

# Copepods parasitic on South Indian Fishes : Family Bomolochidae—3

BY

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(With eight text-figures)

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The present paper describes eight species of *Bomolochus*, four of which are new. In a previous publication (Pillai 1962) I described a new species, *B. aculeatus*, closely resembling *B. leptoscari* Yamaguti (1953) and *Orbitacolax uniunguis* Shen (1957), and also expressed the opinion that *Orbitacolax* cannot be considered as distinct from *Bomolochus*. While describing *B. aculeatus* Pillai, I overlooked its close similarity to *Taeniacanthus hapalogenyos* Yamaguti & Yamasu (1959). The position of the maxilliped with respect to the other mouth parts easily distinguishes bomolochids from taeniacanthids. Yet an experienced worker like Yamaguti erred in placing the above-mentioned species under Taeniacanthidae. It is likely that *B. aculeatus* is the same as *B. hapalogenyos* (Yamaguti & Yamasu).

Wilson (1911), Yamaguti (1939), and Shen (1957) attempted a division of *Bomolochus* into genera or subgenera. As shown by Stock (1953) this division is quite unnatural and the above-mentioned authors themselves contradicted their own observations. In the present study this division is not followed.

Wilson (1911) observed that in Bomolochidae the male is free-living and that mating takes place before the female seeks out a host. Gnanamuthu (1947) and Stock (1953) showed that this is not so. During the course of the present investigation I have been able to collect the males of three species of *Bomolochus* in good numbers and some of them were actually observed in copulation. It is true that the males of a vast majority of species are unknown, but this is not because they are free-living. The male is invariably small and nearly transparent and hence easily overlooked. Flushing the opercular

chamber with water and examining the residue under a binocular microscope was always found highly rewarding.

During the present investigation the detailed structure of the spines arming legs two to four has been found to constitute a very useful diagnostic character. The second antenna of *Bomolochus* has often been described as two-, three-, or even four-segmented. In all the species I have been able to examine this appendage is three-segmented. What is described as the fourth segment is a linguiform prolongation of the third segment. Similarly the fifth leg has been occasionally described as three-segmented, but it consists of only two segments.

Bomolochids are extremely common but only four species, *B. megaceros* Heller (1865), *B. tricerus* Bassett-Smith (1898a), *B. multispinosus* Gnanamuthu (1947), and *B. acutus* Gnanamuthu (1948) have so far been described from this region.

### Genus *Bomolochus* Nordmann

#### *Bomolochus tricerus* Bassett-Smith

*Bomolochus tricerus* Bassett-Smith, 1898a, p. 2, pl. 1, f. 1. ? *Bomolochus managatuwo* Yamaguti, 1939, pl. 3, figs. 28-29, pl. 4, figs. 30-37.

Text-fig. 15.

**Material.** 3 females were collected by the author from the inner surface of the opercle of *Pampus argenteus* (Euphrasen) at Trivandrum.

**Female.** Carapace much broader than long, its antero-median part deeply incised, and posterior border nearly straight. Second thoracic segment posteriorly concave, third segment narrower than second and overlapping the fourth segment, latter short, less than half as broad as third segment, fifth segment very small. Genital segment broader than long, subequal to the first abdominal segment. Abdomen long and four-segmented. Anal laminae longer than broad, with a long distal seta and three smaller setae.

First antenna indistinctly seven-segmented, first four segments stout and partially fused, last three segments slender, second segment with a short but broad process carrying three stout but subequal spines, middle spine chitinised and blunt, others rugose and apically drawn out, second and third segments carrying five modified setae, first seta very long and placed close to the spines. Distal segment of second antenna with well-spaced tubercles and produced into a linguiform process, its distal border with seven claws and a toothed blunt process.

Mandibular blades subsimilar, spiny along the lower border. First maxilla with four plumose setae, two of them large. Blades of second maxilla long and pointed, with barbed edges. Maxilliped with very long claw and three pectinate setae, claw without accessory process.

