898, *Bronn's Kl. Ordn. Tierreichs*, (5) 2:1121.

**Leuciferidae** Barnard, 1950, *Ann. S. Afr. Mus.*, 38: 580,644. Balss, 1957, *Bronn's Kl. Ordn. Tierreichs*, 5(1) 7 (12): 1521.

The family Luciferidae represented by a single genus *Lucifer* typically has a long neck, a short and acute rostrum and very distinctive stalked eyes. Carapace extremely laterally compressed, anteriorly elongate, with mandibles widely separated from antennae and eyes. The length of the eye stalk is significant in *Lucifer* species, some have long eye stalks, where the eye and stalk are as long as the neck, while others have short eye stalks and are about half the length of the neck.

Antennules lack ventral flagellum in both sexes. Mandibles and maxillae lack palps, with exopod in the form of small plate. First maxilliped with no epipod and exopod. Second maxilliped lack epipod. Chelae lacking, or imperfect chela having no fixed finger, present only on the third pereiopod. Only the first three pair of pereiopods are present in the adult and these lack chelae. Fourth and fifth pereiopods absent. Branchiae absent.

Sixth abdominal somite in male bears two ventral processes. Telson in male with strong protuberance on ventral surface. Petasma sessile, attached proximally to the first pleopodal peduncle. Second pleopod in male with unilamellate appendix masculina.

## Genus *Lucifer* Thompson, 1829

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE

***Lucifer*** Thompson, 1829, *Zool. Res.*, 3: 58, pl. 7, Fig. 2. Dana, 1850, *Am. J. Sci. Arts*, (2) 9: Bate, 1888, *Rep. scient. Res. Voy. Challenger*, 24: 443. Hansen, 1919, *Siboga Exped.*, 38: 48; 1922, *Result.Camp. scient. Prince Albert I*, 64: 198. Bowman and Holthuis, 1968, *Crustaceana*, 14(2): 216. Burkenroad, 1983, *Crust. Issues*, I: 283. Squires, 1990, *Can. Bull. Fish. Aquat. Sci.*, 221: 57.

Placed on Official List of Generic Names in Zoology, *International Commission on Zoological Nomenclature*, Opinion 864, Name No. 1817, *Bull. Zool. Nom.*, 25(4/5): 139.

***Leucifer*** H.Milne Edwards, 1837, *Hist. Nat. Crust.*, 467. Ortmann, 1898, *Bronn's Kl. Ordn. Tierreichs*, (5) 2:1122. (Dr. L. Holthuis (in litt., 1996) notes that the name *Leucifer* H. Milne Edwards is an incorrect subsequent spelling of ***Lucifer***, and is not an emendation, as nowhere in Milne Edwards' publication is the spelling ***Lucifer*** cited, and no choice between the two names is mentioned. ***Leucifer*** therefore has no standing and is unavailable.)

**Type species**: By subsequent indication under Article 68b, *International Code of Zoological Nomenclature*, 3rd ed., by H. Milne Edwards, 1837

***Leucifer typus*** H. Milne Edwards, 1837, *Hist. Nat. Crust.*, 469.

**Type Locality** : Atlantic Ocean

**Gender** : Masculine

### Discussion

The position and relationships of the family Luciferidae are problematic, as was pointed out by Burkenroad (1983). Burkenroad included Luciferidae in the sub order Dendrobranchiata but these shrimps do not display any features that he used to characterize the dendrobranchiate crustaceans including the basic feature of retaining the branchiae, except that they hatch as free nauplii (it is a primitive feature according to Kaestner, 1970). Regarded as a subgroup of the Sergestoidea, placement of *Lucifer* within the Penaeidea was based on the presence of (1) petasma in male (a feature found in the eumalacostracan order Euphausiacea) and (2) absence of pereiopods 4 and 5 indicating its relationship with the sergestids: *Acetes*, for example, also lacks pereiopods 4 and 5. "The assumption implicit here is that the loss of pereiopods 4 and 5 is a synapomorphic feature of the Luciferidae and the Sergestidae rather than the two events that occurred independently", Farfante & Kensley (1997). The characters that distinguish the family Luciferidae are (a) the extremely laterally compressed body, (b) lack of chelae, (c) absence of a ventral antennular flagellum, (d) absence of mandibular and maxillar palps, (e) retension of eggs on the third pereiopods of the female, and (f) absence of branchiae. Farfante & Kensley (1997) suggested that the loss of the two posterior pereiopods was part of the suite of extreme modifications for a highly specialized planktonic existence including the complete lack of gills in *Lucifer*.

Diagnostic characters of the genus: As given for the family.

### Diagnostic characters: Male and female of the genus *Lucifer*

**Mature males:** Possess a characteristic petasma on the first pleopod. Of the three main parts of the petasma,

namely, pars-externa, pars-astringens and pars-media, the former two are completely absent in *Lucifer*. Pars-media has no stalk and is an extremely broad plate, flat on the inner side of the pleopod. Its narrow terminal portion constituting a sheath on the side enclose a well chitinized element, the processus ventralis. The shape of the terminal portion of the sheath and that of the processus ventralis are important in species identification. Adult males have two distinctive ventral processes on the sixth abdominal segment and the shape and position of a swollen section on the ventral surface of the telson are very significant in identification. The location of the pair of dorsal spines on the telson and the length of the apical process of the exopod of the uropods and the shape of the terminal margin are also diagnostic characters.

The reproductive organs of the male were first studied by Thompson (1829) and Dana (1852) followed by Semper (1861), Dohrn (1871), Brooks (1882) and Bate (1888). The testes are numerous and suspended in bunches from a continuous cord beneath the alimentary canal, extending anteriorly as far as the third maxillipeds and posteriorly to the first abdominal somite to be connected with a large chamber. This chamber is extended posteriorly in the form of a gradually narrowing and pointed sac in which the spermatophores are developed. From the anterior extremity of this chamber an opening on each side passes anteriorly into a small tubular vas deferens that descends almost vertically or slightly forwards to the ventral extremity of the thorax (Bate 1888). The vas deferens is made up of three portions on each side of the body; a small cavity of thin wall followed by a very large cavity where the male cells are arranged and a third thick-walled chamber where the spermatophores are completely formed (Brooks 1882). The vas deferens has an external opening on the outer edge of the sternum behind the base of the third pereiopod. The paired, pear shaped sac like spermatophores lie side by side. Gordon (1956) recorded that when projected from the vas deferens the sphermatophore was seen to lie on one side of the median line and thus suggesting the presence of two openings.

## Remarks

While studying the diurnal characteristics of the genus in the stratified water column of the Cochin backwaters, Antony (1998) observed one spawning male of *L. typus* of 5.2 mm size with two ripe spermatophores in a ready state of protrusion at the same time, each found on either side behind the third pereiopods. This phenomenon was noticed in the other older males too. The occurrence of two ripe functional spermatophores protruding at the same time on either side is reported for the first time in the genus *Lucifer*. Brooks (1882) was convinced of the presence of two vasa deferentia and two genital openings based on a number of adult specimens he had examined but he believed that only one was functional with a ripe spermatophore at a time. Subsequently Bate (1888) also suggested that two spermatophores are never equally developed at any one time or proceed simultaneously. Gordon (1956) observed that in the adult males of Great Barrier Reef either the right or left vas deferens was well developed indicating only one of them functional at a time.

**Mature females:** The shape of the apex of the sternal plate is a specific character to differentiate the females of the genus. The length of the marginal apical process of the exopod of the uropods and the shape of the terminal angle are also very important. The thelycum consists of a conical median ventral process between the bases of the third pereiopods. According to Bowman (1967) a longitudinal slit leads into the atrium, a sclerotized pouch formed by a median depression of the sternum and the spermatophore is inserted firmly by the narrow neck to the atrium through this slit.

Semper (1861) described for the first time the female reproductive system of the genus and modifications were added later on by others (Bate 1888; Burkenroad 1934; Balss 1944; Bowman 1967 and Hartnoll 1968). The paired ovaries lie just beneath the intestine. Each ovary is very long and extends from the sixth abdominal somite to the posterior edge of the thorax where it bends upon itself at right angle and runs down as duct to its external opening ventrally on the coxa of the third pereiopod. Each oviduct is enlarged to form two pouches with a smaller third pouch between them. The ovaries terminate in a gradually narrowing point full of simple granules in the sixth somite and the anterior portion with ripening ova. According to Burkenroad (1934) in the paired ovaries the laterally flattened ova of each ovary is lying in a single file against the ova of the opposite ovary. The paired, pear shaped, sac like sperm receptacles lie side by side in the protruding thoracic sternum and open separately between the third pereiopods into a common atrium. These sperm receptacles get filled up in impregnated females. Balss (1944) too agreed with the same observations.

Semper in his later account (1872) observed that the genital aperture is single in both sexes. Others like Dohrn (1871); Rosenstadt (1896); Gerstaecker and Ortmann (1901) and Kishinouye (1928) supported this view. Hartnoll (1968) through histological investigations on adult females agreed with Burkenroad (1934) that the paired oviducts of *Lucifer* run lateral to the anterior parts of the spermathecae and each oviduct opens exteriorly at the base of the third pereiopds. Hartnoll concluded that the paired spermathecae or seminal receptacles open by a single median aperture on the sternum and have no internal connection with the oviducts and hence fertilization may be external. The adult females examined by Hartnoll were all with immature ovaries. However, Bate (1888) believed that between the two oviducts only one was functional at a time.

The females carry loosely packed clusters of eggs attached to the ischia of the third pereiopods. Gordon (1956) suggested that these eggs may remain attached until the nauplii emerge. According to Brooks, (1882) the clusters stay attached for a period of more than 36 hours. Bowman (1967) observed well developed nauplii through the egg membranes of *L.chacei*. The eggs get detached very easily in preserved specimens. A nauplius hatches out of the egg and passes through protozoeal and mysis stages into the post larva, juvenile and adult.

### Remarks

Studies conducted on the adult males and females of the genus in the seas around India show that there are two external genital apertures in both sexes, thereby confirming the observations made by Gordon (1956). Brooks (1882) established that there are two external genital openings in males, while Burkenroad (1934); Balss (1944) and Hartnoll (1968) confirmed the same feature in females. Many of the ripe females observed were impregnated with two spermatophores and the sticking out spermatophores could be seen one on either side behind the bases of the third pereiopods. This peculiarity has not been reported earlier in the females of the genus (Antony 1998). Besides, as already stated above, ripe males were also observed to carry spermatophores on either side in a ready state of expulsion.

The highest fecundity per brood recorded in preserved specimens was 21 eggs in the *Lucifer* collected from the bottom layers up to 10 m depth in the Cochin backwaters at 0400 hrs during spring tide.

## Species identification characters

*Lucifer* species are easily recognisable by the elongate, tube-like frontal extension of the carapace and the complete absence of gills. Some species have long eye stalks where the eye and the stalk are nearly as long as the neck, others have short eye stalks about half the length of the neck. The length of the first antennular segment and the last segment of antennal peduncle in relation to the front margin of the eye are distinct identification characters. Hence the significant diagnostic characters that are to be looked for identification of the species are listed below:

- The length of the eye stalk and its shape.
- The length of the first antennular segment to the front margin of the eye.
- The length of the last segment of the antennal peduncle to the front margin of the eye - whether reaching short or middle of cornea or beyond the eye.
- The characteristics of the petasma – (1) sheath; (2) the processus ventralis of the adult male.
- The two ventral processes on the sixth abdominal segment of male– shape and direction.
- The spines on the telson of male.
- The shape of the ventral protuberance on the ventral surface of the telson of male.
- The shape of the apex of the sternal plate of female.
- The length of the rostrum to that of the statocyst.

The spatial distribution and the numerical abundance of the genus *Lucifer* in the EEZ quantified per 1000 $m^3$ of water filtered is depicted (Antony *et al.*,1989) in Fig.1. Schematic representations of the external characters and morphology of an adult prawn are shown (Fig. 2 a - g) along with the taxonomically important appendages, adapted from Farfante & Kensley (1997) to avoid confusion over the usage of updated terminology of the different parts of the shrimp. Further the external morphology of the appendages of male (Fig. 3 a - d) and female of the genus *Lucifer* (Fig. 4 a - g) and the significant diagnostic characters (Fig. 5 a - h) used in species identification are given prime importance and illustrated. Life history stages of the genus collected from the plankton samples as well as those published by others are depicted (Fig. 6 a - l). Developmental stages and structures of *Lucifer hanseni* and *Lucifer* sp. are also illustrated (Figs. 7 a - t; 8 a - l & 9 a - h) before going to the taxonomic placement and distinguishing characters of each of the seven species.

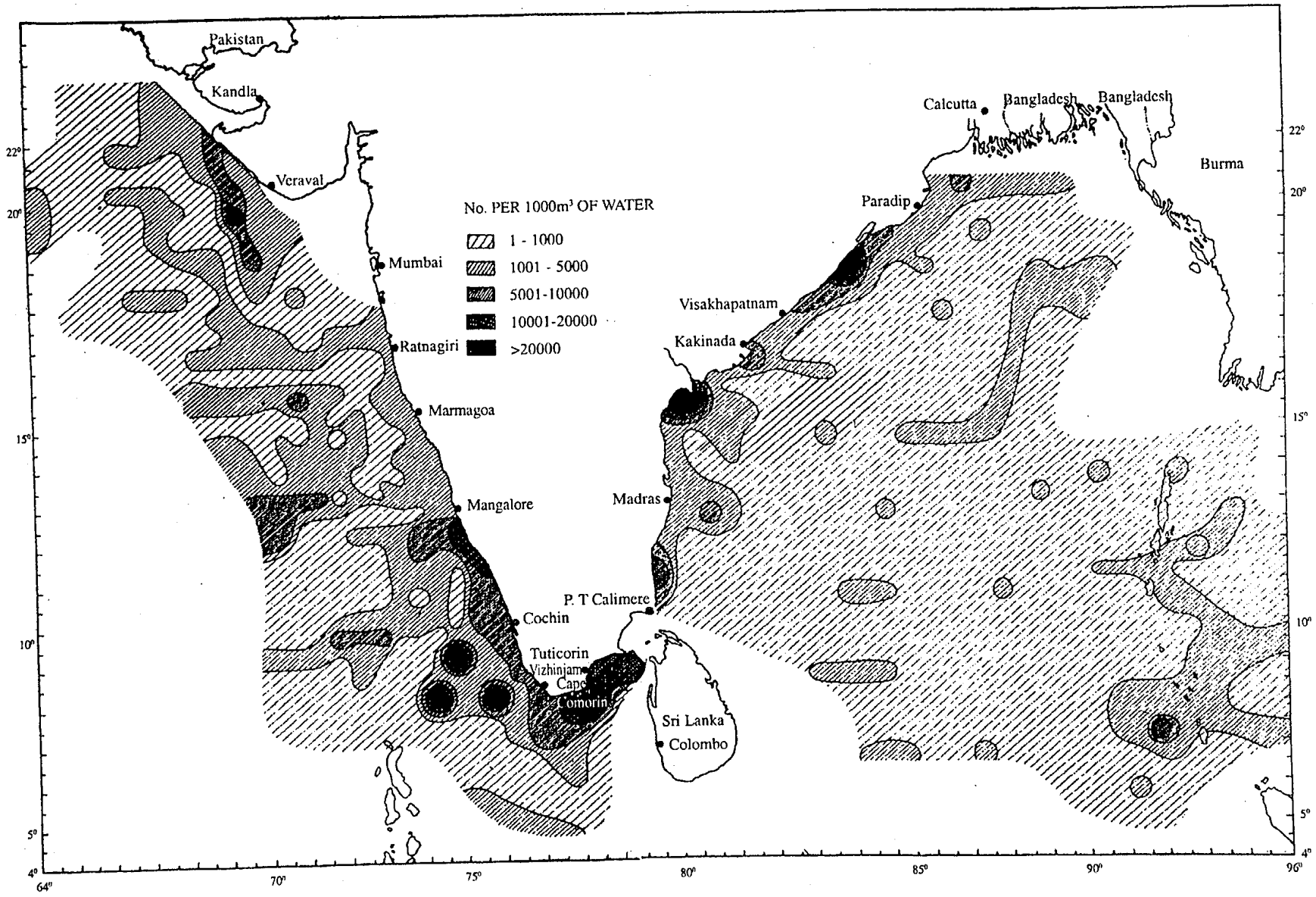



*Fig. 1. Spatial distribution of* **Lucifer** *spp. in the eastern Arabian Sea and the Bay of Bengal (Antony* **et.al.,** *1989)*

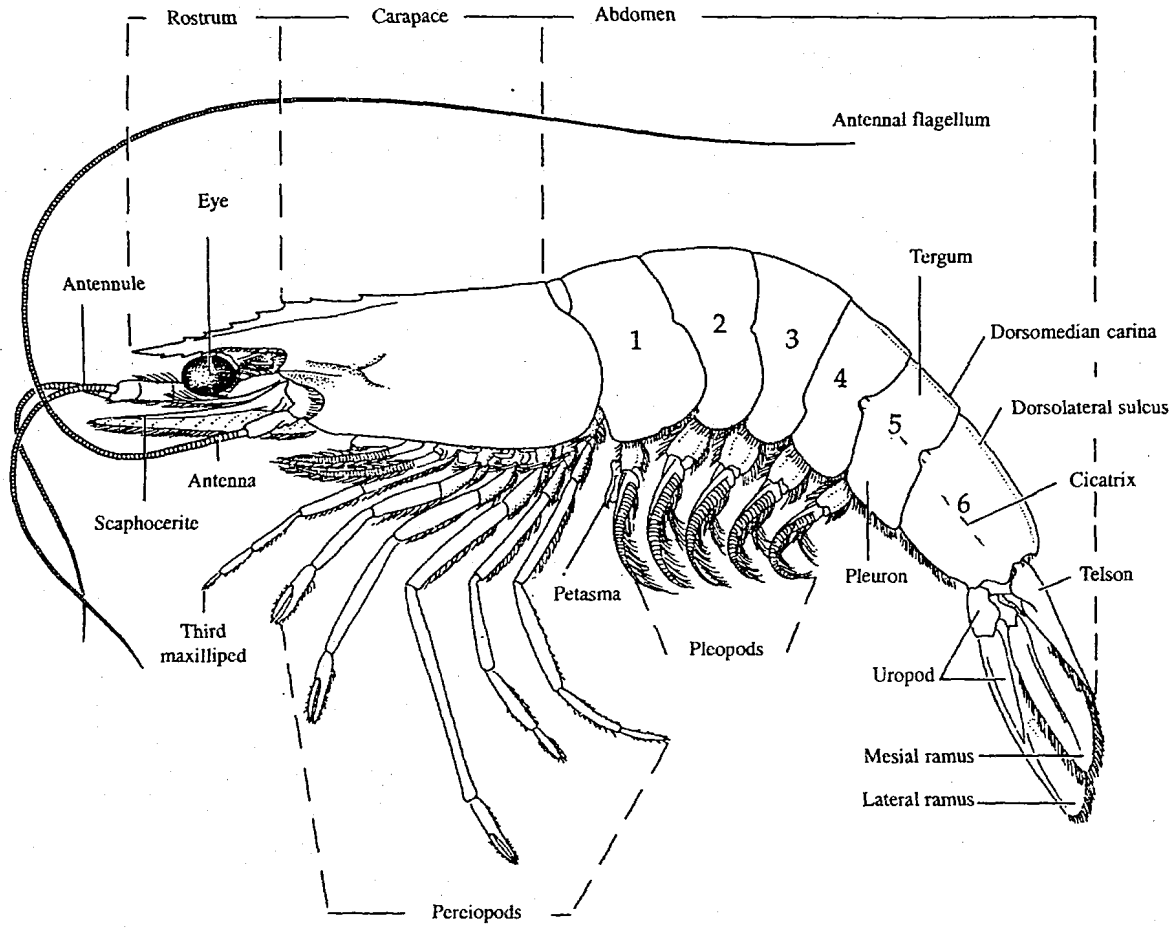



*Fig. 2. a. Diagrammatic representation of a penaeid shrimp showing features used in shrimp taxonomy - lateral view*

