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**STUDIES ON COPEPOD PARASITES ON
ELASMOBRANCHS OF KERALA COAST**

THESIS

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By

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CERTIFICATE

This is to certify that this thesis is an authentic record of research work carried out by Sri Asok Kumar, K. M.Sc. under my supervision and guidance in the Department of Industrial Fisheries, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY and that no part thereof has been submitted for any other degree.

Cochin-16,
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DECLARATION

I, Asok Kumar, K. do hereby declare that the thesis entitled "STUDIES ON COPEPOD PARASITES ON ELASMOBRANCHS OF KERALA COAST" is a genuine record of research work done by me under the supervision and guidance of Dr. M. Shahul Hameed, Professor and Head, Department of Industrial Fisheries, Cochin University of Science and Technology, and has not been previously formed the basis for the award of any degree, associateship, fellowship or other similar title of any university or institution.

Cochin-16

August, 1990.



ASOK KUMAR. K

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CHAPTER I

GENERAL INTRODUCTION

Parasites are organisms which live in intimate interaction with their host. This association always leads to physical and metabolical destruction of the host in one way or other. Copepods are lower animals which are commonly free-living, but a few of them are parasitic on sponges, coelenterates, worms, molluscs, echinoderms and other aquatic animals. Due to its parasitic mode of life, the copepod had undergone certain adaptive modifications with respect to their morphology. The morphological variations have developed to such an extent that it becomes very difficult to recognise them as true copepods.

The interesting adaptive variations exhibited by parasitic copepods has attracted attention of numerous biologists. It is however, Linnaeus who had initiated the study of parasitic copepods with a report on Lernaea cyprinacea in 1758. The study of Muller on Caligus in 1785 followed. The other eminent scientists who had pioneered the work on copepods were Herman (1804), Leach (1816), Risso (1816) and Blainville (1822). In the latter half of the nineteenth century another group of scientists such as Dana (1852 and '53), Gestaecker (1853 and '54),

Steenstrup and Lutken (1861), Kroyer (1863), Heller (1865), Hesse (1873), Richiardi (1883) and Basset-Smith (1898a, b and c) worked on copepod parasites.

C.B. Wilson (1905 - 1937) brought out a series of publications on parasitic copepods of America. Scott and Scott (1913) and Leigh-Sharpe (1925, 1933) studied the parasitic fauna on fishes in British waters. Kirtisinghe (1937) contributed his findings on parasitic copepods in Ceylon. It was followed by Heegard (1942-1963) and Shiino (1952-1960).

The study of copepods parasitic on fishes in Indian waters was initiated by Basset-Smith in 1898. He reported about 32 species in various publications. Till then, for about fifty years, nobody seems to have taken any interest in these particular group of animals. Later in the period 1934 to '64, Kirtisinghe started the study of parasitic copepods collected from waters in and around Ceylon.

The efforts of Kirtisinghe and Basset-Smith was followed by the works of Gnanamuthu (1947 - 1956) and Rangnekar (1950 - 1959). Gnanamuthu's study was based on the copepods collected from the east coast of India. On

the other hand, Rangnekar confined her studies to the parasitic fauna of Bombay region. She had reported thirty one species of parasitic copepods in eleven publications. Besides them, Redkar et al. (1949), Rao (1951), Kurian (1955) and Sebastain (1964) also had contributed much to the development of this field.

Till 1961, no detailed work was done on parasitic copepods of south-west coast of India. Pillai in 1961 started a detailed survey of parasitic copepods of fishes in Trivandrum area. In next seventeen years (1961 - 1978), Pillai described 174 species in thirty two publications. He had also brought out an useful review of work on parasitic copepods of Indian marine fishes.

The work of Pillai was taken up by Hameed (1972). He described 129 species of parasitic copepods from south west coast of India, of which 42 were new and three were new records for Indian waters.

All the works mentioned above are mainly concentrated on the parasites collected from Teleost fishes. The study on copepods parasitising on elasmobranch fishes were lacking and only a few scientists had initiated work in this direction.

Wilson (1935a) registered first record of various species of the genera. Pandarus , Lamna , Demoleus , and Anthosoma parasitising on elasmobranch fishes from the Pacific coast.

Rangenaker (1950, 1959) reported two new species of copepod parasites collected from elasmobranch fishes at Bombay.

Lidia (1952, 1953, 1954a, 1954b, 1954c, 1956a, 1956b and 1957) described many new parasitic copepods collected from elasmobranchs from Mediterranean.

Rose and Vaissiere (1952, 1953) and Vaissiere (1953) gave a detailed account of copepods parasites of African coast, in which several elasmobranch hosts were also included.

Shiino (1956, 1957a, 1957b) in his series of copepod parasitic on Japanese fishes, elaborates various copepod parasites he encountered on elasmobranch hosts. He had reported several new species and redescribed many copepods on elasmobranch hosts.

Pillai (1963a, 1963b, 1964, 1968) reported

numerous copepod parasites collected from elasmobranch and teleost hosts from Trivandrum.

Lewis (1966) in his monograph of copepod parasites on elasmobranchs fishes of Hawaiian islands, gave a comprehensive picture of copepod parasitic fauna infesting various sharks and rays of Hawaii. He reported thirteen species of copepods including one new species of Kroyeria belonging to ten different genera, which frequently infests the sharks and rays in that region.

A monograph on copepod parasitising the sharks of Indian Ocean was published by Cressey (1967a). In this he had described thirty five species of caligid copepods collected from twenty nine different species of sharks. Two new genera and eight new species were also established.

Cressey (1967b) in his revision of the family Pandaridae redescribed twelve genera and twenty eight species of the taxa. Five new species were described and one new genus Pannosus was erected. All the new species were collected from various elasmobranch fishes. According to him, the members of the genus Pandarus are the most frequently encountered Pandarid copepod in

elasmobranch fishes. He observed that the females of some species of Pandarus are heavily pigmented and they frequently occur in clusters of more than hundred individuals on fins of shark. He opined that the members of the genus Echthrogaleus are cosmopolitan as a parasite on elasmobranch fishes. He reported that E. coleoptratus and E. denticulatus are restricted to larger pelagic sharks. Whereas E. torpidinis has been reported only from Torpedo occidentalis.

According to Cressey (1967b) three species viz. N. cuticaudis Dana 1852, N. borealis Steenstrup and Lutken, 1861 and N. bengalensis Gnanamuthu 1949 do not belong to the genus Nessipus. He opined that their taxonomic position remain in doubt owing to the fact that the specimens described were immature and suggested that they should be removed from the genus Nessipus.

Cressey (1968) studied the shift in the habitat shown by the members of genus Pandarus. From his observations of these parasites which were collected from the body of mako shark, Isurus oxyrinchus from Indian and Atlantic Oceans, he reported that a remarkable habitat shift was shown by Pandarus satyrus and Pandarus smithi by shifting their place of attachment from the body surface to the gills and mouth cavity.

In 1972 Cressey revised the genus Alebion based on his collection of copepods obtained from shallow water sharks and observed that members of this genus are found in all major oceans. He redescribed four species and reported nine new species of Alebion in this paper.

Hameed and Pillai (1973 a) redescribed the genus Trebius and recorded three new species of Trebius collected from elasmobranchs at Cochin.

Parasitic copepods of sharks from Pacific coast was described by Kabata (1974 a).

A new genus Boylea was erected based on the parasites collected from sharks of San Francisco Bay by Cressey (1977).

Ho et al. (1981) reported a new species of Eudactylina from the gills of black shark Aculeola nigra De Buen, collected from Pacific coast of Chile. The authors claimed that this is the first record of Eudactylinid copepod ever reported from south east Pacific Ocean.

Benz and Deets (1986) described a new species of Kroyeria viz. Kroyeria caseyi from night sharks

Carcharhinus signatus (Poey, 1868). The peculiarity they observed was that this species is the only known member of the genus Kroyeriidae, which is a mesoparasite, whereas all other members are ectoparasites. Deets and Benz (1986) reported a new species of Eudactylinoides from the Sea of Cortez. The authors had claimed that this was the first record of the genus from the Sea of Cortez and the first record of a Eudactylinid copepod parasitic on Heterodontiformes.

Benz and Deets (1987) reported a new species of Echthrogaleus parasitising the devil ray Mobula lucasana from the Sea of Cortez. In this they give a comprehensive account of the genus Echthrogaleus. They had reported that E. disciari is the second member of Echthrogaleus found to be associated with batoid elasmobranchs, which points out the affinity of Echthrogaleus spp. to batoid rays. They also observed that this species is closely related to E. pellucides and suggested that the emergence of this new species is due to the colonization event from a similar environment rather than strict coevolution.

Dojiri and Deets (1988) established a new genus Norkus under the family Sphyriidae with description of the type species from the elasmobranch Rhinobatus productus. The genera within this family parasitize both

Osteichthyes and Elasmobranchii. The post metamorphic females exhibit a partial or total loss of thoracic appendages as well as varying degrees of degeneration in the head appendages. According to them, the detailed morphology of the appendages in females and males are very similar to that of Lerneopodidae. In this paper a novel attempt is made to study the host-parasite co evolution and phylogenetic relationships of the parasite with the host. A single parasite cladogram, host and ecological summary cladogram are presented and discussed. They concluded that twenty six nominal species comprising the Sphyriidae possess only two major life history tracts.

Cressey and Collins (1988) reported a new species of Pandarid copepod from Australian sharks. This is reported to be the first pseudopandarid copepod parasite ever reported from the South Pacific.

A modification of non redundant linear coding of multistriate characters of copepod parasites on elasmobranchs was attempted by Grady et al. (1989).

Deets and Dojiri (1989) reported three species of Trebius Kroyer (1838) from elasmobranchs of Pacific ocean. They also redescribed all the previously collected Trebius

from the Pacific Ocean. This paper added new hosts to the parasite. A morphological comparison of all congeners was also attempted.

The other important works of interest worth mentioning are that of Wilson (1919, 1935b, 1935c, 1935d), Heegard (1942 and 1962), Gnanamuthu (1948), Pearse (1951, 1952), Capart (1953), Kurian (1955), Shen and Wang (1958), Cressey (1963, 1966, 1988), Ho (1963), Hewitt (1964, 1967, 1969) and Kabata (1970a, 1970b).

CLASSIFICATION

Due to the tremendous diversity exhibited in the morphology of the adult parasite, it became very difficult to assign a systematic position for them. Controversies and disputes regarding the systematic position of the parasites are not uncommon in the realm of parasitic copepods.

Within fifty years, three different approaches to the classification of copepods were suggested. Wilson (1932) divided the order Copepoda into eight suborders viz. Arguloidea, Calanoida, Harpacticoida, Cyclopoida, Nothodelphoida, Monstrilloida, Caligoida and Lerneopoida.

This classification was accepted by almost all workers in the field of copepod research.

The order copepoda has been revised by Yamaguti in 1963. He had upgraded the status of the order proposed by Wilson to that of a class and the sub orders to orders. Thus according to this classification, sub class Copepoda is divided into six orders viz. Cyclopoidea, Caligidea, Philichthyidea, Andreinidea, Lernaeopodidea and Sarcotacidea.

Kabata (1979) further revised the classification of copepods based on primary or primitive characters. He argued that free living copepods should also be taken into account. According to him morphological characters of the organism can be differentiated into primary or primitive characters and secondary or advanced characters. The differences seen in an ectoparasitic copepod with planktonic copepods are mainly due to the development of specialised features which is required for their parasitic mode of life. The primitive characters are less susceptible to paralellism and convergence. Those factors include morphological features inherited from the ancestors and recognisably retained by the latter generations. He observed that intersegmental articulations, the structure of the mouth and mouth parts

remain without much change in the evolutionary process of copepods. These reliable primary characters can be taken as primitive and fundamental clues as regard to the phylogeny of copepods.

According to Kabata (1979), the order copepoda is sub divided into three sub orders which parasitise fishes. The sub orders are: Poecilostomatoida, Cyclopoida and Siphonostomatoida. Sub order Poecilostomatoida consists of five families, viz. Bomolochidae, Taeniacanthidae, Ergasilidae, Chondracanthidae and Philichthyidae. Sub order Cyclopoida is represented by a single family Lernaeidae. The families under Siphonostomatoida are Caligidae, Euryphoridae, Trebiidae, Pandaridae, Cecropidae, Dichelesthidae, Eudactylinidae, Kroyeriidae, Pseudocycnidae, Hatschekiidae, Lernanthropidae, Pennellidae, Sphyriidae and Lernaeopodidae. This classification is easy to follow and also have advantages over the classification proposed by Wilson and Yamaguti. It is accepted by majority of copepodologists of the world. Hence, in the present study, Kabata's classification is followed.

Terminology of cephalic appendages:

Homology of the cephalic appendages still remains as an unsettled problem. Heegard (1947), Lang (1946) and Lewis (1963) studied the homology of mouth parts of copepods. But they could not come to any conclusion. Wilson has classified in his earlier works the cephalic appendages as antennae, mandible, maxillae and maxillipeds.

Lewis (1963), in his work on life history of Lepeophthreirus dissimulatus (Wilson), opined that the appendages so far described as first and second maxilla are not true appendages. He designated first maxilla as post antennal process and second maxilla as post oral process. He applied the term maxilla to the pair of oral appendages immediately behind the mouth cone and post oral process. This has been previously referred by scientists as first maxilliped. The second maxilliped is designated as maxilliped by Lewis. This particular terminology is followed by majority of copepodologists. According to Hewitt (1969), the post oral process of Pandaridae is the second maxilla and the maxilla, first maxilliped. Cressey (1967 b) described the post oral process of Pandaridae as the first maxilla and the first maxilliped described by Wilson and Hewitt as second maxilla. Kabata (1979), studied the homology of the appendages and suggested a

generalised pattern suitable for all groups.

However, for the present study, the terminology proposed by Lewis is adopted for the cephalic appendages of Caligids and the genus Gloipotes. Whereas for the remaining groups, the terminology proposed by Kabata is followed. Thus terminology used for the cephalic appendages of caligids and the genus Gloipotes, in the present study are first antenna, second antenna, post antennary process, post oral process, maxilla and maxilliped. For the rest of the group, the terminology followed is first antenna, second antenna, mandible, first maxilla, second maxilla and maxilliped.

Materials:

The specimens described in the present study were collected by regular examination of elasmobranchs landed at Cochin, Neendakara, Azheekode, Vypeen, Munambam, Vizhinjam and Alleppey of Kerala coast. Collection of parasites were also carried out by undertaking regular fishing trips to the sea, in the long liners of Central Institute of Fisheries Nautical and Engineering Training, Cochin. The collected parasites were cleaned, and stored in buffered formalin. Later the parasites are cleared using lactic acid and appendages are dissected out under the microscope. The animal and the appendages are drawn to scale using a camera lucida. With the aid of diagrams

and available literature, the identity of the parasites are established.

The detailed investigations carried out by Pillai and Hameed has covered almost all aspects of copepods parasitising the teleost fishes. But so far Elasmobranchs fishes were not subjected to any detailed investigations. Hence Dr. Hameed has entrusted me with the present problem for investigation.

Thirty one species of copepods are described in detail in this study. This include fifteen new species belonging to different genera like Nothobomolochus, Caligus, Gloipotes, Alebion, Pandarus, Perissopus, Echthrogaleus and Kroyeria. A new genus called Penicillus is erected. Two genus viz. Echthrogaleus and Entepherus were reported for the first time in India. About fifteen new hosts records are also recorded. In the case of already known species, descriptive notes are avoided.

Holotypes and allotypes will be deposited in Indian National Museum, Calcutta and paratypes will be deposited in the Museum of the Department of Industrial Fisheries, Cochin University of Science and Technology, Cochin -16.

CHAPTER II

LIST OF PARASITES AND THEIR HOSTS

Studies on copepods parasitising elasmobranch fishes of Indian waters are scanty. The aim of the present study is to investigate the parasitic copepods of elasmobranchs of Kerala coast. A classified list of parasites collected during the present study and a list of hosts with their parasites are given below.

CLASSIFIED LIST OF SPECIES

Order	Copepoda
Suborder	Poecilostomatoida
Family	Bomolochidae
Genus	Nothobomolochus Vervoot, 1962

Nothobomolochus eulami sp. nov.

Nothobomolochus indicus sp. nov.

Suborder	Siphonostomatoida
Family	Caligidae
Genus	Caligus Muller, 1785

Caligus hamruri Pillai

Caligus dekari van Beneden

Genus Kroyeria van Beneden, 1853

Kroyeria sphyrnae Rangnekar

Kroyeria tudi sp. nov.

Family Pennellidae

Genus Penicillus gen. nov.

Penicillus indicus sp. nov.

LIST OF HOSTS AND THEIR PARASITES

Alopias vulpinus (Bonnaterre)

Gloipotes vulpinensis sp. nov.

Dasyatis bleekeri Day

Hermilius pseudari Hameed and Pillai

Dasyatis marginatus (Blyth)

Nothobomolochus indicus sp. nov.

Entepherus laminipes Bere

Eulamia dussumieri (Muller and Henle)

Pandarus cranchii Leach

Echthrogaleus denticulatus Smith

Penicillus indicus sp. nov.

Eulamia ellioti (Day)

Alebion eulami sp. nov.

Pandarus cranchii Leach

Echthrogaleus denticulatus Smith

Echthrogaleus coleoptratus Guerin-Meneville

Echthrogaleus eulami sp. nov.

Echthrogaleus kerali sp. nov.

Penicillus indicus sp. nov.

Eulamia melanoptera (Quoy and Gaimard)

Nothobomolochus eulami sp. nov.

Gloipotes huttoni Thomsun

Gloipotes watsoni Kirtisinghe

Gloipotes indicus sp. nov.

Alebion carchariae Kroyer

Pandarus cranchii Leach

Penicillus indicus sp. nov.

Eulamia spallanzani (Le suer)

Pandarus eulami sp. nov.

Galeocerda cuvieri (Le suer)

Gloipotes hygomianus Steenstrup and Lutken

Scoliodon sorrakowah (Cuvier)

Caligus hamruri Pillai

Caligus dekari van Beneden

Caligus parapetalopsis Hameed and Pillai

Caligus foreshori sp. nov.

Pandarus niger Kirtisinghe

Perissopus indicus sp. nov.

Scoliodon walbeehmi (Bleeker)

Alebion walbei sp. nov.

Sphyrna tudes (Valenciennes)

Pandarus bicolor Leach

Pandarus tudi sp. nov.

Kroyeria tudi sp. nov.

Sphyrna zygaena (Linnaeus)

Pandarus cranchii Leach

Pandarus sphyrni sp. nov.

Kroyeria sphyrnae Rangnekar

Stegostoma fasciatum (Hermann)

Perissopus dentatus Steenstup and Lutken

CHAPTER 111
DESCRIPTION OF SPECIES

Order Copepoda

Suborder Poecilostomatoida

Family Bomolochidae

Genus Nothobomolocus Vervoot, 1962

Nothobomolocus eulami sp.nov

Figs 1 - 14.

Material:

Six females were collected from the branchial chamber of the elasmobranch Eulamia melanoptera (Quoy and Gaimard) landed at Cochin Fisheries Harbour.

Female:

Cephalothorax broader than long, anteriorly rounded and posterior margin outwardly curved. Median rostral plates visible. Frontal sinus deep. Anterior 'V' shaped groove converges medially and extends upto the anterior quarter of the carapace. Second thoracic segment broader than long. Postero-lateral side with a notch distally. Third segment transversely ovate, broader than long and longer than the second segment. Fourth and fifth segments broader than long and smaller than the second and third segments. Genital segment equal in width with that of fifth segment, but longer. Abdomen clearly three segmented. Segments sub rectangular and

narrowing posteriorly. Caudal lamina broader than long with the posterior end narrower than the anterior. Lamina armed with a single spine on outer side and one long and three short spines at the tip. Egg sac multiseriate and extends beyond the caudal lamina.

First Antenna: Four segmented with a stout basal segment. Basal segment is the longest of the appendages. Second and third segments sub equal in length. Fourth segment small. Basal segment with sixteen plumose setae of which first two are modified having more length and thickness than normal setae, apically curved and pointed. Sclerotized process extend upto the tip of the modified setae. Second segment with four plumose setae. Third segment armed with a single plumose seta on the outer margin. The terminal segment with seven plumose setae.

Second Antenna: Two segmented. Basal segment stout, longer than broad. Second segment broader at the base, narrowing anteriorly. Second segment subequal in length with first segment. The distal three-fourth area of the second segment denticulated. The tip is armed with four non plumose setae, one spine, one hooked setae and another spiniform process.

Mandible: Single segmented with its anterior end produced

into claws of equal size.

First Maxilla: Single segmented with a basal papilla bearing two long plumose setae.

Second Maxilla: Single segmented and ovate. The terminal end produced into a spine whose outer distal margin ciliated.

Maxilliped: Two segmented. Basal segment bell shaped and broad. A short spine present at the base towards the outer side. A single plumose seta present anteriorly. The second segment is a sigmoid shaped claw with a single long plumose seta at the base.

First Leg: Biramous. Basipod broad. Exopod two segmented. First segment small, broader than long with rounded sides. The terminal segment larger than the first. Armed on the outer margin with a short papillae and a small spine. The tip is armed with five plumose setae. Endopod three segmented. Segments one and two sub equal in length. broader than long and their outer side fringed with setules and the inner side with a single plumose seta. The distal segment bears five plumose setae.

Second Leg: Biramous. Rami three segmented. Basipod

longer than broad and stout. Exopod three segmented. First segment long with outer margin ciliated. The outer terminal end with a stout spine. This spine bears six lateral spinules and a terminal setule. Patches of denticles present on the segment. The second segment smaller than the first. Outer margin with a spine bearing spinules and a terminal setule. The inner margin with a plumose seta. The body of the segment partly denticulated. The terminal segment armed with four spines bearing spinules on the outer margin and a terminal setule. The terminal end with five plumose setae. Endopod three segmented. Segments first and second similar in size. The outer margin of both segments ciliated. The inner margin of the first segment with single plumose seta and the second segment with two plumose setae. The terminal segment ovate with both margins ciliated. The tip is armed with three plumose setae and two spines.

Third leg: Biramous , rami three segmented. Basipod stout, longer than broad. Exopod three segmented. First segment subtriangular in shape, distally armed with a thick spine bearing spinules and a setule. Second segment subequal in length with the first. Inner margin with a plumose seta and outer margin bearing a spine with spinules and a terminal setule. The terminal segment

armed with five long plumose setae and three outer spines with spinules and setules. Endopod three segmented. First two segment equal in size with outer ciliated margin and inner margin with a single plumose seta. The terminal segment with two plumose setae and two spines.

Fourth leg: Biramous. Rami three segmented. Exopod three segmented. First segment subtriangular in shape. The outer tip armed with a thick spine bearing spinules and a setule. Second segment subequal in length with the first. Inner margin with a plumose seta and outer margin bearing a spine with spinules and a terminal setule. The terminal segment armed with five long plumose setae and three outer spines with spinules and setules. Endopod three segmented. Inner distal corner of first and second segments armed with ciliated spines bearing spinules. Outer margins ciliated. Distal segment with one long setae and two spines.

Fifth leg: Uniramous. Two segmented. Basal segment short. Distal segment almost twice the length of first segment. The tip is armed with four naked setae.

Sixth leg: Uniramous with two spines.

Total length: 1.7 mm.

Male : unknown

Remarks:

Among the members of the genus, Nothobomolochus eulami sp. nov. shows similarity only to Nothobomolochus multispinosus Gnanamuthu, 1947. But Gnanamuthu's description lacks details. Pillai in 1965 provided a good description of N. multispinosus.

The cephalothorax of N. multispinosus is concave posteriorly and the frontal sinus reaches beyond the middle region of the carapace. But in the present specimen, the posterior margin of cephalothorax is convex and the frontal sinus extend only upto the anterior quarter of the carapace. In N. multispinosus the second segment is rectangular. But in the present specimen, the segment is broader than long and its posterior lateral corner is provided with a notch. The genital segment is broader than fifth segment in N. multispinosus, where as it is equal in breadth to fifth segment in N. eulami sp. nov. The shape of the three abdominal segment is squarish in N. multispinosus, whereas it is sub rectangular in the present species.

First antenna of N. multispinosus is six segmented and with third to sixth setae of the first segment modified, whereas in the N. eulami sp. nov., the first antenna is four segmented with only first two setae

modified. Second antenna is four segmented in N. multispinosus, whereas it is two segmented in the present species. Mandible is two segmented in N. multispinosus, whereas it is single segmented in N. eulami sp. nov. Variations are observed with regard to legs two to four. In N. multispinosus, the exopod of leg two bears forked spines with spinules on outer margin, whereas in N. eulami sp. nov. exopod bear pectinate spines without forked tip and with a setule at the tip. Besides, both surface of the segment of exopod is denticulated in the present species, whereas it is smooth in N. multispinosus. Similarly, the exopod of legs third and fourth of N. multispinosus bear simple spines on its outer margin. Whereas in N. eulami sp. nov., exopod bear pectinate spines with a setule at the tip.

N. eulami sp. nov. can easily be identified by the presence of a notch on the postero-lateral side of the second segment, modified first antenna and the denticulated exopod of the second leg.

Nothobomolochus indicus sp. nov.

Figs, 15-28.

Material: Three females were collected from the gill

filament of Dasyatis marginatus (Blyth) caught off Cochin.

Female: Cephalothorax broader than long, anterior margin inwardly curved and lateral margins rounded. The frontal sinus shallow. The anterior 'V' shaped groove clearly visible and extends well beyond the centre of the anterior segment. Second thoracic segment very much smaller than first, broader than long and laterally rounded. The third and fourth segment having the same length as that of second segment, but smaller in size. Fifth segment sub-squarish. Genital segment longer than fifth, but the breadth is almost equal to that of fifth segment. Abdomen short, two segmented. The anal laminae large, having about half the length of the second abdominal segment. Laminae are armed with a long naked seta and five small spines. Egg sacs multiseriate.

First antenna: Four segmented. Basal segment long and stout with seventeen plumose and six non plumose setae. Third to fifth setae modified with an apical claw. Second segment small and armed with two plumose setae on the outer and inner side. Third segment smaller than the second with two plumose setae. Fourth segment longer than third, with four long naked setae and six short spines at its tip.

Second antenna: Two segmented. Basal segment sub rectangular and stout. Second segment has almost same length as that of the first. The entire segment denticulated. The distal outer margin bears rows of spinules. The terminal end bears three naked setae, one spiniform process and a single hooked spine.

Mandible: Two segmented. First segment ovate. The second segment produced into two arms. Each arms with serrated margins.

First maxilla: Single segmented. The terminal end is armed with two spines, an outer smaller one and an inner larger one.

Second maxilla: Single segmented. The tip is produced into two arms, both arms ciliated.

Maxilliped: Two segmented. First segment broad and sub triangular. The inner margin ciliated. The second segment is a well developed sigmoid shaped claw. The base of the claw bears a long plumose seta.

First leg: Biramous. Basipod longer than broad without any armature. Exopod two segmented. First segment small and bear three plumose setae. The terminal segment small bears at its tip three long plumose setae. Endopod three

segmented. First two segment sub equal in length. Outer margin ciliated. Inner margin with a single plumose seta. The third segment with a tapering end and bears five plumose setae.

Second leg: Biramous. Rami three segmented. Basipod longer than broad and stout. Exopod three segmented. First segment large. Outer margin ciliated and the distal corner bears a stout spine. Second segment smaller than the first. The outer margin bears a stout spine and inner margin with a long plumose seta. Third segment long. The outer margin is armed with three stout spines and the tip is armed with five plumose setae and one naked seta. Endopod three segmented. First segment ovate. Outer margin ciliated. Inner margin with a plumose seta. Second segment sub equal in size with first. Outer margin ciliated and inner margin bear two plumose setae. The terminal segment sub ovate. Outer margin ciliated. The tip is armed with two small papillae and three plumose setae. The inner margins of all segments ciliated.

Third leg follows the same pattern as that of second leg.

Fourth leg: Biramous, basipod long and stout. Exopod four segmented. Basal segment sub triangular in shape. The outer margin ciliated with a stout spine at the distal

angle. Second segment sub equal in length with first. Inner margin with a single plumose seta and outer margin with a stout spine. Third segment similar to second but smaller in size. The terminal segment small, apex rounded and armed with five plumose setae, a non plumose seta and a spine. Endopod three segmented. Basal segment small with ciliated outer margin. The inner margin with a single plumose seta. The second segment similar to the first segment, but slightly larger in size. Third segment broader at the base and apex bears four non plumose setae.

Fifth leg: Two segmented. First segment sub ovate and bears an outer distal spine. The terminal segment large, ovate in shape and armed with four simple spines. The inner margin near the spines ciliated.

Sixth leg: This is small and represented by three setae and a small spine.

Total length: 1.5 mm.

Male: Unknown.

Remarks:

Among all the species of Nothobomolochus, the N. indicus sp. nov. shows morphological resemblance with N. megaceros Heller, 1865. In both species, the first antenna is four segmented and mandible is short with

serrated margins.

However, the present species exhibits many differences with N. megaceros. In N. megaceros, the second dorsal thoracic plate is having almost equal size as that of first segment. but in N. indicus sp. nov. the second segment is smaller than the first. The abdomen of N. megaceros is three segmented, while it is two segmented in the present species. N. indicus sp. nov. differs from N. megaceros in the armature of leg two and three. All the spines present in the exopods of N. megaceros are spiny and winged, whereas in the present species, it is smooth. Further, the third segment of exopod of legs two and three of N. indicus sp. nov. bear a pair of papillae, which is absent in N. megaceros.

In N. megaceros, the fourth seta of the first antenna is modified into a strongly curved hook, whereas in the present species, no such hook is present and the second to fifth setae of the first antenna are highly modified with an accessory process.

Both margins of the fifth leg of N. megaceros are spiny, where as it is smooth in N. indicus sp. nov. The sixth leg is represented by three setae in N. megaceros, whereas it is represented in the new species by three

setae and one short spine.

N. indicus sp. nov. can easily be identified by the smaller second thoracic segment, two segmented abdomen, modified second to fifth setae of the first antenna and the presence of wingless smooth spines in the armature of the exopods of legs two and three.

Suborder Siphonostomatoida

Family Caligidae

Genus Caligus Muller, 1785Caligus hamruri Pillai

Caligus hamruri Pillai, 1964, p.61 ;

1965, p. 1575; Hameed, 1972, p. 91.

Fig . 29

Material: Three females were collected from the buccal cavity of Scoliodon sorrakowah (Cuvier) landed at Fort Cochin.

Female: Cephalothorax roughly triangular, narrower in front. Frontal plates deep with oval lunules. Dorsal transverse rib placed almost in the middle. Cephalic area sub equal to thoracic segment. Antero-lateral borders of the cephalothorax with an incision, Posterior lobes twice as broad as postero-lateral lobes and projecting beyond the latter. Fourth thoracic segment small, genital segment swollen, with short anterior neck like part, postero-laterally rounded. Abdomen short, two segmented. First segment longer than the second. Egg tubes short

but stout. Anal lamina sub spherical and armed with five plumose setae of which the outer two are small. A small spine present on the inner side.

Distribution: West coast of India.

Total length: 4.1 mm.

Remarks:

The abdomen of the present specimen is barrel shaped with narrow ends and wide centre. Pillai (1964) observed that the abdomen of Caligus hamruri as cylindrical with roughly parallel margins. Rest of the characters of the present specimen are found to be similar to that of the original description.

This species can be identified by the postero-laterally rounded genital segment with an anterior neck and comparatively long distal claw of the first and fourth legs.

Scoliodon sorrakowah is a new host for this species.

Caligus dekari van Beneden

Caligus dekari van Beneden, 1892, p. 243.

Caligus arii Barnard, 1955, p. 298.

Caligus dekari Kirtisinghe, 1964, p.60 ;

Pillai. N.K., 1965, p. 1586.

Fig.30

Material: Three females were collected from the gill filaments of Scoliodon sorrakowah (Cuvier) landed at Cochin Fisheries Harbour.

Female: Cephalothorax nearly circular, Frontal plates narrow, lunules large and circular. Dorsal transverse rib present near the posterior margin of the cephalothorax. The dorsal rib divides the cephalothorax into a large anterior cephalic area and a small posterior thoracic area. A pair of small longitudinal sinus separates the cephalothoracic area into a median lobe and two lateral areas. Posterior margin produced into two small sinuses. Fourth thoracic segment small and convex in shape. Genital segment flask shaped with slightly developed posterio-lateral lobes. Abdomen single segmented, tubular and having equal length as that of genital segment. Anal laminae small, quadrangular and armed with four non plumose setae.

Distribution: South Africa , Sri Lanka and west coast of India.

Total length: 5.1 mm.

Remarks

This species was described by van Beneden (1892), redescribed by Kritisinghe (1964). Pillai (1965) again redescribed the same species.

The characters observed in the present specimen confirms with the observations made by Kirtisinghe and Pillai. C. dekari, even though shows affinity to Caligus arii, can be clearly identified by the presence of one segmented abdomen, larger anal laminae, three segmented fourth leg and differently shaped sternal fork.

Scoliodon sorrakowah is a new host to this species.

Caligus parpetalopsis Hameed and Pillai

Caligus parpetalopsis Hameed and Pillai,

1973 b, p.116.

Fig. 31.

Material: Five females were collected from the buccal cavity of Scoliodon sorrakowah (Cuvier) landed at Cochin

Fisheries Harhour.

Female: Cephalothorax nearly circular. with frontal plates fairly well projecting, with small and circular lunules. Median transverse rib is placed far back and hence cephalic area is nearly twice as broad as lateral lobes and remains in level with latter. Lateral lobes strongly curved towards the median lobe. Fourth thoracic segment is comparatively very small. Genital segment very much enlarged, clearly broader than the cephalothorax. It is nearly twice as broad as long but its postero-lateral regions are produced backwards into two large roughly conical lobes going around upto the middle of the lateral borders of the abdomen. The lobes are only slightly less than median length of the genital segment. Antero-lateral regions of the genital segment are elegantly curved and shoulder like. Abdomen is apparently one segmented. Broadest in the middle, about two-third the width of the genital segment. Its postero-lateral areas are produced into rounded lobes reaching as far as the posterior border of anal laminae. Egg sac rather stout and as long as the post cephalothoracic part of the body.

Distribution: West coast of India.

Total length: 3.6 mm.

Remarks:

This species has been adequately described by Hameed and Pillai (1973 b) and the present specimen fully agrees with the original description of this species. Hameed has given the description based on the specimens collected from Zonichthys nigrofasciata (Ruppell) caught at Trivandrum. The present specimen is collected from the buccal cavity of Scoliodon sorrakowah.

Scoliodon sorrakowah is a new host for this parasite.

Caligus foreshori sp. nov

Figs. 32-44.

Material: Five females were collected from the gill arches of Scoliodon sorrakowah (Cuvier) landed at Cochin.

Female: Cephalothorax shield like. Frontal plates deep, with large circular lunules. The lateral margins of cephalothorax is smooth and rounded. Dorsal ridges present. The cephalothorax is divided into upper and lower part by a transverse ridge present at the middle. A pair of longitudinal groove present on either side divides the cephalothorax into a median lobe and two small lateral lobes. Lateral lobes having almost half the size of

median lobe. A pair of eyes present at the anterior part of the cephalothorax. The postero-lateral part of cephalothorax sharp. The posterior margins produced into two small sinuses, one on either side of median lobe. Fourth thoracic segment small. Genital segment swollen, almost three-fourth the length of cephalothorax, with a short anterior neck like part. Abdomen single segmented with three constrictions giving segmented appearance. Anal laminae small and situated on either side of the abdomen. Each lamina bear three large inner non plumose setae and a short outer seta.

First antenna: Two segmented, basal segment stout and broad. Antero-lateral side bears twenty non plumose setae. The second segment bears at its tip a crown of twelve non plumose setae.

Second antenna: Four segmented. Basal segment stout. The second segment narrow. Third segment broad and stout. Terminal segment is a well developed claw.

Post antennal process: Single segmented with a broad base and tip is being drawn into a strong curved claw. Tines absent.

Post oral process sub triangular. A papilla with a single

spine present at the base.

Maxilla: Two segmented. First segment broad and stout. Second segment longer than the first. Margin not uniform. The tip is divided into two spines, one large and other small. The larger spine is again sub divided into two.

Maxilliped: Two segmented. Basal segment long and stout. The terminal segment is a well developed claw.

Sternal furca: Short and sub triangular in shape. Apex blunt. The postero-lateral parts extended into two stout arms.

First leg: Uniramous. Basipod broad with a spine at the proximal outer margin and a plumose seta at the distal inner corner. Endopod vestigial, carrying a spinule. Exopod two segmented. First segment long with inner margin fringed with cilia. The terminal segment short and bears three denticulated spines distally and four plumose setae.

Second leg: Biramous. Rami three segmented. Basipod longer than broad with two spines: one at the antero-distal corner and the other in the inner margin towards the middle. Exopod three segmented. Basal segment stout and long. The inner margin fringed with cilia and has a

single plumose seta. The lateral outer edge is armed with a long and a short spine. The second segment small with an inner plumose seta and an outer stout spine at the distal edge. The terminal segment small. Apex rounded and with two spines on the outer margin. The tip armed with six plumose setae. Endopod three segmented. Basal segment small with outer margin fringed with cilia. The anterodistal angle bear a group of spinules in the outer side. The inner margin with a single plumose seta at the inner distal end. Second segment longer than broad. The outer margin is bounded with stout spines. The inner margin with two plumose setae. The terminal segment small and armed with six plumose setae at its tip.

Third leg: Biramous. Basal segment broad with inner margin ciliated. Exopod three segmented. First segment developed into a claw like structure. Second segment large with outer and inner margin ciliated. The inner margin with a single plumose seta. The terminal segment subtriangular. The tip armed with five plumose setae and two spines. Endopod two segmented. First segment small with a long plumose seta on the inner margin. Second segment subcircular, larger than the first. The outer margin ciliated, inner margin with six plumose setae.

Fourth leg: Uniramous, three segmented. Basal segment

stout and long. The second segment small and with an antero-lateral spine. The terminal segment small and armed with four naked spines.

Fifth and Sixth legs not observed.

Total length : 4.6 mm.

Remarks:

Among all the species of the genus Caligus so far described, the present specimen shows similarity only to Caligus kuroshio Shiino (1959a).

The present specimen, Caligus foreshori sp.nov. closely resembles C. kuroshio in the general shape of the body. In both the species, the shape of maxilla is similar and the outer margin of the second segment of the endopod of the second leg is bounded by stout spines.

Nevertheless, the C. foreshori sp. nov shows following differences with C. kuroshio.

The genital segment of C. kuroshio is triangular with sharp bend at the lower lateral margin. But in the present specimen, even though the segment is roughly triangular, the edges are rounded. The abdomen of C. kuroshio shows incomplete segmentation, where as there

is no sign of segmentation in the present specimen. The anal laminae of C. kuroshio bears five plumose setae, whereas in C. foreshori sp. nov. the anal laminae bears four naked setae.

Second antenna of C. kuroshio is three segmented. But in the present new species, it is four segmented. The terminal segment of maxilla of C. kuroshio bear two uneven spines and both the spines are winged, whereas in C. foreshori sp. nov. there are three terminal spines and none of which are winged. The sternal furca of C. kuroshio is apically narrowed and the posterior process is drawn into slender rami, whereas in C. foreshori sp.nov., the apex of furca is blunt, the body is short and posterior process is not drawn into rami.

The present new species can easily be identified by the presence of a flask shaped genital segment, four segmented second antenna and a short blunt sternal furca.

Genus Hermilius Heller, 1865

Hermilius pseudari Hameed

Hermilius pseudari Hameed, 1981. p. 164.

Fig.45

Material: Two females were collected from the gill

filament of Dasyatis bleekeri (Day), caught off Cochin.

Female:

Cephalothorax slightly broader than long, frontal plates narrow, lunules absent. Dorsal ribs of cephalothorax very prominent, radiating from the centre. Posterior sinuses small and wide open, median lobe of the cephalothorax nearly as broad as lateral lobes and very slightly over reaching the latter. Membraneous flange of cephalothorax narrow, lateral parts of cephalothorax having frilled ventral surface. Fourth thoracic segment much broader than long. Genital segment pyriform, regularly narrowing backwards. Abdomen very long and one segmented. Anal laminae longer than broad, carrying three curved claws and an inner and outer plumose setae. Egg sac uniseriate.

Distribution : South west coast of Kerala.

Total length: 2.1 mm.

Remarks:

This species is adequately described by Hameed (1981). Hameed has described the specimen based on the collections from Pseudarius jella (Day) at Trivandrum. The present specimen is obtained from gill filament of

Dasyatis bleekeri (Day) . Hermilius pseudari can easily be identified by very long one segmented abdomen and distinctly three segmented fourth leg.

Dasyatis bleekeri (Day) is a new host for this species.

Family Euryphoridae

Genus Gloipotes Steenstrup and Lutken, 1861Gloipotes hygomianus Steenstrup and Lutken.

Gloipotes hygomianus Steenstrup and Lutken, 1861,
 p. 363; Basset-Smith, 1899, p. 458; Wilson, 1907b,
 p. 702; Rao, 1951, p. 254; Shiino, 1954a, p. 278;
 Yamaguti, 1963, p. 103, Hewitt, 1964, p. 95; Lewis,
 1966b, p. 11; Cressey, 1967c, p.8.

Fig. 46.

Material: Two females were collected from the ventral surface of the elasmobranch Galeocerda cuvieri (Le Sueur) seen attached near the anterior side of the pectoral fin.

Female: Cephalothorax ovoid, formed by the fusion of the cephalon and three thoracic segments. Frontal region distinct. Lateral margins convex, flanged with a narrow membrane. A row of fine hair like plumosities present at either margins. The posterior sinus narrow and open. Dorsal cephalothoracic grooves or sinuses distinct forming a 'C' shaped pattern. Another row of hairs present on the either side posteriorly at the lateral area near the sinus. Fourth thoracic segment free, having almost two-

third the length of cephalothorax. The segment consists of a pair of sub rectangular plates separated by deep and narrow sinus posteriorly. The fourth thoracic segment conceals almost two third of the genital segment.

Genital segment pear shaped. Lateral sides fringed with row of spinules along the distal quarter. Posterior end of the segment drawn out into a pair of elongate lobes, which extends to the posterior margin of the abdomen. Lobes with several rows of spines. The median margin of the lobe bear the lamina like fifth leg, projecting laterally and posteriorly. Abdomen two segmented, incompletely separated from genital segment dorsally and ventrally. First segment sub rectangular and small bearing scattered spinules. Second segment longer than the first segment. Distal end of the segment bear a pair of caudal rami. Ramus elongate, rod like with small lateral indentation in proximal half. Indentation bearing two plumose setules. Distal end with three setules of which longer two are plumose.

Distribution : South west Pacific, Mediterranean, South Atlantic, Eastern Indian Ocean, Sri lanka and west coast of India.

Total length: 15.2 mm.

Remarks:

Shiino (1954a) has given a good description of both sexes of this species. But the following differences were observed. Shiino observed the first antenna as three segmented. But it is two segmented in this species. Shiino may be mistaken by the heavy sclerotization of the distal part of the first antenna, which gives the appearance of segmentation. The process described as second maxilla by Shiino is really first maxilla. The process designated by him as maxilla is really the first maxilliped.

The appendages are similar to other species of this genus. This species can easily be identified by the presence of elongate lobes at the posterir end of genital segment and broad fourth thoracic plate which conceals more than two-third of the genital segment.

Shiino has collected his specimen from Acanthocybium solandri and Rao from Xiphias sp. But the present specimen is obtained from tiger shark(Galeocerda cuvieri). This is a new host record for this species.

Gloipotes huttoni Thomson.Lepeopththeirus huttoni Thomson, 1889, p.354.Caligus longicaudatus Marukawa, 1925, p.1243.Gloipotes longicaudatus Shiino, 1954a, p.273;

Heegard, 1963, p.174; Kirtisinghe, 1964, p.87;

Pillai, 1965, p.1614.

Gloipotes huttoni Basset-Smith, 1899, p.104;

Rao, 1951, p. 254; Hewitt, 1964, p.86; Lewis, 1967,

p.56; Cressey, 1967c, p.6.

Fig. 47

Material: Twenty five females were collected from the body surface of the elasmobranch Eulamia melanoptera (Quoy and Gaimard) landed at Vypeen.

Female: Cephalothorax little longer than wide. Frontal area half the width of cephalothorax. Two transverse ribs present across the cephalothorax. The anterior rib, in the form of two shallow curves which meet together to form a 'CV' just below the median eyes. Posterior rib about one-third the width of the cephalothorax is seen just above the posterior sinuses. Lateral margin of the cephalothorax bear a flange along its full length, which ends postero-laterally near the sinuses. Posterior sinuses

narrow and deep. Lateral margin of the cephalothorax bear rows of wavy hairs along their full length. Dorsal surface of the cephalothorax is ornamented with sets of double hairs. Fourth thoracic segment free . It is connected to the carapace with its anterior end. The segment divided into two small subrectangular plates by a wide and deep sinus. Genital segment longer than wide. The postero-lateral side of the segment is drawn into a lobe. The lateral margin of the segment including the lobes forms an entire curve. Segment bears a row of three spines along the postero-lateral margin. Abdomen two segmented. First segment half as long as second. Lateral margins rounded. Second segment longer than wide. Anal laminae long and narrow. Each lamina bears spines on the outer margin and a row of about six small hairs on the inner margin. Egg sacs long and straight.

Distribution: Japan, Sri Lanka and west coast of India.

Total length: 10.8 mm.

Remarks:

This species has been adequately described by Lewis (1967) and Cressey (1967c). The present specimen agrees in all details with the views expressed by authors. However, according to them this copepod parasitise only Marlin or sword fish (Makiara sp.). But the present

specimen is collected from the shark Eulamia melanoptera. This is a new host to this parasite.

Gloipotes watsoni Kirtishinghe

Gloipotes watsoni Kirtisinghe, 1934, p. 167;

Kurian, 1955, p.108; Cressey, 1967c, p.7;

Shiino, 1954a, p.274; Hewitt, 1964, p.95.

Gloipotes auriculatus Bernard, 1957, p.11.

Gloipotes huttoni Lewis, 1967, p. 57.

Fig. 48

Material: Fifteen females were collected from the body surface of Eulamia melanoptera (Quoy and Gaimard) caught off Lakshwadweep. The parasites were collected from the base of dorsal fin.

Female: Cephalothorax orbicular, longer than wide, formed by the fusion of cephalon and first three thoracic segment. Frontal area distinct, median and small. Dorsal cephalothoracic grooves present, which forms an irregular 'CH' shape. Eyes distinct present medially towards the anterior. Lateral margin of the cephalothorax bear a

flange along its full length, which ends postero-laterally near the sinuses. Posterior sinuses present. They are deep with their open ends constricted. Lateral margin of the cephalothorax bear rows of wavy hairs along their full length. Dorsal surface of the cephalothorax is ornamented with sets of double hairs. Dorsal plates of fourth thoracic segment held at an angle with the antero-posterior axis of the body. Genital segment wider than long. The postero-lateral side of the segment is drawn into a lobe. The lateral margin rounded, without any conspicuous bulge and armed with a row of small spinules. Abdomen two segmented. First segment half as long as second. Lateral margins rounded. Second segment longer than wide. Anal laminae long and narrow. Each lamina bear spines on the outer margin and a row of about six small hairs on the inner margin.

Distribution: East coast of India, West coast of India and Sri lanka.

Total length: 11 mm.

Remarks:

This species is adequately described by various authors. Revision of the genus Gloipotes by Hewitt (1964), Lewis (1967) and Cressey (1967c) threw light on the several interesting factors regarding the intra

specific variations and affinities of this genus. Cressey (1967c) opined that the length of the cephalon is getting reduced with the increase in total length of the species. According to him this may be due to the relative abundance of the egg production and egg migration.

This species is very much similar to G. huttoni. But these two can be separated by the nature of genital segment. In G. watsoni the segment is wider than long whereas it is longer than wide in the case of G. huttoni. This observation is in confirmation with that observed by Cressey(1967c).

This species can easily be identified by the posteriorly rounded dorsal thoracic plate, shape of genital segment and the length of the fifth leg which extends upto the end of the abdomen.

E. melanoptera is a new host for this species.

Gloipotes indicus sp. nov.

Figs.49-62.

Material: Twenty four females were collected from the ventral side of the abdominal region of the elasmobranch

Eulamia melanoptera (Quoy and Gaimard) caught off Cochin.

Female: Body little longer than broad. Lateral margins of the cephalothorax almost parallel to the antero-posterior axis of the body. The posterior margin of the cephalothorax drawn inwards to form two sinuses, one on either half of the body. The cephalothorax is divided into two halves by transverse ridges. Two longitudinal ribs run down along either side of the cephalothorax, which join with the anterior margin of the posterior sinuses. Dorsal surface of the cephalothorax provided with many rows of hairs and spinules. Most of the hairs bifurcate. Lateral margin of the cephalothorax bear flange with rows of wavy hairs along their length. Dorsal thoracic plate of the fourth segment wing like. The lateral margin of the plate forms an angle more than fifty five degrees with the antero-posterior axis of the body. The plate is armed with small spinules on its dorsal surface. The postero-lateral lobes of fourth segment slightly overlaps the genital segment. Genital segment wider than long which is broad anteriorly and narrowing posteriorly. Lateral margins of the segment with smooth margins. The postero-lateral part of the segment produced into a lobe. Dorsal surface of the segment provided with six spines, three each on either side. Abdomen two segmented. First segment almost half of the second segment. Second segment

slightly swollen at its anterior end. Both segments are armed with numerous spines. Caudal rami long and slender, bearing a notch, on at the outer edge of the anterior quarter. Each ramus with numerous spines on both surface. Egg sac uniseriate.