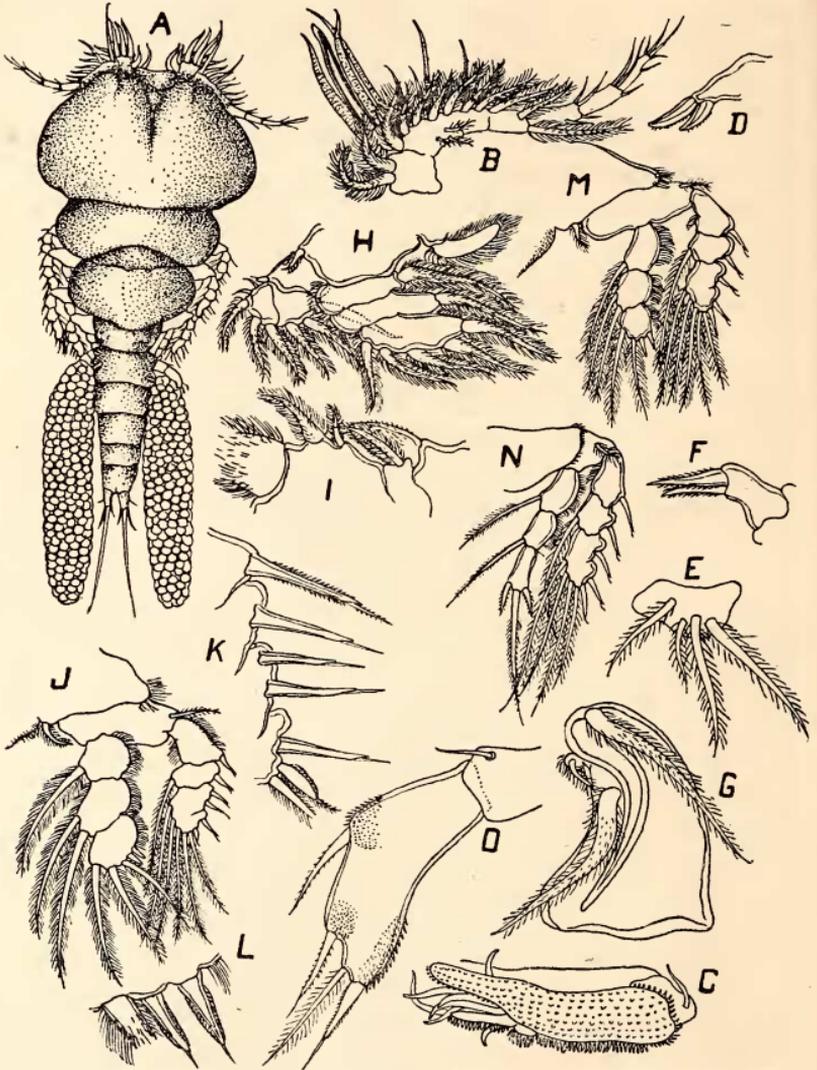


Fig. 15. *Bomolochus tricerus* Bassett-Smith. Female: A. dorsal view; B. antenna 1; C. antenna 2; D. mandible; E. maxilla 1; F. maxilla 2; G. maxilliped; H. leg 1; I. same, exopod; J. leg 2; K. same, exopod; L. same, tip of endopod; M. leg 3; N. leg 4; O. leg 5

First leg with three-segmented rami. Exopod of second leg with five strong, barbed spines, each with a trigger-like apical spinule, sixth

spine broad and blunt, with an outer flange and pectinate subapical spinule, endopod only slightly broader than exopod, distal segment with two identical short spines, with thin flange and an apical spinule. Exopod of third leg slightly broader than endopod, with five similar spines. Endopod of fourth leg very slender, first two segments with an outer long pectinate seta, third segment with one very long and two short pectinate spines. Distal segment of fifth leg with four spines and three groups of spinules. Egg sacs cylindrical, reaching the tip of the caudal setae.

Total length 2.2 mm.

**Remarks.** There are certain minor mistakes in the description of this species by Bassett-Smith. He described the second antenna as two-segmented, but it is, as usual, three-segmented and the distal segment carries seven and not four claws. The maxilliped has three setae, and not one as stated by Bassett-Smith. The rami of the first leg are three- and not two-segmented.

*Bomolochus (Pseudobomolochus) managatuwo Yamaguti (1939)* is so much like the present species even in minute details that I am almost sure that they are identical. Both are parasites of *Pampus argenteus*.

### **Bomolochus denticulatus Bassett-Smith**

*Bomolochus denticulatus* Bassett-Smith, 1898b, p. 77, pl. 3, f. 1.

Text-fig. 16.

**Material.** 28 females and 3 males were collected by the author from the inner surface of the opercle of *Sphyaena jello* Cuvier at Trivandrum.

**Female.** Carapace nearly semicircular, second thoracic segment only slightly narrower than carapace, its hind border slightly concave, third segment roughly equal in length and breadth, completely overlapping the fourth segment, fifth segment much broader than long, partially covered by the third segment. Genital segment slightly narrower than fifth segment. Abdomen three-segmented, anal laminae with one long and four short setae.

Basal segments of first antenna completely fused, with a large process carrying three comparatively short processes, middle process longer and chitinised, others pointed and rugose, modified setae four, one of them very short. Distal segment of second antenna sparsely

spiny, with six claws and a toothed process. Mandible and second maxillae as usual in the genus, first maxilla with three setae, its inner process hairy. Claw of maxilliped without accessory process, a minute knob is occasionally present.

