STUDIES ON THE SYSTEMATICS AND THE BIOLOGY OF SOME INDIAN MARINE COPEPODS

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BY

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ABSTRACT

A study on the systematics and biology of marine copepods of southeast coast of India was taken up in view of its bearing on fishery biology and its scientific interests. There were two principal objectives, namely, a faunistic survey of the copepods of southeast coast of India and a study of the biology of the more common planktonic copepods of the Gulf of Mannar. The work was initiated in December 1958 and continued upto September, 1961. During this period intensive field collections and laboratory studies were carried out. The thesis embodies the results of these investigations. Part of the results, pertaining to some new species and genera, has already been published.

A review of the works on the systematics of Indian marine copepods is hardly necessary here. Attention may be invited here to the recent publications referred to in the introduction to Part I of the thesis. A perusal of the literature would show that much of these earlier works on the taxonomy and distribution of copepods is devoted to species gathered from the open seas and from the neighbourhood of oceanic islands of the Central Indian Ocean. Krishnaswamy's investigations on the copepods of the Madras Coast represent the first exhaustive study of its kind in this country and the present work is another attempt in the same direction.

Our knowledge on the biology of Indian marine copepods is extremely scanty. A brief review of the leterature is given in Chapter 3 of Part II of the thesis. It may, however, be added that the studies carried out in Indian

waters amount to very little compared to the monographic treatises that exist on this subject in other parts of the world. What is known on the biology of Indian marine copepods concerns mainly with seasonal distribution, breeding etc., of a few numerically dominent species. No planktonic calanoid copepod has so far been studied so as to its complete developmental cycle and little is known on the diurnal vertical movements of copepods in Indian waters. During the present study some useful information has been obtained on both these aspects.

The thesis is divided into two parts, the first part dealing with the systematics and the second with the biology.n Following salient features are incorporated under the systematics.

One hundred and eighty three species of copepods belonging to the orders Calanoida, Harpacticoida, Cyclopoida and Monstrilloida are identified. This includes twenty-three new species and four new genera. Of these the descriptions of fourteen new species and two new genera are already published. The unpublished species are listed below:

Ridgewayia krishnaswamyi n. sp.,
Parapeltidium nichollsi n. sp.,
Porcellidium unicus n. sp.,
Echinolaoponte tropica n. sp.,
Indomyzon qasimi n. gen. et n. sp.,
Sewellòpontius rectiangulus n. gen. et. n. sp.,
Sabelliphilus foliacea n. sp.,
Pseudanthessius anormalus n. sp. and
P. brevicauda n. sp.

Besides these the undescribed males of the following seven species of copepods are known for the first time and are described:

Ridgewayia typica Thompson & Scott,
Euryte brevicauda Sewell,
Asterocheres orientalis Sewell,
Cryptopontius graciloides Ummerkutty,
Peltidium angulatum Thompson & Scott,
Porcellidium ravanae Thompson & Scott and
P. scotti Pesta

Twentyfive species are reported for the first time after their discovery. Six Western-Pacific species and six Eastern Atlantic species are recorded for the first time from Indian Ocean. In addition to these, an interesting species of Cyclopoid copepod, so far known only from the west coast of Africa, has been obtained. The cyclopoid family Asterocheridae is split into two subfamilies, *viz.*, Asterocherinae nov. and Cletopontiinae nov. while reasons are formulated for abandoning the division of Entomolepidae into subfamilies as was done by an earlier author(Josef Eiselt, 1959). Brief considerations are included on the classification, specificity of association and distribution of copepods.

The second part dealing with the biology includes the following:

(i) It has been possible to work out for the first time from the Indian region the complete developmental cycle of two calanoid copepods, viz., *Pseudodiaptomus aurivilli* Cleve and *Labidocera bengalensis* Krishnaswamy.

(ii) Attempts have been made to study the nature of vertical movements of planktonic copepods of the Gulf of Mannar.

(iii) Breeding and related aspects of ten species of planktonic copepods of the Gulf of Mannar are studied. The data obtained are compared ~~x~~ with those gathered by earlier workers and interesting points are discussed. Based upon their breeding habits the copepods of the

Gulf of Mannar are tentatively placed in three groups.

Copepods constitute the largest item of the zooplankton, being present in all the seas and oceans. Good amount of research has been done on their taxonomy and biology in temperate and polar waters. The information available on these organisms in tropical and subtropical areas is rather limited. This is particularly true of the Indian Ocean where the chief source of knowledge has been the scientific reports of the few oceanographic expeditions that visited this area. It is believed that the studies embodied in the present thesis would help, to an appreciable extent, to further our knowledge of the systematics and the biology of the marine copepods of the Indian region.

31/8/62

(A. N. P. Ummerkutty)

P R E F A C E

A study on the systematics and the biology of marine copepods of the south-east coast of India was taken up at the suggestion of Dr. S. Jones, Director, Central Marine Fisheries Research Institute, in view of its bearing on fishery biology and its scientific interests. There were two principal objectives, namely, a faunistic survey of the copepods of south-east coast of India and a study on the biology of the more common planktonic copepods of the Gulf of Mannar. The work was initiated in December 1958 and continued upto September 1961. During this period intensive field collections and laboratory studies were carried out. The present thesis embodies the results of these investigations. Part of the results, pertaining to some new species and genera, has already been published and is included here as published material.

A review of the works on the systematics of Indian marine copepods is hardly necessary here and attention may be invited to the recent publications referred to in the introduction to Part I of this thesis. A perusal of the literature would show that much of these earlier works on the taxonomy and distribution of copepods is devoted to species gathered from the open seas and from the neighbourhood of the oceanic islands of the Central Indian Ocean. Krishnaswamy's investigations on the copepods of the Madras Coast represent the first exhaustive study of its kind in this country. The present work is another attempt in the same direction.

Our knowledge on the biology of Indian marine copepods is extremely scanty. A brief review of the literature is given in Chapter 3 of Part II of this thesis. It may, however, be added here that the studies carried out in Indian waters amount to very little compared to the monographic treatises that exist on this subject in other parts of the world. What is known on the biology of Indian marine copepods concerns mainly seasonal distribution, breeding etc., of a few numerically dominant species. No planktonic calanoid copepod has so far been studied so as to its complete developmental cycle and little is known on the diurnal vertical movements of copepods in Indian waters. During the present study some useful information has been obtained on both these aspects.

The present work is divided into two parts, the first part dealing with the systematics and the second with the biology. Following salient features are incorporated under the systematics:

One hundred and eighty three species of copepods belonging to the orders Calanoida, Harpacticoida, Cyclopoida and Monstrilloida are identified. This includes twenty three new species and four new genera. Of these, the descriptions of fourteen new species and two new genera are already published. Twenty five species are reported for the first time after their discovery and the undescribed males of seven species of copepods are described. Six Western Pacific species and six Eastern Atlantic species are recorded for the first time from the Indian Ocean. In addition to these, an interesting species of cyclopoid copepod, so far known only from the west coast of Africa, has been obtained. The Cyclopoid family Asterocheridae is split into two subfamilies viz., Asterocherinae nov. and Cletopontiinae nov. while reasons are formulated for abandoning the division of Entomolepidae into subfamilies as was done by Josef Eiselt (1959). Brief considerations are included on the classification, specificity of association and distribution of copepods.

The second part, dealing with the biology, includes the following:

(i) It has been possible to work out for the first time from Indian region the complete developmental cycle of two calanoid copepods, viz., Pseudodiaptomus aurivilli Cleve and Labidocera bengalensis Krishnaswamy. These two species are fairly common in the plankton of the south-east of India.

(ii) Attempts have been made to study the nature of diurnal vertical movements of planktonic copepods of the Gulf of Mannar.

(iii) Breeding and related aspects of ten species of planktonic copepods of the Gulf of Mannar are studied. The data obtained are compared with those gathered by earlier authors and the interesting points are discussed. Based upon their breeding habits the copepods of the Gulf of Mannar are tentatively placed in three groups.

Copepods constitute the largest item of the zooplankton, being present in all the seas and oceans. Good amount of research has been done on their taxonomy and biology in temperate and polar waters. The information available on these organisms in tropical and subtropical areas is rather limited. This is particularly true of the Indian Ocean where the chief source of knowledge has been the scientific reports of the few oceanographic Expeditions that visited this area. It is believed that the studies embodied in this thesis would help, to an appreciable extent, to further our knowledge of the systematics and the biology of the marine copepods of the Indian region.

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A C K N O W L E D G E M E N T S

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C O N T E N T S

PART I
THE SYSTEMATIC ACCOUNT

Part I. Systematic Account

Introduction

It is hardly necessary here to review the literature on the systematic accounts of Indian marine copepods. Much work has been done in this direction and attention may be invited to the monographic treatments that have recently been published (Sewell, 1929-32; 1940; 1947; 1948; 1949; Krishnaswamy, 1953a, b, c; 1956; 1957). These publications not only serve more or less as summaries of the works that have so far been done in our waters but also provide extensive bibliographies. It, however, appears that we are far from having a full knowledge of Indian marine copepods. This is amply proved by the fact that the present investigations have brought to light several species that have not been so far recorded from Indian waters and several others that are entirely new to science.

Cyclopoid copepods constitute the largest number in the present study, calanoids, harpacticoids and monstrilloids coming next in order. First group has the lion's share in the number of species that are new to science as well as new to our waters. Eighteen new species of cyclopoids are obtained during these studies, besides three other species which appear to be new. Sixteen cyclopoid species are recorded here as first rediscovery after their creation and another six species are recorded for the first time from Indian and neighbouring waters. It may be added that four new genera had to be created to accommodate four of the new species.

Among calanoids only a single new species could be detected while five species are recorded for the first time from the south-east coast of India. The calanoid fauna of this area is not very impressive, only fiftyeight species being reported in the present work.

Harpacticoids, too, present a similar picture. Of the fourty nine ~~fifty~~ species that are included in this work there are four species which are new and three others which appear to be new. Besides these, eight species have been found for the first time after their discovery.

Only two species of monstrilloids are obtained. Both are caught from the plankton in which they appeared occasionally. One species is newly recorded from the south east coast of India.

In the present work, species that have been fully described by earlier authors, especially by those who worked in Indian and neighbouring areas are briefly alluded to, mentioning only points of interest. All the new species as well as the newly recorded species are described in detail. Males of the following species are described for the first time:

1. *Ridgewayia typica* Thompson & Scott, 1903
2. *Euryte brevicauda* Sewell, 1949
3. *Asterocheres orientalis* Sewell, 1949

4. *Cryptopontius gracilioides* Ummerkutty, 1961
5. *Peltidium angulatum* Thompson & Scott, 1903
6. *Porcellidium ravanae* Thompson & Scott, 1903
7. *P. scotti* Pesta, 1935

Material and Methods

Copepods included in the present study are based on (a) regular surface tow-net collections made with organdie and bolting silk nets in the Gulf of Mannar in early hours of the morning (see Section II for details of area etc.); and (b) washings of weeds and invertebrates which were gathered from inshore waters as well as from dredgings made at 1-2 fathoms depth. Altogether about 150 plankton samples, collected from April 1959 to March 1961 were analysed. The shore collections were made chiefly from June 1960 to January 1961. The methods of collection adopted are described in an earlier publication (Ummerkutty, 1961).

Notes on the Classification

G.O. Sars (1903) divided the subclass Copepoda into seven orders, *viz*., Calanoida, Harpacticoida, Cyclopoida, Notodelphyoida, Monstrilloida, Caligoida and Lernaeoida (Lernaeopodoida). This system has been adhered to by great many of subsequent workers because it is simple and complete, furnishing a place for every valid genus. Wilson (1932) extended it to include the argulids which were regarded as representing the eighth order, thus eliminating the usual division of Copepoda into Eucopepoda and Brachiura. However, these two groups are now considered as subclasses of the Class Crustacea, rather than subdivisions of a single subclass. Brachiurans, therefore, do not come under our considerations.

Lang (1948b) has suggested some important revisions to the existing taxonomic system proposed by Sars. The use of the order Notodelphyoida is abandoned by Lang who made it clear that the division between cyclopoids and notodelphyoids is artificial, especially so in view of the discovery made by him of some interesting copepods which he assigned to a new family, Archinotodelphyidae (Lang, 1949). Archinotodelphyids are considered to hold an intermediate position between the families Cyclopinidae of Cyclopoida and Notodelphyidae of Notodelphyoida. With the exception of the families Enterocolidae and Anomopsyllidae, the notodelphyoids, he held, constitute a readily recognisable series with the gnathostomous cyclopoids. He proposed to incorporate the family Enterocolidae with poecilostomous cyclopoids while the systematic position of the family Anomopsyllidae is left uncertain. He divided the non-parasitic copepods into four groups, _viz_., Gymnoplea, Podoplea, Progymnoplea and Propodoplea. Former two terms were first proposed by Giesbrechet (1898) who employed them to denote the calanoids and non-calanoids respectively. Gymnoplea as proposed by Lang includes all calanoids except Platycopiidae and "allied families" which are placed by him in Progymnplea. Podoplea comprises two sections, Harpacticoida and Cyclopoida. Propodoplea is proposed to contain Mesophriidae and "its allied" which were so far included within the Harpacticoida. As M.S. Wilson (1958) pointed out, Lang's system, however, has the nomenclatural defect of eliminating entirely the much-used term Calanoida, which, though equivalent to Giesbrecht's term Gymnoplea has long been preferred and extensively used.

As to the internal organisation of calanoids, they were grouped by Giesbrecht under two divisions, Amphascandria and Heterarthrandria. A third division, Isokerandria, was added by Sars to accommodate a group of rather anomalous genera which shared some of the characters of both the earlier divisions but differed from them in some other characters. Sewell (1932) argued that these divisions should be maintained for, in a large number of species of the genera grouped under Amphascandria there is a brush of long hairs on inner aspects of first basal segment of (second) antenna while no such growth has been observed in any of the Heterarthrandria and Isokerandria. The latter two divisions are separated from each other by the presence or absence of geniculation of the right male antennule. Gurney (1931), however, has clearly shown that reliance on the character of single organ could produce only an unnatural grouping. He proposed an alternative arrangement; certain associations of families which might be regarded as superfamilies. Centropagina, Calanina, Paracalanina, Temorina, Diaixina and Pontellina are the six groups he recognised, the families Arietellidae, Pseudocyclopidae and Candaciidae having been dealt with in an undefined group of "uncertain position". As Gurney himself has indicated Candaciidae and Arietellidae are related to the superfamily Pontellina. Gurney appears to have included in Pseudocyclopidae the genus *Platycopia* G.O. Sars, 1911 which he spoke of as "related to *Pseudocyclops*". But both M.S. Wilson (1946) and Lang (1948b) have abundantly made clear that *Platycopia* is different from all other calanoids. M.S. Wilson (1946) further pointed out that within Centropagina there are some genera like *Isias* Boeck, 1865, with highly modified fifth legs and reduced endopods, and stated that both Ridgewayiidae, a new family created by her to accommodate *Ridgewayia* Thompson & Scott, 1903, as well as Pseudocyclopidae excluding *Platycopia* are referable to that superfamily.

Megacalanidae, created by Sewell (1947), should probably be placed under Calanina for, though the male right antennule is geniculate, structure of the fifth pair of legs is typically calanid. Fleminger (1957) reviewing the family Tharybidae has drawn attention to the close similarities that exist between Phaennidae and Scolecithricidae of Paracalanina and Diaixidae and Tharybidae of Diaixina and suggested that all these four families should be kept under Paracalanina instead of separating them into two superfamilies as was done by Gurney.

Most of the specialists on calanoids agree that the system proposed by Gurney presents a more exact relationship between families than the one propounded by the earlier workers.

Among the Podoplea, harpacticoids form a compact group and could be presented in a series of families which are inter-related by morphological gradations. Cyclopoids have been grouped, as opined by Sars and supported by Long and others, into three divisions, viz., Gnathostoma, Siphonostoma and Poecilostoma.

The definition of gnathostomous cyclopoids has greatly changed, and at present that group contains not only species originally assigned to it by Sars and subsequent workers but also species which formerly belonged to the order Notodelphyoida. This enlarged group is split up into two tribes, Cyclopoida gnathostoma cyclopinidiformes and Cyclopoida gnathostoma notodelphyidiformes. Broadly speaking these two tribes correspond to the original Cyclopoida gnathostoma and Notodelphyoida respectively. A family of copepods, Archinotodelphyidae, has recently been discovered (Lang, 1949) and is considered to constitute a connecting link between these two tribes, inclining more towards the notodelphyidiformes. A representative of this family has now been obtained from Indian waters (Ummerkutty, 1960 c).

Siphonostomous cyclopoids form a coherent group, and according to the original definition are characterised by the presence of an oral siphon. However, both Giesbrecht and Sars have recognised Cancerillidae as an exception to this rule. Recently some more families have been added (Micropontiidae Gooding, 1957; Stellicomitidae and Nanaspidae Humes and Cressey, 1958 & 1959) where, as in cancerillids, the siphon is absent or reduced to a very short extension of the labrum and the labium. The facts, that all these are parasitic on echinoderms and that they share many common features in contrast to the rest of siphonstomes, suggest that the members of these families have taken an altogether different evolutionary track. This view necessarily demands splitting up of Cyclopoida siphonostoma into two groups, one with a well-developed siphon and the other with siphon highly reduced to a pad or even absent.

Lang (1948b) divided Cyclopoida poecilostoma also into two tribes, viz., poecilostoma lichomolgidiformes and poecilostoma enterocolidiformes. He was led to hold this view because he believed that reduction of mouth parts of Enterocolidae (included by Sars in Notodelphyoida) implied that the latter is more related to the poecilostomes than to gnathostomes. However, Illg (1958) does not share this view. To quote: "The existence of the ophioseidid genera in the notodelphyid series possessing incubatoria offers possible objection to Lang's consideration of the enterocolids as poecilostomes. By the loss of mouthparts, the ophioseidids might be considered to qualify as poecilostomes, but the derivation of these genera seems so obviously demonstrable from the notodelphyid stock that other assignment would be purely arbitrary. Since the outstanding character of the poecilostomes is this more or less negative feature and the existence of a convergent parallel is available, the question arises whether the poecilostomes are not in fact an artificial, polyphyletic grouping. There are grounds in the definitions of some of the families to offer support to this suspician. It seems entirely possible that further discoveries among the ascidicolous copepods may yet provide the links that can cannect the enterocolids to the parental gnathostome stock" (p.477). Although Illg threw doubts to the very validity of the poecilostomes as a single phyletic unit, he himself stated that "the question should remain an open one until further facts are available" (p. 477).

<u>Notes on the specificity of association</u>

A note may be added here on the specificity of association of copepods with other invertebrates and weeds. During collections attempts were made to wash the different groups of hosts (holothurians, starfishes, polychaetes etc.) separately so as to study the copepods associated with particular groups. No attention was paid to the species-composition of hosts and no experimental study was undertaken in the laboratory as an extension of field observations.

In the present study only three calanoid species were found to frequent the weedy coastal regions, <u>Ridgewayia typicus</u> Thompson & Scott, <u>R. krishnaswamyi</u> n. sp. and <u>Pseudocyclops obtusus</u> Brady and Robertson. Stray individuals of all these species were also captured from the ~~pm~~ plankton on a few occasions. Commenting on the habitat of species of the genus Ridgewayia, M.S. Wilson (1958) observed: "The warm shallow waters of tropical and subtropical reefs and rocky shores, particularly among islands is, therefore, suggested as a common habitat of the genus". P. obtusus has also been reported from a similar habitat. It is obvious that these animals are not truly pelagic and find their sustenance among the decaying vegetable matter of the inshore littoral areas. But they do not appear to have any special preference for particular species of weeds.

Several species of harpacticoids were captured from among the weeds that were afloat in the sea and they are indicated in the text. Majority of harpacticoids, however, were gathered from washings of the littoral weeds. As solitary monospecific algal colonies were not found to occur in this area, it was not possible to observe whether the copepods living among them will have any preferential relationship. A single species of harpacticoid, Canuella (Canuella) scotti Sewell, 1940 was obtained from washings of the callianassid crustacean, Upogebia darwini.

Several cyclopoid copepods are found to live in association with other invertebrates. Recently many papers have been published on this type of association (Monod and Dollfus, 1932; Sewell, 1949; Bocquet, 1952; Gooding, 1957; Humes, 1957, 1958; Humes and Cressey, 1958a, b & c; etc.). In the present study true specificity was found only in the case of a few species: Lichomolgus serratipes Ummerkutty, Anthessius pinnae Humes, Stephopontius typicus Thompson &

Scott, *Stellicomes tumidulus* Humes & Cressey and *S. guineensis* Humes & Cressey.

L. serratipes was found to occur only in association with the common pteroid of this area, *Pteroides esperi* Herklots. Adult males and females as well as several young stages were found clinging to the pinnules, and would fall to the bottom if the pteroid is dipped into a beaker of dilute formalin. *A. pinnae* described from Madagascar as parasites of *Pinna* sp. is found to occur in good numbers in association with the same host genus. *S. typicus* was obtained from the body cavity of *Holothuria atra*. It was first reported by Thompson & Scott from washings of dredged invertebrates which included the holothurians also. It is likely that the specimens they obtained would have been washed out from holothurians. *Stellicomes tumidulus* and *S. guineensis* appear to have strong bonds of association with the animals from which they are gathered. The two species of *Stellicomes* Humes & Cressey are captured from the body surface of the starfish, *Pentaceros hedemanni*. The original material of these species have also been obtained from starfish washings. Both the species are recorded for the first time outside the type locality and their occurrence in very similar situations, associated with the same groups of hosts would point to the existence of certain mutual relations between the copepods and their hosts.

Notes on the distribution

Sewell (1940, 1948 & 1949) has discussed in detail the distributional patterns of copepods in Indian waters. It is not intended here to deal with the several important factors that are involved in, or the intricate patterns displayed by the distribution of these minute creatures. It is, however, thought fitting to invite attention to a few species whose presence in Indian waters appears to be quite interesting. Below are listed those species which are either entirely new records to Indian waters (indicated with I.W.) or new records to the south east coast of India (indicated with S.I.C.).

Species	Previous record and mode of existance.	Present record and mode of existence.
1. *Eucalanus pseudo-attenuatus* (S.I.C.)	Arabian Sea (Sewell), Madras Coast (Krishnaswamy), Planktonic	Gulf of Mannar, planktonic
2. *Pseudodiaptomus ardjuna* (S.I.C.)	Salsette Is., off Bombay (Brehm), planktonic	Gulf of Mannar, Palk Bay, planktonic
3. *Labidocera acutifrons* (S.I.C.)	Widely distributed in Indian, Pacific and Atlantic oceans (Sewell), planktonic	Gulf of Mannar, planktonic
4. *Acartia tortaniformis* (S.I.C.)	Coast of Burma, Northern Bay of Bengal, Hooghly River (Sewell), planktonic	Pàlk Bay, planktonic
5. *Alteutha interrupta* (I.W.)	East Atlantic (Sars)	Gulf of Mannar, among weeds
6. *Peltidium aurivilli* (I.W.)	Malay Archipelago (Cleve)	Gulf of Mannar, among weeds
7. *Parapeltidium Jhonstoni* (I.W.)	Malay Archipelago (A. Scott), from dredged invertebrates	Gulf of Mannar, planktonic and among weeds

8. *Alteuthella pellucida* (I.W.)	Malay Archipelago (A. Scott)	Palk Bay, among weeds
9. *Porcellidium clavigerum* (S.I.C.)	Hawaii (Pesta), Madras (Krishnaswamy)	Palk Bay, Gulf of Mannar, among weeds
10. *Scutellidium longicaudum* (I.W.)	East Altantic (Sars)	Gulf of Mannar, among weeds
11. *Xouthous maldiviae* (S.I.C.)	Maldive Archipelago (Sewell), among weeds	Palk Bay, among weeds
12. *Echinolaophonte horrida* (S.I.C.)	East Atlantic (Sars), Madras Coast (Krishnaswamy)	Gulf of Mannar, among weeds
13. *Doropygus pulex* (S.I.C.)	Widely distributed in all the oceans (Illg), in Ascidians	Palk Bay, in Ascidians
14. *Euryte brevicauda* (S.I.C.)	Maldive Archipelago (Sewell), among weeds	Gulf of Mannar, Palk Bay, among weeds
15. *Asterocheres orientalis* (S.I.C.)	Maldive Archipelago (Sewell), among weeds	Gulf of Mannar, Palk Bay, among weeds
16. *A. indicus* (S.I.C.)	Jhon Murray Exped., Station 45, among Alcyonarians	Gulf of Mannar, Palk Bay, among weeds
17. *A. latum* (I.W.)	East Atlantic (Sars)	Gulf of Mannar, Palk Bay, among weeds
18. *Scottocheres latus* (I.W.)	South Australia (Nicholls)	Palk Bay, among weeds
19. *Stellicomes tumidulus* (I.W.)	Madagascar, in association with starfishes	Gulf of Mannar, Palk Bay, in association with starfishes
20. *S. guineensis* (I.W.)	Cape Sierra Leone, West Africa, among starfishes	Palk Bay, among starfishes
21. *Dermatomyzon* nigripes (S.I.C.)	Widely distributed in Indian and Atlantic oceans, among weeds and invertebrates	Palk Bay, among weeds
22. *Acontiophorus scutatus* (I.W.)	East Atlantic (Sars)	Palk Bay, among weeds
23. *Cryptopontius brevifurcatus* (S.I.C.)	East Atlantic (Sars), Madras Coast (Krishswamy)	Gulf of Mannar, among weeds

24. _Hemicyclops australis_ (I.W.)	South Australia (Nicholls)	Gulf of Mannar, in the callinassid burrows
25. _H. indicus_ (S.I.C.)	Nicobar Islands (Sewell), weed washings	Gulf of Mannar, in callinassid burrows
26. _Hippomolgus dubia_ (S.I.C.)	Suez Canal (Thomp. & Scott), Madras (Krishnaswamy), planktonic	Gulf of Mannar, planktonic
27. _Hersiliodes latericia_ (I.W.)	Coast of France (Canu), among polychaetes	Palk Bay, among polychaetes
28. _Anthessius pinnae_ (I.W.)	Madagascar (Humes), in association with _Pinna_ sp.	Gulf of Mannar, in association with _Pinna_ sp.
29. _Preherrmanella brevicauda_ (S.I.C.)	Maldive Archipelago (Sewell), weed washings	Palk Bay, weed washings
30. _Kelleria regalis_ (S.I.C.)	Suez Channel (Gurney)	Gulf of Mannar, planktonic
31. _Pseudanthessius sauvagei_ (I.W.)	East Atlantic (Sars)	Gulf of Mannar, among weeds
32. _Thaumaleus bullatus_ (I.W.)	~~Malabar~~ Malay Archipelago (A. Scott), planktonic	Gulf of Mannar, planktonic

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The following species have been identified. Those marked with an asterik (*) are recorded for the first time after their original descriptions.

C A L A N O I D A

CALANIDAE

Genus _Canthocalanus_ A. Scott, 1909

1. _C. pauper_ (Giesbrecht), 1888.

Genus _Undinula_ A. Scott, 1909

2. _U. darwini_ (Lubbock), 1860.
3. _U. vulgaris_ (Dana), 1849.

EUCALANIDAE

Genus *Eucalanus* Dana, 18~~49~~53

4. *E. attenuatus* (Dana), 1849.
5. *E. elongatus* (Dana), 1849.
6. *E. pseudoattenuatus* Sewell, 1947.
7. *E. monachus* Giesbrecht, 1888.
8. *E. crassus*, Giesbrecht, 1888.
9. *E. subcrassus* Giesbrecht, 1888.
10. *E. mucronatus* Giesbrecht, 1888.

Genus *Rhincalanus* Dana, 1853

11. *R. nasutus* Giesbrecht, 1888.
12. *R. cornutus* Dana var. typica Schmaus, 1917.

Genus *Mecynocera* Thompson, 1888

13. *M. clausi* Thompson, 1888.

PARACALANIDAE

Genus *Paracalanus* Boeck, 1864

14. *P. aculeatus* Giesbrecht, 1888.
15. *P. parvus* (Claus), 1863.

Genus Acrocalanus Giesbrecht, 1888

16. *A. gracilis* Giesbrecht, 1892.
17. *A. longicauda* Giesbrecht, 1892.
18. *A. monachus* Giesbrecht, 1892.
19. *A. gibber* Giesbrecht, 1892.

EUCHAETIDAE

Genus *Euchaeta* Philippi, 1843

20. *E. marina* (Prestandrea), 1833.

SCOLECITHRICIDAE

Genus *Scolecithrix* Brady, 1883

21. *S. danae* (Lubbock), 1856.

CENTROPAGIDAE

Genus *Centropages* Kroyer, 1849

22. *C. dorsispinatus* Thompson & Scott, 1903.
23. *C. furcatus* (Dana), 1849.
24. *C. tenuiremis* Thompson & Scott, 1903.

25. C. orsinii Giesbrecht, 1889.
26. C. trispinosus Sewell, 1914.

RIDGEWAYIIDAE

Genus Ridgewayia Thomp. & Scott, 1903

27.*R. typica Thompson & Scott, 1903.
28. R. krishnaswamyi n.sp.

PSEUDODIAPTOMIDAE

Genus Pseudodiaptomus Herrick, 1884

29. P. (Pseudodiaptomus) aurivilli Cleve, 1901.
30. P. (P.) ardjuna Brehm, 1953.
31. P. (Schmackeria) serricaudata (T. Scott), 1894.
32. P. (S.) annandalei Sewell, 1919.

TEMORIDAE

Genus Temora Baird, 1850

33. T. turbinata (Dana), 1849.
34. T. discaudata Giesbrecht, 1889.
35. T. stylifera (Dana), 1849.

LUCICUTIDAE

Genus Lucicutia Giesbrecht, 1898

36. L. flavicornis (Claus), 1863.

ARIETELLIDAE

Genus Metacalanus Cleve, 1901.

37. M. aurivilli Cleve, 1901.

PSEUDOCYCLOPIDAE

Genus Pseudocyclops Brady, 1872

38. P. obtusus Brady & Robertson, 1873.
var. typica Sewell, 1932.
var. latisetosus Sewell, 1932.
var. asymmetrica nov.

CANDACIIDAE

Genus Candacia Dana, 1846

39. C. truncata (Dana), 1849.
40. C. catula (Giesbrecht), 1889.

PONTELLIDAE

Genus *Labidocera* Lubbock, 1853

41. *L. acutifrons* (Dana), 1849.
42. *L. acuta* (Dana), 1849.
43. *L. kroyeri* (Brady), 1883.
44. *L. pavo* Giesbrecht, 1892.
45. *L. pectinata* Thompson & Scott, 1903.
46. *L. bengalensis* Krishnaswamy, 1952.
47. *L. minuta* Giesbrecht, 1892.

Genus *Pontella* Dana, 1846

48. *P. securifer* Brady, 1883.
49. *P. danae* var. *ceylonica* Thompson & Scott, 1903.

Genus *Pontellopsis* Brady, 1883

50. *P. herdmanni* Thompson & Scott, 1903.
51. *P. macronyx* A. Scott, 1909.

Genus *Calanopia* Dana, 1852

52. *C. aurivilli* Cleve, 1901.
53. *C. elliptica* (Dana), 1849.
54. *C. thompsoni* A. Scott, 1909.

ACARTIIDAE

Genus *Acartia* Dana, 1846

55. *A. erythraea* Giesbrecht, 1889.
56. *A. tortaniformis* Sewell, 1912.

TORTANIDAE

Genus *Tortanus* Giesbrecht, 1898

57. *T. forcipatus* (Giesbrecht), 1892.
58. *T. gracilis* (Brady), 1883.

H A R P A C T I C O I D A

LONGIPEDIIDAE

Genus *Longipedia* Claus, 1863

59. *L. coronata* Claus, 1863.
60. *L. weberi* A. Scott, 1909.

CANUELLIDAE

Genus Canuella T. & A. Scott, 1893

61. C. (Canuella) furcigera Sars, 1903.
62. C. (C.) scotti Sewell, 1940.
63. C. (C.) perplexa T. & A. Scott, 1893.

ECTINOSOMIDAE

Genus Microsetella Brady & Robertson, 1873

64. M. rosea (Dana), 1853.

TACHIDIIDAE

Genus Euterpina Norman, 1903

65. E. acutifrons (Dana), 1848.

MACROSETELLIDAE

Genus Macrosetella A. Scott, 1909

66. M. gracilis (Dana), 1852.

CLYTEMNESTRIDAE

Genus Clytemnestra Dana, 1847

67. C. rostrata (Brady), 1883.

PELTIDIIDAE

Genus Alteutha Baird, 1845

68. A. interrupta Goodsir, 1843.
69. Alteutha sp.

Genus Peltidium Philippi, 1839

70. *P. aurivilli (Cleve), 1901.
71. P. speciosus Thompson & Scott, 1903.
72. *P. angulatum Thompson & Scott, 1903.
73. P. ovale Thompson & Scott, 1903.
74. (?) P. cenirium

Genus Parapeltidium A. Scott, 1909.

75. *P. jhonstoni A. Scott, 1909.
76. *P. serratipes (Thompson & Scott), 1903.
77. P. nichollsi n. sp.

Genus Alteuthella A. Scott, 1909

78. A. pellucida A. Scott, 1909.

TEGASTIDAE

Genus Tegastes Norman, 1903

79. T. minutus Sewell, 1940.

Genus Syngastes Monard, 1924

80. Syngastes sp.

PORCELLIDIIDAE

Genus Porcellidium Claus, 1860

81.*P. ravanae Thompson & Scott, 1903.

82. P. acuticaudatum Thompson & Scott, 1903.

83.*P. scotti Pesta, 1935.

84. P. fimbriatum Claus, 1860.

85. P. clavigerum Pesta, 1935.

86. P. unicus n. sp.

87. Porcellidium sp.

HARPACTICIDAE

Genus Harpacticus M. Eswards, 1838

88. H. littoralis G.O. Sars, 1910.

89. H. clausi A. Scott, 1909.

TISBIDAE

Genus Tisbe Lilljeborg, 1853

90. T. furcata (Baird), 1837.

Genus Tisbintra Sewell, 1940

91. T. jonesi Ummerkutty, 1960.

Genus Scutellidium Claus, 1866

92. S. longicaudum (Philippi), 1840.

93. S. plumosum Brady, 1899.

THALESTRIDAE

Genus Rhyncothalestris G.O. Sars, 1905

94. R. rufocincta (Norman), 1880.

95 Genus Xouthous Thompson, 1883

95.*X. maldiviae Sewell, 1940.

Genus Eudactylopus A. Scott, 1909

96. E. striatus Sewell, 1940.

DIOSACCIDAE

Genus Diosaccus Boeck, 1872

97. D. truncatus Gurney, 1927.

Genus Amphiascopsis Gurney, 1927

98. A. dentatus (Thompson & Scott), 1903.

99. A. hirsutus (Thompson & Scott), 1903.

100. A. cinctus (Claus), 1866.

LAOPHONTIDAE

Genus Laophonte Philippi, 1840

101. L. (Laophonte) hirsuta Thompson & Scott, 1903.

102. L. (L.) macani Sewell, 1940.

Genus Echinolaophonte Nicholls, 1941

103. E. horrida (Norman), 1876.

104. E. tropica n. sp.

CANTHOCAMPTIDAE

Genus Orthopsyllus Brady & Robertson, 1873

105. O. linearis (Claus), 1866.

LOURINIIDAE

Genus Lourinia Wilson, 1924

106. L. armata (Claus), 1866.

METIDAE

Genus Metis Philippi, 1843

107. M. jousseaumei forma minor Sewell, 1940.
forma major Sewell, 1940.

C Y C L O P O I D A

Section Gnathostoma

OITHONIDAE

Genus Oithona Baird, 1843

108. O. linearis Giesbrecht, 1891.

109. O. robusta Giesbrecht, 1891.

110. O. rigida Giesbrecht, 1898.

111. O. plumifera Baird, 1843.

112. O. setigera (Dana), 1849.

113. O. nana Giesbrecht, 1892.

CYCLOPINIDAE

Genus Cyclopina Claus, 1863

114. C. gracilis Claus, 1863

CYCLOPIDAE

Genus *Euryte* Philippi, 1843

115. *E. robusta* Giesbrecht, 1900.

116.**E. brevicauda* Sewell, 1949.

117. *Euryte* sp.

ARCHINOTODELPHYIDAE

Genus *Nearchinotodelphys* Ummerkutty, 1960

118. *N. indicus* Ummerkutty, 1960.

NOTODELPHYIDAE

Genus *Doropygus* Thorell, 1859

119. *D. pulex* Thorell, 1859.

Section Siphonostoma

ASTEROCHERIDAE

Genus *Asterocheres* Boeck, 1859

120.**A. major* Thompson & Scott, 1903.

121.**A. minor* Thompson & Scott, 1903.

122. *A. mannarensis* Thompson & Scott, 1903.

123. *A. dentatus* Giesbrecht, 1899.

124.**A. orientalis* Sewell, 1949.

125.**A. indicus* Sewell, 1949.

126. *A. latum* (Brady), 1880.

127. *Asterocheres* sp. (i)

128. *Asterocheres* sp. (ii)

Genus *Scottocheres* Giesbrecht, 1897

129.**S. latus* Nicholls, 1944.

Genus *Dermatomyzon* Claus, 1889

130. *D. nigripes* (Brady), 1880.

Genus *Asteropontius* Thompson & Scott, 1903

131.**A. typicus* Thompson & Scott, 1903.

132. *A. littoralis* Ummerkutty, 1961.

133. *A. sewelli* Ummerkutty, 1961.

Genus *Indomyzon* n. gen.

134. *I. qasimi* n. gen. *et*. n. sp.

ACONTIOPHORIDAE

Genus *Acontiophorus* Brady, 1880

135. *A. scutatus* Brady, 1880.

ENTOMOLEPIDAE

Genus *Paralepeopsyllus* Ummerkutty, 1960

136. *P. mannarensis* Ummerkutty, 1960.

DYSPONTIIDAE

Genus *Sewellopontius* n. gen.

137. *S. rectiangulus* n. gen. *et*. n. sp.

Genus *Cryptopontius* Giesbrecht, 1899

138. *C. brevifurcatus* Giesbrecht, 1899.

139. *C. graciloides* Ummerkutty, 1961.

140. *C. orientalis* Ummerkutty, 1961.

STELLICOMITIDAE

Genus *Stellicomes* Humes & Cressey, 1958

141.**S*. *tumidulus* Humes & Cressey, 1958.

142.**S*. *guineensis* Humes & Cressey, 1958.

NANASPIDAE

Genus *Stephopontius* Thompson & Scott, 1903

143.**S*. *typicus* Thompson & Scott, 1903.

Section Poecilostoma

CLAUSIDIIDAE

Genus *Hemicyclops* Boeck, 1873

144.**H*. *australis* Nicholls, 1944.

145.**H*. *indicus* Sewell, 1949.

146. *H. intermedius* Ummerkutty, 1961.

Genus *Hippomolgus* G.O. Sars, 1917

147. *H. dubia* (Thompson & Scott), 1903.

Genus *Hersiliodes* Canu, 1888

148. *H. lactericia* Canu, 1888.

LICHOMOLGIDAE

Subfamily Sabelliphilinae

Genus *Anthessius* Della Valle, 1879

149.**A*. *pinnae* Humes, 1958.

Genus *Preherrmannella* Sewell, 1949

150.**P*. *brevicauda* Sewell, 1949.

151.**P*. *serendibica* (Thompson & Scott), 1903.

Genus *Sabelliphilus* M. Sars, 1862

152. *S. foliacea* n. sp.

Subfamily Lichomolginae

Genus *Pseudoanthessius* Claus, 1889

153. *P. sauvagei* Canu, 1891.
154. *P. liber* (Brady & Robertson), 1875.
155. *P. luculentus* Humes & Cressey, 1959.
156. *P. anormalus* n. sp.
157. *P. brevicauda* n. sp.

Genus *Kalleria* Gurney, 1927

158.**K. regalis* Gurney, 1927.

~~159.~~ Genus *Macrochiron* Brady, 1872

159. *M.* (*Paramacrochiron*) parvus A. Scott, 1909.
160. *M.* (*Macrochiron*) *rigida* Ummerkutty, 1961.

Genus *Lichomolgus* Thorell, 1860

161.?*L. gigas* Thompson & Scott, 1903.
162. *L. holothuriae* Ummerkutty, 1961.
163. *L. serratipes* Ummerkutty, 1961.
164. *L. indicus* Ummerkutty, 1961.
165. *L. brevifurcata* Ummerkutty, 1961.
166. *Lichomolgus* sp.

ONCAEIDAE

Genus *Oncaea* Philippi, 1843

167. *O. conifera* Giesbrecht, 1892.
168. *O. media* var. *major* Sewell, 1947.
var. *minor* Sewell, 1947.
169. *O. mediterranea* Claus, 1866.
170. *O. venusta* Philippi, 1843.
171. *O. clevei* Fruchtl, 1923.

SAPPHIRINIDAE

Genus *Sappirina* Thompson, 1829

172. *S. iris* Dana, 1853.
173. *S. nigromaculata* Claus, 1863.
174. *S. ovatolanceolata* Dana, 1849.

Genus *Copilia* Dana, 1849

175. *C. mirabilis* Dana, 1849.

CORYCAEIDAE

Genus *Corycaeus* Dana, 1845

176. *C.* (*Urocorycaeus*) *longistylis* Dana, 1845.
177. *C.* (*Ditrichocorycaeus*) *asiaticus* F. Dahl, 1894.
178. *C.* (*Corycella*) *gibbula* Giesbrecht, 1892.
179. *C.* (*Corycaeus*) *speciosus* Dana, 1845.
180. *C.* (*Onchocorycaeus*) *agilis* Dana, 1845.
181. *C.* (*O.*) *catus* F. Dahl, 1894.

M O N S T R I L L O I D A

MONSTRILLIDAE

Genus *Cymbasoma* Thompson, 1888

182. *C.* *bullatus* (A. Scott), 1909.
183. *C.* *tropicus* Wolfenden, 1906.

C A L A N O I D A

CALANIDAE

G.O. Sars, 1903, p.8.

Genus *Canthocalanus* A. Scott, 1909

A. Scott, 1909, p. 9.

1. *C. pauper* (Giesbrecht), 1888.

Giesbrecht, 1888, p. 331.
Sewell, 1929, p. 25.
Krishnaswamy, 1953a, p. 25.

Material examined - This species is captured frequently, often in good numbers. It appears to breed actively twice a year, in June-July and October-December when large numbers of copepodites and adults are present in plankton. Krishnaswamy (*loc. cit.*) has already noted its abundance in the months of November-December both in Krusadai as well as in Madras waters. Size: female 1.3 mm. and male 1.13 mm.

Distribution - Widely distributed in Indian and Pacific oceans and also in the Mediterranean sea.

Genus *Undinula* A. Scott, 1909

A. Scott, 1909, p. 17.

2. *U. darwini* (Lubbock), 1860.

Lubbock, 1860, p. 179, pl. 29, figs. 4 & 5.
Sewell, 1929, p. 42.
Sewell, 1947, pp. 18-20.
Vervoort, 1946, pp. 77-83.
Krishnaswamy, 1953a, p. 110.

Material examined - Few specimens captured in August 1959 are all females. Size: 2.7 mm.

Distribution - Known from Pacific, Indian and Atlantic oceans.

Remarks - Sewell (1929) recognises three varieties, viz., var. typica, var. intermedia and var. symmetrica. I have been able to obtain only the first variety.

3. U. vulgaris (Dana), 1849.

Dana, 1849, p. 22.
Sewell, 1929, p. 31.
Krishnaswamy, 1953a, p. 109.

Material examined - In the Gulf of Mannar the maximum number of this species is present during the months of May-July 1960 when good numbers of copepodites are also noticed. Size: var. giesbrechti female 2.5 mm. and male 2.1 mm; var. typica and var. zealanica are a little smaller.

Distribution - Cosmopolitan, being present in all the three great oceans.

EUCALANIDAE

G.O. Sars, 1903, p. 12.

Genus Eucalanus Dana, 1853

G.O. Sars, 1925, p. 21.

4. E. attenuatus (Dana), 1849.

Dana, 1849, p. 18.
Sewell, 1947, pp. 38-40.
Vervoort, 1946, pp. 95-103.
Krishnaswamy, 1953a, pp. 110-111.

Material examined - This species is found in good numbers in June 1959. Large numbers of copepodites are present in the following months until in September-October the species is rarely seen. Size: female 4.1 mm. and male 3.28 mm.

Distribution - Widely recorded from Atlantic, Indian and Pacific oceans.

5. *E. elongatus* (Dana), 1849.

Dana, 1849, p. 18.
Sewell, 1929, p. 49.
Vervoort, 1946, pp. 84-94.
Sewell, 1947, pp. 43-45.
Krishnaswamy, 1953a, p. 111.

Material examined - This species is neververy common. A few specimens are captured in August 1959 along with other species of this genus. Size: female 4.21 mm. and male 3.40 mm.

Distribution - Throughout the Indo-Pacific.

Remarks - Vervoort (*loc. cit.*) does not recognise any difference between *E. elongatus* (Dana) and *E. bunghii* Johnson. "In my opinion Johnson's species certainly have no specific value. It seems best to distinguish between an Atlantic form with laterally produced thoracic margins, asymmetrical first antenna and slightly spinulated on the dorsal surface and a Pacific form with a smoothly rounded lateral thoracic margins, symmetrical first antenna and without any indication of spinules" (p. 93). This view has been supported by Sewell (1949) who thus remarked on the species he collected during the John Murray Expedition "All the specimens belonged to the variety first described by Giesbrecht (1895, p. 246) and later noted by Esterly (1905, p. 132, fig. 6b) in which the lateral posterior margin of the fifth thoracic segment is rounded and does not exhibit the small spines of the typical form. Both of these records come from the Pacific ocean and it would appear possible that this variety is in reality an Indo-Pacific form" (p. 44). The present material belongs to this Indo-Pacific group.

Tanaka (1956) has, however, preferred to treat the two forms as two species, E. elongatus and E. bunghii.

6. E. pseudoattenuatus Sewell, 1947.

Sewell, 1947, pp. 40-43, figs. 7 A and 8 A-F.
Krishnaswamy, 1956, p. 452.

Material examined - A single specimen of this species is obtained in August 1959. Size: female 3.3 mm.

Distribution - Maldive Islands, Arabian sea, Madras coast and the Gulf of Mannar.

7. E. monachus Giesbrecht, 1888.

Giesbrecht, 1888, p. 333.
Sewell, 1929, p. 51.
Sewell, 1947, p. 46.

Material examined - This species is also captured during August 1959 in small numbers mostly admixed with other larger copepods of this area. Size: female 2.28 mm. and male 1.96 mm.

Distribution - Recorded from Atlantic and Indian oceans.

8. E. crassus Giesbrecht, 1888.

Giesbrecht, 1888, p. 333.
Sewell, 1929, p. 50.
Vervoort, 1946, pp. 112-15.
Sewell, 1947, p. 46.
Krishnaswamy, 1953a, p. 111.

Material examined - Rare individuals are caught almost every month, most of them being in the fifth copepodite stage. The breeding of this species appears to coincide with that of E. attenuatus and takes place mainly twice a year, July-August and November-December. Size: female 2.9 mm. «9 m, and male 2.4 mm.

Distribution - Atlantic and Indo-Pacific.

Remarks - According to Vervoort, *E. oculans* described by Marukawa (1921) is identical with *E. crassus*: "The 'eyes' described by that author very probably are the spots where muscles from the first antenna or the mouthparts are internally attached to the integumentum, and which are distinctly visible in nearly all specimens of *E. crassus* and other species of the genus *Eucalanus* by transparency of the carapace". (p. 114)

9. *E. subcrassus* Giesbrecht, 1888.
   Giesbrecht, 1888, p. 334.
   Sewell, 1929, pp. 51-57, figs. 14-17.
   Vervoort, 1946, pp. 108-112, figs. 8a & b.
   Sewell, 1947, p. 47.
   Krishnaswamy, 1953a, p. 112.

Material examined - This species is obtained in good numbers in August and November 1959. Size: female 2.3 mm. and male 1.8 mm.

Distribution - Greatly distributed in Indian, Pacific and Atlantic oceans.

10. *E. mucronatus* Giesbrecht, 1888.
   Giesbrecht, 1888, p. 334.
   Sewell, 1929, p. 51.
   Sewell, 1947, p. 46.

Material examined - A few female specimens of this species are obtained from plankton near Hare Island in August 1959. Size: female 2.21 mm.

Distribution - Found in Atlantic, Indian and Pacific oceans.

Genus *Rhincalanus* Dana, 1853

G.O. Sars, 1903, p. 14.

11. *R. nasutus* Giesbrecht, 1888.
   Giesbrecht, 1888, p. 334.

Schmaus & Lehnhofer, 1927, pp. 368, 384-86, figs. 3, 15-19, 21 & 26.
Steuer & Hentschel, 1937, pp. 138-50, 151-58, figs. 67-72, 74-79.
Vervoort, 1946, pp. 122-26.
Sewell, 1947, pp. 49-50.

Material examined - This species occurs only sporadically. Large numbers of males, females and late copepodites are obtained in the last week of August 1959. In the middle of December, three sixth nauplii and a few third and fourth copepodites are obtained. Size: female 4.8 mm. and male 4.3 mm.

Distribution - Recorded from all the great oceans.

Remarks - Schmaus and Lehnhofer (*loc. cit.*) have clearly shown that *R. nasutus* is a deep water species, very much controlled in abundance by deep water currents. In Indian ocean it is an inhabitant of the Indian Tropical Intermediate Current.

12. *R. cornutus* Dana forma *typica* Schmaus, 1917.

Dana, 1853, p. 1083; 1855, pl. 76, figs. 2 a-d.
Schmaus, 1917, p. 312, figs. 5-11.
Schmaus & Lehnhofer, 1927, pp. 359, 360, 365-68, 379-82, figs. 1, 2, 8-14, 22 & 25.
Vervoort, 1946, pp. 116-22.
Sewell, 1947, p. 48.
Krishnaswamy, 1953a, p. 112.

Material examined - Two specimens (a fourth copepodite and a fifth copepodite) are collected along with the preceding species. Size: fourth copepodite 3.1mm. and fifth 4.0 mm.

Distribution - Throughout the Indo-Pacific and South Atlantic oceans.

Remarks - This variety is confined to the Indo-Pacific while forma *atlantica* Schmaus is observed in the Atlantic ocean. Like the earlier species this is also a deep water form, adults for the most part being found at depths below 200 meters. However, both species occur and breed in surface as well as in deeper waters (*vide* Sewell, 1947; Wilson, 1932).

Genus *Mecynocera* Thompson 1888

Wilson, 1932, p. 36.

13. *M. clausi* Thompson, 1888.

Thompson, 1888, p. 150, pl. 11.
Sewell, 1929, p. 61.
Krishnaswamy, 1953a, p. 113.

Material examined - Two female specimens are collected from plankton of Hare Island in September 1959. Size: female 1.03 mm.

Distribution - Widely distributed in Indian, Pacific and Atlantic oceans.

PARACALANIDAE

G.O. Sars, 1903, p. 16.

Genus *Paracalanus* Boeck, 1864.

G.O. Sars, 1903, p. 17.
Sewell, 1929, p. 61.

14. *P. aculeatus* Giesbrecht, 1888.

Giesbrecht, 1888, p. 332.
Sewell, 1929, pp. 62-66, figs. 20 & 21.
Vervoort, 1946, pp. 127-28.
Sewell, 1947, p. 51.
Krishnaswamy, 1953a, p. 114.

Material examined - This is a common species of this area and is obtained almost throughout the year. A study of the breeding habits of this species is included in the second part of this thesis. Size: female 1.20 - 1.23 mm. and male 0.81 - 0.85 mm.

Distribution - Distributed in the tropical and subtropical regions of all the oceans.

15. *P. parvus* (Claus), 1863

Claus, 1863, p. 173, pl. 26, figs. 10-14; pl. 27, figs.1-4.
Sewell, 1929, pp. 68-71.
Sewell, 1947, pp. 51-52.
Krishnaswamy, 1953a, pp. 113-14.

Material examined - This is another very common species and can be obtained throughout the year. Size: female 0.65 mm. and male 0.58 mm.

Distribution - Distributed in all the oceans.

Remarks - Wolfenden (1906) recognises two varieties, one found in N. Atlantic and called by him var. *borealis* and the other found in the Indo-Pacific and named var. *indicus*. The present material belongs to the latter category.

Genus *Acrocalanus* Giesbrecht, 1888.

Wolfenden, 1906, pp. 999-1000.

16. *A. gracilis* Giesbrecht, 1888.

Giesbrecht, 1888, p. 332.
Wolfenden, 1906, pp. 1003-1004, pl. XCVII, figs. 23-24.
Sewell, 1929, pp. 79-80, fig. 31.
Sewell, 1947, p. 53.
Krishnaswamy, 1953a, p. 115.

Material examined - This is a rare species captured only on three occasions, January 1959, April 1959 and January, 1960. They occur in very small numbers and only females are caught. Size: female: 1.19 mm.

Distribution - Widely recorded from the warm waters of Indian and Pacific oceans.

17. *A. longicornis* Giesbrecht, 1888.

Giesbrecht, 1888, p. 332.
Wolfenden, 1906, pp. 1000-1002, pl. XCVII, figs. 1, 6, 11-12, 23-24.
Sewell, 1929, pp. 82-83, fig. 33.
Krishnaswamy, 1953a, pp. 114-15.

Material examined - This species is obtained in small numbers during October 1959 and July 1960. Size: female 1.16 mm. and male 1.31 mm.

Distribution - Widely distributed in the tropical and subtropical areas of the oceans.

18. A. monachus Giesbrecht, 1888.

Giesbrecht, 1888, p. 333.
Wolfenden, 1906, pp. 1002-1003, pl. XCVII, figs. 27-28, 49.
Sewell, 1947, p. 53.
Krishnaswamy, 1953a, pp. 115-16.

Material examined - This is a common acrocalanid of this area and is obtained throughout the year. Size: female 0.81 mm. and male 0.69 mm.

Distribution - Recorded from various localities in the Indo-Pacific.

19. A. gibber Giesbrecht, 1888.

Giesbrecht, 1888, p. 332.
Wolfenden, 1906, p. 1003, pl. XCVII, fig. 38.
Sewell, 1929, pp. 80-81, fig. 38.
Vervoort, 1946, pp. 136-37.
Krishnaswamy, 1953a, p. 115.

Material examined - This is a common species occurring in abundance during July-August and November-February months. In small numbers it is present throughout the year. Size: female 1.05 mm. and male 0.93 mm.

Distribution - Widely distributed in Indian and Pacific oceans and in the Mediterranean sea.

EUCHAETIDAE

G.O. Sars, 1903, pp. 36-37.

Genus _Euchaeta_ Philippi, 1843

G.O. Sars, 1903, p. 37.
Sewell, 1947, pp. 110-12.

20. _E_. _marina_ (_Prestandrea_), 1833.

Prestandrea, 1833, p.12.
Sewell, 1929, p. 148.
Sewell, 1947, pp. 113-15.
Krishnaswamy, 1953a, p. 117.

Material examined - A few specimens are obtained during November 1959. All specimens are fifth copepodite females. Size: 3.1 mm.

Distribution - Recorded from Indian, Atlantic and Pacific oceans.

SCOLECITHRICIDAE

G.O. Sars, 1903, p. 49.

Genus _Scolecithrix_ Brady, 1883.

Wilson, 1932, p. 81.

21. _S_. _danae_ (Lubbock), 1856.

Lubbock, 1856, p. 21, pl. 9, figs. 6-9.
Sewell, 1929, p. 209.

Material examined - A single male specimen of this species is taken from plankton in June 1959. Size:male: 1.9 mm.

Distribution - "This is ~~a~~ the most widely distributed species of the genus" (Wilson, 1950).

CENTROPAGIDAE

G.O. Sars, 1903, p. 73.

Genus _Centropages_ Kroyer, 1849

G.O. Sars, 1903, p. 74.
Sewell, 1929, p. 227.
Wilson, 1932, p. 85.

22. _C._ _dorsispinatus_ Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 247, pl. 1, figs. 19-25.
Sewell, 1932, p. 228.
Krishnaswamy, 1953a, p. 120.

Material examined - This species is present in good numbers from November to February. It commences to appear in the beginning of November and by the end of the month both sexes swarm the waters. Intensive breeding seems to take place in January as judged from the presence of enormous number of younger stages. Size: female 1.48 mm. and male 1.35 mm.

Distribution - So far recorded from the eastern and western seas of Indian Peninsula as well as from the Malay Archipelago.

23. _C._ _furcatus_ (Dana), 1849.

Dana, 1849, p. 25.
Sewell, 1932, p. 229.
Krishnaswamy, 1953a, p. 117.

Material examined - This is a common species of this area and is found throughout the year. Size: female 1.8 mm. and male 1.6 mm.

Distribution - "Has a wide distribution throughout the tropical belt" (Sewell, 1932, p. 229).

24. _C._ _tenuiremis_ Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 247, pl. 1, figs. 14-18.
Sewell, 1932, pp. 230-32.
Krishnaswamy, 1953a, p. 120.

Material examined - This is a rare species occurring mostly during colder months of the year, December-January. Adults and younger stages are caught near Hare Island.

Size: female 1.8 mm. and male 1.6 mm.

Distribution - Recorded from the Arabian sea, Bay of Bengal and the Gulf of Mannar.

25. C. orsinii Giesbrecht, 1889.

Giesbrecht, 1889, p. 811.
Sewell, 1947, p. 163.
Krishnaswamy, 1953a, p. 122.

Material examined - This is another not very common species. However, a sporadic appearance of quite a good number of individuals is noticed in November 1959.

Size: female 1.63 mm. and male 1.37 mm.

Distribution - Widely distributed in the tropical and subtropical areas of oceans.

26. C. trispinosus Sewell, 1914.

Sewell, 1914, pp. 223-24, pl. XVIII, figs. 3-8.
Krishnaswamy, 1951, p. 76, fig. 2.
Krishnaswamy, 1953a, p. 121.

Material examined - Sewell (loc. cit.) created this species from this geographical area on the basis of a single female specimen. Krishnaswamy (1951) subsequently described the male. I have obtained this copepod almost throughout the year in small numbers. The maximum number of this species is found in January, both in 1959 and 1960.

Size: female 1.52 mm. and male 1.21 mm.

Distribution - Recorded from the Gulf of Mannar and Madras coast.

RIDGEWAYIIDAE

M.S. Wilson, 1950, pp. 176-77.

Genus <u>Ridgewayia</u> Thompson & Scott 1903

Thompson & Scott, 1903, p. 245.
M.S. Wilson, 1958, pp. 140-42.

27. <u>R.</u> <u>typica</u> Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 245, pl. I, figs. 1-13.
M.S. Wilson, 1958, pp. 142-43.

<u>Material examined</u> - Fifteen females and thirteen males of this species occurred in the washings of weeds collected both from the Gulf of Mannar and the Palk Bay during the months of September-October 1960.

<u>Descriptive notes</u> - Thompson & Scott (<u>loc. cit.</u>) gave the description of female of this species. Some additional notes, however, are given here to provide detailed informations of the various appendages. Male is described for the first time.

<u>Female</u>: Animal is quite robust, with a rather cylindrical presome which is 6-segmented, gracefully rounded anteriorly and ending posteriorly in angular corners. The partition between the first two segments is indistinct. First prosomal segment is very large and contains in it the widest part of body. Last segment, in dorsal view, terminates in angular corners and in lateral view, the inner edge of this segment is broken by a hook-like notch. The area between this notch and posterior tip is very thin and transparent with two minute hairs. The genital segment (Pl. II, 2) looks rather hexagonal in dorsal view and is asymmetrical with the right postero-lateral corner produced into a spine-like structure. In ventral view a pair of genital apertures are seen on the genital segment (pl.II,3).

They are symmetrically arranged, and occupy only a little more than half the width of segment. Next three urosomal segments diminish both in length and width to posterior side. Hind margins of second and third segments are entire. In first segment the mid-dorsal area is slightly produced into a dome, while in last segment the mid-dorsal area is elevated into a pair of symmetrical, triangular structures, each carrying stout, sharp, conical spines. Caudal ramus is simple and rectangular, the narrow distal margin carrying one sub-terminal spine, shorter than the ramus on the outer side, one small subterminal seta on the dorsal side and four long setae on the apical margin. The middle two setae are clearly jointed at proximal area. Second seta from inner side is the longest, almost twice the length of the entire urosome. Fine setae are present on inner margins of caudal rami.

Antennule is 25-jointed, reaching to the posterior margin of the penultimate prosomal segment. The proportionate lengths of the constituting segments and the number of setae and aesthetasks borne by them are presented below:

1	2	3	4	5	6	7	8	9	10	11	12	13
6.2	8.5	3.3	2.3	2.5	2.5	2.8	2.1	2.1	2.5	2.1	3.1	3.6
1s	3s	2s	-	1s	2s	2s	1s	1s	1s	2s	2s	1s
1a	1a	1a	1a	1a	1a	1a	1a	1a	1a	1a	2a	1a

14	15	16	17	18	19	20	21	22	23	24	25	
3.6	3.6	3.6	3.6	3.3	3.6	3.3	3.3	5.0	6.6	9.1	7.8	= 100
1s	1s	2s	1s	1s	1s	1s	1s	2s	2s	2s	4s	
1a	1a	1a	1a	1a	1a	-	-	-	-	-	1a	

(s - represents seta; a - represents aesthetask)

Antenna, maxillule, maxilla and maxilliped have been excellently sketched by Thompson & Scott and need no comments except that they have obviously confused the exopod and the endopod of antenna. Thompson & Scott have also figured first, second, fourth and fifth pairs of legs. In third leg, the endopod is similar to that of second leg and the exopod to that of fourth leg. First leg (Pl. II, 4) shows several distinctive modifications: Outer spines of exopod are very slender and sharp. Outer apical spine is short, but inner apical spine is subequal to the last two exopod segments. Distal to the spine, a flat digitiform process fringed all along the entire margins, is present in first and second segments. In third segment there is no indication of this specialized structure. A long sensory filament is present between the digitiform process and the spine of second exopod segment. There is a curved, sickle-shaped spine on the inner distal margin of second protopod segment. First protopod segment of first leg does not bear any seta.
The next three pairs of legs show little peculiarities. The setae of all the legs are jointed, only the distal parts bearing setules. The ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	0	0	I	0	1	0	2	0	4	1	1	1	I	1	I	4	II	I
P_2	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	II	I
P_3	1	0	I	0	1	0	2	0	4	2	2	1	I	1	I	5	II	II
P_4	1	0	0	0	1	0	2	0	3	2	2	1	I	1	I	5	II	II

(In this and in all other ornamentation formulae of swimming legs the abbreviations used are as follows: P_1 etc.- swimming legs; Si, St and Se - internal, terminal and external margins segments; I etc.- spines; and 1 etc - setae).

In fifth leg only exopod is 3-segmented, endopod being 2-segmented. First protopod segment is without any seta, second protopod segment carries one seta on the middle outer margin. First exopod segment carries on its outer distal angle a seta which is equal in length to the segment itself. Second segment also carries a similar seta, but a little shorter. At almost middle of inner margin of that segment a seta is present. Third segment is just as long as the second and carries an apical, an inner and two outer spines; on the inner margin there are four setae. Apical spine is the longest and proximal outer spine the shortest. First segment of endopod is devoid of any seta, while distal segment carries two outer, two apical and three inner setae. The proximal most inner spine is borne at about one-third of length of the segment. All the setae on both rami are jointed, the setules being present only on the distal parts. Size: 0.8 mm. - 0.82 mm.

Male: The differences between female and male are manifested in the geniculation of right antennule, fifth legs and in the segmentation of urosome.

Left antennule is non-geniculate and 25-jointed as it is in the female. In the number of setae and aesthetasks as well as in their arrangements, the left antennule is very similar to the female antennule. The geniculate right antennule (pl. III, 1) is 22-jointed. First eleven proximal segments roughly correspond to their counterparts of the female antennule, but there is a profusion of aesthetasks, especially in the more proximal segments. In twelfth segment, inner margin is highly shortened with the result that the thirteenth segment looks as if it is directly in contact with the eleventh segment. However, a clear, diagonal demarcation separates the twelfth and the thirteenth segments. Four apical joints are elongated. The third segment from apex is notched at about one-third of its length of both margins, while the fourth segment (Pl. III,2) shows very fine dentition. Proportionate lengths of the various segments and the setae and the aesthetasks borne by them are presented below:

1	2	3	4	5	6	7	8	9	10	11	12
7.8	9.8	3.1	2.1	2.6	2.35	2.6	2.6	1.55	2.8	1.55	2.1
1s	3s	2s	2s	2s	2s	2s	1s	1s	1s	1s	1s
1a	3a	3a	1a	1a	1a	1a	1a	1a	1a	-	2a

13	14	15	16	17	18	19	20	21	22	
3.6	3.6	3.4	3.4	3.1	5.2	10.1	10.1	8.8	7.75	= 100
2s	2s	2s	2s	1s	1s	3s	2s	2s	4s	
1a	1a	1a	1a	-	-	1a	1a	-	1a	

Fifth legs (Pl. III,3) are distinctly modified, both the legs being biramous. In right leg, exopod is 2-jointed, while in left leg it is 3-segmented. Endopod in both legs are 1-segmented and protopod 2-segmented. Protopod is similarly constructed in both legs. Basal protopod segment does not bear any seta or spine, distal segment carries one seta on its outer distal angle in both the legs. First segment of right exopod bears on its distal outer angle a spine which is as long as the segment itself. A number of bristles are present on its distal margin. Second segment is larger than the first and is peculiarly produced inwards into a beak-like structure at its distal end. At base of this beak there is a conical spine. A large spine similar to that of first segment is present on the second segment also; but it originates at about the middle of outer margin. First two segments of left exopod are normal, both bearing spines corresponding to those of the right leg, at the distal outer angles. First segment, however, is one and a half times longer than the other. Last exopod segment (Pl. III, 4) is highly modified and very short. A number of ill-defined processes and spines are brone on that segment, the exact functional importance of which is uncertain.

Right endopod is longer than the left. It is a rather cylindrical structure, terminating in one apical and one subapical spines. There are three setae on the inner margin, first seta taking its origin at about one third of proximal length and the other two being more or less equispaced. Left endopod is much simpler in structure than the right. It is cylindrical in shape, terminating in one apical spine. Endopod is a little longer than exopod.

Urosome is 5-segmented and figured (Pl. II, 5). The segments are columnar and diminish both in length and width posteriorwards. Last segment is much reduced in size and can be seen only on careful examination. Caudal rami borne on this segment are rather rectangular, about one and a half times longer than wide and bearing fine hairs on their inner margins. Size: 0.76 mm. - 0.78 mm.

28. <u>R. krishnaswamyi</u> n. sp.

<u>Material examined</u> - Forty one specimens (twenty females and twentyone males) of this species occurred along with the

preceding species in the weed washings of the Gulf of Mannar and the Palk Bay during the months of September-October 1960. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

Descriptive notes - This species is named after Dr. S. Krishnaswamy of the Madras University in recognition of the valuable contributions he has made towards enhancing our knowledge of Indian copepods.

Female: In general appearance this species is similar to the preceding one, but has a slenderer, more spindle-shaped body (Pl. IV, 1), the ratio of prosome and urosome being 72:28 . There are six segments in prosome and four in urosome. as there are in the preceding species, but variations are seen in the relative lengths of the constituting segments and also in the fact that the partition between cephalosome and first pedigerous segment is much more distinct. In urosome (Pl. V, 1) genital segment is symmetrical, barrel-like and largest of all segments. The relative lengths of different urosomal segments and caudal rami are as follows:

44.3   17.1   15.7   5.8   17.1 = 100

In lateral view the genital segment is moderately bulging ventralwards with a slight depression at posterior one third length, indicating the genital apertures (Pl. V, 3). The latter are set more wide apart than in the preceding species and they occupy a little more than half the width of genital segment. Each caudal ramus bears one subapical spine on outer side, one subapical seta on ventral side and four setae on terminal margin. The middle two setae are jointed at base and bear setules only in distal two third of their lengths. The longest seta is about twice as long as the entire a urosome.

Antennule (Pl. V, 4) is 26-jointed, reaching to posterior end of prosome. The relative lengths of constituting segments and the number of setae and aesthetasks borne by them are presented below:

1	2	3	4	5	6	7	8	9	10	11	12
4.75	6.75	3.5	3.25	3.0	3.0	3.25	2.75	2.5	2.25	2.25	2.8
2s	2s	2s	2s	1s	2s	2s	2s	2s	2s	2s	2s
-	1a	-	1a	1a	1a	1a	1a	1a	1a	1a	1a

13	14	15	16	17	18	19	20	21	22	23	24
2.7	3.5	3.75	3.0	3.25	3.5	4.0	3.5	3.5	3.5	3.5	7.0
2s	1s	2s	1s	1s	2s	2s	2s	1s	1s	2s	2s
1a	1a	1a	1a	1a	1a	1a	-	1a	-	-	-

25	26	
7.5	7.75	= 100
2s	4s	
-	1a	

Antenna (Pl. V, 5), mandible (Pl. V, 6), maxillule (Pl. III, 5), maxilla (Pl. IV, 2) and maxilliped (Pl. IV, 3) are normal. Differences noticed in the number of setae, spinules etc. between the present species and the earlier ones have been commented upon later (vide infra).

All five pairs of legs are biramous, and the rami 3-segmented except the fifth endopod which is 2-segmented. The ornamentation of the first four pairs of swimming legs is ~~are~~ presented below:

	Protopod				Endopod							Exopod						
	1 Si	1 Se	2 Si	2 Se	1 Si	1 Se	2 Si	2 Se	3 Si	3 St	3 Se	1 Si	1 Se	2 Si	2 Se	3 Si	3 St	3 Se
P_1	0	0	I	0	1	0	2	0	4	1	1	1	I	1	I	4	I	II
P_2	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P_3	1	0	I	0	1	0	2	0	4	2	2	1	I	1	I	5	I	III
P_4	1	0	0	0	1	0	2	0	3	2	2	1	I	1	I	5	I	III

In first leg (pl. IV, 4) a spatulate process is present, distal to the external marginal spine in both first and second segments. The process on the second segment is much larger than that on the first. Fine hairs are present on joints between endopodal segments of second and third legs. Basal protopodal segment of first leg does not bear any seta or spine. In the next three pairs of legs a seta is present on that segment. Second protopod segment does not bear any seta in first, second and fourth legs. In third leg, however, a very small spine is present on the outer margin of that segment.

Fifth legs (~~Figx~~ Pl. V, 7) are biramous, exopod 3-segmented and endopod 2-segmented. Proximal protopod segment is without any seta while distal segment carries a seta. There is much similarity in the structure of exopods and endopods of fifth legs of this species and those of the preceding species. As in that species all the setae are jointed and the spines stoutly built. The chief difference consists in length of the spine on inner distal margin of terminal segment of exopod. In *R. typica* it is only as long as the terminal spine; in *R. krishnaswamyi* it is almost double the length of the terminal spine. As will be shown later, this feature is of great importance as the former condition is found only in that species, while in all other known species of this genus the spine on the distal inner margin of terminal exopod segment of fifth leg is only as long as the terminal spine of the same segment. Size: 0.77 mm.

<u>Male</u>: The sexual dimorphism of male is expressed as usual in the organisation of antennule, fifth legs and urosome.

Right antennule is geniculate and 23-segmented. The point of geniculation is between twentieth and twentyfirst segments, so that there are three segments beyond the geniculation. Posterior margin of the thirteenth segment is highly shortened, almost to a point, so that the segment is triangular, two lateral sides serving as partitions between the contiguous segments and base having as the anterior margin. The twentieth segment carries a row of spinules arranged along its length towards anterior face. The proportionate lengths of constituting segments and the number of setae and aesthetasks borne by them are as follows:

1	2	3	4	5	6	7	8	9	10	11	12	13
6.8	5.2	2.8	3.6	3.2	3.2	3.6	3.6	2.8	2.4	2.0	2.0	2.0
2s	3s	2s	2s	-	2s	1s	2s	1s	2s	2s	2s	2s
-	2a	-	1a	1a	1a	1a	1a	1a	1a	1a	1a	1a

14	15	16	17	18	19	20	21	22	23	
4.4	3.6	2.8	3.2	2.8	4.0	9.7	10.1	8.2	8.0	= 100
1s	1s	1s	1s	1s	1s	1s	4s	2s	4s	
1a	1a	-	1a	-	-	1a	1a	-	2a	

In fifth leg (Pl. IV, 7) protopods are without any seta or spine. Distal protopod segment of each leg carries an outer seta at its distal end. Right exopod is 2-jointed. The proximal segment is shorter and carries on its distal outer margin a stout, long spine which is a little shorter than the length of segments. Second segment of exopod consists of a broad proximal half and a narrow digitiform distal half. The latter is broken by a notch on outer side, a little beyond the mid-region. A stout, large spine is present at the junction of proximal broader and distal narrower ix> halves. Left exopod is 3-segmented, first segment being the largest. First two segments are of normal type, each bearing a large spine serrated on both margins. The spine on second segment is one and a quarter times longer than that on first segment.. The last segment is very short and diffuse, carrying several peculiar processes and one stout spine. Some of these processes do not have well-defined edges and give a fleecy appearance.

Left endopod is rather simple, cylindrical with a conical, sharp spinous process at the apex. It also carries an elevated ridge on ventral face, just a little beyond the mid-length. Right endopod is also cylindrical terminating in an obtuse rather round end. It carries three setae on distal half of inner margin and a conical, narrow spinous process subapically on ventral face.

Urosome (Pl. V, 2) is 5-segmented, segments being columnar; their proportionate lengths along with that of caudal rami are as follows:

17.75   23.00   17.75   17.75   6.00   17.75 = 100

The segments diminish in width to posterior side; structure of caudal setae are exactly as in the female.

Remarks - M.S. Wilson (1958) enlists the following as valid species of the genus *Ridgewayia*: *R. canalis* (Gurney), 192f2

R. typica Thompson & Scott, 1903; R. gracilis M.S. Wilson, 1958; R. shoemakeri M.S. Wilson, 1958; and R. marki (Esterly),1911. The first species was known only from male and the second only from female. A sixth species described by Krishnaswamy (1953a) under the name Suesia sp. as well as the copepodite stage of a seventh which M.S. Wilson obtained from Tortugas were left out because of insufficient information and non-availability of adults respectively. In her very detailed discussion, she has pointed out the close relationships that exist between the three species which she grouped as American species, and showed that marked differences exist between these forms on the one hand and R. typica on the other. Both canalis and the species described by Krishnaswamy are, for the most part, excluded from the main discussion as both of them were known only from the male and, even in the available informations, there are several points which need either elaboration or confirmation.

In the present study two species are included, R. typica and a species which appears to be new, both being represented by both sexes. A detailed scrutiny of the figures of the new species shows that it is related to the three American species on the one hand and R. typica on the other. In fact, in some characters, especially those of male, it is somewhat intermediate between R. typica and the American species. A comparison of male of R. typica with the figures and descriptions given by Krishnaswamy for the species he described from Madras shows that he must have been dealing with the same species. The most striking feature which supports this view is that both in

Krishnaswamy's specimen as well as in the male of R. typica, the right endopod of fifth leg reaches beyond apex of the relatively shortened right exopod, while in all other species of this genus endopod is distinctly shorter than exopod. The occurrence of these materials in the same geographic area also renders indirect support. However, some differences are noticed between the two materials: (i) Apical seta of the terminal endopod segment of first leg looks more like a spine in Krishnaswamy's figure. It is not described in the text. But, as M.S. Wilson has pointed out, in the figure of fifth leg, both spines and processes are solidly inked, so that they cannot be distinguished from one another. (ii) Distal protopod segment of left fifth leg of male is shown to carry a seta in Krishnaswamy's specimen. No such seta is seen either in R. typica or in any other species that has so far been described under this genus. (iii) Distal protopod segment in both right and left fifth legs carries a small spine in the male of R. typica. These spines are not shown in the figure given by Krishnaswamy; however, they could easily be overlooked as they are extremely small.

R. canalis cannot be considered here any more than was possible for M.S. Wilson. The Tortugas species described by her also is excluded, as the adult form is yet to be described. Taking into consideration only those species which are known from both sexes, the members of Ridgewayia appear to be divisible into three groups:

(a) R. typica
(b) R. krishnaswamyi

(c) The American species (R. marki, R. gracilis and R. shoemakeri)

The differences existing between these three groups are presented in Table I. It is held, however, that these differences do not necessarily warrant the splitting up of the genus into three independent entities.

The three American species are not quite so uniform in structure as they appear to be. In R. marki the female antennule is 25-jointed and the geniculate male antennule 23-jointed, with four segments after the point of geniculation, while in R. shoemakeri one segment each is added to the geniculate and non-geniculate antennules, the number of segments after the point of geniculation, however, remaining the same. In R. gracilis the female antennule is 26-jointed, while the male geniculate antennule is 23-jointed, having only three segments after the point of geniculation. The presence of a seta on the right endopod and the non-jointed nature of caudal seta of R. shoemakeri are, again, striking features approaching the conditions found in R. typica and R. krishnaswamyi.

M.S. Wilson's discussions on the structure of various appendages of the members of this genus is quite exhaustive, and it is not desired to make any duplications here. It may, however, be stated that in the light of our present knowledge it is proper to keep all these forms in a single genus. It is likely that more representatives may be brought to light if intensive search is made in the littoral areas of the warm waters. Further, even when profound differences exist, it is

Table I. The structural difference between the three groups of the genus *Ridgewayia*

R. typica	*R. krishnaswamyi*	The American species
The genital segment of female is asymmetrical.	The genital segment of female is symmetrical.	Similar to *R. krishnaswamyi*.
The female antennule is 25-jointed, male geniculate antennule 22-jointed with three segments after the point of geniculation.	The female antennule is 26-jointed, male geniculate antennule 23-jointed with three segments after point of geniculation.	The female antennule is 25-or-26-jointed, male geniculate antennule 23-or 24-jointed with three or four segments after point of geniculation.
Terminal and subterminal spines of third segment of fifth exopod of female are about the same size.	Terminal spines on third segment of fifth exopod of female is double the size of the subterminal spine.	Similar to *R. krishnaswamyi*.
Right endopod of fifth leg of male longer than right exopod.	Right endopod of fifth leg of male shorter than right exopod.	Similar to *R. krishnaswamyi*.
Three setae on inner margin and a blunt terminal spine on right endopod.	Similar to *R. typica*.	Right endopod does not bear any seta or spine except in *R. shoemakeri* which carries a single seta on outer margin.
Genital apertures are moderately wide apart.	Similar to *R. typica*.	Genital apertures, wherever known, are quite close together.
Middle two caudal setae jointed at their bases.	Similar to *R. typica*.	Middle two caudal setae jointed or non-jointed at their bases.

noticed that there is some amount of gradations in the structural details between the various representatives.

The genus _Ridgewayia_ occupies a unique position among calanoids, not only in the segmentation of the non-geniculate antennule, but also in the position of the specialized hinge in the geniculate antennule. "It is not too surprising to find calanoid copepods with 26-segmented antennules, but the differences in the hinge position is unexpected" (M.S. Wilson, 1958, p. 167). Even when the non-geniculate antennule is 25-jointed, as in _R. typica_ and _R. marki_, this reduction is brought about by fusion of two segments in the proximal region. The position of the hinge in geniculate antennule does not change.

Within the genus, number of segments in antennule and structural details of fifth legs serve as the main features of identification. The asymmetry of genital segment, the position of genital apertures, the jointed or non-jointed nature of caudal setae and the structural details of maxillule and maxilla also facilitate additional points of difference. The last two structures are fully illustrated for the new species. It may be noted that in the structure of both these appendages the new species exhibits more kinship with the species recorded from the American waters than with those that are found in the Indian and neighbouring waters.

PSEUDODIAPTOMIDAE

Sewell, 1947, p. 164.

Genus _Pseudodiaptomus_ Herrick, 1884

Wilson, 1932, p. 101.

Sewell, 1932, pp. 233-234.
Sewell, 1956, p. 167.

Marsh (1933) removed a number of species of the genus Pseudodiaptomus to an older genus Schmackeria Poppe and Richard. Johnson (1939) created a subgenus Pseudodiaptallous, and stated that a subgeneric status will express its "close relationship to the known Pseudodiaptomus species". Sewell (1956), however, considered all these as three subgenera of Herrick's original genus Pseudodiaptomus s. lat. While Pseudodiaptallous Johnson is clearly defined by the segmentation of urosome and by the peculiarities noticed in some appendages, the distinctions between other two subgenera are very ambiguous. There is very little to distinguish between the females of these two subgenera. According to Marsh (loc. cit.) the subgenus Schmackeria is characterised by the presence of a vestigeal endopod in the form of a process or a spine in both right and left legs of male, and has the posterior corners of prosome rounded in both sexes. Pseudodiaptomus s. str. is said to have the vestigeal endopod only in right fifth leg of male and to have the posterior corners of prosome angular. It is doubtful whether the combination of these two characters could so much be insisted upon, for, there are some species such as P. salinus Giesbrecht, P. hickmani Sewell, P. ardjuna Brehm and P. nudus Tanaka which cut right through the above two characters. The last named species is particularly notable in that the male fifth legs are remarkably close to those of Schmackeria serricaudata T. Scott, but unlike latter, the posterior corners of prosome of P. nudus is distinctly angular. It is, therefore, obvious that these two characters cannot be taken to separate the species of this group of animals into two genera. If we are to depend only on the structure of fifth legs, then little distinction can be made between the females of these two groups. Angular or obtuse nature of the posterior end of prosome is too insignificant to be taken as of generic value. Pending further studies regarding these forms, I have followed Sewell (1956) in recognizing Pseudodiaptomus s. str., Schmackeria and Pseudodiatalleus as three subgenera of the original genus Pseudodiaptomus Herrick s. lat.

29. P. (Pseudodiaptomus) aurivilli Cleve, 1901.

Cleve, 1901, pp. 48-50, pl. VI, figs. 11-22, pl.VII, figs.1-2.
Thompson & Scott, 1903, p. , pl. II, figs. 24-26.
Fruchtl, 1924, pp. 51-53.
Sewell, 1932, pp. 240-41.
Krishnaswamy, 1953a, pp. 122-23.

Material examined - This is a common species of this area. A detailed study on development and biology of this species is given in later part of this thesis. Size: female 1.3 mm. and male 1.19 mm.

Distribution - Malay Archipelago, Southern Burma, Bay of Bengal, Arabian sea and the Gulf of Mannar.

Remarks - There is some amount of uncertainty as to the distinctions between this species and P. mertoni Fruchtl, 1924. According to Fruchtl (loc. cit.) the spines guarding genital apertures of female of P. aurivilli are borne on an elevation; they project prominently in postero-ventral direction. In P. mertoni these spines are held almost parallel to the ventral margin of genital segment, and in effect are directed only backwards. The chief difference between the males of these two species, according to Fruchtl and Sewell, lies in the structure of fifth legs and consists of the differential orientation of constituting parts. Sewell (*loc. cit.*) has given the sketches of male fifth legs of the two species. However, the orientation of constituting elements of both these figures differs from that of the figure of male fifth legs of *P. aurivilli* as given by Thompson & Scott (*loc. cit.*).

Present example agrees fully with the female of *P. aurivilli* as distinguished by Fruchtl, and the male fifth legs correspond more with the figure given by Thompson & Scott than with those given by Sewell for the two species. It is desirable to reexamine the whole question and find whether *aurivilli* and *mertoni* represent two species at all or they are conspecific with geographic variations within the same species. Kasturirangan (1962) has expressed the opinion that they are probably one and the same species and that we may have to drop the term *mertoni*, retaining *aurivilli* which is the older name.

30. *P.* (*Pseudodiaptomus*) *ardjuna* Brehm, 1953.
    Brehm, 1953, pp. 313-15.
    Ummerkutty, 1960d, pp. 179-85, fig. I.

Material examined - Several male and female specimens are obtained from the plankton in the colder months, February-March 1960. They have also been captured from the Marine Fish Farm adjoining the Central Marine Fisheries Research Institute, Mandapam Camp. Size: female 1.31 mm. and male 1.20 mm.

Distribution - Bombay coast, Gulf of Mannar and the Palk Bay.

31. *P.* (*Schmackeria*) *serricaudata* (T. Scott), 1894.

T. Scott, 1894, p. 40, pl.ii, figs. 43-48, pl.iii, figs. 1-7.
Sewell, 1932, p. 235.
Sewell, 1947, p. 164.
Krishnaswamy, 1953a, pp. 123-24.

Material examined - This is also a rather common species of this area occurring almost throughout the year, but in small numbers. Size: female 1.29 mm. and male 1.18 mm.

Distribution - "It would thus appear to be an Indian ocean form that has managed to get round the Cape of Good Hope into the Gulf of Guinea where it was originally taken" (Sewell, 1947).

32. *P.* (*Schmackeria*) *annandalei* Sewell, 1919.

Sewell, 1919, p. 5, pl. X, fig. 9.
Sewell, 1924, p. 787, pl. XLIV, fig. 2.
Brehm, 1953, pp. 306-308, figs. 68-71.

Material examined - Several specimens of both sexes are obtained from plankton collected from the Marine Fish Farm of the Central Marine Fisheries Research Institute, Mandapam Camp during the months of April-May 1960. Size: female 1.15 mm. and male 1.0 mm.

Distribution - Chilka Lake, Madras coast, Bombay coast, and the South east coast of India.

TEMORIDAE

G.O. Sars, 1903, pp. 95-96.

Genus *Temora* Baird, 1850

Wilson, 1932, p. 103.
Sewell, 1932, pp. 244-45.

33. *T.* *turbinata* (Dana), 1849.

Dana, 1849, p. 12.
Sewell, 1947, p. 165.
Krishnaswamy, 1953a, pp. 124-25.

Material examined - This is a common species occurring throughout the year in fairly good numbers. Size: female 1.25 mm. and male 1.12 mm.

Distribution - Widely distributed in the tropical and temperate water of Pacific, Indian and Atlantic oceans.

34. *T. discaudata* Giesbrecht, 1889.
Giesbrecht, 1889, p. 814.
Sewell, 1947, pp. 164-65.
Krishnaswamy, 1953a, p. 125.

Material examined - This species occurs only rarely and is found mostly in the colder months. Size: female 1.56 mm. and male 1.49 mm.

Distribution - Widely distributed in the tropical and temperate regions of Indian and Pacific oceans as well as in the Mediterranean sea.

35. *T. stylifera* (Dana), 1849.
Dana, 1849, p. 13.
Sewell, 1932, p. 246.
Krishnaswamy, 1953a, pp. 125-126.

Material examined - This is the rarest temorids in the area investigated and is caught in July-August 1960. In size it is intermediate between the two earlier species, the female measuring 1.5 mm. and male 1.23 mm.

Distribution - Widely distributed in the tropical and temperate regions of Indian and Pacific oceans and in the Mediterranean sea.

LUCICUTIIDAE

Sewell, 1947, p. 173.

Genus Lucicutia Giesbrecht, 1898

Wilson, 1932, p. 128.

36. L. flavicornis (Claus), 1863.

Claus, 1863, p. 183, pl. 32, figs. 1-7.
Sewell, 1947, p. 174.

Material examined - A single male specimen of this copepod is obtained in December 1960. Size: 1.33 mm.

Distribution - Widely distributed in Indian, Pacific and Atlantic oceans.

Remarks - Farren (1920) called attention to the existence of two very closely related species, L. flavicornis (Claus) and L. gemmina Farren which differ in size and in certain details of structure. Sewell (loc. cit.) states that the true flavicornis is the smaller of the two, females of this species measuring 1.47 mm. - 1.58 mm. and males 1.44 mm. - 1.56 mm. Sewell's single female specimen measured 1.46 mm. and the specimen described by Krishnaswamy measured 2.5 mm. This last one is particularly notable in its very large size. The present male is much smaller but agrees in all details with the true flavicornis.

ARIETELLIDAE

G.O. Sars, 1903, pp. 123-24.

Genus Metacalanus Cleve, 1901.

Cleve, 1901, p. 43.

37. M. aurivilli Cleve, 1901.

Cleve, 1901, p.43, pl. IV, figs. 16-25, pl. V, figs. 1-6.
Sewell, 1932, p. 330.
Krishnaswamy, 1953a, p. 127, fig. 6.

Material examined - This is a very common species of this area and is present almost throughout the year. Size:

female 0.6 mm. and male 0.5 mm.

Distribution - Malay Archipelago, Madras coast and the Gulf of Mannar.

PSEUDOCYCLOPIDAE

G.O. Sars, 1903, p. 129.

Genus Pseudocyclops Brady, 1872

G.O. Sars, 1903, p. 130.

38. P. obtusus Brady and Robertson, 1873

Brady & Robertson, 1873, p. 128, pl. viii, fig. 4-7.
Sewell, 1932, pp. 330-31, fig. 108.

Material examined - Several male and female specimens of this species are captured from the weed washings of the Gulf of Mannar and Palk Bay during the months of August-November 1960.

Descriptive notes - Sewell (loc. cit.) has added a new variety, var. latisetosus Sewell, besides the typical form of Brady & Robertson which may be termed as var. typicus. These two forms and a new variety are found in the present collection. The differences between these forms are mainly in the structure of caudal setae. In var. typicus caudal setae are of normal structure. In var. latisetosus Sewell, second and third caudal setae from the inner side are thickened and flattened and about half way along their lengths, the width is suddenly diminished. Lateral margins of proximal portions of these setae are armed with numerous small spines. In var. asymmetrica nov. (Pl. XIII, 17) the caudal setae of left and right sides are not similar. On right side they correspond exactly with what is described by Sewell for latisetosus. On the left side, second and third setae from the inner side are highly flattened, are without any spinule or setule on the margins and lack the constriction in the middle. Differences are also noticed in the structure of fifth legs. In male, fifth legs differ from those sketched by Sars for typicus as well as from those sketched by Sewell for latisetosus. Sewell has not figured the female fifth legs for the latter, but has stated: "The fifth pair of legs shows certain small differences of structure from that of the typical form" but in the main character they agree with sufficient closeness to render it undesirable to create a new species for this form". (p. 331) The female fifth leg (Pl. XIII, 19) of var. asymmetrica differs from that of var. typicus in the following points: (a) in the complete separation of first and second segments of endopod; (b) in the presence of a lateral projection on outer margin of basal endopod segment; (c) in having long, distinct setae on endopodal segments; and (d) in having biarticulate setae on exopodal segments. Size:

var. typicus female 0·81 mm. and male 0·76 mm.
var. latisetosus female 0·80 mm. and male 0·75 mm.
var. asymmetrica female 0·80 mm. and male 0·76 mm.

Distribution - Recorded from the Atlantic ocean, Suez Canal, Arabian sea and the Gulf of Mannar. Sewell does not mention the area from where he collected var. latisetosus.

CANDACIIDAE

G.O. Sars, 1903, p. 132.

Genus Candacia Dana, 1846

Wilson, 1932, p. 138.
Sewell, 1932, p. 334.

39. C. truncata (Dana), 1849.

Sewell, 1932, p. 338.
Krishnaswamy, 1953a, p. 129.

Material examined - This species is fairly common in the Gulf of Mannar. Numerous late copepodite stages have been found in the winter months indicating a breeding period. Size: female 1.49 mm. and male 1.29 mm.

Distribution - Widely distributed in Indian and Pacific oceans and its offshoots, having been recorded from Philippines, Malay Archipelago, S. Burma, Persian Gulf, Maldive Archipelago, Madras coast and the Gulf of Mannar.

40. C. catula (Giesbrecht) 1889.

Giesbrecht, 1892, p. 425, pl. 22, figs. 27-28.
Sewell, 1932, p. 335.

Material examined - A single female example of this species is obtained from plankton in March 1960. Size: 1.67 mm.

Distribution - Recorded from Malay Archipelago, coast of Burma, Arabian sea, Red sea, Maldive Archipelago, coast of Africa and the Gulf of Mannar.

PONTELLIDAE

G.O. Sars, 1903, p. 137.

Genus Labidocera Lubbock, 1853

G.O. Sars, 1903, p. 141.
Wilson, 1932, p. 144.
Sewell, 1932, pp. 350-51.

41. L. acutifrons (Dana), 1849.

Dana, 1849, p. 30.
Sewell, 1947, p. 249.

Material examined - Several female specimens occurred in plankton collected in July 1960. Size: 3.3 mm.

Distribution - Widely distributed in Indian, Atlantic and West Pacific oceans.

42. *L. acuta* (Dana), 1849.

Dana, 1849, p. 30.
Sewell, 1932, pp. 351-58, fig. 116.
Sewell, 1947, pp. 248-49.
Krishnaswamy, 1953a, p. 139.

Material examined - This species occurred in plankton in several times during July-September, 1960. Size: female 3.6 mm. and male 3.1 mm.

Distribution - "This species appears to be widely distributed throughout Indian seas and has also been taken in brackish waters of the Chilka Lake in which it appeared to be actively breeding. Gurney has recorded its occurrence in the Suez Canal". (Sewell, 1932, p. 365).

43. *L. kroyeri* (Brady), 1883.

Sewell, 1932, pp. 302-303.
Krishnaswamy, 1953a, pp. 132-33.

Material examined - A few female specimens are caught in March, June and September 1960. Size: 2.32 mm. (var. *stylifera*))

Distribution - Eastern and western seas of Indian Peninsula.

Remarks - Sewell (*loc. cit.*) enlisted four varieties: var. *gallensis* Thompson & Scott, var. *stylifera* Thompson & Scott, var. *burmanica* Sewell and var. *bideus* Sewell. Wolfenden (1906) has recognized var. *similis* from the Maldives. Krishnaswamy (*loc. cit.*) identified var. *gallensis* and a new unnamed variety from Madras coast and the Gulf of Mannar. He has also noted that considerable differences exist in the projections on abdominal segments of this species.

44. L. pavo Giesbrecht, 1889.

Giesbrecht, 1889, p. 27.
Sewell, 1914, p. 234, pl. XXI, fig. 1-3.
Sewell, 1932, pp. 365-372, figs. 121-123.
Krishnaswamy, 1953a, p. 131, fig. 12.

Material examined - This is a rare species and occurred only on a few occasions during the entire period of two years. Size: 1.65 mm. and male 1.43 mm.

Distribution - Widely distributed in Indian ocean.

45. L. pectinata Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 252, pl. ii, figs. 10-14.
Sewell, 1912, p. 370, pl. XXIII, figs. 8-9.
Sewell, 1932, pp. 372-74, fig. 124.
Krishnaswamy, 1953a, pp. 135-36.

Material examined - This is a common species of the area investigated and is obtained almost throughout the year. Size: female 2.1 mm. and male 1.83 mm.

Distribution - Arabian sea, Bay of Bengal and Gulf of Mannar.

46. L. bengalensis Krishnaswamy, 1952.

Krishnaswamy, 1952, p. 332, figs. 12-15.
Krishnaswamy, 1953a, p. 134.

Material examined - This is another common species of the genus in the inshore waters of the Gulf of Mannar. A complete account of the life cycle of this species is given elsewhere in this thesis. Size: female 1.48 mm. and male 1.27 mm.

Distribution - So far recorded from Madras coast and the Gulf of Mannar.

47. *L. minuta* Giesbrecht, 1889.

Giesbrecht, 1889, p. 27.
Sewell, 1947, p. 249-50.
Krishnaswamy, 1953a, p. 134.

Material examined - A few specimens of this species are caught in plankton collected in the first week of May 1960. Size: female 2.11 mm. and male 1.58 mm.

Distribution - Recorded from Indian ocean and its offshoots and from west Pacific.

Genus *Pontella* Dana, 1846

Wilson, 1932, p. 149.
Sewell, 1932, p. 374.

48. *P. securifer* Brady, 1883.

Brady, 1883, p. 96, pl. 45, figs. 1-9.
Sewell, 1947, p. 250.
Krishnaswamy, 1953a, pp. 136-37.

Material examined - This species frequents the area under investigation almost every month, although in small numbers. Presence of spermatophore-carrying females in December indicates a breeding period. Size: female 3.6 mm. and male 3.0 mm.

Distribution - Reported from Pacific, Atlantic and Indian oceans.

49. *P. danae* var. *ceylonica* Thompson & Scott, 1903.

Giesbrecht, 1889, p. 28.
Thompson & Scott, 1903, p. 252, pl.II, figs. 1-5.
Sewell, 1932, pp. 375-76, fig. 125.
Krishnaswamy, 1953a, p. 136.

Material examined - Two female specimens are obtained from plankton in January 1960. Size: 3.1 mm.

Distribution - Throughout Indo-Pacific.

Remarks - Sewell (loc. cit.) has pointed out that the specimens gathered by A. Scott in the Malay Archipelago was intermediate in structure between the Pacific form and var. ceylonica of the Indian coast and that they form a series rather than separate varieties. In shape of body the typical Pacific form tapers gradually from second to last prosomal segments, while in the forms present in our waters prosome is nearly the same width throughout. Another variation noticed is the shape of genital segment, the Pacific form having a quadrate segment while in the Indian forms it is more globular.

Genus Pontellopsis Brady, 1883

Wilson, 1932, p. 157.
Sewell, 1932, p. 384.

50. P. herdmani Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 253, pl. II, figs. 15-17.
Sewell, 1932, pp. 385-86.
Krishnaswamy, 1953a, p. 137.

Material examined - A few male and female specimens of this species are captured in September 1960. Female specimens are carrying spermatophores. Size: female 2.1 mm. and male 1.81 mm.

Distribution - So far recorded only from the east coast of India.

51. P. macronyx A. Scott, 1909.

A. Scott, 1909, p. 173, pl. LIV, figs. 1-10.
Sewell, 1912, p. 375, pl. XXIV, fig. 5.
Sewell, 1932, p. 387.

Material examined - A single female specimen of this species is taken from plankton collected in third week of January 1960. Size: 1.8 mm.

Distribution - Malay Archipelago, Bay of Bengal and the Gulf of Mannar.

Genus *Calanopia* Dana, 1852

A. Scott, 1909, p.
Sewell, 1932, pp. 340-41.

A. Scott (*loc. cit.*) has discussed in detail and made a comparative study of all the species of this genus. The three species occurring in our waters can very easily be separated by the size, the relative lengths of prosome and urosome and by the presence of absence of cephalic hooks. No structural peculiarities are noticed in any species, distinct from those given by A. Scott. However, one abnormal male of *C. thompsoni* is found and this is briefly described.

52. *C. aurivilli* Cleve, 1901.

Cleve, 1901, pp. 40-41, pl. III, figs. 11-19, pl.IV, figs.1-2.
A. Scott, 1909, p. 181, pl. XLVIII, figs. 16-20.
Sewell, 1932, p. 341.
Krishnaswamy, 1953a, pp. 138-39.

Material examined - This is a common species of our waters and is picked almost throughout the year. Size: female 1.25 mm. and male 1.1 mm.

Distribution - Widely distributed in the Indo-Pacific.

53. *C. elliptica* (Dana), 1849.

