

MISCELLANEOUS PUBLICATION
OCCASIONAL PAPER NO. 46

Records of the Zoological Survey of India

**Additions to the copepods parasitic
on the marine fishes of India
I. On Twelve species of Caligids**

**C. Prabha
and
N. Krishna Pillai**

**Issued by the Director
Zoological Survey of India, Calcutta**

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ZOOLOGICAL SURVEY OF INDIA**

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**ADDITIONS TO THE COPEPODS PARASITIC ON
THE MARINE FISHES OF INDIA
1. ON TWELVE SPECIES OF CALIGIDS**

By

C. PRABHA AND N. KRISHNA PILLAI



सत्यमेव जयते

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1983

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ADDITIONS TO THE COPEPODS PARASITIC ON THE MARINE FISHES OF INDIA

1. ON TWELVE SPECIES OF CALIGIDS

By

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INTRODUCTION

The caligid copepods parasitic on the fishes inhabiting the inshore waters of Kerala have been fairly extensively studied. A review of the available information on the group is under publication (Pillai in press). The first author who is currently making a detailed study of the caligids of the Kerala waters succeeded in collecting a large number of species which are new, new records or hitherto only insufficiently known due to dearth of material. It is proposed to describe these species in a series of papers of which the present is the first contribution. The second deals with a new genus, *Kabataella*.

TAXONOMIC ACCOUNT

Family CALIGIDAE

Sub-family CALIGINAE

Genus *Caligus* Muller

Caligus bennetti Causey

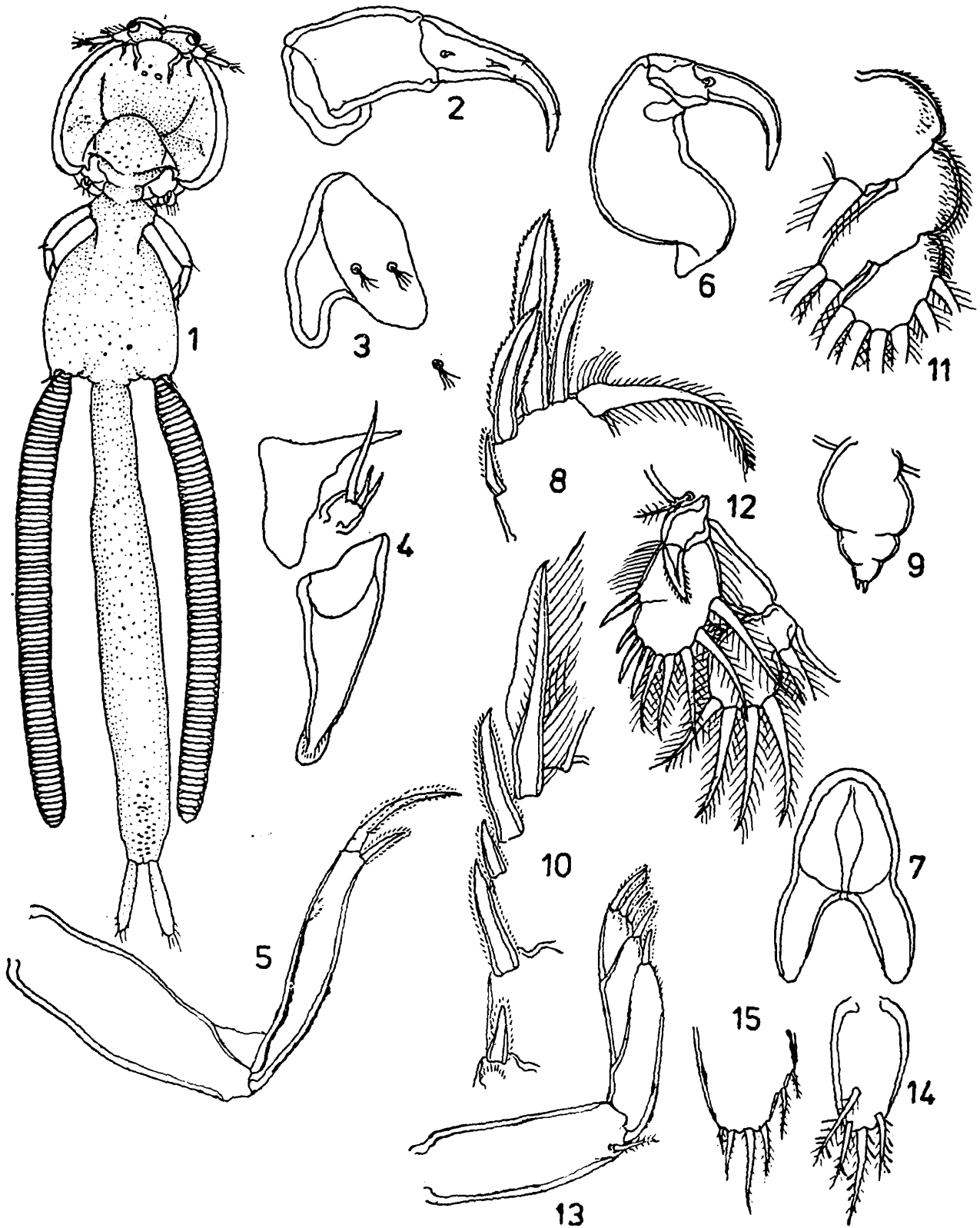
(Figs. 1-24)

1953. *Caligus bennetti* Causey, *Occ. Pap. Mar. Lab. Louis. State Univ.*, 7 : 3, Figs. 13, 17-22.
1963. *Sciaenophilus bennetti*, Yamaguti, *Parasitic copepoda and Branchiura of fishes*, p. 66, pl. 85, Fig. 3.
1977. *Caligus bennetti*, Ho and Bashirulla. *J. Nat. Hist.*, 11 : 703, Figs. 1-2.

Material.—Several females and males from the buccal cavity of *Labotes surinamensis* (Bloch) examined at Trivandrum.

Female.—Cephalothorax nearly equal in length and width, broadening backwards. Frontal plates projecting, with moderately prominent lunules. Postero-lateral lobes of cephalothorax about half as broad as the median

lobe, curving inwards but not making the posterior sinuses narrow. Median lobe produced far beyond the lateral lobes and distally constricted. Fourth thoracic segment much broader than median lobe of cepha-



Figs. 1-15. *Caligus benneti* Causey. Female. 1. female, dorsal view ; 2. Antenna ; 3. Post-antennal process ; 4. Post-oral process and maxillule ; 5. Maxilla ; 6. Maxilliped ; 7. Sternal fork ; 8. Leg 1, tip of exopod ; 9. Same, vestigial endopod ; 10. Leg 2, exopod ; 11. Same, endopod ; 12. Leg 3 ; 13. Leg 4 ; 14. Leg 5 ; 15. Tip of caudal ramus.

lothorax, fused with the genital segment. Genital segment enlarged, subequal to cephalothorax in length and width, steadily widening backwards, its hind border subtruncate. Abdomen apparently one-jointed, clearly longer than the rest of the body, anterior and posterior parts constricted. Caudal rami large, laminate with six comparatively small setae. Egg sacs long, only slightly shorter than the abdomen.

Antennule fairly stout, its distal segment clearly longer than basal, both armed with prominent setae. Basal segment of antenna without the usual process, distal segment only moderately curved. Post-antennal process an irregular plate demarcated into a broad thin plate and a short blunt curved claw. Post-oral process elongate-triangular, apex flattened. Maxillule a projecting nodule carrying one long and two short setae. Basal segment of maxilla as long as distal but much stouter, outer flange on distal segment small and indistinct, distal claws greatly unequal. Maxilliped comparatively stout and strongly built, distal segment long and distally curved at right angles. Sternal fork with stout base, limbs of the fork apically blunt and slightly diverging, shorter than base.

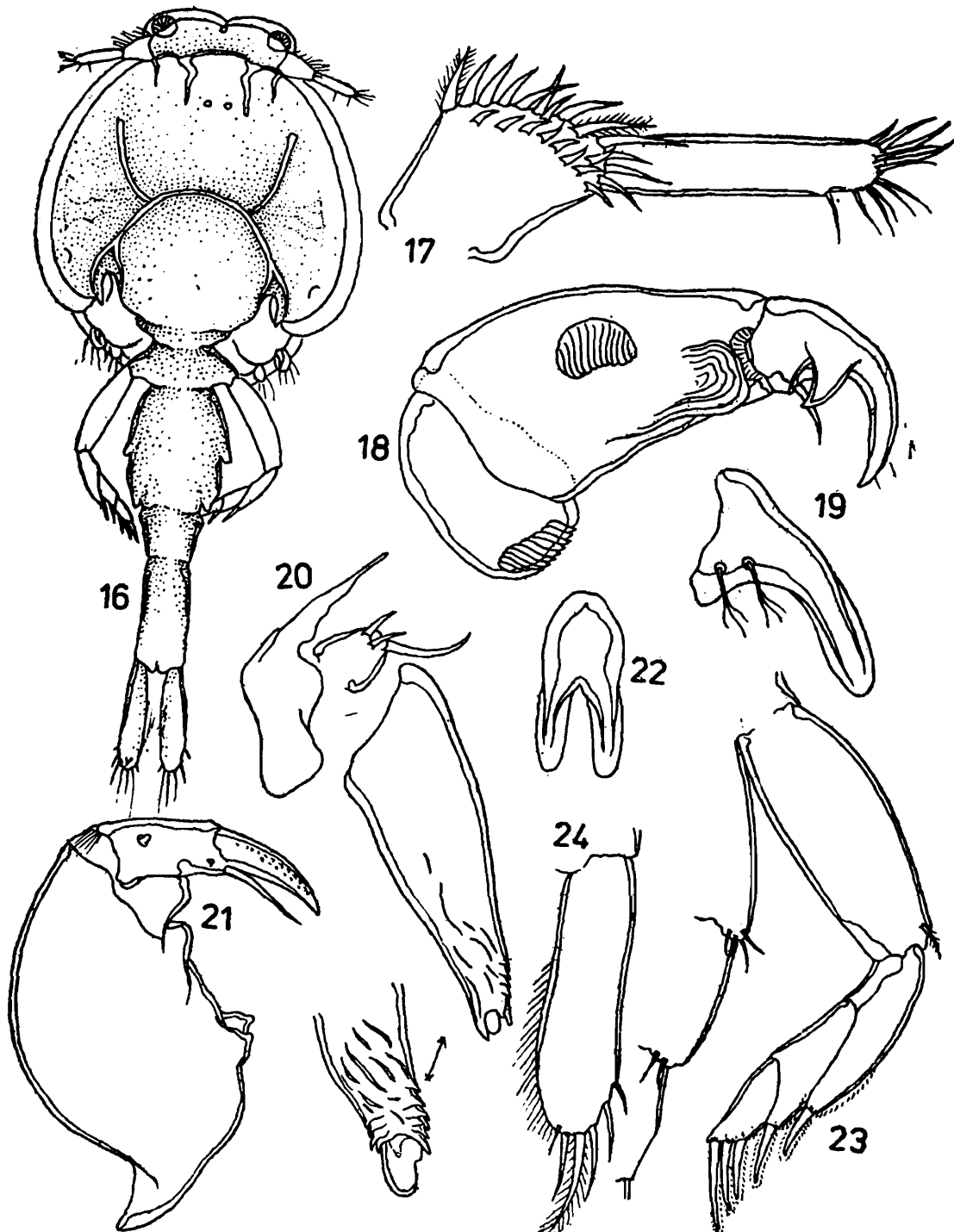
Basipod of first leg with scattered fine denticles, vestigial endopod pyriform and indistinctly three-jointed, with two short apical spines. Distal exopod segment with strong armature, first claw very small and dorsal in position, second and third large, with broad serrate flange on both sides, spine-like seta bilaterally pectinate, ventral setae well developed. First segment of exopod of second leg with a small process, second with a larger process, third with a small and a large process, all processes bilaterally dentate, first seta with upper thin flange and lower hairs. Endopod segments externally hairy. Apron of third leg with scattered fine denticles and proximal outer adhesion pad. Basal claw of exopod with fine teeth, rami indistinctly two-jointed, outer spines on exopod rather stout. Fourth leg four-jointed, with five claws carrying broad wings, each claw with a long row of spinules near its base. Fifth leg a small process carrying four setae.

Length.—8.8 mm

Male.—Cephalothorax similar to that of female, frontal plates more projecting. Postero-median lobe less produced. Fourth thoracic segment shorter but broader, partially fused with genital segment, latter barrel-shaped, with median and distal indentations housing the vestigial fifth and sixth legs. Abdomen short, clearly two-jointed, first segment half the length of second and narrowing backwards, second broadening backwards. Caudal rami comparatively large, as long as distal abdominal segment, with inner hairs and long apical setae.

Distal segment of antennule longer than in the female. Basal seg-

ment of antenna with one and second with two adhesion pads, third segment slender and strongly curved, with proximal inner seta and a stout accessory process carrying a small seta. Post-antennal process different



Figs. 16-24. *Caligus benneti* Causey Male. 16. Male, dorsal view ; 17. Antennule ; 18. Antenna ; 19. Post-antennal process ; 20. Post-oral process and Maxillule ; 21. Maxilliped ; 22. Sternal fork ; 23. Leg 4-6 ; 24. Caudal ramus.

from that of female, an elongate-triangular, curved, apically flanged claw. Post-oral process distally irregularly produced into teeth, appearing as if the tip is broken off, its ventral surface with irregular ridges. Basal

segment of maxilliped with a pair of proximal processes and a distal inner process, distal segment only moderately curved, with an unusually long seta. Thoracic appendages generally as in female. Sternal fork with parallel limbs. Distal half of fourth leg broader than in female.

Length.—3.26 mm.

Remarks.—The original description of this species by Causey was very brief. Because of its abdomen, longer than the rest of the body, Yamaguti transferred it to *Sciaenophilus*. But Ho and Bashirulla gave a detailed description and returned it to *Caligus*. We are describing the male for the first time. It has a few unusual characters.

C. bennetti is unique in having an abdomen which is longer than the rest of the body. This is one of the important characters which distinguishes *Sciaenophilus* from *Caligus*. *Sciaenophilus* lacks the post-antennal process and the sternal fork. However, there are species of *Caligus* lacking the post-antennal process and sternal fork. This leaves the long abdomen as the only character which serves to distinguish these two genera. *C. bennetti* eliminates this distinction also.

Ho and Bashirulla gave a detailed description of the female and we have only to add some minor details. The tip of the post-oral process is flattened and the limbs of the sternal fork are apically more rounded. The vestigial endopod of the first leg is different in shape and has two apical spines. The second claw of the exopod of the second leg is subequal to the fourth in size and is considerably longer than the first and third which are subsimilar. The basal claw of the exopod of the third leg has a serrate flange.

The male differs from the female in the nature of the antenna, post-antennal process, post-oral process and the maxilliped. The post-oral process appears as if its tip got broken off. This is something unusual. The male is hardly distinguishable from typical *Caligus* males.

Ho and Bashirulla observed that the second endopod segment of the third leg of *C. bennetti* has only five setae instead of the usual six. We find only four in the female and five in the male. They also suggested that *C. macrurus* Heller (1868) might be the same as *C. bennetti*. The present collection from the Indian ocean shows that this suggestion is valid.

***Caligus reniformis* sp. nov.**

(Figs. 25-38)

Material.—A single female from the branchial cavity of *Lethrinus reticulatus* Valenciennes examined at Trivandrum.

Holotype.—Female, Regd. No. C2897/2 Zoological Survey of India, Calcutta, loc. : Trivandrum, Kerala, host. *Lethrinus reticulatus* Val., branchial cavity, Coll. C. Prabha.

Female.—Cephalothorax equal in length and width, membranous flange narrow. Frontal plates deep and projecting, lunules of average size. Postero-lateral lobes of cephalothorax about half as broad as median lobe, latter slightly projecting beyond the former. Posterior sinuses wide open. Dorsal ribs prominent. Fourth thoracic segment broader than long. Genital segment enlarged and reniform, broader than cephalothorax. Abdomen slightly less than half the total length of the body, two-jointed, first segment swollen, second segment about one fourth the length of the first and indicated only by an abrupt constriction. Caudal rami large, oblong, with four long and two short setae. Egg tubes missing.

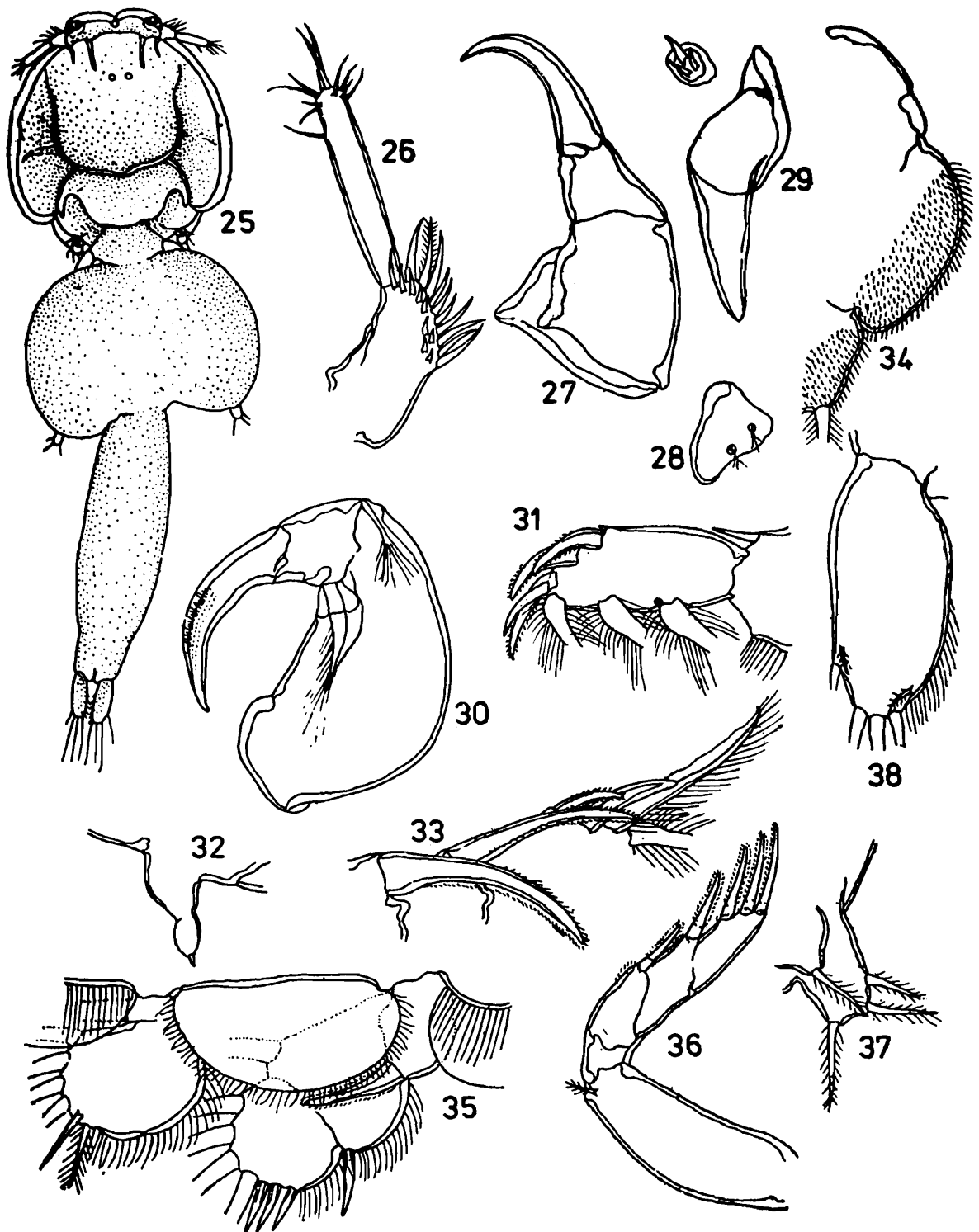
Basal segment of antennule narrow, with comparatively long setae, distal segment longer than basal, two of the apical setae large. Basal segment of antenna with very small process, second roughly squarish, third long and apically curved, with a very small seta. Post-antennal process a simple chitinised plate. Post-oral process an elongated apically blunt process. Maxillule with three short setae. Maxilla of the usual type. Maxilliped massive, basal segment without the usual process, its inner surface deeply concave, distal segment as long as basal and strongly curved. Sternal fork absent.