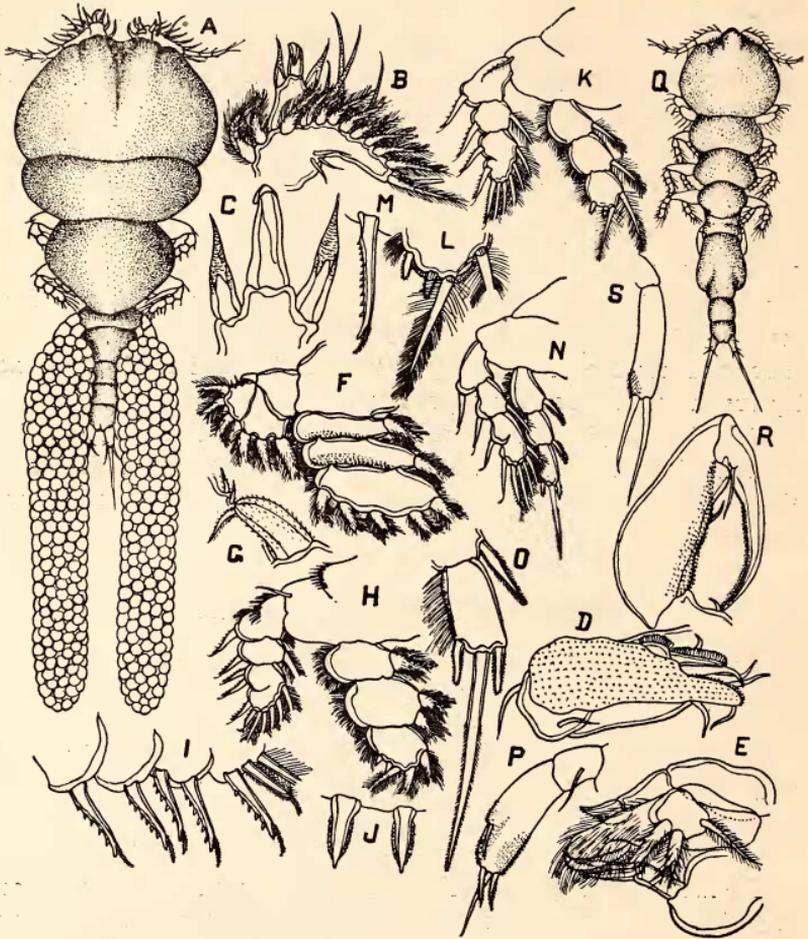


Fig. 16. *Bomolochus denticulatus* Bassett-Smith. A-P. Female: A. dorsal view; B. antenna 1; C. same, spinous processes; D. antenna 2; E. mandible and maxillae; F. leg 1; G. exopod; H. leg 2; I. exopod; J. tip of endopod; K. leg 3; L. tip of endopod; M. spine on exopod; N. leg 4; O. tip of endopod; P. leg 5. Q-S. Male: Q. dorsal view; R. maxilliped; S. leg 5.

Rami of first leg very much flattened, three-segmented, first two endopod segments pustulose: Endopod of second leg flattened, third segment with two stout but short-winged spines, exopod with six spines, first five with five to six teeth on the outer border and a

pectinate apical spinule, sixth spine apically blunt and externally pectinate. Third leg with subsimilar rami, spines on third endopod segment barbed, exopod similar to that of second leg. Endopod of fourth leg slender, with two short outer pectinate spines, third segment with two short and one very long pectinate spines. Fifth leg comparatively narrow, distal segment with three pectinate spines and a long spine seta. Egg sacs stout and cylindrical, as long as the body.

Total length 2.6 mm.

**Male.** Body slender, carapace nearly circular, with very prominent rostral process. Thoracic segments two to four steadily decreasing in length and breadth, fifth segment short, completely free. Genital segment pyriform and large, abdomen three-segmented, with parallel sides. Second and third segments of maxilliped with tuberculate inner border, each with a spine seta. Fifth leg slender, distal segment with long spines and a patch of spinules.

Total length 1.3 mm.

**Remarks.** As observed by Bassett-Smith this species can be easily distinguished by the shape of the prominent frontal processes on the first antenna, denticulated claws of the legs and the extremely enlarged third segment of the trunk. Bassett-Smith described the processes on the first antennae as very short, obtuse-ended bristles of about equal length. But the middle spine alone is obtuse-ended, the others are apically drawn out as usual. Generally these processes remain bent and their true shape will be visible only if examined under a cover glass.

### ***Bomolochus megaceros* Heller**

*Bomolochus megaceros* Heller, 1865, p. 153, pl. 13, f. 2.

Text-fig. 17

**Material.** Several females and males were collected by the author from the gills and inner surface of the opercle of *Parastromateus nigër* (Bloch) at Trivandrum.

**Female.** Carapace nearly twice as broad as long, frontal incision shallow and broad. Second thoracic segment slightly narrower than carapace, third segment as long as second but narrower, fourth segment transversely ovate and as long as third segment. Fifth segment transversely rectangular, slightly narrower than fourth.

Genital segment longer and broader than fifth, abdomen short, three-segmented. Anal laminae with two long distal setae and three or four smaller ones.

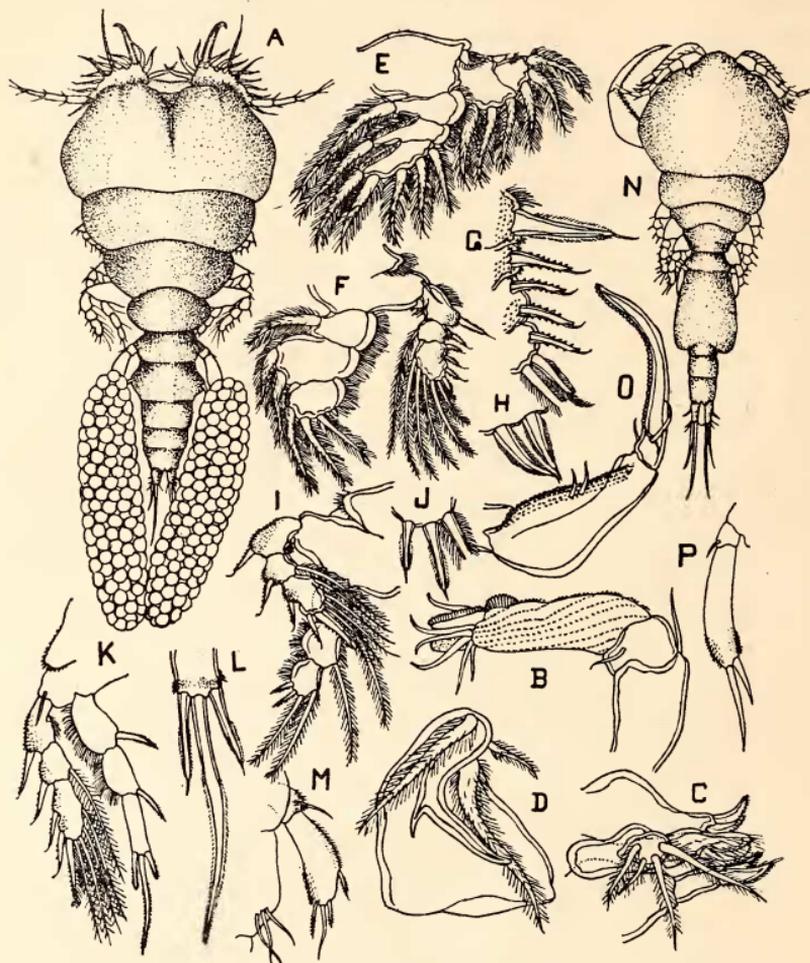


Fig. 17. *Bomolochus megaceros* Heller. A-M. Female: A. dorsal view; B. antenna 2; C. mandible and maxillae; D. maxilliped; E. leg 1; F. leg 2; G. exopod; H. tip of endopod; I. leg 3; J. tip of endopod; K. leg 4; L. tip of endopod; M. legs 5 and 6; N-P. Male: N. dorsal view; O. maxilliped; P. leg 5

First antenna with a prominent strongly curved chitinised process and a long and a short modified seta. Third segment of second antenna with longitudinal rows of spines, distal border with six claws and a blunt spiny process. Blades of mandible rather long and spiny. First maxilla with four setae, one of them very small, inner process

hairy. Second maxilla with broad barbed blades. Claws of maxilliped strongly curved, with a prominent sharp accessory process.