Dana, 1849, p. 27.
A. Scott, 1909, p. 176, pl. XLVIII, figs. 1-5.
Sewell, 1947, p. 248.
Krishnaswamy, 1953a, p. 138.

Material examined - This is another common species of this genus frequenting our waters. Because of its very large size and occasional appearence in large numbers, it seems to have some importance among the plankton copepods of this area.

Size: female 2.0 mm. and male 1.68 mm.

Distributions - Widely distributed in the whole of Indo-Pacific, Suez Canal and the Mediterranean sea.

54. *C. thompsoni* A. Scott, 1909

A. Scott, 1909, p. 178, pl. XLIX, figs. 1-18.
Sewell, 1932, pp. 342-50, figs. 112-15.
Krishnaswamy, 1953a, p. 139.

Material examined - This is also a common species of this area and is taken not only in plankton of the Gulf of Mannar and Palk Bay but also ~~in that~~ from the Marine Fish Farm adjoining the Central Marine Fisheries Research Institute. This species is particularly abundant during the colder months. Size: female 2.35 mm. and male 2.18 mm.

Abnormal male - An abnormal male specimen (Pl. XIII, 20) is obtained from plankton collected in the last week of December 1959. All appendages including the right geniculate antennule of this specimen are normally constructed, but urosome is very abnormally developed. Here, the five segments are clearly tracable, but the orientation and size are curiously distorted. The animal, in live condition, moved freely without showing any sign of discomfort. However, it died in the laboratory on the second day. "It is not difficult to find representatives of a single species with a short abdomen, showing a telescoped condition of the abdominal segments, and more or less normal specimens, where the abdominal segments have the position they apparently had in the living state" (Vervoort, 1946).

Distribution - Recorded from the Malay Archipelago, Bay of Bengal and the Gulf of Mannar.

ACARTIIDAE

G.O. Sars, 1903, p. 147.

Genus *Acartia* Dana, 1846

Wilson, 1932, p. 159.
Sewell, 1932, pp. 391-92.

55. *A.* (*Odontacartia*) *erythraea* Giesbrecht, 1889.

Giesbrecht, 1892, p. 508, pl. XXX, figs. 5, 19, 32, pl. XLIII, figs. 12, 13 & 55.
Steuer, 1923, p. 118, figs. 142-45.
Sewell, 1947, p. 252.
Krishnaswamy, 1953a, pp. 139-40.

Material examined - This is one of the commonest of calanoid copepods of our waters, occurring almost throughout the year and in good numbers. Size: female 1.28 mm. and male 1.16 mm.

Distribution - Widely distributed throughout Indian ocean and its offshoots.

56. *A.* (*Acartiella*) *tortaniformis* Sewell, 1912.

Sewell, 1912, p. 346, pl. XXI, figs. 1-10.
Steuer, 1923, p. 100.
Sewell, 1932, p. 393.

Material examined - Several male and female specimens of this copepod are obtained from Palk Bay near the Marine Fish Farm in July 1960. Size: female 0.8 mm. and male 0.68 mm.

Distribution - Coast of Burma, off Chittagong, East Pakistan, Hooghly river and the Gulf of Mannar.

TORTANIDAE

Sewell, 1932, p.

Genus *Tortanus* Giesbrecht, 1898

Wilson, 1932, p. 166.
Sewell, 1932, p. 399.

Sewell (loc. cit.) divided this genus into two subgenera, viz., Tortanus s. str. with fourth and fifth thoracic segments separate and Atortus with fourth and fifth thoracic segments completely fused. The two species recorded here belongs to the first subgenus. Both are easily recognized by the peculiarly asymmetrical caudal rami. Female of gracilis is characterised by symmetrical fifth legs, while female forcipatus is distinguished by asymmetrical fifth legs, left leg being twice the length of the right. Males are separated by the shape of caudal rami.

57. T. (Tortanus) forcipatus (Giesbrecht), 1889.
Giesbrecht, 1889, p. 26.
Sewell, 1932, p. 399.
Krishnaswamy, 1953a, pp. 140-41.

Material examined - Although rare, this species occurs quite often in the inshore waters of this area. Large numbers of copepodite stages are noticed in December and January, indicating a possible breeding period. Size: female 1.82 mm. and male 1.51 mm.

Distribution - Red sea, Malay Archipelago, Madras coast, Maldive Archipelago and the Gulf of Mannar.

58. T. (Tortanus) gracilis (Brady), 1883.
Brady, 1883, p. 71, pl. 3, figs. 1-14.
Sewell, 1932, p.
Krishnaswamy, 1953a, p. 141.

Material examined - This is rarer than the preceding species, but is often obtained ~~xx~~ admixed with it. Size: female 1.73 mm. and male 1.42 mm.

Distribution - Red sea, Malay Archipelago, Madras coast, Maldive Archipelago and the Gulf of Mannar.

H A R P A C T I C O I D A

LONGIPEDIIDAE

G.O. Sars, 1903-11, p. 8.
Lang, 1948, pp. 152-53.

Genus Longipedia Claus, 1863

G.O. Sars, 1903-11, p. 9.
Nicholls, 1941a, p. 383.
Lang, 1948, p. 153.

59. L. coronata Claus, 1863.

Claus, 1858, p. 111, pl. XIV, figs. 14-24.
Sewell, 1940, p. 131.
Lang, 1948, p. 155, Abb. 99.
Krishnaswamy, 1957, p. 8.

Material examined - Three female specimens are obtained from the weed collections of the Gulf of Mannar in October 1960. Size: 1.1 mm.

Distribution - Widely recorded from the Indian and Atlantic oceans.

60. L. weberi A. Scott, 1909.

A. Scott, 1909, p. 196, pl. LIX, figs. 9-12.
Sewell, 1940, pp. 130-32, figs. 1 A-F.
Lang, 1948, p. 155, Abb. 100, 4.
Krishnaswamy, 1957, pp. 8-9.

Material examined - A few specimens of both sexes are captured from the weed washings along with the preceding species. Size: female 0.75 mm. and male 0.67 mm.

Distribution - Widely distributed in Indian ocean and the Mediterranean sea.

Remarks - The salient features of the two species discussed in this paper are given below:

L. coronata	*L. weberi*
(i) Size: female 1.1 mm.	Size: female 0.75 mm. and male 0.67 mm.
(ii) Proportionate lengths of prosome and urosome is 53:47 .	Proportionate lengths of prosome and urosome is 64:36 .
(iii) Widest part of the body is at level of second prosomal segment.	Widest part of the body is at junction of middle and posterior thirds of cephalosome.
(iv) Third segment of exopod of first leg with four spines and one seta.	Third segment of exopod of first leg with four spines and two setae.

CANUELLIDAE

Lang, 1944, p. 4.
Lang, 1948, p. 160.

Genus *Canuella* T. & A. Scott, 1893.

G.O. Sars, 1903-11, p. 16.
Lang, 1948, p. 162.

Subgenus *Canuella* Sewell, 1940

Sewell, 1940, p. 134.

61. *C.* (*C.*) *furcigera* Sars, 1903.

G.O. Sars, 1903-11, p. 18, pl. X.
Sewell, 1924, p. 807, pl. XLIX, fig. 1.
Lang, 1948, p. 164, Abb. 102, 2.
Krishnaswamy, 1957, pp. 9-10.

Material examined - A single female specimen is obtained from plankton in the second week of June 1959. Size: 1.18 mm.

Distribution - Recorded from Atlantic ocean, Mediterranean sea, Nicobar Island, Madras coast and the Gulf of Mannar.

62. *C.* (*C.*) *scotti* Sewell, 1940.

A. Scott, 1909, p. 197, pl. LXIV, figs. 1-6.
Sewell, 1940, p. 136, fig. 2 A-H.

Material examined - About forty female and five male specimens of this species are captured from the washings of the callianassid crustacean *Upogebia darwini*. The callianssids are collected by breaking large submerged coral stones which harbour the former in their numerous holes.

Descriptive notes - This species is reported from Malay Archipelago by A. Scott (*loc. cit.*) under *Canuella curticauda* Thompson & Scott. Sewell, however, pointed out that there are differences existing between *C. curticauda* Thompson & Scott and the species described from Malay Archipelago by A. Scott and named the latter *Canuella scotti* Sewell.

Female: Female has been thoroughly described by A. Scott (*loc. cit.*) and Sewell (*loc. cit.*). However, the following structural peculiarities may be noted: (i) First post-genital segment (third segment in the 5-segmented urosome) carries a pair of dorso-lateral and a pair of ventro-lateral spines which are set in small pits, symmetrically arranged near the posterior margin of segments. (ii) A pair of ventro-lateral spines is noticed in a similar position in the genital segment also. (iii) Innermost apical caudal seta is much produced in the proximal half. This has been sketched by A. Scott, but not mentioned in the text, probably as he was confusing his material with *C. curticauda* Thompson & Scott. (iv) The animal is slightly larger than that recorded by earlier workers, the size being 1.3 mm.

Male: A. Scott (*loc. cit.*) gave the size of male as 0.94 mm. which is much less than that of female. However, he did not describe the male. In the present case, differences in size between the two sexes is very negligible. Sexual dimorphism is expressed both in antennule and the in urosome. Antennule (Pl. VI, 2) is highly modified and the segmentation is scarcely discernible. However, the posterior margin is constricted at five places, thus indicating six segments. The penultimate segment is developed into a highly chitinous, rather rectangular structure with a sharp angular corner at the antero-distal angle. The distal half of antennule carries profuse number of setae and aesthetasks while the proximal half carries only setae. Urosome (Pl. VI, 1) is 6-segmented. First segment carries fifth legs which are very small, each consisting of only four setae borne on four elevated knobs. The genital segment (Pl. VI, 3) carries the genital armature which is represented by a pair of lappets, terminating in strong spines. In the space between two lappets a pair of smaller spines is present. In lateral view the lappets projecting dowmwards with a spine directed backwards. There are four post-genital segments which diminish both in length and width to posterior side. Dorsolateral and ventrolateral spines are present in the case of first two postggnital segments, and are comparable to those of female. Caudal rami are only a little longer than last abdominal segment. Size: 1.28 mm.

Distribution - Malay Archipelago, Nicobar Islands and the Gulf of Mannar.

63. *C.* (*C.*) *perplexa* T.& A. Scott, 1893.

T. & A. Scott, 1893, p. 92.
G.O. Sars, 1903-11, pp. 17-18, pl. VIII, IX.

Material examined - A single female specimen occurred in plankton of the Gulf of Mannar in October 1959.

Descriptive notes - Caudal rami are greatly divergent as in the preceding species, but is easily distinguished by the fact that the length of ramus does not exceed the joined length of last two abdominal segments. The ratio of presome and urosome is 54:46 . The genital segment is long with clear dorsal transverse suture, but is distinctly shorter than the last three segments combined. Size: female 1.2 mm.

Distribution - British Isles, Norwegian coast and the Gulf of Mannar.

ECTINOSOMIDAE

G.O. Sars, 1903-11, p. 28.
Lang, 1948, p. 189.

Genus *Microsetella* Brady & Robertson, 1873

G.O. Sars, 1903-11, p. 43.
Lang, 1948, p. 230.

64. *M. rosea* (Dana), 1853.

Dana, 1853, p. 1189, 1855, pl. 83, fig. 10.
Lang, 1948, p. 232.
Johnson, 1942, pp. 231-32, pl.I, figs. 1-5.
Krishnaswamy, 1957, p. 13.

Material examined - A few specimens of both sexes are obtained from plankton of the Gulf of Mannar in November 1959. Size: female 0.8 mm. and male 0.6 mm.

Distribution - This copepod has a world wide distribution being found in all the great oceans.

TACHIDIIDAE

G.O. Sars, 1903-11, p. 327.

Genus *Euterpina* Norman, 1903

G.O. Sars, 1921, pp. 96-97.
Lang, 1948, p. 285.

65. _E._ _acutifrons_ (Dana), 1848.

Dana, 1853, p. 1192, 1855, pl. 83, figs. 11 a-b.
G.O. Sars, 1921, pp. 97-99, pl. LXVIII.
Krishnaswamy, 1957, p. 14.

Material examined - This is one of the common planktonic harpacticoids of our waters and is caught throughout the year. Size: female 0.67 mm. and male 0.64 mm.

Distribution - This is a very cosmopolitan species being present in all the oceans.

MACROSETELLIDAE

A. Scott, 1909, p. 230.

Genus _Macrosetella_ A. Scott, 1909

A. Scott, 1909, p. 230.

66. _M._ _gracilis_ (Dana), 1853.

Dana, 1853, p. 1198, 1855, pl. 84, fig. 3.
Lang, 1948, p. 770, Abb. 311, 4.
Krishnaswamy, 1957, p. 14.

Material examined - This species is caught quite often in plankton of the Gulf of Mannar both during 1959 and 1960. Size: female 1.16 mm. and male 1.15 mm.

Distribution - Widely distributed in the warm regions of all the oceans.

CLYTEMNESTRIDAE

(Syn: PSEUDOPELTIDIIDAE)

G.O. Sars, 1921, p. 99.
Lang, 1944, p. 11.
Lang, 1948, p. 460.

Genus _Clytemnestra_ Dana, 1848

A. Scott, 1909, p. 200.
G.O. Sars, 1921, p. 99.
Lang, 1948, p. 460.

67. _C._ _rostrata_ (Brady), 1883.

Brady, 1883, p. 77, pl. 4, figs. 1-2, pl. 24, figs.12-15.

Lang, 1948, p. 461, Abb. 195, 1.
Krishnaswamy, 1957, p. 16.

Material examined - This species is obtained from plankton almost throughout the year, but in small numbers. Size: female 0.72 mm. and male 0.62 mm.

Distribution - Widely distributed in the Indian, Pacific and Atlantic oceans.

PELTIDIIDAE

G.O. Sars, 1903-11, p. 61.
Nicholls, 1941a, pp. 386-87.
Lang, 1948, p. 426.

Genus *Alteutha* Baird, 1845

G.O. Sars, 1903-11, pp. 61-62.
Nicholls, 1941a, p. 387.

68. *A. interrupta* (Goodsir), 1843

Goodsir, 1843, p. 326, pl. XI, fig. 10.
G.O. Sars, 1903-11, pp. 62-64, pls. XXXVI & XXXVII.

Material examined - One female and one male specimens are obtained from plankton in the first week of January 1960.

Descriptive notes - Body is flattened and characteristically peltidiid. Rostrum is marked and rounded. Posterior half of first segment is the widest part of body which tapers posteriorwards. Urosome is short and flattened with posterior corners of first three segments conically produced. Caudal rami almost as long as wide, with six setae, one of which is dilated at the base. Antennule is 8-segmented. In antenna exopod is 2-segmented. Oral appendages and first to third swimming legs are typical of the genus. In fourth leg, basal endopod segment has an inner seta and terminal exopod segment has three outer spines. In fifth leg proximal joint is very short carrying three setae, two on outer and one on inner side. Distal joint is quite large, flattened and provided with three strong apical spines of varying lengths; distal segment also bears three outer spines which are equispaced from the middle to the distal end and an inner seta. In male, antennule is geniculate and urosome 5-segmented. There is a pair of sixth legs on genital segment. Size female 0.86 mm. and male 0.80 mm.

Distribution - British Isles, Baltic seas, coast of France, Mediterranean sea, Norwegian coast and the Gulf of Mannar.

69. Alteutha sp.

Material examined - A single female specimen of this copepod is captured from weed washings of the Gulf of Mannar in December 1960. This appears to be different from all other known species of the genus Alteutha. However, due to dearth of material the species could not be fully studied.

Descriptive notes - The salient features are presented below. The animal is dorso-ventrally depressed slightly vaulted dorsally and about two times as long as broad. First prosomal segment carries minute pitted spines along its margins and is the largest of all body segments. Its anterior side is rather truncate while its posterior margin is crescent-shaped, the concavity smoothly fitting into the convex anterior margin of next segment. Rest of the body segments gradually diminish in width to posterior side. Margins of all the segments are chitinised.

Antennule is 7-jointed, the constituting segments having the following relative lengths:

1	2	3	4	5	6	7	
16	24	15	13	8	10	14	= 100

The presence of a slender, long aesthetask on fifth segment and profusion of setae on the last terminal segments are notable features. Other mouth-parts are similar to those of _Alteutha sewelli_ Krishnaswamy, 1952.

First leg is slender, endopod being only two-third as long as the exopod which bears five terminal appendages. In fourth leg, the terminal exopod segment carries only two outer spines which are long and slender. Fifth leg is 2-jointed, the distal segments being much longer than the proximal which bears two spines, one on either side. The distal segment is broad in its proximal half and carries five spines, three marginal and two terminal. The latter are stout and blunt, the inner spine being more than twice as long as the outer.

Caudal rami are short, each ramus being hardly as long as wide and carrying four setae and a spine. Size: 0.44 mm.

Remarks - As only a single specimen is available which is deposited and not dissected, it has not been possible to make a critical study which should await until more specimens are available.

Genus Peltidium Philippi, 1839

G.O. Sars, 1803-11, pp.
Nicholls, 1941a, p. 386.

70. P. aurivilli (Cleve), 1901.

Cleve, 1901, pp.50-51, pl. VII, figs. 3-10.
Nicholls, 1941a, pp. 391-92.

Material examined - Three female specimens are obtained from the washings of the dredged weeds in November 1960.

Descriptive notes - Body (Pl. VI, 7) is rather elongate ovate. The pattern of chitinising bands is shown in the figure. Posterior lateral margin of first body segment (Pl. VI, 8) carries two highly transparent spines and a small sensory filament. The spines are inserted in cubical pits which encreach into the chitinous margins. A number of other pits which do not carry spines and which reach only half the thickness of the chitin bands are also seen. Uresome is only 1-segmented and is not visible from dorsal side. Caudal rami are partly visible from dorsal side and are longer than broad.

Antennule (Pl. VI, 9) is 6-jointed, the segments having the following relative lengths:

1	2	3	4	5	6	
24.5	28.5	20.0	12.3	3.7	11.0	= 100

Third and fourth segments bear each an aesthetask. Outer margin of first segment carries a number of hairs. Fourth, fifth and sixth segments are provided with profuse number of setae. In antenna, exoped consists of two segments. Mandible, maxillule, maxilla and maxilliped are quite typical of the genus.

First leg (Pl. VI, 10) is plumpy and well developed. Protoped segments are ~~with~~ with chitinised and hairy margins, second segment carrying one outer (at just a little before the mid-length) and an inner (at distal angle) spines. Exopod is 3-segmented, first segment with one outer distal and second segment with one outer and one inner spines. In third segment there are two stout, large and three small spines. Basal region of some of spines are overlapping. In endopod, basal segment carries one spine at inner distal angle; distal segment carries one apical seta, one subapical seta on the outer side and three spines, which are rather modified, on the inner margin. Second, third and fourth legs are typical of the genus. Fifth legs (Pl. VI, 11) are each 2-segmented. Basal segment carries a single broad-based seta on outer distal angle and two setae on inner distal angle. Second segment carries three spines on inner margin and two setae on apex. The distalmost spine on the inner margin is sow-like and rather stout. Size: 1.15 mm. (egg-carrying female).

Remarks - Cleve (1901) described this species under the name Reticulina aurivilli, apparently being unaware of the genus Peltidium Philippi, 1839. There is no subsequent record of this copepod from anywhere. The species is very inadequately described, and the accompanying figures are too sketchy to be acurate. The reference of the present material to Cleve's species, therefore, is done with some reservations. "The thick carapace prevented the close examination of all the organs, still, it will, no doubt, be easily recognized, for which reason I do not hesitate to describe it, however, incomplete and perhaps in some details erroneous the description may be". (Cleve, 1901, p. 50.). The large number of species that have since then been added and the increasing degree of refinement in taxonomic works make the identification of Cleve's species very difficult, if not impossible. The only course available would have been to reexamine the single original specimen which unfortunately does not appear to have been deposited anywhere. The present species is referred to P. aurivilli (Cleve) chiefly because of the following reasons:

(1) The structure of first legs is very identical in P. aurivilli, P. elegans Wolfenden, 1906 and in the present form with five appendages in the terminal segment of first endopod. According to Nicholls's review of the genus, eligans and aurivilli are the only two known species in which the end segment of first endopod has five appendages. However, the present material is certainly not the former species, for, there are several distinct features diagnostic to that species, including the segmentation of antennule and the arrangement of setae and spines on fifth leg.

(2) Distal segment of fifth leg (Cleve does not show partition between distal and proximal segments, although the constriction between them is clearly indicated) of aurivilli bears three marginal and two apical spines. The latter are thin and seta-like, while marginal spines are thick bearing denticles. A similar situation is seen in the present material.

(3) Cleve figures antennule as 5-segmented. The relative

l[illegible]th of fourth segment is, however, equal to the combined relative length of fourth and fifth segments of the present material. It may also be added that the division between these segments could be overlooked as there is no abrupt reduction in their widths.

(4) Size is comparable. Cleve's specimen measured 1.0 mm. and the present material measures 1.15 mm.

(5) Abdomen is 1-segmented in both cases and is only partly visible from the dorsal side.

There are other similarities, too, such as the shape of anterior end, chitinization of first segment etc. Because of the evidences cited above the present material is thought to be the same as P. aurivilli (Cleve).

It is pointed out earlier that aurivilli is close to elegans, both having five appendages in terminal segment of first endopod and five spines in terminal segment of fifth leg. The material under examination reveals some more similarities: (i) In both, the posterior part of lateral margins of first body segment carries spines which are implanted in pits. In elegans there is one and in aurivilli, as ~~xxx~~ represented by the present material, two such pits. (ii) Antennal structure is absolutely similar in both cases. (iii) There is some resemblance also in the general shape of body and in ornamentation of first segment.

It appears that Nicholls' grouping together of elegans and aurivilli, basing on the number of spines and setae on terminal segment of first endopod is not accidental; they are probably closely related species.

71. *P*. *speciosum* Thompson & Scott, 1903.
Thompson & Scott, 1903, p. 274, pl. XIII, figs. 12-17.
Nicholls, 1941a, p. 397, figs. 5m & 8.
Lang, 1948, p. 434, Abb. 185, 4.

Material examined - Several male and female specimens as well as copepodites are obtained from the washings of floating weeds from the Gulf of Mannar in December 1959. Size: female 1.1 - 1.2 mm. and male 0.75 - 0.90 mm.

Distribution - South Australia, Cape Comorin and the Gulf of Mannar.

72. *P*. *angulatum* Thompson & Scott, 1903.
Thompson & Scott, 1903, pp. 273-74, pl. XIII, figs.7-11.

Material examined - Several females, male and fifth copepodites of this species occurred in the washings of littoral weeds both from the Gulf of Mannar and Palk Bay during the months of July - October 1960.

Descriptive notes - This is the first record of this species after its creation. Originally obtained from washings of dredged invertebrates, the present record is from the washings of littoral weeds. This species is characterised, as is indicated by its name, by the angular growths of mid-dorsal line of all the body segments. Thompson & Scott (*loc. cit.*) described the female in detail; additional notes on male are given below.

General shape of body is similar to that of female, including the well developed dorsal crests along the mid-dorsal line. The characteristic darkening of the ring-like chitinous bands on either side of anterior part of first body segment is present here also. Abdomen (Pl. VII, 3) is 1-segmented, and partly covered by last prosomal segment. Caudal ramus is slightly more than twice as long as broad.

Antennule (Pl. VI, 12) is 7-jointed and geniculate. The segments are rather swollen, second segment carrying conical spines on outer side. Fourth and fifth segments carry long aesthetasks. All other appendages are similar to those of female. The two rami of first legs, however, are very narrow, as has been noted in all described males of this genus. Further, the protopod segments are relatively longer and thinner. Terminal segment of first leg carries two apical spines and two modified spines on inner side. Distal segment of fifth leg (Pl. VII, 4) carries three spines on inner margin and two on apex. The proximal two marginal spines are stout and denticulate. A pair of sixth legs (Pl. VII,35) is present. Each sixth leg is simple, rather elongate with three apical spines which are longer than the appendage itself. The sixth leg does not reach end of urosome.
Size: female 1.30 mm and male 1.0 mm.

<u>Distribution</u> - Gulf of Mannar.

73. <u>P. ovale</u> Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 273, pl. XIII, figs. 1-6.
Sewell, 1940, p. 143, fig. 5, A-G.

<u>Material examined</u> - A single female specimen is gathered from plankton of the Gulf of Mannar in July 1960.

Distribution - Nicobar Islands, Maldive Archipelago and the Gulf of Mannar.

74. *P. cinereum* Brady, 1915.
Nicholls (1941a, p. 392.

Material examined - A single male specimen of this copepod is obtained from weed washings of the Gulf of Mannar in November 1960. Size: 1.1 mm.

Distribution - S. Africa (?) and the Gulf of Mannar.

Remarks - It is quite uncertain whether the species dealt with here is *cinereum*. Brady appears to have described this species (I have not seen Brady's original paper) from female only and Nicholls does not include *cinereum* in his key to the males of *Peltidium*. The diagnostic features of the present material are, however, illustrated (Pl. VII, 12-17).

Genus *Parapeltidium* A. Scott, 1909

A. Scott, 1909, p. 212.
Nicholls, 1941a, pp. 398-99.

75. *P. johnstoni* A. Scott, 1909.
A. Scott, 1909, pp. 212-13, pl. LXV, figs. 1-5.

Material examined - A single male specimen of this copepod is obtained from plankton in December 1960.

Descriptive notes - A. Scott (*loc. cit.*) based his description on a single specimen which he considered as a female. Nicholls (1941a) has, however, pointed out that the specimen examined by A. Scott could be a male. ".....
....there are no specifically female characters described

or portrayed, whereas the first leg is obviously that of a male and although supporting male characters are lacking, yet in Peltidium also males with unmodified antennae are known. A very strong chitinization of the fifth leg may perhaps be regarded as a male character". (pp. 398-99) The present material corresponds with the description and figures given by A. Scott except that a pair of rudimentary sixth legs is present. Each sixth leg is represented by an exceedingly small rectangular structure which bears a pair of terminal setae. The sixth legs are arranged on the ventral side of the last urosomal ~~sg~~ segment, parallel to its lateral margins. Size: 0.9 mm.

Distribution - Malay Archipelage and the Gulf of Mannar.

Remarks - It is possible that A. Scott would have overlooked the sixth legs, as they are extremely small and are almost affixed to the ventral side of the last urosomal segment. It is interesting to note that both the original specimen as well as the present material are obtained from plankton.

76. P. serratum (Thompson & Scott), 1903.
Thompson & Scott, 1903, p. 274, pl. XIII, figs. 18-22.

Material examined - A single specimen is captured from the washings of weeds from Palk Bay off Mandapam in July 1960.

__Descriptive notes__ - This species is easily recognised by the serrate margins of all body segments except the first. The animal is extremely flat with dorsal medial lines of all the presomal segments being slightly elevated to crest-like structures. The ornamentation of first and last segments are quite complicated while that of the other segments are rather simple. The clear four-angled anterior region is also characteristic. Urosome is not visible in dorsal view, except for the rod-like caudal rami. Antennule, antenna, maxilla, maxilliped and first and fifth legs are figured by Thompson & Scott. Mandible, maxillule and four pairs of swimming legs are typical of the genus. Size: female 1.6 mm.

__Distribution__ - Gulf of Mannar. This is the first record of this species after its discovery.

__Remarks__ - Thompson & A. Scott (1903) assigned this species to __Peltidium__. Nicholls (1941a) removed it to __Parapeltidium__ because of the 1-segmented nature of fifth legs.

77. __P.__ __nichollsi__ n. sp.

__Material examined__ - Six adult females and five adult males of this species occurred in the washings of littoral weeds collected from Palk Bay in July 1960. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam. Camp.

__Descriptive notes__ - This species is named after Dr. A.G. Nicholls of Australia whose contributions to the knowledge of the copepod fauna of the Indo-Pacific are highly valuable.

__Female__ - The body is ovoid, very stout, the dead specimens always being bent as sketched (Pl. VIII, 1 & 2). There are apparently six segments, the abdomen being more or less hidden from dorsal view. First segment is the widest part of the body, and is only a little less than the length of ~~xxxxx~~ rest of the body. The mid-dorsal areas of all segments are elevated to moderate sized crests. The margins of all segments as well as median crests are highly chiti nised and have beautiful bluish violet tinge. Abdomen is 2-segmented and completely covered from dorsal view. Caudal ramus is short, twice as long as wide, each ramus carrying one marginal and five apical setae, all of which are spine-like.

Antennule (Pl. IX, 3) is 7-segmented and very short. First and second segments are subequal; third and fourth segments are much smaller each of them bearing fairly long aesthetasks. Last three segments are very small, all carrying a good number of setae except sixth which carries only two setae. Small sensory filaments are also distributed on the segments. The relative lengths of the constituting segments are given below.

1	2	3	4	5	6	7	
35.2	29.0	14.0	7.5	3.4	2.5	8.4	= 100

Antenna (Pl. IX, 3) is 3-segmented with a very rudimentary exopod attached to the middle of second joint. There are a number of sensory filaments on this segment. The setae and the spines borne by antennae are sketched. Mandible exactly resembles that of P. cristatus Nicholls. Maxillule, maxilla and maxilliped are figured (Pl. VIII, 4, 5 & Pl. IX, 2).

In first legs (Pl. VIII, 7), exopod is 3-segmented and endopod 2-segmented. Protopod segments are long, the second segment bearing a seta on outer margin at mid-length and a seta on inner distal angle. Basal exopod segment carries a seta on distal inner angle; middle exopod segment carries two spines, one on either side, both in the distal part; terminal exopod segment is provided with two long, stout spines and four sensory appendages. In endopod the basal segment carries an inner seta in the distal angle; distal segment carries two apical spines and one inner spine. Near the base of latter, there are also three sensory appendages. The next three pairs of legs (Pl. VIII, 8, 9 and Pl. IX, 4) are typical of the genus. Fifth leg (Pl. VIII, 9) is 1-segmented. The basal part corresponding to the proximal segment of the genus Peltidium carries, as in that genus, a broad based seta on outer side. On inner side it carries a spine and a seta. Distal part of fifth leg bears two spines on outer, two on apical and one on inner margin. The fifth legs are highly chitinised. Size: 1.35 mm.

Male: Male differs from female in the structure of antennule, and first pair of legs and also in the presence of a sixth pair of legs.

Antennule (Pl. IX, 1) is 7-jointed, segments having the following relative lengths:

1	2	3	4	5	6	7		
30.0	30.0	13.6	8.2	6.4	3.6	8.2	=	100

The segments are rather stout and bear larger number of setae than in the female. Third and fourth ~~ka~~ segments, as in female, carry aesthetasks.

Protopod segments as well as the two rami of first pair of legs (Pl. III, 6) are much narrower, but bear the same number of setae and spines as in female. The only difference, however, is that the inner marginal spine of distal endopod segment is longer and thinner than that of the female.

A sixth pair of legs is present. They are set parallel to the lateral margins of urosomal segments (Pl.VIII, 11). Each leg consists of a long, flat strip with two apical setae. Sixth leg just exceeds the posterior margin of first urosomal segment. Size: male 1.15 mm.

Genus <u>Alteuthella</u> A. Scott, 1909

A. Scott, 1909, pp. 208-209.

78. <u>A. pellucida</u> A. Scott, 1909.

A. Scott, 1909, pp. 209-210, pl. LXVI, figs. 13-20.

<u>Material examined</u> - Two female specimens of this copepod are obtained from weed washings of the Gulf of Mannar in November 1960.

<u>Descriptive notes</u> - The present material corresponds with the excellent description and figures given by A. Scott.

Two additional structural peculiarities may be added here. The posterior margins of third, fourth and fifth pedigerous segments are lined with smooth denticulations which are seen only when carefully examined. A few smooth spines, embedded in conical pits are present along both margins of the first prosomal segment. Size: 0.71 mm. (See Pl. VI, 4-6).

<u>Distribution</u> - Malay Archipelago and the Gulf of Mannar.

TEGASTIDAE

G.O. Sars, 1903-11, pp. 67-68.

Genus <u>Tegastes</u> Norman, 1903

G.O. Sars, 1903-11, pp. 68-69.

79. <u>T. minutus</u> Sewell, 1940.
Sewell, 1940, pp. 147-48, fig. 7 A-C.
Krishnaswamy, 1957, p. 19.

<u>Material examined</u> - A single female specimen of this species occurred in June 1960 in the littoral weed washings of Palk Bay. Size: 0.3 mm.

<u>Distribution</u> - Maldive Archipelago and the Gulf of Mannar.

Genus <u>Syngastes</u> Monard, 1928

Monard, 1928, p. 336.
Sewell, 1940, p. 148.
Lang, 1948, p. 482.

80. <u>Syngastes</u> sp.

<u>Material examined</u> - A single female specimen of this copepod occurred in the weed washings of Palk Bay in June 1960.

<u>Descriptive notes</u> - It is typically tegastid in shape (Pl. VI, 13) with highly thickened skeleton. In lateral view caudal ramus is lobular, carrying four setae.

Antennule (Pl. VI, 14) is 8-segmented, constituting segments having the following proportionate lengths:

1	2	3	4	5	6	7	8
23.2	26.7	19.5	12.0	3.8	4.4	3.0	7.4 = 100

The aesthetask on the fourth segment is about three-fourth as long as the entire appendage. Third and fourth segments are partly calcified. In antenna (Pl. VI, 15), endopod is 2-segmented, the ~~xxxxx~~ terminal segment bearing a claw and two setae. Exopod is 1-segmented and short, carrying three setae. Other oral appendages are similar to those of the genus.

In first leg (Pl. X, 1), proximal protopod segment is very short, less than half the length of second segment, which carries a single seta in outer distal angle. The two rami are subequal, outer ramus carrying four setae and inner five setae arranged as figured. Second and third legs are normal, exopod being 2-segmented and endopod 3-segmented in both the cases. In fourth leg (Pl. VI, 16) exopod is 3-segmented and endopod 2-segmented. The former is however, just as long as the latter. The second seta on inner margin of terminal exopod segment is modified into a large spine which is longer than the entire ramus. In endopod the two segments are subequal in length, the basal segment carrying one spine and distal segment~~s~~ four spines. Protopods of second, third and fourth legs are similar to those of first leg, but the second segment does not carry any seta. Fifth leg could not be observed. Size: 1.08 mm.

Remarks - Sewell (*loc. cit.*) stated that the genus *Syngastes* contains eight species, divisible into three groups, depending upon the number of segments in the female antennule. Antennule is 5-segmented in *S. macrognathus* Monard and *S. cornalinus* Monard. It is 6-segmented in *S. clausi* (Thompson), *S. imthurni* (Thompson & Scott) and *S. twynami* (Thompson & Scott). A 7-segmented antennule is found in *S. chalmersi* (Thompson & Scott) and *S. donnani* (Thompson & Scott) and *S. indicus* Sewell. An unnamed species with 8-segmented antennule is reported by Krishnaswamy (1957) who obtained a single specimen of that species from the present geographical locality. The species dealt with in this paper agrees with his species in possessing an 8-segmented antennule, but is not referred to that species because of the following differences:

Present species	*Syngastes* sp. Krishnaswamy
Antennule carries the aesthetask on fifth segment.	Antennule carries the aesthetask on fourth segment.
Exopod of antenna 1-segmented.	Exopod of antenna 2-segmented.
Second segment of maxilliped long, bearing a group of long hairs near the proximal end.	Second segment of maxilliped short without hairs.
Rami are subequal in first leg.	Rami of first leg are very unequal.
Exopod is just half of endopod in fourth leg.	Fourth leg not described.
Size: 1.08 mm.	Size: 0.5 mm.

Besides these, there are also differences in the shape of body and relative lengths of the antennular segments. Fifth leg, however, could not be observed in the present case.

PORCELLIDIIDAE

G.O. Sars, 1903-11, p. 74-75.
Lang, 1948, p. 417.

Genus <u>Porcellidium</u> Claus, 1860

G.O. Sars, 1903-11, p. 75.
Lang, 1948, p. 417.
Nicholls, 1941a, pp. 403-405.

81. <u>P. ravanae</u> Thompson & Scott, 1903.
Thompson & Scott, 1903, pp. 275-76, pl. XII, 19-22.

<u>Material examined</u> - Eighteen female (several carrying eggs) and thirteen male specimens occurred in the collections of littoral weed washings of the Gulf of Mannar during August-September 1960.

<u>Descriptive notes</u> - The male of the species is described here for the first time. Some additional notes are given on the female also for this is the first record of the species after its discovery.

<u>Female</u>: Body is elongate ovate, with a truncate rostrum at the anterior end. Posterior projections of the genital segment (Pl. VII, 2) do not reach half the length of caudal rami which are taken into posterior side. Each lateral margin of first segment carries three pitted spines, that of the second and third segment one spine each. Dorsal surfaces of all segments, fifth legs and caudal rami are provided with calciferous spots. Margins of the segments are thickened. Right caudal ramus is slightly longer than the left. Each ramus carries six setae (Thompson & Scott figured seven setae).

In third endopod, the first seta of second segment and second seta of third segment are modified into spines.

They are quite strong, rather flattened and bear spinules along their distal inner margins. Second seta of third segment of third endopod has been shown by the earlier authors to be thicker than the endopodal setae. But in the present study all the seven species examined showed modifications of these two setae to a great degree, in both sexes. Both are spine-like with comb-like spinular arrangement on the distal halves of their inner margins. Fifth leg (Pl. VII, 4) is foliaceous and two and a half times as long as broad. Its outer margin is ciliated and carries one spine at its mid-length and another at posterior end. There chitinous ridge in the medial line along the entire length of fifth leg. A strong spine is borne on the proximal end of the ridge. Fifth leg not only exceeds caudal rami but also grows round them.
Size: 0.7 mm.

<u>Male</u>: Male is sexually dimorphic and displays structural variations in antennule, fifth legs and urosome.

Antennule (Pl. VII, 3) is 4-segmented and geniculate. The constituting segments are quite stout but unlike several species, they are separated clearly. Third segment carries a pair of bulbous growths on anterior margin and an aesthetask on distal end. There is also a calcified crest on proximal side of the segment. All segments carry profuse number of setae; in first segment the anterior margin carries a number of long hairs.

Fifth leg (Pl. VII, 5) is different from that of female.

It is much smaller in size, and appears to be 2-segmented, the proximal segment bearing a spine. Distal segment is somewhat 5-sided, tapering to posterior side. Each postero-lateral margin of this segment carries six plumose, conical structures whose basal regions give a knotty appearence. Along the antero-lateral and the inner margins chitinous ridges are present; the ridge on the former margin is ciliated on both sides.

In urosome (Pl. VII, 5) the prolongation of genital segment exceeds the latter. Caudal rami are quite small, as long as wide and carry each one diffuse sensory structure and four spines. There is calcification along the margins of caudal rami. Size: 0. 64 mm.

Distribution - Gulf of Mannar.

82. *P. acuticaudatum* Thompson & Scott, 1903.
Thompson & Scott, 1903, p. 275, pl. XII, figs. 15-18.
Gurney, 1927, p. 494, fig. 128.
Sewell, 1940, p. 151.
Krishnaswamy, 1957, p.

Material examined - Twelve females (some of them being berried) and fifteen males are obtained from the washings of inshore weeds from the Gulf of Mannar and Palk Bay during October-November 1960.

Descriptive notes - Gurney (*loc. cit.*) noted a red colour in the specimens he gathered from Suez Canal. In the present instance a pink colour is observed, but is confined to dorsal medial area and posterior margins of prosomal segments as well as the entire urosome. The most salient feature of this species is, as indicated by the specific name, the acutely pointed caudal rami. Each ramus carries four spines, two on ventral face in proximal region, one on posterior acute point and one on outher margin just where it makes an angle with posterior margin. This is what exactly Thompson & Scott found in their specimens. Gurney, however, showed two spines in that position for his Suez Canal example and Sewell observed a group of three spines in specimens he collected from the Maldives. The projections of genital segment reach middle of caudal rami. The modificationsof the spines into setae on second and third segments of third endopod are noticed in the present species also.

Male shows sexual dimorphism. Antennule has, undergone a great degree of geniculation than in the preceding species. The segments are highly swollen and bent upon one another. Third segment carries on its proximal area, a spatulate structure one side of which is closely applied to the segment itself. The aesthetask is very short and has a peculiar shape. Fifth leg is more or less similar to that of preceding species, but of larger relative width. Caudal ramus is one and a quarter times longer than wide and carries five spines. The projection from genital segment does not exceed the posterior margin of anal segment and fifth leg reaches only to one third of the proximal length of caudal rami.

Size:female 0.64 mm. and male 0.58 mm.

<u>Distribution</u> - Gulf of Mannar, Suez Canal and the Maldive Archipelago.

83. *P. scotti* Pesta, 1935.

Thompson & Scott, 1903, p. 275, pl. XII, figs. 1-10.
Pesta, 1935, p.
Nicholls, 1941a, pp. 403-04.

Material examined - Nineteen females and twelve males of this species are captured from the weed washings of the Gulf of Mannar and Palk Bay during July-August 1960. Several females are ovigerous.

Descriptive notes - The female has been thoroughly described by earlier workers. Male is described here for the first time. Size: female 0.57 mm. and male 0.49 mm.

Male: It is very similar (Pl. VII, 8) to the male of *P. fimbriatum*, but differs from it in some structural details: (i) In antennule (Pl. VII, 9) first segment is longer than that of ~~the~~ *P. fimbriatum*. (ii) Third segment displays less calcification and less ornamentation than in *P. fimbriatum*. (iii) A pair of thorn-like elevations is present, one on either lateral margin of anal segment, while in *P. fimbriatum* they are absent.

Remarks - This species is very similar to *P. fimbriatum* Claus and was, in fact, referred to that species by Thompsen & Scott (1903). Pesta (1935), however, suggested its recognition as a separate species and renamed it *P. scotti*. Nicholls (1941a) agreed with Pesta's suggestion and discussed few more points of difference between the two forms. I have been able to collect and examine both *fimbriatum* and *scotti*, and I have no hesitation in recognising their specific validities. Nicholls (*loc. cit.*) observed: "The position of the inner seta on the first endopod is probably due to faulty observation since the point of attachment of this seta is always hard to make out". (p. 403). Figures given by Thompson & Scott showed the origin of the seta at about two-third the length of inner margin while in the present specimens it is clearly at the point of the proximal bent, on inner margin as in all other species. The differences between the two species are presented below:

P. fimbriatum Claus	*P. scotti* Pesta
The ratio of widths of proximal and distal areas of caudal rami is 48:52 .	The ratio of widths of proximal and distal areas of caudal rami is 37:63 .
Lateral margins of posterior half of first prosomal segment are parallel.	Lateral margins of posterior half of first prosomal segment slightly converge so that they are not parallel.
The ratio of greatest length and greatest width of caudal ramus is 71:29 .	The ratio of greatest length and greatest width of caudal xxxx ramus is 64:36 .
The postero-lateral projections of genital segment are distinctly rounded (Pl. VII, 10).	The postero-lateral projections of genital segment are distinctly angular forming a graceful trâangles (Pl. VII, 6).
First endopod much larger than other endopods, segments being rather swollen.	First endopod normal, segments not swollen.
Fifth legs do not reach ends of the projections of genital segment. (Pl. VII, 10)	Fifth legs extend beyond end of the projections of genital segment (Pl. VII, 6).

Distribution - The distribution of this species cannot at present be determined precisely, for some authors did not recognize its validity. Thompson & Scott referred this species to *fimbriatum*. We do not know whether the species recorded by Sewell from Nocobar Islands represents *fimbriatum* or *scotti* for,

for he makes no mention of Pesta's suggestion, nor does he give any description of ~~x~~ the species. Krishnaswamy (1953c & 1957) who reported fimbriatum from Krusadai Islands has referred both to Pestas' and to Nicholls' papers but did not make clear whether the species he examined was scotti or fimbriatum.

84. P. fimbriatum Claus, 1863.

G.O. Sars, 1903-11, pp. 76-77, pl. XLIV & XLV.
Nicholls, 1941a, pp. 405-406, fig. 12.

Material examined - Eight ovigerous females are captured in September 1960 from the weed washings of the Gulf of Mannar. Size: female 0.58 mm.

Distribution - British Isles, Norwegian Coast, Mediterranean sea, S. Australia and the Gulf of Mannar.

85. P. clavigerum Pesta, 1935.

Pesta, 1935, p. 377, fig. 7.
Lang, 1948, p. 425, Abb. 183,4.
Krishnaswamy, 1957, pp. 23-24, fig. 3.

Material examined - Fifty females and thirty one males and many copepodites of this species are obtained from weed washings of the Gulf of Mannar and Palk Bay during July-August 1960. Several females are ovigerous and males are found to be attached to copepodites either in the fourth or fifth stage.

Descriptive notes - The female agrees fully with the description given by Krishnaswamy. Size: female 0.53 mm.

Male is sexually dimorphic showing modifications in antennule, fifth legs and urosome. In antennule there are only four joints which are all highly modified with calcified

margins. There is a thick, short aesthetask broken on margins, on third segment. In urosome, posterior prolongation of genital segment exceeds the anal segment only by one fourth the length of caudal ramus. Posterior tip of the prolongation is sharply conical. Caudal ramus is squarish, the length and breadth being equal. On ventral face of ramus there are two equispaced setae, one at one third and the other at two third the length. Posterior margin of ramus carries one seta and four digitiform processes. Fifth leg corresponds to that of other representatives of this genus. It is calcified along the margins and carries six appendages in the distal margin.
Size: male 0.48 mm.

<u>Distribution</u> - Pacific ocean, Madras coast and the Gulf of Mannar.

86. <u>P</u>. <u>unicus</u> n. sp.

<u>Material examined</u> - Two hundred female and one hundred and fifty male specimens and several copepodites, most of them in fourth and fifth stages, are obtained from the sponge and weed washings of the Gulf of Mannar and Palk Bay during July-October 1960. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

<u>Descriptive notes</u> - The name of the species has reference to the combination of unique characters that are distinct from other representatives of the genus.

<u>**Female**</u>: The yellow colour of this species, bright in life and immediately after killing and faint after days of formalin

preservation, is very characteristic. Body (Pl. X, 15) is elongate ovate and typically of the porcellidiid type with a squared rostrum at aterior side. The ratio of length and width of body is approximately 1.5 : 1.0 . Second segment is as broad as the first, but other body segments smoothly narrow down to posterior side. Genital segment (Pl. X, 12) is expanded backwards, the expansion reaching three fourth the length of caudal rami. Each expansion sharply tapers and terminates in a fine spinule. Abdominal segment is inserted between genital segment and caudal rami and is very short. Its anterior margin is bordered by a chitinous band on either end of which a stout backwardly directed spine is present. Caudal rami are thin and cylindrical, carrying three setae terminally and two setae ventrally.

The antennule is 6-joined, the segments having the following proportionate lengths:

1	2	3	4	5	6	
27	33	17	11	8	4	= 100

Other cephalosomal appendages and first pair of legs are normal. Next three pairs of legs (Pl. X, 16-18) are remarkable in possessing only two external spines on the terminal exopod segments. The ornamentation of the three pairs of legs is presented below:

	Protepod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_2	0	A	0	A	1	0	2	0	1	2	1	1	I	1	I	2	2	II
P_3	0	0	0	0	1	0	2	0	2	2	1	1	I	1	I	3	2	II
P_4	0	0	0	0	1	0	I	0	I	2	1	1	I	1	I	3	2	II

As in all other species of this genus, the inner setae on the terminal segment of second endopod, the proximal seta on the second segment of third endopod and the terminal seta of the terminal segment of the same leg are modified. Inner distal margins of these setae carry a number of sharp bristles giving a comb-like appearence. Another important feature of this species is the modification of inner setae on second and third segments of fourth endopod into spine-like structures with bristles on their margins. Fifth leg (Pl. X, 12) is 2-segmented and rather hexagonal. First segment is short, bearing one seta; distal segment has a pronounced calciferous ridge, running along its entire length and dividing it into two halves. Outer margin of distal segment carries a number of spinules on the entire posterior two third of its length. This spinular area is divisible into more or less equal halves by a seta. A number of fine sensory hairs also are present on outer margin of distal segment. Size: 0.75 mm.

Male: General shape of body (Pl. X, 11) is identical to that of female, but anterior margin of first prosomal segment is highly concave. This appears to be an adaptation to facilitate greater degree of clinging power during pairing. Posterior end of fifth copepodite female fits very well into this concavity of the male prosome.

Antennule (Pl. X, 13) is geniculate and apparently 5-segmented. An aesthetask is borne on the fourth segment. The segments are highly shortened and their margins calcified. Numerous bristles are borne on the margins of second segment. Fifth leg is very small and 2-segmented. First segment is devoid of any seta or spine. Second segment is pentagonal, the outer margin being divisible into proximal and distal halves. The former is bordered by a thick ridge carrying numerous fine bristles. The distal half carries one seta in its proximal part and three spines in its distal part. The margins of these spines are not ~~[illegible]~~ fringed as they are in other species. In urosome (Pl. X, 14) genital segment and anal segment are quite short. Former just exceeds the anterior margin of latter. Caudal rami are short and squarish with three setae on posterior margin and one on ventral face. The sides of rami are calcified. Size: 0.63 mm.

Remarks - Nicholls (loc. cit.) reviewed this genus and considered the following twelve species as valid:

P. lecanoides Claus, 1889;
P. scotti Pesta, 1935;
P. acuticaudatum Thompson & Scott, 1903;
P. tenuicauda Claus, 1860;
P. brevicaudatus Thompson & Scott, 1903;
P. ravanae Thompson & Scott, 1903;
P. affine Quidor, 1906;
P. interruptum, G.M. Thompson, 1883;

P. *fimbriatum* Claus, 1863;
P. *australe* Brady, 1910;
P. *fulvum* G.M. Thompson, 1883; and
P. *charcoti* Quidor, 1906.

P. *parvulum* and P. *ovatum* Haller, 1886 are left out because of insufficient description. P. *clavigerum* is considered by him to be synonymous with P. *lecanoides*. Lang (1948), however, considered them to be valid and separate, but synonymised P. *australe* and P. *affine*, thus bringing the total number of species again to twelve. In the present collection seven species are represented, two of which appear to new. One of them is named *unicus* while the other is left unnamed as only one specimen is available to me. It should be added that papers by Claus, Quidor and G.M. Thompson are not available to me and that I have heavily drawn from the discussions provided by Nicholls. (Nicholls, 1941a)

P. *unicus* is diagnosed as follows: (a) One of the most salient features of this species is the presence of only two marginal spines on outer side of terminal segment of second, third and fourth expods. However, in all other respects these legs are typically porcellidiid, including the presence of modified setae on second and third segments of third endoped. (b) Anterior margin of prosome is clearly concave in male while in female it is smoothly convex with a distinct rostrum. (c) The postero-lateral projections of genital segment of female are quite large, extending upto three fourth the length of caudal rami. These expansions taper to finely angular corners.

In male they just exceed the posterior margin of anal segment. (d) Caudal rami of female are cylindrical and thin, each ramus bearing two spines on ventral face and three along the posterior margin which is smoothly rounded. In male the caudal rami are short and squarish, each ramus bearing one ventral and three apical spines. (e) Fifth legs of female are foliaceous and reach behind the caudal rami, but do not meet behind. Posterior side of fifth leg is rounded, giving the appendage a five-cornered appearance. A thick longitudinal ridge almost divides this into two halves. Outer margin of fifth leg carries a number of spinules in its distal two-third region. In male fifth leg is 4-sided. Proximal half of outer margin is almost parallel to inner margin, while distal half deeply steepens to merge with the posterior margin which is highly reduced. Along the proximal half of outer margin an elevated thickening is present bearing spinules. The steepening posterior half carries four spines, the proximal-most being long and stout while the other spines are crowded towards the terminal area. None of the spines has fringes in its margins. A few fine bristles are found on the inner margin.

87. Porcellidium sp.

Material examined - A single egg-carrying female specimen of this copepod is obtained from the weed washings of Gulf of Mannar in December 1960.

Descriptive notes - The expansions of genital segment

(Pl. IX, 6) are very large, foliaceous, reaching almost the tip of caudal rami. Posterior margin of the expansion is provided with fine bristles. A little proximal to this area several hairs are arranged in a radiating fashion.

Caudal rami are thin and long, with flat posterior margins which bear each three long setae and a number of small setules. On ventral face, each ramus carries a solitary seta in the proximal region. The margins are highly calcified.

Fifth legs are almost alike with those of *P. fimbriatum*, but its length in relation to the expansion of genital segment is a little less. The adult animal as well as the various appendages are figured (Pl. IX, 5-13). Size: 1.0 mm.

Remarks - The specimen under study is very close to *P. fimbriatum* and the chief points of difference between these consist in the size in the structure of caudal rami and in the shape of the expansions of genital segment. In some respects it also resembles *P. fulvum*, but it differs from the latter species in the proportionate length and breadth of the body. However, no opinion is given here as to the specificity or otherwise of the [redacted] specimen as it necessarily requires a more detailed study.

HARPACTICIDAE

G.O. Sars, 1903-11, p. 48.
Lang, 1944, pp. 9-10.
Lang, 1948, p. 307.

Subfamily Harpacticellinae

Lang, 1948, p. 307.

Genus Harpacticus M. Edwards, 1838

G.O. Sars, 1903-11, p. 49.
Lang, 1948, p. 309.

88. H. littoralis Sars, 1911.

G.O. Sars, 1903-11, suppl. p. 363, pl. 8.
Sewell, 1924, p. 810, pl. 1, fig. 1.
Lang, 1948, p. 328, Abb. 149, 4: 152, 1.
Krishnaswamy, 1957, p. 26.

Material examined - Several male and female specimens of this copepod are obtained from washings of floating weeds in June 1960 from the Gulf of Mannar. Size: female 0.62 and male 0.50 mm.

Distribution - British Isles, Norwegian coast, Chespeake Bay, Chilka Lake, Nicobar Islands and the Gulf of Mannar.

89. H. clausi A. Scott, 1909.

A. Scott, 1909, p. 201, pl. LXI, figs. 9-12 A.
Sewell, 1940, pp. 153-56, figs. 9-10.
Lang, 1948, pp. 335-37, Abb. 153, 2.
Krishnaswamy, 1957, p. 25.

Material examined - A single female specimen is obtained along with the preceding species from the floating weeds of the Gulf of Mannar. Size: 0.63 mm.

Distribution - Malay Archipelago, Nicobar Islands and the Gulf of Mannar.

TISBIDAE

G.O. Sars, 1903-11, p. 78.
Lang, 1948, p. 358.

Subfamily Tisbinae

Lang, 1948, pp. 364-68.

Genus S TIS

Genus __Tisbe__ Lilljeborg, 1853

G.O. Sars, 1903-11.
Lang, 1948, p. 364.

90. __T__. __furcata__ (Baird), 1850.

Baird, 1850, p. 210, pl. XXV, figs. 1,2, pl. XXX, figs. 1-6.
G.O. Sars, 1903-11, pp. 88-89, pl. LI & LII, fig. 1.
Lang, 1948, p. 369. Abb. 163, 1, 164.
Sewell, 1940, p. 159.
Krishnaswamy, 1957, p. 29.

__Material examined__ - Several specimens of both sexes are obtained from weed washings of the Gulf of Mannar in November 1960. Size: female 1.1 mm. and male 0.78 mm.

__Distribution__ - Widely distributed in Atlantic, Indian and Pacific oceans.

Genus __Tisbintra__ Sewell, 1940

Sewell, 1940, p. 161.
Ummerkutty, 1960b, p. 156.

91. __T__. __jonesi__ Ummerkutty, 1960.

Ummerkutty, 1960b, pp. 149-56.

__Material examined__ - Several specimens of both sexes are captured from the Gulf of Mannar in April 1960. Size: female 1.1 mm. and male 0.67 mm.

__Distribution__ - Gulf of Mannar.

Genus __Scutellidium__ Claus, 1866

G.O. Sars, 1903-11, pp. 82-83.
Lang, 1948, p. 386.

92. __S__. __longicaudum__ (Philippi), 1840.

Philippi, 1840, p. 189, pl. IV, fig. 1.
G.O. Sars, 1903-11, pp. 83-84, pl. XLIX.
Sewell, 1940, p. 169.

__Material examined__ - Several male and female specimens are obtained from weed washings of the Gulf of Mannar in December 1960.

December 1960. Size: female 0.73 mm. and male 0.59 mm.

Distribution - Widely distributed in Atlantic; also reported from Mediterranean sea, Maldive Archipelago, New Zealand coast and the Gulf of Mannar.

Remarks - This species is readily recognized from the related species, *S. plumosum* Brady by the following features: (i) Second free prosomal segment is narrower than first and third segments (Pl. X, 19, 20). This character is specially pronounced in female. (ii) Posterior margin of last segment is smooth and rounded in *plumosum* while it is angular in the present case. (iii) In first leg the third exopod segment carries "four pulvinular recurved spines accompanied by a slender ciliated seta". In *plumosum* there are two setae and four spines. (iv) Basal segment of first leg bears a single seta on the outer distal angle while on the distal inner angle there are also two small accessory setae. In *plumosum* these accessory setae are absent. (v) Apical seta of the distal segment of fifth leg (Pl. X, 21) is stout and short whereas it is quite long and like other setae in *plumosum*.

93. *S. plumosum* Brady, 1899.

Brady, 1899, p. 45, pl. cii, figs. 16-21, 23-25.
Sewell, 1940, pp. 173-76, figs. 17-18.
Lang, 1948, p. 392, fig. 171, 3.
Krishnaswamy, 1957, pp. 30-31, fig. 4.

Material examined - Five female specimens of this copepod are obtained from weed washings of the Gulf of Mannar in November 1960. Size: 0.8 mm.

Distribution - South Pacific, Nicobar Islands, Cape Comorin and the Gulf of Mannar.

THALESTRIDAE

G.O. Sars, 1903-11, p. 102.
Lang, 1948, p. 141.

Genus Rhynchothalestris Sars, 1905

G.O. Sars, 1903-11, p. 119.

94. R. rufocincta (Norman) Brady, 1880.

Brady, 1880, p. 125, pl. LVII, figs. 1-9.
A. Scott, 1909, p. 215, pl. LXII, figs. 12-16.
Sewell, 1940, pp. 184-85.

Material examined - Two female specimens of this copepod are captured in plankton in May 1960 from the Gulf of Mannar. Size: 1.12 mm.

Distribution - This species has a very wide distribution, having been recorded from Indian and Atlantic oceans.

Genus Xouthous Thompson, 1883

Thompson, 1883, p. 103.
Sewell, 1940, pp. 196-97.

95. X. maldiviae Sewell, 1940.

Sewell, 1940, pp. 198-200, fig. 30.

Material examined - A single female specimen is captured from weed washings of the Gulf of Mannar in December 1960.

Descriptive notes - General shape of the body agrees closely with that of other members of the genus being highly flattened and quite elongate ovate with prosomal segments clearly demarcated from each other and without rostrum. Proportionate lengths of prosome and urosome are 65:35 . Lateral margins of prosomal segments are quite smooth and entire from dorsal view. In ventral view, however, the margins carry a number of small spines as shown in the figure (Pl. VIII, 12). A little anterior to the posterior of margins of prosomal segments rows of fine spinules are observed in lateral view. Antennule (Pl. XVII, 7) is 6-segmented, the segments having the following relative lengths:

1	2	3	4	5	6	
22	24	18	16	12	8	= 100

There is a fairly long aesthetask on fourth segment. All other appendages are exactly as described by Sewell. In the structure of fifth leg the present species is much similiar to _S. laticaudata_ and _X. aemula_ both Thompson & Scott. But, as Sewell has already pointed out, whereas in both _X. laticaudata_ and _X. aemula_ the distal segment does not extend beyond distal margin of the proximal segment, in the present form, margin of proximal segment lies at a level that is less than half the length of distal ~~xxx~~ free segment. In this character it agrees with _X. purporucinctum_, but in the latter a proximal segment is fringed with six setae and not with broad, flat spines, forming a palisade, as it is in _X. maldiviae_. Size: female 0.6 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar.

DIOSACCIDAE

G.O. Sars, 1903-11, p. 114.
Lang, 1948, pp. 592-96.

Genus _Eudactylopus_ A. Scott, 1909

A. Scott, 1909, p. 219.
Sewell, 1940, p. 200.

96. _E. striatus_ Sewell, 1940.

Sewell, 1940, pp. 211-13, fig. 36, A-J.
Krishnaswamy, 1957, pp. 35-36.

Material examined - A single male specimen of this copepod is obtained from the weed washings of the Gulf of Mannar in August 1960. Size: 1.1 mm.

Distribution - Nicobar Islands and the Gulf of Mannar.

DIOSACCIDAE

G.O. Sars, 1903-11, p. 114.
Lang, 1948, pp. 592-96.

Subfamily Diosaccinae

Nicholls, 1941b, p. 67.

Genus _Diosaccus_ Boeck, 1872.

G.O. Sars, 1903-11, p. 145.

97. _D. truncatus_ Gurney, 1927.

Gurney, 1927, p. 513, fig. 136.
Sewell, 1940, p. 20.
Krishnaswamy, 1957, pp. 40-41.

Material examined - A single female specimen is taken from the floating weeds of the Gulf of Mannar in January 1960. Size: 1.0 mm.

Distribution - Burma coast, Port Said, Madras coast and the Gulf of Mannar.

Subfamily Amphiascinae

Nicholls, 1941b, p. 68.

Genus _Amphiacopsis_ Gurney, 1927

Gurney, 1927, p. 150.
Nicholls, 1941b, p. 74.

98. *A. dentatus* (Thompson & Scott), 1903.

Thompson & Scott, 1903, p. 268, pl. IX, figs. 1-10.
Sewell, 1948, p. 286.

Material examined - Six female and one male specimens of this copepod ~~of this copepod~~ occurred in the bottom weed washings of the Gulf of Mannar in September. Size: female 1.12 mm. and male 0.82 mm.

Distribution - Nicobar Islands and the Gulf of Mannar.

99. *A. hirsutus* (Thompson & Scott), 1903.

Thompson & Scott, 1903, p. 269, pl. IX, figs, 19-24.
Sewell, 1940, pp. 247-49, figs. 50-51.
Krishnaswamy, 1957, p. 46.

Material examined - Three female and two male specimens of this species are obtained in the weed washings of Palk Bay in September 1960. Size: female 1.23 mm. and male 0.87 mm.

Distribution - West Australia, Andaman Islands, Maldive Archipelago, Burmuda and the Gulf of Mannar.

100. *A. cinctus* (Claus), 1866.

Claus, 1866, p. 27, pl. III, figs. 8-12.
Sewell, 1940, p. 256, figs. 54-55.
Nicholls, 1941b, p. 414, fig. 17.
Krishnaswamy, 1957, pp. 44-45.

Material examined - Two female specimens of this copepod are gathered from the weed washings of Palk Bay in August 1960. Size: female 0.95 mm.

Distribution - This species appears to have a wide distribution and has been recorded from Indian, Atlantic and Pacific oceans.

LAOPHONTIDAE

G.O. Sars, 1903-11, p. 234.
Nicholls, 1941b, pp. 92-95.

Genus *Laophonte* Philippi, 1840

G.O. Sars, 1903-11, p. 234.
Nicholls, 1941b, pp. 97-100.

Subgenus *Laophonte* Nicholls, 1941

Nicholls, 1941b, 99-100.

101. *L.* (*L.*) *hirsuta* Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 226, pl. VIII, figs. 1-8.
Krishnaswamy, 1957, pp. 66-69, fig. 14.

Material examined - Numerous specimens of both sexes as well as several copepodite stages are obtained from the sponge and weed washings both from the Gulf of Mannar and Palk Bay during July-August 1960. Size: female 0.58 mm. and male 0.49 mm.

Distribution - Suez Canal and the Gulf of Mannar.

102. *L.* (*L.*) *macani* Sewell, 1940.

Sewell, 1940, pp. 319-22, fig. 73.
Krishnaswamy, 1957, p. 71.

Material examined - Two female specimens of this copepod are obtained from littoral weed washings of the Gulf of Mannar in October 1960. Size: 0.49 mm.

Distribution - South Arabia and the Gulf of Mannar.

Genus *Echinolaophonte* Nicholls, 1941

Nicholls, 1941, p. 95.

103. *E.* *horrida* (Norman), 1876.

Norman, 1876, p. 206.
G.O. Sars, 1903-11, pp. 246-47, pl. CLXVI & CLXVII.

Sewell,

Nicholls, 1941b, p. 95.
Krishnaswamy, 1957, pp. 63-64, fig. 13.

Material examined - A single damaged female is obtained from the washings of dredged weeds of the Gulf of Mannar in November 1960. Size: 0.98 mm.

Distribution - British Isles, Greenland, Polar Islands, Norwegian coast, Madras coast and the Gulf of Mannar.

104. E. tropica n. sp.

Material examined - Numerous specimens of both sexes of this copepod are gathered on several occasions from the Gulf of Mannar and Palk Bay, mostly from weed washings. They are also found to live in association with sponges. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

Descriptive notes - Four valid species are recognized under the genus Echinolaophonte and the present material appears to be the fifth species to be described. The name of the species has reference to the locality of occurrence.

Female: The cephalosome (Pl. XI, 11) exhibits a tripartite division - anterior and posterior regions and an intervening middle region with lateral wings - . There are four pedigerous segments besides the cephalosome. First three segments are more or less of equal dimensions, while the last one is larger than the others. Genital segment is quite large and is much wider than long. The three abdominal segments diminish both in length and width to posterior side. Caudal ramus is less than twice as long as wide, bearing six setae two of which are much longer than the others and widened in the proximal region. In lateral view (Pl. XI, 2) the postero-dorsal margins of cephalosome are produced into spines. Similar spine-like projections are noticed also in some of the prosomal and urosomal segments.

Antennule (Pl. XI, 3) is 6-segmented, the fourth segment bearing a fairly long aesthetask. Following are the proportionate lengths of the constituting segments:

1	2	3	4	5	6
19.2	29.8	31.2	7.1	2.8	9.9 = 100

Antenna (Pl. XI, 4) is 2-segmented; the exopod is 1-segmented, very short with four setae and is borne on outer margin of the basal antennal segment; the latter bears two setae, one each on its distal outer and inner corners; the second antennal segment bears four apical and one subapical spines, besides a small setae in the inner distal region. The spines have a bent appearance with serrated medial areas. Mandible (Pl. XI, 5) is quite normal with a masticatory blade and 1-segmented palp. Maxillule (Pl. XI, 9) and maxilla are typical of the genus. In maxilliped the terminal claw is characteristically incurved and the setae at distal margins of first and second segments are moderately developed. Inner margin of second segment is finely ciliated.

In first pair of legs (Pl. XI, 8) both endopod and exopod are bimerous. Endopod is quite well developed, basal segment bearing one seta and second segment bearing a stout terminal claw and an accessory seta. Exopod is very fragile, just exceeding half the length of basal endopod segment. There are five setae on the distal segment, three apical and two outer, while the proximal segment bears an outer seta. In protopod the basal segment is devoid of any seta, while the proximal segment has a seta on each margin. The ornamentation of the swimming ~~less~~ legs 2-4 is given below: (See also pl. XI, 10, 11 & 13).

	Protopod				Endopod					Exopod						
	1		2		1		2			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_2	0	0	0	1	0	0	2	2	0	0	I	1	I	2	2	II
P_3	0	0	0	1	0	0	1	2	0	0	I	1	I	1	2	II
P_4	0	0	0	1	0	0	1	2	0	0	I	1	I	2	2	II

Fifth leg (Pl. XI, 11) is very similar to that of other representatives of the genus. The proximal segment, however, is quite large, its inner projection reaching almost the whole length of the distal segment. Proximal segment bears a single seta on the outer and four setae on the inner margin. Distal segment bears three setae on the outer side. Size: 0.85 - 0.95 mm.

<u>Male</u>: Male is sexually dimorphic showing modifications in antennule, third, fourth, fifth and sixth legs and urosome. Antennule is geniculate and apparently 5-segmented. As in female, the aesthetask is borne on fourth segment which is much swollen with thickened margin. Terminal segment is short and narrow, but carries large number of setae along its

margins. Exopod of third leg is very powerfully developed with all the joints considerably thickened and having the spine very coarse and setae of inner edge short and spiniform; endopod of third leg is of the usual structure. In fourth leg, too, exopod is much coarser than in female, the setae of inner edge being spiniform. Fifth leg is much different from that of female. Each leg is rectangular in shape; basal segment is indicated by a broad based seta; distal segment carries unequal setae at the apex. Sixth leg also is rectangular in shape, carrying at its apex two setae one of which is strong and spine-like. In urosome there is an additional segment, and the genital segment is not as large as it is in female. Size: 0.65 - 0.75 mm.

CANTHOCAMPTIDAE

Lang, 1948, p. 899.

Genus Orthopsyllus Brady & Robertson, 1873

G.O. Sars, 1903-11, p. 288.

105. O. linearis (Claus), 1866.

Claus, 1866, p. 22, pl. II, figs. 1-8.
G.O..Sars, 1903-11, p. 289, pl. CXCIX.
Sewell, 1940, p. 343.
Krishnaswamy, 1957, p. 74.

Material examined - A single female specimen of this species is taken from the weed washings of the Gulf of Mannar in November 1960. Size: 0.84 mm.

Distribution - This is a very widely distributed species and has been taken from Indian, Atlantic and Antarctic oceans.

LOURINIIDAE

Sewell, 1940, p. 328.
Lang, 1948, p. 1215.

Genus Lourinia Wilson, 1924

Sewell, 1940, p. 326.
Lang, 1948, p.
Nicholls, 1941a, p. 23.

106. L. armata (Claus), 1866.

Claus, 1866, p. 25, pl. II, figs. 15-24.
Thompson & Scott, 1903, p. 265, pl. VII, figs. 11-23.
Sewell, 1940, pp. 328-32, figs. 77-78.
Krishnaswamy, 1957, pp. 79-80.

Material examined - Several male and female specimens of this copepod are gathered from the weed washings of the Gulf of Mannar in June 1960. Size: female 1.1 mm. and male 0.90 mm.

Distribution - This species has been widely reported from the Indo-West Pacific and Atlantic oceans.

Remarks - This species was originally described by Claus (1866) under the name Jurinia armata. Thompson & Scott, (1903) apparently unaware of Claus's paper created Ceylonia aculeata for the same species. Wilson (1924) pointed out that both these generic names are preoccupied and proposed Lourinia and Ceyloniella respectively under the impression that they were different genera. Subsequent workers, however, showed that Lourinia armata and Ceyloniella aculeata are synonymous and the specific name should be Ceyloniella armata (Claus), as this genus has priority. "Though Ceyloniella has distinct page priority over Lourinia the proper name, according to the prevailing International Rules of Zoological Nomenclature, is that used by the first reviser (i.e. Monard, 1927, p. 173) who used the name Lourinia armata (Claus, 1866)".

Lang (1948) has distinctly established this, and Nicholls (in a personal communication) agrees with this, quoting supports from Vervoort.

METIDAE

G.O. Sars, 1903-11, p. 344.

Genus Metis Philippi, 1843

G.O. Sars, 1903-11, p. 344.
Gurney, 1927, p. 567.

107. M. jousseaumei (Richard), 1892.

Richard, 1892, p. 69.
Sewell, 1940, pp. 346-51, fig. 86.
Krishnaswamy, 1957, p. 80.

Material exa mined - Several specimens are obtained from plankton as well as from weed washings of the Gulf of Mannar and Palk Bay during June - September, 1960. Size: forma major, 0.72 - 0.76 mm.; forma minor, 0.45 - 0.51 mm.

Distribution - This species has a very wide distribution having been taken from Indian, Atlantic and Pacific oceans.

C Y C L O P O I D A

Section GNATHOSTOMA

OITHONIDAE

G.O. Sars, 1913-18, p. 4.

Genus Oithona Baird, 1843

G.O. Sars, 1913-18, pp. 4-5.
Wilson, 1932, p. 311.

108. O. linearis Giesbrecht, 1891.

Giesbrecht, 1891, p. 475
Wolfenden, 1906, p. 1025, pl. XCI, fig. 49.
Krishnaswamy, 1953b, p. 63.

Material examined - This species is obtained in small numbers very often. It is an inconspicuous item of plankton not only because of its rarity, but also because of its small size. Size: female 1.13 mm.

Distribution - Maldive Archipelago, Madras coast, the Gulf of Mannar

109. O. robusta Giesbrecht, 1892.

Giesbrecht, 1892, p. 475
Rosendorn, 1917, pp. 29-32, figs. 16 a-e.
Krishnaswamy, 1953b, pp. 63-64, fig. 1.

Material examined - This is another rare oithonid of this area, appearing in small numbers on few occasions in the Gulf of Mannar. Size: female 1.41 mm.

Distribution - Widely distributed, having been recorded from all the great oceans.

110. O. rigida Giesbrecht, 1897.

Giesbrecht, 1897, p. 324, pl. V, figs. 10-15.
Rosendorn, 1917, p. 39.
Sewell, 1947, pp. 256-57.
Krishnaswamy, 1953b, p. 65.

Material examined - This is a common species and is captured throughout the year. Size: female 0.76 mm. and male 0.60 mm.

Distribution - "This species appears to be widely distributed throughout the northern region of the Indian ocean". (Sewell, 1947).

111. *O. plumifera* Baird, 1843.

Baird, 1843, p.
Rosendorn, 1917, pp. 10-12, fig. 1 a-d.
Sewell, 1947, pp. 255-56.
Krishnaswamy, 1953b, p. 64.

Material examined - This species occurs in small numbers quite often in plankton of the Gulf of Mannar. Size: female 1.15 mm.

Distribution - Similar to that of preceding species.

Remarks - This species has been synonymised with *O. spinirostris* and *O. atlantica* by Rosendorn(1917) and Kiefer (1929). Wilson (1932) and Sewell (1947) admit the synonymy of the latter two species, but consider *plumifera* as a separate species. Sewell (*loc. cit.*) pointed out that there are only three setae on the endopod of the mandibular palp of *O. plumifera* while four setae arise from that position in *O. spinirostris* (= *O. atlantica*).

Farren (1913) pointed out that in some of his examples the plumose setae were not present on the posterior legs. He inferred that they would have been broken off. Sewell (*loc. cit.*) carefully examined several exampƒes he obtained from John Murray collections and found no sign of their being broken or of any feathering. "It seems probable that the plumose termination is a variable character and may in some cases be wanting" (Sewell, 1947, p. 255).

112. O. setigera (Dana), 1849.

Dana, 1849, p.
Rosendorn, 1917, pp. 20-24, figs.10 a, 11b.
Sewell, 1947, p. 257.
Krishnaswamy, 1953b, p. 64.

Material examined - This species occurs often in plankton of the Gulf of Mannar. Size: female 1.23 mm.

Distribution - Widely distributed

Remarks - Sewell (loc. cit.) considers this species to be synonymous with O. tropica Wolfenden and O. pelagica Farren, for the presence and the location of the club-shaped setae on basal segment of swimming leg is not a constant feature.

113. O. nana Giesbrecht, 1892.

Giesbrecht, 1892, p. 538, pl. IV, fig. 8, pl. XXXIV, figs. 10, 11, 20, 21-26, 34, 35.
Wilson, 1932, pp. 316-17.
Sewell, 1947, p. 254.

Material examined - This is a common species and is captured throughout the year from plankton of the Gulf of Mannar. Size: female 0.54 mm.

Distribution - This is another widely distributed species, occurring in all the three great oceans.

CYCLOPINIDAE

Lang, 1946, p. 3.
Sewell, 1949, pp. 20-24.
Lindberg, 1952, pp. 311-25.
Krishnaswamy, 1957, pp. 132-33.

Genus Cyclopina Claus, 1863

G.O. Sars, 1913-18, pp. 10-11.
Wilson, 1932, p. 317.

114. <u>C. gracilis</u> Claus, 1863.

Claus, 1863, p. 104, pl. X, figs. 9-15.
G.O. Sars, 1913-18, pp. 11-12, pl. IV.

<u>Material examined</u> - Eight female and two male specimens are gathered from the weed washings of the Gulf of Mannar in March 1961. Size: female 0.48 mm. and male 0.39 mm.

<u>Distribution</u> - Arctic ocean, North Atlantic, Baltic sea, Mediterranean sea, Black sea, Gulf of Oman and the Gulf of Mannar.

CYCLOPIDAE

G.O. Sars, 1913-18, pp. 22-23.
Sewell, 1949, pp. 26-30.

Genus <u>Euryte</u> Philippi, 1843

G.O. Sars, 1913-18,pp. 23-24.
Sewell, 1929, pp. 30-31.

115. <u>E. robusta</u> Giesbrecht, 1900.

Giesbrecht, 1900, p. 58, pl. IV, figs. 1-14, 16 & 18.
G.O. Sars, 1913-18, pp. 24-26, pl. XII.
Sewell, 1949, pp. 31-33, fig. 2.

<u>Material examined</u> - Numerous males and females and a few fifth copepodites are obtained from weed washings of the Gulf of Mannar and Palk Bay during September-October 1960.

<u>Descriptive notes</u> - Sewell has redescribed the female of this species in some detail. The present material corresponds in all details with his descriptions. However, some fresh sketches are given here to facilitate comparison with other species that are discussed in the present work (Pl. XIV, 2,3). Male (Pl. XIV, 1) shows the usual points of sexual dimorphism. Antennule is 16-jointed and geniculate. Urosome is 6-segmented, the genital segment carrying at each of its postero-lateral

corners a pair of spines of unequal lengths. The spines are borne on a small prominence which represents the sixth pair of legs. Caudal ramus is four times longer than wide and is only a little shorter than the last two abdominal segments combined. Size: female 0.80 mm. and male 0.61 mm.

Distribution - Maldive Archipelago, Suez Canal, Gulf of Naples, Norwegian coast and the Gulf of Mannar.

116. E. brevicauda Sewell, 1949.
Sewell, 1949, pp. 33-35, fig. 3.

Material examined - Numerous female and two male specimens as well as a few fifth copepodite stages of this species are caught during September - November 1960 from amongst the weeds of the Gulf of Mannar and Palk Bay.

Descriptive notes - Female of this species is described by Sewell (loc. cit.). Male is described here for the first time.

Female: Prosome is apparently 5-segmented, the fusion between cephalosome and first pedigerous segment being incomplete. The genital segment which is a result of coalescence of two segments is broader in its proximal part, and is a little shorter than the three abdominal segments combined. Caudal rami and last abdominal segment are of equal length. The spine on the outer lateral margin of fifth leg (Pl. XIV, 4) is almost as long as the outer apical spine; the inner apical spine is a little longer than both the other spines; the apical seta is slender.

Male: Like other species of the genus, male (Pl. XV, 1) differs from female in the smaller size and the sexual dimorphism which is manifested in antennule and urosome. The former is 16-segmented (Pl. XIV, 5), the segments having their relative lengths as follows:

1	2	3	4	5	6	7	8	9	10	11	12
15.9	6.3	6.8	3.2	3.1	2.6	2.6	3.2	4.7	3.7	3.7	5.2

13	14	15	16	
4.2	9.5	10.5	14.8	= 100

Segments of the proximal region are provided with several setae. There is an aesthetask from the last segment. Antennule is strongly hinged and it reaches to the posterior margin of first prosomal segment. Urosome (Pl. XV, 2) is 6-segmented. The genital segment is of uniform breadth throughout and is broader than other abdominal segments which are columnar. The former carries on each of its postero-lateral corners a prominence which bears two unequal setae. Caudal rami are slightly longer than the last abdominal segment.

Size: female 0.75 mm. and male 0.56 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar. This is the first record of this species outside its type locality.

117. *Euryte* sp.

Material examined - Numerous female specimens and a few fifth copepodites of this species occurred in the collections made during September-October 1960 from the weed washings of the Gulf of Mannar and Palk Bay.

<u>Descriptive notes</u> - In life, a beautiful pinkish tinge is seen over the whole length of caudal rami, margins of prosomal and urosomal segments, joints of the segments of swimming legs and along the mid-dorsal cephalosome. In formalin preserved specimens the bright pink colour fades out and ~~pxrix~~ persists only in caudal rami.

Prosome is apparently 5-segmented, the fusion between cephalosome and first pedigerous segment being incomplete. The latter segment is however, much narrower than the cephalosome and second pedigerous segment. In urosome (Pl. XVI, 1) the genital segment is equal to the three abdominal segments joined together. Caudal ramus is four and a half times longer than wide and is a little shorter than the last two abdominal segments combined together. There are six setae on each ramus two of which are jointed at base. The rostrum is incurved and rather broad. The labrum is a wavy structure with about nine stout teeth in the middle concavity and several, thin, incurved teeth on either convex sides.

Antennule (Pl. XVI, 2) is 21-segmented, the constituting segments having the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11	12
15.4	8.0	5.0	3.0	2.5	3.2	1.8	3.0	3.6	4.3	4.3	4.3
13	14	15	16	17	18	19	20	21			
3.6	3.0	5.0	3.6	3.6	4.0	5.4	5.4	8.0 = 100			

Antenna (Pl. XVI, 3), the oral appendages and swimming legs are very close to those of the earlier species. Fifth leg is rectangular, about three times as long as wide. A striking difference from the earlier two species is noticed in the lengths of spines on fifth leg. The spine on outer margin of distal segment is just as long as the outer terminal spine; the inner terminal spine, as in other species, is the longest; the seta on apex is slender and rather sharp. Size: 0.75 mm.

The fifth copepodite stage resembles the adult very closely including the structure of fifth pair of legs, but differs from it in the organization of antennule and urosome. Antennule is 16-segmented and there~~s~~ seems to be no sexual distinction at this stage. The relative lengths of the constituting segments of antennule are as follows:

1	2	3	4	5	6	7	8	9	10	11	12
11.1	8.4	5.8	6.5	6.2	5.2	3.9	7.1	3.9	3.2	3.5	4.5

13	14	15	16
10.5	5.8	6.5	7.9 = 100

There are five segments in urosome. The genital segment is only slightly wider than the other segments and carries on each of its postero-lateral corners a pair of spines. Caudal rami are quite short, hardly twice longer than wide and distinctly shorter than the last abdominal segment. Caudal setae are fully developed. Size: 0.62 mm.

Remarks - Sewell recognized only four species in this genus *viz*., *E. robusta* Giesbrecht, *E. longicauda* Philippi, *E. curticornis* G.O. Sars and *E. brevicauda* Sewell. Two other species that have been described earlier namely *E. propinqua* Brady and *E. similis* T. Scott are considered by Gurney as synonymous and by Sewell ("as slight variations of *E. robusta*".

A third form described still earlier by Thompson (1883) from New Zealand under the name E. longicauda var. antarctica is, according to Sewell, almost certainly not a variety of that species. He thinks that Thompson's material comes much nearer to E. robusta, as the caudal ramus figured by Thompson, is four times longer than wide which is much shorter than that of E. longicauda.

Sewell (1949) did not make any mention of E. minor T. Scott. G.O. Sars (1921) has reported this species from the Norwegian coast. "This form was considered by Scott and also by myself as only a variety of E. longicauda. I am however, now of the opinion that it should more properly be regarded as a separate though closely allied species" (Sars, loc. cit., p. 107). According to Sars E. minor is different from E. longicauda in the size, in the more slender form of the body, in the thin nature of genital segment and in the less divergent ovisacs. Kiefer (1929) includes this form in E. longicauda, but Lang (1946b, pp.1,2) distinguishes it as separate species by the relatively longer abdomen and divergent caudal rami. Gooding (1957) follows T. Scott (1905) and considers it as a variety of E. longicauda. In any case both these species constitute a closely related group, separate from other species of the genus. E. brevicauda probably represents the other extreme with short caudal rami, while both E. robusta and the species described in this work are somewhat intermediate in position. Grandori (1925) has described another species, E. longiseta, from the Mediterranean. I could not consult this important paper and therefore no comparison is possible between the species described here and E. longiseta Grandori.

The available evidences indicate that the present species represents a new species. Though it is close to *E. robusta* in the proportions of caudal rami and in the structure of cephalosomal and thoracic appendages still the differences between them are substantial and are listed below:

E. robusta Giesbrecht	*Euryte* sp.
Prosome is oval both in dorsal and lateral views.	Prosome is oval only in dorsal view; in lateral view the posterior half is much narrower than the anterior half.
First pedigerous segment is more or less fused with cephalosome.	The fusion between the first pedigerous segment and the cephalosome is • incomplete and the former is distinct ffom the latter.
First prosomal segment is more than twice as long as all other prosomal segments combined, the ratio being 5:2 .	First prosomal segment is just one and a half times as long as the rest of prosomal segments combined, the ratio being 3:2 .
The proportions of urosomal segments and caudal ramus are as follows: 14.0, 32.0, 11.3, 8.7, 13.0, 21.0 = 100	The proportions of urosomal segments and caudal ramus are as follows: 15.0, 29.0, 13.5, 11.0, 12.5, 19.0 = 100
In fifth leg the relative lengths of outer marginal, outer apical and inner apical spines are: 38.5, 32.7, 28.8 = 100	In fifth leg the relative lengths of outer marginal, outer apical and inner apical spines are: 39.2, 35.3, 25.5 = 100
In life, caudal rami are dirty brown in colour. Formalin preserved specimens become opaque.	In life, caudal rami are pinkish in colour and this persists even in formalin preserved specimens.

E. longicauda is separable from all other species by its exceedingly long caudal rami, "equalling in length the last three segments combined". *E. curticornis* is distinct not only because of the very short antennule but also because of the structural deviations noticed in the maxilliped. *E. robusta* and *E. brevicauda* are represented in the present collection, and opportunity has been availed of to make a detailed scrutiny of these species as well as the unnamed species treated in this work. It appears that this last species is quite distinct from all other forms. It resembles *E. robusta* in the proportions of caudal rami and in the structure of the cephalosomal appendages and swimming legs. It resembles *E. brevicauda* in the general shape of body and in the incomplete fusion of cephalosome and first pedigerous segment.

I have not seen the descriptions of *E. longicauda* var. *antarctica*, *E. propinqua* or *E. similis*. All these three forms are reported from the Antarctic and the neighbouring areas. Both Gurney who synonymised the latter two forms and Sewell who went further and regarded all the three as slight variations of *E. robusta*, did not have the material at their disposal for examination. It is probable that the species described above is the same as the one reported from the Souther waters by Thompson, Brady and T. Scott.

ARCHINOTODELPHYIDAE

Lang, 1949, pp. 1-2.
Ummerkutty, 1960c, p. 177.

Genus *Nearchinotodelphys* Ummerkutty, 1960

Ummerkutty, 1960c, pp. 165-78.

118. *N. indicus* Ummerkutty, 1960.

Ummerkutty, 1960c, pp. 165-78, figs. 1-4.

Material examined - Reference may please be made to copy of the above publication attached with the thesis.

Distribution - The Gulf of Mannar.

NOTODELPHYIDAE

Illg, 1958, pp. 470-79.

Genus *Doropygus* Thorell, 1859

Illg, 1958, pp. 518-24.

119. *D. pulex* Thorell, 1859.

Thorell, 1859, pp. 46-49, pl. VI, fig. 8.
G.O. Sars, 1921, pp. 42-43, pl. XX.
Illg, 1958, pp. 525-30.

Material examined - Five female (two of them carrying empty pouches and others egg-filled ones) and one male specimens are obtained from the branchial chambers of *Molgula* sp. from Palk Bay in July 1960. Size: female 1.5 mm. and male 1.2 mm.

Distribution - This is a very widely distributed species, occurring in all the oceans in association with diverse species of ascidian hosts. "The recorded distribution of this species is the most wide spread so far compiled for Notodelphyid. The list of hosts is also the most diverse and extensive known" (Illg, *loc. cit.*, p. 530).

Section SIPHONOSTOMA

ASTEROCHERIDAE

G.O. Sars, 1913-18, p. 83.
Nicholls, 1944, p. 16.
Sewell, 1949, p. 47.

Genus *Asterocheres* Boeck, 1859

G.O. Sars, 1913-18, p. 84.

120. A. major Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 287, pl. XVIII, figs. 21-28.

Material examined - Several specimens of both sexes are obtained from the Gulf of Mannar sponges during September-October 1960.

Descriptive notes - Thompson & Scott (loc. cit.) has given excellent diagrams of cephalosomal appendages and fourth and fifth legs of the adult female as well as urosome and antennule of the adult male. The siphon is very broad and short, pyriform in shape and only extending to the insertions of maxillipeds. The ornamentation of swimming legs is presented below:

	Protopod 1 Si	Protopod 1 Se	Protopod 2 Si	Protopod 2 Se	Endopod 1 Si	Endopod 1 Se	Endopod 2 Si	Endopod 2 Se	Endopod 3 Si	Endopod 3 St	Endopod 3 Se	Exopod 1 Si	Exopod 1 Se	Exopod 2 Si	Exopod 2 Se	Exopod 3 Si	Exopod 3 St	Exopod 3 Se
P_1	I	0	I	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	I	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
P_3	I	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
P_4	0	0	0	1	1	0	2	0	2	II+1	1	1	I	1	I	4	I	III

The spine on proximal segment of first exopod is rather short, hardly reaching the middle of the next segment. The spine on this latter segment gives the appearance of bifurcation because of the presence of a small outgrowth at its base. The basal protopod segment of first leg carries a spine. Size: female 1.15 mm. and male 1.05 mm.

Distribution - The Gulf of Mannar. This is the first record of this species after it was created by Thompson & Scott.

121. <u>A.</u> <u>minor</u> Thompson & Scott.

Thompson & Scott, 1903, p. 288, pl. XVIII, figs. 29-31.

<u>Material examined</u> - Several specimens of both sexes are gathered from the Gulf of Mannar sponges, along with the preceding species. Size: female 0.83 mm. and male 0.71 mm.

<u>Distribution</u> - The Gulf of Mannar. This is the first record of this species after its creation by Thompson & Scott.

<u>Remarks</u> - This is very close to the preceding species in the structural details including the ornamentation of swimming legs. "The distinguishing characters of this species are the differences in the proportional lengths of the abdominal joints and furca, the latter being about half the length of the last abdominal joint". (Thompson & Scott, 1903)

122. <u>A.</u> <u>mannarensis</u> Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 287, pl. XIX, figs. 11-20.
Sewell, 1949, pp. 50-51.

<u>Material examined</u> - Three female specimens of this copepod are obtained from the washings of sponges from the Gulf of Mannar in October 1960.

<u>Descriptive notes</u> - The specimens (Pl. XVII, 1-2) agree entirely with the descriptions given by earlier workers. The ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Si	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	1	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	1	III
P_4	1	0	0	1	1	0	2	0	2	2	1	1	I	1	I	4	1	III

Size: female 0.70 - 0.73 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar.

123. A. *dentatus* Giesbrecht, 1897.

Giesbrecht, 1897, p. 9.
Thompson & Scott, 1903, p. 287.

Material examined - Several specimens of both sexes are captured from the weed and sponge washings of the Gulf of Mannar and Palk Bay during July - September 1960.

Descriptive notes - This species is fully illustrated (Pl. XVIII, 1-9) and the ornamentation of swimming legs is given below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	III
P_3	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	III
P_4	1	0	0	1	1	0	2	0	2	2	1	1	I	1	I	4	I	III

In size this species is very small, female varying between 0.53 - 0.63 mm. and male between 0.45 - 0.50 mm.

124. A. *orientalis* Sewell, 1949.

Sewell, 1949, pp. 51-53, fig. 9 a-j.

Material examined - Several males and females of this copepod are obtained from washings of dredged weeds of the Gulf of Mannar in December 1960.

Descriptive notes - Sewell (*loc. cit.*) gave a detailed account of female. Male is described here for the first time.

Male (Pl. XVII, 5) retains the general appearence of female, but is slightly smaller in size. Prosome is only a little more than twice the size of urosome. The latter is 5-segmented (Pl. XVII, 6), the genital segment being much longer and wider than all other segments. It carries a pair of spines on its postero-lateral corners. Caudal rami, as they are in female, are wider than long. Antennule (Pl. XVI, 6) is 17-segmented and geniculate. The setae borne on different segments are extremely short and bristle-like except one seta on the apical segment. The aesthetask on penultimate segment is fairly long, being more than one third of the appendage. The relative lengths of different antennular segments are presented below:

1	2	3	4	5	6	7	8	9	10	11	12
11.3	2.8	3.5	2.8	2.8	4.0	4.0	3.6	3.6	1.6	5.7	5.1

13	14	15	16	17	
6.3	6.8	13.5	11.3	11.3	= 100

All other appendages are similar to those of female except the fifth leg. The latter hardly reaches one fourth of the genital segment while in female it is half the length of that segment. Again, it is very slender in male, whereas in female fifth leg is stout and cylindrical. The outer caudal seta of fifth ~~k~~ leg is insignificant in male. Size: female 0.68 mm. and male 0.61 mm.

<u>Distribution</u> - Maldive Archipelago and the Gulf of Mannar. This is the first record of this species outside its type locality.

125. A. *indicus* Sewell, 1949.

Sewell, 1949, pp. 53-56, fig. 10.

Material examined - Seven female specimens of this species are obtained from the weed washings of the Gulf of Mannar in December 1960.

Descriptive notes - Some points of difference are noticed between the Maldive example and the present specimens. The segments nine and ten of antennule are incompletely divided in the Maldive specimens, while they are completely separate in the present example (Pl. XV, 7). In fifth leg, Sewell shows only two terminal setae. In the present case, three setae are distinctly seen(Pl. XIX, 1-2). A pair of rather strong setae is present on the ventral side of genital segment, guarding the genital apertures. In all other characters the present example agrees fully with Sewell's description and figures. Size: female 0.61 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar. This species also is reported from outside of its type locality for the first time.

126. A. *latum* (Brady), 1880.

Brady, 1880, p. 56, pl. LXXXIX, fig. 12; pl. XC, figs.11-14.
G.O. Sars, 1913-18, pp. 90-91, pl. LVI.

Material examinedSeveral specimens of this species are captured from the sponge and weed washings of Palk Bay and the Gulf of Mannar.

Descriptive notes - This species is very easily recognized by the angular nature of the postero-lateral corners of prosomal segments (Pl. XIX, 3). First prosomal segment is distinctly wider than long. The length and width of genital segment is more or less the same (Pl. XIX, 4). Lateral margins of this segment are broken by indentation, and are lined with spinules and bristles. Last abdominal segment is a little longer than caudal rami. The distal segment of fifth leg carry three apical setae, the middle one of which is very small. In the figure given by G.O. Sars (loc. cit.) this seta is not shown. Size: female 0.68 mm.

Distribution - British Isles, Gulf of Naples, Norwegian coast and the Gulf of Mannar. This is the first time that this Northern species is recorded from Indian waters.

127. Asterocheres sp.(i)

Material examined - A singlefemale specimen of this species is obtained from washings of the mud-covered coral stones in Palk Bay in August 1960.

Descriptive notes - Prosome and urosome (Pl. XII, 1) are clearly marked, the former being very conspicuous, much wider and longer than the latter. First prosomal segment is the largest and the widest of body segments. Second and third segments diminish both in length and width to posterior side. All these three segments end in angular corners on posterior side. Fourth prosomal segment is very small, just half as long and half wide as the preceding segment. Urosome consists of four segments, the fifth leg-bearing segment, the genital segment and two abdominal segments. They decrease in breadth gradually posteriorwards. In length, the genital segment is the longest, while the other three segments are subequal and much shorter than the genital segment. The latter is wider in its proximal half. At the junction of proximal and distal halves there are tufts of hairs on either side. Caudal ramus is much longer than last abdominal segment and is slightly broader on the hinder side. Each ramus bears five setae, the medial seta being much longer than the entire urosome. As usual, two of the setae are jointed at base. The relative lengths of urosomal segments and caudal ramus are:

17.8, 32.2, 14.5, 13.3, 22.2 = 100

The relative lengths of prosome and urosome are 1 : 1.5 . Prosome is slightly longer than its own width.

Antennule (Pl. XII, 2) is 20-segmented and is divided into proximal wide and distal narrow regions, composed of nine and eleven segments respectively. There is an aesthetask on eighteenth segment, while setae are borne on all segments. The antennular segments have the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11	12
11.3	3.6	3.3	2.4	2.4	2.3	1.8	2.3	2.0	1.6	2.1	5.2
13	14	15	16	17	18	19	20				
6.0	8.4	7.5	9.0	9.2	8.4	3.4	7.8 = 100				

Antenna is 4-segmented, the second segment bearing rudimentary endopod which is like a spherical bud with a single apical seta. Third segment is the longest, about equal in length to the first and second segments combined. Last segment is the smallest and bears two apical spines, one of them being very long, about half the length of antenna. Siphon (Pl. XII,3) is very stout and short. Its wider proximal region narrows down to the posterior tip which is trilobed. Mandible (Pl. XII,4 consists of the masticatory blade and a biarticulate palp. The latter is only one fifth as long as the blade and bears two apical setae of unequal lengths. The combined lengths of the palp and its longer seta is equal to that of the blade. Maxillule (Pl. XII, 5) is bilobed, both lobes borne on a partially divided protopod. The two lobes are very much unequal in size and each bears apical setae of varying lengths. Maxilla (Pl. XII, 6) which is composed of a very small proximal and a large distal segment, carries a long tapering claw on apex. Maxilliped (Pl. XII, 7) is 4-segmented, the distal two segments being much smaller and held at an angle to the axis of proximal two segments. The fourth segment bears a long tapering claw and a small seta on its apex. First and third segments of maxilliped each bears a small seta in the distal part. The second segment is devoid of any accessory structure.

Four pairs of swimming legs are biramous (Pl. XII, 8-9), each ramus being trimerous. First legs are the smallest while the other legs are more or less of equal size. The ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod							
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	I	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	I	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	4	I	III

In fifth leg (Pl. XII, 10) the proximal segment is indicated by the presence of a single seta. The distal segment is rather rectangular, bearing three apical setae, the median of which is longer than the other two. There are bristles on both margins of the distal segment. Size: female 1.27 mm.

<u>Remarks</u> - <u>Asterocheres asterocheres</u> Sars reaches nearer to the present species than any other known member of the genus. However, a detailed description is given above because the present species appear to differ from all known forms in a few important details: (i) Caudal ramus is much longer than last abdominal segment. Sars (<u>loc</u>. <u>cit</u>.) in his definition of the genus mentioned that the caudal rami are comparatively short and a study of the forms that have been described after his "Account" reveals that the last urosomal segments always exceeds the caudal rami in length. (ii) The length-width ratio of the ramus itself is still more striking. While in all recorded species the caudal rami are hardly more than twice as long as broad, in the present case the length-width ratio is 3.5 : 1 . (iii) The proportionate sizes of prosome and urosome are 62.5 : 37.5 . This is different from what is described for all earlier species

where prosome is found to be generally twice as long as urosome. (iv) The proportionate lengths of the antennular segments and the ornamentation of swimming legs are as given in the text.

It is likely that the present species is an undescribed form.

128. *Asterocheres* sp.(ii)

Material examined - A single female specimen of this copepod is obtained from washings of asteroids of the Gulf of Mannar in December 1960.