First antenna: Three segmented, basal segment broad, bears twelve plumose setae and fourteen non plumose setae at its outer antero-lateral side. Second and third segments equal in length. The third segment bears a crown of non plumose setae at its distal end and a single non plumose seta on the outer side towards the middle region.

Second antenna: Two segmented. Basal segment broad and stout. The distal segment is a well defined claw. Outer proximal angle of the claw bearing a ridge with a spine. Another spine at the outer margin at the centre of the segment.

Post antennal process: Roughly triangular. Basal part produced into two spinous projections, one on either side of the base. The inner projection bifurcate. The dorsal side of the process bear two set of tines. One set at the distal lateral margin is branched into four. The other set, at the centre of the dorsal side is small, multibranched and highly pigmented.

The post oral process : Without any tines, heavily pigmented. Roughly triangular and outer margin produced into two sub equal branches.

First Maxilla reduced into a solitary spine anterior to post oral process.

Second Maxilla: Two segmented. Basal segment shorter than the distal. Second segment long with a swelling at the centre with two uneven curved spines of which the longer is fringed with setae. The outer margin of the segment serrated.

Maxilliped: Two segmented. Basal segment broad and ovate. Second segment is a well developed claw, heavily pigmented at the tip. The proximal end of the claw bears a non plumose seta.

Sternal furca: Placed on the mid line on the ventral surface, immediately posterior to the post oral process and maxilliped. Nearly triangular, apex rounded. Basal area produced into two posterior and two lateral branches. The posterior branch bilobed. Antero-lateral margin with slight depression on either sides and with spine like projections. Apex and branch tips heavily pigmented.

First leg: Biramous. Basipod longer than broad, sub rectangular, with a solitary spine at the base towards the outer side. Another spine at the base of endopod. Endopod very small, vestigial and two segmented. Distal segment small bearing two small spines. Exopod two segmented. First segment longer than broad, inner margin ciliated. The outer antero-lateral edge is provided with a solitary spine. The second segment short. The terminal end bear three spines and four plumose setae. Out of the three spines, two inner spines bifid, with delicate median spine.

Second leg: Biramous. The basipod longer than broad. The inner margin ciliated. The lateral outer edge and middle of inner margin bear spines. Exopod three segmented. Each segment with well developed spine on outer distal corner. The first segment longer than broad, the outer distal corner of the segment bear two spines - one small and the other long. The inner margin bears a solitary plumose seta. The second segment small, with a single naked spine at the outer margin. Distal segment rounded, outer margin with two naked spines. The tip and inner margin with seven plumose setae. Endopod three segmented. First segment small with its outer margin ciliated. The inner margin with a single plumose seta. The second segment having twice the length as that of first. Both

margins ciliated. A flange is present in the full length of the outer margin of the second segment. Outer margin of the flange ciliated. The lateral inner edge with a single plumose seta. The third segment rounded with seven plumose setae.

Third leg: Biramous. Exopod two segmented. First segment is highly bifurcated spine, pointing inwards. The spine carries small spinules. The distal segment bears five spinules and six plumose setae. Endopod three segmented. Basal segment fused with coxopod. Second segment apron like with ciliated outer margin. Third segment small and bear six plumose setae at its tip.

Fourth leg: Uniramous and four segmented. Basal segment long and stout bearing a solitary spine on the lateral outer edge. The second segment long with a large spine and a row of spinules at the outer margin. The proximal part of the first segment bears seven small spines. The third segment bears on its outer lateral edge, a large spine and a row of spinules. The fourth segment small with three large and two small spines at its tip. A row of spinules present at the outer margin.

Fifth leg: Projecting beyond the outer distal corner of genital segment to the end of second abdominal segment. It

is armed with nine strong spines.

Total length: 10.2 mm

Remarks:

The present species, Gloipotes indicus sp.nov was collected off Cochin. Among the all known members of the genus Gloipotes, the present specimen shows resemblance only with G. watsoni Kirtisinghe, 1934. In both these species, the lateral margins of the genital segment are uniformly rounded and are wider than long. The fifth leg extends upto the lower end of the abdomen in both the species.

But in G. watsoni, the lateral margin of the genital segment is fringed with spinules, whereas in G. indicus sp.nov. The lateral margin is devoid of spines. In G. watsoni, the lateral margin of the fourth dorsal thoracic plate is at an angle of about forty five degrees with the antero-posterior axis, whereas in G. indicus sp. nov. the angle is always more than fifty five degrees.

The present species can be easily identified from all other known species by the following characters. The lateral margin of the fourth dorsal thoracic plate forms an angle of more than fifty five degrees with antero-

posterior body axis. The lateral margin of genital segment uniformly rounded, without any spines and the tip of the fifth leg extends upto the end of the second abdominal segment.

Gloipotes vulpinensis sp. nov.

Figs. 63-78.

Material: Eight females were collected from the the ventral side of a thresher shark Alopias vulpinus (Bonnaterre) landed at Integrated Fisheries Project, Cochin.

Female. Body little longer than wide. Lateral margins of the cephalothorax parallel to the antero-posterior axis of the body. The posterior margin of the cephalothorax drawn inwards to form two sinuses. The cephalothorax is divided horizontally into two halves by transverse ridges. Two longitudinal ribs run down along either side of the cephalothorax, which join with the sinuses posteriorly. Dorsal surface of the cephalothorax is ornamented with numerous hairs and spines. Most of the hairs bifurcate. The lateral margin of the cephalothorax bordered with a thin flange and fringed with numerous wavy hairs. The

Fourth segment broad and wing like and extending over the genital segment. The plate is armed with spinules at its dorsal surface. The postero-lateral part is produced into two lobes. Genital segment longer than wide. Lateral margins smooth and curved. The postero-lateral part is produced into two lobes, one on each side. Abdomen two segmented. First segment short and shows an incomplete division towards the middle. The second segment also shows an incomplete segmentation towards the anterior side. All segments armed with a few spines.

Caudal rami long and slender, bearing a notch at the outer edge of the anterior quarter. Each ramus at its tip bear a strong spine and three setae. Egg sac long and uniseriate.

First antenna: Two segmented, basal segment broad bearing sixteen setae and seven spines at its antero-lateral margin. Second segment long and cylindrical. The distal end bear a crown of nine non plumose setae. A single seta present on the inner side towards the anterior region.

Second antenna: Three segmented, Basal segment narrow with a sub triangular projection towards the outer anterior end. Second segment short and stout. Third

segment is a well developed claw. The outer margin of the third segment uneven.

Post antennal process: Roughly triangular. Basal part produced into spinous projections, one on either side of the base. The inner projection bifurcates. The entire process highly pigmented.

Post oral process without any tines, highly pigmented and sub triangular in shape. The outer distal corner produced into two sub equal branches.

First maxilla: This is reduced into a pair of spines, one small and the other long, at the antero-lateral side of the post oral process.

Second maxilla: Two segmented. Basal segment long and stout. The second segment longer than the first with a swelling near its base. The distal end bears two smooth and curved spines, of which one is very long.

Maxilliped: Two segmented, basal segment ovate, broad and stout. The second segment is a well developed claw. The claw being clearly marked off from the rest of the segment. A small spine present at the base of the claw and the inner margins bear a small spine like projection

in middle.

Sternal furca: Situated on the mid line of the ventral surface posterior to post oral process and maxilliped. Nearly triangular. Apex pointed. Basal area produced into two branches, two lateral and two posterior. Both branches bilobed. Apex and branch tips heavily pigmented.

First leg: Biramous, basipod broad, sub rectangular. Endopod vestigial and two segmented. Distal segment small and bears two spinules. Exopod two segmented. First segment longer than broad, inner margin ciliated, outer margin smooth. The disto-lateral edge bears a solitary spine. Second segment smaller than the first. Terminal end bear three spines, three plumose and a single non plumose setae. Two inner spines bifurcate with a delicate median spine.

Second leg: Biramous, basipod longer than broad. The inner margin ciliated. Exopod two segmented. First segment with two well developed spines on the outer margin and a single plumose seta in the inner margin. The terminal segment sub triangular, bears a solitary spine and seven unequal plumose setae. Endopod three segmented. First segment small with outer ciliated margin. The inner margin with single plumose seta. Second segment longer

than the first, outer margin ciliated and the inner margin smooth. A flange at the centre appears to divide the segment longitudinally. Outer margin of the flange ciliated. Third segment round in shape with eight plumose setae of varying length.

Third leg: Biramous. Exopod two segmented. First segment is a highly bifurcated spine. The spine bears small spinules. Terminal segment with three spines, five non plumose setae and a single plumose seta. Endopod three segmented. Basal segment fused with coxopod. Second segment broad and spread like an apron. Third segment small with five plumose setae. The outer margin of the coxopod bear a spine and inner margin a plumose seta.

Fourth leg: Uniramous. Four segmented. Basal segment long and stout carrying a plumose seta and a short spine at the distal outer and inner margins respectively. Second and third segment similar with a large spine and a row of spinules at the inner margin. Fourth segment having same size as that of second and third. It bear a row of spinules at the inner margin and three stout serrated spines terminally.

Fifth leg: Projecting beyond the outer distal corner of genital segment to the middle of the second segment of the

abdomen. It is armed with three spines, of which the proximal one is denticulated.

Total length: 10.1 mm

Remarks:

Among the various species of Gloipotes so far described, the Gloipotes vulpinensis sp. nov, shows similarity only to G. huttoni Thomsun, 1889 and G. watsoni Kirtisinghe, 1934. In all these species, the dorsal body surface is with conspicuous ornamentation, posterior process of sternal furca bifid, distal lobe of genital segment not extending beyond the end of fifth leg, lateral margin of dorsal thoracic plate nearly forty five degree angle to antero-posterior axis of the body and lateral margin of genital segment uniformly rounded.

But the dorsal thoracic plate of the fourth segment of the G. vulpinensis sp. nov. covers almost three fourth length of the genital segment, whereas in G. huttoni and G. watsoni, it covers only the anterior part of the segment. The genital segment is fringed with spinules in both species. But the genital segment G. vulpinensis sp. nov is smooth.

The abdomen of the both G. huttoni and G. watsoni

are two segmented. But in G. vulpinensis sp. nov. each segment is further divided incompletely into two. Further the lateral process of sternal furca in G. huttoni and G. watsoni is not bilobed. But in the present new species, the lateral process is bilobed.

This species can easily be distinguished from G. huttoni by the following characters. Dorsal surface of genital segment of G. huttoni bear two rows of three spinules and the posterior lobe of genital segment is well developed and projecting beyond the middle of fifth leg. But in the present new species, the genital segment bears only two rows of two spinules on either side. Further the posterior lobe of genital segment of the present species is not well developed and it only extend till the anterior border of fifth leg.

Genital segment of G. watsoni is wider than long. lateral margins with spines and tip of fifth leg reach till the end of the abdomen, whereas in present species, the genital segment is longer than wide and its lateral margin is free of spines and fifth leg does not reach till the end of abdomen.

The G. vulpinensis sp. nov. can easily distinguished from the other species of this genus by the

large fourth dorsal plate, which conceals more than three-fourth of the genital segment, smooth lateral margins of the genital segment, presence of two pairs of spinules on either side of genital segment and the bilobed lateral branches of sternal furca.

Genus Alebion Kroyer, 1863

Alebion carchariae Kroyer.

Alebion carchariae Kroyer, 1863, p. 165;

Heegard, 1955, p. 49; Yamaguti, 1963, p. 99; Cressey,

1970, p. 4; 1972, p.3.

Alebion difficilis Yamaguti, 1963, p. 100

Alebion gracilis Lewis, 1966 a, p.136.

Fig. 79.

Material: Ten females were collected from the body surface of Eulamia melanoptera (Quoy and Gaimard) caught off Cochin. These parasites were collected along with Pandarus cranchii Leach.

Female: Cephalothorax orbicular, formed by the fusion of the first three segments. Lateral margins bearing a

membraneous flange. 'Postero-lateral margins rounded and bear spinules. The posterior margins are drawn inwards to form two sinuses, one on each side. Posterior end of median cephalothoracic region with eight spines. Dorsal cephalothoracic grooves distinct forming an irregular 'H' shaped groove. Fourth pedigerous segment free, bilobed and separated by a wide and shallow sinus. Each lobe orbicular in shape. Segment overlaps the anterior part of genital segment. Genital segment wider than long. Anterior end narrower. The wider posterior outer corners produced to form lateral processes which nearly extends beyond the posterior margin of the abdomen and bears a row of spines on the inner margin. Lateral margin of the genital segment in the wider area bear prominent spines on the outer margin. Abdomen two segmented. First segment with lateral processes extending nearly to the junction of caudal rami. Second segment sub rectangular. Caudal ramus longer than wide. Each ramus bear four plumose setae at the tip.

Distribution: Senegal, Japan, Sri Lanka, Hawaii and east and west coasts of India.

Total length : 8.2 mm.

Remarks:

This species has been reported by several copepodologists after its first report by Kroyer (1863). Cressey (1972) has revised the genus Alebion and opined that there are eight valid species in the genus. Present collection agrees with the illustration and description given by Cressey (1972) in all details. The specimen of the present collection is larger than that reported by Cressey. This may be due to the larger size of the host fish and geographical variations. In all the specimens collected during this study, it is found that the attached spermatophores are either with a closed sinus or kept at nearly parallel distance with anterior end. The identifying characters suggested by Cressey seems to be valid for the identification of this species.

Alebion walbei sp. nov.

Figs. 80-89.

Material: Two females were obtained from the ventral side of the body of the shark Scoliodon walbeehmii (Bleeker) landed at Vypeen.

Female: Cephalothorax orbicular, formed by the fusion of

the first three segments. Lateral margins bearing a membranous flange. Postero-lateral margins rounded and bear spinules. The posterior margins are drawn inwards to form two sinuses, one on each side. Posterior end of median cephalothoracic region with eight spines. Dorsal cephalothoracic grooves distinct, forming an irregular 'H' shaped groove. Fourth pedigerous segment free, bilobed and separated by a wide sinus. Each lobe orbicular in shape. Segment overlaps the anterior part of genital segment. Genital segment broad with rounded lateral margins. Lateral posterior side drawn into a long sclerotized process with inner margin bearing spines. In the posterior margin of the segment, a broad and shallow sinus is formed between the processes. Another plate like structure present over the genital segment, which almost conceals it. Abdomen two segmented, attached to the posterior surface of genital segment. First segment approximately equal to the length of the second, with a pair of long lobate extensions projecting laterally and curving posteriorly and extending to the end of the abdomen. Second segment broader than the first, with bulged margin. Caudal rami longer than broad, narrow proximally. The terminal end with four plumose setae.

First antenna: Two segmented. Basal segment stout with about thirty spines, at antero-lateral side. The terminal

segment small with ten non plumose setae. A single seta at the distal end of the inner margin.

Second antenna: Three segmented. Basipod broad and large. Second segment longer than broad. Entire segment is curved. The third and terminal segment is a strongly developed and heavily sclerotized claw, bearing a small accessory process at its base towards the inner side.

Mandible: Sub triangular, with blunt tip. Inner margin curved bearing a tuft of non plumose setae distally.

Maxilla: Two segmented. Basal segment elongated. The terminal segment narrow having almost equal length as basal segment. The terminal end is drawn into two uneven ciliated setae.

Maxilliped: Two segmented. Basal segment stout and long. The terminal segment is a well developed claw and is smaller than the basal segment. A short accessory spine present at the inner margin of the claw.

First leg: Biramous, rami two segmented. Basal segment broad and large. Exopod two segmented. First segment longer than broad. Inner margin ciliated and devoid of any

setae. Terminal segment small and bear three plumose setae at its tip and two small spines. Endopod two segmented. Basal segment long and devoid of any spines or setae. The terminal segment small and rounded bearing three non plumose setae at its tip.

Second leg: Biramous. Basipod stout with its outer margin bearing a non plumose seta. Exopod three segmented. Basal segment sub rectangular. The outer distal angle with two spines. Second segment small with outer margin bearing two stout claws. The terminal segment small bearing six plumose setae at its tip. Endopod two segmented. First segment sub squarish with inner margin bearing a plumose seta. The terminal segment longer than broad. Outer margin with a ciliated apron. The tip with seven plumose setae.

Third leg: Biramous, rami wide apart. Exopod four segmented. Basal segment with a short outer spine and a long inner seta. Second and third segment each with an outer stout claw and a single inner seta. The terminal segment with a similar claw and five plumose setae. Endopod two segmented. Basal segment broad and apron like. The terminal segment small and bear six plumose setae.
Fourth and fifth legs not observed.

Total length : 9.8 mm.

Remarks:

Among the various members of the genus Alebion so far reported, Alebion walbei sp. nov. shows similarity only to Alebion echinatus Capart, 1953.

In both the species, a second plate like structure is present over the genital segment, which conceals it almost completely. Cephalothorax is orbicular shaped in both the species.

But in A. walbei sp. nov., the lateral posterior margin of the cephalothorax bear spine, which is absent in A. echinatus. The lateral margin of the genital segment is smoothly rounded and devoid of spines at the dorsal surface in A. walbei sp. nov. But in A. echinatus, the lateral margin of the genital segment has a bulbous projection which bear spinules at the dorsal surface. In A. walbei sp. nov. the postero-lateral extension of the genital segment do not extend beyond the caudal rami, whereas in A. echinatus, the process extends well beyond the caudal rami.

The caudal rami of the present species is armed

with four plumose setae alone, whereas in A. echinatus , caudal rami bear four setae, one setule and a small spine.

Alebion walbei sp. nov. can easily be identified by the following characters. Postero-lateral process of genital segment of the present species does not extend beyond the caudal rami. A second plate like structure present above the genital segment, which conceals it almost completely and the presence of spinules at the postero-lateral margin of cephalothorax.

Alebion eulami sp. nov.

Figs. 90-98.

Material: Five females were collected from the dorsal surface of Eulamia ellioti (Day) landed at the Integrated Fisheries Project, Cochin.

Female: Cephalothorax subtriangular. The first three segments fused with the cephalon. Lateral margins bearing a membranous flange. Postero-lateral margins sharp. The posterior margins are drawn inwards to form two sinuses,

one on each side. Sinuses shallow and open. Dorsal cephalothoracic grooves distinct forming an irregular 'CH' shaped structure. Fourth pedigerous segment free, bilobed and separated by a wide and shallow sinus. Each lobe sub oval in shape. Segment covers the anterior part of genital segment. Genital segment wider than long. Segment without any posterior process. The lateral margins of the genital segment is bulged and convex giving the segment a pear like appearance. The margin armed with numerous spinules. Abdomen two segmented. First segment broad and is provided with lateral alae. Alae extends upto the posterior margin of the first abdominal segment. Second segment small. Caudal ramus longer than wide. Each ramus bear four plumose setae and a small spine.

First antenna: Two segmented. Basal segment stout with thirteen small spines, at antero-lateral side. The terminal segment small, apex rounded and swollen and armed with five plumose setae and five short spines.

Second antenna: Three segmented. Basipod small. The second segment large, longer than broad. The third segment is a well developed and heavily sclerotized claw, bearing a small accessory process at the outer margin.

Maxilla: Two segmented. Basal segment long and stout. The

terminal segment long and narrow. The tip of the segment is drawn in to two uneven setae, a long ciliated one and another short and naked.

Maxilliped: Two segmented. Basal segment stout and long. The terminal segment is a well developed claw and is smaller than the basal segment. A short accessory spine present at the outer margin of the claw.

First leg: Biramous, rami two segmented. Basal segment broad and large with a short spine near the base of endopod. Exopod two segmented. First segment longer than broad with a small plumose seta at the outer distal corner. Terminal segment small and bear three plumose setae and two spines at its tip. Endopod two segmented. First segment subrectangular and small, devoid of any spines or setae. Second segment small and rounded bearing three plumose setae at its tip.

Second leg: Biramous, rami three segmented. Basipod broad. Exopod three segmented. Basal segment sub rectangular with a solitary seta at the inner margin and four spinules at the outer distal corner. The second segment smaller than the first. Inner margin with a single plumose seta. The outer margin bears a big claw at the

distal end. The terminal segment longer than the second segment. The segment bears a large claw at the outer margin and six plumose setae at its tip. Endopod three segmented. Basal segment subrectangular. The outer margin ciliated and inner margin with a long plumose seta. The second segment twice as long as first. Distal end broader than the base. outer margin ciliated. Inner margin with a single plumose seta on the distal corner. The terminal segment small, apex rounded and bears six plumose setae.

Third leg: Biramous, rami three segmented and placed wide apart. Exopod three segmented. Basal segment with a short outer spine and a long inner seta. Second segment with an outer stout claw and a single inner seta. The terminal segment with two similar claws and six setae. Endopod three segmented. Basal segments broad. The outer margin rounded and free. The second segment long with outer margin ciliated and inner margin with a distal single plumose seta. Terminal segment small and bear five plumose setae.

Fourth and fifth legs vestigial.

Total length : 8 mm.

Remarks:

Among the members of the genus Alebion, so far described, Alebion eulami sp. nov. shows affinity only to Alebion glaber Wilson (1905b). This species is similar to A. glaber in that the genital segment is without any posterior process. The shape of the cephalothorax in both species is subtriangular and their abdomen is two segmented.

The genital segment of A. glaber is subrectangular with its lateral margins almost parallel to each other, whereas in A. eulami sp. nov., the lateral margins of the genital segment is bulged and convex, giving it a pear like appearance. Further, the distal lateral margin of genital segment of A. glaber is without any ornamentation. But in the present species, the lateral margins are armed with numerous spinules.

First segment of the abdomen of A. eulami sp. nov. is provided with lateral alae which is curved and reaches upto the posterior margin of the first abdominal segment, whereas in A. glaber, alae is replaced by small swelling alone. In A. glaber, the basal segment of the exopod in second leg bears a stout spinous knob like process. But in A. eulami sp. nov. only simple spines are present in the exopod of second leg.

The present new species can easily be identified from all other known species of Alebion by the pear shaped genital segment without any posterior process, lateral ornamentation of genital segment and by the presence of curved alae in the first abdominal segment.

Family Pandaridae

Genus Pandarus Leach, 1819Pandarus cranchii LeachPandarus cranchii Leach, 1819, p.535.

Wilson, 1907a, p.403; Heegard, 1943. p.27;

Cressey, 1967b, p.9; Hewitt, 1967, p. 249.

Pandarus armatus Heller 1865, p.202;

Basset-Smith, 1899, p.467; Wilson, 1907a,

p.448, Barnard, 1955, p. 258.

Fig. 99.

Material: More than fifty females were collected from the ventral surface of four elasmobranchs viz. Eulamia dussumieri (Muller and Henle), E. ellioti (Day) E. melanoptera (Quoy and Gaimard) and Sphyrna zygaena (Linnaeus).

Female: Dorsal shield of the cephalothorax caligiform, lateral margins diverging with narrow strips of membrane on lateral side. Postero-lateral margins inwardly curved and posterior margin nearly truncated. The cephalothorax laterally and posteriorly possesses two rows of sharp,

small spines. First leg bearing segment fused with the cephalon. Dorsal plate of the second segment large, wing like and reaching nearly upto the posterior margin of the dorsal plates of the third segment. Dorsal plate of third segment broader than that of second segment. It is fused at the base. A deep narrow sinus divides the segment. Fourth pair of dorsal plates much enlarged overlapping almost half of the genital segment. This plate is separated into two lobes by a shallow sinus. Genital segment broad and with rounded margins. Both posterior corners pointed and is separated by a wide shallow sinus. Abdomen one segmented, pear shaped and is concealed. Only its dorsal plate is visible in dorsal view. Dorsal plate sub triangular, posterior margins rounded and with small prominences on either side. Caudal rami long and just reaches the posterior margin of the abdominal plate. The entire body is covered with spinules. Egg sac long and uniseriate.

Distribution: cosmopolitan.

Total length: 10 mm

Remarks:

The present specimen was collected from sharks caught off Cochin. It is closely similar in all major details with that of the description and illustration

given by Cressey (1967b).

Cressey (1967b) in his revision of the family Pandaridae, described the affinity of the P. cranchii with P. satyrus Dana (1852). He observed that difference between these two are comparatively less. Due to the close similarity in structure and morphology of this species with P. satyrus, Shiino (1954b) placed it in synonymy with P. satyrus. But Cressey (1967b) after a thorough examination established the validity of these two species. Cressey pointed out that, the main difference between the two species lies in the length of caudal ramus. In P. cranchii, the rami just reaches the tip of the lower border of abdominal plate, whereas the rami of the P. satyrus extends only about half the length of abdominal plate. The setal formulae of both species are same, however, the patches of spinules are much heavier in P. cranchii.

E. melanoptera and E. dussumieri are new hosts for this parasite.

Pandarus niger Kirtisinghe

Pandarus niger Kirtisinghe, 1950, p.83;

Cressey, 1967b, p.22.

Fig. 100.

Material: Twelve females were collected from the ventral side of the body of elasmobranch Scoliodon sorrakowah (Cuvier) landed at Integrated Fisheries Project, Cochin.

Female: Dorsal shield of the Cephalothorax roughly triangular, narrow anteriorly and without any armature. Frontal plates well separated. Posterior margin of the dorsal shield with two pairs of laterally placed denticles. Dorsal plates of the second and third leg bearing segments are of equal size and fused at the base. Fourth segment with a lateral sclerotized ridge with three sharp denticles on either side. Posterior sinus shallow and the dorsal plates are less prominent. Genital segment smaller than the fourth leg bearing segment, posterolaterally produced into conical lobes. Abdomen unsegmented. Dorsal plate semicircular with a neck anteriorly. Caudal lamina about twice the length of the dorsal abdominal plate with two sharp spines on the middle and a distal spine.

Distribution : Sri Lanka, Formosa and West coast of India.

Total length : 9.2 mm.

Remarks:

Pandarus niger Kirtisinghe (1950) has so far been described only from Sri Lankan and Formosan waters (Cressey, 1967b). So far this species was not reported from Indian waters. This is the first report of the parasite from Indian waters. Cressey (1967b) in his revision of pandarid copepods has given details of taxonomic features pertaining to P. niger and also variations among the related species. When comparing the present specimen with that described by Kirtisinghe (1950) and Cressey (1967b) it is observed that the median sinuses of the dorsal plates of third and fourth segments in the present specimen are more deep and prominent, whereas they are shallow in the illustrations provided by Kirtisinghe and Cressey.

Pandarus bicolor Leach

Pandarus bicolor Leach, 1816, p.405.

Pandarus boscii Leach 1816, p.406.

Pandarus fissiformis Milne-Edwards, 1840, p.470.

Pandarus bicolor Scott T., 1900, p.157;

Scott and Scott, 1913, p.95 ; Cressey, 1967b, p.20;

Hewitt, 1967 , p.239.

Fig. 101.

Material: Ten females were collected from the shark, Sphyrna tudes (Valenciennes) landed at Cochin. The parasites were found attached on the base of dorsal fin.

Female: Cephalothorax little longer than wide, frontal plates present with a shallow median sinus. A pair of eyes present at the median line towards anterior part of cephalothorax. The postero-lateral part are extended posteriorly. The lower margin of the cephalothorax without any spines. Second segment sub rectangular, with large postero-laterally directed plates. Third segment seen on either side of second segment. Sub triangular, wider than long. Dorsal plate of the segment is partially divided by a wide median sinus. Fourth segment broader than long. The posterior margin is divided into two lobes by a wide median sinus. The posterior margin of each lobe rounded. Genital segment sub rectangular, postero-lateral angles rounded. A shallow sinus present medially in which abdominal plate is accomodated. Abdominal plate sub circular and large. Abdomen single segmented, and not visible from the dorsal view. Caudal rami sub triangular, base flattened, inner margin with five spines. The end of the rami not even reaches the anterior quarter of abdominal plate.

Distribution: Shetland island, Aberdeen, Mediterranean,

Angola, South Africa, Java, New South Wales and west coast of India.

Total length : 8.7 mm

Remarks:

This species has been adequately described by Scott and Scott (1913), Hewitt (1967) and Cressey (1967b). According to Cressey, this species is limited to the waters of Eastern Atlantic and in coastal waters of Europe. Hewitt, however, reported this species from South Africa.

This is the first record of the species from Indian waters. Sphyrna tudes is a new host record for this species.

Pandarus sphyrni sp. nov.

Figs: 102-110.

Material: Six females were collected from the base of pectoral fin of shark Sphyrna zygaena (Linnaeus) caught off Cochin.

Female: Cephalothorax truncated, without any prominent sinuses. Narrow anteriorly and wider posteriorly. Frontal

plates prominent. A pair of eyes present at the antero-median region of cephalothorax. The postero-lateral part of the cephalothorax produced into lobes. The posterior margin without any spines and have five small protuberances. First thoracic segment fused with cephalon. Second to fourth thoracic segments free. All the free thoracic segments bears dorsal plate. Second thoracic plate oval in shape, comparatively small and placed on either side of third segment. It reaches about one-half the length of third thoracic segment. The third thoracic plate completely separated into lobes by a median deep sinus. The third thoracic segment overlaps the fourth segment concealing almost three-fourth of its dorsal surface. Fourth thoracic segment sub rectangular, which consists of a pair of plates, completely separated by a median deep sinus. The cephalon and thoracic plates are armed with small spines scattered all over the dorsal surface. Genital segment pear shaped, having about one-half the length of the entire body. Broad anteriorly and narrow posteriorly. The posterior part is produced into two projections separated by a wide sinus. Abdomen concealed from dorsal view. Abdominal plate present. Sub triangular in shape with smooth posterior margin. The lateral margins bear small notch. Caudal rami present on either side of abdominal plate. Tip of the rami extends beyond the posterior margin of abdominal plate. Rami long

with a broader base and two spinules on the inner margin. Another spine present on the dorsal side towards the centre.

First antenna: Two segmented. Basal segment broad and stout, bears twelve stout spines at the disto-lateral side. Second segment small, about half the length of basal segment. The tip is armed with seven non plumose setae and one spine. Another spine present on the inner margin towards the middle.

Second antenna: Four segmented. Basal segment stout nearly squarish and unarmoured at its base bearing a large flat adhesive pad. Second segment large, with bulbous sclerotized protuberance. Third segment almost with half the length of second, bearing a small spine on the outer margin. Fourth segment is a well developed claw bearing two submedian sharp spines on the outer margin.

Maxilla: Two segmented basal segment very stout and sub rectangular with well developed adhesion pad. Second segment broader at the base and narrow towards the distal end. The tip bears two uneven spines, which are denticulated and curved. A small plumose setae present at the base of the longer spine.

Maxilliped: Two segmented, basal segment unarmoured, stout and strong. Second segment slender and short with bilobed tip bearing a plumose seta just below the apex. A patch of spinules present at the upper and lower segments.

First leg: Biramous, rami two segmented. Basipod stout and broad with a solitary spine at the base of endopod. Exopod two segmented, first segment broad and large with an outer distal spine. Terminal segment long, broader at the base and tapering anteriorly. Outer margin bear a patch of spinules. The outer and inner margin towards the tip bear three spines. The tip is armed with a claw like process. Endopod two segmented. Basal segment small, broader than long with free margins. Terminal segment longer than the first. Tip bulbous. The tip and outer margin denticulated. Inner margin with three stout serrated spines.

Second leg: Biramous, rami two segmented. Basal segment broad with outer and inner margin armed with spinules. Exopod two segmented. Basal segment stout, outer margin and the distal end denticulated. Disto-lateral edge bear a serrated spine. Terminal segment bulbous, outer margin denticulated. The tip is armed with ten stout spines of which the outer three are serrated. Endopod two

segmented. Basal segment squarish. Outer margin denticulated with a bulbous projection at the distal edge. The terminal segment longer than broad. The outer margin denticulated and the tip is armed with six stout spines.

Third leg: Biramous and rami two segmented. Basal segment transversely flat with outer and inner margins denticulated. Exopod two segmented. First segment sub ovate. The outer margin denticulated with a solitary spine at the disto-lateral edge. The terminal segment longer than broad, slightly pointed at the tip. The outer margin denticulated, the tip bear six stout spines. Endopod two segmented. Basal segment small and with denticulated outer distal margin. Second segment ovate with smooth inner margin and uneven denticulated outer margin. The segment distally bear two uneven spines.

Fourth leg: Biramous, rami single segmented. Basipod very broad with denticulated inner and outer margins. Exopod single segmented. The segment with uneven denticulated outer margin. Base of the segment bears a solitary spine, another spine towards the centre at the outer margin. Inner margin smooth. The tip bears five stout spines. Endopod single segmented, smaller than exopod, segment with smooth inner margin and uneven

denticulated outer margin. The tip is armed with a solitary spine.

Total length: 8.9 mm

Remarks:

Among the members of the genus Pandarus, the present new species shows affinity only to Pandarus zygaenae Brady (1883). Pandarus sphyrni sp.nov. resembles P. zygaenae in the following characters. The cephalothorax of both the species are truncated. The third thoracic segment completely separated from one another and the tip of caudal rami extends beyond the hind margin of the abdominal plate.

In P. sphyrni sp. nov., the plates of second thoracic segment does not extend beyond the posterior margin of the third, whereas in P. zygaenae, the plate of second thoracic segment extend well beyond the posterior margin of segment three.

In P. sphyrni sp.nov., the plates of fourth thoracic segment are broad and is completely separated by a deep sinus. Whereas in P. zygaenae, the plates of fourth thoracic segment are united and only a shallow sinus is present at the posterior margin. In P. zygaenae, the

outer margin of the genital segment is convex in shape whereas in the present new species, it is pear shaped. Even though the caudal rami of both species extends beyond the posterior margin of abdominal plate, the rami of P. zygaenae are held parallel to each other, whereas in the present new species, they are held at an angle to each other.

P. sphyrni sp. nov. can be easily identified by the following characters. The plate of second thoracic segment does not extend beyond the posterior margin of the third thoracic segment. The plates of fourth thoracic segment completely separated into two by a deep median sinus. The shape of the genital segment is pear shaped and the tip of caudal rami extends beyond the posterior margin of the abdominal plate.

Pandarus eulami sp. nov

Figs. 111-121

Material : Twenty five females were collected from the ventral surface of body near the gill slits of Eulamia spallanzani (Le Sueur) landed at Alleppey.

Female: Cephalothorax truncated, narrow anteriorly and

wider posteriorly. First thoracic segment fused with head. Anterior margin with a shallow median depression. Lateral margin smooth. Posterior margin truncated and provided with six smooth projections. The second dorsal thoracic plate extends only as far as the posterior edge of the plate of third segment. Plates of segment three broader than plate of segment two. Segment fused at the base and a deep and narrow sinus divides the third segment almost into two lobes. The fourth pair of dorsal thoracic plates much enlarged, overlapping almost half of the genital segment. The plate is separated by a broad and shallow sinus. The genital segment broad and rounded with a small prominent posterior lobes and a rounded shallow sinus. Abdomen concealed. Abdominal plate rounded, with almost one-third width of the genital segment. It is placed in the posterior sinus of the genital segment. Caudal rami long and extend beyond the posterior margin of the abdominal plate.

First antenna: Two segmented. Basal segment broad and stout, bears twenty stout spines at the antero-lateral part. The larger part of basal segment concealed beneath the frontal plate. Second segment small, about half the length of basal segment. The tip is armed with ten non plumose setae.

Second antenna: Three segmented. First segment broad and stout. The inner margin towards the middle bears a small ridge. Second segment sub rectangular. Outer margin bears a single spine towards the middle. The terminal segment is a well developed claw, with a small accessory spine on the inner margin in about the middle of the segment.

Mandible: Long and slender with pointed tip.

Maxilla : Two segmented, basal segment very stout and long. Margins smooth. Terminal segment long, armed with two uneven curved claws. Both claws bear rows of spinules through out its length. A small plumose setae present at the base of longer spine.

Maxilliped: Two segmented, basal segment stout and strong. Second segment slender and short with bilobed tip. A patch of spinules present at the upper and lower segments. The terminal segment bear a plumose seta just below the apex.

First leg: Biramous, rami two segmented. Basipod stout and broad . Exopod two segmented, first segment broad and large. Terminal segment small, broader at the base and tapering anteriorly. Outer margin bear a patch of spinules. The outer margin of the segment bear three

spines. The tip is armed with a claw like process. Endopod two segmented. Basal segment small, broader than long with rows of denticles on the outer margin. Terminal segment larger than the first. Tip bulbous. The tip and outer margin denticulated. Inner margin with three stout serrated spines.

Second leg: Biramous, rami two segmented. Basal segment broad. Disto-lateral margin armed with spinules. Exopod two segmented. Basal segment stout. The outer margin and the distal end denticulated bearing a solitary spine. Terminal segment sub ovate, antero-lateral margin denticulated. The tip is armed with ten stout spines of which the outer three are serrated. Endopod two segmented. Basal segment squarish. Outer margin denticulated with a bulbous projection at the distal edge. The terminal segment longer than broad, denticulated and the tip is armed with six stout spines.

Third leg: Biramous and rami two segmented. Basal segment broad and bears rows of spine at its inner margin. Exopod two segmented. First segment sub ovate. The outer margin denticulated with a distal solitary spine. The terminal segment pear shaped with rounded apex. The outer margin denticulated, the tip bear six stout spines. Endopod small and two segmented. Basal segment small and

squarish and devoid of any spines. Second segment large and sub ovate. The entire surface is denticulated. The tip bears a solitary inwardly curved spine.

Fourth leg: Biramous, rami single segmented. Basipod very broad and plate like. The outer margin denticulated. Exopod single segmented. The segment long with a shallow depression on the outer margin towards the middle. The outer margin bears a solitary spine at the area of depression. The apex bears six spines of which outer three are smaller than the rest. The outer lateral margin is completely covered with denticles.

Total length: 10 mm

Remarks:

Among the members of the genus Pandarus, the P. eulami sp. nov. shows close affinity to P. carcharini Ho (1963). This species resemble P. carcharini in that dorsal plate of the abdominal segment is one-third the width of genital segment. In both these species, this plate is rounded posteriorly, narrowed anteriorly and its posterior margin never surpasses the tips of caudal rami. Abdomen of both species is quadrangular with all angles rounded. Both the species have their second dorsal thoracic plate extending only as far as the posterior edge

of plate three. Caudal rami of both species is long and extends beyond the abdominal plate.

The lateral margin of the cephalon is finely serrated in P. carcharini, whereas in P. eulami sp.nov., it is smooth. Second dorsal plates of P. carcharini is indistinct and short. But in the present species, it is distinct and broad. The third thoracic segment of P. carcharini is seperated by a 'rather wide and shallowly depressed sinus'. But in P. eulami sp.nov., it is narrow and deep. In P. carcharini the fourth dorsal plate is enlarged and its posterior sinus is rather wide and deep. But in the present species it is wide and shallow.

P. eulami sp. nov. can be identified by the wedge shaped cephalon with smooth lateral margins, distinct second thoracic segment, deep and narrow sinus of third dorsal thoracic plate and the enlarged fourth dorsal thoracic plate..

Pandarus tudi sp.nov.

Figs. 122-131

Materials: Twelve females were collected from the shark

Sphyrna tudes (Valenciennes) caught off Cochin. The parasites were obtained from the ventral surface of the body near gill slits.

Female: Cephalothorax broader than long with rounded lateral margins. Frontal plate narrow in the middle and expanding laterally. First thoracic segment fused with cephalothorax. The Postero-lateral side of the cephalothorax produced into lobes which project downwards. Posterior margin of the cephalothorax between the lobes armed with nine short spines. Dorsal thoracic plates present on segments two to four. Second dorsal thoracic plate is seen on either side of third dorsal thoracic plate. Posterior end of the second dorsal thoracic plate pointed and it reaches just above the posterior margin of third dorsal plate. The third thoracic plate broad and is divided into two semicircular lobes by a deep sinus posteriorly. Fourth segment larger than third segment. This segment is also divided into two lobes partially by a deep sinus. Lateral margins of the genital segment rounded. Posterior end produced into sharp points separated by a broad sinus. Abdomen one segmented. Abdominal plate sub triangular with a notch on either side towards the posterior end. Abdominal plate is placed on the shallow posterior sinus of fourth segment. Caudal rami long and slender, wider at the base and tapering

distally. The inner lateral margin has a sharp ridge towards the middle and bear three uneven spines. The posterior tip of the rami extends beyond the abdominal plate.

First antenna: Two segmented. First segment stout and bears nineteen setae on the outer lateral margin. The second segment longer than wide. Terminal end rounded, armed with eight sub equal setae. A solitary seta at the outer margin towards the middle.

Second antenna: Four segmented. First and second segment broad and stout. Base of the first segment with an adhesion pad. Third segment short with two setae at the outer margin towards the middle of the segment. Two patches of denticles present at the base of the third segment. Fourth segment is a straight curved claw, with pigmented tip.

Mandible: Long and slender shaft with serrated tip.

Maxilla: Two segmented. Basal segment long and stout. Terminal segment narrow, the distal end bear two curved spines. One small and another long. The longer spine is curved and fringed with spinules. The second short spine is curved and fully covered with spinules.

Maxilliped: Two segmented. Basal segment stout bearing an adhesion pad. Terminal segment conical. Tip bilobed with an adhesion area. When closed, the terminal segment will approximate with the adhesion pad on basal segment. A row of spinules present from the tip to the middle of the terminal segment.

First leg: Biramous, rami two segmented. Basipod broad with a ridge at the outer margin. The surface of the segment with four ridges. Ridges covered with spinules. Exopod two segmented. First segment large with a stout denticulated spine at the outer distal edge. The terminal segment long, sub triangular and curved. The proximal outer margin bear patches of spinules. The narrow distal end with six pinnate setae, three on each side. Apex with a blunt process. Endopod two segmented. Distal margin rounded. The inner margin with two small spines near the base. The terminal segment longer than basal one. Apex rounded. Outer margin and apex denticulated. Inner margin with three pinnate setae.

Second leg: Biramous, rami two segmented. Basal segment broad. Postero-lateral margin armed with spinules. Exopod two segmented. Basal segment stout and sub triangular in shape. The outer distal area denticulated with a single pinnate setae. Terminal segment sub ovate,

outer margin denticulated. The tip is armed with ten stout spines of which the outer three are denticulated. Endopod two segmented. Basal segment stout. Outer margin with denticles. The terminal segment longer than broad, outer margin denticulated and the tip is armed with four stout spines.

Third leg: Biramous and rami two segmented. Basal segment broad and bears rows of spine at its inner margin. Exopod two segmented. First segment broad with denticulated inner margin. The terminal segment large, longer than broad. The inner margin denticulated. The tip bear two stout spines. Endopod two segmented. Basal segment broad. The inner margin with denticulated and with a stout spine at the antero-distal angle. Second segment bigger than the first. Entire inner margin with patch of spinules. Outer margin free. The tip armed with four spines and three pinnate setae.

Fourth leg: Biramous . Basipod very broad and plate like. The outer margin denticulated with a pinnate spine near the base of endopod. Exopod single segmented. The segment sub ovate with four patches of spinules on the inner side. The outer margin bears a solitary spine distally. Endopod two segmented. Basal segment small, inner margin with a patch of spines. Distal segment

bigger than first. Inner margin with patches of spinules and six spines of varying sizes.

Total length : 6 mm

Remarks:

Pandarus tudi sp. nov. shows close resemblance to P. carcharini Ho, 1963. In both the species, the second dorsal thoracic plate does not extend beyond the posterior margin of third dorsal thoracic segment and the posterior region of the second and third thoracic plates are fused together. The posterior margin of third and fourth thoracic plate are nearly parallel to each other in both species.

But in P. tudi sp. nov., the posterior end of second dorsal thoracic plate is pointed, whereas in P. carcharini it is almost flat in line with the posterior end of third thoracic plate. The median sinus of fourth thoracic plate is wide in P. carcharini, whereas it is narrow in P. tudi sp. nov. Further the genital segment of P. tudi sp. nov. is bulged, whereas it is conical in P. carcharini.

In P. carcharini, the caudal rami is about two times as long as dorsal abdominal plate and it extends

well beyond it. But in P. tudi sp. nov. the rami is having only almost equal length as that of abdominal plate and it extends only slightly beyond it. The posterior median sinus of genital segment is deep in P. carcharini whereas it is shallow in the case of P. tudi sp. nov.

P. tudi sp. nov. can be easily identified by the following characters. The posterior end of the second dorsal thoracic plate is pointed. The posterior margins of third and fourth thoracic segments are nearly parallel to each other and the shallow posterior median sinus of the genital segment.

Genus Perissopus Steenstrup and Lutken. 1861.

Perissopus dentatus Steenstrup and Lutken.

Perissopus dentatus St. and Lut., 1861, p. 393.

Chlamys incisus van Beneden, 1892, p.227.

Perissopus communis Rathbun, 1887, p. 560;

Wilson, 1907a, p. 354 ; Brian, 1924, p.394;

Perissopus crenatus Leigh-Sharpe, 1930, p.7.

Perissopus manuelensis Gnanamuthu, 1951, p.9.

Perissopus travacorensis Kurian, 1955, p.108.

Perissopus serratus Heegard, 1962, p.175.

Perissopus dentatus St. and Lut., Kirtisinghe,
1964, p.92; Cressey, 1967b, p.35; Hewitt, 1967, p.252.

Fig. 132

Material: Five females were collected from the elasmobranch Stegostoma fasciatum (Hermann) landed at Integrated Fisheries Project, Cochin.

Female: Cephalothorax as long as broad, widening gradually from frontal plate to gain its maximum width just anterior to posterior margin. Frontal plate not distinctly separate. First thoracic segment fused with cephalon. Postero-lateral angles extended posteriorly to constitute almost one-fifth length of the cephalothorax. The margin between them sub linear. Second segment largely hidden by cephalothorax in dorsal view. Segment bears postero-laterally directed plates on lateral margins. Third segment similar in size with second. Segment bears a pair of sub ovate plates which overlap in midline so that no sinus is present between them. Fourth segment similar in structure with third, but larger in size. Plates of fourth segment, covering the anterior portion of genital segment. Genital segment as wide as long. Lateral margins sub linear and nearly parallel, postero-lateral angles projecting slightly. A small

shallow sinus present in the posterior margin medially. Abdomen visible through the sinus. Abdomen longer than wide. Lateral margin curved. Caudal rami attached to the lateral margins of the abdomen, the distal margin armed with seven small spines.

Distribution: South west Pacific ocean, North east Atlantic, Mediterranean, Indian Ocean and Arabian sea.

Total length: 5.1 mm

Remarks:

Much has been written on the synonymy and intraspecific variation of this species. Capart (1953) synonymised P. communis Rathbun and P. crenatus Leigh-Sharpe. This has been done on account of their similarity of body shape and the extent of denticulation of the posterior margin of carapace and dorsal plates. Pillai (1964) synonymised P. manuelensis Gnanamuthu and P. travancorensis Kurian. Kirtisinghe (1964) attributed that these species similar to that of P. dentatus. Hewitt (1967) confirmed this view. Cressey (1967b) compared the characters of all the known species of Perissopus and conditionally accepted the original suggestion of Capart. In the present specimen the postero-lateral angles of the genital segment are angular and drawn out into a spine like process which confirms with the views of Cressey and

Hewitt.

Stegostoma fasciatum is a new host for this parasite.

Perissopus indicus sp. nov.

Figs. 133-144.

Material: Five females were collected from the ventral side of the body of Scoliodon sorrakowah (Cuvier) landed at Cochin.

Female: Frontal plate not distinctly separate. Cephalothorax bell shaped, narrow anteriorly and broad posteriorly. Postero-lateral side extended outwards, which gives the cephalothorax, the shape of bell. Cephalothorax without any prominent sinus. Thoracic segments four. First thoracic segment fused with the cephalon. Second to fourth thoracic segments free. The free thoracic segments bear dorsal plates. Second thoracic plate roughly triangular in shape and present on either side of the third thoracic segment. Third thoracic segment nearly circular and its plates, are completely free from one another. The second and third thoracic

plates jointly covers the anterior part of fourth thoracic segment. Fourth thoracic plate broad, with rounded lateral margins. The posterior margin of the plate is divided into two lobes by a deep median sinus. The plates of fourth segment covers the anterior part of genital segment. Genital segment large and comprising of about one half of total body length. The lateral sides convex. The posterior margin produced into two pairs of small lobes. Inner lobe smooth and outer pointed. Abdomen single segmented, nearly hidden in the dorsal view. Caudal rami broad. Each ramus roughly triangular with five plumose setae distally and a short spine on the outer margin. The inner margin ciliated.

First antenna: Two segmented. Basal segment long, distal end broader and armed with eight stout spines. A row of three spines and two setae present just below the outer margin. The second segment smaller than the first and distally with ten non plumose setae and two spines. A solitary spine present near the apex just medially.

Second antenna: Four segmented. Basal segment broader than long. Second segment broad and stout. Third segment narrow with a spine on the outer margin. Fourth segment long, pointed with its tip developed into a flanged hook like process.

First maxilla: Sub triangular. The inner margin slightly depressed bearing three non plumose setae.

Second maxilla: Large and two segmented. Basal segment broad and long, unarmed. The terminal segment almost half the length as that of the basal segment, and armed with two uneven curved spines. The surface of spine denticulated.