Vestigial endopod of first leg two-jointed, ending in a spine, first segment of exopod with strong upper distal spine, second segment with three curved and feebly pectinate claws, spine-like seta similar to the claws but smooth, ventral setae very large. First segment of endopod of second leg without armature, second and third with several irregular rows of spinules. First claw of exopod stout, long and curving downwards, second similar to first but more slender, third short, first seta stout and without hairs, second ventrally hairy and dorsally flanged. Basal claw of exopod of third leg long and flanged, slightly curved. Rami two-jointed, velum large. Fourth leg four-jointed, with five pectinate claws successively increasing in length. Fifth leg a small process carrying a seta and sixth a conspicuous process carrying three setae.

Length.—4.36 mm.

Remarks.—This species closely resembles *C. kanagurta* Pillai, 1961, in the general shape of the body, particularly of the post-cephalothoracic part. The resemblance is also evident in many of the appendages. But *C. kanagurta* has a well developed sternal fork and its fourth leg is totally different from that of *C. reniformis*. *C. reniformis* can be easily distin-

guished by the reniform genital segment, long abdomen and the absence of the sternal fork.



Figs. 25-38. *Caligus reniformis* sp. nov. Female. 25. Female, dorsal view ; 26, Antennule ; 27. Antenna ; 28. Post-antennal process ; 29. Post-oral process and maxillule ; 30. Maxilliped ; 31. Leg 1, tip of exopod ; 32. Same, vestigial endopod ; 33. Leg 2, exopod ; 34. Same, endopod ; 35. Leg 3 ; 36. Leg 4 ; 37. Legs 5 & 6 ; 38. Caudal ramus.

Thomsen (1949) created subgenus *Metacaligus* to include those species of *Caligus* which lacked sternal fork. Under this subgenus he placed *C.*

uruguayensis Thomsen (= *C. longicervicis* Gnanamuthu, 1950), *C. afurcatus* Wilson, 1913, *C. enormis* Wilson, 1913, and *C. rufus* Wilson, 1908. Ho and Bashirulla (1977) while describing *C. uruguayensis* observed that only *C. uruguayensis*, *C. rufus* and *C. hilsae* Shen and Li, 1959, can come under *Metacaligus* which they raised to the status of a genus. According to them these three species have identical first and second legs with very characteristic armature. Ho and Bashirulla examined the type material and found that *C. enormis* does not belong to *Caligus*. If these opinions are accepted *C. afurcatus*, *C. grandiaabdominalis* Yamaguti, 1954, and *C. reniformis* will form a group holding an anomalous position in the genus *Caligus*. We are of opinion that irrespective of other characters all species of *Caligus* lacking sternal fork can be included in *Metacaligus* as suggested by Thomsen. After all the armature of the legs of *Caligus* spp. shows wide variation. On the other hand absence of sternal fork is a stable character.

As stated above *Sciaenophilus* differs from *Caligus* in having an abdomen longer than the rest of the body, and in the absence of post-antennal process and sternal fork. *C. reniformis* has a long abdomen, though not longer than the rest of the body, has only a poorly developed post-antennal process and lacks sternal fork. Indeed the existing difference between *Caligus* and *Sciaenophilus* is getting eliminated.

Genus *Parechetus* Pillai

Parechetus carangis (Bassett-Smith)

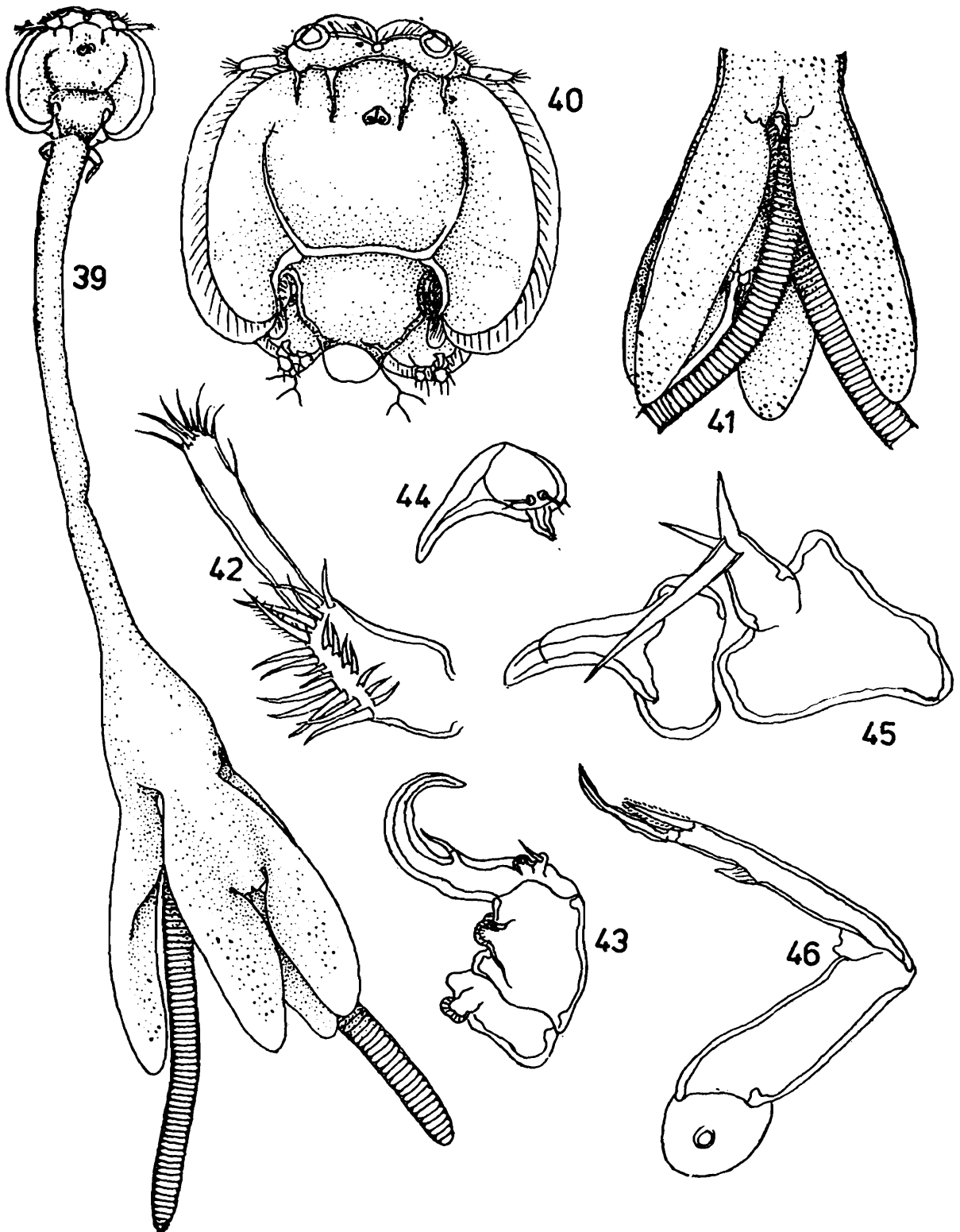
(Figs. 39-61)

1898. *Caligodes carangis*, Bassett-Smith, *Ann. Mag. nat. Hist.*, 5: 361, pl. 2, fig. 4.
 1961. *Parechetus carangis*, Pillai, *Bull. Res. Inst. Univ. Kerala*, 8: 118, fig 18.
 1964. *Parachetus constrictus* Kirtisinghe, *Bull. Fish. Res. Stn. Ceylon*, 17: 45.

Material.—Several females and one male from the roof of the buccal cavity of *Caranx* sp. examined at Trivandrum.

Female.—Cephalothorax circular, frontal plates very slightly projecting, lunules of normal size. Postero-lateral lobes of cephalothorax slightly narrower than median lobe, curving inwards and contacting the latter and nearly closing the posterior sinuses. Median lobe produced backwards and overlapped by the fourth segment. Latter fused with the genital segment and its limit indicated only by the presence of the fourth legs. Fourth genital segment complex long and parallel sided at the proximal two-thirds, progressively widening at the distal one third and postero-laterally expanded into two large petaloid lobes situated partly lateral and partly ventral. Abdomen as long as the genital wings, con-

siderably flattened into a distally bilobed lamina, the tip of the abdomen carrying the caudal rami projecting within the sinus, exactly in the middle



Figs. 39-46. *Parechetus carangis* (Bassett-Smith), Female. 39. Female, dorsal view; 40. Cephalothorax enlarged; 41. Hind end of the body, ventral view; 42. Antennule; 43. Antenna; 44. Post-antennal process; 45. Post-oral process and maxillule; 46. Maxilla.

of the abdominal wings. Each caudal ramus with four large and two small setae. Egg sacs attached to step-like lobes on the ventral side of the genital segment.

Antennule comparatively long, distal segment clearly longer than basal, latter with long setae. Antenna rather small, basal segment indistinct, with a projecting adhesion pad, second segment with a basal pad and an outer double pad, third segment rather strong, distally strongly curved, with a proximal and a median spine. Post-antennal process with swollen base carrying an accessory process, main claw slightly curved and blunt. Post-oral process rather small. Maxillule with unusually large base carrying three setae, one of them very long and stout. Maxilla with nearly straight distal claws. Maxilliped enormous, inner proximal part of basal segment with large projecting expansion, its lower surface with stout two-pronged conspicuous process, basal half of distal segment highly swollen, with a distal seta, distal half narrow and strongly curved. Base of sternal fork regularly widening distalwards, limbs of the fork shorter than base and slightly diverging.

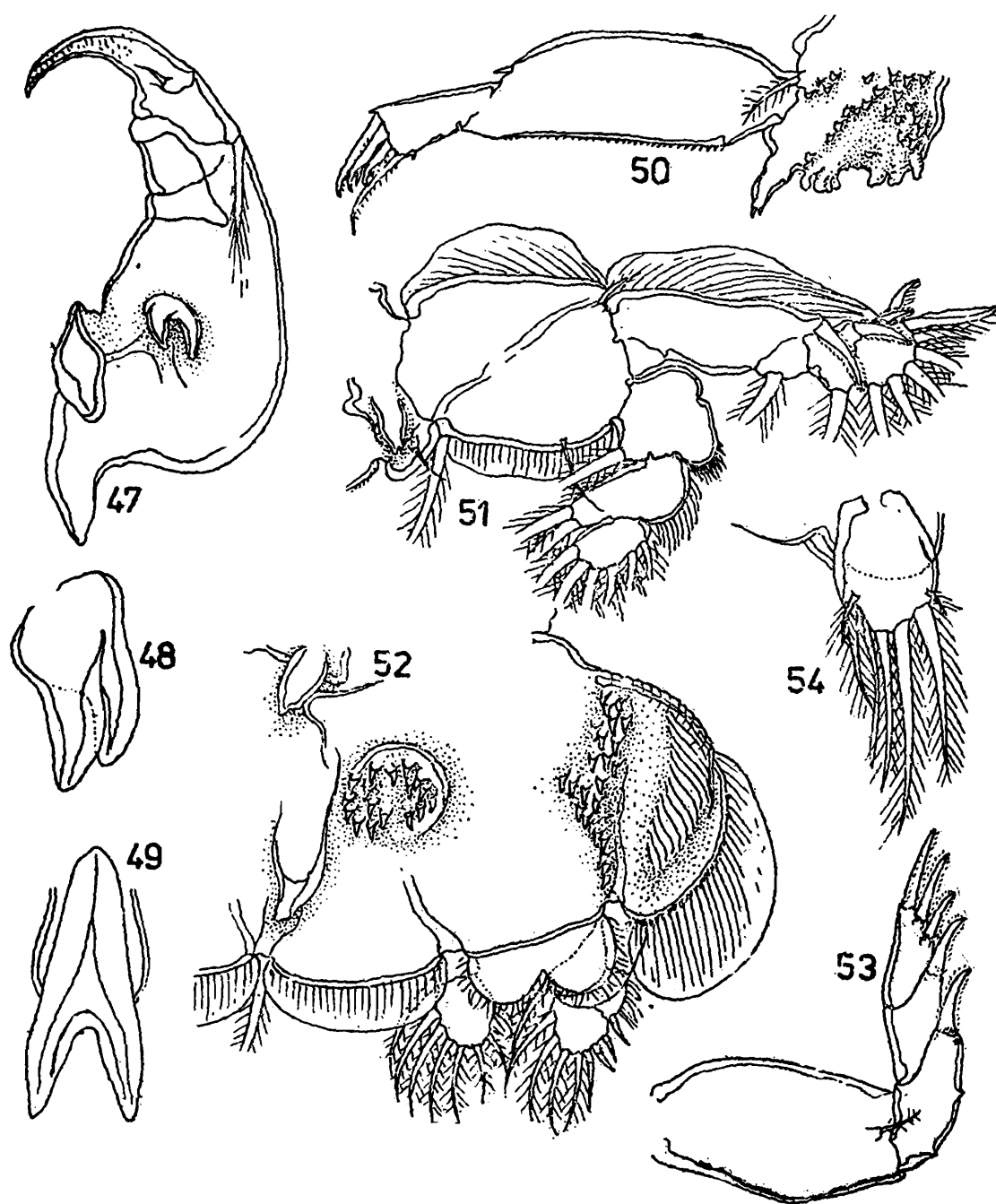
First leg with very characteristic structure, basipod armed with unusually large teeth, vestigial endopod with two apical spinules. First segment of exopod rather swollen, with upper distal spine, ventral border with a row of small teeth instead of stiff hairs, distal segment with three claws successively decreasing in length, spine-like seta pectinate and longer than the claws, ventral setae absent, occasionally represented by a small tooth. Each of the exopod segments of the second leg with a barbed claw, successively decreasing in length, first two setae of third segment modified. Basal segment of endopod with a distal crest of spines, other segments hairy. Exopod of third leg with a strongly curved basal claw, both rami two-jointed, apron elaborately armed, with proximal outer adhesion pad, outer distal marginal row of spines, longitudinal row of teeth in line with the exopod and a circular patch of teeth in line with the endopod, inner to the latter a pair of chitinised conical processes, one belonging to the intercoxal bar. Identical processes are present on the intercoxal bar of the second leg also. Fourth leg small and four-jointed, with five claws, basal segment broad and nearly as long as the rest of the limb. Fifth and sixth legs not observed.

Length.—9.3 mm.

Male.—Cephalothorax comparatively large, widening backwards, membranous flange fairly broad. Frontal plates low but projecting. Postero-median lobe of cephalothorax only very slightly projecting beyond the latter, posterior sinuses wide open. Fourth thoracic segment distinct, nearly equal in length and width. Genital segment pyriform, widening backwards. Abdomen two-jointed, segments subequal in length, first segment narrowing and second slightly widening backwards.

Antenna highly modified, basal segment with two adhesion pads,

second with a large pad, and an arcuate pad, third segment apically slightly curved, with a basal pad and two setae. Post-oral process could not be studied properly, apically trifid and transversely grooved. Basipod of first leg with small teeth. The process on the intercoxal bar of the second leg saw-like. Other legs as in female. Fifth leg represented by one seta and two other setae just behind. Sixth leg composed of two setae.



Figs. 47-54. *Parechetus carangis* (Bassett-Smith). female continued. 47. Maxilliped; 48. Sternal fork, lateral view; 49. Same, ventral view; 50. Leg 1; 51. Leg 2; 52. Leg 3; 53. Leg 4; 54. Caudal ramus.

Length.—2.9 mm.

Remarks.—This genus now contains two species, *P. carangis* (Bassett-Smith) and *P. constrictus* Kirtisinghe, 1964. The latter differs from the

former only in minor characters the most important of which is the presence of a constriction on the elongated part of the genital segment. We have in our collection both types of females and apart from the presence or absence of the constriction they do not show any difference. *P. constrictus* is obviously a synonym of *P. carangis*.