Descriptive notes - Prosome is squarish, 4-segmented and one and a half times longer than urosome (Pl. XIX, 5). First segment constitutes three fourth of the entire prosome and is clearly broader than long. Next three segments abruptly diminish both in length and width. Urosome (Pl. XX, 2) is 4-segmented and much narrower than prosome. The first segment carrying fifth pair of legs is very short. The genital segment is long and is divided into three parts of about equal lengths; proximal part is the widest and carries the genital apertures on its ventral side; the middle part is less broad, but is clearly marked off from other divisions by sharp, angular corners, and carries a few hairs on its distal margins; the distal division is the narrowest and tapers towards the posterior side. Two abdominal segments are of about equal diamensions and ~~are~~ are columner. Caudal rami are longer than the last abdominal segment and three times as long as wide. Both inner and outer margins of the ramus are straight; there are five caudal setae, two of which are longer than the others and are jointed at base.

Antennule (Pl. XIX, 6) is 20-segmented and stoutly built. There is an aesthetask on eighteenth segment. The constituting antennular segments have the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11	12
13.0	4.0	4.0	3.0	3.5	3.5	3.0	4.0	5.0	3.0	4.0	5.0
13	14	15	16	17	18	19	20				
5.0	5.0	6.5	6.0	6.5	5.5	4.0	6.5	= 100			

Other cephalosomal appendages (Pl. XX, 1) are typically asterocherid. Antenna is 5-segmented with a vestigeal exopod on second segment. Siphon is very short and stout, hardly reaching the base of maxilla. Mandible has a well developed 2-segmented palp and a long, narrow masticatory blade. In maxillule the difference of size between the two lobes is negligibly small. Maxilla has its terminal claw longer than the basal segment. Maxilliped is 5-segmented with a strong claw.

Four pairs of swimming legs (Pl. XIX, 7-9) are biramous, the rami being 3-segmented. The ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	I	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	3	I	III

The constituting segments of legs are stout and the lateral spines of exopods are beautifully spindle-shaped with dentate margins. Fifth leg is normal. The proximal segment is represented by a seta on the outer lateral margin. The distal segment is quite developed with a narrow proximal area and broad distal area, the latter carrying three unequal terminal setae. Size: female 0.61 mm.

<u>Remarks</u> - The species dealt with above appears to be new to science. However, as only a single female specimen is available I have chosen to leave it unnamed. The following are the characteristic features of the species: (i) First prosomal segment is one and one quarter times broader than long. Anterior end is smoothly rounded while posterior end is rather straight. Next three prosomal segments together is only about one fourth of first segment, the segments gracefully diminishing both in length and width to posterior side. (ii) In urosome, the genital segment is very short, forming a narrow strip between the last prosomal segments and fifth leg-bearing segments. Genital segment is characteristically divided into three equal parts.

Proximal part is the widest and encloses the genital apertures in it. Middle part is a little less wide, but distinctly marked off by angular corners. The posterior half of lateral margins of this middle part carries four stout spinules on each side. Distal part is the narrowest and does not carry any appendage. Next two urosomal segments are more or less of equal size and squarish. Each caudal ramus is two and a half times longer than wide. (iii) Antennule is 20-segmented, their relative lengths and arrangement of setae and aesthetasks being given in the text. (iv) The setal formula of swimming legs is as shown earlier. One notable feature about legs is the stout rounded nature of exopodal spines. Even the spine on the first segment of first exopod which, in other species of the genus exceeds the length of second segment of the same leg, is spindle-shaped in the present case with smooth terminal end. Fifth leg is rectangular with little difference in width between proximal and distal halves. There are three long setae on the terminal segment. (v) There is a high degree of calcification not only in the segments of antennule but also in other appendages as well as along the margins of various segments of the copepod body. (vi) It is obtained from washings of the starfish, *Pentaceros hedemanni* (Lutken).

Genus *Scottocheres* Giesbrecht, 1897

G.O. Sars, 1913-18, pp. 106-107.

129. *S. latus* Nicholls, 1944.

Nicholls, 1944, pp. 18-20, fig. 7.

Material examined - Few female specimens of this copepod are obtained from inshore waters of the Gulf of Mannar during September-November 1960. Size: female 0.98 mm.

Distribution - South Australia and the Gulf of Mannar. This is the first time that this species is recorded outside its type locality.

Remarks - I have not seen the descriptions of either *S. stylifera* or *S. longifurca*. However, the present species has been assigned to *S. latus* because it corresponds in all respects with Nicholls's species. It may be mentioned here that both *S. longifurca* Giesbrecht and *S. elongatus* (T. & A. Scott) have been recorded from this area by Thompson & Scott(1903).

Genus *Dermatomyzon* Claus, 1889

G.O. Sars, 1903-18, p. 95.

130. *D. nigripes* (Brady), 1880.

Brady, 1880, p. 54, pl. LXXXIX, fig. 1-11.
G.O. Sars, 1913-18, pp. 95-97, pl. LIX & LX.

Material examined - Two female specimens of this copepod occurred among the sponge washings of the Gulf of Mannar in October 1960.

Descriptive notes - In almost all respects the present example corresponds to the excellent description and figures given by Sars (*loc. cit.*) and is fully illustrated here (Pl. XXI, 1-3). The only point of difference noticed is the slight variation in the relative lengths of antennular segments (Pl. XX, 5) and it is presented below for comparison:

1	2	3	4	5	6	7	8	9	10	11	12
11.2	4.7	7.0	3.5	4.7	3.5	4.7	4.1	3.0	3.5	5.2	4.7
13	14	15	16	17	18	19 (Norwegian example, after Sars)					
4.8	4.7	5.8	5.8	7.0	3.0	9.1 = 100					

1	2	3	4	5	6	7	8	9	10	11	12
10.7	3.6	6.5	2.6	2.2	2.2	5.6	3.3	3.0	3.6	5.1	5.1
13	14	15	16	17	18	19 (Present example)					
4.4	6.0	6.0	6.3	8.0	5.1	10.7 = 100					

Size: female 0.92 mm.

Distribution - British Isles, Gulf of Naples, Spitsbergen and Norwegian coasts and the Gulf of Mannar. This is the first record of this species from Indian waters.

Genus *Asteropontius* Thompson & Scott, 1903

Thompson & Scott, 1903, p. 288.

131. *A. typicus* Thompson & Scott, 1903.

Thompson & Scott, 1903, pp. 288-89, pl. XIX, figs. 1-10.

Material examined - Three female specimens of this copepod occurred in washings of dredged weeds from the Gulf of Mannar in November 1960. Size: 0.7 mm.

Distribution - The Gulf of Mannar. This is the first time that this species is reported after its discovery.

Remarks - The specimens examined by Thompson & Scott were much larger measuring 0.96 mm. As both these are reported within the same geographical area, it is obvious that great range of variation in size of body occurs in this species. In general appearance it has great resemblance to <u>Asterocheres mannarensis</u>. However, it is easily distinguishable from the latter by the differences in the relative lengths of urosomal segments as well as by the generic distinctions. The figures given by Thompson & Scott are excellent and the present material agrees with them in all details (Pl. XX, 3-4).

132. <u>A. littoralis</u> Ummerkutty, 1961
Ummerkutty, 1961, pp. 4 – 6

<u>Material examined</u> - Several female specimens are captured in September 1960 from washings of weeds from the Gulf of Mannar. Size: female 1.2 mm.

<u>Distribution</u> - The Gulf of Mannar.

133. <u>A. sewelli</u> Ummerkutty, 1961.
Ummerkutty, 1961, pp. 7 – 10

<u>Material examined</u> - Besides the type specimens no further examples of this copepod is obtained. Size: female 1.1 mm.

<u>Distribution</u> - The Gulf of Mannar.

Genus <u>Indomyzon</u> n. gen.

<u>Diagnosis</u>: Body cyclopoid. Cephalosome fused with first pedigerous segment to form the cephalothorax. Urosome 4-segmented in female and 5-segmented in male; caudal rami swollen in proximal region and caudal setae non-jointed. Antennule 20-segmented in female, 17-segmented and geniculate in male. Mandibular palp 1-jointed. Siphon very short and broad. Other mouthparts typically asterocherid. Setae and spines of swimming legs greatly reduced.

Second endopod segment of first leg with one seta; the corresponding segments of other legs without any seta. Fourth endopod fragile and setation highly reduced. Fifth leg with a single segment, bearing three unequal apical setae; the proximal segment represented by a single lateral seta.

Type species: Indomyzon qasimi n. sp.

Type locality: Off Mandapam, Gulf of Mannar.

134. Indomyzon qasimi n. gen. et. n. sp.

Material examined - Ten females (one of them carrying egg sacs), eight males and five fifth copepodites of this species are obtained from washings of the staffish Pentaceros hedemanni (Lutken) from the Gulf of Mannar in December 1960. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

Descriptive notes - The present species is obtained during a collection trip to the Hare Island along with Dr. S.Z. Qasim of the Department of Zoology, Aligarh Muslim University. Dr Qasim's constant encouragement and continued interest in the present investigations have been quite inspiring and I have great pleasure in naming the present species in his honour.

Female: The animal (Pl. XXII, 1) is very easily recognized by the rather rectangular shape of prosome. Latter is equal to urosome (Pl. XXI, 4) in length. Second, third and fourth segments of prosome diminish both in length and width to posterior side. First urosomal segment is moderately developed and carries fifth pair of legs. The genital segment is quite large, equal to the combined size of the second and third segments. It is broader in its anterior half and bears a seta each, on ventral side near to the genital aperture. Anterior and posterior halves of the genital segment smoothly merge with each other. There are no setae at their junction. Third urosomal segment is double the size of the fourth, but both segments are of about the same width. Caudal rami are peculiarly shaped; while the inner margin of the ramus is straight, the proximal half of outer margin is bulged. At the posterior margin five setae are borne, none of them being jointed at base. Caudal ramus is longer than the last abdominal segment and is almost twice as long as wide.

Antennule (Pl. XXII, 3) is strongly built with a high degree of calcification along the margins of segments. There is a fairly long aesthetask on eighteenth segment. The relative lengths of the constituting segments are as follows:

1	2	3	4	5	6	7	8	9	10	11	12
12.7	5.0	3.6	3.6	4.5	3.2	4.5	5.0	2.7	2.7	3.2	5.0
13	14	15	16	17	18	19	20				
6.4	6.4	5.5	4.5	5.5	6.0	4.5	5.5 = 100				

Antenna is 5-segmented, the second segment carrying a rudimentary exopod with two terminal setae. The penultimate segment bears two marginal setae while the last segment has two terminal setae. Siphon is very short, hardly reaching the point of origin of maxillipeds. It is broad in its proximal half gradually narrowing down to distal end. Mandibular palp is uniarticulate with terminal setae of unequal lengths. The masticatory blade tapers to a fine point, and is four times longer than the palp. Maxillule is small and bilobular. Both the lobes carry apical setae, and the size difference between the two lobes is negligibly small. Maxilla is apparently 1-segmented with ther terminal claw almost as long as the segment. The latter is very short and strong. Maxilliped is 5-segmented; second segment is the longest and is only a little less than the combined length of other segments; first and fourth segments have each a solitary seta in the distal angle, while the last segment has an apical seta and a claw. The latter is very fragile and just as long as the terminal segment.

Four pairs of swimming legs (Pl. XXI, 5) Pl. XXII, 4-6) are biramous, each ramus being composed of three segments. However, setae and spines on different segments are highly reduced. Most notable features are the complete abse nce of seta on second endopod segment of second, third and fourth legs, the presence of only one inner seta on first and second segments of first endopods and first segment of second and third endopods and the highly reduced nature of fourth endopods. The ornamentation of swimming legs is given below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	1	0	3	2	1	1	I	1	I	3	1	III
P_2	1	0	1	1	1	0	0	0	3	2	1	0	I	1	I	4	I	III
P_3	1	0	0	1	1	0	0	0	2	2	1	0	I	1	I	4	I	III
P_4	0	0	0	1	0	0	0	0	0	I	1	0	I	1	I	3	I	III

The proximal segment of fifth leg (Pl. XXII, 2) is fused with the body of the animal and is indicated by the presence of a seta. The distal segment is quite developed, rectangular in shape with three apical setae of unequal lengths. It reaches beyond one third of the genital segment. Size: female 0.62 mm.

<u>Male</u>: In appearance male (Pl. XXII, 7) is very similar to female. However, urosome (Pl. XXI, 6) is clearly 5-segmented, and the genital segment is very much broadened carrying at its postero-lateral angles the sixth pair of legs; each sixth leg consist of two unequal setae borne on a prominence. In length it is equivalent to the next two abdominal segments joined together. Caudal rami are very similar to those of female. The proportionate lengths of prosome and urosome are also identical to those of that sex. Antennule (Pl. XXII, 8) is 17-jointed and geniculate. The sixteenth segment bears an aesthetask

which is equal to the length of the last three antennular segments. The tenth segment, as it is in female, is with profuse number of setae. The relative lengths of antennular segments are given below:

1	2	3	4	5	6	7	8	9	10	11	12
7.0	4.5	4.5	3.0	4.0	3.5	4.5	5.0	4.5	2.0	4.5	10.0

13	14	15	16	17	
5.0	6.5	12.0	11.0	8.5	= 100

Other cephalosomal appendages and swimming legs are exactly similar to those of female. Fifth legs are, however, much smaller and narrower. Size: 0.57 mm.

Remarks - Sewell (1949) has discussed the arrangement of setae and spines of the x swimming legs and has given a series of ornamentation formulae for the different genera included in the family Asterocheridae. He observed that throughout the family there is a tendency towards the reduction of total number of setae and spines. In most of the genera the reduction of spines and setae has taken place in exopod and endopod segments of the fourth leg, while the third leg also has been affected in some cases like *Rhyncomyzon*, *Dermatomyzon* and *Collocheres*. There has been little reduction in the number of setae and spines on first and second pairs of legs except in *Asteropontius* where the situation is as follows:

P_1	1	0	2	0	3	2	1	1	I	1	I	3	I	III or II
P_2	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
						or								
					3	2	1							

The specimens under present study are unique in that the

the reduction of setae and spines has proceeded to an extreme case, effecting both exopods and endopods of all the pairs of legs to a greater degree than is found in other genera. Further, fourth endopod is much smaller and fragile as compared with the exopod of the same leg as well as with the rami of other legs. The present material cannot be accommodated into any of the existing genera, and is, therefore, considered here to represent a new genus.

Attention may be drawn here to some very interesting genera which were discovered sixty years ago by Thompson & Scott from Ceylon side of the Gulf of Mannar. Besides *Asteropontius* in which we have already seen a greater reduction in the number of setae and spines of swimming legs, they also described four other siphonostomatous genera viz., *Stephopontius*, *Doropontius*, *Cletopontius* and *Lepeopsyllus*. The systematic position of the first genus is discussed later (*vide infra*); the last genus has recently been placed under Entomolepidae by Josef Eiselt (1959). Of the remaining two genera, *Doropontius* has been correctly placed by Wilson (1932) under Asterocheridae. *Cletopontius* has been included under Dyspontiidae by Nicholls who has obviously followed Wilson (*op. cit.*) who assigned a similar position to this genus. Both these authors appear to have been misled by the nature of fourth swimming leg which completely lacks the endopod, thus displaying superficial resemblance to some dyspontiid genera. The real systematic position of this genus, however, has clearly been indicated by its authors who observed: "The characters of this genus do not agree in all respects with any of the known subfamilies of the Asterocheridae, and a new subfamily, may therefore, be required for its reception." (Thompson & Scott, 1903, p. 292) Thompson & Scott were apparently referring to the family as conceived by Giesbrecht with subfamilies Asterocherinae, Dyspontiinae and Cancerillinae contained therein. These subfamilies were later upgraded, and in some cases split up, into more than one family by G.O. Sars (1913-18). A study of various appendages of *Cletopontius*, however, shows that this genus cannot, with certainity, be accommodated into any of the families proposed and defined by Sars, nor to those that have since then been added. In the structure of antennule, antenna, mandible, maxillule, maxilla, maxilliped and first swimming legs, this copepod is typically asterocherid. Second swimming leg and siphon are not described by Thompson & Scott. The structure of third swimming legs comes nearer to that of *Indomyzon* with the following formula:

P_3 0 0 0 0 1 0 1 0 3 1 1 1 I 1 I 4 1 II

In fourth leg, as noted, the endopod is absent. The ornamentation of that leg is as follows:

P_4 0 0 0 0 ______absent______ 0 I 1 I 2 I I

The fifth legs are clearly 2-segmented, and the body is flat and ovoid with a very short urosome.

Cletopontius is discussed in detail because it is felt that the discovery of the new genus *Indomyzon* throws more light on the systematic position of the former genus. Both are asterocherids with a greater tendency to reduction of setae and spines of swimming legs. In Indomyzon the fourth leg is fragile with first two segment devoid of setae and spines and with only one seta and one spine on the terminal segment. In Cletopontius the endopod is entirely absent. First and second segments of fourth exopods are similar in both cases. Terminal segment of fourth exopod has two setae and two spines in Cletopontius, while there are three setae and four spines on that segment in Indomyzon. Finally in both genera the second segment of third endopod carries only one seta, a character never met with in any ~~of~~ other asterocherids. Following Thompson & Scott's suggestion a new sub-family is, therefore, proposed here to accommodate both Cletopontius and Indomyzon.

Family Asterocheridae Giesbrecht s. str.

Subfamily Asterocherinae nov.

All four pairs of legs are biramous, rami being 3-segmented. Second endopod segment is provided with two inner setae in all the four pair of legs.

Subfamily Cletopontiinae nov.

First three pairs of legs are biramous, rami being 3-segmente In fourth leg endopod is present or absent; when present setae and spines are reduced. Second endopod segment is with one or two setae in first and second legs and with one or no seta in third and fourth legs.

ACONTIOPHORIDAE

G.O. Sars, 1913-18, p. 109.

Genus *Acontiophorus* Brady, 1880

G.O. Sars, 1913-18, p. 110.
Nicholls, 1944, p. 20.

135. *A. scutatus* (Brady & Robertson), 1873.

Brady, 1880, p. 69.
G.O. Sars, 1913-18, p. 110.

Material examined - Five female and two male specimens of this species are obtined from night shore collections from among weeds in Palk Bay during August 1960.

Descriptive notes - Some notes are added here to the excellent description and figures given by Sars . Antennule (Pl. XXIII, 5) is 11-segmented, the fourth segment bearing a pretty long aesthetask. However, the relative lengths of constituting segments in the present material displays slight variations from those given by Sars:

	1	2	3	4	5	6	7	8	9	10	11	
Present specimen	20.0	17.3	3.8	3.8	3.9	11.2	6.6	5.2	5.8	5.2	17.2	= 100
Norwegian specimen	18.2	19.2	4.9	3.7	6.2	12.0	4.9	6.2	7.3	8.5	8.3	= 100

Antenna (Pl. XXIII, 6), mandible (Pl. XXIII, 7), maxillule (Pl. XXIII, 8), maxilla (Pl. XXIII, 9) and maxilliped (Pl. XX, 6) are sketched. In antenna, the exopod extends to ~~xx~~ a little beyond middle of the end segment of endopod. Siphon reaches almost to the tip of caudal rami. Swimming legs have the following ornamentation:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	2	0	3	2	1	1	I	1	I	3	2	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	III
P_3	1	0	0	1	1	0	2	0	3	I	1	1	I	1	I	4	I	III
P_4	1	0	0	1	1	0	2	0	2	I	1	1	I	1	I	3	I	III

Fifth leg is represented by a well developed subrectangular segment, bearing five setae, two on the inner, two on the outer and one on the apical margins. Basal segment which is fused with ~~a~~ corresponding body segment is represented by a single seta. Size: female 0.8 mm.

Male shows sexual dimorphism. Antennule (Pl. XXIII, 12) is geniculate and 10-segmented. Fifth legs are constructed on the same pattern as in female, but looks more robust. Urosome (Pl. XXIII, 11) is 5-segmented, the second segment carrying a pair of long setae on each of its postero-lateral angles. The urosomal segments gradually diminish in width to posterior side. This situation agrees well with the generic diagnosis given by G.O. Sars who stated: "Tail composed in female of three, in male of four segments, none of them produced at the posterior corners." However, the male described by Nicholls (1944) for A. zealandicus has its first urosomal segment swollen laterally in the fashion of many asterocherids.

Distribution - British Isles, Coast of France, Mediterranean, Norwegian coast and the Gulf of Mannar. This is the first time that this species is recorded from Indian waters.

Remarks - It is with some hesitation that the present example is referred to *A. scutatus* (Brady & Robertson). Three points of difference are noticed in the present example from the detailed account given by Sars for *A. scutatus*: (i) The last two segments of antennule have different relative lengths. (ii) Endopod of antenna exceeds the middle of distal segment of exopod in the present example, whereas in the Norwegian specimens it hardly reaches middle of distal exopod segments. (iii) Present example is smaller in size.

Five species are described in this genus. *A. ornatus* (Brady & Robertson) and *A. maldivensis* Sewell are easily separable because of the sixteen-segmented nature of antennule. *A. zealandicus* Nicholls is characterised by (a) a siphon which is one and a quarter times longer than the body; (b) caudal rami which are only twice longer than wide; and (c) exopod of antenna which reaches beyond the middle of terminal segment of endopod. In the last character the present material agrees with *A. zealandicus*, but differs considerably in the first two characters. *A. antennatus* Hansen differs from the present material in some ways: (i) siphon is much shorter; (ii) distal segment of antennal endopod is twice as long as proximal segment; and (iii) caudal ramus is four times longer than wide.

It is felt in the present circumstances that it is best to refer this example to *A. scutatus*.

A. antennatus deserves some comments. In the first instance there is ground to doubt whether the two specimens one of which was double the size of the other, obtained by Hansen, belonged to a single species. Besides the size, the two specimens also differed in the length of siphon and in the comparative dimensions of caudal rami. These characters are of specific importance and Hansen himself has stated that the length of siphon is one of the two criteria on which *A. antennatus* could be distinguished from *A. scutatus*. Nicholls (*loc. cit.*) has made use of the proportionate dimensions of caudal rami to distinguish his new species, *zealandicus* from Brady's *scutatus*. Hansen's statement that: " The strong difference in length and slenderness of the caudal rami between the two specimens is curious, but may be due to age" is vague and does not help to solve the problem. However, the fact that Hansen had at his disposal only two specimens behoves us to be cautious on passing judgements on the specificity or otherwise of these examples.

ENTOMOLEPIDAE

Brady, 1899, pp. 48-54.
Eiselt, 1959, pp. 656-59.

Genus *Paralepeopsyllus* Ummerkutty, 1960
Ummerkutty, 1960, pp. 105-06.

136. *P. mannarensis* Ummerkutty, 1960.
Ummerkutty, 1960, pp. 106-11, figs. 1-2.

Material examined - One male and two female specimens of this species are caught from sponge washings of the Gulf of Mannar in December 1960. Size: female 1.2 mm. and male 0.93 mm.

Distribution - The Gulf of Mannar.

Remarks - Josef Eiselt (1959) has revived the family Entomolepidae which was almost buried in literature and has added a new species to this group. He divided the family into two subfamilies, Entomolepinae to include *Lepeopsyllus* Thompson & Scott and *Entomolepis* Brady and Parmulodinae to include *Parmulodes* Wilson. The latter genus was incorrectly placed by its author under Clausidiidae.

Paralepeopsyllus belongs to the family Entomolepidae but it is difficult to assign to any of the subfamilies proposed by Eiselt (*loc. cit.*). The present genus almost cuts across the two subfamilies and in some points differs from both, for instance, in such features as the uniarticulate mandibular palp and the absence of fourth and fifth legs. It appears best that we would not divide the family at the present state of our knowledge and would wait until more related forms are known.

DYSPONTIIDAE

G.O. Sars, 1913-18, p. 117.
Nicholls, 1944, pp. 23-24.

Genus *Sewellopontius* n. gen.

Diagnosis - Body typically dyspontiid, depressed with well developed median dorsal crests on first three prosomal segments; latter with epimeral plates. Last prosomal segment highly reduced. Urosome 5-segmented in female and 6-segmented in male. Genital segment much wider than other urosomal segments in both sexes and provided with postero-lateral expansions, exceeding posterior margin of the segment. Antennule 9-segmented in female, 10-segmented and geniculate in male. Antenna 3-segmented with rudimentary exopods on first segment. Siphon quite well developed. Maxillule, maxilla and maxilliped of the dyspontiid type. First three pairs of legs biramous, fourth pair uniramous; rami of all four pairs of legs trimerous. Setation of first pair of legs highly reduced: in endopod three segments provided with 1, 1, 5 setae; in exopod proximal segment without any seta or spine, second segment with one inner seta and last segment with three setae and two spines. Fifth leg represented by a seta.

Type species: Sewellopontius rectiangulus n. sp.

Type Locality: Off Mandapam, The Gulf of Mannar.

137. Sewellopontius rectiangulus n. gen. et. n. sp.

Material examined - Fifteen male and twelve female specimens of this species are obtained from washings of dredged weeds of the Gulf of Mannar in September 1960. Holotype, allotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam.

Descriptive notes - This genus is named in honour of Dr. R.B.S. Sewell, F.R.S., of Cambridge University whose untiring scientific works have enormously enhanced our knowledge of the copepod fauna of Indian waters. The specific name is derived from the general shape of the body.

__Female__: Prosome and urosome are composed of four and five segments (Pl. XXIV, 1) respectively. First three prosomal segments are large, provided with ~~mxt~~ epimeral plates. Last segment is highly reduced and is only partially visible in dorsal view. In urosome (Pl. XXIV, 2) the fifth leg-bearing segment is very small, forming a narrow strip proximal to the genital segment. The latter is very large with lateral expansions, which grow postero-laterally exceeding the length of second urosomal segment. Lateral margins of the genital segments are characteristically broken into three divisions in both sexes. The relative lengths of prosome and urosome are 77 : 23 and the relative lengths of urosomal segments and caudal rami are:

10.5, 41.0, 13.0, 12.0, 14.5, 9.0 = 100.

Caudal ramus is wider than long, bearing five setae, two of which are jointed at base. The rostrum is conical, incurved, reaching the base of antennae.

Antennule (Pl. XXIV, 3) is 9-jointed with a faint marking of the tenth. The relative lengths of the constituting segments are given below:

1	2	3	4	5	6	7	8	9	
18.8	22.4	6.0	8.2	4.4	10.0	6.0	7.1	17.1	= 100

The terminal segment bears an aesthetask which is about half the length of antennule. The setae borne by various segments are very short. Antenna (Pl. XXIV, 4) is 3-segmented, first segment being the longest and last two segments being more or less of equal size. The end segment bears one small lateral and two larger unequal terminal setae. Siphon is fairly long, reaching almost to the point of origin of first pair of legs. Mandible is too slender to be distinguished from siphon. In maxillule (Pl. XXIV, 5) the outer lobe bears two subapical setae. Maxilla (Pl. XXIV, 6) forms a grasping organ, the terminal claw being larger than the whole basal part and being distinctly jointed at proximal end. Maxilliped (Pl. XXIV, 7) is apparently 4-segmented, the terminal segment bearing a serrated spine. A seta is present on inner distal margin of first segment, and a few hairs on its outer margin. Second maxilliped segment has a stout small spine on its two third length on the inner margin. The last segment carries a small accessory spine along with the serrated one.

The ornamentation of the swimming legs is given below: (see also Pl. XXV, 3-5)

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	1	0	3	2	0	0	0	1	0	2	1	II
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_4	0	0	0	0			Absent					1	I	1	I	5	I	III

The constituting segments of legs are rather slender and long, and spines of exopods are stoutly built. Fifth leg is represented by a seta borne on ventro-lateral corner of first urosomal segment. Size: female 1.22 mm.

Male (Pl. XXIV, 8) has a more compact appearance, the prosomal segments leaving little gap between them. In urosome there are six segments. First segment bearing the fifth legs is considerably smaller than other segments. The genital segment is very large with lateral expansions which are broken into three parts as they are in the female. Next four segments are more or less of equal dimensions and form a column.

Antennule (Pl. XXV, 2) is 10-segmented and geniculate. All the segments carry one or more aesthetasks. The aesthetasks on terminal segment is larger and thicker and corresponds to that of female. The relative lengths of the antennular segments are given below:

1	2	3	4	5	6	7	8	9	10	
19.6	19.0	5.7	5.1	5.7	3.8	6.3	14.5	6.3	14.0	= 100

All other appendages are similar to those of female.

Size: 0.83 mm.

Remarks - G.O. Sars (1913-18) listed the following seven genera as belonging to the family Dyspontiidae:

Dyspontius Thorell, 1859;
Cryptopontius Giesbrecht, 1889;
Arctopontius, G.O. Sars, 1915;
Bradypontius Giesbrecht, 1895;
Cribropontius Giesbrecht, 1899;
Pteropontius Giesbrecht, 1895; and
Sestropontius Giesbrecht, 1889.

Nicholls (1944) who briefly reviewed this family included in his key the following additional genera:

Discopontius Nicholls, 1944;
Urogonia Brady, 1910;
Metapontius Hansen, 1923;
Cletopontius Thompson & Scott, 1903; and
Lepeopsyllus Thompson & Scott, 1903.

It is obvious that the last two genera are not dyspontiids at all. *Lepeopsyllus* has been removed by Josef Eiselt (1959) to Entomolepidae and *Cletopontius* is shown to belong to Asterocheridae (*vide supra*). To the remaining ten genera, *Danodes* Wilson, 1942 may be added. This is a rather aberrant genus which lacks the typical dyspontiid appearance. However, an examination of cephalosomal and thoracic appendages of this genus shows real affinities with dyspontiids.

Sewellopontius n. gen. is related to *Dyspontius* and *Cryptopontius* on the one hand and *Pteropontius* on the other and is somewhat intermediate between these forms. All these four genera are characterised by the complete absence of endopod in fourth leg. *Pteropontius* is easily recognized by having both rami of first legs 2-segmented. The other three genera are distinguished from one another by the number of setae and spines on the terminal segment of first exopod. In *Dyspontius* the terminal segment of first exopod carries two spines and four setae; in *Cryptopontius* this segment carries three spines and four or five setae; and in the present case the reduction has gone much further, there being only two spines and three setae on terminal segment of first exopod.

Genus Cryptopontius Giesbrecht, 1899

G.O. Sars, 1913-18, p. 120.
Nicholls, 1944, pp. 24-25,

138. C. brevifurcatus Giesbrecht, 1899.

Giesbrecht, 1899, p. 109, pl. 1, fig.7, pl. 8, figs. 1-12.
G.O. Sars, 1913-18, pp. 120-22, pl. LXXI.
Nicholls, 1944, p. 24.
Krishnaswamy, 1954, p. 26.

Material examined - A single adult female of this species occurred in weed washings of Palk Bay in June 1960. Size: 0.78 mm.

Distribution - Bay of Naples, Norwegian coast, Gulf of Mexico, Madras coast and the Gulf of Mannar.

139. C. graciloides Ummerkutty, 1961.

Ummerkutty, 1961, pp. 11 – 13.

Material examined - Several male and female specimens of this species are obtained from weed washings of the Gulf of Mannar in November 1960.

Descriptive notes - A detailed description of female has been given in the reference quoted. Male is described here for the first time.

First prosomal segment (Pl. XXIII)1) is longer than wide and narrower than that of female. Second and third segments of prosome are short and curved backwards and downwards as they do in female. The last segment is extremely short. Urosome (Pl. XXIII, 2) is 6-segmented and similar to that of the males of related species except in relative lengths.

Antennule (Pl. XXIII, 3) is 10-segmented and geniculate. All the segments from first to sixth bear very slender aesthetasks. That on the terminal segment is quite thick but less long than the slender aesthetasks of other segments. The relative lengths of antennular segments are given below:

1	2	3	4	5	6	7	8	9	10	
18.8	8.1	10.8	6.1	5.5	6.8	6.1	12.9	7.4	17.5	= 100

Other appendages are similar to those of female. The spine representing fifth leg is relatively smaller. Size: 1.13 mm.

Distribution - The Gulf of Mannar.

140. C. orientalis Ummerkutty, 1961.
Ummerkutty, 1961, pp. 13–18.

Material examined - Few female and male specimens are caught near the Pamban Bridge in the Gulf of Mannar in December 1960. Size: female 1.05 mm. and male 1.0 mm.

Distribution - The Gulf of Mannar.

STELLICOMITIDAE
Humes & Cressey, 1958, p. 395.

Genus Stellicomes Humes & Cressey, 1958
Humes & Cressey, 1958, p. 395.

141. S. tumidulus Humes & Cressey, 1958.
Humes & Cressey, 1958, pp. 395-97, figs. 1-17.

Material examined - About 100 individuals of both sexes are obtained in June 1960 from washings of the common asteroid, Pentaceros hedemanni (Lutken). Size: female 0.35 - 0.39 mm. and male 0.30 - 0.32 mm.

Distribution - Madagascar and the Gulf of Mannar. This is the first record of the species outside its type locality.

142. S. *guineensis* Humes & Cressey, 1958.
Humes & Cressey, 1958, p. 397, figs. 18-31.

Material examined - About eighty specimens of both sexes are captured along with the preceding species from washings of *Pentaceros hedemanni* (Lutken) during June 1960 from the Gulf of Mannar. Size: female 0.36 - 0.40 mm. and male 0.31 - 0.33 mm.

Distribution - Cape Sierra Leone, West Africa and the Gulf of Mannar. This is the first record of this copepod outside its type locality. The occurrence of this South Atlantic species in Indian waters is quite interesting. Probably it is suggestive of its wide distribution.

NANASPIDAE

Humes & Cressey, 1959, p. 209.

Genus *Stephopontius* Thompson & Scott, 1903

Thompson & Scott, 1903, p. 293.
Humes & Cressey, 1959, p. 212.

143. S. *typicus* Thompson & Scott, 1903.
Thompson & Scott, 1903, p. 293, pl. XX, figs. 19-31.

Material examined - Eight females and seventeen males (three of them in paired condition) are obtained from washings of *Holothuria atra* from the Gulf of Mannar in December 1960.

Descriptive notes - Thompson & Scott (*loc. cit.*) reported the sizes of the two sexes as 6.7 and 8.0 mm. respectively. This is, as Humes & Cressey have pointed out, obviously a topographical error. In their figures of adult female and male Thompson & Scott have given a magnification scale. According to this scale, male is smaller than female, their respective sizes being 0.5 mm. and 0.65 mm. This is the same size range as that of the present example.

__Female__ - Prosome (Pl. VII, 6) is 3-segmented. First segment is the cephalothorax, having been formed by fusion of cephalosome and first pedigerous segment. Second segment is the result of fusion of second and third pedigerous segments and bear those legs. Last segments carries fourth pair of legs. An elongated, rather spindle-shaped process is borne on each of the postero-lateral corners of the last ~~last~~ prosomal segment. At about the junction of this segment with urosome (Pl. VII, 7) a pair of foliaceous structures is borne, one on either side. They can be compared to the somewhat similar structures found in __Micropontius__ __ovoides__ Gooding.

There is a pair of egg sacs, each egg sac is cylindrical, a little incurved containing 5-7 eggs,~~and~~ arranged one above the other. The cephalosomal appendages (Pl. VII, 10) and first, second and fourth pairs of legs correspond to the excellent figures given by Thompson & Scott. Third leg (Pl. VII, 11) is uniramous and similar to fourth leg. But it differs from the latter in possessing three spines and four setae on the second exopod segment. Fifth leg is foliaceous and uniarticulate without any accessary process. Urosome is a rectangular mass, with a slight indication of division into two segments. Fifth legs are borne on the antero-lateral corners of the proximal segment. Caudal rami are a ~~pair~~ small sub-spherical structures borne on the posterior side of urosome, one on either side. Each ramus carries four setae which are flattened and non-jointed. These structural details are not seen in dorsal view as they are covered by a transparent flap.

Male: Male (Pl. VII, 6) differs from female in the smaller size, in the geniculation of antennule and in the presence of sixth pair of legs and in the structure of urosome.

Antennule (Pl. VII, 9) is a highly modified structure, apparently 2-segmented, but possibly containing more segments. The first segment is simple, carrying three setae on anterior margin; the second segment is covered by a transparent flap on dorsal side. In ventral view it is seen to terminate in three lobes, all carrying a number of terminal setae. Both segments are highly calcified. Urosome (Pl. VII, 8) is 3-segmented, the division between first and second segments being indistinct on ventral side. The sixth leg consists of a small rounded lobe, bearing three setae. It is borne on the postero-lateral corners of ~~the~~ second urosomal segment. Size female 0.66 mm. and male 0.55 mm.

Distribution - Thompson & Scott (loc. cit.) reported this species from the Ceylon Pearl Banks and the present record is the first rediscovery of this species.

Remarks - Stephopontius Thompson & Scott is related to Nanaspis Humes & Cressey and could fit into the definition of the family Nanaspidae as given by the latter authors. However, substantial differences exist between these two genera and it would appear that they could be kept in two separate subfamilies. The differences between the two forms are listed below:

Nanaspis Humes & Cressey	*Stephopontius* Thompson & Scott
Prosome is 2-segmented. First segment is the cephalosome and second segment is the result of fusion of all the four pedigerous segments.	Prosome is 3-segmented. First segment is the cephalothorax formed by the fusion of cephalosome and first pedigerous segment. Second segment is the result of fusion of next two pedigerous segments. Last segment is the actual last pedigerous segment.
Last segment of prosome does not carry any accessory appendage.	Last segment of prosome carries two pairs of expanded structures, one pair on each side in female; in male no such appendage is seen.
Urosome ~~xx~~ in both sexes consists of a legless first segment, genital segment and an abdominal segment. Genital segment bears a pair of sixth legs.	Urosome is incompletely 2-segmented in female and incompletely 3-segmented in male. First segment carries foliaceous fifth legs. The genital segment carries sixth pair of legs in male.
Geniculate male antennule is 6-jointed.	The geniculate male antennule is 2-jointed.
Exopods of second and third legs are each 3-jointed.	Exopods of second and third legs are each 2-jointed.

Humes & Cressey (*loc. cit.*) have sufficiently established the closeness of these two genera and the present redescription would throw more light to this aspect. The morphological similarities, as well as the same host-parasite relationships (both are reported from holothurians) are suggestive of a real evolutionary kinship between these forms.

Humes & Cressey (*loc. cit.*) have discussed the interrelations between Nanaspidae, Stellicomitidae, Micropontiidae, and Cancerillidae. The discovery in recent years of these several new families of copepods, living in association with Echinoderms have brought to light a highly specialised group of siphonostomatous cyclopoids. It is difficult to clearly assess the systematic position of these copepods in relation to other siphonostomes. It has already been indicated that a division of siphonostomes into two tribes, based upon the well developed or poorly developed nature of the oral siphon as well as on the non-prehensile or prehensile nature of antenna may be required (*vide supra*).

Section POECILOSTOMA

CLAUSIDIIDAE

G.O. Sars, 1913-18, p. 144.
Nicholls, 1944, pp. 45-46.

Genus *Hemicyclops* Boeck, 1873

G.O. Sars, 1913-18, p. 145.
Light & Hartman, 1937, pp. 173-84.
Gooding, 1960, pp. 159-95.

144. *H. australis* Nicholls, 1944.

Nicholls, 1944, pp. 48-49, figs. 20-21.

Material examined - Two female specimens of this copepod are obtained from washings of dredged weeds from the Gulf of Mannar in August 1960.

Descriptive notes - The present material (Pl. II, 18) corresponds in all details with the excellent figures and descriptions offered by Nicholls. The ornamentation of swimming is presented below as the formula given by Nichools does not distinguish between spines and setae.

	Protopod				Endopod							Exopod							
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	3	II	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	2	0	I	II	II	0	I	1	I	5	I	II

"The setae and spines are arranged in a more or less continuous series around the margins of the distal segments of these legs so that it is difficult to decide how many are terminal and where the inner and outer begin or end". (Nicholls, 1944) In the case of terminal segment of endopod and exopod of first leg, ~~[illegible]~~ Nicholls has given the ~~gt~~ figures as 5, 1 and 6, 2 respectively, whereas in the present case it is seen to be 3, III and 4, IV respectively. This does not appear to be a very serious difference as Nicholls himself has stated: "On the end segment of the third exopod the figures given are five, four but on the other leg of that pair there are five setae but only three spines". It appears that the conversion of setae of swimming legs into spines is not so much uncommon within the same species of this genus. Size: female 1.34 mm.

<u>Distribution</u> - South Australia and the Gulf of Mannar. This is the first record of this species outside its type locality.

145. H. *indicus* Sewell, 1949.

Sewell, 1949, pp. 69-72, fig. 16.

Material examined - Two female specimens of this copepod obtained from washings of dredged weeds in November 1960 from the Gulf of Mannar.

Descriptive notes - This species (Pl. II, 16) is easily distinguished from the following and preceding species by the fact that while the genital segment in those two species are long and divisible into wider proximal and narrower distal areas in H. *indicus* the genital segment is very short with no clear demarcation between proximal and distal halves. Further, the present specimen is much smaller with a more compact body. Sewell has given detailed account of both male and female. The ornamentation of swimming legs is added here in tabular form:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	4	I	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	2	0	1	I	III	0	I	1	I	5	I	II

Size: female 1.05 mm.

Distribution - Nicobar Islands and the Gulf of Mannar. This is the first time that this species is recorded outside its type locality.

146. H. *intermedius* Ummerkutty, 1961.

Ummerkutty, 1961, pp. 18-25.

Material examined - Besides the type specimens no further examples are available. Size; 1.9 mm. (female).

Distribution - The Gulf of Mannar.

Genus Hippomolgus G.O. Sars, 1917

G.O. Sars, 1913-18, pp. 147-48.

147. H. dubia Thompson & Scott, 1903.

Thompson & Scott, 1903, p. 284, pl. III, figs. 18-27.
Krishnaswamy, 1953b, p. 66, fig. 7.

Material examined - A few fifth copepodite stages are caught from plankton in December 1960. Size: 1.63 mm.

Distribution - Suez Canal, Madras coast, and the Gulf of Mannar.

Genus Hersiliodes Canu, 1888

Bocquet & Stock, 1957a, pp. 215-18.

148. (?) H. lactericia Canu, 1888

Bocquet & Stock, 1957a, pp. 215-18.

Material examined - A single female specimen is gathered from washings of mud-covered coral stones where polychaetes are also found to inhabit. It is captured from Palk Bay in July 1960.

Descriptive notes - The general shape of body (Pl. XXVI, 1) is that of harpacticoid with little demarcation between prosome and urosome. The former is apparently 4-segmented with a small rounded rostrum anteriorly. Urosome is cylindrical, 5-segmented and longer than prosome, relative lengths of the two areas being 40 : 60 . First urosomal (fifth leg-bearing) segment is as wide as third prosomal segment and is the widest of all urosomal segments. Last abdominal segment (Pl. XXVI, 2) is longer than caudal ramus in the proportion of 52 : 48 . Each ramus carries one seta on the ventral face near proximal area and five setae on apex, two of which are jointed at base. The longest caudal seta is only one and a half times longer than caudal ramus.

Antennule (Pl. XXV, 6) is 6-jointed with the following relatige lengths:

1	2	3	4	5	6	
20.5	24.6	22.0	9.6	11.0	12.3	= 100

None of the antennular segments bears any aesthetask. Antenna (Pl. XXVI, 7) is 4-segmented. First segment is a little more than half the length of next three segments combined and bears a seta. Second segment also bears a seta and is smaller than first segment. Third segment carries four appendages, one of which is a claw and other setae. Terminal segment carries seven appendages, four of which are quite stout and spine-like. Mandible (Pl. XXV, 8) is stout with a terminal claw. Just proximal to this claw, there is a long serrated appendage and two equally long setae. The inner rounded margin of mandibular base carries a number of setae. Maxillule (Pl. XXV, 9) is bilobed, the inner lobe carrying three setae and the outer five setae. Maxilla (Pl. XXV, 10) is 2-segmented. First segment bears two plumose setae on inner distal margin. Second segment terminates in a spine which is serrate on inner side. A small rod-like process with spines on either side, is borne on the inner margin of this distal segment at about its midlength. Maxilliped (Pl. XXV, 11) is trimerous and stoutly built. First segment carries two plumose setae on inner distal margin; second segment carries a single plumose seta in a similar position and third segment bears a stout claw, equal in length with two distal segments of maxilliped and four spines, two distal and two proximal to the base of large claw.

First four pairs of swimming legs (Pl. XXVI, 4-7) are biramous, the rami being 3-segmented. The ornamentation of swimming legs is given below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	3	1	II	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	1	0	2	II	II	0	I	1	I	5	I	II

Fifth leg (Pl. XXVII, 1) is 2-segmented; first segment is very short, and bears a very short seta; distal segment bears one subapical seta and three spines, one of them being apical and other two marginal, arranged on the distal one third of outer margin. Size: female 1.65 mm.

Distribution - Coast of France (?) and the Gulf of Mannar.

Remarks - I am not quite certain whether the species described above could be referred to *H. lactericia* Canu. Bocquet & Stock (1957) in their redescription of a related species, _H_. _cylindracea_ (Pelseneer) indicated the synonymy of _C_. _lactericia_ and _C_. _pelseneeri_ Canu. There is a reference to another species _H_. _puffini_ Canu in Sewell (1949). However, as descriptions of these species are not available to me, it is not possible to state to which of these species the present material belongs. It is provisionally referred to _H_. _lactericia_, because like the latter it is found to live in association with polychaetes.

LICHOMOLGIDAE

G.O. Sars, 1913-18, pp. 149-50.

Subfamily Sabelliphilinae

Gurney, 1927, p. 463.
Sewell, 1949, pp. 72-75.

Genus _Anthessius_ Della Valle

G.O. Sars, 1913-18, p. 181.
Sewell, 1949, p. 76.
Stock, 1959, p. 50.

149. _A_. _pinnae_ Humes, 1958.

Humes, 1958, pp. 279-90, figs. 1-35.

Material examined - Several specimens belonging to both sexes are captured from washings of _Pinna_ sp. from the Gulf of Mannar in December 1960. The washing is done in dilute magnisium sulphate solution for several hours.

Descriptive notes - Prosome is moderately broad and urosome narrow with caudal rami which are about four times longer than wide. The last segment of antenna is distinctly longer than the penultimate segment. There are three spines and four setae on terminal segment of fourth exopod. Fifth leg is quite broad, the length-width ratio being 1.7 : 1.0 .

The ornamentation of swimming legs is presented below as Humes (*loc. cit.*) in his table did not distinguish between spines and setae:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	3	I	II	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	2	0	1	II	II	0	I	1	I	5	I	II

Size: female 1.43 mm. and male 1.1 mm.

__Distribution__ - Madagascar and the Gulf of Mannar. This is the first record of this species outside its type locality.

Genus __Preherrmannella__ Sewell, 1949

Sewell, 1949, p. 82.
Humes & Cressey, 1959 , p. 25.

150. __P. brevicauda Sewell__, 1949.
Sewell, 1949, pp. 82-85, fig. 19.

__Material examined__ - Six female specimens of this copepod are obtained from weed washings of the Gulf of Mannar in September 1960.

__Descriptive notes__ - The species is easily identified by the very short caudal rami, the peculiar ornamentation of swimming leg, the non-prehensility of antenna and the angular nature of posterior margins of body segments. The ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2+I	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	1	0	II	I	II	0	I	1	I	5	I	II

In fifth leg the proximal segment is produced into a downward projection which looks like a beak. Size: 0.91 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar. This is the first report of this species outside its type locality.

151. *P. serendibica* (Thompson & Scott), 1903.
Thompson & Scott, 1903, pp. 282-83, pl. XVII. fig. 11

Material examined - Two female specimens of this copepod occurred in washings of weeds collected from the Gulf of Mannar in September 1960.

Descriptive notes - Only antennule, antenna and the dorsal habitat of this species have been sketched by Thompson & Scott and they correspond in all details with those of the present material. Mandible, maxillule, maxilla and maxilliped are highly reduced and correspond very much with those of the preceding species. It may be noted that unlike in that species antenna is prehensile and that the prehensility is attained by the development of a strong spine on the penultimate segment of that appendage. The ornamentation of swimming legs is as follows:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2+I	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	1	0	II	I	II	0	I	1	I	5	I	II

Fifth leg is rectangular with two setae at apex. Size: 1.20 mm.

Distribution - The Gulf of Mannar. This is the first rediscovery of this species.

Genus Sabelliphilus M. Sars, 1862

G.O. Sars, 1913-18, pp.

152. S. foliacea n. sp.

Material examined - Six female and thirteen male specimens of this copepod are obtained from the body cavity of Holothuria atra from the Gulf of Mannar in November 1960.

Descriptive notes - This species derives its name from the peculiar, flattened, leaf-like structures that are present on the distal outer angle of the basal protopod segment. Both both in second and third legs.

Female: The body (Pl. XXVII, 3) is elongate and narrow with the demarcation between prosome and urosome rather inconspicuous. Cephalosome is fused with first pedigerous segment, but trace of division is still visible. Urosome is composed of five segments, the genital segment being equivalent in length to the three abdominal segments joined together. Caudal ramus is a little longer than last abdominal segment and bears four setae terminally and a single seta on its outer margin at about midlength. The longest apical seta, second from inner side, is characteristically incurved in its distal half. Female bears a pair of egg sacs which reaches the middle of caudal rami and are gracefully cylindrical.

Antennule (Pl. XXVII, 7) is 7-segmented and short, hardly reaching the posterior margin of cephalosome. The constituting antennular segments have the following relative lengths:

1	2	3	4	5	6	7	
12.3	18.8	11.5	16.0	23.7	17.4	10.3	=100

A notable feature above antennule is the presence of a digitiform spine on the antero-distal corner of second segment. Antenna (Pl. XXVII, 4) is 4-segmented and prehensile. It is a little shorter than antennule, but is much more stoutly built. The first and second segment each bears a seta. The third segment bears a ~~xkx~~ strong claw and three spines. The last segment carries eight setae of varying lengths. Other mouthparts (Pl. XXVIII, 1-3) are typically lichomolgid, being highly reduced.

All four pairs of swimming legs (Pl. XXVII, 5); Pl. XXVIII, 4-6) are biramous, the ramus being 3-segmented. The rami are all of equal length and the constituting segments are rather stout. Second and third legs differ conspicuously from first and fourth in that in the former two the distal outer angle of basal protopod segment is drawn out, on its posterior face, into large foliaceous structure. This structure in second leg is almost as large as the ramus, but in third leg it is a little shorter. In first three pairs of legs the seta on inner distal angle of basal protopod segment is highly flattened. In fourth leg it is normal. The ornamentation of the swimming leg is shown below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	*F	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	*F	0	1	1	0	2	0	2	I	I	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	1	0	1	I	I	0	I	1	I	5	I	II

In fifth leg (Pl. XXVII, 6) the basal segment is fused with the body and is indicated by a seta. The distal segment is stout, cylindrical, almost twice as long as wide and bearing two setae of unequal lengths terminally. Size: 0.79 mm.

<u>Male</u>: Male (Pl. XXVII, 2) shows sexual dimorphism. Urosome is 6-segmented and consists of the fifth leg-bearing segment, the genital segment which bears the rudimentary sixth pair of legs and four abdominal segments. Caudal rami and setae are identical to those of female.

Maxilliped (Pl. XXVIII, 11) is geniculate and large with a well developed terminal claw while other mouthparts and antennule and antenna are quite normal. First four pairs of legs (Pl. XXVIII, 7-10) exhibit very interesting modifiations. The second and third segments of endopods of all gs are indistinctly separated. The constrictions them, however, are clear enough and the sum of setae nes borne by these segments is similar to that of female. nenon is observed in all five male specimens, which are for examination.

Size: Male 0.75 mm.

Remarks - The species described above differs from all the known representatives of the subfamily Sabelliphilinae in the following characters: (i) The ornamentation of swimming legs is unique and is as given in text. (ii) Foliaceous outgrowths are developed on proximal protopod segments of second and third legs. (iii) Differences are noted between the two sexes in the segmentation of endopod and exopod of swimming legs.

It is difficult in view of these unique characters to assign the present species to any particular genus. However, there are two known genera *Sabelliphilus* M. Sras and *Diogenidium* C.L. Edwards which should be considered for accommodating it. The present material agrees with *Sabelliphilus* in several morphological characters, including the general shape of body and the presence of a claw on third antennal segment, but it differs from it not only in the characters listed above but also in the structure of antenna. The latter is prehensile in both cases. In *Sabelliphilus* the prehensility is attained by the development of strong teeth on second segment and stout claws on third and fourth segments. In the present material, however, antenna is simpler; there is a single claw on third segment and several spine-like setae on fourth segment; there is no teeth on second segment. The genus *Diogenidium* also differs from *Sabelliphilus* in the structure of antenna. In the former genus no teeth is present on second segment and the prehensility is attained by the subchelate curved claw and short spine on fourth segment. In these two points it also differs from the present species, but it agrees with the latter in the habitat, both being found in association with a holothurian.

It is probable that all these three forms represent only a single flexible genus whose members live not only in association with sabellids but also with a variety of other hosts. A strong support to this proposition is the fact that in recent years several lichomolgid species have been reported with a wide range of host preference. The life in association with tube-dwelling polychaetes is not probably very different from the life inside the body cavity of a holothurian. Nicholls (1944) has indicated that the number of setae and spines on swimming legs cannot be solely relied upon, for generic distinction among the poecilostomes and Sewell (1949) has included under his new genus Preherrmannella several forms, some of them with a prehensile antenna and others without such antenna. It is, therefore, obvious that the structure of antenna alone cannot be taken as the criterion of generic separation. The foliceous outgrowths of swimming legs of the present material and the teeth on second antennal segment of Sabelliphilus appear to be only of specific importance. The aberrant nature of Sabelliphilus has already been recognized by G.O. Sars (1913-18). When dealing with such aberrant representatives, care should be taken not to lay too much stress on such characters. It would seem probable that the genus Diogenidium is synonymous with Sabelliphilus. The former lives in association with holothurians, and the latter with Sabellids. Although the present species differs from both these genera in some structural details, it has been placed under *Sabelliphilus* in the belief that all these forms constitute a single closely related group which, however, has diverged in some structural peculiarities, in order to meet the demands of their habits.

Subfamily Lichomolginae

Gurney, 1927, p. 463.
Sewell, 1949, pp. 91-96.

Genus *Pseudanthessius* Claus, 1889

G.O. Sars, 1917, p. 166.
Nicholls, 1944, pp. 54-55.
Illg, 1950, pp. 129-30.

153. *P. sauvagei* Canu, 1891

Canu, 1891, p. 243, pl. XXV.
G.O. Sars, 1913-18, pp. 171-72, pl. XCVI.

Material examined - A single female specimen of this copepod is gathered from echinoid washings of the Gulf of Mannar in September 1960.

Descriptive notes - G.O. Sars (*loc. cit.*) rendered excellent description and figures and the present examples correspond very closely with them. A few points of difference may be reported. Proximal part of the genital segment is slightly broader than what is found in the Norwegian example. Further, the spines shown on proximal and ventral sides of that segment by Sars are very inconspicuous. The relative lengths of urosomal segments are similar. In Antennule slight variations in the relative lengths are noticed.

However, the number and nature of setae borne by different segments are similar.

	1	2	3	4	5	6	7	
Norwegian example	15.3	23.0	9.2	12.3	18.5	14.0	7.7	= 100
Present example	11.2	22.8	9.7	17.0	18.3	12.5	8.5	= 100

Antenna, mandible, maxillule and maxilla are built in the same pattern as in other representives of the genus. Maxilliped terminates in a claw which is accompanied by a stout seta. A little proximal to this terminal claw, on anterior face, is another stout claw, accompanied in its turn by a small seta. The specimens from Norwegian coast differ in this latter character: instead of a strong claw the anterior face carries a very long seta.

The ornamentation of swimming legs is fully identical in the two examples and is given below:

	Protopod 1		Protopod 2		Endopod 1		Endopod 2		Endopod 3			Exopod 1		Exopod 2		Exopod 3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	1	0	0	1			II					0	I	1	I	5	I	III

Endopod of fourth leg in the present example is a little shorter than the combined length of two proximal protopod segments, whereas in the Norwegian example it is shown to be a little longer. Fifth leg in both cases consists of a strong backwardly directed spine and two small setae.

Size: female 1.1 mm.

Distribution - Coast of France, Norwegian coast and the Gulf of Mannar. This is the first report of this Atlantic species from Indian waters.

Remarks: - The availability of only a single specimen makes me hesitant to refer the present material to P. sauvagei and the minor differences noticed in the structure of maxilliped and genital segment add to this difficulty. But a careful study of all known species shows that the present form comes nearest to that species. The differences mentioned do not allow sufficient ground to separate them and the occurrence of the present material in association with an echinoid supports this conclusion.

154. P. liber (Brady & Robertson), 1875.
Brady, 1880, p. 44, pl. LXXXVI, figs. 1-13.
Thompson & Scott, 1903, p. 277.
G.O. Sars, 1913-18, p. 169, pl. XCIV.
Sewell, 1949, p. 121.

Material examined - Several specimens of both sexes of this copepod are gathered during January-February 1961 from washings of echinoids from the Gulf of Mannar. Size: female 1.2 mm. and male 0.85 mm.

Distribution - British Isles, Norwegian Coast, Nicobar Islands and the Gulf of Mannar.

155. P. luculentus Humes & Cressey, 1959.
Humes & Cressey, 1959, pp. 75-81, figs. 31-56.
Ummerkutty, 1961, pp. 25-29.

Material examined - Numerous specimens of both sexes of this species are obtained from echinoid washings of the Gulf of Mannar during October-December 1960. Size: female 1.2 mm. and male 0.87 mm.

__Distribution__ - Madagascar and the Gulf of Mannar.

__Remarks__ - This species was described by me (Ummerkutty, 1961) under the name __*Pseudanthessius agilis*__ n. sp. Subsequently I have come across a paper by Humes & Cressey (1959) who had described it under the name __*Pseudanthessius luculentus*__ Humes & Cressey. I have no doubt about their synonymy, but by the time I received the above cited account by Humes & Cressey, my paper had already gone to the press. According to the rule of priority this species should now be known as __*Pseudanthessius luculentus*__ Humes & Cressey.

156. __*P. anormalus*__ n. sp.

__Material examined__ - Twentyfive female specimens of this copepod are gathered from the starfish washings of the Gulf of Mannar in August 1960. Holotype, ~~allotype~~ and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

__Descriptive notes__ - The specific name of this form is derived from the nature of the structure of the fifth pair of legs, caudal rami and genital segment. These structures are found to show great deviations from what is generally observed for other species of this genus. Excepting for the presence of a rudimentary spine, the fifth leg of this species is very similar to that of __*Nasomolgus cristatus*__ Sewell.

__Female:__ Prosome (Pl. XXIX, 1) is broadly oval, cephalosome contributing more than half the size. Posterior margin of cephalosome is the widest part of body, next three free metasomal segments diminishing both in length and width to posterior side. Urosome (Pl. XXIX, 9) is 5-segmented, first segment bearing the fifth pair of legs. Genital segment is very broad and is longer than the entire length of three abdominal segments joined together. The narrower posterior division of genital segment is very short compared to the broad anterior part. Caudal rami are peculiar. They are hardly as long as broad and are distinctly shorter than the last abdominal segment. Caudal setae are fairly long, the middle two setae being jointed at base.

Antennule (Pl. XXIX, 2) is 7-segmented, segments bearing the following relative lengths:

1	2	3	4	5	6	7
16.5	30.7	8.0	17.0	14.2	6.8	6.8 = 100

Antenna (Pl. XXIX, 3) is 4-segmented, terminal segment bearing two spines and a few setae. First and second segments are each with a single small seta and the third with two setae and several hairs. Mandible and maxillule show little peculiarities. In maxilla (Pl. XXIX, 4) both the terminal lappet and the process just proximal to it carry spinules on their anterior margins. Maxilliped (Pl. XXIX, 5) is apparently 2-segmented. The first segment is naked, the second carries one seta at its mid-posterior margin and two stout spines on its innermost part (actual apex of the appendage).

Swimming legs are on the whole normal. The 1-segmented endopod of fourth leg (Pl. XXIX, 8) is slightly swollen in the proximal region, but no knob or notch are present. The second endopod segment of first, second and third legs (Pl. XXIX, 6-7; Pl. XXXI, 1) is produced at its outer angle into a beak-like structure. The following is the ornamentation of swimming legs:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	0	0	0	1				II				0	I	1	I	5	I	II

Fif legs are rather modified; the spine is highly reduced and is seen only if observed ventrally; on the upper and lower sides of this reduced spine are borne two setae, the much longer lower one being jointed at base. Size: 0.75 mm.

__Male__: Unknown.

__Remarks__ - The most salient features of __P__. __anormalus__ n. sp. are given below: (i) Genital segment is slightly broader than long, the narrow posterior division being very short compared to the anterior broad division. (ii) caudal ramus is slightly broader than long and is distinctly shorter than last urosomal segments. (iii) endopod of fourth leg is slightly swollen in the proximal half but does not display any notch or knob. (iv) Fifth leg consists of a very highly reduced spine seen only from the ventral side and two unequal setae, one of which is jointed at base.

157. P. brevicauda n. sp.

Material examined - Four female specimens of this copepod are obtained from echinoid washings of the Gulf of Mannar in October 1960. Holotype and paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

Descriptive notes - The specific name of this species has reference to the very short nature of caudal rami.

Female: Prosome (Pl. XXX, 2) is large and ovoid and very distinctly separated from urosome. First pedigerous segment is fused with cephalosome and the combined cephalothorax is broader than long; it is the widest part of the prosome. The next two segments diminish gradually both in length and width. The postero-lateral edges of both these segments are prolonged backwards. Last prosomal segment is very small and partly overlapped by the preceding segment. First urosomal segment (Pl. XXX, 3) is normal. The genital segment is swollen in anterior half but the demarcation between the two parts is not very pronounced. Guarding the genital apertures there is a pair of sharp spines. The next three urosomal segments are small and their combined length is just half that of the genital segment. Caudal ramus is short, its length and width being subequal.

Antennule is 7-jointed and similar to that of the preceding species. Antenna (Pl. XXXI, 1), mandible, maxillule (Pl. XXX, 4) maxilla (Pl. XXX, 5) and maxilliped (Pl. XXX, 6) are as figured. They do not shew many peculiarities except that they are stoutly built. In antenna the third segment is exceedingly shart. Mandible has a chitinous rod-like process extending postero-laterally; the distal end of the process shows fine denticulation. The terminal spines of maxillule are strong and broad based. In maxilla teeth on the apical lash are very strong, somewhat like in those species that belong to the genus <u>Macrochiron</u>.

Ornamentation of swimming legs is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1				II				0	I	1	I	5	I	II

The fourth endopod (Pl. XXX, 7) is half the length of exopod. Its inner margin is broken twice, one at two third and other at one third lengths, both accompanied by notches. The first two third lengths of inner margin is lined with fine setae. Fifth leg consists of a graceful spindle-shaped spine with serration all along the two margins and two short setae. One of the setae is close to the base of spine while the other is a little above. Size: 1.13 mm.

<u>Male</u>: Unknown.

<u>Remarks</u> - <u>P</u>. <u>brevicauda</u> n. sp. is diagnosed as follows: (i) First prosomal segment is very large and broader than long. (ii) Second and third segments gradually diminish both in length and width and produced backwards

at their postero-lateral corners. (iii) Last prosomal segment is short and overlapped partly by the preceding segment. (iv) Caudal ramus is very short, length and width being subequal. (v) Cephalosomal appendages are stoutly built, especially maxillule and maxilla. (vi) The endopod of fourth leg is half as long as exopod. Its inner margin is broken by notches, one at one third and the other at two third lengths. (vii) Fifth leg consists of a spindle-shaped spine and two setae. (viii) The proximal half of genital segment is broad and its width only a little less than the length of the segment.

Genus _Kalleria_ Gurney, 1927

Gurney, 1927, p. 470.

158. _K_. _regalis_ Gurney, 1927.

Gurney, 1927, p.

Material examined - A single female specimen occurred in weed washings of the Gulf of Mannar in November 1960. Size: 1.1 mm.

Distribution - Suez Canal and the Gulf of Mannar. This appears to be the first report of the species outside its type locality.

Genus _Macrochiron_ Brady, 1872

G.O. Sars, 1913-18, p. 163.

Subgenus _Paramacrochiron_ Sewell, 1949

Sewell, 1949, p. 108.

Monod & Dollfus (1932) do not recognise the generic validity of the genus _Macrochiron_ Brady. According to them it is a subgenus of Lichomolgus Thorell while Stellicola Kossman is considered as another subgenus of the same genus.

Sewell (1949) not only recognised Macrochiron as a valid genus but divided the latter into two sub-genera: Macrochiron s. str. characterised by 1-segmented nature of the fourth endopod and Paramacrochiron characterised by 2-segmented nature of the fourth endopod. According to him Macrochiron is distinguished from Lichomolgus chiefly by a long fifth leg and by a maxilla whose basal part is conspicuously dilated. Although Sewell's classification has been followed here, it does not appear that Sewell's system represents the final answer to the proper assignment of the vast complex of lichomolgid group of cyclopoids.

Stock (1957) expressed the opinion that the name Macrochiron should be used at generic level for the conception of a limited number of species, all agreeing in the possession of a complexly built 3-segmented antenna. The species that do not possess this feature were transferred by him to Lichomolgus or other related genera. He, however, recognized that those species that are removed to Lichomolgus could well be grouped into a subgenus for they all are characterised by the following features: (i) Mandible has the lappet conspicuously dilated at base, while its armature consists not only of cilii but also crest-like ridges, denticulations etc. (ii) Maxillipeds of female are well developed, 3-segmented with at least one longer and one shorter seta on the second segment and a cheliform structure on the third segment. (iii) The third segment of fourth leg usually has three outer spines, though some species have only two.

It would appear that until more forms are described and the already known forms are better understood, it is difficult to reach an agreeable arrangement.

Subgenus Paramacrochiron Sewell, 1949

Sewell, 1949, p. 108.

159. M. (P.) parvus (A. Scott), 1909.

A. Scott, 1909, p. 269. pl, LXIX, figs. 1-7.
Sewell, 1949, p. 109.

Material examined - Several females and a few fifth copepodite males of this species are gathered from plankton of the Gulf of Mannar in July 1960. Size: female 1.14 mm. and fifth copepodite male 1.02 mm.

Distribution - Malay Archipelago, Nicobar Islands and the Gulf of Mannar.

Subgenus Macrochiron Sewell, 1949

Sewell, 1949, p. 99.

160. M. (M.) rigida Ummerkutty, 1961.

Ummerkutty, 1961, pp. 29-34

Material examined - Two female specimens are taken from sponge washings of the Gulf of Mannar in December 1960. Size: female 1.25 mm.

Distribution - The Gulf of Mannar.

Genus Lichomolgus Thorell, 1860.

G.O. Sars, 1913-18, p. 150.
Sewell, 1949, p. 96.

161. (?) L. *gigas* Thompson & Scott, 1903

Thompson & Scott, 1903, P

Material examined - Five female specimens occurred in starfish washings of the Gulf of Mannar in September 1960.

Descriptive notes - The oral appendages resemble the figures rendered by Thompson & Scott. The proportionate lengths of the last two segments of antenna, however, are slightly different in the two examples. The length-width ratio of caudal ramus also is slightly variant. The ornamentation of swimming legs is given below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	—	—	1	0	II	—	—	0	I	1	I	5	I	II

Fifth leg is rather slender and narrow with outer margin smooth and the inner margin slightly swollen at base. There are two setae on apex of the distal segment; the proximal segment is represented by a seta. Size: 1.5 mm. This is much smaller than the specimens obtained by Thompson & Scott who gave 2.0 mm. as its size.

Distribution - Malay Archipelago and the Gulf of Mannar.

Remarks - Whether the slight variations noted between the present example and that obtained by Thompson & Scott are more than local variation within the species are not clear. However, because of other similarities this example is referred to _L. gigas_ Thompson & Scott.

162. _L. holothuriae_ Ummerkutty, 1961.
Ummerkutty, 1961, pp. 34–37.

Material examined - This species is first recorded from inside the body cavity of holothurian. Subsequently numerous specimens have been taken from sponge and starfish washings. Size: female 1.2 mm. and male 0.75 mm.

Distribution - The Gulf of Mannar.

163. _L. serratipes_ Ummerkutty, 1961.
Ummerkutty, 1961, pp. 37–41.

Material examined - This species is exclusively caught from washings of the common pteroid of this area, _Pteroeides esperi_ Herklots. About one hundred and twenty individuals of both sexes and several copepodite stages are obtained from washings of seapens collected off Vedalai in the Gulf of Mannar during November - December 1960. The copepods cling to the spaces between pinnules of the pteroid. Size: female 1.6 mm. and male 0.77 mm.

Distribution - The Gulf of Mannar.

164. _L. indicus_ Ummerkutty, 1961.
Ummerkutty, 1961, pp. 44–48.

Material examined - A single female and a fifth copepodite of this species are captured from starfish washings from the Gulf of Mannar in October 1960. Size: female 1.1 mm. and male 1.05 mm.

__Distribution__ - The Gulf of Mannar.

165. __L. brevifurcata__ Ummerkutty, 1961.
Ummerkutty, 1961, pp. 41-44.

__Material examined__ - No further example of this copepod is obtained after the type specimens. Size: female 1.6 mm. and male 1.5 mm.

166. __Lichomolgus__ sp.

__Material examined__ - A single female specimen of this copepod is obtained from washings of __Pentaceros hedemanni__ (Lutken) in September 1960 from the Gulf of Mannar.

__Descriptive notes__ - This specimen (Pl. XXXI, 2) is distinct from all other lichomolgids gathered during the present study. Prosome is clearly oval and 4-segmented. In urosome (Pl. XXXI, 11) there are five segments. The genital segment is quite large and is more or less hexogonal because of lateral bulging of that segment along the mid-transverse area. The genital apertures are present in this area and they are each guarded by a pair of small spines. Each caudal ramus is hardly as long as wide and bears six setae.

Antennule (Pl. XXXI, 3) is seven segmented and peculiar in having the following relative lengths:

1	2	3	4	5	6	7
23.3	9.0	21.9	12.3	10.3	15.0	8.2 = 100

The very short second segment may particularly be noted. It is much shorter than half the length of either first or second segment. Antenna (Pl. XXXI, 4) is 4-segmented, second segment being the largest and the third the shortest.

Mandible (Pl. XXXI, 5), maxillule (Pl. XXXI, 6), maxilla (Pl. XXXI, 7) and maxilliped (Pl. XXXI, 8) are all distinctly developed. The peculiar basal chitinous ridge of maxillule and very minute terminal spine of maxilliped may be noted.

Ornamentation of swimming legs (Pl. XXXI, 9-10) is presented below:

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	5	I	0	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0	1			II		0	I	1	I	5	I	III

The most important feature notable in the ornamentation is the presence of a seta on the inner side of proximal segment of fourth endopod. The rather stout nature of the constituting segments as well as the haired margins of all endopods are also notable. In fifth leg proximal segment is almost fused with the body and is indicated only by a single seta. The distal segment is rectangular with a slight bulge on the posterior margin. It carries two terminal setae, one of which is much longer than the other. Size: 0.96 mm.

<u>Remarks</u> - The presence of a seta on inner distal angle of the proximal segment of fourth leg endopod, the very short second segment of antennule and the distinctness of mouthparts are the most salient features of this species. In the first character it approaches the condition found in <u>Lichomolgus astropectinis</u> Humes & Cressey and related forms which are included by Bocquet & Stock under the subgenus

Stellicola. However, the present material profoundly differs from this group in the structure of antennule and antenna, in these respects agreeing with the more typical members of the genus. Like the members of subgenus Stellicola, the present species is also found in association with the starfish. However, the availability of a single specimen has set limitations on taking any decision regarding its true relationship.

ONCAEIDAE

G.O. Sars, 1913-18, p. 190.

Genus Oncaea Philippi, 1843

G.O. Sars, 1913-18, pp. 190-91.

167. *O. conifera* Giesbrecht, 1892.

Giesbrecht, 1892, p. 591, pl. II, fig. 10, pl. XLVII, figs. 4, 16, 21, 28, 34, 42, 55 & 56.
Farran, 1936, p. 127, figs. 25 a-f and 26 a-c.
Sewell, 1947, pp. 259-61.

Material examined - This species occurred in the plankton quite often as stray individuals. Size: female 1.2 mm.

Distribution - The existence of a number of varieties and the confusion that prevailed in the past regarding the real determination of these, it is not possible to be absolutely certain on the distribution of this species. Taken as a whole, the species is well represented in all the oceans.

Remarks - Sewell (1947) stated: "Included under the name 'conifera' we have either a species that is extremely plastic or more probably a number of separate species". He has further discussed in detail the variations that have been recognized from the various geogrophical areas and presented the morphological pecularities in a tabular form. In the present study a detailed morphometric study is not carried out as only stray individuals are caught on different occasions.

168. *O. media* Giesbrecht, 1892.

Giesbrecht, 1892, p. 591, pl. II, fig. 12, pl. XLVII, figs. 1, 11, 29-33, 40.
van Breman, 1908, p. 187, fig. 200.
Sewell, 1947, pp. 261-62.

Material examined - Like the preceding species this also occurred in plankton occasionally. Both forma *major* Sewell and forma minor Sewell are caught. Size: female, forma *major* 0.78 mm. and forma minor 0.59 mm.

Distribution - This is a cosmopolitan species occurring in all the great oceans. One interesting feature is that both forma *major* and forma *minor* occur together in the same geographical area.

169. *O. mediterranea* (Claus), 1863.

Giesbrecht, 1892, p. 591, pl. IV, figs. 4, 16, pl. XLVIII, figs. 8-10, 47.
van Breeman, 1902, p. 107, fig. 199.
Sewell, 1947, pp. 262-63.

Material examined - A single female specimen of this species is taken from plankton of the Gulf of Mannar in January 1961. Size: 1.1 mm.

Distribution - This species has been recorded from Atlantic, Pacific and Indian oceans.

170. *O. venusta* Philippi, 1843.

Philippi, 1843, p. 63, pl. 3, fig. 2.
Farren, 1929, p. 284, fig. 33.
Sewell, 1947, pp. 263-64.

Material examined - This is the commonest of oncaeids that occurs in our waters. However, it occurs in only small numbers in plankton. Size: female 1.25 mm. and male 1.0 mm.

Distribution - This species is reported from all the great oceans.

Remarks - Sewell (1947) recognised two varieties: forma _typica_ Sewell ranging from 1.85 - 1.25 mm. and forma _venella_ Farren ranging from 0.85 - 0.95 mm. The main points of morphological difference between these two forms, besides the size range consist in that the genital segment is a little longer and the last abdominal segment a little shorter in forma _typica_ than the corresponding segments forma _venella_. It is obvious from the size that the present material represents forma _typica_.

171. _O. clevei_ Fruchtl, 1923.

Fruchtl, 1929, p. 455, pl. XXVI, figs. 19-22.
Sewell, 1947, p. 258.

Material examined - Three female specimens of this copepod are taken in plankton of the Gulf of Mannar in March 1960. Size: female 0.95 mm.

Distribution - Australian Barrier Reefs, Malay Archipelago, Aru Archipelago, Arabian Sea and the Gulf of Mannar.

SAPPHIRINIDAE

Sewell, 1947, p. 264.

Genus _Sapphirina_ Thompson, 1829

G.O. Sars, 1921, pp. 113-14.
Sewell, 1947, p. 264.

172. _S. iris_ Dana, 1853.

Dana, 1853, p. 1239; 1855, pl. 87, figs. 1a-d.
Sewell, 1947, p. 266.

Material examined - Five female and three male specimens of this copepod are obtained from plankton in April 1960 from the Gulf of Mannar. Size: female 5.1 mm. and male 5.0 mm.

Distribution - This is a very widely distributed species being present in Atlantic, Pacific and Indian oceans.

173. S. nigromaculata Claus, 1863.

Claus, 1863, p. 152.
Wilson, 1932, pp. 372-74.
Sewell, 1947, p. 267.
Krishnaswamy, 1953b, pp. 73-74.

Material examined - Two female and three male specimens are caught freely from plankton along with preceding species from the Gulf of Mannar in April 1960. Size: female 1.98 mm. and male 2.15 mm.

Distribution - This species has also a very wide distribution and is found in all the great oceans.

174. S. ovatolanceolata Dana, 1849, var. gemma Dana

Dana, 1853, p. 1251; 1855, pl. 87, figs. 15 a-c and 16 a-b.
Sewell, 1947, p. 268.

Material examined - A single female specimen of this copepod is obtained along with the preceding species from plankton of the Gulf of Mannar in April 1960. Size: 2.52 mm.

Distribution - Very cosmopolitan species, having been reported from all the great oceans.

Genus Copilia Dana, 1853

Wilson, 1932, pp. 374-75.

175. C. mirabilis Dana, 1849.

Dana, 1849, p. 40.
Lehnhofer, 1926, p. 136, fig. 13, 1-5.
Sewell, 1947, p. 270.
Krishnaswamy, 1953b, p. 74.

Material examined - A single male specimen of this copepod occurred in plankton of the Gulf of Mannar in October 1960. Size: 4.25 mm.

Distribution - This is a very widely distributed species and is taken from all the great oceans.

CORYCAEIDAE

G.O. Sars, 1913-18, p. 194.

Genus *Corycaeus* Dana, 1845

G.O. Sars, 1913-18, pp. 194-95.

Subgenus *Urocorycaeus* M. Dahl, 1912

M. Dahl, 1912, p. 42.

176. *C.* (*U.*) *longistylis* Dana, 1849

Dana, 1849, p. 36.
M. Dahl, 1912, p. 42, pl. VI, figs. 6-13, pl. VII, figs. 1-3.
Sewell, 1947, pp. 277-78.

Material examined - A few male specimens occurred in plankton of the Gulf of Mannar in August 1960. Size: male 2.05 mm.

Distribution - This species is widely distributed in the Indo-West Pacific.

Subgenus *Ditrichocorycaeus* M. Dahl, 1912.

M. Dahl, 1912, p. 31.

177. *C.*(*D.*) *asiaticus* F. Dahl, 1894.

M. Dahl, 1912, p. 74, pl. XI, figs. 1-9.
Tanaka, 1960, p. 79, pl. [redacted] XXXIV, figs. 3-4.

Material examined - Several specimens of both sexes occurred in plankton of the Gulf of Mannar in October 1960. Size: female 1.18 mm. and male 1.10mm.

Distribution - This is widely distributed in the Indo-West Pacific but the present record appears to be the first for this species from the Gulf of Mannar.

Remarks - Like other ditrichocorycaeids this species also has two setae on the peg-like rudiment of fourth endopod.

(Pl. XIII, 11). In dorsal view [redacted] anal segment is broader in proximal half. In male the genital segment (Pl. XIII, 10) is as long as the abdominal segment. Caudal rami are as long as abdominal segment in female but are slightly longer in male (Pl. XIII, 12). M. Dahl (1912) in her key to the identification of species divided *Ditrichocorycaeus* into two groups, first group consisting of those species in which the rami are short or only slightly longer than anal segment, and not two third as long as the genital segment. *C.* (*D.*) *asiaticus* falls into this group.

Subgenus *Corycella* Farren, 1911

Farren, 1911.

178. *C.* (*C.*) *gibbulus* Giesbrecht, 1892.

Giesbrecht, 1892, p. 675, pl. 51, figs. 22-23.
M. Dahl, 1912, pp. 115-18, pl. 15, figs. 1-4, 9, 10, 25, 35 & 36.

Material examined - This is the commonest of corycaeids of this area and is obtained in good numbers during September-December. Size: female 0.93 mm.

Distribution - Mediterranean sea and the Indo-West Pacific.

Subgenus *Corycaeus* M. Dahl, 1912.

M. Dahl, 1912, p. 12.

179. *C.* (*C.*) *speciosus* Dana, 1849.

Dana, 1849, p. 38.
M. Dahl, 1912, p. 13, pl. i, figs. 1-13, pl. ii. figs.1-4.

Material examined - This species occurred in rare numbers several times in plankton of the Gulf of Mannar, particularly during colder months. Size: female 1.75 mm. and male 1.50 mm.

Abnormal male - A single abnormal male specimen of this species is obtained in the first week of July 1960 from plankton of the Gulf of Mannar. This specimen differs from the typical males in the asymmetry of caudal rami. The left ramus is distinctly shorter, having a 25:33 ratio with the right ramus. The specimen is fully illustrated (Pl. XIII, 1-9). The abnormality of the caudal rami has already been noticed in other species of this genus; but in such cases the left ramus is the longer.

Distribution - This is a very widely distributed species being present in all the great oceans.

Subgenus *Onchocorycaeus* M. Dahl, 1912

M. Dahl, 1912, p. 82.

180. *C.* (*O.*) *agilis* Dana, 1849.

Dana, 1849, p. 37.
M. Dahl, 1912, p. 84, pl. XII, figs. 10-20.
Sewell, 1947, p. 284.

Material examined - Several specimens of both sexes occurred in the plankton of the Gulf of Mannar in January 1960. Size: female 1.02 mm. and male 0.98 mm.

Distribution - Distributed in tropical Atlantic and the Indo-Pacific.

Remarks - This species as well as the following one are characterised by a very large male antenna. The endopod of fourth leg (Pl. [redacted] XIII, 13) is represented by a single seta borne distinctly on second protopod segment. In female genital segment (Pl. XIII, 14) and caudal rami are of equal lengths while in male rami are a little shorter. No hook is present on male genital segment. Sewell (loc. cit.) noted that the two rami are, in several instances, of unequal lengths, the left being larger in proportion of 20:21 .

181. *C.* (*O.*) *catus* F. Dahl, 1894.

F. Dahl, 1894, p. 72.
M. Dahl, 1912, p. 99, pl. XII, figs. 17-24.

Material examined - Several female specimens of this copepod are collected from plankton of the Gulf of Mannar in October 1960. Size: 0.9 mm.

Distribution - This species appears to have a confined distribution in the Indo-Pacific. This is the first record of this species from the Gulf of Mannar.

M O N S T R I L L O I D A

MONSTRILLIDAE

G.O. Sars, 1921, pp. 7-10.

Monstrilla Dana, Thaumaleus Kroyer, Cymbasoma Thompson, Haemocera Malaquin and Monstrillopsis G.O. Sars are the five genera, arranged chronologically, belonging to this family. Sewell (1949) has, however, recognised the difficulty experienced in differentiating these various genera. The only characters that appear to be of some use in separating the different genera are the number of segments in abdomen of female and the number of setae of caudal rami, but even these characters are of only limited value. G.O. Sars (loc. cit.) has synonymised Haemocera with Cymbasoma. Sewell (loc. cit.) argues: "If the differences between Monstrillopsis dubia (T. Scott) and all other species in the group are sufficient as suggested by Sars to warrant the creation of a separate genus for its accommodation, I can see no reason for refusing to recognise the genus Haemocera as distinct from Cymbasoma". (p.132) Thaumaleus is conceived in a restricted sense, being confined to Kroyer's original species. In the present study only two species of Cymbasoma are obtained and therefore, no effort is made at reexamining any generic validity. Attention is drawn to the detailed discussion rendered by Sewell (loc. cit.).

Genus Cymbasoma Thompson, 1888

Thompson, 1888, p. 145.
Giesbrecht, 1892, p. 578.
G.O. Sars, 1921, p. 19.
Sewell, 1949, p. 142.

182. C. bullatus (A. Scott), 1909.

A. Scott, 1909, p. 240, pl. LVIII, figs. 7-8.

Material examined - A few male specimens of this copepod are obtained from plankton of the Gulf of Mannar in August 1960. Size: 1.6 mm.

Distribution - Malay Archipelago and the Gulf of Mannar. This is the first record of this species outside its type locality.

183. C. tropica Wolfenden, 1906.

Wolfenden, 1906, pp. 1025-26, pl. XCIX, fig. 31—33
Prasad, 1946, p.

Material examined - A single female specimen is obtained along with the preceding species from plankton of the Gulf of Mannar in August 1960. Size: 1.89 mm.

Distribution - Maldive Archipelago and the Gulf of Mannar.

S U M M A R Y

One hundred and eighty three species of copepodes belonging to the orders Calanoida, Harpacticoida, Cyclopoida and Monstrilloida are identified and included in the present account. The following nine species are entirely new to science and are described in detail; two new species are accommodated in two new genera:

Ridgewayia krishnaswamyi n. sp.,
Parapeltidium nichollsi n. sp.,
Porcellidium unicus n. sp.,
Echinolaeponte tropica n. sp.,
Indomyson qasimi n. gen. et. n. sp.,
Sewellopontius rectiangulus n. gen. et. n. sp.,
Sabelliphilus foliacea n. sp.,
Pseudanthessius anormalus n. sp. and
P. brevicauda n. sp.

Six other species (three Harpacticoids and three Cyclopoids) appear to be new, but are left unnamed because of insufficient material.

The undescribed males of the following species are known for the first time and their descriptions are included in the present work:

Ridgewayia typica Thompson & Scott,
Euryte brevicauda Sewell,
Asterocheres orientalis Sewell,
Cryptopontius graciloides Ummerkutty,
Peltidium angulatum Thompson & Scott,
Porcellidium ravanae Thompson & Scott and
P. scotti Pesta.

Twentyfive species included in this thesis are reported for the first time after their discovery. Some additional morphological notes are given on these species.

Fifteen species of copepods are recorded for the first time from the Northern Indian Ocean, while several others are reported

newly from the south-east coast of India. The presence of several Atlantic species in our waters is particularly interesting.

The Cyclopoid family Asterocheridae Giesbrecht is divided into two subfamilies, Asterocherinae nov. and Cletopontiinae nov. Arguments are put forward for abandoning the division of Entomolepidae into two subfamilies as was done by Eiselt (1959).

Brief considerations are included on the classification, specificity of association and distribution of copepods.

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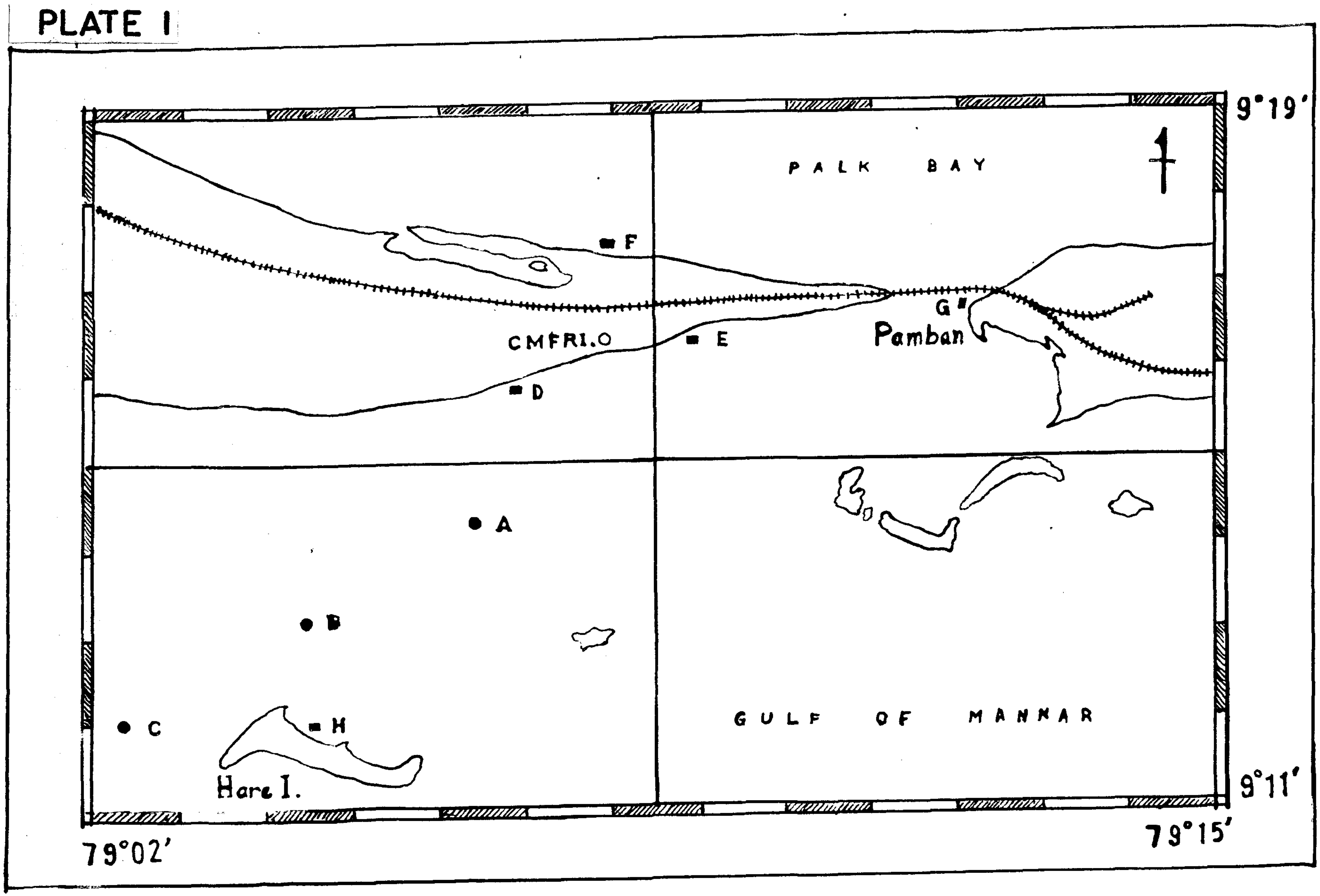
References marked with an asterik (*) are not consulted in original.

Explanation of Plate I

Map of Mandapam area showing the various centres of collection: A - C are the plankton collection stations and D - H are the shore collection stations.

PLATE I



PALK BAY
F
CMFRI.O
E
D
G
Pamban
A
B
C
H
Hare I.
GULF OF MANNAR
9°19'
9°11'
79°02'
79°15'

Explanation of Plate II

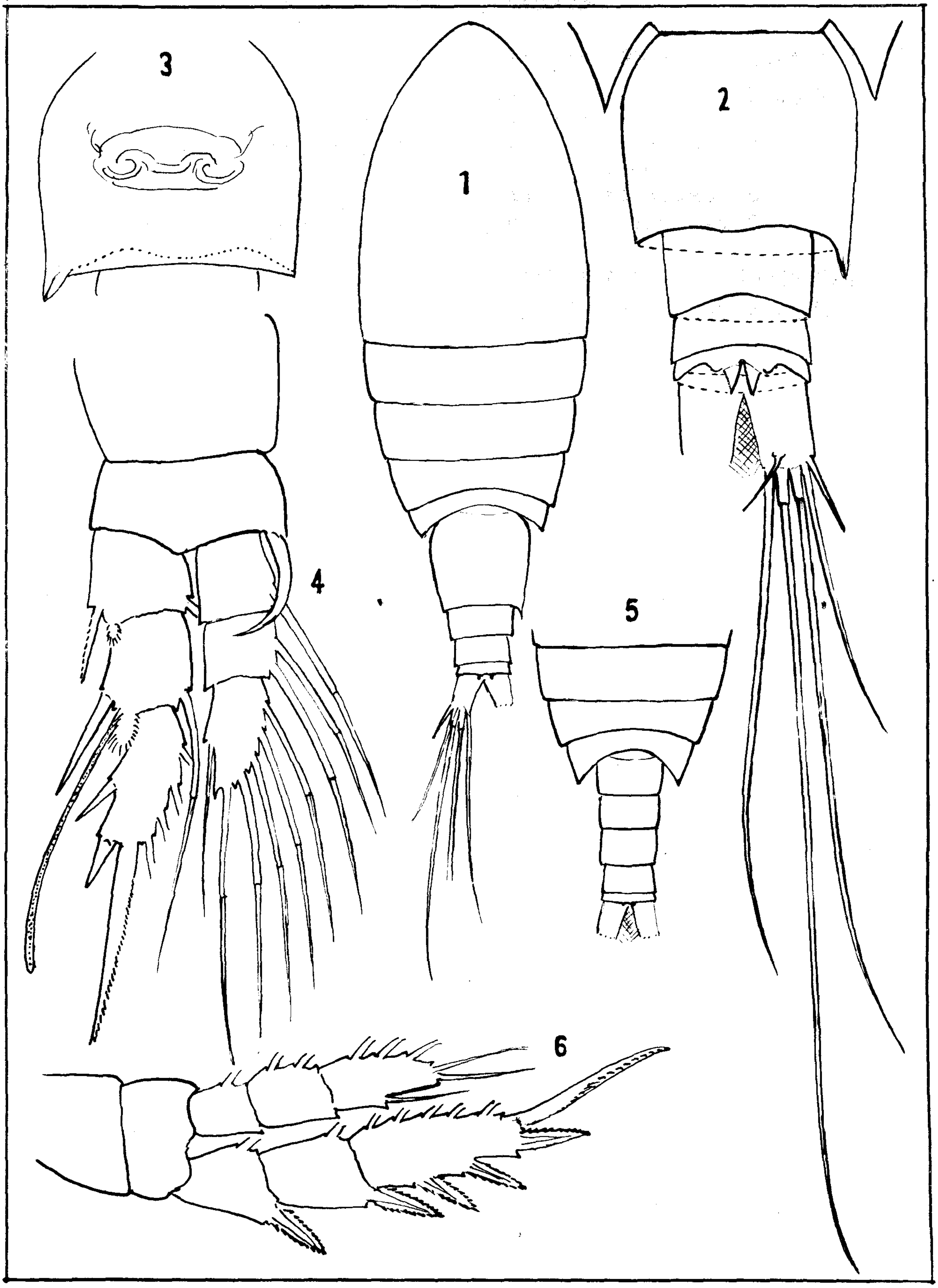
<u>Ridgewayia typica</u> Thompson & Scott

Fig. 1 female dorsal view
2 female urosome dorsal view
3 female genital segment ventral view with genital apertures
4 female first leg
5 male urosome and part of prosome dorsal view

<u>Ridgewayia krishnaswamyi</u> n. sp.

Fig. 6 female fourth leg

PLATE II



Explanation of Plate III

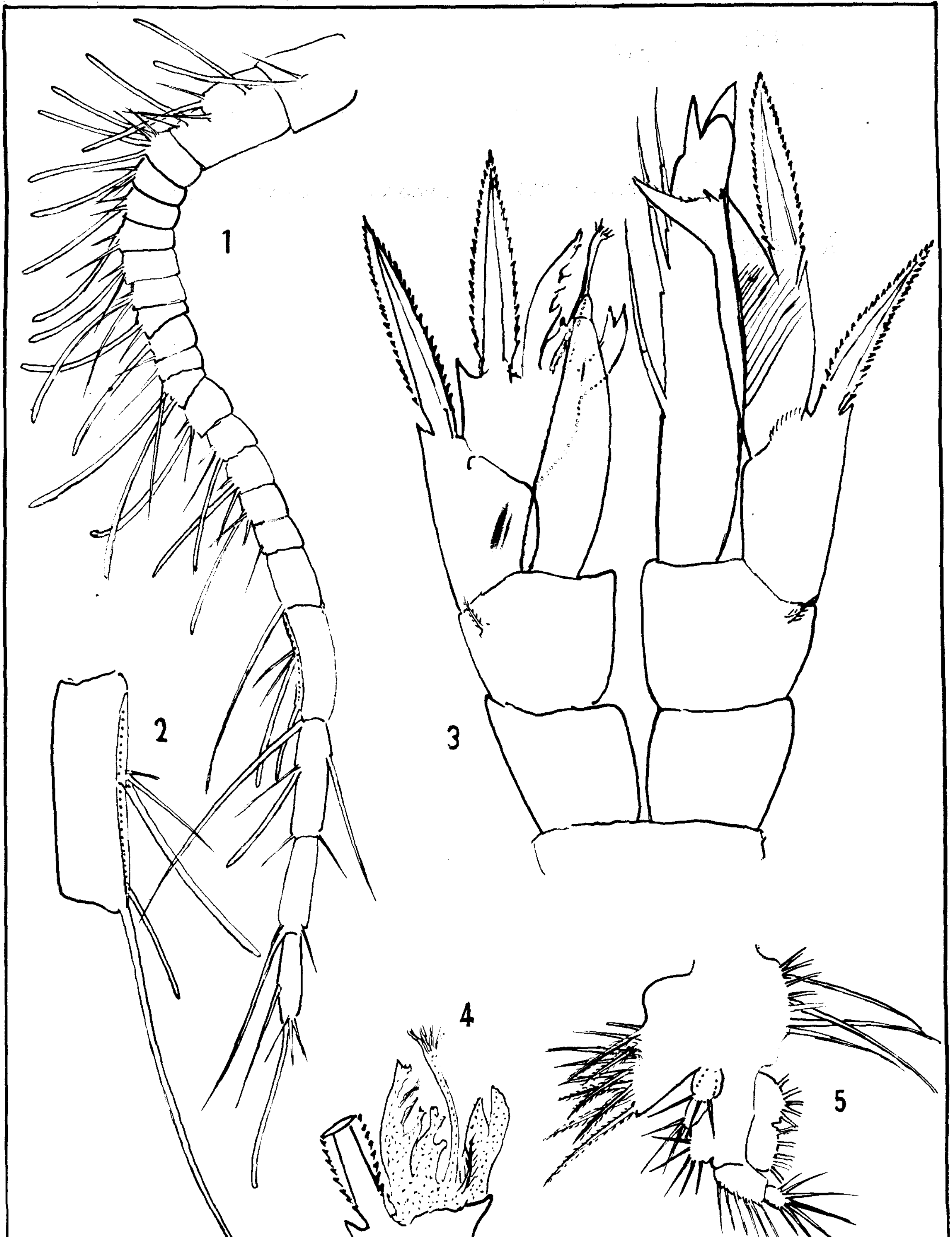
<u>Ridgewayia typica</u> Thompson & Scott

Fig. 1 male right geniculate antennule
2 male right geniculate antennule, nineteenth segment enlarged
3 male fifth legs
4 male right fifth exopod, terminal part enlarged

<u>Ridgewayia krishnaswamyi</u> n. sp.

