THREE NEW SPECIES OF BOMOLOCHIDAE (COPEPODA, CYCLOPOIDA) FROM TROPICAL ATLANTIC TUNNIES

by

W. VERVOORT
Rijksmuseum van Natuurlijke Historie, Leiden
with 22 text-figures

Dr. J. F. Aldrin, Sous Direction de Pêche, Abidjan, Côte d'Ivoire, during an extensive survey of tropical Atlantic Tunnies, discovered the presence of Cyclopoid Copepods of the family Bomolochidae in the nasal fossae of three species of tunnies, viz., *Euthynnus alleteratus* (Rafinesque), *Auxis thazard* (Lacépède) and *Sarda sarda* (Bloch). The material was placed into my hands for study by mediation of Dr. R. Repelin, Director, Centre de Recherches Océanographiques, Abidjan, Côte d'Ivoire. The material from *Euthynnus alleteratus* and *Auxis thazard* has been described below. From *Sarda sarda* I have sofar seen only two male specimens, that I cannot possibly distinguish from the males of one of the species observed in *Euthynnus alleteratus*. I will await the discovery of female specimens in the nasal fossae of *Sarda sarda* before dealing with the material from this host.

I want to express my sincere gratitude to Dr. R. Repelin and Dr. J. F. Aldrin for kindly supplying me with this interesting material.

Parabomolochus anonymus nov. spec. (fig. 1-6)

Material examined. — Gulf of Guinea, off Abidjan, Côte d'Ivoire, leg. Dr. J. F. Aldrin, 12 adult, partly ovigerous females from the nasal fossae of *Euthynnus alleteratus* (Rafinesque) (type host). An ovigerous female of 932 μ length has been selected the holotype; the drawings of the external appearance have been taken from this specimen. The remaining females vary in length between 1000 and 1150 μ and have been labelled as paratypes. One of the paratypes, a non-ovigerous female of 1030 μ length, has been dissected and the appendages mounted. All specimens and the slides are in the Rijksmuseum van Natuurlijke Historie, Leiden, the Netherlands.

Description. — Adult female, total length 932 μ. The greatest diameter of the body is at the cephalic somite, measuring 486 μ in width. The length of the cephalic somite, measured from the end of the rostral plate to the line

separating this somite from somite 2, is 215 μ, the diameter 486 μ. For the remaining somites these figures are: 121 and 457 μ for the second thoracic,