Exopod of first leg as broad as endopod and two-segmented. Exopod of second leg pustulose, first spine winged, second to fifth toothed on both sides, sixth winged on one side, all the spines with a subapical spinule, endopod very broad, third segment with two winged triggered spines. Exopod of third leg pustulose, spines barbed only on one side, third segment of endopod with two long pectinate spines. Exopod of fourth leg similar to that of third, endopod slender, with two pectinate outer spines and three distal spines, median distal spine very long. Fifth leg with a long simple spine seta and three pectinate spines on second segment. Sixth leg formed of three setae. Egg sacs large, with large eggs.

Total length 2.9 mm.

Male. Carapace nearly equal in length and breadth, with a short but broad rostrum. Trunk segments regularly narrowing, fifth segment broader than fourth. Genital segment longer than broad, broader behind. Abdomen three-segmented. Distal segment of fifth leg long and slender, with two short spines. Inner part of second segment of maxilliped with several rows of pustules, inner border of distal segment with a closely packed row of tubercles.

Total length 1.3 mm.

Remarks. Heller's figure of the entire animal is far from correct and in the illustrations of the appendages he has omitted practically all details. Nevertheless the identity of the present material is very clear.

### **Bomolochus multispinosus** Gnanamuthu

*Bomolochus multispinosa* Gnanamuthu, 1947, p. 309, figs. 1-5.

Text-fig. 18

Material. 3 females were collected by the author from the inner surface of the opercle of *Dussumieria hasselti* Bleeker at Trivandrum.

Female. Carapace nearly one and a half times as broad as long, slightly concave posteriorly, frontal sinus deep. Second thoracic segment transversely rectangular, third transversely ovate and partially overlapping the fourth segment, latter very narrow, fifth segment still narrower. Genital segment broader than fifth segment. Abdomen

three-segmented, narrowing backwards. Anal laminae  $2\frac{1}{2}$  times as long as broad, with a very long distal seta.

First antenna with a stout basal part carrying three large chitinised processes, middle process slightly longer than the others, modified setae four, first placed close to the third process. Distal segment of second antenna sparsely spiny, with a spinous process, four claws, and two spine setae. Mandible with two smooth blades, lower

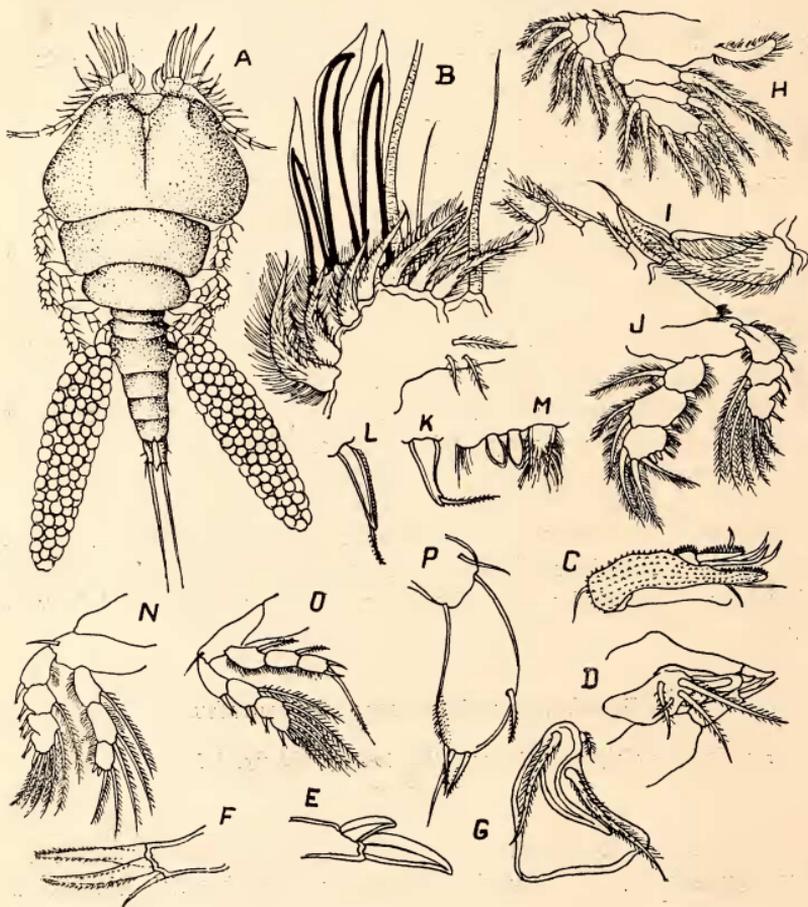


Fig. 18. *Bomolochus multispinosus* Gnanamuthu. Female: A. dorsal view; B. antenna 1; C. antenna 2; D. mandible and maxillae; E. mandible; F. maxilla 2; G. maxilliped; H. leg 1; I. exopod; J. leg 2; K-L. spines on exopod; M. tip of endopod; N. leg 3; O. leg 4; P. leg 5

blade smaller. First maxilla with one small and three large setae. Second maxilla with a slender spine and two long barbed blades. Claw of maxilliped moderately curved, without accessory process.