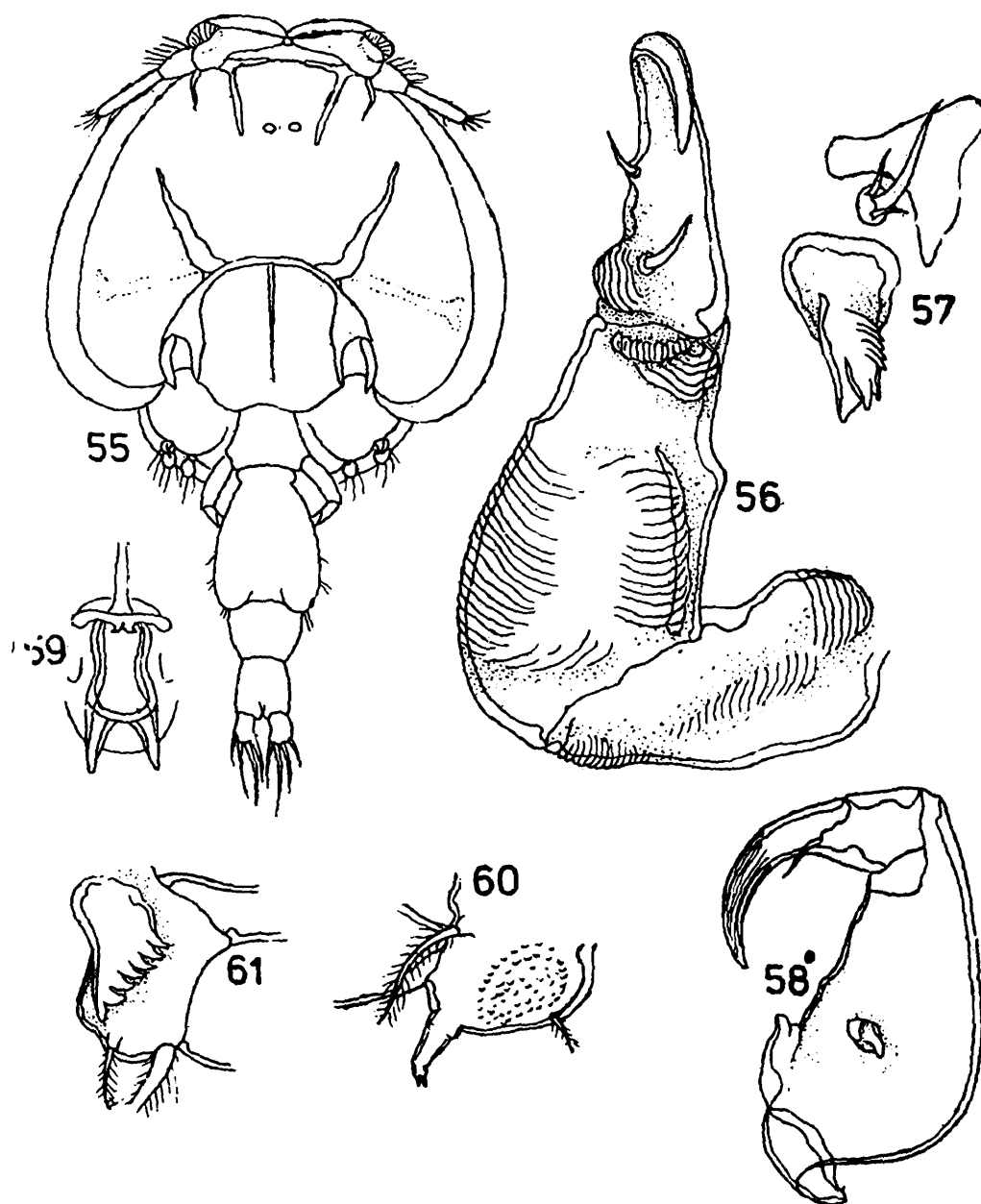


Fig. 55-61. *Parechetus carangis* (Bassett-Smith), Male. 55. Male dorsal view; 56. Antenna; 57. Post-oral process and Maxillule; 58. Maxilliped; 59. Sternal fork; 60. Leg 1, basipod; 61. Leg 2, process on intercoxal bar.

Pillai had only a single specimen and hence could not give a detailed description. We have therefore provided a fully illustrated description. Pillai's description left out a few interesting details. A lateral view of the animal shows the sternal fork and the bifid process on the maxilliped as strong hooks projecting downwards and backwards. They must certainly help the parasite in maintaining its hold. This is significant in the context

of the disagreement regarding the function of the sternal fork in caligids. In *Parechetus*, like a few other caligids, the post-cephalothoracic region of the body is large and heavy and the comparatively small cephalothoracic cup cannot provide adequate attachment. The large maxillipeds, with their bifid processes and the sternal fork give additional support.

The male is hardly distinguishable from the male of *Caligus*. Among the genera of Caliginae it is only the females which show difference in the shape of the body. This is the main character on which several genera were created. On the other hand the males which are more free from the influence of the host retain the typical shape seen in *Caligus* males.

Genus *Caritus* Cressey

Caritus serratus Cressey

(Figs. 62-79)

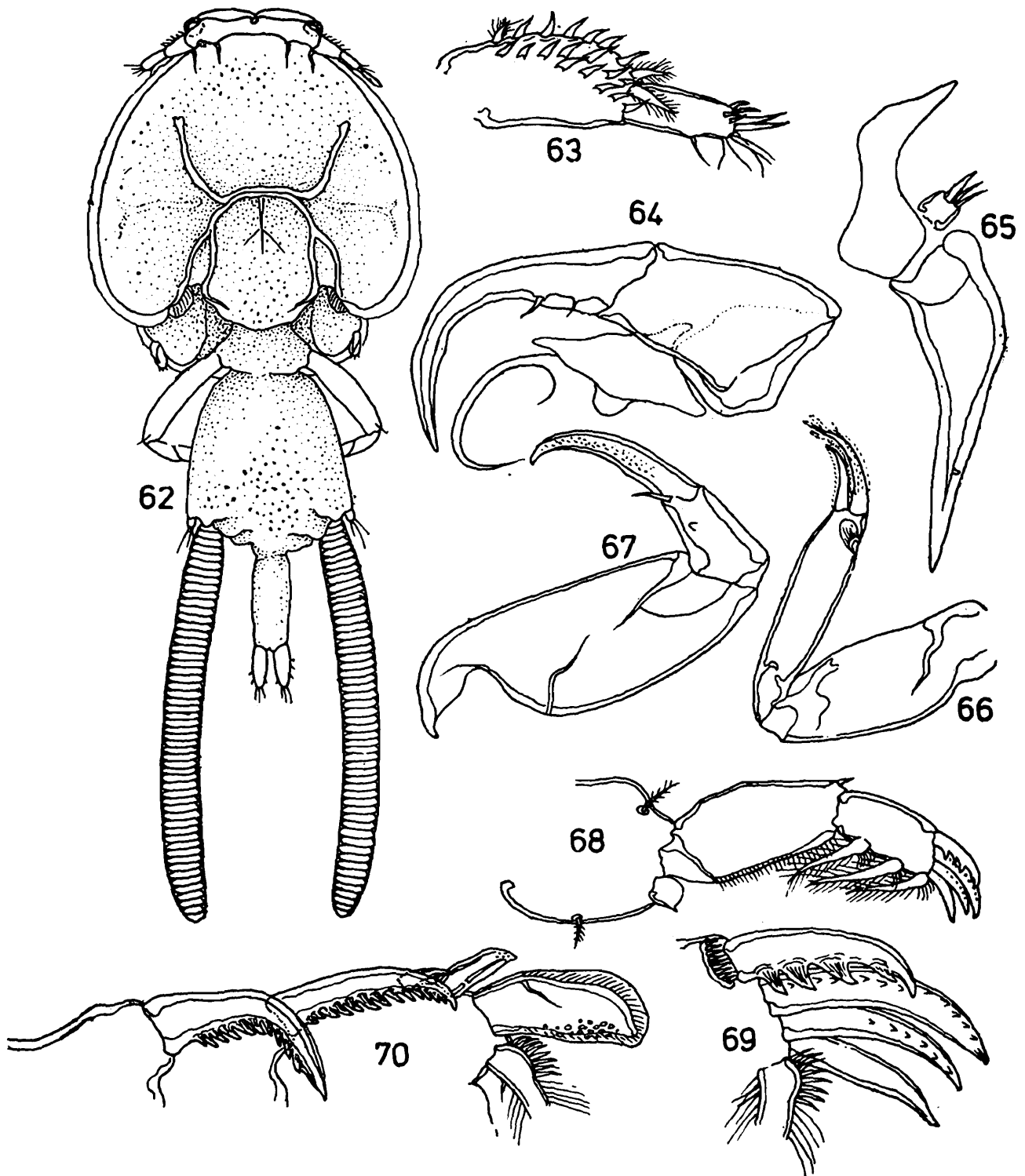
1967. *Caritus serratus* Cressey, *Proc. U.S. natl. Mus.*, 123 : 2, Figs. 1-18.

Material.—Four females and two males from the gills of *Chanos chanos* (Forsk.) examined at Trivandrum.

Female.—Cephalothorax comparatively large, gradually widening backwards and slightly broader than long. Frontal plates low, with narrow membranous flange, lunules of moderate size. Postero-lateral lobes of cephalothorax broad and rounded, as broad as median lobe, posterior sinuses wide open and nearly non-existent. Membranous flange of cephalothorax narrow, in preserved material usually folded downwards. Fourth thoracic segment distinct, slightly broader than long. Genital segment moderately enlarged, gradually widening backwards, its hind border irregular and subtruncate. Abdomen two-jointed, first segment very short and indistinct, caudal rami oblong and leaf-like, half as long as distal abdominal segment and armed with six short setae. Egg tubes as long as the post-cephalothoracic part of the body.

Antennule short but stout, segments somewhat cylindrical. Antenna strong, basal segment without the usual process, distal segment long and slightly curved, with two proximal setae. Post-antennal process absent, but the three bunches of hairs usually associated with it present. Post-oral process very long and slender, steadily narrowing distalwards. Maxillule composed of a projecting base carrying three short, setae, one of them slightly stouter. Basal segment of maxilla as long as distal but stouter, outer flange on distal segment displaced forwards, claws subequal in length. Basal segment of maxilliped with subparallel sides, distal segment nearly as long as basal, with a small tooth and a spine, apically curved and acute. Sternal fork absent.

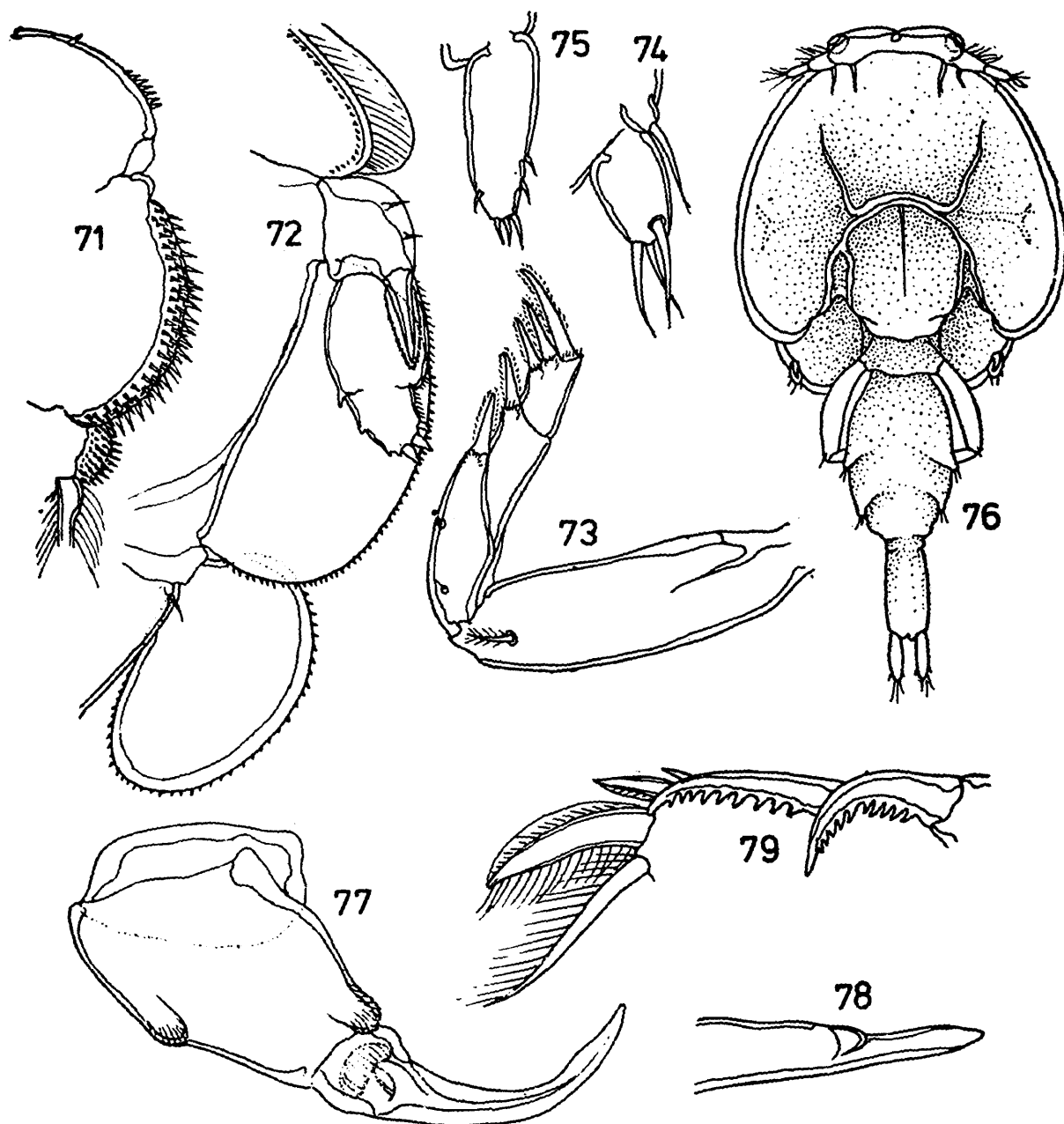
First leg normally developed, vestigial endopod a squarish lamina ending in a spine, distal exopod segment with three strong claws, first claw



Figs. 62-70 *Caritus serratus* Cressey. Female. 62. Female, dorsal view ; 63. Antennule ; 64. Antenna ; 65. Post-oral process and maxillule ; 66. Maxilla ; 67. Maxilliped ; 68. Leg 1 ; 69. Same, tip of exopod ; 70. Leg. 2, exopod.

with four strong ventral teeth, second and third with a row of small teeth, spine-like seta converted into a naked claw similar to the third claw, ventral setae well developed, their basal outer part with a row of spines.

First claw of exopod of second leg strongly curved, with a ventral row of about ten strong teeth, second claw less curved, with about thirteen ventral teeth, third claw small, without teeth; first two setae converted into flattened laminae, first small, second large; basal segment of endopod with



Figs. 71-79. *Caritus serratus* Cressey 71-75, Female; 76-79. Male. 71. Leg 2, endopod; 72. Leg 3; 73. Leg 4; 74. Legs 5 & 6; 75. Caudal ramus; 76. Male, dorsal view; 77. Antenna; 78. Post-oral process, tip enlarged; 79. Leg 2, exopod.

a short row of spines, other segments with several irregular rows. Third leg highly modified, apron without elaborate armature. Basal claw of exopod with stout base, claw proper with serrate flange, exopod indistinctly two-jointed and armed with short spines and outer marginal spinules. Endopod represented by an oblong lamina with marginal

spines, velum very large, similar to the endopod in shape and armature. Fourth leg normally developed, four-jointed, with five winged claws, basal segment longer than rest of the limb. Fifth leg represented by a tubercle carrying one seta and sixth by a process carrying three setae.

Length.—4.81 mm.

Male.—Cephalothorax as in the female, frontal plates slightly less projecting, postero-lateral lobes somewhat diverging making the posterior sinuses wide open. Median lobe of cephalothorax and fourth thoracic segment as in female. Genital segment elliptic or barrel-shaped, with two marginal indentations in the posterior half housing the vestigial legs. Abdomen two-jointed, first segment very short. Caudal rami as in female.

Antenna very much similar to that of female but its second segment with outer median and inner distal small pads, distal segment with a strong accessory claw and an arched adhesion pad. Post-oral process with a small accessory projection. First two claws on exopod of second leg with a smaller number of teeth, ten and nine respectively, first modified but not flattened as in female. Other appendages generally as in female.

Length.—4.0 mm.

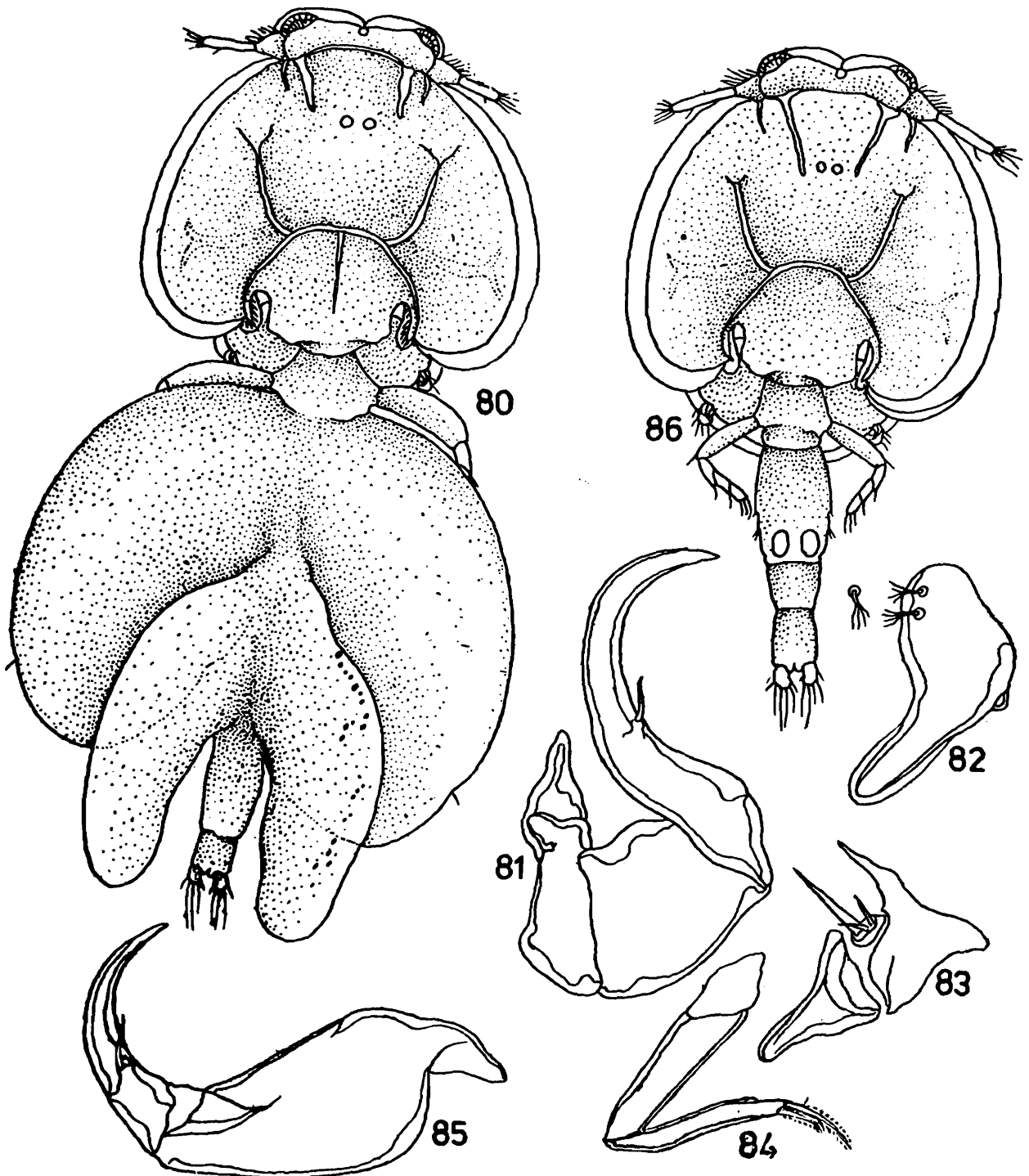
Remarks.—Cressey has given a full description of this species. We therefore point out a few minor omissions. Cressey omitted from his figure the membranous flange of the frontal plates and cephalothorax. Cressey's figure of the female does not correctly depict the hind border of the cephalothorax. There is as usual a median lobe though the posterior sinuses are very small. The abdomen shows an anterior constriction. Cressey has shown the second and third claws on the distal segment of the first leg as bilaterally pectinate. They actually carry a single row of small teeth. The first two setae on the exopod of the second leg are as shown by Cressey but more elaborately ornamented. The basal endopod segment has a short row of teeth not shown by Cressey. The exopod of the third leg is indistinctly two-jointed.