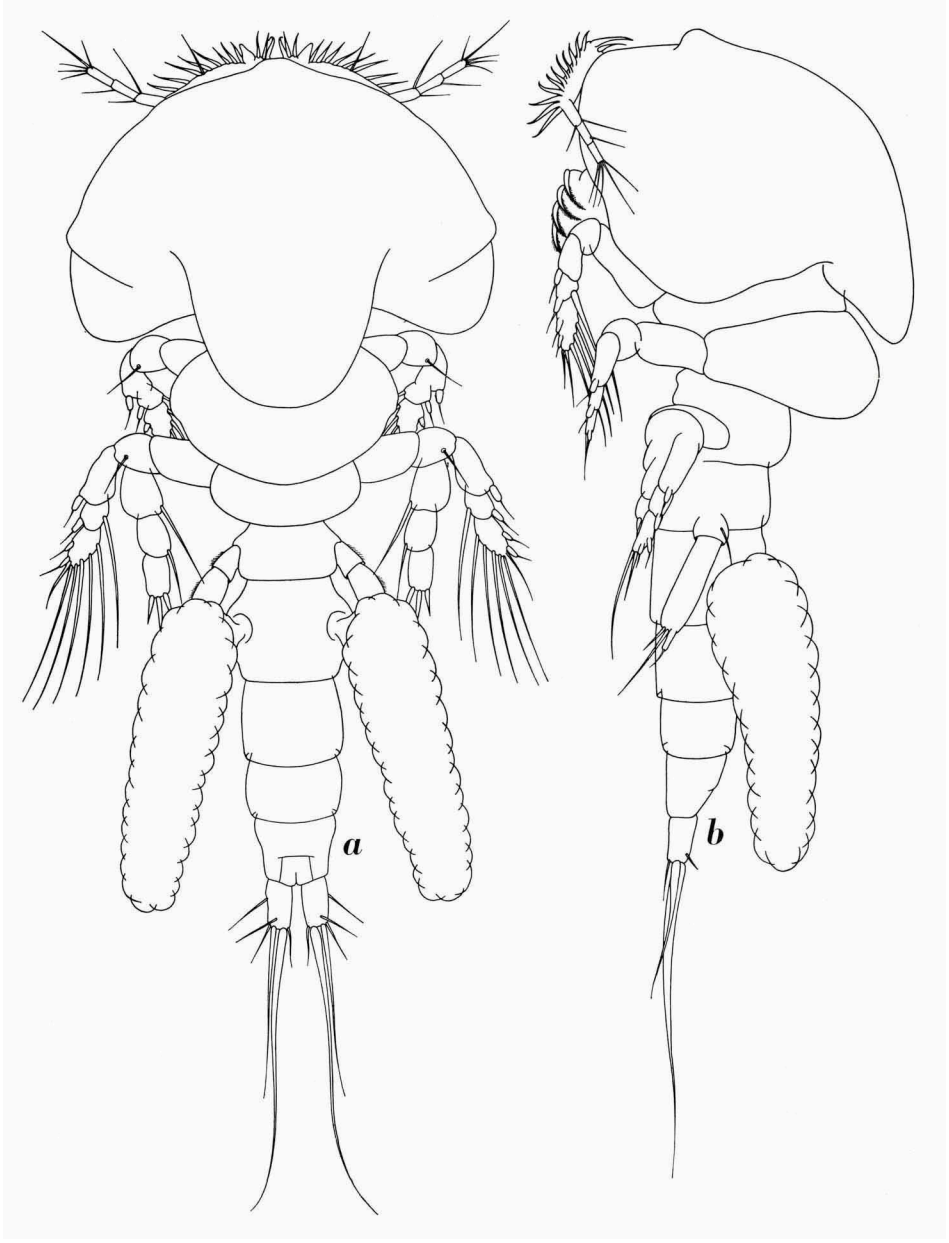

Fig. 1. *Parabomolochus anonymus* nov. spec., ad. ♀, holotype, Gulf of Guinea.
a, whole animal, dorsal view; b, whole animal, lateral view from left side. × 115.

138 and 297 μ for the third thoracic, 55 and 193 μ for the fourth thoracic, 44 and 154 μ for the fifth thoracic somite, 121 and 149 μ for the genital complex,