***Fig. 2. a-g Taxonomic features used in shrimp taxonomy***
***(Farfante & Kensley, 1997)***

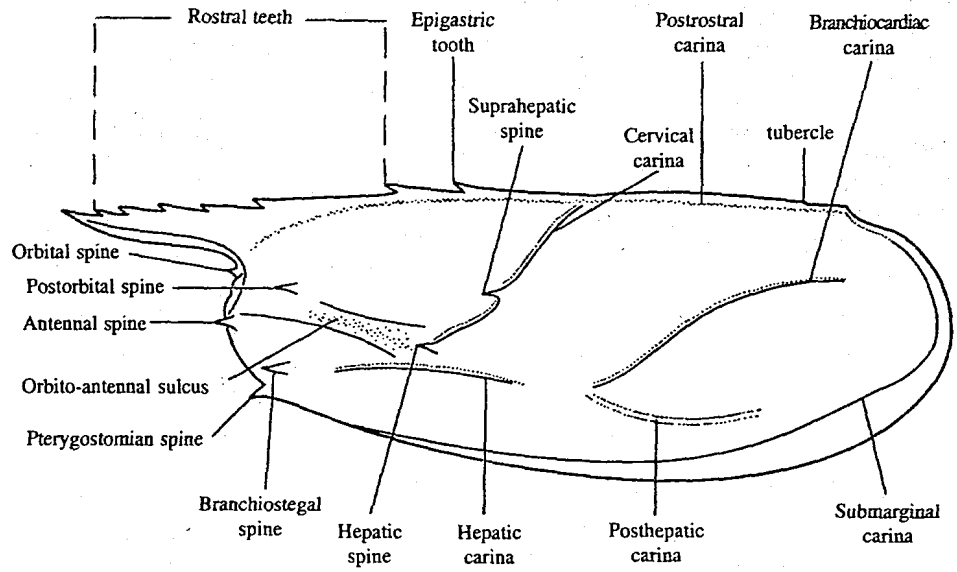



*Fig. 2. b. Diagrammatic representation of carapace - lateral view*

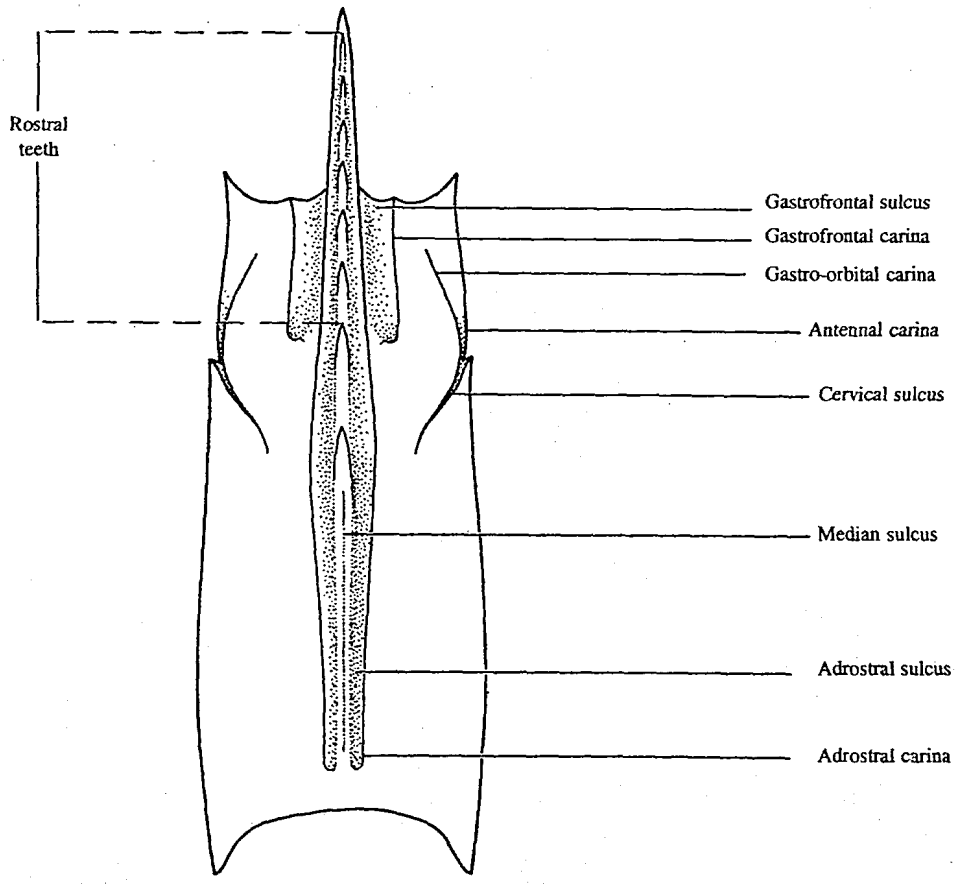



*Fig. 2. c. Diagrammatic representation of carapace - dorsal view*

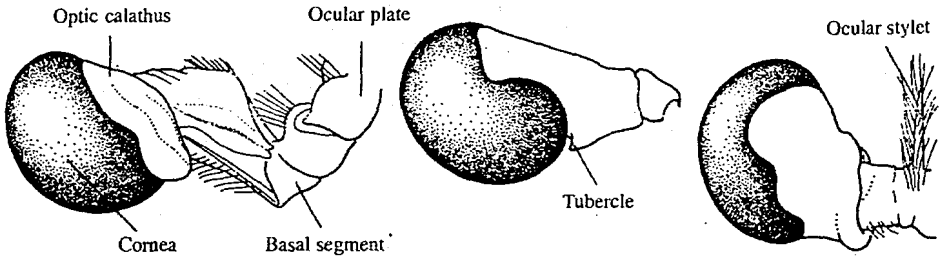



*Fig. 2. d. Diagrammatic representation of eye*

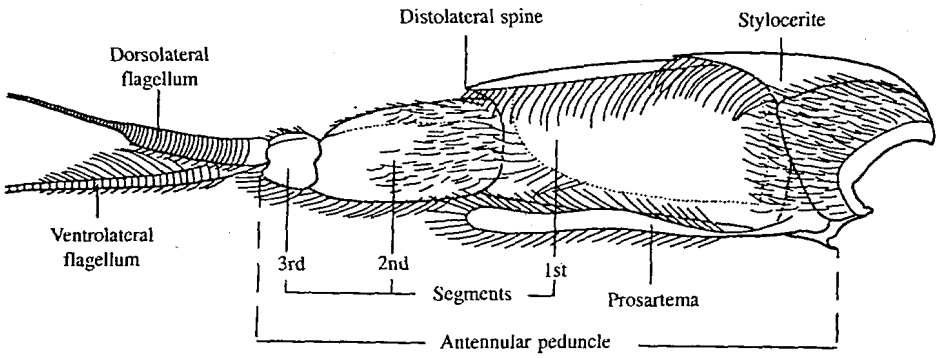



*Fig. 2. e. Diagrammatic representation of antennule*

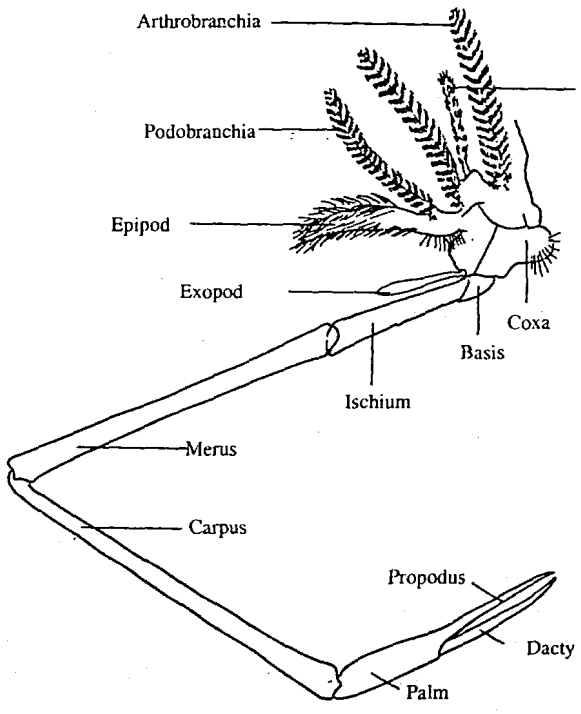



*Fig. 2. f. Diagrammatic representation of pereiopod*

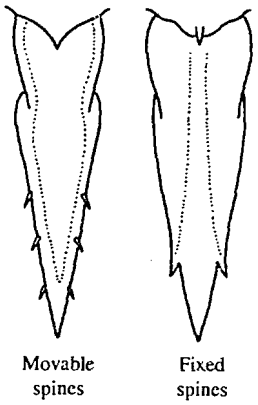



*Fig. 2. g. Diagrammatic representation of telson - dorsal view*

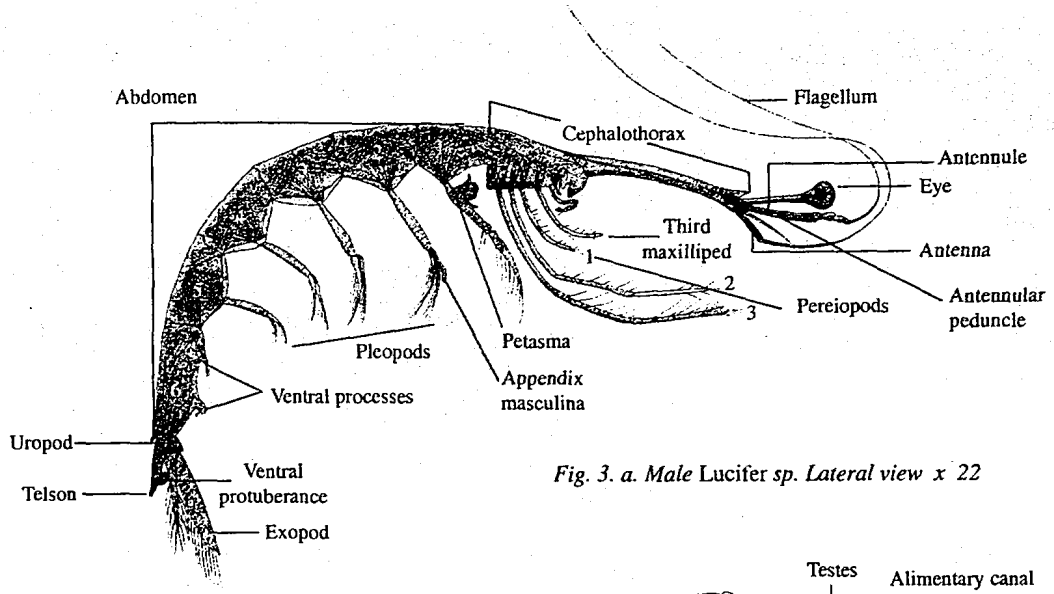



*Fig. 3. a. Male* Lucifer *sp. Lateral view x 22*

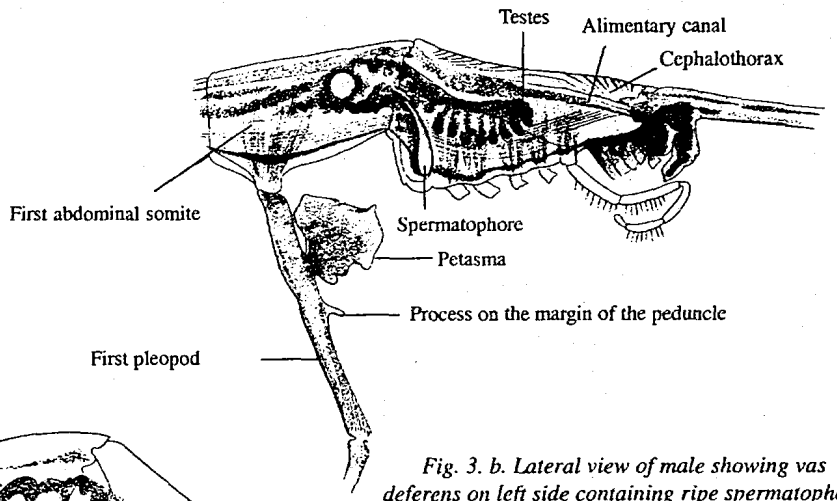



*Fig. 3. b. Lateral view of male showing vas deferens on left side containing ripe spermatophore*

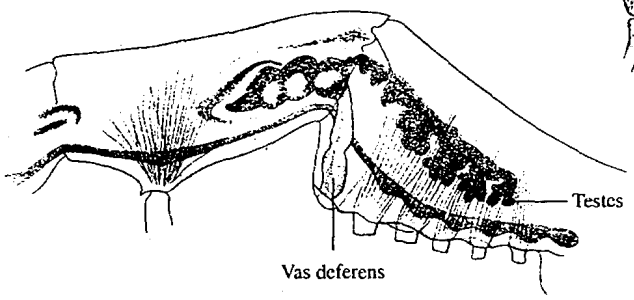



*Fig. 3. c. Lateral view of male showing vas deferens on right side*

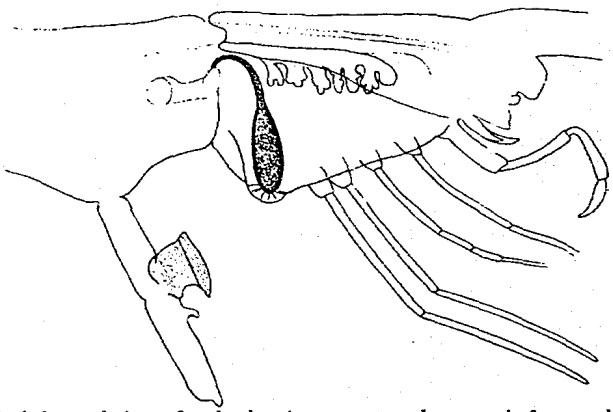


*Fig. 3. d. Lateral view of male showing spermatophore ready for expulsion*

***Fig. 3. a-d External morphology of adult male* Lucifer *sp.***
***(Bate, 1888)***

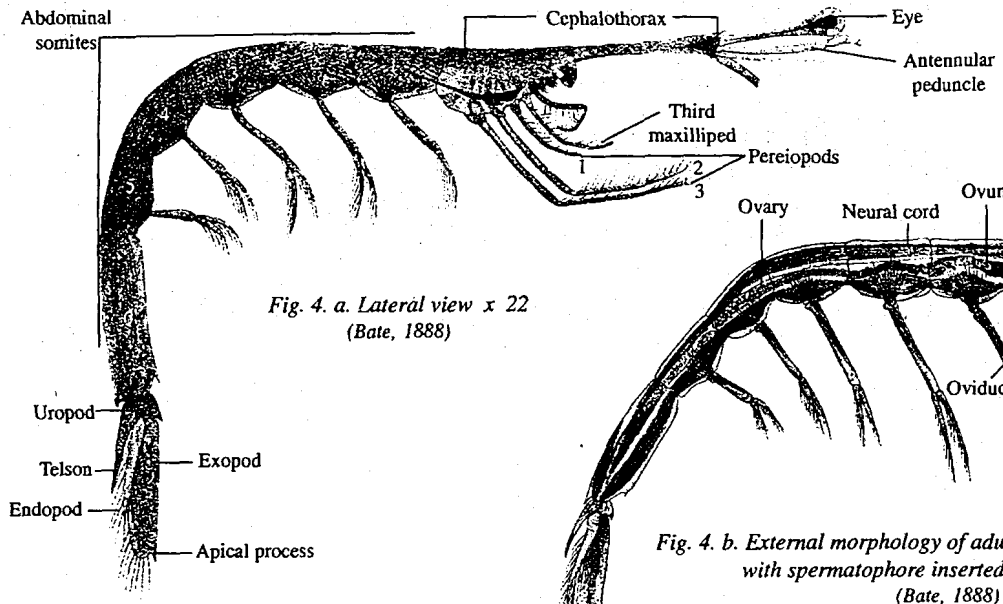



*Fig. 4. a. Lateral view x 22*
*(Bate, 1888)*




*Fig. 4. b. External morphology of adult female showing ovaries with spermatophore inserted into the oviduct*
*(Bate, 1888)*

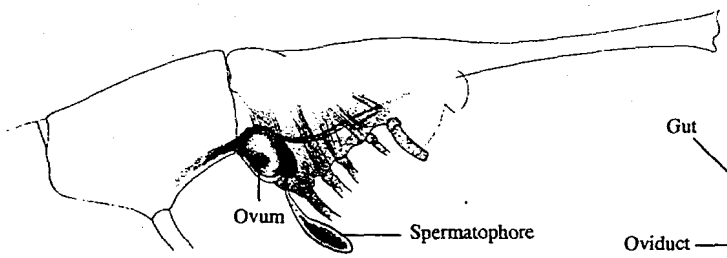



*Fig. 4. c. Lateral view of female showing ovum approaching extrusion with spermatophore inserted*
*(Bate, 1888)*

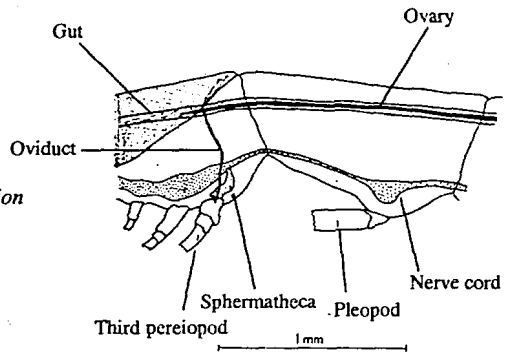



*Fig. 4. d. Female posterior part of thorax and first abdominal somite from left side*
*(Hartnoll, 1968)*

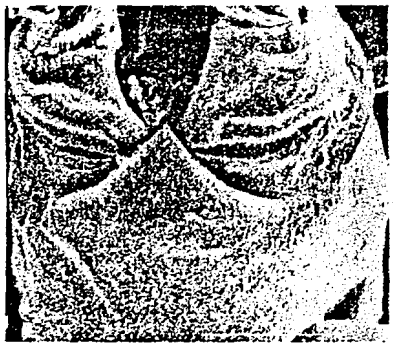


*Fig. 4. e. Last thoracic sternal plate of female showing thelycum*
*(Hayashi & Tsumura, 1981)*

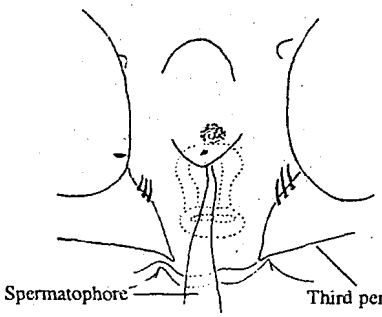



*Fig. 4. f. Female thelycum ventral view*
*(Bowman, 1967)*

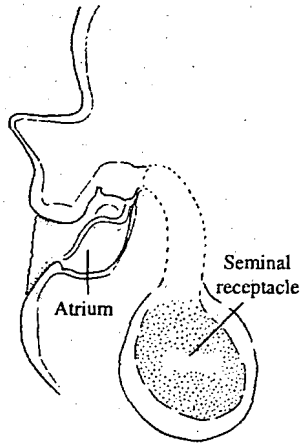



*Fig. 4. g. Female thelycum lateral view*
*(Bowman, 1967)*

***Fig. 4. a-g External morphology of adult female* Lucifer *sp.***

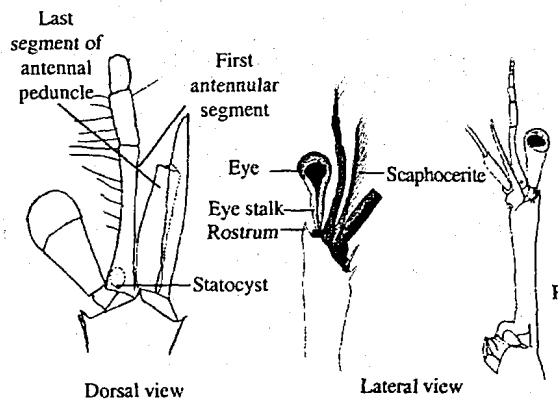



*Fig. 5. a. Shape of the eye, length of the eye and eye stalk to the length of first antennular segment*

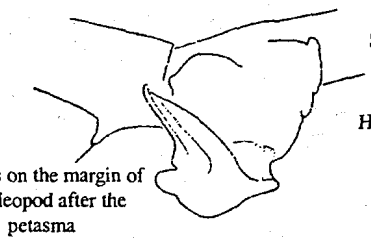



*Fig. 5. b. Petasma in situ of the adult male unfolded on the first pleopod*

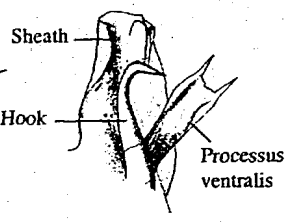



*Fig. 5. c. Sheath and processus ventralis of petasma*

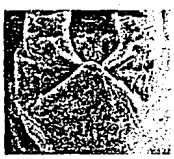


*Fig. 5. d. The thelycum of the adult female*

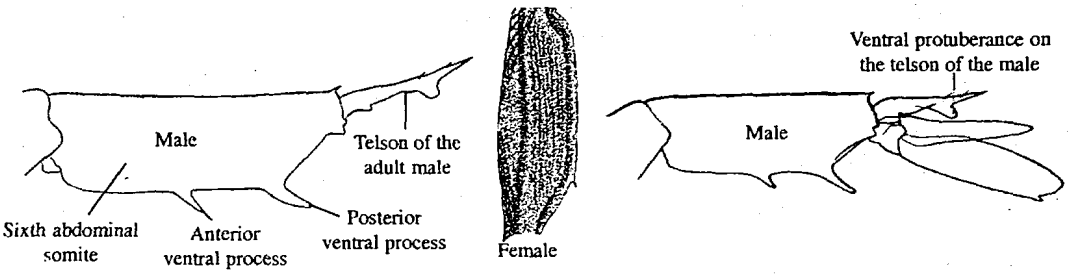



*Fig. 5. e. Sixth abdominal somite of the male and female, Shape and length of the two ventral processes - lateral view*

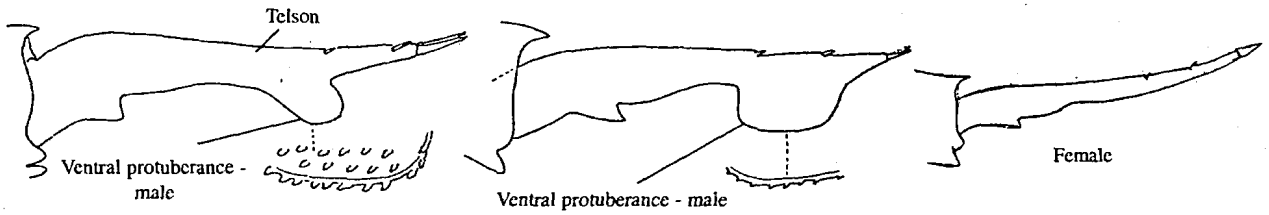



*Fig. 5. f. Shape of the ventral protuberance and its distance from the tip of the telson - lateral view*

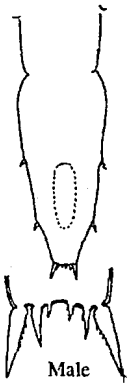



*Fig. 5. g. Dorsal view of the telson, the shape and length of the spines*

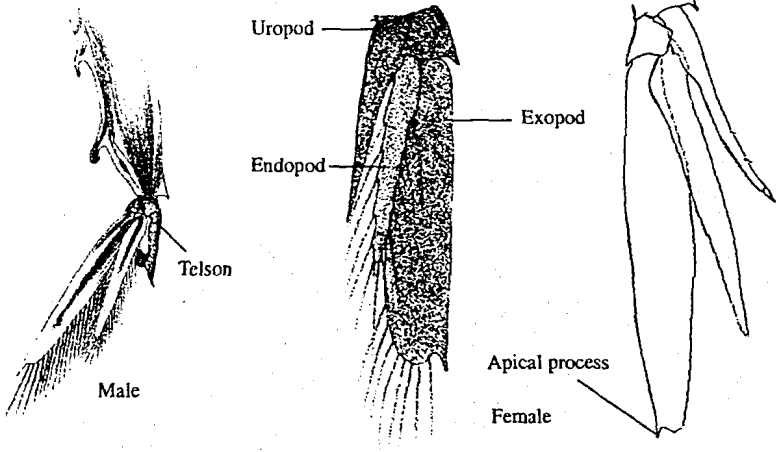



*Fig. 5. h. Terminal margin of the exopod of uropods, length and shape of the apical processes of the adult*