The most characteristic feature of this species is the modification of the endopod of the third leg into a lamina identical to the velum, intervening the rami. According to Parker *et al.* (1968) the velum is the modified and displaced first segment of the endopod. The nature of the endopod of this species lends support to this interpretation.

Genus *Parapetalus* Steenstrup and Lutken
***Parapetalus orientalis* Steenstrup and Lutken**
 (Figs. 80-100)

1861. *Parapetalus orientalis* Steenstrup and Lutken, *K. danske Vidensk. Selsk. Skr. Naturv. Math.*, 5 : 365, Fig. 10.
 1962. *Parapetalus orientalis*, Pillai, *Crustaceana*, 3 : 290, Fig. 2.

Material.—3 ♀♀ 3 ♂♂, Reg. No. C2140/2, Zoological Survey of India, Calcutta, loc : Trivandrum, Kerala, host : *Caranx* sp., gills, Coll. C. Prabha. Three females and three males from the gills of *Caranx* sp. examined at Trivandrum.



Figs. 80-86. *Parapetalus orientalis* Stp. & Lutk. 80-85, Female. 86. Male.
 80. Female, dorsal view; 81. Antenna; 82. Post-antennal process;
 83. Post-oral process and Maxillule; 84. Maxilla; 85. Maxilliped;
 86. Male, dorsal view.

Female.—Cephalothorax with moderately broad membranous flange, regularly widening backwards. Frontal plates deep and projecting. Postero-lateral lobes of cephalothorax slightly curving inwards and nearly as broad as the median lobe, latter very slightly projecting beyond the former. Posterior sinuses fully open. Fourth thoracic segment well developed, slightly broader than long. Genital segment highly flattened and expanded into two large horizontal wings extending outwards and also backwards, reaching beyond the middle of the abdomen. Abdomen long, its proximal half expanded into a pair of comparatively narrow wings extending backwards beyond the tip of the caudal rami. Distal half of the abdomen narrow, with an incomplete septum demarcating a short distal segment. Caudal rami normal, with two small and four large setae. Egg tubes comparatively short.

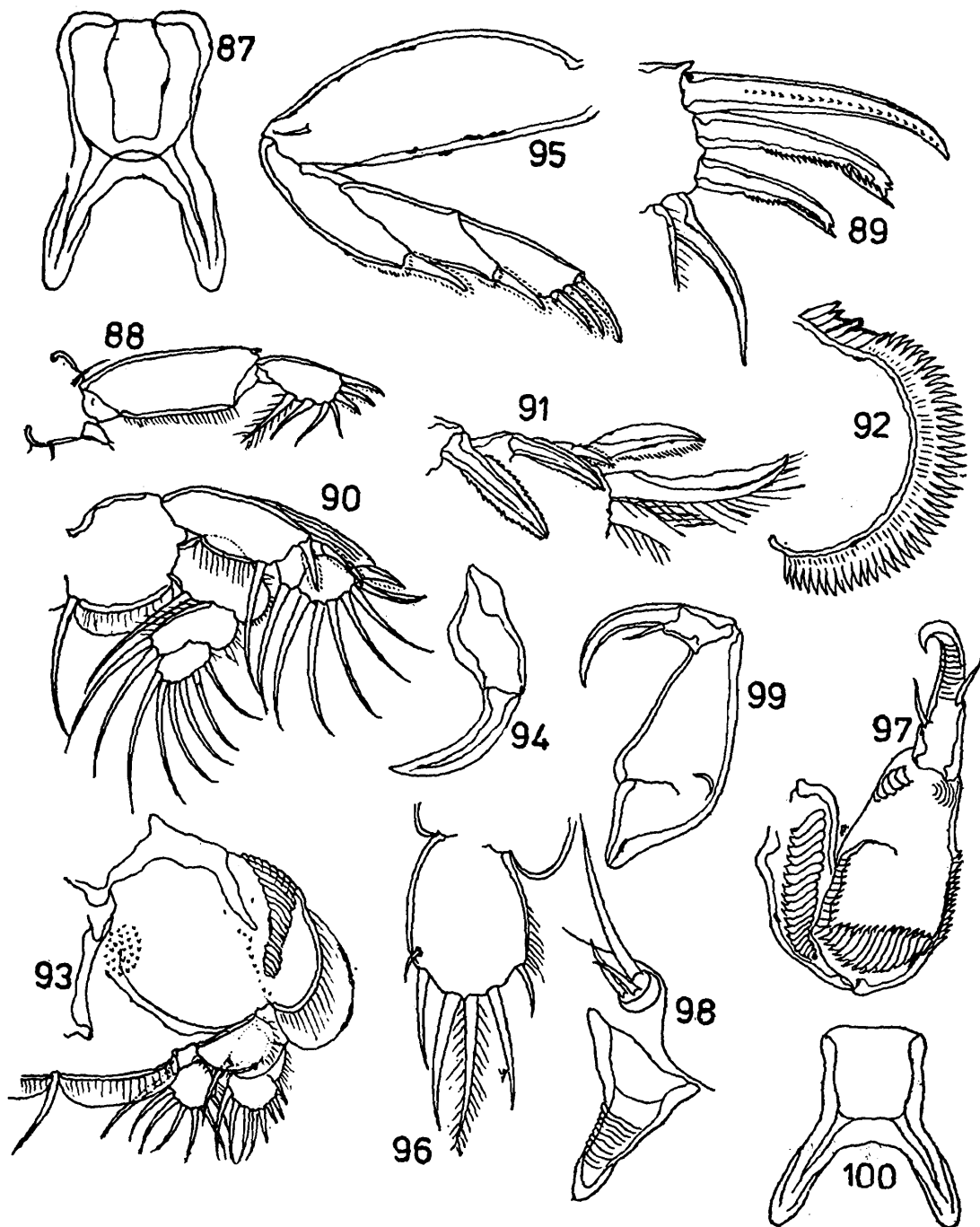
Distal segment of antennule clearly longer than basal, latter with fairly large setae. Basal segment of antenna small and somewhat indistinct, with a rounded process, third segment very long and strongly falcate, with a median inner seta. Post-antennal process with broad base carrying an outer conical projection, claw bent, apically rounded and flanged. Post-oral process triangular, with outer distal flange. Maxillule with one of the setae very long. Maxilla of the usual caligid type. Maxilliped comparatively large, basal segment proximally bulged on the inner side, distal segment strong, as long as basal and strongly curved. Sternal fork with roughly squarish base, limbs of the fork nearly as long as base, somewhat flattened and irregular in outline, apically diverging.

First leg with the usual armature. Vestigial endopod with two spinules, distal exopod segment with three spiny claws successively decreasing in length, first with a row of small teeth, second and third with a row of teeth and a long accessory process, one or two teeth are distal or dorsal making the tip appear bifid or trifid. Spine-like seta stout and naked. Exopod of second leg with the usual three claws, successively decreasing in size, all with serrate flange, first seta with outer membranous flange and inner pectinate flange, second externally flanged and internally plumose. Basal segment of endopod proximally hairy, distally expanded and with a high crest of spines. Apron of third leg with a longitudinal row of teeth in line with the exopod and a circular patch in line with the endopod and a proximal outer adhesion pad. Basal claw of exopod strongly curved. Fourth leg four-jointed, with five prominently winged claws. Fifth leg represented by a seta on the outer distal border of the genital segment.

Length.—4.6 mm.

Male.—Cephalothorax very much similar to that of female, but the frontal plates more projecting, postero-lateral lobes curving slightly more

inwards. Post-cephalothoracic region very narrow, fourth segment as long as broad, genital segment one and a half times as long as broad. Abdomen two-jointed, segments subequal in length, first narrowing backwards.



Figs. 87-100. *Parapetalus orientalis* Stp. & Lutk. 87-96, female ; 97-100 Male.
 87. Sternal fork ; 88. Leg 1 ; 89. Same tip of exopod ; 90. Leg 2 ;
 91. Same, exopod ; 92. Same, endopod ; 93. Leg 3 ; 94. Same basal
 claw of exopod ; 95. Leg 4 ; 96. Caudal ramus ; 97. Antenna ; 98. Post-
 oral process and maxillule ; 99. Maxilliped ; 100. Sternal fork.

Sexual dimorphism evident only in the antenna, post-oral process and the sternal fork. Antenna with several prominent adhesion pads. Sternal fork with more diverging limbs. Post-oral process with grooved surface

and an accessory process. One of the setae of the maxillule exceptionally long.

Length.—3.3 mm

Remarks.—Pillai had only one specimen and had to study the appendages *in situ*. The present collection which includes both males and females permitted a detailed study of this type species.

While revising the genus Pillai (1962) retained *P. orientalis*, *P. occidentalis*, *P. hirsutus* and *P. longipennatus* in *Parapetalus* and removed *P. caudatus* Gnanamuthu, 1950 and *P. formicoides* Redkar *et al.*, 1949, to a new genus *Pseudopetalus*. It should however be pointed out that *P. orientalis* and *P. occidentalis* are very much similar in every character while *P. hirsutus* and *P. longipennatus* are very different. It is true that in the last two species the genital segment and abdomen are flattened. But this is so in many species of *Caligus* like *C. parapetalopsis* Hameed and Pillai, 1973. It would appear that only *P. orientalis* and *P. occidentalis* belong to this genus and the others have to be transferred to *Caligus*.

Genus *Midias* Wilson

Midias lobodes Wilson

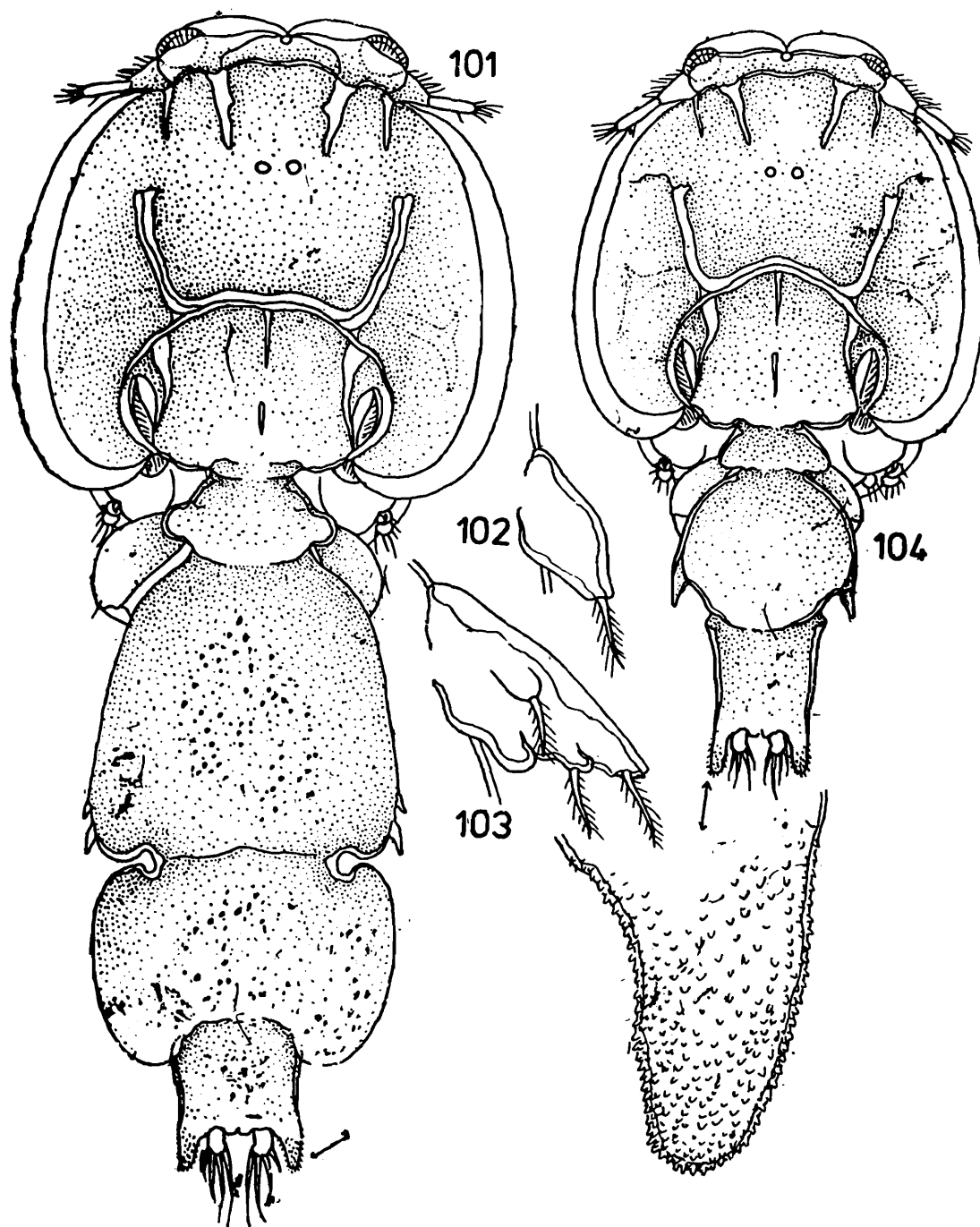
(Figs. 101-121)

1911. *Midias lobodes* Wilson, *Proc. U.S. natl. Mus.*, **39** : 626, pl. 65.
 1958. *Midias lobodes* Shiino, *Ann. Rep. Pref. Univ. Mie*, **2** : 98, Figs. 1-3.
 1963. *Midias lobodes* Yamaguti, *Parasitic Copepoda and Branchiura of fishes*. 107, pl. 127, fig. 1.
 1967. *Midias lobodes*, Lewis, *Proc. U.S. natl. Mus.*, **121** : 94, Figs. 34-36.

Material.—Several females and males from the jaws of *Sphyræna picuda* Bloch examined at Trivandrum.

Female.—Cephalothorax elegantly rounded, equal in length and width, frontal plates low and not projecting, lunules fairly large. Postero-median lobe of cephalothorax more than twice as broad as lateral lobes, its distal border transverse, lateral lobes curving inwards, closing the posterior sinuses, latter deep and very conspicuous. Fourth thoracic segment broader than long, produced over the base of the fourth legs as rounded lobes. Genital segment enlarged, gradually widening backwards, postero-laterally rounded. Abdomen apparently two-jointed and incompletely fused with the genital segment. First segment laterally expanded into large rounded lobes making it as broad as genital segment. Second segment narrow, squarish, postero-laterally produced into spiny processes over-reaching the caudal rami. Caudal rami sunk into the abdomen.

Antennule without any special features. Basal segment of antenna with small rounded process, distal segment distally curved, with one seta. Post-antennal process elongate-triangular and slightly curved. Post-oral

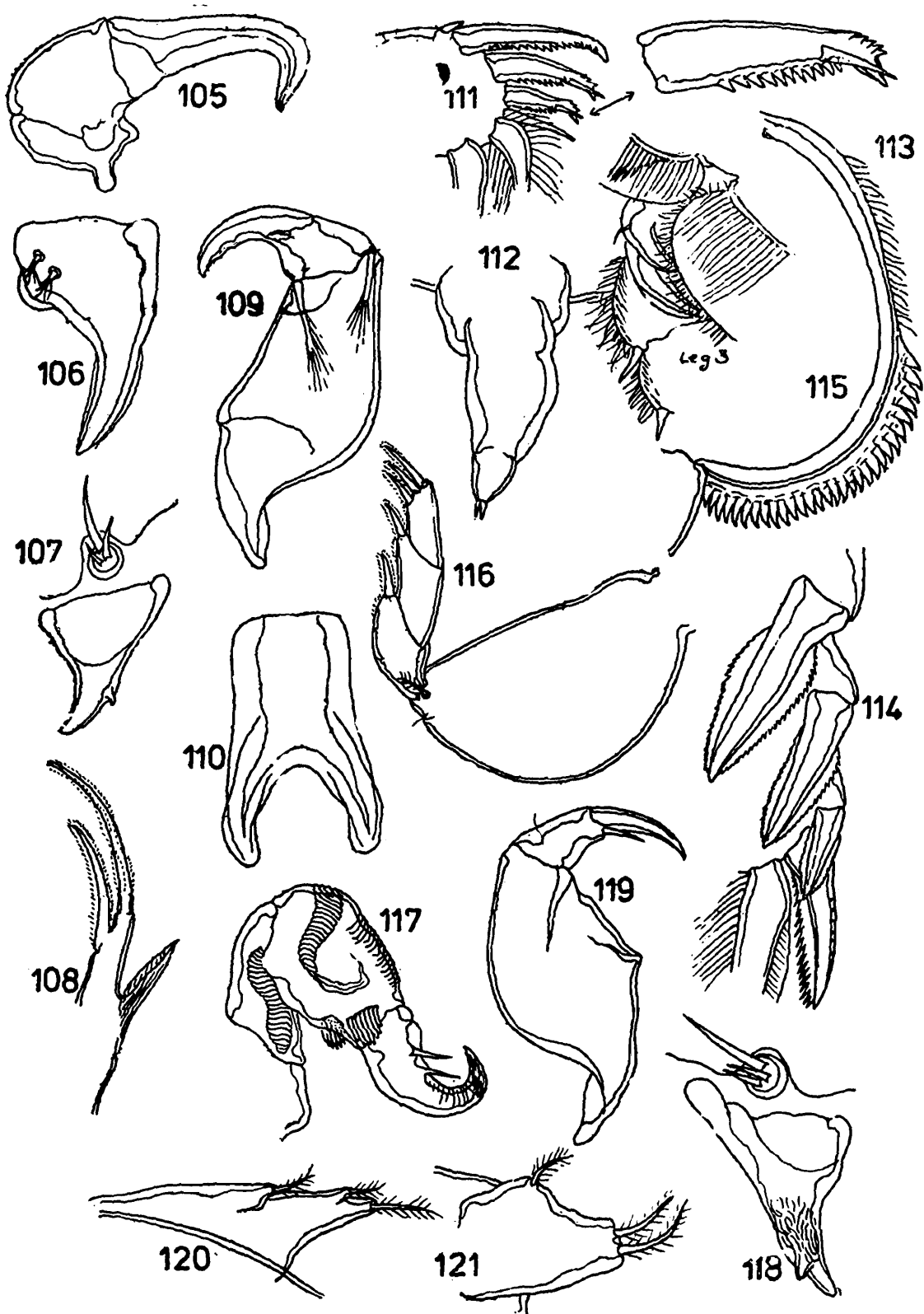


Figs. 101-104. *Midias lobodes* Wilson. 101. female, dorsal view ; 102. Leg 5 ; 103. Leg 6 ; 104 Male, dorsal view.

process triangular, with small accessory process. One of the setae of maxillule long, others very short. Distal segment of maxilla with unusually large outer lobe. Basal segment of maxilliped stout, distal short but stout. Sternal fork with squarish base, limbs of the fork distally curving inwards.