Fig. 5 female maxillule

PLATE III

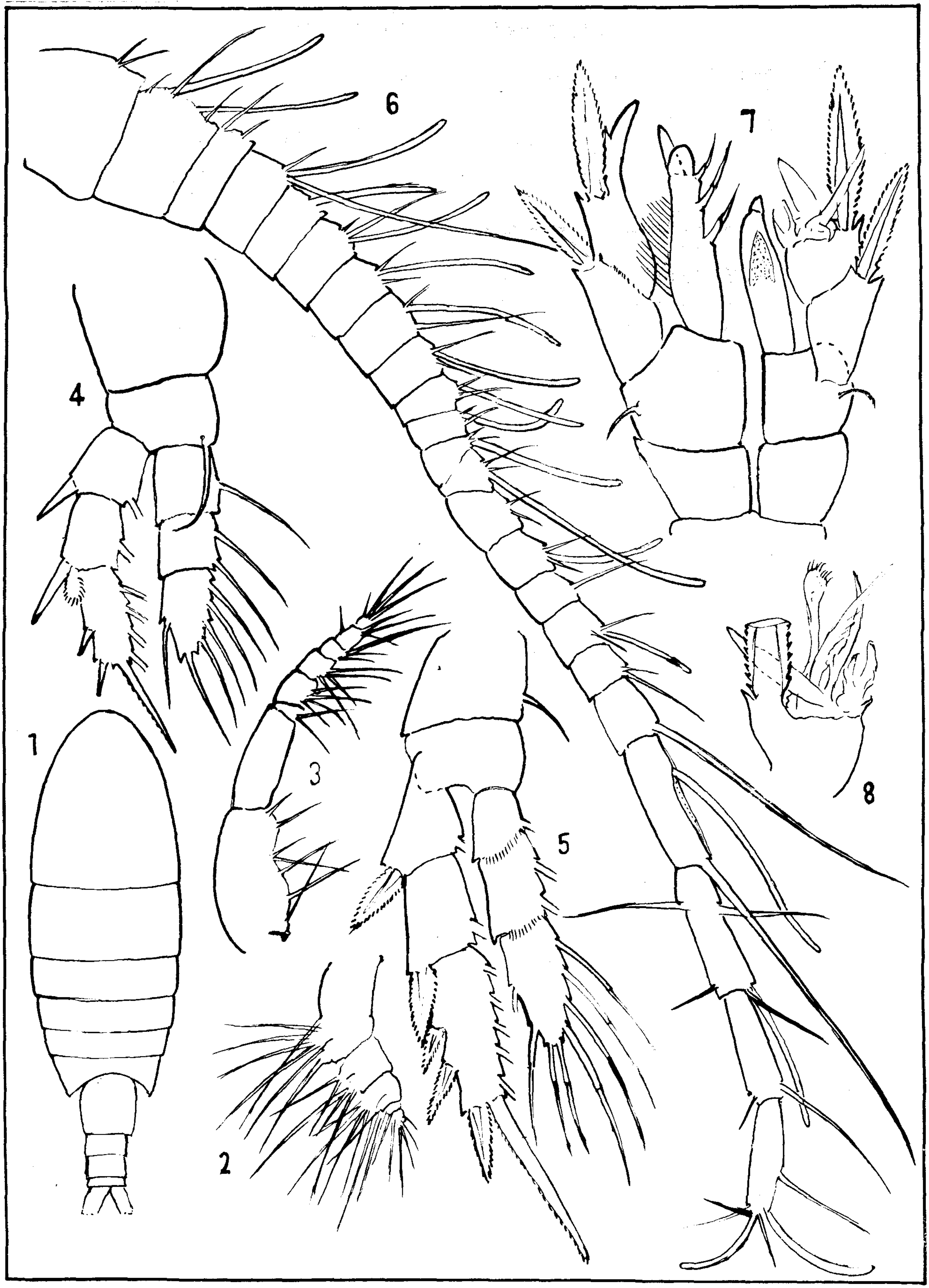


Explanation of Plate IV

<u>Ridgewayia krishnaswamyi</u> n. sp.

Fig. 1 female urosome with genital apertures
2 male dorsal view
3 female urosome and posterior part of prosome, lateral view
4 female antennule
5 female antenna
6 female mandible
7 female fifth leg
8 female second leg, exopod and protopod

PLATE IV

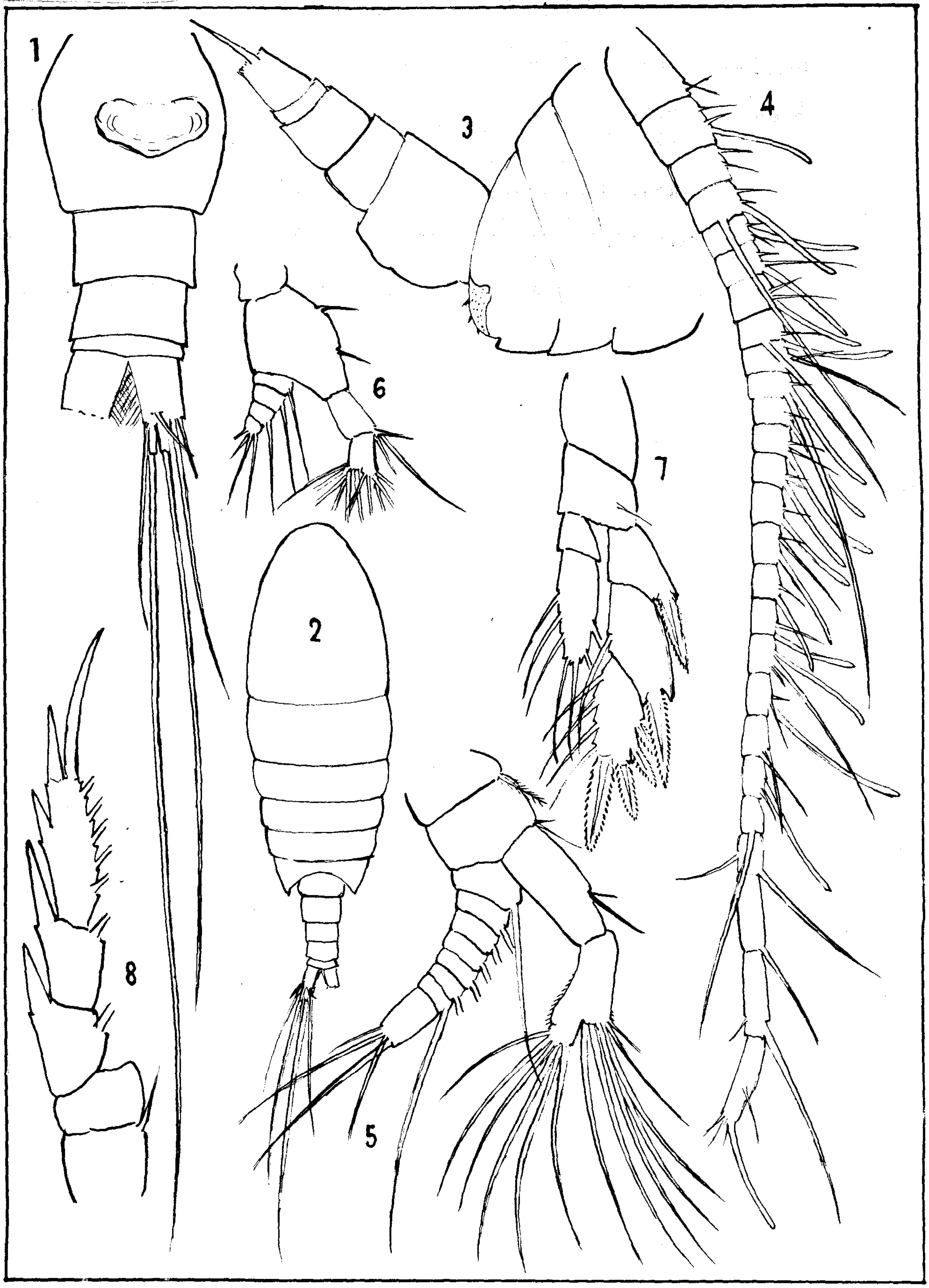


Explanation of Plate V

Ridgewayia krishnaswamyi n. sp.

Fig. 1 female dorsal view
2 female maxilla
3 female maxilliped
4 female first leg
5 female third leg
6 male right geniculate antennule
7 male fifth legs
8 male fifth left exopod, terminal part enlarged

PLATE V



Explanation of Plate VI

Canuella scotti Sewell

Fig. 1 male uresome, lateral view
2 male antennule
3 male second and third urosomal segments, ventral view

Alteuthella pellucida A. Scott

Fig. 4 female third, fourth and fifth pedigerous segments, showing posterior spinular margins
5 lateral margins of prosomal segments
6 female uresome with fifth legs

Peltidium aurivilli Cleve

Fig. 7 female dorsal view
8 female lateral margin of first prosomal segment with pitted spines
9 female antennule
10 female first leg
11 female fifth leg

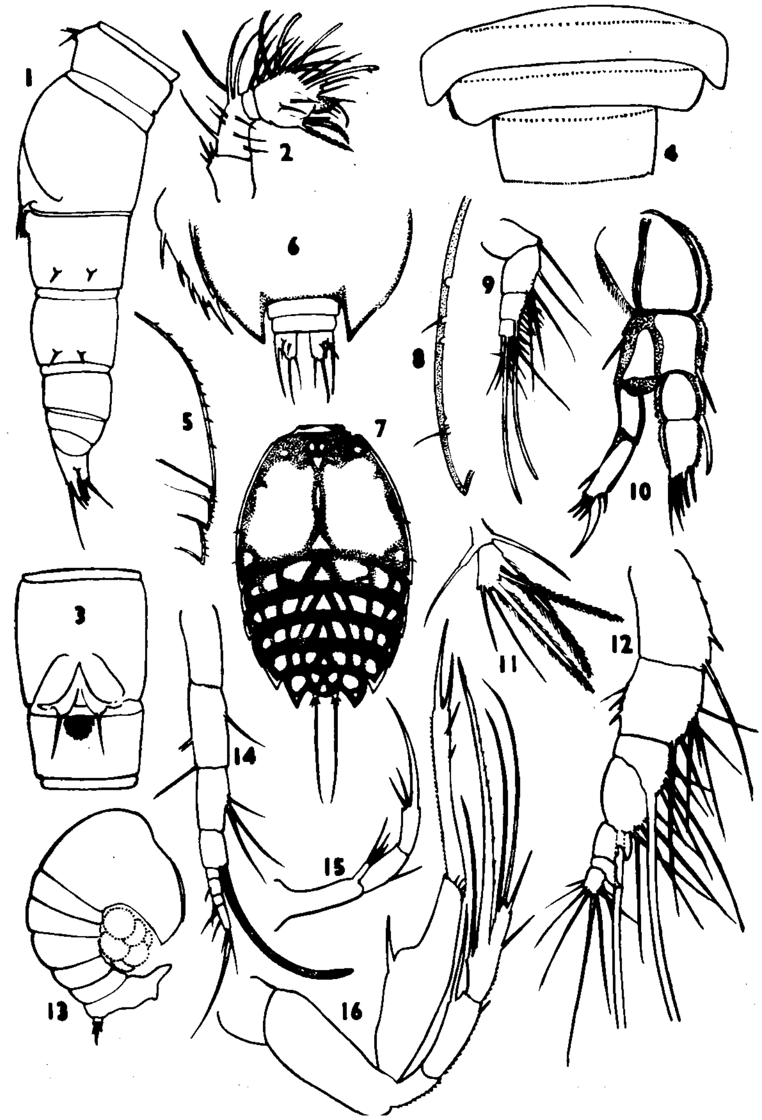
Peltidium angulatum Thompson & Scott

Fig.12 male antennule

Syngastes sp.

Fig.13 female lateral view
14 female antennule
15 female antenna
16 female fourth leg

PLATE VI



Explanation of Plate VII

<u>Peltidium</u> <u>angulatum</u> Thompson & Scott

Fig. 1 male lateral view
2 male first leg
3 male urosome, ventral view
4 male fifth leg
5 male sixth leg

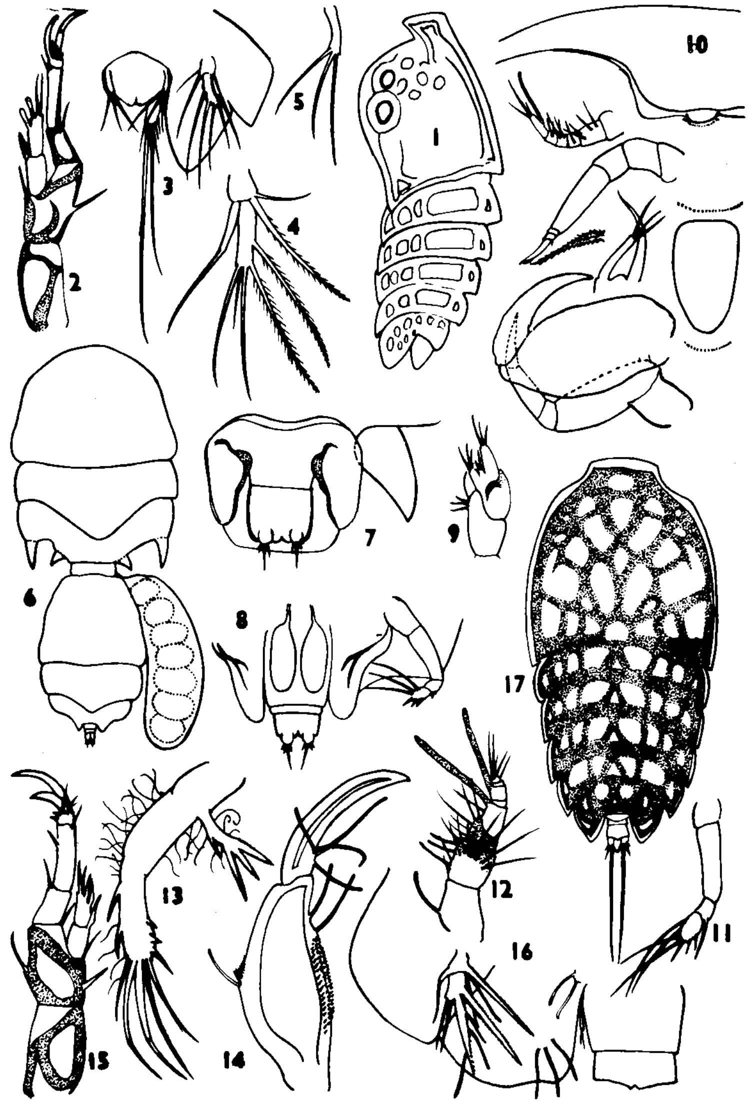
<u>Stephopontius</u> <u>typicus</u> Thompson & Scott

Fig. 6 female and male in paired condition (only one ovisac is shown in female)
7 female urosome, ventral view
8 male urosome, ventral view
9 male antennule
10 female part of cephalosome, showing various appendages
11 female third leg

? <u>Peltidium</u> <u>cenirium</u>

Fig. 12 male antennule
13 male antenna
14 male maxilliped
15 male first leg
16 male urosome with fifth and sixth legs
17 male dorsal view

PLATE VII



Explanation of Plate VIII

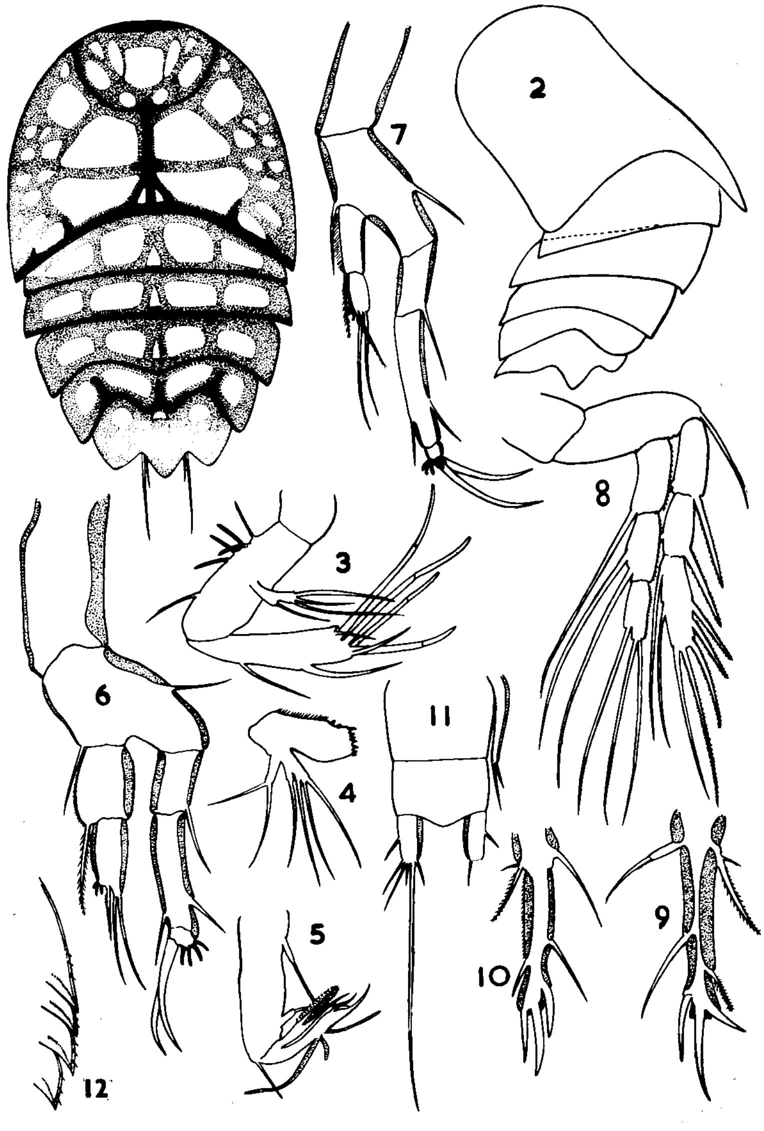
Parapeltidium nichollsi n. sp.

Fig. 1 female dorsal view
2 female lateral view
3 female antenna
4 female maxillule
5 female maxilla
6 female first leg
7 male first leg
8 female second leg
9 female fifth leg
10 male fifth leg
11 male urosome with sixth leg

Xouthous maldiviae Sewell

Fig. 12 female lateral margins of prosomal segments

PLATE VIII



Explanation of Plate IX

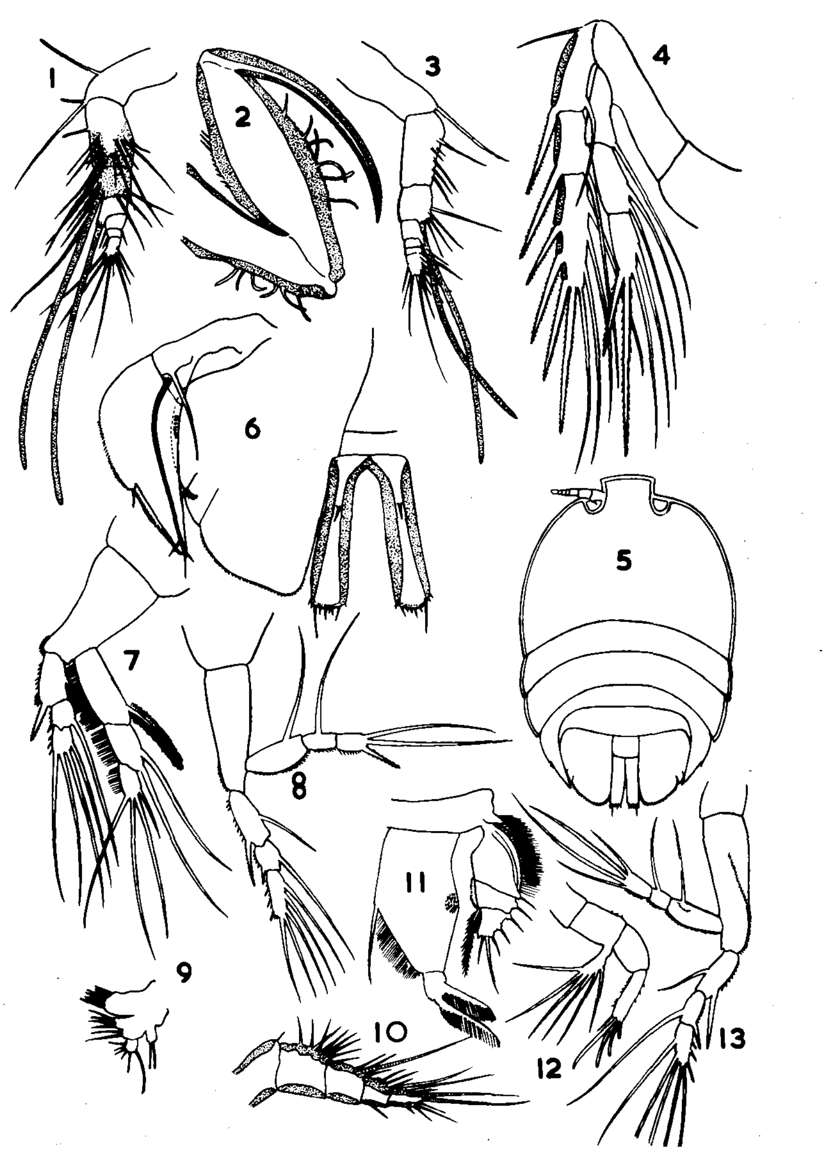
<u>Parapeltidium nichollsi</u> n. sp.

Fig. 1 male antennule
2 female maxilliped
3 female antennule
4 female fifth leg

<u>Porcellidium</u> sp.

Fig. 5 female dorsal view
6 female urosome with fifth leg
7 female second leg
8 female third leg
9 female maxillule
10 female antennule
11 female first leg
12 female antenna
13 female fourth leg

PLATE IX



I

Explanation of Plate X

<u>Syngastes</u> sp.

Fig. 1 female first leg

<u>Porcellidium</u> <u>ravanae</u> Thompson & Scott

Fig. 2 female urosome dorsal view
3 male antennule
4 female fifth leg
5 male urosome with fifth leg
6

<u>Porcellidium</u> <u>acuticaudatum</u> Thompson & Scott

Fig. 6 female urosome with fifth leg
7 male urosome with fifth leg
8 male dorsal view
9 male antennule

<u>Porcellidium</u> <u>fimbriatum</u> Claus

Fig. 10 female urosome with fifth leg

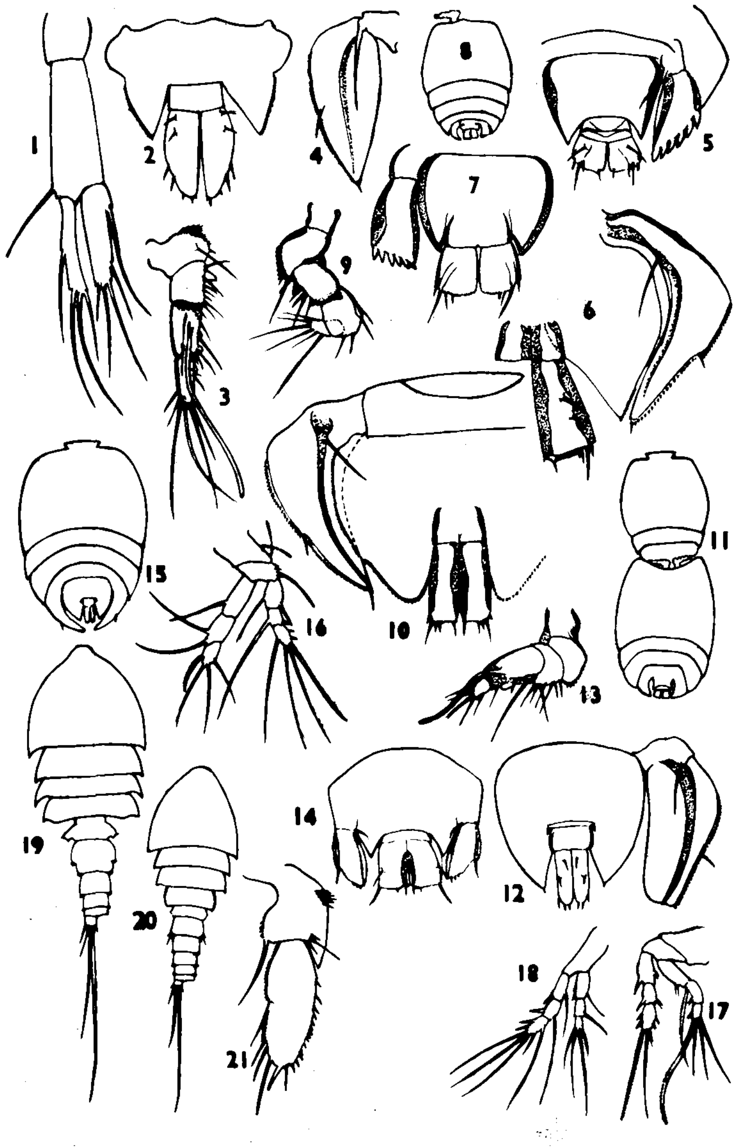
<u>Porcellidium</u> <u>unicus</u> n. sp.

Fig. 11 male and young female in paired condition
12 female urosome with fifth leg
13 male antennule
14 male urosome with fifth legs
15 female dorsal view
16 female second leg
17 female third leg
18 female fourth leg

<u>Scutellidium</u> <u>longicaudam</u> (Philippi)

Fig. 19 female dorsal view
20 male dorsal view
21 female fifth leg

PLATE X

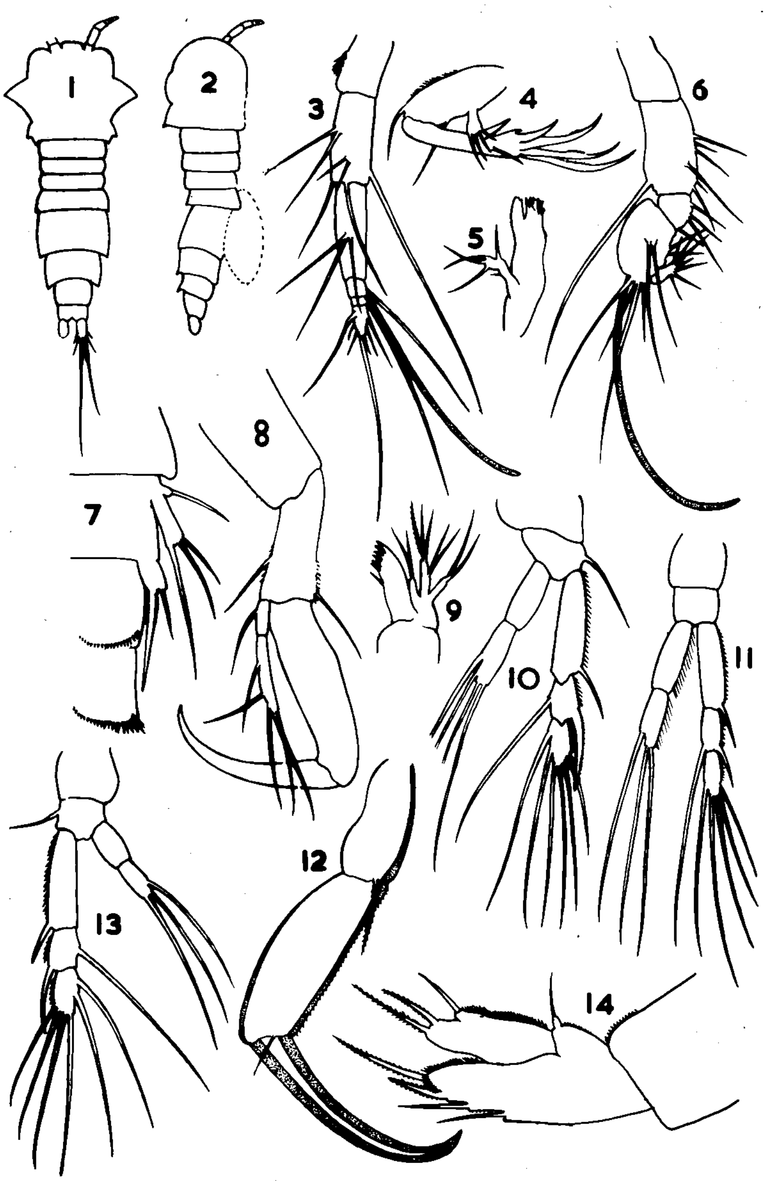


Explanation to Plate XI

<u>Echinolaophonte tropica</u> n. sp.

Fig. 1 female dorsal view
2 female lateral view
3 female antennule
4 female antenna
5 female mandible
6 male antennule
7 male urosome showing fifth and sixth legs
8 female first leg
9 female maxillule
10 female third leg
11 female second leg
12 female maxilliped
13 female fourth leg
14 female fifth leg

PLATE XI

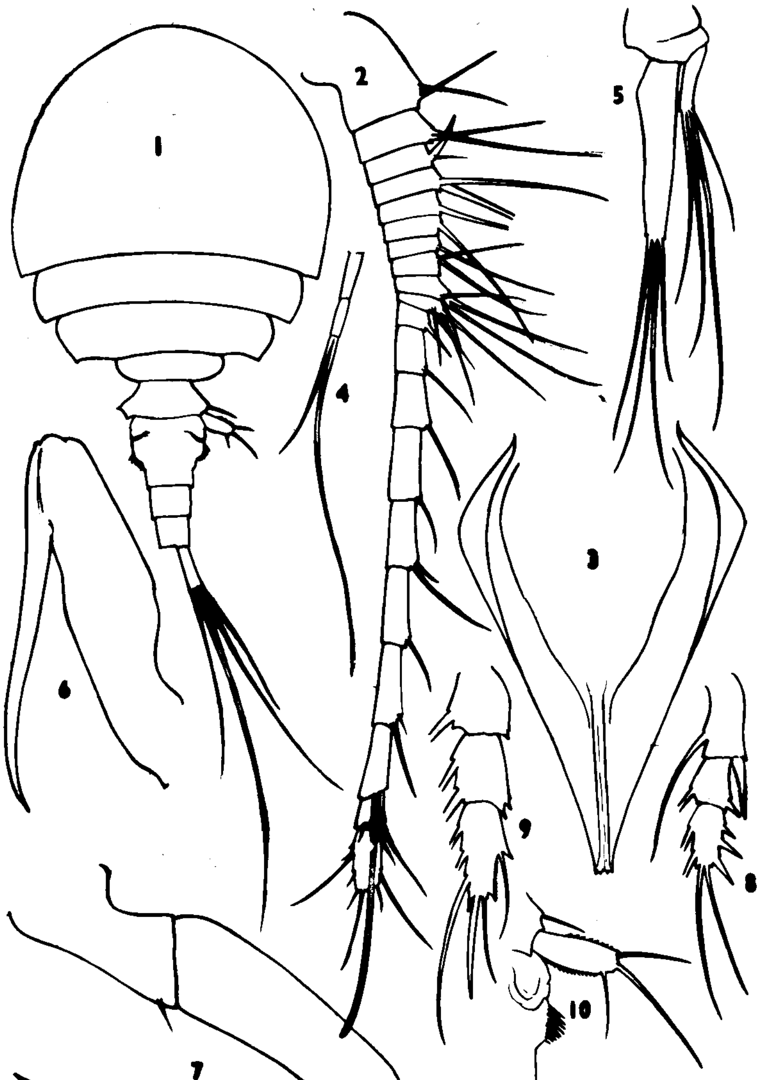


Explanation of Plate XII

<u>Asterocheres</u> sp. (i)

Fig. 1 Female dorsal view
2 Female antennule
3 Female siphon
4 Female mandibular palp
5 Female maxillule
6 Female maxilla
7 Female maxilliped
8 Female first exopod
9 Female third endopod
10 Female fifth leg

PLATE XII



Explanation of Plate XIII

Corycaeus speciosus Dana

Fig. 1 abnormal male dorsal view
2 abnormal male lateral view, right side
3 abnormal male antennule
4 abnormal male antenna
5 abnormal male mandible and maxillule
6 abnormal male maxilla
7 abnormal male maxilliped
8 abnormal male caudal rami enlarged
9 abnormal male fourth leg

Corycaeus (Ditrichocorycaeus) asiaticus F. Dahl

Fig. 10 female urosome
11 female fourth leg
12 male urosome

Corycaeus (Onchocorycaeus) agilis Dana

Fig. 13 female fourth leg
14 female urosome

Corycaeus (Corycella) gibbula Giesbrecht

Fig. 15 female fourth leg

Hemicyclops indicus Sewell

Fig. 16 female dorsal view

Pseudocyclops obtusus var. asymmetrica nov.

Fig. 17 male dorsal view

Hemicyclops australis Nicholls

Fig. 18 female urosome and part of prosome

Pseudocyclops obtusus var. asymmetrica nov.

Fig. 19 female fifth leg

Calanopia thompsoni A. Scott

Fig. 20 male (abnormal), urosome

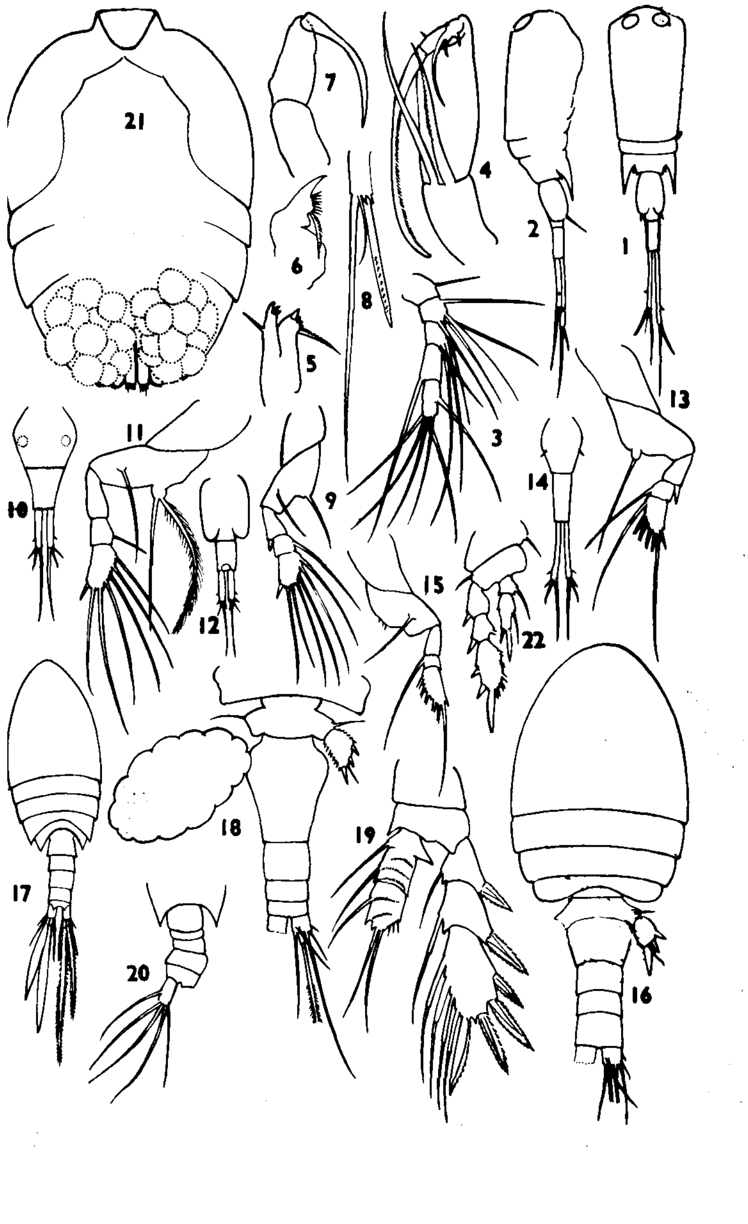
Porcellidium sp.

Fig. 21 female ventral view

Lichomolgus sp.

Fig. 22 female fourth leg

PLATE XIII



Explanation of Plate XIV

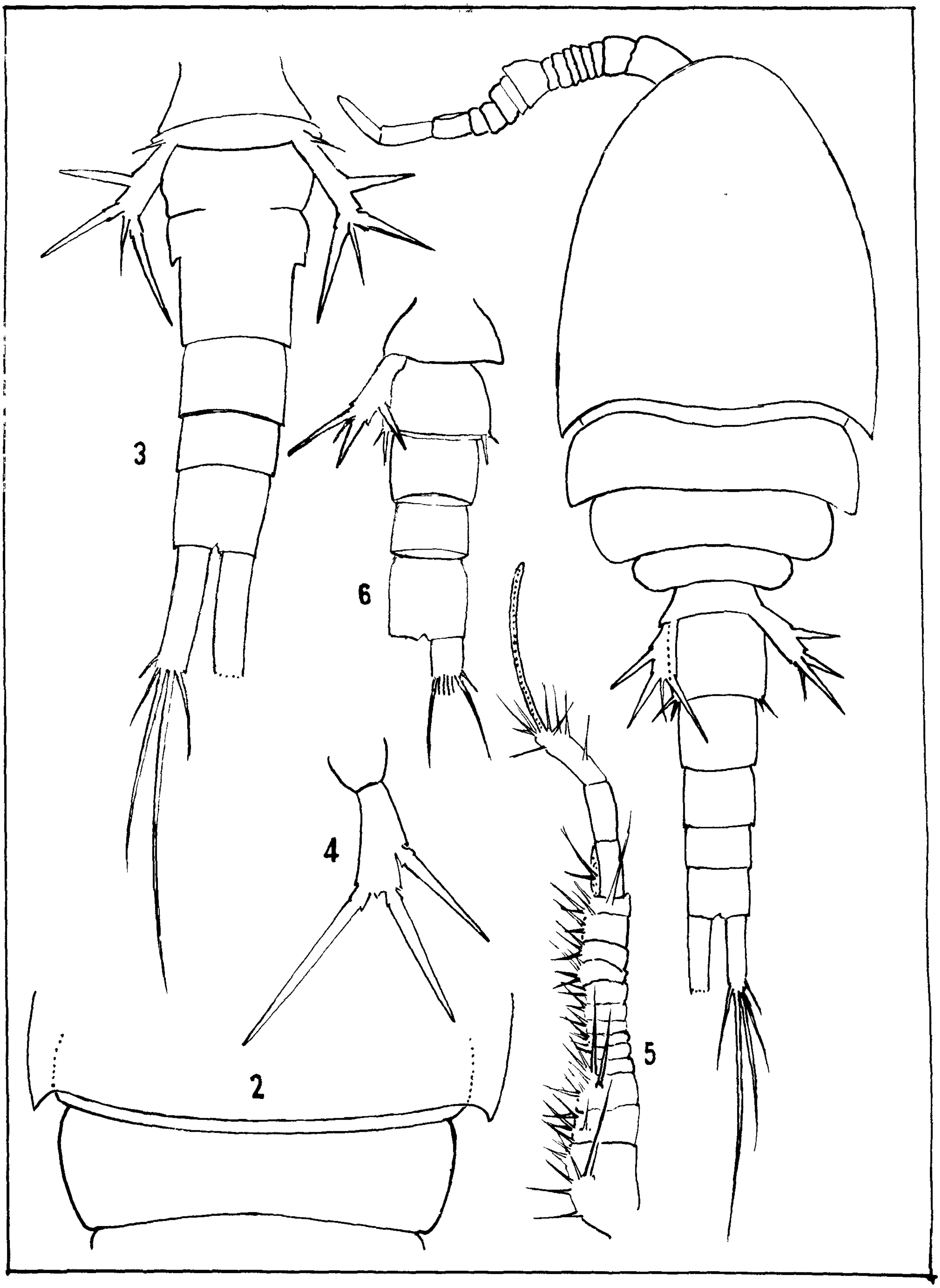
Euryte robusta Giesbrecht

Fig. 1 male dorsal view
2 female first, second and third prosomal segments
3 female urosome with fifth legs

Euryte brevicauda Sewell

Fig. 4 female fifth leg
5 male antennule
6 ~~[illegible]~~ fifth stage urosome

PLATE XIV



Explanation of Plate XV

Euryte _brevicauda_ Sewell

Fig. 1 male dorsal view
2 male urosome with fifth legs
3 fifth stage antennule

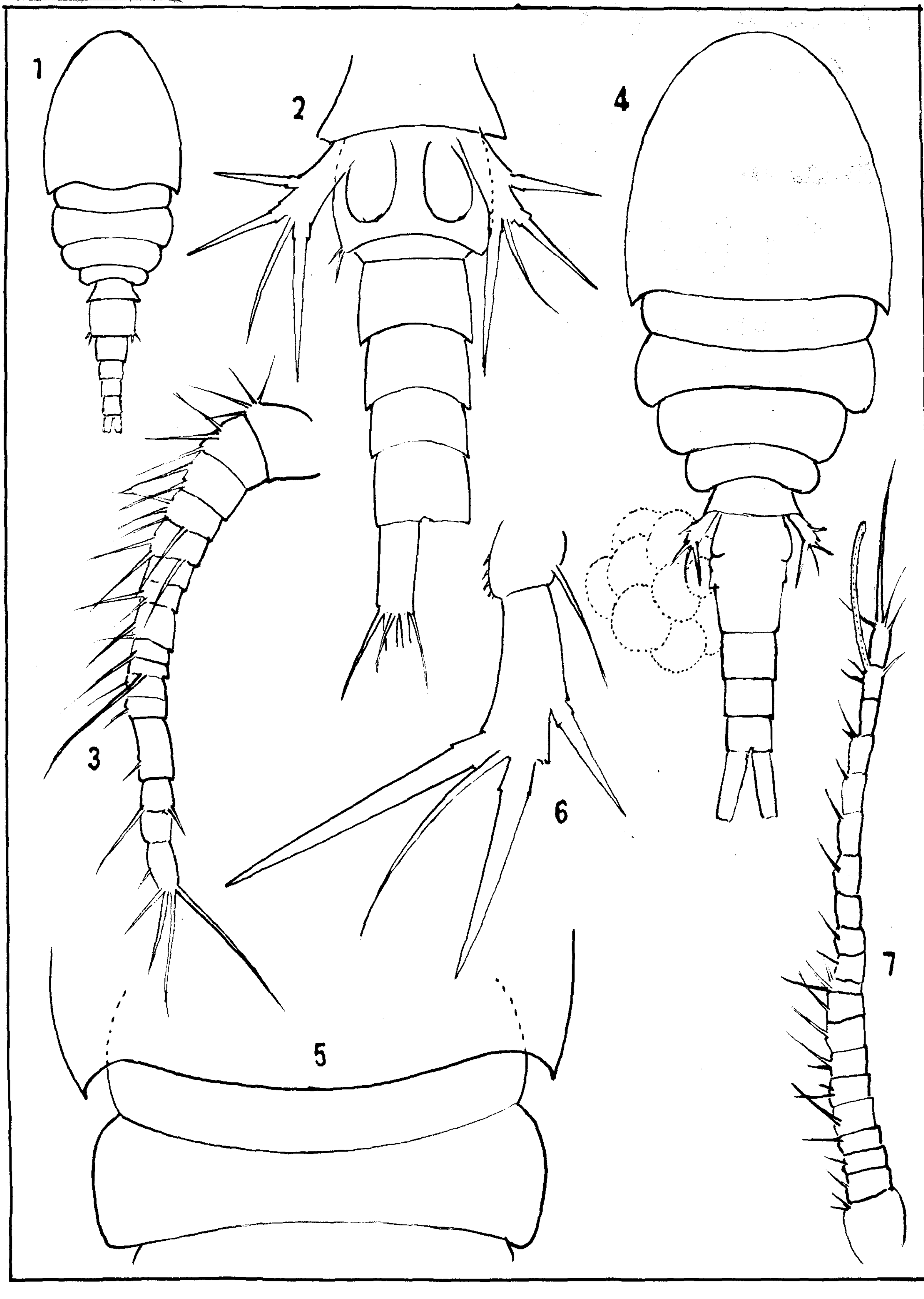
Euryte sp.

Fig. 4 female dorsal view
5 female first, second and third prosomal segments
6 female fifth leg

Asterocheres _indicus_ Sewell

Fig. 7 female antennule

PLATE XV



Explanation of Plate XVI

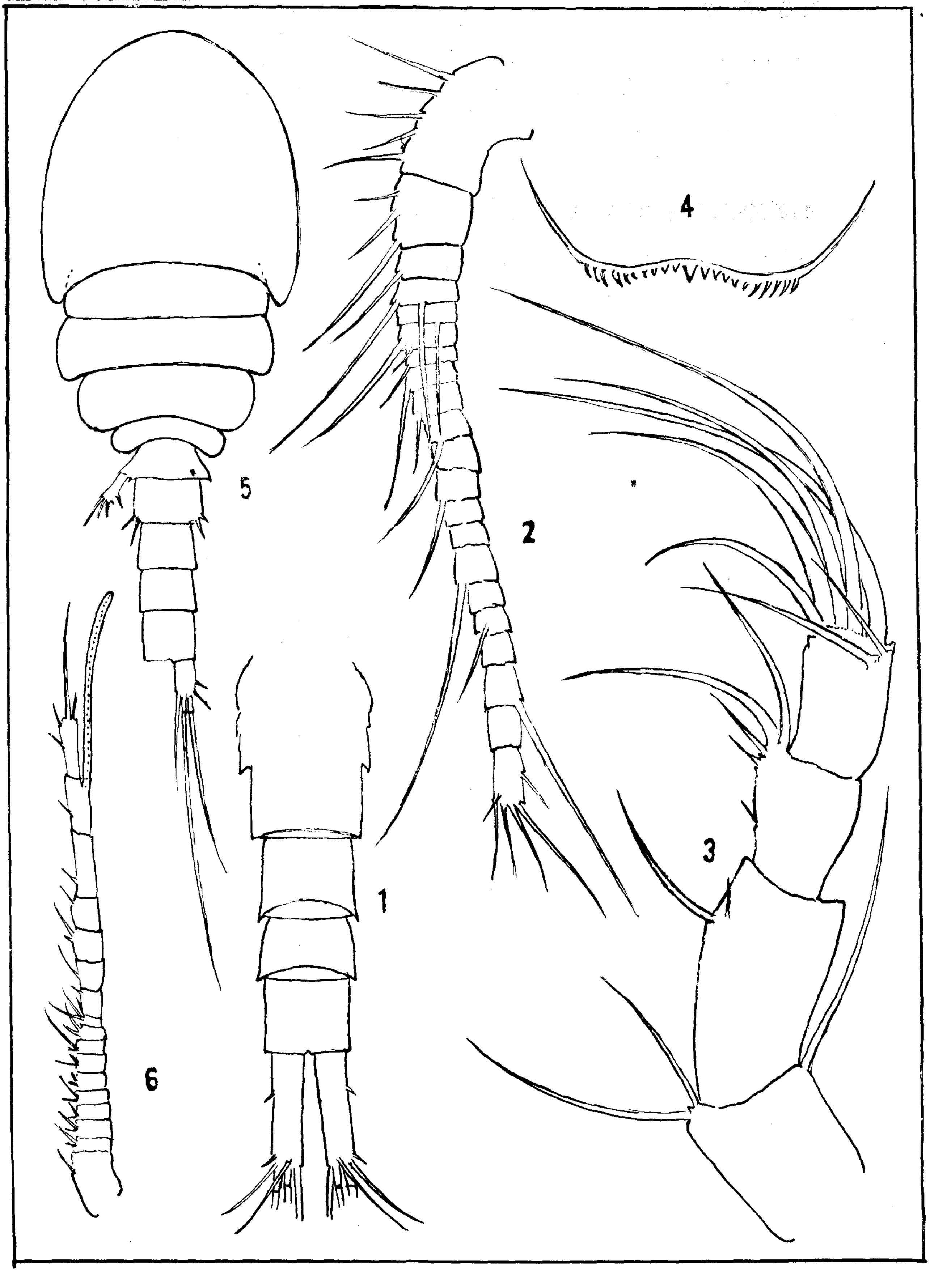
<u>Euryte</u> sp.

Fig. 1 female urosome dorsal view
2 female antennule
3 female antenna
4 female labrum
5 fifth stage dorsal view

<u>Asterocheres</u> <u>orientalis</u> Sewell

Fig. 6 male antennule

PLATE XVI



Explanation of Plate XVII

<u>Asterocheres</u> <u>mannarensis</u> Thompson & Scott

Fig. 1 female dorsal view
2 female urosome with fifth legs

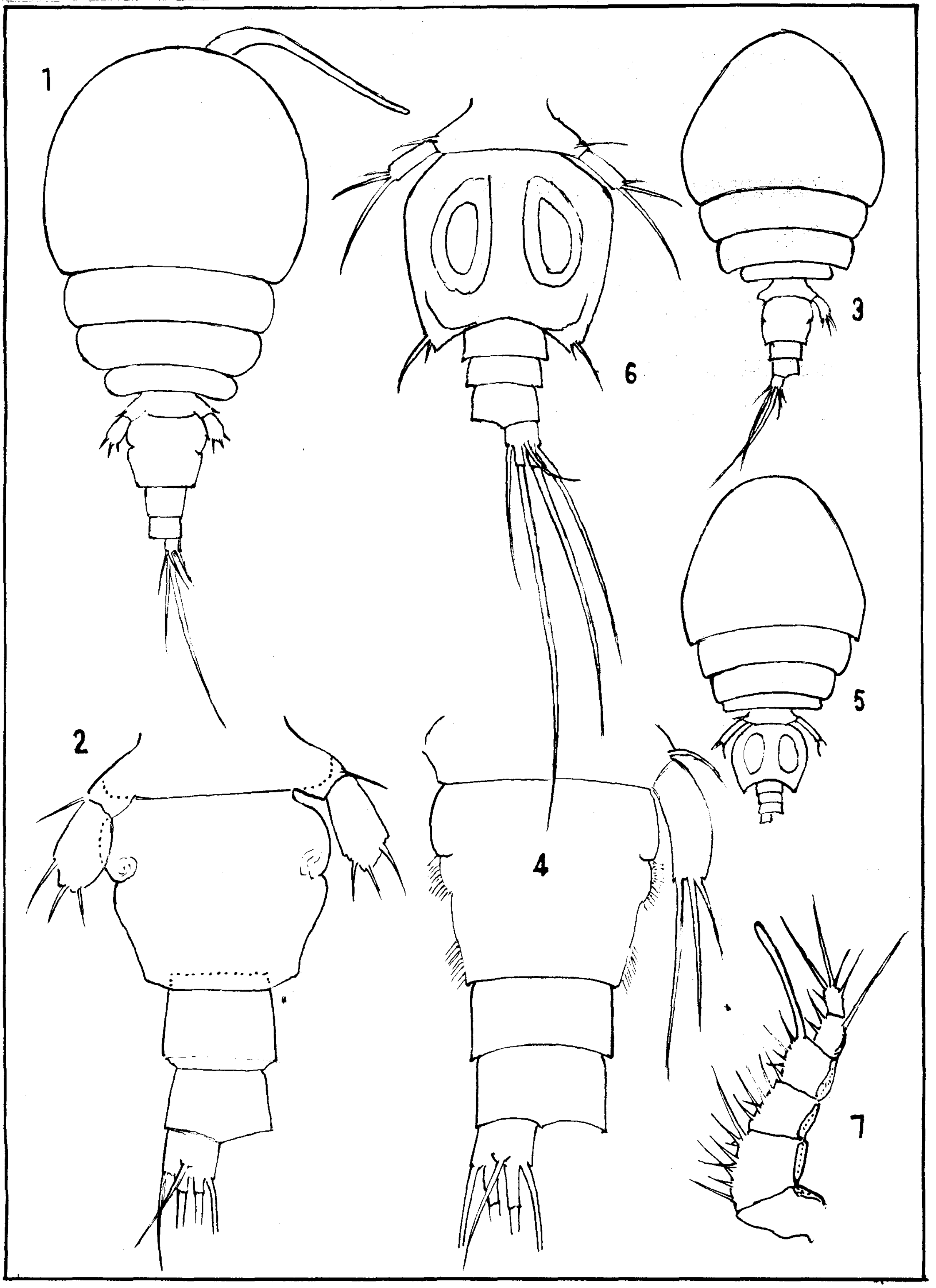
<u>Asterocheres</u> <u>orientalis</u> Sewell

Fig. 3 female dorsal view
4 female urosome with fifth leg
5 male dorsal view
6 male urosome with fifth legs

<u>Xouthous</u> <u>maldiviae</u> Sewell

Fig. 7 female antennule

PLATE XVII

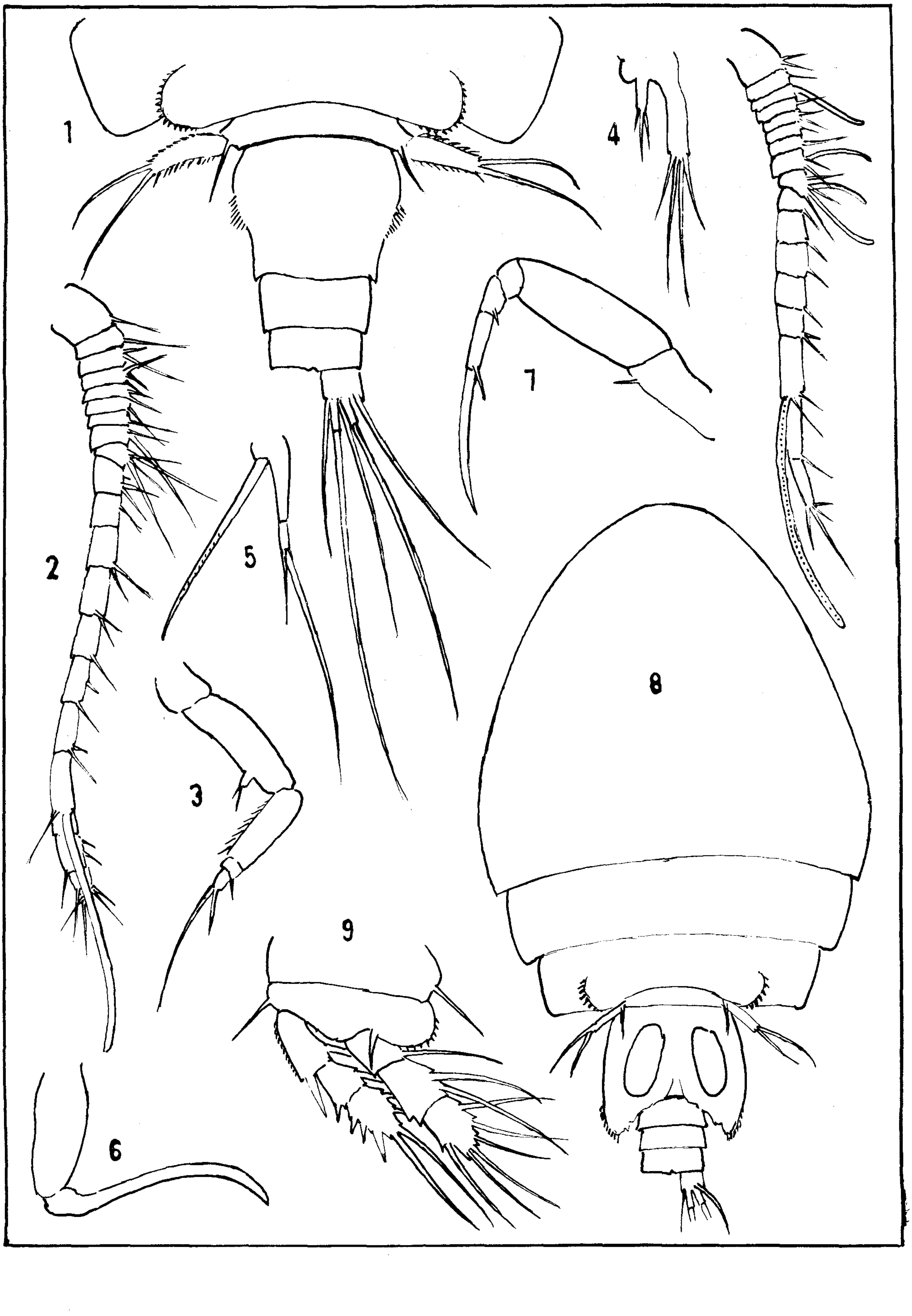


Explanation of Plate XVIII

Asterocheres dentatus Giesbrecht

Fig. 1 female posterior part of prosome and urosome, ventral view
2 female antennule
3 female antenna
4 female mandible
5 female maxillule
6 female maxilla
7 female maxilliped
8 male ventral view
9 male antennule

PLATE XVIII



Explanation of Plate XIX

Asterocheres indicus Sewell

Fig. 1 female dorsal view
2 female urosome with fifth legs
3

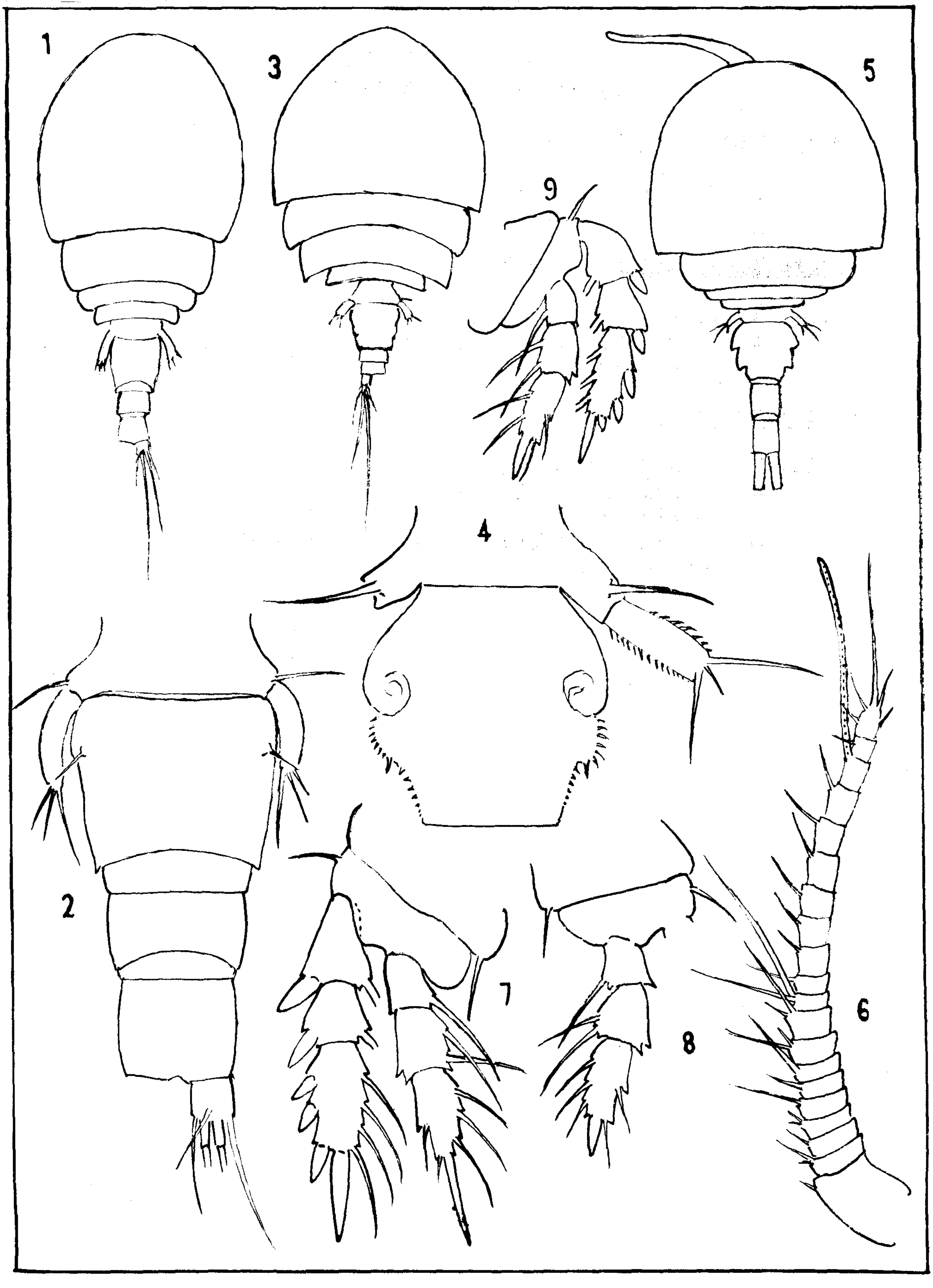
Asterocheres latum (Brady)

Fig. 3 female dorsal view
4 female urosome, first and second segments with first leg

Asterocheres sp. (ii)

Fig. 5 female dorsal view
6 female antennule
7 female second leg
8 female third leg (exopod not shown)
9 female fourth leg

PLATE XIX



Explanation of Plate XX

Asterocheres sp. (ii)

Fig. 1 female cephalosomal appendages *in situ*
2 female part of prosome and urosome ventral view

Asteropontius typicus Thompson & Scott

Fig. 3 female dorsal view
4 female urosome ventral view

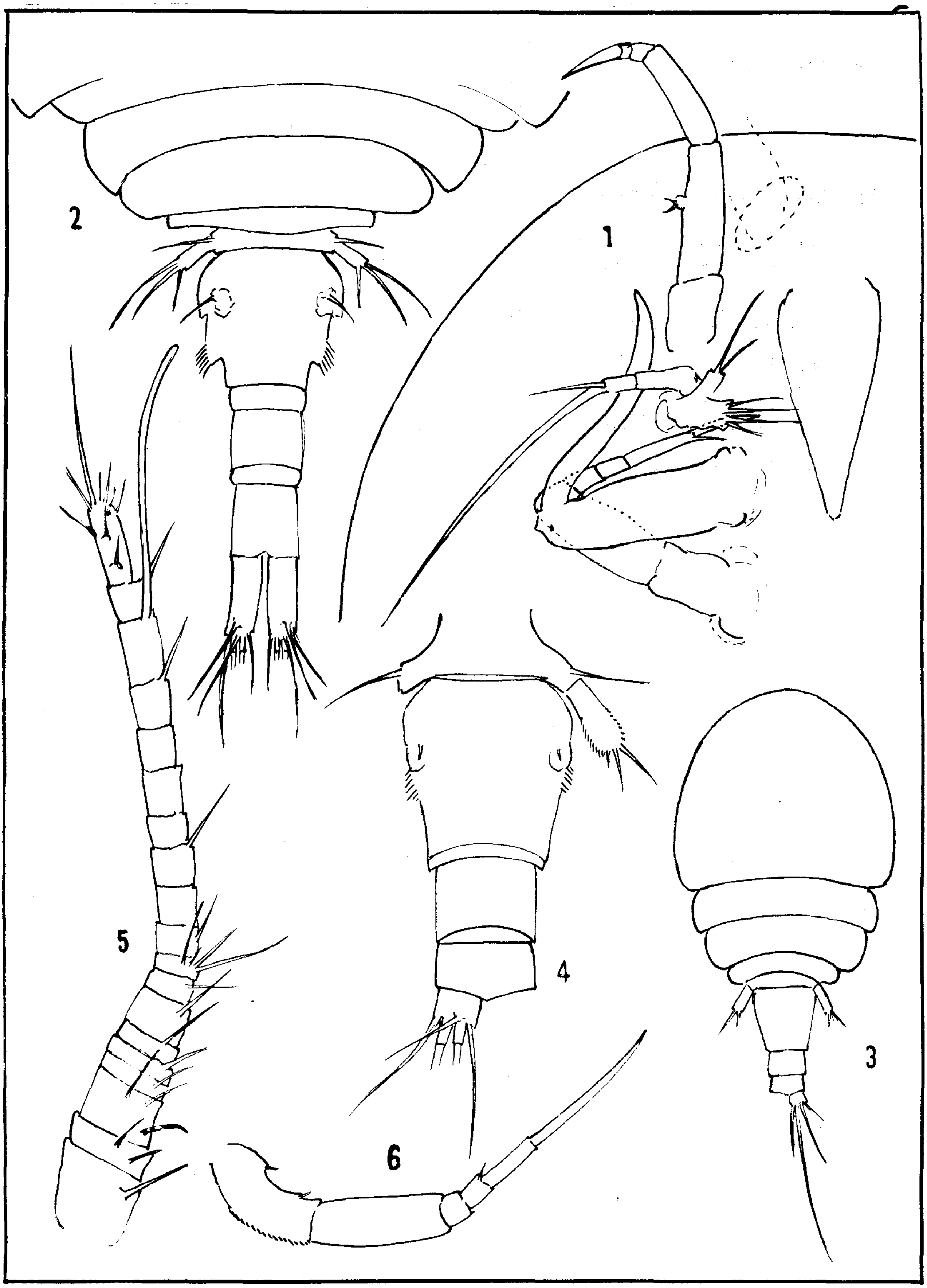
Dermatomyzon nigripes (Brady)

Fig. 5 female antennule

Acontiophorus scutatus Brady

Fig. 6 female maxilliped

PLATE XX



Explanation of Plate XXI

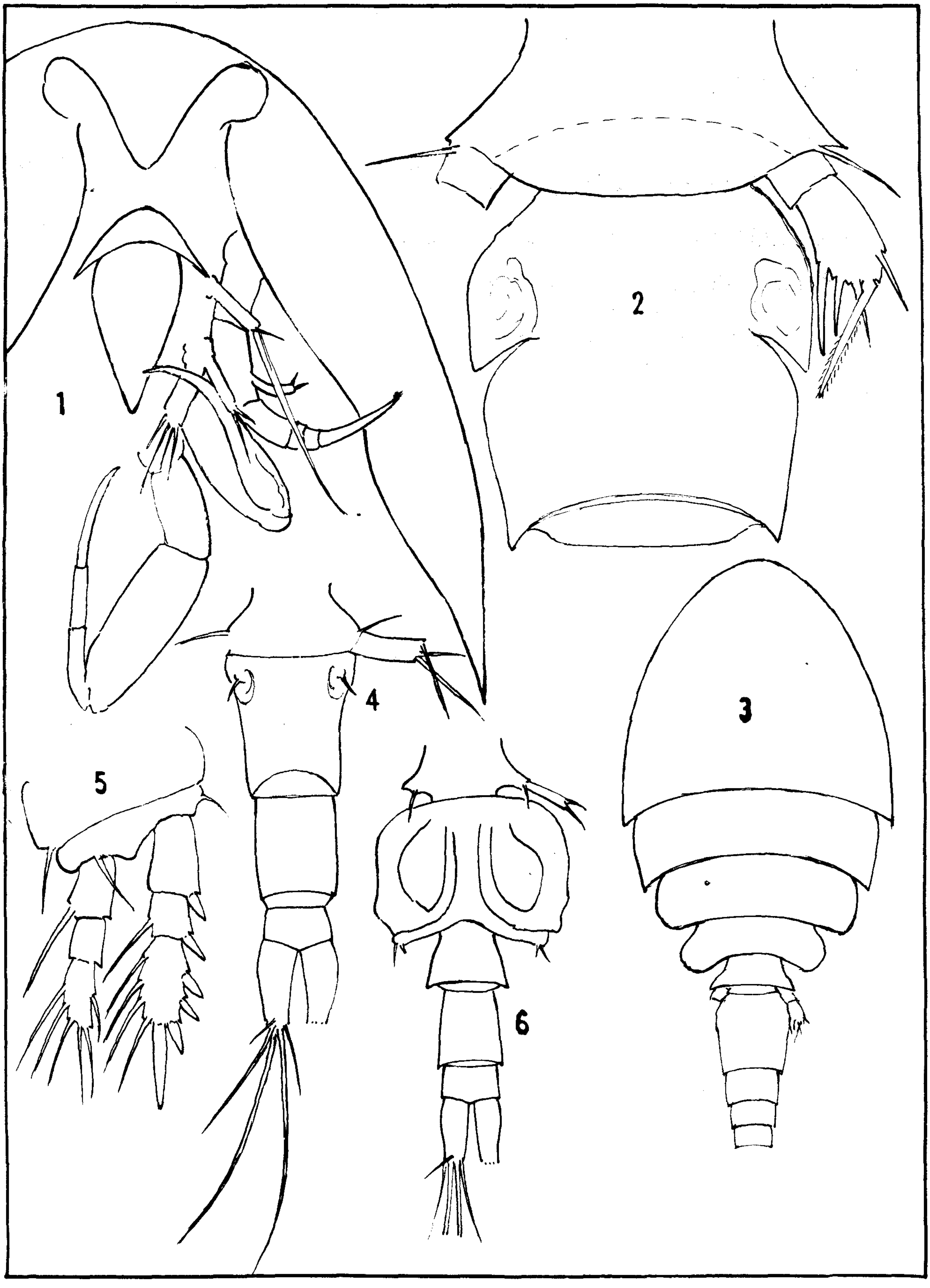
<u>Dermatomyzon nigripes</u> (Brady)

Fig. 1 female cephalosomal appendages <u>in situ</u>
2 female first and second urosomal segments with fifth leg
3 female dorsal view

<u>Indomyzon qasimi</u> n. gen. <u>et</u>. n. sp.

Fig. 4 female urosome with fifth leg
5 female second leg
6 male urosome ventral view

PLATE XXI

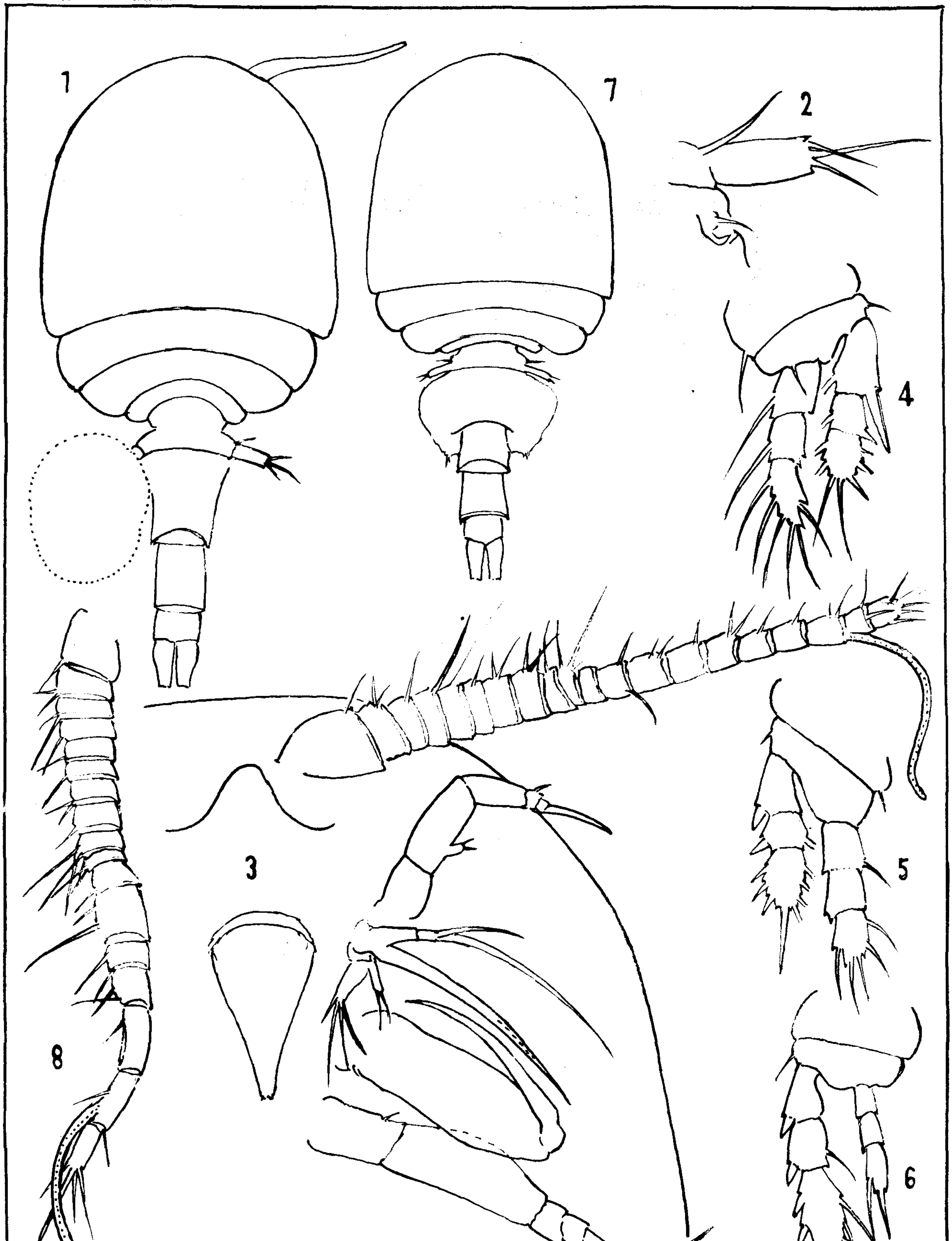


Explanation of Plate XXII

Indomyzon qasimi n. gen. *et*. n. sp.

Fig. 1 female dorsal view
2 female fifth leg with spine on the genital segment
3 female cephalosomal appendages *in situ*
4 female first leg
5 female third leg
6 female fourth leg
7 male dorsal view
8 male antennule

PLATE XXII



Explanation of Plate XXIII

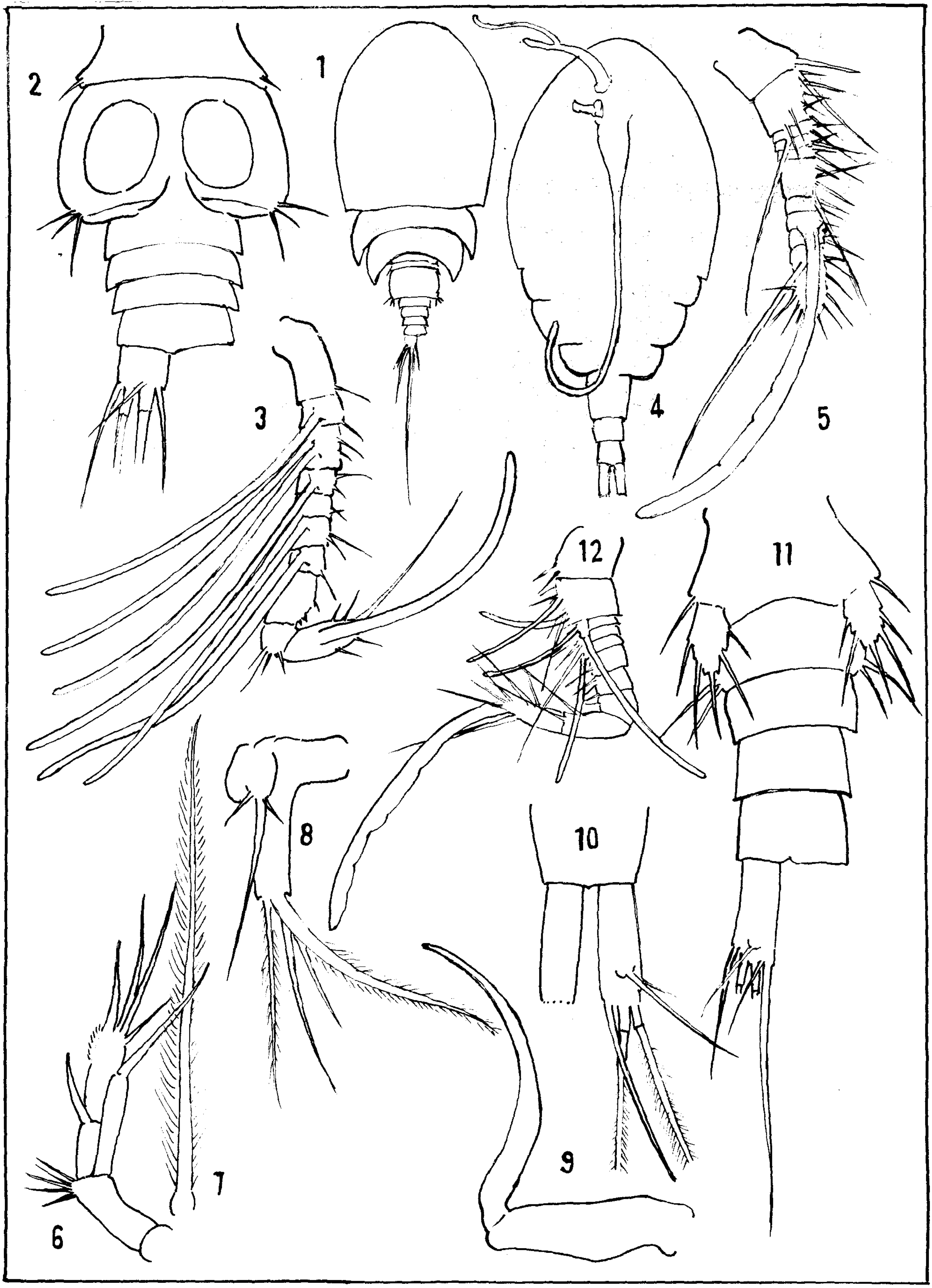
Cryptopontius gracileides Ummerkutty

Fig. 1 male dorsal view
2 male urosome ventral view
3 male antennule

Acontiophorus scutatus Brady

Fig. 4 female ventral view showing the relative length of siphon
5 female antennule
6 female antenna
7 female maxilla
8 female maxillule
9 female maxilliped
10 female caudal rami and last urosomal segment
11 male urosome with fifth legs
12 male antennule

PLATE XXIII

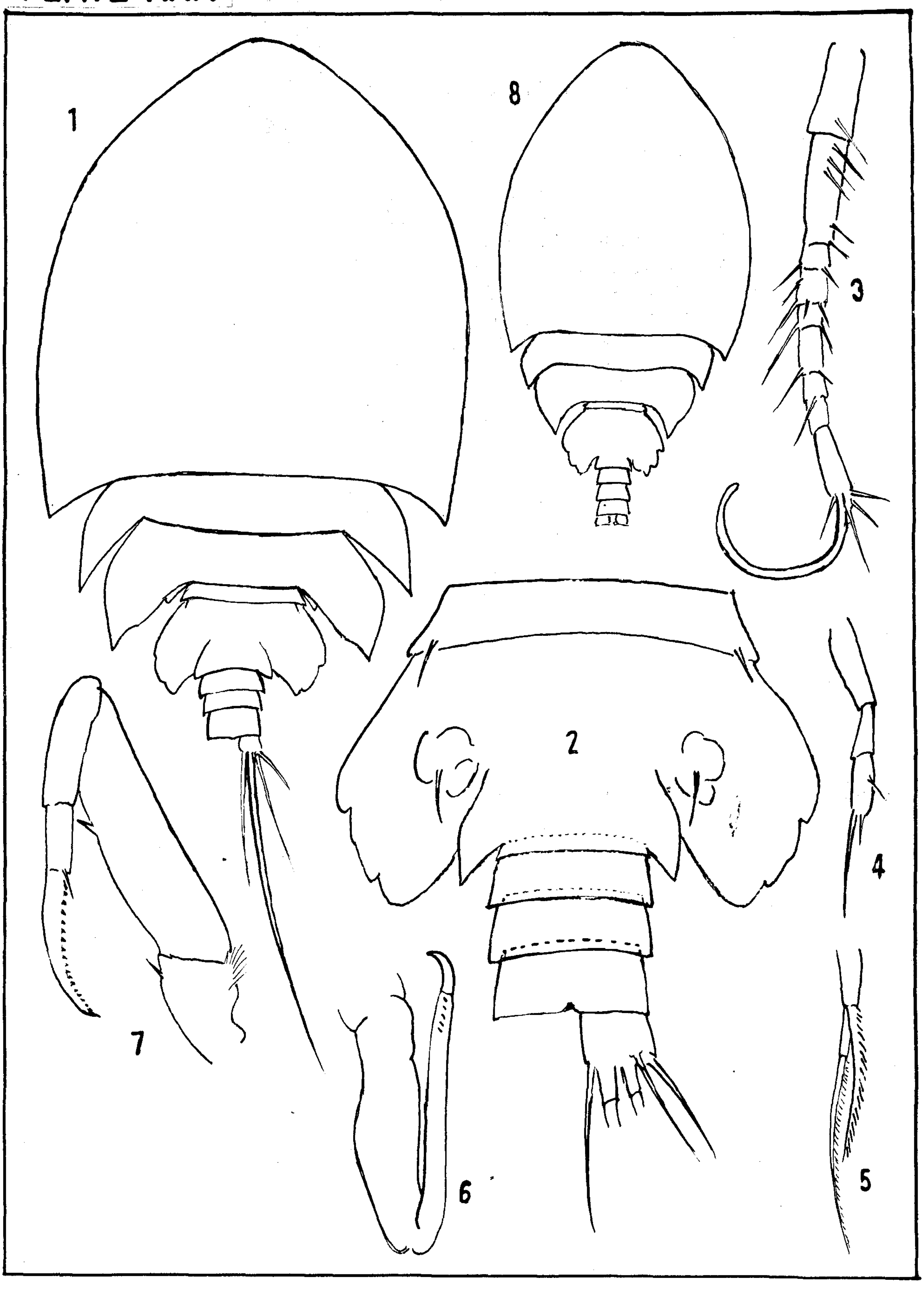


Explanation of Plate XXIV

Sewellopontius rectiangulus n. gen. *et.* n. sp.

Fig. 1 female dorsal view
2 female urosome ventral view
3 female antennule
4 female antenna
5 female maxillule
6 female maxilla
7 female maxilliped
8 male dorsal view

PLATE XXIV



Explanation of Plate XXV

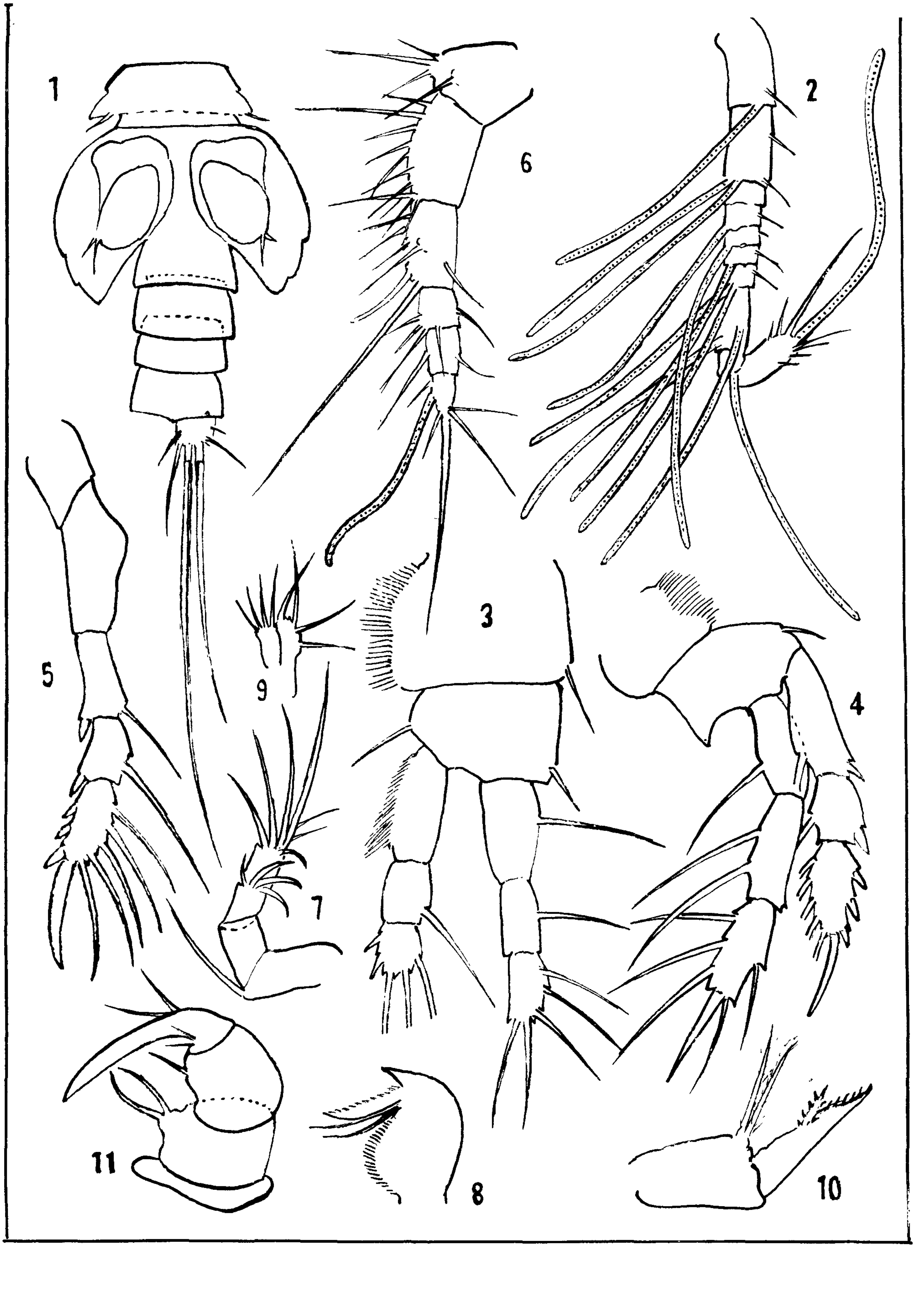
__Sewellopontius rectiangulus__ n. gen. __et.__ n. sp.

Fig. 1 male urosome ventral view
2 male antennule
3 female first leg
4 female third leg
5 female fourth leg

__Hersiliodes latericia__ Canu

Fig. 6 female antennule
7 female antenna
8 female mandible
9 female maxillule
10 female maxilla
11 female maxilliped

PLATE XXV

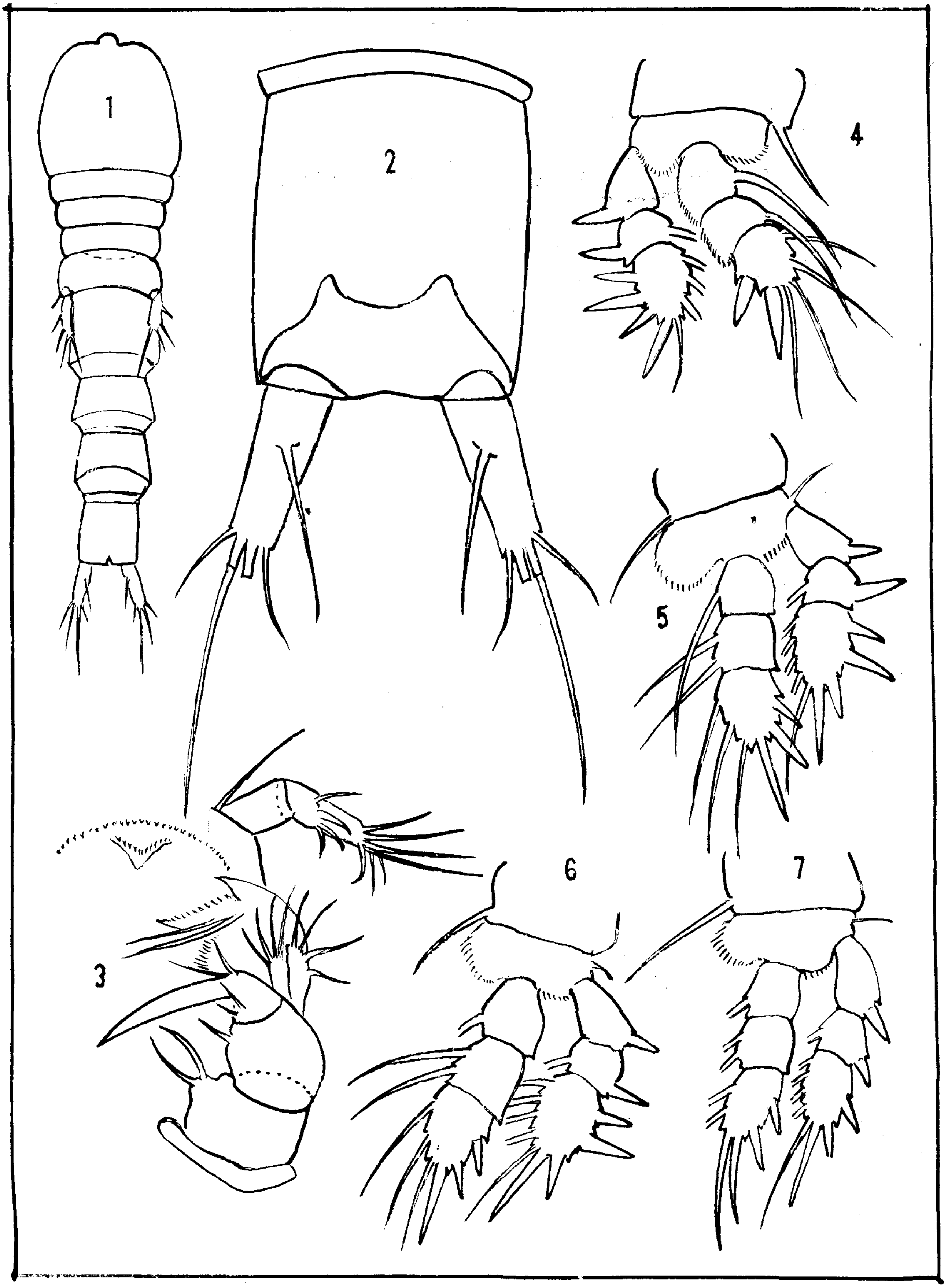


Explanation of Plate XXVI

Hersiliodes latericia Camu

Fig. 1 female dorsal view
2 female last urosomal segment with caudal rami
3 female cephalosomal appendages *in situ*
4 female first leg
5 female second leg
6 female third leg
7 female fourth leg

PLATE XXVI



Explanation of Plate XXVII

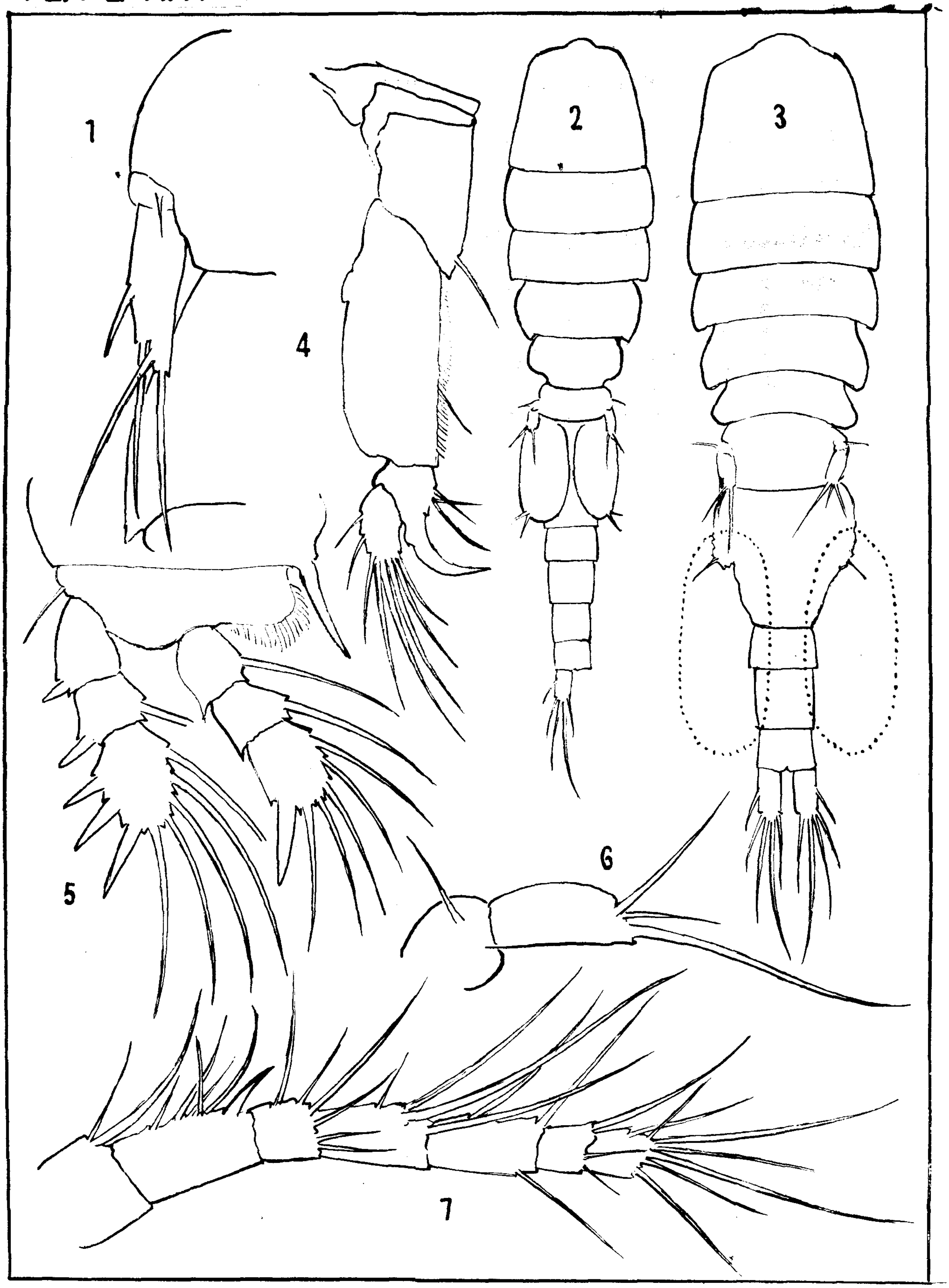
Hersiliodes latericia Canu

Fig. 1 female fifth leg *in situ*

Sabelliphilus foliacea n. sp.

Fig. 2 male dorsal view
3 female dorsal view
4 female antenna
5 female first leg
6 female fifth leg
7 female antennule

PLATE XXVII

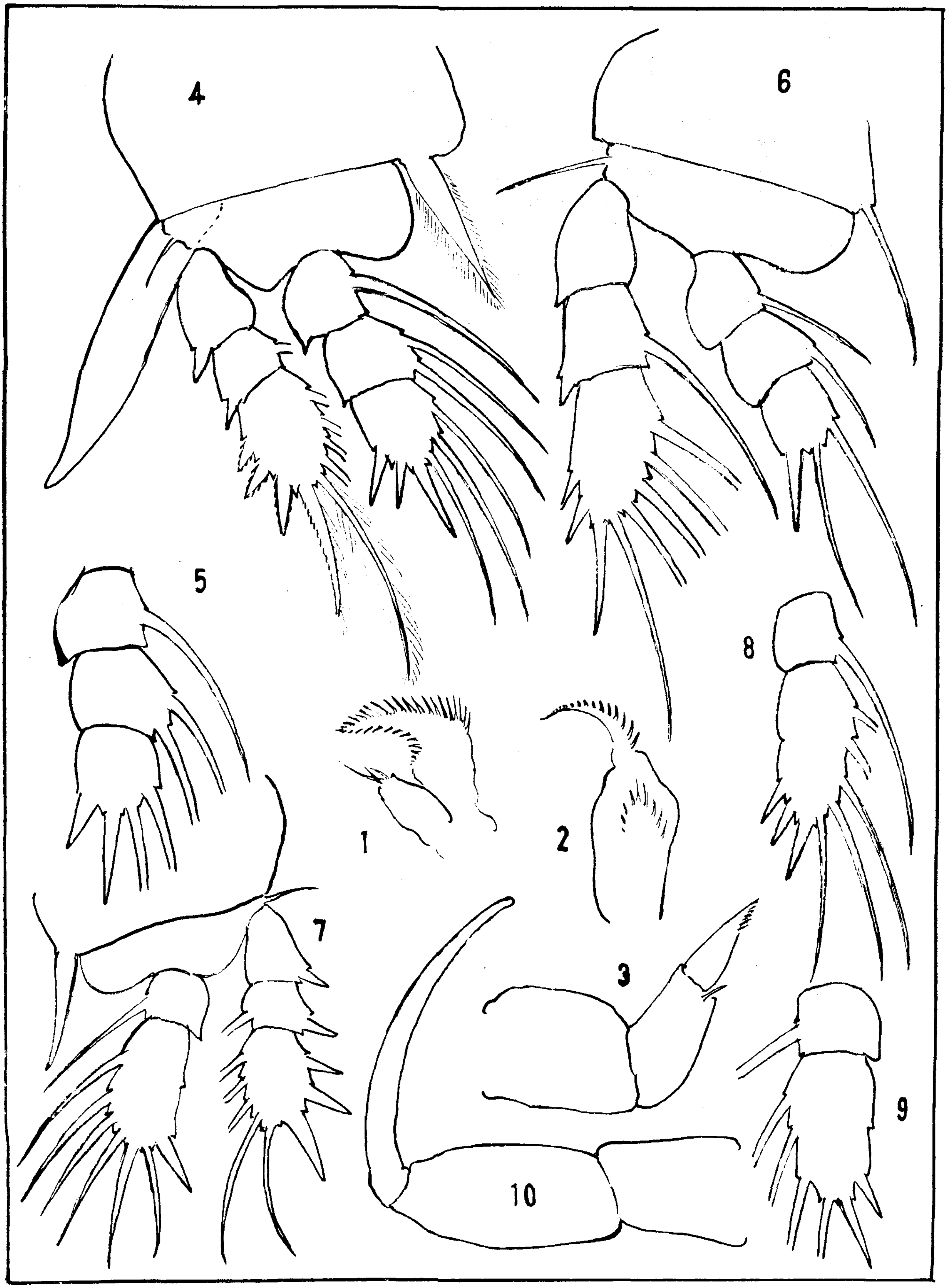


Explanation of Plate XXVIII

Sabelliphilus foliacea n. sp.

Fig. 1 female mandible and maxillule
2 female maxilla
3 female maxilliped
4 female second leg
5 female third endopod
6 female fourth leg
7 male first leg
8 male second endopod
9 male third endopod
10 male maxilliped

PLATE XXVIII

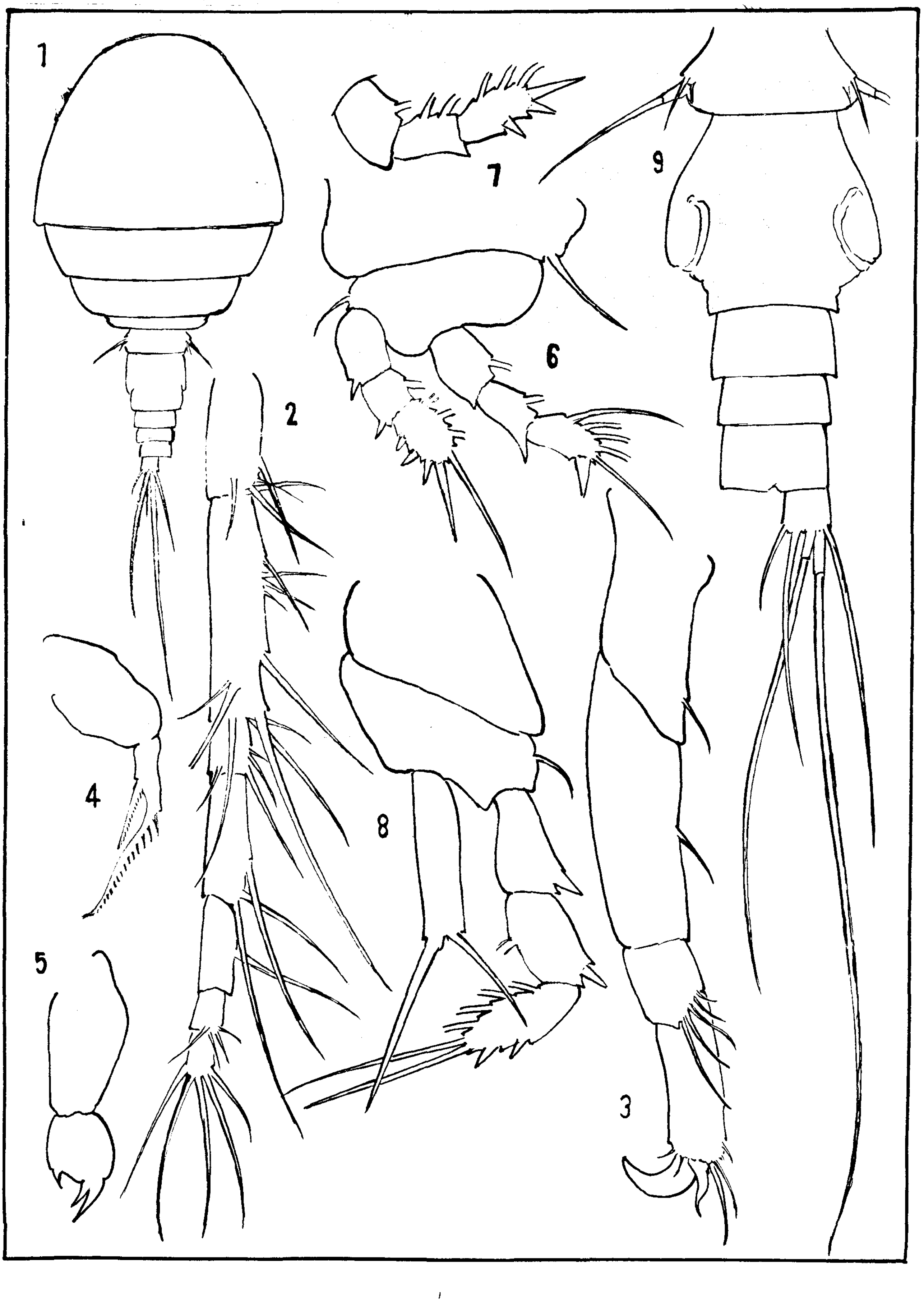


Explanation of Plate XXIX

<u>Pseudoanthessius</u> <u>anormalus</u> n. sp.