Maxilliped : Two segmented. Basal segment broad, with an adhesion pad on the inner distal margin. Terminal segment is a small spine, opposed to the adhesion pad of the basal segment.

First leg: Biramous, rami two segmented. Basipod broad with one plumose setae and one naked spine. Exopod two segmented. Basal segment large. The outer margin spinulated and bears a denticulated spine at the outer distal margin. The inner margin smooth and fringed with cilia. The terminal segment sub circular. The proximal half of the outer margin spinulated. The distal half is armed with four denticulated spines and three plumose setae. Endopod two segmented. Basal segment sub rectangular. The outer margin spinulated. The terminal segment with spinules on outer margin and armed with

three long plumose setae.

Second leg: Biramous, rami two segmented. Basipod very broad with one plumose setae on the inner margin and a single naked spine at the base of exopod. Exopod two segmented. First segment long with spinulated outer margin and a denticulated spine at the outer distal corner. The inner margin smooth and bears a plumose seta. The terminal segment sub circular with spinulated outer margin bearing three denticulated spines. The inner margin with two plumose setae and the tip bears three plumose setae. Endopod two segmented. First segment sub rectangular with spinules and cilia on the outer margin. Inner margin smooth bearing a single plumose seta. The terminal segment bigger than basal segment. The proximal half of the outer margin denticulated. The entire outer margin fringed with setae. The terminal end is armed with seven plumose setae.

Third leg: Biramous , rami two segmented. Basipod very broad, with a single plumose seta on the inner margin and a spine at the base of exopod. The inner margin fringed with cilia. Exopod two segmented. Basal segment with spinulated outer margin which bears a denticulated spine at the outer distal corner. The second segment sub circular with spinules on the outer margin and armed with

four denticulated spines and two plumose setae. Endopod two segmented. First segment broader than long with spinulated outer margin fringed with cilia and the inner distal corner with a long plumose seta. Second segment long, outer margin with spinules and tip bearing four plumose setae.

Fourth leg: Biramous and rami single segmented. Basipod broad. Exopod single segmented. Segment longer than broad, outer margin denticulated and armed with three spines, one laterally and other two distally. Endopod single segmented. Segment wider than long. The terminal margin is divided into two lobes by a deep sinus. The outer margin of the outer lobe spinulated and Inner margin smooth.

Fifth leg: Uniramous, segment longer than broad. The tip is armed with four spines of which two are long and two small.

Total length: 6.9 mm.

Remarks:

Among the members of the genus Perissopus, the P. ^{di} incus shows similarity only with P. dentatus, Steenstrup and Lutken, 1861.

P. indicus sp. nov. exhibits considerable variation in general morphology with P. dentatus. Eventhough the both the species has their posterior corner of the genital segment shraply angular and the endopod of the fourth leg unarmed, these two species can easily be seperated by the following characters. The dorsal plates of the fourth thoracic segment is completely free in P. dentatus, where as in P. indicus sp. nov, the dorsal plates are united with a sinus at the posterior margin. In P. dentatus, the posterior margin of the thoracic plates and genital segment are denticulated, whereas it is smooth in the case of present species. In the case of P. dentatus, the endopod of legs first to third are unarmed. But in the present species, the endopod of first to third legs are heavily armed with setae.

P. indicus sp. nov can easily be distinguished by the presence of single dorsal thoracic plate of fourth thoracic segment, smooth posterior margin of thoracic plates and heavily armed endopod of legs one to three.

Genus Echthrogaleus Steenstrup and Lutken, 1861.

Echthrogaleus denticulatus Smith.

Echthrogaleus denticulatus Smith, 1874, p.282.

Dinematura neozealanica Thomson, 1889, p.359.

Pandarus armatus Heller, 1889, p.363.

Echthrogaleus neozealanicus Basset-Smith, 1899,

p.464; Echthrogaleus denticulatus Wilson, 1907a,

p.369; Shiino, 1959b, p.352; Cressey, 1967b, p.56;

Hewitt, 1967, p.341.

Fig. 145

Material: Ten females were collected from the ventral side of the sharks Eulamia dussumieri (Muller and Henle) and E. ellioti (Day) landed at Cochin.

Female: Cephalothorax wider than long, laterally rounded and with a flange on either side. Frontal plate distinct. The cephalothorax divided into various zones by a pair of longitudinal ribs. Second and third segments fused. Lateral margins of dorsal plates smooth and rounded. The posterior lateral side rounded and slightly extends over the fourth thoracic segment. Fourth thoracic plate large, antero-lateral angle expanded as spine like projections. Postero-lateral angles rounded and projecting posteriorly. The plate is nearly divided into equal halves by a posterior median sinus. Sinus deep and narrow. Posterior and median margins of the plate denticulated. Genital segment as long as wide. Median margins slightly

expanded. Posterior margin concial with a deep and wide sinus. Tip of fifth leg visible from the dorsal view. Abdomen single segmented, sub rectangular , narrowing posteriorly slightly. Caudal rami semi circular, seen on the lateral side of the posterior margin of the abdomen. Each ramus is armed with four spines and a tuft of setae.

Distribution: North east Pacific, North west Pacific, South west Pacific , Madagascar and west coast of India.

Total length: 10.1 mm

Remarks:

This is the first report of the genus Echthrogaleus from Indian waters. This species was originally described by Thomson as Dinematura neozealanica and was later transferred to the genus Echthrogaleus by Basset-Smith (1899). The idendity of the species was confirmed by Cressey (1967) and Hewitt (1967).

The morphological details of the present specimen is in full agreement with that of Cressey and Hewitt. This species is recorded from Eulamia dussumieri (Muller and Henle) and E. ellioti (Day) from Arabian Sea. Both are new hosts for this parasite.

Echthrogaleus coleoptratus (Guerin-Meneville)

Dinematura coleoprata Guerin-Meneville,

1837, p.35.

Dienmatura alatus Guerin-Meneville,

1837,p. 43.

Pandarus alatus Johnson, 1835, p.202.

Echthrogaleus coleoptratus Steenstrup and Lutken,

1861, p. 380; Cressey, 1967b,p. 56;

Hewitt, 1967. p.223.

Fig. 146.

Material: Three females were collected along with the collection of Echthrogaleus denticulatus from Eulamia ellioti (Day), caught off Cochin.

Female: Cephalothorax as long as wide, expanded and rounded laterally with a median notch bordered laterally by a flange. The cephalothorax is divided into a medial area and two lateral areas by a pair of longitudinal ribs which terminates anteriorly just behind the frontal plate. Lateral area again divided into two regions by another tranverse rib. Second segment sub ovate and bears plate

which are directed postero-laterally. Third segment sub rectangular, wider than long. Fourth segment wider than long. The fourth dorsal plate is divided into two by a very narrow and deep median sinus. The anterior end of the sinus rounded. The posterior margin of the plate expanded laterally. The postero-median edges of the plates overlap each other. The posterior margin devoid of any spines. Dorsal surface of the plate with scattered denticles. Genital segment broad with postero-lateral process divided by a median narrow sinus. The process overlap each other posteriorly. Abdomen sub rectangular, angles rounded. Caudal rami subovate, with four small spines on the posterior margin. Neither the caudal rami nor the abdomen are visible from the dorsal view.

Distribution: North west Atlantic, North Pacific, Indian ocean and South west coast of India.

Total length: 8.5 mm

Remarks:

This is the first record of the specimen from Indian waters. Earlier this specimen was reported from Indian ocean off Madagascar. The morphological characters of present specimen is fully in agreement with that of Cressey (1967b) and Hewitt (1967).

Eulamia elliotti is a new host for this parasite.

Echthrogaleus eulami sp. nov.

Figs.147-157.

Materials: Thirteen females were collected from the ventral side of the body of Eulamia elliotti (Day), landed at Vypeen, Cochin.

Female: Cephalothorax little wider than long. Frontal plates very short, slightly convex and curved. Median area having same width as frontal plates. Lateral side extending posteriorly, beyond the posterior margin of the median plate and extending into the thoracic plate. Posterior margin of the lateral area almost truncated. Outer margin of the lateral area bordered with a thin flange. Second and third segments fused. Broader than long. Second thoracic plate posteriorly rounded. Third thoracic plate indistinct and wing like. Fourth segment modified into a broad plate, broader than long. Antero-lateral edges having spines. Postero-lateral part sharp. The dorsal plate of the fourth segment divided into almost two parts by a median deep sinus. The anterior end of the sinus rounded. The posterior margin of the plate serrated. The segment conceals almost two-third of the

genital segment. Genital segment as long as wide, with two posterior processes. Each process one-third the length of genital segment. Posterior margin rounded. Abdomen single segmented, sub rectangular. Caudal rami longer than broad, the posterior margin armed with six non plumose setae. The inner margin with small spines on the proximal half and cilia on the distal half.

First antenna: Two segmented, Basal segment stout with a bunch of plumose setae distally. Eight small spinules present amidst them. Second segment about half the length of the first. Distal end rounded with several non plumose setae. A solitary seta on the outer side, little beyond the middle of the segment. Adhesion pad present at the base of the first segment.

Second antenna: Three segmented. First segment longer than the second. Second segment some what rounded. Third segment a curved claw having an indistinct division in the middle of the curve. The distal end curved strongly. The base of the outer margin of the segment bears two spines and a plumose seta.

Maxilla: Two segmented. segments elongated. First segment as long as the second. Distal end of the second segment bears two slender and unequal spines, covered

with longitudinal rows of denticles.

Maxilliped: Three segmented. Basal segment stout. Second segment broad and roughly triangular. The segment bears two small spines near the base. The third segment is a sharp claw. Inner margin serrated and bears a solitary spine at the base.

First leg: Biramous, rami two segmented. Basipod broad. Exopod two segmented. First segment stout and large and bears a single curved stout spine at the outer distal end. The second segment almost rounded bearing four denticulated spines and three plumose setae at its distal end, inner margin of the segment ciliated. Endopod two segmented, segments sub rectangular, and with uneven margins. Second segment short, with its tip bearing three plumose setae. A row of spinules present at the base of the middle seta. The outer side of the segment ciliated.

Second leg: Biramous. Basipod sub rectangular. Exopod three segmented. First segment as long as the second and third segments put together, armed with rows of spinules on the distal end and outer margin. The segment bears a single strong spine at the distal corner and a solitary plumose seta at the inner margin. The second segment half

the size of the first, outer margin armed with a row of spinules and a single spine at the distal end. The inner margin with a single plumose seta. The third segment comparatively small, outer margin with spinules. The distal armature consists of three spines and five plumose setae. Endopod two segmented. First segment as long as broad with a single plumose setae at the inner margin. The terminal segment longer than broad, the tip is armed with eight unequal plumose setae. The inner margin ciliated.

Third leg: Biramous, rami three segmented. Basipod much expanded. Exopod three segmented, first and second segment similar in size. Their outer margin armed with spinules and a single large spine distally. The inner margins provided with long plumose seta. The third segment bears small spinules at the outer margin and two large spines. The distal end has three large spines and five plumose setae. Endopod three segmented. All segments equal in size and fringed with cilia on their outer side. The first segment bears a single non plumose seta on the inner distal margin. Second segment devoid of any setae and spines. Third segment sub triangular with six non plumose setae.

Fourth leg: Biramous, rami single segmented. Basipod a little smaller than exopod. It is as wide as long and

bears a row of spinules on the outer distal margin. Exopod little bigger than endopod. A protruberance on the outer side with a stout spine. The outer margin covered with spines upto the base of swelling. Distal end bears several ridges with spines. The terminal end with eight short spines. Endopod ovate, both margins smooth. Distal end bilobed, bearing several rows of spinules. A linear row of spinules run along the body of endopod from just above the base to the distal end ^{on} the outer side.

Fifth leg: Long and slender. It bears on its inner side three sub terminal process.

Total length: 11 mm.

Remarks:

Echthrogaleus eulami sp. nov. resembles E. denticulatus Smith, 1874 and E. torpedinis Wilson, 1907 in general body shape and the presence of serrated posterior border of fourth dorsal thoracic plate. However, in E. denticulatus, the dorsal thoracic plate does not conceal more than half of the genital segment, whereas in the present species it covers more than three-fourth of the genital segment. Further in E. denticulatus, fifth leg bears only two sub terminal spines, whereas in E. eulami sp. nov, three sub terminal spines are present.

Both in E. eulami sp. nov and E. torpedinis, the posterior border of the caudal rami bear six naked setae. But in E. torpedinis, the inner margin of caudal rami is lined with spinules, whereas in the present species, inner margin bears both spines and cilia.

Eventhough the present species shows similarity with E. coleoptratus (Guerin-Meneville, 1837) in the general body shape, the present species can easily be differentiated by the presence of serrated posterior margin of dorsal thoracic plate. The posterior margin of dorsal thoracic plate is smooth in E. coleoptratus.

The present new species can easily be identified from other known species by the serrated posterior margin of the dorsal thoracic plate, which conceals more than three-fourth of the genital segment and by the arrangements of spines, setae and cilia on the appendages.

Echthrogaleus kerali sp. nov.

Figs:159-168.

Material: Sixteen females were collected from the ventral side of the shark Eulamia ellioti (Day) near the base of pelvic fins.

Female: Cephalothorax wider than long, frontal plates narrow with a slight notch at the centre. Cephalothorax divided into various sections by a series of ridges. Median area almost three-fifth the width of the cephalothorax. Lateral area having one-third the cephalothorax width. Lateral area divided into two by a transverse ridge. The posterior margin of the lateral area truncated and drawn inside to form two small sinuses. Second and third segments fused. Second thoracic plate wider with two postero-lateral lobes. Third thoracic plate overlapping fourth segment at the anterior end. Fourth segment almost three-fourth length of cephalothorax. The dorsal surface of the segment provided with a plate. The plate is divided into two lobes by means of a deep sinus at the centre. Antero-lateral angles of the plates expanded to spine like projections. Posterior margin of the plates armed with spinules. The plate conceals about half the genital segment. Genital segment longer than broad. Posterior margin flat and is divided into two by a shallow sinus. Abdomen single segmented, longer than broad and projecting well beyond the posterior margin of the genital segment. Caudal rami situated at the posterior margin of the abdomen. Ramus one segmented, longer than broad and armed with four plumose setae.

First antenna: Two segmented, basal segment stout with a

bunch of plumose setae distally. Distal segment slender carrying about ten spines apically and a seta on the inner margin.

Second antenna: Two segmented. Basal segment stout, margins rounded. The terminal segment developed into a well developed claw.

Maxilla: Two segmented, basal segment stout and long. The terminal segment sub equal in length with first segment. The segment has a broad base which tapers distally. The tip is armed with two uneven setae. Both setae has serrated margins.

Maxilliped: Three segmented. The basal segment broad. The second segment with broad proximal end which narrows distally with a notch on inner margin. Third segment is a well developed smooth claw.

First leg: Biramous, rami two segmented. Basipod strong and stout, naked. Exopod Two segmented. First segment longer than broad. Outer margin an entire curve with a spine on the outer distal corner. The inner margin sublinear and smooth. Second segment smaller than first, rounded distally with a row of spinules on the outer margin and three denticulated spines and three plumose

setae on the inner margin. Endopod two segmented. First segment sub rectangular. An adhesion pad present near the inner margin. Second segment sub rectangular. Same in size as that of first segment. A row of cilia present in the outer margin. The tip is armed with three long plumose setae.

Second leg: Biramous, rami sub equal in length. Basipod subrectangular, as long as the exopod, with three striated adhesion areas. Exopod three segmented. First segment of exopod long and subrectangular. A spine on the outer distal angle and a several rows of spinules just proximal to this spine. The inner margin ciliated with a long plumose seta towards the middle. Second segment sub rectangular with ciliated inner margins. Outer margin denticulated. The third segment small and the tip is armed with six plumose setae and two spines. Endopod two segmented. Basal segment stout and broad. The inner margin ciliated and bears a plumose seta towards the middle. The second segment short and inner margin ciliated. The segment bear a suture in the inner margin which gives the appearance of an incomplete segmentation. The tip is armed with eight plumose setae, and two short spines.

Third leg: Biramous, rami three segmented. Basipod

expanded. Exopod three segmented. First segment long. Outer margin denticulated and the outer distal angle with a well developed spine. Inner margin ciliated with a long plumose seta. Second segment with short spines on the outer margin and a well developed spine. Inner margin ciliated and bears a plumose seta. Third segment sub ovate. Outer margin denticulated. The tip armed with three well developed spines and six plumose setae. Endopod three segmented. First segment broad, outer margin rounded and ciliated. Inner margin with a long plumose seta. Second segment sub rectangular, outer margin ciliated. Terminal segment rounded distally. Armed with five plumose setae and two spines.

Fourth leg: Biramous, rami single segmented. Basipod as long as endopod. Exopod pear shaped having denticulation along the proximal half of the outer margin. A stout spine present towards the middle of outer margin. The terminal end with few scattered spinules. Endopod sub ovate. A row of spinules present near the inner margin along the full length of the segment. Tip bilobed and denticulated.

Fifth leg: A slender spine like process from the ventral surface of posterior process of genital segment, bearing two spines distally.

Total length: 8.5 mm.

Remarks:

Among the members of the genus Echthrogaleus the present species shows affinity only to E. denticuatus Smith 1874. Both in E. denticulatus and E. kerali sp. nov., the posterior margin of fourth dorsal thoracic plate is serrated. The caudal rami of both species bear four setae. Further the inner margin of the caudal rami is ciliated in both species.

In E. denticulatus, the fourth dorsal thoracic plate does not conceal even half the length of genital segment, whereas in E. kerali sp. nov, it conceals more than half of the genital segment. The posterior margin of the genital segment of E. denticulatus is roughly pointed, whereas it is blunt and flat in the case of E. kerali. The fifth leg can easily be seen from the dorsal view in E. denticulatus, whereas the fifth leg cannot be seen from the dorsal view of the present species. The abdomen of all Echthrogaleus species will be below the posterior margin of the genital segment. It is a unique feature of E. kerali sp.nov. that the abdomen clearly projects beyond the posterior margin of the genital segment.

The present new species can easily be identified from other known species of this genus by the presence of

fourth dorsal thoracic plate which conceals more than half of the genital segment, the smooth and blunt posterior margin of the genital segment and by the presence of abdominal segment which clearly projects beyond the posterior margin of genital segment.

Family : Cecropidae

Genus: Entepherus Bere, 1936.

Entepherus laminipes Bere.

Entepherus laminipes Bere, 1936, p 577.

Yamaguti, 1963, p 90; Kabata, 1979 ,p.229;

Benz & Deets, 1988; p.856.

Fig. 169-181.

Material: Two females were collected from Dasyatis marginatus (Bleeker) from the gill filaments landed at fish landing centre of Integrated Fisheries Project, Cochin.

Female: Cephalothorax caligiform. Dorsal shield without any lateral flanges. Cephalothorax prominently divided into zones by sutures. Two longitudinal sutures divide the cephalothorax into two lateral zones and a median zone. The lateral zone again subdivided into two

by another transverse suture. Posterior edges of lateral zone denticulated. Frontal plate slender with marginal membranes and fused to cephalothorax. The medial zone at its posterior margin is armed with a patch of denticles. Thoracic region divided into three free segments. First Thoracic plate on either side of second with denticulated posterior margin. The second plate lobe like with denticulated posterior margin. The third thoracic plate overlaps the genital segment. The posterior border divided into two lobes by means of a median deep sinus. Posterior margin denticulated. Genital segment orbicular. Anterior region masked by the dorsal plate of third thoracic segment. Posterior margin is denticulated and provided with a shallow median sinus. Fifth leg projecting laterally from genital segment just beneath the mid point, visible from dorsal view. Abdomen single segmented and not visible from dorsal view. Caudal rami not visible dorsally, broad with six apical setae and denticulated lateral and distal margin.

First antenna: Two segmented, basal segment long and about twice the width of distal segment. Basal segment with seventeen seven distal spiniform setae, distal segment with one sub apical and twelve apical spiniform setae.

Second antenna: Three segmented. First two segment unarmed. Second segment sub rectangular with an adhesion pad at the inner side. Third segment is claw like with two median spiniform process and the tip of the claw is heavily sclerotized.

Mandible : Long with twelve distal teeth.

First maxilla: Conical with two small median spines on the inner margin and bearing a distal spine with blunt tip.

Second maxilla: Three segmented . Basal segment stout, longer than broad. Second segment long with two stout denticulated spines on either side anteriorly. The third segment is a well developed curved claw.

Maxilliped: Three segmented. Sub chelate and basal segment unarmed, inner side with a projection bearing three tines. Second segment longer than broad with a median spine. The third segment is a well developed claw, with heavy cuticular striations on one side.

First leg: Biramous and rami two segmented. Basipod with a single lateral seta. Exopod two segmented. First segment longer than broad with a single latero-distal

spine on the outer margin. The inner margin spinulated. Second segment sub-spherical. Both margins spinulated and the distal end armed with seven denticulated spines. Endopod two segmented. First segment with ^aspinulated patch at lower inner side and lateral denticulated border. Second segment broader than first. Border spinulated. Inner margin with three denticulated spines.

Second leg: Biramous, rami two segmented. Basipod broad. Exopod two segmented. The first segment longer than broad. Both lateral margins on the distal side have spinulated projections. Both projections bear single plumose seta. The second segment sub spherical. The outer margin denticulated. The inner margin with three denticulated setae. The tip is armed with six short denticulated spines. Endopod two segmented. First segment short with spinulated outer lateral margin. The proximal projection bear a solitary spine. The second segment longer than broad. The outer lateral margin spinulated. The tip is armed with seven denticulated spines.

Third leg: Biramous, rami two segmented. Basipod broad, lateral edge on either side denticulated bearing short spines. Exopod two segmented. First segment with smooth inner margin. The distal half of outer margin spinulated

and a solitary spine. The second segment sub spherical with spinulated outer margin. The inner margin without any denticulation. Armed with four spines. The terminal end is armed with four naked spines. Endopod two segmented. First segment sub spherical. The inner margin is with a notch. The anterior margin spinulated. The terminal segment larger than first. The segment with broad base which tapers anteriorly. The segment with outer spinulated margin. The inner border is with five small spines.

Fourth leg: Biramous, rami single segmented. Basipod broad and smooth. Exopod lamelliform with seven short spines and spinulated margins. Endopod lamelliform with three short spinules and denticulated outer border.

Fifth leg: Uniramous, one segmented with three slender spiniform setae, one stout spine and scattered denticles.

Total length: 10.1 mm

Remarks:

The genus Entepherus was originally placed by Bere under family Pandaridae. Yamaguti (1960) placed this genus in the family Cecropidae, Kabata (1979) confirms the identity of the species.

The specimen generally confirms with the original description by Bere (1936) and Benz et al. (1988) in general morphological characters. However, the following differences were noted.

It is described that the posterior margin of the second thoracic segment as smooth by Bere and Benz. But it is denticulated in the present specimen. According to Benz the genital complex does not have a dorsal plate. But the present specimen confirms with Bere (1936) that it does have a dorsal plate.

So far, this parasite has been reported only from Manta rays (Mobula spp). The present specimen is collected from Dasyatis sp. It may be concluded that E. laminipes specifically parasitise only rays. The present finding extends the geographical range of this Parasite to Arabian Sea.

Dasyatis marginatus is a new host for this parasite.

Family : Kroyeriidae

Genus: Kroyeria van Beneden, 1853

Kroyeria sphyrnae Rangnekar.

Kroyeria sphyrnae Rangnekar, 1957, p 14;

Pillai, 1967, p.286; Kabata, 1979, p.265.

Fig. 182.

Material: Three females were collected from the gill filaments of Sphyrna zygaena (Linnaeus) landed at Integrated Fisheries Project, Cochin.

Female: The cephalothorax is slightly longer than broad, with its lateral borders regularly arched. The posterolateral lobes are rather small. The free border of the first thoracic segment, nearly half as broad as the cephalothorax. The cephalic process is very long, slender and rather flexible and reach slightly beyond the distal border of fourth thoracic segments. The tip of the process slightly bifid. The second to fourth segment of the trunk free. The second and third segments are subequal in length. The fourth segment is nearly one and a half long as the third segment. Genital segment long and

about three times longer than the head and trunk segments put together. Abdomen is long, elliptic and apparently unsegmented. But on close examination, it is found that it is indistinctly three segmented. Caudal lamina short, about one third length as that of abdomen. Each lamina bears at its tip two stout spines and two long plumose setae. The inner border of the lamina is bordered with setae.

Distribution: West coast of India.

Total length: 3 mm.

Remarks:

The present specimen was collected from the gills of Sphyrna tudes landed at Cochin. The specimen confirms to K. sphyrae described by Rangnekar (1959) and Pillai (1967). But the following variations were observed.

Rangnekar has observed that all the three thoracic segments bear dorsal plates. But the present specimen conform to the observations given by Pillai in that no dorsal plates were present.

According to Rangnekar, the second antenna is two segmented. Whereas in the present species, it is four

segmented. Again Rangnekar stated that, the abdomen as unsegmented, whereas in the present specimen, the abdomen is indistinctly three segmented.

Kroyeria tudi sp. nov

Figs. 183-193

Material: Six females were collected from the gill filaments of Sphyrna tudes (Valenciennes) landed at Cochin.

Female: Cephalothorax triangular in shape. Broader than long. It is produced anteriorly between the first antennae into a broad frontal lobe. The postero-lateral lobes rounded and reaches the middle of the first thoracic segment. Thorax four segmented. The first thoracic segment fused with cephalon anteriorly. On the either side of this segment, there is an irregular sinus, which lodges a long cephalic process. Cephalic process narrow, long and distally pointed and it reaches the middle of the fourth thoracic segment. Thoracic segment two to four are sub equal in length and width. Each bears a faint longitudinal ridge and a pair of lateral ridges. A dorsal plate is present above the fourth thoracic segment. The genital segment long, nearly three times longer than the

trunk and cephalothorax put together. Abdomen cylindrical, three segmented, bears a pair of anal laminae posteriorly. The laminae bears two plumose setae and three stout spines, of which one is very small.

First antenna: Six segmented, first segment longer than others and bears two non plumose setae on the outer side. Second and third sub equal in length and bears two non plumose setae on the outer margin. Fourth and fifth segment smaller than the third. The terminal segment bears nine non plumose setae at the tip.

Second antenna: Three segmented. Basal segment broad and irregular. Second segment stout and is distally produced into slightly curved thumb against which dactyliform third segment closes.

Mandible: Styliform, with a curved end. The inner margin at the distal end serrated.

First Maxilla: Single segmented, with a broad base. The anterior end is produced into a pair of setae sub-equal in length.

Second Maxilla: Five segmented. Basal segment broad.

Second segment small. Third segment broader than second with distal end of inner margin ciliated. Outer margin with a single spine. Fourth segment small. Fifth segment long with a blunt end.

Maxilliped: Two segmented. Basal segment stout and broad. Second segment is a well developed claw.

First leg: Biramous, rami three segmented. Basipod broad, with a solitary spine at the base of exopod. Exopod three segmented. Basal segment long with a long plumose seta on the inner margin. The second segment small with a long plumose seta on the inner margin. Terminal segment sub spherical with a single non plumose seta and five plumose setae at the tip. Endopod three segmented. All segments sub equal in length. First segment with its outer border ciliated. Inner border with a single plumose seta. The second segment with outer margin ciliated and bearing three stout spines. Third segment with six spines on the outer side and two plumose setae on the inner side. The terminal end is armed with three plumose setae.

Second leg: Biramous, rami three segmented. Basipod broad with a solitary spine at the base of exopod. Exopod three segmented. Basal segment long, inner margin with a single

non plumose seta. Outer margin with a solitary spine at the distal corner. Second segment smaller than the first. The inner margin is armed with a plumose seta and outer margin with a spine at the distal edge. The third segment sub spherical with six plumose setae at the tip. Outer margin denticulated with two spines. Endopod three segmented. First segment sub cylindrical. The outer margin ciliated, inner margin bears a plumose seta. Second segment sub rectangular in shape with its ciliated outer margin armed with four stout spines. The terminal segment is sub circular with ciliated outer margin and five stout spines. The tip is armed with six plumose setae.

Third leg: Biramous, rami three segmented. Basipod broad. Exopod three segmented. First segment long and its inner margin bears a single plumose seta. Second segment smaller than the first with a single plumose seta on the inner margin. The apical segment sub triangular and is armed with six plumose setae. The endopod three segmented. First segment small with ciliated outer margin. Inner margin with a single plumose seta. Second segment with ciliated outer margin and armed with four stout spines. The terminal segment sub ovate. Outer margin armed with five stout spines. The inner margin bear a single plumose seta and the tip is armed with three plumose setae.

Fourth leg: Biramous, rami three segmented. Basipod broad. Exopod three segmented. Basal segment long. The inner margin with a single plumose seta. The second segment small with a single plumose seta on the inner side. The third segment sub circular, with two inner plumose setae and three plumose seta at the tip. Endopod three segmented. First segment sub squarish. The inner distal corner bears a plumose seta. The second segment smaller than the first. The inner margin is armed with a plumose seta. The outer margin ciliated and bears four stout spines. Third segment subsquarish with outer margin ciliated and bears seven stout spines. The distal margin with two spine like projection and three plumose setae.

Total length: 10.1 mm

Remarks:

Among the species of Kroyeria so far described, K. tundi sp. nov. shows resemblance only to K. minuta Pillai, 1968. In K. minuta the postero-lateral lobes are reported to be triangular, where as it is rounded in the case of present new species. In K. minuta, the cephalic process is long, which is apically forked and reaches upto the hind border of the fourth thoracic segment where as, in the present species the cephalic process is pointed and reaches only upto the middle of fourth thoracic segment. In K. minuta, dorsal thoracic plates were absent, but in

the present species, a dorsal thoracic plate is present at the dorsal side of fourth thoracic segment. Abdomen is single segmented in K. minuta, where as it is distinctly divided into three segments in the present specimen. Inner margin of caudal rami of K. minuta is ciliated, whereas it is naked in the case of the present new species. The armature of the thoracic appendages are different in both these species.

K. tudi sp.nov. can easily be identified from other known species of Kroyeria by the presence of rounded postero-lateral lobes, pointed cephalic process which reaches upto the middle of fourth thoracic segment and the presence of dorsal thoracic plate of the fourth segment.

Family: Pennellidae

Genus Penicillus gen. nov.

Cephalothorax subspherical, antennary process well developed. Holdfast unbranched and directed downwards. Neck cylindrical, slender, long and imperceptibly passing into genital trunk. Genital trunk sub-cylindrical, transversely ridged, abruptly narrowing at the region of oviduct orifice. Abdomen subcylindrical, transversely striated and shorter than the genital trunk. Abdominal brush present latero-ventrally. It is filiform and unbranched.

5-10 hollow bell shaped structures attached on the sides of the abdomen. Egg sacs long and uniserial. Appendages greatly reduced. Mouth pennellid like. Four pairs of swimming legs present, uniramous, devoid of spines and setae.

Male Unknown.

Penicillus indicus sp. nov.

Figs. 194-203

Material: Eight ovigerous females were collected from the ventral side of the body of the shark Eulamia melanoptera (Quoy and Gaimard), E. ellioti (Day) and E. dussumieri (Muller and Henle) caught Cochin, Mangalore and Lakshadweep respectively.

Female: Head sub spherical. The anterior surface of the head slightly convex, with short and minute papillae arranged in two pairs of patches. A pair of small, concave patches at the centre and another larger pair on either side.

A pair of holdfasts arise from the posterior side of cephalothorax. They are unbranched and directed posteriorly. The neck is slender and long. Subequal in length with the genital segment. Genital trunk broad and subcylindrical. The entire segment is completely covered with transverse ridges. Abdomen about one-third the length of genital trunk, tapering posteriorly.

Abdominal brush or plumes present ventro-laterally. Plumes numerous in number and unbranched. Five to ten hollow bell shaped structures present on either side of the abdomen. These structures are brown in colour with longitudinal white striation. Distribution of these

structures does not follow any pattern as regard to size and shape. These structures are strengthened by chitinous border. The inner margin, which faces the abdomen is open.

Within the bell shaped structure, there is another organ, which is subspherical in shape and folded. The outer margin bear seven pairs of appendages. Each appendage is further branched into two arms. Each arm six segmented. Distal segment pointed. The arms bear spinules on the upper surface and setules at the lower surface.

Appendages: First antenna not observed in this species. Second antenna stout and three segmented. The first and second segment subequal in length. Third segment modified into a chela. Maxilla and Maxilliped absent. Four pairs of thoracic legs present on the ventral side at the beginning of the neck. All legs uniramous. First leg broad, two segmented. Second and third legs small, subequal in length and two segmented. Fourth leg minute and single segmented.

Total length : 6.35 cm.

Remarks: Among the members of the family Pennellidae, the present new species shows resemblance only to the members of the genus Pennella. Penicillus indicus sp.nov.

broadly exhibits similarity to Pennella spp. in all aspects as far the cephalothorax and genital trunk are concerned. But the abdominal region of P. indicus has remarkable variation with the genus Pennella. The presence of bell shaped structures at the abdominal region of P. indicus is a very distinct character that is not seen in any other genera of the family Pennellidae. Because of this peculiarity, the present species could not be included in the genus Pennella. This new species was collected from different hosts at different localities viz. Cochin, Mangalore and Lakshadweep from three different species of sharks. All the species collected from these localities exhibit similar characters. This clearly shows that this is an established character of the genus. Hence the new genus Penicillus is erected in the family Pennellidae.

The new genera and new species can easily be separated and identified from all other known genera of the family Pennellidae, by the presence of peculiar bell shaped structures at the abdominal region.

CHAPTER IV

GENERAL OBSERVATIONS AND HOST-PARASITE RELATIONSHIP

Studies on parasitic copepods are highly diversified with many disciplines. Initial studies were only on taxonomy of parasitic copepods with the description of many new species and genera. Parasitic copepods exceed any other group of parasites in number and abundance. Copepods are widely distributed and are found to be parasitising on almost all variety of fishes. They exhibit varying degrees of modification in their structural and functional morphology. The modifications may be simple on one hand and on the other hand it may be highly evolved which leads to the loss of all characteristic features.

The present study is mainly on the taxonomy of parasitic copepods on elasmobranch fishes and provides limited scope for a comprehensive discussion. Nevertheless, certain interesting observations on various aspects of copepod parasitism arising out of the present investigation are briefly dealt with in the following pages.

Copepods parasitic on fishes mainly belong to three groups viz. Poecilostomatoida , Cyclopoida and Siphonostomatoida. Poecilostomatoids are the least modified, whereas Siphonostomatoids are highly modified. Cyclopoids come in between the two. These groups exhibit a gradual transformation from nearly free living life to a sedentary parasitic mode of life.

It is difficult to find any convincing explanation for the way in which parasitic copepods find their host and the method of getting attached to the preferred site on the host. So one can only speculate that the infestation of copepods may occur at certain age or size of the host which is accessible to the infective stages of the parasite.

Chemoreception is considered to be a possible way of finding a specific host. Fryer (1966) observed that once a host is infested with a parasite, it may have a tendency to acquire more parasites. According to him, a chemical attractant is produced by the parasite, which gets attached initially. This will attract more parasites of the same species to the same host. Kabata (1974b) reported a chemoreceptive organ situated in the middle of the anterior margin of the dorsal shield of Caligus clemensi, C. curtus, and Lepeophtherius salmonis. Cressey

and Cressey (1979) reported the presence of a chemoreceptive structure in the genus Abasia Wilson. The authors described the sensitive area as 'Rugose' which appears to be similar to that described by Kabata. This increases the probability that all caligids might possess such chemo-receptive organs, which help the parasite to detect the host and find specific site of attachment. Many authors uphold the tactile sensation as another method adopted by the parasites to find its potential host. But this is still a hypothesis, for any report on direct observation in this regard is lacking.

Parasitic copepods are host specific, with varying degree of site specificity. Majority of copepod parasites encountered in the present study are ecto parasites. Members of genus Penicillus is observed to be host specific on the members of the genus Eulamia. All the parasites are collected from E. ellioti (Day) , E. melanoptera (Quoy and Gaimard) and E. dussumieri (Muller and Henle).

According to Cressey (1967a), the copepods belonging to the family Pandaridae were specifically parasitic on elasmobranchs. Present study is also in confirmation with the view expressed by Cressey. All the Pandarid copepods collected during the study were from

various species of Eulamia.

Cressey (1967c) has reported that the genus Gloipotes were exclusively parasitic on members of the family Istiophoridae, and Xiphidae. In the present study, many species of Gloipotes were collected from elasmobranchs such as Eulamia spp. and Scoliodon sorrakowah. These are the new hosts for these parasites and it proves that the genus Gloipotes can also parasitise elasmobranch fishes. The genus Echthrogaleus parasitises only elasmobranch fishes (Cressey, 1967b). In the present study four species of Echthrogaleus were collected from elasmobranch fishes which confirm Cressey's observation.

It is well established that parasites frequently display an affinity for particular parts or region of their host body. In the case of gills of fishes, non random distribution of the parasites over the available sites of attachment are common, although the exact mechanism giving rise to such distributions are less clearly understood (Fryer, 1966). Most commonly, the force and direction of branchial ventilating currents are presumed to dictate the observed pattern of parasitic attachment (Hughes and Morgan, 1973). It is however beleived that the existing pattern are susceptible to modifications due to influence of many external and

internal factors (Van den Broek, 1979).

It is also observed that irrespective of the host fishes, the same species of parasites show an affinity to a particular region of the host. All the species of Kroyeria were collected from the anterior side of the fourth gill filament. The members of the new genus Penicillus were collected from three species of elasmobranchs. In all the cases, the parasites were found attached to the ventral side of the host. On dissection, the bulla of the parasites were found near the vicinity of the liver.

Kroyeria is found only in the gill cavity of the host, whereas Echthrogaleus is found exclusively on the ventral body surface of the elasmobranchs. The members of the genus Alebion is found parasitic on the body surface of Sphyrna zygaena, Scoliodon sorrakowah and other elasmobranchs. Bomolochids and Taeniacanthids are found to be attached on the branchial cavity of the host. The members of the genus Caligus prefer mucus covered body surface and gill cavity. These are a few examples to support the site specificity exhibited by copepod parasites.

Morphological modifications exhibited by parasitic copepods are quite astonishing and to a certain extent, it

is decided by the site of attachment. The parasites which attach on the body surface of the host are more exposed to the external environment and effective attachment is attained by the peculiar structure of cephalothorax and cephalic appendages. Such parasites are adhering to the surface of the host by the suction force produced by the cephalothorax along with the prehensile power of the second antenna. The suction is produced by pressing down the saucer shaped cephalothorax by muscles as suggested by Kabata (1979).

Members of the genus Caligus Muller, possess a sucker shaped cephalothorax with a circular sucking disc called lunules on their frontal plates. This structure acts as a powerful organ of attachment. Caligus, with the help of sternal fork, creates a vacuum by increasing the concavity of cephalothorax. In order to fill the gap found at the posterior margin of the carapace, the basipod of the third leg in Caligus is highly flattened and provided with marginal membranes.

The second antenna is the most important prehensile organ by which the parasite is firmly attached to its host. This is effected by virtue of the shape of the second antenna, which is either sharply pointed or chelate. With the aid of these structures, the parasite

anchor itself to the host. The second antenna with pointed claw is found in the members of the genus Caligus, Gloipotes and Alebion. While the members of the genus Kroyeria and Eudactylina possess chelate second antennae by which it holds on to the host tissue.

The members of the new genus Penicillus , collected during the present study, was found attached to the host with their anterior half buried in the tissues and this makes them invariably mesoparasites.

Parasites belonging to the family Pandaridae such as Pandarus, Perissopus and Echthrogaleus collected during this study have fairly prominent dentiform outgrowths, with grooved surfaces. These are usually seen situated at the postero-medial position to the base of maxillipeds and other appendages. These rugose area are termed adhesion pads, whose function is to provide an extra grip to the parasite on the host. According to Kabata (1979) the exact function of these pads are not known. But taking into account of the fact that the members of the family Pandaridae have less suction effect on cephalothorax and poorly developed blunt claw of the second antenna, one could only justify the part played by the adhesion pads as supplementary organs for attachment.

All the species of Kroyeria collected during the study possess posteriorly directed dagger like process of hard cuticle connected with their interpodal base. They are also equipped with a pair of stylets situated in the posterior side of the dorsal shield. These organs are believed to be the prehensile organs of the parasite which aid the second antenna for attachment with host.

Another interesting observation which is made in the present study is that old and large elasmobranchs bear larger number of parasitic fauna than its smaller counterparts. This is evident from the collection of large numbers of Pandarus cranchii, P. bicolor and Gloipotes watsoni from the body surfaces of Eulamia ellioti, E. melanoptera, Scoliodon sorrakowah etc. Cressey and Collette (1970) found that the specialised groups of parasites which are permanently attached on the host increase in number with the increase in size of the host. This is attributed to the availability of large area of attachment with the increase in size of the host. Heavy infestation may also be due to the adaptability of free living stages of parasites to the habitat of the host (Boxshall 1974). It is also found that in the case where large number of parasitic assemblage is found, the possibility of finding large parasites is also higher. In the present study, specimens of Pandarus cranchii, upto

15 mm in length were collected. In another collection of parasites belonging to the family Pennellidae, specimens upto the length of 156 mm were collected from three species of Eulamia.

It is observed that cephalon of the genus Gloipotes becomes shorter with the increase in length. But the length of the genital segments becomes proportionally longer as the length increases. This observation is in confirmation with that of Cressey (1967h). He attributed the increase in length of genital segment to the production and distribution of eggs within the body of the parasite. Several numbers of copulating stages of Gloipotes were collected during the present investigation. The females were attached to the host in the usual manner and the males were attached to the ventral side of the female by its ventral side. A detailed study in this line is highly essential.

The distribution of parasitic copepods usually follow the distribution of their specific host. Even though elasmobranchs enjoy a cosmopolitan distribution their parasites do not have the continuity in their distribution. Gloipotes huttoni, G. watsoni, Alebion carchariae are distributed in Indian and Japanese waters. This has been confirmed by the collection of these

species during the present study.

It is interesting to note that a copepod parasite Entephereus laminipes, which was initially described by Bere in 1936 from Madagascar and subsequently reported by Benz and Deets in 1988, from American waters is at present recorded from Indian waters. This has confirmed that this parasite enjoys cosmopolitan distribution. The earlier two reports were based on the collections from Mobula spp. whereas the present collection is from Dasyatis marginatus. This is a new host record of Entephereus laminipes.

Gloipotes ornatus, enjoys a wide distribution in Southern Indian Ocean, North Atlantic and Arabian sea. Gloipotes huttoni is reported from Indian ocean and Western Pacific Ocean, whereas G. watsoni is seen only in Indian Ocean. G. hygomianus is distributed in Pacific, Atlantic and Indian Ocean. Pandarus cranchii is reported from North Atlantic, Pacific Ocean and Indian Ocean. P. niger is seen only in Indian Ocean. P. bicolor is a common parasite on elasmobranchs in Pacific, North Atlantic and Indian Ocean. The genus Echthrogaleus is restricted to larger pelagic sharks. During the present investigation, four species of the genus Echthrogaleus were collected from elasmobranch fishes. This is the first

record of the genus from Indian waters. Echthrogaleus coleoptratus enjoys a wide distribution in North West Atlantic, North Pacific and Indian Ocean. The range of E. denticulatus is now extended to Indian waters, which was formerly seen only in Pacific ocean and eastern Indian Ocean.

It is evident from the above that most of the copepods, parasitic on elasmobranchs are common in Indian, Australian, African and American waters. It is clear from the present study that the elasmobranchs of Indo-Pacific region harbours a vast variety of parasitic copepod fauna.

An appraisal of the earlier works on parasitic copepods reveal that so far major emphasis was given only on taxonomic studies. Except for a few works of Kabata, Cressey etc., no attempts have been made to study the biology, ecology and functional morphology of marine copepod parasites. A number of works on evolution and phylogenetic relationship of parasites and hosts are attempted recently. But the effect of parasites on the physiology of the host is still unknown except for few fresh water parasites. In this regard, a detailed investigation is highly essential for further studies.

CHAPTER V

SUMMARY

The present study of the parasitic copepods gives the taxonomic description of thirty one species of parasites collected from various elasmobranch fishes of Kerala coast.

Copepods parasitic on fishes include three sub orders, viz. poecilostomatoida, cyclopoida and siphonostomatoida. Parasitic copepods of elasmobranch fishes for the present study were collected from different fish landing centres of Kerala and by undertaking regular fishing trips. The collected parasites are identified to the species level and described.

It is found that out of thirty one species, fifteen are new to science. They belong to the genera viz. Nothobomolochus Vervoot, 1962, Caligus Muller, 1785, Alebion, Kroyer, 1863, Gloipotes Steenstrup and Lutken, 1861, Pandarus Leach, 1819, Perissopus Steenstrup and Lutken, 1861, Echthrogaleus Steenstrup and Lutken, 1861 and Kroyeria van Beneden, 1853. Fifteen new host records were reported. Two genera viz. Echthrogaleus and Entepherus were reported for first time from Indian

waters. A new genus called Penicillus was erected.

The general observations made during this study revealed certain interesting aspects of host-parasite relationship, host specificity, site specificity, adaptive modifications and geographical distribution. A brief discussion of these observations made is also presented.

* * * * *

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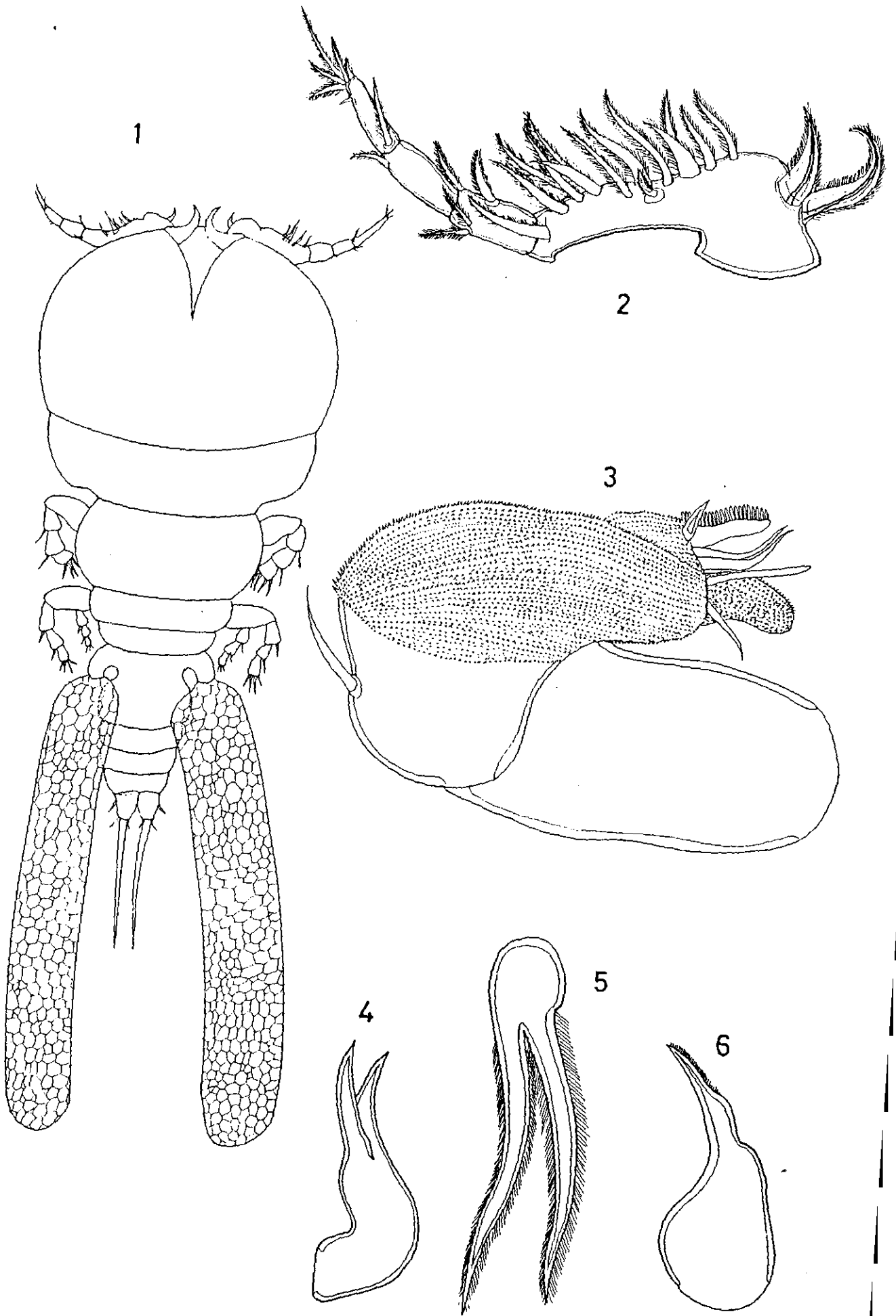
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EXPLANATION OF FIGURES

Nothobomolochus eulami sp.nov.