Vestigial endopod of first leg large, indistinctly three-jointed and

terminating in two spines. Distal segment of exopod with the second and third claws toothed on both sides and with accessory process. Spine-like



Figs. 105-121. *Midias lobodes* Wilson. 105-116. female; 117-121. Male; 105. Antenna; 106. Post-antennal process; 107. Post-oral process and maxillule; 108. Maxilla; 109. Maxilliped; 110. Sternal fork; 111. Leg 1, tip of exopod; 112. Same, vestigial endopod; 113. Leg 2, endopod; 114. Same exopod; 115. Leg 3; 116. Leg 4; 117. Antenna; 118. Post-oral process and maxillule; 119. Maxilliped; 120. Leg 5; 121. Leg 6.

seta short and naked. Claws on exopod of second leg stout, with broad serrate flange, first two setae modified as usual. Basal segment of endopod proximally hairy and distally with a crest of spines. Rami of third leg two-jointed, basal claw of exopod stout and strongly curved, with a prominent accessory process. Fourth leg with exceptionally large flattened basal segment followed by three short narrow segments. Vestigial legs carried on prominent projecting conical processes.

Length.—9.5 mm

Male.—Cephalothorax as in female. Fourth thoracic segment not forming rounded lobes overlapping the base of the fourth legs. Genital segment nearly rounded, with very prominent postero-lateral lobes carrying the vestigial legs. Abdomen one-jointed, postero-laterally produced as in female.

Basal segment of antenna with one and second with four adhesion pads, third segment stout and strongly curved, with two spine-like setae. Surface of post-oral process prominently furrowed and with an accessory process. Basal segment of maxilliped with conical projection in the middle of the inner side, distal segment slender, with median spine.

Length.—7.5 mm

Remarks.—Only two species, *M. lobodes* and *M. carangis* have been so far assigned to this genus. *M. carangis* is very different from *M. lobodes* and Pillai (1961) showed that it is a true *Caligus*.

Alleging that the fourth thoracic segment has a pair of dorsal plates Wilson placed this genus under Euryphoridae. As euryphorid characters Wilson also mentioned the extreme flattening of the basal segment of the fourth leg, the strong chitination of the body and the nature of the vestigial endopod of the first leg and the fifth and sixth legs and also the presence of an accessory claw on the basal claw of the exopod of the third leg. There is no doubt that all these characters added up make *M. lobodes* really unique.

The one character which distinguishes euryphorids from caligids is the presence of a pair of dorsal plates on the fourth thoracic segment. But all agree that the small lobes visible on the fourth segment of *M. lobodes* are not comparable to the dorsal plates of euryphorids. Pillai (in press) suggested that *M. lobodes* should be treated as a species of *Caligus* since every peculiar character of *M. lobodes* is actually present in one species of *Caligus* or another.

This brings in the question of the validity of many genera in the subfamily Caliginae. The females of *Caligus*, *Pseudocaligus*, *Caligopsis*, *Alicalgus*, *Parapetalus*, *Pseudopetalus*, *Synestius*, *Abasia*, *Caritus*, *Echetus*,

Parechetus, *Pseudechetus*, *Caligulus* and *Caligulina* differ primarily in the shape of the body. Their males are hardly distinguishable from those of *Caligus*. Until the validity of these genera is studied in depth it is better to recognise *Midias* as a valid genus.

Subfamily LEPEOPHTHERINAE

Genus *Lepeophtheirus* Nordmann

Lepeophtheirus rotundigenitalis sp. nov.

(Figs. 122-132)

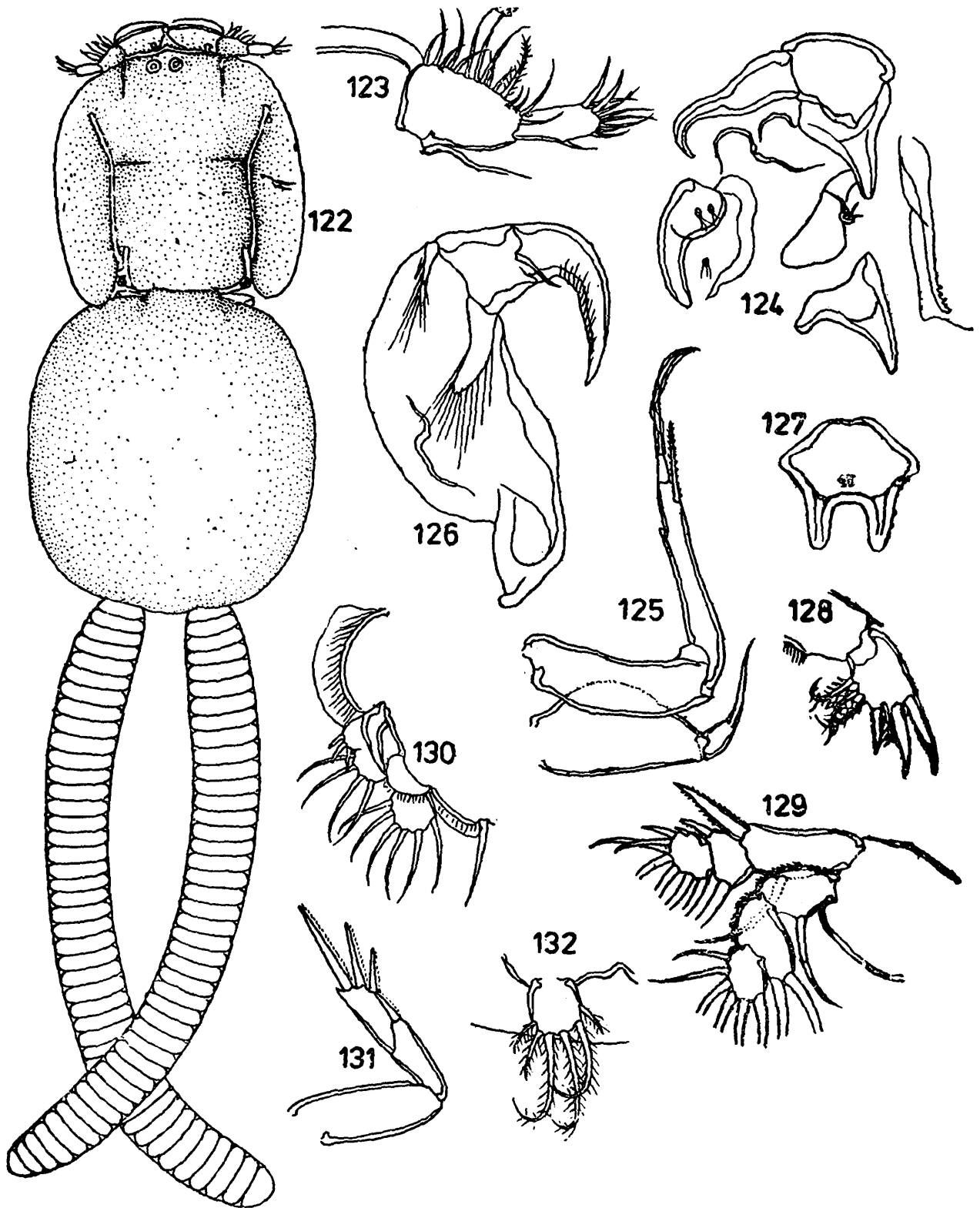
Material.—Several females from the inner surface of the opercle of *Gaterin schotaf* (Forsk.) examined at Trivandrum.

Holotype.—Female Reg. No. Zoological Survey of India, Calcutta; loc. Trivandrum, Kerala; host: *Gaterin schotaf* (Forsk.); inner surface of opercle, Coll. C. Prabha.

Female.—Lateral parts of cephalothorax folded downwards making it equal in length and width, though actually broader than long. Frontal plates prominently projecting, with narrow membranous flange. Posterolateral lobes of cephalothorax less than half as broad as the median lobe and clearly over-reaching the latter; median lobe with nearly straight hind border, almost completely hiding the fourth segment in dorsal view. Posterior sinuses narrow and deep. Fourth thoracic segment short. Genital segment highly enlarged, nearly circular in outline and larger than cephalothorax. Abdomen reduced to a bilobed projection on the ventral side of the genital segment. Caudal rami normally developed, with three long and three short setae. Egg sacs stout and very long, longer than the body.

Antennule short, with long sparsely distributed setae, two of the setae on distal segment stout. Basal segment of antenna with a very stout process, distal segment distally narrow and strongly curved. Post-antennal process large and moderately curved, with slightly enlarged base, post-oral process comparatively small and irregularly triangular. Maxillule shifted forwards, situated away from the post-oral process, with very small base carrying three small setae. Basal segment of maxilla slightly shorter and broader than distal, latter with very small outer lobe. Inner claw straight and fairly long, outer very long and curved. Whip-like process large and three-jointed. Maxilliped very stout and strong, distal segment bent at right angles in the middle. Sternal fork with stout base drawn out laterally, limbs of the fork short and very slightly diverging.

Distal exopod segment of first leg with the usual armature, claws straight, setae well developed, spine-like seta placed between the second



Figs. 122-132 *Lepeophtheirus rotundigenitalis* sp. nov. 122. female, dorsal view ; 123. Antennule ; 124. Antenna, post-antennal process, post-oral process, maxillule and oral cone ; 125. Maxilla ; 126. Maxilliped ; 127. Sternal fork ; 128. Leg 1 ; 129. Leg 2 ; 130. Leg 3 ; 131. Leg 4 ; 132. Caudal ramus.

and third claws. Basal segment of exopod of second leg with an unusually stout claw, second and third claws small, all straight, first two setae only

slightly modified; endopod segments externally sparsely hairy. Basal claw of exopod of third leg straight, exopod indistinctly two-jointed, velum shifted to the base of the endopod, apron reduced in size. Fourth leg three-jointed and short, with four straight pectinate claws, last claw comparatively long.

Length.—1.7 mm.

Remarks.—This species belongs to the group of *Lepeophtheirus* spp. with the abdomen very short or absent and the caudal rami originating directly from the genital segment. Some of the species belonging to this group are hardly distinguishable from *Anuretes*. Pillai and Natarajan (1974) recently described an aberrant species of *Lepeophtheirus* and we have described elsewhere a lepeophtherine copepod under a new genus. These species of *Lepeophtheirus* can be referred to *Anuretes* also and are quite a problem for taxonomists. Ho and Bashirulla (1977) even sunk *Anuretes* into the synonymy of *Lepeophtheirus*.

L. rotundigenitalis is unique in that it bridges the gap between several genera of Lepeophtherinae and Anuretinae. The median lobe of the cephalothorax completely hides the fourth segment. The genital segment is swollen and the abdomen is suppressed. As in *Pseudanuretes* it has a maxillary whip which is larger than any so far discovered in any other species. The maxillule as in species of *Heniochophilus* is shifted away from the post-oral process. The fourth leg is somewhat degenerated and only three-jointed. The rami of the third leg are exactly as in the genera of Anuretinae. Though *L. rotundigenitalis* shows the characters of several genera it can at present be referred only to *Lepeophtheirus*. The shape of its enormous genital segment serves to distinguish it from all the others.

Subfamily ANURETINAE

Genus *Anuretes* Kroyer

Anuretes rotundus sp. nov.

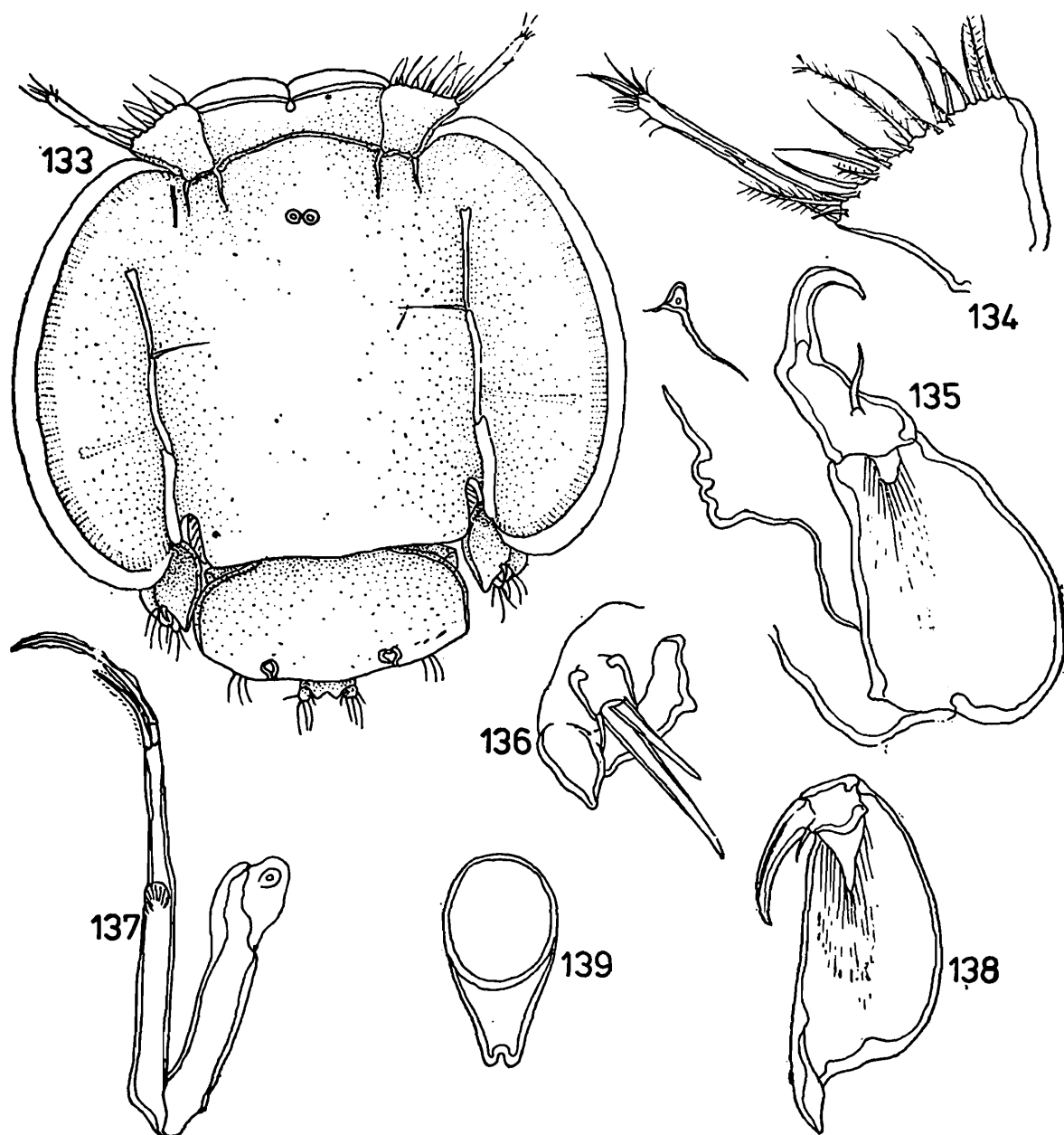
(Figs. 133-144)

Material.—A single female from the nasal fossae of *Pomacanthodes imperator* (Bloch) examined at Trivandrum.

Holotype.—Female, Reg. No. C 2898/2, Zoological Survey of India, Calcutta; loc. Trivandrum, Kerala, host: *Pomacanthodes imperator* (Bloch), nasal fossae, Coll. C. Prabha.