***Fig. 5. a-h Diagnostic characters used in the identification of male & female of* Lucifer *sp.***

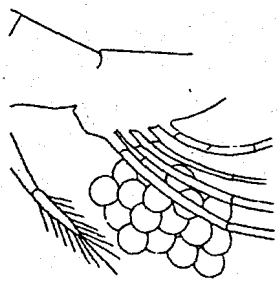


*Fig. 6. a.* Lucifer *sp. Female showing retension of eggs on the third pereiopod*
*(Brooks, 1882)*

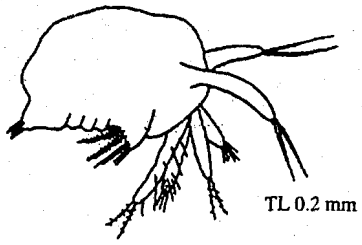



*Fig. 6. b. Nauplius*
*(Brooks, 1882)*

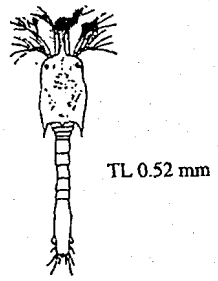



*Fig. 6. c. Protozoea I*
*(Wickstead, 1965)*

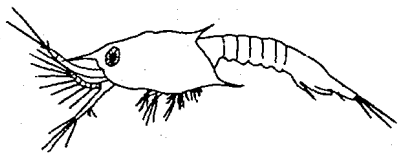


*Fig. 6. d. Mysis I*
*(Brooks, 1882)*

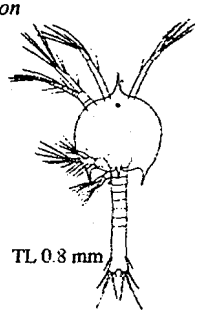



*Fig. 6. e. Protozoea II*
*(Dakin & Colefax, 1940)*

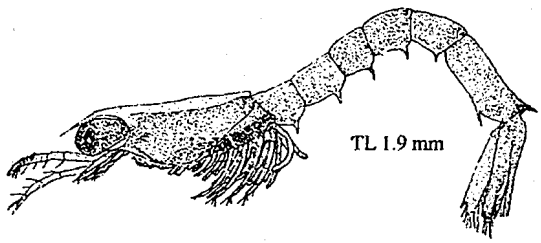



*Fig. 6. f. Mysis I*
*(Dakin & Colefax, 1940)*

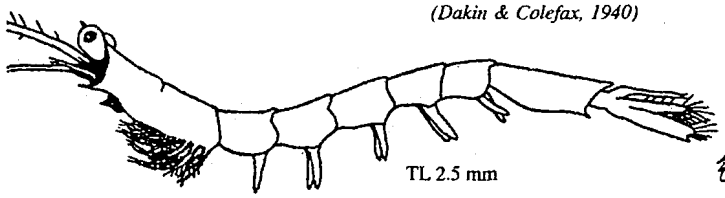



*Fig. 6. g. Mysis II*
*(Brooks, 1882)*

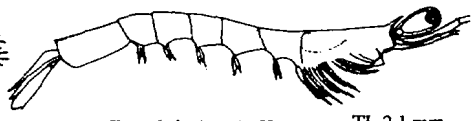



*Fig. 6. h. Mysis II*
*(Antony, 1998)*

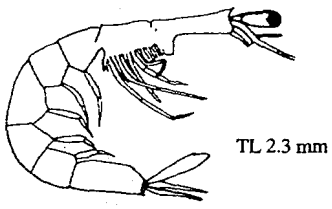



*Fig. 6. i. Postlarva I*
*(Antony, 1998)*

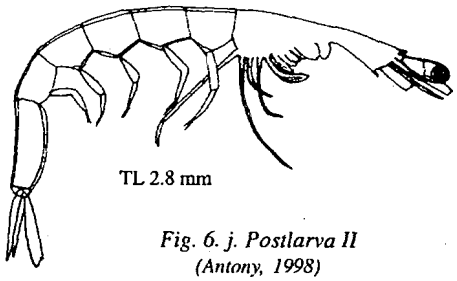



*Fig. 6. j. Postlarva II*
*(Antony, 1998)*

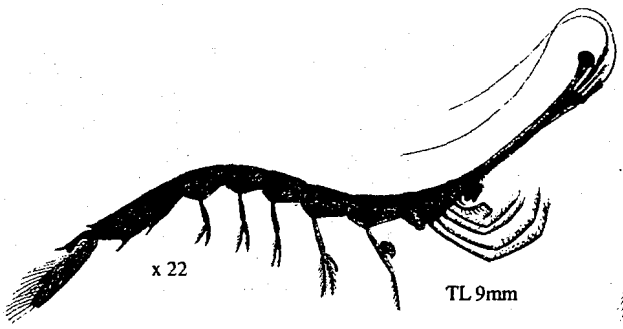



*Fig. 6. k.* Lucifer *sp. adult male*
*(Bate, 1888)*

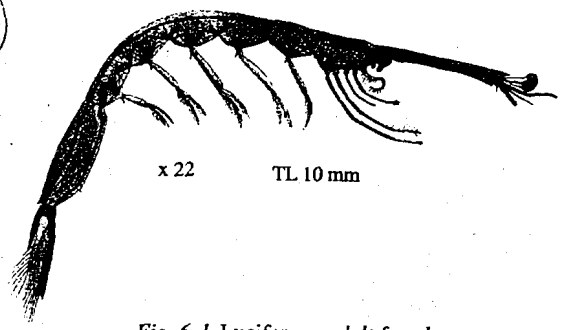



*Fig. 6. l.* Lucifer *sp. adult female*
*(Bate, 1888)*

***Fig. 6. a-l Life history stages of* Lucifer *sp.***

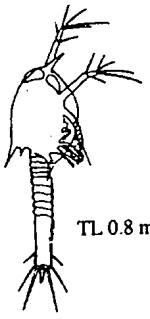



*Fig. 7. a.* Lucifer hanseni *Protozoea II entire animal lateral view*

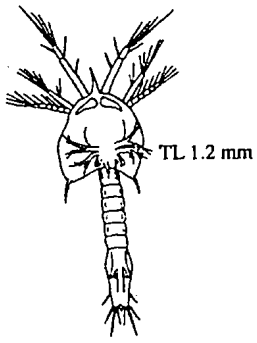



*Fig. 7. b.* Lucifer hanseni *Protozoea III entire animal ventral view*

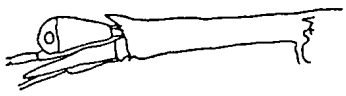


*Fig. 7. c.* Lucifer hanseni *anterior part of juvenile*

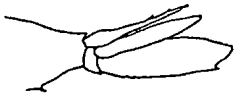


*Fig. 7. d. Sixth abdominal somite, telson and uropod of juvenile*

*Appendages Protozoea II* Lucifer hanseni

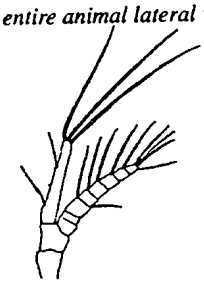


*Fig. 7. e. Antenna*

*Fig. 7. f. Mandible*

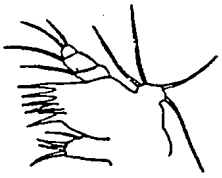


*Fig. 7. g. Maxilla I*

*Fig. 7. h. Maxilla II*

*Fig. 7. i. Maxilliped I*

*Fig. 7. j. Maxilliped II*

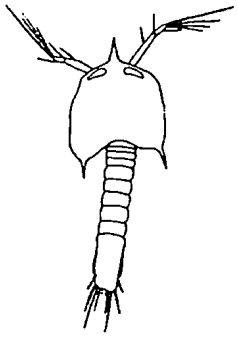


*Fig. 7. k.* Lucifer *sp. Protozoea II entire animal dorsal view*

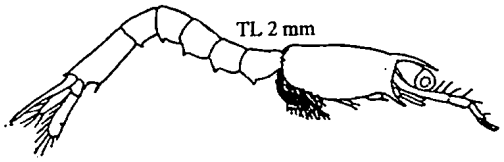



*Fig. 7. l.* Lucifer *sp. Mysis I entire animal lateral view*

*Appendages of Mysis I* Lucifer *sp.*

*Fig. 7. m. Antenna*

*Fig. 7. n. Maxilla I*

*Fig. 7. o. Maxilla II*

*Fig. 7. p. Maxilliped II*

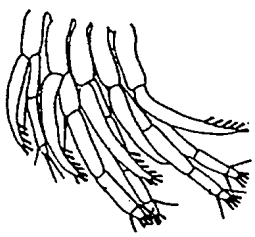


*Fig. 7. q. Maxilliped III and legs*

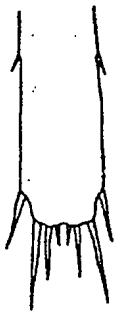


*Fig. 7. r. Telson*

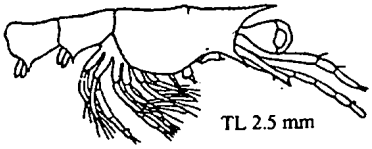



*Fig. 7. s. Anterior part of Mysis II*

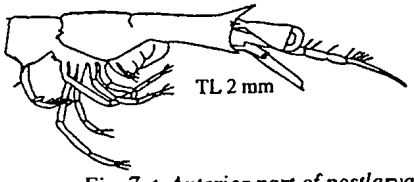



*Fig. 7. t. Anterior part of postlarva*

***Fig. 7. a-t Developmental stages and structures of* Lucifer hanseni *and* Lucifer *sp.***
***(Menon, 1933)***

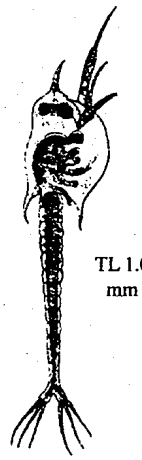



*Fig. 8. a. Protozoea of* Lucifer *sp. entire animal dorsal view*

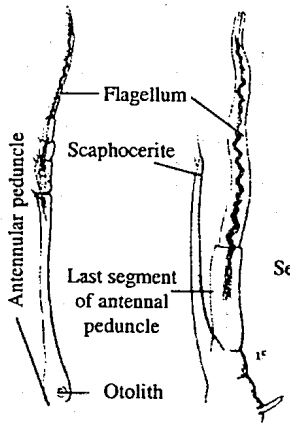



*Fig. 8. b. First antennule*



*Fig. 8. c. Second antenna*

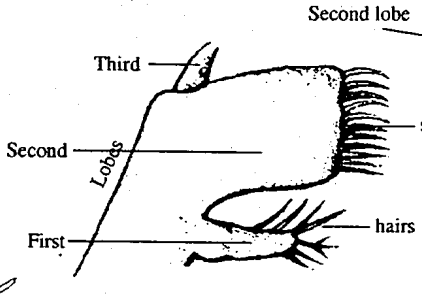



*Fig. 8. d. First maxilla*

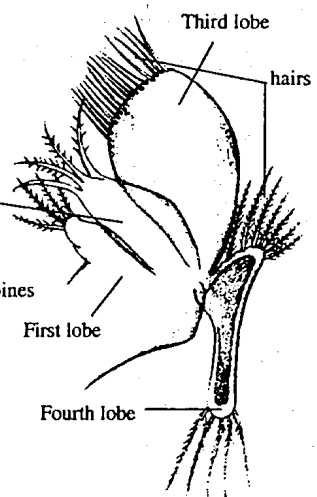



*Fig. 8. e. Second maxilla*

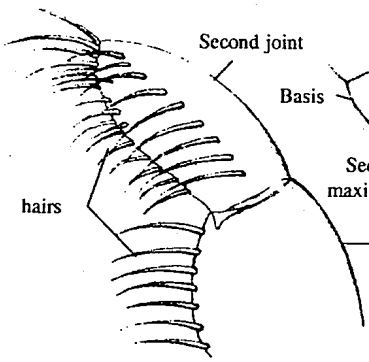



*Fig. 8. f. First maxilliped*

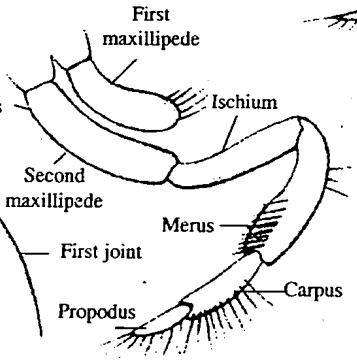



*Fig. 8. g. First & Second maxilliped*

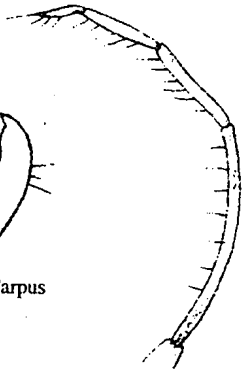


*Fig. 8. h. Third maxillipede*

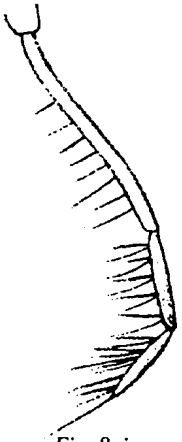


*Fig. 8. i. First pereiopod*

*Fig. 8. j. Second pereiopod*

*Fig. 8. k. Third pereiopod*

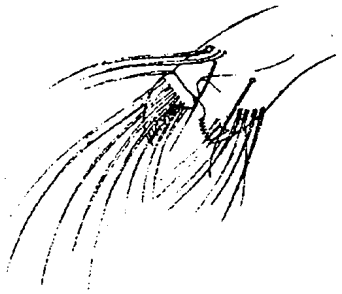


*Fig. 8. l. Chela of third pereiopod*

***Fig. 8. a-l Developmental structures of protozoea***
***(Bate, 1888)***

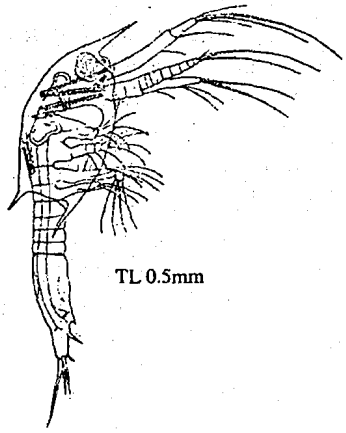



*Fig. 9. a.* Lucifer hanseni *protozoea I lateral view*

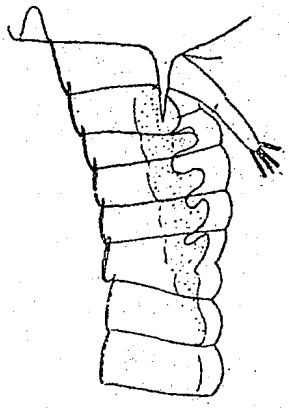


*Fig. 9. b. Thoracic region of protozoea II lateral view*

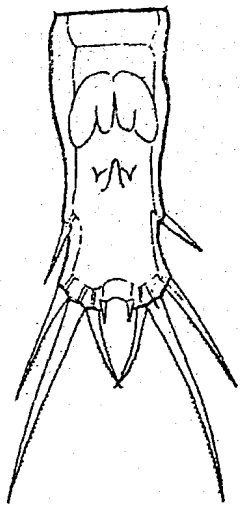


*Fig. 9. c. Telson of protozoea II ventral view*

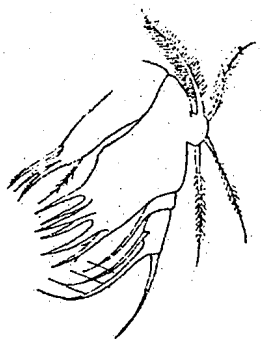


*Fig. 9. d. Protozoea III first maxilla*

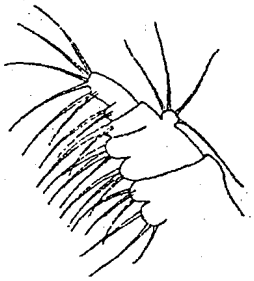


*Fig. 9. e. Protozoea III second maxilla*

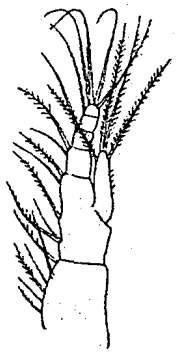


*Fig. 9. f. Protozoea III first maxilliped*

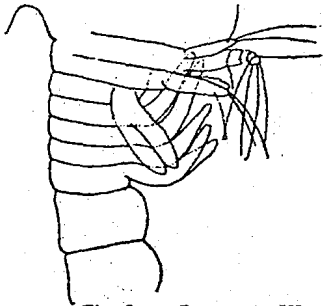


*Fig. 9. g. Protozoea III thorax*

(Gurney, 1927)

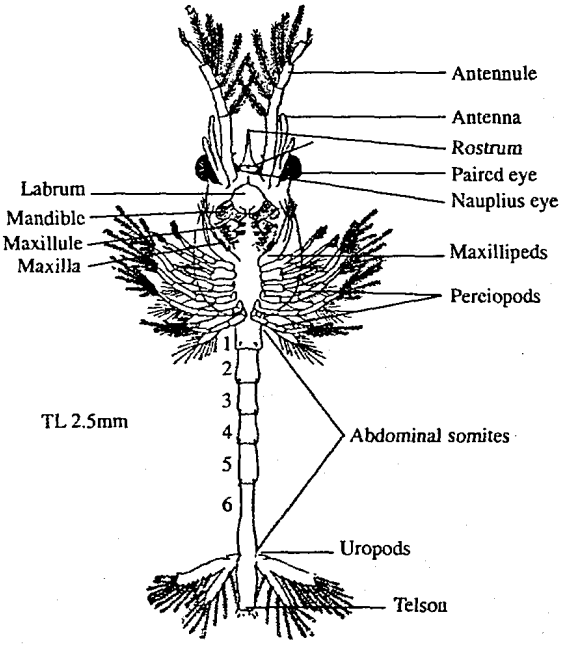



*Fig. 9. h.* Lucifer *sp mysis ventral view (Calman, 1909)*

***Fig. 9. a-g* Lucifer hanseni, *h.* Lucifer *sp. Developmental stages and structures***

## Species composition and abundance in the EEZ

Out of 918 samples collected from the entire EEZ of India, 910 samples contained *Lucifer* with an average density of 3,199 specimens per 1000 $m^3$ of water. Three more new records namely, *L. chacei* Bowman, 1967; *L. intermedius* Hansen, 1919 and *L. orientalis* Hansen, 1919 were added to the already known four species from the Indian subcontinent (Antony 2005).

Maximum density of the genus *Lucifer* was recorded in the eastern Arabian Sea - the average number of individuals 4,142/1000 $m^3$ (52.7%); Bay of Bengal - 2,991/ 1000 $m^3$ (38.1%) and Andaman and Nicobar Sea - 727/1000 $m^3$ (9.2%). In the eastern Arabian Sea, *L. penicillifer* dominated over the other species (48.4 %) followed by *L. hanseni* (29.2%) and *L. typus* (21.8%). Other species namely *L.chacei, L.faxoni, L.intermedius* and *L.orientalis* observed in the eastern Arabian Sea together constituted less than 0.6% of total population.

In the Bay of Bengal, *L. penicillifer* dominated with 49.7 % of the total population followed by *L.chacei* (25.5%), *L.typus* (13.6%), *L.hanseni* (9.5%) and *L.intermedius* (1.2%). *L.orientalis* and *L.faxoni* together formed 0.5 % of the total population.

In the Andaman & Nicobar waters, *L.typus* was the most dominant species (54.6%) followed by *L.hanseni* (27. 5%), *L.chacei* (9.5%) and *L.penicllifer* (8 %). *L. faxoni* and *L. intermedius* were the least abundant and together formed 0.4% of the total population. *L. orientalis* was not observed in the Andaman Sea. All the known seven world species of the genus *Lucifer* were recorded from the oceanic waters beyond 50 m depth zone in the Lakshadweep waters.

Depth-wise distribution according to distance from the coast showed that the neretic region up to the 50 m depth of the Indian EEZ supported 51 % of the total population while 29% occurred in the mid-shelf where the depth varied between 50 and 100 m; 12% in the outer shelf between 100 and 200 m and 8% in the oceanic waters where the depth was greater than 200m.

In the fishery environment off Cochin up to 30 m depth zone *L.hanseni* was found to be the predominant species followed by three other species namely, *L.typus* H.Milne Edwards, 1837; *L.penicillifer* Hansen, 1919 and *L. chacei* Bowman, 1967 of which the last two are new records for the coastal area.