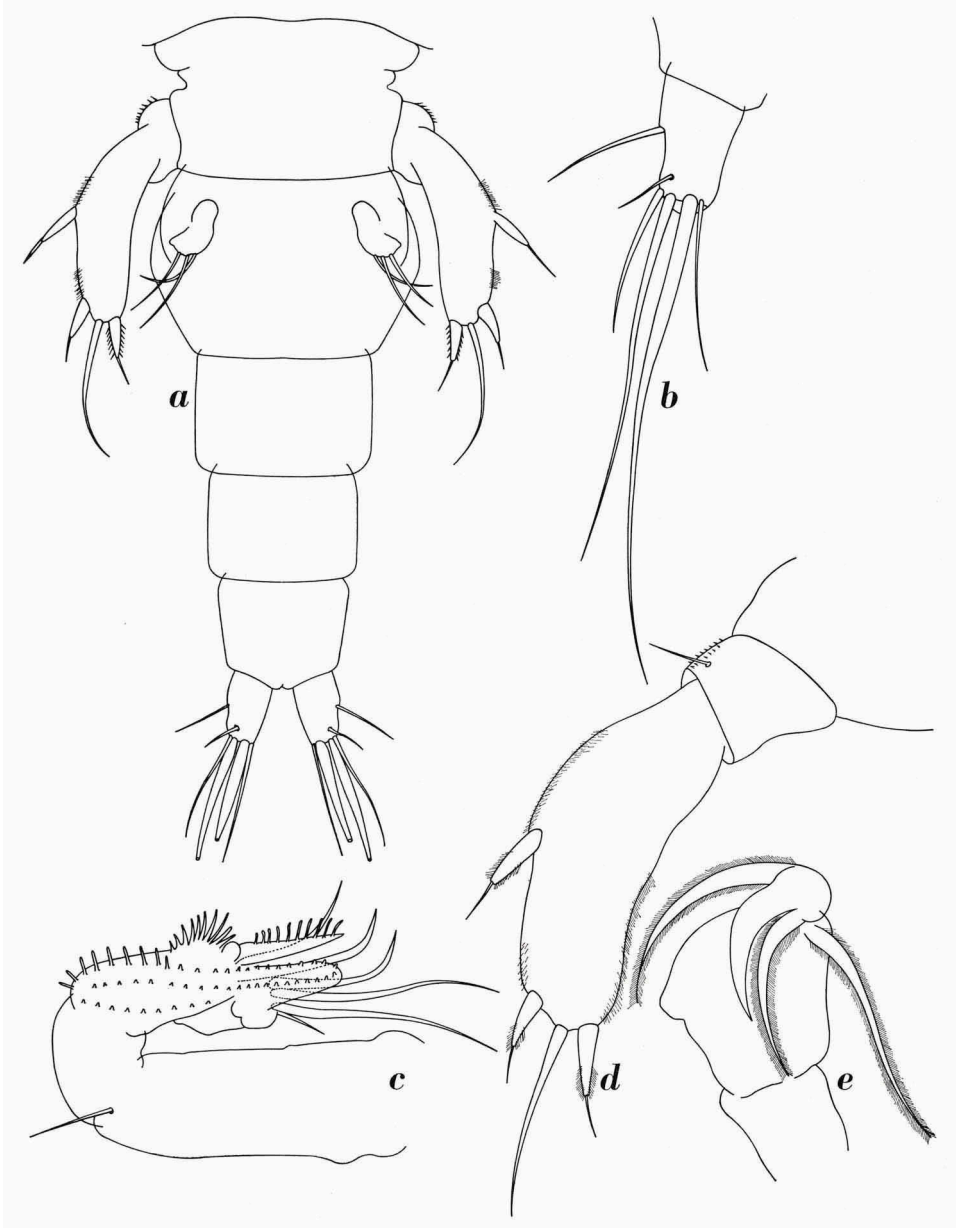

Fig. 2. *Parabomolochus anonymus* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, fifth thoracic somite and abdomen, dorsal view; b, left furcal ramus, dorsal view; c, antenna; d, leg 5; e, maxillipede. a, × 220; b, d, × 400; c, e, × 550.

77 and 127 μ for the third abdominal, 61 and 99 μ for the fourth abdominal and 55 and 88 μ for the fifth abdominal somite. The furcal rami are 33 μ long and 28 μ wide at the base. The length of the longest furcal seta is 138 μ.

The general shape of the body (fig. 1a) is cyclopoid, with an almost globular cephalic somite and a considerable constriction between the second and third thoracic somites; behind the third thoracic somite the remaining somites narrow gradually. The head and the first thoracic somite are completely fused to form the cephalic somite. There is a distinct line separating this complex from the second thoracic somite, but cephalic somite and somite 2 together form a globular structure (fig. 1a), slightly wider than long. There is no median longitudinal groove; the anterior margin of the cephalic somite, between the proximal parts of the antennules, is slightly depressed. The rostral plate is distinctly visible from above; it curves ventrally and there it terminates into a rounded, slightly thickened margin (fig. 4). There are no rostral points.

As indicated above, there is a considerable constriction between the thoracic somites 2 and 3. Thoracic somite 3, in dorsal view, is a shield-shaped structure, in lateral view it appears to be swollen and slightly produced backward (fig. 1b). The thoracic somite 4 is much narrower than somite 3 and not swollen or produced. The epimeral plates of all thoracic somites are poorly developed, so that the coxae of the swimming legs are distinctly visible.

The fifth thoracic somite is distinctly trapezoid; the intermediate segment of leg 5 is not fused with the somite (fig. 2a).

As in the other species of *Parabomolochus* the genital somite and abdominal somite 2 are fused to form the genital complex, which is distinctly wider than long. The genital orifices are placed latero-caudally and covered by a rounded flap; from each orifice protrude 3 fine setae. There are no spinules on the abdominal somites. The anal plate on the anal somite is very indistinct.