Fig. 1 female dorsal view
2 female antennule
3 female antenna
4 female maxilla
5 female maxilliped
6 female first leg
7 female second endopod
8 female fourth leg
9 female urosome with fifth legs

PLATE XXIX



Explanation of Plate XXX

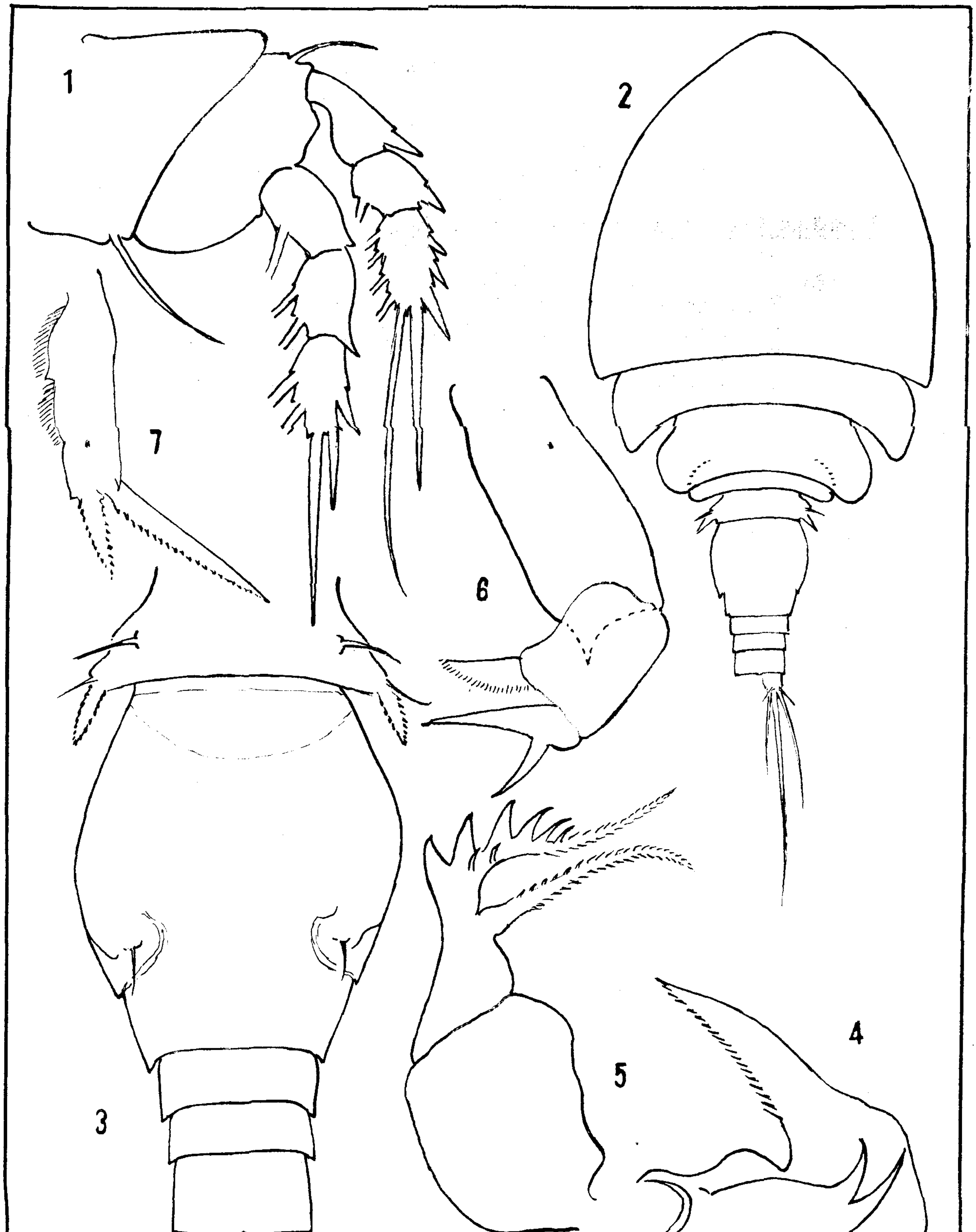
Pseudoanthessius anormalus n. sp.

Fig. 1 female third leg

Pseudoanthessius brevicauda n. sp.

Fig. 2 female dorsal view
3 female urosome with fifth legs
4 female mandible and maxillule
5 female maxilla
6 female maxilliped
7 female fourth endoped

PLATE XXX



Explanation of Plate XXXI

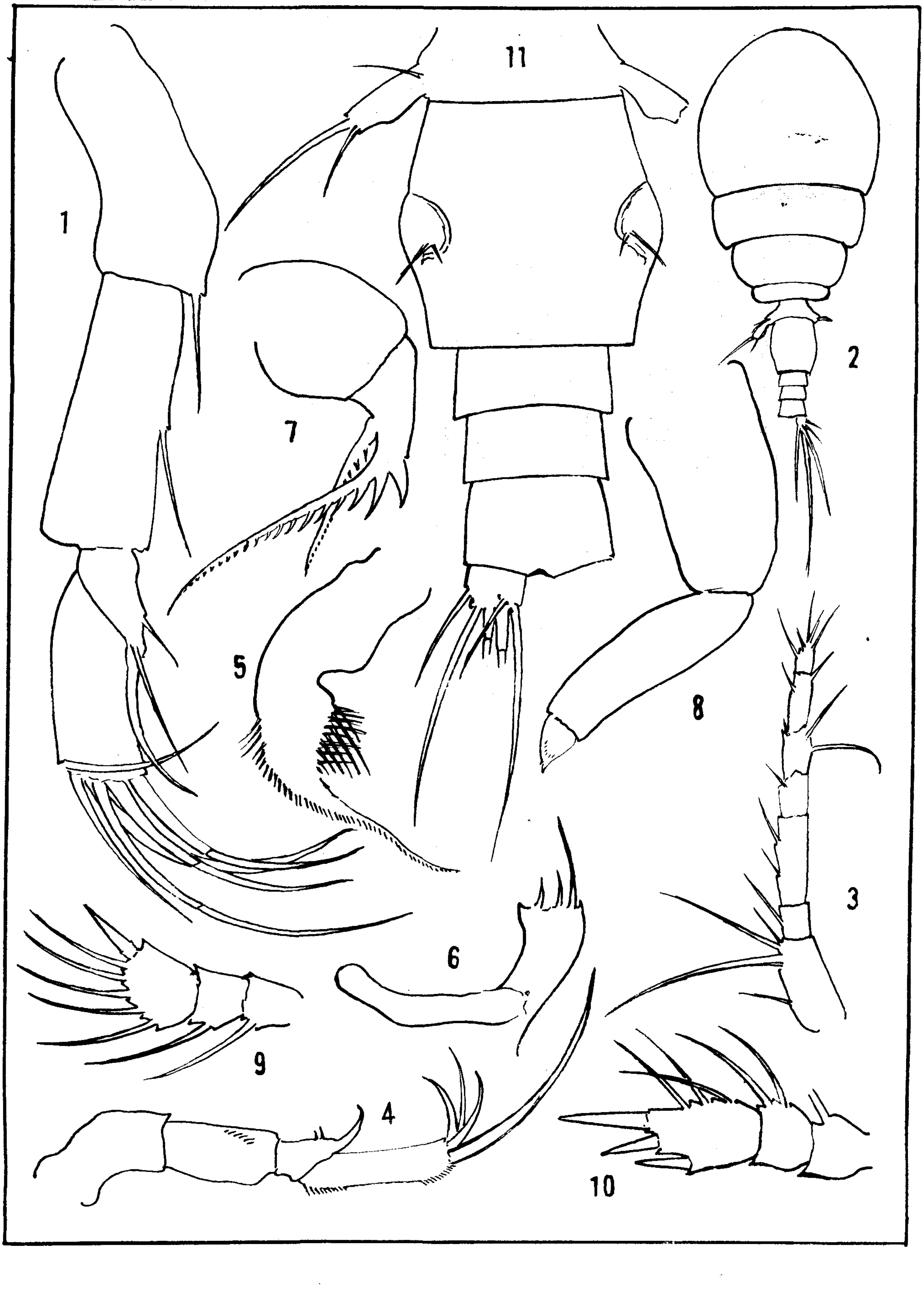
Pseudoanthessius brevicauda n. sp.

Fig. 1 female antenna
2

Lichomolgus sp.

Fig. 2 female dorsal view
3 female antennule
4 female antenna
5 female mandible
6 female maxillule
7 female maxilla
8 female maxilliped
9 female first endopod
10 female second endopod
11 female urosome with fifth legs

PLATE XXXI



PART II

THE BIOLOGY

Chapter 1. Developmental Cycle

Introduction

The developmental stages of the marine calanoid copepods have been rather well studied in countries adjoining temperate seas. In our country, however, no calanoid species has been investigated as to its complete development though the late copepodite stages of a number of species have been described by Sewell (1932, 1947). This lag in studies on the development of marine calanoids is attributable to the facts that majority of them do not carry eggs and that great difficulty is experienced in the laboratory in tracing out the life histories from the various stages as collected from the plankton. In tropical and subtropical countries this is greatly enhanced by difficulties encountered in keeping the copepods alive for a fairly long period under captivity. This unbalanced state of affairs in our knowledge of the life cycles of marine planktonic fauna of the tropics has recently been pointed out by Bogorev (1958) who has greatly stressed the need for working out the developmental stages of the numerically important planktonic sitems. During the present investigations it has been possible to study, in full detail, the developmental cycle of two species, *Pseudodiaptomus aurivilli* Cleve, 1901 and *Labidocera bengalensis* Krishnaswamy, 1952.

The copepod life cycle generally includes six naupliar stages, the last of which moults into the first copepodite stage. In both the above species, however, there are only five free-living naupliar stages, the first stage being suppressed. In the case of P. aurivilli this has been experimentally established. Whether it is true or not for L. bengalensis could not be proved as the adult spermatophore-carrying females never laid eggs in the laboratory. However, even with No. 20 bolting silk nets no nauplius which could be linked with the second nauplius of this species was obtained. This tendency to reduce the number of early developmental stages has been noticed in a number of copepods by the earlier workers (vide. Johnson, 1948).

In all other features the development proceeds in the general calanoid pattern. There are five pre-adult copepodite stages, the sexual distinctions such as those found in the antennule and fifth legs commencing to appear from the fourth stage onwards. Beginning from that stage the male is of smaller size. The order of segmentation of the four pairs of swimming legs follows the same pattern as that found in other calanoids that have been studied.

Procedure

The material used in the present study was obtained from the surface plankton collections taken in the two stations, A and B, in the Gulf of Mannar (Pl. I). Both bolting silk and organdie nets were employed in the collection which extended from April, 1959 to March, 1961. Living as well as preserved specimens were examined for working out the successive stages.

In the case of P. aurivilli the egg-carrying adult females were freshly picked from the plankton and kept individually in separate beakers of 100 cc. and 250 cc. capacities. In most cases hatching took place within 24 hours. Batches of nauplii were removed at 8-hourly intervals and preserved for later examinations. However, in majority of the cases all the nauplii in the culture dishes died on the fourth or fifth day and none lived through all the ~~six~~ stages. Consequently different stages freshly picked from the plankton were reared through at least one moult in the laboratory and thus the next higher stage determined. A total of five specimens of the last nauplius moulted into the first copepodite from which it was comparatively easy to trace to the adult stage.

Spermatophore-carrying adult females of L. bengalensis were similarly kept in the laboratory so as to obtain the first nauplii. But all attempts in this direction failed as the copepod died on the second or third day and no eggs were laid under captivity. However, during the months of April-May, 1960 numerous adults and earlier stages of L. bengalensis were found to swarm the surface waters. As no other species of this genus was found to occur during this period, it was proposed that the earlier stages noticed might belong to the same adult species.

These nauplii were freshly taken from the plankton and reared in the laboratory, establishing, in all, five sequential stages. The correct identity of the larvae was then determined by rearing the last nauplius through the critical moult to the first copepodite which was traceable to the adult of _L. bengalensis_.

Pseudodiaptomus aurivilli

This species is common in Indian waters and is taken in great numbers during the breeding periods. Johnson (1948) has described the post-embryonic development of _Pseudodiaptomus_ (_Pseudodiaptallous_) _euryhalinus_, a species which he himself created a few years earlier (Johnson, 1939). The developmental history of _P. aurivilli_ shows close relationship with that of _P._ (_P._) _euryhalinus_, especially in the structure and segmentation of the various appendages of both naupliar and copepodite stages and in the suppression of the first nauplius, the egg hatching into a stage which is morphologically equivalent to the second nauplius of other calanoid species. However, profound differences exist in the pattern of segmentation of the body and in the fifth pair of legs. The most important specific feature of the nauplii appears to be the length-breadth relationship, along with the structure of caudal armature and the number of setae borne on antennule. In the present species the nauplius that hatches out from the egg has a 62:38 relation between its length and breadth and this is maintained, with little alteration, through all the moults to the first copepodites. In the following pages structures that have already attained adult features in the first copepodite itself are only briefly alluded to while others are described in detail.

Nauplius II (Pl. XXXII, 1.)

Average size 0.162 mm. Body very opaque, eye red. General form oval without indication of hind body. Labrum is prominent in lateral view. Caudal armature, in ventral view, consists as follows: The posterior tip is bifurcated with the right lobe slightly at a higher level than the left one. A strong fairly long spinous seta is borne on the left lobe while an almost equally long fragile seta is borne on the right side. Tufts of small bristles are present at the bases of these two setae. Slightly in front of the caudal armature hairs are present in horizontal rows.

Antennule is 3-segmented, the segments bearing one, two and five setae respectively. The last segment also bears a number of setules on its inner margin. There is a gradual increase in size from the short basal to the fan-like terminal segment.

In antenna the protopodite is 2-segmented, the endopodite is 1-segmented and the exopodite 6-segmented. The basal protopodite bears a strong masticatory process and two short setae. The former is orientated in such a way that its free end is directed towards the labrum. The second protopodite segment also bears two short setae. The endopodite is short and stumpy, bears a single seta on the inner lateral margin and three setae on the apex. Each of the segments in the exopodite is provided with one seta except the last which has two.

The segmentation of the protopodite and the endopodite of mandible is similar to that of antenna, the exopodite, however, being only 4-segmented. In the basal protopodite the future masticatory blade is indicated by a stout spine. The second segment carries only two short setae. In the endopodite two groups of setae are seen. As the segment is more or less circular these groups cannot be termed as inner and terminal. The 4-segmented exopodite is hardly longer than the endopodite and bears five setae. There is no trace of other appendages.

Nauplius III (Pl. XXXII, 2.)

Average size 0.186 mm. The length-breadth ratio of this stage is 62:38 . The posterior side tapers more acutely so that what may be termed the posterior body is indicated. In lateral view this is seen more sharply. In the caudal armature the strong seta on the left side is slightly reduced in comparative length. A short seta is added towards the left side on the same lobe. The orientation of the different setae is better observed in the lateral view where the fragile seta on the right side is seen projecting postero-dorsally, while the left side seta is projecting straight backwards. The newly added seta occupies an intermediate position.

There is no change in the first and second segments of antennule which continue to be as such through all the further stages as well. The fan-like third segment now carries seven setae which are arranged more or less equispaced on the terminal subcircular margin. A few setae are seen on the inner margin in continuation with these setae.

The masticatory process of first protopodite of antenna becomes stronger. An additional seta is present on the second segment. In the exopodite the full complement of eight setae are present, the first four segments with one seta each, the last two segments with two each. The endopodite is 1-segmented and has three setae on the lateral and four on the apical margins.

The masticatory blade of mandible is toothed at its free end. In the second segment of the protopodite one more seta is added, making a total of three. In the endopodite also there are two additional setae, one in the proximal group and the other in the distal. The exopodite is 5-jointed, first four segments with one seta each and the last with two setae.

Maxillules are represented by two strong incurved spines, borne a little behind the mandibles.

Nauplius IV (Pl. XXXII, 3.)

Average size 0.216 mm. In general shape there is not much change from the previous stage except that the dorsal side is more convex. In the caudal armature there are four setae now, two on each lobe. The spinous seta remains the longest and stoutest though its length compared to that of the body is much less. There are several bristles around the caudal setae, as well as in front of it in the posterior region of nauplius. The length-breadth ratio is 62:38 .

There are eleven setae and an aesthetask on the terminal segment of antennule, besides, again, a few hairs on the lower inner margin. The setae towards the apex are longer than those which are more proximal.

The change in the structure of antenna consists in the addition of one seta each on the first protopodite segment and on lateral side of the still 1-segmented endopodite and the transformation of the masticatory process of basal protopodite into a normal spine.

In mandible the broad protopodite segment has a seta in addition to the fairly strong masticatory blade. There is also addition of one seta each both on the second protopodite and on the exopodite.

Maxillule is now a bilobed structure, each lobe bearing three setae which are rather stout and arranged in a radiating manner.

Nauplius V (Pl. XXXII, 4.)

Average size 0.246 mm. The length-breadth ratio is 63:37 . The body shows traces of segmentation. The caudal armature is fully developed and differs from that of fourth stage in having one more short seta on the right lobe, besides a number of bristles and hairs.

There are thirteen setae and an aesthetask in the last segment of antennule. Few setules are present on the inner lower margin.

There is no change in antenna, mandible and maxillule. A rudimentary lobular maxilla with two setae is present a little beyond maxillule.

Nauplius VI (Pl. XXXII, 5-6.)

Average size 0.273 mm. Well-defined constituents of the future cephalosome, two pedigerous segments and the posterior body are present. The length-breadth ratio of the larva is 63:37 .

The last segment of antennule carries sixteen setae and an aesthetask. There is no change in the structure of antennae, mandibles, maxillules and maxillae from that of the earlier stage. Maxilliped and first two pairs of legs are represented by rudimentary leaf-like structures.

Copepodite I (Pl. XXXII, 7-9.)

Average size 0.45 mm. The body is composed of a prosome of four segments and a urosome of two segments.

The cephalosomal segment is more or less rectangular with a broad anterior end. The posterior corners of prosome are rounded. The first and second thoracic segments bear a pair of legs each, while the third segment carries rudimentary third legs. The first urosomal segment is short and at first looks a part of the prosome. But that this segment belongs to the urosome is clearly indicated by its fate in the subsequent stages. There are five caudal setae on each ramus which bear very fine hairs.

Antennule (Pl. XXXII, 10.) is composed of nine segments which bear the following relative lengths:

1	2	3	4	5	6	7	8	9	
18.5	12.0	16.0	7.25	6.75	8.0	9.0	9.5	13.0	= 100

There are very few setae and aesthetasks on the constituting segments, though they are abundantly present in the later stages. Antenna (Pl. XXXII, 11.) has a protopodite of two segments, an endopodite of two segments and an exopodite of three segments. This is also the pattern of segmentation noticed in the adult. Mandible (Pl. XXXII, 12.) is formed by a biting ramus and a biramous palp. It is clear that there are two segments in protopodite, two in endopodite and four segments in exopodite, as there are in the adult. However, the lines of separation between the various segments are indistinct. The basic pattern of adult structure has also been developed in maxillule (Pl. XXXII, 13). But, here, the distal parts of appendage, especially exopodite and endopodite are ill-formed without clear partitions. In maxilla (Pl. XXXII, 14) the protopodite with four endites is clearly seen. Each endite bears, however, only two setae, except the first endite which carries three setae. The segmentation of endopodite is very indistinct as it is in all the stages including the adult. Maxilliped (Pl. XXXII, 15) is only 3-segmented. The first segment is very large with three groups of setae. The second and third segments carry terminal setae, two and six respectively.

The two pairs of swimming legs (Pl. XXXII, 16-17) are biramous, each ramus being 1-segmented. The setal arrangements are shown in the figures. The third leg is rudimentary.

Copepodite II (Pl. XXXII, 18.)

Average size 0.54 mm. An additional segment is present in the prosome, the urosome, again, being 2-segmented. The first three thoracic segments bear biramous legs while the last segment is provided with rudimentary fourth legs. The posterior corners of prosome are rounded.

Antennule (Pl. XXXII, 19) is 14-segmented, the segments bearing the following comparative lengths :

1	2	3	4	5	6	7	8	9
9.63	9.63	5.30	4.70	3.77	4.30	5.01	5.66	7.20
10	11	12	13	14				
6.40	8.30	8.70	9.90	11.50 = 100				

Maxilliped (Pl. XXXIII, 7) is 4-segmented. First segment resembles the corresponding segment of the earlier stage. The second segment which is nearly half the size of first bears three equispaced setae in its distal half. Last two segments are rather small and bear two and six setae respectively. First three segments, in fact, represent the symped while the terminal segment represents endopodite which becomes segmented in later stages.

There are three pairs of biramous swimming legs (Pl. XXXIII, 4-6) and a rudiment of the fourth, borne by four free thoracic segments. In first two legs each ramus is 2-segmented while in the third it is only 1-segmented. The protopodite segments do not bear any seta in any of these legs.

Copepodite III (Pl.XXXIV, 1.)

Average size 0.63 mm. In prosome the full complement of six segments is present, whereas urosome continues to be 2-segmented. There is no sign of the fusion of the first two and the last two segments of prosome, a feature observed in adult animals. The posterior corners are still rounded.

Antennule (Pl. XXXIV, 2) is 21-segmented, the constituting segments having the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11
7.5	2.7	2.4	2.4	2.7	3.0	1.35	2.4	2.4	3.0	3.75
12	13	14	15	16	17	18	19	20	21	
4.1	5.1	5.1	6.1	6.5	5.8	7.15	7.5	8.2	10.85 = 100	

Maxilliped has reached its full development. The endopodite is 5-segmented though some of the partitions are not very discernible.

First four pairs of swimming legs (Pl. XXXIII, 8-11) ~~xxx~~ are biramous and the fifth legs rudimentary. The rami of first three pairs of legs are 2-segmented each, while those of the fourth legs are unimerous. Basal protopodite of the first three legs bear one seta each. No sexual distinction is possible.

Copepodite IV (Pl. XXXIV, 3.)

Average size female, 0.81 mm. and male, 0.78 mm. The fusion of cephalosome and first prosomal segment as well as that of the last two prosomal segments are indicated, though the distinctness of the various segments is still very clear. Posterior corners of the last segment are clearly produced into symmetrical angular projections in both sexes. Urosome is 3-segmented.

Antennule (Pl. XXXIV, 4) is 21-segmented in both sexes. The male antennule, however, differs in the different relative lengths of segments 13-17 (both inclusive). The segments of female antennule share the following proportionate lengths:

1	2	3	4	5	6	7	8	9	10	11
8.4	3.7	4.6	3.1	3.4	2.0	2.0	2.6	2.8	4.0	3.7
12	13	14	15	16	17	18	19	20	21	
4.5	4.2	7.9	4.9	4.6	5.1	5.5	6.7	7.6	8.7 = 100	

Rami of first four pairs of legs (Pl. XXXIII, 12-15) are all 2-segmented. Fifth legs (Pl.XXXIII, 16-17) are similarly constructed in both sexes. Each leg consists of a single, rather elongate segment on each side, continuous with each other at base. Each segment bears three spines, two at the apex and one on the outer margin at about two-third of distal length. The legs of two sides are symmetrical. But male legs differ from those of female in that they are slightly larger than female counterparts and that the terminal spines are comparatively of larger dimensions.

Copepodite V (Pl. XXXIV, 5-6.)

Average size, female 1.0 mm. and male 0.90 mm. The fusion between cephalosome and first pedigerous segment as well as that between last two prosomal segments are complete, though traces of division still exist in the former case. The spines on posterior corners are well-developed and symmetrical, with margins between the two spines being characteristically wavy. Spines of last prosomal segments in female are rather divergent while those in male are projecting directly backwards. Urosome is 3-segmented in female and 4-segmented in male.

Antennule (Pl. XXXIV, 7-8) in both sexes consists of twenty apparently free segments. In female the constituting segments have the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11
7.7	5.0	4.6	3.4	5.7	2.4	2.3	4.7	4.6	5.0	5.8
12	13	14	15	16	17	18	19	20		
5.7	5.8	4.6	4.7	5.7	5.1	5.0	5.8	6.4 = 100		

In male the antenular segments share the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11
8.0	4.5	5.2	4.0	4.0	2.6	2.6	3.2	3.2	5.2	5.2
12	13	14	15	16	17	18	19	20		
5.2	4.5	10.3	5.2	4.5	5.2	5.2	5.2	7.0 = 100		

All the four pairs of swimming legs are well developed, the rami being 3-segmented with final complement of spines and setae (Pl. XXXIII, 18, 19). In female, fifth leg (Pl. XXXIII, 22) is 2-segmented, the basal segment of one side merging with that of the other side. While the basal segment is without any accessory parts, the distal segment bears five spines. Two of these spines are borne on apex while two other spines are set one on either side of this apical complex. Inner apical spine is very large, about four times larger than the outer apical.

Fifth spine is borne on the outer margin of second segment, at about its midlength. Legs of the two sides are symmetrical. In male right leg (Pl.XXXIII, 21) is slightly larger than the left though both are constructed on the same pattern. The male fifth leg also consists of two segments. Basal segments of two sides are fused and do not carry any spine or seta. The arrangement of spines on distal segment is as follows: Two spines on apex, a little separated from one another; two spines on outer margin at about one-third and two-third lengths respectively. The proximal marginal spine and the outer apical spine are of equal size and are larger than the other two spines. There is no trace of endopod either in right or left leg.

Adults

As in many sexually dimorphic species the advancements made by adults over fifth stage consist in the complete development and modification of antennules and fifth legs as well as in the addition of one more segment in urosome. There is complete fusion between cephalosome and first pedigerous segment as well as between the last two prosomal segments.

There is some doubt as to the correct nomenclature of present species and this aspect is discussed in an earlier part where the salient features of adult animals have also been described.

Labidocera bengalensis

There are five naupkiar stages, the first stage being suppressed. Nauplius is characteristically elongate, rather spindle-shaped with posterior part tapering gradually and anterior part abruptly. Anteriormost part is constricted off from rest of body in the form of a hood. The posterior ~~xxx~~ end bears a number of setae, some of which are very long. General pattern of the development of appendages is similar to that of the other two species of this genus whose developmental cycles are known (Johnson, 1935). However, specific differences are clearly expressed. An important character by which the nauplii of this species could be separated from those of other species appears to be the enormous development of one of the setae on second protoped segment of antenna. In other species of Labidocera whose nauplii have been described, this seta is indistinguishable from others and is of no specific significance. Distinct differences are also noticed in the number of setae borne on posterior end of body and on various appendages. The increase in size from first to last stage is explicitely marked and can be used as a safe criterion for ready identification of various stages. Labrum is quite well developed, narrow in the anterior half and is very sparsely armed with short weak setae.

Following the critical moult there are six stages the last of which is adult animal. Copepodites are only immature adults and the chief points of distinction between them consist in the segmentation of body and metasomal appendages. In first copepodite there ~~are~~ is a total of five segments, four prosomal and one urosomal. Second copepodite possesses an additional urosomal segment, the total segments being six. In third stage, urosome is still 2-segmented while one segment is added in prosome which now has reached its full development of five segments. Urosome becomes 3-segmented in fourth stage and remains thus thereafter in female. In male one more urosomal segment is added in fifth stage. This condition persists in adults. The lateral hooks of prosome make their appearance in second stage and are present throughout the life-cycle. Posterior corners of prosome become asymmetrical in male only from fifth stage onwards. Sexual distinction, as usual, can be made out only from the fourth stage.

Nauplius II (Pl.XXXV, 1)

Average size 0.235 mm.

Antennule is 3-segmented, first segment being the shortest and ~~the~~ last the longest. Former bears only a single seta on distal margin. Second segment carries two setae, one about the mid-length and the other on the distal margin. There are three apical setae on third segment and they are all much longer than the other setae. Antennule is directed anteriorwards, both in preserved and living specimens.

In antennaprotopodite is 2-segmented and much longer than exopodite or endopodite. First protopodite carries a masticatory hook and a seta, former being much stouter than latter, although they are more or less of the same length. Second protopodite bears two setae at about the mid-length and a single seta at the inner distal angle. The setae at mid-length are borne on a prominence and one of the setae is extremely large. It is always directed at a distal inner angle and appears to have special masticatory or sensory function. Endopodite is 1-segmented, with one lateral and three apical setae. The outermost apical seta is the longest. Exopodite is apparently 5-segmented, proximal two segments not heving been separated. Each of the segments bears one seta except the terminal which bears two. Antenna is the longest of appendages and appears to play the leading role in locomotion of the nauplius.

In mandible division of protopodite into two segments is not yet clear although the constriction between two future segments is clear enough. On the second half there are two setae. Endopodite is 1-segmented. However, the future segments are indicated by arrangements of setae. Distal segment is indicated by a group of four setae and proximal by three spines. Exopodite is 4-segmented, first and last segments bearing two setae each and others one each. Mandible is usually held in an extero-posterior direction.

Caudal armature consists mainly of two setae, one long and heavily spinous and the other very short and rather spine-like. The point of origin of these setae is guarded by a row of four spinules.

Nauplius III (Pl. XXXV, 2.)

Average size 0.115 mm. The structural advances of second stage over the first are as follows:

Antennule - In terminal segment an additional seta appears at about mid-length. The anteriormost of the apical setae becomes quite long and carries a number of bristles.

Antenna - First protopodite carries one masticatory hook and two setae, one of which is smaller than the other. In second protopodite, one more seta is added, borne very close to the proximal group of two setae found in the earlier stage. In exopodite an additional seta appears on proximal segment, which still is undivided. Endopodite also bears an additional lateral seta, besides the original one lateral and three apical setae.

Mandible - Protopodite is now clearly 2-segmented. First segment bears a single seta and a chewing process; second segment bears three spines, the distal two close together and the proximal separate. Endopodite has three strong spines on inner side (representing the proximal segment) and four slender setae on outer side.

Exopodite has two setae on the proximal segment, indicating the latent 2-segmented nature of that segment.

Maxillule - Bud-like structures with a few hairs appear as maxillules.

Caudal armature - There are two long setae besides a short one. The longest seta is spinous while the shortest is very stout. Spinules guarding the base of caudal setae are reduced to two. However, a group of four spinules, two of them longer than others, are present at some distance anterior to the base of caudal setae. Midway between maxillular bud and this group of spinules a few bristles are borne on either lateral side.

Nauplius IV (Pl. XXXV, 3.)

Average size 0.423 mm. Fourth stage exhibits the following morphological advancements over the third:

Antennule - There is a total of six setae on terminal segment. Three of these might still be termed apical, but it will be more appropriate to state that the six setae are linearly arranged from about mid-length to apex of the segment.

Antenna - Segmentation of proximal segment of exopodite becomes deeper, but still remains incomplete. In endopodite one more seta appears on lateral side, the total now being three apical and three lateral.

Mandible - Masticatory process ~~[illegible]~~ on first protopodite is larger and its apex gives a bifid appearence. Second protopodite bears an additional spine, making the total four which are all closely arranged. In endopodite also there is an increase of one spine on proximal segment.

Maxillule - Maxillule is a clearly defined structure bearing three radiating setae.

Caudal armature - This is more or less fully developed. There are four spines on posterior apex. The two setae on left side are much longer than the two on the right. The longest seta is heavily spinous. Outer of the two right side setae is spine-like and stout. Two masticatory spines found in the earlier stage is highly reduced in size. The groups of spinules and bristles noticed earlier between maxillule and caudal setae are also present.

Nauplius V (Pl. XXXV, 4)

Average size 0.466 mm. This stage differs from the fourth in the following structural details:

Antennule - The second segment of antennule carries three setae, while it was only two in the preceding stage. Two additional setae appears on last segment bringing the total number to eight. All the setae are much longer than before.

Antenna - This appendage reaches its full development. Six segments are clear in exopodite which bears eight setae, second and last having two each and the others one each. In endopodite one more apical seta is added besides a few fine hairs on inner lateral margin.

Mandible - The masticatory process on first protopodite is quite well developed. There are five setae on second protopodite segment, arranged in a radiating way. Spines on the inner side of endopodite are much larger and stouter, one of them carrying spinules on it.

Maxillule - An additional seta appears on inner side. Other posterior appendages are represented by blunt rudiments.

Caudal armature - The main change is in the group of spinules that were arranged accross the ventral surface at some distance in front of caudal setae. These spines have been displaced to lateral positions, three spines being present on each side.

Nauplius VI (Pl. XXXV, 5.)

Average size 0.497 mm. Although several appendages have reached their full development in the preceding stage itself, following structural advancements are noticed in sixth stage:

Antennule - There are ten setae on first segment, linearly set from proximal region to apex. This segment is much larger than other segments. There are also a few hairs near the base of some of the setae.

Maxillule - Proximal portion is contricted from the distal. There are six setae on each maxillule, all on distal half.

Maxilla, maxilliped and first and second legs are clearly visible although they are very rudimentary in structure. While these appendages are mre buds in the earlier stage, here they have become flap-like structures with sharp processed on their posterior margins. They can be snapped off by a fine needle and mounted separately.

Copepodite I (Pl. XXXV, 6-7.)

Average size 0.553 mm. Prosome is composed of four segments and urosome of one segment. First prosomal segment is far larger than all other segments joined together. It is narrow in the middle than in anterior and posterior regions, thus indicating a future division in that region. There is no lateral hook on the cephalosome. Posterior corners of last prosomal segment are rounded. Urosome consists of only a single segment which is rather square, bearing the caudal rami. The latter are longer than wide and bear five setae each. The rostral spine on cephalosome is not yet developed. In lateral view anterior end, in front of antennule, looks quite rounded. Eyes are prominent.

Antennule (Pl. XXXV, 8) consists of nine segments, which bear the following relative lengths:

1	2	3	4	5	6	7	8	9	10
6.0	10.4	12.3	16.6	9.1	10.4	10.4	11.6	13.2	=100

Third and fifth segments are devoid of seta while other segments carry one or more setae. Antenna (Pl.XXXIV, 9), mandible (Pl. XXXIV, 10) and maxillule (Pl. XXXIV, 11) have developed all the features of adult and are sketched. In maxilla (Pl. XXXIV, 12) the distal portion is only 3-segmented while it is 4-segmented in all other copepodites and adults. A few smaller setae on the endites of various segments are also not fully expressed. Maxilliped (Pl. XXXIV, 13) is poorly developed. The sympod is unsegmented as it is in adult and bears four setae, outermost of which is the longest. In endopod only two segments are formed, distal segment carrying two setae which are rather small.

There are two pairs of biramous swimming legs (Pl.XXXIV, 14-15) and a rudiment of the third. Rami of the two legs are each 1-segmented. Protopodites are already divided but the constituent segments do not bear setae. Both first and second endopods carry six setae each whhile exopod carries three setae, four spines and a terminal blade in the case of first leg and three setae, three spines and a terminal blade in the case of second legs.

Copepodite II (Pl. XXXV, 9-10)

Average size 0.680 mm. There is no change in the segmentation of prosome except that traces of partition have appeared in first segment. An additional segment is present in urosome. The anterior urosomal segment is much smaller than the posterior. Lateral spines have appeared on the cephalosome and are situated at about one-third of its length from anterior end. Rostral spines are also developed and can easily be seen projecting prominently ventralwards.

Antennule (Pl. XXXV, 11) is composed of twelve segments sharing the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11	12	
8.8	9.2	5.0	6.3	7.1	9.6	10.5	6.7	7.9	9.2	9.6	10.1	= 100

First and second segments are devoid of setae whereas one or more of them are borne by other segments. Maxilla (Pl. XXXIII, 25) has reached its full development and resembles that of adult except for the smaller size. In maxilliped (Pl. XXXIII, 26) the sympod is fully grown with all seven setae arranged in three groups, first two segments containing two setae each and last three. In endopod there are three segments, proximal two carrying two setae each and distal three setae. The setae are all much long and widely stretched out.

There are three biramous swimming legs (Pl.XXXIII, 1-3) and a rudiment of the fourth, which resembles, in structure, the rudimentary third leg of earlier stage. Exopods of first two legs are 2-segmented while endopods of these legs and both rami of third leg are only 1-segmented. First and second endopods carry eight setae each while third endopod has only six setae. Proximal segment of exopod carries one spine both in first and second legs and is without any seta. Second exopod segment in these two legs bears four setae and a terminal blade. However, the number of spines in first leg is three while it is two in second leg. In last leg endopod has six setae and exopod three setae, three spines and one terminal blade. First protopodite carries one seta in the case of first two legs while it has no seta in last leg. Second protopodite segment is devoid of any seta in any of the legs.

Copepodite III (Pl. XXXVI, 6.)

Average size 0.847 mm. Prosome has reached its full development of five segments, cephalosome and four thoracic segments, last of which is the result of fusion of the original fourth and fifth segments. Lateral hooks and rostral spines look like those of adult. Posterior end of prosome is symmetrical. Urosome still consists of two segments, but there is distinct increase in their comparative sizes.

Antennule (Pl. XXXVI, 24) consists of seventeen segments having their relative lengths as follows:

1	2	3	4	5	6	7	8	9	10	11
6.1	10.3	2.0	3.2	3.0	4.0	4.2	4.4	4.2	6.2	6.0

12	13	14	15	16	17	
8.3	7.1	7.1	7.8	7.8	8.3	= 100

Second segment shows signs of division into three segments. Setal arrangement on that segment also is in agreement with this potential partition. All segments bear setae, but there is a profusion of it in the first seven proximal segments. All other cephalosomal appendages have reached the condition of adult structures. In maxilliped the sympod which is a massive structure now bears seven setae, three of them being of large dimensions. All these setae carry stiff setules on them. Endopod consists of four segments, first and second segments bearing two setae each, third one seta and the last three setae. The setae are all setiferous on one side. Between sympod and endopod there is a spine. Although it looks more a part of sympod, it has been interpreted as representing the first segment of endopod which can be distinguished only with difficulty.

All four pairs of swimming legs (Pl. XXXVI, 13-16) are developed. Exopods of first three pairs of legs are 2-segmented while endopods of these legs as well as both rami of fourth leg are 1-segmented. Basal protopodites of first three legs bear one seta each, distal segments are devoid of any seta. First endopod bears eight setae; second and third endopods nine setae each; and fourth endopod six setae. Basal segments of first and second exopods bear one spine and one seta each, while that of third exopod bears only the spine. Three spines and one terminal blade are present in distal segment of first to third exopods. In the number of setae on distal segment, second and third exopods are similar, bearing five setae each; in first exopod distal segment has only three setae. The 1-segmented fourth exopod bears three setae, three spines and one terminal blade.

Copepodite IV (Pl. XXXVI, 5.)

Average size female, 1.10 mm and male, 1.00 mm. Male is only a little longer than third copepodite while female is much larger. Segmentation of body is similar in both the cases.

Antennule is 17-segmented, the constituting segments having their relative lengths as follows:

1	2	3	4	5	6	7	8	9	10	11
3.9	10.6	4.3	2.6	5.3	3.6	4.3	4.3	6.3	6.6	7.3

12	13	14	15	16	17
7.0	6.3	7.0	7.0	7.0	6.6 = 100

Second segment shows signs of division into four segments. These potential segments find their expression in fifth copepodite. In other mouth-parts the difference~~s~~ from adult structure consists only in size.

Four pairs of swimming legs (Pl. XXXVI, 17-20) and fifth legs are present. Exopods in four pairs of legs are 2-segmented while endopods remain 1-segmented. The number of setae borne by four endopods are nine, ten, nine and seven respectively. In exopod, first segment bears one seta and one spine in the case of first three legs and one spine alone in the case of fourth leg. Distal segment of exopod carries three spines and one terminal blade in all four legs. In the number of setae borne by that segment, however, first leg differs from the others. In the former it is only four while in the latter it is five setae each.

Fifth legs (Pl. XXXVI, 11-12) both in male and female are biramous and constructed more or less on the same pattern. First protopodite segment of both sides are confluent. Second protopodite segment bears a fine seta on its distal outer angle. Endopod, represented by a short smooth segment is devoid of any seta. Exopod is also 1-segmented and carries four short spines, two lateral and two apical. One of the lateral spines originates at about the middle of segment while the other spine is borne towards outer lateral angle. Two apical spines are of unequal sizes.

Fifth legs show slight signs of sexual distinction. In female the right and left legs are symmetrical and of equal dimensions. But in male right leg is slightly larger than the left. This is particularly true of exopodite: right exopodite is clearly broader and longer than that on left side.

Copepodite V (Pl. XXXVI, 3-4.)

Average size female, 1.36 mm. and male, 1.21 mm. Fifth copepodite has assumed practically all the adult structural peculiarities and the changes that follow this stage relate mainly to sexual maturation. In female, prosome has symmetrical posterior margin; in male right posterior corner is prolonged into a digitiform growth while that on left side is conical and much smaller. Female urosome is 3-segmented, first segment (genital) being much larger than the other two combined. It has also developed to some extent the characteristic curvature of right lateral margin of that segment. The numerous glandular openings present on right posterior area in adult female is also observed here. In male urosome is 4-segmented. The small posteriormost segment is added only in the next stage. Segments of urosome diminish in size to posterior side. Caudal rami do not show differences in the two sexes.

Female antennule (Pl. XXXIV, 16) consists of twenty-three segments, the latter having their proportionate lengths as follows:

1	2	3	4	5	6	7	8	9	10	11	12
3.3	8.9	1.6	1.1	0.8	1.9	1.3	2.6	2.6	2.2	3.8	4.5
13	14	15	16	17	18	19	20	21	22	23	
4.8	5.3	6.1	6.4	6.7	6.4	5.3	6.1	6.1	6.5	5.7 =	100

The number of setae borne by various segments are similar to that of adult. Antenna, mandible, maxillule, maxilla and maxilliped have all attained the adult pattern of structure.

Four pairs of swimming legs (Pl. XXXVI, 21-23) have also developed fully, exopods being 3-segmented and endopods 2-segmented. The ornamentation of the swimming legs is given below and is similar to that of adult.

	Protopod				Endopod					Exopod						
	1		2		1		2			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	0	3	0	3	2	1	1	I	1	I	4	I	II
P_2	1	0	0	0	3	0	4	2	2	1	I	1	I	5	I	III
P_3	1	0	0	0	3	0	4	2	2	1	I	1	I	5	I	III
P_4	1	0	0	0	3	0	3	2	2	1	I	1	I	5	I	III

In basic pattern of organisation, female fifth legs (Pl.XXXVI, 9) like those of fourth stage, resemble fifth legs of adult. On each side it consists of a 2-segmented protopodite and two rami, both of which are uniramous and of different sizes. Endopodite is devoid of setae; however, its apex gives a split appearance. Exopodite which is longer than endopodite bears two equispaced lateral and two apical spines. The latter are much stouter and of larger size than the former. In protopodite the basal segments are still confluent, while the separate distal segment bears a long slender seta on each side.

Male is smaller than female and shows sexual dimorphism which is externally expressed in the structure of antennules, fifth pair of legs, posterior corners of prosome and in segmentation of urosome.

Right antennule (Pl. XXXIV, 17) is geniculate and composed of nineteen segments. The partitions between second and fifth segments are, however, not very clear unless carefully observed. The constituent segments show the following relative lengths:

1	2	3	4	5	6	7	8	9	10	11	12	13
4.1	10.2	1.0	1.3	2.6	3.3	2.6	2.3	3.6	4.3	3.6	5.1	7.6
14	15	16	17	18	19							
7.1	12.3	9.2	6.1	6.6	7.1 = 100							

Besides setae, the segments in middle region of antennule also bear a number of aesthetasks.

Male fifth legs (Pl. XXXVI, 10) differ from those of female not only in structural pattern but also in that they are highly asymmetrical, right leg being larger than that of female. Each leg consists of a 2-segmented protopodite and an 1-segmented exopodite, the endopodite entirely lacking. Basal protopodite of two sides are, again, confluent. Distal segments do not bear seta. Exopodite of left side bears a lateral spine which is conical and rather insignificant and two stout apical spines. Exopodite of right side bears two apical spines which correspond to those of left side and two lateral spines. One of these lateral spines is much long and is borne a little proximal to middle of the segment while the other small spine is borne at midway between the large spine and the apex.

Adults (Pl. XXXVI, 1-2.)

Average size female, 1.43 mm. and male, 1.20 mm. Krishnaswamy (1952) who first described this species has given a detailed account of the adult male and female. However, one or two minor differences in structural details are noticed and are recorded below. Krishnaswamy (loc. cit.) in his text mentions that there are twentytwo joints in female antennule but figures only twenty. Probably it is because "the joints between three and five are not very clear". However, in the present case, twentytwo joints are very clear and there is indication of a twentythird segment. Further, a comparison of the lengths of proximal eight segments (six segments in the figure given by Krishnaswamy) show that the proportionate sizes of these segments do not exactly correspond in the two cases. Probably this is not a very serious variation for, the partitions between some segments are discernible only with difficulty. In the organisation of male geniculate antennule, there is full agreement between the present observations and the accounts given by Krishnaswamy.

S U M M A R Y

The post-embryonic development of two species of calanoid copepods, Pseudodiaptomus aurivilli and Labidocera bengalensis are described in detail. The ~~identifying~~ diagnostic features of various nauplii and copepodites of the two species are presented and figured.

There are only five naupliar stages, instead of the usual six met with in several other calanoids, the first nauplius being suppressed. Last nauplius metomorphoses into first copepodite which moults five times to become adult, passing on the whole through five stages. In both species the sexual dimorphism sets in from the fourth stage onwards and the chief difference between the fifth stage and adults consists in the sexual maturation and the related changes.

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Explanation of Plate XXXII

<u>Pseudodiaptomus euryhalinus</u> [illegible]

Figs. 1-5 Second to sixth naupliar stages

6 Sixth nauplius, antenna

-8 First copepodite, dorsal and lateral views

9 First copepodite, posterior region enlarged to show the rudimentary third leg

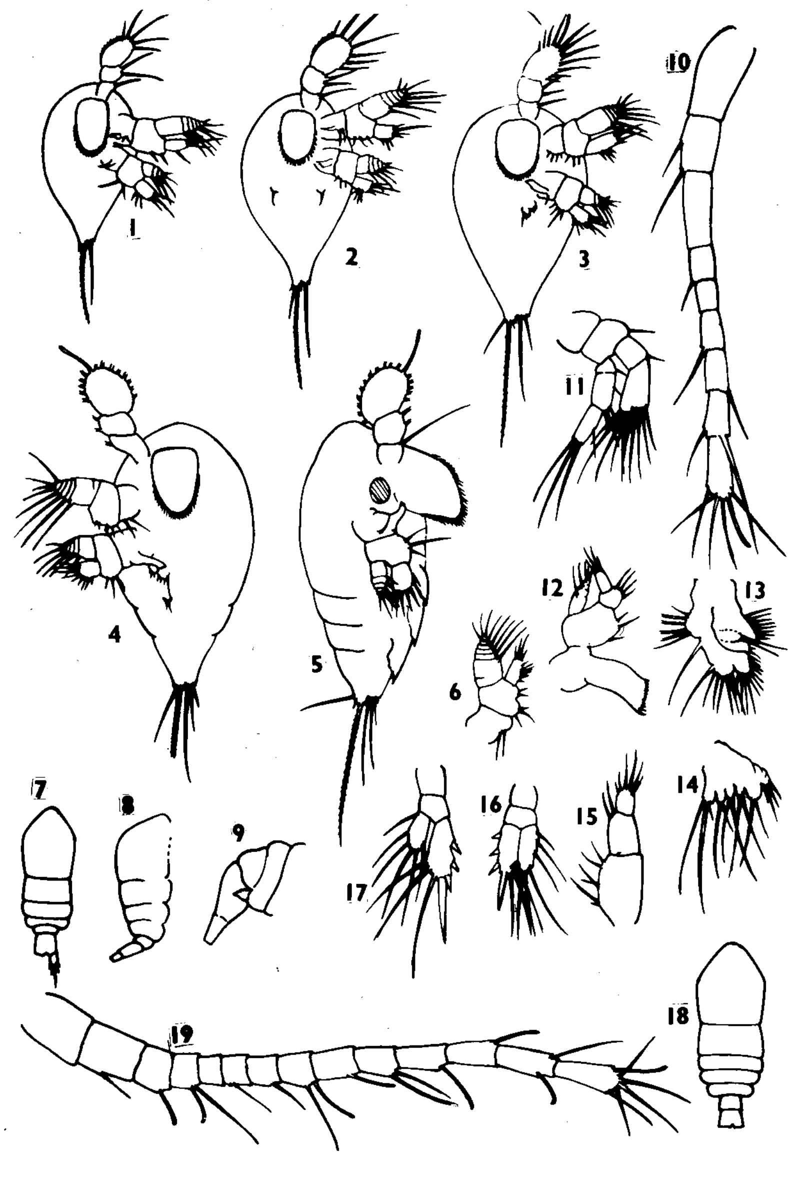
10-15 First copepodite cephalosomal appendages

16-17 First copepodite, first and second swimming legs

18 Second copepodite dorsal view

19 Second copepodite antennule

PLATE XXXII



Explanation of Plate XXXIII

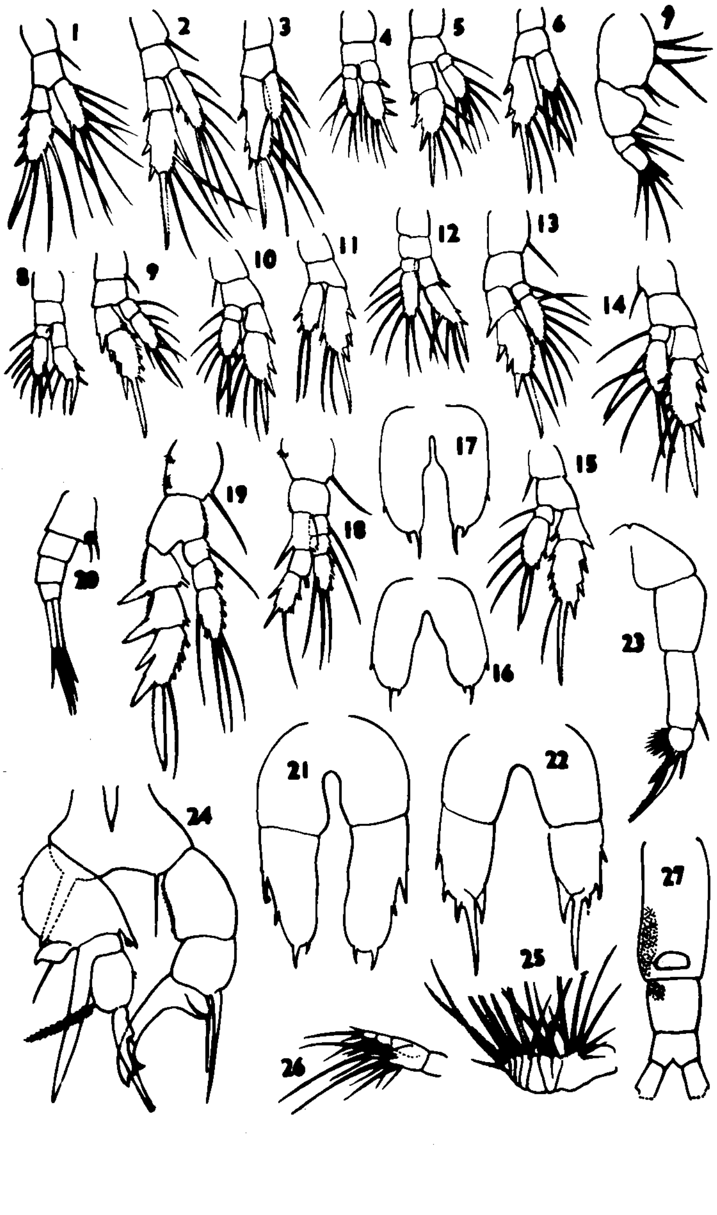
Labidocera bengalensis Krishnaswamy

Figs.	1-3	Second copepodite, first to third legs

Pseudodiaptomus aurivilli Cleve

Figs.	4-6	Second copepodite, first to third legs
	7	Second copepodite maxilliped
	8-11	Third copepodite first to fourth legs
	12-15	Fourth copepodite first to fourth legs
	16-17	Fourth copepodite female and male fifth legs
	18-19	Adult, first and second legs
	20	Adult, urosome with genital spines
	21-22	Fifth copepodite male and female fifth legs
	23-24	Adult, female and male fifth legs

PLATE XXXIII

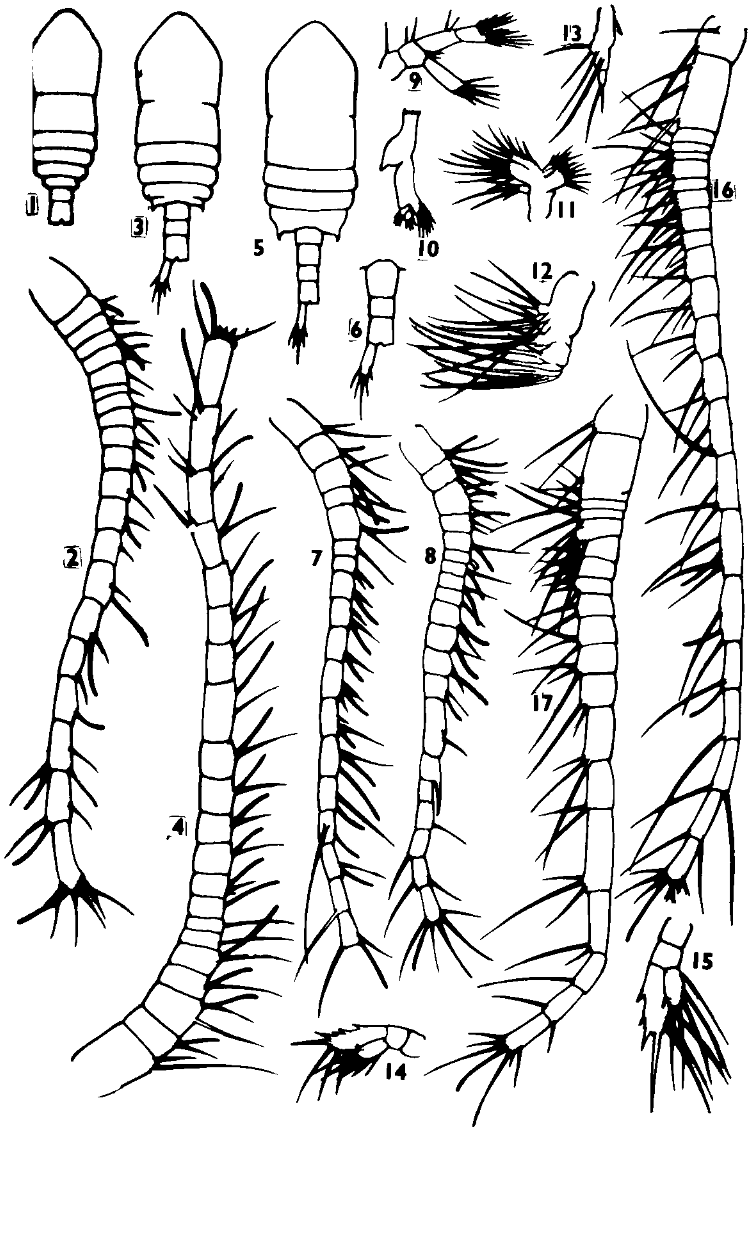


Explanation of Plate XXXIV

Pseudodiaptomus aurivilli Cleve

Figs.	1	Third copepodite, dorsal view
	2	Third copepodite, antennule
	3	Fourth copepodite, dorsal view
	4	Fourth copepodite, antennule
	5	Fifth copepodite, male dorsal view
	6	Fifth copepodite, female urosome dorsal view
	7	Fifth copepodite, female antennule
	8	Fifth copepodite, male geniculate antennule
	9-13	First copepodite, cephalosomal appendages
	14-15	First copepodite, first and second swimming legs
	16	Fifth copepodite, female antennule
	17	Fifth copepodite, male antennule

PLATE XXXIV

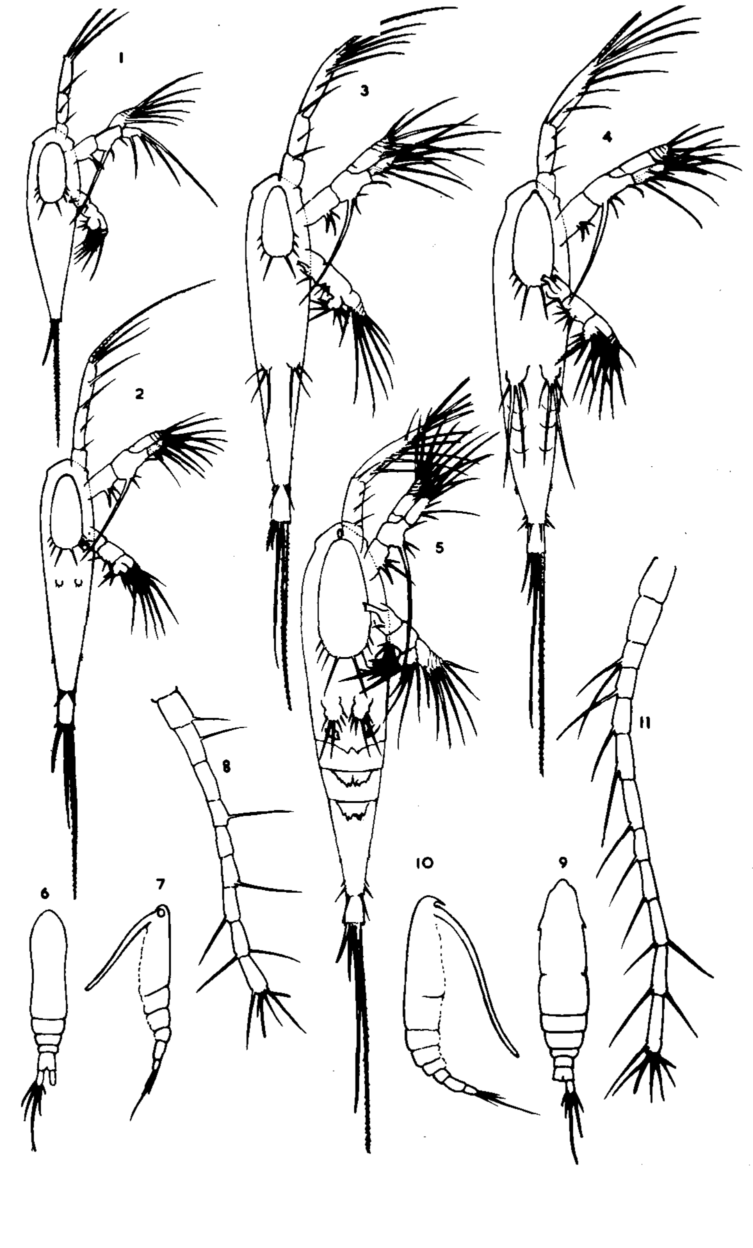


Explanation of Plate XXXV

Labidocera bengalensis Krishnaswamy

Figs.	1-5	Second to sixth naupliar stages
	6-7	First copepodite, dorsal and lateral views
	8	First copepodite, antennule
	9-10	Second copepodite, dorsal and lateral views
	11	Second copepodite, antennule

PLATE XXXV



Explanation of Plate XXXVI

Labidocera bengalensis Krishnaswamy

Figs.	1-2	Adult, female and male urosome, dorsal view
	3	Fifth copepodite, female dorsal view
	4	Fifth copepodite, male urosome, dorsal view
	5-6	Fifth and fourth copepodites, dorsal view
	7-8	Adult, female and male fifth legs
	9-10	Fifth copepodite, female and male fifth legs
	11-12	Fourth copepodite, female and male fifth legs
	13-16	Third copepodite, first to fourth legs
	17-20	Fourth copepodite, first to fourth legs
	21-22	Fifth copepodite, first and second legs
	23	Fifth copepodite, endopod of fourth leg
	24	Third copepodite, antennule

Chapter 2. Diurnal Vertical Migration

Introduction

Both Russell (1927) and Cushing (1951) have reviewed this problem excellently and have shown that majority of the zooplankton species undertake extensive vertical movements in the waters they inhabit. The massive movement of these organisms, upwards and downwards during the period of 24 hours, is an impressive phenomenon which must be fully studied in order to obtain a closer understanding of the biological and ecological conditions characteristic of a given species. The patterns of vertical movements may differ not only between different species, but also between different developmental stages and sexes of the same species. It may also vary in different latitudes, under different physico-chemical environments of the same latitude and also in various seasons. It is the result of a combination of several physical and physiological factors which, while acting together, produce a unique rhythm, more or less steady in a species under a particular set of conditions.

The vertical movements of copepods have been subjected to extensive investigations in Polar and Temperate waters (Bogorov, 1946; Ussing, 1938; Wiborg, 1954; Russell, 1925, 1926, 1928a & b; Nicholls, 1933; Clarke, 1933; 1934a, b & c; Farren, 1947; Bainbridge, 1952). The informations available on this subject in tropical and subtropical waters are, however, very meagre. This is particularly true of the Indian region where little work has been done in this field. The studies reported here aim at establishing the nature of vertical migration performed by planktonic copepods in our waters. It must, however, be noted that the investigations have been carried out at a depth of about six fathoms, and the data on which the present concusions are based, therefore, refer to shallow waters only.

The results obtained indicate that the idea of diurnal vertical migration holds valid in tropical waters also, at least in some species of copepod. This statement is based upon two types of evidences: (i) The number of individuals of a species, especially adults and late copepodite stages vary considerably in surface hauls made at 4-hourly intervals. During the dark hours there is a great increase in their number, while a considerable reduction is observed during the bright day-light hours. This indicates that the population as a whole withdraws itself from the brightly-lit zones, although stray individuals remain present in all the layers, ~~in~~ irrespective of changing light intensities. (ii) Simultaneous collections made with Clarke-Bumpus Apparatus at surface and at depth indicate that during the day time adults and late copepodites concentrate more in the deeper areas and that they extend their distribution to the upper waters only when darkness sets in, This alteration in distribution of populations in the two layers, coinciding with the changes in the intensity of light is consistent and falls in accordance with the idea of diurnal vertical movements.

Material and Methods

The material for the present study was collected at Station C (Pl. I) in the Gulf of Mannar. It is situated at about six miles from the Central Marine Fisheries Research Institute and about one mile from the Hare Island. Three series of collections were made: (1) Using both organdie and No. 16 bolting silk nets, 4-hourly surface hauls were made on 12th and 13th January, 1960 commencing at at 6 a.m. on the first day and ending at 6 a.m. on the second day. Temperature of the water both at surface and at depth were noted along with each collection and water samples were taken for determining the salinity from both hauls. During this first series of collections the weather was fair and there was moon light upto early hours of the morning.
(2) Attempts to make similar collections throughout day and night did not succeed on 20th February 1960. After 6 p.m. the sea became rough, with a strong wind blowing towards the mainland and it was found difficult to continue the work in the sea. In this second series of collections data are, therefore, available only for the day. (3) Four-hourly collections were made for 24 hours on 8th and 9th March 1960. The Clarke-Bumpus Apparatus was employed for making collections both at the surface and down below. Organdie and bolting silk half-metre nets were put to use for making surface hauls. The sky was bright during the day and cloudy during the night.

All the collections were preserved in 5% formalin immediately after the haul. Subsampling for laboratory analysis was done as follows: All samples were made to 250 cc. by adding properly diluted formalin and a subsample of 10 cc. pipetted out. In the case of collections obtained by Clarke-Bumpus Apparatus the entire subsample was examined. However, the half-metre net collections invariably contained a much higher amount of organisms and hence it was found difficult to subject the entire subsample to a detailed study. Subsequently, further subsampling had to be done in the case of collections made by organdie and bolting silk nets and only a sample of 2 cc. of the original 250 cc. was examined in detail.

Volumetric Composition

The volumetric composition of copepod and non-copepod items was determined in wet condition using the principle of displacement and is presented in table II. After qualitative analysis, copepod and non-copepod items of each subsample were sorted out separately and were introduced to graduated capillary tubes which contained known quantities of sea water. The volumetric value of the introduced item was then directly found from the difference of initial and final readings of water levels.

The maximum concentration of copepods at surface was found at 9.45 p.m. The persistent distribution of a certain percentage of copepods in the surface waters is because of early larval forms which are relatively less rapid in changing the site than adults and late copepodites. Some of the non-copepod items of plankton show as much migratory behaviour as copepods. *Sagitta* spp. and *Lucifer* spp. both of which are well-known to display pronounced vertical movements have been found performing day and night journeys in response to light.

Gravimetric Estimation

To give a clearer picture of the whole series of changes in diurnal migration, a gravimetric estimation is more important. A subsample of copepods contained in 2 cc. of the surface hauls made by organdie net was dried in a watch glass and weighed. Similarly a subsample of 10 cc. of each of the collections taken by Clarke-Bumpus Apparatus at surface and at 5 metre depth was dried and weighed. The data obtained are presented in tables III & IV and figures 1 & 2 (Pl. XXXVII). In the figures copepod populations are expressed as a whole and include adults and copepodites of both sexes. As can be seen from the figures, although the population as a whole is subjected to up and down movements, yet a certain percentage of plankton retains their respective levels, without undertaking ~~of several species~~ migrations. These include not only copepodites of several species but also adults of such species as *Acrocalanus monachus*, *Paracalanus parvus* and *Oithona* spp. which are composed of small-sized individuals. It is, however, clear that there occurs a conspicuous reduction in the abundance of copepods at the surface during the mid-day hours and this is followed by a high concentration of these creatures in surface waters during midnight.

Numerical Composition of Species

Pseudodiaptomus aurivilli Cleve - Figures 3 & 4 (Pl.XXXVII) show the distributional pattern of this species at 5 metre level and at the surface as sampled by a Clarke-Bumpus Apparatus during March 1960 and the actual numbers of copepodites and adults caught in the surface hauls by organdie net during the 24 hour period are presented in table V. It can be seen both from figures and table that the adult population of this species displays great variation in their numbers in surface waters. After sunset as many as five times more adults are caught at surface than at noon. There seems to be little change in the distributional pattern of copepodites except, to some extent, in the case of fifth stage which shows a higher concentration at surface during late hours of the evening. The complete absence of first stage and less numbers of the next two stages in the surface hauls is probably due to sampling inadequacies.

A sex-wise analysis of adults does not show any difference in the pattern of response. The males dominate most of the time except during the dusk and early morning hours when they are slightly less than the females. This is due to a greater preponderance of males in the population during breeding months (December - March).

<u>Centropages furcatus</u> (Dana) - This species is composed of fairly large-sized individuals, but it occurs only in small numbers. The members of this species appear to react strongly to day and night changes. During noon not a single adult animal was observed at surface in any of the three subsamples analysed, but in samples taken at 10 p.m. and at 2 a.m. twelve and sixteen individuals respectively were

caught. During the intergening hours the increase or decrease showed gradations (Fig. 5, Pl. XXXVII). Due to the scarcity of this species in plankton it was not possible to sample it properly by the Clarke-Bumpus Apparatus and therefore no thorough observation could be made on the distribution of this species in different vertical levels.

<u>Calanopia elliptica</u> Dana - In this species also substantial evidence has been obtained to illustrate migratory movements. At dawn the species is represented by a few adults in the plankton, but as the day advances it gradually disappears from the surface waters and none is seen throughout the brightly-lit hours. During the night at about 10 p.m. large numbers became available at surface. However, a decline in the abundance is observed in the early hours of the following morning (by 2 a.m.). This probably may be attributed to what Cushing (1951) termed a departure from the surface at midnight. According to this view, copepods migrate upwards as darkness intensifies and reach their maximum surface distribution by about 10 p.m. In complete darkness these organisms stop swimming and sink passively down. Thus, being unable unable to maintain their topmost level, they get distributed in layers down below. This phenomenon which could be termed positive geotaxis gets combined with photokinesis. It is particularly notable in the present species probably because of its larger size (Fig. 6, Pl. XXXVII).

<u>Acartia erythraea</u> Giesbrecht - This is one of the commonest species of this area and appears to have preference for upper water layers during the hours of darkness Minimum numbers are found at surface during noon while the maximum

concentration occurs eight hours later which condition persists till the early hours hours of the morning. The data obtained for the months of January and March are plotted in Fig. 7 (Pl. XXXVII) and that for March alone are presented in table VI. In March only the adults and the fifth copepodites were found. It can, therefore, be inferred that at this time of the year the species reaches the end of its breeding season. As in C. furcatus in this species also the maximum concentration in surface waters is reached at about 10 p.m. This is followed by a slight declination.

The data obtained for this species from collections made by a Clarke-Bumpus Apparatus do not substantiate the conclusions derived at from the studies of organdie net collections. Table VI shows the distribution of fifth copepodites and the adults of this species at 5 metre level and at the surface during the month of March.

Probably in this species also like several others, the diurnal migratio is not an obligatory phenomenon. They tend to avoid the b ghtly-lit surface layer during the day time and in doing so get distributed at lower layers. The chief notable feat presented in table VI are the low number of adults cau t the surface during noon and gradual higher conc ppearing at deeper levels. After sunset there is ne iable decrease in their numbers in areas near the bot nifies that the population remains fairly at all levels above the bottome. In the surface here occurs a progressive increase as the

Centropages dorsispinatus Thompson & Scott - This species showed a very irregular distribution. Although there was an apparent withdrawal of the population away from the surface during the sun-lit hours, the population did not return to its original density in the surface waters even during the darkest hours (Table VII). Cushing (loc. cit.) and other earlier workers have rightly pointed out the inadequacies of the studies of selected horizontal stations in the investigations on vertical migration. Cushing has shown that neither the vessel marking the collections nor the water mass in which the collections are made remain static even for short intervals. There is always an exchange of fauna with the surrounding waters. This changing pattern becomes all the more complicated by the patchy nature of the distribution of copepods in the sea. An area where there is a swarming of copepods in the morning could be replaced in the evening by a mass of water containing little of them. The example of C. dorcispinatus may be a case of such an instance.

*Pseudodiaptomus (Schmackeria) serricaudata T. Scott - Within the limits of the available data for this species, it appears that there is an inherent, positive, migratory behaviour. The maximum number is found in the surface layer during the dawn, and then there occurs a decline in their numbers. A slight increase is noticed at dusk which is maintained upto midnight after which the species records appreciable increase (Table VIII). Why there should be a concentration on the surface in early morning hours, rather than during darkness, immediately after dusk is hard to explain. In spite of the fact that migratory

*The systematic position adopted for this species in the present work is discussed in Part I.

behaviour of this species is governed by diurnal changes, yet a clear response could not be obtained. It is likely that an accidental error might have crept into the data because of their patchy distribution in plankton, a feature common in copepods and has already been noted earlier.

General Remarks

As outlined by Cushing (*loc. cit.*) the general pattern of diurnal vertical migration of planktonic crustacea are governed by the following features: (1) Ascent towards the surface from the day depth, although animals, particularly oceanic species do not necessarily reach the surface, but merely rise to a higher level. (2) Departure from the surface, at or before midnight. (3) Return to surface just before dawn. (4) Descent to the day depth when the sunlight starts penetrating the water. (5) The variable day depth which recalls an uneven distribution of these animals from ½ metre in Lake Mendota to 800 metres in North Atlantic. This depends on various factors such as depth, type of water mass, the species under study, the currents and a host of others (*vide* Cushing, *loc. cit.*).

Russell (1927) and Cushing (*loc. cit.*) have discussed earlier the various factors which influence the~~ir~~ behaviour pattern of the migrating species. These factors include sunlight, weather, water temperature, presence and abundance of phytoplankton, age of the animal concerned.etc. In addition to this, physiological factors have also been held responsible for the hazarduous vertical sojourns that these tiny creatures undertake during the course of a day.

The effect of weather is rather indirect. During a cloudy day, the penetration of light into the water is poor. It thus creates artificially a situation which is comparable to dawn or dusk. A windy weather will make the surface turbulent thus making this layer physically uninhabitable.

The effect of temperature appears to act chiefly in the regions of thermoclines: "It is a possibility that a homogeneous group of animals (stage, sex or brood of a species) has a temperature range beyond the extremes of which the animal does not appear; a thermocline near the limits of this range will be obviously more effective in ~~mt~~ modifying migration that one in the centre of the range. As a mediator of migration temperature was shown by Esterley (1912) to be without effect as the diurnal differences in temperature at any depth was only a small fraction of the temperature range through which the animals moved" (Cushing, p. 165). This view is substantiated by the present series of observations. The change in temperature between the surface and the depth during the 24 hours was very negligible (table IX).

The importance of phytoplankton in the migratory activities of planktonic copepods has recently been discounted as these animals are filter feeders and are incapable discriminating between the food-abundant areas and others. The age as well as the inner physiological rhythm certainly play important roles in deciding the migratory pattern of individual species. But the most important factor appears to be the light. The large amount of works that has been done in the boreal and austral waters on this subject demonstrates beyond doubt that the changes in the intensities of light that penetrate into the water during different hours of the day have direct bearing on the diurnal vertical movements of copepods". "It is now generally agreed that the immediate stimulus to diurnal migration is light, perhaps modified in extreme cases by temperature. The conception of an optimum light intensity inside which the copepods keep, each stage and each population, having perhaps its own optimum, has proved the most fruitful explanation of their movements"(Marshall & Orr, 1955). Why and how the changes in light intensity come to exert such strong influence on the movements of these creatures is not clear.

The fact that in the present studies all species avoid the bright light of the sun to a great extent is in full agreement with the conclusions arrived at by earlier workers. But why the adult population does not withdraw completely from the surface during the day and why some species are quite indifferent to changing light intensities are not clearly understood. A fuller and comprehensive studies on these lines are needed in our waters.

Table II. The actual volumes of copepods and non-copepod items and their percentages in the surface hauls in January 1960.

Date & Time	Total volume in cc.	Relative volumes in cc.		Percentage	
		Copepod	Non-copepod	Copepod	Non-copepod
12-1-1960					
5.45 a.m.	2.2	1.2	1.0	54.5	45.5
9.45 a.m.	1.2	0.6	0.6	50.0	50.0
1.45 p.m.	1.15	0.6	0.55	53.0	47.0
5.45 p.m.	1.3	0.7	0.6	53.8	46.2
9.45 p.m.	2.0	1.15	0.85	57.5	42.5
13-1-1960					
1.45 a.m.	2.2	1.18	1.02	53.6	46.4
5.45 a.m.	2.8	1.5	1.3	53.4	46.6

Table III. The actual dry weights of copepods in the 2 cc. subsample of the surface hauls made in January 1960.

Date & time	Actual dry weight in grms.
12-1-1960	
9.45 a.m.	0.0221
1.45 p.m.	0.0147
5.45 p.m.	0.0286
9.45 p.m.	0.0445
13-1-1960	
1.45 a.m.	0.0950
5.45 a.m.	0.0540

Table IV. The actual dry weights of copepods in 10cc. subsamples of the collections made with Clarke-Bumpus Apparatus in March 1960 at surface and at 5 metre depth.

Date & Time	5 metre depth		Surface	
	Actual wt.	Percentage	Actual wt.	Percentage
8-3-1960				
9.45 a.m.	0.0054	38.6	0.0086	61.5
1.45 p.m.	0.0081	89.0	0.0010	11.0
5.45 p.m.	0.0087	59.3	0.0056	40.7
9.45 p.m.	0.0058	42.0	0.0086	58.0
9-3-1960				
1.45 a.m.	0.0044	28.8	0.0109	71.2
5.45 p.m.	0.0042	30.7	0.0095	69.3

Table V. <u>Pseudodiaptomus</u> <u>aurivilli</u>: Actual numbers of adults and copepodites caught in the surface hauls with organdie nets during the 24 hour period on 12th - 13th January 1960.

Date & Time	Cope I	Cop. II	Cop. III	Copepodite IV		Copepodite V		Adults	
				Male	Female	Male	Female	Male	Female
12-1-1960									
5.45 am	0	1	4	26	22	73	38	121	50
9.45 am	0	2	5	22	16	32	32	34	17
1.45 pm	0	0	8	13	12	20	15	33	14
5.45 pm	0	3	11	12	20	24	49	71	106
9.45 p.m	0	0	6	12	19	44	42(42)	115	100
13-1-1960									
1.45 am	0	0	2	10	11	24	27	68	82

Table VI. *Acartia erythraea* : Distribution of adults and fifth copepodites at 5 metre level and at surface during the month of March 1960.

Date & Time	Fifth copepodite				Adult			
	5 metre depth		Surface		5 metre depth		Surface	
	Male	Female	Male	Female	Male	Female	Male	Female
8-3-1960								
9.45 am.	0	0	0	0	2	4	3	4
1.45 pm.	3	1	0	0	8	11	3	2
5.45 pm.	4	6	3	2	12	17	4	2
9.45 pm.	2	4	0	1	13	17	12	17
9-3-1960								
1.45 am.	2	11	4	2	11	8	14	5
5.45 am.	2	4	0	1	13	18	7	6

Table VII. *Centropages dorsispinatus* : Distribution of adults and copepodites in the surface layer on 12th and 13th January 1960.

Date & Time	Cop. I	Wop. II	Cop. III	Copepodite IV		Copepodite V		Adult	
				Male	Female	Male	Female	Male	Female
12-1-1960									
5.45 am.	0	7	19	36	33	50	27	36	31
9.45 am.	1	2	5	5	9	3	1	5	2
1.45 pm.	0	5	7	36	39	18	16	8	5
5.45 pm.	0	4	6	7	12	4	2	2	2
9.45 pm.	2	3	7	5	5	5	6	2	3
13-1-1960									
1.45 am.	1	2	7	9	7	6	5	2	1
5.45 am.	0	2	5	10	12	13	18	16	11

Table VIII. *Pseudodiaptomus* (*Schmackeria*) *serricaudata* – Distribution of adults and copepodites in the surface waters on 12th and 13th January 1960.

Date & Time	Cop. I	Cop. II	Cop. III	Copepodite-IV Male	Copepodite-IV Female	Copepodite-V Male	Copepodite-V Female	Adult Male	Adult Female
12-1-1960									
5.45 am	0	0	0	0	0	6	4	28	25
9.45 am	0	0	0	0	1	5	0	5	4
1.45 pm	0	0	1	3	2	4	7	5	7
5.45 pm	0	0	0	0	0	8	8	7	8
9.45 pm	0	0	0	1	2	4	7	8	7
13-1-1960									
1.45 am	0	0	0	2	2	4	7	14	12
5.45 am	0	0	0	0	0	3	1	3	1

Table IX. The temperature of the water mass at Station 'C' in the Gulf of Mannar during January, [redacted] and March, 1960.

Date	Time	Temperature in centigrade: Surface	Temperature in centigrade: 5 metre depth
12-1-1960	5.45 a.m.	26.1	26.0
	9.45 a.m.	26.2	26.0
	1.45 p.m.	26.6	26.3
	5.45 p.m.	26.8	26.4
	9.45 p.m.	26.4	26.3
13-1-1960	1.45 a.m.	26.2	26.1
	5.45 a.m.	26.0	26.0
8-3-1960	5.45 a.m.	26.5	26.4
	9.45 a.m.	27.0	26.8
	1.45 p.m.	27.3	27.2
	5.45 p.m.	27.5	27.3
	9.45 p.m.	27.1	27.0
9-3-1960	1.45 a.m.	26.6	26.5
	5.45 a.m.	26.6	26.5

S U M M A R Y

The diurnal vertical movements of the following species of planktonic copepods are studied:

Pseudodiaptomus aurivilli,
Centropages furcatus,
Calanopia elliptica,
Acartia erythraea,
Centropages dorsispinatus and
Pseudodiaptomus (*Schmackeria*) *serricaudata*.

It is found that all these species are fairly well-distributed in the surface waters from dusk to dawn, but they avoid the top layer during the brightly-lit hours of the day. The salient features of these migratory movements and the probable causes that influence them are briefly discussed.

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Explanation of Plate XXXVII

Fig. 1 The actual dry weights of copepods in a subsample of 10cc at surface and at five metre depth collections made with a Clarke-Bumpus Apparatus during March 1960 (——Surface; .....depth)

2 The same depth collection expressed as percentages of the total catch from the two layers of the water column

3 *Pseudodiaptomus aurivilli*: Distribution of adults at surface and at five metre depth on 12th, 13th January 1960 as collected by bolting silk net (——Surface; ......Depth)

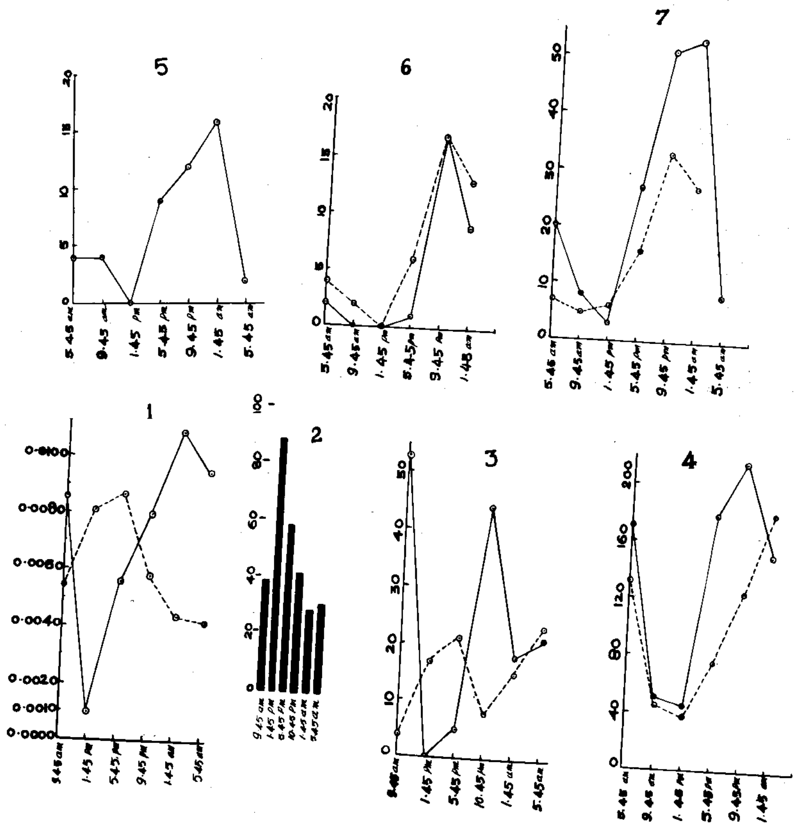
4 *Pseudodiaptomus aurivilli*: Distribution of adults at surface on 8th, 9th March 1960 and on 12th, 13th January 1960 as collected by organdie net (——March; .....January)

5 *Centropages furcatus*: Distribution of adults at surface on 12th, 13th January 1960 as collected by organdie net.

6 *Calanopia elliptica*: Distribution of adults at surface on 12th, 13th January and 8th, 9th March 1960 as collected by organdie net (——March, ...January)

7 *Acartia erythraea*: Distribution of adults at surface on 12th, 13th January and on 8th, 9th March 1960 as collected by organdie net (——March; .... January)

PLATE XXXVII



Chapter 3. Breeding and Related Aspects

Introduction

There have been three principal objectives for the present investigations: (a) determination of the breeding seasons of different copepod species; (b) estimation of quantitative seasonal distribution of different species; and (c) determination, if possible, of the number of broods in a year and the longevity of broods. It is not claimed that full success has been achieved in all these aims, but it may be stated that some useful informations have been obtained on the general pattern of breeding, quantitative variations of various species throughout the year and the succession of their life cycles. It was not possible during these investigations to gather simultaneous data on the hydrology of water or on the biology of other phyto and zooplankton organisms. Consequently wherever any correlation is formulated between these aspects and the biology of copepods, the relevant informations have been taken from earlier works. The investigations were confined to adults and copepodites of all species except in the case of <u>Pseudodiaptomus aurivilli</u> where in addition to these, the naupliar stages were also taken into account. The correct identification of the naupliar stages is an extremely difficult task as the collections invariably contain various developmental stages of several species.

Ten species which constitute the more common forms of the area investigated have been included in the present study (eight calanoids, one harpacticoid and one cyclopoid). From the point of view of total abundance Acartia erythraea could be said to be a most important species, though in tropical waters it is diffcult to regard any single species as a dominant item of plankton. Some species are found throughout the year without much seasonal variations while some others display great fluctuations. Digbey (1950) in his excellent studies on the biology of the small planktonic copepods of the Plymouth area derived his conclusions on following three types of evidences: (i) comparative abundance of different stages; (ii) their percentage distribution; and (iii) the size of adults. He has also pointed out the drawbacks of each of these considerations. Nevertheless a study of these factors forms an important prerequisite to an understanding of their biology as it reveals many important facts. In the present work conclusions have been drawn by taking into consideration the first two types of evidences.

Material and Methods

The present study is based on the examination of 88 horizontal surface plankton hauls each of 15 minutes duration. These hauls were made from May 1959 to December 1960. All the collections were made between 5.30 and 6.30 a.m. Two half-metre nets, one made of organdie cloth (Ca 36 strands/cm, the mesh size 0.230 mm.) and the other made of bolting silk No. 21 (Ca 450 strands/cm, the mesh size 0.069 mm.) were used. The latter type of net was employed only from November 1959 to December 1960. All organisms were preserved immediately after collection. On several occasions duplicate hauls were also made by both nets. These were taken to the laboratory and utilized mainly for life-cycle studies etc. The duplicate hauls were also used for comparing the two sets of bree readings. In most cases they were fairly comparable to one another.

Collections made by the bolting silk net differed considerably from those made by the organdie net. The former always fished a greater proportion of nauplii and early copepodites than the latter. This is due to the difference in the mesh size of the two types of nets.

For laboratory analysis the total catch was subsampled as follows: The entire quantity was transferred to a wide-mouthed bottle and diluted upto 250 cc. by adding formalin. In the case of organdie net collections a subsample of 2 cc. was taken out by means of a graduated pippette, 5 mm. wide. All the organisms contained in this example subsample were counted by employing a plankton counting chamber. In the case of bolting silk collections, a subsample of 10 cc. was pippetted out and then was further diluted to 50 cc. by adding 5% formalin. After shaking properly a 5 cc. subsample was again taken and counted under a binocular microscope. Thus in the case of collections made by bolting silk net the analysed subsample is equal to one cc. of original catch.

All collections which formed the basis of present analysis were made at Station 'A' of the Gulf of Mannar (Pl. I). The depth of this place ranged from 3 to 4 metres. Duplicate samples were taken at Station 'B' (Pl. I) which is more or less of the same depth.

Earlier works

Recently a few papers have been published on the biology of plankton communities of the Gulf of Mannar (Sundara Raj, 1935-38; Chacko, 1950; Prasad *et al*. 1952; Prasad, 1954a & b; Prasad and Jayaraman, 1954; Prasad, 1956; Prasad, 1958; Kartha, 1959; Prasad & Kartha, 1959). However, only the last two papers deal exclusively with the copepods while others give accounts of the composition, sequential changes that take place throughout the year etc. of the planktonic community in general.

Sundara Raj (*loc. cit.*) while making a seasonal record noticed some increase in the plankton production during colder months of the year. However, even this increase was not very significant.

Chacko (*loc. cit.*) described the plankton from the waters around Krusadai Island based on the data collected from various Stations. He gave a list of phyto- and zoo-planktonic organisms occurring in the area and observed; "The plankton of the waters around Krusadai is rich both in bulk and variety. Most of the important species appear to be cosmopolitan in distribution. The maximal period of phytoplankton is from June to November and that of zooplankton from October to April".

Prasad _et al_. (_loc_. _cit_.) gave the results of preliminary observations on the distribution of plankton at six inshore stations in the Gulf of Mannar.

Prasad (1954a) dealt with the biology of phyto- and zooplankton groups but did not "identify specifically the large number of species represented in the catches because the object of this study has been to give a knowledge of only the more important elements of the zooplankton community". Some valuable informations have, however, emerged from his study. He observed that the copepods show two distinct peaks in the Gulf of Mannar, one during the early part of the year, _viz_. January-February and the other in October. According to him the copepod populations suffer declination in March and reach their lowest ebb by about July whence they steadily increase attaining a maximum in October. This is followed by an abrupt fall in November but by December there is again a tendency to increase resulting in a maximum during January-February. This bimodal distribution of copepod populations in the Gulf of Mannar was interesting, as it was quite contrary to what was found elsewhere along the Indian coasts by the earlier workers all of whom recorded a unimodal distribution (K.S. Menon, 1931; M.A.S. Menon, 1945; Jacob & Menon, 1952) except Bal and Pradhan (1952) who noticed that in Bombay waters copepods show two or three peaks from May to September and that their numbers dwindle considerably from November to April.

In a later publication Prasad (1956) compared the pattern of distribution of gross copepod population in the Gulf of Mannar and the Palk Bay and observed that in the former area the fluctuations were apparently dicyclic, thus confirming the results of his earlier studies. There were slight shifts in the periods of occurrence of the maximum and the minimum population from year to year, but the general pattern more or less remained the same.

Prasad (1958) in his 'plankton calenders' summed up the works so far done on the hydrology and biology of plankton of the seas around Mandapam.

Kartha (loc. cit.) attempted to study not only the seasonal abundance of the copepod populations of the Gulf of Mannar and Palk Bay but also made observations on the breeding seasons of some of the more important species. Regarding the seasonal distributions he agrees with the observations of Prasad and reports a dicyclic pattern in the Gulf of Mannar. His observations on the breeding seasons were based on the relative abundance of the copepodites of various species during different months of the year. According to Kartha, spawning goes on more or less throughout the year, with only a slight increase during September-November for in these three months he found a higher copepodite population. His observations were confined to the following species:

Acartia (Odontacartia) erythraea Giesbrecht
Paracalanus parvus Claus
Metacalanus aurivilli Cleve
Euterpina acutifrons (Dana)
Corycaeus spp.
Oithona spp.

Prasad & Kartha (1959) went further and extended their investigations to the breeding of copepods in general and its relations to the diatom cycle in particular. Their observations could be summed up as follows: (1) In the Gulf of Mannar breeding takes place throughout the year. Breeding intensity is at its lowest between May and August when it is at a peak in Palk Bay and highest during September and March or April. (2) There is a greater naupliar copepodite population in the Palk Bay than in the Gulf of Mannar. However, in the earlier reports Prasad (1956) and Kartha (1959) have shown that in the latter area during the years 1951-1953 and 1953-1954 the average annual stading crop of copepods is higher compared to that of Palk Bay. The following reasons are brought forward to explain this apparent discrepancies. They believe that during January-February there is a large-scale migration of copepods from Palk Bay where the sea is turbulent and phytoplankton productions is at an extremely low level, to the Gulf of Mannar where conditions more favourable. This migration has been held responsible for the higher average annual population in the Gulf. The fact that the mesh size of the net employed was much largerthan the size of several nauplii netted also is shown to be a factor responsible for the apparent anomaly noticed between the average annual copepod populations and the distribution of naupliar and copepodite stages of the two areas. They also pointed out that the breeding of copepods in the Gulf from September to March coincides with the spawning of fishes of this area with the result that although there is active breeding of copepods during this period a substantial portion of the naupliar population is being constantly consumed by the larval fishes. The difference between the intensity of breeding at the two regions is thus explained . (3) Close relation between breeding of copepods and the diatom cycles of the two regions is discussed and it is observed that in both the areas breeding is to a large extent dependant upon the diatom cycle.

Results of the present study

Breeding periods

Pseudodiaptomus (*Pseudodiaptomus*) *aurivilli* Cleve* - Large numbers of adult males and females as well as copepodites swarmed the surface waters in the months of December-January 1959-60. This was to some extent accompanied and lateron followed by large number of naupliar stages. The abundance was maintained in February though a steep reduction was noticed from the January level. A clear and gradual declination was observed during subsequent months and in July the species vertically disappeared. The data for next four months (August-November) display a gradual increase in the population. It is interesting to note that the level in November was almost the same as for the same month of the preceding year (Pl. XXXIX, fig. 1).

A close study of the data available for 1959 revealed that in the month of May a fair number of individuals, more than half of which were adults, were caught. This was followed by a declination in June, July and August and in September the species was at its minimum of occurrence. The months of

October and November witnessed an abrupt upward change in this species which compares quite well with the condition found in 1960.

The percentage distribution of adults throws more light on the breeding pattern of this species. August-September 1959 and July-August 1960 were the periods of lowest abundance of the species. During these periods only the adults were caught both years(Pl. XXXVIII, Fig. 3). During the few months following this low peak, the population consisted chiefly of the adults. By the end of November, both in 1959 and 1960 good numbers of adult females were observed to carry eggs and this was followed by a sudden increase of early stages in the population in December and January. This suggests that intensive spawning takes place during the months of December-January. As yound stages were also found during ~~xx~~ subsequent months, it appears that the breeding of stray individuals ~~are~~ or isolated late spawners continues till about February.

2. <u>Calanopia thompsoni</u> A. Scott - This species shows a great similarity to the earlier species in its distributional pattern except that the non-peak period its abundance becomes very insignificant. It also has smaller peaks during the months of May-June (Pl. XXXIX, Fig. 2). But this peak could be considered a continuation of the larger peak. During these months a fair number of first to third copepodites are present. In July and August these stages are replaced by g higher stages (fourth or fifth). The adults begin to appear in small numbers in August and from September onwards they increase steadily and

attain the maximum in January. The early copepodites of this species are seen in the months of September which signifies the commencement of breeding season. During subsequent months when intensive spawning recurs the lifecycle passes in quick succession. In February and March the early stages begin to disappear, thus indicating the completion of breeding season. In these months the species is represented prodominently by late copepodites and adults.

Although occurring in relatively small numbers, *Calanopia thompsoni* appears to have some importance by virtue of its large size. If weight value is taken as a criterion the contribution of this species, during its peak period, to the total biomass will be found to be quite substantial.

3. *Acartia* (*Odontacartia*) *erythraea* Giesbrecht - This is one of the commonest species of this area and is found almost throughout the year. However, during the peak of October-January, because of the swarming of so many other copepods, its comparative importance is reduced. There are two well-defined peak periods of abundance for this species, one in April-May and the other in October-January. During the latter peak, however, the population suffers a minor decimation in November (Pl. XXXIX, Fig. 3). A study of the percentage distribution of the various stages show that the setback in November is more due to a lower rate of recruitment of new copepodite populations, rather than due to any real reduction in the relative abundance of later stages or adults.

Kartha (loc. cit.) found two distinct peaks for this species: first in March-April and the other in November-January with an additional smaller peak in September. During the year 1960, these sequential ~~xx~~ changes appear to have shifted forward by one month. The first maximum is found in April-May, extending even upto the first first half of June. The smaller peak noticed by Kartha in September is found to occur in October and almost entirely merges with the second large peak of the year. The facts that during the year 1954 no such intermediate peak was recorded by Kartha and that even when present the peak is extremely small suggest that this smaller peak could better be considered in continuation with the all-round increase of the species during the colder months of the year.

4. Paracalanus aculeatus Giesbrecht - This species was found at its maximum during January-March whence it decreased gradually. The lowest number was observed in May. During June-July another peak was found to occur. But while in 1959 this latter peak was conspicuous it turned out to be quite insignificant in 1960 (Pl. XXXIX, Fig. 4). In September the species reached the second minimum and during this month the population consisted chiefly of copepodites. By October, however, all the young stages have moulted either into fifth stages or adults. Incidentally this was the month when the adult population recorded its greatest percentage of abundance. This not only shows that the breeding has practically ceased a month or so earlier but may also indicate that the next active breeding season of the species is in the offing.

Sewell (1929) has made the suggestion that it is probable that the abundance of this species and of the following is more or less mutually exclusive. He found that when P. parvus was dominant in a particular locality P. aculeatus was almost entirely absent or present only in small numbers. The reverse situation of abundance of P. aculeatus and an absence of P. parvus was also noticed. This situation, however, does not hold valid for the present area. Two significant breeding periods almost corresponding in time are noticed for both species. In both cases the summer peak was comparatively smaller. However, in the case of P. parvus an additional peak was seen in September. Whether this peak is considered separately or in continuation with the following peak (as is suggested for Acartia erythraea), the abundance of one species does not seem to alternate with that of the other.

5. Paracalanus parvus Claus - Kartha (loc. cit.) noted great variations in the trend of seasonal changes of this species. Both in 1952 and 1953 he observed only a single prolonged breeding period with its maximum in December-January. In 1954 he found a second increase with breeding activity during April-June. This was, according to him, mainly responsible for the total copepod peak in May-June. The data available for 1960 present a picture almost intermediate to the two extremes (Pl. XXXIX, Fig. 5). The species reaches the maximum in November-January months. A second peak which comparatively is quite insignificant is found in May-June. A third increase occurs in September, just prior to the most intensive breeding period of the year. Probably the September peak is non-significant

and is comparable to that observed for *Acartia erythraea*. It is more probable that active breeding starts early in September and continues upto January or February. The steep reduction found in October is mainly due to a lesser percentage of adults.

Besides the main peak during the colder months, the presence of a second peak is reported for 1954 (Kartha, *loc. cit*.). Its occurrence in 1960 as well indicates that it is probably a regular feature of the species. Even in 1953 Kartha's figure shows a minor peak (Kartha, *loc*. *cit*. fig.3b), which is not mentioned in the text and which resemble s the second peak observed in 1960. The correspondence of the present data with these earlier reports, thus, is not a mere coincidence.

6. *Calanopia aurivilli* Cleve - Generally the maximal occurrence of this species is during the months of November-December. It may however extend as far as January or even upto February. The lowest numbers are found in May and August. There is a slight increase during the intervening months of June and July.

By September the species starts increasing in number. This process goes on steadily until November when the species attains its annual maximum (Pl. XXXIX, Fig. 6). That November is the most active breeding month is shown by the percentage distribution of the adults and copepodites. Copepodites which formed only 42 percent of the total population in September, now swarm the water constituting about 78 per cent. Further, while in September the early copepodites (I - III) were entirely absent, in subsequent months they contributed a major share in their total population.