Female.—Body nearly circular, the even contour preserved by the basal segment of the antennule, modified apron of the third legs and the transversely expanded genital segment. Cephalothorax clearly broader

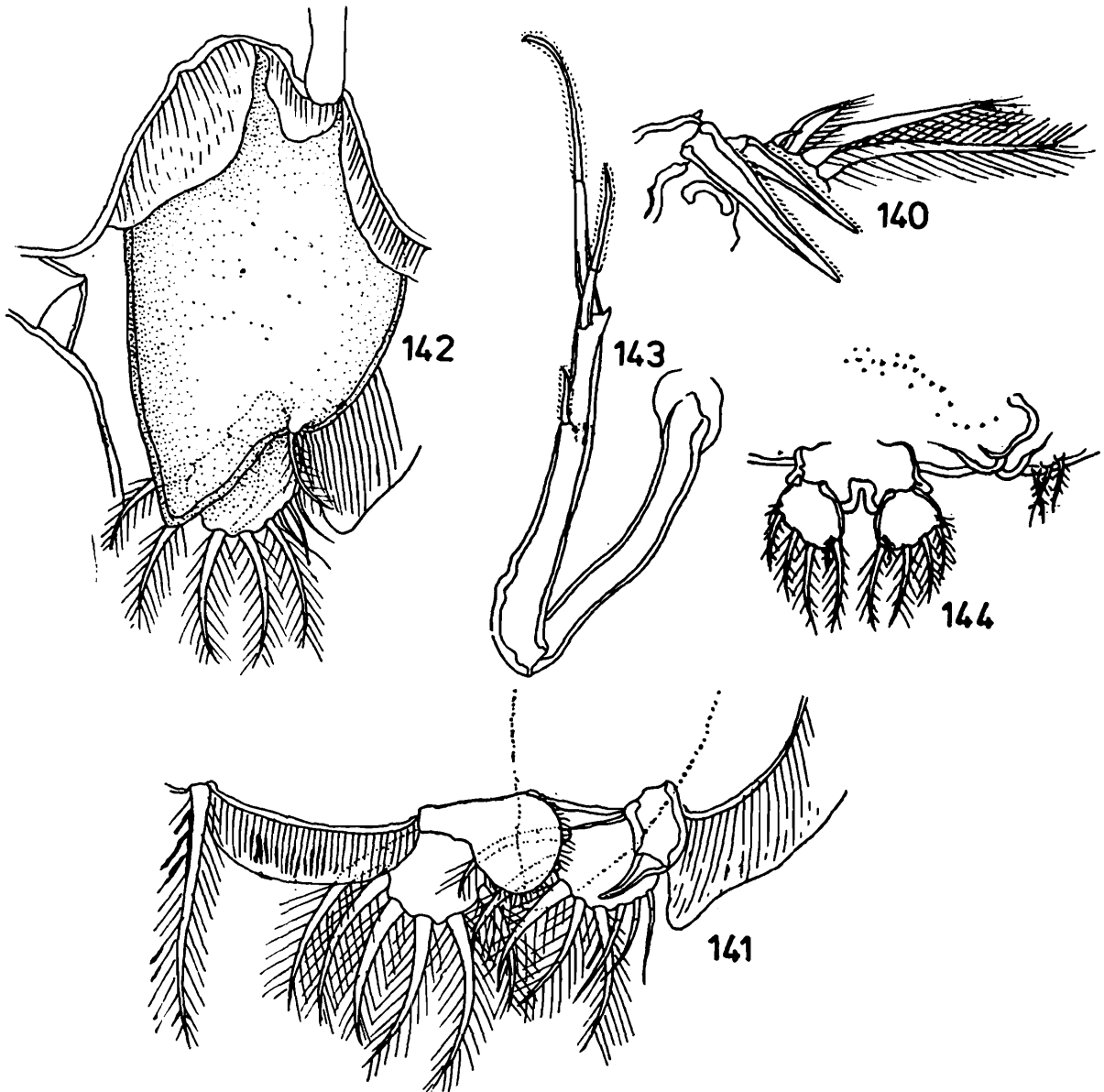
than long, with elegantly curved lateral borders, membranous flange moderately broad. Dorsal side with chitinised ridges much reduced,



Figs. 133-139. *Anuretes rotundus* sp. nov. 133. Female, dorsal view ; 134. Antennule ; 135. Antenna ; 136. Post-oral process and maxillule ; 137. Maxilla ; 138. Maxilliped ; 139. Sternal fork.

consisting of a pair of broken longitudinal ones and very indistinct transverse ridge. Frontal plates very deep but not projecting as the antennules fill the gap on either side. Postero-lateral lobes of cephalothorax about half as broad as the median lobe, latter hardly over-reaching the former and with nearly straight hind border. Posterior sinuses wide open. Fourth thoracic segment hidden in dorsal view. Genital segment short but broad, nearly as broad as the median lobe of cephalothorax. Abdomen small, slightly projecting beyond the hind border of the genital segment. Caudal rami small, with four long and two short setae. Egg sacs absent.

Basal segment of antennule triangular and very deep, with sparsely distributed long setae, distal segment slender and very long, ventral seta



Figs. 140-144. *Anuretes rotundus* sp. nov. 140. Leg 2, exopod ; 141. Leg, 3 ; 142. Same pad between rami, dorsal view ; 143. Leg 4 ; 144. Caudal rami.

placed in the middle of the segment. Basal segment of antenna indistinct, second segment large, third rather slender, abruptly narrowed in the middle and distally strongly curved, basal part with a stout seta. Post-oral process a very small chitinised process. Maxillule with large projecting base carrying the usual three setae, one of them very small and one very stout. Distal segment of maxilla one and a half times as long as basal, apical claws long and very slender. Basal segment of maxilliped stout, distal short, slender and moderately curved. Sternal fork a pyriform process, apically bilobed.

First leg being out of position, could not be studied properly, claws on distal segment toothed. Endopod segments toothed. Endopod

segments of second leg externally hairy, first two exopod segments with a stout claw, third with a small claw, first two claws externally with pectinate flange, first two setae of third segment modified. Third legs very characteristic, apron with a large conical muscular pad projecting like two stumpy horns filling the posterior sinuses of the cephalothorax ; rami one-jointed, outer spines on exopod slender and setiform, basal claw of exopod small and very slender. Fourth leg remotely resembling the maxilla, long slender and three-jointed, second segment with one short spine, third with two long spines, this limb apparently approaching the degenerated condition evident in *Pseudanuretes*. Fifth leg represented by a group of three setae.

Length.—2.5 mm

Remarks.—This species can be easily recognised by the shape of the body. In every appendage one or other characteristic feature is apparent. The deep basal segment and the long distal segment of the antennule, the short distal segment of the antenna, absence of the post-antennal process, degeneration of the post-oral process, presence of a stout seta on the maxillule, the long slender maxilla which is almost a replica of the fourth leg, the degenerated sternal fork, the large muscular pad on the third leg and the fourth leg with an unusually long distal claw make this species stand aloof from its congeners.

***Anuretes shiinoi* sp. nov**

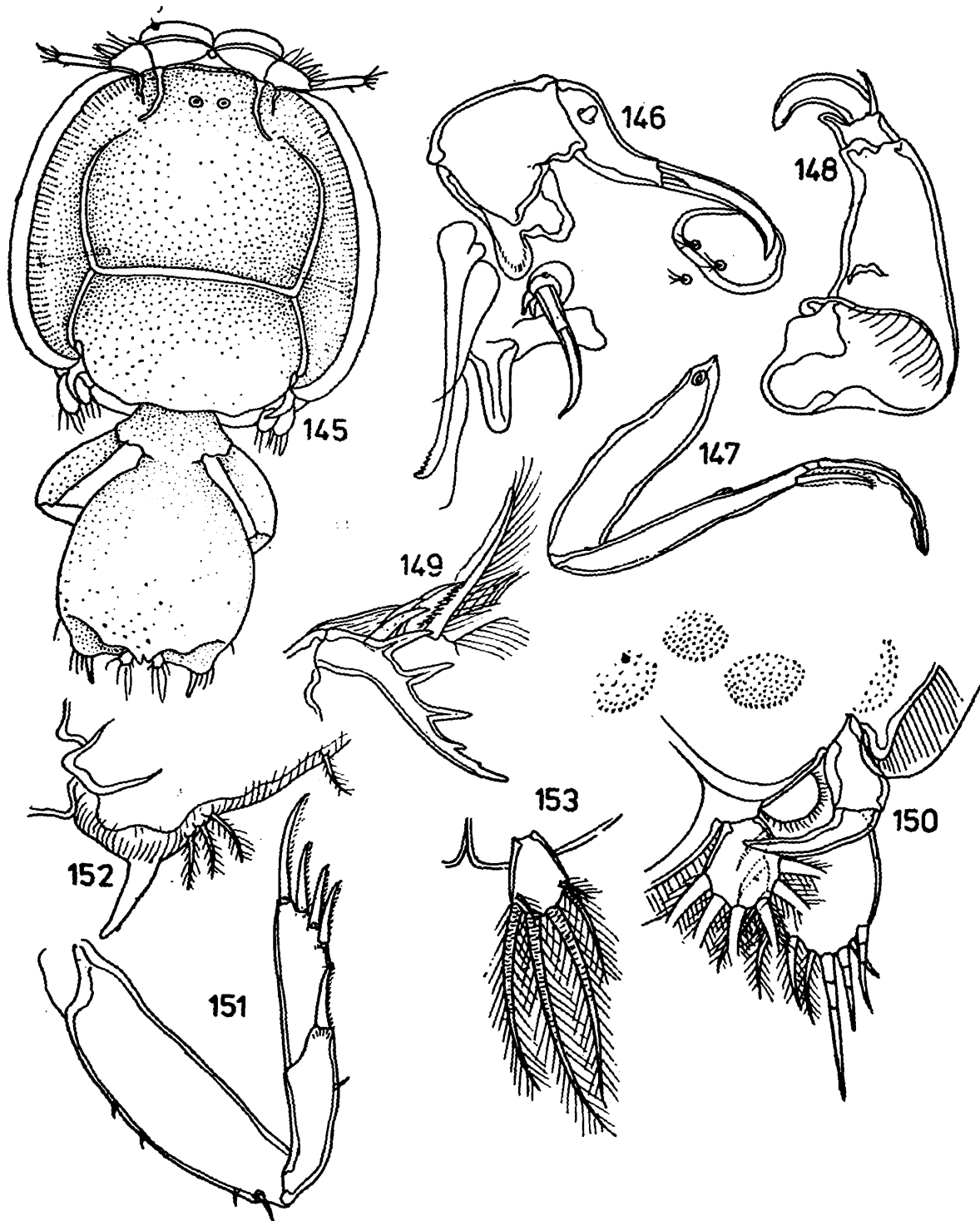
(Figs. 145-153)

Material. A single female from the inner surface of the opercle of *Naso* sp. examined at Trivandrum.

Reg. No. C 2899/2, Zoological Survey of India, Calcutta ; Loc. Trivandrum, Kerala ; host : *Noso* sp., inner surface of opercle ; Coll. C. Prabha.

Female. Cephalothorax nearly equal in length and width, with fairly broad membranous flange. Frontal plates projecting but made to appear low by the antennules filling the gap on either side. Postero-lateral lobes very narrow, curving inwards and touching the median lobe and closing the small posterior sinuses. Postero-median lobe exceptionally broad, about three fourths the maximum width of the cephalothorax. Fourth thoracic segment large, broader than long and fully exposed. Genital segment moderately large, gradually widening backwards and at three fourths its length from base suddenly narrowing and expanding into postero-lateral chitinised and grooved pads or lobes carrying the vestigial

legs and a small hyaline horn-shaped process. The development of the lobes apparently pushed the abdominal lobe to the dorsal side of the genital segment, abdomen as such absent. Caudal rami normally developed, with three very long setae, one moderately long seta and two small setae. Egg tubes absent.



Figs. 145-153 *Anuretes shiinoi* sp. nov. 145. Female, dorsal view; 146. Antenna, post antennal process, post-oral process, maxillule and oral tube; 147. Maxilla; 148. Maxilliped; 149. Leg 2, exopod; 150. Leg 3; 151. Leg 4; 152. Leg 5; 153. Caudal ramus.

Antennule similar to that of *A. rotundus* but smaller. Basal segment of antenna with a rounded flattened process, third segment exceptionally long and slender with basal process and median seta. Post-antennal process a circular plate carrying the three bunches of hairs. Post-oral process cylindrical and apically rounded. Maxillule with two very short setae and a third very stout and long jointed seta. Maxilla with small outer lobe, claws long, outer twice as long as inner. Maxilliped could not be properly studied, its basal segment large, with projecting proximal pad, distal segment comparatively short, stout and well curved, with an accessory process and a seta. Sternal fork absent.

First leg in the only specimen was out of position and could not be studied adequately, distal claws apparently toothed as in *A. serratus* Shiino. Endopod segments of second leg hairy, first segment of exopod with a very long claw carrying five subsidiary outer processes, second and third claws short and apparently naked, first seta with a ventral flange of spines, second with dorsal membranous flange. Basal claw of exopod of third leg stout and strongly curved, exopod one-jointed and large, second outer spine much smaller than first, fourth exceptionally long, endopod one-jointed, velum very small, apron armed with four pairs of patches of small denticles. Fourth leg three-jointed, basal segment slightly longer than rest of the limb, claws finely pectinate, last one and a half times as long as the penultimate. Fifth leg represented by one seta and sixth by three setae and a hyaline process.

Length.—2.8 mm.

Remarks.—This species resembles *A. serratus* Shiino, 1954 in the nature of the first claw on the exopod of the second leg, in the armature of the distal claws on the first leg and in the presence of an accessory process on the distal segment of the maxilliped. But *A. shiinoi* can be distinguished by its more slender antennae, totally different post-oral process, maxillule and fourth leg. The most obvious difference is however in the shape of the genital segment which in *A. shiinoi* is posterolaterally expanded into lobes carrying a hyaline process. Due to want of material a more detailed study could not be made.

Genus *Pseudanuretes* Yamaguti

Pseudanuretes pomacanthodi sp. nov.

(Figs. 154-170)

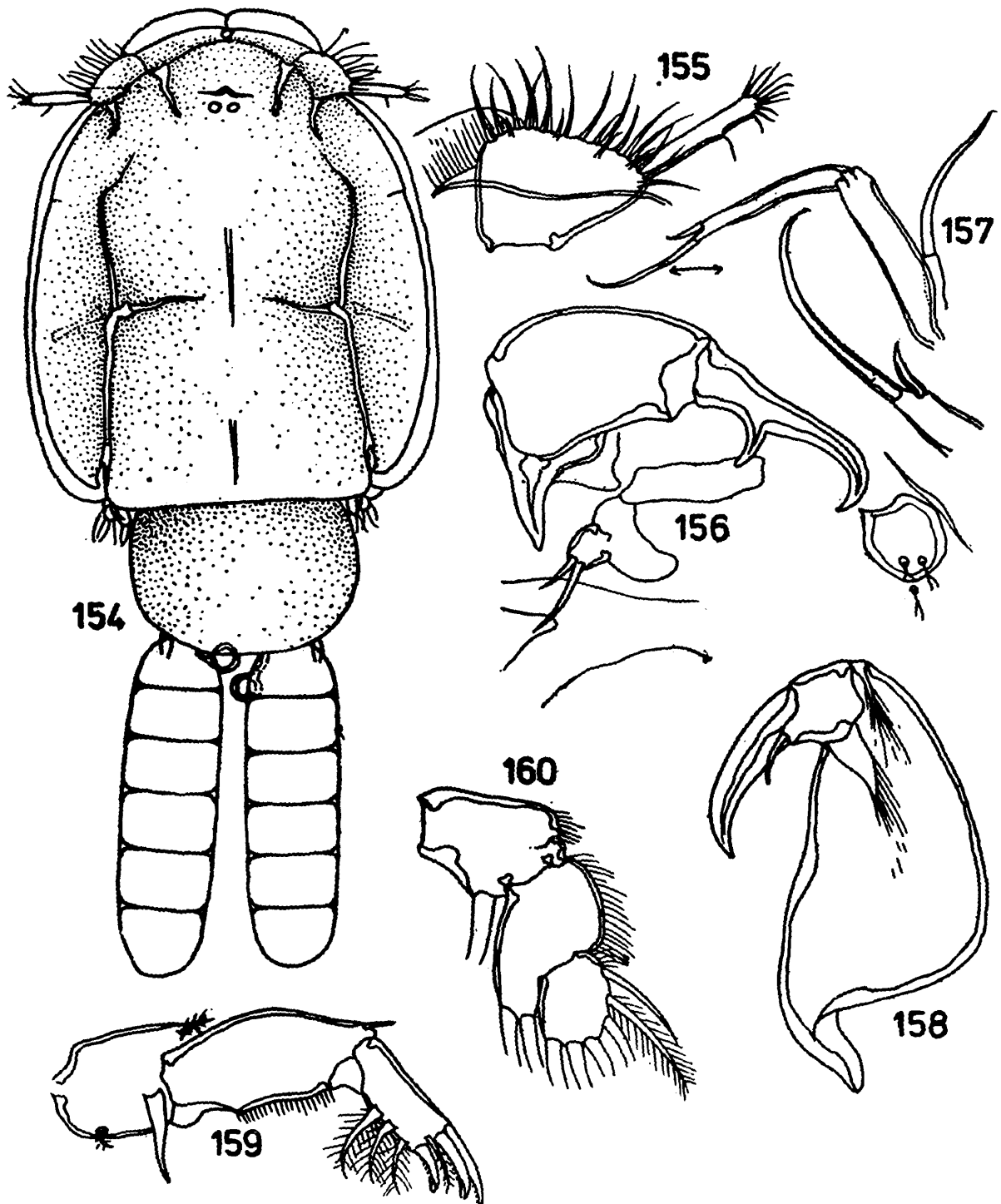
Material.—Several females and males from the gills of *Pomacanthodes imperator* (Bloch) examined at Trivandrum.

Holotype ♀ Reg. No. C2900/2, Zoological Survey of India,

Calcutta ; loc : Trivandrum, Kerala, host : *Pomacanthodes imperator* (Bloch), gills ; coll. *C. Prabha*.