## Key to the species of the Genus *Lucifer* Thompson, 1829

1. Eye stalk more than half distance between bases of eye and labrum - 2
   Eye stalk less than half distance between bases of eye and labrum - 3
2. In males the ventral protuberance on telson situated somewhat remote from the apex and posterior ventral process on 6th abdominal segment bend up or well curved
   - *L. typus* H.Milne Edwards

   Swollen distal half of the posterior ventral process of the 6th abdominal somite only feebly bend, ventral protuberance in telson ending at apex.
   - *L. orientalis* Hansen
3. Outer marginal spine of exopod of uropod not reaching lamellar part. Terminal portion of petasma sheath is acute and curved; processus ventralis is a slender needle with acute end
   - *L. hanseni* Nobili

   Outer marginal spine of exopod of uropod reaching beyond lamellar part - 4
4. Terminal portion of petasma acute. Sheath of petasma curved, processus ventralis is needle like. Ventral protuberance in male telson much broader than its posterior height. Last segment of peduncle of 2nd antenna in male reaches beyond eye and nearly to the distal margin of first segment of antennular peduncle. In females it reaches beyond middle of cornea and to the distal third of first segment of antennular peduncle
   - *L. chacei* Bowman

   Sheath of petasma straight. Last segment of peduncle of 2nd antenna in male reaches middle of cornea. In female it reaches proximal margin of cornea
   - *L. faxoni* Borradaile

   Terminal portion of petasma not acute. In females first antennular segment almost reaching or mostly not beyond eye - 5
5. Petasma has the end broadly rounded with a number of fine transverse lines. In females apex of sternal plate between the third pereiopods rounded
   - *L. intermedius* Hansen
6. Petasma ending in knot – like process, without tranverse lines. Processus ventralis is brush-like. In females apex of sternal plate between the third pereiopods pointed
   - *L. penicillifer* Hansen

## 1. *Lucifer typus* H. Milne Edwards, 1837

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer* Vaughan Thompson, 1829 , *Zool.Researches*, IV, p.58, Pl. VII, Fig.2
*Leucifer typus* Milne-Edwards 1837, *Hist.Nat.Crust.*, T.II, p.469.
*Lucifer acestra* Dana, 1852, *U.S.Expl.Exped.Crust.*, I, p.671, Pl. XLIV, Fig. 1-10.
*Lucifer pacificus* Dana, 1852, *U.S.Expl.Exped.Crust.*, I, p.673, Pl. XLIV, Fig. 2 (young).
*Lucifer Reynaudi* Dohrn, 1871, *Zeitschr.wiss.Zool.Bd.* XXI, p.357, Taf. XXVII, Fig. 1-10.
*Lucifer Reynaudii* Bate, 1888, *Challenger Rep., Zool.*, XXIV, p.466, Pl. LXXXIV.
*Lucifer typus* H. M.-Edw., Borradaile, 1915, *Ann.Mag.Nat. Hist.ser.*, 8, Vol.XVI, p.227.
*Lucifer typus* M. - Edw., Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p. 53, Pl.IV, Figs.6. a-k.
*Lucifer typus* Dakin & Colefax, 1940, *Publ.Univ.Sydney, Dept.Zool.Monogr.*, I. Part I. p.148, Fig.240.
*Lucifer typus* Gordon, 1956, *Sci.Rep.Great Barrier Reef Exped.*, 6, p. 326, Figs. 1-3.
*Lucifer typus* Kensley, 1971, *Ann.S.Afr.Mus.*, 57, p.220, Figs. 2. a-d.
*Lucifer typus* Omori, 1992, *J.Crust.Biol.*, 12, p. 109, Figs.4 .a-g.
*Lucifer typus* H.Milne Edwards 1837, Farfante & Kensley, 1997, *Mem.Mus.natn.Hist.nat. Paris*, p.183, Fig.126-127.

### Short description of the species

The length of the neck is greater than the length of the eye stalk. The eye stalks are long and slender. Length of the first antennular segment reaches to the edge of the cornea. Length of the rostrum reaches only to the base of the eye stalk. The terminal portion of the sheath of the petasma is broad, flat and obliquely rounded, with a rudimentary protuberance and enclosed with a very conspicuous long hook. The lamelliform processus ventralis is distinct; the bottom of the deep terminal incision is transverse between the two horns. The anterior ventral process on the sixth abdominal segment in male is almost as long as the posterior process and slender, but the swollen distal part of the posterior process is bent considerably upwards. In the male telson the swollen section, the ventral protuberance, is large. The posterior margin of the ventral protuberance is somewhat remote from the end of the telson. The end of the telson narrows abruptly after the last pair of lateral spines on the telson. There are three pairs of spines on the tip of the telson. The outer pair of the spines are the longest but shorter than the width of the tip of the telson, each of the long spine has 4 spinules on the first half of the inside edge. The two pairs of inner spines do not

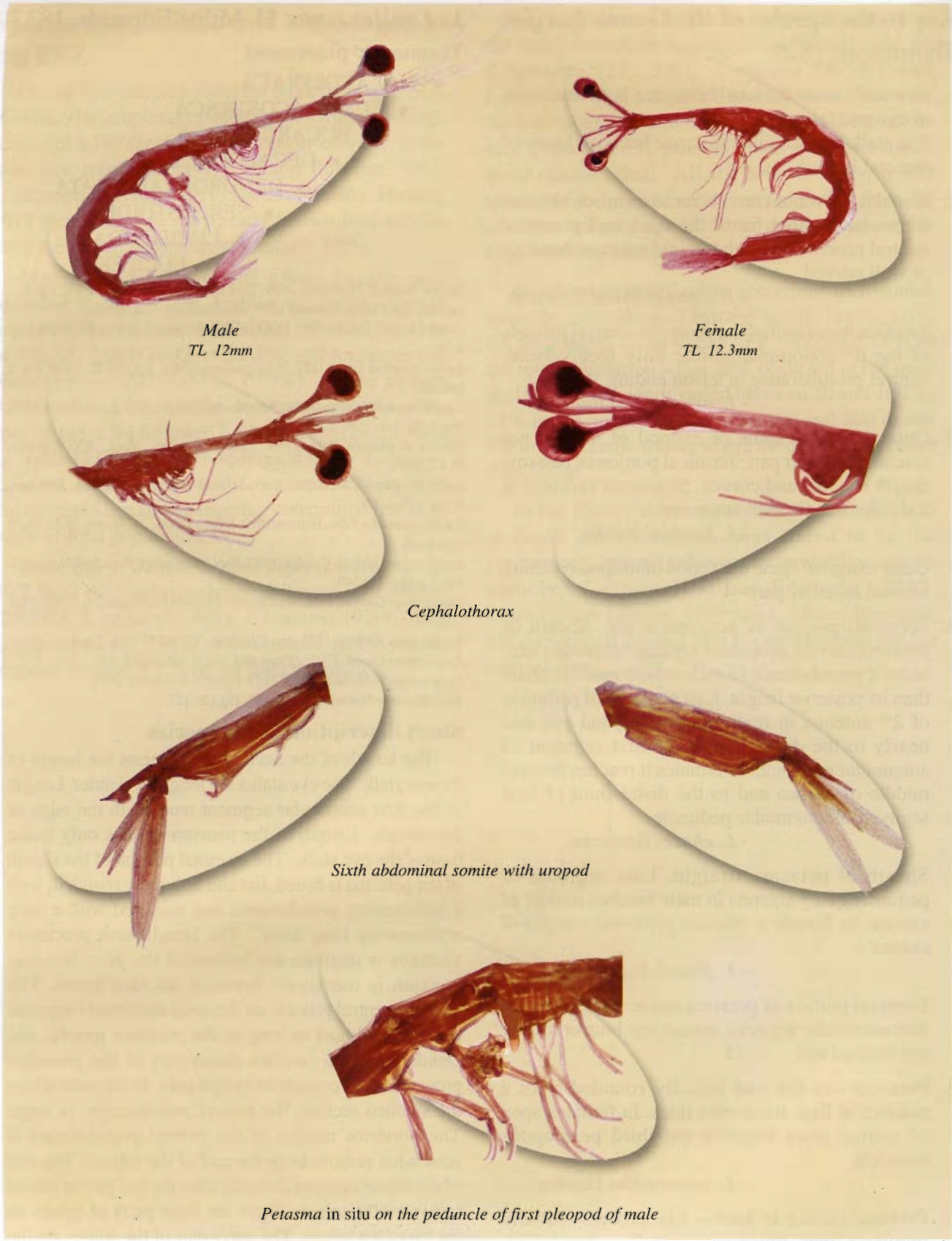



***Plate 1.*** **Lucifer typus** *H. Milne Edwards, 1837*

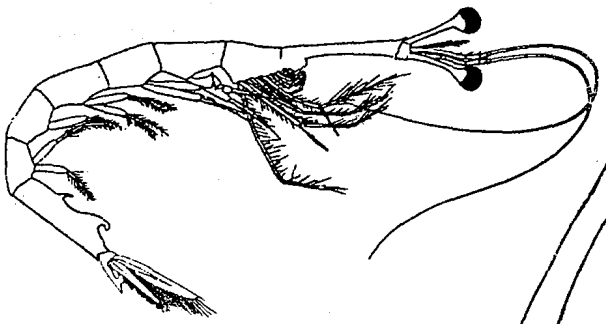


*Fig. 10. a. Adult male - lateral view*
*(Dakin & Colefax, 1940)*

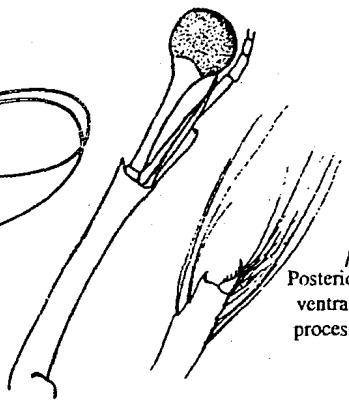


*Fig. 10. b. Anterior region - lateral view*
*(Kensley, 1971)*

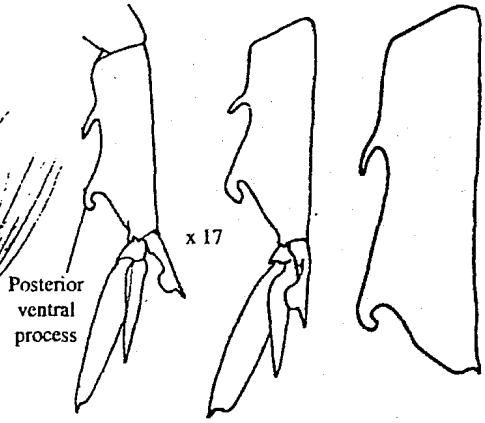



*Fig. 10. c. Chela of third pereiopod - lateral view*
*(Bate, 1888)*

*Fig. 10. d. Sixth abdominal somite with uropod - lateral view*
*(Hansen, 1919; Kensley, 1971 & Omori, 1992)*

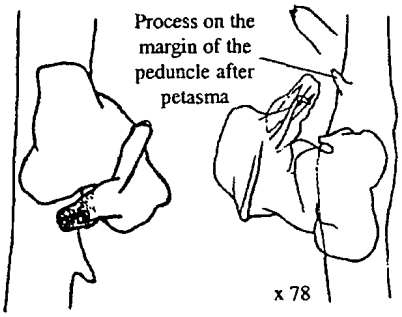



*Fig. 10. e. Petasma* in situ *on the peduncle of first pleopod of male*
*(Kensley, 1971 & Hansen, 1919)*

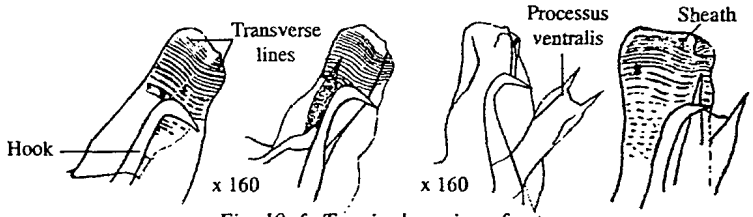



*Fig. 10. f. Terminal portion of petasma*
*(Hansen, 1919 & Kensley, 1971)*

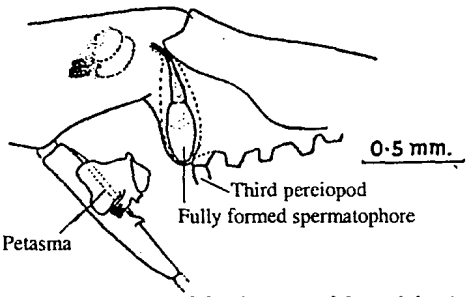



*Fig. 10. g. Posterior part of the thorax and first abdominal somite in lateral view showing fully formed spermatophore*
*(Gordon, 1956)*

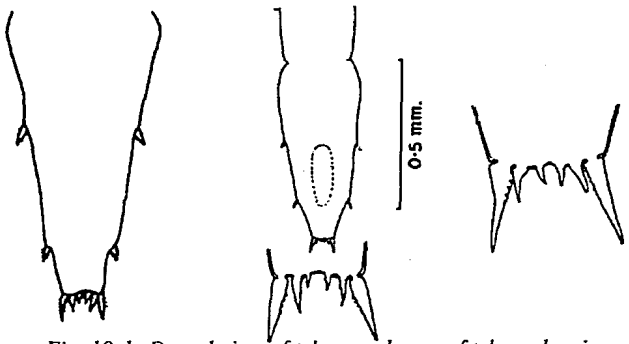



*Fig. 10. h. Dorsal view of telson and apex of telson showing the spines*
*(Omori, 1992 & Gordon, 1956)*

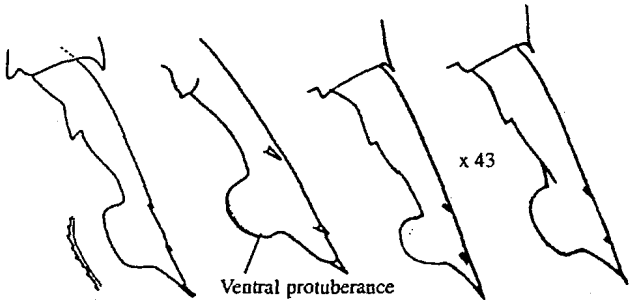



*Fig. 10. i. Lateral view of telson*
*(Gordon, 1956; Omori, 1992 & Hansen, 1919)*

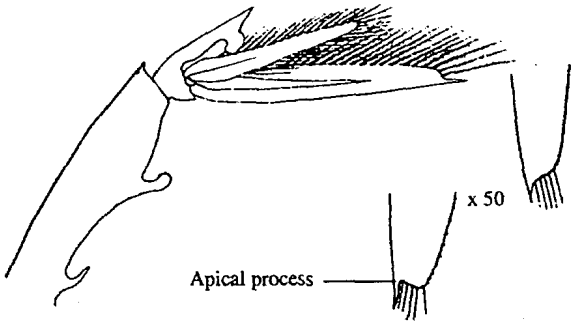



*Fig. 10. j. Sixth somite showing ventral processes, telson and uropod lateral view*
*(Bate, 1888)*

*Fig. 10. k. Exopod of uropod showing apical process*
*(Hansen, 1919)*

***Fig. 10. a-m Diagnostic characters of* Lucifer typus *male***

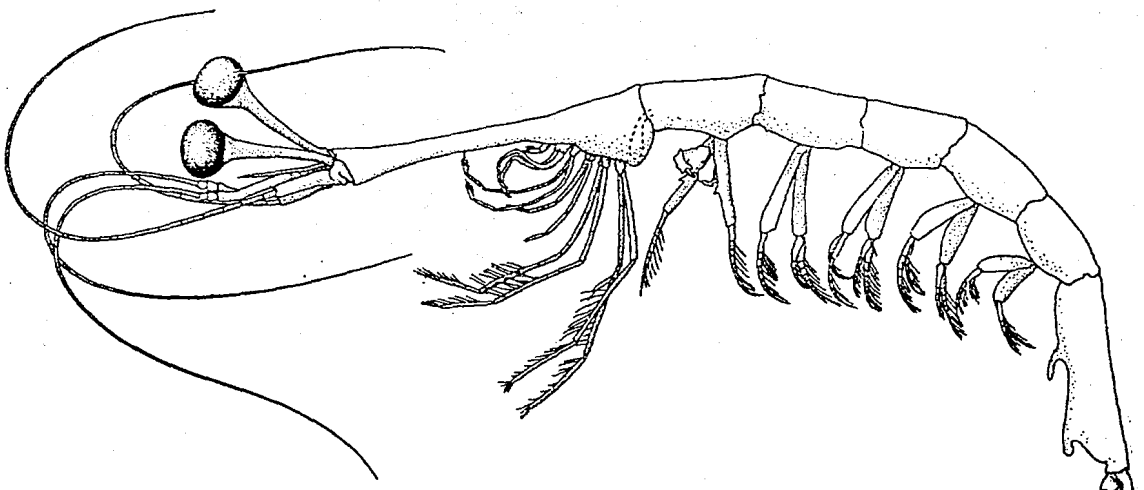


*Fig. 10. l.* Lucifer typus *male - lateral view. Another specimen*
*(Farfante & Kensley, 1997)*

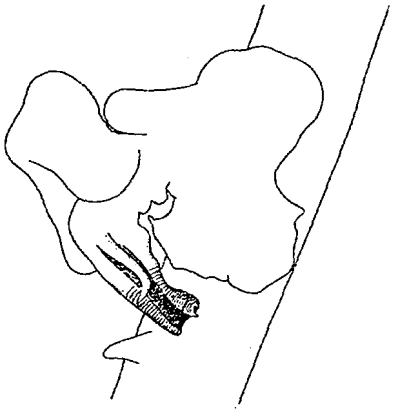


*Fig. 10. m. Male petasma*
in situ - *lateral view.*
*(Farfante & Kensley, 1997)*

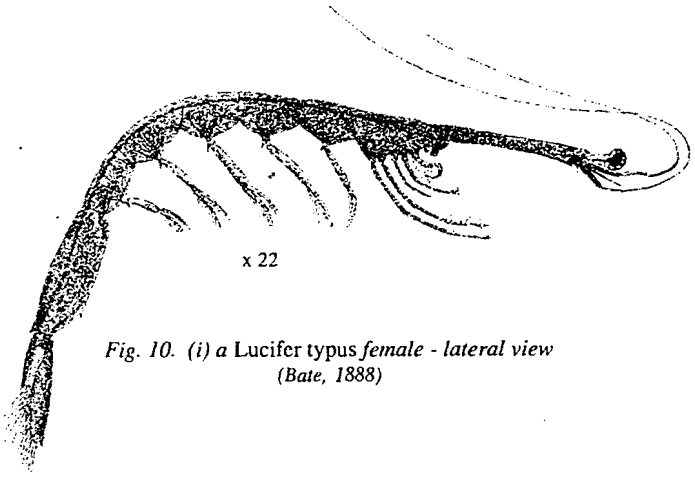



*Fig. 10. (i) a* Lucifer typus *female - lateral view*
*(Bate, 1888)*

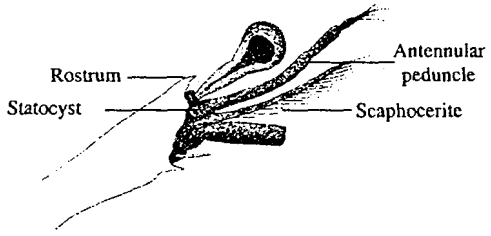



*Fig. 10. (i) b. Anterior region of cephalothorax - lateral view*
*(Bate, 1888)*

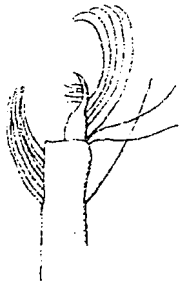


*Fig. 10. (i) c. Chela of third pereiopod - dorsal view*
*(Bate, 1888)*

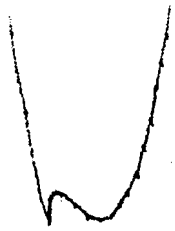


*Fig. 10. (i) d. Female terminal part of exopod of uropod - lateral view*
*(Hansen, 1919)*

***Fig. 10. (i) a-d* Lucifer typus *female***

have any spinules. The apical process of the terminal margin of the exopod of uropod is moderately long and deeply curved in male. In female the exopod is five times as long as broad; the end is oblique and the marginal apical process is smaller than in male (Fig.10 a-m and Fig. 10 (i) a-d).

Colour: Semi-transparent

Common size: TL male 12 .4 mm; TL female 12 mm.

### Diagnostic characters

- Length of the eye stalk - very long.
- Shape of eye stalk – thin and slender.
- Length of the first antennular segment to the front margin of the eye - reaches the edge of the cornea, antennal scaphocerite also reaches the edge of cornea.
- Length of rostrum - reaches only to the base of the eye stalk.
- Petasma a) Terminal portion of sheath obliquely rounded, broad and encloses a long hook.
  b) Processus ventralis plate shaped, the terminal incision is deep, bottom area is transverse between the two horns.
- Process on 6th abdominal segment – anterior ventral process slender, swollen distal part of posterior process bent up.
- Terminal margin of exopod of uropod – long end of the apical process deeply curved.

### Ecology/Biology

Habitat : Pelagic, over the shelf waters beyond 50 m

### Distribution in the Indian EEZ

Eastern Arabian Sea: Maximum number of *L.typus* in oceanic waters beyond 50 m and off southwest coast in less than 50 m depth.

Lakshadweep Islands: In oceanic waters beyond 50 m.

Bay of Bengal: More number within 50 m in the south than in the north.

Andaman & Nicobar waters: *L.typus* abundant in the depth zone between 100 and 200m.

### Distribution in the world

Northeast Pacific Ocean, off Baja California, Gulf of California to north of 4° N; off New Foundland; Northwest Atlantic Ocean off U.S.A.;Sargasso Sea; Brazil; northeast Atlantic Ocean; Mediterranean; southeast Atlantic Ocean off Cape of Good Hope; east coast of South Africa; Philippines; Queensland; Australia; eastern Central Pacific Ocean.

### Remarks

Similar to male *L.orientalis*. Eye stalks are slightly longer. In comparison, the posterior margin of the ventral protuberance on the telson and the distal pair of dorsal spines of the telson in male *L. typus* are somewhat remote from the end of the telson. In the case of *L.orientalis* the same are nearer to the end of the telson.

### Literature

### Indian EEZ

Prasad *et al.*, (1952), Prasad (1954, 1958), George and Paulinose (1973), Ganapathy and Ramanamurthy (1975), Rani Mary *et al.*, (1981), Nair *et al.*, (1981), Madhupratap *et al.*, (1981), Goswami (1983), Naomi (1986), Sarkar *et al.*, (1986), Rajagopalan *et al.*, (1992) and Antony (2005).

### Other areas

Milne Edwards (1837), Hansen (1919), Cecchini (1933), Dakin and Colefax (1940), Gordon (1956), Kensley (1971), Bate (1888), Ma Zhaodang (1992), Omori (1977 & 1992) and Farfante and Kensley (1997).

## 2. *Lucifer hanseni* Nobili, 1905

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer Hanseni* Nobili,1905, *Bull.Mus. d'Hist.nat.*, 6. p.394.