The furcal rami are about twice as long as broad; there are five marginal setae and a dorsal appendicular seta on each ramus. The relative length of the setae appears clearly from figure 2b.

The proximal parts of the antennules are distinctly visible from above; each antennule is composed of a proximal portion, ventrally reinforced with chitinized plates, and a 3-segmented distal part (fig. 3a). The proximal part has 14 plumose sensory setae and a highly chitinized, curved hook, representing the strongly modified fourth sensory seta. Setae 2, 3, and 5-10 have chitinized median parts; all setae are supported by chitinized plates, covering the basal part of the antennule. That of the modified seta 4 is particularly

big. In addition to the sensory setae there are, on the antennule, some additional setae, the position of which appears from figure 3a.

The antennae (fig. 2c) have the usual structure, with the endopodite folded over the coxa and basis. At the end of the coxa, which is fairly long, there is a small seta. On the endopodite there are 3 rows of slender, fairly long teeth. The lamelliform process has a pectinate row of 10 slender spines; this row continues on the endopodite as a slightly elevated and curved patch of spinules. In addition there are 3 hooked setae, 2 strong, straight setae and one fine seta.

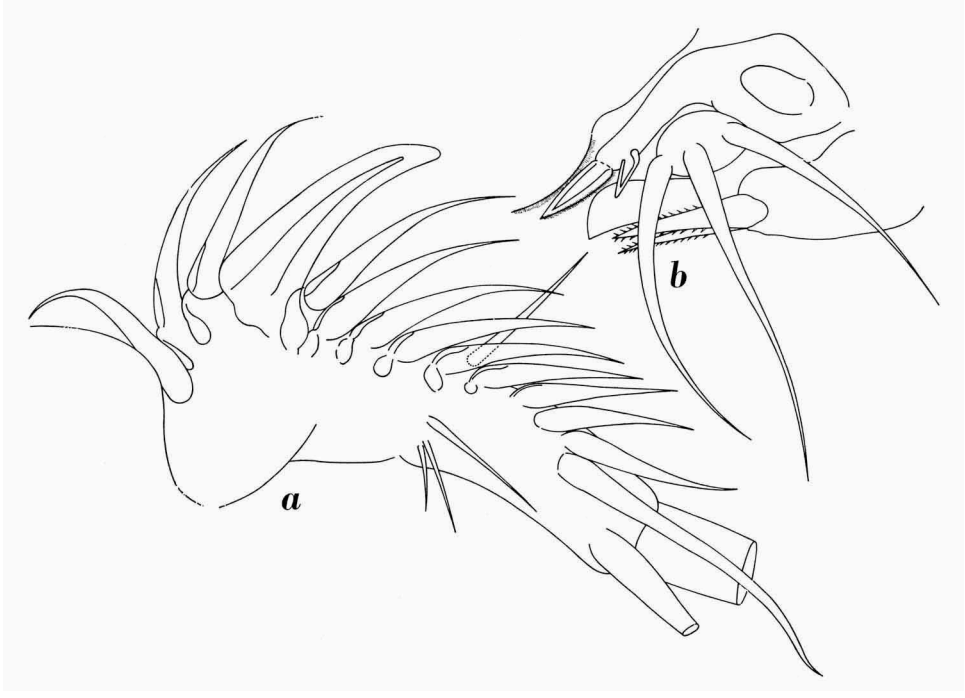

Fig. 3. *Parabomolochus anonymus* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, basal part of antennule, ventral view; b, oral parts of left side, ventral view. × 550.

The mandible (fig. 3b) has a large apical tooth with crenulated internal edge. In addition there is a smaller tooth. On the maxillule there are 3 strong, densely plumose setae. The paragnath has only been observed in situ; its frontal margin appears to be strongly curved; the caudal margin is straight. The maxilla has two large spines, set with strong spinules along both margins. The claw of the maxillipede is short, strong and sigmoid, there is no auxiliary tooth. In addition there are, on the maxillipede, 3 strong, haired setae (fig. 2e).