Rami of first leg three-segmented, exopod nearly as broad as endopod. Exopod of second leg with six spines, first five with forked tip carrying a spinule, last spine with a frilled external flange, endopod only very slightly broader than exopod, its distal segment with two blunt ovate spines with thin border. Third leg smaller than second. Fourth leg smaller than third, rami very slender, endopod with two outer pectinate spines and three distal spines, middle distal spine very long. Distal segment of fifth leg with a long spine seta and three pectinate spines.

Total length 2.3 mm.

**Remarks.** As Gnanamuthu has given only simple illustrations the more obvious differences alone could be pointed out. The first maxilla has four setae and the second maxilla a slender spine in addition to the two blades. The maxilliped carries three instead of two setae. The terminal segment of the endopod of the first leg carries five and not six setae. Gnanamuthu described legs two to four as similar, but they show clear differences in size as well as in armature. He has described the exopods of the legs as four-segmented, but the strong constriction on the distal segment does not appear to indicate a fourth segment.

*B. multispinosus* has the closest resemblance to *B. tricerus* Bassett-Smith but in the latter only the middle process of the first antenna is chitinised. In the structure of the spines on the legs also they differ.

### **Bomolochus selaroides** sp. nov.

Text-fig. 19

**Material.** 5 females were collected by the author from the inner surface of the opercle of *Selaroides leptolepis* (Cuvier) at Trivandrum. Holotype, female, is deposited in the Indian Museum, Calcutta (Reg. No. C4613/1).

**Female.** Carapace broader than long, with a broad prominent frontal incision and a pair of shallow lateral ones. Second trunk segment narrower than carapace, its hind border concave. Third segment transversely ovate, as long as second but narrower, fourth segment transversely oblong, fifth segment very small. Genital segment large, twice as long as fifth segment but much broader. Abdomen very short, three-segmented. Anal laminae slightly longer than broad. Egg sacs long and elliptical.

First antenna six-segmented, first three segments stout and partially fused, with a strong apically recurved chitinised process.

fourteen stout plumose setae and three modified setae, middle modified seta very long. Distal segment of second antenna with longitudinal rows of spines, margin with long closely packed blunt teeth, distal border with a blunt toothed process and a bunch of five claws. Mandible with two blades, upper blade large, curved, and spiny, lower

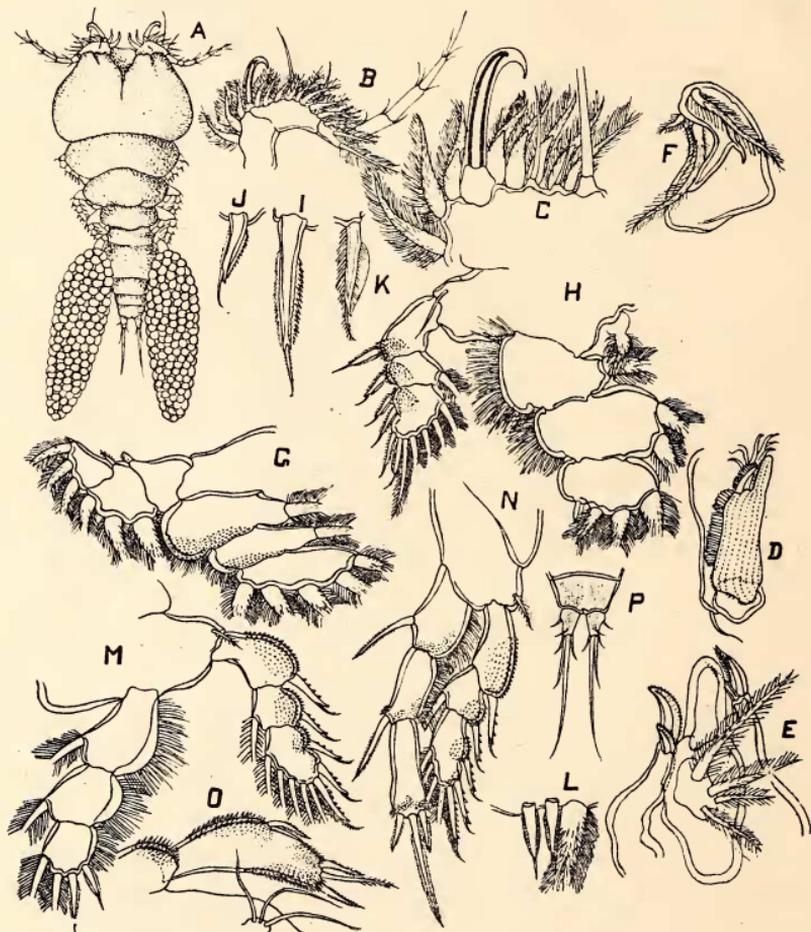


Fig. 19. *Bomolochus selaroides* sp. nov. Female: A. dorsal view; B. antenna 1; C. base enlarged; D. antenna 2; E. mandible and maxillae; F. maxilliped; G. leg 1; H. leg 2; I-K. spines on exopod; L. tip of endopod; M. leg 3; N. leg 4; O. legs 5 and 6; P. tip of abdomen

much smaller. First maxilla with four plumose setae, second maxilla with two unequal barbed blades. Claw of maxilliped with a prominent, curved, and acute accessory process.

First leg highly flattened, with three-segmented rami, first two endopod segments pustulose. Exopod of second leg pustulose, first spine winged, next four not winged, last externally winged, all the spines with a subapical pectinate spinule; endopod very broad, with two short winged spines, each with an apical spinule. Third leg with prominently pustulose exopod, spines externally toothed and with a subapical spinule, endopod only slightly broader than exopod, spines on third segment longer than those on second leg. Fourth leg with comparatively slender rami, both pustulose, exopod spines similar to those of third leg, endopod with two outer pectinate spines and three distal winged spines, middle distal spine moderately long. Fifth leg prominently spiny, with three pectinate spine setae and a slender plumose seta. Sixth leg formed of three simple setae.