*Lucifer Hanseni* Nobili,1906, *Annls.Sci.nat.Zool.Paris*, 9, T.IV, p.25, Pl.II, Fig.I.

*Lucifer inermis* Borradaile, 1915, *Ann.Mag.Nat. Hist.*, 8, Vol.XVI, p.229.

*Lucifer hanseni* Borradaile, 1916, *Nat.Hist.Rep.Brit.Antarct.Terra Nova Exped., Crust.* I, *Decapoda*, p. 83.

*Lucifer Hanseni* Nobili, Hansen,1919, *Siboga Exped.*,38, *Monog.*, p. 63, Pl.V, Figs.4. a-o.

*Lucifer hanseni* Gurney, 1927, *Trans.Zool.Soc.London*, 22(2), p. 248.Figs. A-G.

*Lucifer hanseni* Menon, 1933, *Bull.Madras Govt.Mus.N.S., Nat.Hist.Sect.*, 3(6), p.7, Figs.13-22.

*Lucifer hanseni* Dakin & Colefax, 1940, *Publ.Univ.Sydney, Dept.Zool.Monogr.*, I. Part I. p.148, Fig.241.

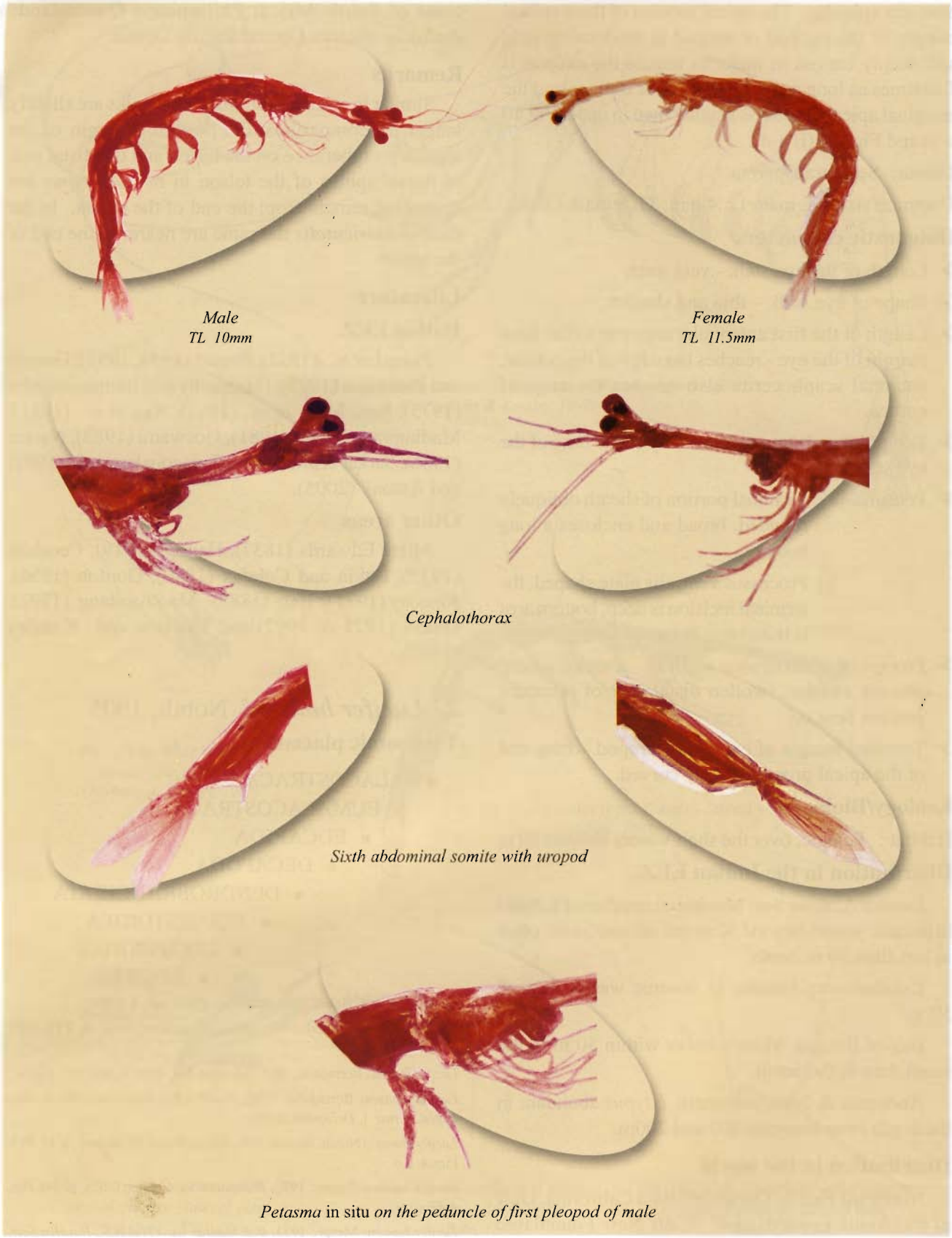



***Plate 2.*** **Lucifer hanseni** *Nobili, 1905*

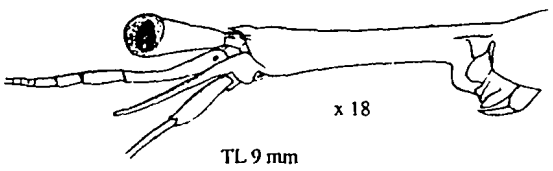



*Fig. 11. a. Adult male, anterior region of cephalothorax - lateral view*
*(Hansen, 1919)*

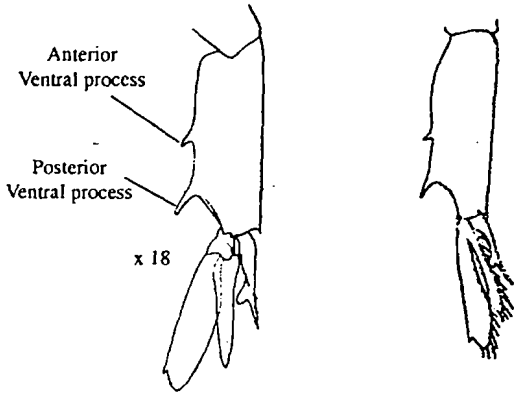



*Fig. 11. b. Sixth abdominal somite, ventral processes and uropod - lateral view*
*(Hansen, 1919 & Dakin & Colefax, 1940)*

*Fig. 11. c. Dorsal view of telson and uropod*
*(Dakin & Colefax, 1940)*

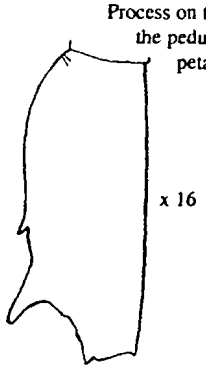



*Fig. 11. d. Sixth abdominal somite - lateral view*
*(Hansen, 1919)*

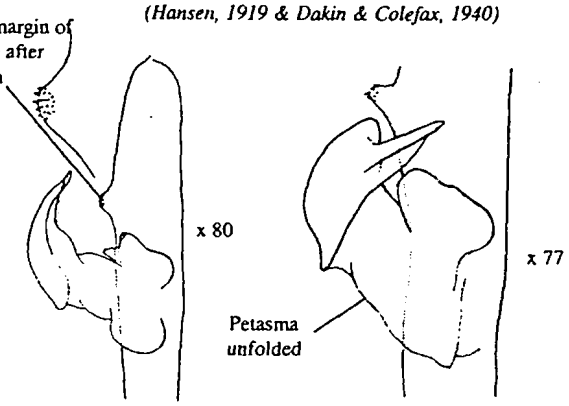



*Fig. 11. e. Petasma* in situ *on the peduncle of first pleopod of male - lateral view*
*(Hansen, 1919)*

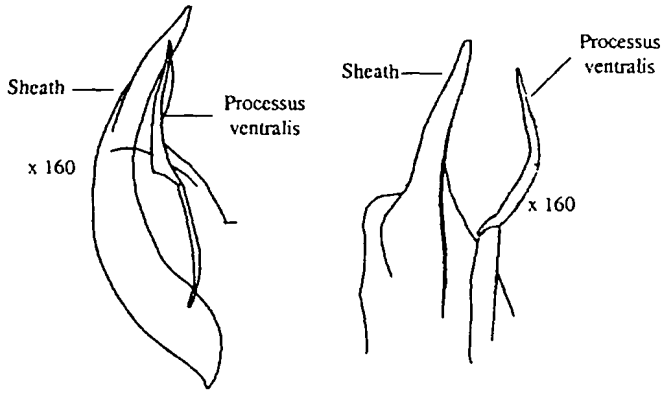



*Fig. 11. f. Terminal portion of petasma*
*(Hansen, 1919)*

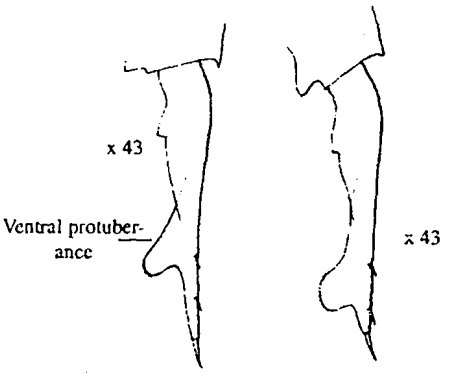



*Fig. 11. g. Lateral view of telson*
*(Hansen, 1919)*

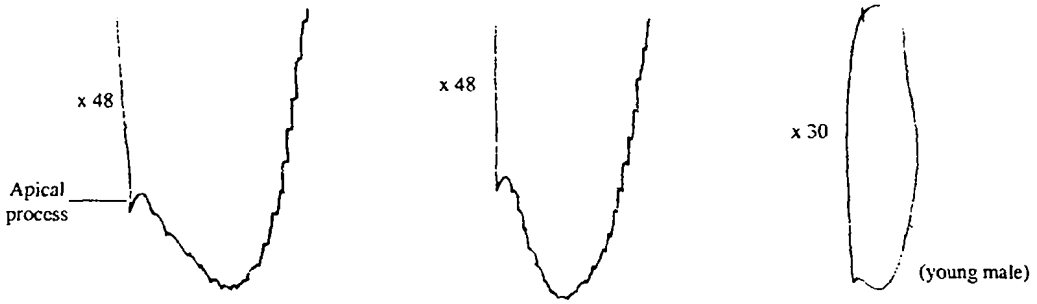



*Fig. 11. h. Exopod of uropod showing apical process - lateral view*
*(Hansen, 1919)*

**Fig. 11.** ***a-h Diagnostic characters of*** **Lucifer hanseni** ***male***

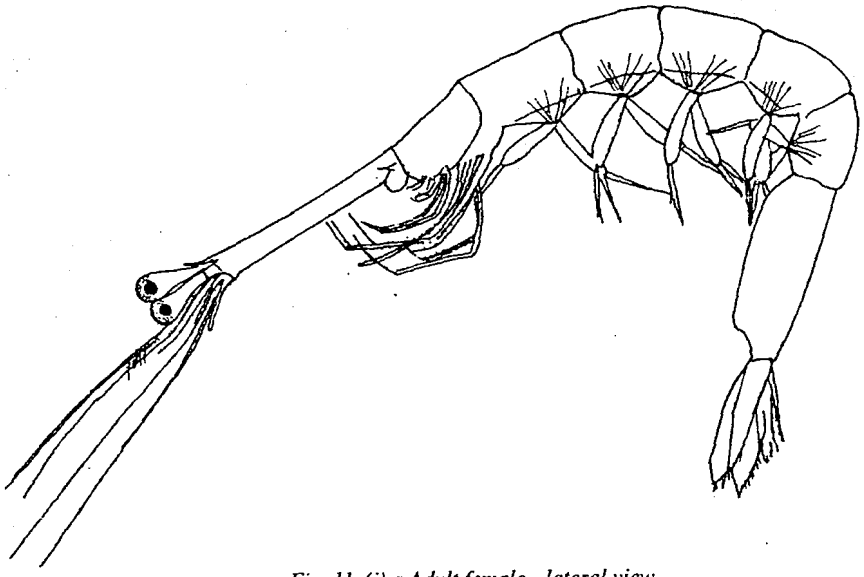


*Fig. 11. (i) a Adult female - lateral view*
*(Dakin & Colefax, 1940)*


*Fig. 11. (i) b. Exopod of uropod showing apical process -lateral view*
*(Hansen, 1919)*

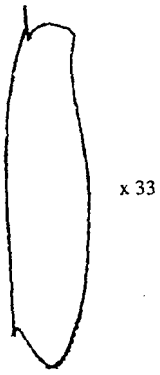



*Fig. 11. (i) c. Exopod of uropod showing apical process of young female - lateral view*
*(Hansen, 1919)*

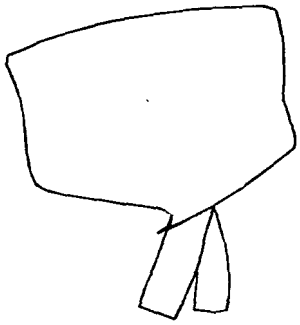


*Fig. 11. (i) d. Abdominal somite of the female showing lateral spine*
*(Hansen, 1919)*

***Fig. 11. (i) a-d* Lucifer hanseni *female***

## Short description of the species

Rostrum short and acute not reaching the statocyst. Carapace extremely laterally compressed, anteriorly elongate. Length of the eye stalk short, sometimes inverted conical. First antennular segments in both sexes reach a little beyond the cornea. The terminal portion of the sheath of petasma is acute and not curved in the opposite direction towards the end. The processus ventralis has its distal half shaped as a curved acute needle. The process on the front margin of the pleopod is short and broad in proportion to its length and with several or many prickles. Sixth abdominal segment in male is much deeper, in proportion to its length. The anterior ventral process is much shorter than the posterior and placed nearer to the posterior process than to the base of the segment. The exopod of uropods in male is more than four times as long as broad, the upper distal angle of the exopod reaches beyond the end of the small marginal apical process (tooth) (Fig.11 a-h and Fig. 11 (i) a-d)).

Colour: semi-transparent.

Common size: TL males 9 mm, TL females 12 mm.

## Diagnostic characters

- Length of the eye stalk- short to moderate.
- Shape of eye stalk –thick, conical.
- Length of the first antennular segment to the front margin of the eye - reaches slightly beyond the cornea.
- Length of rostrum – short, not reaching statocyst.
- Petasma a) Terminal portion of sheath acute and not curved in opposite direction.
  b) Processus ventralis - curved needle with acute end.
- Process on 6th abdominal segment – anterior process shorter than the posterior and placed nearer to 2nd process than to the base of the segment.
- The marginal apical process of the exopod of uropod in male terminates conspicuously far before the upper terminal angle. The same in female terminates considerably before the upper terminal angle.

## Ecology / Biology

Habitat: Pelagic, mainly neretic within 50 m, observed even up to 200 m.

## Distribution in the Indian EEZ

Eastern Arabian Sea: In the inner shelf within the 50m-depth zone of the seas around India where the occurrence of *L.hanseni* was as high as 76% of the total population.

Lakshadweep Islands: Oceanic waters within and beyond 50m around the island.

Bay of Bengal: Waters within and up to 100 m.

Andaman & Nicobar waters: More in depths between 50 and 200 m.

## Distribution in the world

Madagascar; Red Sea; South China Sea; Victoria; Australia.

## Remarks

Eye stalks short and increasing feebly in thickness nearer to or beyond the middle show resemblance to those of *L.penicillifer*. The petasma is similar to that in *L.faxoni*, but the terminal portion shorter, its acute or sub acute end less produced and not curved in the opposite direction towards the end in *L.hanseni*.

## Literature

### Indian EEZ

George (1958), Ganapathy and Ramanamurthy (1975), Patel (1976), Goswami *et al.*, (1977), Nair *et al.*, (1981), Rani Mary *et al.*, (1981), Madhupratap *et al.*, (1981), Naomi (1986), Sarkar *et al.*, (1986), Paulinose *et al.*, (1988), Rajagopalan *et al.*, (1992), Goswami and Shrivastava (1996) and Antony (2005).

### Other areas

Hansen (1919), Gurney (1924), Balss (1927), Dakin and Colefax (1940), Petit (1973), Yamazi (1974), Michel *et al.*, (1986 a), Grabe and Lee (1992) and Farfante and Kensley (1997).

# 3. *Lucifer faxoni* Borradaile, 1915

## Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

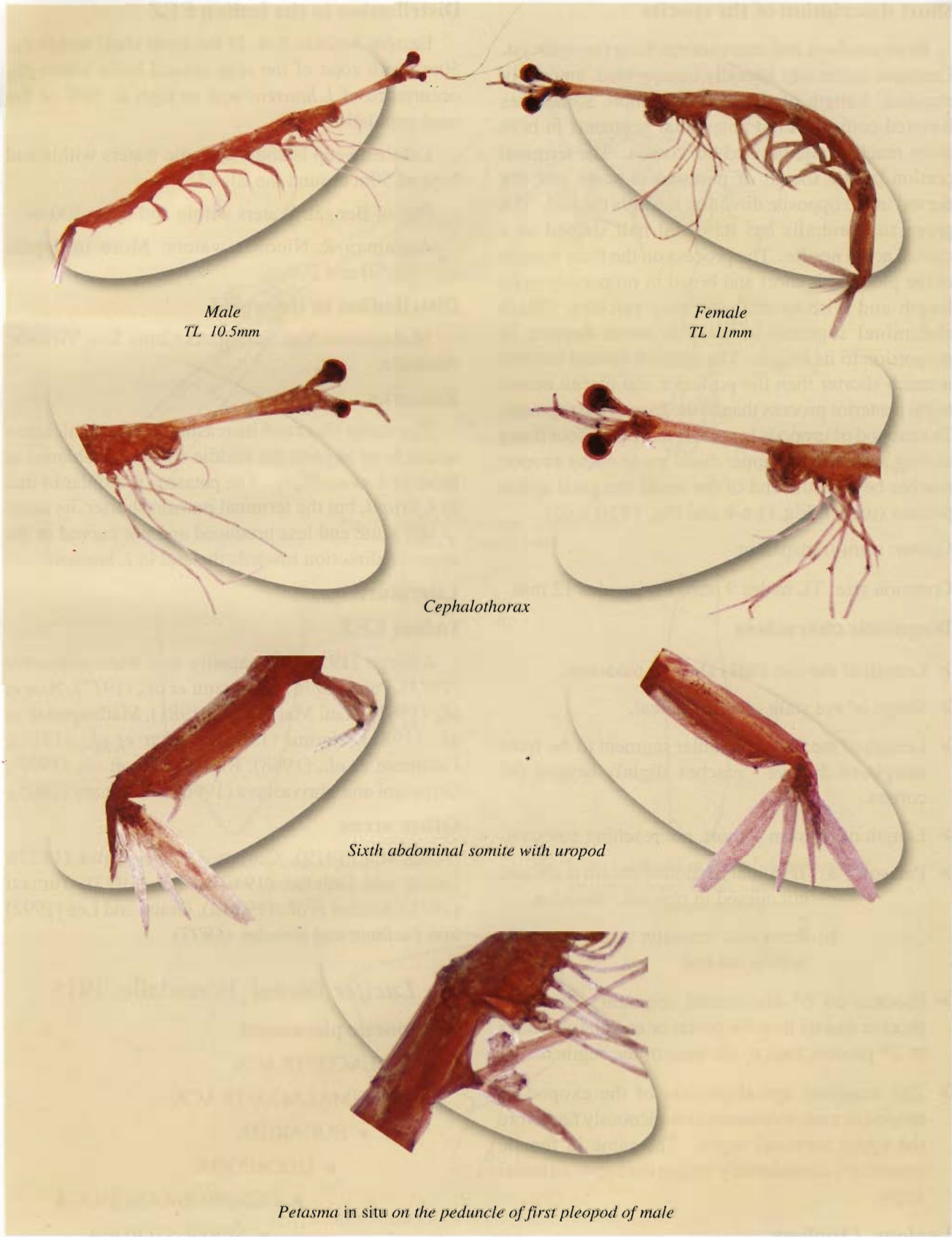



***Plate 3.*** **Lucifer faxoni** *Borradaile, 1915*

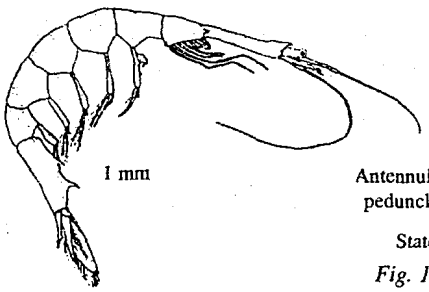



*Fig. 12. a. Adult male - lateral view*
*(Williams, 1965)*

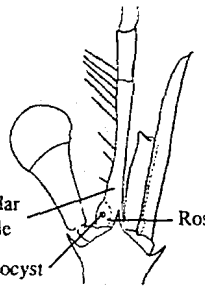



*Fig. 12. b. Anterior region of head - dorsal view*
*(Bowman, 1967)*

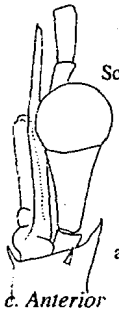


*Fig. 12. c. Anterior region of head - lateral view*
*(Bowman, 1967)*

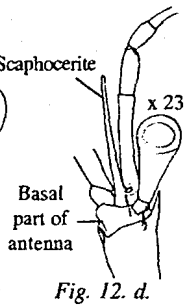



*Fig. 12. d. Anterior region of cephalothorax - lateral view*
*(Bowman, 1967)*

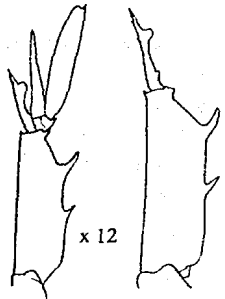



*Fig. 12. e. Sixth abdominal somite with uropod - lateral view*
*(Hansen, 1919 & Bowman, 1967)*