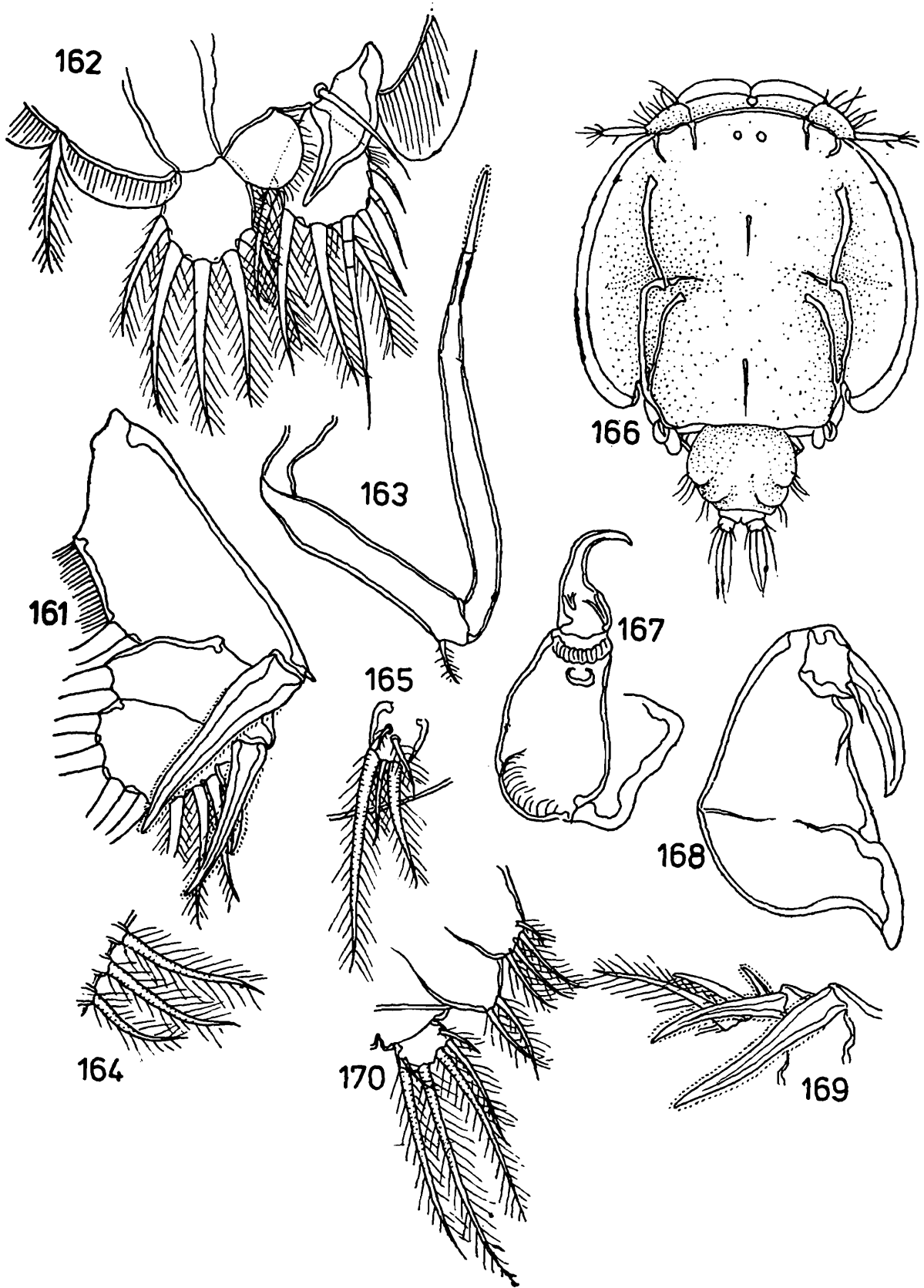
Paratypes : ♂ ♀, Reg. No. C2901/2 other details same as for holotype.

Female.—Cephalothorax longer than broad, posteriorly truncated, lateral borders evenly curved, with small antero-lateral indentation. Frontal plates low and not projecting, membranous flange prominent.



Figs. 154-160 *Pseudanuretes pomacanthodi* sp. nov. 154. Female, dorsal view ; 155. Antennule ; 156. Antenna, post-antennal process and post-oral process ; 157. Maxilla and maxillary process ; 158. Maxilliped ; 159. Leg 1 ; 160. Leg 2, endopod.

Postero-lateral lobes very narrow, median lobe very broad, with transverse hind border, posterior sinuses nearly absent. Genital segment hemispherical, overlapped by the median lobe of cephalothorax. Abdomen absent,



Figs. 161-170 *Pseudanuretes pomacanthodi* sp. nov. 161-165. Female 166-170. Male ;
 161. Leg 2, exopod ; 162. Leg 3 ; 163. Leg 4 ; 164. Legs 5 & 6 ;
 165. Caudal ramus ; 166. Male, dorsal view ; 167. Antenna ; 168.
 Maxilliped ; 169. Leg 2, exopod ; 170. Legs 5 & 6 and caudal ramus.

caudal rami originating from the ventral side of genital segment, each with two stout and three slender setae. Egg tubes stout but short, with six large eggs.

Antennule with deep and flattened basal segment with sparsely distributed slender setae, distal segment nearly as long as basal, very slender. Basal segment of antenna with a large process, second segment stout, third very slender, apically curved and acute, with prominent accessory claw situated in the basal half. Post-antennal process represented by a circular chitinous ridge and three bunches of hairs. Post-oral process absent. Maxillule composed of a nodule carrying two setae. Maxilla very slender, basal segment stouter than distal, latter without outer lobe, claws highly dissimilar and apparently unarmed, whip-like process near base indistinctly two-jointed. Maxilliped massive, basal segment very stout, distal short but stout and moderately curved, with a spine. Sternal fork absent.

First leg rather stout, vestigial endopod a long spine narrowing distalwards, first segment of exopod short but deep, with prominent outer distal spine, second segment with three slender claws, a spine-like seta between the second and third claws and three ventral setae. First segment of exopod of second leg with a stout claw over-reaching the third segment, claw of second segment also stout but shorter than first, third claw small, first seta alone modified; endopod segments hairy. Third leg with one jointed rami, claw at the base of exopod small and straight, outer spines on exopod especially the fourth elongated and setiform. Fourth leg very long, slender and two-jointed, basal segment with distal seta, distal segment with a pectinate distal spine. Fifth leg represented by three setae.

Length.—1.15 mm.

Male.—Cephalothorax nearly circular, with low frontal plates, postero-median lobe covering only a small part of the genital segment, posterior sinuses small but clearly visible. Genital segment small, nearly circular. Abdomen small, caudal rami with four very long and two short setae.

Antenna with short, very slender, strongly curved distal segment, with two accessory claws, second segment with proximal and distal adhesion pads, basal segment without process. Distal segment of maxilliped shorter and basal broader than in female. Claws on exopod of second leg more slender. Fifth leg composed of four and sixth of two setae.

Length.—0.89 mm.

Remarks.—*Pseudanuretes* contains three species namely *P. chaetodontis* Yamaguti, 1936, *P. fortipedis* Kabata, 1965 and *P. pomacanthi* Lewis, 1964. *P. schmidti* Rangnekar, 1957 is apparently not a member of

this genus. All the three species show such close similarity that the genus is well characterised. The main character which helps to distinguish the species is the nature of the fourth leg. In *P. chaetodontis* this leg is composed of a short segment carrying a spine-like seta. In *P. fortipedis* this leg is two-jointed and folded as usual and ends in a single naked spine. In *P. pomacanthi* the leg is two-jointed but ends in two spines. In the nature of the fourth leg *P. pomacanthodi* resembles *P. fortipedis* but the apical spine is jointed and pectinate.

Kabata did not describe *P. fortipedis* in detail but observed that it closely resembles *P. chaetodontis* in the nature of its appendages. A comparison of the illustrations included here with those published by Yamaguti shows a number of small but significant differences. Kabata has illustrated two spines on the distal segment of the antenna of the male. In *P. pomacanthodi* there are two backwardly directed processes. We do not rule out the possibility that *P. pomacanthodi* may turn out to be the same as *P. fortipedis* but for the present it is advisable to maintain their separate identity.

Genus *Heniochophilus* Yamaguti and Yamasu

Heniochophilus indicus Pillai

(Fig. 171)

1978. *Heniochophilus indicus* Pillai, *Aquat. Biol.*, 2 : 55, Figs. 15-29.

Material.—1 ♂ ♀ ♀, Reg. No. C2149/2 Zoological Survey of India, Calcutta, loc : Trivandrum, Kerala ; host : *Platax teira* (Forsk.) gills ; coll : C. Prabha.

Male.—Cephalothorax similar to that of female but armed dorsally with small tubercles, some of them carrying branched hair-like processes. Postero-median lobe perfectly semicircular and covering one fourth of the genital segment. Posterior sinuses distinct. Genital segment small, broader than long and laterally armed with tubercles identical to those on cephalothorax. Abdomen comparatively large, fused with genital segment. Caudal rami well developed. Appendages as in female.

Length.—1.4

Remarks.—This is the first record of the male of this genus. In the general nature of the cephalothorax the genital segment and the abdomen it closely resembles the male of *Pseudanuretes* except that the postero-median lobe of the cephalothorax, as in the female, is more produced backwards. The close similarity between the males of these two genera indicates that *Pseudanuretes* is more closely related to *Heniochophilus* than

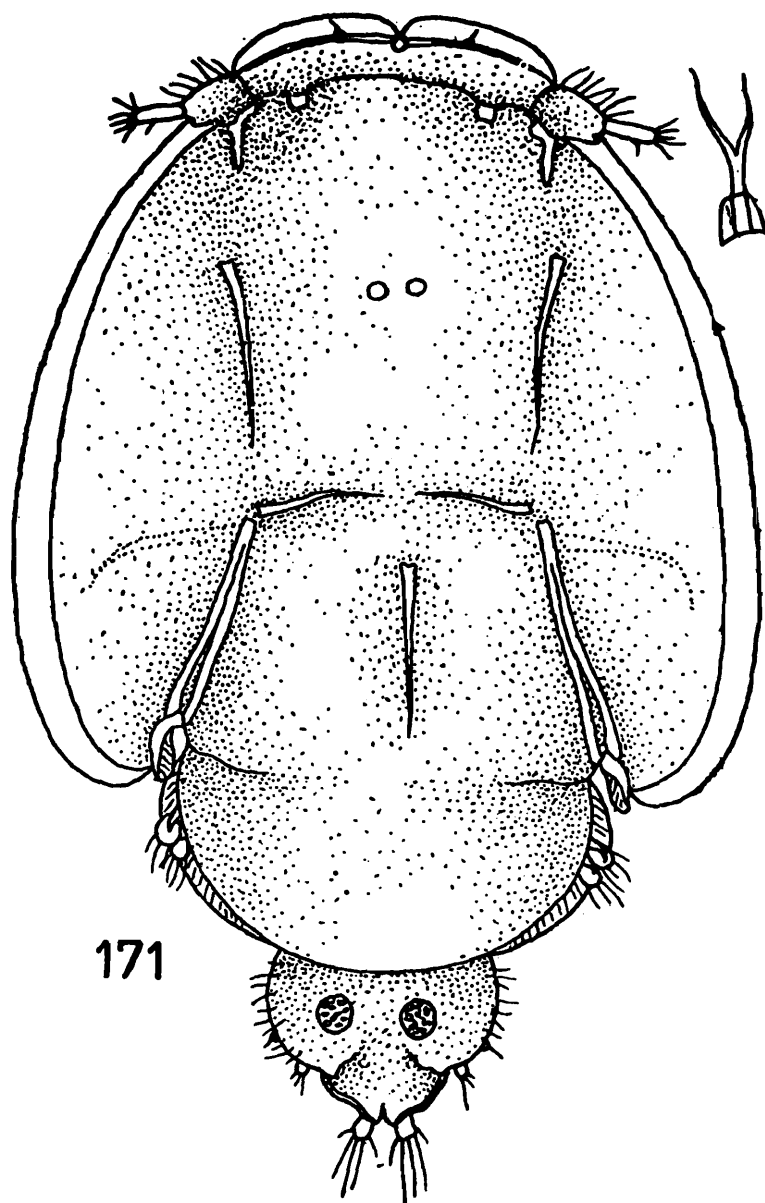


Fig. 171. *Heniochophilus plataxus* Pillai. 171. Male, dorsal view.

to *Anuretes* and *Lepeophtheirus* as against Yamaguti's classification of these genera. The male of *Mappates* is still unknown but one may assume that it will be similar to that of *Heniochophilus* and *Pseudanuretes*.

Genus *Mappates* Rangnekar

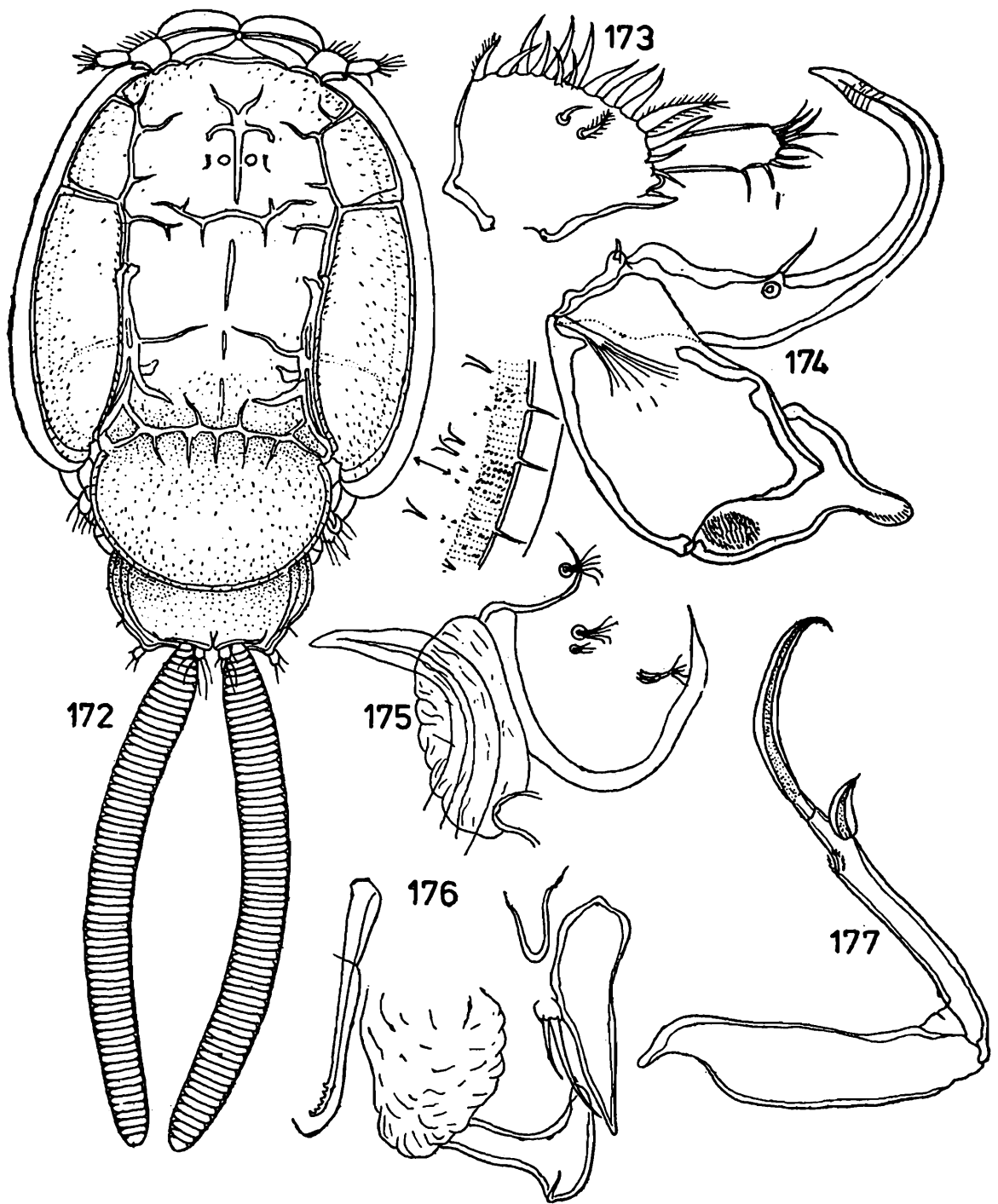
Mappates plataxus Rangnekar

(Figs. 172-187)

1958. *Mappates plataxus* Rangnekar, *Rec. Indian Mus.*, 53 : 304, Fig. 1.
 1964. *Eirgos plataxus*, Kirtisinghe, *Bull. Fish. Res. Stn. Ceylon*, 17 : 77, Figs. 89-90
 1965. *Mappates plataxus*, Pillai, *Symposium on Crustacea, Cochin*, 5 : 1611, Fig. 120.
 1973. *Mappates plataxus*, Hameed and Pillai, *Hydrobiologia*, 42 : 403, Figs. 1-17.
 1978. *Mappates plataxus*, Pillai, *Aquat. Biol.*, 2 : 53, Figs. 1-14.

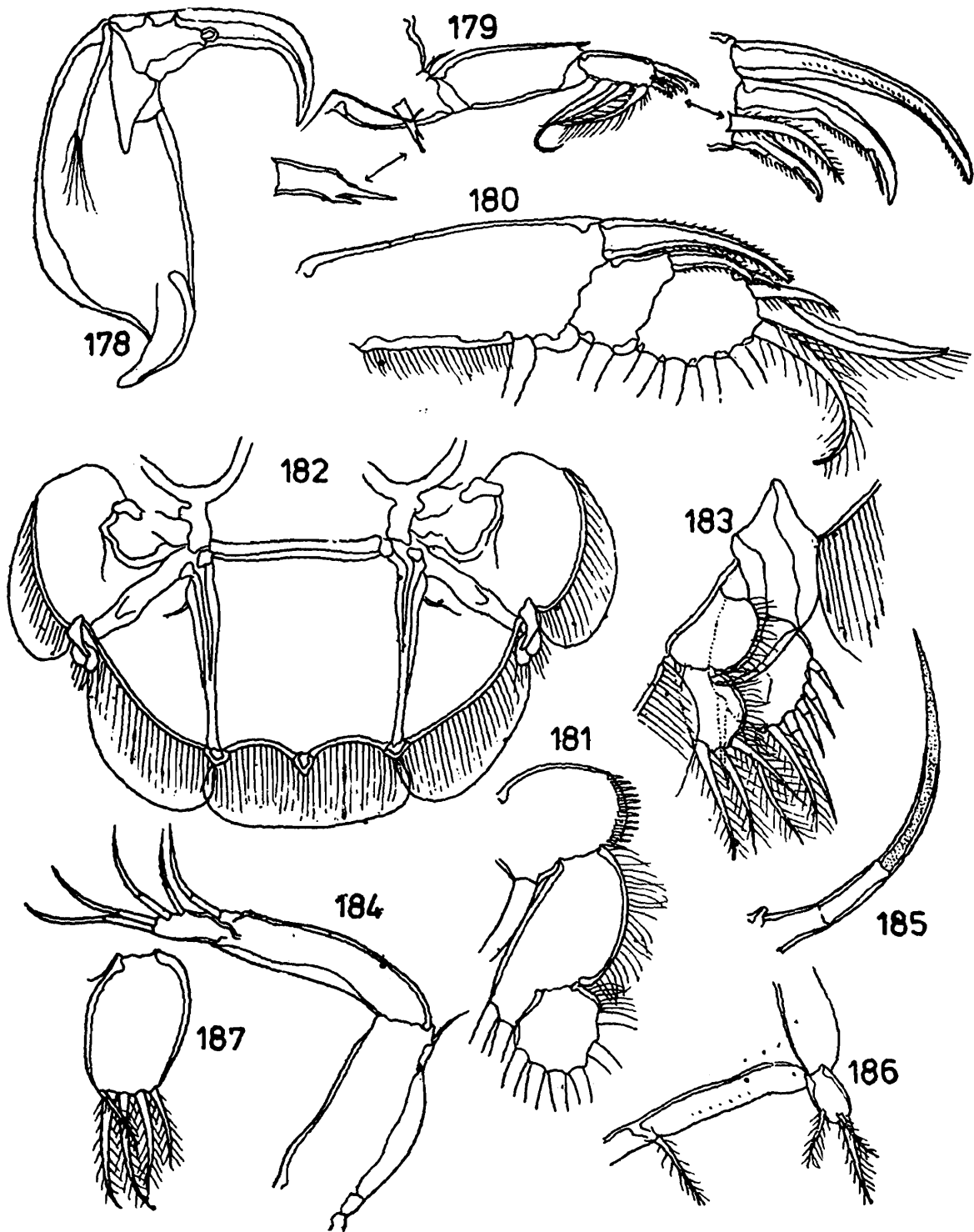
Material.—Several females from the gills of *Drepane punctata* (Linnaeus) examined at Trivandrum.