Although small, the June-July peak also indicates a clear breeding period. From April to June practically there was no new recruitment of early copepodites. But in July there is a sudden appearance of these stages, forming about 60 per cent of the total population of this species. By August all the young ones moult to higher stages and by September the population predominently attains adulthood and this marks the beginning of another active breeding period.

7. *Acrocalanus gibber* Giesbrecht - Kartha (*loc. cit.*) treated three species of this genus together and stated that in the Gulf of Mannar there "was a fairly good population from June to August in 1952, with a peak in August; and July-September in 1953". He further stated that "in 1954 there was a peak of short duration in May". The present observations differ from these records. It may be because of the fact that in the earlier account these different species were pooled and dealt with together.

A. gibber displays two major peaks in the year, the first in January-February extending upto March and the second in June-July extending upto August. There are clear gaps between the intervening periods (Pl. XL, Fig. 1). However, a percentage distribution of different copepodite stages and adults reveals little information as to any change in the rate of breeding between different seasons. But it seems probable that the species as a whole becomes reproductively more active and a greater relative abundance prevails during these periods. It is interesting to note that the peaks observed for this species correspond to those recorded for *Calanopia aurivilli* and *Paracalanus parvus* the only difference being that the June-July peak is slightly larger and the winter peak is shifted more towards the colder months.

8. *Acrocalanus monachus* Giesbrecht - The only definite thing that could be said about the distributional pattern and breeding of this species for the year 1960 is that there was an enormous increase of the population during the months of November-February, attaining the maximum in January. After February there was a steep reduction, which reached its minimum in March. From then onwards small fluctuating peaks were observed, almost at intervals of two months until October when the species displayed a gradual increase. A study of the percentage distribution of various copepodites and adults does not reveal much except that in December the adult population reaches its maximum. The annual maximum population observed in January is due to active breeding of these adults.

A. monachus is a small species and it is possible that the sampling of the early copepodites is probably inadequate. It is also possible that during the laboratory analysis some of the copepodite stages could have been mixed up with those of a related species, *A. gracilis*. The latter is a large species and occurs only occasionally. However, when both species occur together and especially when the population is dominated by the early copepodites, the correct identification becomes a difficult task.

9. __Euterpina acutifrons__ (Dana) - According to Kartha (loc. cit.) this species occurs throughout the year, with slight variations in its abundance and with an over-all increase during the cold months. Only in 1954 he observed an additional peak during May-August. There is general agreement between the present data and the earlier accounts. The species started a steady increase in October and the tendency is continued upto January whence it takes a reverse direction. During March-October the species undergoes considerable fluctuations (Pl. XL, Fig. 3), the yearly minimal level being recorded in the month of May. However, it is surprising that during this month the population was composed mainly by the copepodites especially the earlier ones and that the largest percentage of the adults was found to occur during the preceding month~~s~~ of April.

10. __Oithona rigida__ Giesbrecht - Kartha (__loc. cit.__) found that the species of the genus __Oithona__ showed irregularity in its distribution from year to year, with, however, a constant peak in September. There is a good agreement between the present findings and the earlier records. The species attains its annual maximum during the months of December-January. Other peaks are observed almost at equal intervals in March-April, June-July and September-October (Pl. XL, Fig. 4).

The four peaks observed in the present investigations correspond to those reported by Kartha, especially for the years 1953 and 1954. The present data differ from those of the year 1952 in that the peaks recorded in March-April and June-July in that year are considerably insignificant. It appears justified to state that this species is a prolonged spawner, but with distinct periods of active breeding which are intercepted by short intervals of lesser reproductive activity.

Quantitative distribution

The copepod population as represented by the ten species noted above of the Gulf of Mannar is the highest during the coldest months of the year November-February. By the end of February or March almost all the species record varying degrees of declination (Pl. XXXVIII, Figs. 1 & 2). In several species the decrease is consistent during the summer months and a reversal towards the other direction is marked in the beginning of August and September whence the increase in their numbers becomes steady. By taking all species together it appears that the copepods show a unimodal pattern of distribution. However, this picture is obscured if we examine individual species separately. Not only do several of them show more than one peak in a year but the peaks of different species are not often synchronised. In all species, however, one of the annual peaks corresponds with the cold months of the year, thus resulting in an over-all increase of the copepod~~it~~ population during that season. Prasad (1954 & 1956) found that although the copepod population showed an increase in October there was a reduction in November before attaining a subsequent increase resulting in a peak in December, January or February. Kartha (loc. cit.) obtained more or less similar informations. However, Prasad and Kartha (loc. cit.) have clearly demonstrated that a close relationship ~~between the~~

exists between the breeding of copepods and the diatom cycles and that treated in a general way "the maximum breeding in the Gulf of Mannar is during September to March". It is probable that the reduction of population obtained in November during certain years is not due to any real break in the reproductive activities but may be due to a slowing down of the ~~xxx~~ new recruitments of nauplii and copepodites after the completion of an initial generation. In several species (*P. aurivilli*, *C. thompsoni*, *A. erythraea*, *P. parvus*, *A. gibber*, *O. rigida*) this disjunction is seen in the winter peak. But in several others (*P. aculeatus*, *C. aurivilli*, *A. monachus*, *E. acutifrons*) the increase initiated furing September or October is steady and continuous, attaining a single prolonged annual maximum. Prasad (1954) who first observed dicyclicity in the distribution of copepods in the Gulf of Mannar offered the following explanation: "It is possible that while in other localities the maximum occurrence of one or more species may overlap, there may be still others whose maxima fall in such a ~~x~~ way as to fill the gaps and present an overall unimodal distribution. A similar phenomenon may not be taking place here thereby resulting in an apparent reduction in population level and a bimodal curve".

Bogorov (1958) reviewed the earlier works on the study of seasonal changes of plankton all over the world. He attempted to generalize the interrelationship between the abundance of plankton organisms and the climatic changes of different latitudes. According to him the fluctuations in the animal numbers in different latitudes give rise to what he terms as biological seasons": "In general the biological winter is characterised by a minimum organisms, especially phytoplankton and a simultaneous increase of biogenic matter (salts of nitrogen, phosphorus and other matter indispensable to, or limiting, the nutrition of plants) determined by the decomposition of plankton and the absence of consuming phytoplankton; The biological spring is characterised by a rapid increase of plankton, especially phytoplankton; at this time the latter reaches its annual maximum. In boreal areas the main mass of phytoplankton consists of diatoms. Zooplankton abounds in eggs, larvae and juvenile stages of development. Then comes the biological summer accompanied by an abrupt decrease of biogenic matter accounted for by the vernal development of phytoplankton. The quantity of phytoplankton diminishes rapidly, owing to a lesser supply of nutrient salts and to increasing quantities of zooplankton, the latter feeding on the phytoplankton directly or indirectly........... The summer period is characterised by a rapid development of zooplankton. The dying off of zooplankton and the absence of great masses of phytoplankton result in an increase of biogenic matter toward the end of the biological summer, thus providing a basis for a second maximum of phytoplankton. The latter at this time consists mainly of peridinians. This is the biological autumn period of growth of animal plankton which reaches its hibernating stages; phytoplankton develop hibernating pores or cells" (pp. 148-49). Bogorov then presents a scheme dividing the earth's lattitudes in to the arctic (antarctic also?), moderate climate, subtropical and tropical regions. In the tropical seas the biological summer lasts seven months whereas in polar seas it is restricted to a single month. The winter scarcely expressed in tropics, lasts nine to ten months in the polar seas. The intermediate latitudes display varying degrees of gradations between these two extremes (see Bogorov's Figs. 1 & 2 for details).

If individual species are considered separately it is found that the annual maximal peaks coincide with a most active breeding periods. It has been observed that the breeding activity is a continuous process ~~ka~~ in great many of the species and takes place almost throughout the year. Only a few species (e.g. P. aurivilli) there is a cessation of spawning activities during the periods of minimal occurrence. However, in all the continuous spawners there is a great reduction in the rate of production and the succession of broods during the non-peak periods. It appears that during this period different naupliar and copepodite stages take longer durations than those during the peak periods when because of the highly favourable environmental conditions the reproductive activities are accelerated ~~conditions~~ and that the life cycles are spent in quicker succession.

The relative differences in the distribution of the two sexes of adult animals do not exhibit any particularly interesting trend, except that in some species the females tend to dominate almost always while in other a fifty-fifty ratio is roughly maintained.(Table XII). In species with strongly defined annual peaks (e.g. P. aurivilli, C. thompsoni) the males slightly outnumber the females during the breeding periods. It is also interesting to note that in these species the females form a greater proportion of the adult population during the periods of minimal occurrence. Among the late copepodite stages, the ratio of sexes is monotonously uniform, each sex equalling the other. A sex-wise analysis of the earlier copepodites is not possible as in these cases, there is apparently no external characters of sexual determination.

Annual number of broods and their longevity.

Pseudodiaptomus (*Pseudodiaptomus*) *aurivilli* and *Labidocera bengalensis* have been reared in the laboratory for studying the stages of their life cycles. *Calanopia thompsoni*, *Centropages furcatus* and *C. dorsispinatus* were also tried but full success was not obtained. It was possible to trace only the copepodites of these three species. In none of the species it was possible to rear the animal through the first naupliar stage to the adult. The method adopted for rearing was to select specimens of a particular stage and allow them to moult to the next stage. In this way, by repeated observation on different stages, a continuity of all stages could be traced and maintained. In some cases the specimens survived longer than one moult, thus giving an actual indication of the time required by organism to moult from one stage to the other. However, the time taken by plankton organisms to moult in captivity to next higher stage may not be ~~xxxx~~ same as in their natural environment. None of the nauplii and the early copepodites which underwent more than one consequtive moult in the laboratory took more than 2 - 3 or rarely 4 days for the process. The late copepodites hardly lived for 4 days after their first captive moult. Probably the duration required for the next moult is longer in these k cases but may not exceed six or 7 days. Giving an average of 3 days for the nauplius and 4 or 5 days for the copepodite, it is found that a nauplius freshly hatched and reared under captive conditions could attain adulthood in 5 or 6 weeks. This could possibly depend on optimum conditions of the environment.

There are many types of evidences to show that the period required for the completion of the entire life cycle is much shorter during the propitious colder months. It has been found both in the earlier studies (ch. Prasad, 1954 & 1956; Kartha, 1959) and also in the present investigations that for several species (A. erythraea, P. parvus etc.) the winter increase is interrupted after a month or so before reaching the maximal peak. It has been suggested by earlier workers that this interruption period is a gap between two distinct breeding periods. The present studies show that there occurs a slowing down of reproductive activities after the completion of one active initial generation. It is not a stop-gap of spawning activities but is more of a 'breathing space' in a long and continuous activity. If this interpretation is acceptable it can be seen that during the favourable periods the entire life cycle requires 4 to 5 weeks for its completion.

During the non-peak periods the life activities in most of the species are slackened and although breeding takes place, the rate of production of new stocks appears to be at a much lower rate and the nauplii and copepodites appear to last for longer durations. *Oithona rigida* which shows several peaks in a year provides a fine example. The breeding in this species is a continuous activity. As noted earlier the species reaches its maximal abundance during December-January. Following this period there is a month of recuperation before the species launches for the next generation. The latter lasts exactly for two months before attaining maturity and for preparing the species to start on a new generation. The colder months, however, present a different picture. During this period, two or even more successful generations are completed in rather quick series within a period of 3 to 4 months, the generations sometimes being interrupted only by short periods of lesser activity.

It is possible that species with one annual maximum would have two or three broods during the active period and one or two during the rest of the year. The species with two or more annual maximal periods would certainly have additional broods. Prasad & Kartha (loc. cit.) observed: "In the temperate waters the usual number of broods is three or four and in cold waters this appears to be reduced to one. It is not unlikely that in the tropical waters there are more number of broods than in the temperate and cold waters".

Remarks

Breeding habits of copepods of the Gulf of Mannar appear to be divisible into three categories: (1) Those breeding throughout the year with irregular variations in the frequencies so that their population includes not only adults but also the various copepodites. All these stages are caught irrespective of any seasons. *Acrocalanus monachus* and *Oithona rigida* exemplify this group. (2) Those breeding throughout the year but with distinct peaks during certain months so that although the various copepodites and adults of the species are available in every month, yet their percentage abundance displays considerable differences. Several species fall into this group: *Acartia erythraea*, *Paracalanus aculeatus*, *P. parvus*, *Calanopia aurivilli*, *Acrocalanus gibber* and possibly *Euterpina acutifrons*. (3) Those breeding only during certain seasons. Among the species studied *Pseudodiaptomus aurivilli* and *Calanopia thompsoni* come under this group.

This grouping of copepods on the basis of breeding habits is made with some reservations and should be regarded as tentative. In the first instance it is questinable why species residing under similar environmental conditions should have differential breeding seasons. It will not be out of place to suggest that the availability of food may serve as an important factor in controlling the breeding behaviour of copepods in tropical waters. The synchronisation of diatom outbursts and naupliar development of marine invertebrates has clearly been demonstrated (Ussing, 1938; Marshall & Orr, 1952; Barnes, 1957; Prasad & Kartha, 1959). Those species with clear seasonal spawning habits could be said to be under the strong influence of regular periodicities of phytoplankton. The breeding of other species, irrespective of the season could be due to the fact that in tropical waters phytoplankton may be available almost throughout the year in varying quantities. This latter suggestion is, again, illustrated by _Tortanus gracilis_ and _T. forcipatus_ both of which are predatory and feed on nauplii and other minute creatures. These species are not very common in this area but whenever present they are represented not only by the adults but also by copepodites indicating a continued breeding throughout the year. As the naupliar diet is invariably present throughout the year these copepods do not find any scarcity of food, They therefore breed all the year round.

Prasad & Kartha (_loc. cit._) suggested "In the Gulf there is distinctly a greater proportion of copepodites during September to March whereas in Palk Bay their maximum is during May to September...... During January-February a large scale migration of copepods from Palk Bay where the sea is turbulent and the phytoplankton production is at extremely low level , to the Gulf of Mannar, where the conditions are highly favourable seems possible". To what extent such movements could affect the copepod population of the Gulf could not be determined in the present study as no biometric study was undertaken. In any case it is quite interesting to find that there is so much of variations in the breeding behaviour of copepods in neighbouring waters of such close proximity and free exchange of waters.

The temperature variations in the Gulf of Mannar have recently been discussed by Prasad (1957) who noted that temperature is maintained more or less at a uniform level throughout the year except during some months corresponding to the calender winter when there is an abrupt reduction. The earlier part of these colder months represent the biological spring of this area with a great bloom of phyto-plankton and the later part the biological summer with greatest number of zooplankton. The coincidence of the breeding of copepods with this part of the year, is, therefore, natural. However, why several species should have another significant peak period during the months of May-July, extending even upto August is not clear. This is parti-cularly interesting in view of the fact that during this period active breeding of copepods occurs in the Palk Bay.

A final word may be said about the continuity of the species throughout the year. In temperate and colder waters several earlier workers have noticed (for a review see Digbey, 1950 and Marshall & Orr, 1955) that species with well-defined seasonal breeding disappear almost altogether during the unfavourable periods. In such cases it is held that either these species migrate at lower depths during the unfavourable conditions or they never disappear completely from the water column but merely become scarce enough to remain unnoticed. In tropical waters the breeding appears to be a continuous process and only the intensity differs from season to season. The influence exerted by the immediate favourability or unfavourability of the environment is manifested in the breeding behaviour of the copepods in the form of seasonal rhythms.

Table X. Seasonal distribution of the total number of adults and copepodites of different species (as collected by organdie net) during 1960.

	Pseudodiaptomus serricaudatus	*Calanopia thompsoni*	*Acartia erythraea*	*Paracalanus parvus*	*Acrocalanus gibber*	*Paracalanus aculeatus*	*Calanopia aurivilli*	*Oithona rigida*	*Euterpina acutifrons*	*Acrocalanus monachus*	Total
January	714	67	702	135	104	148	46	167	237	686	2,793
February	156	2	184	60	205	393	32	40	101	348	1,521
March	61	4	86	65	118	125	27	53	17	34	590
April	29	5	144	20	26	81	14	191	15	97	587
May	9	7	408	55	15	9	4	28	5	57	572
June	14	7	236	77	116	13	8	61	29	121	668
July	3	6	127	36	196	69	10	147	21	104	696
August	8	2	34	30	132	18	3	69	32	280	484
September	16	14	139	295	114	4	20	39	16	180	778
October	28	171	490	50	76	104	49	224	40	297	1,529
November	68	52	366	361	82	135	181	130	47	503	1,740
December	397	86	246	350	58	147	30	237	142	348	1,968

Table XI. Seasonal distribution of the total number of adults of the different species (as collected by organdie net) during 1960

	Pseudodiaptomus aurivilli	*Calanopia thompsoni*	*Acartia erythraea*	*Paracalanus parvus*	*Acrocalanus gibber*	*Paracalanus aculeatus*	*Calanopia aurivilli*	*Oithona rigida*	*Euterpina acutifrons*	*Acrocalanus monachus*	Total:
January	437	50	249	35	28	64	27	84	209	8	1,191
February	116	1	47	13	77	252	22	36	88	26	678
March	39	2	43	38	24	37	25	41	15	21	305
April	11	1	66	7	5	9	11	162	13	62	~~382~~ 347
May	6	1	229	13	3	3	4	17	2	32	310
June	6	1	83	43	35	6	5	43	24	109	355
July	3	1	49	11	36	16	5	80	11	81	293
August	5	0	11	16	33	6	2	43	23	154	293
September	7	0	39	138	27	0	12	26	12	121	382
October	5	17	192	33	17	61	15	54	18	263	675
November	36	12	143	278	13	47	53	49	33	318	982
December	242	23	75	234	14	88	13	144	126	275	1,234

Table XII. Percentage distribution of the sex among adults of various copepods species in diffierent months of 1960.

	Jan.		Feb.		Mar.		Apr.		May		June		Jul.		Aug.		Sept.		Oct.		Nov.		Dec.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Pseudodiaptomus aurivilli	60	40	57	43	45	55	50	50	50	50	33	67	0	0	71	29	66	34	54	46	52	48	57	43
Calanopia thompsoni	52	48	33	67	33	67	67	33	25	75	0	100	0	100	0	0	0	100	39	61	42	58	53	47
Acartia erythraea	28	72	40	60	56	44	51	49	39	61	33	67	53	47	46	54	51	49	46	54	48	52	47	53
Paracalanus aculeatus	23	77	29	71	13	87	24	76	0	100	27	73	36	64	17	83	0	0	22	78	31	69	31	69
Paracalanus parvus	24	76	45	55	11	89	30	70	25	75	19	81	30	70	24	76	23	77	26	74	19	81	18	92
Calanopia aurivilli	48	52	57	43	47	53	47	53	50	50	50	50	67	33	25	75	52	48	50	50	58	42	63	37
Acrocalanus gibber	32	68	41	59	23	77	33	67	33	67	29	71	39	61	37	63	33	67	32	68	36	64	27	73
A. monachus	17	83	39	61	33	67	28	72	19	81	20	80	24	76	5	95	20	80	18	82	24	76	20	80
Euterpina acutifrons	Sex-wise data not available																							
Oithona rigida	43	57	30	70	25	75	15	85	40	60	27	73	41	59	33	67	26	74	72	28	44	56	21	79

S U M M A R Y

The quantitative biology of the following ten species of planktonic copepods is included in the present work:
Pseudodiaptomus aurivilli,
Calanopia thompsoni,
Acartia erythraea,
Paracalanus aculeatus,
P. parvus,
Calanopia aurivilli,
Acrocalanus gibber,
A. monachus,
Euterpina acutifrons, and
Oithona rigida.

There have been three principal aims: (a) determination of the breeding seasons of different copepod species; (b) estimation of quantitative seasonal distribution of different species and (c) determination of the number of broods in a year and the longevity of broods.

The work so far done on the quantitative biology of the planktonic copepods of the Gulf of Mannar is briefly reviewed. The present data are compared with these earlier works and points of interest are discussed.

Based upon the breeding habits the planktonic copepods of the Gulf of Mannar are divided into three groups - those having a single, well-defined breeding season; those having more than one breeding season and those having irregular breeding periods. It may be added, however, that this division is purely tentative for it is hard to explain why organisms living under more or less similar environmental conditions should have different breeding habits.

R E F E R E N C E S

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Explanation of Plate XXXVIII

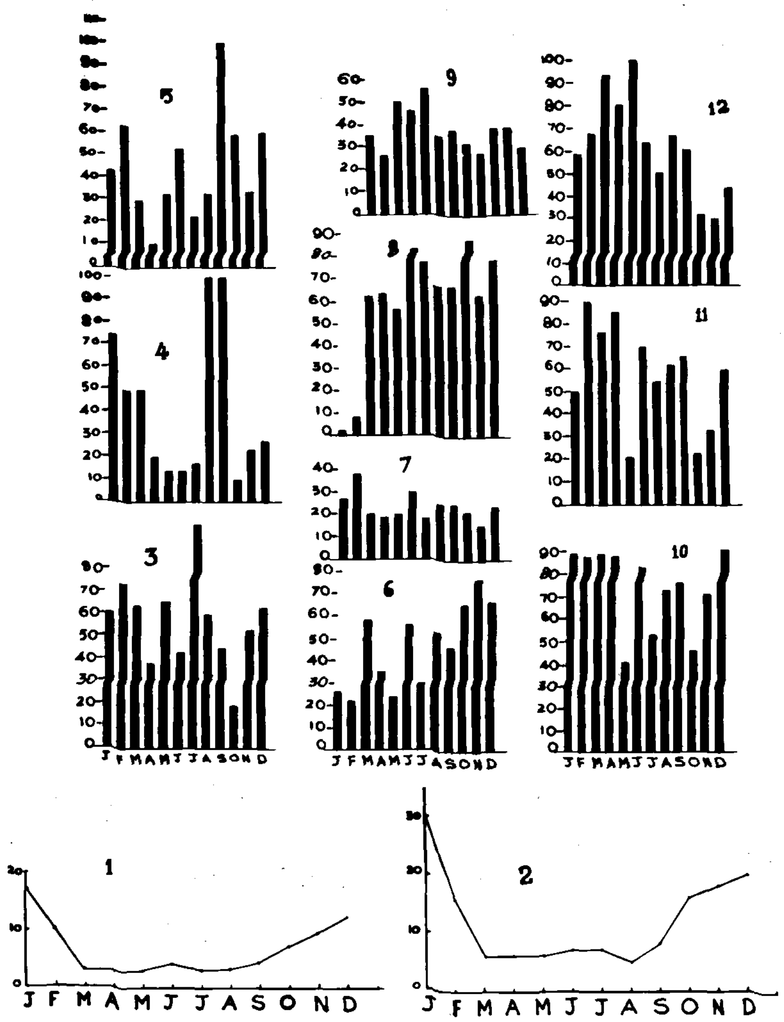
Fig. 1 Distribution of total adult copepods of the ten species studied in the Gulf of Mannar during 1960 as collected by organdie net

2 Distribution of total copepod population (adults and copepodites)of the ten species studied in the Gulf of Mannar during 1960 as collected by organdie net

3 Pseudodiaptomus aurivilli: Distribution of adults (males and females) in the Gulf of Mannar during 1960 as collected by organdie net.

4	Calanopia thompsoni	"do"
5	Paracalanus aculeatus	"do"
6	Paracalanus parvus	"do"
7	Acrocalanus gibber	"do"
8	Acrocalanus monachus	"do"
9	Acartia erythraea	"do"
10	Euterpina acutifrons	"do"
11	Oithona rigida	"do"
12	Calanopia aurivilli	"do"

PLATE XXXVIII



Explanation of Plate XXXIX

Fig. 1 *Pseudodiaptomus aurivilli* - Distribution of total population (adults and copepodites) in the Gulf of Mannar during 1960 as collected by organdie net.

2 *Calanopia thompsoni* - -do-

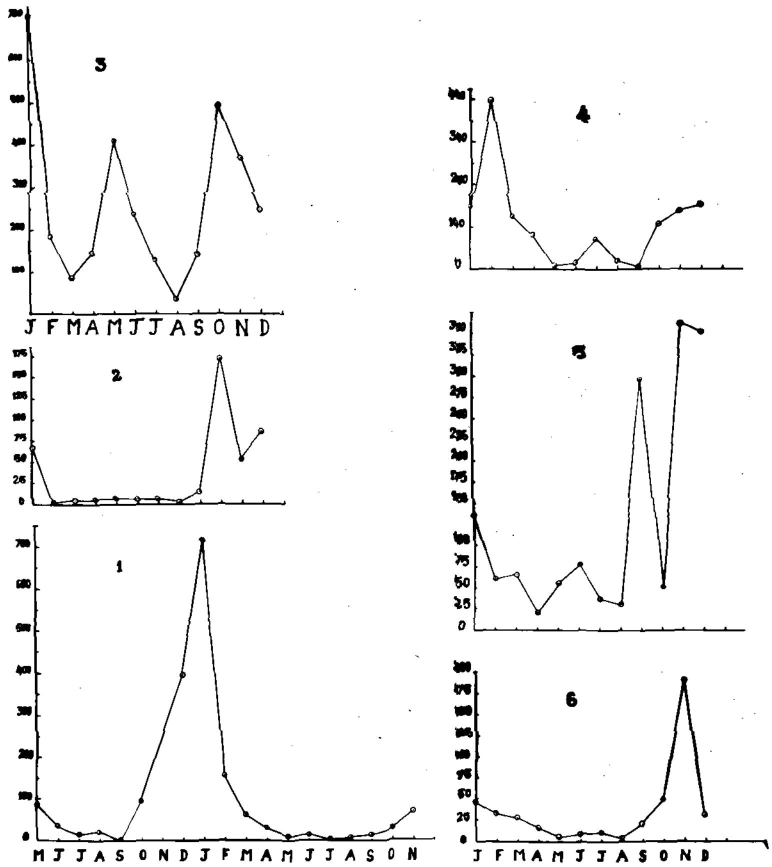
3 *Acartia erythraea* - -do-

4 *Paracalanus* ~~*Pseudodiaptomus*~~ *aculeatus* - -do-

5 *Paracalanus parvus* - -do-

6 *Calanopia aurivilli*- -do-

PLATE XXXIX



Explanation of Plate XL

Fig. 1 *Acrocalanus gibber* - Distribution of total population (adults and copepodites) in the Gulf of Mannar during 1960 as collected by organdie net.

2. *Acrocalanus monachus* - "do"

3 *Euterpina acutifrons* - "do"

4 *Oithona rigida* - "do"

5-13 Percentage distribution of adult females in different species in the Gulf of Mannar during 1960:

5 *Pseudodiaptomus aurivilli*

6 *Calanopia thompsoni*

7 *Acartia erythraea*

8 *Paracalanus aculeatus*

9 *Paracalanus parvus*

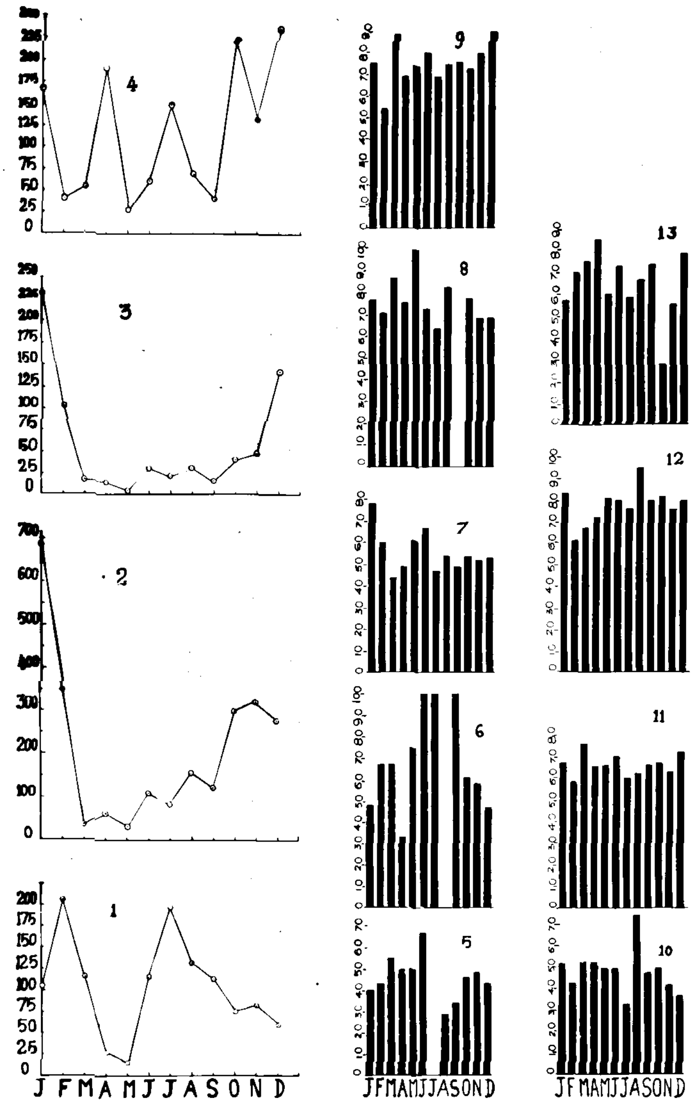
10 *Calanopia aurivilli*

11 *Acrocalanus gibber*

12 *Acrocalanus monachus*

13 *Oithona rigida*

PLATE XL



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Published Papers

Studies on Indian copepods I.
Paralepeopsyllus mannarensis, a new genus and species of cyclopoid cope-po~~i~~d from the Gulf of Mannar

J. Mar. biol. Ass. India, 1960, **2** (1): 105-114

STUDIES ON INDIAN COPEPODS I. *PARALEPEOPSYLLUS MANNARENSIS*, A NEW GENUS AND SPECIES OF CYCLOPOID COPEPOD FROM THE GULF OF MANNAR*

By A. N. P. UMMERKUTTY

Central Marine Fisheries Research Station, Mandapam Camp

THOMPSON and Scott (1903) in their supplementary reports of the faunistic survey of the Pearl Oyster Fisheries of Ceylon reported on a number of copepods, many of which were new to science. Two of the new species, *typicus* and *ovalis*, both belonging to the genus *Lepeopsyllus*, which was also newly erected, were remarkable in their general resemblance to the members of the harpacticoid family Peltidiidae, especially in the shape of the body, in the posteriorward growth of the last prosomal segment and the complete overlapping of the urosome by the latter so that when viewed dorsally only the caudal rami are visible besides the prosomal region. A flattened oval or circular body as seen in *Lepeopsyllus* Thomp. and Scott is shared by many other cyclopoids and the prosomal segments may exhibit varying degrees of expanded growth posteriorly or laterally. But in all such instances the urosome is never fully covered over by the prosome. In *Lepeopsyllus*, however, the last prosomal segment grows over the urosome so that the latter is hidden by the former. Nevertheless a study of the various appendages of this copepod shows beyond doubt that it is a siphonostomous cyclopoid, very much related to dyspontiids, and understandably Thompson and Scott placed this genus under Asterocheridae of Giesbrecht which in fact is included in the Siphonostoma by Sars (1918) wherein he groups together all those cyclopoids having a siphon in the oral region. Wilson (1932) included the genus *Lepeopsyllus* under the family Dyspontiidae Sars, and placed it very near *Dyspontius* Thorell and *Cryptopontius* Giesb. Nicholls (1944) follows Wilson and treats it in the same way. In his brief systematic review of the different genera that should be included in the family Dyspontiidae, he states that *Lepeopsyllus* Thomp. and Scott is 'recognisable as belonging to this family', with no further comments. In a latter part of this paper I have tried to draw attention to all the distinctive characters of this genus which distinguish it from a typical dyspontiid. The very close affinities that exist between *Lepeopsyllus* and the present form described below, and their distinctness from all other cyclopoids in certain important morphological features appear to suggest the creation of a new sub-family or family for their reception ; this point is considered later (*vide infra*).

Paralepeopsyllus Gen. Nov.

Body thin, scale-like, oval or circular ; prosome 3-segmented and urosome 4-segmented in both sexes ; in the female, however, the first two proximal segments may be only partially separated; the urosome is completely overlapped by the

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last prosomal segment ; the margin of all the prosomal segments thickly lined with papilla-like prolongations of irregular lengths, forming an ornamentation. Antennule 14-segmented in female, 12-segmented and geniculate in male. Antenna 5-segmented, the last segment carrying terminal spines ; the second segment carries a rudimentary endopod provided with terminal setae. Siphon rather short and shield-shaped, hardly reaching about two-third the length of first prosomal segment. Mandible consists of a thin linear blade and a 1-segmented palp carrying two terminal setae of unequal length. Maxillule with a bimerous basipod and two palpi of unequal length, both carrying tufts of setae at the apex. Maxilla 1-segmented, strongly built and carrying a stout terminal claw. Maxilliped 5-segmented and strongly built, the last segment having a strong apical claw. There are only three pairs of swimming legs ; the first and second pairs biramous and the last pair uniramous ; the rami of all the legs are 3-segmented. Caudal furca moderately divergent and cylinderical. Eggs carried in two ovisacs, attached on either side of the genital segment and covered over by the last prosomal segment.

Genotype : *Paralepeopsyllus mannarensis* sp. nov.

Paralepeopsyllus mannarensis sp. nov.

Material examined: In the first week of August, 1960 eight females and five males of this copepod were obtained from the sponge washings from the Gulf of Mannar off Vedalai. None of the females in this collection was carrying egg-sacs. In the last week of the same month two egg-carrying females were obtained from the same locality, but this time from crinoid beds.

The generic name of the present species refers to its systematic relationship and the specific name to the locality of occurrence. The holotype, the allotype and the paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station, Mandapam Camp and bear the registered numbers J. 525/3, J. 526/3 and J. 527/3 respectively. All the drawings have been made with the aid of a camera lucida and the description and the diagrams are based on the examination of many specimens.

Description.

FEMALE

Colour. Freshly captured individuals were transparent with beautiful shining ornamentations along the prosomal margins. Formalin preserved specimens became opaque with a pale yellowish tinge ; darker shades are present along the thickened areas. *Body.* (Fig. I, 1)—The body consists of the prosome and the urosome but the latter is entirely hidden beneath the former which actually accounts for the whole size of the animal. The prosome is oblong-oval with a clear rostral prominence on the anterior side. It consists of only three segments, the margins of all of which are greatly ornamented with papilla-like growths. The ornamentation of one lateral half roughly corresponds to that of the other half. The ornamented area appears to be thicker than the non-ornamented part. The first prosomal segment is much larger, both in length and width, than the other two segments combined. The second segment is broader than the third but distinctly shorter than the latter ; it is rather crescent-like with the two lateral edges much

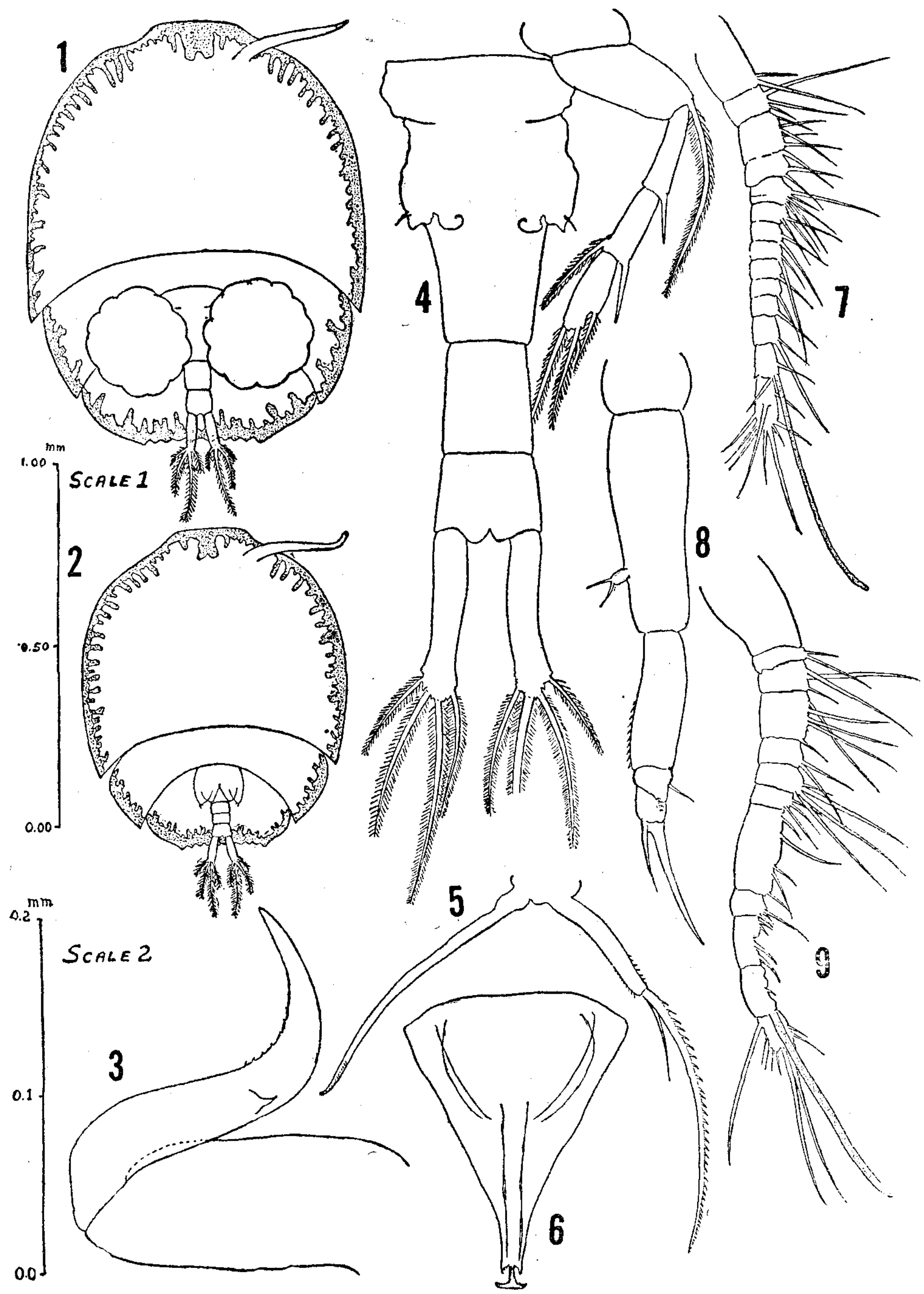

FIG. 1. *Paralepeopsyllus mannarensis* gen. et. sp. nov. 1. Adult female, habitus, ventral view. 2. Adult male, habitus, ventral view. 3. ♀ Maxilla. 4. ♀ Urosome with left third leg. 5. ♀ Mandible. 6. ♀ siphon. 7. ♀ Antennule. 8. ♀ Antenna. 9. ♂ Antennule. (The habitus of the adult male and female are drawn to scale 1, and all the appendages to scale 2).

thickened ; the ornamentation of this segment is broken from that of the first segment but appears to be continuous with that of the following segment. The last prosomal segment has a peculiar shape, with the highly convex anterior margin fitting into the concavity of the preceding segment and with the posterior margin being wavy ; the two lateral sides smoothly curve down to the posterior wavy margin which is less than half as long as the widest part of the same segment ; in the case of this segment the ornamentation is present both on the lateral and the posterior borders. The urosome consists of a genital segment and two abdominal segments ; the former, however, shows a partial division into first urosomal segment which in the related genus, *Lepeopsyllus*, bears the fifth pair of legs and the genital segment proper. It is longer than the two abdominal segments combined ; the genital segment proper exhibits a proximal wider and a distal narrower regions, a spine on either side being present at about the junction of the two. The genital segment carries a pair of ovisacs, one on each side. Of the two abdominal segments the proximal is the larger but they are of equal breadth. The last abdominal segment bears a pair of caudal rami which are cylindrical, rather elongated and slightly divergent. Each of them bears four setae of unequal lengths, the longest of them being only a little longer than the ramus itself.

Antennule (Fig. I, 7)—Compared with the size of the body the antennule is rather small and consists of fourteen segments. The first five segments as a whole, are distinctly wider than the next nine and the fifth segment shows a partial division. While the segments 6-11 are subequal, other segments are of varying lengths, with the first segment as the longest. All the segments are provided with setae, often many of them on a single segment. But the arrangement of the setae does not appear to give any clue to the number of original segments that would have fused together in the formation of the present condition. The thirteenth segment bears a fairly long aesthetask. The proportionate lengths of the antennular segments are as follows :

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
16·4	6·5	10·0	5·3	6·4	4·7	4·7	4·4	4·7	4·1	5·0	7·3	8·2	12·3	= 100

Antenna (Fig. I, 8). This is 5-segmented. The basal two segments form the basipod and the next three segments the endopod ; the exopod is represented by a bud-like structure that arises from anterior margin of the second basipod segment ; the first basipod segment does not bear any accessory structure. The first endopod segment is devoid of any seta or spine but are provided with very small spinules along its distal anterior margin ; second endopod segment bears a slender spine on its posterior margin and the last segment two terminal spines of unequal length ; there are a few small spinules arranged obliquely along its length on this last segment. *Siphon* (Fig. I, 6). This is rather short and pyriform, hardly reaching the two-third length of the first prosomal segment. Its distal part is very narrow, about one-tenth of the wide proximal. The former bears a club-shaped structure at the middle of its concave tip. *Mandible* (Fig. I, 5). Consists of a masticatory blade and a palp which is less than half the length of the former ; the palp has its distal one-third margin ciliated and bears two terminal setae ; one of the setae is slender and short while the other is quite large, equal in length to the masticatory blade and bearing sharp spinules along its entire length on one side. The masticatory blade is slender and long, the thick basal part gradually diminishing in width to the distal tip which is serrated. *Maxillule* (Fig. II, 10). Is composed of a basipod which is indistinctly divided into two segments and a pair of lobes arising from it. One of the lobes is much larger being about two and a half times thicker and longer than the other ; the former bears four setae which are graduated in length and the latter five setae of varying lengths. Along the inner margin of the larger lobe there is a row of spinules. *Maxilla* (Fig. I, 3). Maxilla is peculiar in being uniarticulated with no trace of division. It is large, cylindrical and devoid of any seta or spine except the terminal claw ; the latter is very large and stout and has a characteristic shape in the form of a reversed ' S '. There are a few minute spinules on its distal inner margin and a separate miniature claw just beyond its middle bent. *Maxilliped* (Fig. II, 11). Fairly large and consists of five segments, the fifth segment bearing two terminal spines, one of which is much larger than the other. The segments are uneven in their lengths ; second segment is the largest and the fourth the smallest ; the latter bears a small spine on its inner margin.

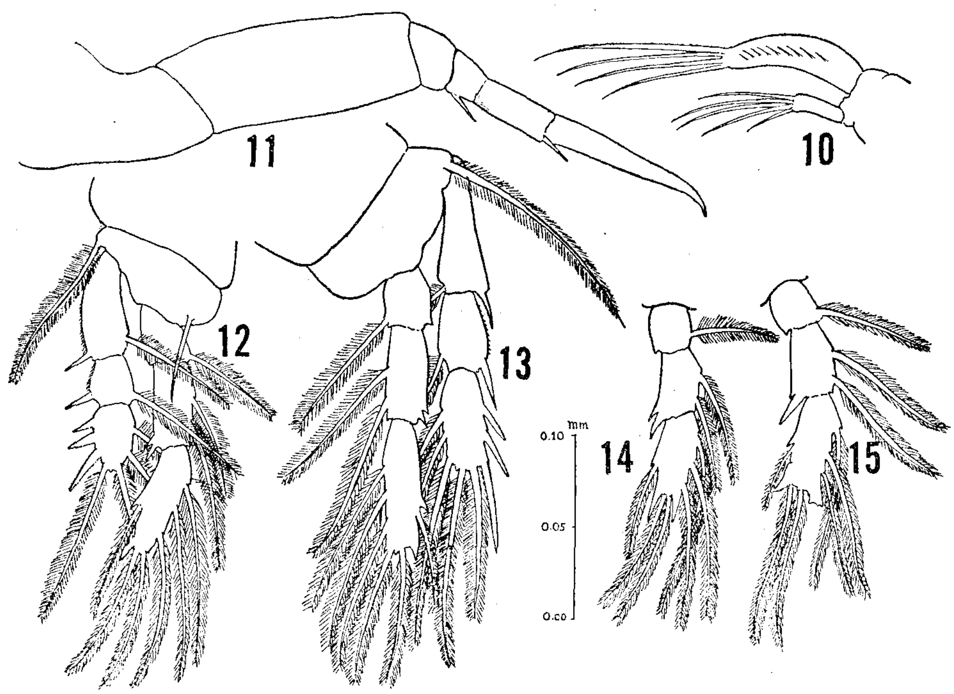

FIG. II. *Paralepeopsyllus mannarensis* gen. et. sp. nov. (contd.) 10. ♀ Maxillule. 11. ♀ Maxilliped. 12. ♀ First swimming leg. 13. ♀ Second swimming leg. 14. ♂ Endopod of first swimming leg. 15. ♂ Endopod of second swimming leg.

Swimming legs (Fig. II, 12, 13). There are only three pairs of swimming legs. Fourth and fifth legs are entirely lacking. They are borne by the three prosomal segments. The first two pairs of legs are biramous while the third is only uniramous. Each ramus is composed of three segments. In the first two pairs of legs, constituting segments are rather elongate ; even when it is short, the segment is distinctly longer than wide. In the first leg the exopod is shorter than the endopod while in the second leg the reverse situation is true. The basipods in both cases are stumpy and broad, the first basal bearing no setae or spine and the second basal bearing one seta and one spine in the case of first pair of legs, and one seta alone in the case of second and third pairs of legs. In the third leg the endopod is entirely lacking; the exopod is rather slender, the segments subequal; in the basipod the basal one is short and broad while the basal two is quite long bearing the exopod almost at right angles to its length. The setal formula for the swimming legs is given below:

Following Sewell (*loc. cit.*) I have used Arabic numerals to indicate setae and Roman numbers for spines.

	Basipod				*Endopod*							*Exopod*						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P^1	0	0	I	1	1	0	1	0	3	2	1	1	I	1	I	3	1	III
P^2	0	0	0	1	1	0	2	0	3	2	1	1	I	1	I	3	2	III
P^3	0	0	0	1	Absent							0	I	1	I	0	1	1+1

The absence of the fourth pair of legs is the consequence of the absence of fourth prosomal segment. However, the fifth legs also are entirely lacking although the fifth leg-bearing segment is present in partial union with the following genital segment. The length of the female is 1·2 mm.

MALE

The male (Fig. I, 2) is much smaller than the female and shows sexual dimorphism in the structure of antennule, urosome and in the endopods of first and second pairs of legs. The urosome is clearly 4-segmented; the first of these segments is the result of the fusion of the original fifth leg-bearing segment and the genital segment. The next three segments constitute the abdomen and are post-genital in origin. The first segment is three times wider and three times longer than the abdominal segments combined. It is barrel-like and carries a pair of spines on each of its posterior corners. The abdominal segments are subequal, the last of them bearing the caudal rami. The latter in male appears to be as long as the last two abdominal segments combined, while in the female it is definitely shorter.

Antennule (Fig. I, 9). Is geniculate and consists only of twelve segments. First segment is the largest and may be compared to the corresponding segment in the female. The last two segments also are comparable to their female counterparts for, the penultimate segment here also bears the aesthetask. The identity of other segments are not clear. All the segments are provided with setae, while segments 9-11 also carry a few spines. The proportionate lengths of the various segments are given below:

1	2	3	4	5	6	7	8	9	10	11	12
17·7	3·8	5·5	9·1	5·3	4·8	4·3	16·8	5·0	10·0	10·0	7·7 = 100

The variations in the structure of the endopods of the male first and second legs (Fig. II, 13, 14) are not very profound. In the first endopod it consists in the presence of spinous growths on either distal corner of the third segments while in the female this spinous process is present only on the outer corner. In the second endopod the male has its distal corners of the third segment produced into peculiar structures, the outer of these is conical and serrated on the outer margin while the inner is irregular ; in the female there is no structure corresponding to this latter ; but the outer conical process is the counterpart of the spine in a similar position in the female.

Discussion

There are a number of characters which the present genus shares with the genus *Lepeopsyllus* Thom. & Scott. Some of these are peculiar to these two genera while some other features are exhibited by the members of one or other related families. The characters shared by these two genera are indeed substantial, the most notable of them being the exceedingly large development of the prosomal segment, especially the last one. The nearest approach to this condition is apparently met with in the genus *Micropontius* Gooding, 1957 (Family Micropontiidae). But the differences between *Micropontius* on the one hand and *Lepeopsyllus* and *Paralepeopsyllus* on the other, are too many to establish any real relationship between them. Among other siphonostomous cyclopoids an expanded growth of the prosomal segments is possessed, to some extent, by the members of the families Dyspontiidae, Artotrogidae and Cancerillidae ; but in all these cases the last prosomal segment always remains small and inconspicuous. However, in the genus *Discopontius* Nicholls, 1944 (Dyspontiidae) the prosome is very large and the last prosomal segment grows posteriorwards, covering not only the first urosomal segment but also a part of the genital segment. This tendency of *Discopontius* to a backward development of the last prosomal segment seems to indicate a genuine kinship with *Lepeopsyllus* and *Paralepeopsyllus*, for there are a number of other features which also point to this conclusion.

In *Lepeopsyllus*, the prosome is 4-segmented, each segment bearing a pair of swimming legs. First segment is far larger than the entire remainder of the body ; next in size comes the last segment which, although only half the size of the first segment, still constitutes a major part of the body and grows over the urosome, fully covering the latter ; second and third segments are rather thin strips, inserted between the first and the last segments. In *Paralepeopsyllus*, a similar situation exists, but the process of reduction has gone still further with the result that there are only three segments in the prosome, each bearing a pair of swimming legs. In size, the first segment remains the largest, accounting for more than half of the body, while the last segment is the next larger and covers the entire urosome dorsally ; the second segment forms a crescent-shaped strip of body between the first and the third segments.

The marginal ornamentation of the prosomal segments also deserves some comments : this character is peculiar to these two genera among the cyclopoids ; a nearest comparable feature found among other genera, such as *Micropontius*, is the thickening of the edges and margins of the prosomal segments. Both are probably for imparting strength to the region, but their morphological history appears to be different. Another character not usually known for the siphonostomous cyclopoids but is noticed in the present genus is the slight structural modifications of the first and second swimming legs of the male. The terminal segment of the endopods of these legs exhibits an expanded development as is described in an earlier part of this paper. Unfortunately this point cannot be discussed as the male is yet to be known for the related genus, *Lepeopsyllus*.

It has been pointed out earlier that both Wilson (*loc. cit.*) and Nicholls (*loc. cit.*) have included *Lepeopsyllus* under Dyspontiidae. One should presume that this was done so only because of the absence of a different family suitable for its reception, rather than by its agreement with the genuine features of a typical dyspontiid. In dyspontiid, the antennule consists of a reduced number of segments and is not divided into a proximal wider and a distal narrower region, except in *Discopontius* where the first two segments are distinguished from the rest by their larger size. In fact, the division of antennule into a proximal wider and a distal narrower region is a condition usually found in Asterocheridae. Further, the geniculate male antennule of the members of Dyspontiidae contains usually an equal or a larger number of segments than the corresponding structure of the female. But in Asterocheridae and in the present genus the reverse is true, namely, the geniculate male antennule is composed of a smaller number of segments than the corresponding organ of the female sex. The structure of the antenna is still more striking. It is 5-segmented both in *Lepeopsyllus* and *Paralepeopsyllus* (although Thompson and Scott state that it is 4-segmented, their diagrams clearly show 5-segments) as it is in most of the asterocherids, while in all dyspontiids it invariably consists of four or less number of segments. The resemblance of these two genera with asterocherids in the structure of the antenna becomes complete when one takes into account the proportionate lengths of the constituting segments. In these forms, the second segment which bears rudimentary exopod is the largest, being equivalent to or larger than the combined size of the next three segments ; while the third and first segments come next in order of size, the last two segments are extremely small and subequal ; the terminal segment bears one or more strong spines. In dyspontiids the last two segments are never so small compared to the size of other segments. Further, although the second segment is still the largest, it is not equal to or longer than the combined length of the two following segments, the only exception, again, being *Discopontius* Nicholls.

It may be noted that the genus *Paralepeopsyllus* tends to exhibit certain similarities with the Artotrogidae and Cancerillidae, especially in the reduction of the posterior pairs of legs. The Artotrogidae differs from Dyspontiidae essentially in the total absence of the fourth pair of legs, in this respect approaching the Cancerillidae ; the latter is, however, distinguishable very easily by the enormous development of antennae which are unlike those in any other siphonostomous family. The reduction in the number of legs, however, need not be taken as a close relationship between *Paralepeopsyllus* and Artotrogidae, for they are quite separated in many other morphological features.

This tendency has been prevalent even in Dyspontiidae where the fifth leg is highly reduced in all the genera ; and the endopod of fourth leg is entirely lacking in a number of genera such as *Dyspontius* Thorell, 1859, and *Cryptopontius* Giesbrecht, 1889, while in some others like *Bradypontius* Giesb. 1895, *Arctopontius* Sars, 1915, *Discopontius* Nicholls, 1944, *Sestropontius* Giesb. 1899, *Metapontius* Hansen, 1923 and *Cribropontius* Giesb. 1899 the endopod is reduced in size. In the genus *Pteropontius* Giesb. 1895 not only is the endopod of fourth leg absent but the rami of the first legs are only 2-segmented, thus exhibiting a tendency for the reduction of other appendages also. It may be only contended that this tendency for a reduction in the number of the swimming legs or their constituting segments has been present in the evolution of different groups of siphonostomous cyclopoids.

Thus it appears clear that the genera *Lepeopsyllus* and *Paralepeopsyllus* constitute a natural group, sharing many peculiar features distinct from those of all other siphonostomous cyclopoids. These two genera retain many characters of the family Asterocheridae found in such structures as the antennule and the antennae and combine them with those of the family Dyspontiidae. However, this is a little known group ; *Lepeopsyllus* is known only from two species, *typicus* and *ovalis*, both based on one or two individuals and *Paralepeopsyllus* is a monotypic genus. Until more species and genera related to these are known it would probably be unfair to erect a new family for accommodating them, although their distinctness is clear enough.

Discopontius referred to above may also be briefly considered here. As pointed out earlier this genus deviates from the definition of typical dyspontiids in a number of ways : (*a*) in the tendency of the prosomal segments to grow posterior-wards over the urosome ; (*b*) in the apparent division of antennule into a wider proximal and a narrower distal region ; and (*c*) in the proportionate lengths of the antennal segments. In all these features the genus tends more towards *Lepeopsyllus* and *Paralepeopsyllus* than to any other member of the family Dyspontiidae. Probably these three genera are not true dyspontiids at all ; or the family Dyspontiidae need to be redefined to include them all.

Summary

Paralepeopsyllus mannarensis, a new genus and species of cyclopoid copepod is described in detail ; it is an inshore-dwelling form, living in association with invertebrates such as sponges and crinoids ; the species is known from both the sexes.

The genus is related to *Lepeopsyllus* Thompson & Scott and its systematic position is very near to that genus. The very close affinities that exist between these two genera and their distinctness from other cyclopoids appear to justify their inclusion in a separate family. The arguments in favour of and against this postulation are discussed.

Acknowledgements

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Studies on Indian copepod II.
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STUDIES ON INDIAN COPEPODS 2. AN ACCOUNT OF THE MORPHOLOGY AND LIFE HISTORY OF A HARPACTICOID COPEPOD, *TISBINTRA JONESI*, SP. NOV. FROM THE GULF OF MANNAR*

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Part I. Description of the Species

Sewell (1940) erected the genus *Tisbintra* to receive a single female copepod which he obtained during the John Murray Expedition in a surface tow-netting in the Nankauri Harbour, Nicobar Islands. To my knowledge no other species has so far been added to this genus and the genotype itself, *T. nankaurica* Sewell, has never again been recorded (Dr. Sewell has confirmed this in a personal communication). The discovery of a new representative of this genus with many morphological deviations is, therefore, of interest; specially so, because of the light it throws on the systematic position of the genus. Below is given an account of the morphology and life history of a new copepod obtained from the Gulf of Mannar and identified as a species of *Tisbintra* Sewell.

The occurrence of this species was first observed by Dr. S. Jones and it was at his instance that a detailed examination was undertaken. I have, therefore, much pleasure in naming the species *T. jonesi*.

Gooding (1957) has called attention to the fact that several terms have from time to time been used to differentiate the regions of the copepod body. Sars (1901) was the first to introduce some order by suggesting the terms cephalosome, metasome and urosome, the first two together to denote the usually broader anterior region and the last to denote the narrower posterior region respectively, irrespective of the morphological origin. Wilson (1932) adopted the nomenclature of Sars but interpreted that part of the body in front of the movable articulation as the metasome

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(which actually is the combined cephalosome and metasome of Sars) and the part behind the articulation as the urosome ; but in the text he has used other terms very frequently. I have adopted the terminology suggested by Gooding (*loc. cit.*) which appears to have definite advantages over the earlier ones. But the term abdomen may be added to denote the post-genital segments. In an earlier paper (Ummerkutty, 1960) I used the terms basipod, exopod and endopod to indicate the basal segment-complex and the external and internal rami respectively. The first term is probably not appropriate for the basal segment-complex actually comprises what are usually termed as coxopodite and basipodite; the term ' protopod ' would be a correct one. In this paper the ' endopod ', the ' exopod ' and the protopod have been employed not only to describe the parts of the swimming legs but also for those of the cephalosomal appendages of the adult animals. The terms ' protopodite, ' ' endopodite ' and ' exopodite ' have been used only in the case of copepodites. In describing the ornamentation of the swimming legs I have followed Sewell (1949) in differentiating spines by Roman and setae by Arabic numerals.

The holotype, allotype and paratypes have been deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station. All the diagrams are drawn with the aid of a *camera lucida.*

Tisbintra Jonesi sp. nov.

Occurrence. The species was first observed in the marine aquarium tanks of the Central Marine Fisheries Research Station. The animal was found to creep on the glass walls and on the decaying vegetable matter on the bottom, probably feeding on them. It is of interest to note that this was one of the few copepods found to establish in good numbers in the aquaria to which it gains access through the pumping system.

In nature they were captured in the coastal plankton when the sea was in a disturbed condition. It appears that it is a bottom dweller and is brought upto the surface by water movements.

FEMALE

The colour. Body is transparent, tinged with faint yellow ; dark shades are present in the mid-dorsal region of the metasomal segments. In mature specimens the ovary and its branches are seen as dark bands. So also is the gut when it is filled with food. *The body* is depressed, the anterior and posterior regions being clearly demarcated. The prosome is rather elongate-ovate, a little less than twice as long as wide and is vaulted dorsally. Cephalosome is fused with the first pedigerous segment and is almost as long as all the metasomal segments combined. The epimeral plates of the second and third prosomal segments are well-developed, being produced laterally and posteriorly and are rounded at the edge ; that of the last segment is very small without lateral expansion. Urosome is moderately slender ; the genital segment is as long as the next three segments combined and is divided dorsally along the middle (Fig. I, 1). On the ventral side the division is incomplete and there is a transverse genital aperture which is guarded by a long slender spine on each side (Fig. I, 2). The longest specimen measures 1.1 mm. and the proportional lengths of the prosome and the urosome are 59 : 41. The second innermost furcal seta is the longest and is distinctly longer than the urosome.

Antennule (Fig. I, 3) is short, hardly exceeding the length of cephalosome and consists of 8 segments having the following proportions :

1	2	3	4	5	6	7	8
9.5	25.0	21.0	22.5	4.0	5.0	4.5	8.5=100

The antennule carries a large number of rather short setae and the presence of a crescent-shaped knob, just beyond the mid-length of the third segment bearing 4 radiating setae, is a characteristic feature. The aesthetask on the 4th segment is well-developed and extends far beyond the tip of the antennule. The latter is divided into proximal wider and distal narrower parts, each being composed of 4 segments ; the distal four segments are much smaller and their combined length is just a little more than 1/4th of the proximal wider part. *Antenna* (Fig. I, 4) : The endopod consists of 3 segments, the terminal segment being the longest. The first segment carries a very small bristle on the outerside, at one-third of the length of the segment and a long seta at its distal inner margin. The second segment is devoid of any seta. The third segment has two stout setae on the anterior margin a little beyond the mid-length. At the apex it has one spine and five setae, 3 of which have a characteristic curve. The exopod is composed of two segments and is attached to the side of the basal endopod segment ; the proximal segment is shorter bearing one seta ; the distal one bears two setae basally and three terminally one of which is very small. *Labrum* (Fig. I, 5) : This is rather prominent tapering distally ; terminal edge is denticulate, coarse in the middle and finer at the sides. In addition, two fine hairs are present on either side of the denticulated area. *Mandible* (Fig. I, 6) : This consists of a biramous palp and a slender biting ramus. The latter is provided with several teeth at the apex and has a truncate projection on its postero-lateral margin. The rami of the palp are uniarticulate and slender and are borne on a uniarticulate protopod. The two rami represent the exopod and the endopod. *Maxillule* (Fig. I, 7) : A palp is present but an epipodal lobe is entirely lacking. The body of the maxillule is provided with a tuft of setae at its apex, a strong solitary seta sub-terminally on the distal outer margin and 2 short setae on the ventral side ; the latter actually terminate two elevated lines which converge towards the apex. The palp carries a number of setae which are arranged linearly along its inner margin from the mid-length to the apex. *Maxilla* (Fig. I, 8) : This is two-segmented but the segmentation is not easily discernible ; there is no lateral lobe on the basal segment ; the distal segment bears at its apex a long stout claw which is serrate at the distal inner edge ; a process, spatulate and fringed, is present on the inner margin of the claw just beyond its mid-length ; a group of 4 radiating bristles and an accessory spine are present near the base of the claw. *Maxilliped* (Fig. I, 9) : In the maxilliped, the third segment is not separated from the second ; the terminal claw is very slender and distinctly longer than the second and third segments combined ; the accessory spine, as in the maxilla, is close to the base of the claw ; the basal segment is sparsely provided with hairs ; in addition, it bears a small projection at its proximal outer margin which is provided with a tuft of hairs.

First leg (Fig. I, 10) : The exopod consists of three stout segments and the endopod of two much elongated segments, both closely resembling those of *T. nankaurica* Sewell ; but the arrangements of spine on the exopod is different from that of the latter species. The marginal spine on the first exopod segment is long with a wavy appearance whereas that on the second exopod segment is short and stout, a condition generally found in species of *Tisbe* and in contrast to that of *T. nankaurica*. Exopod II is of about the same length as exopod I and bears an inner seta and an outer spine ; exopod III is quadrate in form and bears two slender spines

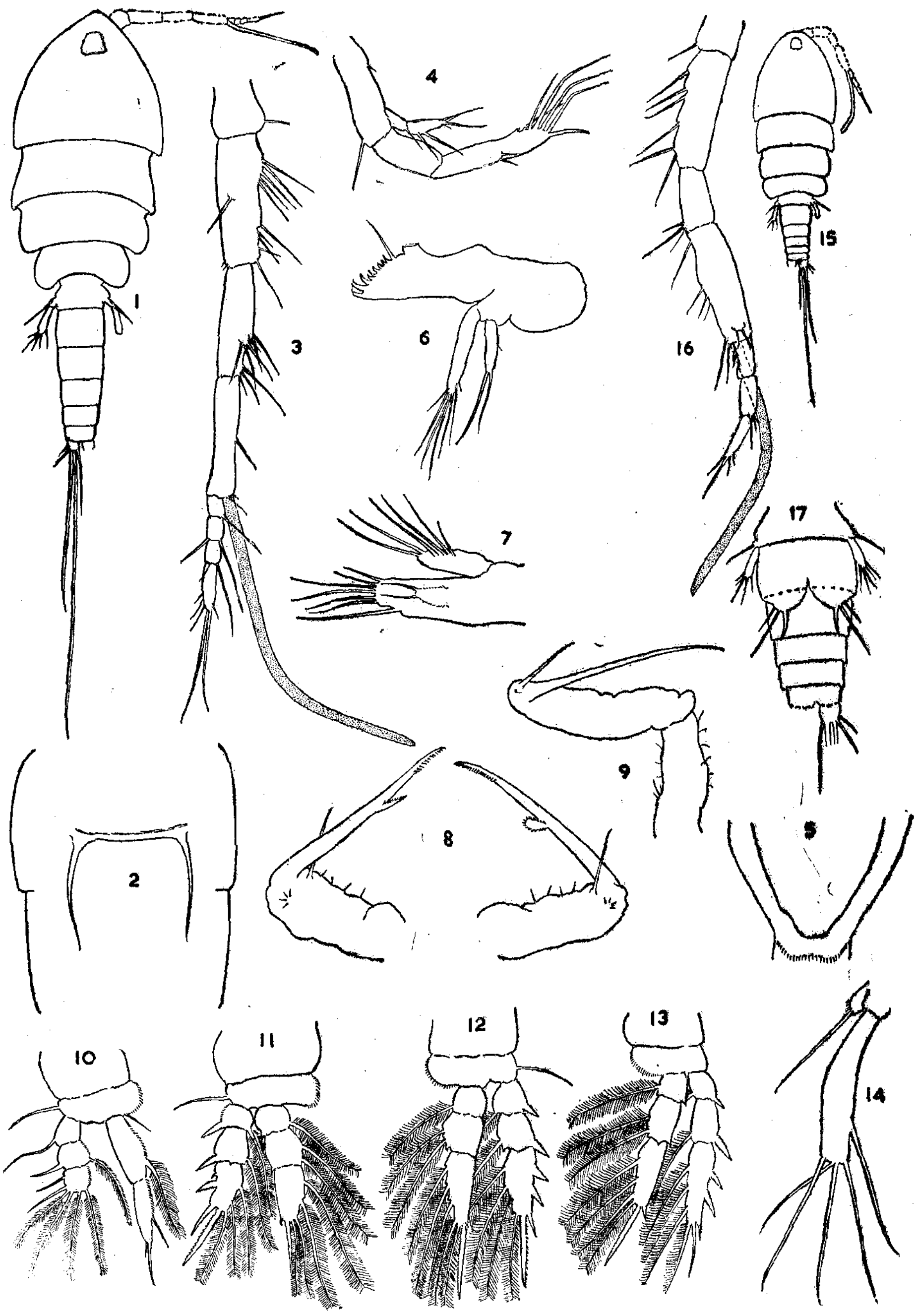

FIG. I

1. Female, adult, dorsal view.
2. ,, genital segment ventral view.
3. ,, antennule.
4. ,, antenna.
5. ,, labrum.
6. ,, mandible.
7. ,, maxillule.

8. Female, maxillae.
9. ,, maxilliped.
10-14. First to fifth legs.
15. Male, adult, dorsal view.
16. ,, urosome ventral view.
17. ,, antennule.

on its outer margin and four plumose setae at the apex. The endopod is considerably longer than the exopod and consists of only two segments of approximately equal length; the proximal segment is moderately stout, is equal in length to the three exopod segments combined and bears a single inner seta at about the junction of the middle and distal thirds; the distal segment is slender and bears a spine at about its mid-length and two spines at its apex one of which is stronger and longer than the other. Both segments of endopod bear small hairs on their inner margins. Second, third and fourth legs (Fig. I, 11, 12 & 13) are all with 3-segmented rami and are more or less similar in appearance. However, in the second leg the proximal spine on the third segment of the exopod is markedly reduced in size. The number of setae and spines borne by different segments of the endopods and exopods are given below (Si, St and Se represent the inner, the terminal and the outer margins of the segments; and P_2-P_4 represent the second to third swimming legs).

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P2	0	0	0	1	1	0	2	0	4	I	0	1	I	1	I	3	I	III
P3	0	0	0	1	1	0	2	0	5	I	0	1	I	1	I	4	I	III
P4	0	0	0	0	1	0	2	0	4	I	0	1	I	1	I	4	I	III

Fifth leg (Fig. I, 14): In the fifth leg the basal segment is produced externally in a small conical process that bears a long and a short seta and a few hairs at its tip; there is no inner expansion; the distal segment is cylindrical, narrower at the base than at the apex and is 6 times as long as broad; it bears one seta subterminally on its distal inner margin and 4 setae at the apex, one of which is smaller than the other three setae which are rather subequal.

MALE

The male (Fig. I, 15) resembles the female in general form but measures only 0.64 mm. The proportionate lengths of the prosome and urosome are 66.6 : 33.4. The differences between the two sexes consist of the geniculate antennule, the presence of vestigeal sixth pair of legs and the six-segmented nature of the urosome of the male, besides the smaller size of the latter. *Antennule* (Fig. I, 17): This forms a grasping organ and is strongly built and consists of only 7 segments having the following proportions.

1	2	3	4	5	6	7
9.5	25.0	11.5	25.5	9.0	9.5	10.0 = 100

The aesthetask is borne by the fourth segment as in the female. The antennules are not provided with as many setae as are present in the case of female.

The genital armature or sixth pair of legs (Fig. I, 16) is a broad bi-lobed flap covering the entire ventral side of the genital segment and part of the succeeding segment. It bears 3 spines on either side; the innermost is stout and backwardly directed; the outer ones are rather slender and posterolateral.

The urosome is 6-segmented consisting of the fifth leg-bearing segment, the genital segment and 4 abdominal segments. The first segment is of about the same proportionate dimensions as in the female. The genital segment and the first abdominal segment are subequal and are the largest segments of the urosome. The last three abdominal segments diminish in size to the posterior side.

T. jonesi differs from *T. nankaurica* in a number of features and they are listed below :—

T. nankaurica Sewell	*T. jonesi* sp. nov.
Size of the female 1.23 mm. and the proportional lengths of prosome and urosome = 62 : 38	Size of the female 1.1 mm. and the proportional lengths of prosome and urosome = 59 : 41.
Rostrum distinct.	Rostrum indistinct.
Second inner furcal seta is as long as the urosome.	Much longer than the urosome.
Genital segment in female divided laterally.	Divided laterally and dorsally.
The genital aperture situated very near to the proximal end of the segment and the spines guarding the aperture hardly reaching its mid-length.	The genital aperture situated at about $\frac{1}{4}$ the length of the genital segment away from its proximal end and the spines guarding the aperture reaching well into its $\frac{3}{4}$ length.
The setation on the antennule very sparse.	Rather profuse. A characteristic crescent-shaped knob bearing 4 radiating setae present on the third segment.
The apical setae of the endopod of second antenna all straight.	Three of the setae have a characteristic outward bend at their 2/3 lengths.
Maxillule and its palp each tipped with a tuft of stout spine-like setae.	In addition to the terminal tuft of setae, the maxillule also bears 3 spines, one on the distal outer margin and 2 on the ventral side. The maxillular palp bears a number of setae on its inner margin arranged linearly from about the mid-length to the apex.
Maxilla is comparatively simple in structure with only a single stout terminal claw, having no serration.	An accessory spine present near the base of the terminal claw which bears on its inner margin near the centre, a spatulate and fringed process. The distal end of the claw is serrate.
Maxilliped not described or sketched by Sewell.	Maxilliped apparently with no division between the second and third segments. An accessory spine and a terminal claw present.
The marginal spine on the first exopod segment of the first leg is of moderate length whereas that on the second segment is considerably longer.	The marginal spine on the first exopod segment of the first leg is considerably longer than that on the second segment.
Exopod III of first leg bears 3 delicate setae-like spines on the outer margin and 4 plumose setae on the distal margin.	Exopod III of first leg bears 2 delicate seta-like spines on the outer margin 4 plumose setae on the distal margin.
Second segment of first endopod bears a single straight spine distally.	Second segment of first endopod bears 2 spines one of which is shorter than the other.
Fifth leg long and slender with one inner and three terminal setae.	Fifth leg long and slender with one inner and four apical setae.

Notes on the Genus—The absence of male specimens of *T. nankaurica* and the fact that the genus has been based on a single species have naturally placed limitations on the scope of its definition as provided by Sewell. When new allied forms, not sharing all the features of the genus are discovered, the original definition would

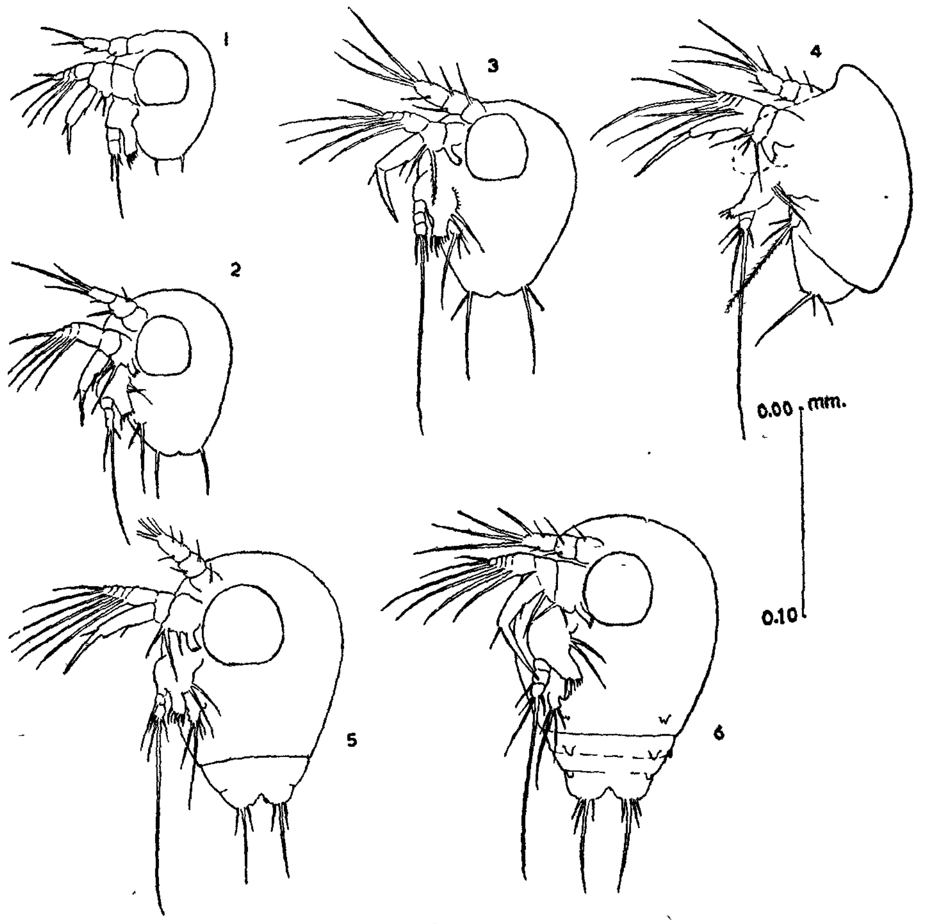

FIG. II

1-6. Naupliar stages first to sixth. Fourth stage lateral view ; all the others ventral view.

require either modification or expansion. Alternately the new forms could be kept as a subgroup in the older genus. In the present case it appears that it is not in the fitness of things to treat *T. nankaurica* and *T. jonesi* as anything more than two species of the same genus for they both possess many common features. However, this would necessitate some alteration in the definition of the genus *Tisbintra*. The presence of a rounded rostral projection on the cephalosome, for instance, is considered as a generic character by Sewell. In the present species the rostrum is absent although it is undoubtedly a representative of the genus. Again, in *T. nankaurica* the genital segment shows transverse division only laterally and this is described as a generic character by Sewell ; in *T. jonesi* the division extends to the dorsal side as well. Conversely, the highly reduced proximal spine on the terminal segment of the exopod of the second leg is described as a specific feature by Sewell. It appears that this character may well be of generic importance for it is present in *T. jonesi* also. In view of these facts the genus *Tisbintra* Sewell is redefined here as follows :

Body depressed ; cephalosome fused with the first segment, forming the cephalothorax ; the epimeral plates of first and second metasomal segments are produced laterally and posteriorly and are rounded at the edge ; that of the third metasomal segment distinctly less wide. Urosome half as wide as the metasome ; the segment bearing the fifth leg greatly narrowed and is almost as wide as the following genital segment ; the latter in female long and divided and is provided with 2 long spines, one on either side of the genital aperture ; in male it is provided with a well developed genital armature ; Abdomen 3-segmented in female and 4-segmented in male. Caudal rami short with second inner seta much elongate ; antennule slender, 8-segmented in female, 7-segmented and geniculate in male ; endopod of antenna 3-segmented, exopod 2-segmented and much smaller ; the mandible possesses a biramous palp and a slender biting ramus provided with several teeth distally and with a truncate projection on its posterior margin; maxillule without an epipodal lobe; maxilla and maxilliped both uncinate. Endopod of first legs 2-segmented and prehensile, exopod 3-segmented and natatory ; rami of second, third and fourth legs 3-segmented ; proximal spine on the third exopod segment of second leg markedly reduced in size ; fifth leg 2-segmented, basal segment without an inner expansion, distal segment narrow, and elongate. A single ovisac present.

PART II. LIFE HISTORY

Procedure. Live egg-carrying females were picked from aquarium tanks and fresh plankton and kept in filtered sea water contained in beakers of 100 cc. and 200 cc. capacities. In most cases it hardly took more than 24 hours for the larvae to hatch out, depending on the condition of maturity of the eggs. The hatching was cent percent successful and the larvae thus hatched developed through all the naupliar and copepodite stages to the adults, the whole process taking 7 to 9 days, in normal room temperature (28° C-31° C), varying according to the intensity of feeding. The animals were fed on a variety of marine food items such as powdered *Gracillaria crassa*,* ground dried clams and a variety of fresh chopped sea weeds. All these appeared to be quite acceptable to the copepod.

Stages were picked at regular frequent intervals and preserved for subsequent study. Live specimens of the various stages also were examined. Experiments were repeated and the nauplii and copepodites were studied from different series of culture to confirm the results. Samples containing all the different developmental stages were also taken from aquarium tanks for examination and comparison. However, no nauplius or copepodite (except a few fifth stages) were obtained from the plankton.

All drawings have been made from specimens reared in the laboratory. The instars are separated only by one moult as in other copepods that have been studied. There are six naupliar and six copepodite stages, the last of which is the adult. They are described below in detail. All the diagrams were made with the aid of a camera lucida.

* Kindly supplied by Dr. (Mrs.) F. Thivy.

Naupliar Stages. There are six naupliar stages the last of which moults into the first copepodite. Like most of the harpacticoids the naupliar stages are bottom-living and come up to the surface waters only when they are disturbed. They are highly depressed, sub-circular in shape and transparent. They swim about gracefully and are capable of performing quick creeping movements along the glass walls of the culture jars and the pieces of algae that are introduced as food items.

NAUPLIUS I. (Fig. II, 1)

The first nauplius varies in length from 0.58-0.62 mm. and lasts for about 12 hours at 28° C-31° C. It has 3 pairs of appendages, the antennule, the antenna and the mandible. The antennule is 3-segmented with the terminal segment bearing 3 setae, two at the apex and one at the mid-length, and the middle segment carrying 1 seta. In the antenna the endopodite is stoutly built and 1-segmented, terminating in a stout claw more than half as long as the ramus itself. It also carries 2 spines, one near the claw and the other at the mid-length. The exopodite is 4-jointed, first three of them carrying 1 seta each and the apical one 2 setae. The endopodite and the exopodite are borne on a bimerous protopodite. The protopodite I of antenna is provided with a rudimentary masticatory blade ; Protopodite II bears 2 spines. Mandible consists of an exopodite of only two joints of equal length and an endopodite of one segment which is as long as the combined length of the exopodite segments. Exopodite II bears 3 setae, one of which is very long. Endopodite bears 2 fine setae and 3 spines. The caudal armature consists of 2 rather flaccid setae.

NAUPLIUS II. (Fig. II, 2)

The second nauplius varies in length from 0.80-0.90 mm. and lives for about 16-20 hrs. at normal room temperature. The structural advances over the first stage are as follows : Antennule is 3-segmented; 2 setae are present on the second segment and an additional apical seta on the third segment; first segment is still without any seta. The masticatory blade of the antenna is well defined and is denticulate. Of the two setae present on the second protopodite, the inner one becomes longer and setiferous while the outer one is more spine-like. Mandible: The protopodite (which is still unsegmented) bears 2 setae, one of these being twice as long as the other. Maxillule appears as two strong setae, borne on a bud, one on either side just behind the mandible. Caudal armature, again, consists of 2 setae which are comparatively longer and stouter than those of the first stage. The posterior margin of the body of the nauplius gives a cleaved appearance.

NAUPLIUS III. (Fig. II, 3)

The length varies from 0.10-0.105 mm. and the duration of life is the same as in the second stage at 28°C-31°C. The third stage shows the following morphological advances over the second stage. Antennule : First segment now carries 1 seta and the terminal segment is with one more seta at mid-length. Mandible : Fine bristles appear in the basal inner margin, of the protopodite, just before the two setae and the long seta of the terminal exopodite segment is longer than the entire body. Maxillule : A small additional seta appears on the inner side of the large seta and a protopodite is present. Caudal armature now consists of two setae on either side, the inner one being much longer than the outer,

Nauplius IV. (Fig. II, 4)

The length varies from 0.12-0.125 mm. and lasts for about 14 to 16 hours at normal room temperature. The number of setae present on the segments of antennule remains the same except that one seta is added in the terminal segment, bringing the total number to six. Antenna : The masticatory blade is quite long and a seta is present near its base. A third seta is added to the two setae on the second protopodite segment. The exopodite becomes 5-segmented, the first 4 segments bearing one seta each and the terminal segment 2 setae. Mandible : Terminal exopodite segment bears 4 apical and one subapical seta. The masticatory palp is stouter than in the previous stage. Maxillule is quite well-developed with 4 setae, one of which is very stout and long bearing hairs all along its length. Each caudal ramus carries 2 small setae in addition to the long seta.

Nauplius V. (Fig. II, 5)

The fifth stage varies in length from 0.135-0.140 mm. and live for 14 to 18 hours at normal room temperature before moulting into the next stage. This stage is very similar to the fourth stage, but the segmentation of the posterior region becomes much more distinct. The oral appendages show little change except the maxillule which now shows signs of segmentation. Each caudal ramus carries 3 setae.

Nauplius VI. (Fig. II, 6)

This stage varies in length from 0.14-0.15 mm. and lives for about 20 to 24 hours. The sixth nauplius moults into the first copepodite and is far advanced in structure than the fifth stage. The rudiment of maxillae and first and second pairs of legs are present as buds. But none of these bears any seta. The other appendages are very similar to those of the fifth stage. There are four setae on each caudal ramus and they are all longer and stouter than those of the previous stages. The distinguishing features of the sixth nauplius are the clearly segmented hind part of the body and the presence of the rudiments of the first and second swimming legs.

Copepodite Stages. There are five copepodites, the last of which moults into the adults. Like the nauplii the instars are separated by only one moult. The copepodites are active creatures most of them creeping about on the algal pieces in the culture dishes and making quick movements at slight disturbances. The segmentation of the prosome and the urosome as well as that of the swimming feet follow the general pattern of the harpacticoid development.

Copepodite I. (Fig. III, 1)

The first copepodite is a miniature adult, but with only 5 segments, 3 prosomal and 2 urosomal and the distinction in width between the two regions is considerably small. The caudal rami is wider than long and stuffy. The furcal setae are all well-developed and resemble those of the adult.

All the mouth parts have made their appearances and resemble the adult structures in their basic pattern. The details of the differences from the latter are

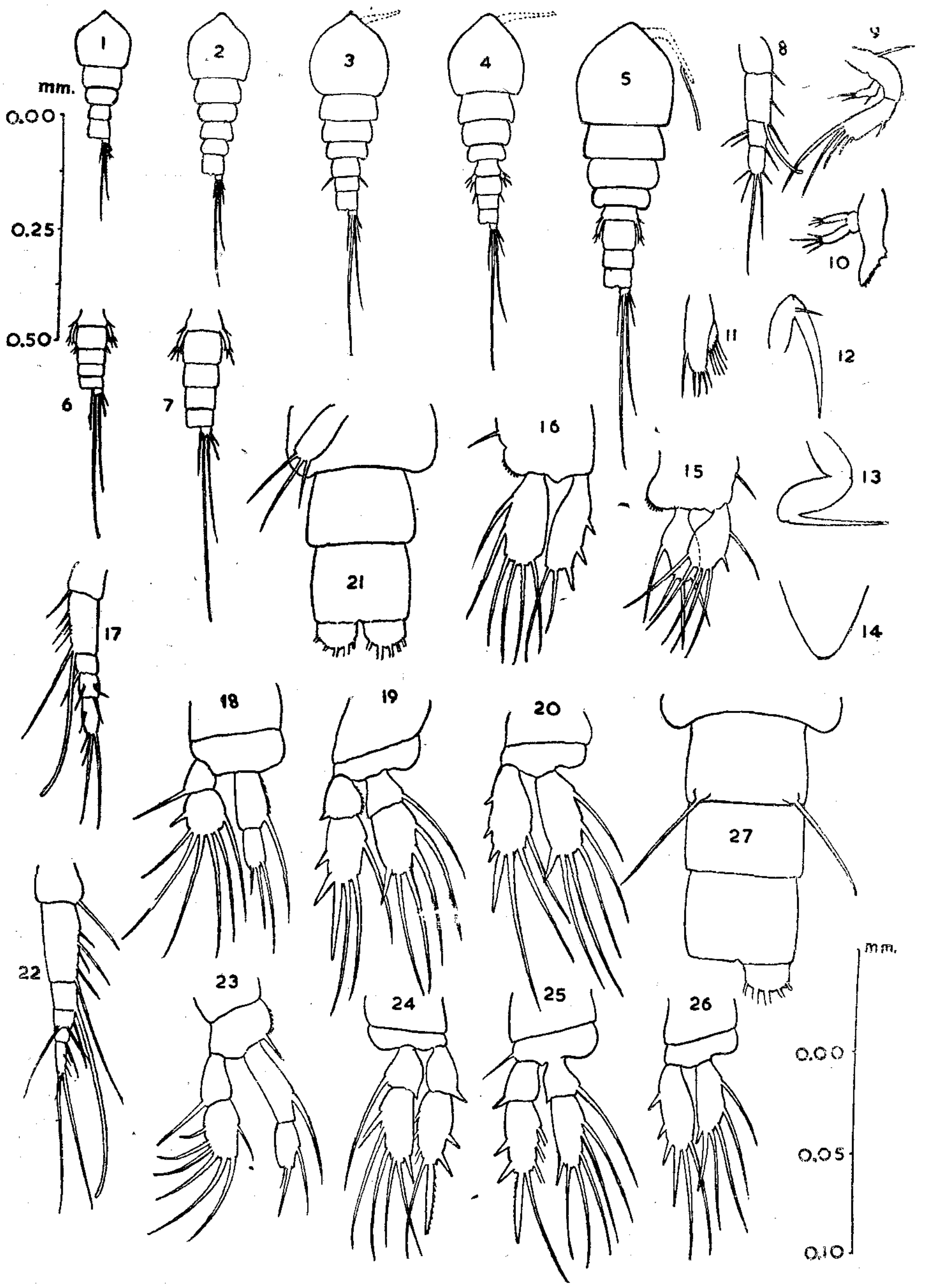

FIG. III

1-3. Copepodite first to third.
4. Copepodite IV male.
5. Copepodite IV female.
6. Urosome of Copepodite V male.
7. ,, ,, V female.
8. First Cop. antennule.
9. ,, antenna.
10. ,, mandible.
11. ,, maxillule.
12. ,, maxilla.
13. ,, maxilliped.
14. ,, labrum.

15-16. first and second swimming legs.
17. Second Cop. antennule.
18-20. ,, first to third swimming legs.
21. ,, urosome with last prosomal segment carrying the fifth leg.
22. Third Cop. antennule.
23-26. ,, first to fourth legs.
27. ,, Urosome with vestigeal fifth leg, ventral view.

(Diagrams 1 to 7 of Fig. III are drawn according to Scale 1 and 8 to 27 according to Scale 2).

noted below : Antennule (Fig. III, 8) : This is only four segmented ; the third segment bears a fine aesthetask. Antenna (Fig. III, 9) : The division of exopodite into 2 segments is not discernible. In the endopodite there are only 4 apical setae and a small bristle. Maxilla (Fig. III, 12) : The spatulate process of the apical claw has not yet appeared ; the terminal edge of the claw not serrated. Maxilliped (Fig. III, 13) : No accessory spine is present ; the tuft of hairs on the proximal segment is absent.

There are only two pairs of swimming legs and vestige of the third (Fig. III, 15 & 16). The rami of both the first and second legs are 1-segmented. The vestigeal third leg is peg-like, bearing 3 setae. The exopodite of first leg anticipates the adult structure: the proximal spine is already much longer than the second spine, a character which the present species possesses, in contrast to the only other known species of the genus, *T. nankaurica*. The division of the protopodite is not clear. The average length of this stage is 0.208 mm. It lives for about 18 hours under normal room temperature (28°C-31°C).

Copepodite II. (Fig. III, 2)

The number of segments is increased to six, 4 prosomal and 2 urosomal. The general appearance is similar to that of the first stage. Antennule (Fig. III, 17) is 5-segmented, the second one bearing the aesthetask. All other mouth parts show adult structures except the maxilla which still has not developed the spatulate process on the terminal claw. There are three pairs of swimming legs and a vestige of the fourth (Fig. III, 18, 19, 20 & 21). The rami of the first two legs are 2-segmented and those of the third leg 1-segmented ; the protopodites of all the three pairs of legs are clearly 2-segmented. The vestigeal fourth leg is only a small process with three terminal setae. The average length of this stage is 0.375 and the duration of life about 20 hours.

Copepodite III. (Fig. III, 3)

There are 4 segments in the prosome while a third segment is addeo to the urosome. The distinction in width between the two divisions is more pronounced than in the preceding stages. Antennule (Fig. III, 22) is 6-segmented the third segment bearing the aesthetask. The other cephalosomal appendages are very similar to those of the adult. There are 4 pairs of biramous legs and a vestige of the fifth (Fig. III, 23, 24, 25, 26 & 27). The rami of the first three pairs are 2-segmented and those of the fourth only 1-segmented. The protopodite of all the four pairs of legs are clearly segmented. The protopodite II of firstlegs has not yet developed the seta on its outer margin. The fifth vestigeal segment is borne by the first urosomal segment and is each represented by only a single seta with a well defined base. The average length is 0.460 mm. This stage lasts for about 20 hours.

Copepodite IV. (Fig. III, 4 & 5)

Prosomal and urosomal segments are now equal in number, each region being composed of four segments. The body has all the adult features, including the lateral expansion of the first and second metasomal segments and the dimorphism of the sexes. The male is much smaller than the female being only slightly longer than the third stage :

The size of the male=0.490 mm.

The size of the female=0.577 mm.

The sexes are easily distinguished by the presence on the second urosomal (genital) segment of the male of a spine representing the vestige of the sixth pair of legs (the so-called genital armature, Fig. IV, 1).

The antennule is 7-segmented in both sexes (Fig. IV, 2). The first four pairs of swimming legs are biramous, each ramus being composed of 2 segments (Fig. IV, 3, 4, 5 & 6). The fifth pair of legs (Fig. IV, 1) consists of a short peg-like structure with three apical and one basal setae. In the male the sixth pair of legs is each represented by a single seta projecting postero-laterally from the second urosomal (genital) segment. The fourth stage lives for about the same period as the third stage.

COPEPODITE V. (Fig. III, 6 & 7)

This stage has nine segments, 4 prosomal and 5 urosomal in both sexes. In the female the genital segment is not yet divided but is distinctly longer than the other segments of urosome. The two spines on either side of the genital aperture are present but are shorter than those of the adult. Length of the female is 0.832 mm. and that of male 0.535. Antennule : This is stumpy and 7-segmented in male (Fig. IV, 8) and normal and 8-segmented in female (Fig. IV, 7). In the latter all the adult features, including the crescent-shaped knob on the third segment have been formed.. But in the male although the proximal segments of the antennule are foreshortened it has not become completely geniculate. All the swimming legs are present (Fig. IV, 10, 11, 12 & 13). The first four pairs of legs are biramous, the rami being 3-segmented except the first endopod which is only 2-segmented. The setation of the various segments are similar to those of the adult except in the fifth leg (Fig. IV, 14) where there are only 3 apical and 1 sub-apical setae whereas in the adult the corresponding numbers are 4 and 1. The proximal spines of the third exopodite segment of the second leg is considerably reduced in size.

THE ADULTS

The detailed description of the adult male and female are given in the earlier part of this paper.

Remarks. Johnson and Olson (1948) have given an account of the life history of *Tisbe furcata* which they reared through all the stages in the Laboratory. Few more marine harpacticoids have been subjected to large amount of investigations and much detail is known about their life histories and reproduction. (Nicholls, 1935 ; Fraser, 1936 ; Gurney, 1930 & 1932). However, the knowledge of the life histories of harpacticoid copepods from Indian waters is extremely meagre. Krishnaswamy (1950 and 1955) has given an account of the life histories of *Macrosetella gracilis* and *Leptostacus euryhalinus*. Rao (1958) described the developmental stages of *Euterpina acutifons*. Of these *Leptostacus euryhalinus* is a psammophilious copepod, the other two being planktonic in their habits.

Many previous investigators (Gurney, *loc. cit* ; Johnson, 1934 a & b ; 1935) have called attention to the striking similarity that exists between the nauplius larvae of marine copepods belonging to the same genus. Johnson (1935) cites the developmental stages of *Labidocera*, *Epilabidocera* and *Pontella* to show that this identity can be found even in the larvae of different but closely related genera and concludes

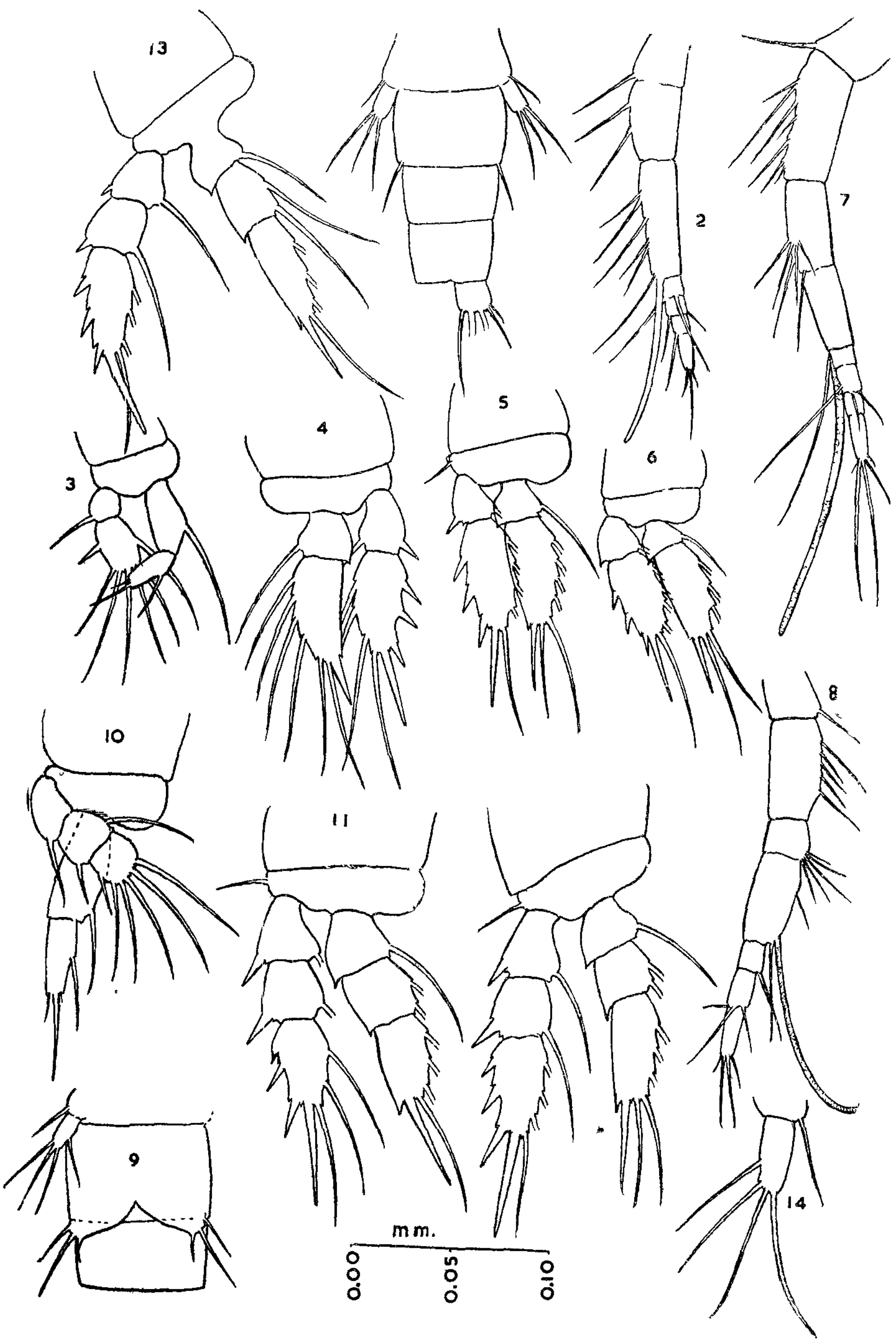

Fig. IV

1. Fourth Cop. male urosome with fifth leg, and vestigeal genital armature.
2. " antennule.
3. " first leg.
4-6. " female second to fourth legs.
7. Fifth Cop. female antennule.
8. Fifth Cop. male antennule.
9. " " first and second urosomal segments with fifth leg and genital armature.
10-14. " Female first to fifth legs.

that the larvae of allied genera conform each other in essential structural details. It is, therefore, not surprising to observe a very close similarity between the larvae of *Tisbintra* and *Tisbe*. In fact, that is what one should expect for these forms have not only close systematic kinship but they both occupy the same ecological niche, namely, the bottom inshore waters. A very close similarity exists between the naupliar stages of *Tisbintra jonesi* and *Tisbe furcata*. The real differences between these species, however, make their appearances from first copepodite onwards. Judging from the figures of Johnson and Olson (*loc. cit.*) it is clear even in the general appearance they are widely separated ; while the cephalothorax of *T. furcata* is almost as long as the combined length of all other four segments that of *T. jonesi* is just a little more than one-third the entire body length. The differences in the various copepodite stages of the two species, such as the reduced development of the proximal spine of the third segment of the second exopodite and 2-segmented nature of the endopodite of the first leg are traceable to the conditions of the adult.

SUMMARY

(1) A new species of harpacticoid copepod *Tisbintra jonesi* is described in detail and a redefinition of the genus *Tisbintra* Sewell is rendered in the light of the information available regarding the male.

(2) The complete account of the life-cycle of this species is given. As in all other copepods that are studied there are six naupliar and six copepodite stages, the last of which is the adult.

(3) The striking similarities of the naupliar stages of *Tisbintra jonesi* with those of *Tisbe furcata* are briefly discussed.

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I am grateful to Dr. S. Jones for his kind encouragement and guidance during the period of this work and to Dr. R. B. S. Sewell, Cambridge University, England, for the confirmation of the identification of the species. My thanks are also due to Dr. S. Krishnaswamy of the Madras University for going through the manuscript and offering valuable criticisms, and to Dr. S. Z. Qasim of Aligarh University and Dr. R. Raghu Prasad of this Station for many helpful discussions during the preparation of this paper.