(Figs. 1-14)

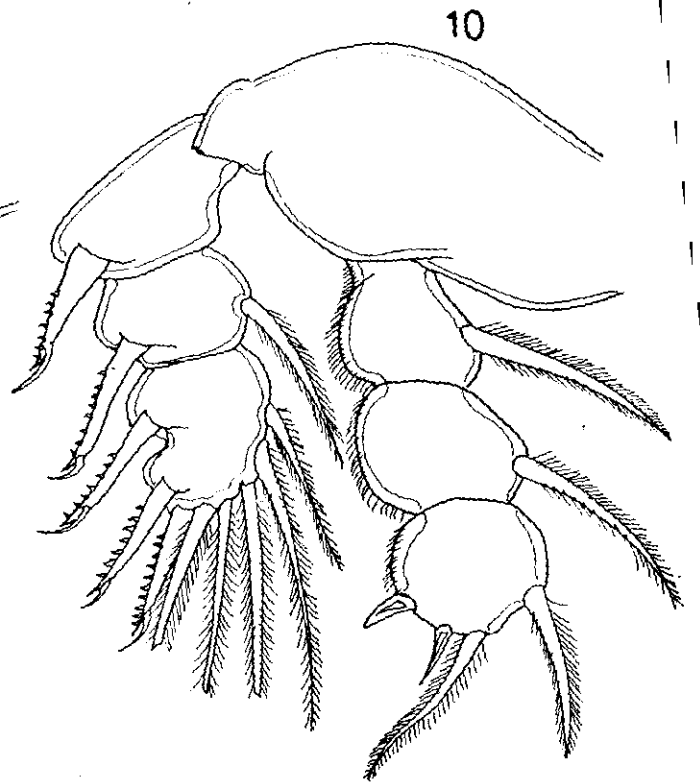
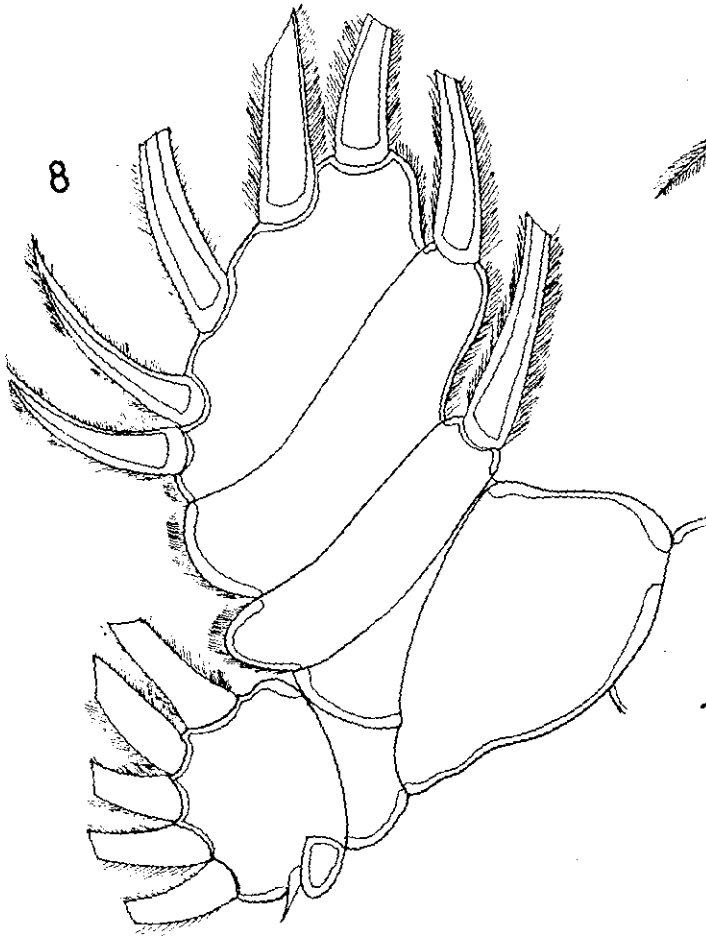
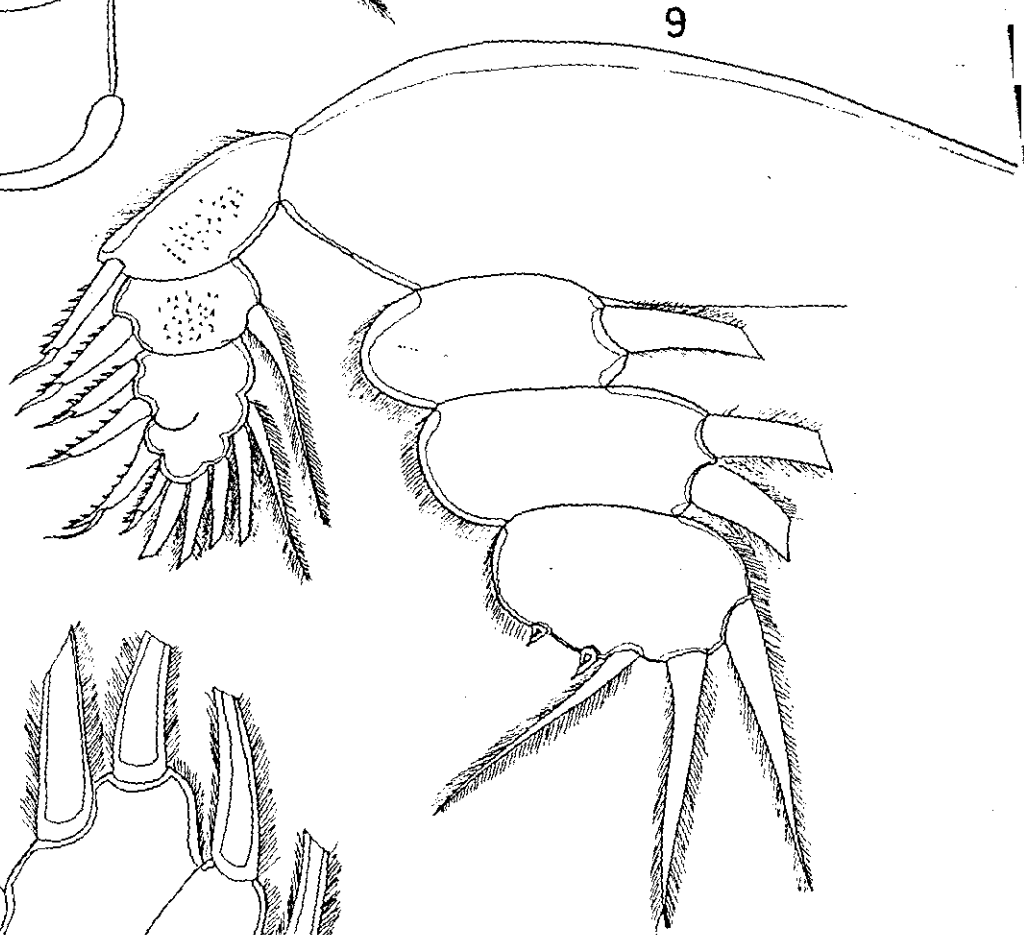
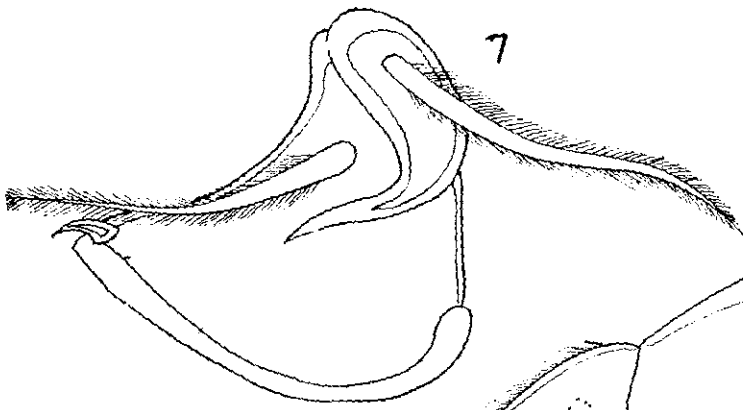
1. Female, dorsal view
2. First antenna
3. Second antenna
4. Mandible
5. First maxilla
6. Second maxilla



EXPLANATION OF FIGURES

Nothobomolochus eulami sp. nov.

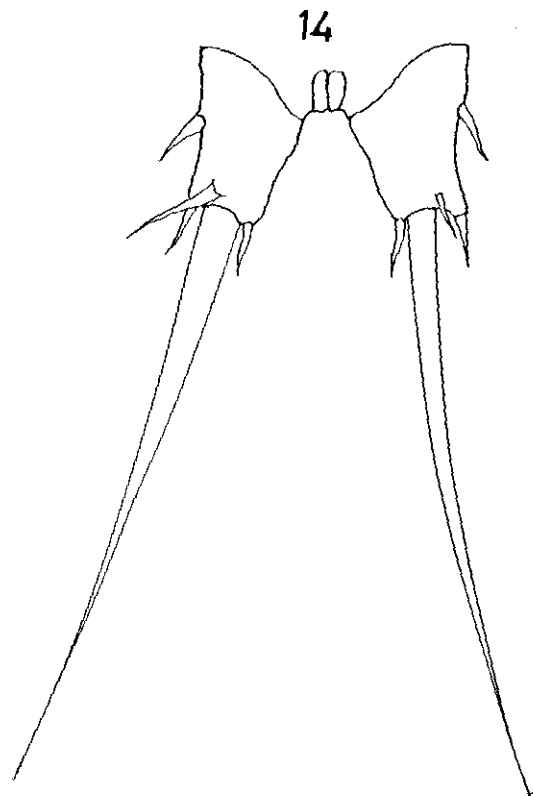
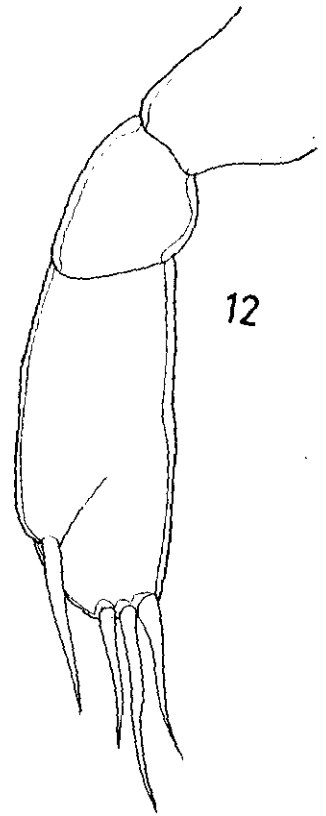
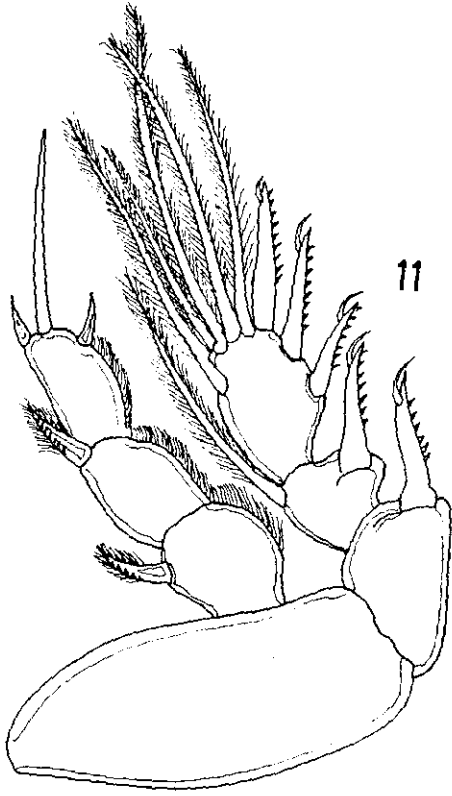
- 7. Maxilliped.
- 8. First leg
- 9. Second leg
- 10. Third leg



EXPLANATION OF FIGURES

Nothobomolochus eulami sp. nov.

11. Fourth leg
12. Fifth leg
13. Sixth leg
14. Caudal rami

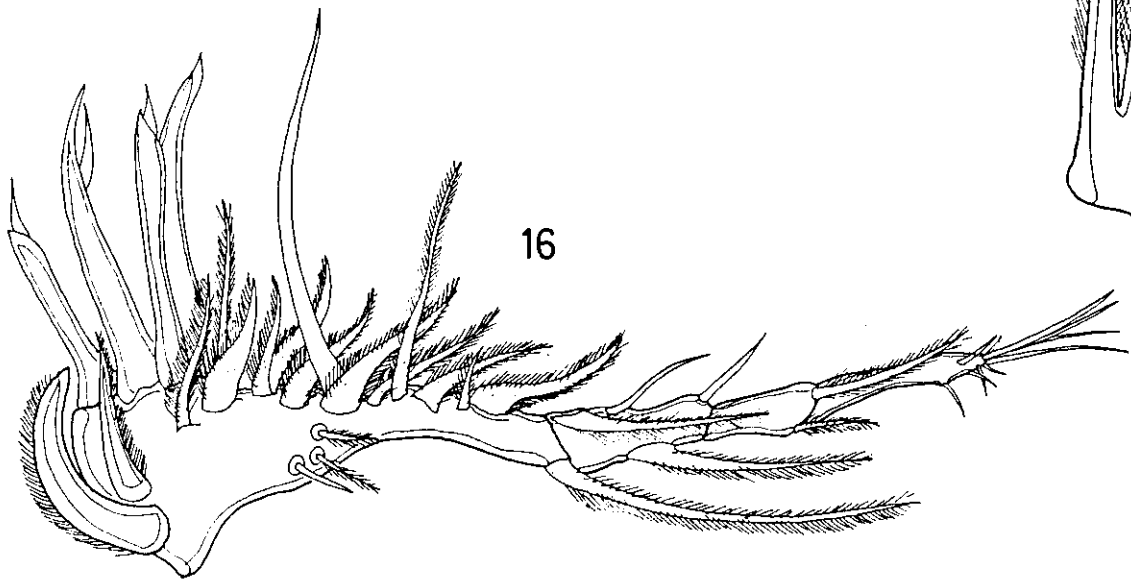
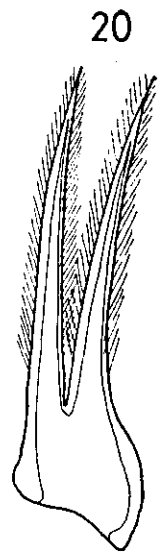
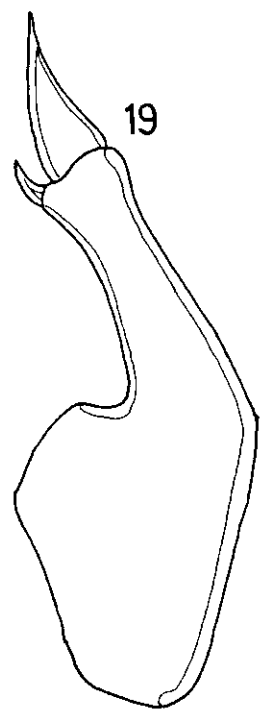
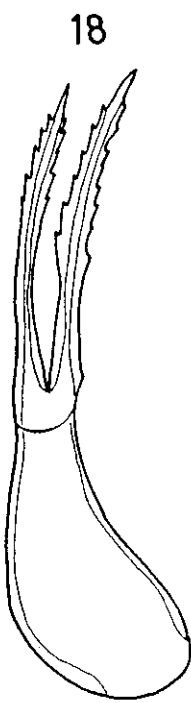
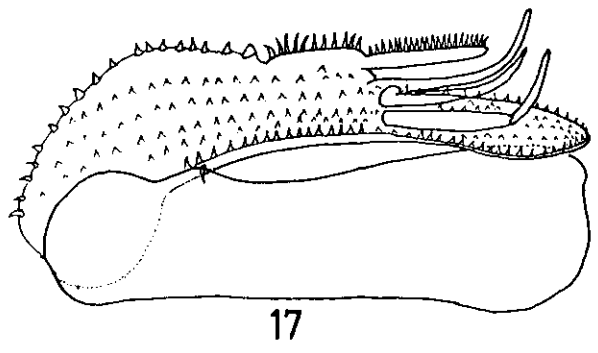
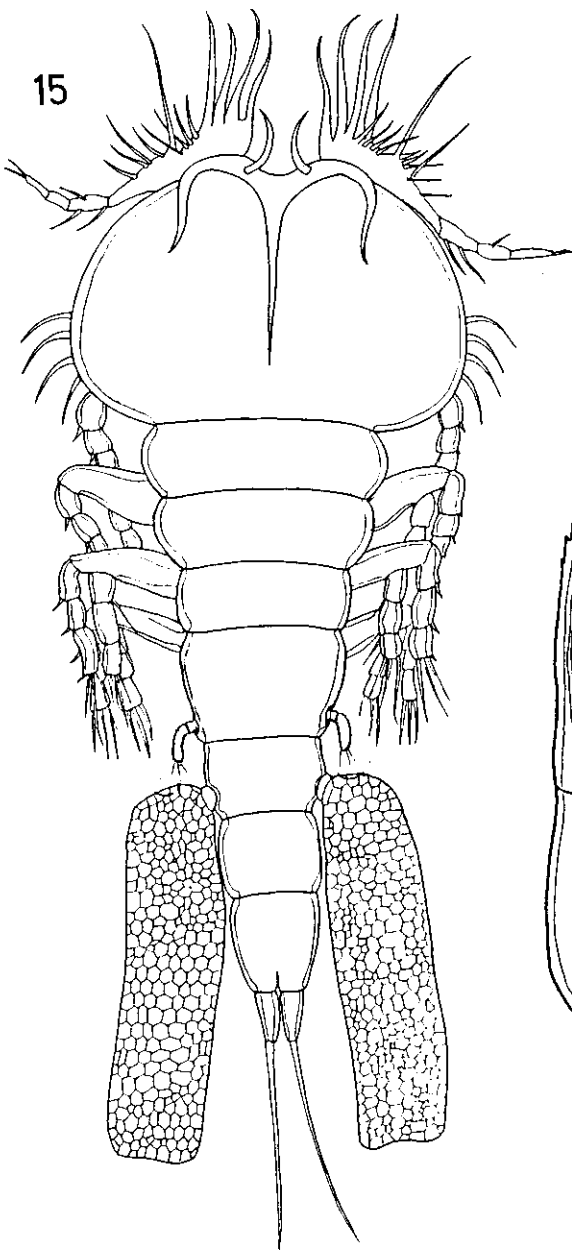


EXPLANATION OF FIGURES

Nothobomolochus indicus sp.nov.

(Figs. 15-28)

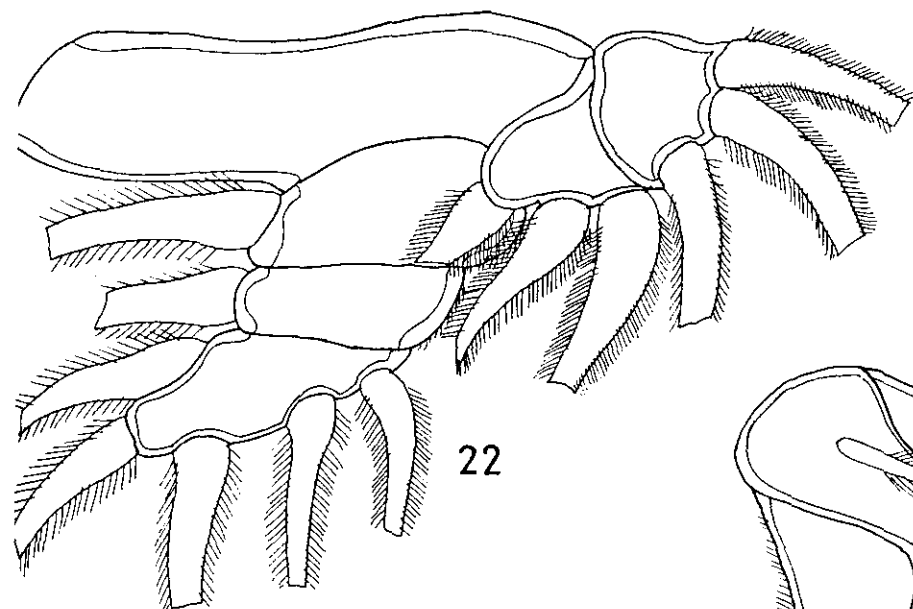
15. Female, dorsal view
16. First antenna
17. Second antenna
18. Mandible
19. First maxilla
20. Second maxilla



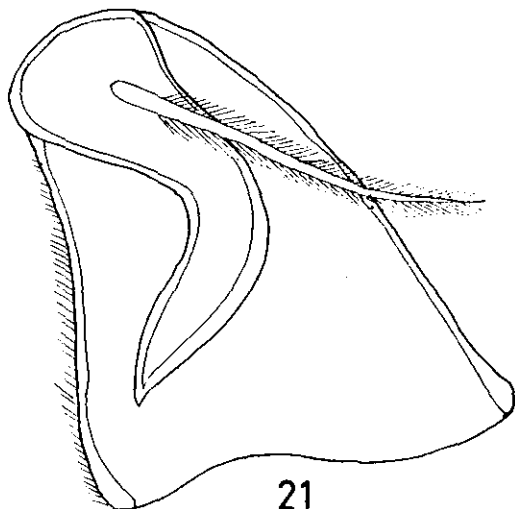
EXPLANATION OF FIGURES

Nothobomolochus indicus sp. nov.

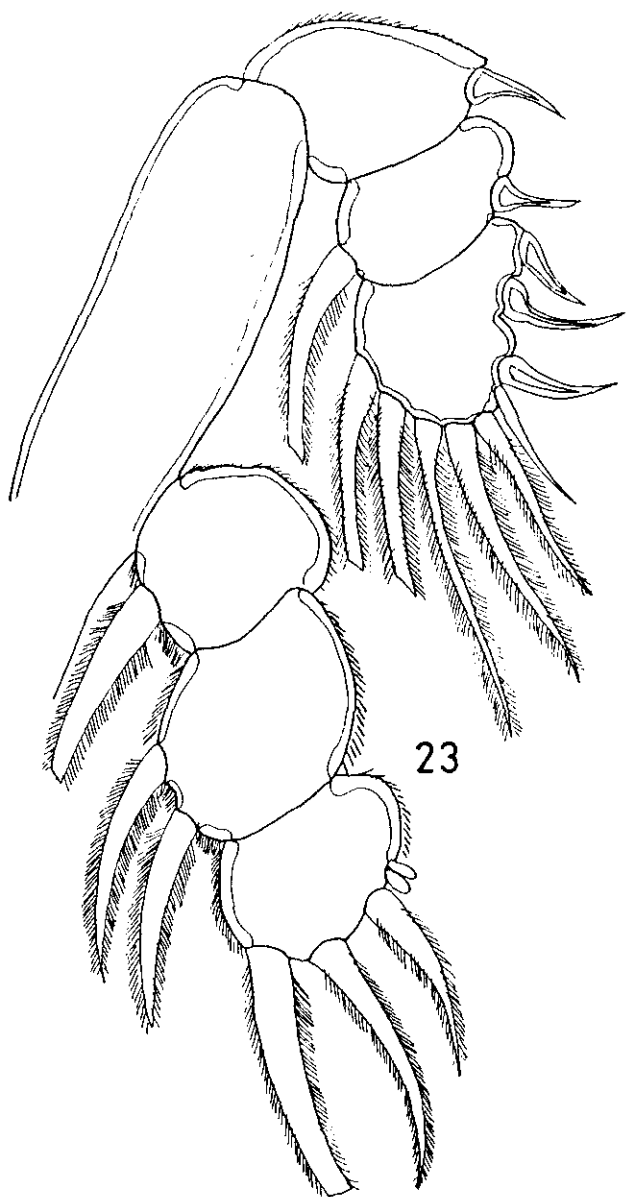
- 21. Maxilliped
- 22. First leg
- 23. Second leg
- 24. Third leg



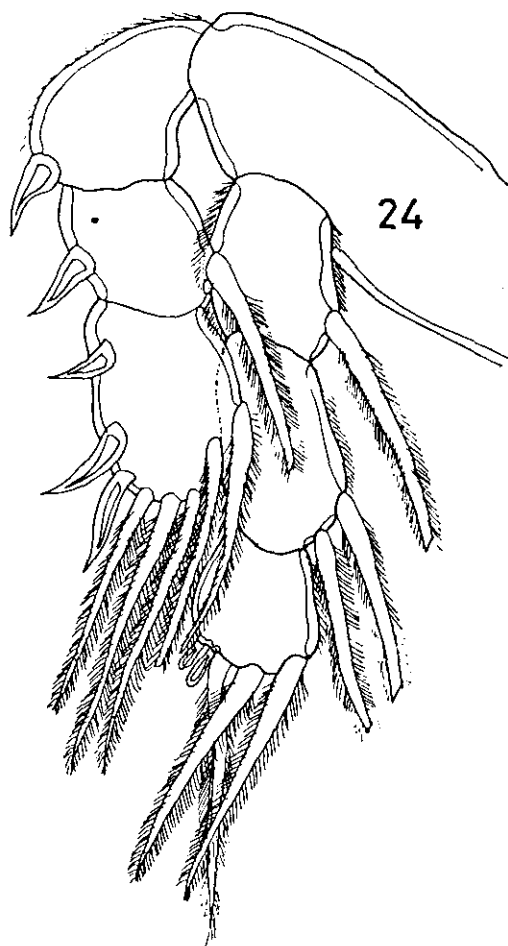
22



21



23

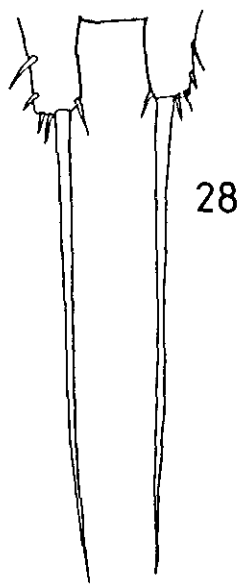
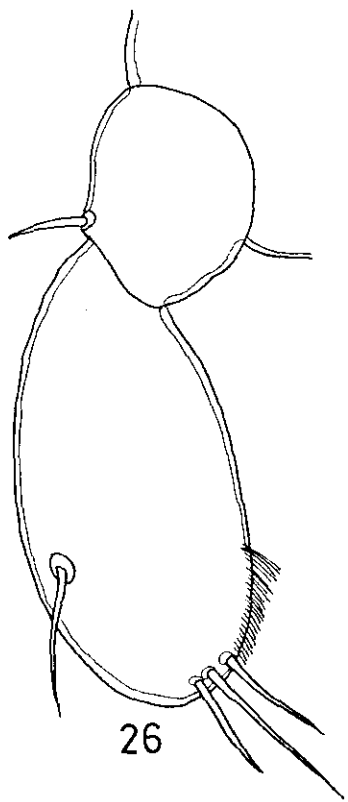
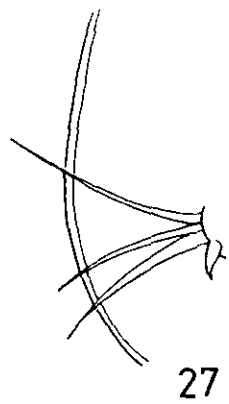
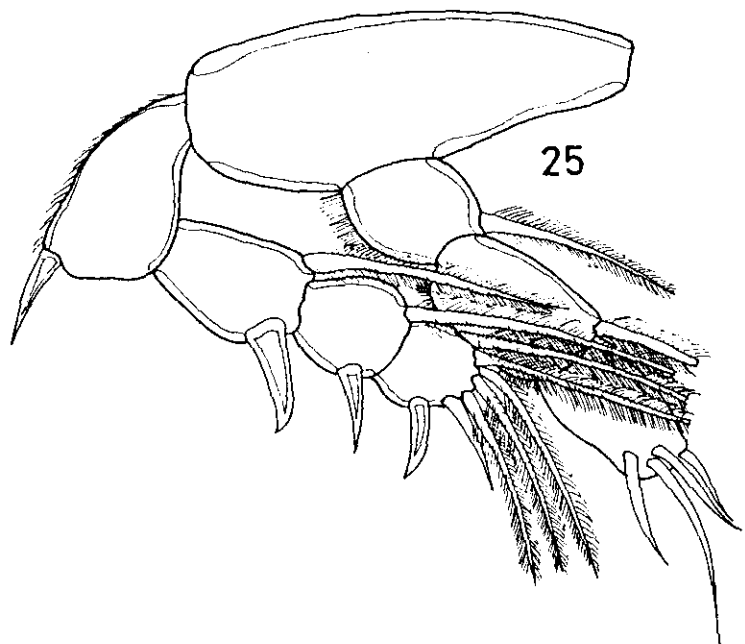


24

EXPLANATION OF FIGURES

Nothobomolochus indicus sp. nov.

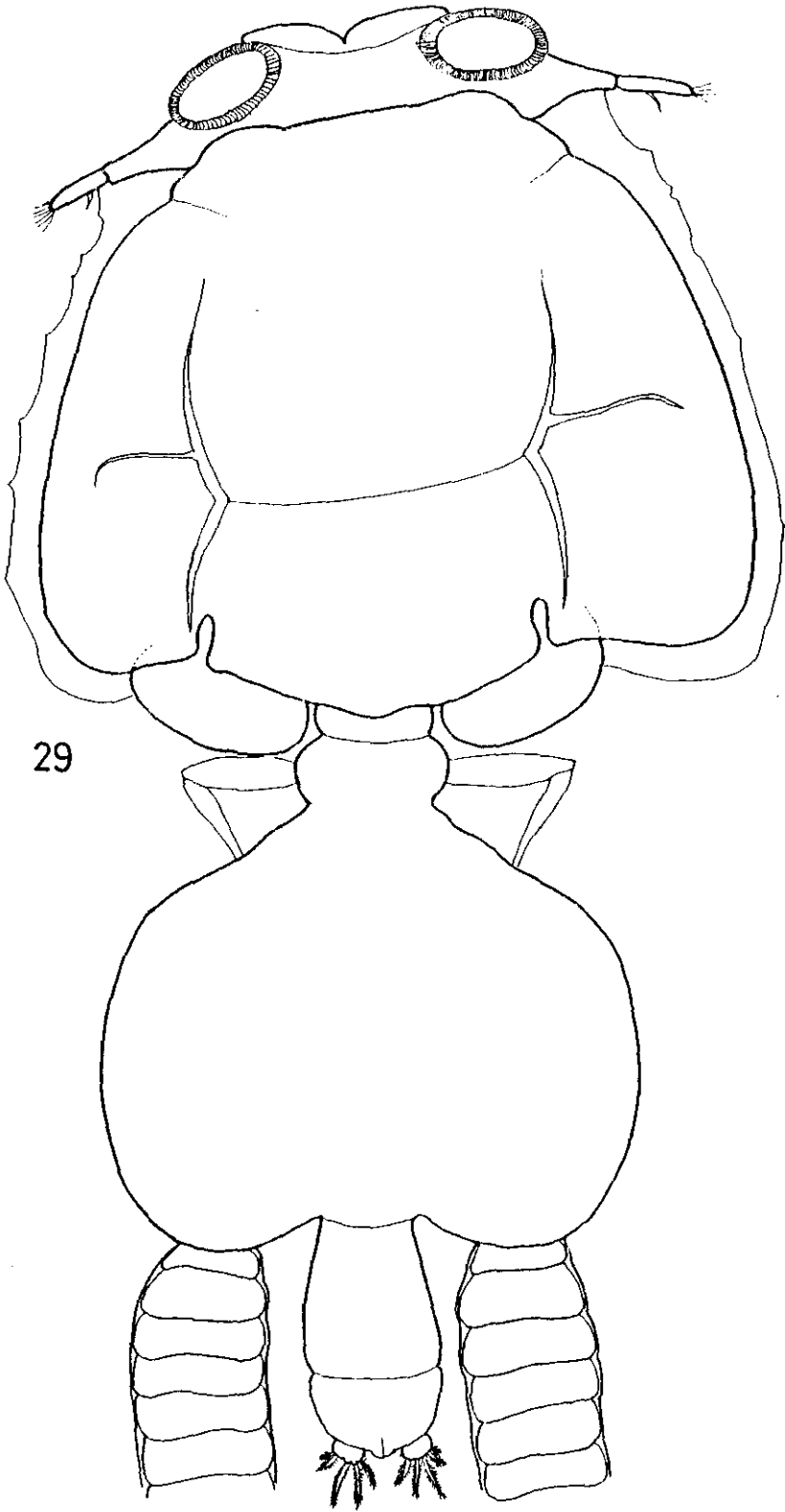
- 25. Fourth leg
- 26. Fifth leg
- 27. Sixth leg
- 28. Caudal rami.



EXPLANATION OF FIGURES

Caligus hamruri Pillai

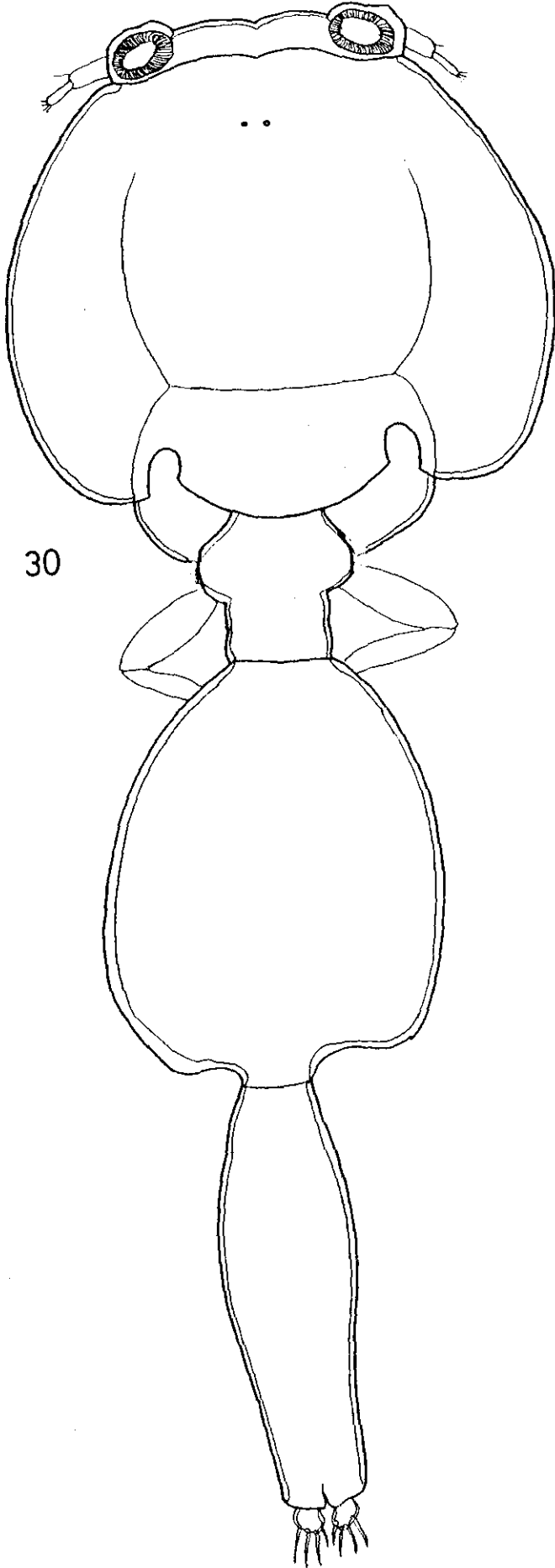
29. Female, dorsal view



EXPLANATION OF FIGURES

Caligus dekari van Beneden

30. Female, dorsal view

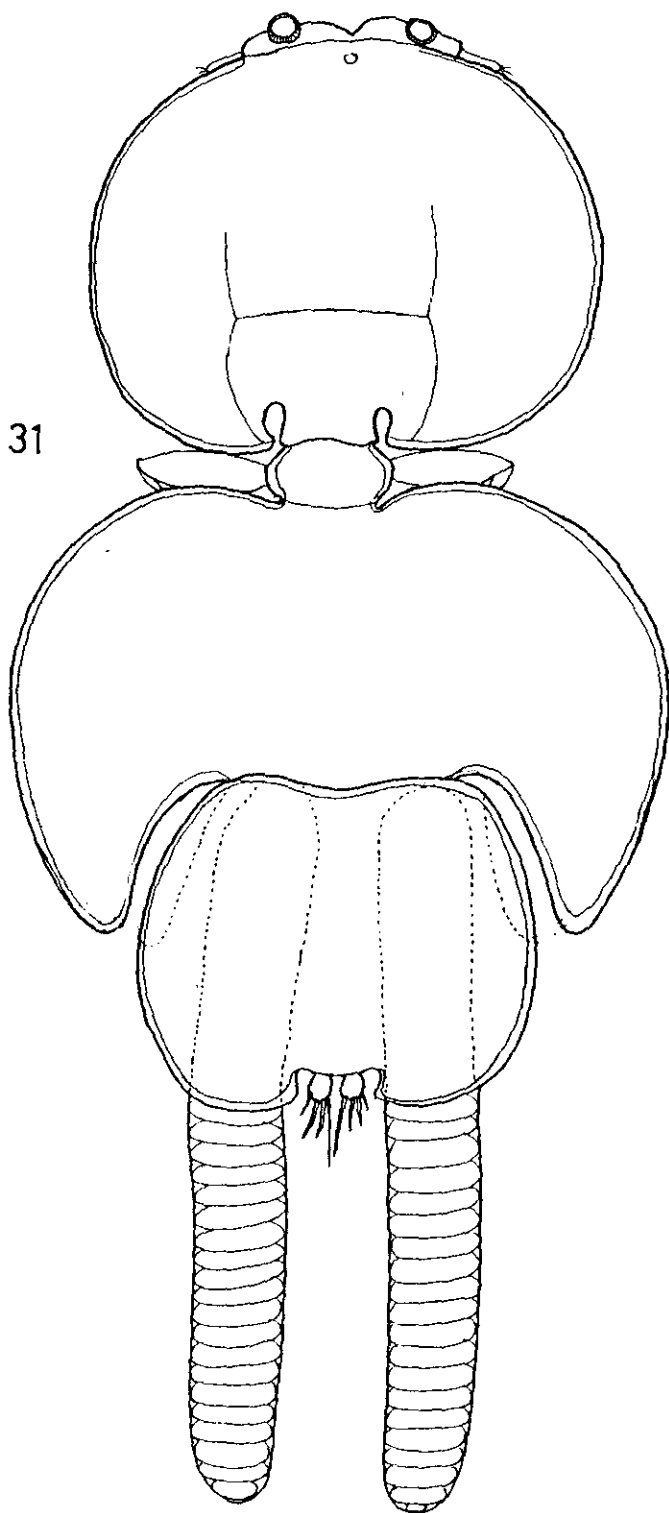


EXPLANATION OF FIGURES

Caligus parapetalopsis Hameed & Pillai

31. Female, dorsal view.

31

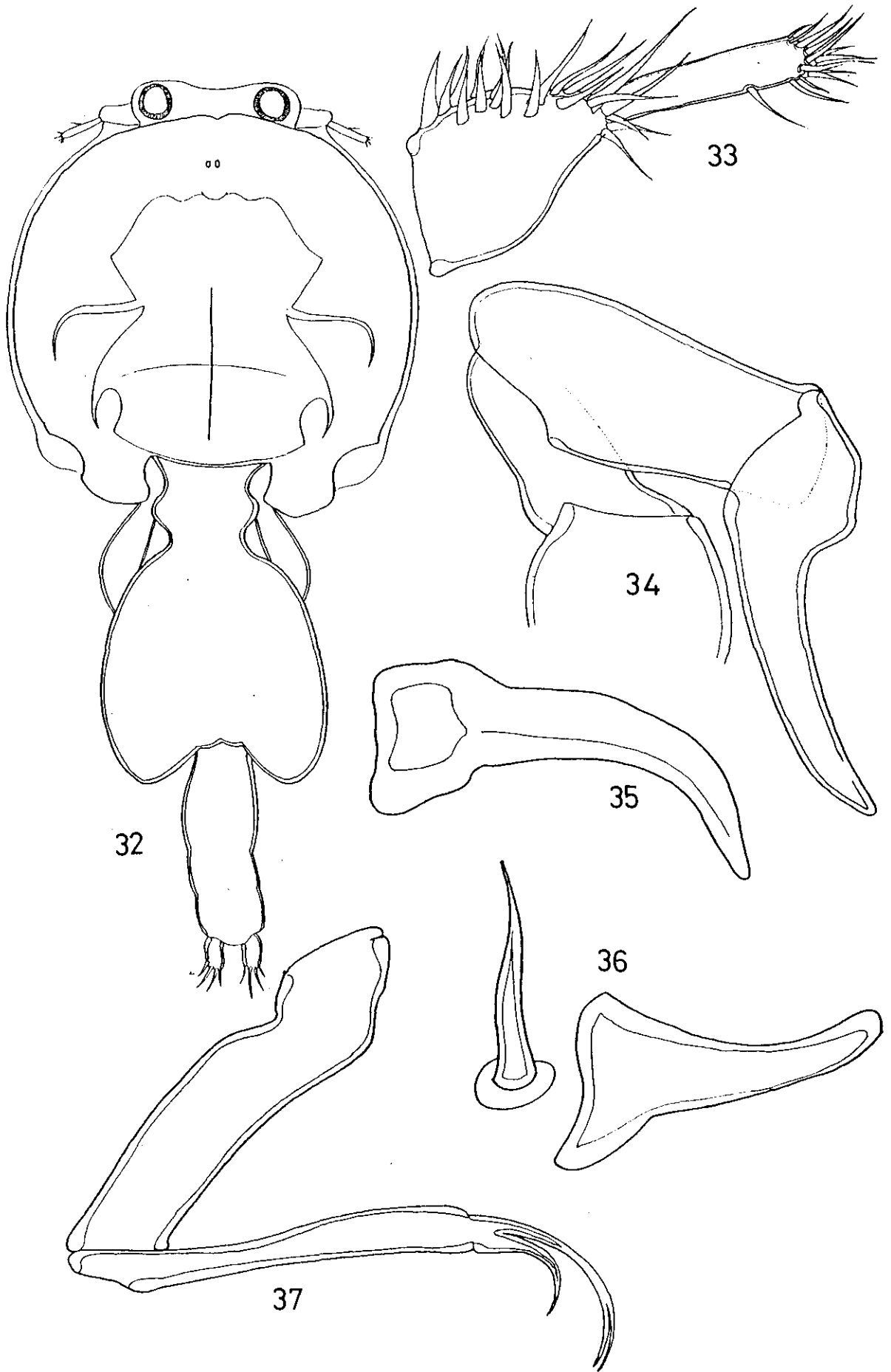


EXPLANATION OF FIGURES

Caligus foreshori sp. nov.

(Figs. 32-44)

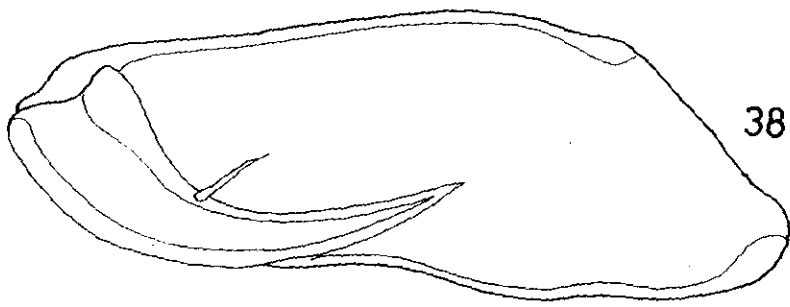
- 32. Female, dorsal view
- 33. First antenna
- 34. Second antenna
- 35. Post antennal process
- 36. Post oral process
- 37. Maxilla



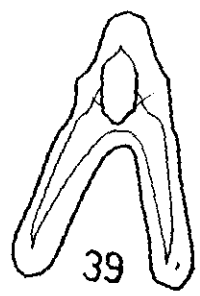
EXPLANATION OF FIGURES

Caligus foreshori sp. nov

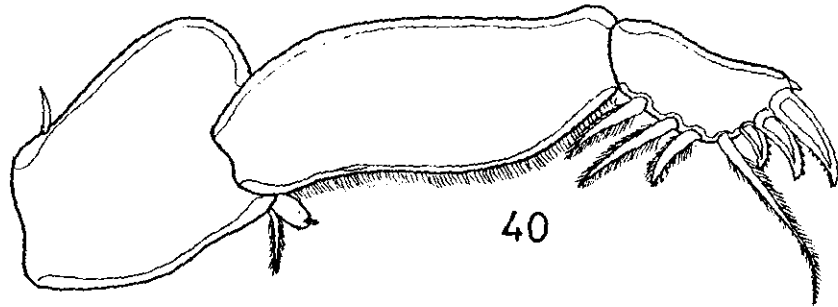
- 38. Maxilliped
- 39. Sternal furca
- 40. First leg
- 41. Second leg
- 42. Third leg
- 43. Fourth leg
- 44. Caudal rami



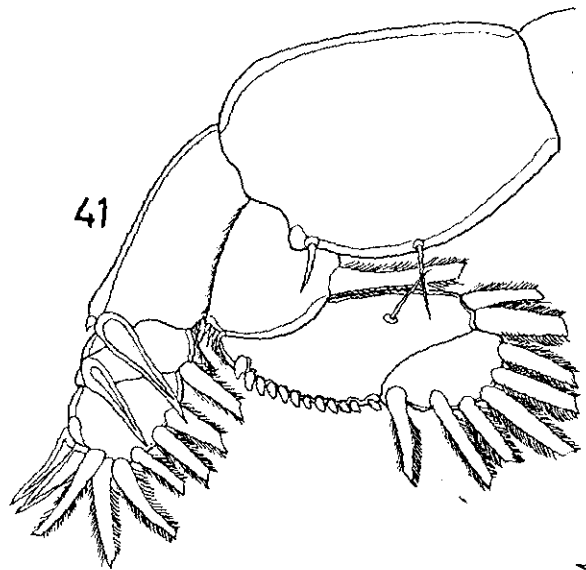
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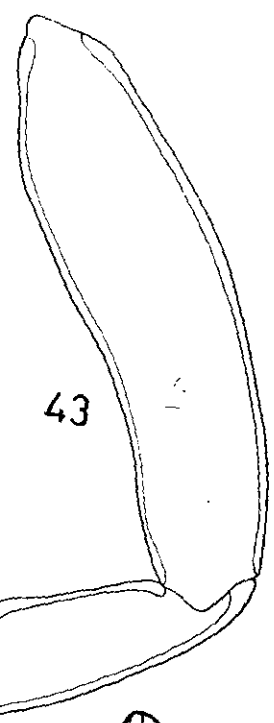
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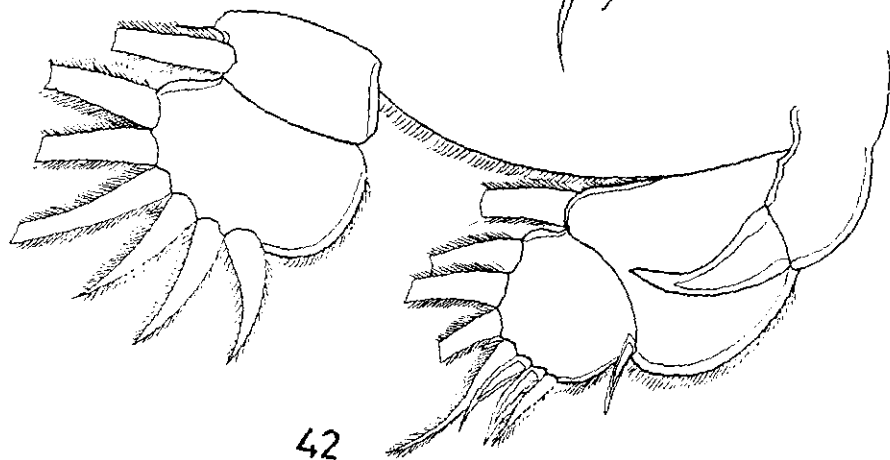
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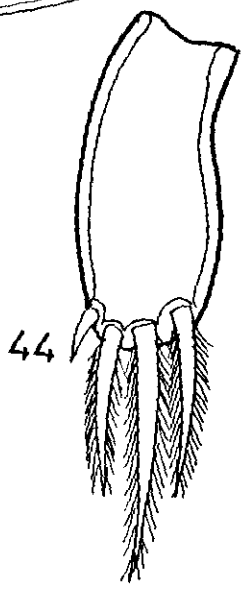
41



43



42



44

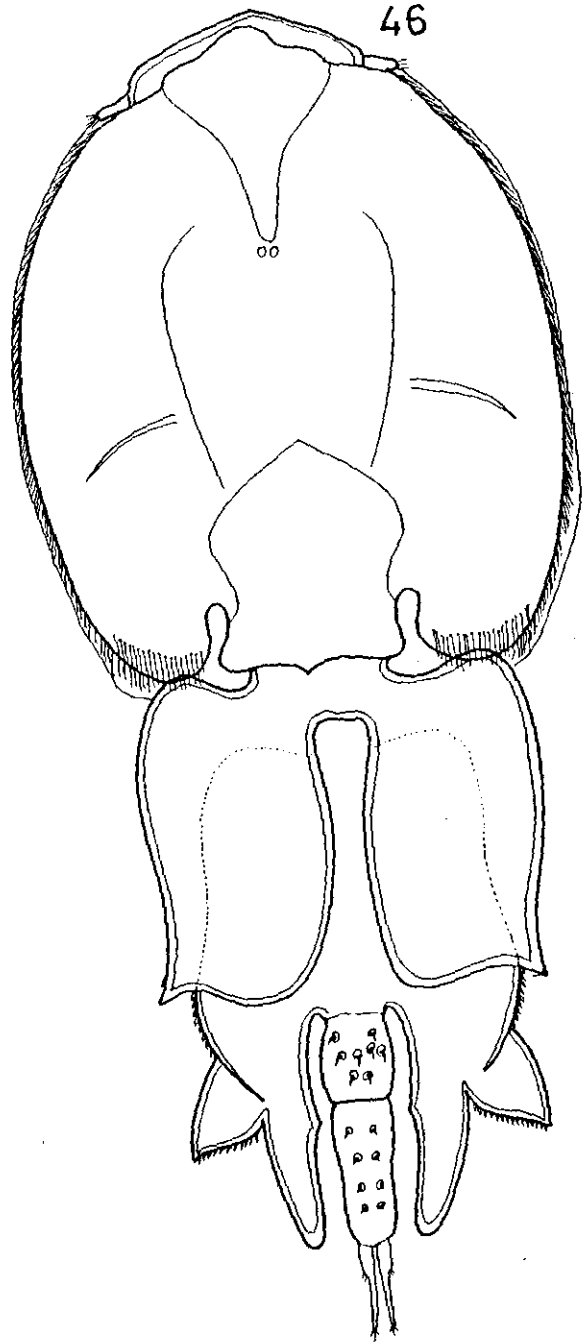
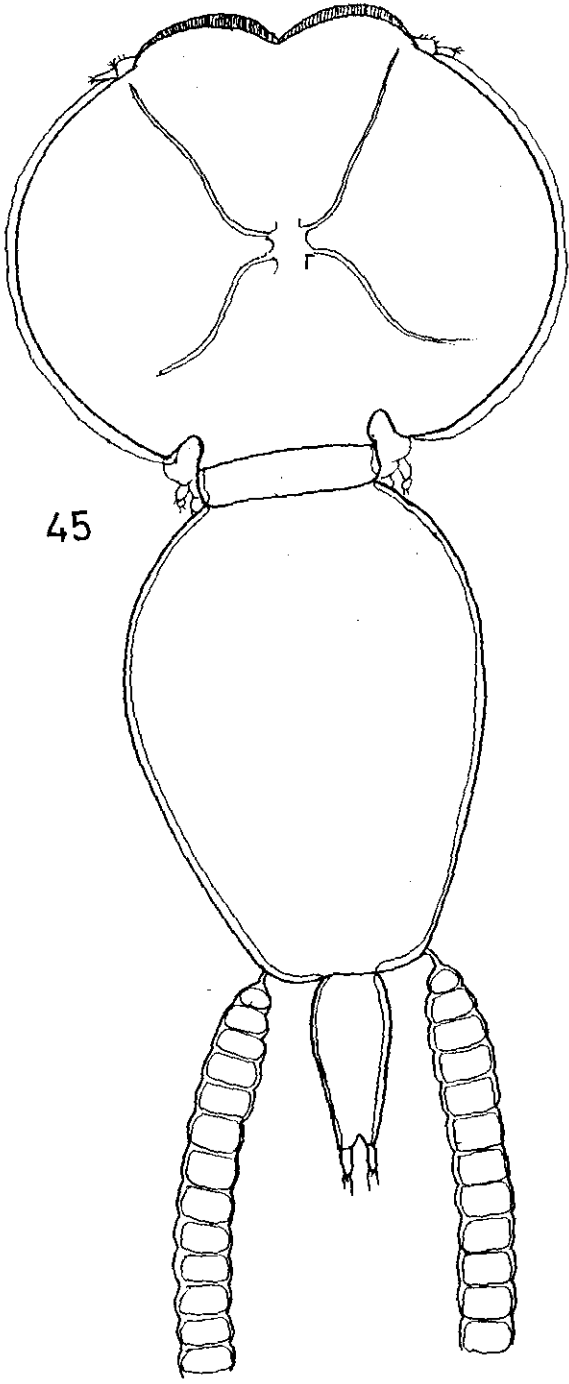
EXPLANATION OF FIGURES

Hermilius pseudari Hameed

45. Female, dorsal view

Gloipotes hygomianus Steenstrup and
Lutken.