Total length 2.1 mm.

**Remarks.** *B. selaroides* closely resembles *B. decapteri* Yamaguti (1936) even in details. The shape and the armature of the legs are almost identical, but in *B. decapteri* the body is more robust and comparatively short and the egg sacs almost oblong.

#### **Bomolochus hemirhamphi** sp. nov.

Text-fig. 20

**Material.** 20 females were collected by the author from the inner surface of the opercle of *Hemirhamphus marginatus* Forskal at Trivandrum. Holotype, female, is deposited in the Indian Museum, Calcutta (Reg. No. C4614/1).

**Female.** Body short but stout. Carapace semicircular, with shallow median and indistinct lateral grooves. Second trunk segment immersed in carapace, laterally rounded and posteriorly concave. Third segment transversely oblong, immersed in second segment, fourth segment fairly large, overlapping fifth segment, fifth segment as broad as genital segment. Abdomen short, three-segmented. Egg sacs oblong and short.

First antenna six-segmented, first three segments stout, with fourteen large plumose setae, a stout curved sickle-shaped spine, and three modified setae. Distal segment of second antenna with longitudinal rows of spines, margin with a row of closely packed teeth, distal border with a spiny process and six claws. Mandible with broad blades, lower blade much smaller. First maxilla with four setae. Second maxilla with a small spine and two long strongly barbed blades. Claw of maxilliped with prominent accessory process.

First leg with moderately flattened three-segmented rami. Exopod of second leg with six spines, each spine with outer wing and subapical

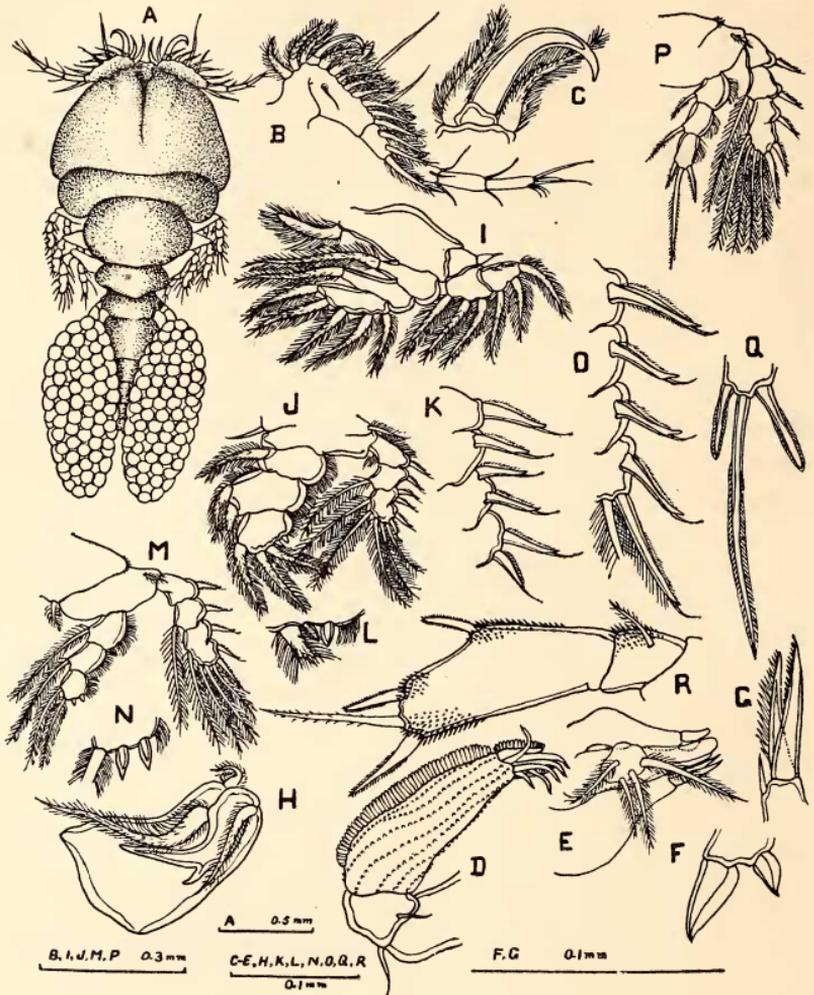


Fig. 20. *Bomolochus hemirhamphi* sp. nov. Female: A. dorsal view; B. antenna 1; C. chitinous process; D. antenna 2; E. mandible and maxillae; F. mandible; G. maxilla 2; H. maxilliped; I. leg 1; J. leg 2; K. exopod; L. tip of endopod; M. leg 3; N. tip of endopod; O. exopod; P. leg 4; Q. tip of endopod; R. leg 5

spinule, endopod broad, with two short blunt spines. Third leg with subsimilar rami, exopod very slightly broader, with five spines, very much similar to those on second leg except that the first spine is winged on both sides and the fifth is much longer. Exopod of fourth leg

exactly like that of third, endopod slender, with two pectinate outer spine setae and three distal winged spines, median distal spine very long. Distal segment of fifth leg with three strong, pectinate spines, each with a patch of spinules at its base and a long sparsely pectinate spine, basal segment with a seta and a patch of spinules.

Total length 1.8 mm.