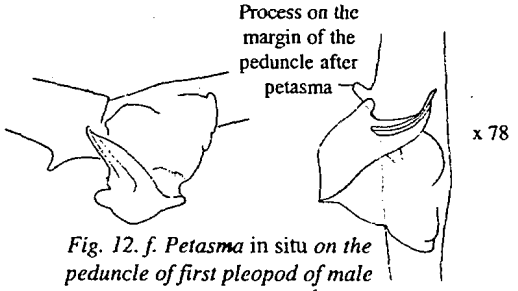



*Fig. 12. f. Petasma* in situ *on the peduncle of first pleopod of male*
*(Bowman, 1967 & Hansen, 1919)*

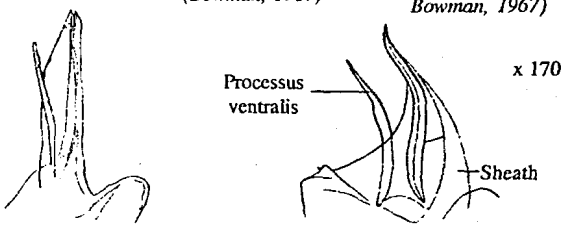



*Fig. 12. g. Terminal portion of petasma*
*(Hansen, 1919 & Bowman, 1967)*

*Fig. 12. h. Endopod of second pleopod*
*(Bowman, 1967)*

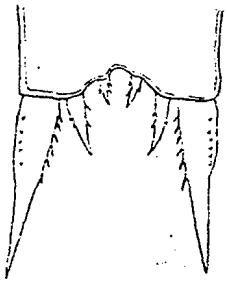


*Fig. 12. i. Dorsal view of telson apex showing the spines*
*(Bowman, 1967)*

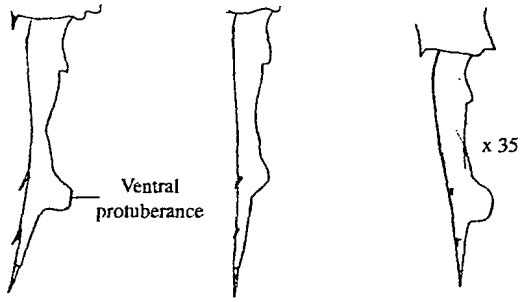
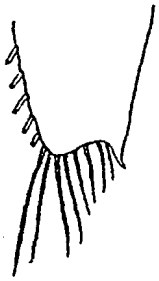



*Fig. 12. j. Lateral view of telson*
*(Bowman, 1967 & Hansen, 1919)*





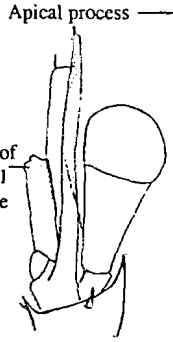



Fig. 12. k. Apex of exopod of uropod - lateral view
(Hansen, 1919 & Bowman, 1967)

***Fig. 12. a-k Diagnostic characters of* Lucifer faxoni *male***




*Fig. 12. (i) a. Anterior region of female head - lateral view*
*(Bowman, 1967)*

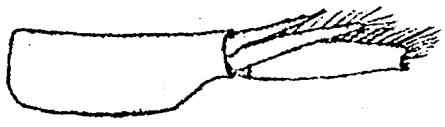


*Fig. 12. (i) b. Sixth abdominal somite and uropod - lateral view*
*(Williams, 1965)*

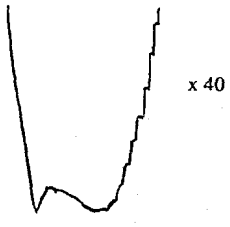



*Fig. 12. (i) c. Apex of exopod of female uropod lateral view*
*(Hansen, 1919)*

***Fig. 12. (i) a-c* Lucifer faxoni *female***

*Lucifer typus*? Faxon, 1878, *Scient. Res.Chesap. Zool.Lab.*, p.113, Pls. VII.

*Lucifer* sp. Brooks, 1882, *Phil.Trans.Roy.Soc.London*, 173, p. 87, Pls.VII-IX, Figs. 61-75.

*Lucifer faxoni* Borradaile, 1915, *Ann.Mag.Nat.Hist. ser.*, 8, Vol.XVI, p.228.

*Lucifer faxoni* Hay & Shores, 1918, *Bull.Bur.Fish.*, p.381, Pl.XXVI, Fig. 4.

*Lucifer Faxonii* Borrad., Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p. 61, Pl.V, Figs.3. a-i.

*Lucifer faxoni* Holthuis, 1959, *Zool.Verh., Leiden*, 44, p.52 (rev.).

*Lucifer faxoni* Williams, 1965, *U.S.Bur.Comm.Fisheries, Fish.Bull.*, 65(1), p. 40, Fig.32.

*Lucifer faxoni* Bowman, 1967, *Pacif.Sci.*, XXI,.2, p. 266, Figs. 2.c-k and 3.d-e.

## Short description of the species

Body small, thin, integument smooth and transparent. Eyes large, prominent, on stout conical stalks. Eye stalks increase gradually and considerably in thickness from the base to the eye. Rostrum small, a spine on each side behind eye and at anterolateral corner. Rostrum reaches almost to distal end of statocyst. First antennular segment in male reaches just beyond the front margin of cornea, in female it reaches very considerably beyond the cornea. Last segment of antennal peduncle in male reaches middle of cornea and distal third of first segment of antennular peduncle. In female last segment of antennal peduncle reaches proximal margin of cornea. Petasma – terminal portion tapers gradually from base with acute end considerably curved, but a short part near the end is curved in the opposite direction. Processus ventralis shaped needle like and tapers to acute end. The process on the front margin of the pleopod is as long as broad at the base with some or several prickles on the end. Of the two ventral processes on sixth abdominal segment of male the anterior process is placed backwards - more distant from the base of the segment than from the second process. A small median spine above base of telson. Telson slender, about half-length of uropods; truncate distally with a strong spine at each corner; two pairs of intermediate spines on distal border and two pairs of lateral spines about equidistant. In males with a prominent ventral projection on distal half of telson. Exopod of uropod – terminal margin is oblique; marginal apical process reaches beyond the upper distal angle in male; does not reach the upper angle but the terminal margin is always oblique in female also (Fig.12 a-k and Fig. 12 (i) a-c).

Colour: Almost transparent in life.

Common size: TL male 11 mm, TL female 11.5 mm.

## Diagnostic characters

- Length of the eye stalk- short.
- Shape of eye stalk – stout and conical.
- Length of the first antennular segment to the front margin of the eye – reaches just beyond the front margin of cornea in male, reaches considerably beyond the cornea in female.
- Last segment of peduncle of 2nd antenna to the front margin of the eye – in male reaches middle of cornea. In female reaches proximal margin of cornea.
- Length of rostrum – reaches almost to distal end of statocyst.
- Petasma a) Terminal portion of sheath tapers from the base to acute end and curved distinctly in the opposite direction.
  b) Processus ventralis is shaped needle like with acute end.
- Exopod of uropod - terminal margin oblique, apical process reaches beyond upper distal angle in male, does not reach in female.

## Ecology/Biology

Habitat: From 50 m up to 200 m.

## Distribution in the Indian EEZ

Eastern Arabian Sea: *L. faxoni* in the mid shelf between 50-100 m depth zone in the northern section.

Lakshadweep Islands: Oceanic waters beyond 50m around the island.

Bay of Bengal: In the oceanic waters beyond 50m and up to 100 m.

Andaman & Nicobar waters: More in depths between 100 and 200 m.

## Distribution in the world

Western Atlantic Ocean from Long Island Sound to Rio de Janeiro; Gulf of Mexico; Caribbean Sea; Bermuda; eastern Atlantic Ocean off Senegal and Congo.

## Remarks

The two ventral processes on the sixth abdominal segment in male are shaped similarly like those of *L.intermedius* but the anterior process is placed more backwards in *L. faxoni*. Males of *L. faxoni* and *L. hanseni* show resemblance in the terminal portion of the petasma with the acute end curved but in *L. faxoni* the end is curved distinctly in the opposite direction. Again, the ventral protuberance on the telson of the males also show similarity, however, it is as broad as its posterior height in *L. faxoni* when compared to *L. hanseni*.

## Literature

## Indian EEZ

Nair *et al.*, (1981) and Antony (2005).

### Other areas

Hay and Shores (1918), Hansen (1919), Edmondson (1925), Cecchini (1933), Burkenroad (1934), Hiatt (1947), Holthuis (1959), Williams (1965), Seguin (1966), Bowman and McCain (1967), Troost (1975), and Farfante and Kensley (1997).

## 4. *Lucifer orientalis* Hansen 1919

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer orientalis* Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p. 55, Pl. IV, Figs.7 a-g.

*Lucifer orientalis* Cai & Chen 1965, *Shiamen Da Shue Shwe Pau.*, 12: p.113, Pl.III, Figs.1-6.

*Lucifer orientalis* Kensley, 1971, *Ann.S.Afr.Mus.*, 57, p.220, Figs. 2. e-g.

*Lucifer orientalis* Khan, 1976, *Agriculture Pakistan* 27, p.115.

*Lucifer orientalis* Omori, 1992, *J.Crust.Biol.*, 12, p. 107, Figs. 2. a-l and 3. a-j.

### Short description of the species

Eye stalks very long, thin and cylindrical. Eye and eye stalks slightly shorter than the distance between eye stalk base and labrum. First antennular peduncle segment reaching to the edge of cornea. Rostrum extends a little beyond the base of the eye stalks. Petasma with the sheath terminates in three triangular lobes with transverse lines on the outer surface of two large lobes, covering the processus ventralis. The processus ventralis consists of two diverging lobes with terminal incision deeper and narrowing to its acute end. Sixth abdominal segment in male with anterior process curved, apically acute. Swollen distal half of posterior process is bent feebly upwards. Telson in male short, rounded, ventral protuberance more semi globular ending distally at apex. Apical marginal process on the outer exopod of uropod more produced in male; in female it almost reaches the upper terminal angle when the terminal angle is considerably oblique (Fig. 13 a-k and Fig. 13 (i) a-i).

Colour : Semi-transparent.

Common size: TL male and female 11.5 mm

### Diagnostic characters

- Length of the eye stalk - very long.
- Shape of eye stalk - thin and cylindrical.
- Length of the first antennular segment to the front margin of the eye – reaches the edge of cornea, antennal scaphocerite does not reach the edge of cornea.
- Length of rostrum – extends a little beyond the bases of eye stalks.
- Petasma a) Terminal portion of sheath in three triangular lobes, transverse lines on outer surface of two large lobes.
  b) Processus ventralis - two diverging lobes with acute ends, terminal incision deeper directed ventrolaterally.
- Process on 6$^{th}$ abdominal segment – anterior process curved, apically acute, posterior process distal end swollen, feebly bent upwards.
- Telson in male short, rounded, ventral protuberance semi globular ending distally at apex.
- Exopod of uropod – apical marginal process prominent in male, reaching almost the oblique distal terminal angle in female.

### Ecology/Biology

Habitat: Oceanic.

### Distribution in the Indian EEZ

Eastern Arabian Sea: *L. orientalis* in the mid shelf between 50-100 m depth zone off the northern section and between 100 and 200 m off the southwest coast.

Lakshadweep Islands: Oceanic waters beyond 50m around the island.

Bay of Bengal: The southwest and northeast coast of India in the oceanic waters beyond 50m.

Andaman & Nicobar waters: Not observed.

### Distribution in the world

East coast of South Africa; Red Sea; Indonesia; Malaysia to China Sea; Philippines; eastern Central Pacific Ocean.

### Remarks

Very similar to *L. typus*, but eye stalks slightly longer. Ventral processes on sixth abdominal segment in males similar but the swollen distal half of posterior

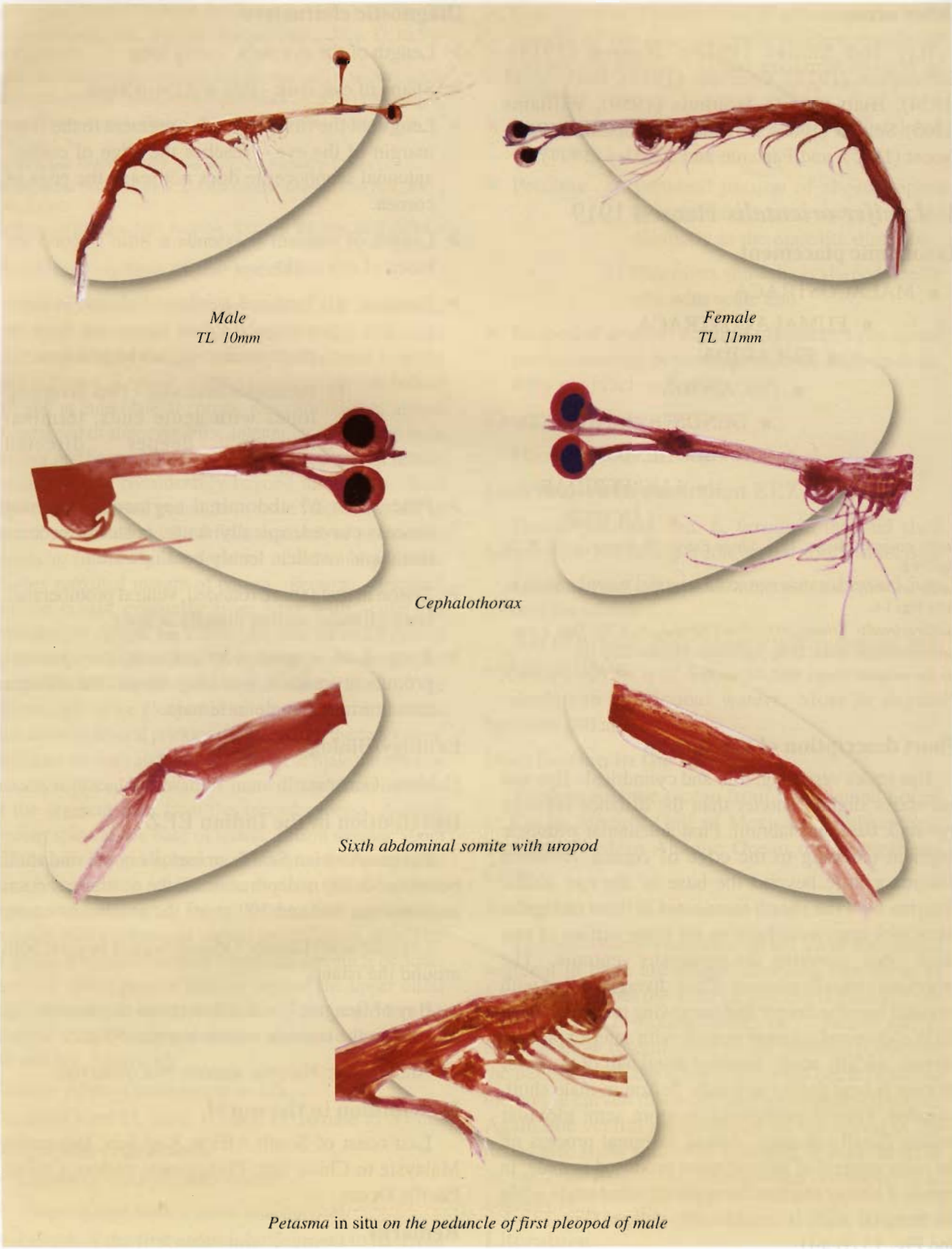



***Plate 4.*** **Lucifer orientalis** *Hansen, 1919*

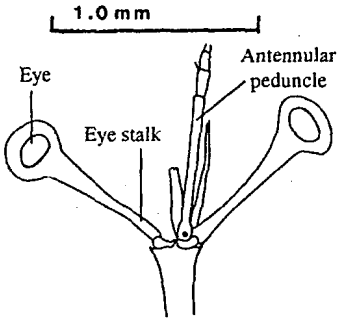



*Fig. 13. a. Adule male anterior region of head - dorsal view (Omori, 1992)*

*Fig. 13. b. Anterior region of cephalothorax - lateral view (Kensley, 1971)*

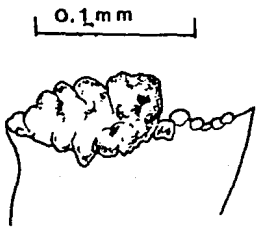



*Fig. 13. c. Mandibular blade (Omori, 1992)*

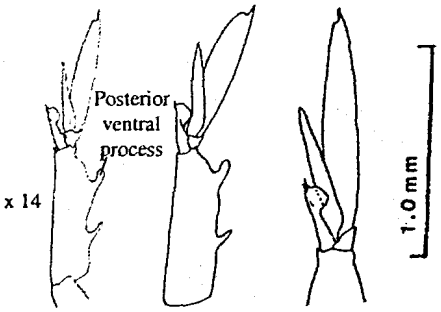



*Fig. 13. d. Sixth abdominal somite with uropod - lateral view (Hansen, 1919; Kensley, 1971 & Omori, 1992)*

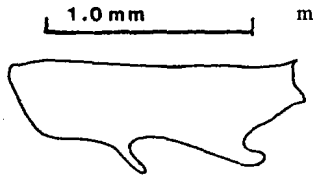



*Fig. 13. e. Sixth abdominal somite - lateral view (Omori, 1992)*

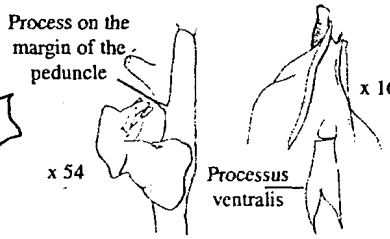



*Fig. 13. f. Petasma* in situ *on the peduncle of the first pleopod (Hansen, 1919)*

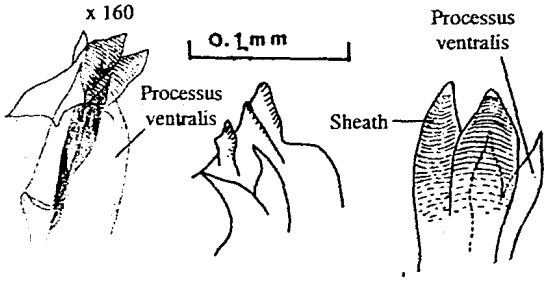



*Fig. 13. g. Terminal portion of the petasma with processus ventralis (Hansen, 1919, Omori, 1992 & Kensley, 1971)*

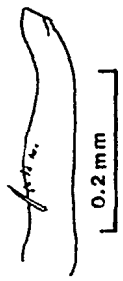



*Fig. 13. h. Median appendix of endopod of second pleopod (Omori, 1992)*

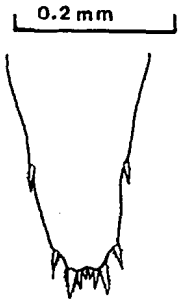



*Fig. 13. i. Telson - dorsal view (Omori, 1992)*

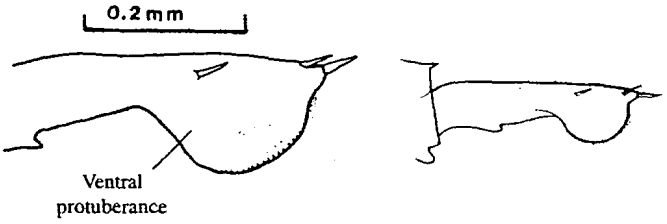



*Fig. 13. j. Telson - lateral view (Omori, 1992.& Hansen, 1919)*

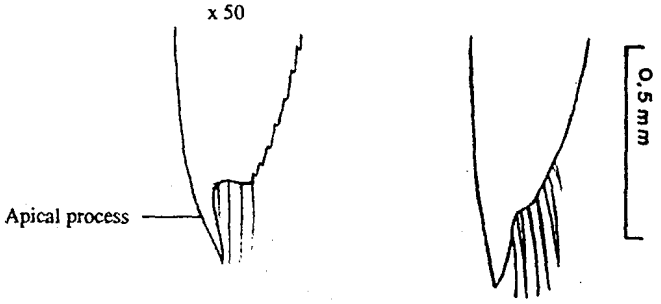



*Fig. 13. k. Terminal part of exopod of uropod - lateral view (Hansen, 1919 & Omori, 1992)*

***Fig. 13. a-k Diagnostic characters of* Lucifer orientalis *male***

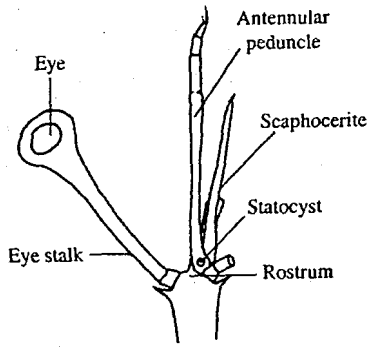



*Fig. 13. (i) a. Adult female anterior region of head - dorsal view*
*(Omori, 1992)*

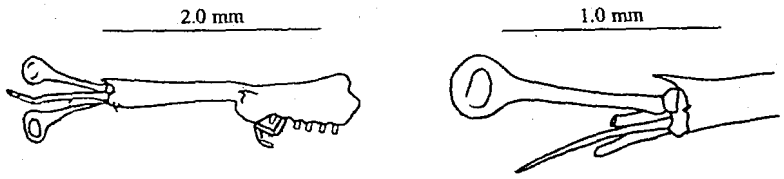



*Fig. 13. (i) b. Anterior region of cephalothorax - lateral view*
*(Omori, 1992)*

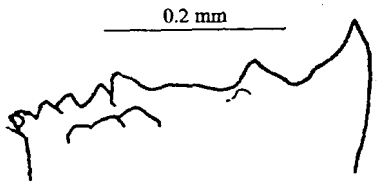



*Fig. 13. (i) c. Mandibular blade*
*(Omori, 1992)*

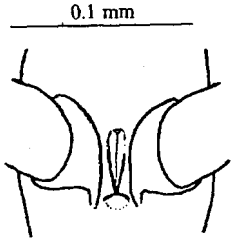



*Fig. 13. (i) d. Thelycum - ventral view*
*(Omori, 1992)*

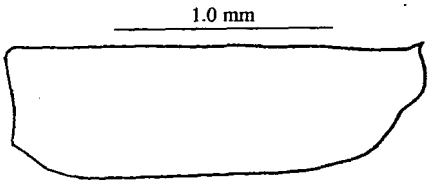



*Fig. 13. (i) e. Sixth abdominal somite - lateral view*
*(Omori, 1992)*

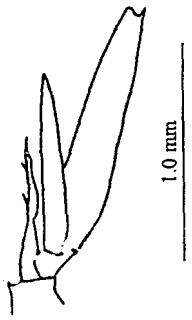



*Fig. 13. (i) f. Telson and uropod - lateral view*
*(Omori, 1992)*

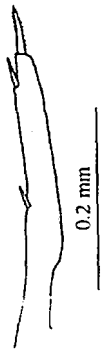



*Fig. 13. (i) g. Telson - lateral view*
*(Omori, 1992)*

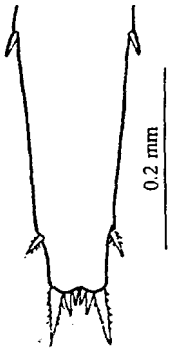



*Fig. 13. (i) h. Telson - dorsal view*
*(Omori, 1992)*


*Fig. 13. (i) i. Terminal part of exopod of uropod - lateral view*
*(Hansen, 1919 & Omori, 1992)*

***Fig. 13. (i) a-i* Lucifer orientalis *female***

process is feebly bent upwards in *L. orientalis*, conspicuously less than in *L.typus*. Ventral protuberance more semiglobular in *L. orientalis*, the middle part of its lower margin more convex than in *L.typus*. Processus ventralis is bent backwards, lamellar process differs from *L.typus* in having incision much deeper and narrowing to its acute end, the long hook-shaped process in *L.typus* is absent in *L. orientalis*. The marginal process of the exopod of uropod very prominent in the male of *L. orientalis*.