46. Female, dorsal view



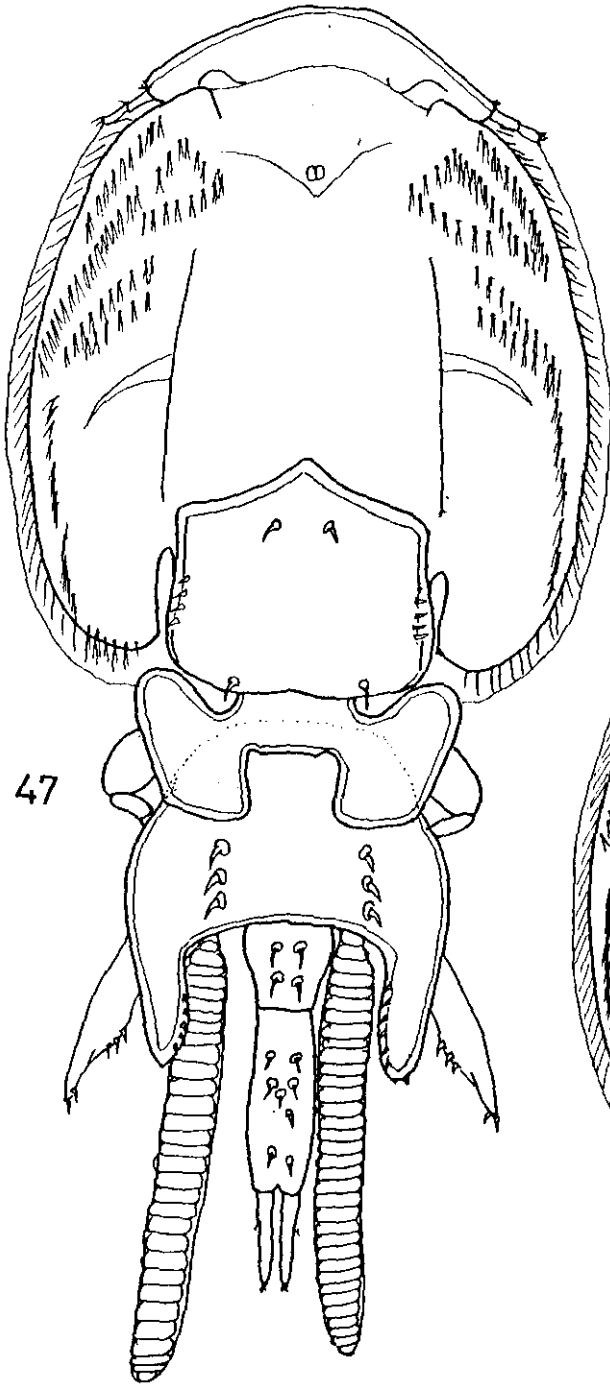
EXPLANATION OF FIGURES

Gloipotes huttoni Thomson

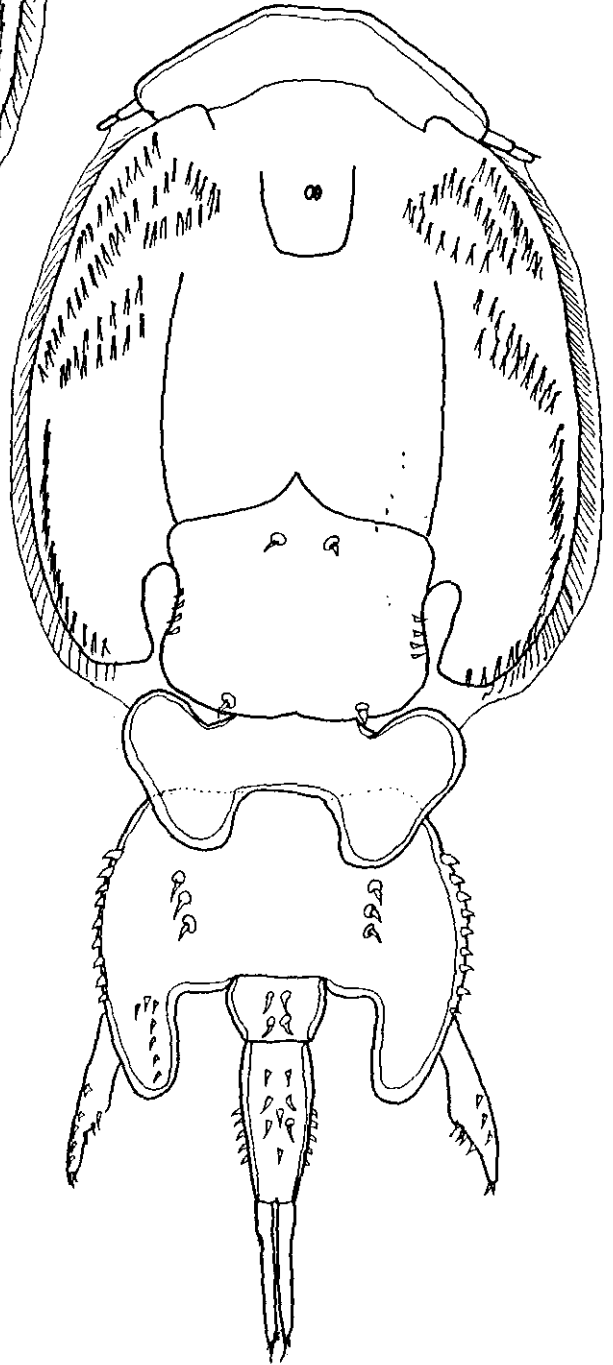
47. Female, dorsal view

Gloipotes watsoni Kirtisinghe

48. Female, dorsal view



48



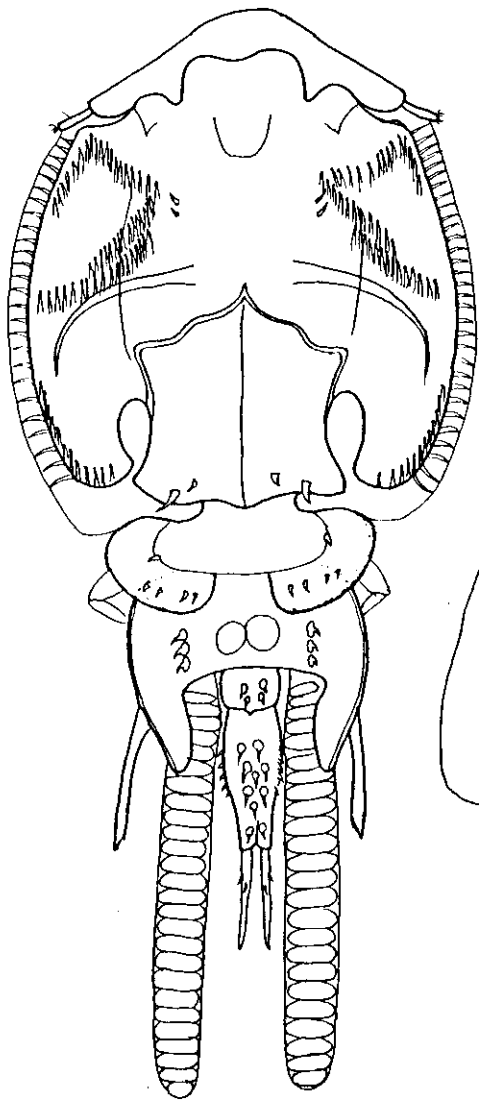
EXPLANATION OF FIGURES

Gloipotes indicus sp.nov.

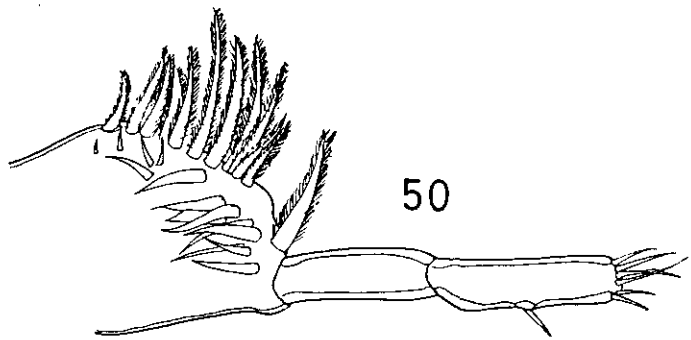
(Figs 49-62)

- 49. Female, dorsal view
- 50. First antenna
- 51. Second antenna
- 52. Post antennal process

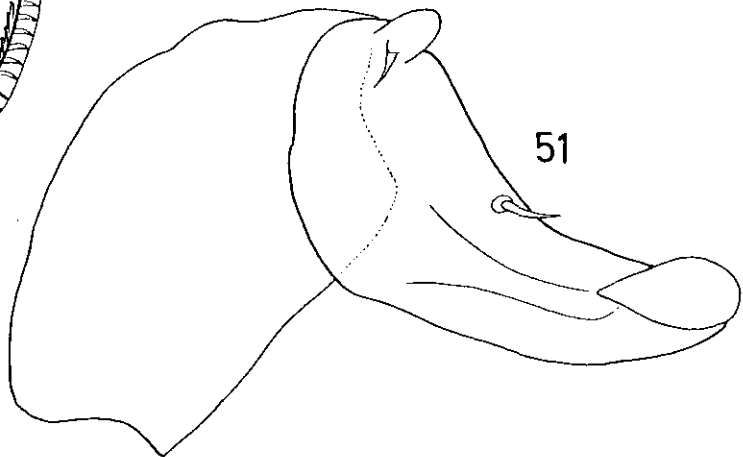
49



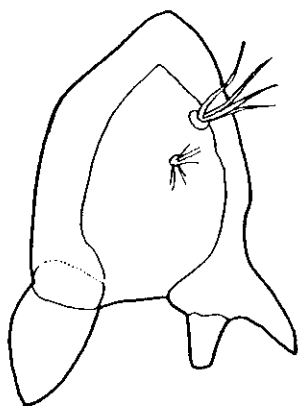
50



51



52



EXPLANATION OF FIGURES

Gloipotes indicus sp. nov.

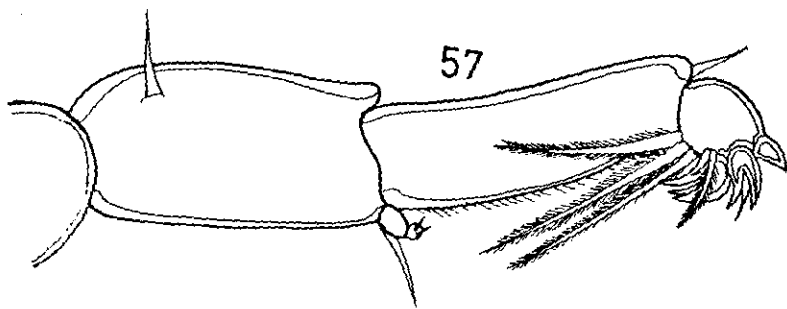
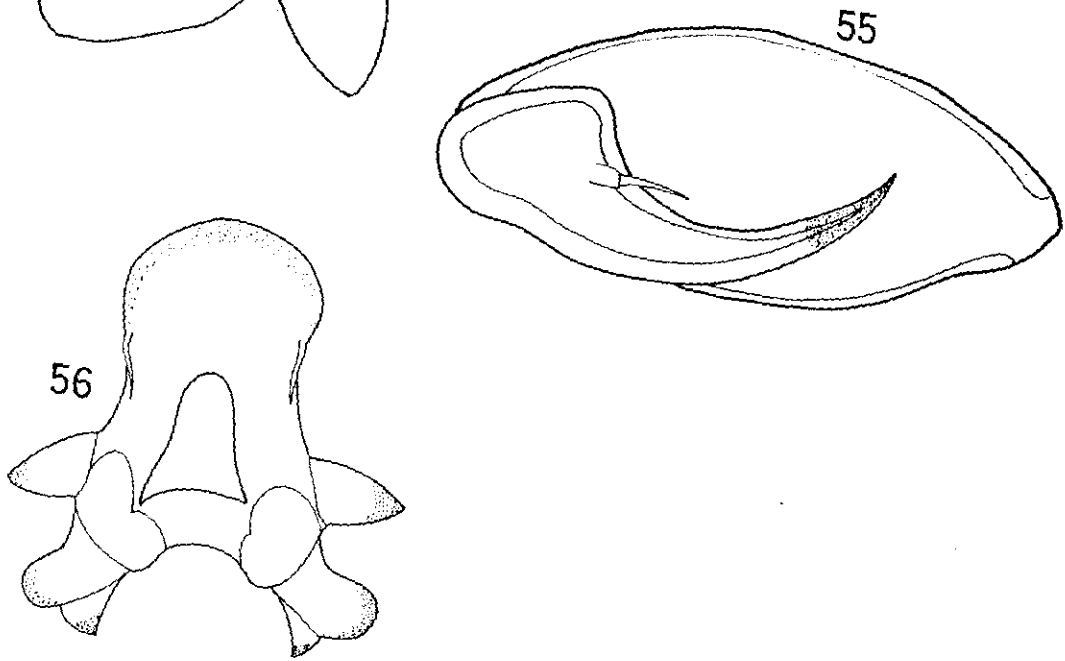
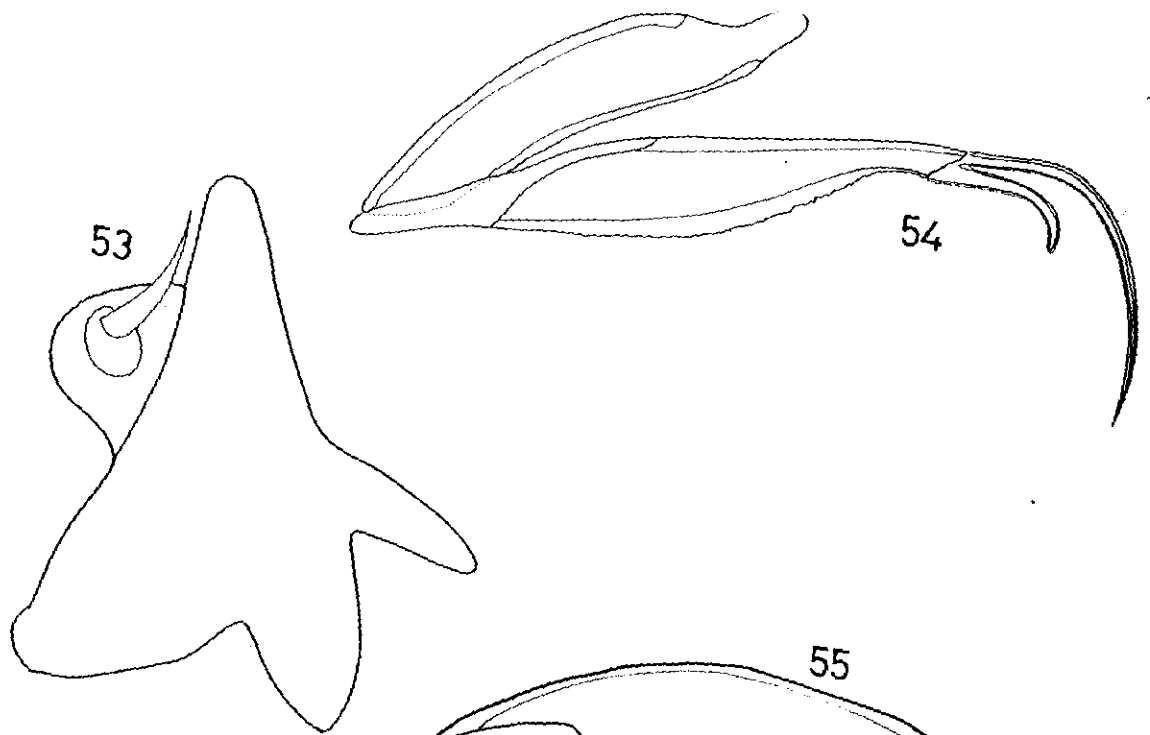
53. Post oral process

54. Maxilla

55. Maxilliped

56. Sternal furca

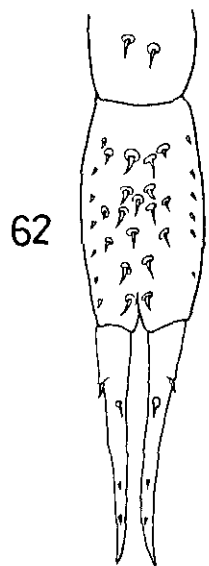
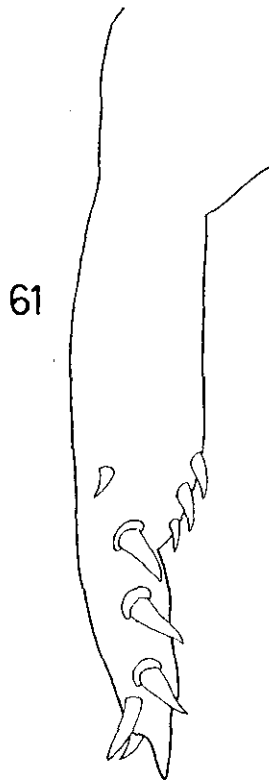
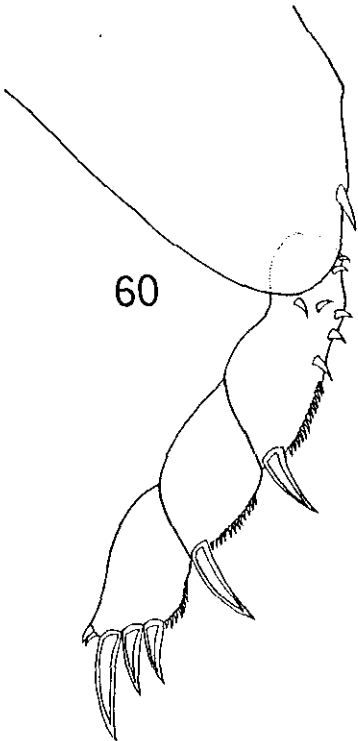
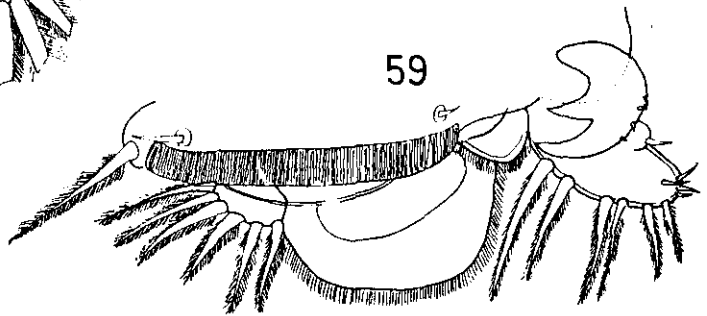
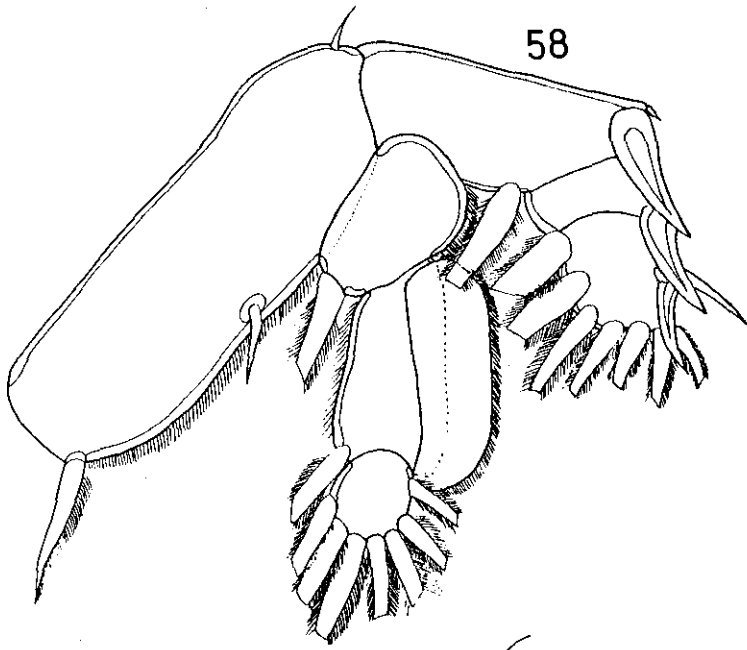
57. First leg



EXPLANATION OF FIGURES

Gloipotes indicus sp.nov.

- 58. Second leg
- 59. Third leg
- 60. Fourth leg
- 61. Fifth leg
- 62. Abdomen & Caudal rami

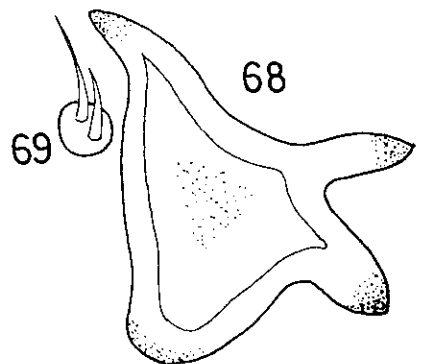
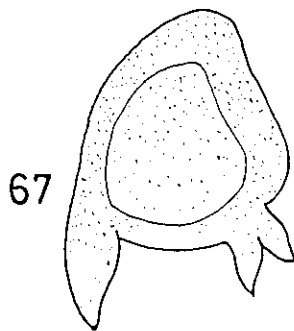
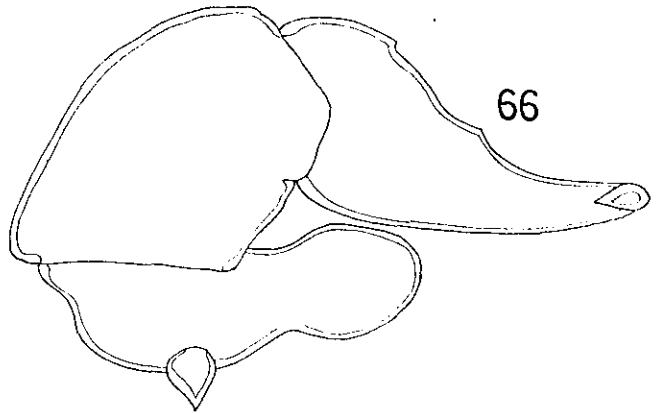
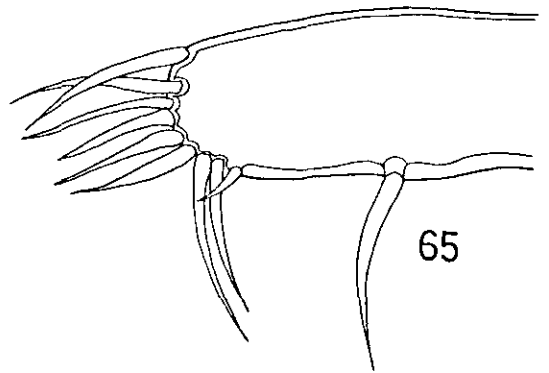
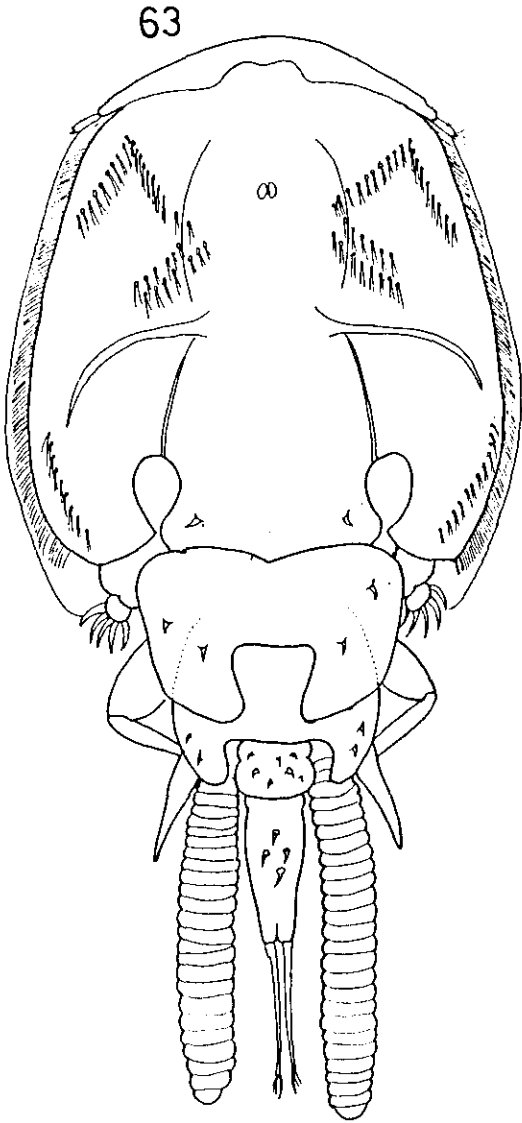
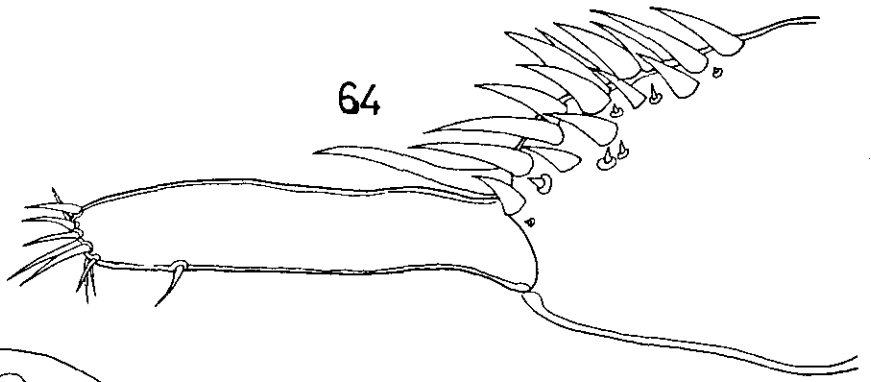


EXPLANATION OF FIGURES

Gloiopotes vulpinensis sp. nov.

(Fig. 63-78)

- 63. Female, dorsal view
- 64. First antenna
- 65. Same, tip enlarged
- 66. Second antenna
- 67. Post antennal process
- 68. Post oral process
- 69. First maxilla



69

EXPLANATION OF FIGURES

Gloipotes vulpinensis sp. nov.

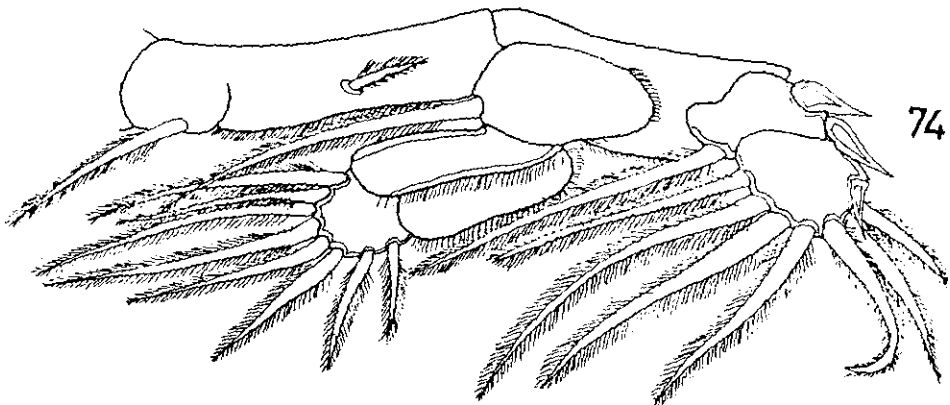
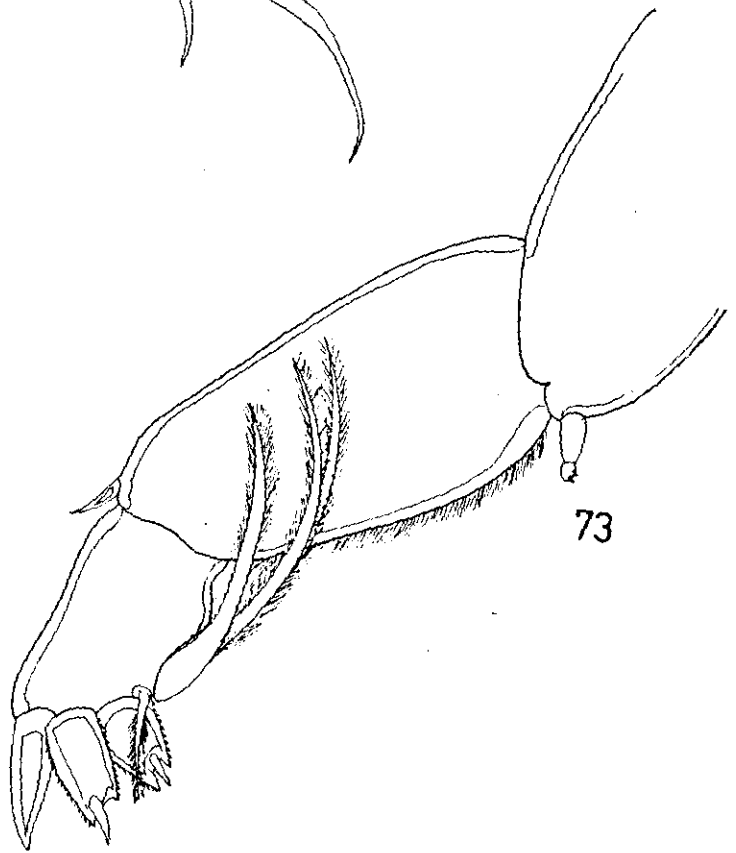
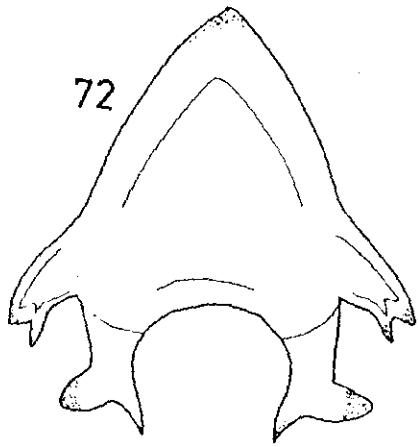
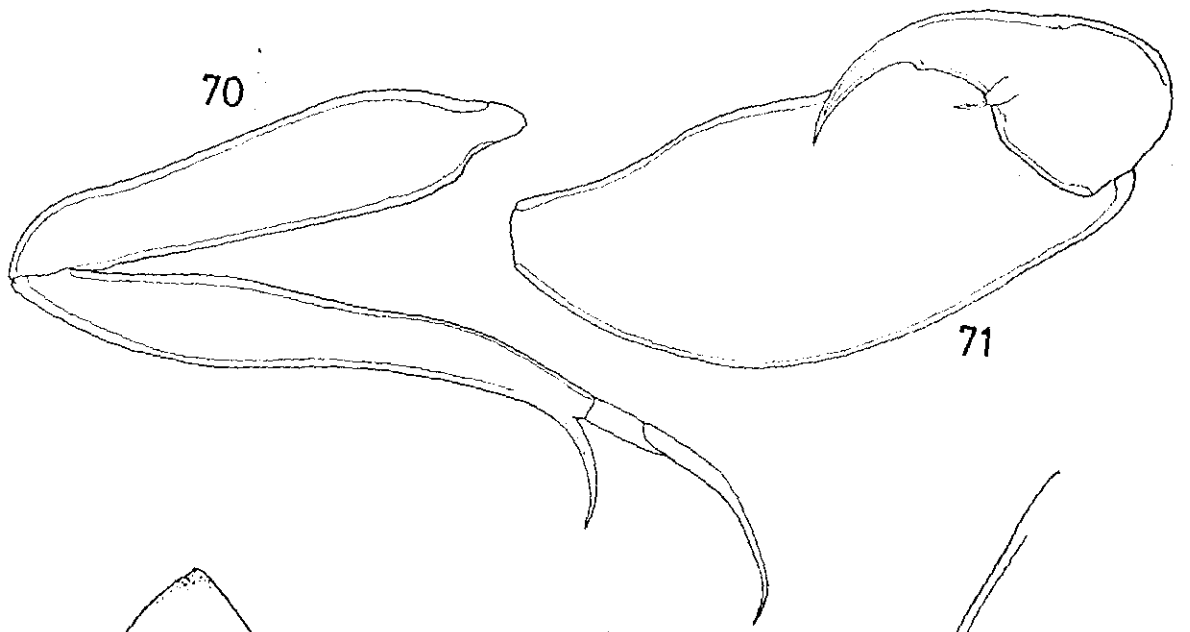
70. Second maxilla

71. Maxilliped

72. Sternal furca

73. First leg

74. Second leg



EXPLANATION OF FIGURES

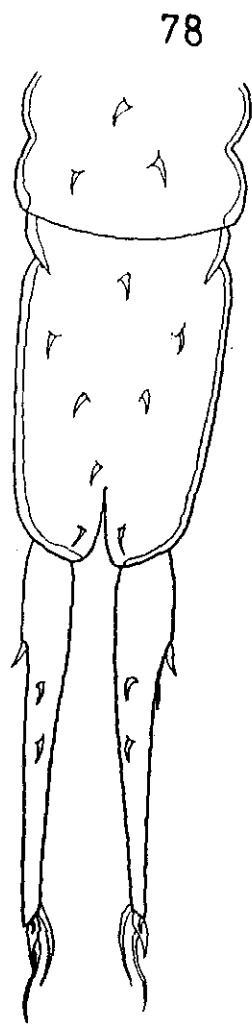
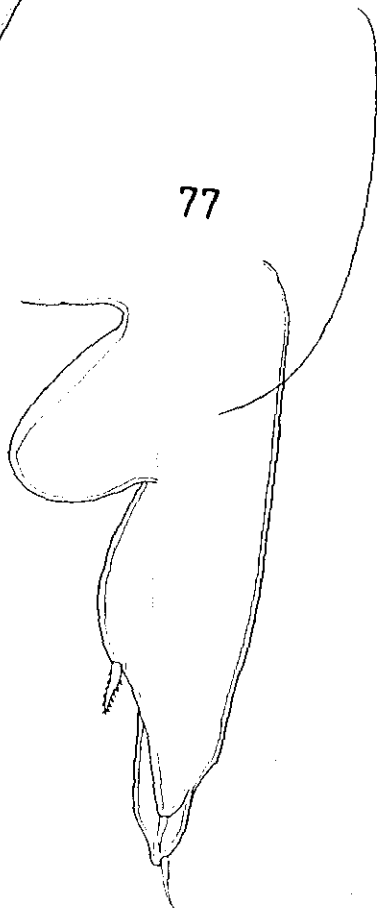
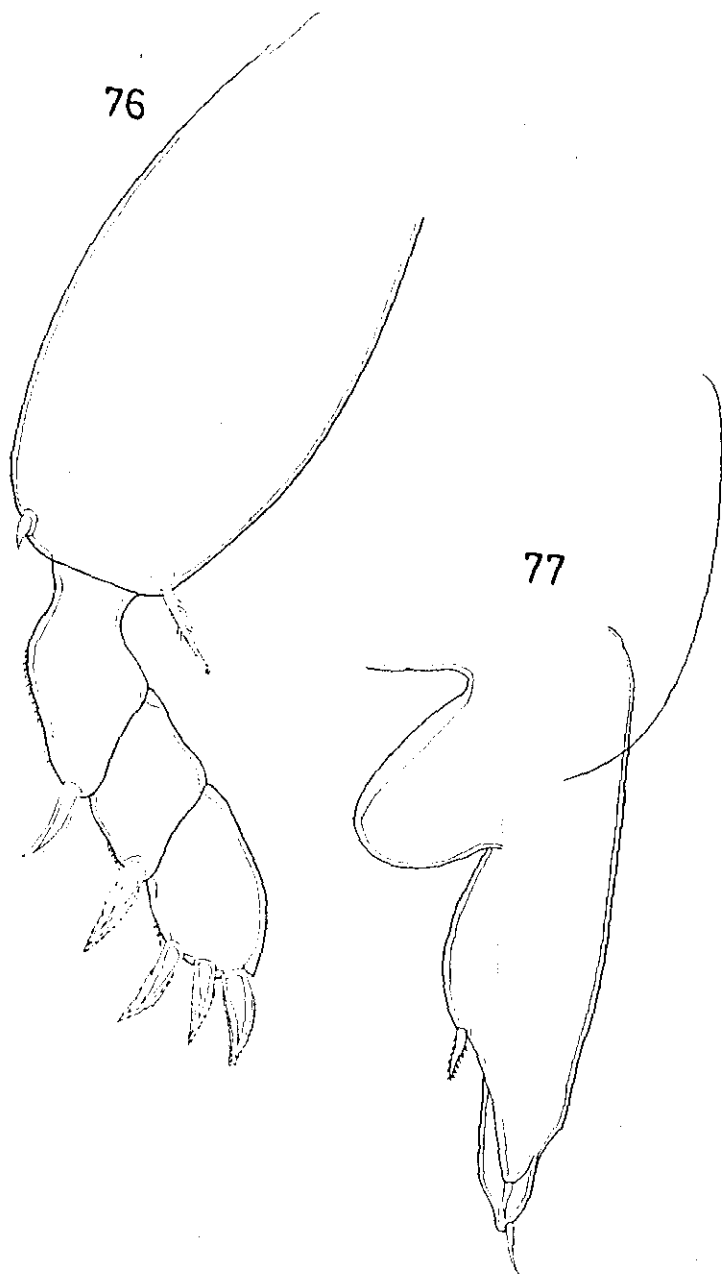
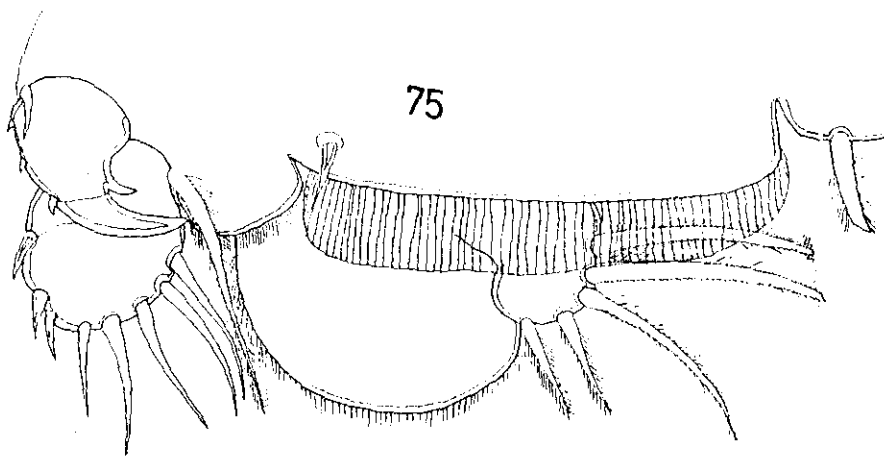
Gloipotes vulpinensis sp.nov.

75. Third leg

76. Fourth leg

77. Fifth leg

78. Abdomen and Caudal rami



EXPLANATION OF FIGURES

Alebion carchariae Kroyer

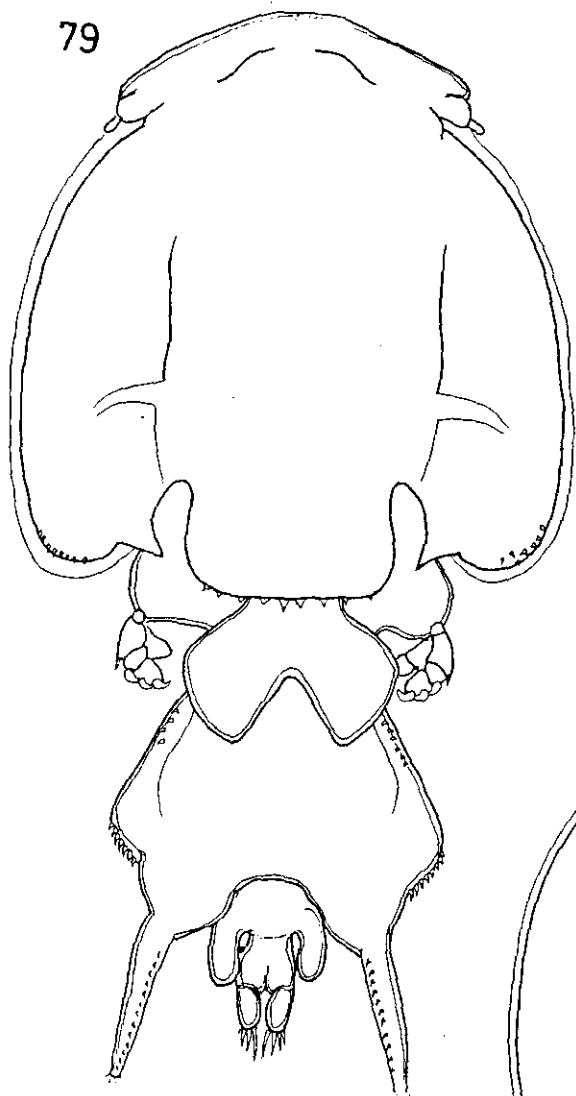
79. Female, dorsal view

Alebion walbei sp. nov.

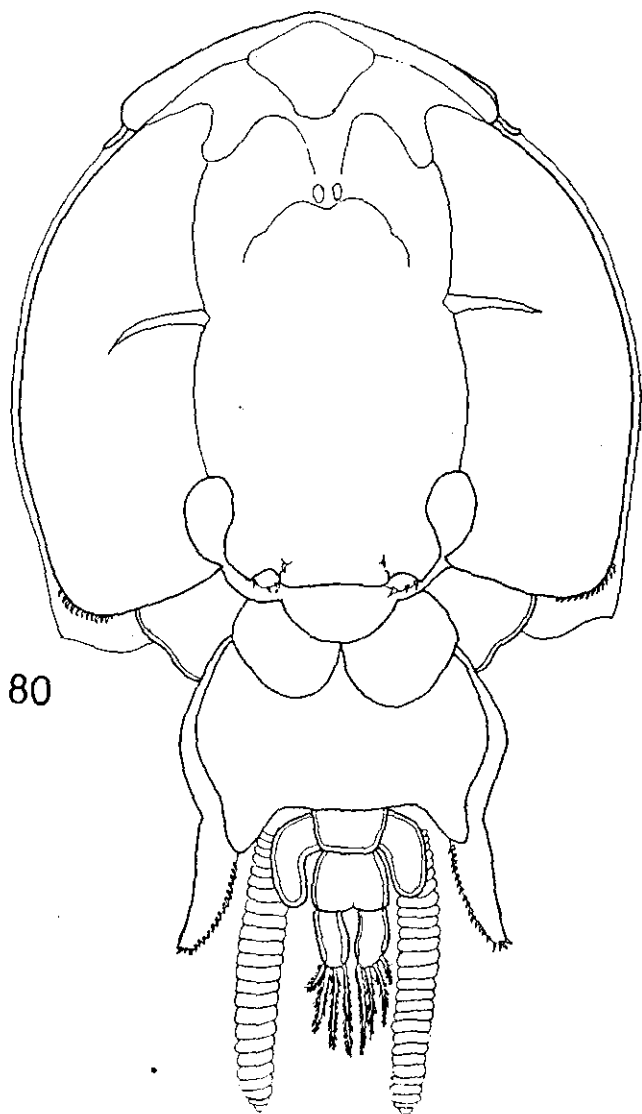
(Figs. 80- 89)

80. Female, dorsal view

79



80

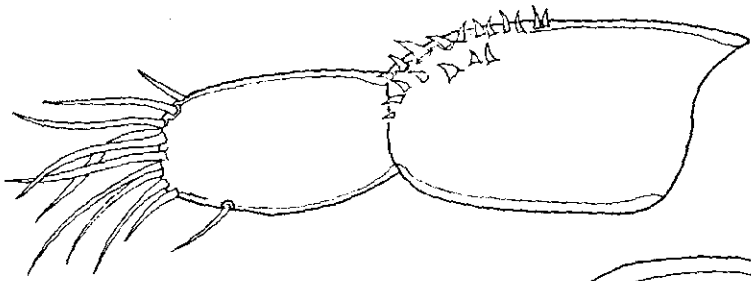


EXPLANATION OF FIGURES

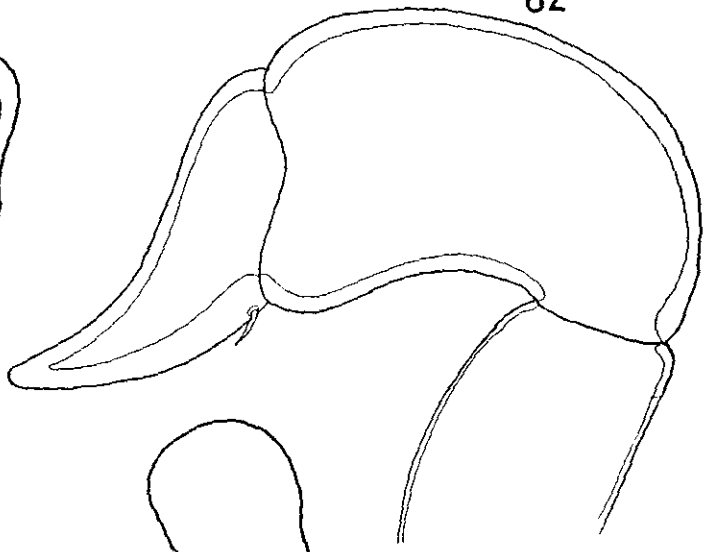
Alebion walbei sp. nov.