**Remarks.** In the general shape of the body and the structure of the appendages *B. hemirhamphi* closely resembles *B. decapteri* Yamaguti (1936). They agree in the presence of a single spine on the first antenna, shape of the legs, especially of the first, second, and fifth pairs, and also in the shape of the egg sacs. But in *B. decapteri* the spines on the legs two to four are denticulated and the exopod segments are pustulose. In *B. hemirhamphi* the spines are winged and the exopod segments are not pustulose. *B. hemirhamphi* also resembles *B. hyporamphi* Yamaguti & Yamasu (1959), but in the latter the egg sacs are elliptical and Yamaguti & Yamasu make no mention of the armature of the spines on the legs. *B. hemirhamphi* has a spinule in addition to the two blades on the second maxilla; according to Yamaguti & Yamasu this spine is not present in *B. hyporamphi*. The present species also resembles *B. tumidus* Shiino (1957) to some extent.

#### ***Bomolochus kanagurta* sp. nov.**

Text-fig. 21

**Material.** 18 females and 6 males were collected by the author from the inner surface of the opercle of *Rastrelliger kanagurta* Cuvier at Trivandrum. Holotype, female, and allotype, male, are deposited in the Indian Museum, Calcutta (Reg. Nos. C4616/1 and C4617/1).

**Female.** Body stout and tumid. Carapace with a broad shallow frontal incision and a pair of lateral grooves, its posterior border nearly straight. Second trunk segment narrow, its hind border concave. Third segment transversely ovate, longer than second and almost completely hiding the fourth segment in dorsal view, fourth segment overlapping fifth, fifth segment short, slightly broader than first abdominal segment. Abdomen four-segmented, steadily narrowing backwards. Anal laminae twice as long as broad, with a long stout apical seta. Egg sacs as long as body in front of fourth segment, narrowing backwards, eggs large and rounded.

First antenna with a bunch of three spines borne on a chitinous base and three modified setae successively decreasing in length,

middle spine shorter than the lateral ones and chitinised. Distal segment of second antenna with longitudinal rows of denticles, distal border with a spiny process and six claws. Mandible with two curved subsimilar blades. First maxilla with four setae, two of them large, inner process spiny and hairy. Distal segment of second maxilla short, with a large spiny spatulate blade, a narrow strongly barbed

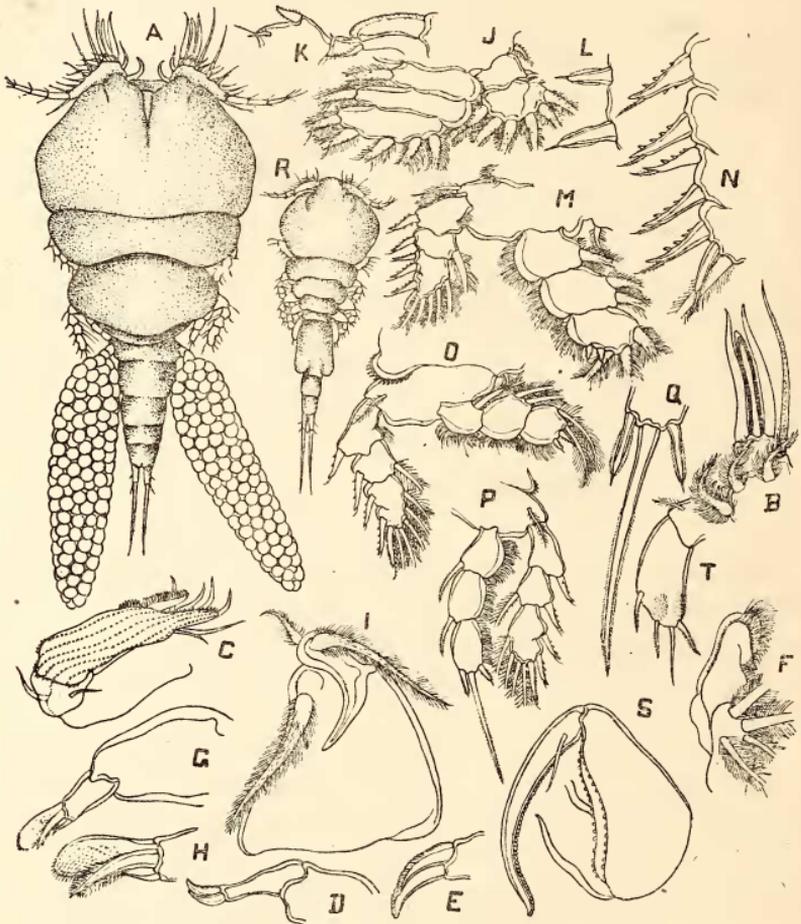


Fig. 21. *Bomolochus kanagurta* sp. nov. A-Q. Female: A. dorsal view; B. antenna 1, base; C. antenna 2; D. mandible; E. mandible, blades enlarged; F. maxilla 1; G. maxilla 2; H. blades enlarged; I. maxilliped; J. leg 1; K. exopod; L. tip of endopod, leg 2; M. leg 2; N. exopod; O. leg 3; P. leg 4; Q. endopod. R-T. Male: R. dorsal view; S. maxilliped; T. leg 5

spine, and a simple third spine. Second segment of maxilliped comparatively broad, claw short, with a small blunt accessory process.

First leg with three-segmented rami. Endopod of second leg broad, third segment with two short winged spines, each carrying an apical spinule, exopod with six spines, first spine toothed on both sides, second to fifth only on the outer side, and sixth without teeth, each spine with a pectinate apical seta. Endopod of third leg very slightly broader than exopod, exopod with five spines, last spine pectinate externally. Rami of fourth leg of equal breadth, spines on exopod similar to those on third leg, endopod with two outer pectinate spines and three pectinate distal spines, median distal spine moderately long. Fifth leg of uniform width, second segment with three pectinate spines and a simple seta.

Total length 2.5 mm.