Female.—Cephalothorax elliptical, with evenly curved borders. Frontal plates deep and projecting but not spoiling the even contour of the body. Membranous flange fairly broad. Postero-lateral lobes of cephalothorax comparatively small and slightly curving inwards, median lobe very large, perfectly semicircular and covering the fourth segment and nearly half of the genital segment. Dorsal transverse rib of cephalothorax branched, shifted to the level of the posterior sinuses and separating the median lobe from the cephalothorax. Longitudinal ribs starting from the posterior sinuses, composed of several parts and dividing the



Figs. 172-177 *Mappates plataxus* Rangneker. 172. Female, dorsal view ; 173. Antennule ; 174. Antenna ; 175. Tip of antenna, post-antennal process and pad ; 176. Post-oral process and maxillule ; 177. Maxilla.

cephalothorax into two lateral parts and a median part, latter twice as broad as former. Dorsal surface of cephalothorax armed with fine denticles of different sizes. Antero-lateral parts of cephalothorax with two pairs of marginal indentations continued inwards as prominent grooves. Genital segment enlarged, broadest in the middle, postero-laterally slightly produced and angular. Abdomen fused with the genital



Figs. 178-187 *Mappates plataxus* Rangnekar. 178. Maxilliped ; 179. Leg 1 ; 180. Leg 2, exopod ; 181. Same, endopod ; 182. Leg 3 ; 183. Same, rami enlarged ; 184. Leg 4 ; 185. Same, one of the claws enlarged ; 186. Legs 5 & 6 ; 187. Caudal ramus.

segment, visible as a low bilobed projection carrying the caudal rami, each ramus with five long setae. Egg sacs as long as cephalothorax.

Basal segment of antennule large, nearly equal in length and width, sparsely setose, lower distal part produced into a strong process, distal segment nearly half as long as basal. Basal segment of antenna with a moderately large apically flattened process, distal segment long, slender and strongly curved, with a proximal spine and median seta. Post-antennal process apparently absent but represented by a few bunches of hairs and a pad. Post-oral process replaced by a pad. Maxillule a small nodule carrying two unequal setae. Maxilla with short basal segment and long slender distal segment, inner distal claw situated away from the apical and with broad wings, apical claw very long and winged, outer flange situated opposite the inner claw. Basal segment of maxilliped stout, distal slender and apically strongly curved. Sternal fork absent.

Vestigial endopod of first leg ending in an apical and a subapical spine, first segment of exopod with long ventral row of hairs, distal segment armed exactly as in *Pseudanuretes* and *Heniochophilus*. Basal segment of exopod of second leg with a long stout claw as in *Heniochophilus*, second and third claws short, first two setae modified. First segment of endopod with a row of spines, others hairy. Apron of third leg enlarged, rami reduced and one-jointed, exactly as in *Heniochophilus*, *Pseudanuretes* and some species of *Anuretes*. Two longitudinal ribs meeting the distal border of the apron project as rounded elevations with an identical projection between them, border of the apron between the projections deeply concave. Membranous flange very broad. Fourth leg two-or indistinctly three-jointed. Basal segment enlarged, with distal seta, second segment with one claw, third with four claws successively increasing in length, each claw with a false partition and beyond the partition showing a pitted appearance. Fifth leg represented by one seta and sixth by a nodule carrying one long and two short setae.

Length.—3.0 mm.

Remarks.—This genus includes only two species, *M. plataxus* and *M. alter* Kabata, 1964 which show such clear cut differences in the shape of the genital segment and the apron of the third leg that they can be easily distinguished.

Because of the faulty original discription of the type species, *M. plataxus*, by Rangnekar a lot of confusion arose. Hameed and Pillai (1973) redescribed it. We are giving yet another description as in the discussion which follows reference will have to be made to details of its morphology.

DISCUSSION

Yamaguti (1963) classified family CALIGIDAE thus :

Subfamily CALIGINAE

Genus *Caligus* Muller

Sciaenophilus van Beneden

Pseudocaligus Scott

Caligopsis Markewitsch

Parapetalus Steenstrup and Lutken

Synestius Steenstrup and Lutken

Alicaligus Shiino

Caligodes Heller

Subfamily ANURETINAE

Genus *Anuretes* Heller

Pseudanuretes Yamaguti

Subfamily ECHETINAE

Genus *Echetus* Kroyer

Subfamily LEPEOPHTHERINAE

Genus *Dartvellia* Brian

Calistes Dana

Calina van Beneden

Pupulina van Beneden

Diphyllogaster Brian

Homoioetes Wilson

Dentigryps Wilson

Hermilius Heller

Abasia Wilson

Heniochophilus Yamaguti and Yamasu

Lepeophtheirus Nordmann

Pseudolepeophtheirus Markewitsch

Subfamily MAPPATINAE

Genus *Mappates* Rangnekar

After the publication of Yamaguti's work a number of caligid genera were erected and suggestions for invalidating at least a few well established genera were put forth. Disagreement has also been voiced regarding the classification proposed by Yamaguti. In the following discussion we attempt a review of the literature on the subject published since Yamaguti published his and comment on the validity of the various genera.

According to the key provided by Yamaguti Subfamily Echetinae is characterised by the absence of lunules. But *Echetus*, the type and only genus in the subfamily, has lunules. Hence Echetinae merges into Caliginae. Subfamily Mappatinae is characterised by the prolongation of the postero-median lobe of the cephalothorax so as to cover the fourth thoracic segment and a good part of the genital segment. This is so at least in some species of *Anuretes*, *Pseudanuretes* and *Heniochophilus*. It should also be pointed out that the inadequate original description of *M. plataxus* also must have prompted Yamaguti to create Mappatinae. *Mappates* surely can go in Anuretinae. Only three subfamilies, Caliginae, Lepeophtherinae and Anuretinae are therefore valid.

Caligus is the type genus of subfamily Caliginae. All genera possessing lunules, irrespective of other differences should come in this subfamily. *Pseudocaligus* differs from *Caligus* only in the reduction of its fourth leg to a stump carrying one or two setae or even to a single seta. *Caligopsis* differs from *Caligus* and *Pseudocaligus* in the total absence of the fourth leg. As the difference between these three genera is the extent of the reduction of the fourth leg, an appendage which shows all stages of degeneration among caligids, the validity of *Pseudocaligus* and *Caligopsis* has to be reassessed.

Metacaligus was proposed by Thomsen (1949) as a subgenus of *Caligus* to include species lacking sternal fork. Ho and Bashirulla (1977) raised it to the generic rank. They also observed that out of the five species of *Caligus* lacking sternal fork only three belong to *Metacaligus*. This suggestion was prompted by the difference in the nature of the first and second legs between the two groups. The difference is indeed significant but it should be remembered that within a fundamental pattern the legs of *Caligus* spp. show endless variety. Hence a more natural course would appear to be to include all species lacking sternal fork under *Metacaligus* as suggested by Thomsen. If one takes the various caligid genera into consideration it can be seen that at least in a few genera there are species with or without sternal fork. But it may serve as a convenient basis for the division of genera, especially overburdened ones like *Caligus*.

Sciaenophilus differs from *Caligus* in having an abdomen which is longer than the rest of the body and in lacking sternal fork. As we have already seen at least five species formerly placed in *Caligus* lack sternal fork and *Caligus bennetti* has an abdomen which is considerably longer than the rest of the body. *C. reniformis* lacks sternal fork and its abdomen is as long as the rest of the body. Surely the gap between *Caligus* and *Sciaenophilus* is getting narrowed.

The recently created genus *Caritus* is hardly distinguishable from

Caligus in general appearance. But the appendages are very characteristic. The post-antennal process and sternal fork are absent and the second and third legs are peculiar, the third leg especially so. A somewhat identical third leg is present in *Kabataella* belonging to Lepeophtherinae. *Caritus* is a good genus but only the discovery of additional species can confirm its validity. This is indeed the case with regard to monotypic genera such as *Caligopsis*, *Synestius* and *Midias*.

Among the genera of Caliginae the post-cephalothoracic part of the body exhibits two distinct lines of evolution. In the first group the genital segment or abdomen or both undergo enlargement by simple flattening. In the second the genital segment and abdomen get elongated. In both groups the cephalothorax remains virtually unchanged, except for the enlargement of the maxillipeds.

In *Synestius* the genital segment is enlarged to the size of the cephalothorax (this is so in some species of *Caligus*) and has two pairs of digitiform processes. In *Alicaligus* and *Abasia* both genital segment and abdomen are enlarged and flattened and subequal to the cephalothorax in size. The same character is exhibited by *Parapetalus* though in two species namely *P. orientalis* and *P. occidentalis* the genital segment is much broader than the cephalothorax. The condition in *Parapetalus* is identical to what one finds in *Caligus parapetalopsis* and *C. grandiabdominalis*. Thus the main character namely the enlargement of the genital segment and abdomen, supposed to help in distinguishing *Parapetalus*, *Alicaligus* and *Abasia* from *Caligus* is quite variable and is also evident in some species of *Caligus*.

Caligodes, *Pseudopetalus*, *Echetus*, *Parechetus* and *Pseudechetus* exhibit elongation of the post-cephalothoracic part of the body. In all these the fourth thoracic segment fuses with the genital segment partially or fully and the complex thus formed is an elongated neck, short in *Caligodes* and very long in *Echetus*. In *Echetus* the genital segment lacks processes and the abdomen though swollen is cylindrical. In *Pseudopetalus* the neck is short as in *Caligodes* but both genital segment and abdomen are elongated and flattened. In *Caligodes* the genital segment is produced into a pair of large flattened processes remaining dorsal to the abdomen. The abdomen is cylindrical. In *Parechetus* the genital wings are ventral to the abdomen and the abdomen is expanded into lateral lobes or wings remaining dorsal to the genital wings. In *Pseudechetus* the genital segment has two pairs of cylindrical processes, more or less as in *Synestius* but the abdomen has a pair of processes similar to those on the genital segment.

In all the above mentioned genera the cephalothorax is comparatively small (except in *Synestius*) and cannot provide adequate attachment. They

have therefore large maxillipeds which pinch the skin of the host and the parasite remains virtually hanging inside the buccal cavity or the throat which is generally the site of attachment. This mode of attachment perhaps resulted in the elongation of the body.

Subfamily CALIGINAE now contains the following genera :

Caligus Muller
Pseudocaligus A. Scott
Caligopsis Markewitsch
Metacaligus Thomsen
Sciaenophilus van Beneden
Caritus Cressey
Caligodes Heller
Echetus Kroyer
Parechetus Pillai
Pseudechetus Prabha & Pillai
Abasia Wilson
Alicaligus Shiino
Midias Wilson
Synestius Steenstrup & Lutken
Parapetalus Steenstrup and Lutken
Pseudopetalus Pillai
Caligulus Heegaard
Caligulina Heegaard

Not all the above genera are apparently valid. For example *Alicaligus* shows unmistakable resemblance to *Abasia* and may be a synonym. *Midias* in all probability is a synonym of *Caligus*. *Caligulina* was created on a single male which has two very peculiar characters, namely a pair of conspicuous conspicillae in front of the eyes and a very peculiar third leg. The sternal fork is absent. But it must be pointed out that it is inadvisable to create species based solely on males. Until the female is found and described the validity of *Caligulina* must be kept in doubt.

Heegaard placed *Caligulus* in Euryphoridae alleging that dorsal plates of the third segment entirely cover the fourth segment. In euryphorids the dorsal plates belong to the fourth segment and not the third. It is obvious that *Caligulus* is a synonym of *Caligus*. The postero-median lobe of the cephalothorax is highly produced as in some members of the subfamily Anuretinae but this does not exclude it from Caliginae.

The presence or absence of cuticular structures like the post-antennal and post-oral processes and the sternal fork, if not accompanied by other dependable characters, are not sufficient for differentiating genera. The shape of the post-cephalothoracic part of the body is apparently the

most important character depended upon in creating genera. At least in a few cases this character shows much intraspecific variation creating problems for the taxonomist.

The morphology of the males is very significant. Notwithstanding the very wide difference in the shape of the body of the females the males of the various genera show similarity to that of *Caligus*. The males which are more free from the influence of the host retain the original shape and reveal the homogeneity of the Caliginae.

Lepeophtheirus is the type genus of Lepeophtherinae and should be taken as the basis for assessing the validity of the genera. Species of *Lepeophtheirus* fall into two groups, one with distinct abdomen and the other with the abdomen short or nearly absent. Species of the latter group are taxonomically important as they closely resemble *Anuretes*. Ho and Dojiri (1977) even made *Anuretes* a synonym of *Lepeophtheirus*.

Pillai (1970) made *Homoiotetes* a synonym of *Lepeophtheirus* after studying the paratypes of *H. palliata* in the British Museum (N. H.) London. Kabata (1973) examined the type collection in the U.S. National Museum and reported that it consists of a mixture of three species namely *L. parvipes* Wilson, *L. breviventris* Fraser and McLean and *L. bifidus* Fraser. *Homoiotetes*, therefore, becomes a synonym of *Lepeophtheirus*.

Pillai (1966) suggested that *Dentigryps* is a synonym of *Lepeophtheirus* and Hewitt (1971) actually made it a synonym. Ho and Dojiri re-examined this question and concluded that *Dentigryps* as defined by Lewis (1964) may be recognised as valid and that *Lepeophtheirus lichiae* Barnard, 1948 and *L. spinifer* Kirtisinghe, 1937 may be transferred to it. We disagree with this suggestion as examination of the known species of *Dentigryps* and *Lepeophtheirus* shows a progressive elongation of the fifth leg. There is no doubt that *Dentigryps* is a synonym of *Lepeophtheirus*.

Pillai and Padmanabhan (1963) observed that *Diphyllogaster thomsoni* Brian, 1899 is probably a synonym of *Pupulina brevicauda*. Brian's description of the species is not detailed enough for making a decision. These two species resemble in every detail except that in *D. thomsoni* the first leg is uniramous.

This brings us to the question whether *Pupulina* belongs to the subfamily Lepeophtherinae. In *Pupulina* legs one to three are biramous and fourth uniramous. No caligid has this type of legs. Yamaguti included three genera namely *Calina* van Beneden, 1892, *Calistes* Dana, 1852 and *Dartvella* Brian, 1939 under Lepeophtherinae. The information available on these genera is meagre. *Calina* is probably a synonym of *Pupulina* as it has accessory lobe on the post-oral process and biramous first leg. However *Calina* has sternal fork unlike *Pupulina*. In *Calistes* legs one to

four are apparently biramous though the endopod of the first is very small. *Dartvellia* in addition to having large abdominal lobes has minute rami on the third leg. Until more accurate information on these three genera becomes available nothing definite can be stated. It would appear that *Calina*, *Calistes*, *Pupulina* and probably *Dartvellia* and *Diphyllogaster* can form a separate subfamily.

Among the other well known genera *Pseudolepeophtheirus* differs from *Lepeophtheirus* only in the absence of the fourth leg. *Heniochophilus*, which Yamaguti placed in this subfamily, must be transferred to Anuretinae and *Abasia* to Caliginae. Wilson placed *Paralebion* in Euryphoridae. But like *Midias* this genus belongs to Caligidae and *Paralebion* should come under Lepeophtherinae. *Hermilius*, though very peculiar, satisfies all conditions for inclusion in Lepeophtherinae. Prabha and Pillai (in Press) described *Kabataella* which is very different from all other caligids but it can only be accommodated in Lepeophtherinae. The characters of the genera of Lepeophtherinae are such that the subfamily lacks homogeneity. It contains the following genera :

Lepeophtheirus Nordmann
Pseudolepeophtheirus Markewitsch
Hermilius Heller
Pupulina van Beneden
Diphyllogaster Brian
Paralebion Wilson
Kabataella Prabha & Pillai
Dartvellia Brian
Calina van Beneden
Calistes Dana

Difference between *Lepeophtheirus* and *Anuretes* is so unstable that it is difficult to define Anuretinae. However the following genera must come under it :

Anuretes Kroyer
Pseudanuretes Yamaguti
Heniochophilus Yamaguti and Yamasu
Mappates Rangnekar

Mappates has very unusual characters which isolate it from the rest. But this is so with respect to *Caritus* in Caliginae and *Kabataella* in Lepeophtherinae. Anuretine copepods show the following combination of characters :—Cephalothorax usually broader at the hind end, median lobe of cephalothorax always broader than lateral lobes, often appreciably overlapping the fourth segment and even part of the genital segment. Latter generally broader than long ; fourth segment always very short.

Abdomen very small or absent. Basal segment of antennule generally deep, often with lower distal process, setae few but long and slender. Antenna, post-antennal process, post-oral process and sternal fork generally small, one or other often absent. Maxillule shifted forwards. Maxillipeds generally large. Spine-like seta on distal segment of first leg placed between second and third claws. First claw on exopod of second leg large, overreaching the third segment, endopod segments externally hairy. Rami of third leg one-jointed, often degenerated. Genital segment of male without processes carrying the vestigial legs.

Though the above characters apply to the subfamily as a whole it should be conceded that certain species of *Anuretes* closely resemble species of *Lepeophtheirus*. On the other hand aberrant species of *Lepeophtheirus* like *L. latigenitalis* Pillai and Natarajan and *L. rotundigenitalis* sp. nov. have many of the characters of *Anuretes*. Kabata (1964) observed in *Pseudanuretes* what he termed a whip-like process at the base of the maxilla. He supposed that it is a generic character. This whip-like process is present in *Heniochophilus*, *Anuretes* and in *Lepeophtheirus*. All those who have dealt with the subject have conceded that lepeophtherine and anuretine copepods cannot be easily distinguished from one another. Yet the two groups have each a set of characters which enables a worker familiar with them to identify them.

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