- 81. First antenna
- 82. Second antenna
- 83. Mandible
- 84. Maxilla
- 85. Maxilliped
- 86. First leg

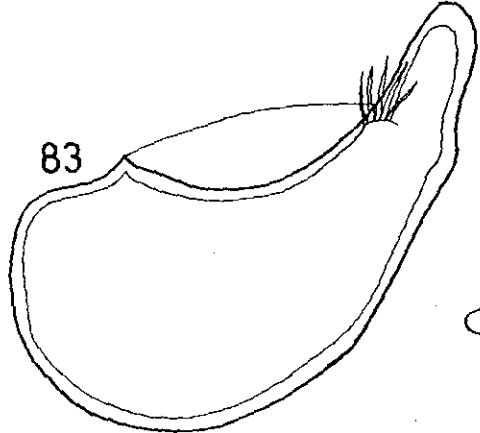
81



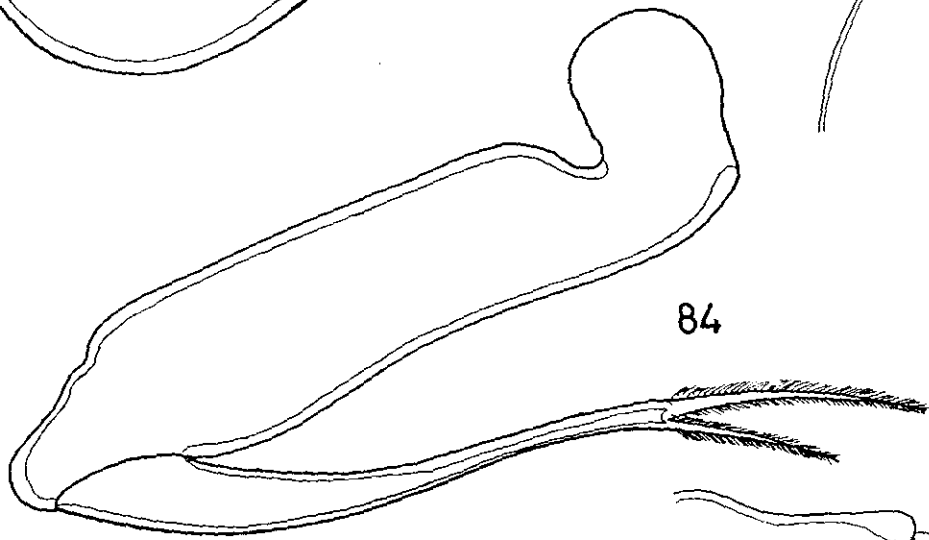
82



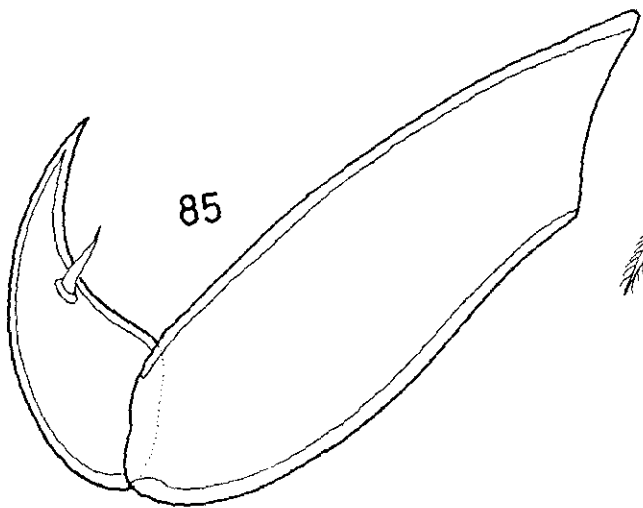
83



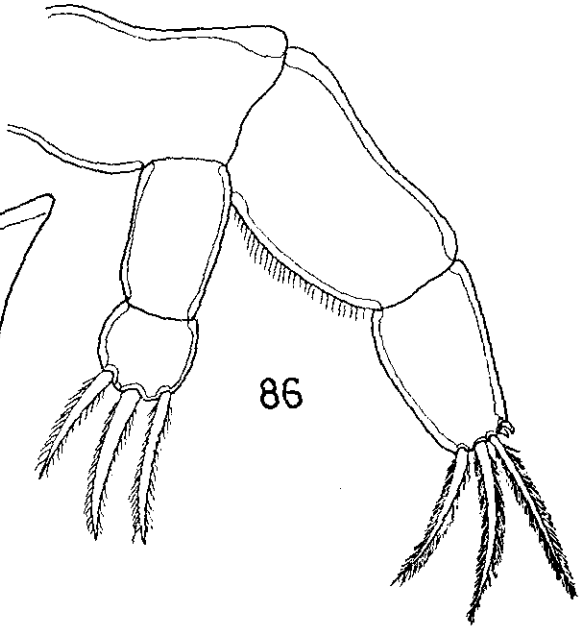
84



85



86



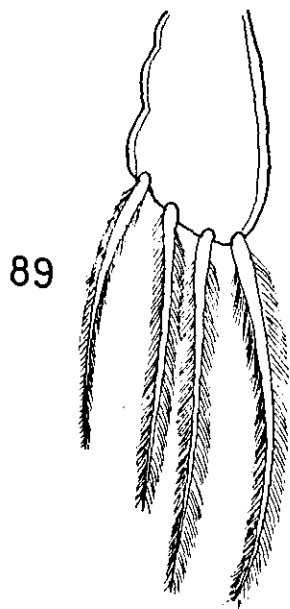
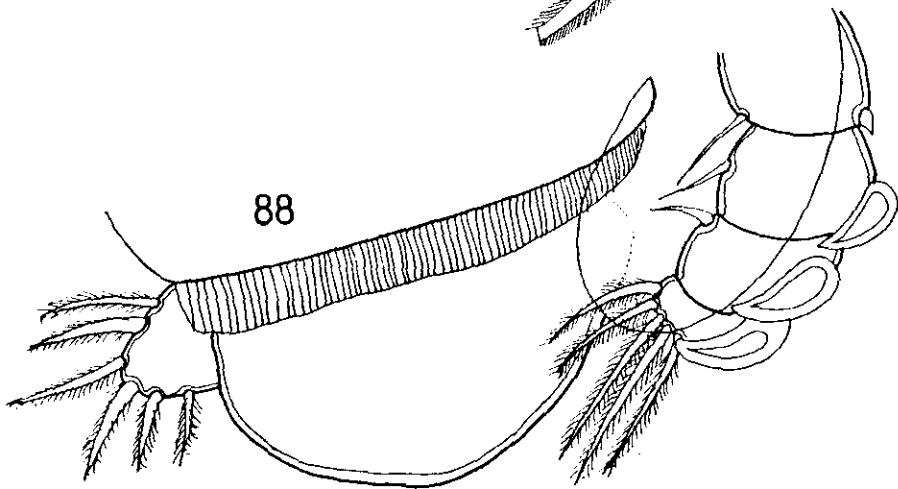
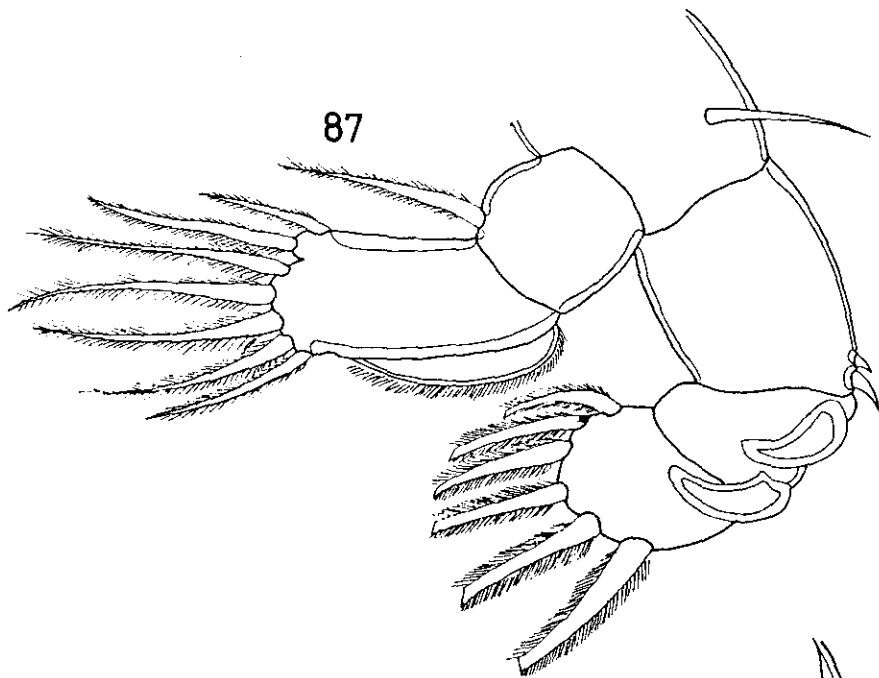
EXPLANATION OF FIGURES

Alebion walbei sp. nov.

87. Second leg

88. Third leg

89. Caudal rami



EXPLANATION OF FIGURES

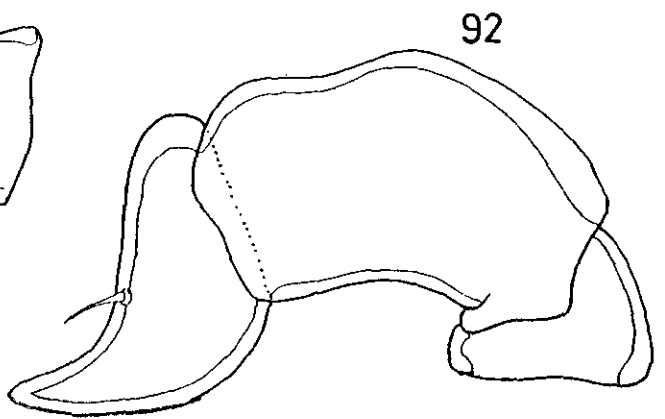
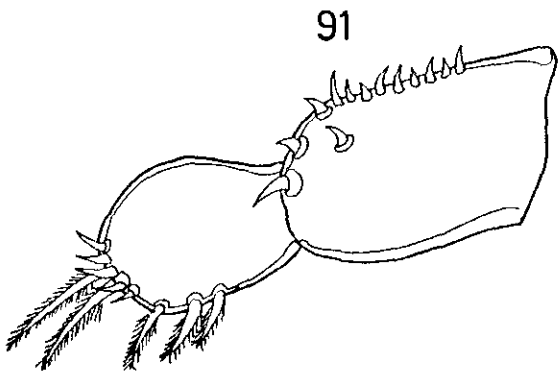
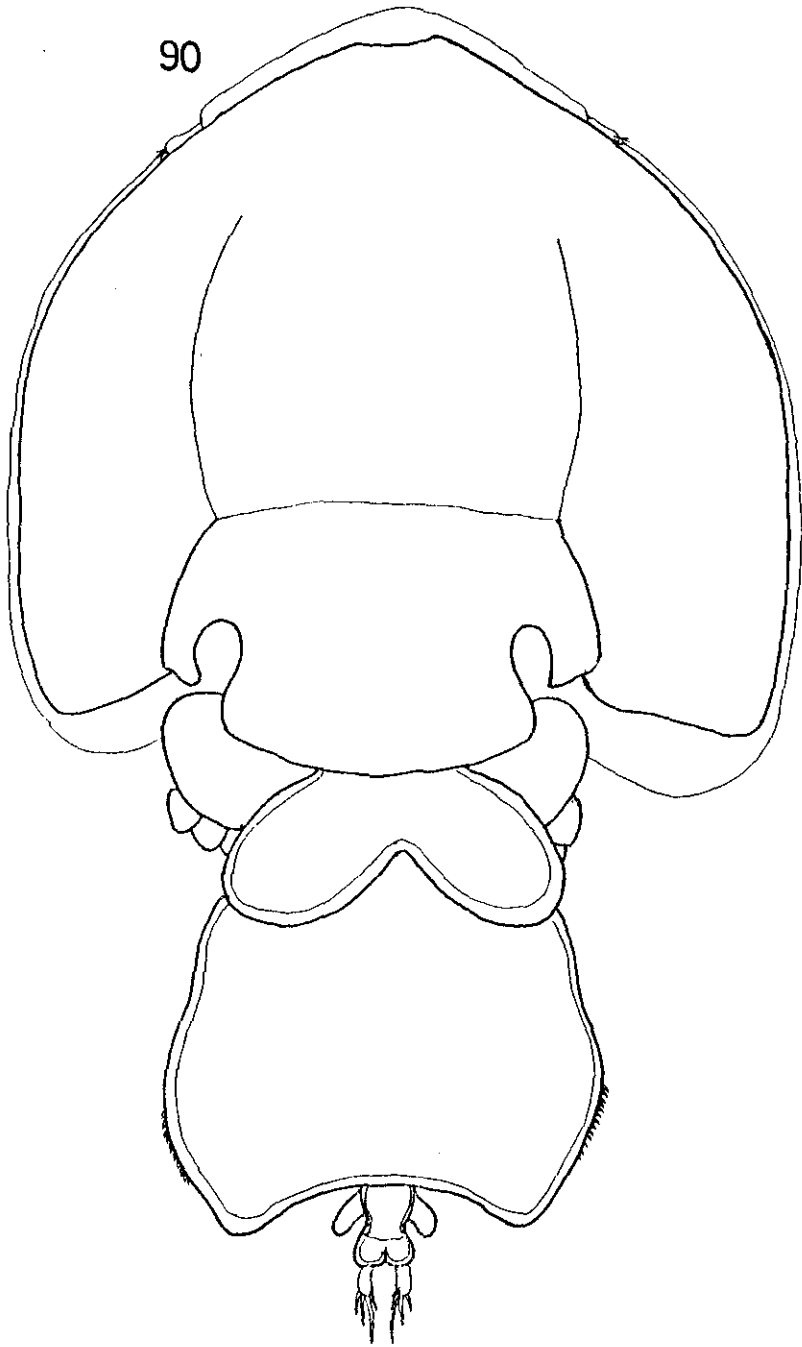
Alebion eulami sp. nov.

(Figs. 90-98)

90. Female, dorsal view

91. First antenna

92. Second antenna

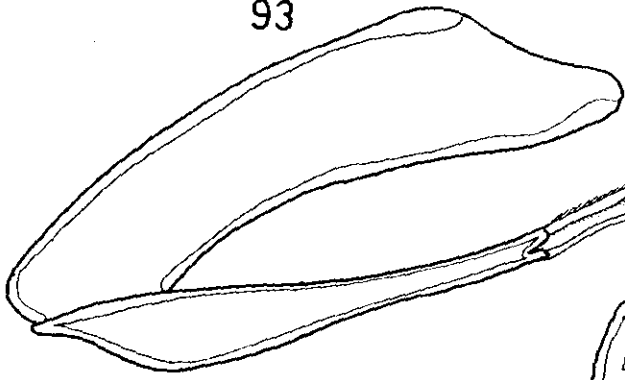


EXPLANATION OF FIGURES

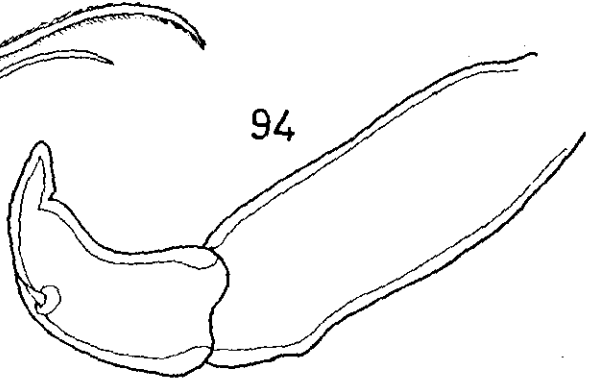
Alebion eulami sp. nov.

- 93. Maxilla
- 94. Maxilliped
- 95. First leg
- 96. Second leg
- 97. Third leg
- 98. Caudal lamina

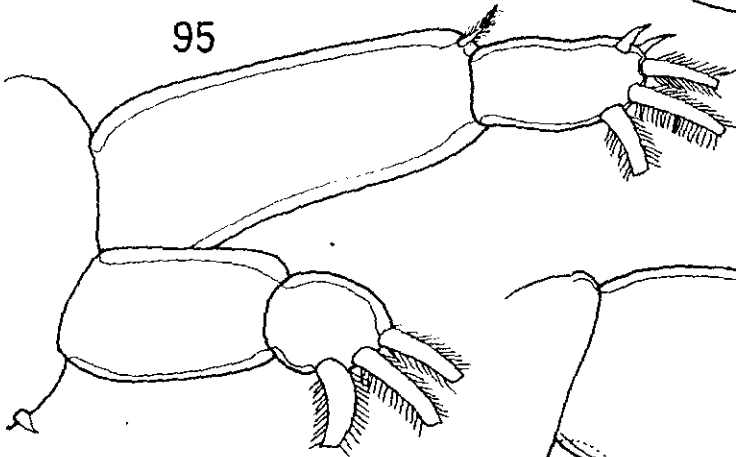
93



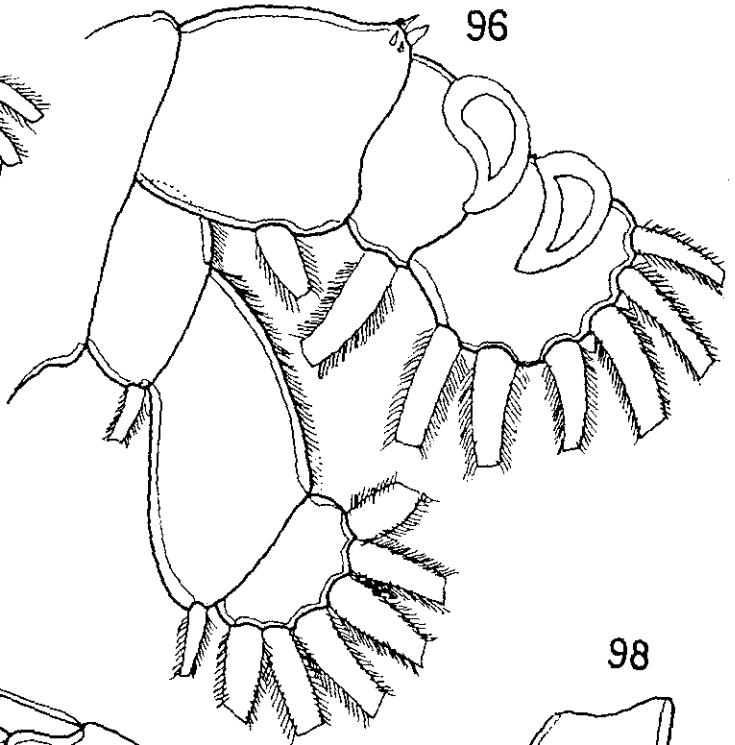
94



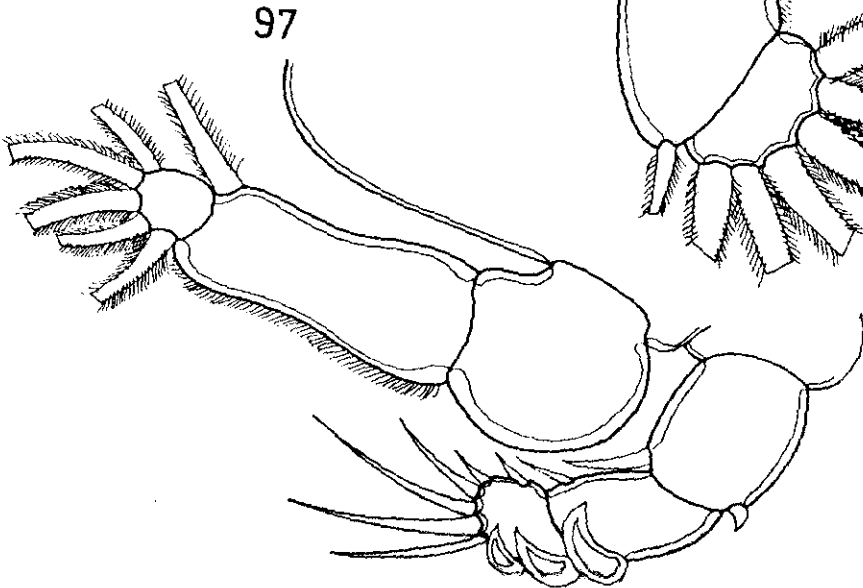
95



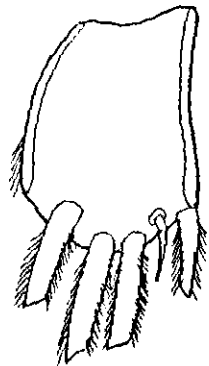
96



97



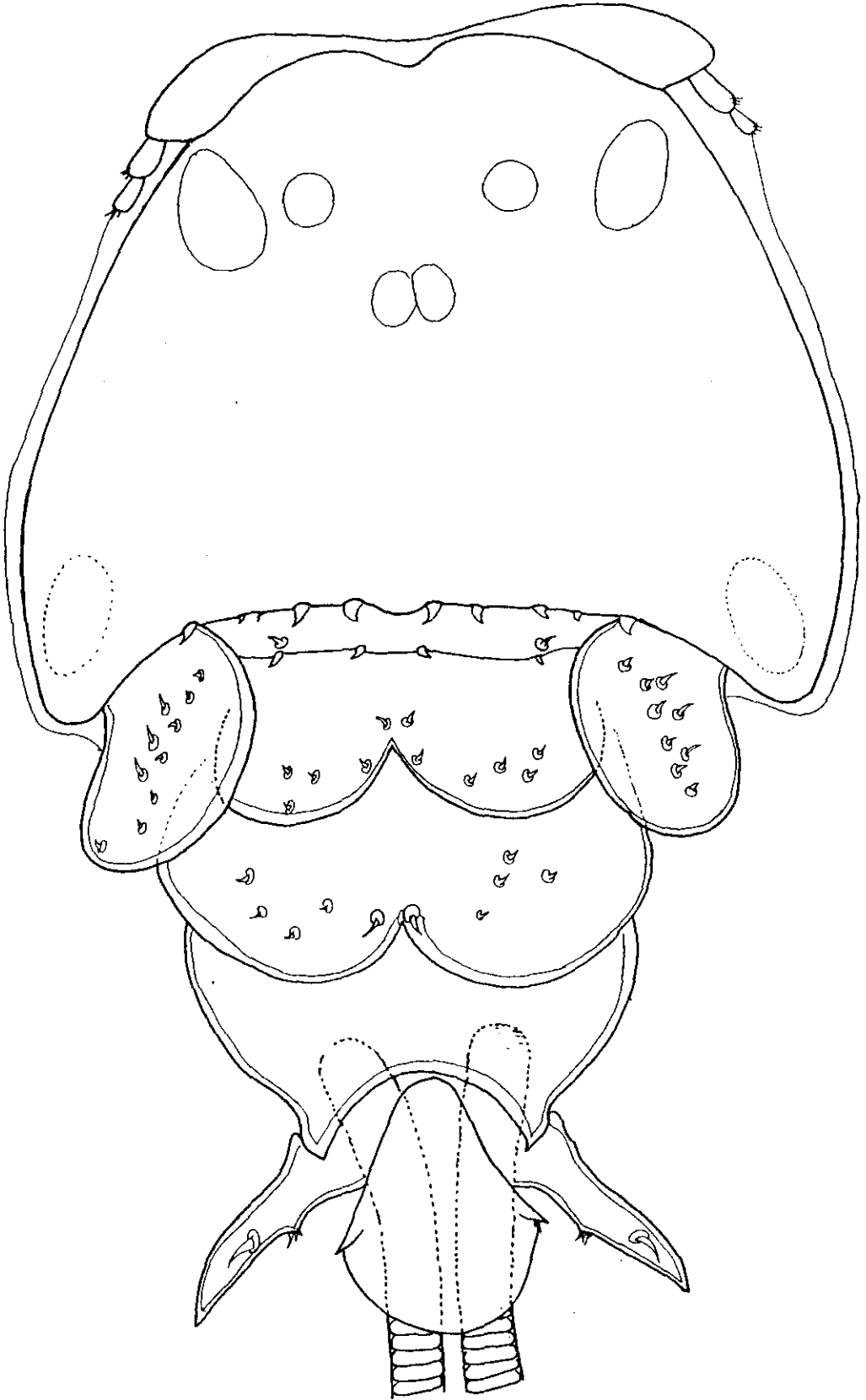
98



EXPLANATION OF FIGURES

Pandarus cranchii Leach

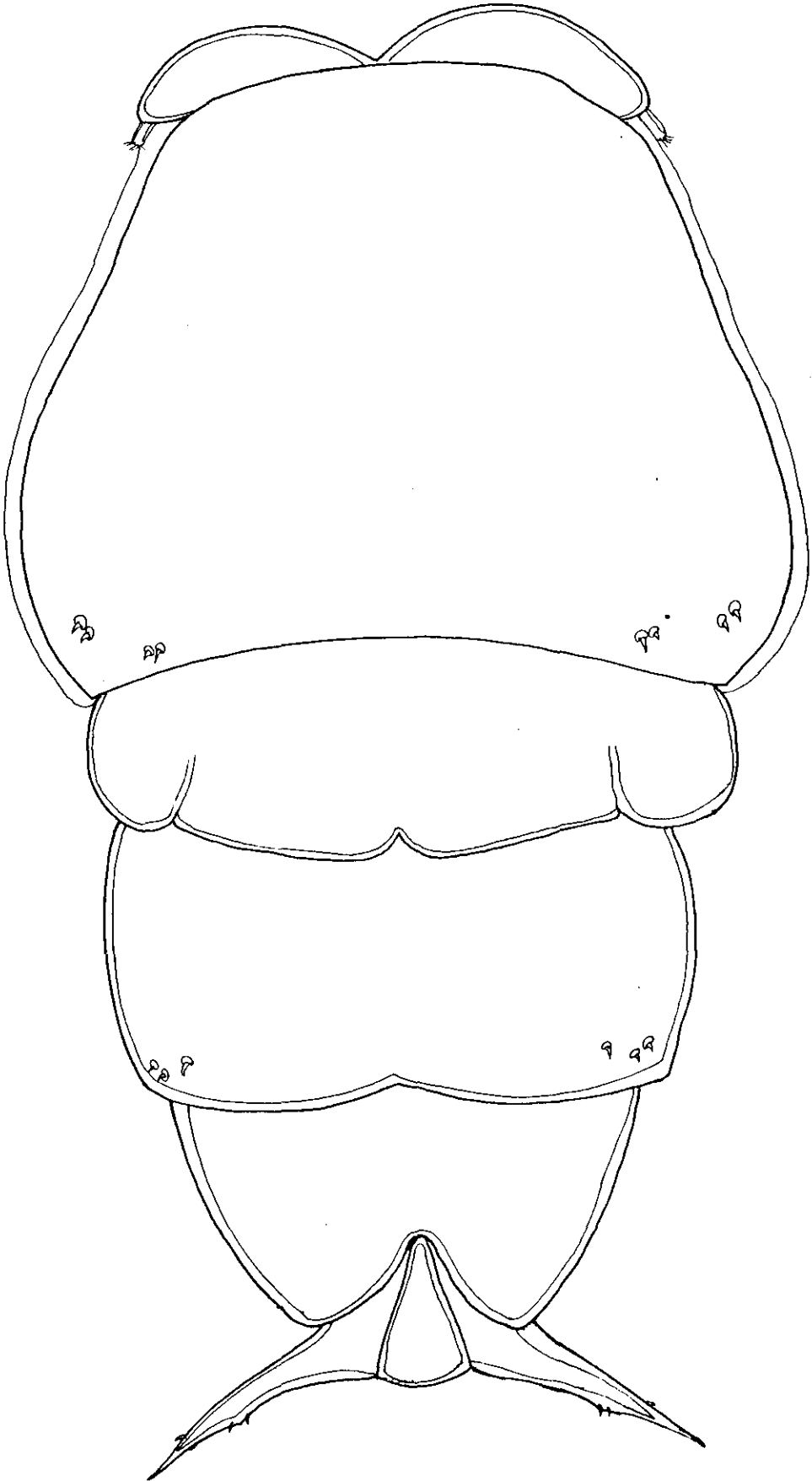
99. Female, dorsal view



EXPLANATION OF FIGURES

Pandarus niger Kirtisinghe

100. Female, dorsal view



EXPLANATION OF FIGURES

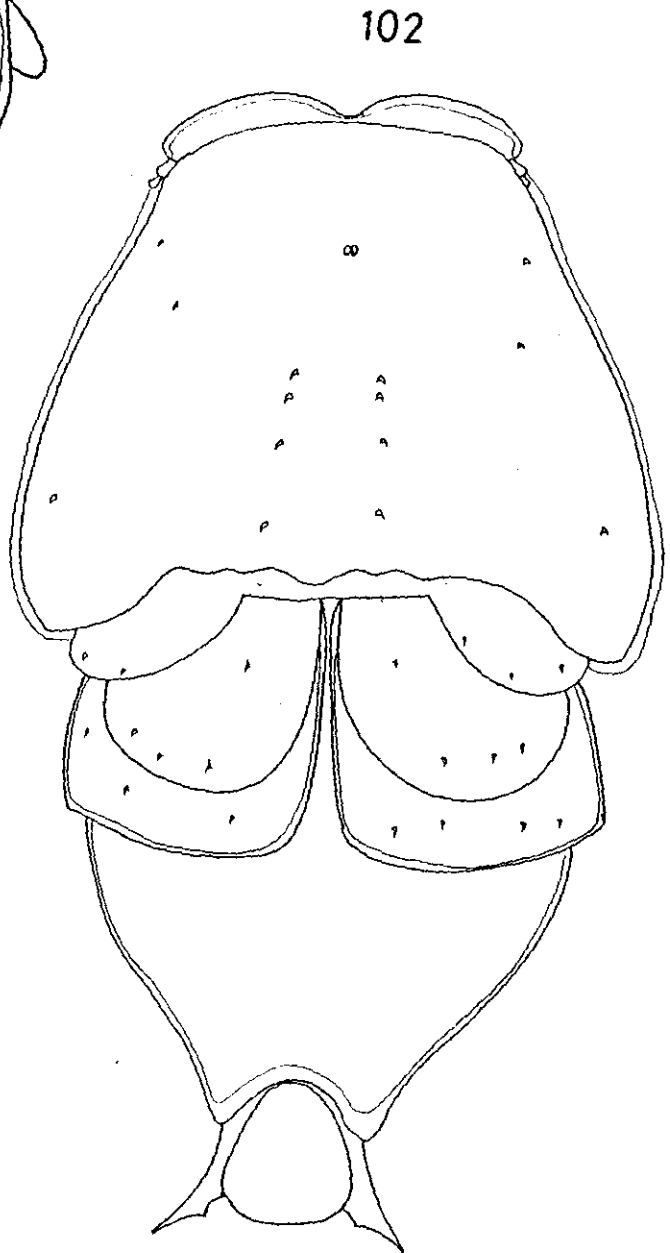
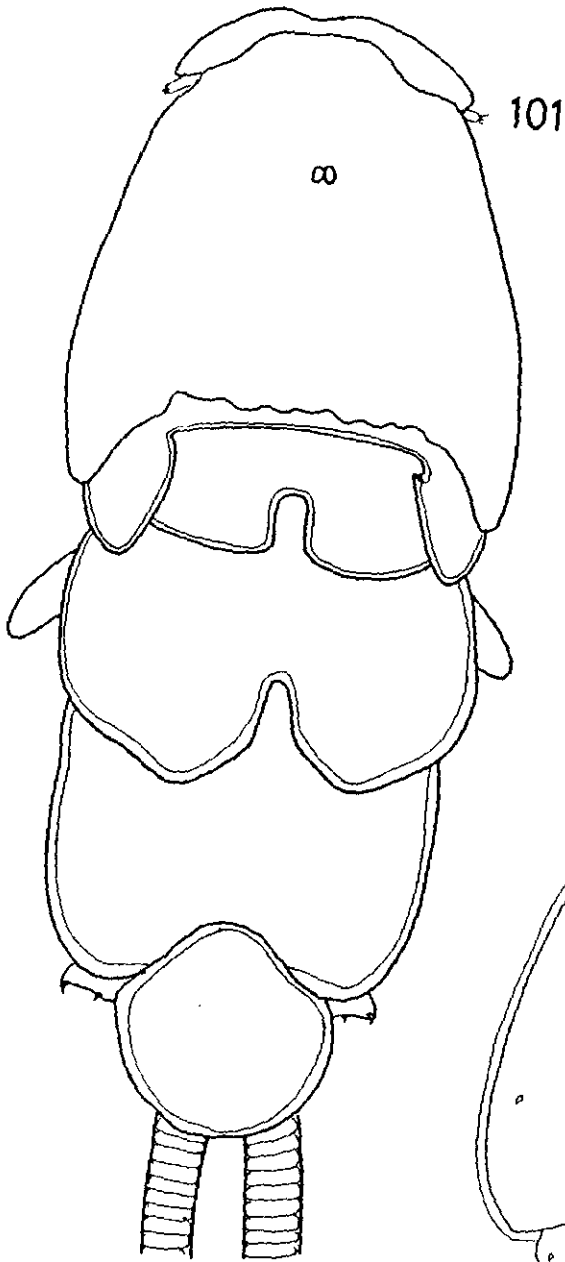
Pandarus bicolor Leach

101. Female, dorsal view

Pandarus sphyрни sp. nov.

(Figs. 102-110)

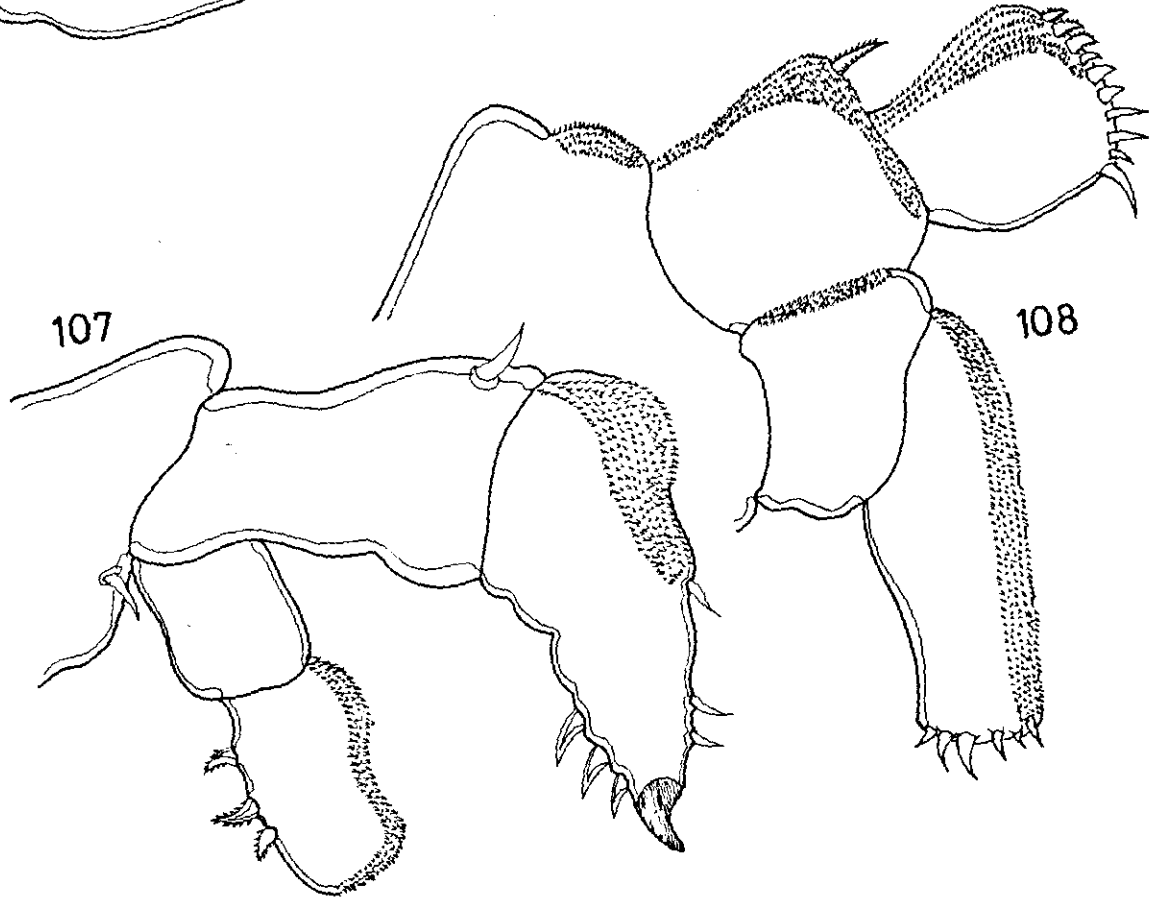
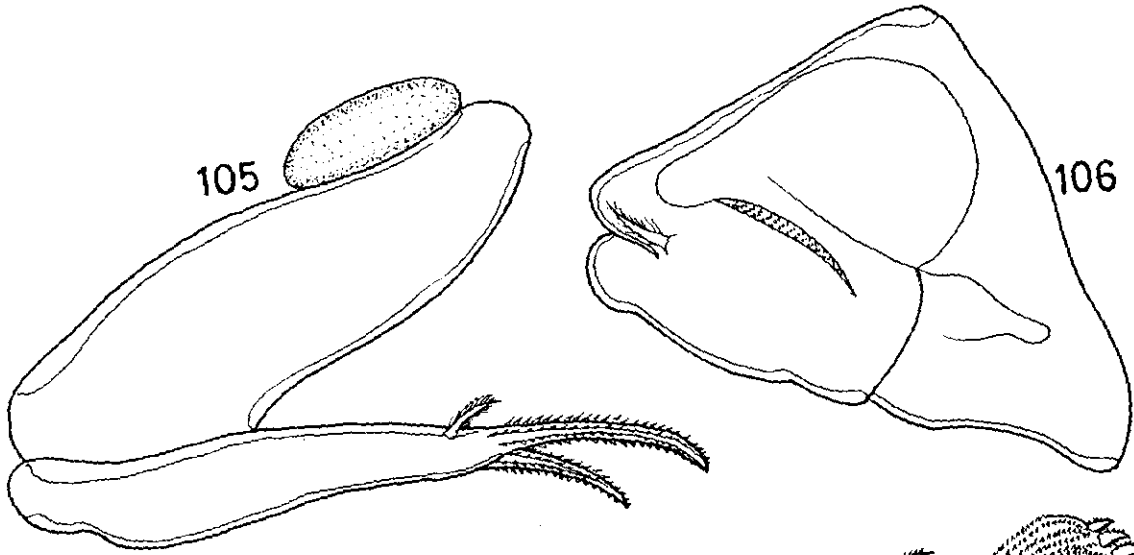
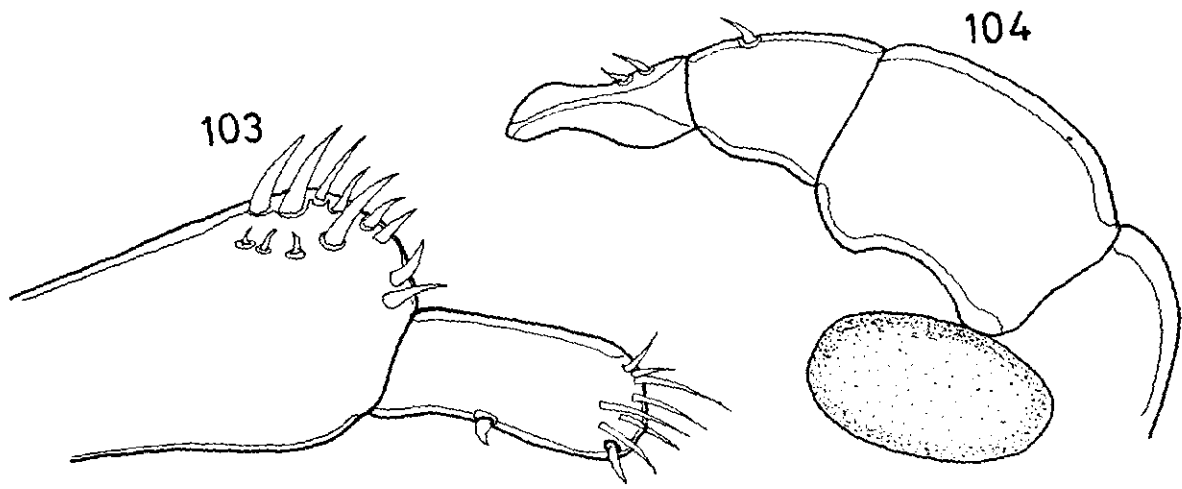
102. Female, dorsal view



EXPLANATION OF FIGURES

Pandarus sphyрни sp.nov.

- 103. First antenna
- 104. Second antenna
- 105. Maxilla
- 106. Maxilliped
- 107. First leg
- 108. Second leg



EXPLANATION OF FIGURES

Pandarus sphyrni sp. nov.

109. Third leg

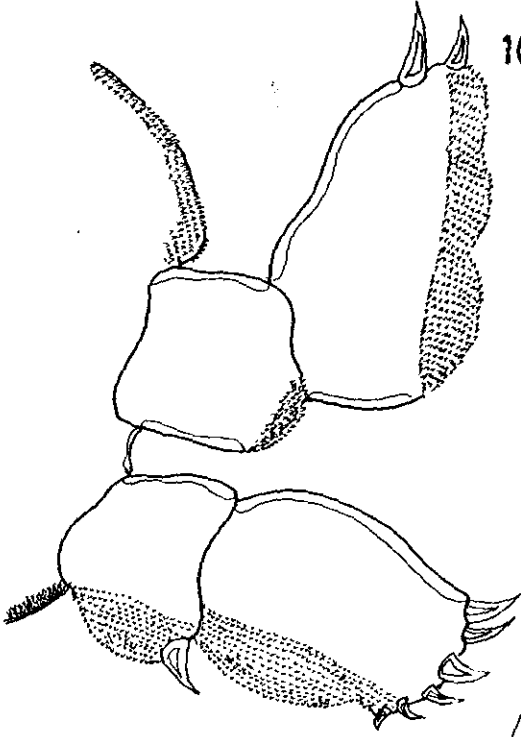
110. Fourth leg

Pandarus eulami sp. nov.

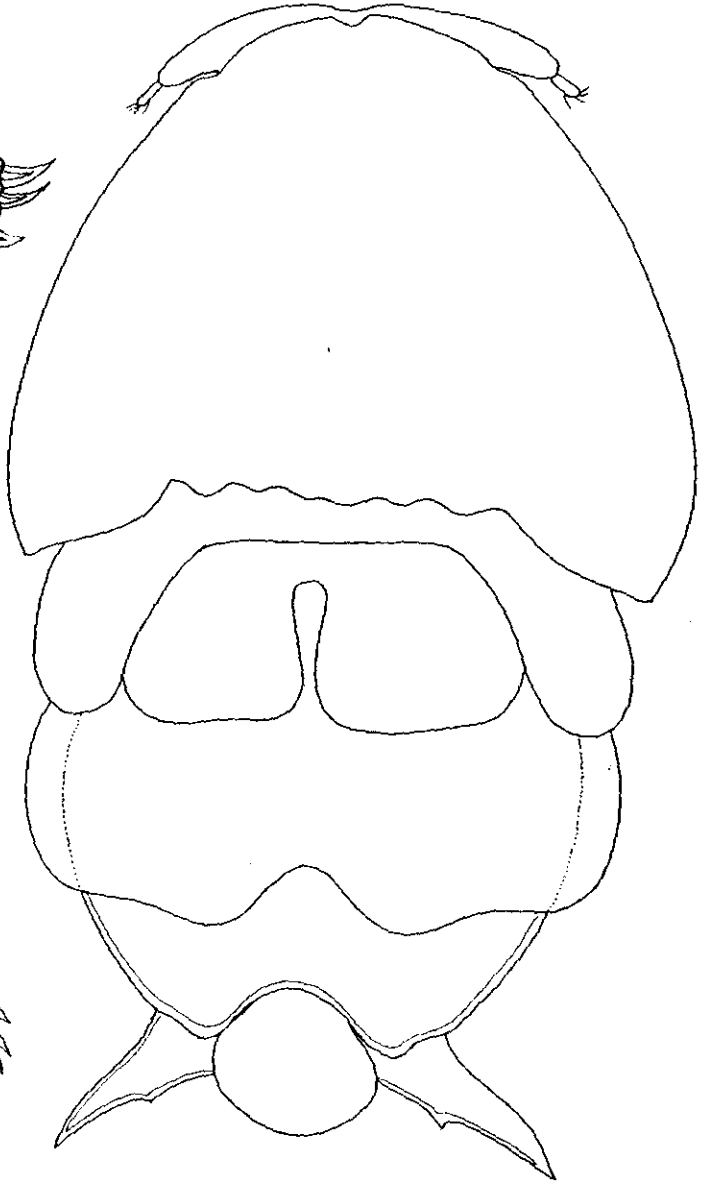
(Figs. 111-121)

111. Female, dorsal view

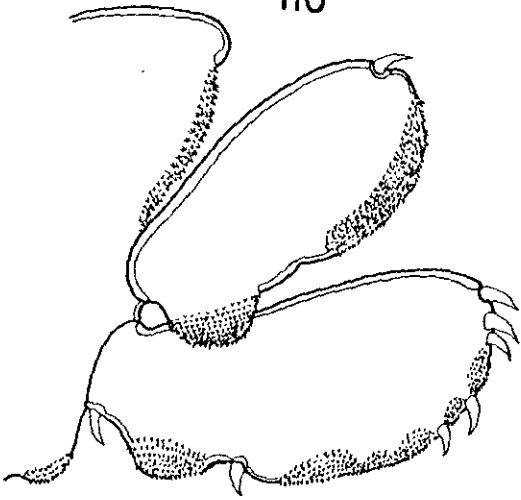
109



111



110



EXPLANATION OF FIGURES

Pandarus eulami sp. nov.