### Literature

### Indian EEZ

Antony (2005).

### Other areas

Hansen (1919), Cecchini (1933), Kensley (1971), Yamazi (1974), Khan (1976), Huang and Jinchuan (1987), Omori (1992), Ma Zhaodang (1992) and Farfante and Kensley (1997).

## 5. *Lucifer intermedius* Hansen 1919

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer intermedius* Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p.57, Pl. IV, Figs. 8. a-b; Pl.V, Figs.1.a-g.

*Lucifer intermedius* Hayashi & Tsumura, 1981, *Bull.Jap.Soc.Sci.Fish.*, 47, p.1437, Fig.1.

### Short description of the species

The distance between the labrum and the base of eye stalks is about or more than twice as long as the stalks with eyes; the eye stalks are not conical but sub cylindrical. First antennular segment almost reaching the anterior margin of the eyes, generally distinctly shorter. The terminal portion of the petasma sheath is narrow and broadly rounded with two small conspicuous protuberances on the distal lateral margin, the proximal one broader than the distal; each with an obliquely inserted plate with its free margin almost semicircular. The distal part of the inner side of the terminal portion of the sheath with distinct transverse lines. The processus ventralis is a very long, narrow plate with its distal part slightly widened and its apical end deeply and broadly incised with a round bottom area. On the sixth abdominal segment the short, very acute and slightly curved anterior ventral process is placed about midway between the base of segment and the posterior ventral process, which is tapering to a narrow obtuse end. Telson in male differs considerably in having the ventral protuberance much smaller; this protuberance is directed downwards and only a little or slightly backwards. Exopod of uropods in the male five or little more than five times as long as broad; the short terminal margin is transverse or a little oblique; the apical process overreaches the upper distal angle of the exopod. In female the exopod is a little broader, the terminal margin is oblique, the apical marginal process terminates below or a little before the upper distal angle (Fig.14 a-g and Fig 14 (i) a-b).

Colour : Semi-transparent

Common size : TL male 10.3 mm, TL female 11mm.

### Diagnostic characters

- Length of the eye stalk - moderate.
- Shape of eye stalk – sub cylindrical.
- Length of the first antennular segment to the front margin of the eye – not reaching the cornea.
- Petasma a) Terminal portion of sheath rounded, transverse lines on inner side; 2 plates at the distal lateral margin.
  b) Processus ventralis is a long narrow plate. Terminal part deeply incised with the bottom rounded.
- Process on 6$^{th}$ abdominal segment – anterior process very acute and curved, positioned midway between base of the segment and the posterior process. Posterior process tapers to rather obtuse end.
- Exopod terminal margin – apical process reaches beyond the transverse distal margin in male. In female, the apical marginal process terminates below or a little before the upper distal angle.

### Ecology/Biology

Habitat : Within 50 m up to 100 m.

### Distribution in the Indian EEZ

Eastern Arabian Sea: *L. intermedius* over the mid shelf between 50-100 m depth.

Lakshadweep Islands: Oceanic waters beyond 50m around the island.

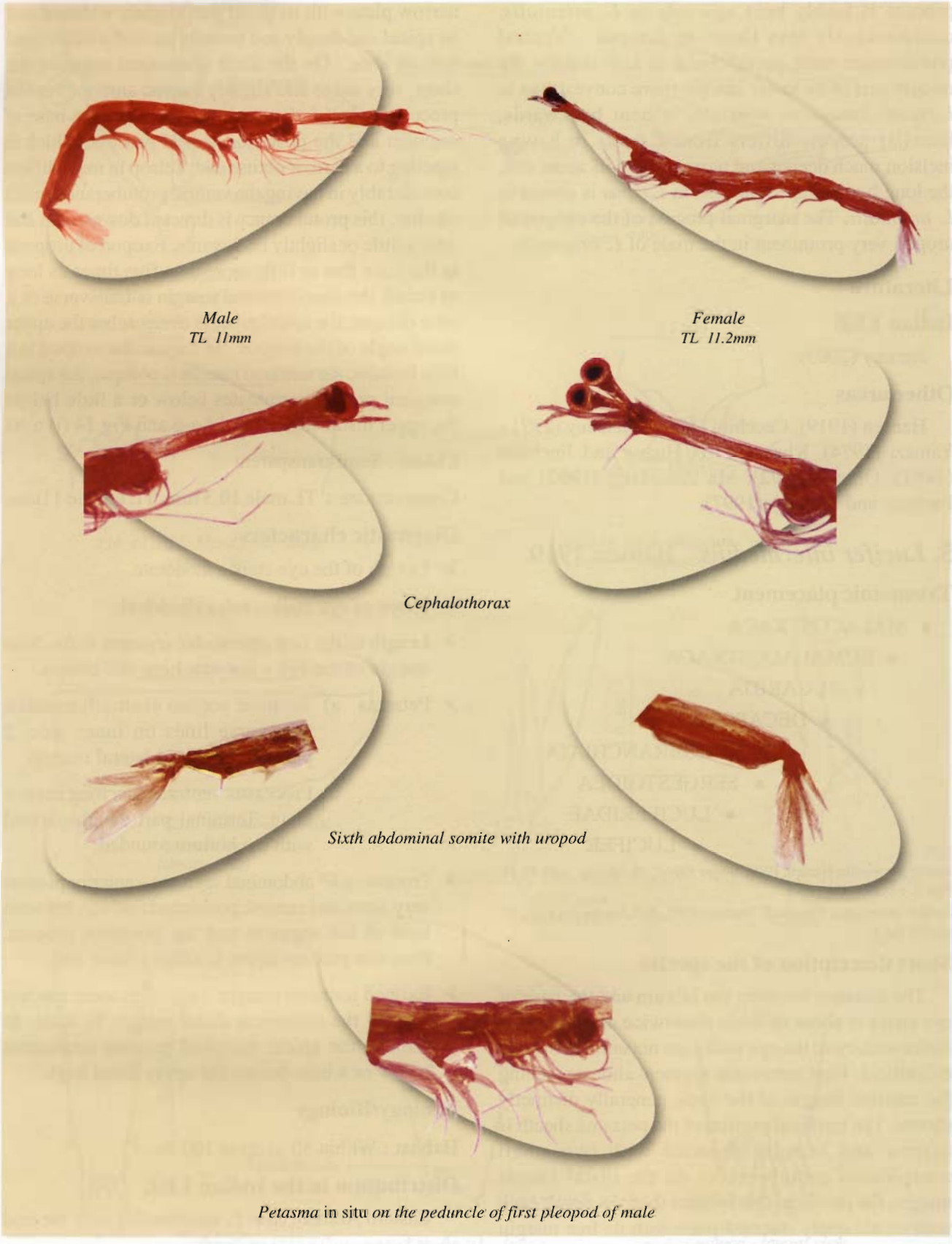



***Plate 5.*** **Lucifer intermedius** *Hansen, 1919*

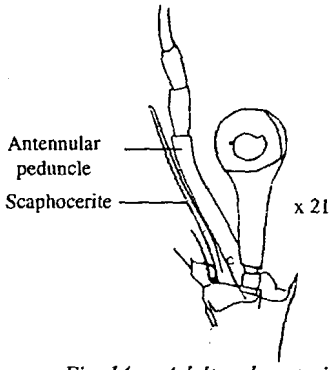



*Fig. 14. a. Adult male anterior region of head - lateral view*

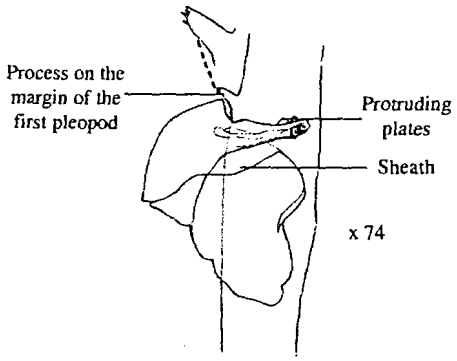



*Fig. 14. b. Petasma* in situ *on the peduncle of the first pleopod*

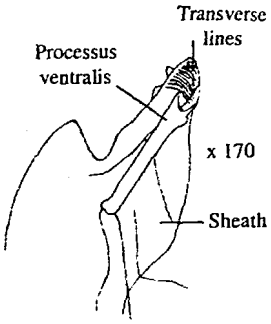



*Fig. 14. c. Terminal portion of the petasma*

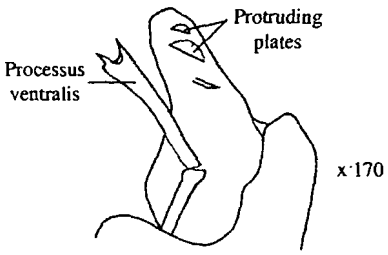



*Fig. 14. d. Terminal portion of the petasma*

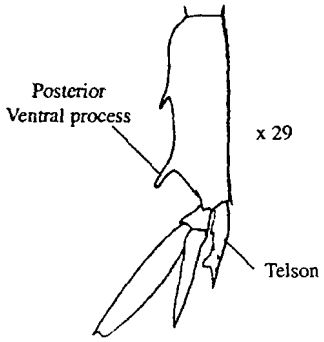



*Fig. 14. e. Sixth abdominal somite with uropod - lateral view*

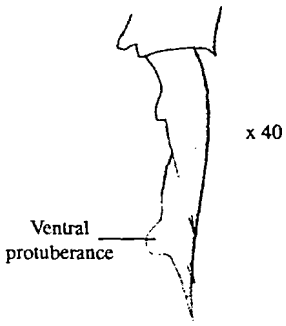



*Fig. 14. f. Telson - lateral view*

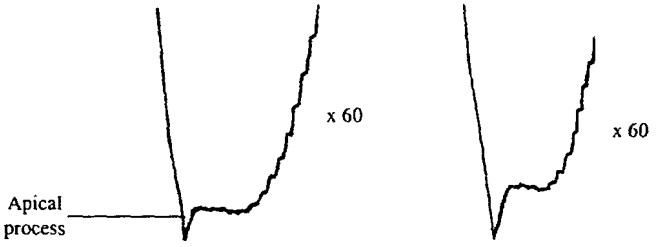



*Fig. 14. g. Terminal part of exopod of uropod - lateral view*
*(Hansen, 1919)*

***Fig. 14. a-g Diagnostic characters of* Lucifer intermedius *male***

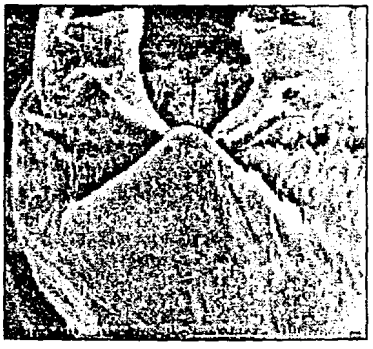



*Fig. 14. (i) a. Female SEM photograph of thelycum, last thoracic sternal plate*
*(Hayashi & Tsumura, 1981)*

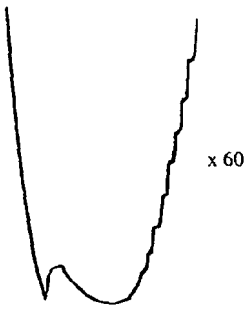



*Fig. 14. (i) b. Female exopod of uropod - lateral view*
*(Hansen, 1919)*

***Fig. 14. (i) a-b* Lucifer intermedius *female***

Bay of Bengal: Neretic waters within 50m, most abundant in the northern section.

Andaman & Nicobar waters: Least abundant.

### Distribution in the world

Gulf of Oman; Indonesia; Malacca Straits to Japan.

### Remarks

The females of *L. intermedius* show similarities to *L. penicillifer* - the terminal apical process on the margin of the exopod of uropod of both terminates only somewhat or a little beyond the distal upper angle. The first antennular segment to the front margin of the eye reaches a little or most frequently not beyond the cornea.

### Literature

### Indian EEZ

Antony (2005).

### Other areas

Hansen (1919), Omori (1977), Ma Zhaodang (1992), and Farfante and Kensley (1997).

## 6. *Lucifer penicillifer* Hansen 1919

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer typus* (*non* Milne Edwards) Stebbing, 1914, *Ann. S.Afr.Mus.*, 15, p. 28.

*Lucifer penicillifer* Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p. 59, Pl. V, Figs. 2. a –k.

*Lucifer penicillifer* Barnard, 1947, *Ann.Mag.Nat.Hist. ser.*, 11, Vol.XIII, p.384.

*Lucifer penicillifer* Barnard, 1950, *Ann.S.Afr.Mus.*, 38, p.645, Fig. 121.

*Lucifer penicillifer* Gordon, 1956, *Sci.Rep.Great BarrierReef Exped.*, 6, p.331, Figs.4-6.

*Lucifer penicillifer* Nasima & Wali, 1971, *Crustaceana*, 20, p.317, Fig.1.

*Lucifer penicillifer* Kensley, 1971, *Ann.S.Afr.Mus.*, 57, p. 218, Figs.1. a-d.

*Lucifer penicillifer* Hayashi & Tsumura, 1981, *Bull.Jap.Soc.Sci.Fish.*, 47, p. 1437, Fig.2.

### Short description of the species

The length of the neck is just greater than twice the length of the eye and eye stalks. Eye stalks conical in shape. First antennular segment reaches slightly beyond the eyes, in some cases; it does not reach the front margin of the eyes. The terminal portion of the petasma sheath is curved with a large number of small, sharp tubercles on the inner side especially on the major distal part of its convex margin. The processus ventralis is flattened; narrow at the base and broad towards the end which is incised and adorned with a bipartite brush of numerous, short chitinous threads. The brush and the distinctly widened plate-shaped end of the sheath are excellent specific characters of the species. In male there are two hook like processes on the ventral surface of the 6th abdominal segment, the posterior ventral process is larger than the anterior ventral process and tapers to a point. The swollen section on the ventral surface of the telson is much smaller than that of *L.typus* and is situated further away from the tip of the telson. The last pair of lateral spines on the telson is close to the tip; they are large and have spinules on the first half of their length. The central pair of spines at the tip of the telson is very short. The outer pair of spines is as long as the width of the tip of the telson, or slightly longer, and has between 5 and 8 spinules on either side. The apical marginal process of the exopod of uropods in both male and female is a triangular tooth not reaching beyond the upper distal angle; the terminal margin is oblique in male, considerably oblique in female (Fig. 15 a-m and Fig. 15 (i) a-c).

Colour : Semi- transparent

Common size: TL Male 9.5 –10 mm, TL Female 10-11 mm.

### Diagnostic characters

- Length of the eye stalk- short.
- Shape of eye stalk –conical.
- Length of the first antennular segment to the front margin of the eye –extend slightly beyond the cornea.
- Petasma
  a) Terminal portion of sheath expanded as an oblique plate. Distal part curved with small tubercles on the inner side.
  b) Processus ventralis: slender plate, narrow at the base and broad towards the end, terminates in a bipartite brush of numerous short chitinous threads.
- Process on 6th abdominal segment – anterior process very acute and curved.
- Exopod of terminal margin – short triangular apical

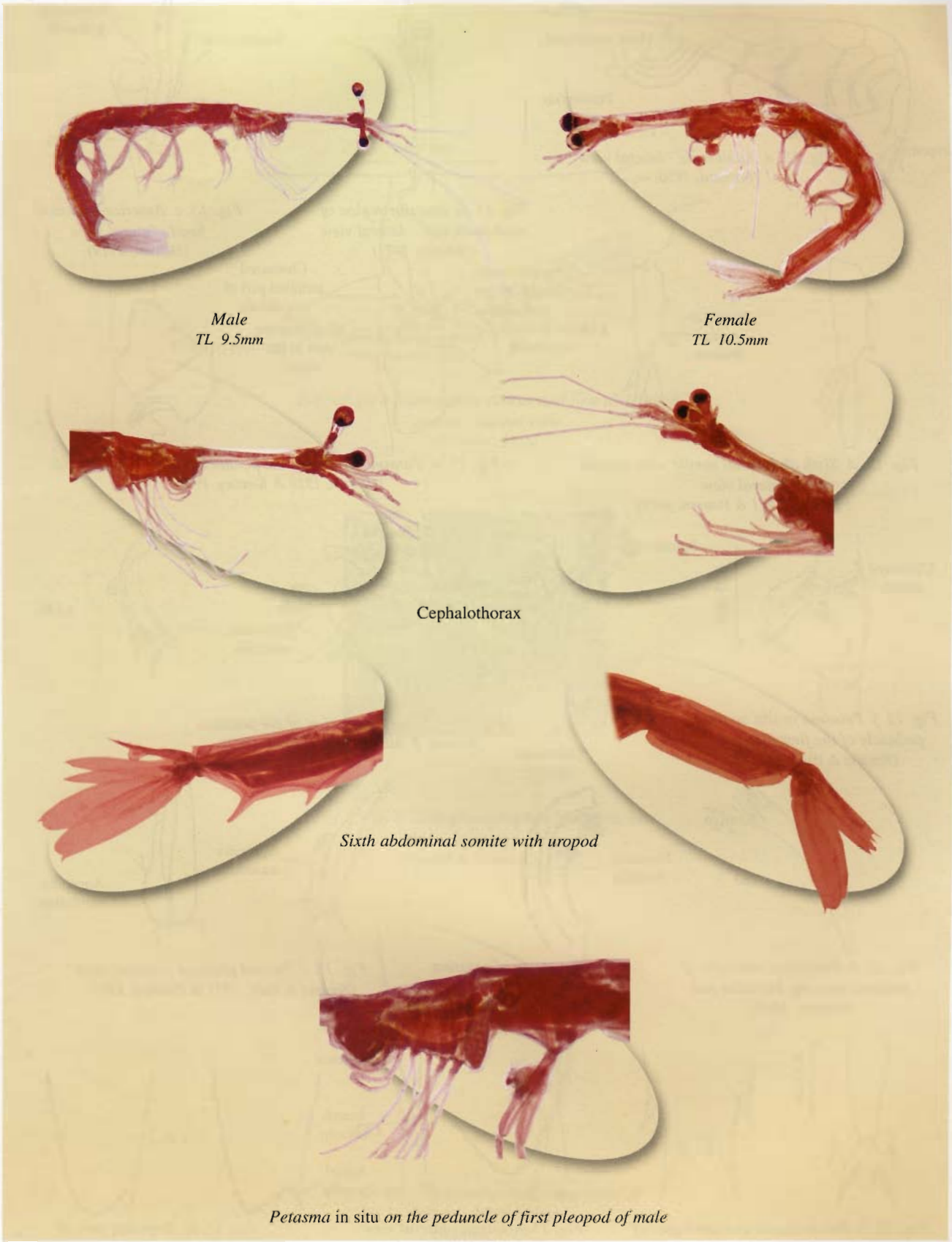



***Plate 6.*** **Lucifer penicillifer** *Hansen, 1919*

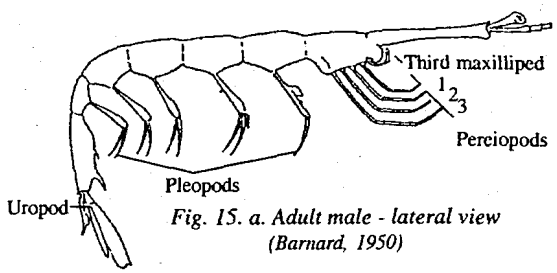



*Fig. 15. a. Adult male - lateral view*
*(Barnard, 1950)*

*Fig. 15. b. Anterior region of cephalothorax - lateral view*
*(Kensley, 1971)*

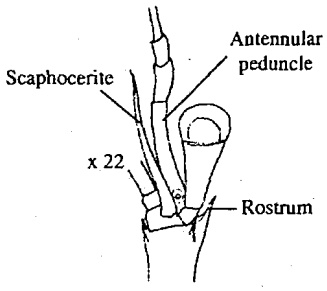



*Fig. 15. c. Anterior region of head - lateral view*
*(Hansen, 1919)*

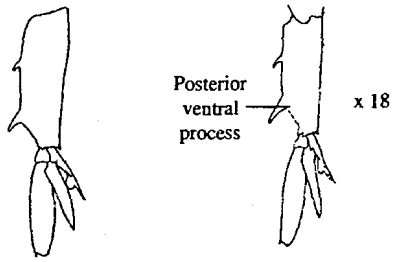



*Fig. 15. d. Sixth abdominal somite with uropod - lateral view*
*( Kensley, 1971 & Hansen, 1919)*