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Studies on Indian copepods III.
Nearchinotodelphys indicus, a new genus and species of Archinotodelphyid copepod from Indian Seas

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STUDIES ON INDIAN COPEPODS 3. *NEARCHINOTODELPHYS INDICUS*, A NEW GENUS AND SPECIES OF ARCHINOTODELPHYID COPEPOD FROM INDIAN SEAS*

By A. N. P. UMMERKUTTY

Central Marine Fisheries Research Station, Mandapam Camp

Hansen (1923) obtained from *Phallusia obliqua* (=*Ascidia obliqua*) an interesting species of copepod which he named *Cyclopina phallusiae.* Hansen himself was uncertain about the correct systematic position of this copepod, for a species of the genus *Cyclopina* was never known to live within the ascidian. Lang (1949) suggested the creation of a new family Archinotodelphyidae to receive *C. phallusiae* Hansen and a new species of copepod which he gathered from *Pyura georgiana* Mchlsn during the Swedish Antarctic Expedition. He placed the two species in two monotypic genera, *Archinotodelphys* to contain his own new species and *Pararchinotodelphys* to include *C. phallusiae.* This was a fitting arrangement in view of the important and far-fetching suggestions he had already made regarding the classification of copepods (Lang, 1948).

Illg (1955) discovered a second species of *Pararchinotodelphys* from the branchial cavities of *Styela partita* caught off Marthas Vineyard, Massachussetts. He provided an excellent discussion regarding the systematic position of all the three species and that of *Pseudocyclopina belgicae* Giesbrecht which was considered as congeneric with *Cyclopina phallusiae* by Lindberg (1952). In fact Lang's account of his new family and the two genera contained therein were very short and it was Illg who enlarged our understanding of this group.

Pararchinotodelphys phallusiae was obtained during the Danish Ingolf Expedition ; Lang obtained specimens of *Archinotodelphys typicus* from the Antarctic ; and Illg reported *P. gurneyi* from north-west Atlantic. The archinotodelphyid copepod described below is collected from the south-east coast of India and appears to require a new genus and species to accommodate it. The male is not known for any of the earlier species. In the present case a fair number of males and females have been obtained and efforts have been made to elucidate points of sexual dimorphism in this primitive family. In describing the various morphological characters I have mainly adopted the terminology suggested by Gooding (1957) with some alterations (Ummerkutty, 1960) There is no absolute agreement between the various investigators on the homology of the constituting parts of the cephalosomal appendages of the copepoda. The terms ' protopod ', ' endopod ' and ' exopod ' are used in this paper rather in a descriptive sense than to indicate any strict morphological origin. These terms have been employed not only to describe the constituting parts of the swimming legs but also for those of the cephalosomal appendages of the adult animals.

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Family : ARCHINOTODELPHYIDAE LANG (Lang, 1949, p. 3.)

Genus : *Nearchinotodelphys* nov.

The prosome consists of four segments : a cephalothorax formed by the fusion of the cephalosome and the first pedigerous segment and three free metasomal segments. The urosome consists in the female of the segment bearing the fifth legs, the genital segment and three abdominal segments ; in the male it consists of the fifth leg-bearing segment, the genital segment and four abdominal segments. The antennule is 15-segmented in the female and 14-segmented and geniculate in the male. The antenna is 4-segmented, the last segment bearing a strong claw accompanied by a number of setae. The mandibular palp has a 2-segmented endopod and a 4-segmented exopod. In the maxillule the endopod is 2-segmented while the exopod is only 1-segmented. The maxilliped is 3-segmented. The natatory legs have both rami 3-segmented. The fifth legs are 2-segmented ; 4 setae are borne on the terminal segment and 1 on the basal segment.

Genotype : *Nearchinotodelphys indicus* sp. nov.

Nearchinotodelphys indicus sp. nov.

Material examined—The material of the present study was obtained from the mantle cavity of a boring bivalved molluscan, *Lithophaga strimineus*.* The specimens were first noticed by Dr. E. G. Silas who kindly passed them over to me. There were 11 females and 10 males. A few of them were slightly damaged but the majority of them were in good condition so as to permit a thorough examination. It is interesting to note that although the two sexes were present more or less in equal numbers, no egg-carrying female or naupliar or copepodite stages were found. The type specimens, the holotype, the allotype and the paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station, Mandapam Camp and bear the registered Nos. J 511/2, J 512/2 and J 513/2 respectively.

FEMALE

In general appearance the female (Fig. I, 1) resembles the three other known species except that in the present case the cephalosome and the first pedigerous segment are fused to form a cephalothorax. The latter is the widest part of the body and is almost twice as wide as the last metasomal segment and three times wider than the widest part of urosome. There is a distinct cap-like rostrum, narrower at the base. There are only 3 metasomal segments, diminishing in width posteriorly. The urosome consists of 5 segments : the fifth leg-bearing segment, the genital segment and 3 abdominal segments, the last of which bears a pair of caudal rami. The genital segment is the longest and shows signs of division laterally. The three abdominal segments are more or less of equal dimensions and distinctly smaller than the genital segment. The fifth leg-bearing is the widest of all urosomal segments ; the posterior half of this segment is narrower than its anterior half which carries the fifth legs ; in preserved specimens a part of this anterior half is covered over by the last prosomal segment.

* Kindly identified by Mr. K. V. Rao.

The caudal ramus calls for some comments. It is very different from those described for all the three known species. In the earlier species it is more or less cylindrical and at least one-half longer than the last abdominal segment and bears 4 fairly long apical setae, besides one (in *Archinotodelphys typicus* and *Pararchinotodelphys phallusiae*) or two (in *P. gurneyi*) short setae at some distance from the apex. In the present case, the caudal ramus is very short, just as long as the last abdominal segment and the setae are much shorter, the longest seta being only just a little more than half the length of the ramus itself. Further the setae are thicker at the base and taper posteriorly. In the earlier species the setae are long and slender and more or less of uniform thickness.

The proportionate lengths of the prosome and the urosome are 59 : 41.

Antennule (Fig. I, 3)—Antennule is very short, extended laterally in the natural position and hardly reaching the posterior margin of the cephalothorax, if held backwards. There are only 15 segments in the antennule and the proportions of the constituting segments are given below (All segments are measured along the middle line).

1	2	3	4	5	6	7	8	
17.3	8.0	11.7	4.4	4.8	11.2	8.7	4.8	
9	10	11	12	13	14	15		
3.5	3.5	3.5	7.0	3.0	3.0	5.6		=100

All the segments are provided with many setae except the 10th and 11th which are provided with one seta each. The proximal segments are much wider than the distal ones, the first segment being 8 times as wide as the 15th and the segments between them tapering gradually to the distal end. The 7th segment shows a slight sign of lateral division, but otherwise the segments are normal. No aesthetask or sensory filament is borne by any segment. The lengths of the different segments are uneven ; the first segment is the longest ; second, third, sixth and seventh are of moderate length with two short segments, the fourth and fifth segments, inserted between them. Eighth to fifteenth segments are short and subequal, excepting the 12th which is almost double the length.

Antenna (Fig. II, 7)—It is 4-segmented. In the first segment (basal) there are two juxtaposed setae of equal length, bearing hairs throughout their lengths. This condition is found only in *A. typicus* among the known species. The second segment is devoid of any seta. In the third segment there are two long setae at the outer distal margin and one short seta just before the mid-length. The last segment gives the appearance of being segmented ; whether the two halves represent actual segments or the division is only apparent is not clear ; probably the division is superficial for no constriction is observed in the region of the partition. Further, the proximal half is devoid of any seta. The last segment bears five setae and one claw on the apex and a very short seta on the ventral face at about one-third the proximal length of the segment. Of the apical setae, the distal two are very long and bent towards the claw ; the other three terminal setae are much shorter and rather straight. The claw is very large, broader at the base than at the apex and characteristically bent.

Mandible (Fig. I, 4)—The mandible is normal and is identical to that described for earlier species. It is a fairly massive structure having a masticatory blade and a biramous palp. The former is denticulated at the inner edge, the teeth becoming

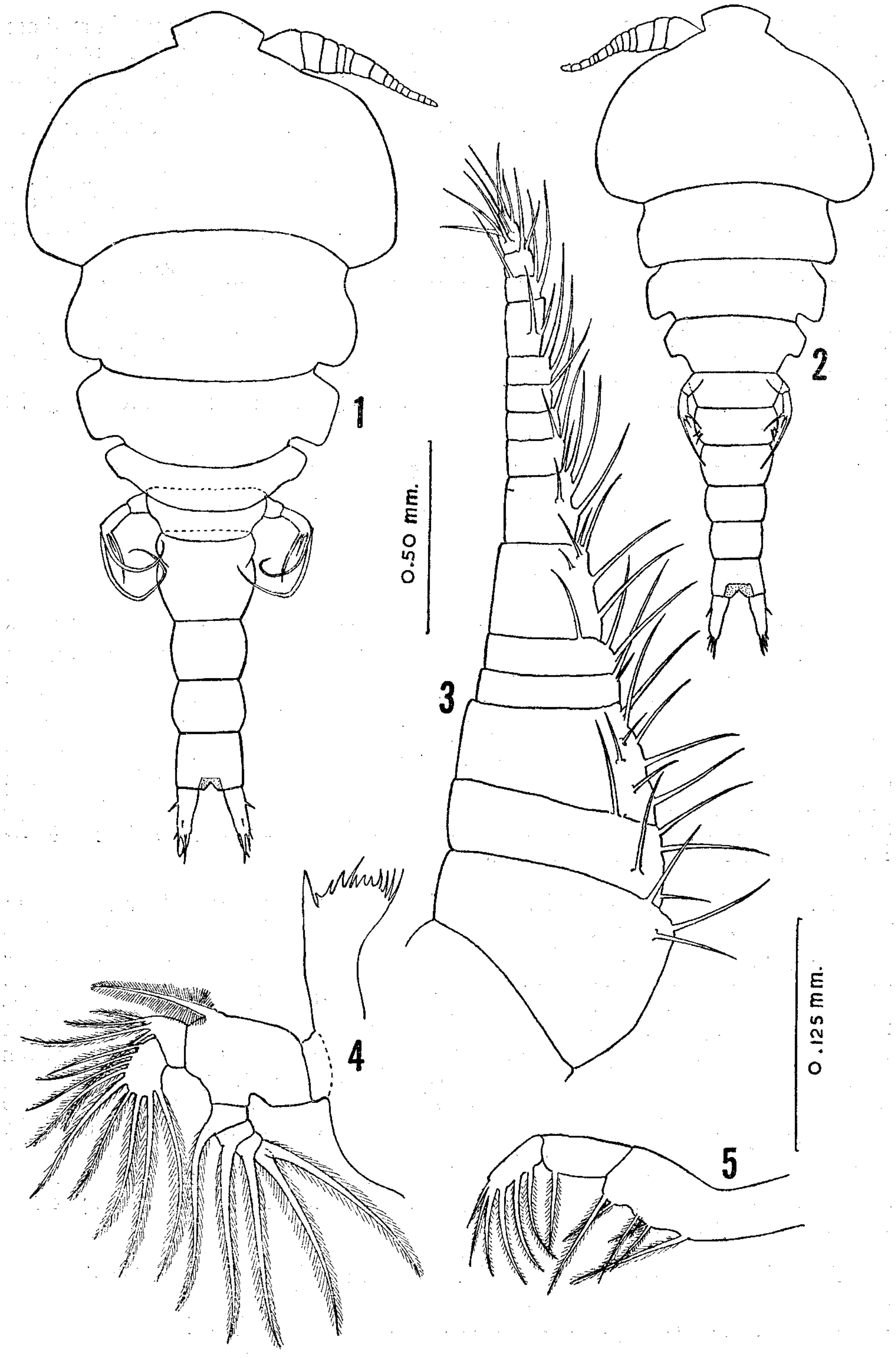

FIG. I.

ale, adult, dorsal view.
1. Fem dult, dorsal view.
2. Male,

3. Female, adult, antennule.
4. ,, ,, mandible,
5. ,, ,, maxilliped.

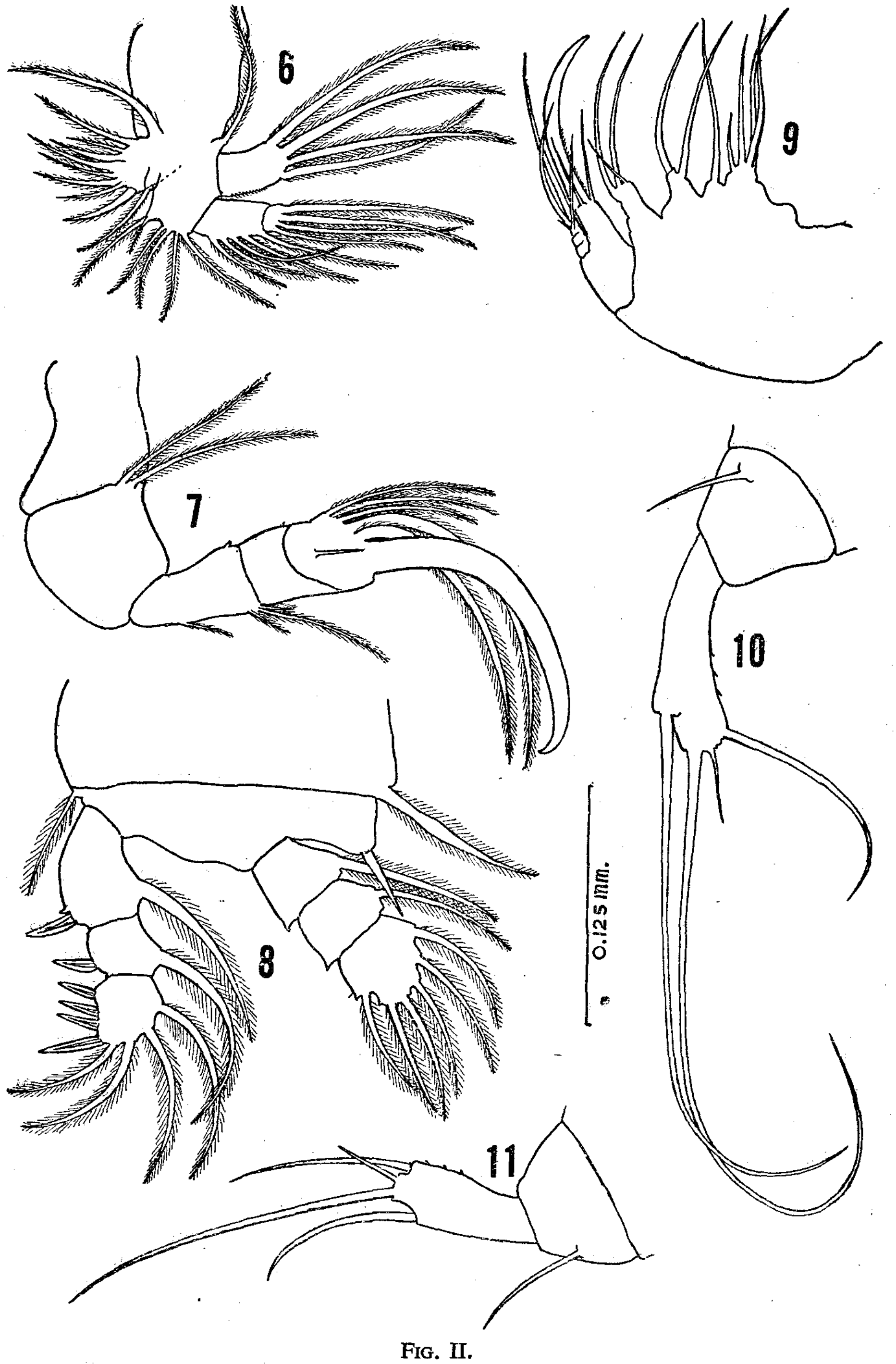

FIG. II.

6. Female, adult, maxillule.
7. ,, ,, antenna.
8. ,, ,, first swimming leg.
9. Female, adult, maxilla.
10. ,, ,, ,, fifth leg.
11. Male, adult, fifth leg.

more seta-like on one side and stout and strong on the other. The palp of the mandible consists of a protopod and two rami. The protopod is quite large and carries only a single seta, heavily setiferous and placed towards the distal margin. The endopod is 2-segmented, the basal segment carrying four setae. The distal segment bears nine setae which are arranged continuously along the inner, lateral and apical margins. The exopod is 4-segmented. Each of the first three segments bears one long seta, and the last two setae. All the setae are plumose.

Maxillule (Fig. II, 6)—A protopod, an exopod and an endopod can be distinguished in the maxillule. The protopod is a complicated structure and has been discussed in detail by Illg (*loc. cit.*). I am inclined to accept his interpretation and the following description is offered. The protopod is apparently bimerous. The basal protopod segment probably represents in the present case a fusion of the two endites. The proximal one is rather massive, bearing medially along its margin nine setae (some of which look more like spines) of varying proportions. The proximal-most seta is striking in that it is separated from the rest and is very long having a peculiar curve. The distal endite is very small and peg-like, bearing a solitary seta at the apex. The basal protopod segment also supports at the base of the exopod a protuberance carrying a seta. This is interpreted as representing a coalesced epipod.

The distal protopod segment is rather simple, but quite expanded. Its apparently outer lateral margin bears both the endopod and the exopod. On the opposite margin it bears two groups of setae ; the proximal group consists of one long and one short seta and the distal group of four setae of more or less equal length. The endopod is 2-segmented and the exopod is 1-segmented. The former bears five setae on the proximal segment, arranged all along its entire inner margin and four on the distal segment set apically. They are continuous and about equispaced and show gradual increase in length from the basal to the apical setae. The exopod is rather rectangular in shape, as large as the endopod but bearing only four setae, two of them apical and the other two subapical on either side. These setae are the longest of the maxillule and are plumose.

Maxilla (Fig. II, 9)—Here the first segment bears four groups of setae, each probably representing one endite. The first group bears four setae one of which is spiniform and shorter than the others. The second endite bears a long solitary seta. On the third endite there are two long apical setae and on the fourth there are three setae two of which are very long and the third spiniform and short. The second segment is produced medially as a heavy, tapering, slightly curved spine. At the base of this spine there is a pair of small setae, a feature not found in any other known species of the genus. The distal region is 3-segmented, each segment bearing a single long seta. It is a far smaller region, forming only a fragment of the whole appendage.

Maxilliped (Fig. I, 5)—This is 3-segmented. The basal segment is the longest, being longer than the other two segments combined. It carries three protuberances on the medial margin. The first is at about the mid-length of the segment and a single seta is borne on it. The second protuberance is equidistant from the first and the third and bears four setae of varying lengths. The third one is almost at the distal medial angle of the segment and is provided with two setae. The second segment is small, less than half the length of the basal and its ornamentation consists of a single seta borne subterminally on the medial margin. The last segment is the smallest both in length and width and bears six setae graduated in length from the base to the distal end.

FIG. III.

12. Female, adult, second leg.
13. ,, ,, fourth leg.
14. Male, adult, antennule.
15. ,, ,, maxilliped.
16. ,, ,, genital segment, ventral view.

Swimming legs (Fig. II, 8 and Fig. III, 12 & 13)—These appendages exhibit a similar pattern of organisation except in the setation of the various segments which is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P1	1	0	I	1	1	0	1	0	3	2	1	1	I	1	I	3	1	IV
P2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	IV
P3	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	IV
P4	1	0	0	1	1	0	2	0	2	2	1	1	I	1	I	4	1	III

(Si, St and Se represent the internal, terminal and external margins of the constituting segments and P1—P4 represent the first to the fourth swimming legs. Spines are indicated by the Roman and setae by the Arabic numerals). The appendages are strongly built, biramous, each ramus being composed of three segments. In size the first legs are the smallest. It is borne by the cephalothorax, while the succeeding legs are each borne by a separate metasomal segment. In first legs the protopod I carries a single seta at the inner distal angle ; the protopod II a simple spine at the distal inner angle. The segments of the endopod are subequal in size and are more or less of equal length and width. In the exopod the first segment is the longest and second the shortest ; the former is narrower at the base. The second and third legs are alike in all respects. The first protopod is large and carries one seta at the distal innner angle. The second protopod segment carries a seta on its outer lateral margin. The segments of both rami resemble those of the first legs and differ only in ornamentation. The fourth leg although built on the same pattern gives a narrower appearance of the constituting segments of both the rami. The spines of the exopod segments are specially noticeable in that they are rather slender and straight and do not possess the partial curvature of the tip, a feature present in the spines of first, second and third exopods.

Fifth leg (Fig. II, 10)—The fifth leg is borne by the first urosomal segment and is bimerous. The proximal segment is stout, broader at the base than at the apex and bears a single seta at its one-third length. The narrower tip of the proximal segment merges into the base of the distal segment which is broader at its distal region. There are four setae on the distal segment, two apical and two subapical. Of the latter, one is borne on a protuberance in the distal outer side and is very long, about two times longer than the entire fifth leg ; the second seta is on the inner distal margin and is much shorter, only a little more than one-third length of the outer seta. The apex bears the shortest and the longest of the setae. The latter is one-fifth longer than the outer subapical seta and the former is extremely short, just a little more than half the length of the seta on the proximal segment of the fifth leg. All the setae bear minute hairs all along their lengths. Three bristles are found on the inner margin of the distal segment of the fifth leg.

Genital apertures (Fig. IV, 1)—The genital apertures are not described for any of the earlier species of this family. It is probably because of the limited number of specimens available to the investigators. The genital apertures in the present species are very widely separated. They are set about one-third the proximal length of the genital segment and more or less ventro-laterally. The two apertures are connected by a narrow grove that run across the segment. The apertures are provided with minute spinules, probably guarding them.

MALE

The male (Fig. I, 2) is much smaller than the female, but is very similar to it. The differences noticed in the structural details are in the antennule, the maxilliped, the fifth leg and in the urosome. In other aspects there is absolute similarity between the male and the female except for the smaller size of the former.

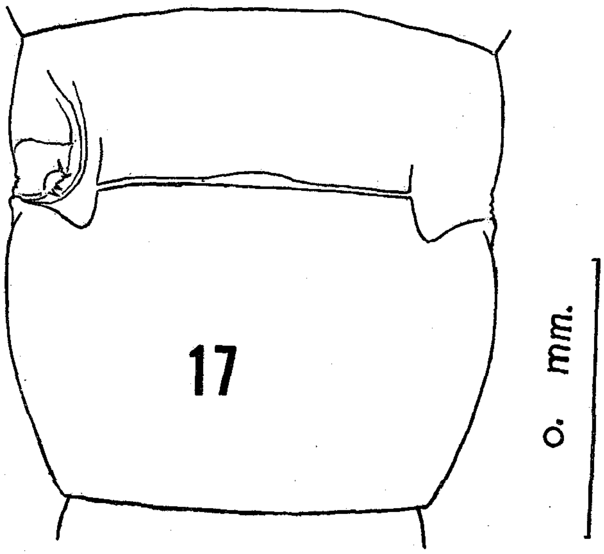

FIG. IV.
17. Female, adult, genital segment, ventral view.

Antennule (Fig. III, 14)—The structure of the antennule may really be termed primitive for the geniculation found here is one of the simplest among the cyclopoids and the points of departure from the female antennule are not many. Both the left and the right antennules are built on the same pattern and each consists of only fourteen segments. The proportionate lengths of the constituting segments are as follows (All measured through the mid-line).

1	2	3	4	5	6	7	8		
20.2	7.4	10.6	5.3	5.3	5.8	4.3	3.7		
9	10	11	12	13	14				
7.4	4.3	4.3	8.0	6.9	6.5	..	..	=	100

It can clearly be seen that only the first five proximal segments have the same proportionate dimensions as those of the female antennule ; sixth and seventh segments which are fairly large in the female are here, only as large as the fourth and fifth ; the eighth segment is smaller than any of the four earlier segments ; the ninth segment is quite large and is equivalent to the tenth and eleventh combined; the last three segments are subequal and are geniculated. The twelfth segment bears a spine on its distal posterior margin and two fairly long setae on the same side. The thirteenth segment has a characteristic concavity on its anterior margin and bears a small straight spine at the depression and a long seta at the distal anterior angle. The last segment is profusely setated ; one seta is borne at one-third proximity, and the others at the distal region. There is a spine at half the length on the anterior margin. The length of the antennule in relation to the cephalothorax is similar to that in the female.

Maxilliped (Fig. III, 15)—This appendage shows variations from that of the female only in the proximal segment. While in the female it is longer than the combined lengths of the distal two segments, here it is distinctly smaller than that. It differs also in the setation : there is a solitary seta just beyond the one-third the proximal length and one long and two short spine-like setae at about two-third the length.

Fifth leg (Fig. II, 14)—The structural deviations of the male fifth legs are rather few. In the basal segment the position of the seta appears to have changed ; it is seen just beyond the middle length. In the distal segment the setae give an entirely different appearance. While the outer subapical seta in female is about two times the length of the entire fifth leg here it is only just a little longer than the distal segment of the latter ; the outer apical seta is again considerably reduced in length. Here also it remains the longest seta and is about twice as long as the outer subapical seta, but its length in proportion to that of the fifth leg itself is far less. Further both these setae lack their characteristic curved shape of the female. The reduction in length of the other two setae, namely, the inner apical and inner sub-apical, are only proportionate to that of the appendage itself. The three bristles found on the inner margin of the distal segment of the females are also present in the male.

Urosome—It is 6-segmented, consisting of the fifth leg-bearing segment, the genital segment and four abdominal segments. The segments are graduated, the first segment being the widest. The latter and the genital segment are more or less of equal length. On the ventral side of the genital segment is present what is generally called the genital armature (Fig. III, 16) or the vestigeal sixth pair of legs. The spines of this appendage are faintly seen from the dorsal side but the structural details can be studied only from the ventral side. It is peg-like, one on either half, occupying a major portion of the ventral surface of the segment and orientated more or less diagonally. There are three spines on the posterior tip of it ; the innermost is very small and the outer two are long and sub-equal. The four abdominal segments are barrel-like and approximately of equal length. The last one bears the caudal rami which show no speciality.

Discussion

Both Lang (1949) and Illg (1955) have stated that in the species they described the prosome consists of the cephalosome and four free leg-bearing segments and that the host animal is an ascidian. The present species differs from both these conditions on which so much stress has been made by Lang (*loc. cit.*) when he created the new family Archinotodelphyidae and the two genera contained therein. In accordance with *Cyclopinella* the first leg-bearing segment is free in *Archinotodel-*

phys and *Pararchinotodelphys*. But they differ from each other in the number of segments of the urosome. While *Archinotodelphys* has a urosome of six segments *Pararchinotodelphys* has only five segments in the urosome, a feature which relates the former genus to Notodelphyidae.

In the present example the cephalosome and the first pedigerous segment are fused ; this is a character which directly relates it to many Cyclopinidiformes and Notodelphyidiformes and which is customarily held significant at a generic level (*vide* Sars, 1918, p. 16). The occurrence of the species in a molluscan host instead of the ascidian in unison with its relatives is another important fact in the evolution of the host-parasite relationship in this group of animals. *Nearchinotodelphys indicus* is also notable in that while it has developed its own specialities in many features it combines in it many morphological characters of both *Archinotodelphys* and *Pararchinotodelphys* thus making it difficult to assign it to either of the two genera. One gets the impression that if the present species does not represent a new genus the only other alternative will be to place all the four known species in a single flexible genus, *Archinotodelphys* Lang. It is probably more convenient and reasonable to treat the known four species as representing a single old genus with tendencies to specialize in various directions rather than to treat them as already specialized entities. The genus, in such a case, will combine in it all the characters of the family Archinotodelphyidae. However this procedure is not adopted here for the male is still unknown for the three earlier species. The degree of geniculation of the male antennule is an important criterion of generic distinction amongst the copepods and therefore, we have to await the descriptions of the males of these earlier species before proposing a merger of the existing genera as well as the present species into a single genus, *Archinotodelphys* Lang (1949).

Morphological specialities of N. indicus—In all the discussions of the comparative morphology of the three earlier species and the present one, the male is omitted for, it is not known in the former cases. The fusion of the cephalosome and the first pedigerous segment is already discussed. In the antennule there are only fifteen segments in the female and fourteen in the male on both right and left sides. The female antennule is 17-segmented in *Archinotodelphys* and 16-or 17-segmented in *Pararchinotodelphys*. In the antenna the structure of the terminal claw deserves some attention. In *P. phallusiae* it is described as one among the setae ' which in reality is somewhat small spiniform and very curved hook ' (Hansen, *loc. cit.* p. 5). In the diagram it appears to be hardly one-third the length of the last antennal segment. In *P. gurneyi* it is moderately long, having the same length as the terminal antennal segment. A similar situation is found *A. typicus*. In all these cases the claw is rather weak. In *N. indicus* it is very strong and stout, being as long as the third and fourth antennal segments combined ; and it has got a characteristic curved posture. It may also be noted that the distal two setae are similarly curved and are of the same length as the claw while the proximal three setae are only less than half the length and possess no special bent.

Fifth leg of *A. typicus* is very short, only about one and a half times as long as wide and carrying three apical and one middle seta. Basal segment does not bear any seta. In *P. phallusiae* too it is short, distal segment about two times as long as wide and carrying two apical and two subapical setae ; the basal segment also carries a seta. In *P. gurneyi* the fifth leg is fairly long, the distal segment being about three times longer than wide and carrying two apical, one sub-apical and one middle seta ; the basal segment bears one seta. In all these cases the fifth leg is more or less cylindrical and the setae borne by it are as long as or a little longer than the distal segment. In the present case there is great difference in the dimensions of the proximal and distal segments of the fifth legs. While the proximal segment is very broad at the base tapering gradually to the distal tip, a reverse state is found true in the case of the distal segments : a narrower basal region increasing in breadth to the distal part. Further two of the setae borne by the distal segment are very long, one of them being about three times longer than the entire fifth leg and the other a little shorter.

In the structure of the caudal rami, *N. indicus* differs from all the three other species ; while it is at least one and half times as long as the last abdominal segment in all the earlier species, it is hardly as long as the last abdominal segment in the present case. Further while in the known species the setae on the ramus are fairly long, some of them being as long as or longer than the ramus itself, it is very much shortened in *N. indicus* : the longest seta is just half the length of the caudal ramus.

Resemblances with Archinotodelphys—In *Archinotodelphys* the basal segment of the antenna is with two juxtaposed setae on the outer distal angle and with one seta on the inner angle. In the two species of *Pararchinotodelphys* there is only one fine seta instead of the two juxtaposed ones. However, in *P. phallusiae* a stout seta is borne separately at the inner angle. In *N. indicus* the condition is similar to that of *A. typicus* but the separate seta on the inner angle is lacking.

Illg (*loc. cit.*) has pointed out the possibility of differences at generic level in the armature of maxillule. It is doubtful whether any set limit can be placed at generic level on the structural pattern of maxillule in the family Archinotodelphyidae. However, the maxillule of the present species resembles very much that of *A. typicus*. In a sense *P. phallusiae* also approximates with that of *A. typicus* in the structure of the maxillule. The condition in the former may well be considered somewhat intermediate between *P. gurneyi* on the one hand and *A. typicus* and *N. indicus* on the other.

In *P. gurneyi* the maxilla is 6-segmented, the first two basal segments bearing two setiferous endites each. The third segment as in all other known species of this family is produced into a strong spine. There are four free segments in the distal region. In *P. phallusiae*, however, the situation is different : the two basal segments are fused and together bear four endites. The process of fusion has extended to the distal region also where all the four segments are fused together forming a large segment bearing a number of setae. The middle segment bearing the spine is, however, quite distinct. In *A. typicus* the two basal segments are fused and together bear four endites ; the distal region, however, is 2-segmented. Thus, in the case of maxilla also the present species has more kinship with *Archinotodelphys*.

Resemblances with Pararchinotodelphys :—In the number of segments of the urosome *N. indicus* approximates more with the species of *Pararchinotodelphys*. In these, it is 5-segmented and consists of the fifth leg-bearing segment, the genital segment and three abdominal segments, the last of which bears a pair of caudal rami. This is an important criterion on which *Archinotodelphys* is separated from *Pararchinotodelphys* and which the latter shares with *N. indicus*.

The structure of the maxilliped in *N. indicus* resembles that in *Pararchinotodelphys*. In both species of this latter genus it is 3-segmented as it is in the present case. The similarity is found also in the number of setae borne by different segments.

Notes on the family Archinotodelphyidae—Lang (*loc. cit.*) thus defined the family Archinotodelphyidae : ' General form as in *Cyclopinella* G. O. Sars. First leg-bearing segment free. Antennae with one apical claw accompanied by a number of setae. No brood-pouch, the eggs being carried in two dorsal sacs.' It is obvious that in order to receive *N. indicus* into this family an important alteration is to be made in its definition. The archinotodelphyids are distinguished from the cyclopinids by the presence in the former of a claw on the terminal antennal segment; they are separated from the notodelphyids by the facts that eggs are carried in two dorsal sacs and that no known notodelphyid antenna shows the sub-division of the terminal portion into the clear cut segments found throughout the archinotodelphyids. The fused or free state of the first pedigerous segment cannot be considered as a character of the family for in *N. indicus* it is fused with the cephalosome while in all earlier species it is free from the latter. In the fusion of the cephalosome with the first pedigerous segment and in the extremely high development of the terminal hook of the antenna, *N. indicus* tends more towards the notodelphyid pattern than any other related species. The cyclopinids is thought of as the parental stock and the notodelphyids as the descendant group; the archinotodelphyids are somewhat intermediate but aberrant group and 'the group as a whole exhibits a complex of primitive and advanced characters with no one member corresponding to the demonstrable archetypical requirements.' The discovery of this new species, *N. indicus*, with many morphological deviations and combinations as well as a profound change in the host preference probably adds to the complexity of the problem of their evolutionary lineage.

The following key to the identification of the various genera and species is rendered in compliance with the systematic procedure adopted in this paper; however, the male is omitted from the key.

KEY TO THE IDENTIFICATION OF FEMALES:

1. Prosome consists of a cephalosome and four free leg-bearing segments; host is an ascidian 2

   Prosome consists of a cephalothorax, formed by the fusion of the cephalosome with the first leg-bearing segment and three free leg-bearing segments; host is a mollusc........ ....*Nearchinotodelphys* g. nov. (only one species, *N. indicus* sp. nov. is known).

2. Urosome consists of six segments: the fifth leg-bearing segment, the genital segment and four free abdominal segments; basal segment of the antenna carries two juxtaposed setae..........*Archinotodelphys* Lang, 1949. (only one species, *A. typicus* Lang, 1949 is known).

   Urosome consists of five segments: the fifth leg-bearing segment, the genital segment and three free abdominal segments; basal segment of antenna carries only one seta instead of the two juxtaposed ones..........*Pararchinotodelphys* Lang, 1949.

   The genus consists of two species:

   Antennule 17-segmented; maxilla 3-segmented; the terminal segment of the endopod of fourth leg bears two inner, one terminal and one outer setae (as shown in the figure) ....*P. phallusiae* (Hansen, 1923).

   Antennule 16-segmented; maxilla 6-segmented; the terminal segment of the endopod of fourth leg bears two inner, two terminal and one outer setae.......... *P. gurneyi* Illg, 1955.

SUMMARY

Nearchinotodelphys indicus, a new genus and species of cyclopoid copepod, belonging to the family Archinotodelphyidae, is described in detail. Only three other species have so far been assigned to this family, all of them being known only from the female sex. *N. indicus* is represented by both the sexes.

The points of similarities and differences between the known representatives of Archinotodelphyidae are discussed briefly: *Nearchinotodelphys* differs from both *Archinotodelphys* Lang and *Pararchinotodelphys* Lang in a number of characters but also combines in it many other features of both these latter genera.

The cephalosome and the first pedigerous segment are free in all the earlier species whereas they are fused in *N. indicus*. Further while the ascidian has been the host of the earlier forms, *N. indicus* is harboured by a mollusc. These characters have been incorporated in the definition of the family Archinotodelphyidae.

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Studies on Indian copepods IV.
Description of the female and a redescription of the male of *Pseudodiaptomus ardjuna* Brehm (Copepoda, Calanoida) with notes on the distribution and affinities of the species

J. Mar. biol. Ass. India, 1960, **2** (2): 179-185

STUDIES ON INDIAN COPEPODS 4. DESCRIPTION OF THE FEMALE AND A REDESCRIPTION OF THE MALE OF *PSEUDODIAPTOMUS ARDJUNA* BREHM (COPEPODA, CALANOIDA) WITH NOTES ON THE DISTRIBUTION AND AFFINITIES OF THE SPECIES*

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In 1953, Brehm described a new species of calanoid copepod, *Pseudodiaptomus ardjuna* from Salsette Island, Thana District, Bombay. He had at his disposal only two male specimens, one of which was damaged. However, he could rightly identify it as a new species of the genus *Pseudodiaptomus* Herrick and gave a brief description of the male. The female of this species has not so far been described and there is no subsequent report of the male itself from anywhere. This short paper is meant to give a full account of both male and female collected from the South-East coast of India, off Mandapam.

The present study is based on the examination of numerous specimens obtained from the plankton hauls, in the Gulf of Mannar and the Palk Bay ; samples were also obtained from the saline creeks leading to the Central Marine Fisheries Research Station Experimental Fish Farm. No morphological differences were noticed between the three examples ; however, the present material differs in some details from the descriptions and diagrams given by Brehm for the specimens he collected from Bombay waters and these differences are discussed below. In describing the various parts of the body, I have adopted the terminology suggested by Gooding (1957) with some modifications (Ummerkutty, 1960 & 1960*a*). In presenting the ornamentation of the swimming legs Sewell's suggestion (1949) to differentiate spines by Roman and setae by Arabic numerals is adopted.

All the drawings are made with the aid of a camera lucida.

Genus *PSEUDODIAPTOMUS* Herrick

Marsh, 1933, p. 46.

Sewell, 1956, p. 167.

Wilson, 1932, p. 101.

PSEUDODIAPTOMUS ARDJUNA Brehm

Brehm, 1953, p. 313.

Female

The body (Fig. I, 1) is rather narrow, smoothly rounded anteriorly. The prosome consists of five segments. The first segment is the cephalothorax, formed

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by the fusion of the cephalosome and the first leg-bearing segment ; it is the longest of prosomial segments and is widest at its posterior margin. The second segment is rectangular with the long axis being the width of the copepod body. The third and fourth segments are rather short and subequal ; the latter is, however, wider than the former and is the widest part of the prosome. The fifth prosomal segment is armed on each of its postero-lateral corners with a sharp spine, directed backwards and slightly outwards ; the right spine is slightly larger than the left one. The urosome consists of four joints, the genital segment and three abdominal segments. The genital segment is barrel-like and exceeds other urosomal segments both in length and width ; it has a well-marked ventral swelling on which is borne the genital operculum ; the latter does not bear any spine. The abdominal segments are subequal, each segment being about half as long as the genital segment. The caudal rami are narrow, cylindrical and more or less parallel. It is one and a half times longer than the last abdominal segment and bears numerous setules on its inner margin. Each ramus bears five setae, four of which are apical and one subapical on the outer side.

The antennule (Fig. I, 2) is moderately long reaching the posterior margin of the prosome. It has 23 segments which bear the following proportions (all measured through midline).

1	2	3	4	5	6	7	8	9	10
5.5	4.1	3.0	3.4	3.3	1.7	3.0	4.1	2.2	3.1
11	12	13	14	15	16	17	18	19	20
4.5	4.5	5.3	5.9	6.0	6.0	6.9	5.4	4.3	4.3
21	22	23							
4.3	4.1	5.1	=100						

Segments 1st to 15th and also the 18th and the 23rd segments bear each an aesthetask besides one or more setae ; the aesthetask is short, but very distinctly developed. The 21st segment bears a specialized seta whose inner margin carries a row of teeth at about its mid-region. This last character is also met with in a number of other species of this genus (Sewell, 1932. p. 239). The antenna (Fig. I, 3) has the usual characters of the genus : a 2-articled protopod, a 2-segmented endopod and a 4-segmented exopod ; it, however, differs from others in possessing two rows of small spinules on the distal inner margin of the last segment of the endopod. The mandibular palp (Fig. I, 4) is with 4-segmented exopod, 2-segmented endopod and a 2-segmented protopod ; the masticatory blade normal with numerous teeth. The maxillule (Fig. I, 5) is probably the most conservative of all structures in this genus ; it is quite normal and typical in the present species. The maxilla (Fig. I, 6) is apparently 3-segmented but consists of 7 endites, the first and second segments with 2 endites each and the third with 3 endites ; the endites bear 3 or 4 fairly long setae. The maxilliped (Fig. I, 7) is 7-segmented ; first and second segments are quite large and subequal and other segments are much smaller and their combined length is a little less than that of either first or second segment ; the first segment bears 7 setae and a spine ; the second only 3 setae and a number of minute hairs ; and each of the distal 5 segments bears two or more setae.

The four pairs of swimming legs (Fig. I, 8, 9 and 10) are borne by the first 4 prosomal segments. All the legs are biramous and constructed on identical plans.

While the second and third legs resemble each other in all the structural details, the first and fourth segments show differences both in size and in setation. The ornamentation of the swimming legs are as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	0	1	0	1	0	3	2	1	1	I	1	0	3	I	II
P_2	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P_3	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P_4	1	0	0	I	1	0	2	0	3	2	2	1	I	1	I	5	I	II

It may be seen that the terminal exopod segment of each leg is provided with two outer spines and that the other exopod segments each bears a single outer spine except the second segment of the first pair of legs which has no spine at all. There is a single inner seta on the first and second segments of each exopod. The terminal exopod segment of first legs bears 3 setae while the second, third and fourth legs bear each 5 setae on this segment. The first endopod segment in all the four pairs of legs each carries a single seta while the second segment in these legs carries 1 seta in the first leg and 2 setae each in the next three legs. The terminal endopod segment in the first legs bears 6 setae, in the second and third legs 8 setae each and in the fourth leg 7 setae. The basal protopod segment carries a single seta in all the four legs, while the second protopod segment does not bear any seta or spine except in the fourth leg where a small spine is present.

The fifth legs (Fig. I, 11) are uniramous, symmetrical and small. On each side it consists of 4 articles ; the first segment is devoid of any seta or spine ; second and third segments each bears a single setule ; the last segment bears 2 setae of unequal length and 2 flattened spinelike structures, bearing minute teeth on the inner margin. In this genus the basal two segments of the fifth leg represent the protopod and the distal two segments the exopod ; the endopod is entirely lacking.

The female carries a single ovisac, rather irregular in shape and containing about 25 eggs. Length of the female is 1.31 mm.

Male

The male (Fig. I, 12) shows sexual dimorphism in the antennule, the fifth pair of legs and in the urosome. It is smaller than the female but has the same general appearance. The spines on the posterior prosomal segments are, however, much less pronounced, although their slight asymmetry is maintained. The urosome is 5-segmented, of uniform width and more cylindrical than in the female ; first segment is the shortest and second the longest while other three segments are subequal and of moderate length.

The right antennule (Fig. I, 13) is geniculate while the left is quite normal and resembles that of the female in all structural details, including the specialized seta

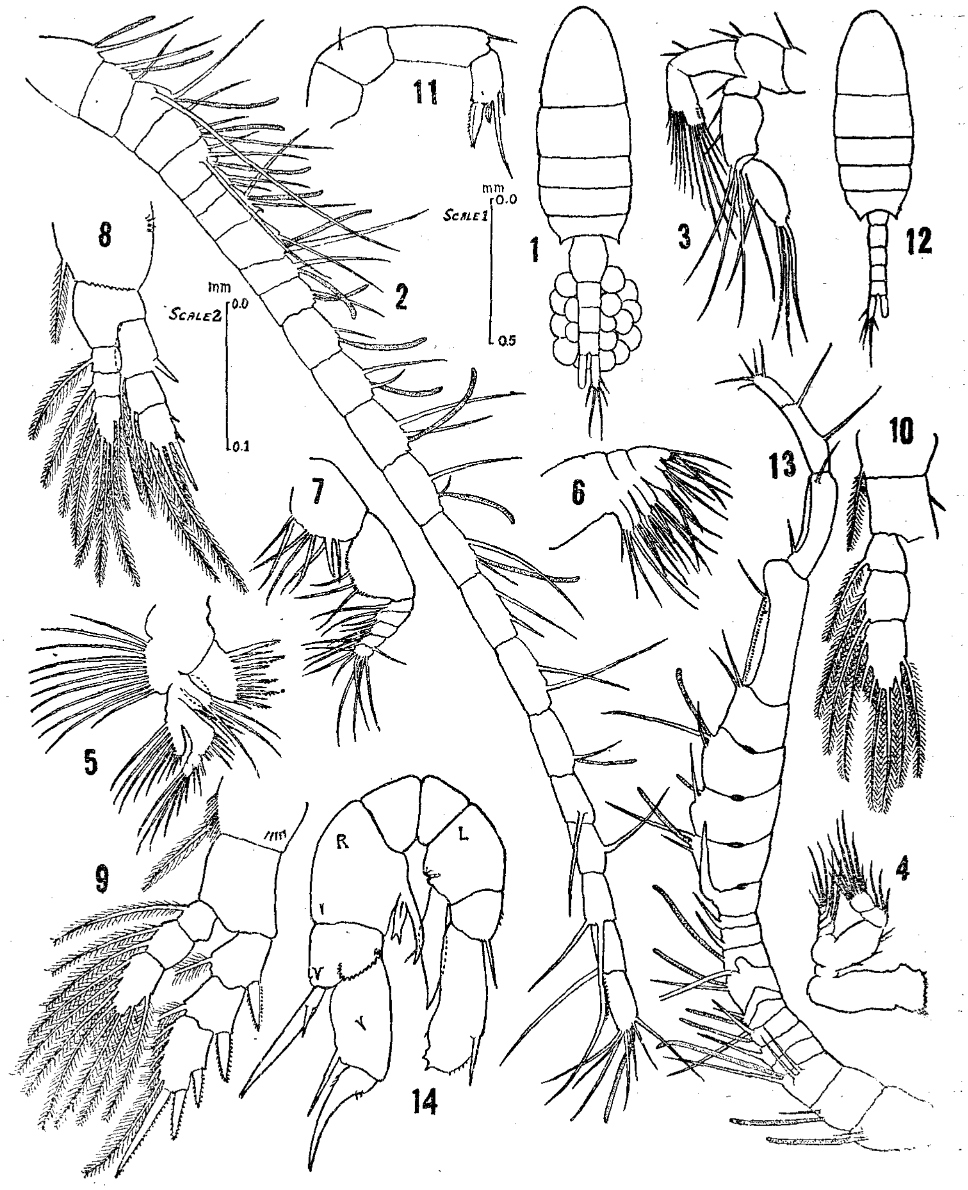

FIG. I, 1-14 : *Pseudodiaptomus ardjuna* Brehm.

1. Adult, egg-carrying female, dorsal view.
2. Female, antennule
3. ,, antenna
4. ,, mandible.
5. ,, maxillule
6. ,, maxilla.
7. ,, maxilliped.
8. ,, first swimming leg.
9. ,, second swimming leg.
10. ,, endopod of fourth swimming leg.
11. ,, fifth leg.
12. Male, adult, dorsal view.
13. ,, ,, geniculate antennule.
14. ,, ,, fifth pair of legs.

of the twenty-first segment. The geniculate antennule consists of 21 segments which bear the following proportions :—

	1	2	3	4	5	6	7	8	9	10
	7.8	5.5	4.2	2.4	1.8	2.1	2.1	1.7	2.5	2.4
11	12	13	14	15	16	17	18	19	20	21
2.1	1.2	3.5	5.1	5.6	6.0	5.8	12.8	11.8	8.5	5.1=100

As the lines of separation are not exactly parallel in all cases and as the measurements are done through the midline of the segments, the proportions given for some segments are not accurate. The segments from 1st to 16th each bears an aesthetask, except the fifth, seventh and eleventh to thirteenth segments ; the latter 3 segments, however, each bears a stout spine.

Fifth legs (Fig. I, 14) are rather strongly built, asymmetrical and close together ; the right leg is slightly longer than the left ; right basal one is, of moderate size with no accessory process ; basal two is very large and slightly longer than wide ; it carries on its inner margin a ' y '-shaped spinous process with the arms of unequal length ; this process represents the vestigeal endopod ; it also carries at its distal outer corner a small spine on the anterior face. Exopod is displaced into medial line and consists of 3 segments ; the first segment is fairly large and much wider than long ; three features are notable in this segment : (*a*) at the distal outer angle there is a spinous process which is quite long and which, in its turn, bears a smaller spine at one-sixth of its proximal length, thus giving a forked appearance to that region ; (*b*) a small, almost conical spine, also borne on the distal outer corner, is present just below the preceding larger spine ; and (*c*) a serrated edge is seen along the line of separation of the first and second segments ; this edge curves down after the mid-width of the segment. The second exopod segment is much longer than the first segment, but distinctly less wide ; it carries a fairly long spine on its distal outer angle and a smaller spine at about the centre of the segment on the anterior face. Exopod segment 3 is modified into a stout spine ; its base is bulbous, bearing a few spinules on either side.

Left basal one is smaller than its right counterpart and with no accessory spines or processes. Left basal two is quite large with its breadth larger than the length. It bears at its inner distal angle a digitiform process which is fairly long almost equivalent to the length of the entire protopod. This process probably represents the endopod. In the left side, too, the exopod is displaced to a medial line and consists of only two segments ; the first segment is quite short, the greatest length and breadth being almost equal ; it bears a sharp spine at its latero-distal angle ; the second segment consists of a thin plate, more or less rectangular in shape ; on its outer margin it bears a spine at two-third of its length and a few minute spinules after that ; on the left side the distal margin is provided with three spinules borne on small projections.

In the structure of other appendages and legs the male is identical with the female except in the smaller proportionate sizes. The length of the male is 1.1 mm.

A redescription of the male is provided above as it is found to show some variations in the structural details of the fifth legs from those of the specimens described by Brehm (*l. c.*). The basal II of the right leg, in Brehm's diagram is shown to have a digitiform process, instead of the ' y '-shaped process seen in the present specimens. The bifurcated spines on the outer distal angle of the basal exopod segment of the right fifth leg in Brehm's diagram appears to be only a different view of the same shown for the present material. In the left leg the terminal exopod segment is flat and leaf-like in both ; but in Brehm's diagram the proximal part is shown to be only half as wide as the distal area, whereas in the present example it is more or less of uniform breadth throughout. It is possible that these differences are real and are probably geographic variations within the same species ; it is also possible that these apparent differences do not exist at all and that Brehm's specimens exhibit deviations only because they would have been mounted and examined in a different angle. However, I feel that the species dealt with in this paper is the same as that erected by Brehm from Bombay waters.

Distribution—Until now this species is known only from the Bombay coast. Its occurrence both in the Palk Bay and in the Gulf of Mannar, off Mandapam extends its distribution to the south-east coast of India. It is likely that a careful examination would reveal its presence all along the west coast and possibly the east coast. It is an inshore dwelling species and gets into the saline creeks that are connected to the sea. In the Gulf of Mannar it is found in good numbers during the late winter months, February and March, majority of the females at that time carrying egg sacs. Rare individuals are caught almost throughout the year especially in the very inshore waters. The saline creeks, referred to above are on the Palk Bay side. They experience great variations in the salinity and temperature not only from season to season but in the different hours of the same day, depending upon the level of water present in them. Specimens were caught in April and May when usually there would be a fair amount of water in the creek. There is no information available as to its presence or absence in other months. The specimens taken from the creeks appeared to be actively reproducing as shown by the large number of ovigerous females and naupliar and copodite stages.

Notes on the affinities of the species—The genus *Pseudodiaptomus* was established by Herrick in 1884 to receive a brackish water species, *pelagicus*, taken in Mississippi Sound, North America. Although this species has not been subsequently recorded from anywhere, there has been a steady increase in the number of known species of this genus, the total number at present being thirty-six. Marsh (1933) divided the species of this genus, placing a number of them in an older genus *Schmackeria* Poppe and Richard, (1890) in which the 'second segment of the basipod of the left fifth foot of the male is armed ; and its inner border is with a long curved projection' ; and in which the last prosomal segment of the female is rounded. Johnson (1939) obtained a new species *euryhalinus*, from the California Coast and created a new subgenus *Pseudodiaptallus* to accommodate it, so that its 'close relationship to the known *Pseudodiaptomus* species is well expressed'. This subgenus is easily distinguishable by the presence of only two free segments in the urosome. Sewell (1956) regards all these, namely, *Pseudodiaptomus* (*s. str.*), *Schmackeria* and *Pseudodiaptallus* as three subgenera of Herrick's original genus *Pseudodiaptomus* (*s. lat.*). However, the distinctions between *Pseudodiaptomus* (*s. str.*) and *Schmackeria* still appear to be far from clear, if there is any difference at all. If we accept Marsh's contention that *Schmackeria* has a vestigeal endopod in the form of process, spine, etc., in both right and left legs of the male and has the posterior corners of the prosome rounded in both sexes, in contrast to *Pseudodiaptomus* (*s. str.*) which is said to have the vestigeal endopod only in the right fifth leg of the male and to have the posterior corners of the prosome angular, it appears that some of the species are not assigned to their proper systematic places. *Pseudodiaptomus salinus* Giesb. and *P. hickmani* Sewell, both recorded from Indian waters, for example, possess a vestigeal endopod in both right and left male fifth legs ; Sewell, however, lists them in the subgenus *Pseudodiaptomus*. They can certainly be included in that subgenus if we take into account only the angular nature of the posterior corners of the prosome ; in the structure of the male fifth legs their affinities are with *Schmackeria.*

The present species is very closely related to *P. hickmani* and *P. salinus*. The fifth legs, both in the male and in the female are very identical in all these species and differ from each other chiefly in the proportionate dimensions of the constituting parts. Whether all the three species should be placed under the subgenus *Pseudodiaptomus* or the subgenus *Schmackeria*, it is not clear in the light of the present definitions given to the two groups. The genus has grown very large and the bizarre addition of the new species from time to time, many of them inadequately described, necessitates an urgent revision of the genus.

Summary

The unknown female of a calanoid copepod *Pseudodiaptomus ardjuna* Brehm is described. A redescription of the male also is rendered as it is found that a few differences of structural details exist between male fifth legs of the present specimens and the male fifth legs described and sketched by Brehm (1953).

The systematic kinship of the species is briefly considered. It is very close to *Pseudodiaptomus salinus* and *P. hickmani.* A note is also given on the distribution of the species in the light of our present knowledge.

Acknowledgement

I am thankful to Dr. S. Jones, the Chief Research Officer for his guidance and encouragement. I wish to thank Shri L. R. Kasturirangan for going through the manuscript and offering valuable suggestions.

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Studies on Indian copepods V.
On eleven new species of cyclopoid copepods from the south east coast of India

STUDIES ON INDIAN COPEPODS 5. ON ELEVEN NEW SPECIES OF MARINE CYCLOPOID COPEPODS FROM THE SOUTH-EAST COAST OF INDIA*

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Central Marine Fisheries Research Institute, Mandapam Camp

INTRODUCTION

SEWELL (1949) has pointed out that our knowledge of the cyclopoid copepods of Indian waters, especially those inhabiting the littoral regions in association with invertebrates and sea weeds and in which the type of existence is usually referred to as 'semi-parasitic', is extremely scanty. The oldest account available on this little known crustacean group in our waters is that of Thompson & Scott (1903) who, in their supplementary reports of the faunistic survey of the Pearl Banks of Ceylon, gave brief description of the copepods they came across. The cyclopoid copepods they dealt with were mostly obtained by examination of washings from dredged materials such as ascidians, sponges, corals, pearl oysters etc. Although the exact depth at which they were caught is not given in specific instances it is presumably from sea bottoms, at least a few fathoms deep. 'This collection of copepods have proved to be exceedingly rich and varied, containing as it does, no less than 283 species, of which 76 are new to science while at least 10 new genera are required' (Thomp. & Scott, *loc. cit.*). Of these copepods, the 'semi-parasitic' cyclopoids were one of the richest groups; it was represented by 42 species of which 25 were new and no less than six new genera were required to accommodate eight of the new species. The only other exhaustive work on these tiny creatures in the Indian waters is that of Sewell (*loc. cit.*) who described the species obtained during the John Murray Expedition and also those he gathered during the long years of his valuable service in this country in the Marine Survey of India. He recorded 44 species belonging to this group, out of which 25 were new and 3 new genera and 2 sub-genera,

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had to be created to include some of the new species. Krishnaswamy (1954) recently reported three species from Madras coast ; all the three are new to our waters and one of them is new to science. Attention may be drawn here to the 2 new genera of cyclopoid copepods that have recently been reported from this area (Ummerkutty, 1960a and 1960b).

The present paper deals with the following new species of copepods :—

(1) *Asteropontius littoralis*
(2) *A. sewelli*
(3) *Cryptopontius graciloides*
(4) *C. orientalis*
(5) *Hemicyclops intermedius*
(6) *Pseudoanthessius agilis*
(7) *Macrochiron (Macrochiron) rigida*
(8) *Lichomolgus holothuriae*
(9) *L. serratipes*
(10) *L. brevifurcatus*
and (11) *L. indicus.*

It is of interest to note that many of the copepods recorded or discovered from the Ceylon Pearl Oyster Grounds by Thompson & Scott about 60 years back have now been obtained by me from the Indian side of the Gulf of Mannar. A detailed account of these species will be published elsewhere.

Gooding (1957) has pointed out the undesirability of referring these animals collectively under such terms as ' parasitic ', ' semi-parasitic ', ' commensal ' etc., for there is little definite evidence about the nature of the association and little work to this end has been done on the copepods. Sars (1918) who first referred to their parasitic existence has qualified his statement by adding that ' in most cases, however, the parasitism may be merely temporary '. The fact is that most of the species are found to occur in association with a variety of hosts and the exact relationship between the copepod and the associated invertebrate is yet to be investigated in specific cases. Because of this ambiguity in their relationships I have preferred to refer to them as ' associated with invertebrates ' instead of referring them as parasitic or semi-parasitic. In the present collection only *Lichomolgus holothuriae* was found constantly to live inside the body cavity of *Holothuria sp.* Although there is no positive evidence that it is not found in association with other invertebrates, quite a number of holothurians examined yielded this copepod. *P. serratipes* was obtained from the washings of *Pteroeides esperi* Herklots, the common sea-pen of this coast. *Asteropontius littoralis* was obtained mostly from washings of weeds and mud-covered coral stones. Whether it has any relation with the Polychaetes observed to inhabit the same niche is not clear. Of the species discussed below, the following are represented by both the sexes.

(1) *Cryptopontius orientalis*
(2) *Pseudoanthessius agilis*
(3) *Macrochiron (Macrochiron) rigida*
(4) *Lichomolgus holothuriae*
(5) *L. brevifurcatus*
and (6) *L. indicus*

In describing the various body segments I have mainly adopted the terminology suggested by Gooding (*loc. cit.*) with some alterations (Ummerkutty, 1960 a & b). In the section Siphonostoma all the cephalosomal appendages are easily distinguishable ; but in the section Poecilostoma there is a reduction in the mouth-parts and the homology of the various appendages has been a source of discussion among the carcinologists. Brady (1880) considered that the mandible, the maxillule (first maxilla), the maxilla and the maxilliped are present ; and this view has been shared by great many of the subsequent workers. [Gurney, 1927 ; Nicholls, 1944 ; Sewell (*loc. cit.*) and Gooding (*loc. cit.*)] However, Sars (*loc. cit.*) held a different view. He maintained that the mandible is absent in all the Poecilostoma and what is usually described as mandible is nothing but ' a part of the foremost pair having been erroneously taken for an independent limb '. At least as far as the family Clausidiidae is concerned Nicholls (*loc. cit.*) has shown beyond doubt that there are four pairs of oral appendages present : ' The few specimens of *Hemicyclops* found in this collection have been dissected with particular attention as to whether these two anterior pairs of mouth-parts came away together or were attached separately. In each case I found no attachment between them and during dissection observed that they were independently mounted side by side on the supporting skeleton. I am, therefore, convinced that there are two separate appendages : the mandible, which has the typical shape of such an appendage though lacking a palp and having a somewhat specialized armature and the maxillule, which is here distinctly cleft, the smaller lobe armed with strong spines representing the gnathobase, the larger lobe with setae only being the palp ' (p. 44). Gurney (*loc. cit.*) goes further and states that even in Lichomolgiade, the mandible and its ' palp ' are separable and can be recognized as distinct appendages.

As to the oral appendages of lichomolgids that are dealt with in this paper it is clear that all the four pairs are present, although highly reduced in some cases. In all cases, however, the mandible and the maxillule are very closely set. The drawings of these appendages have been made together. In describing the various appendages I have confined to the usage of those terms which are currently in vogue among the copepodologists. The terms protopod, exopod and endopod are used to indicate the basal, the external and the internal components respectively. These terms have been employed to describe not only the swimming legs but also the cephalosomal appendages.

Material and Methods

The material of the present study was obtained from the Gulf of Mannar and the Palk Bay on the south-east coast of India off Mandapam. Some of the species were found to occur in both the areas. Others were caught only in one of the two seas. All the collections were made in the inshore waters with a maximum depth of two meters and the period of collections was spread over from May to August 1960. The following method was adopted for the collection : Weeds, mud-covered coral stone, sponges, holothurians, starfishes etc. etc., were vigorously washed separately into hand-nets made of organdie cloth. Smaller mud particles were sifted out by repeated dipping of the net into sea water. The remaining portion was transferred to large glass jars and preserved in formalin. Larger non-copepod items were later hand-picked and discarded. The copepods were sorted out by examining the residue under a binocular microscope. Attempts to pick out some of the copepods alive seldom meet with success as they tend invariably to hide under some coverage, thus making it difficult to spot them. All the species are present in fairly good numbers. The type specimens are deposited at the Reference Collection

Museum of the Central Marine Fisheries Research Institute, Mandapam Camp. The description and the diagrams are based on the examination of more than one specimen. All the drawings have been made with the aid of a *camera lucida.*

Section SIPHONOSTOMA

Family ASTEROCHERIDAE GIESBRECHT s. str.

(Syn. ASCOMYZONTIDAE Sars)

Sars, 1918, p. 83.
Nicholls, 1944, p. 16.

Genus *Asteropontius* Thompson & Scott 1903

Thompson & Scott, 1903, p. 288.

Asteropontius littoralis sp. nov.

Material examined—Many specimens were collected during the months of June and July 1960. Most of the specimens were obtained from the Palk Bay off Mandapam and a few examples were also caught near the Pamban bridge, the meeting place of Gulf of Mannar and Palk Bay. The holotype and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered Nos. J. 535/4 and J. 536/4 respectively.

Description: A. FEMALE

The body (Fig. I, 1): The general appearance is typically asterocherid. The prosome is distinctly oval and is composed of four segments. The first segment is longer than the length of all other segments combined. The latter diminish gradually in width, the last of them being less than half as wide as the first. The urosome (Fig. I, 12) is only half the length of the prosome and consists of the fifth leg-bearing segment, the genital segment and two abdominal segments. The genital segment is the largest and has its anterior region wider than the posterior ; at the junction of these two, there are tufts of hairs on either side. Urosomal segments are wider in front, gradually narrowing posteriorwards. Each caudal ramus bears six setae, one of which is distinctly longer than the entire urosome.

Antennule (Fig. I, 2) is 19-segmented and reaches to the posterior margin of the first prosomal segment. The segments of the antennule are divisible into a wider proximal and a narrower distal region, consisting of nine and ten segments respectively. All the segments are provided with setae, more than one in many cases, especially on ninth to eleventh segments where there is a profusion of setae. The eighteenth segment bears a fairly long aesthetask. The proportions of the various segments are given below (All segments are measured through the middle line).

1	2	3	4	5	6	7	8	9	10	
13.2	2.6	3.1	4.0	3.5	3.3	4.4	4.4	4.4	1.8	
11	12	13	14	15	16	17	18	19		
2.6	5.3	6.6	7.0	5.3	6.2	5.9	7.0	9.4		= 100

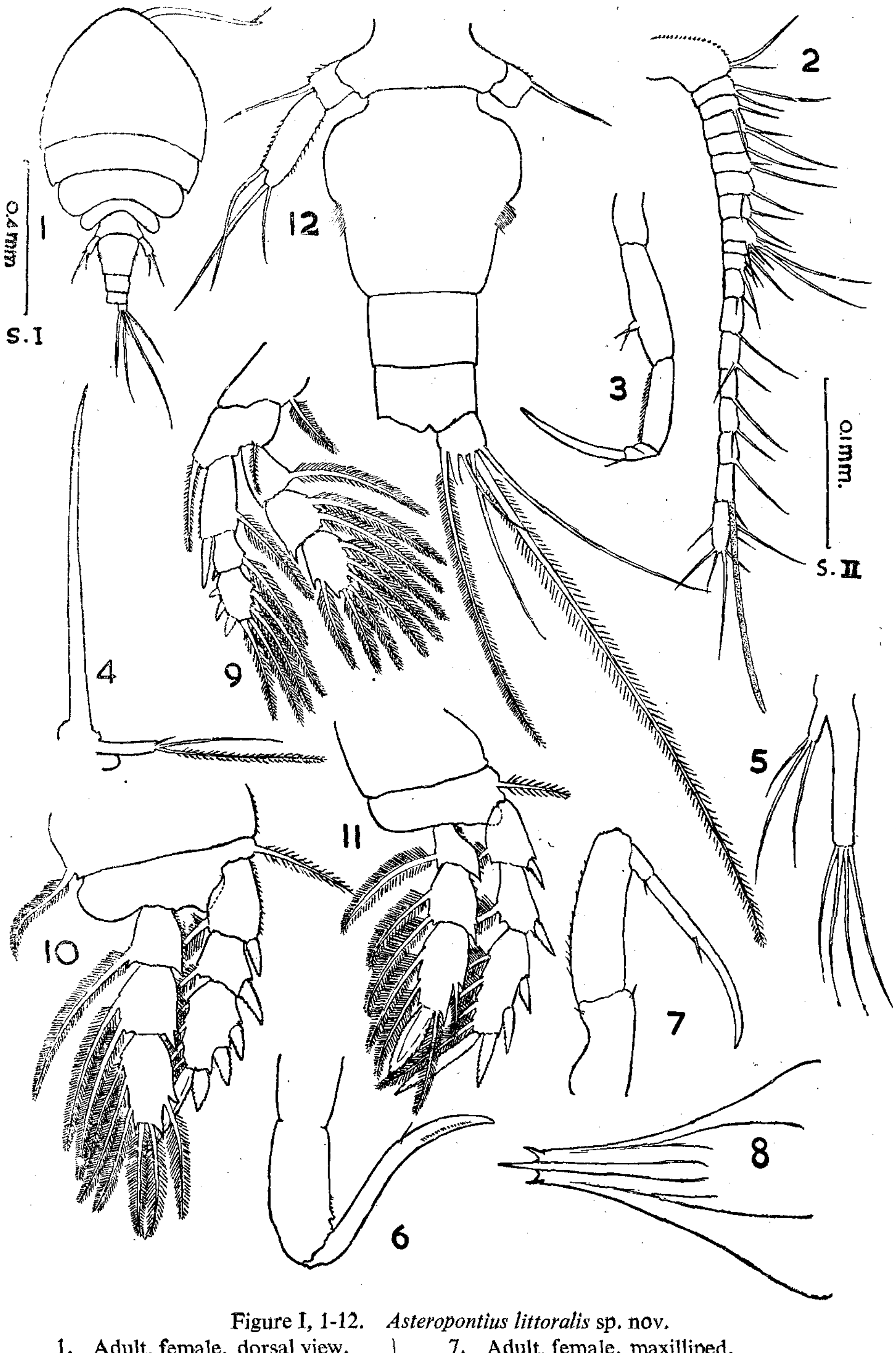

Figure I, 1-12. *Asteropontius littoralis* sp. nov.

1. Adult, female, dorsal view.	7. Adult, female, maxilliped.
2. ,, ,, antennule.	8. ,, ,, siphon.
3. ,, ,, antenna.	9. ,, ,, first swimming leg.
4. ,, ,, mandible.	10. ,, ,, second swimming leg.
5. ,, ,, maxillule.	11. ,, ,, fourth swimming leg.
6. ,, ,, maxilla.	12. ,, ,, urosome with the fifth leg.

(Diagram 1 is drawn according to scale I and diagrams 2-12 according to scale II).

Antenna (Fig. I, 3) is 5-segmented ; the last two segments, however, are not fully segmented. The second segment is the largest, the third, first, fourth and the fifth coming next in order. The second segment bears at about two-third of its length a rudimentary endopod which carries two small setae on the apex. The terminal antennal segment bears a fairly large spine and a stout seta at its apex. Hairs are present on the inner margin of the third segment. *Siphon* (Fig. I, 8) is stoutly built, pyriform in shape and only extending to the insertions of the maxillipeds ; its posterior edge is marked by three sharply spine-like structures, one medial and two lateral. *Mandible* (Fig. I, 4) is with a very long masticatory blade and a short uniarticulate palp which bears at its apex three setae of unequal length. The blade is five times as long as the palp. This condition is not found in any other known species of this genus. *Maxillule* (Fig. I, 5), as usual, is composed of two lobes which are much unequal in size. Both the lobes are provided with a number of apical setae which are rather strong and finely ciliated. *Maxilla* and *maxilliped* (Fig. I, 6 & 7) are of the usual asterocherid pattern, the only notable difference being that in the former the line of separation between first and second segments are not distinct although there is a clear constriction between them.

The four pairs of *swimming legs* (Fig. I, 9, 10 & 11) are borne by the four prosomal segments. They are all biramous, each ramus being composed of three segments. In the first legs, the basal exopod segment is elongated, almost equivalent to the combined length of second and third segments. The spine on that segment also is quite long. The second and third legs are very similar to each other in structural details and are quite normal. In the fourth leg the segments of both endopod and exopod are slender and long and differ from those of the preceding legs in setation. The setal formula of the four pairs of swimming legs are given below :—(In this and in all the subsequent accounts of the ornamentation of the swimming legs the following abbreviations have been used : P_1-P_4 stand for the first to the fourth swimming legs and Si, Se and St represent the internal, the external and the terminal margins respectively of the constituting segments. The setae are indicated in Arabic and the spines in Roman numbers).

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	II	II
P_3	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	II	II
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	4	II	II

The fifth leg (Fig. I, 12) is quite moderate in size, reaching upto the middle of the genital segment. It consists of two segments of unequal size ; the basal bears a single seta and the distal three setae, two of which are apical and the third subapical. Stiff hairs are present on the outer margin of the basal and on both margins of the distal segment. The size of the adult female is 0.8 mm.

B. MALE

Unknown.

Asteropontius sewelli sp. nov.

Material examined—Four specimens were obtained from the washings of the bottom weeds from Palk Bay in June 1960. All are females. The holotype and the paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and have the registered Nos. J. 569/5 and J. 570/5 respectively.

Description:

A. FEMALE

The body (Fig. II, 1)—Like the preceding species, here also, the body is more or less oval. The first prosomal segment is, however, much wider and longer than the other three segments combined. The urosome consists of four segments, the genital segment being the largest. The latter is vase-like, with the anterior part wider than the posterior and the two areas being separated by tufts of hairs on the lateral margins. The post-genital segments are cylindrical and narrow. The caudal ramus is short and distinctly smaller than the last abdominal segment ; each ramus bears six setae, the longest of them being one and a half times longer than the entire urosome ; it is 2-segmented and profusely setiferous.

The antennule (Fig. II, 2) is fairly long reaching to the posterior margin of the first prosomal segment. It consists of nineteen segments, the first nine segments being distinctly wider and longer than the remaining segments. The eighteenth segment bears an aesthetask which is rather short. The proportionate lengths of the antennular segments are as follows :—

	1	2	3	4	5	6	7	8	9	
	8.69	3.00	2.55	2.78	2.55	2.33	2.21	2.55	2.33	
10	11	12	13	14	15	16	17	18	19	
1.23	1.47	5.85	7.36	8.69	8.69	9.49	8.68	9.75	9.81	= 100

Antenna (Fig. II, 3)—is 5-segmented and quite normal in structure. The second segment bears the rudimentary endopod ; there are two short spines and a long spine on the terminal segment. *Siphon* (Fig. II, 4) is very short and stout, having two sharp needle-like points at the posterior tip ; no medial spine is present. In the *mandible* (Fig. II, 5) the masticatory blade is very long and pointed while the palp is uniarticulate and rather short, bearing two setae, one of which is extremely long, being longer than the masticatory blade and ciliated on both margins. *Maxillule* (Fig. II, 6) consists of two lobes which are very much unequal in size, the smaller one being only one-fifth of the larger and appearing more as a process of the latter. *Maxilla* and *maxilliped* (Fig. II, 7 & 8) are quite normal and similar to those of the preceding species. The terminal claw of the maxilla, however, is much more slender and long.

Of the four pairs of *swimming legs* (Fig. II, 9, 10 & 11) which are borne by the our prosomal segments respectively, the first leg is the smallest. The second and

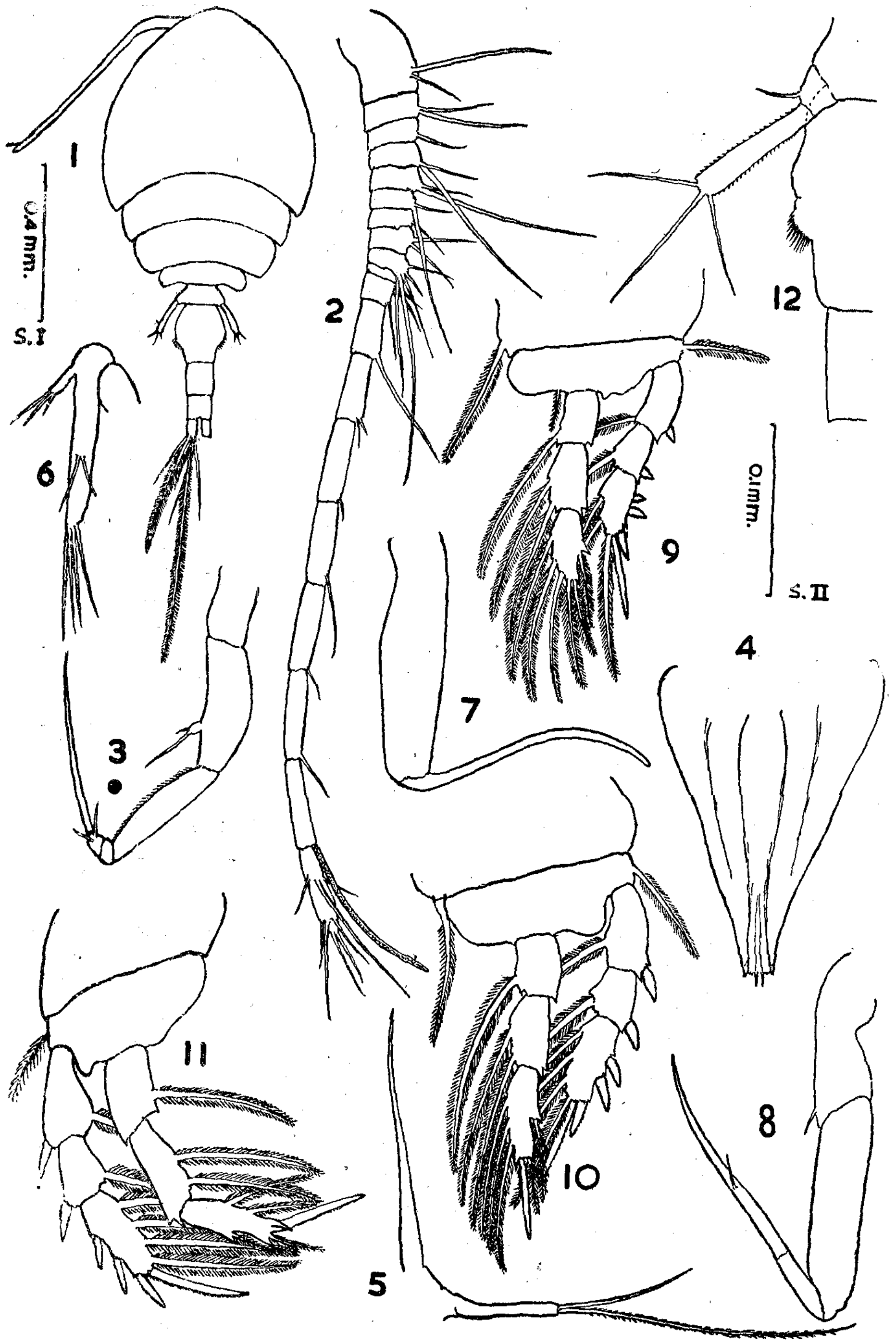

Figure II, 1-12. *Asteropontius sewelli*, sp. nov.

1. Adult, female, dorsal view.	7. Adult, female, maxilla.
2. ,, ,, antennule.	8. ,, ,, maxilliped.
3. ,, ,, antenna.	9. ,, ,, first swimming leg.
4. ,, ,, siphon.	10. ,, ,, second swimming leg.
5. ,, ,, mandible.	11. ,, ,, fourth swimming leg.
6. ,, ,, maxillule.	12. ,, ,, fifth leg with parts of urosome.

(Diagram 1 drawn according to scale I and diagrams 2-12 according to scale II).

third legs are exactly similar in structure and appearance. In the fourth leg the constituting segments are longer than those of the preceding legs. The setal formula of the swimming legs is as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	1+I	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	II
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	II
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	4	I	III

It may be seen from above that the terminal endopod segment in the second, third and fourth pairs of legs bears one seta and one spine instead of the usual single spine or single seta. The fifth leg (Fig. II, 12) is fairly long and thin and is 2-segmented, the proximal segment being contained about four times in the distal segment ; the former bears a single seta at its postero-lateral corner and the latter three radiating setae on the apex. There are stiff hairs on either margins of the distal segment. The size of the female is 1.1 mm.

B. Male

Unknown.

This species is named after Col. R. B. S. Sewell, C.I.E., SC.D., F.R.S., in recognition of the very valuable contributions that he has made towards our understanding of the Indian copepods.

Remarks—Thompson & Scott (1903) created this genus to include two species of copepods, *A. typicus* and *A. attenuatus* which they obtained from the sponge and invertebrate washings. Since then two more species have been added, *A. nicobaricus* Sewell from Nicobar Islands and *A. mycalei* Krishnaswamy, from Madras. The genus is very closely related to *Asterocheres* and can be distinguished only on careful examination. Thompson & Scott defined the genus *Asteropontius* as follows : ' Cephalothorax roundly ovate, five-jointed, the cephalic segment larger than the combined length of the four following segments. Anterior antenna 18-19 jointed. Abdomen 3-jointed. Outer branch of the posterior antenna 4-jointed, a small 1-jointed branch springing from the first joint. Maxilla 2-branched. Mandible long and narrow ; palp i-jointed. Maxilliped and natatory legs 1st to 5th as in *Asterocheres* ' (*loc. cit.* p. 288). They remarked at the end of the description of *A. typicus* that ' the species bears a general resemblance to *Asterocheres*, but the 19-jointed antennae and the 1-jointed mandible palp separate therefrom.' The antennular segmentation does not hold valid as a generic character for the number of segments in the antennule is now established to vary from eighteen to twenty in *Asteropontius* and fourteen to twenty in *Asterocheres.* The statement that the antenna is 4-jointed and that the rudimentary endopod is borne by the basal antennal segment does not conform to their diagrams (Pl. XVIII, Fig. 13 & Pl. XIX, Fig. 3) which clearly show that antenna is 5-jointed in both the species, and that the rudimentary edopod is borne by the second segment. In *A. nicobaricus* the antenna is 5-jointed, the proportions of the different segments being almost identical with those of the preceding two species. *A. mycalei* has an antenna which is 3-jointed; it appears from the diagram of the latter species that the last two segments have undergone a fusion. The fact is, however, is clear that as far as the segmentation of the antenna is concerned no distinction can be made between the two genera. Thus the only distinguishing feature of the genus *Asteropontius*, not shared by *Asterocheres*, is the uniarticulate nature of the mandibular palp.

The third segment of the first exopod also deserves some comments. Three types of conditions are met with in the present genus. In *A. typicus* there are four setae and two spines. In *A. attenuatus* the number of setae are four and that of spines three; this latter condition is also found in *A. nicobaricus* and *A. littoralis* sp. nov. A third type of situation occurs in *A. mycalei* and *A. sewelli* sp. nov.; here there are three setae and four spines. Thus the tendency towards an increase in the number of spines is accompanied by a reversed tendency in the case of setae.

Krishnaswamy (*loc. cit.*) has provided a key to the identification of the different species known upto that time. The number of segments of the antennule was the main criterion on which his key was based. It now appears that the number of setae and spines on the third segment of the first exopod also provides a good point of specific distinction and the identification key is here revised employing these two characters along with the structure of the caudal rami when it is required.

Key to the identification of the females

1.	Antennule composed of 18 segments	 2
	Antennule composed of 19 segments	 3
	Antennule composed of 20 segments	.... *A. mycalei* Krishnaswamy, 1954.
2.	Caudal rami longer than wide, the proportions of length and width being 5 : 2	*A. attenuates* Thomp. & Scott, 1903.
	Caudal rami wider than long, the proportions of length and width being 4 : 5	*A. nicobaricus* Sewell, 1949.
3.	The third segment of first exopod with four setae and two spines	*A. typicus* Thomp. & Scott. 1903.
	The third segment of first exopod with four setae and three spines	*A. littoralis* sp. nov.
	The third segment of first exopod with three setae and four spines	*A. sewelli* sp. nov.

Family Dyspontiidae Sars

Sars, 1918, p. 117.
Nicholls, 1944, p. 23.

Genus *Cryptopontius* Giesbrecht, 1899

Sars, 1918, p. 120.
Nicholls, 1944, p. 24.

Cryptopontius Graciloides Sp. Nov.

Material examined.—Fourteen female specimens were obtained from washings of weeds from the Palk Bay. They were captured on two occasions. No specimen was available from the Gulf of Mannar even after many searches. The holotype and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J. 572/6 and J. 573/6 respectively.

Description: A. Female

The body (Fig. III, 1).—The prosome consists of four segments and the urosome of five segments. The first prosomal segment is very large being distinctly larger than the rest of the body. It is slightly wider than long and the length-breadth proportion is 48 : 52. Second and third segments are less wide than the first segment but still with epimeral plates which are crowded together and curved backwards. The last prosomal segment is very small without epimeral plates and partly concealed by the preceding segment. The first segment of the urosome bears the highly reduced fifth pair of legs. It is only about as large as the last prosomal segment. The genital segment (Fig. III, 8) is quite large, being equivalent in length to the combined length of the three following segments. Its anterior part is very much widened, more than twice as wide as the last abdominal segment, and bears on each side a pair of spines towards the postero-lateral margin of the widened area. Of the three abdominal segments the first is the longest, and the second the shortest. They diminish in width posteriorly. The caudal ramus is a little wider than long and bears six setae, one of which is very long, being more than twice as long as the entire urosome ; the furcal setae are plumose.

Antennule (Fig. III, 2) is 9-segmented and rather stout. The first, third and the last segments are fairly long ; second segment is the shortest and is distinctly wider than long ; the fifth segment is square. Other segments are of moderate length and are longer than wide. The last segment bears an aesthetask which is about two-third the length of the antennule itself. Following are the proportions of the different segments :—

1	2	3	4	5	6	7	8	9		
18.2	3.8	19.5	7.2	6.0	8.3	8.3	9.8	18.9	=	100

Antenna (Fig. III, 3) is 4-segmented, the second segment carrying a rudimentary endopod bearing a single terminal seta. The second, third and fourth segments are of about equal lengths while the basal segment is distinctly shorter. The terminal segment bears three setae, one at about its mid-length on the ventral side and the

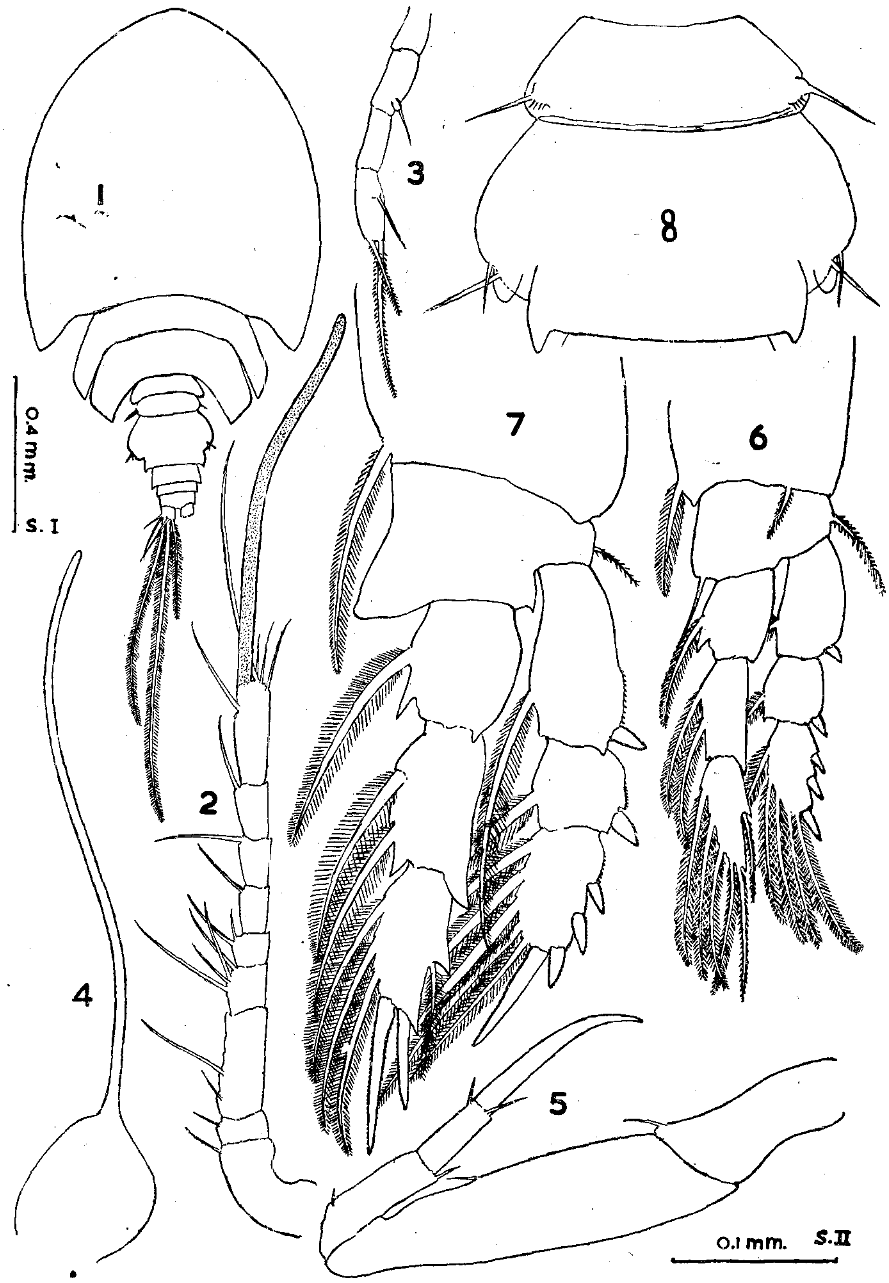

Figure III, 1-8. *Cryptopontius graciloides*, sp. nov.

1. Adult, female, dorsal view.	5. Adult, female, maxilliped.
2. ,, ,, antennule.	6. ,, ,, first swimming leg.
3. ,, ,, antenna.	7. ,, ,, second swimming leg.
4. ,, ,, siphon.	8. ,, ,, fifth leg with parts of urosome.

(Diagram 1 is drawn according scale I and diagrams 2-8 according to scale II).

other two terminally ; the terminal setae are of unequal length. *Siphon* (Fig. III, 4) is extremely slender and consists of a bulbous proximal portion and a narrow distal portion which is of uniform thickness throughout and which extends almost to the end of the prosome. *Mandible* without any palp, masticatory blade slender, styliform and long. *Maxillule* (Fig. IV, 1) has both lobes slender, the outer more than three-fourth as long as the inner and armed with a very short spine and a fairly long seta ; the inner lobe bears on its apex a spine, and a seta, the latter being more than one and a half times longer than the lobe itself and provided with stiff hairs on the inner margin. The *maxillae* and *maxillipeds* (Fig. IV, 2 & III, 5) are normal in structure and resemble those of the type species of the genus.

The four pairs of swimming legs (Fig. III, 6, 7 and Fig. IV, 3) are borne by the four prosomal segments respectively. First three pairs are biramous while the fourth is uniramous, the endopod entirely lacking. While the second and third legs are similar to each other in structure and size, the first is distinctly smaller and shows differences in the setation. The setal formula of the swimming legs is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	1	I	1	1	0	2	0	4	1	1	1	I	1	I	4	1	III
P_2	1	0	0	1	1	0	2	0	3	II	1	1	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	II	1	1	I	1	I	5	1	III
P_4	0	0	0	0	Absent							1	I	1	I	5	I	III

The fifth legs (Fig. III, 8) are extremely rudimentary and are represented on each side by a single seta borne on a bud-like protrusion ; there are a few stiff hairs on the lower margin of this bud. The size of the female is 1.3 mm.

B. Male

Unknown.

Cryptopontius orientalis sp. nov.

Material examined.—Along with the preceding species, two female examples, each carrying a pair of beautifully rose-coloured ovisacs were obtained from Palk Bay in June, 1960. A few weeks after that some more examples, about fifteen specimens, were caught near the Pamban Bridge and the latter collection included both males and females. The type specimens, the holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J 658/7, J 659/7 and J 660/7 respectively.

Description:

A. Female

Although the ovisacs are of fine rose colour, the body is dull opaque, as in most of the cyclopoides. The oviscas also lost their colour after a few days of preservation in formalin. *The body* (Fig. IV, 4)—This is more robust than in the preceding

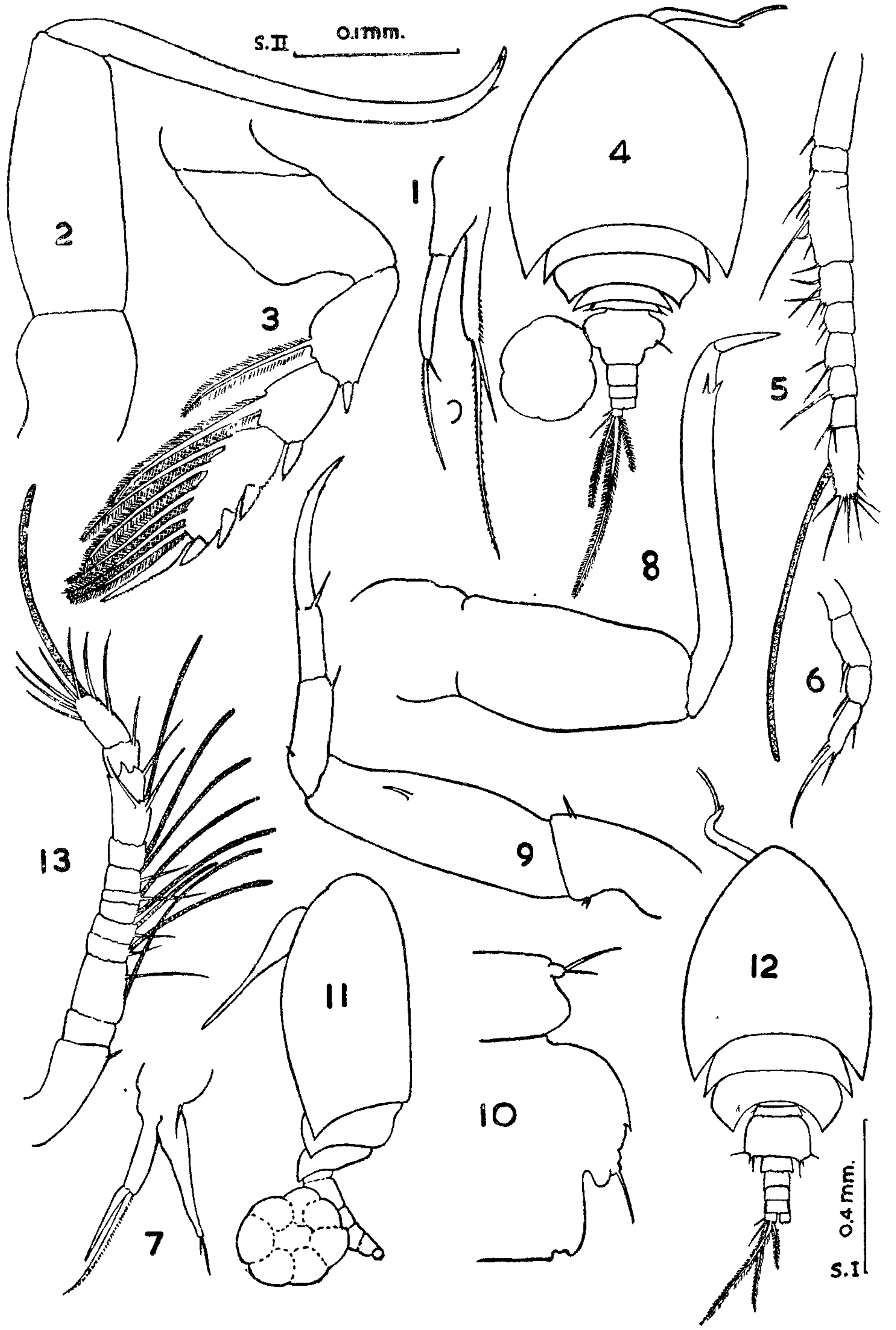

Figure IV, 1-13. *Cryptopontius graciloides* sp. nov.

1. Adult, female, maxillule.
2. ,, ,, maxilla.
3. Adult, female, fourth swimming leg.

Cryptopontius orientalis sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, antenna.
7. ,, ,, maxillule.
8. ,, ,, maxilla.
9. Adult, female, maxilliped.
10. ,, ,, fifth leg with parts of urosome.
11. ,, ,, lateral view.
12. Adult, male, dorsal view.
13. ,, ,, antennule.

(The fourth, eleventh and twelfth diagrams are drawn according to scale I and others according to scale II).

species and the first prosomal segment still constitutes the major part of the body. It is wider than long and is one-quarter time longer than the entire remainder of the body. Second and third prosomal segments are less wide but are provided with epimeral plates. The last segment is very small both in length and width and is without an epimeral plate but is provided with posterior angular corners like the preceding segments. The urosome is 5-segmented and is much similar to that of the earlier species. The anterior part of the genital segment, however, is comparatively wider. Although the three abdominal segments diminish in size posteriorly, the ratio of the length is different from that of the earlier species. The caudal rami are wider than long, each bears five setae, two of them appearing more like spines ; the longest seta is one and a half times longer than the entire urosome.

Antennule (Fig. IV, 5) is 9-segmented, the third segment showing a slight partial division. Segments 1-3, 5 and 9 are of the same length-width relations as in the preceding species, while the fourth, sixth, seventh and eighth segments are much shorter and are only a little longer than wide. The last segment bears an aesthetask which is about three-fourth as long as the entire antennule. The proportiônate lengths of the constituting segments are :—

1	2	3	4	5	6	7	8	9		
22.0	5.1	19.8	8.8	6.9	7.8	6.9	6.9	15.8	=	100

Antenna (Fig. IV, 6) is 4-segmented, the second segment bearing the rudimentary endopod. The basal segment is equivalent to the third in length and is shorter than the second and fourth which are more or less of equal dimensions. While the third segment bears a single seta, the fourth has four of them, one at about half its length and three terminally. The setae are unequal in size. *Mandible* is quite normal and typical of the genus. *Maxillule* (Fig. IV, 7) has both lobes slender, the outer two-third as long as the inner and armed with a seta and a spine ; the inner lobe armed with two slender spines ; at the base of the inner lobe there is another spine. *Maxilla* and *maxilliped* (Fig. IV, 8 & 9) bear a great resemblance to those of the earlier species. A notable difference in the maxilla, however, is that the division between the first and the second segment is incomplete. In the maxilliped, the basal segment bears a pair of small spines on the outer distal margin, in addition to the one present on the inner distal margin.

First three pairs of swimming legs (Fig. V, 1, 2 & 3) are biramous, while the fourth is uniramous, the endopod entirely missing. The legs two and three are absolutely identical in structure and size, while the first leg is smaller. The outer margins of all the segments of the exopods of second, third and fourth legs are clearly dentate. The setal formula for the swimming legs is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	S	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	4	1	1	1	I	1	I	3	1	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_4	0	0	0	0	Absent							1	I	1	I	5	I	III

The number of setae and spines of the third segment of first exopod is different from that of the earlier species ; while in the latter there are five setae and three spines, here the number of setae is reduced to four. Further the setae on the inner side of the third endopod segment of the first leg is very small compared to that of the earlier species. *Fifth leg* (Fig. IV, 10) is highly reduced in size and it is represented on each side by a protrusion which bears two slender setae at its apex. The size of the female is 1.05 mm.

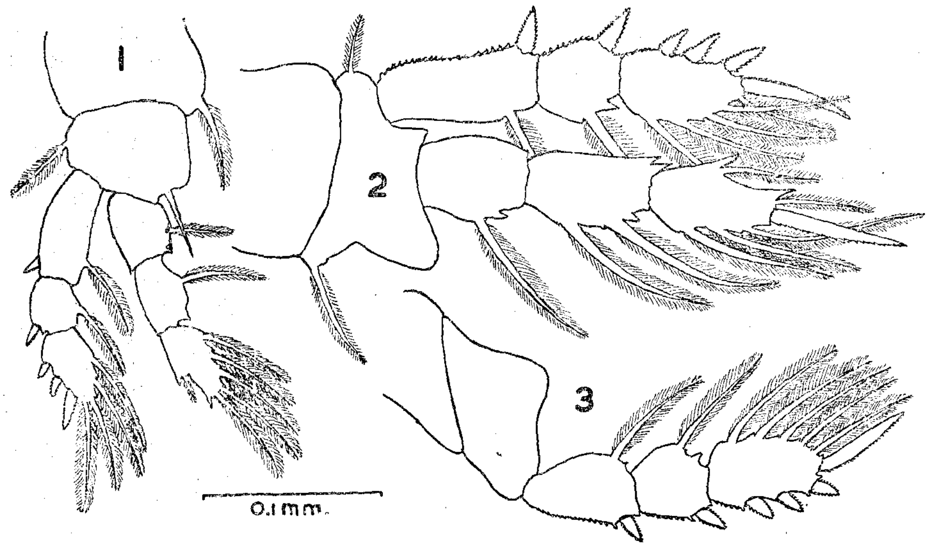

Figure V, 1-3. *Cryptopontius orientalis* sp. nov.

1. Adult, female, first swimming leg.
2. ,, ,, second swimming leg
3. ,, ,, fourth swimming leg.

B. Male

The general body (Fig. IV, 12) of the male is more slender than that of the female. While in the former the first prosomal segment is only one-quarter time as wide as that of the second prosomal segment, in the latter it is one and a half times wider. The last prosomal segment in formalin preserved specimens is entirely concealed by the preceding segment. The urosome consists of six segments. The genital segment is very large, equivalent in length to the three following abdominal segments. But unlike in the female it is more or less of uniform width and bears on each side posteriorly three spines, two of them directed backwards and the third sidewards. The abdominal segments diminish slightly, both in width and length, towards the posterior side. The caudal ramus is wider than long and bears the same number of setae, with same proportionate lengths, as in the female. The size of the male is 1.0 mm.