Male. Carapace broader than long, with very prominent rostrum, trunk segments steadily narrowing backwards, genital segment large, abdomen three-segmented, slightly narrowing backwards. Second segment of maxilliped with two rows of tubercles, third segment with a spine and a marginal row of tubercles.

Total length 1.4 mm.

Remarks. In the shape of the processes of the first antenna *B. kanagurta* resembles *B. tricerus* Heller, but in the latter the nature of the third and fourth trunk segments and the spinulation of the legs are different. In the over-all shape of the body and the structure of the legs *B. kanagurta* also resembles *B. denticulatus* Bassett-Smith, but the structure of the processes on the first antenna easily distinguishes them. The denticulate and hairy inner process of the first maxilla and the spatulate blade of the second maxilla are very characteristic of *B. kanagurta*.

#### ***Bomolochus monoceros* sp. nov.**

Text-fig. 22

Material. 7 females were collected from the inner surface of the opercle of *Carangoides malabaricus* (Bloch) by the author at Trivandrum. Holotype, female, is deposited in the Indian Museum, Calcutta (Reg. No. C4615/1).

Female. Carapace roughly semicircular, with nearly straight hind border, antero-median groove fairly deep. Trunk segments steadily narrowing backwards. Genital segment enlarged, much longer than adjacent segments. Abdomen short, three-segmented. Anal

laminae short. Egg sacs long, slender, and cylindrical, nearly as long as the body.

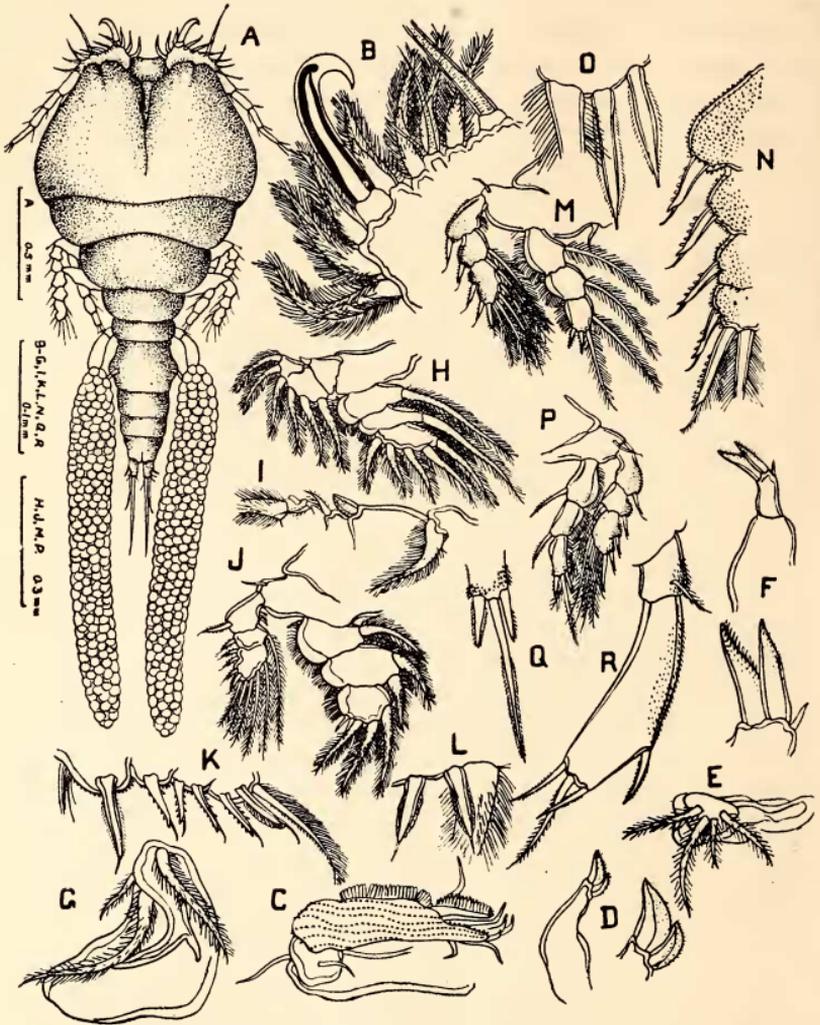


Fig. 22. *Bomolochus monoceros* sp. nov. Female: A. dorsal view; B. antenna 1; C. antenna 2; D. mandible; E. maxilla 1; F. maxilla 2; G. maxilliped; H. leg 1; I. exopod; J. leg 2; K. exopod; L. tip of endopod; M. leg 3; N. exopod; O. tip of endopod; P. leg 4; Q. endopod; R. leg 5

Basal part of first antenna with a single large chitinised, apically curved spine. Distal segment of second antenna with longitudinal rows of denticles, distal border with a bunch of seven comparatively weak claws. Mandible with broad spiny blades, lower

blade smaller. First maxilla with four setae. Second maxilla with a small spine and two subsimilar spiny blades. Claw of maxilliped with well-developed accessory process.

First leg with three-segmented rami. Endopod of second leg broad, with two winged spines, each carrying a spinule, exopod with six spines, first spine winged on both sides, last winged externally, others toothed on both sides, each spine with a subapical spinule. Endopod of third leg only slightly broader than exopod, latter with the surface pustulose and carrying five spines toothed externally, fifth spine comparatively large. Exopod of fourth leg similar to that of third, endopod with two outer pectinate spines and three distal spines, third segment distally spiny. Basal segment of fifth leg with a patch of spinules and a plumose seta, distal segment comparatively long and externally spiny, with three pectinate spines and a long spine seta.

Total length 1.9 mm.

**Remarks.** In the structure of the legs, particularly the spinulation of the exopods, this species resembles *B. decapteri* Yamaguti (1936) but in the latter the third trunk segment overlaps the fourth considerably and the egg sacs are oblong.

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