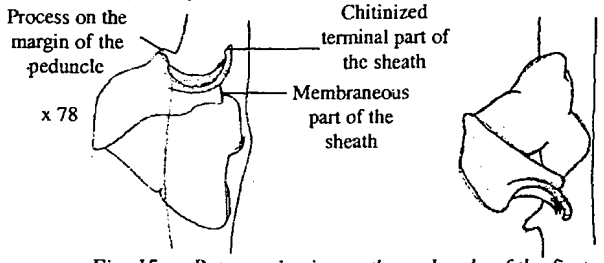



*Fig. 15. e. Petasma in situ on the peduncle of the first pleopod*
*(Hansen, 1919 & Kensley, 1971)*

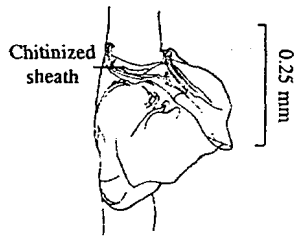



*Fig. 15. f. Petasma* in situ *on the peduncle of the first pleopod*
*(Nasima & Wali, 1971)*

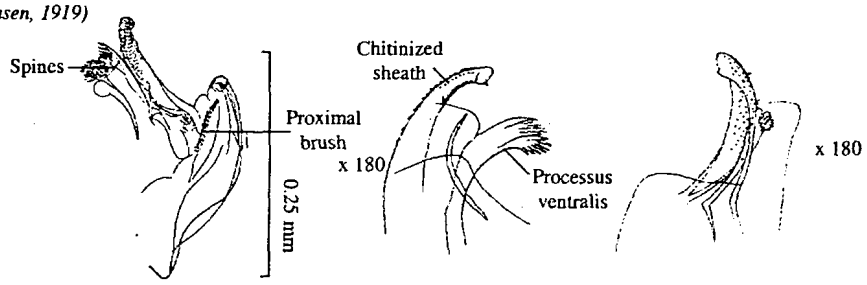



*Fig. 15. g. Terminal portion of the petasma*
*(Nasima & Wali, 1971 & Hansen, 1919)*

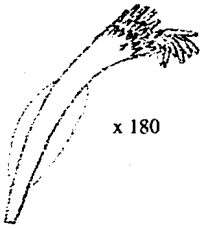



*Fig. 15. h. Processus ventralis of petasma showing bipartite end*
*(Hansen, 1919)*

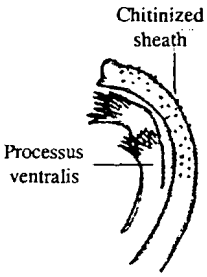



*Fig. 15. i. Apex of petasma*
*(Kensley, 1971)*

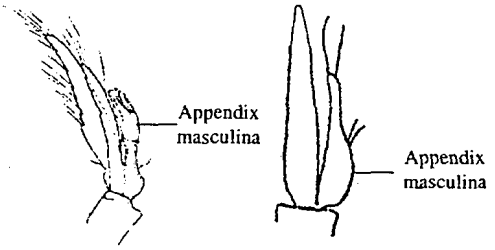



*Fig. 15. j. Second pleopod - ventral view*
*(Nasima & Wali, 1971 & Barnard, 1950)*

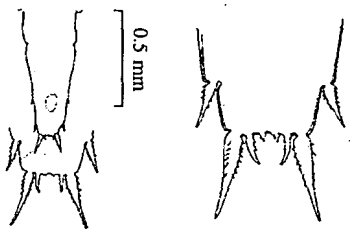



*Fig. 15. k. Telson dorsal view and apex of telson showing the spines*
*(Gordon, 1956)*

*Fig. 15. l. Telson - lateral view*
*(Gordon, 1956 & Hansen, 1919)*

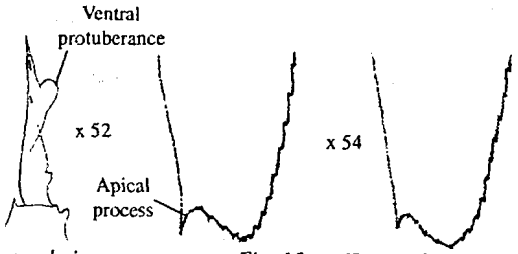



*Fig. 15. m. Terminal part of exopod of uropod - lateral view*
*(Hansen, 1919)*

***Fig. 15. a-m Diagnostic characters of* Lucifer penicillifer *male***

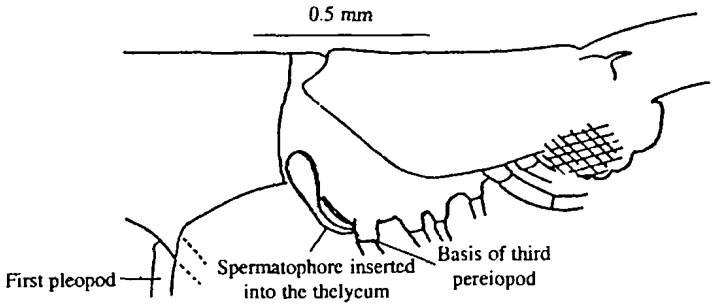



*Fig. 15. (i) a Adult female thorax and first abdominal somite - lateral view*
*(Gordon, 1956)*

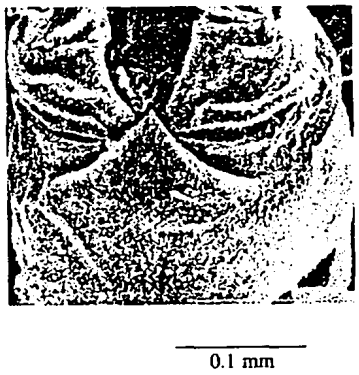



*Fig. 15. (i) b. SEM photograph of thelycum, last thoracic sternal plate*
*(Hayashi & Tsumura, 1981)*

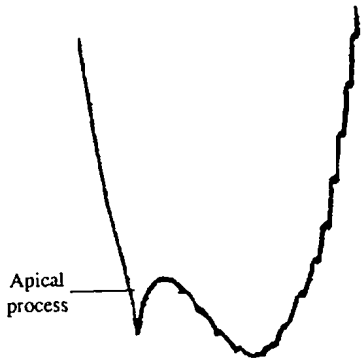



*Fig. 15. (i) c. Terminal part of the exopod of uropod - lateral view*
*(Hansen, 1919)*

***Fig. 15. (i) a-c* Lucifer penicillifer *female***

marginal tooth not reaching beyond upper distal angle, terminal end considerably oblique.

### Ecology/Biology

Habitat : Pelagic, neretic, up to 100m.

### Distribution in the Indian EEZ

Eastern Arabian Sea: *L. penicillifer* typically neretic occur within 50 m. More than 44 % of the total population of the genus in the seas around India is by this species. Highest abundance within 50 m off the south west coast.

Lakshadweep Islands: Oceanic waters beyond 50m around the island.

Bay of Bengal: Abundant within 50m and up to 100 m in the northern and southern sections.

Andaman & Nicobar waters: Neretic in distribution.

### Distribution in the world

South-east coast of South Africa; east African coast; Bay of Bengal; Malaysia; Indonesia; South China Sea; Philippines; Hong Kong; Japan; Northern Australia.

### Remarks

Eye stalks shaped as in *L.intermedius* but conical. Exopod of uropods in male also shows resemblance but considerably oblique in *L.penicillifer.*

### Literature

### Indian EEZ

Ganapathy and Ramanamurthy (1975), Nair *et al.*, (1981), Madhupratap *et al.*, (1981) and Antony (2005).

### Other areas

Hansen (1919), Barnard (1950), Gordon (1956), Kensley (1971), Win (1977), Omori (1977), Ma Zhaodang (1992) and Farfante and Kensley (1997).

## 7. *Lucifer chacei* Bowman, 1967

### Taxonomic placement

- MALACOSTRACA
  - EUMALACOSTRACA
    - EUCARIDA
      - DECAPODA
        - DENDROBRANCHIATA
          - SERGESTOIDEA
            - LUCIFERIDAE
              - LUCIFER

*Lucifer Faxonii* Borrad., Hansen, 1919, *Siboga Exped.*, 38, *Monog.*, p. 61, Pl. V, Figs. 3. a -i.

*Lucifer reynaudi* H. Milne Edwards , Edmondson,1923, *B.P. Bishop Mus. Bull.*, 5.

*Lucifer faxoni* Edmondson,1925, *Crustacea, B.P. Bishop Mus. Bull.*, 27, p.3.

*Lucifer faxoni* Hiatt, 1947, *Pacif.Sci.*, 1 (4):241.

*Lucifer faxoni* Chace 1955, *Proc.U.S.Natl.Mus.*, 105(3349): 4.

*Lucifer chacei* Bowman, 1967, *Pacif.Sci.*, XXI, 2, p. 266, Figs.1. a-j, 2. a-b, 3. a-c and 4. a, b.

*Lucifer chacei* Kensley, 1971, *Ann.S.Afr.Mus.*, 57, p. 218, Figs.1. e-g.

### Short description of the species

Eye and eye stalks about two-fifths the length of distance between eye stalk base and labrum. The length of the eye stalks is very short; shape gradually increases in thickness from base. First antennular segment reaches considerably beyond the cornea in male; in female it reaches to the end of cornea. Last segment of the antennal peduncle reaches beyond the eye in male; it reaches middle of the cornea in female. Length of the rostrum reaches to proximal boarder of statocyst. Petasma sheath with the terminal portion curved, apical acute; processus ventralis slender and needle-like. Sixth abdominal segment in male with short straight anterior ventral process placed more backwards, posterior ventral process slender and curved. Apical marginal spine on the outer margin of exopod of uropod, not quite reaching the distal terminal angle in male; it reaches in female. The ventral protuberance of telson in male is much broader than its posterior height. Process on anterior margin of first pleopod in male is longer than broad (Fig.16 a-e and Fig. (i) a-k).

Colour : Semi-transparent

Common size : TL male 11mm, TL female 11.5mm

### Diagnostic characters

- Length of the eye stalk - very short.
- Shape of eye stalk – increases gradually in thickness from base.
- Length of the first antennular segment to the front margin of the eye – overreaches considerably in male, reaches somewhat beyond in female.
- Last segment of antennal peduncle to the front margin of the eye – in male reaches beyond the eye. In female reaches middle of cornea.
- Length of rostrum – reaches to proximal border of statocyst.

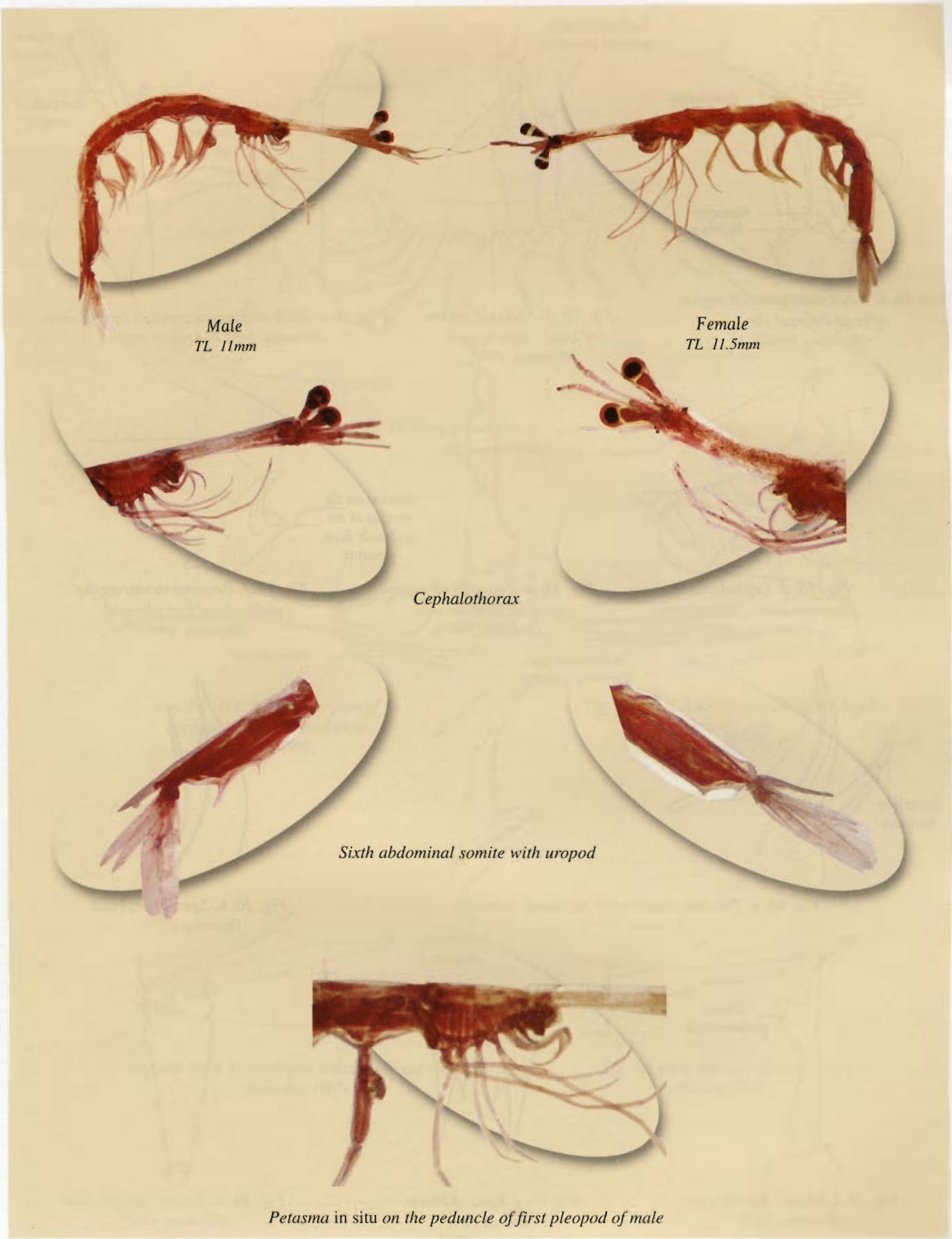



***Plate 7.*** **Lucifer chacei** *Bowman, 1967*

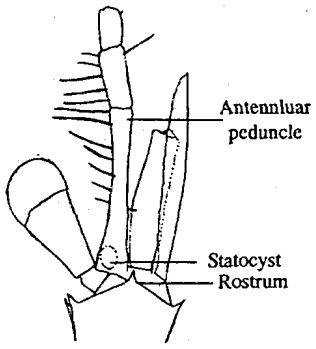



*Fig. 16. a. Adult male anterior region of head - dorsal view*
*(Bowman, 1967)*

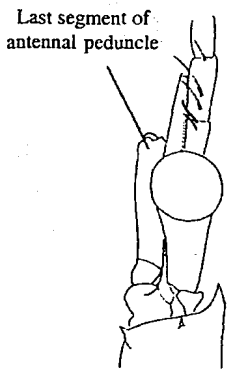



*Fig. 16. b. Anterior region of head - lateral view*
*(Bowman, 1967)*

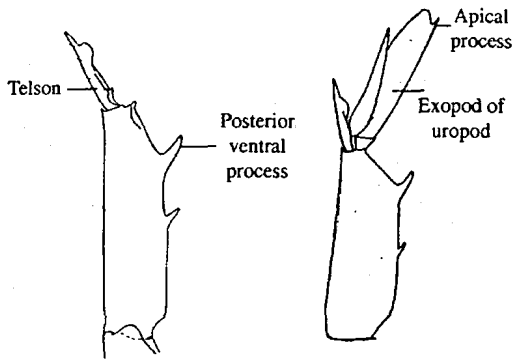



*Fig. 16. c. Sixth abdominal somite - lateral view*
*(Bowman, 1967 & Kensley, 1971)*

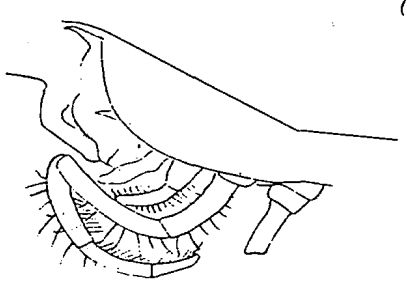


*Fig. 16. d. Cephalothorax posterior part - lateral view*
*(Bowman, 1967)*

*Fig. 16. e. Endopod of second pleopod anterior view*
*(Bowman, 1967)*

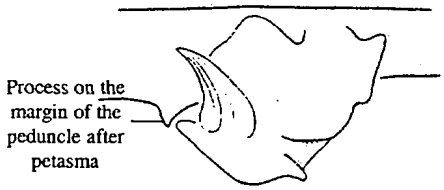



*Fig. 16. f. Petasma* in situ *on the peduncle of first pleopod*
*(Bowman, 1967)*

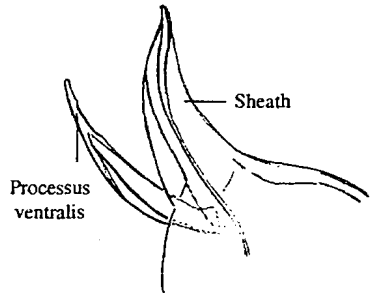



*Fig. 16. g. Petasma sheath with processus ventralis*
*(Bowman, 1967)*

*Fig. 16. h. Apex of petasma*
*(Kensley, 1971)*

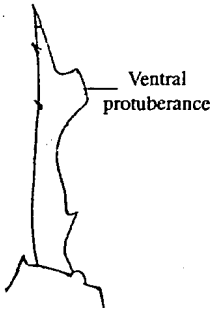



*Fig. 16. i. Telson - lateral view*
*(Bowman, 1967)*

*Fig. 16. j. Apex of telson - dorsal view*
*(Bowman, 1967)*

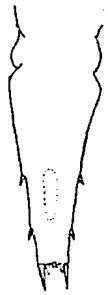


*Fig. 16. k. Telson - dorsal view*
*(Bowman, 1967)*

***Fig. 16. a-k Diagnostic characters of* Lucifer chacei *male***

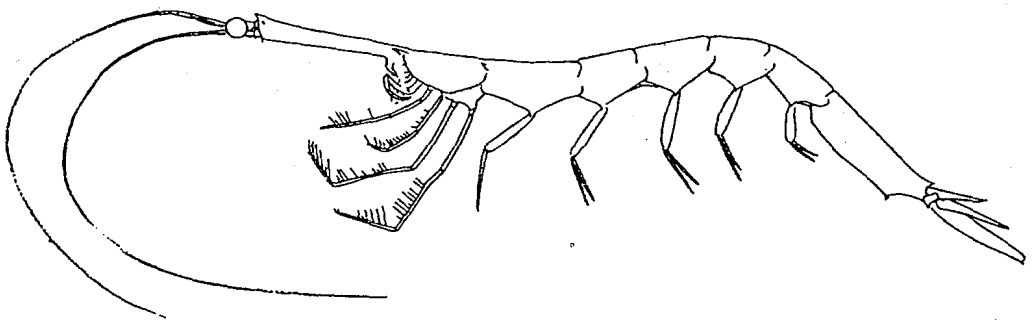


*Fig. 16. (i) a. Adult female - lateral view*
*(Bowman, 1967)*

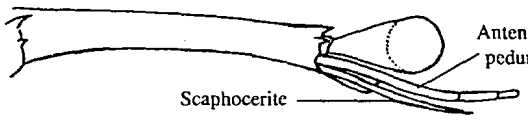



*Fig. 16. (i) b. Anterior region of cephalothorax - lateral view*
*(Kensley, 1971)*

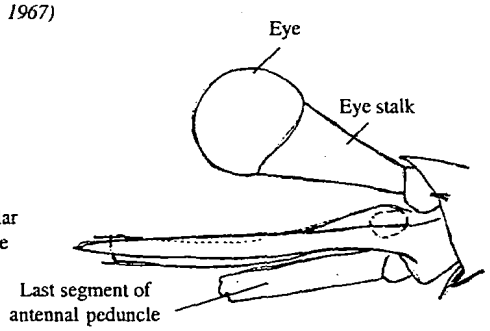



*Fig. 16. (i) c. Anterior region of the head - lateral view*
*(Bowman, 1967)*

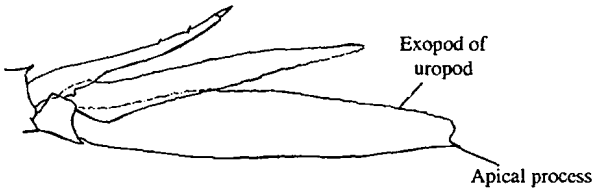



*Fig. 16. (i) d. Uropod and telson - lateral view*
*(Bowman, 1967)*

*Fig. 16. (i) e. Telson - lateral view*
*(Bowman, 1967)*

***Fig. 16. (i) a-e* Lucifer chacei *female***

- Petasma a) Terminal portion of sheath curved, apical acute.
  b) Processus ventralis nearly needle like, directed ventrolaterally.
- Process on 6th abdominal segment – anterior process placed more backwards.
- Exopod of terminal margin – apical process not reaching the upper terminal angle in male.

## Ecology/Biology

Habitat : Within 50m and up to 200 m.

## Distribution in the Indian EEZ

Eastern Arabian Sea: *L. chacei* abundant within 50 to100m in the southern section and in nearshore areas. Moderate numbers occur in the northern area between 100 and 200m.

Lakshadweep islands: Oceanic waters beyond 50m around the island.

Bay of Bengal: Abundant within 50 and up to 100m in the northern and southern sections.

Andaman & Nicobar waters: Higher numbers between 100 and 200m.

## Distribution in the world

East coast of South Africa; Madagascar; Indonesia to Hawaii; Tahiti.

## Remarks

Similar to *L. faxoni* but it is distinct from *L. faxoni* in four different characters. In *L.chacei* sheath of petasma curved, the ventral protuberance of telson in male much broader than its posterior height, rostrum reaches proximal border of statocyst and in male last segment of antennal peduncle reaches beyond the eye and nearer to distal margin of first antennular peduncle. In female last segment of antennal peduncle reaches beyond middle of cornea and to distal third of first segment of antennular peduncle.

## Literature

## Indian EEZ

Antony (2005).

## Other areas

Kensley (1971), Omori (1977) and Farfante and Brian Kensley (1997).

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