Antennule (Fig. IV, 13) is geniculate on both sides. It is 12-segmented, with the first segment being the longest and seventh the shortest. The tenth segment is somewhat dilated, exhibiting near the end, in front, a short dentiform projection. Segments 3-10 bear each an aesthetask which is fairly long. The last segment also bears an aesthetask which is corresponding to that of the female. The proportionate lengths of the different segments are given below :

1	2	3	4	5	6	7	8	9	10	11	12	
21.6	5.5	13.1	4.5	4.5	4.0	2.5	5.2	4.2	15.7	6.0	13.2	= 100

The setae on the antennule of the male are longer compared to those of the antennule of the female. All other appendages including the fifth legs are identical to those of the female sex ; but they are relatively smaller.

Remarks—Nicholls (1944) has reviewed this genus and pointed out that it contains ten species including the four new species he added from the Australian waters. So far only one species has been reported from the Indian waters, *C. brevifurcatus*, recorded from Madras coast by Krishnaswamy (*loc. cit.*). The addition of the two present species brings the total number of known forms to twelve and shows that the genus probably is quite represented in our waters. The genus is very closely related to *Dyspontius* and the most reliable character by which they are distinguished is the armature of the first exopod : *Dyspontius* has only two outer spines on the end segment, whereas *Cryptopontius* has three. Wilson's definition (1932, p. 594) of the genus *Cryptopontius* as having the first prosomal segment longer than wide and third segment of first exopod with three spines and five setae, in contrast to *Dyspontius* which is said to have the first prosomal segment wider than long and the third segment of the first exopod with three spines and four setae is not correct, as is seen from a glance through the species described so far. All the species of the genus *Cryptopontius* are consistent in possessing three spines on the end segment of first exopod. The number of setae on that segment and the length-width ratio of the first prosomal segment, however, are not identical in all the species.

As far as the number of setae on the end segment of the first exopod is concerned, two types of situations are met with in the genus. There are five setae and three spines in the case of *C. brevifurcata* Giesb., *C. proximus*, Nicholls, *C. similis* Nicholls, *C. gracilis* Wilson and *C. graciloides* sp. nov., while there are only four setae and three spines in the case of *C. longipes* Nicholls, *C. latus* Nicholls and *C. orientalis* sp. nov. I have not been able to go through the original descriptions of the four remaining species ; but the essential specific distinctions are available for the four remaining species, namely, *C. thorelli* Giesb., *C. capitalis* Giesb., *C. innominatus* Brady and *C. tenuis* Giesb. The first two species belong to the second group, namely, the group having four setae and three spines. Of the remaining two species, it is uncertain whether *innominatus* should be included at all in this genus. ' Brady's specimen was apparently damaged, but the urosome which he figures shows the genital segment of the same width throughout whereas it is characteristic of the genus that it should be very much widened anteriorly ' (Nicholls, *op. cit.* p. 25). Whether the number of setae in the case of *C. tenuis* is four or five could not be known ; presumably it is five as Wilson (*op. cit.*) has considered that number as the more normal for the genus. However, the fact becomes clear that the species of this genus are separable into two groups, namely, those having five setae in the third segment of the first exopod and those having only four setae on that segment.

C. graciloides is much related to *C. gracilis* but the differences between the two species are many : (i) in *C. gracilis* the first prosomal segment is as long as wide while here it is slightly wider than long ; (ii) in *C. gracilis* the abdominal segments decrease in width but increase in length posteriorly ; in *C. graciloides* the posteriormost segment is the longest and the middle segment the shortest ; in width, here also, they decrease posteriorly ; (iii) siphon is short and stout in *C. gracilis* ; the siphon is very long and slender in *C. graciloides* and (iv) size of the female 1.3 mm. in *C. graciloides* ; in *C. gracilis* the female measures only 1.0 mm. and the male 0.85 mm.

C. orientalis as noted earlier is close to *C. longipes* and *C. latus* in that in all these three species the terminal exopod segment of first legs carries three spines and four setae. *C. longipes*, however, is very easily distinguished from the other two species by the fact that in the former the first and second antennular segments are subequal and much longer than the third antennular segment while in both *C. latus* and *C. orientalis* the second antennular segment is much shorter than the first and third which are subequal. *C. orientalis* is identified from *C. latus* by the following differences : (1) Female of *C. orientalis* measures 1.05 mm. and male 1.0 mm. ; the female of *C. latus* is 1.30 mm. long. (2) The genital segment of *C. latus* is shown to be very wide, about three times wider than the following abdominal segment ; in *C. orientalis* the genital segment is about two and a half times wider than the next abdominal segment. At the junction of the wider proximal and narrower distal halves of the genital segment of *C. orientalis* there are two stout spines, on either side directed postero-laterally. In *C. latus* these spines are absent. (3) In *C. latus* the abdominal segments are more or less of equal dimensions, with the first segment a little longer than the other two segments. In *C. orientalis* the three abdominal segments diminish both in width and length to the posterior side. (4) The rudimentary exopod of the antenna is without any apical seta in *C. latus* while it is with one apical seta in *C. orientalis*. (5) The larger lobe of the maxillule carries one seta alone in *C. latus* and two apical and one basal setae in *C. orientalis* (6) On the inner margin of the terminal segment of first endopod there is one seta present in the case of *C. orientalis* whereas there is no seta in that position in *C. latus*. (7) The rudimentary fifth leg in *C. latus* bears only a single apical seta while that of *C. orientalis* bears two apical setae.

Section **POECILOSTOMA**

Family CLAUSIDIIDAE EMBLETON

(Syn. HERSILIIDAE CANU)

Sars, 1913-1918, p. 144.

Genus *Hemicyclops* BOECK

Sars, 1913-18, p. 145.

Light and Hartman, 1937, p. 173.

Sewell, 1949, p. 65.

Gooding, 1960, p. 159.

Hemicyclops intermedius sp. nov.

Material examined—Two female specimens were obtained along with other weed washings from the Gulf of Mannar in July 1960. An additional single specimen was obtained from the same area in the following month. The type specimen is deposited in the Central Marine Fisheries Research Institute and bears the registered number J/575/8.

Description : A. FEMALE

This (Fig. VI, 1) is a fairly moderate-sized species with clearly marked prosome and urosome. The prosome is elongate-ovate and comprises the cephalothorax and three free metasomal segments. The cephalothorax is quite large, contains in it the widest part of the body and is longer than the other three prosomal segments combined. The latter gradually diminish in width to the posterior side and are subequal in length. The lateral margin of the third prosomal segment gives an articulated appearance. The posterior margin of the last-prosomal segment is truncate in dorsal view. No rostral protuberance is visible dorsally. The urosome is 5-segmented and consists of the fifth leg-bearing segment, the genital segment and three abdominal segments. The first segment is small and rather six sided, each lateral margin being set apart into anterolateral and posterolateral divisions because of an expanded growth along the mid-transverse line. The fifth legs are borne on the postero-lateral margins. The genital segment is the largest and consists of an anterior wider half and a posterior narrower half which merge into each other without any trace of division between them. The abdominal segments decrease, both in length and breadth, to the posterior side. The combined length of the three abdominal segments is equal to that of the genital segment. The furcal rami are square and a little less long than the last urosomal segment. Each ramus bears five apical setae, one of which is very long, longer than the entire urosome, and one very short and subapical in position.

Antennule (Fig. VI, 2) is 7-segmented. Attachment of the basal segment to the cephalosome is at right angles to the plane of projection of the remainder of the appendage. In life the latter is held perpendicular to the main axis of the body. The relative lengths of the different antennular segments are as follows :

1	2	3	4	5	6	7		
13.8	10.6	11.2	22.4	15.2	13.4	13.4	=	100

The second segment is the shortest and the fourth the longest. The segments gradually diminish in their thickness to the distal tip. All the segments are provided with a number of setae, especially the second and third segments where there is a profusion of it. Many of the setae bear setules on their margins, several with setules on their tips alone. *Antenna* (Fig. VI, 3) is 4-segmented. It is twice bent on itself so that it looks like an inverted U-tube, with the first and the fourth segments forming the two limbs of unequal length and the middle two segments forming the base. The basal segment bears two setae on the proximal inner margin and a single seta on the distal outer corner. Three groups of ' comb rows ' of setae are found on this segment ; one row on the mid-inner margin and two rows on the outer margin, one each in the proximal and distal halves with some space left between the two rows. First segment is the longest. The second segment is almost as equal as the first. It bears on its outer margin at about the mid-length a stout seta which is ciliated on the outer margin. A ' comb row ' of setae is present on the outer margin between this seta and the base. The inner margin is uniformly ciliated. The third segment is peculiarly orientated ; its outer lateral margin is bent almost at right angle so that the proximal half of this bent side now becomes the outer lateral margin proper and the distal half becomes the apparent apical margin ; the original apical margin is displaced to the position of inner lateral margin ; the real inner lateral margin is highly reduced and constitutes the insignificant proximal

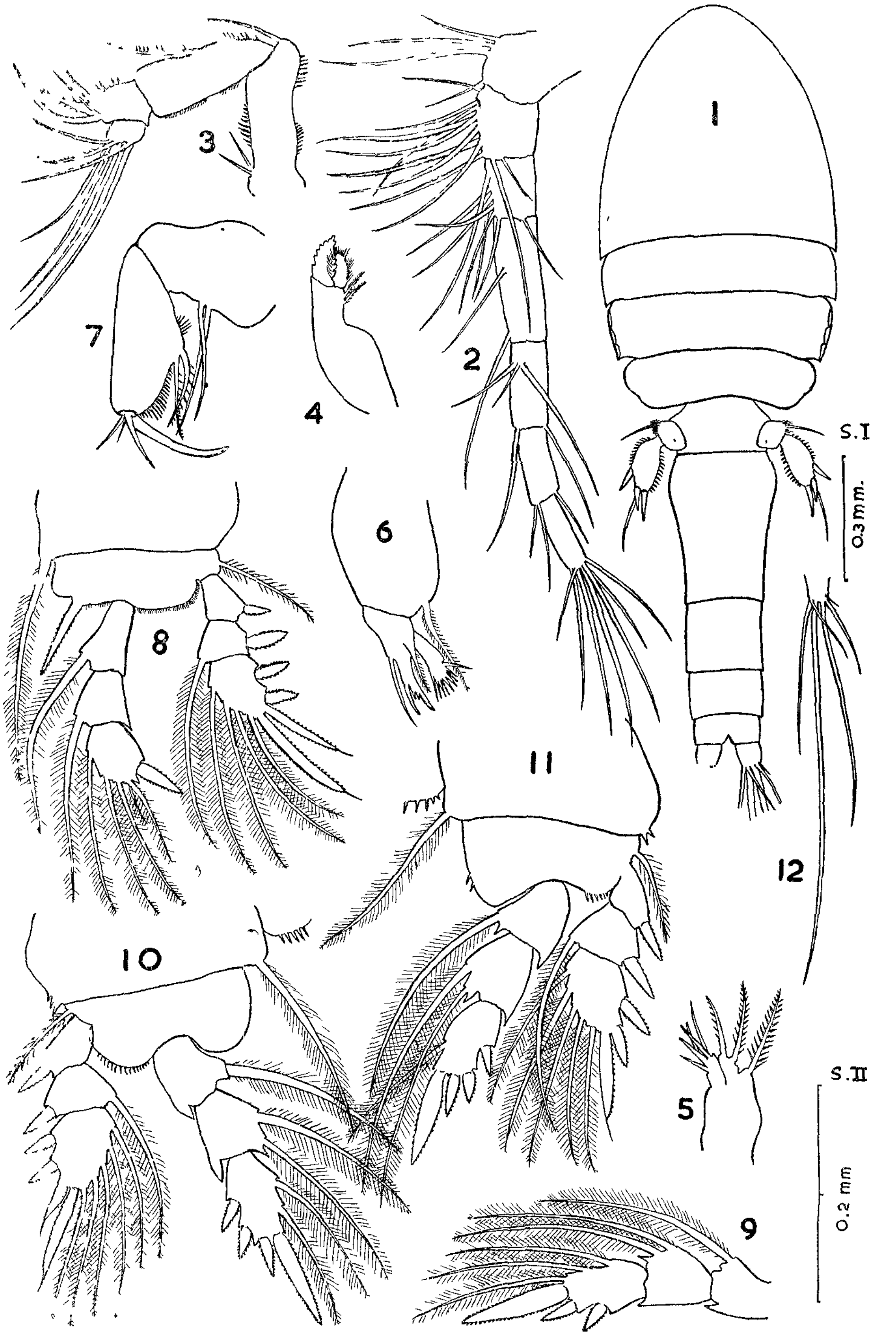

Figure VI, 1-12. *Hemicyclops intermedius* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, mandible.
5. ,, ,, maxillule.
6. ,, ,, maxilla.
7. Adult, female, maxilliped.
8. ,, ,, first swimming leg.
9. ,, ,, endopod of second swimming leg.
10. ,, ,, third swimming leg.
11. ,, ,, fourth swimming leg.
12. ,, ,, caudal ramus.

(First and twelfth diagrams drawn according to scale I and others to scale II).

region of this side. The third segment bears two spines, two setae and a single group of ' comb row ' of setae, all on the original outer lateral margin ; the ' comb row ' is borne on the lateral half and the setae and spine on the apical half of this original outer lateral margin. The last segment of the antenna is the smallest with all the four sides clearly marked, held at right angle to the preceding segment and rather subrectangular and wider than long ; this segment bears on its apical margin seven setae four of which are long and characteristically curved, while the other three are short and slender ; one of these shorter setae is strongly ciliated on its inner margin.

All the four pairs of mouth appendages are present and they are closely compacted in typical poecilostome fashion. *Mandible* (Fig. VI, 4) is a small structure with the proximal half of its body proper much larger than the distal half ; the latter bears two ciliated setae on its outer (in natural position rather directed posteriorwards) distal margin ; the terminal armature consists of a foliaceous flap fringed all along its borders with cilia and a broad rather conical spine which is serrated on both margins. *Maxillule* (Fig. VI, 5) is only as large as the mandible and is clearly bilobed towards the distal side ; each lobe bears four setae, those on the inner appearing more like spines and much shorter ; three of the longer setae are ciliated. *Maxilla* (Fig. VI, 6) is bimerous ; basal segment much inflated, bearing on its distal inner face a stout solitary seta which is ciliated on both margins. The armature of the distal segment is quite complex ; in a lateral view the apex is Y-shaped with asymmetrical limbs and a thick body ; below this a seta is borne on each side, the one on the inner margin being ciliated and a little shorter than that on the outer margin ; on the inner face between the seta and the base of the segment is borne a subrectangular structure which is denticulated on the apical margin. *Maxilliped* (Fig. VI, 7) is probably the most conservative structure. It is trimerous, first two segments being subequal and large and the third highly reduced. The basal segment is armed with two long setae and the second with an inner prominence carrying two spinous setae. The terminal segment bears two claws of unequal lengths and two short setae.

All the four pairs of *swimming legs* (Fig. VI, 8, 9, 10 and 11) are biramous and with two segmented protopods. The rami are all trimerous but the exopod is invariably shorter. The setal formula of the swimming legs is as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	III	0	I	1	I	5	I	III
P_4	1	0	0	I	1	0	2	0	1	I	III	0	I	1	I	5	I	II

In the first leg the apical margin of the second protopod segment is uniformly ciliated. In the second and third legs the first protopod segment bears a group of three spinules on its outer distal margin and the second protopod segment, on its face between the exopod and endopod, a ' comb row ' of spinules. In the fourth leg spinules on the first protopod segment are reduced to two ; the second protopod segment bears, besides the ' comb row ', two small spinules on its inner distal face. *Fifth leg* is 2-segmented and inserted on the ventro-lateral face of the first urosomal segment, one on each side. The proximal segment bears a single seta externally and is armed at the distal external angle with a row of fine spinules. The second is typical of the genus and more than twice as long as the first segment ; it is much narrower at the base and is provided with spinules on both the outer and inner margins. It bears three rather conical broad based spines and a delicate seta between the second and third spines ; the latter two spines may be termed apical in position while the first spine is sub-apical on the outer side.

B. MALE

Unknown.

Remarks—Light and Hartman (1937) reviewed this genus and considered the following species as valid :

1. *H. pugettensis* Light and Hartman, 1937.
2. *H. aberdonensis* (Scott & Scott), 1892.
3. *H. adhaerens* (Williams), 1907.
4. *H. callianassae* Wilson, 1935.
5. *H. purpureus* Boeck, 1873.
6. *H. thysonotus*, Wilson, 1935. and
7. *H. americanus* Wilson, 1932.

H. elongatus Wilson, 1937 was described in the same year as Light and Hartman's review and so was not included in their list. All these species were reported to occur along the American coasts except *H. aberdonensis* which was recorded only from Scottish seas. Gooding (*loc. cit.*) provided an excellent review of the American species of this genus and considered *H. pugettensis* and *H. callianassae* to be synonymous with *H. thysonotus* ; and *H. americanus* as a synonym of *H. adhaerens*. He added two new species *H. arenicola* Gooding and *H. subadhaerens* Gooding to bring the total number of known American species again to six. *H. purpureus* has, however, been omitted from his key for he is not sure whether Wilson's identification of this species from the Canadian waters is correct in view of 'Wilson's lapses in descriptions of other species in this genus '.

The report of the occurrence of the species of this genus in other parts of the world is rather scanty. Besides the two American species referred to above, I am aware of the following species having been reported as belonging to this genus after Light and Hartman's review :

1. *H. leggi* (Thomp. & Scott), 1903 2. *H. tamilensis* (,,), ,,	Both from Ceylon ; transferred to this genus as suggested by Sewell 1949.
3. *H. australis* Nicholls, 1944	Australia
4. *H. indicus* Sewell, 1949	Nicobar Islands
5. *H. visendus*, Humes, Cressey and Gooding, 1958	Madagascar.
6. *H. bacescui* (Serban) 1956	Mediterrannean
7. *H. dilatatus* Shen and Bai, 1956	China

H. thompsoni Canu was kept in abeyance by Light and Hartman from the genus *Hemicyclops* because that species was based upon two immature females found on the body of *Callianassa subterrannea* Montagu. However both Stock (1959) and Humes, Cressey and Gooding (1958) have recognised this as a species of *Hemicyclops*. There are, therefore, fifteen species including the one described in this paper known in the genus *Hemicyclops*.

Gooding (*loc. cit.*) has pointed that four of the American species namely, *adhaerens, subadhaerens, arenicolae* and *elongatus* fall into a distinct group, more or less constituting a superspecies. ' This superspecies would be characterised mainly by the separation between genital and first abdominal segments and the well-developed sixth legs in the adult females ; the reduced mandibular setation and presence only of simple terminal elements on the maxilla and of setulose exopod spines on all the swimming legs in both sexes ; and the attenuated ' scaly ' tip of the male maxilliped ' (p. 164). To this superspecies—complex should probably be added *H. tamilensis* for in this species also the genital and the first abdominal segments are completely free. However, we have no information about the various appendages which are of systematic importance. *H. indicus* and *H. dilatatus* are separated from others easily by the subquadrate nature of the genital segment which is followed by three abdominal segments. In *H. leggi* only the male is known and the possibility or otherwise that the present example represents the unknown female of that species is discussed later (*vide infra*).

In the remaining seven species the genital segment is quite elongate with a broader anterior and a narrower posterior regions and there are three post-genital segments. However, in *bacescui, visendus, thompsoni* and *thysonotus* the caudal ramus is distinctly long, always more than twice as long as wide and are easily distinguished from *purpureus, australis* and the present species, all of which have their caudal rami sub-quadrate.

H. intermedius sp. nov. is not referred to *H. purpureus* because of the following differences :

H. intermedius	*H. purpureus*
1. The exopod of first leg has four setae and four spines.	The exopod of first leg has two spines and six setae.
2. Relative lengths of the antennular segments : 13.8 ; 10.6 ; 11.2 ; 22.4 ; 15.2 ; 13.4 ; 13.4=100	Relative lenghts of the antennular segments : 10.0 ; 23.2 ; 9.4 ; 18.8 ; 13.5 ; 14.1 ; 11.0=100
3. The antennal segments are bent twice forming an inverted ' U '-tube	The first segment is bent at right angles to the next three segments which are linear.
4. Caudal ramus as long as wide.	Caudal ramus slightly longer than wide.
5. The basal segment of maxilla with one seta. The distal segment as described.	Basal segment of maxilla with two setae. The distal segment simpler in structure.
6. Terminal segment of maxilliped bears limited number of setae and spines.	Terminal maxilliped segment bears four setae and two spines.
7. Length of female 1.9 mm.	Length of female 1.15 mm.

The present species is related to *H. australis* but the following differences are noticeable between the two species :

H. australis	*H. intermedius*
1. Size : 1.38–1.40 mm.	1.9 mm.
2. Prosome : Urosome=53 : 47	Prosome : Urosome=51 : 49
3. Proximal half of genital segment more than one and a half times wider than the distal half.	Proximal half of genital segment only a little wider than the distal half.
4. The genital segment longer than the three abdominal segments combined.	The genital segment only as long as the three abdominal segments combined
5. Caudal ramus longer than the last abdominal segment.	Caudal ramus not as long as the last abdominal segment.
6. Third antennular segment much shorter than the second.	Third antennular segment as long as the second
7. In the mandible, the body proper bears a single seta on its distal inner margin.	In the mandible the body proper bears two setae on its distal inner margin.
8. In the first leg the terminal exopod segment carries six setae and two spines.	In the first leg the terminal exopod segment carries four setae and four spines.

H. leggi was created by Thompson & Scott (*loc. cit.*) from the Ceylon side of the Gulf of Mannar and was referred to the genus *Hersiliodes* Canu. Sewell (*loc. cit.*) suggested its removal to the genus *Hemicyclops*. The single male specimen which they obtained from sponge washings measured only 1.5 mm. Taking into consideration this size difference of the male of *H. leggi* and the female of *H. intermedius* as well as the same area of the distribution (hardly 50 miles apart) of the two species, one is tempted to suggest that they represent the male and the female of the same species. However a number of difficulties come in the way. Although the male is generally smaller in size than the female in many of the species of the genus, this condition is never the rule, for in *H. visendus* it is clearly larger than the female : the male measures 2.06 mm. while the female is only 1.87 mm. long. However, in this genus the male is known to differ from the female only in the structure of the maxilliped and the urosome. The differences observed in other structural details are considered of specific importance. Such characters are listed below :

(*a*) The proportionate lengths of the antennular segments are distinctly different in the two species.

	1	2	3	4	5	6	7	
H. leggi	13.0	16.0	8.5	23.0	15.0	10.5	14.0	= 100
H. intermedius	14.5	10.6	10.7	22.0	15.5	13.35	13.35	= 100

(*b*) First segment of the antenna in *H. leggi* is bent at right angles to the remainder of the appendage ; in *H. intermedius* the antenna is bent twice on itself forming an inverted U-tube with the first and the last segments forming the two limbs and the middle segments forming the base. Further the setation of the constituent segments is also different in the two species.

(*c*) In the maxilla of *H. intermedius* the basal segment bears only a single seta on its distal inner margin, while two distinct setae are borne in *H. leggi* ; further the segment itself is very short in *H. leggi.*

(*d*) The terminal endopod segment of first leg bears five setae and one spine in the present species whereas for *H. leggi* it is shown to be only four setae and one spine.

(*e*) The length-breadth ratio of the fifth leg in *H. leggi* is 3 : 2 while it is 2 : 1 in *H. intermedius.* Since Thompson & Scott (*loc. cit.*) themselves have pointed that their species ' is easily recognized from any other members of the genus by the proportionate lengths of the joints of the anterior antennae and by the quadrangular fifth leg ', I consider the present form as a new species.

Family LICHOMOLGIDAE SARS

Sars, 1918, p. 149.

Sub-family LICHOMOLGINAE GURNEY

Gurney, 1927, p. 463.

Genus *Pseudoanthessius* Canu

Canu, 1889, p. 344.

Sars, 1918, p. 166.

Pseudoanthessius agilis sp. nov.

Material examined—Numerous males and females of this copepod were captured from the sponge washings from the Gulf of Mannar in July and August 1960. On one occasion it was obtained from general invertebrate and weed washings (which of course included sponges). The holotype, allotype, and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J. 576/9, J. 577/9, and J. 578/9 respectively.

Description : A. FEMALE

Colour is monotously whitish opaque ; but the edges of the different segments possess a beautiful tinge of violet which appears to be due to the deposit of calcium. *The body* (Fig. VII, 1) is very graceful in appearance, quite symmetrical and almost cylindrical. The prosome consists of four segments and the urosome of five segments. The first prosomal segment is, however, partially divided into the cephalosome and the first leg-bearing segment. The cephalothorax is the widest part of the body, being almost three times wider than the last prosomal segment. In length the cephalothorax is twice as long as that of the three following segments combined. The matasomal segments gradually diminish in width posteriorly. All the segments excepting the last prosomal segment are provided with epimeral plates. There is a clear rostral prominence on the anterior margin of the first prosomal segment. In the urosome the first segment bears the fifth pair of legs which are typically reduced. The genital segment forms a major part : it is much longer and wider than the other segments joined together and carries on each side a small spine on

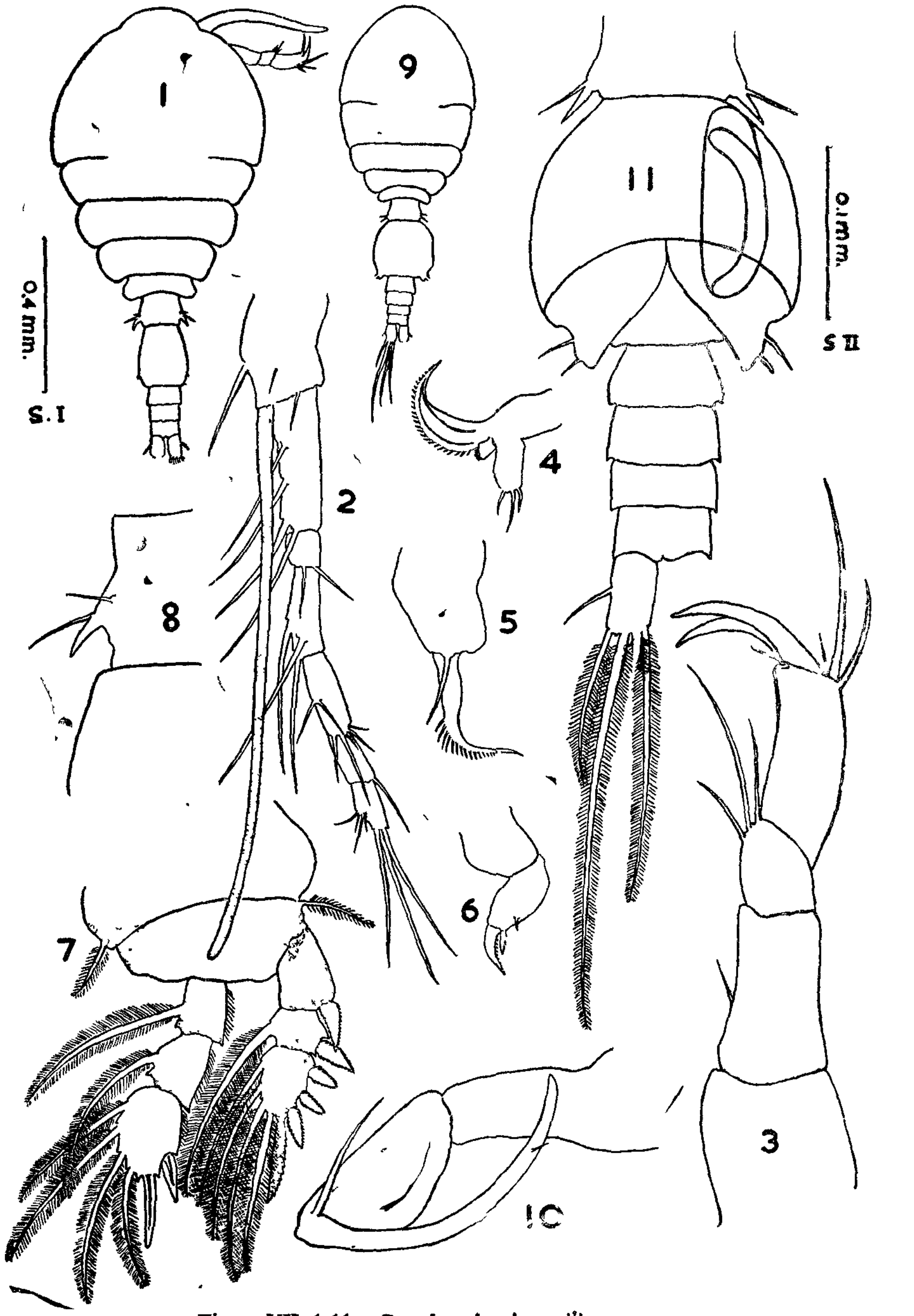

Figure VII, 1-11. *Pseudoanthessius agilis* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, maxillule and mandible.
5. ,, ,, maxilla.
6. ,, ,, maxilliped.
7. Adult, female first swimming leg.
8. ,, ,, fifth leg with parts of urosome.
9. ,, male, dorsal view.
10. ,, ,, maxilliped.
11. ,, ,, urosome.

(First and ninth diagrams are drawn to scale I and others to scale II) its postero-lateral margin. First, second and third abdominal segments are subequal in length but diminish in width posteriorly. Caudal rami are parallel, distinctly exceeding the last abdominal segment in length and a little less than twice as long as wide. Each of them bears four terminal setae and a small spine on the outer margin at its mid-length.

Antennule (Fig. VII, 2) is moderately long, reaching when extended posteriorly to the end of the cephalosome. It is 7-segmented and the segments have the following relative lengths :

1	2	3	4	5	6	7	
19.6	24.8	6.0	15.7	13.9	10.0	10.0	= 100

The second segment is the largest and the third the shortest. Fourth and fifth segments are approximately of equal length ; so also are the last two segments. The first segment is fairly stout and long and bears an aesthetask equal in length to that of the entire antennule. All the segments are provided with number of setae. The antenna is well-developed and consists of four segments. First segment is devoid of any seta. The third segment bears three setae, of unequal length on its inner anterior distal margin. The last segment bears four setae of varying lengths and two stout spines ; the latter are characteristically bent to the anterior side. *The mandible* (Fig. VII, 4) as usual, is a flat blade, produced into an elongate, tapering tip which curves outwards. The entire inner margin is lined by minute spinules. A broad, rather rectangular, chitinized flap is present near the inner base of the blade. It is tipped with fine spinules. The base of the mandible is closely associated with the base of the maxillule and are mounted on the same skeletal frame work. *Maxillule* (Fig. VII, 4) is simple, rather rectangular in shape, bearing three spines of unequal length on the apical margin. In the *maxilla* (Fig. VII, 5) the basal segment is quite pronounced and bears a seta besides the apical lash ; the latter is moderately long, bent at about right angles in the distal part and bearing along its entire length slender spinules which diminish in length distalwards. The *maxilliped* (Fig. VII, 6) consists of two segments, the basal is the wider, but the distal is the longer ; the latter bears two serrated spines at the apex and a small spinule at about two-third length. Maxilliped is rather feeble.

The *swimming feet* (Fig. VII, 7 ; Fig. VIII, 1, 2 and 3) are biramous, the ramus being three-segmented, except in the case of the endopod of the fourth leg which is only one-segmented. The legs are notable in that the corners and edges of the various segments are highly calcified and have a dark violet tinge. The setal formula of the swimming legs are as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	0	0	0	1	II							0	I	1	I	5	I	II

First leg is the smallest. Second and third legs are similar except for the differences in the setation of the terminal segment of the endopod. In the fourth leg the reduced endopod is half as long as the exopod and its margins are entire. The fifth pair of legs, as in other species of the genus, are replaced on each side by a spine inserted directly to the posterolateral margin of the first urosomal segment and accompanied by two small setae ; the spine is smooth, exhibiting at the base a slight dilation and is directed posteriorwards. One of the setae arises just close to the spine and the other a little upwards. The size of the female is 1.18 mm.

B. Male

The male (Fig. VII, 9) is much smaller than the female, displaying the usual sexual differences. The prosome is more oval and compact than in the female and the first and the second prosomal segments only partly fused. *The urosome* (Fig. VII, 11) is 6-segmented. The genital segment is very much widened, almost as wide as long and uniform throughout the length. At the posterolateral corners the segment becomes constricted to a bud-like structure, each of which bears two fine spines. The four abdominal segments diminish both in length and width to the posterior side. The caudal rami and setae are similar to those of the female. *The maxilliped* (Fig. VII, 10) is very large and prehensile, many times longer than the corresponding structure of the female. It consists, however, of the same two segments which are subequal in length. The terminal spine of the second segment is extremely large, characteristically bent inward and bears a small spine on its distal posterior margin. There is also a seta close to the base of the terminal spine. The mouth parts as well as other remaining appendages are identical to those of the female.

Remarks—A number of species that were originally attributed to this genus have been recorded from Indian waters but several of these have subsequently been transferred to other genera.

Nicholls (*loc. cit.*) provided an excellent key to the genus and enlisted the following species as known to the time of his writing :

1. *P. liber*, (Brady & Robertson), 1875.
2. *P. assimilis* Sars, 1917.
3. *P. sauvagei* Canu, 1891.
4. *P. obscurus* A. Scott, 1909.
5. *P. mucronatus*, Gurney, 1927.
6. *P. tenuis* Nicholls, 1944.
7. *P. gracilis* Claus, 1889.
8. *P. weberi* A. Scott, 1909.
9. *P. nemertophilus* Gallien, 1935.
10. *P. thorelli* (Brady & Robertson), 1875.
11. *P. dubius* Sars, 1918.
12. *P. concinnus* Thompson & Scott, 1903.

Illg (1950) revised the key incorporating three more species, *P. spinifer* Lindberg, 1946, *P. graciloides* Sewell, 1949 and *P. latus* Illg, 1950 that have since then been added. The present species brings the total number of known numbers of this genus to sixteen. The species of this genus are divisible into two groups ; those in which the outer margin of the fourth endopod is entire or is simply convex ; and those in which the outer margin of the fourth endopod is broken by a swelling or indentation which may become a conspicuous knob or notch. *P. spinifer*, *P. liber*, *P. assimilis* and the present species fall under the first group. *P. spinifer*, however, is easily separated by the fact that the lateral margins of the genital segment of this species are produced into conspicuous expansions. The distinctions between *P. liber* and *P. assimilis* on the one hand and *P. agilis* sp. nov. on the other are many, and the most important of them consists of : (*a*) the general shape of the body ; (*b*) the nature of the fusion of the first and second prosomal segments ; (*c*) the proportionate lengths of the segments of the antennule ; (*d*) the proportionate lengths of the segments and the size of the terminal spines of the antenna ; and (*e*) the number of setae borne on the inner margin of the third segment of the third leg. The differences between *P. liber* and *P. assimilis* have already been pointed out by Nicholls and consists chiefly the length-width relationship of the caudal rami and in the general form of the body.

Genus *Macrochiron* BRADY

Brady, 1872, p. 433.

Sars, 1913-18, p. 163.

Subgenus *Macrochiron* SEWELL

Sewell, 1949, p. 99.

Macrochiron (*Macrochiron*) *rigida* sp. nov.

Material examined—Eight females and three males were obtained from the general weed and invertebrate washings mainly sponges from the Gulf of Mannar. The holotype, allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and bear the registered numbers J. 616/10, J. 617/10 and J. 618/10 respectively.

Description : A. FEMALE

The body (Fig. IX, 6) is moderately slender and cylindrical with the prosome not much dilated, being regularly oblong-oval in outline and rather strongly vaulted dorsally. The prosome is 4-segmented and the urosome 5-segmented. The first prosomal segment constitutes the major part of the body being only a little less than equal in length to the entire remainder of the body ; it is also the widest of all segments. Second, third and fourth segments diminish in width posteriorwards. Of these, second is the longest and third the shortest. The first urosomal segment is moderately large and bears the fifth pair of legs. The genital segment is the largest urosomal segment, being distinctly wider and longer than the combined length of the three abdominal segments. The caudal ramus is as long as the last abdominal segment and is slightly longer than broad. Each ramus bears six setae, two of them being slender, looking more like spines.

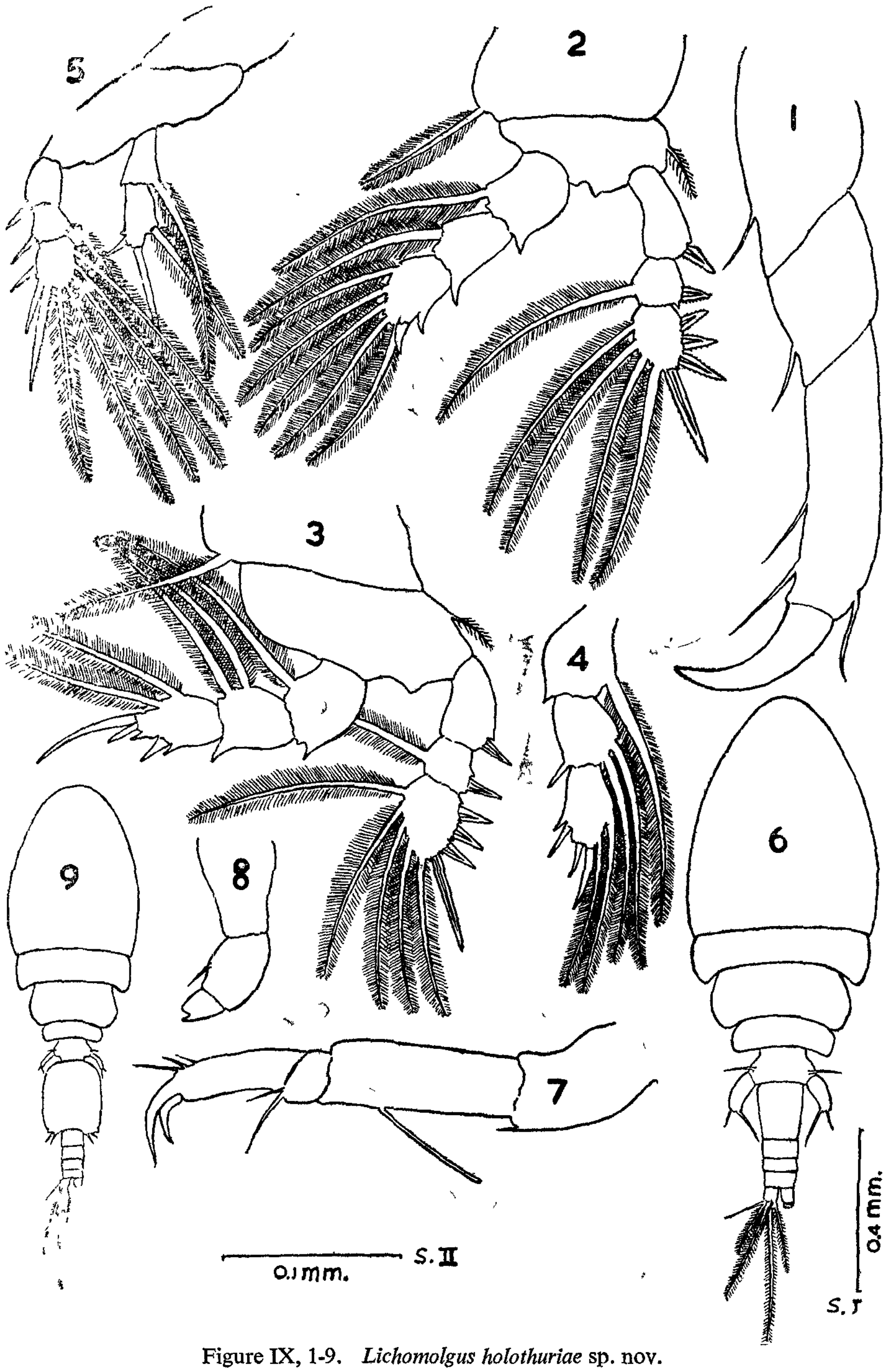

Figure IX, 1-9. *Lichomolgus holothuriae* sp. nov.

1. Adult, female antenna.
2. ,, ,, first swimming leg.
3. ,, ,, second swimming leg.
4. Adult, female, endopod of third swimming leg.
5. ,, ,, fourth swimming leg.

Macrochiron (*Macrochiron*) *rigida* sp. nov.

6. Adult female, dorsal view.
7. ,, ,, antenna.
8. Adult, female, maxilliped.
9. ,, male, dorsal view.

(Sixth and ninth diagrams drawn according to scale I and others according to scale II).

Antennule (Fig. X, 1) is 7-segmented, and rather not very long. Second segment is the largest and last the shortest. All the segments are provided with a number of setae ; first segment also carries a small finger-shaped structure on its anterior distal corner ; two fairly long aesthetasks are borne, one each by the fifth and seventh segments. The proportionate lengths of the antennular segments are given below :

1	2	3	4	5	6	7	
14.6	22.7	9.6	18.3	14.6	11.7	8.5	= 100

Antenna (Fig. IX, 7) is comparatively short and consists, as usual, of four segments. Second segment is the largest and third the shortest while the first and the last are subequal in between these two extreme situations. Although the second segment of the antenna in this genus usually bears a spine, in the present case it is found to be a sensory filament rather than a spine. Other cephalosomal appendages are quite normal.

The four pairs of *swimming legs* (X, 3, 4, 5 & 6) are biramous, each ramus being 3-segmented, except the fourth endopod which is 2-segmented. First to third legs are more or less of equal size while the fourth is distinctly smaller ; in the latter, although the endopod is only 2-segmented, it is only a little less than the length of the exopod. The setal formula of the four pairs of the swimming legs are given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	3	1+I	III
P_2	1	0	0	0	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P_3	1	0	0	0	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	0	0	0	I	1	0			II			0	I	1	I	5	I	III

Fifth leg is cylindrical and fairly large, reaching more than half the lengths of the genital segment. The basal segment, as usual, is fused, with the first urosomal segment and each bears a solitary seta at its distal outer corner. The distal segment is slightly curved inwards and bears two terminal setae of unequal length. The size of the female is 1.25 mm.

B. Male

The male (Fig. IX, 9) is much smaller than the female but retain the general form of the female. The prosome is greatly identical in both shape and proportionate lengths of different segments. The urosome is 6-segmented, consisting of the fifth leg-bearing segment, the genital segment and four abdominal segments. Of these, the first segment is comparable to that of the female and bears the fifth legs which are much reduced in size. The genital segment is greatly enlarged both in length and width. It is almost equivalent to the combined length of the other

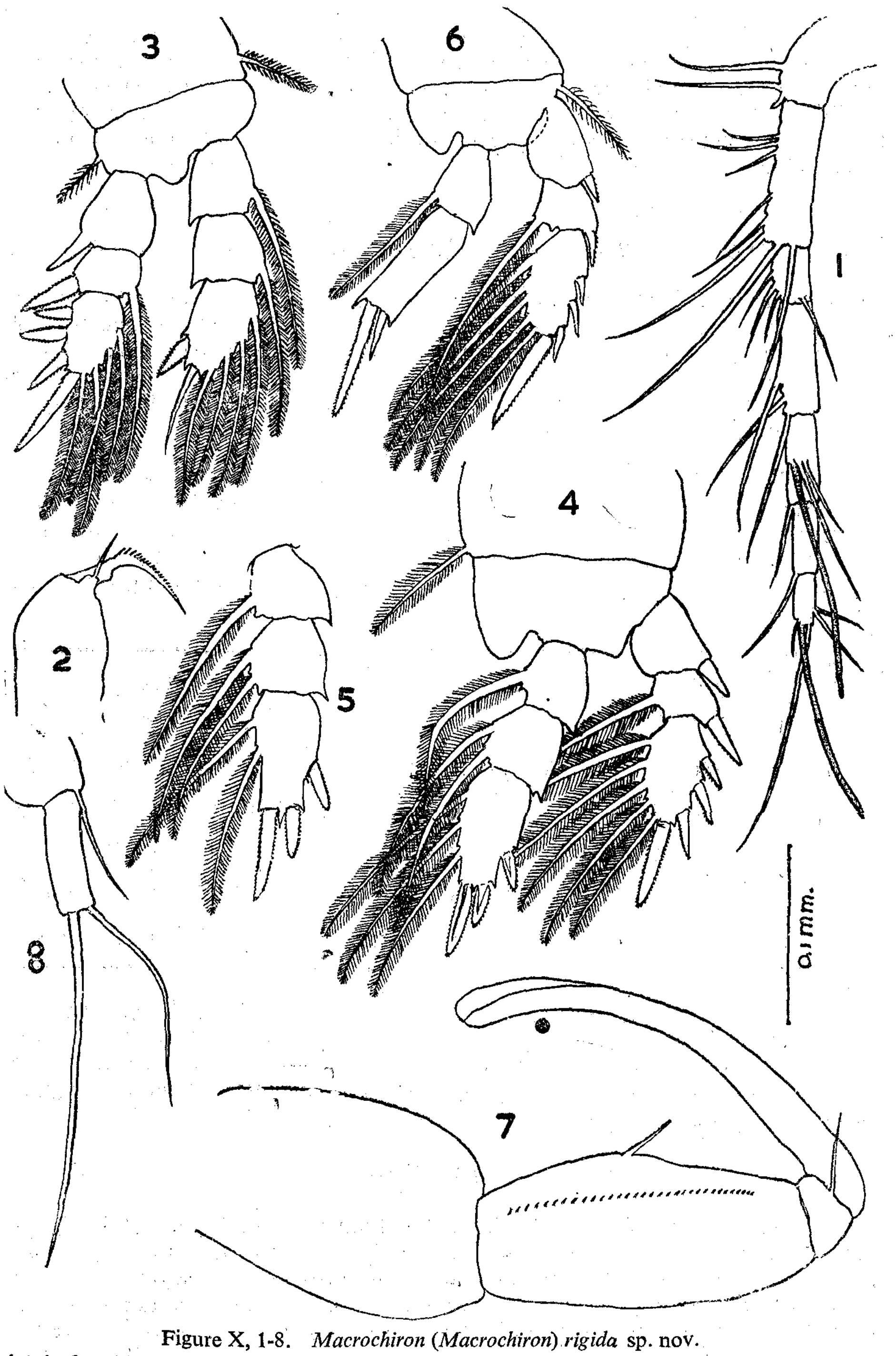

Figure X, 1-8. *Macrochiron* (*Macrochiron*) *rigida* sp. nov.

1. Adult, female, antenna.
2. ,, ,, maxilla.
3. ,, ,, first swimming leg.
4. Adult, female, second swimming leg.
5. ,, ,, endopod of third swimming leg.
6. ,, ,, fourth swimming leg.

Lichomolgus brevifurcata sp. nov.

7. Adult, male, maxilliped.
8. Adult, female, fifth leg.

urosomal segments ; at its posterior margin it bears, on either side, a pair of spines which are directed postero-laterally. The abdominal segments diminish both in length and width to the posterior side. The length of the male is 1.0 mm. The *maxilliped* is quite large, similar to that of the related species and exhibiting sexual dimorphism. The fifth legs are much smaller in size and are also slender although in essential features they are similar to those of the female. The two segments of the fifth leg bear the same number of setae as in the female.

Remarks : Sewell (*loc. cit.*) has split the genus *Macrochiron* Brady into two subgenera, *Macrochiron* (*Macrochiron*) to receive all those species in which the endopod of the fourth leg is composed of two segments, as in the case of the type species, *M. fucicolum* Brady and *Macrochiron* (*Paramacrochiron*) to include those species in which the fourth endopod is only 1-segmented. He attributed the following species to the subgenus *Macrochiron* (*Macrochiron*) Sewell.

1. *M.* (*Macrochiron*) *fucicolum* Brady.
2. *M.* ,, *hirsutipes* (T. Scott).
3. *M.* ,, *alabatensis* (Kossman) (=*Lichomolgus alabatensis*)
4. *M.* ,, *simplex* (Thom. & Scott) (=*L. simplex*)
5. *M.* ,, *buddhensis* (Thom. & Scott) (=*Lichomolgus buddhensis*)
6. *M.* ,, *robustus* (,,) (= *L. robustus*)
7. *M.* ,, *gracilipes* (A. Scott) (= *L. gracilipes*)
8. *M.* ,, *congoensis* (T. Scott) (= *L. congoensis*)
9. *M.* ,, *longipes* Sewell
10. *M.* ,, *spinipes* Sewell

The present species does not correspond to any of the known forms and therefore is treated here as a new species. *M.* (*Macrochiron*) *rigida* may be defined as follows : (1) Length of the female 1.25 mm. ; length of the male 1.0 mm. (2) the cephalosome and first pedigerous segment are fused and the combined cephalothorax is only a little less long than the entire rest of the body. (3) The posterior half of the cephalothorax is the widest part of the body. (4) The genital segment in the female is vase-like, the proximal wider part gradually but slightly diminishing in width to the posterior side ; it is distinctly longer and wider than the three abdominal segments together. In the male the genital segment is rather rectangular with parallel sides ; it is almost as long as the entire remainder of the urosome ; there is a pair of postero-laterally directed spines on either of its posterior margins. (5) Caudal ramus as long as the last abdominal segment and is longer than wide. (6) The proportionate lengths of the antennular segments and the setal formula of the swimming legs are as given in the text. (7) The fifth pair of legs stout, incurved, rather cylindrical and wider in the proximal half ; the male fifth legs are highly reduced.

Recently Stock (1957) expressed the opinion that the name *Macrochiron* should be used at generic level for the conception of a limited number of species all agreeing in the possession of a complexly built 3-segmented posterior antenna. According to him, all other species that have been referred to this genus but in which there is a normally built 4-segmented posterior antenna should be removed to the genus *Lichomolgus* or other related genera. Those transferred to *Lichomolgus* differ, however, from the typical members of the genus in a number of characters : (1) The mandibles have the lappet conspicuously dilated at the base. Its armature consists not only of spinules lining the margin but also of crest-like ridges, denticulations, etc.

(2) The maxillipeds of the female are well-developed, three-segmented, with at least two setae on the second segment and a cheliform structure on the third segment. (3) The third exopod segment of the fourth leg has usually three outer spines, though some species have two outer spines.

To accommodate this rather natural group of uncertain systematic status within the genus *Lichomolgus*, Stock (1959) proposed to erect a new subgenus, but left it unnamed, ' since no name is available at the moment for the subgenus and since some species tend to be intermediate. . .'.

If Stock's suggestions are accepted and *Macrochiron* is redefined as proposed by him, then the present species should be transferred to *Lichomolgus* and placed under the subgenus proposed by him.

Genus *Lichomolgus* THORELL

Canu, 1892, p. 227

Sars, 1918, p. 150

Sewell, 1949, p. 96

Lichomolgus holothuriae sp. nov.

Material examined—Numerous females and a few males were obtained from the holothurian washings of the Gulf of Mannar. They live inside the body cavity of the holothurians and are obtained by keeping the host in seawater to which menthol is added. The copepods are brought out by vigorously shaking the host after the interval of an hour or so. In colour they are dull whitish approaching to a pale yellow. The holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and have the registered numbers J. 628/11, J. 629/11 and J. 630/11 respectively.

Description : A. FEMALE

The body (Fig. VIII, 4) is highly depressed, flattened and more or less oval in outline. The prosome consists of four segments. The first prosomal segment is eminently large, only a little less than the combined length of the rest of the body. Its posterior corners end in angular edges. There is no trace of division between cephalosome and first leg-bearing segment. Second and third segments are moderately large but much smaller than the first prosomal segment. They are provided with epimeral plates and have angular posterior edges. The last prosomal segment is quite small, less than one-third of the width of the prosomal segment and about one-ninth of the latter's length. It is partly hidden by the preceding segment. The four prosomal segments bear the four pairs of swimming legs. The urosome is 5-segmented, consisting of the fifth leg-bearing segment, the genital segment and three abdominal segments. The first two segments are very large, subequal each distinctly longer than the combined lengths of the three abdominal segments. In width the genital segment exceeds all other segments of the urosome. It bears a pair of spines on either of its postero-lateral margins; one of the spines is much larger than the other and is borne on a protrusion. The caudal rami are very short,

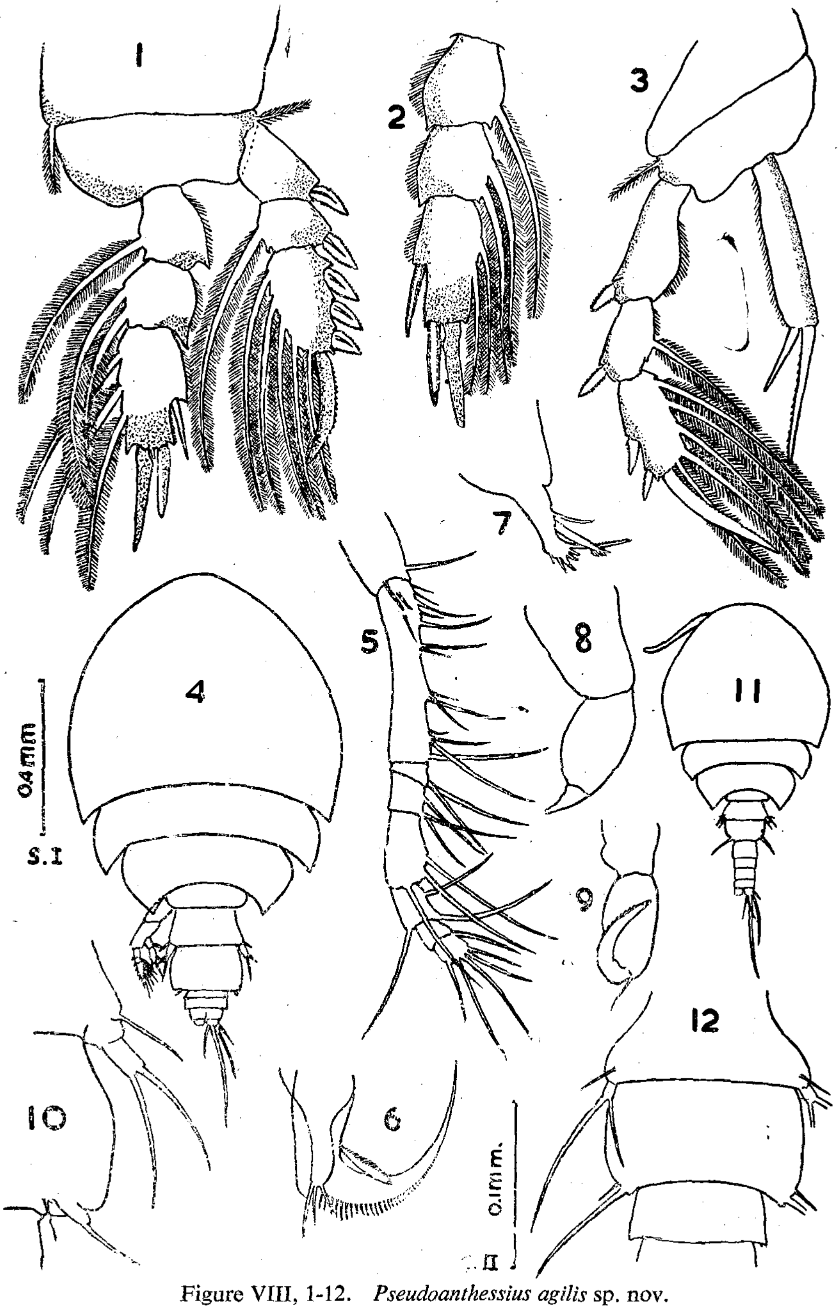

Figure VIII, 1-12. *Pseudoanthessius agilis* sp. nov.

1. Adult, female, second swimming leg.
2. ,, ,, endopod of third swimming leg.
3. Adult, female, fourth swimming leg

Lichomolgus holothuriae sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, mandible and maxillule.
7. ,, ,, maxilla.
8. ,, ,, maxilliped.
9. Adult, male, maxilliped.
10. ,, female, fifth leg with parts of urosome
11. ,, male, dorsal view.
12. ,, ,, fifth leg with parts of urosome.

(Fourth and eleventh diagrams are drawn according to scale I and others according to scale II stumpy, much wider than long, the length-width ratio being 5 : 3. Each of the rami bears five setae, one of which is clearly long, almost equivalent to the urosome.

Antennule (Fig. VIII, 5) is 8-segmented, typically of the lichomolgid type with the second segment being the largest and third the shortest. First and fifth segments are fairly large but each of them is less than half the length of the second segment. While the fourth and fifth segments are longer than wide, the reverse is true of the last two segments. All the segments are provided with a number of setae, some of them appearing more like spines. The antennule does not bear any aesthetask. The relative lengths of the various segments are as follows :

1	2	3	4	5	6	7	8	
13.0	40.2	2.6	7.4	17.0	8.9	5.3	5.6	= 100.

Antenna (Fig. IX, 1) is very large in size compared to the antennule. While the latter hardly reaches the middle of the first prosomal segment and is fragile, the antenna is stoutly built and extends to more than three-fourth the length of that segment. However, it is only three-segmented. The first two segments are subequal, while the third is quite large and almost as large as the former two combined. The two segments bear a seta each. The third segment bears three setae and a stout terminal spine which is half the length of the segment itself. The spine is incurved like a beak. The *mandible* (Fig. VIII, 6) is distinct from the maxillule and juxtaposed to it. It consists of a blade with its anterior (outer) margin lined by fine long spinules which decrease in length distalwards. At the base of the posterior (inner) margin of this blade, there is an oblique ridge with fine cilia on one of its margins. The blade is produced into a flagellum. The *maxillule* (Fig. VIII, 6) is rather small, elongated and bearing terminally three spines. The *maxilla* (Fig. VIII, 7) is rigid. It has two separate spines besides the terminal lash which is denticulated ; while the proximal spine is simple, the distal one is stout and has its tip provided with small denticles ; the distal part of the apical lash is much slender than in all other known species and is rather straight, being ciliated on the inner margin. The basal part of the lash is distinct and is provided with stout but small spinules instead of the usual setae. *Maxilliped* (Fig. VIII, 8) is simple and small. It consists of two segments of approximately equal length and width. The distal segment bears a seta and a terminal claw which is conical and rather small.

The first three pairs of *swimming legs* (Fig. IX, 2, 3, 4 & 5) are biramous, each ramus being trimerous. The legs are approximately of equal size but differs in setation. In all the legs, while the exopod is orientated in the same axis as the protopod, the endopod is borne at an angle ; in the case of third legs exactly at right angles to the protopod. The fourth leg is biramous. The exopod is 3-segmented ; the endopod is only 2-segmented. The fourth leg is much smaller than the other legs. The setal formula of the swimming legs are as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	2	II	I	0	I	1	I	4	1+I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	4	1+I	III
P_4	0	0	0	0	1	0		1		II		0	I	1	I	4	1+I	II

Fifth leg (Fig. VIII, 10) is 2-segmented, the basal segment being fused with the first urosomal segment and bearing a single seta ; the second segment is well defined and fairly large ; it bears two terminal setae of unequal size. The size of the female is 1.2 mm.

B. MALE

The male (Fig. VIII, 11) is much smaller than the female measuring only 0.75 mm. The prosome is very similar to that of female except in size. The urosome is composed of six segments. The first two segments are subequal in length and width. The second segment bears on each of its postero-lateral corners a fairly long spine which is said to be the remains of the sixth pair of legs. The four abdominal segments are much narrower and form a cylinder ; of these, the third to fifth segments are more or less of equal dimensions while the second abdominal segment is distinctly longer and wider. All the appendages are similar to those of the female except the *maxilliped* (Fig. VIII, 9) which is very peculiar. In the males of the lichomolgids the maxilliped is generally well developed being many times larger than that of the female. It is supposed to have a geniculate function. In the present species the male maxilliped exhibits some differences in the structure from that of the female but is hardly larger. In both cases it is 2-segmented. In the female the two segments are sub-equal and the terminal spine of the second segment is very small. In the male, however, the second segment is larger and the terminal spine of that segment is quite large. Further the outer margin of the spine is partly serrated.

Lichomolgus serratipes sp. nov.

Material examined. Eighteen female specimens were obtained from washings of the seapen *Pteroides esperi* Herklots ; the specimens were given to me by Dr. S. Jones. Some of these were carrying egg-sacs which were asymmetrical and which appeared to have started hatching. The left egg sac is always longer and contains a larger number of eggs than the right one. The holotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J. 658/12 and J. 659/12 respectively.

Description : A. FEMALE

The animal (Fig. XIII, 5) is very robust and rather elongate-oval. The prosome is very conspicuous, constituting as it does, more than four-fifth of the length of the body. It consists of four segments : The first segment is quite large, equal in length to the entire remainder of the body. This segment is considerably expanded and much broader than the succeeding ones ; its posterior margin is concave so that the postero-lateral corners constitute acute angles. The second segment is distinctly less wide that the first one and is crescent-like with arms directed backwards. The third segment is less broad than the preceding one but exceeds the latter in length, the medial line being the longest part. The postero-lateral margins of this segment are finely serrated. The fourth segment is very small, a little wider than the genital segment and completely hidden by the preceding segment in formalin preserved specimens. The postero-lateral margin of this segment also is finely serrated and the specific name of the species has reference to this character. The urosome is 5-segmented (Fig. XIV, 4) but is very small compared to the size of the prosome. The pre-genital segment is rather small and bears the fifth pair of legs. In length it is only one-third of the genital segment, but it exceeds the latter in breadth. The genital segment is stumpy, much broader than long and without

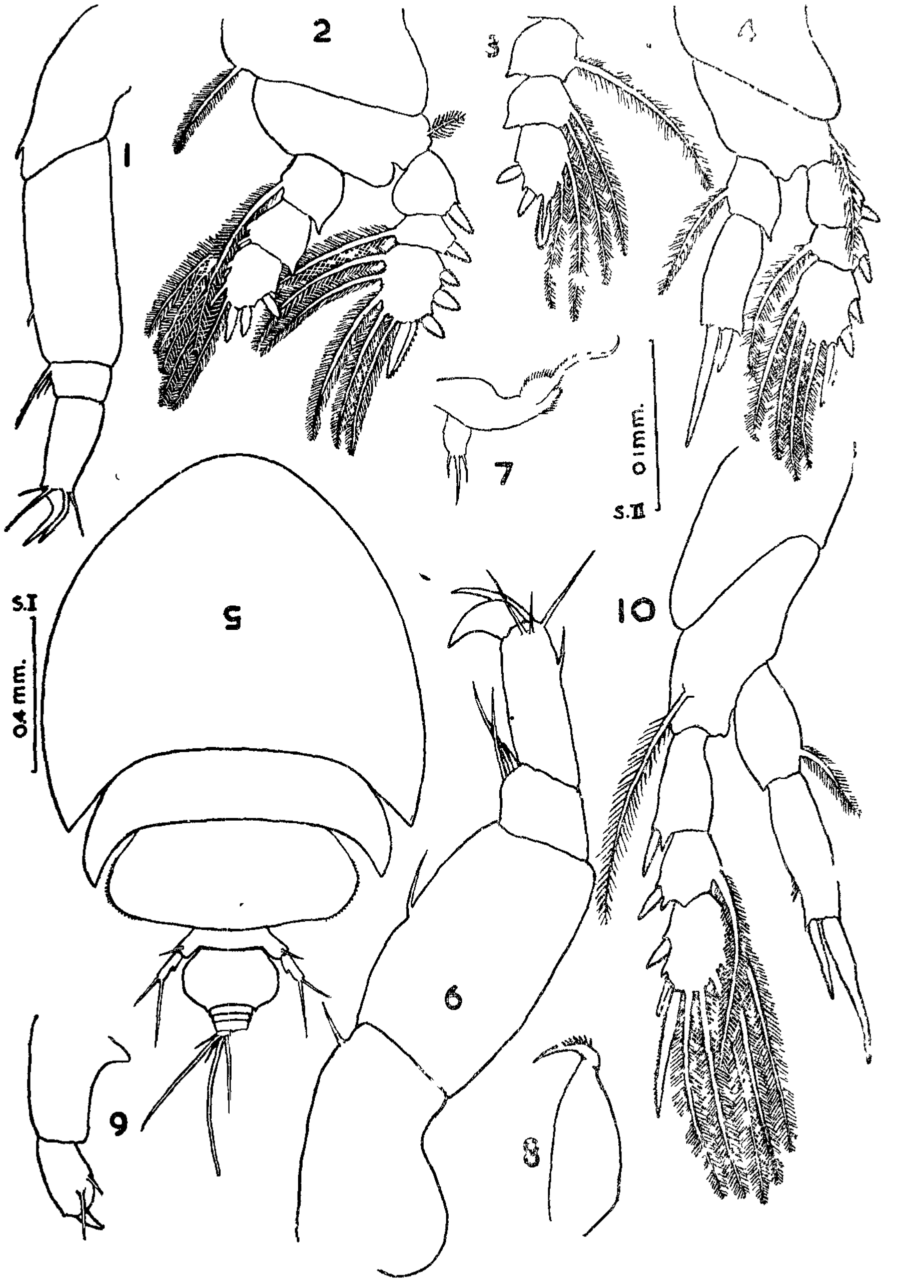

Figure XIII, 1-10. *Lichomolgus indicus* sp. nov.

1. Adult, female, antenna.
2. ,, ,, second swimming leg.
3. ,, ,, endopod of third swimming leg.
4. ,, ,, fourth swimming leg.

Lichomolgus serratipes sp. nov.

5. Adult, female, dorsal view.
6. ,, ,, antenna.
7. ,, ,, maxillule and mandible.
8. Adult, female, maxilla.
9. Adult, female, maxilliped.
10. ,, ,, fourth swimming leg.

(Diagram 1 and 5 are drawn according to scale I and others according to scale II).

any accessory spine or seta. The three abdominal segments are very inconspicuous and crowded together behind the genital segment. They are subequal in length but decrease gradually in breadth to the posterior side. The last segment bears the caudal rami which are distinctly wider than long. Each of the rami bears five setae, the second one from the inner side being the longest.

The antennule (Fig. XIV, 3) consists of eight segments which bear the following proportionate lengths :

1	2	3	4	5	6	7	8	
13.2	30.0	5.0	10.5	14.0	10.0	7.0	10.3	= 100

The first segment is rather short, bearing three stout setae. The second segment is very large, equivalent in length to that of all other segments combined. This segment bears a number of setae spread all along its length. Third segment is the shortest and characteristically wider in its anterior half. The fourth segment is longer than the third. Both these segments bear three setae each. The next four segments diminish both in length and width to the apex, quite a number of setae being borne on these segments. *Antenna* (Fig. XIII. 6) is very stoutly built and is equivalent in length to the antennnule in the natural position. They are held at right angles to the main axis of the body. Each antenna consists of four segments. First segment has a deep curve in its distal posterior margin and bears a solitary seta on the opposite margin. The second is the largest segment of the antenna and is barrel like, bearing one seta on its anterior margin at its mid-length. The third segment is the shortest of all and has three setae on its antero-lateral corner. The distal segment bears two claws and four setae ; three of the setae are apical and of unequal length, the fourth one is rather small and subapical on the posterior margin. *Mandible* (Fig. XIII, 7) consists of basal broader blade and a distal tapering lappet. The latter is lined on its both margins with fine spinules. The basal broader part carries a ridge with fine spinules on it on the postero-distal margin. The antero-distal margin bears a similar row of spinules. *Maxillule* (Fig. XIII, 7) is similar to that of the preceding species. *Maxilla* (Fig. XIII, 8) is rather simple. It is a rectangular appendage with an apical lash which, compared to that of the known species of the genus, is quite short ; the lash is provided with stiff hairs on one margin. *Maxilliped* (Fig. XIII, 9) is very small and consists of two segments. The first segment is larger than the second and has its proximal part expanded inwards. The second segment bears a small spine and two setae both of which are borne at some distance from the apex.

The four pairs of swimming legs (Fig. XIII, 10 & Fig. XIV, 1, 2 & 5) are borne by the four prosomal segments. The first three pairs are biramous, the ramus consisting of three segments. The last pair of legs are biramous, too, but the inner ramus consists only of two segments. The first pair of legs are slightly smaller than the following legs. The ornamentation of the swimming legs are as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	0	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	0	0	0	0	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	0	0	0	0	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	0	0	0	1	1	0			II			0	I	1	I	4	I	III

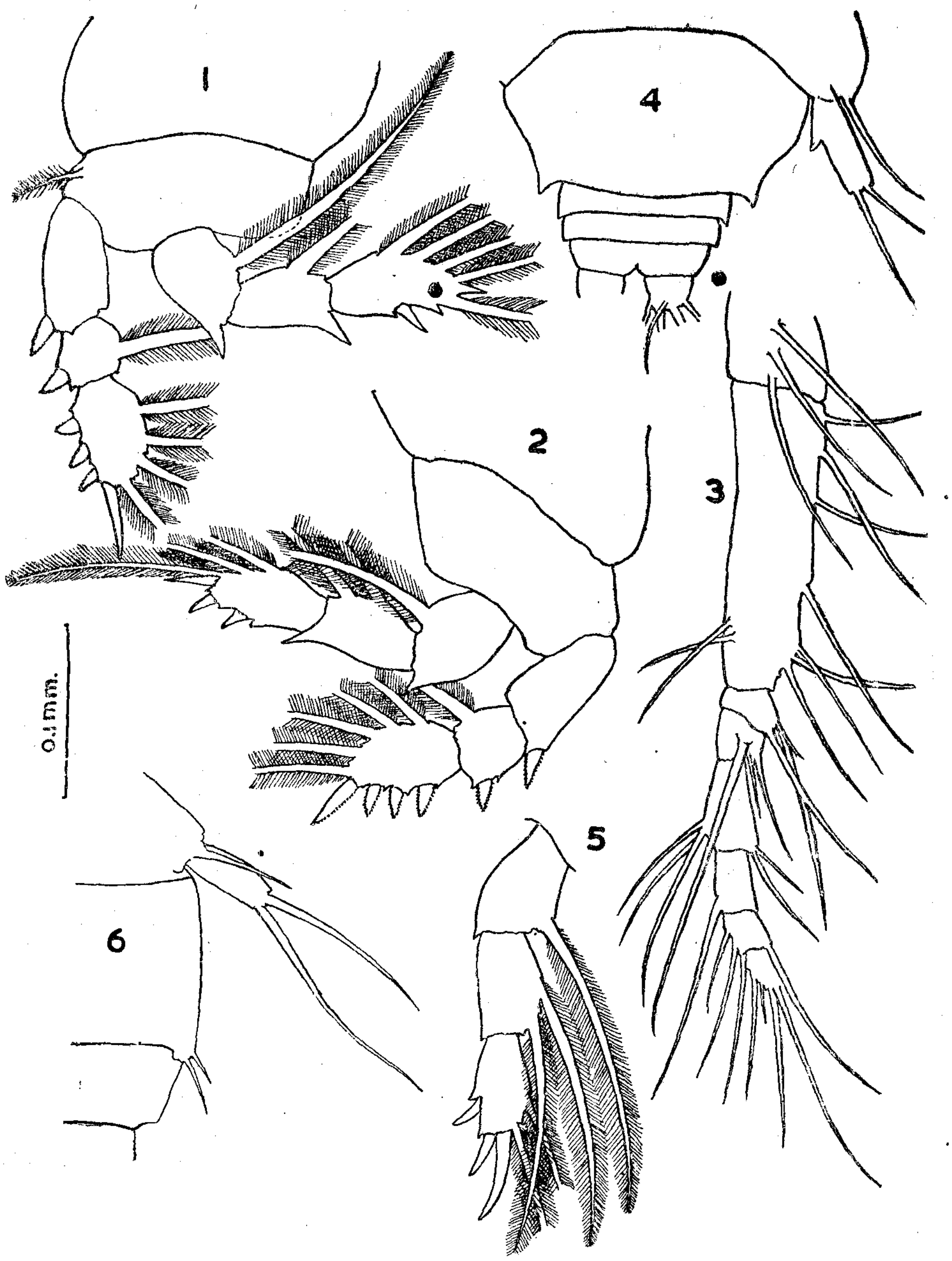

Figure XIV, 1-6. *Lichomolgus serratipes* ps. nov.

1. Adult, female, first swimming leg.
2. ,, ,, second swimming leg.
3. ,, ,, antennule.
4. Adult, female, fifth leg with parts of urosome.
5. ,, ,, endopod of third swimming leg.

Lichomolgus indicus sp. nov.

6. Adult, female, fifth leg with parts of urosome.

The fifth leg (Fig. XIV, 4) is 2-segmented, but the basal segment is completely confluent with the first urosomal segment. It bears a solitary seta on the distal outer angle. The distal segment is rather rectangular having two setae of unequal length on the terminal margin ; the inner margin of the distal segment is broken at about the midlength by an indentation which projects prominently towards the posterior side. The fifth legs, in their natural position, just reach the posterior margin of the genital segment. The female is 1.5 mm. long.

B. MALE

See Addendum.

Lichomolgus brevifurcatus sp. nov.

Material examined : Two female and several male specimens of this species were obtained in the Gulf of Mannar from the starfish washings. The specimens were all in good condition and were pale yellow in colour. The holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and have the registered numbers J. 662/13, J. 663/13 and J. 664/13 respectively.

A. FEMALE

Description :

The Body : (Fig. XI, 11) is graceful, rather elongate, with the prosome and urosome merging into each other. The prosome is composed of only four segments, the cephalosome and the first metasomal segments having been fused completely to form a cephalothorax. The latter is the largest of the body segments and constitutes two-fifth of the whole body ; it is also quite wide, more than twice as wide as the last prosomal segment. A semi-spherical rostral prominence is present on the anterior margin. The posterior corners of this segment is smoothly curved. Of the remaining three segments the second is the longest and the third the shortest. These segments diminish in width gradually to the posterior side. All segments are provided with lateral expansions. The urosome consists of five segments, the fifth leg-bearing segment, the genital segment and three abdominal segments. The first two are of equal width while the last three decrease in breadth posteriorwards ; in length, however, the three abdominal segments show the reverse situation, namely, the last segment is the longest and the first the shortest. The genital segment is barrel-like and does not become narrowed in the posterior half. The caudal ramus is very short, distinctly wider than long. It is only half as long as the last abdominal segment. Each furca bears six setae, four of them much smaller than the other two.

The antennule (Fig. XI, 2) is 7-segmented, segments bearing the following proportionate lengths :—

1	2	3	4	5	6	7	
15.4	33.1	8.1	18.2	10.3	7.2	7.7	= 100

The second segment is the longest and is half as long as the length of all other segments combined ; the last segment is the shortest and bears a single aesthetask on its apex. All the segments are provided with a number of setae. The *antenna*

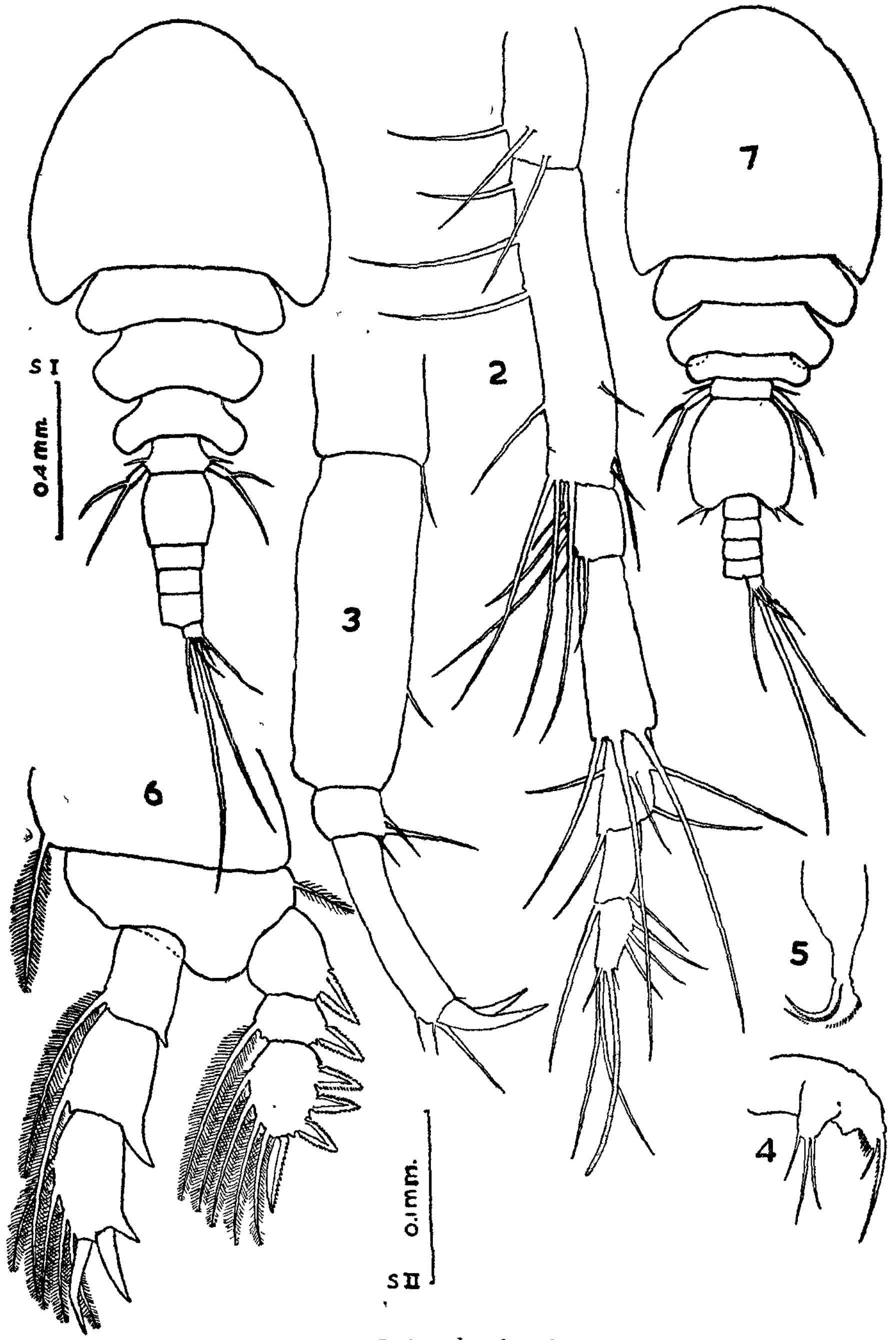

Figure XI, 1-7. *Lichomolgus brevifurcatus* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, male, antenna.
4. ,, ,, mandible and maxillule.
5. ,, ,, maxilla.
6. ,, ,, first swimming leg.
7. ,, ,, dorsal view.

(Diagrams 1 and 7 drawn according to scale I and 2-6 to scale II).

XI, 3) is stoutly built, only a little smaller than the antennule and 4-segmented. first segment bears a solitary seta at its antero-distal corner. The second ent bears a seta on its anterior margin at about two-third the length. The third ment is provided with three setae of unequal length all on the distal an- rior margin. There are two short spines and three setae on the last segment, besides a few hairs. Two of the setae are apical and one subapical. The *mandible* (Fig. XI, 4) is moderately developed with broader basal and narrower distal parts. The former carries a ridge at its distal outer margin and a number of large spinules on its distal inner margin. The apical lash is long and carries spines on the margins. The *maxillule* (Fig. XI, 4) is normal similar to those described for earlier species The *maxilla* (Fig. XI, 5) with none of the spinules of the apical lash parti- cularly strong; the body proper narrower towards the distal part. *Maxilliped* is quite normal, short and stout, two-articulate, the last segment bearing a spine which is broad at the base.

There are four pairs of *swimming legs* (Fig. XI, 6 & Fig. XII, 1, 2 & 3); all are biramous; the rami of the first three pairs of legs as well as the exopod of the fourth leg are 3-segmented, while the endopod of the fourth leg is only 2-segmented. The ornamentation of the swimming legs is as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	III	I	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	III	I	0	I	1	I	5	I	III
P_4	0	0	0	1	1	0	—	—	—	1 I	—	0	I	1	I	5	I	II

All the legs are more or less of equal length. In the first three pairs of legs the endopods are distinctly longer than the exopods while in the fourth leg the situation is reverse. The protopod in all cases is very much stumpy and large. *Fifth leg* consists of two segments. The basal segment, however, merges with the first urosomal segment, and bears a solitary seta at its outer upper angle. The distal segment is rather rectangular with the long axis more than twice as long as its short axis; it bears two setae terminally and they are of unequal length. The length of the female is 1.6 mm.

B. Male

The male (Fig. XI, 7) is much smaller than the female but is more robust in ap- pearance. In the prosome the reduction in breadth from the first to the second segment is gradual while it is rather abrupt in the female. This is because of a proportionate increase in the width of second and third prosomal segments. The urosome is composed of six segments, the fifth leg-bearing segment, the genital seg- ment and four abdominal segments. The first segment is the shortest; in breadth it is only half as wide as the last prosomal segment. The genital segment is quite large and is equivalent in length to that of all other urosomal segments combined; it is very much expanded laterally and bears two spines of unequal length on its pc ' lateral corners. The abdominal segments are more or less of equal dime and form a column. The furcal rami are similar to those of the female. The measures 1.5 mm.

All the appendages are identical with those of the female except th maxilliped which is well developed, subcheliform with a long curved hook ; it probably has a geniculate function. The second segment bears a seta on its inner margin at about its mid-length, and the third segment bears a single seta on its apical margin ; a number of stiff hairs, linearly arranged on its long axis, are present on the second segment.

Lichomolgus indicus sp. nov.

Material examined.—Four female and two male specimens were obtained along with the preceding species from the Gulf of Mannar in July 1960. A single female specimen was later obtained from the sponge washings of the same area. The type specimens, the holotype, allotype and paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and have the registered numbers J. 667/14, J. 668/14 and J. 669/14 respectively.

A. Female

Description :

This (Fig. XII, 4) is much smaller species than the preceding one. In the prosome, the cephalosome is separate from the first metasomal segment but the line of demarcation is rather faint. The cephalosome bears a distinct rostral prominence. Both these segments are more or less of equal breadth. The following three prosomal segments diminish in width posteriorwards. In length they are subequal. The urosome consists only of four segments, the pregenital, the genital and two abdominal segments. The first segment is quite normal and bears the fifth pair of legs. The genital segment is partly divided at about its three-fourth length and the portion posterior to the line of division is narrower than that before it. Two spines of unequal length are present at the postero-lateral corners of the proximal division. Of the abdominal segments, the second is larger than the first, but they are both of equal width. Caudal ramus is very short, less than half the length of the last abdominal segment ; it is distinctly broader than long ; each ramus bears five setae, two of which are fairly long while other three are very small.

Antennule (Fig. XII, 5) is 7-segmented, the relative lengths of the different segments being as follows :

1	2	3	4	5	6	7	
14.2	32.5	6.1	15.0	13.4	9.4	9.4	100

While in the preceding species the terminal segment is the shortest antennular segment, in the present case it is third segment which is the shortest. The relative length of the second segment is similar in both cases. The setation of the different segments also bears certain kinship, especially in the presence of two very long setae on the distal margin of the fourth segment. However, no aesthetask is present on the terminal antennular segment. *Antenna* (Fig. XIII, 1) is quite normal, 4-segmented and having great resemblance to that of the preceding species. *Mandible* and *maxillule* (Fig. XIII, 6) are normally built and are as shown in the figure. *Maxilla* (Fig. XII, 7) is stouter than that of the earlier species, apical lash with spinules of uniform size ; the spine at the base strongly built. *Maxilliped* (Fig. XII, 8) is very small and 2-segmented ; the first segment bears a few spinules on its mid-inner margin ; the second segment bears a solitary seta at about its mid-length and a conical, broad-based spine at the apex.

The four pairs of *swimming legs* (Fig. XII, 9 and XIII, 2, 3 & 4) are borne by the last four prosomal segments respectively. Both rami are of about equal length in all legs except the fourth where the endopod is shorter because of its two segmented nature. The ornamentation of the swimming legs is as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	0	1	I	I	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0			II			0	I	1	I	4	I	II

A number of differences can be noticed in the setal arrangement of the swimming legs of this species and this difference extends to the terminal endopod segments of all the four pairs of legs and in the terminal exopod segment of the fourth leg. In general the tendency in the present species is to a reduction in the number of spines. The fifth legs (Fig. XIV, 6) are 2-segmented, but, here again, the basal segment merges into the leg-bearing segment ; the terminal segment is a little more than twice as long as broad and bears two terminal setae, directed posterolaterally. The size of the female is 1.05 mm.

B. MALE

The male (Fig. XII, 10) exhibits the sexual dimorphism and is smaller than the female. The prosome is very similar in both cases. The urosome in male comprises five segments, the fifth leg-bearing segment, the genital and three abdominal segments. The first segment and the abdominal segments are very much identical with those of the female. The genital segment, however, is quite developed, has no trace of any sub-division and is more or less of uniform breadth throughout. Each postero-lateral corners of this segment bears a pair of spines. Caudal ramus is identical to that of the female. The male measures 1.00 mm.

Among the appendages only the maxilliped shows structural modifications from that of the female. While in the latter it is very dwarf and 2-segmented, here it is fairly large and with a long apical hook. The appendage bears great resemblance to that of the preceding species.

Remarks.—The genus *Lichomolgus* is an extremely vast group of animals, ' a lumber-room for those species that do not belong to any of the other genera ' of the

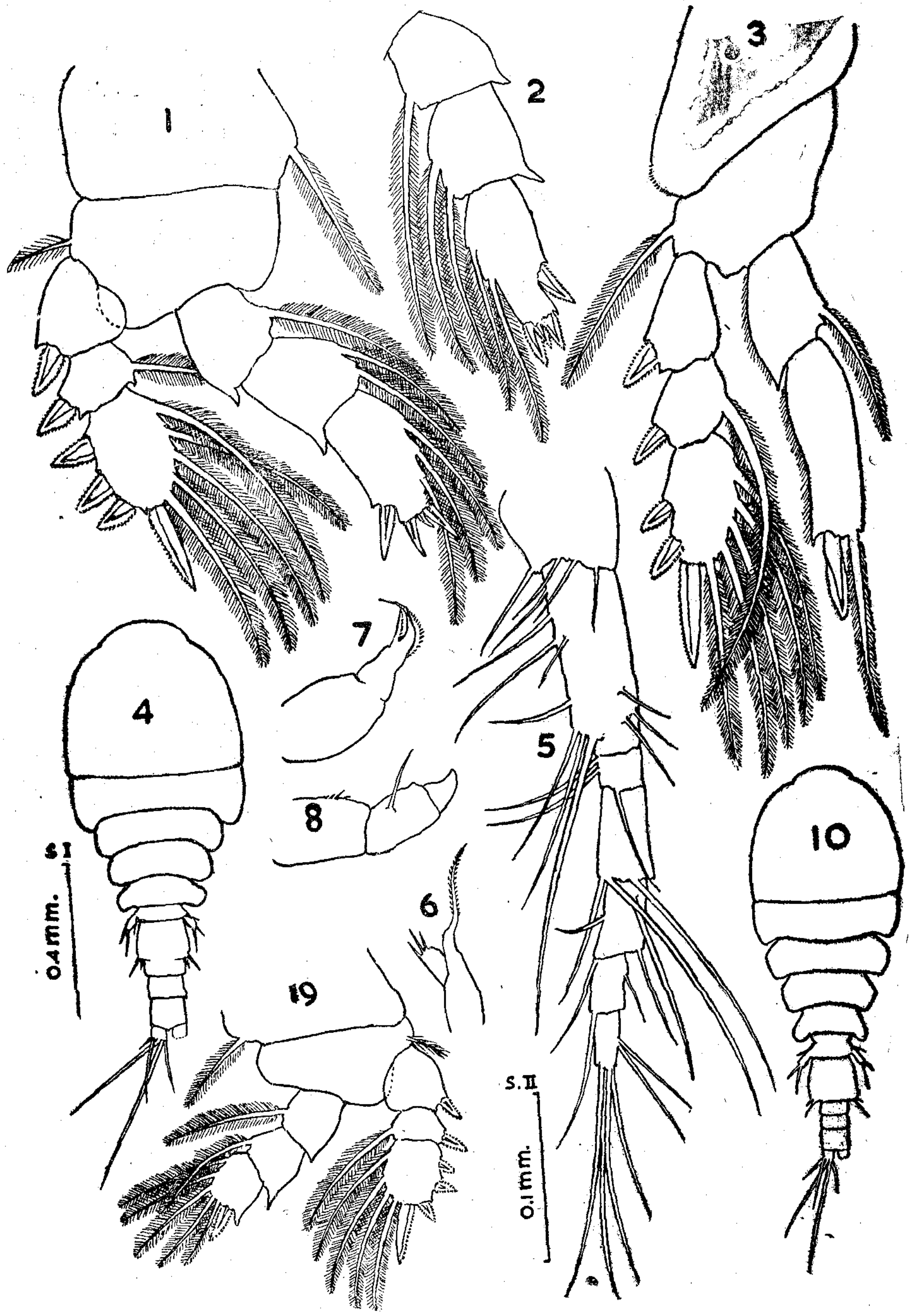

Figure XII, 1-10. *Lichomolgus brevifurcata* sp. nov.

1. Adult, male, second swimming leg.
2. ,, ,, endopod of third swimming leg.
3. ,, ,, fourth swimming leg.

Lichomolgus indicus sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, mandible and maxillule.
7. ,, ,, maxilla.
8. Adult, female, maxilliped.
9. ,, ,, first swimming leg.
10. ,, male, dorsal view.

(Diagrams 4 and 10 are drawn to scale I and others according scale II).

subfamily Lichomolginae. The difficulty of obtaining large number of representatives, the meagreness of the descriptions of the several species and the innumerable number of species that have been assigned to this genus from various parts of the world at different times make a comparative study of the known species of this genus extremely delicate. To this must be added the fact that several species have been transferred and retransferred from genus to genus because of the disagreement that exists among the scientists as to the validity or otherwise of some of the genera of the subfamily Lichomolginae. No attempt is, therefore, made here, to determine the validity or synonymy of any of the species. The four species described in this paper do not correspond exactly to any of the known forms and, therefore, are treated as new.

Lichoomolgus serratipes is very near to *L. pteroidis* Della Valle but differs from it in several details :

L. pteroidis	*L. serratipes*
1. Size—not given. (ch. Stock, 1959)	Size 1.5 mm., female .76 mm. male.
2. The length-width ratio of the first prosomal segment is 40 : 60.	Length-width ratio of the first prosomal segment is 45 : 55.
3. The marginal serration of the second prosomal segment is visible from the dorsal side.	The marginal serration of the second prosomal segment not visible from the dorsal side.
4. Antennule 7-Segmented.	Antennule 8-Segmented.
5. The terminal segment of the first endopod of male carries a large spinular growth which is half the length of the segment itself.	The spinular growth on the terminal segment of the first endopod is hardly one-fourth of the segment.
6. The post-genital segments of urosome are clearly visible from the dorsal side. The middle region of the lateral margins of the male genital segment is smooth.	The post-genital segments of the urosome in male are completely covered by the large posterior flap of the genital segment. The middle region of the lateral margins of the genital segment of the male is toothed.
7. In the female the spiniform projection and the lateral expansion of the fifth leg well beyond the $\frac{3}{4}$ length.	The spiniform projection and the lateral expansion of the fifth leg in front of half the length.

Recently, Stock has described another species, *P. pterophilus* from the Indonesian waters. Unfortunately I have not seen the description of the species.

Both *L. pteroidis* and *L. serratipes* (and probably *L. pterophilus*) are closely allied to the four species of lichomolgids, *L. venustus*, *L. patulus*, *L. audens* and *L. asaphidis*. Humes that have recently been added from Madagascar (Humes, 1958). In all these forms the antennule is 8-segmented, the body, particularly the first prosomal segment, is very much broadened (except in *asaphidis*), the genital segment in both sexes is very large and there is complete fusion between the cephalosome and the first pedigerous segment. There is great similarity also in the oral appendages and the swimming legs.

L. holothuriae appears to be a true representative of the subgenus *Stellicola*. This species, together with *L. curticaudata* (Thompson & Scott) *L. asterinae* Bocquet *L. frequences*, *L. astropectinis*, *L. luidiae* and *L. lautus* Humes & Cressey constitute a closely related group of species. All are characterised by (a) an 8-segmented antennule ; (b) a 3-segmented antenna and (c) the setal formula for the fourth endopod of 0I, II 1.

L. holothuriae is quite close to *L. curticaudatus* and may even be conspecific with it. However, it is treated as a separate species because of the following reasons : (1) There is complete fusion of the cephalosomal segment and the first pedigerous segment in *L. holothuriae* while they are distinctly separate in *L. curticaudatus.* (2) The urosome is less than one-third the length of the prosome in *L. curticaudatus* ; in the present species it is clearly more than one-third the length of the prosome. (3) In *holothuriae* the genital segment is longer than the next three segments joined together ; in *curticaudatus* it is distinctly shorter. (4) The maxilla is different in the two species.

The nearest relative of *L. brevifurcatus* is perhaps *L. robustus* Thomp. & Scott, but the differences between the two forms are many and are noted below : (1) in *L. robustus* the cepholosome and the first metasomal segment are separate while in *L. brevifurcatus* they are completely fused. (2) In *L. robustus* the genital segment is $1\frac{1}{2}$ times wider than long ; in *L. brevifurcatus* the breadth and length of the genital segment are the same. (3) A distinct rostral prominence is visible from the dorsal side in the present species, whereas it is not visible in *L. robustus.* (4) Caudal ramus in *L. robustus* is only a little shorter than the last abdominal segment ; it is only less than half the length of the last abdominal segment in *L. brevifurcatus.* (5) The longest furcal seta in the present form is longer than the urosome while it is less than half the length of the urosome in *L. robustus.* (6) The last exopod segment of the fourth leg in *L. robustus* bears three spines on the outer margin and one spine terminally while in the present case there are only two spines on the outer margin besides the apical spine.

L. indicus is quite distinct enough from all other species in the very general appearance and comparatively smaller size. The two-segmented nature of the abdomen brings down its immediate probable relatives to quite a few. The species is easily identified by the combination of the following characters. (1) Cephalosome and the first metasomal segment separate. (2) The fifth leg-bearing segment is very short, being the shortest of the urosomal segment. (3) The genital segment exhibits a partial division at about three-fourth the length in its distal part ; the posterior division is narrower ; at the posterolateral corner of the latter there is a pair of spines. (4) The genital segment is equivalent in length to that of the two abdominal segments joined together. (6) In the antennule the second segment is the longest and the third the shortest. (7) The setal formula of the swimming legs is peculiar and is given above in the text.

Summary

Eleven new species of cyclopoid copepods, four belonging to the section Siphonostoma and the rest to the section Poecilostoma are described in detail. Six of the species are represented by both the female and the male sexes while others are known only from the females. The material of the present investigations was collected both from the Gulf of Mannar and the Palk Bay off Mandapam on the south-east coast of India during the months of May, June, July and August, 1960. The collections were made in the inshore waters and the methods of collection are discussed.

The composition of the cephalosomal appendages of the siphonostomatous cyclopoids is briefly considered. The present study shows that there are four pairs of oral appendages, the mandible, the maxillule, the maxilla and the maxilliped besides the preoral antennule and antenna on the cephalosome.

The following genera are represented in the present collection :

1. *Asteropontius* Thompson & Scott.
2. *Cryptopontius* Giesbrecht.
3. *Hemicyclops* Boeck.
4. *Pseudoanthessius* Canu.
5. *Macrochiron* (*Macrochiron*) Brady, Sewell.
6. *Lichomolgus* Thorell.

A key to the identification of the various known species is provided for the genus, *Asteropontius*. In other cases the species described in this paper are diagnosed and a comparison between the forms treated here and the previously known forms is rendered.

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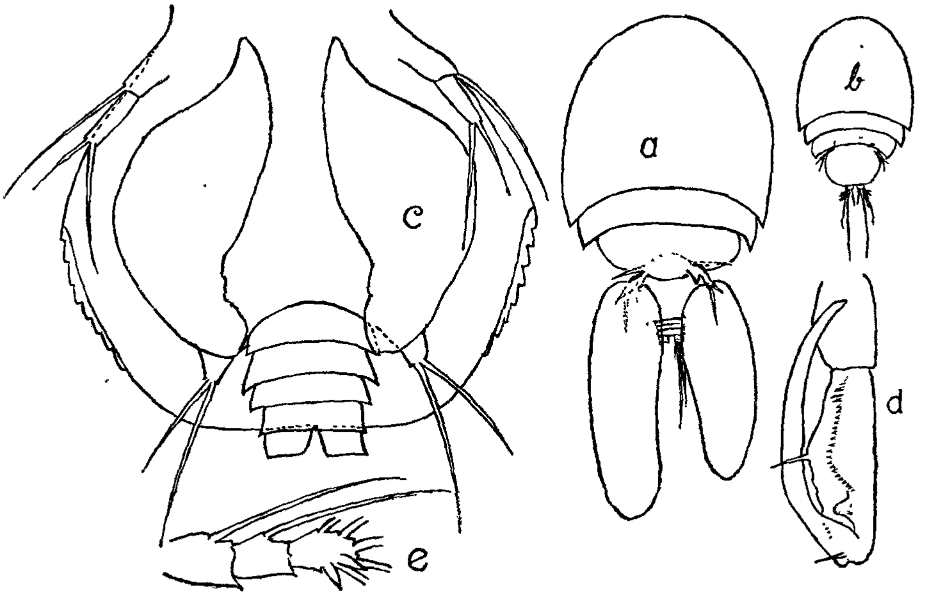
ADDENDUM

Lichomolgus serratipes sp. nov.

MALE

Size—0.76 mm. The male (Fig. 1, b) is only a little more than half the length of the female. The general body shape corresponds to that of the female. The sexual dimorphism is expressed in the structure of the maxilliped and the urosome.

The maxilliped (Fig. 1, d) is very large, the terminal segment carrying an incurved claw which is equivalent to the two segments combined. The second segment carries also two setae, one at about the mid-length and the other near the base of the claw. There is a row of spinules along two-third the length of this segment. An elevated ridge is present on the distal area, in continuation with this row of spinules.



Lichomolgus serratipes, sp. nov.

Fig. 1, a— Adult female, dorsal view
,, b— ,, male, dorsal view.
,, c— ,, female, urosome, ventral view.
,, d— ,, ,, maxilliped.
,, e— ,, ,, first endopod.

The urosome is 6-segmented, consisting of the fifth-leg bearing segment, the genital segment and four abdominal segments. All segments are very short and crowded together except the genital segment which is exceedingly large and grows both posteriorwards and sidewards, covering most of the abdominal segments. The caudal rami are, however, visible from the dorsal side.

The fifth leg is rectangular, without any lateral expansion or spinular growth. The basal segment, as in the female, is confluent with the first urosomal segment and carries one seta. The distal segment carries two apical setae. All other structures, including the terminal segment of the first endopod (Fig. 1, e) are similar to those of the female.