112. First antenna

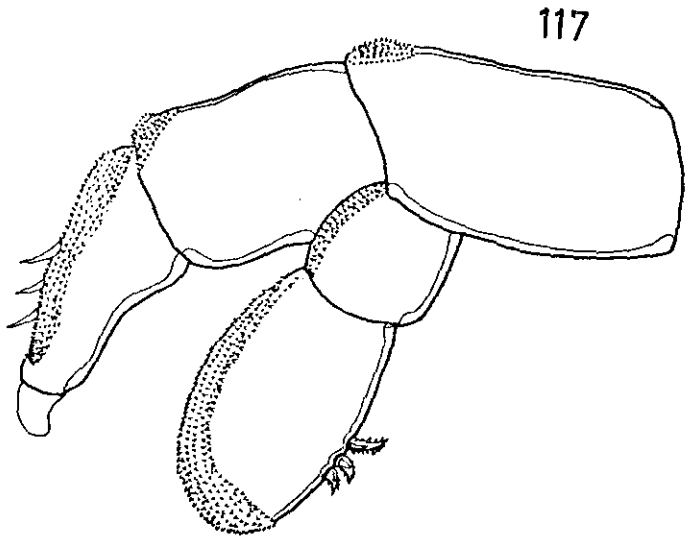
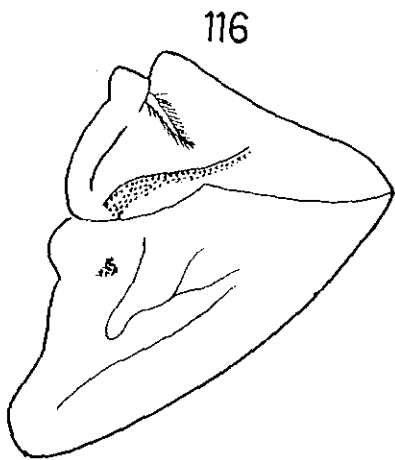
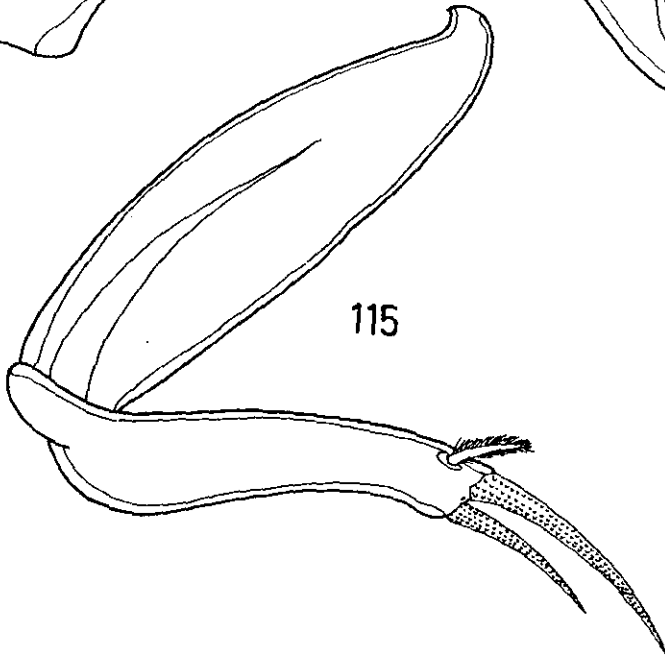
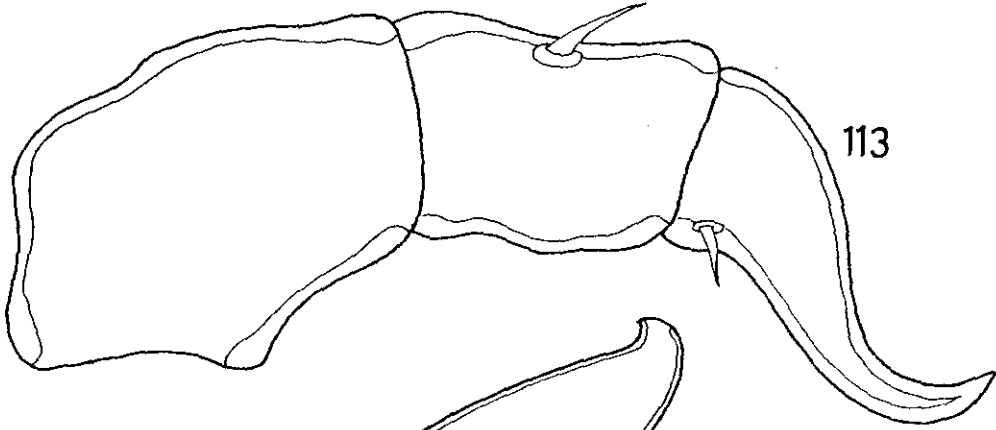
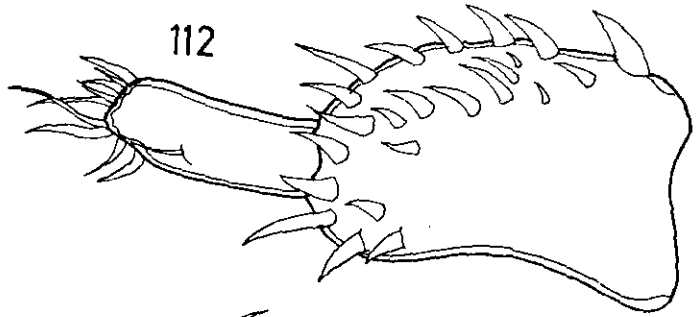
113. Second antenna

114. Mandible

115. Maxilla

116. Maxilliped

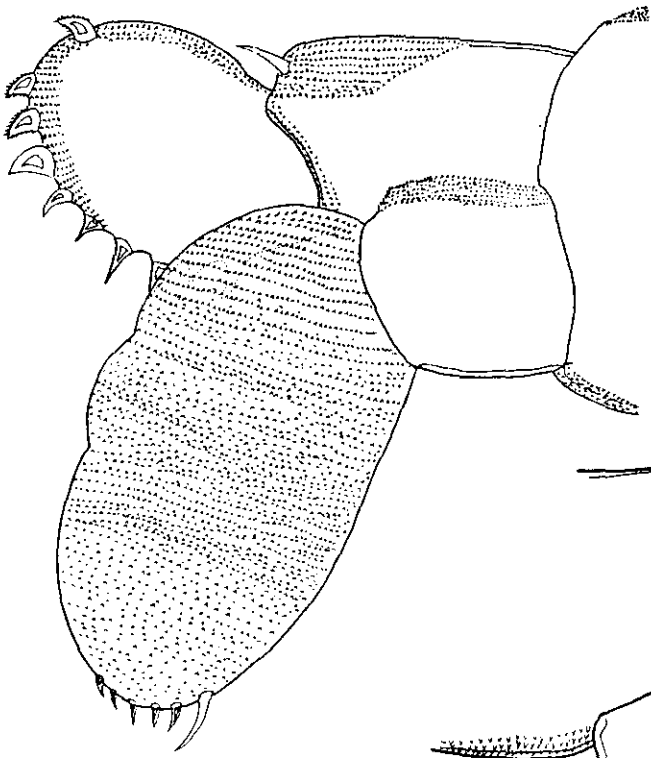
117. First Leg



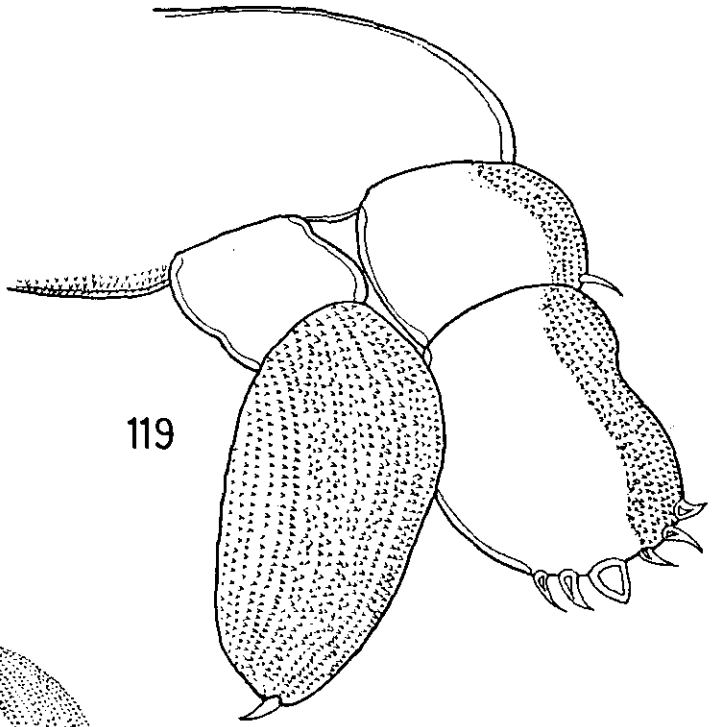
EXPLANATION OF FIGURES

Pandarus eulami sp. nov.

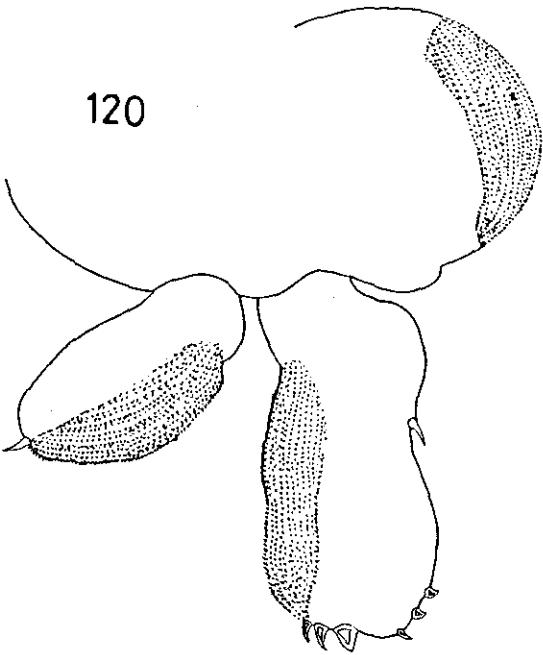
- 118. Second leg
- 119. Third leg
- 120. Fourth leg
- 121. Caudal rami



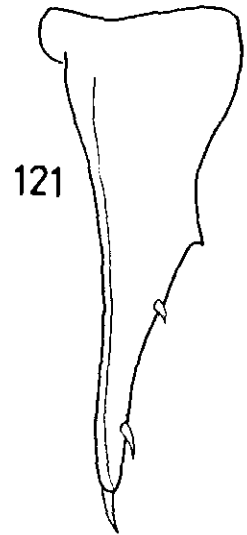
118



119



120



121

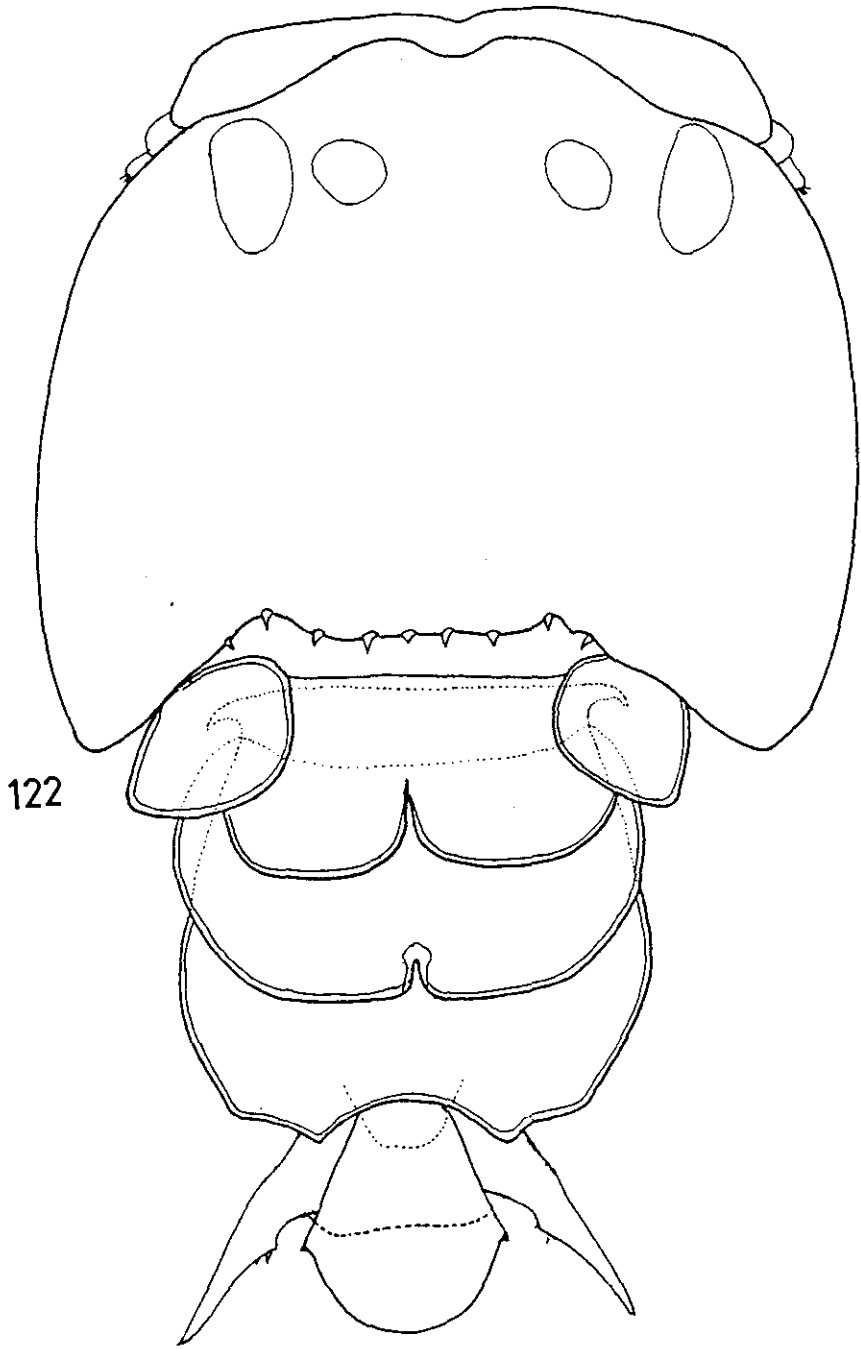
EXPLANATION OF FIGURES

Pandarus tudi sp. nov.

(Figs. 122-131)

122. Female, dorsal view

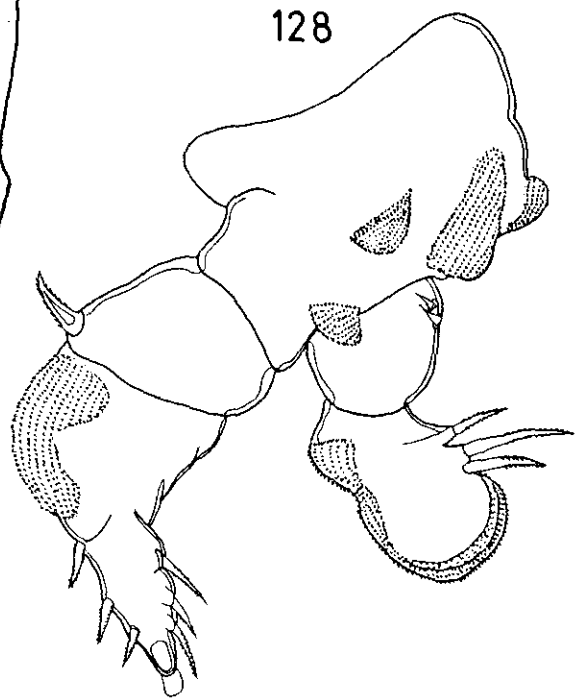
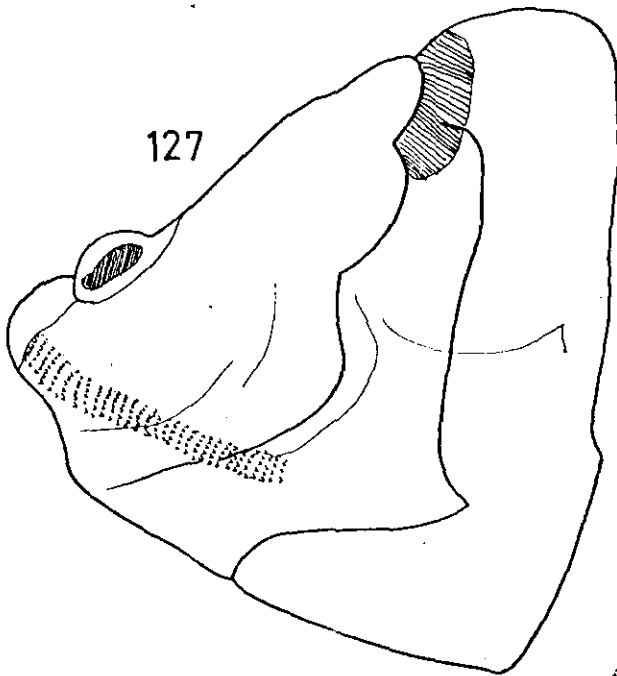
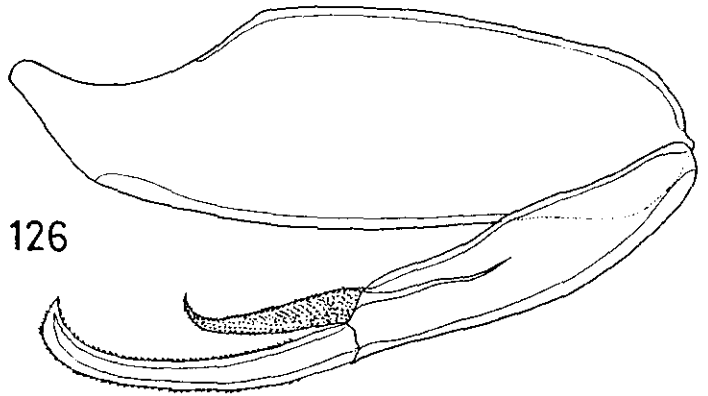
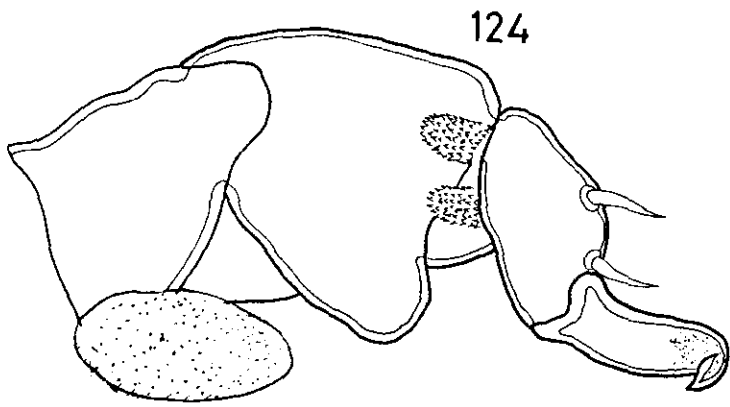
123. First antenna



EXPLANATION OF FIGURES

Pandarus tudi sp. nov.

- 124. Second antenna
- 125. Tip of mandible
- 126. Maxilla
- 127. Maxilliped
- 128. First leg



EXPLANATION OF FIGURES

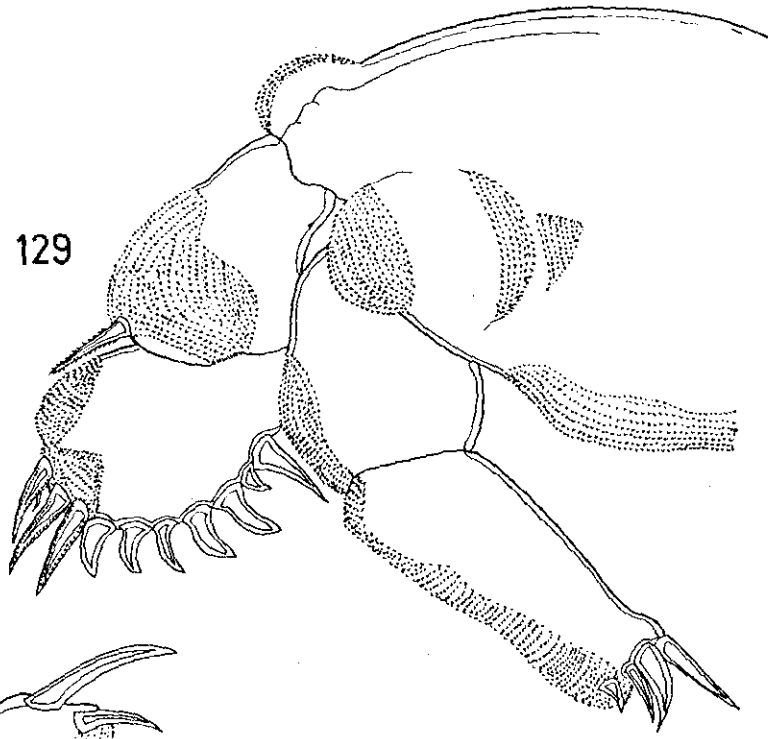
Pandarus tudi sp. nov.

129. Second leg

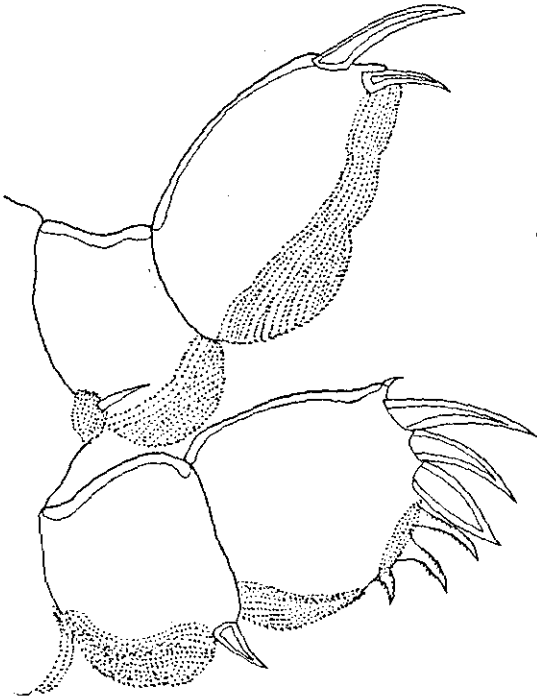
130. Third leg

131. Fourth leg

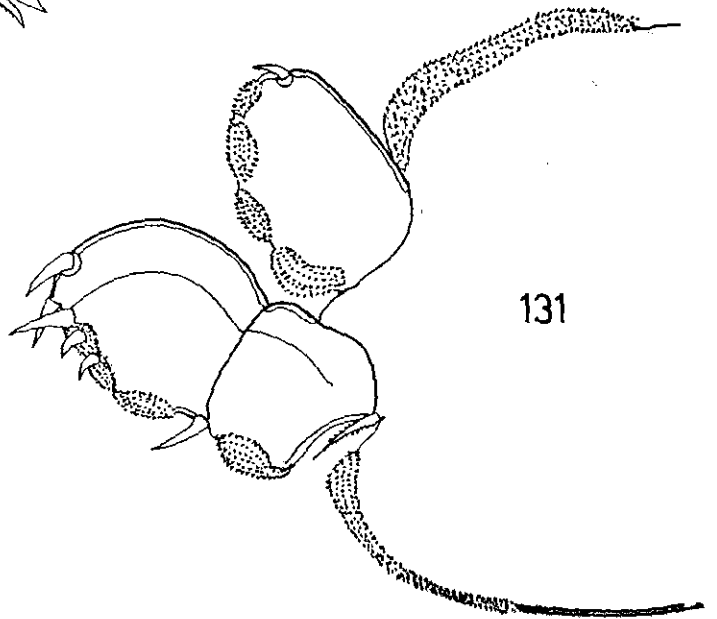
129



130



131



EXPLANATION OF FIGURES

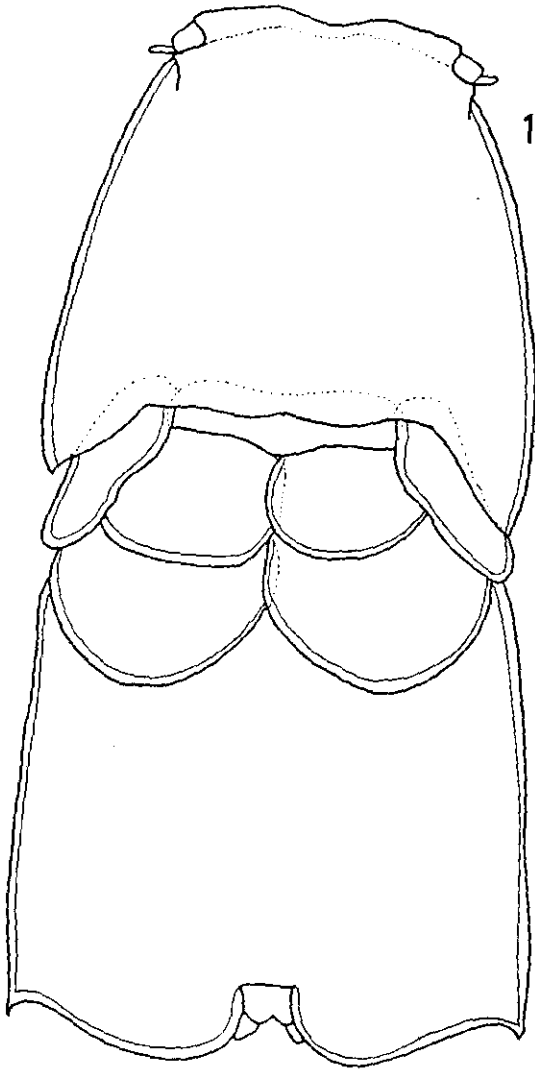
Perissopus dentatus Steenstrup & Lutken

132. Female, dorsal view

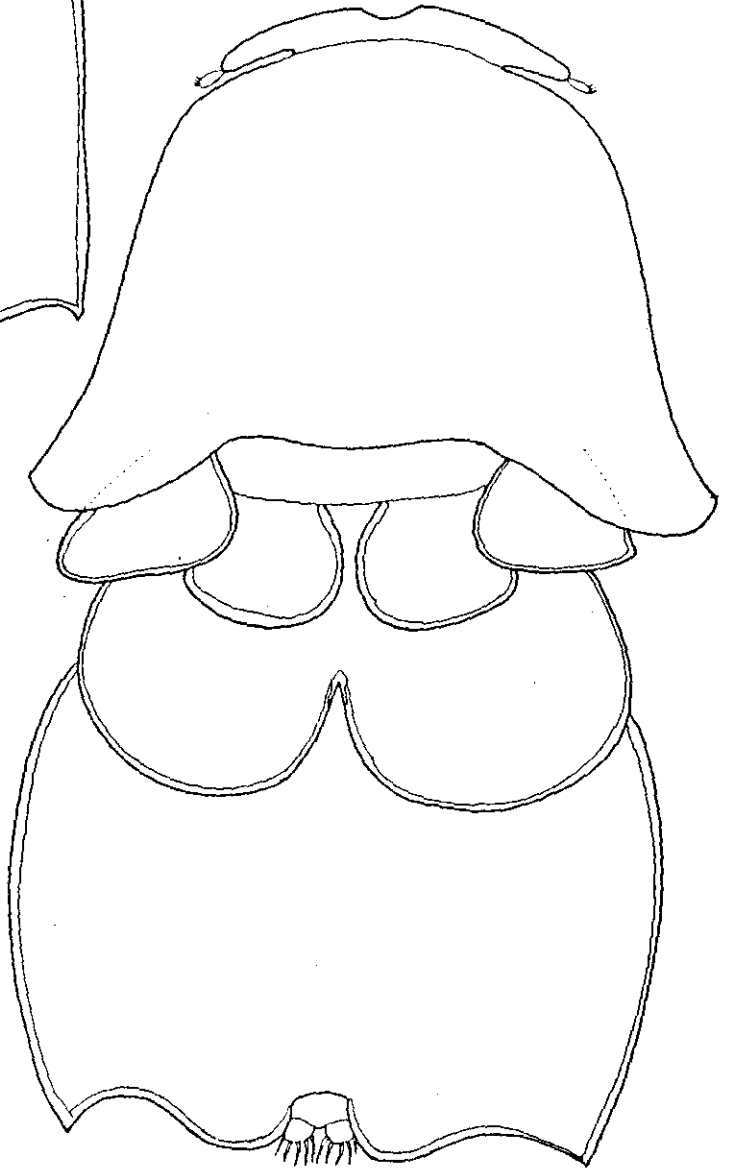
Perissopus indicus sp. nov.

(Figs. 133-144)

133. Female, dorsal view



132

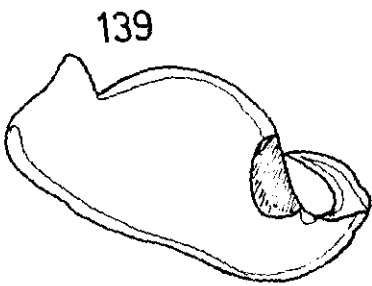
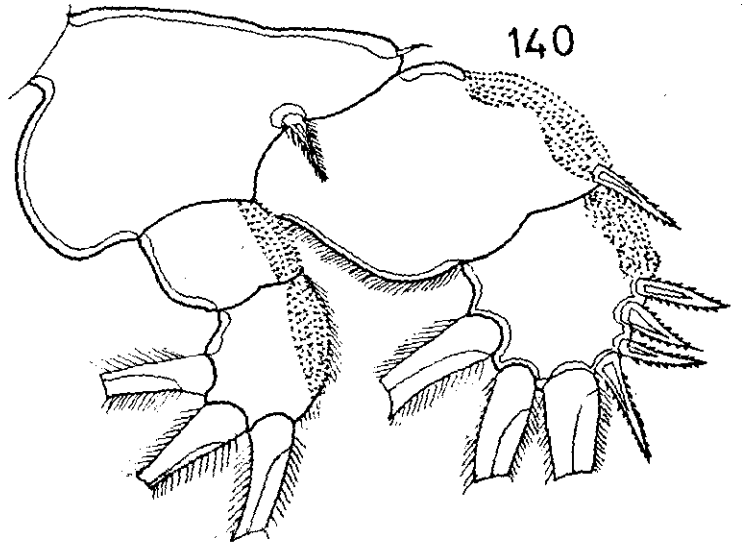
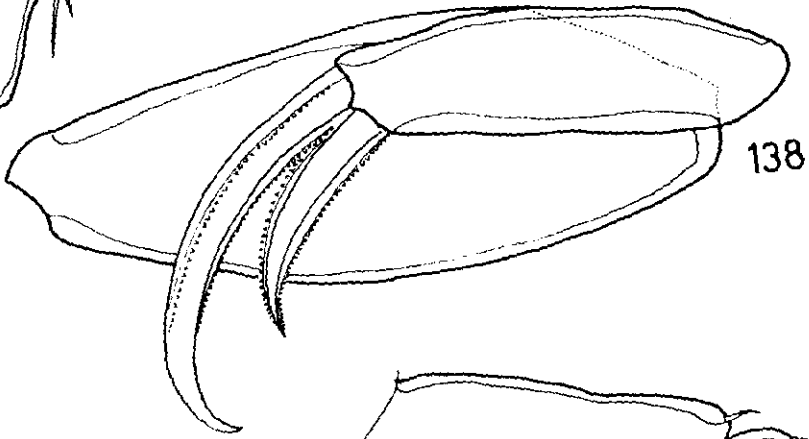
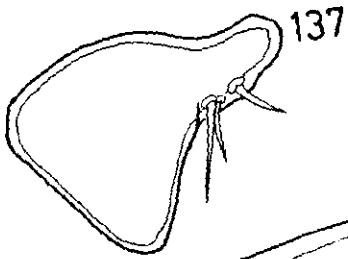
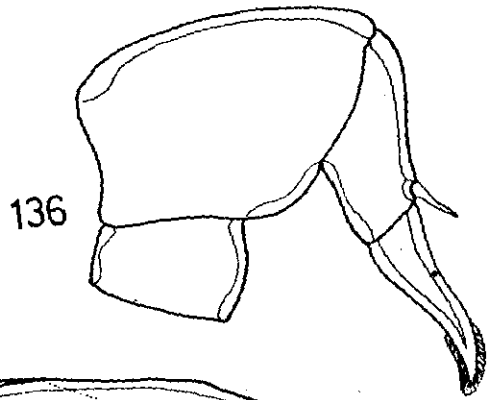
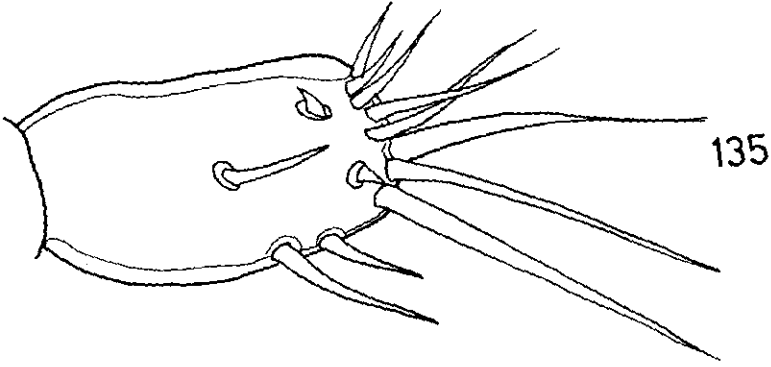
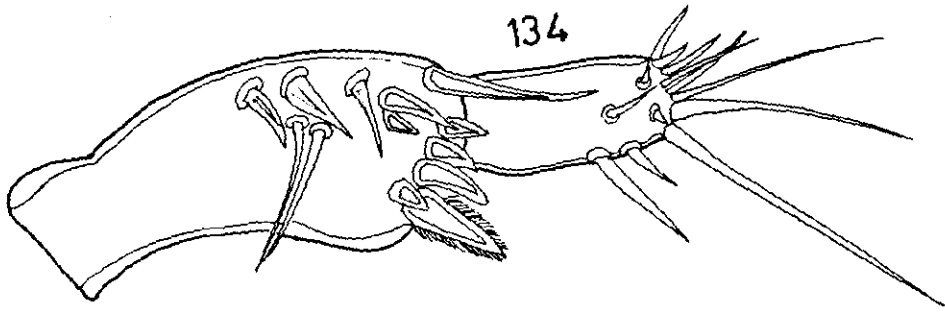


133

EXPLANATION OF FIGURES

Perissopus indicus sp. nov.

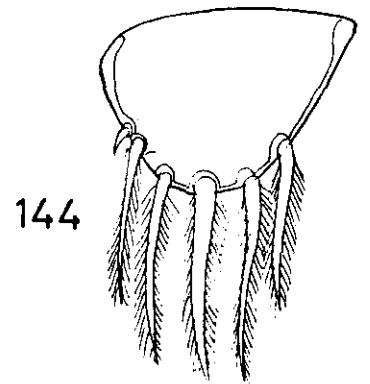
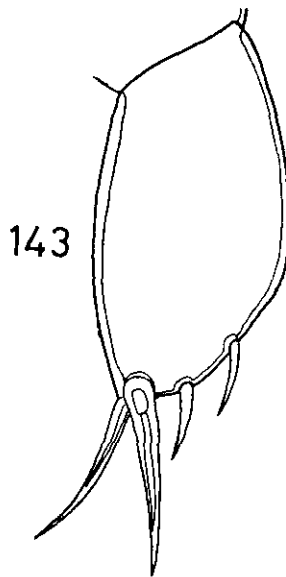
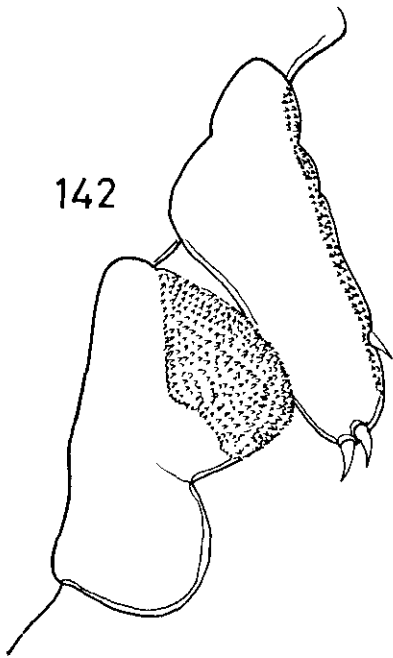
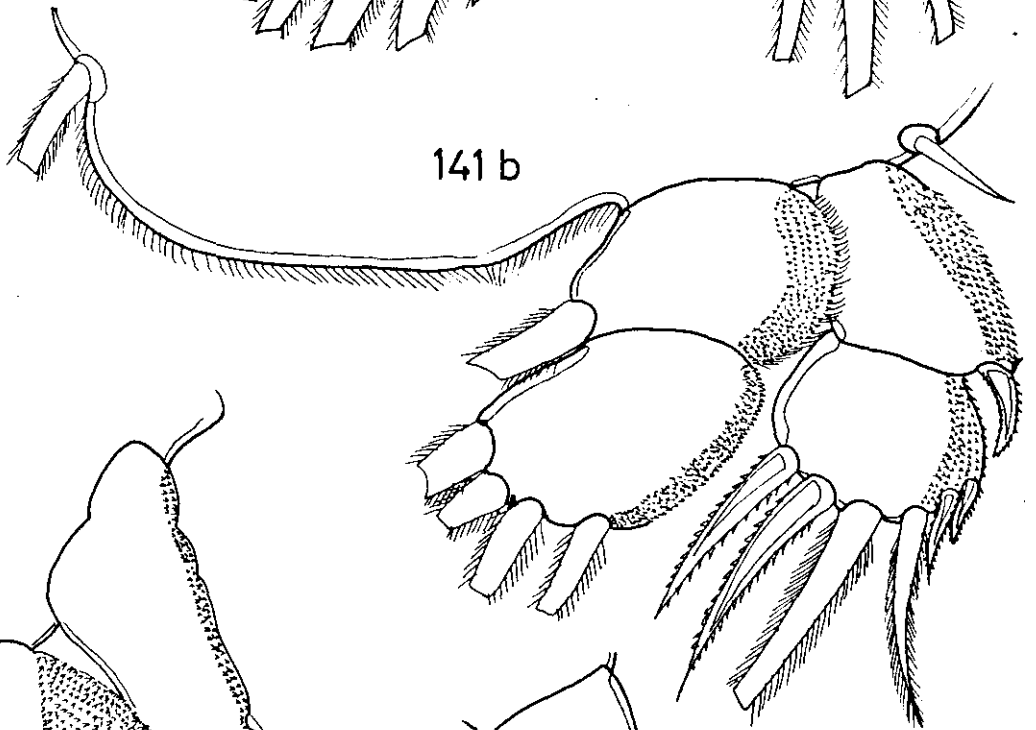
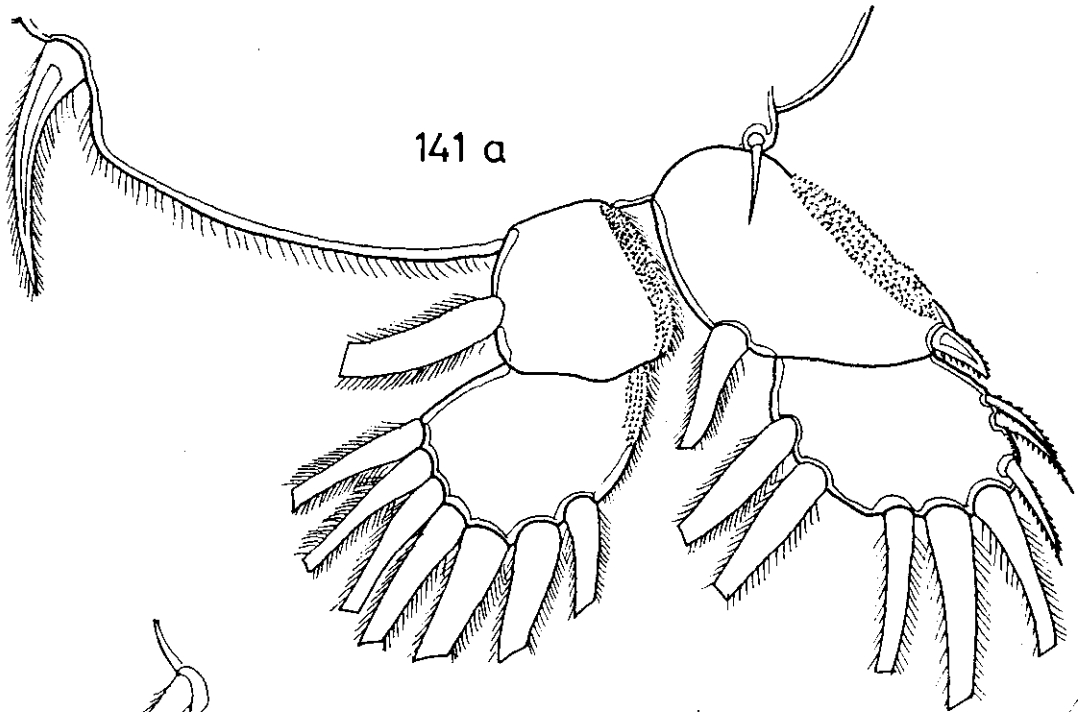
- 134. First antenna
- 135. Same, tip enlarged
- 136. Second antenna
- 137. First maxilla
- 138. Second maxilla
- 139. Maxilliped
- 140. First leg



EXPLANATION OF FIGURES

Perissopus indicus sp. nov.

- 141a. Second leg
- 141b. Third leg
- 142. Fourth leg
- 143. Fifth leg
- 144. Caudal rami



EXPLANATION OF FIGURES

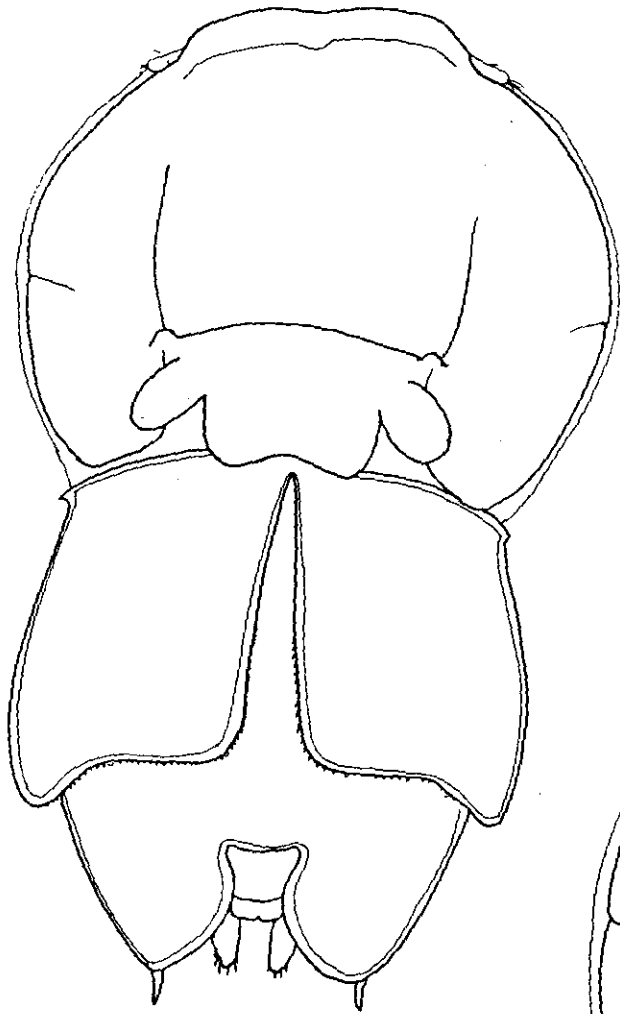
Echthrogaleus denticulatus Smith

145. Female, dorsal view

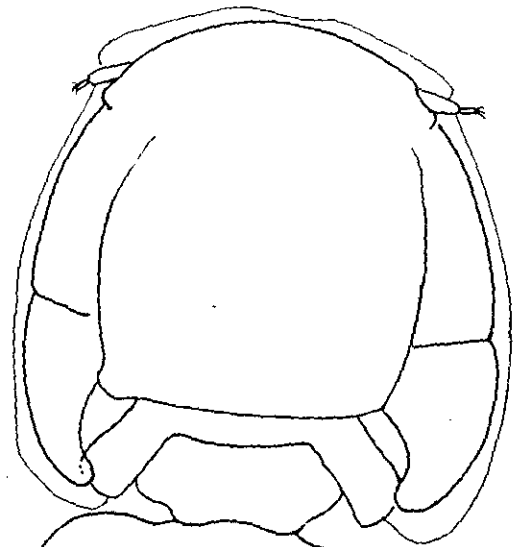
Echthrogaleus coleoptratus

(Guerin-Meneville)

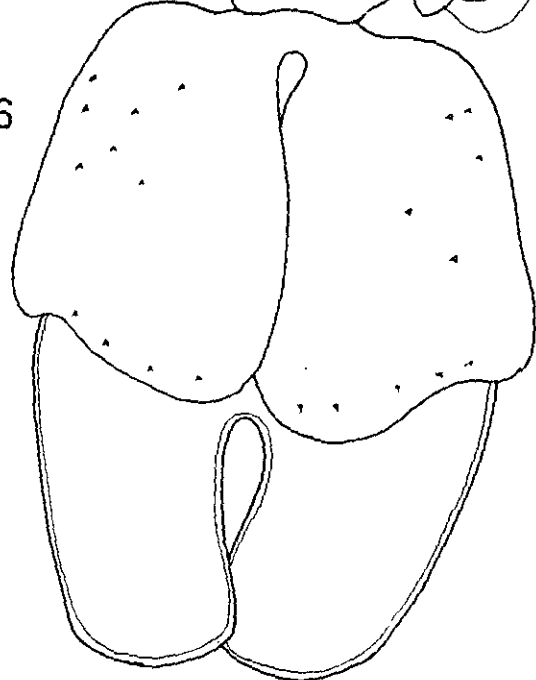
146. Female, dorsal view



145



146

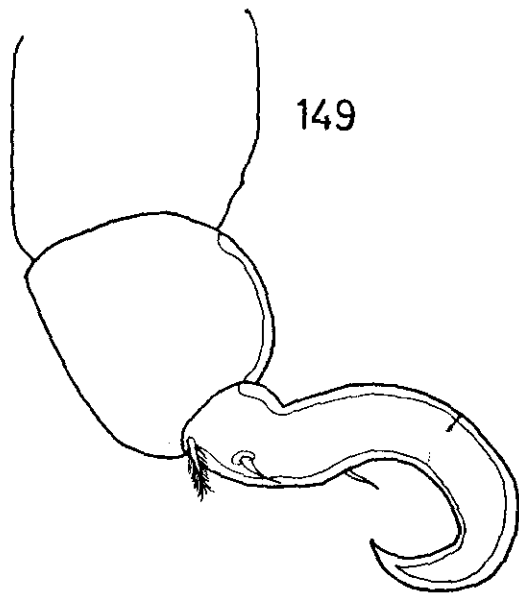
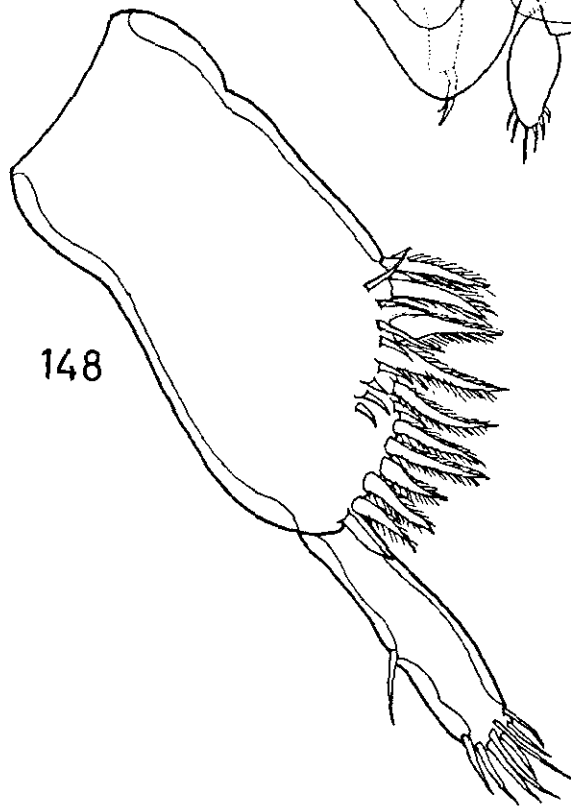
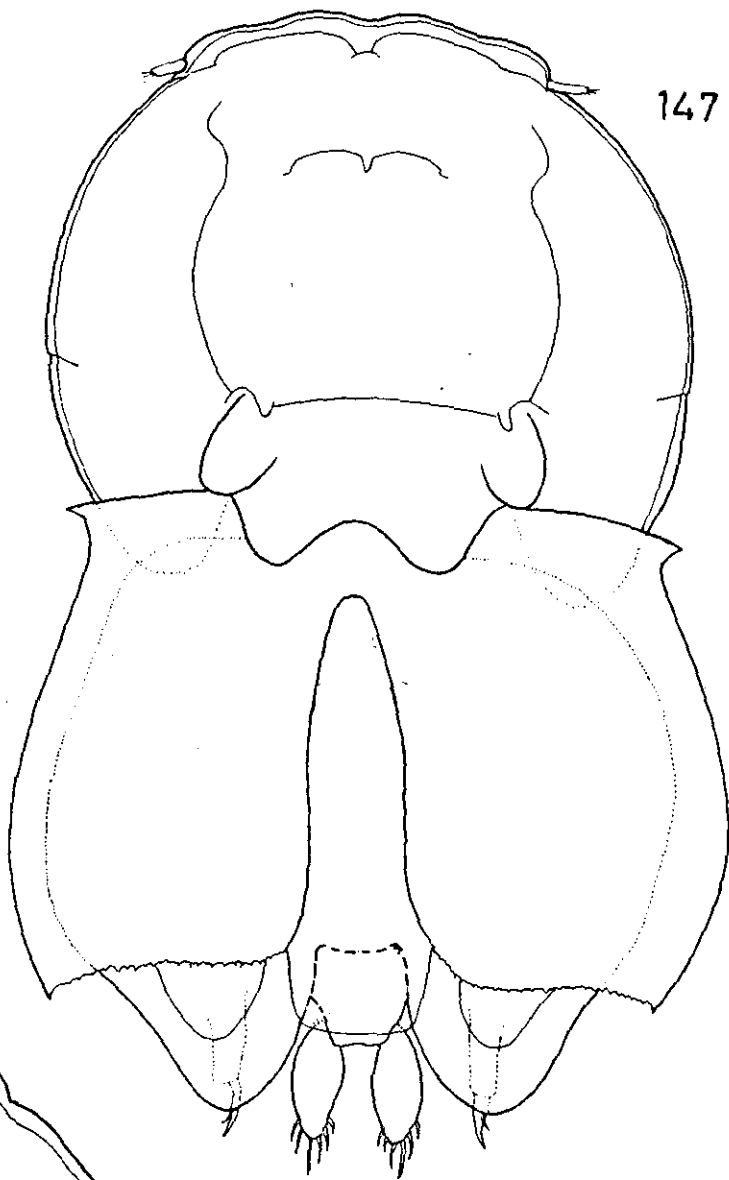


EXPLANATION OF FIGURES

Echthrogaleus eulami sp. nov.

(Figs. 147-157)

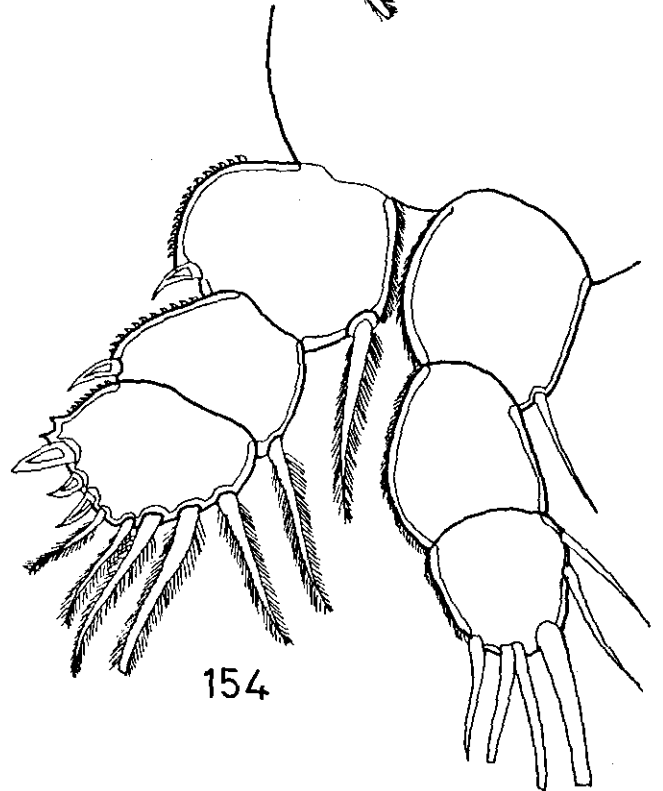
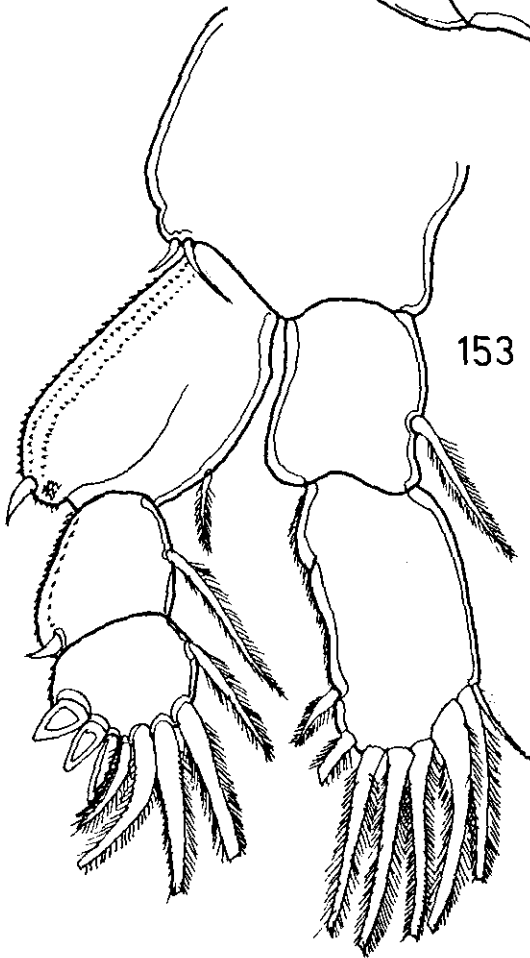
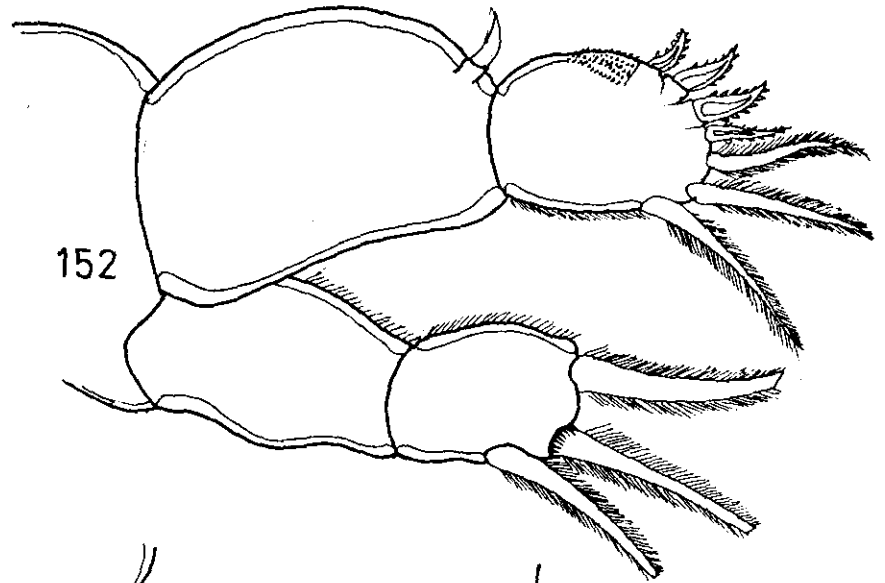
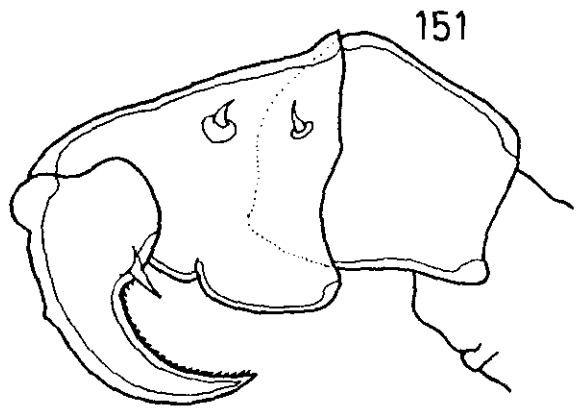
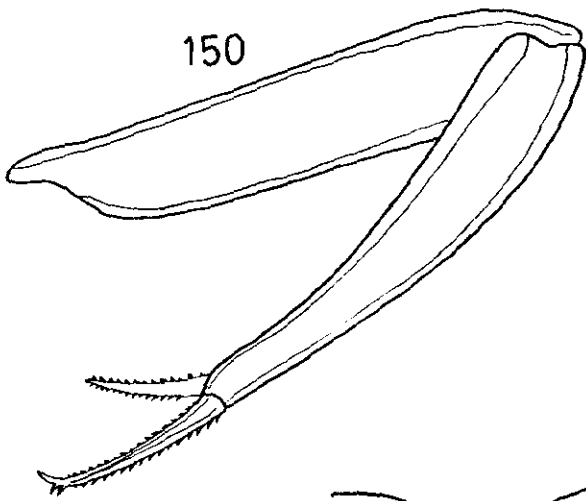
- 147. Female, dorsal view
- 148. First antenna
- 149. Second antenna



EXPLANATION OF FIGURES

Echthrogaleus eulami sp. nov.

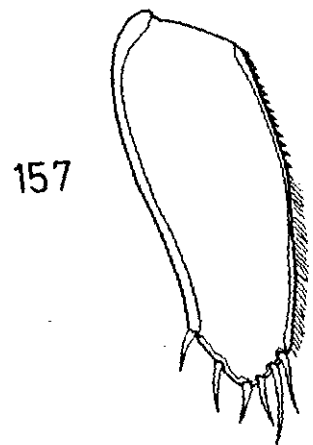
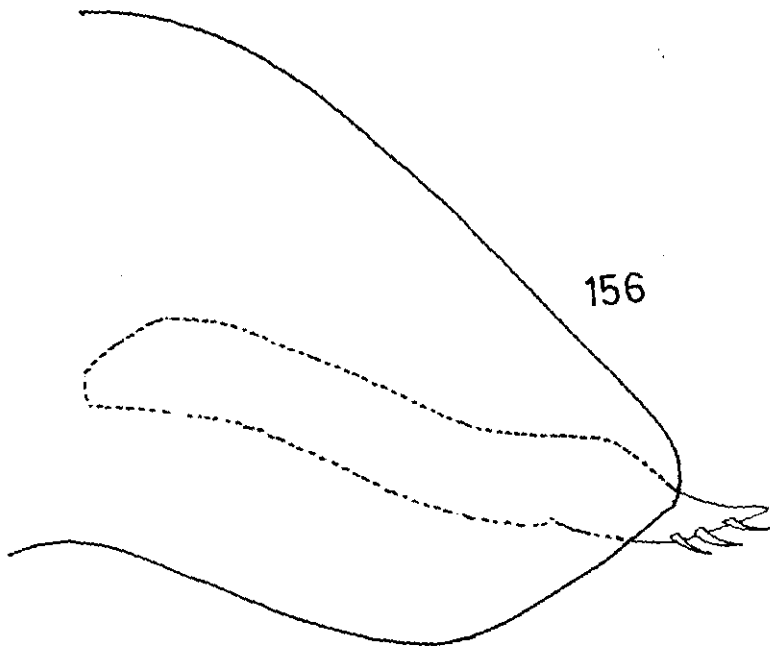
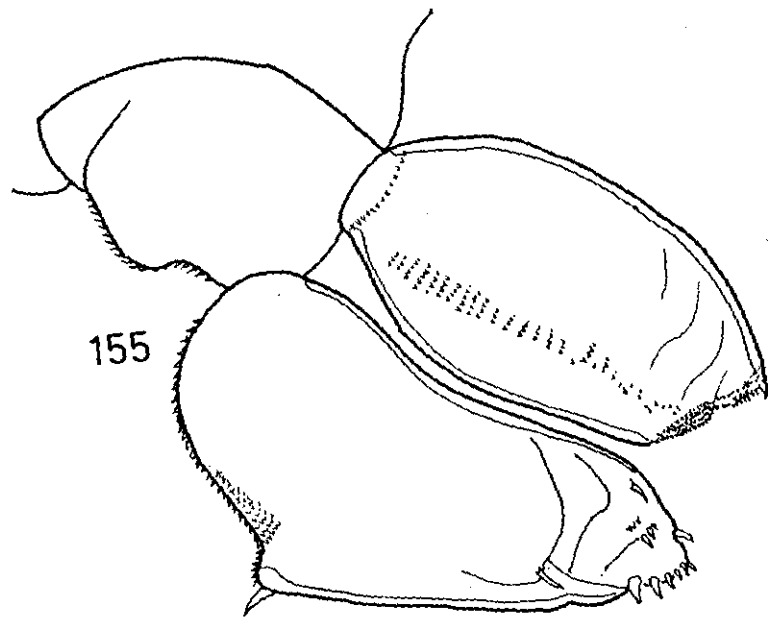
- 150. Maxilla
- 151. Maxilliped
- 152. First leg
- 153. Second leg
- 154. Third leg



EXPLANATION OF FIGURES

Echthrogaleus eulami sp. nov.

- 155. Fourth leg
- 156. Fifth leg
- 157. Caudal rami



EXPLANATION OF FIGURES

Echthrogaleus kerali sp. nov.

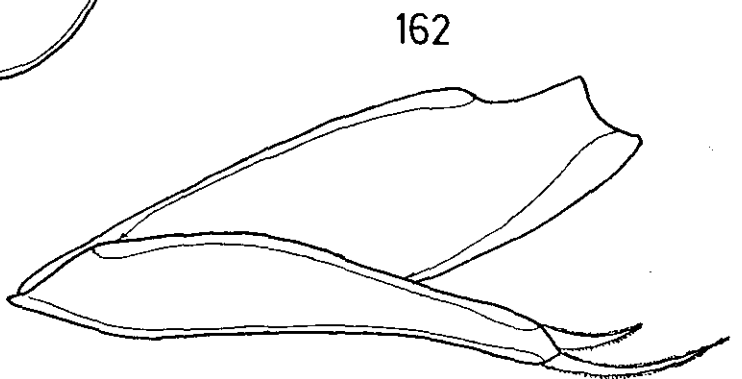
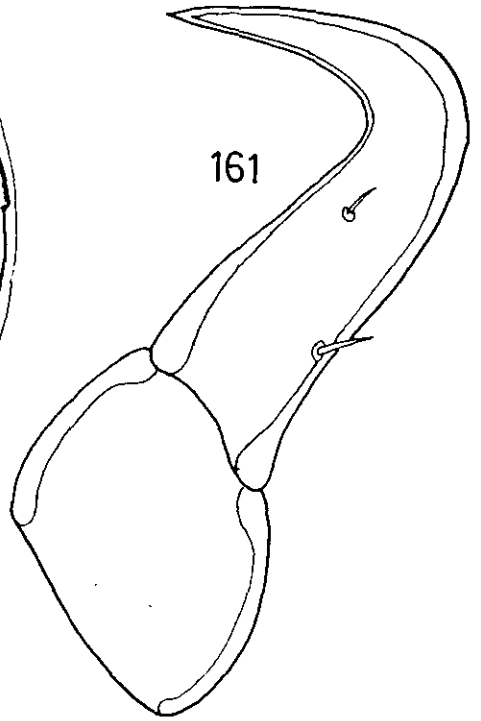
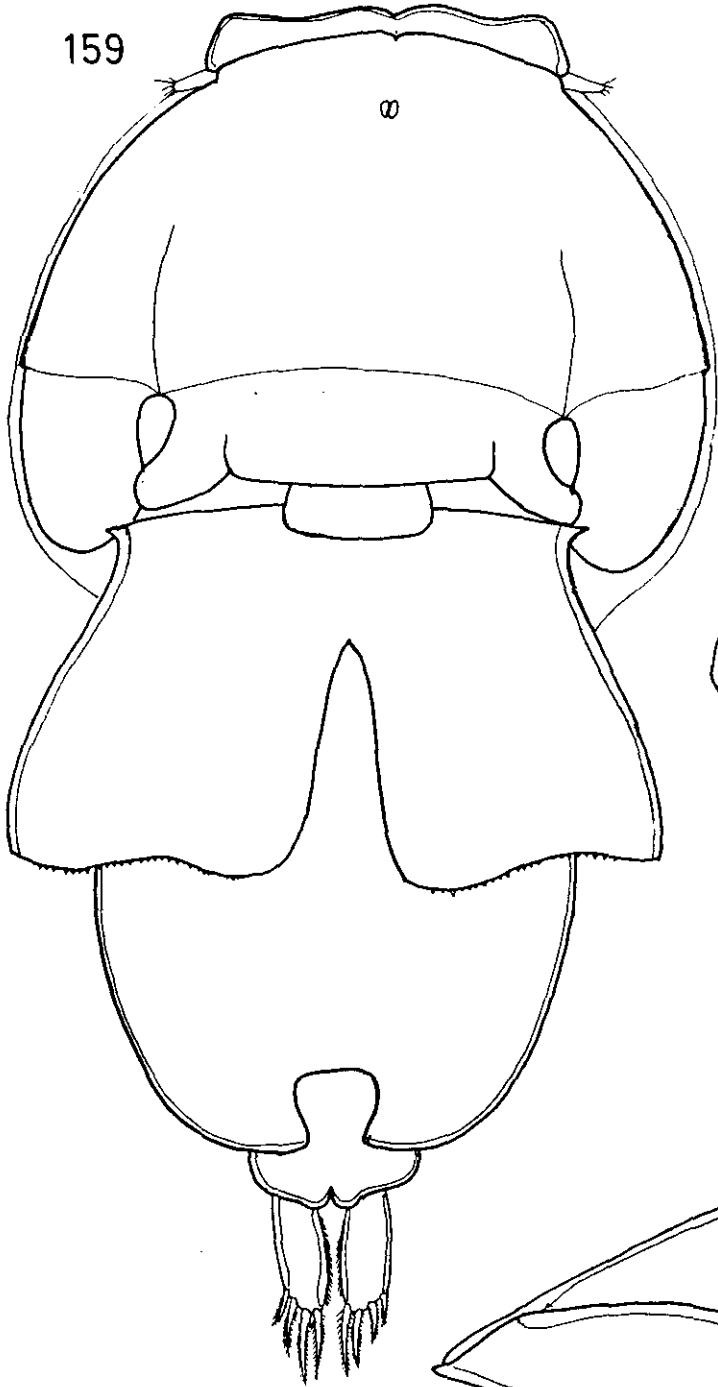
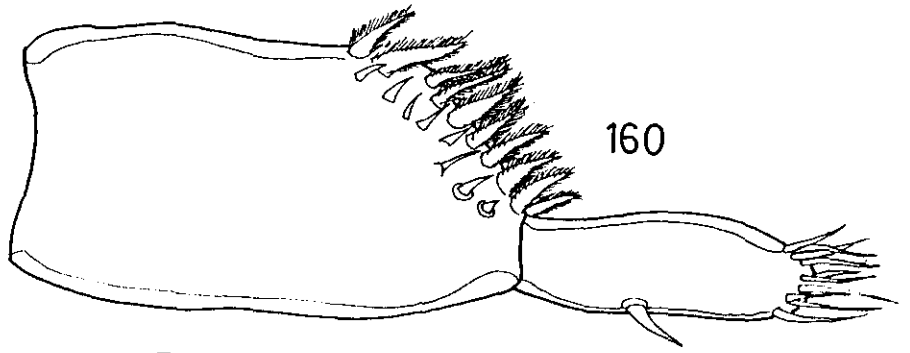
(Figs 159-168)

159. Female, dorsal view

160. First antenna

161. Second antenna

162. Maxilla



EXPLANATION OF FIGURES

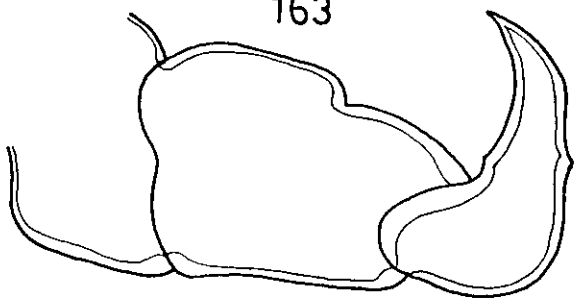
Echthrogaleus kerali sp. nov.

163. Maxilliped

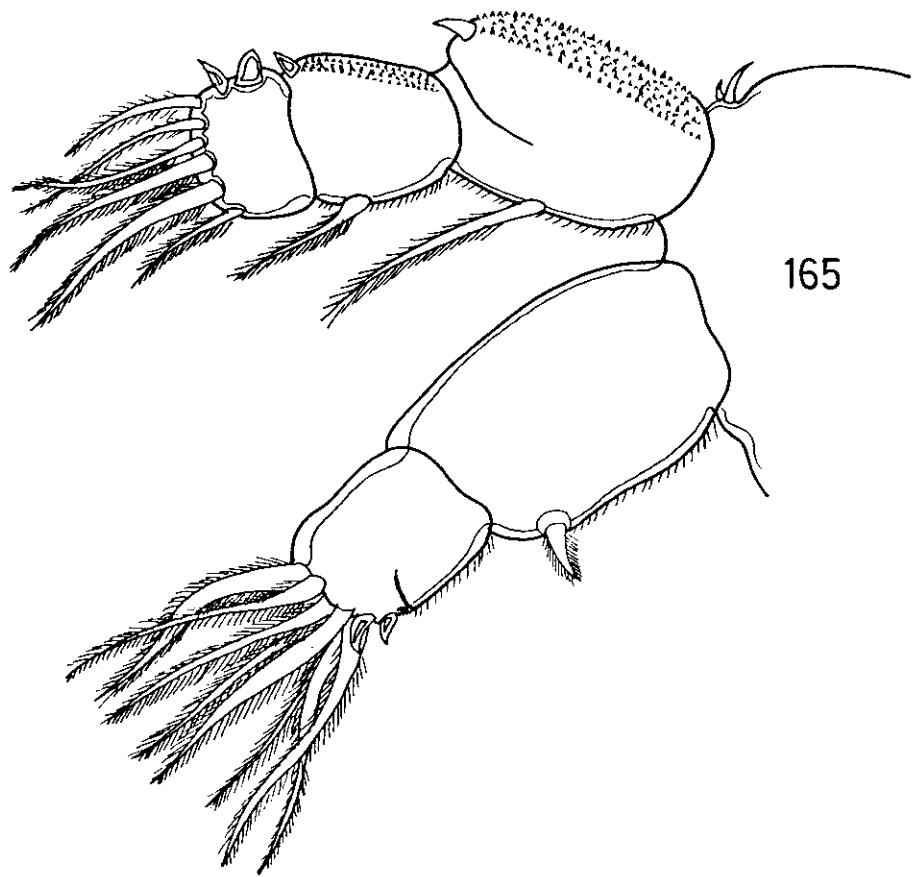
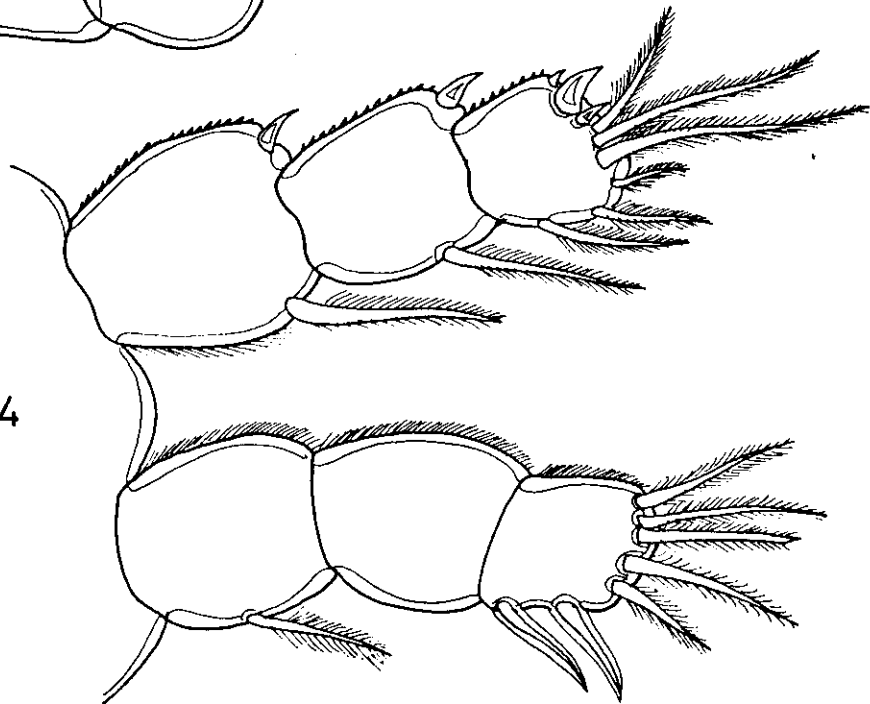
164. First leg

165. Second leg

163



164



165

EXPLANATION OF FIGURES

Echthrogaleus kerali sp. nov.

166. Third leg

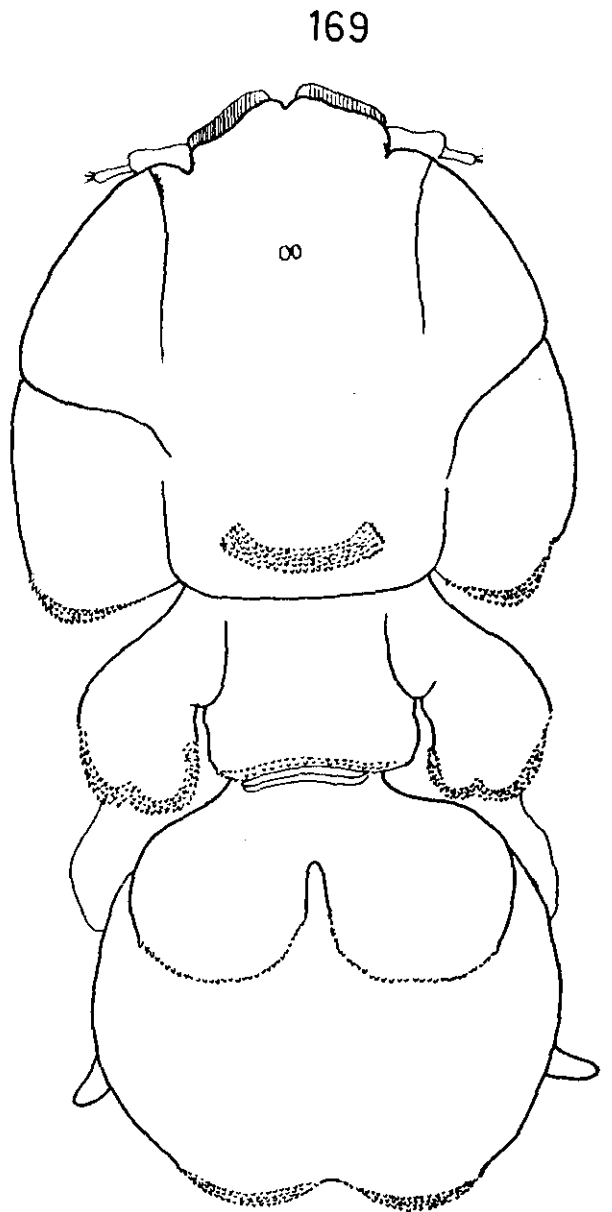
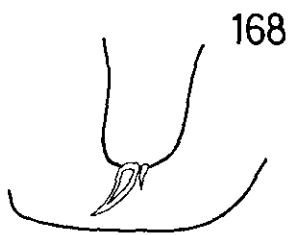
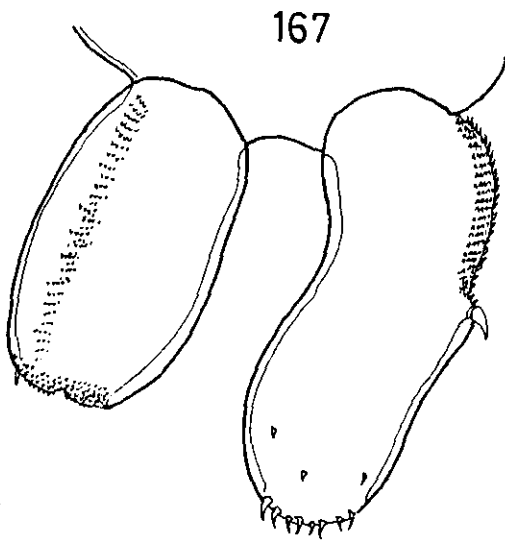
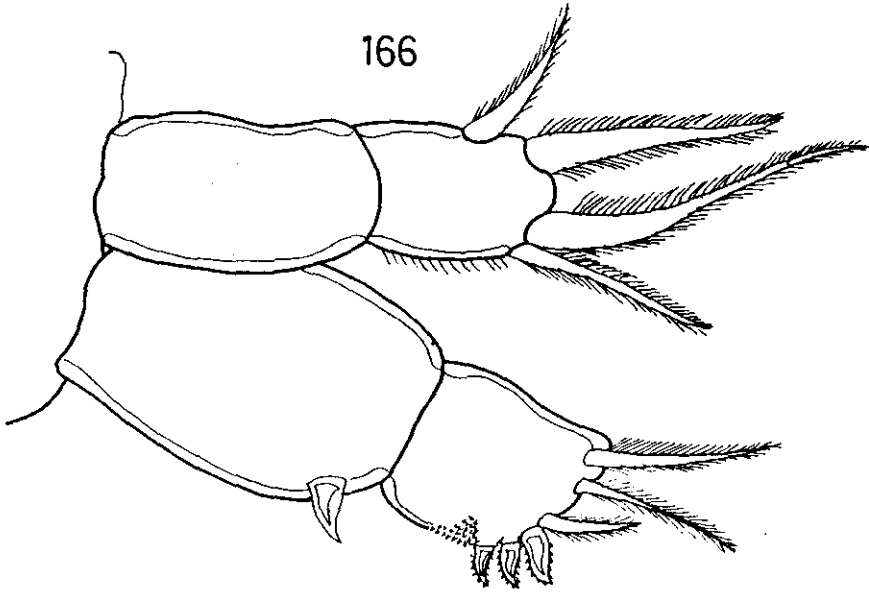
167. Fourth leg

168. Fifth leg

Entepherus laminipes Bere

(Figs. 169-181)

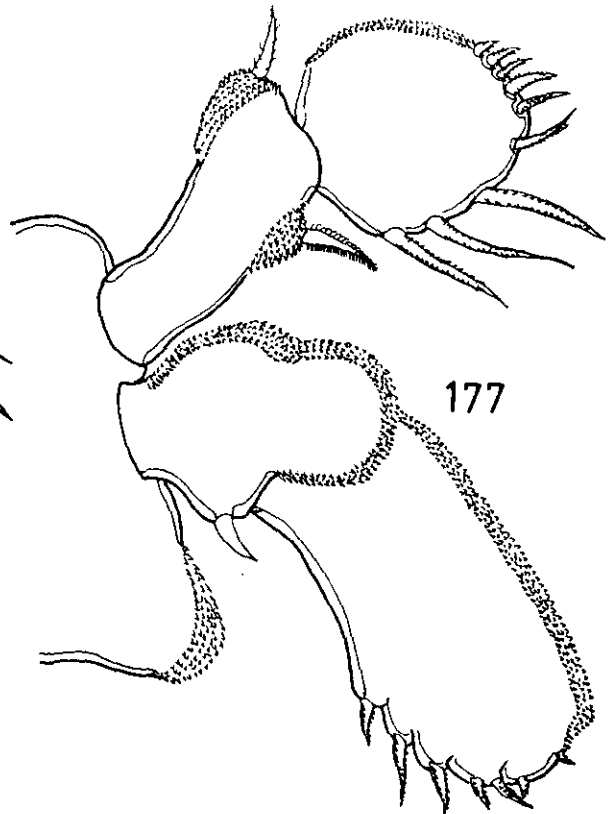
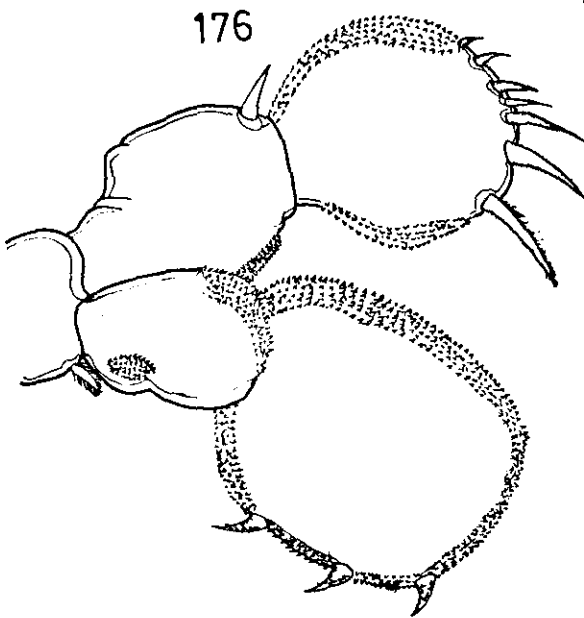
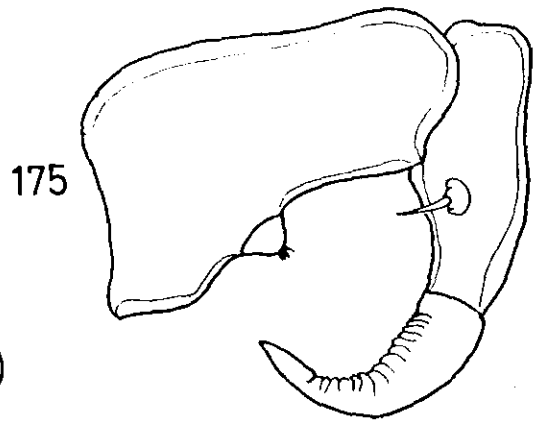
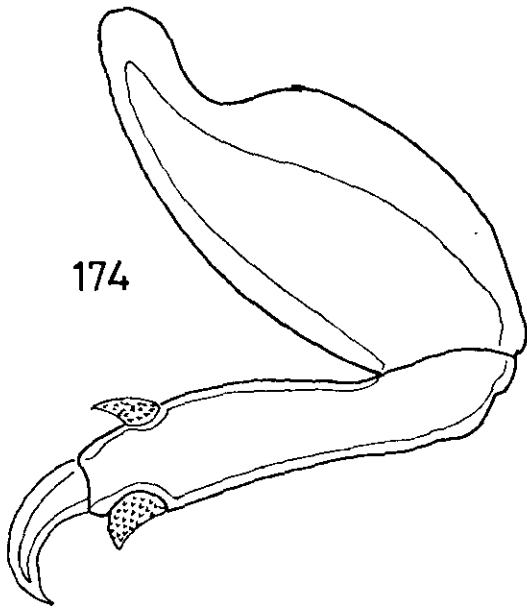
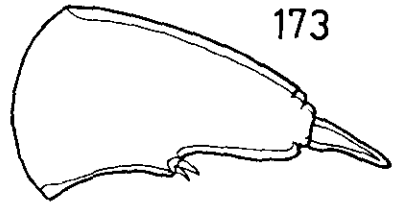
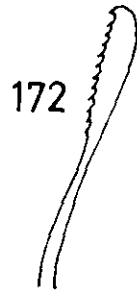
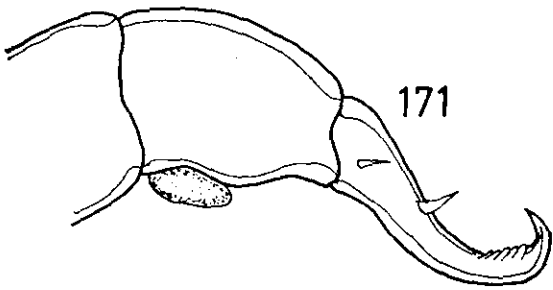
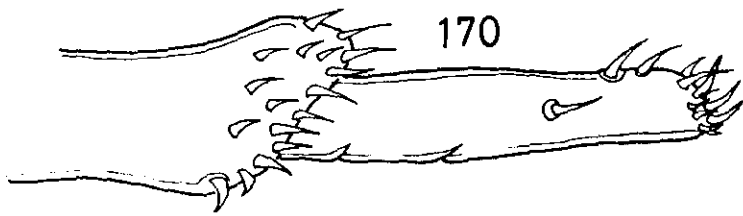
169. Female, dorsal view



EXPLANATION OF FIGURES

Entepherus laminipes Bere

- 170. First antenna
- 171. Second antenna
- 172. Tip of mandible
- 173. First maxilla
- 174. Second maxilla
- 175. Maxilliped
- 176. First leg
- 177. Second leg



EXPLANATION OF FIGURES

Entepherus laminipes Bere

178. Third leg

179. Fourth leg

180. Fifth leg

181. Caudal rami

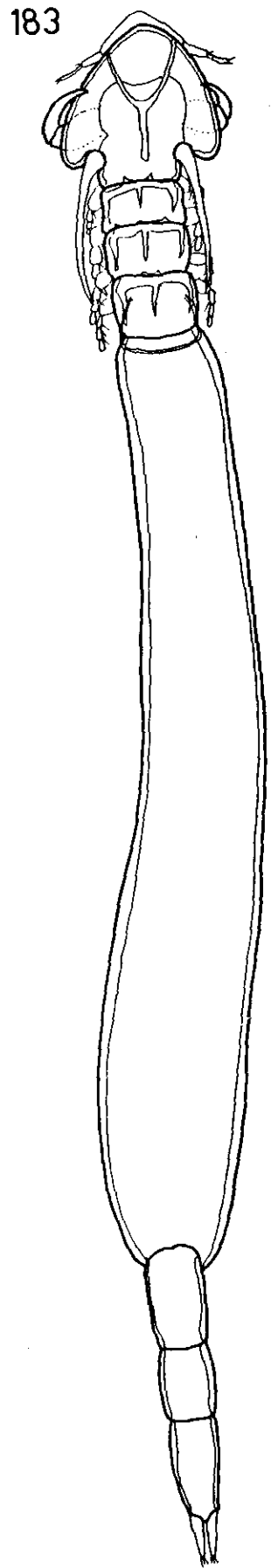
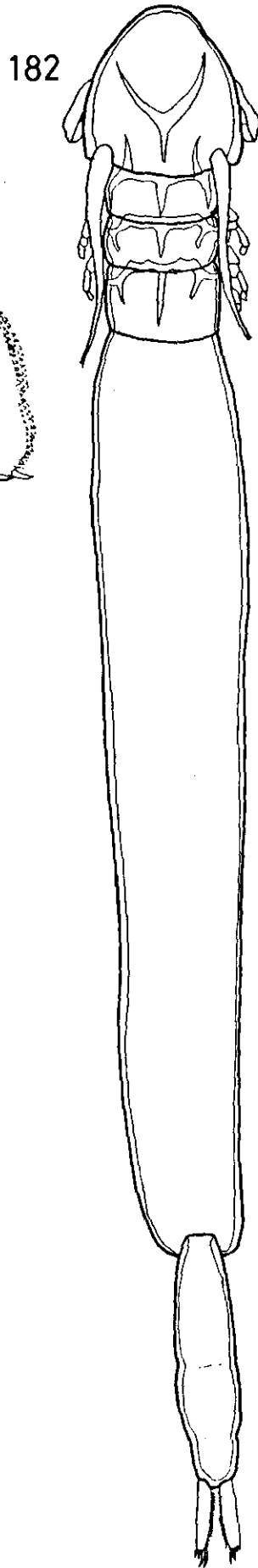
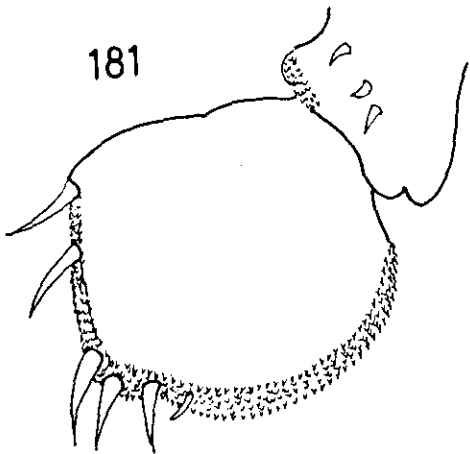
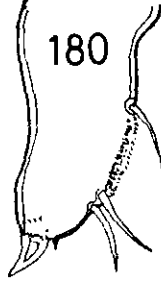
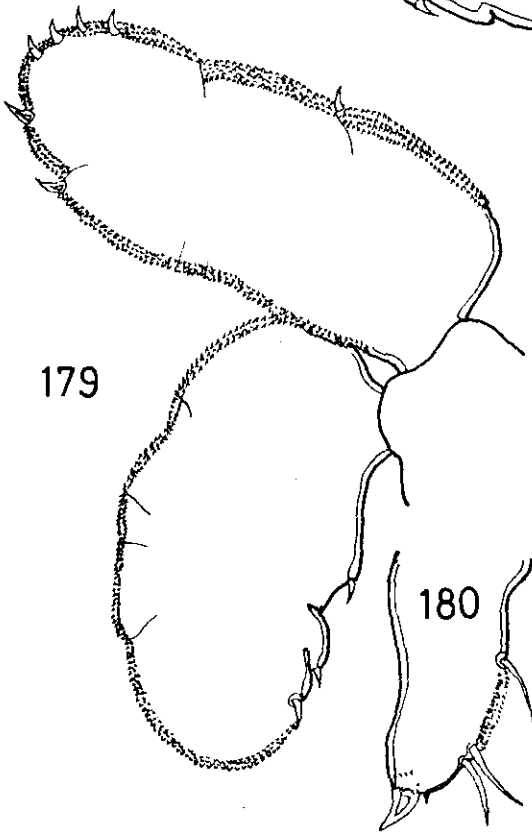
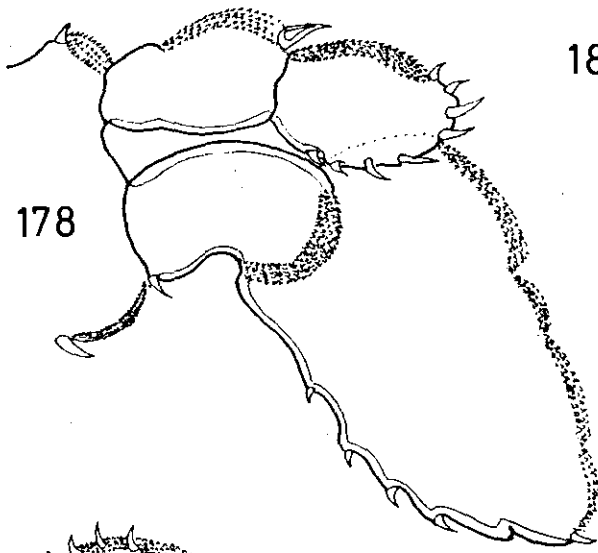
Kroyeria sphyrnae Rangnekar

182. Female, dorsal view

Kroyeria tudi sp. nov.

(Figs. 183-193)

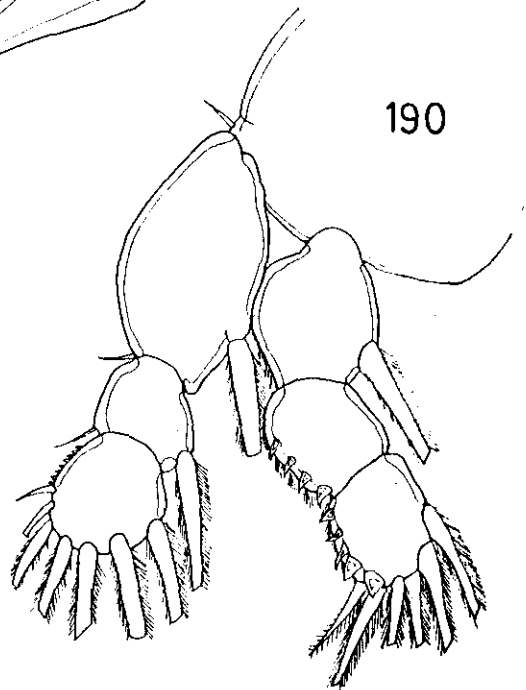
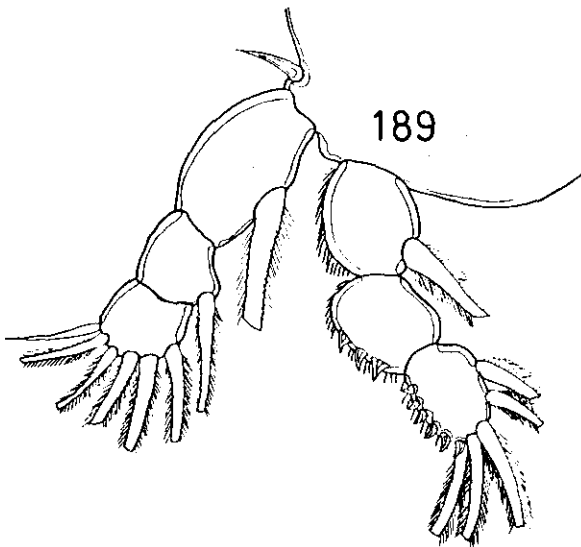
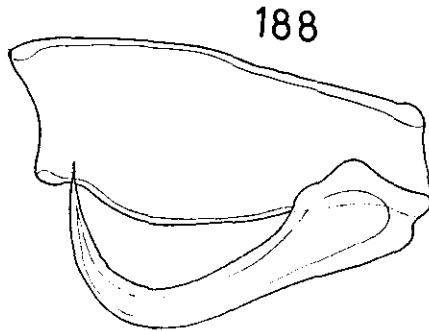
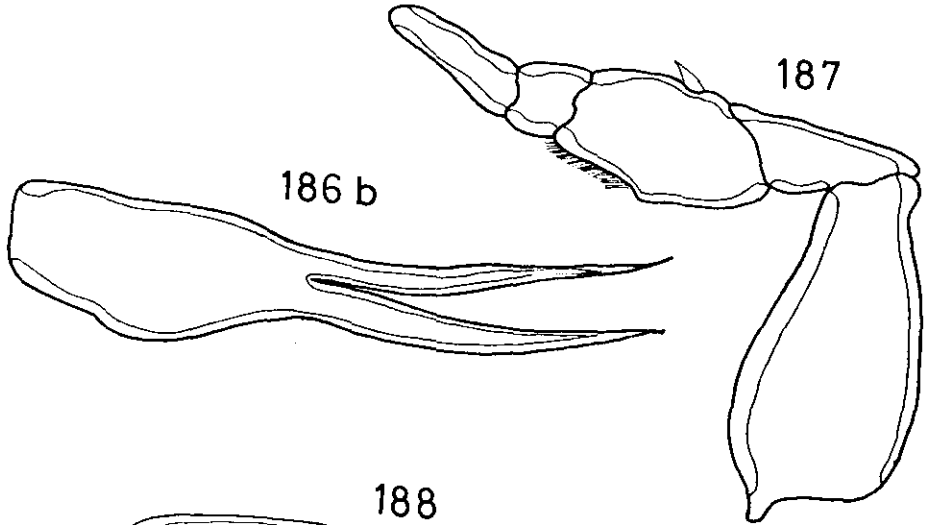
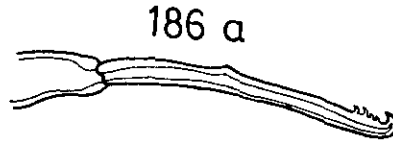
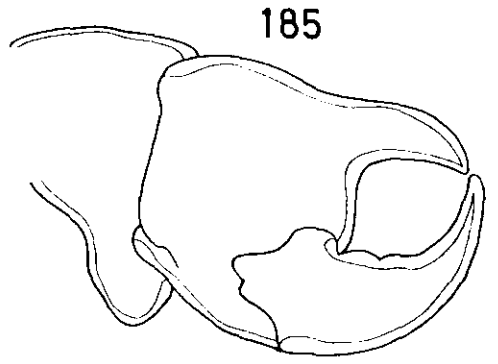
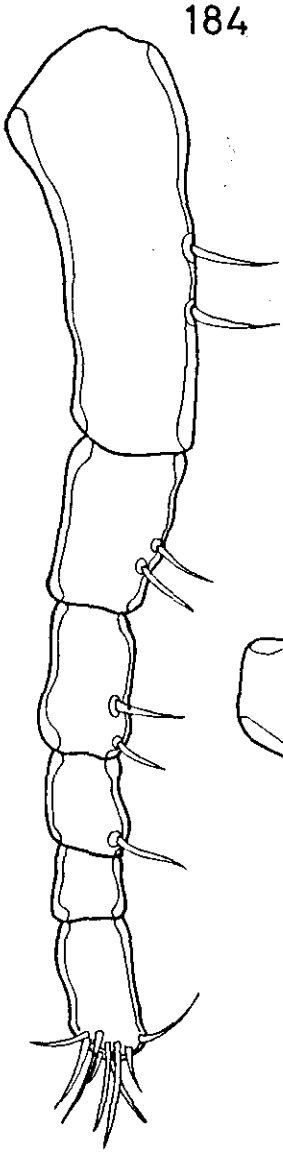
183. Female, dorsal view



EXPLANATION OF FIGURES

Kroyeria tudi sp. nov.

- 184. First antenna
- 185. Second antenna
- 186a. Mandible
- 186b. First maxilla
- 187. Second Maxilla
- 188. Maxilliped
- 189. First leg
- 190. Second leg



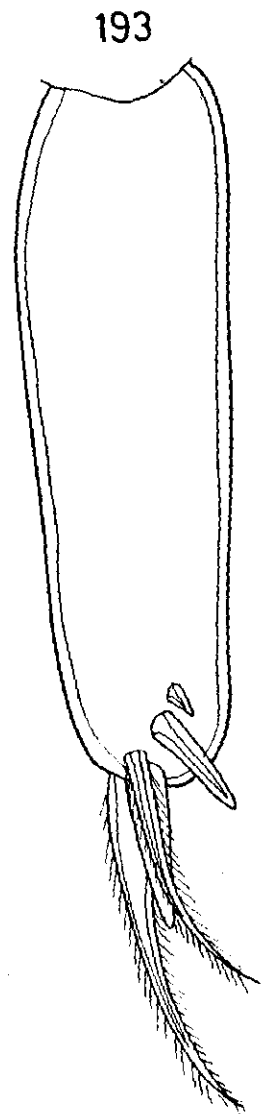
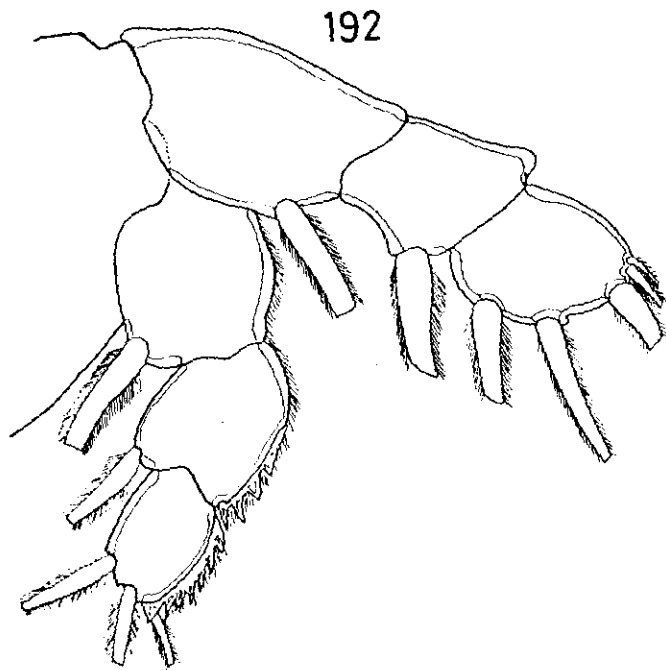
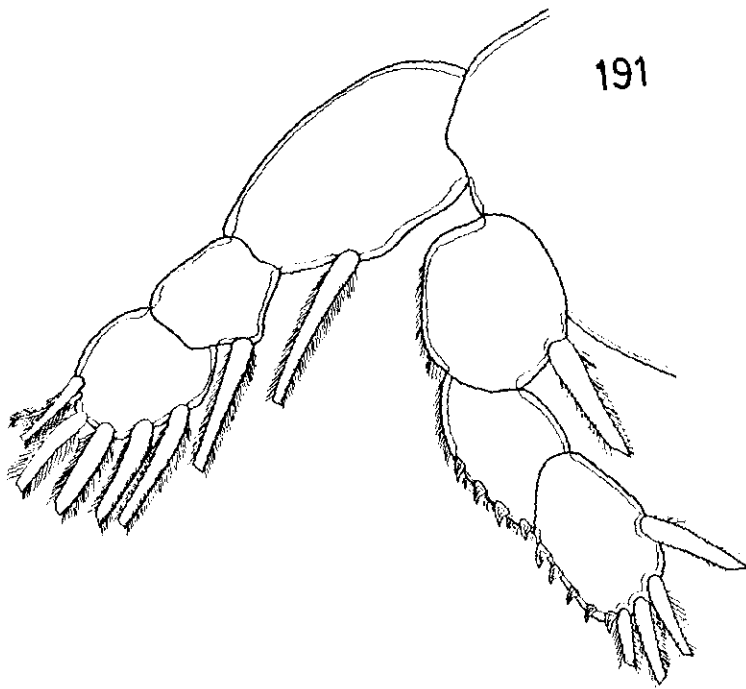
EXPLANATION OF FIGURES

Kroyeria tudi sp.nov.

191. Third leg

192. Fourth leg

193. Caudal rami



EXPLANATION OF FIGURES

Penicillus indicus gen. nov., sp. nov.

(Figs. 194-203)

- 194. Female
- 195. Bulla enlarged
- 196. Abdomen with bell shaped structures
- 197. Bell enlarged
- 198. Organ inside the bell
- 199. Second antenna
- 200. First leg
- 201. Second leg
- 202. Third leg
- 203. Fourth leg