The legs 1 to 4 have the following setal and spinal formula:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5	6 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 5 + IIII
leg 3	1 + 0 . 1 + 0 . 2 + II	0 + I . 1 + I . 5 + III
leg 4	1 + 0 . 1 + 0 . I + 1 + I	0 + I . 1 + I . 4 + III

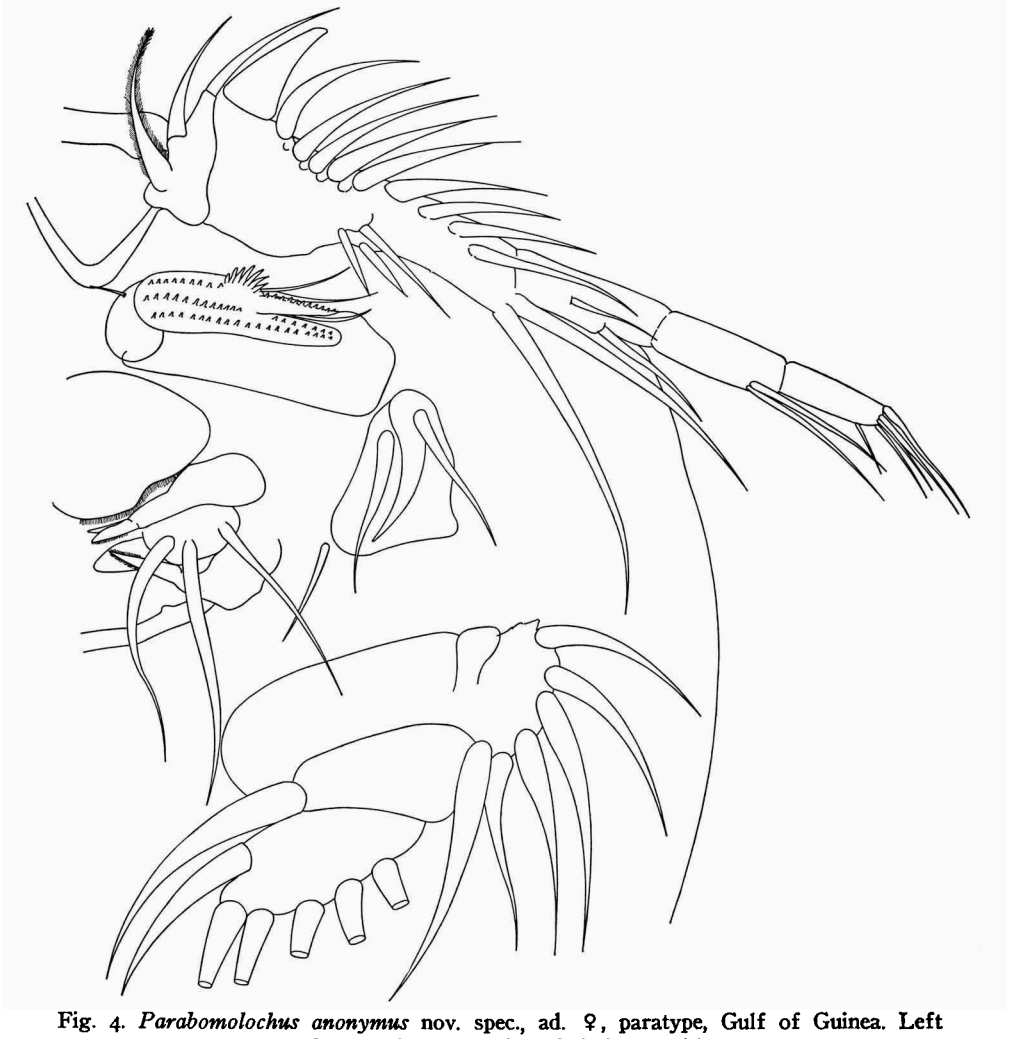

Fig. 4. *Parabomolochus anonymus* nov. spec., ad. ♀, paratype, Gulf of Guinea. Left part of ventral aspect of cephalothorax. × 400.

Both rami of leg 1 (fig. 5a) are strongly flattened. The coxa has a thick external seta and an internal flabelliform process, densely covered with hairs.

The endopodite of leg 2 (fig. 5b) is flattened. The intercoxal plate is

spinulose along its free margin. The coxa has a distinct internal seta; the basis has a fine external seta.

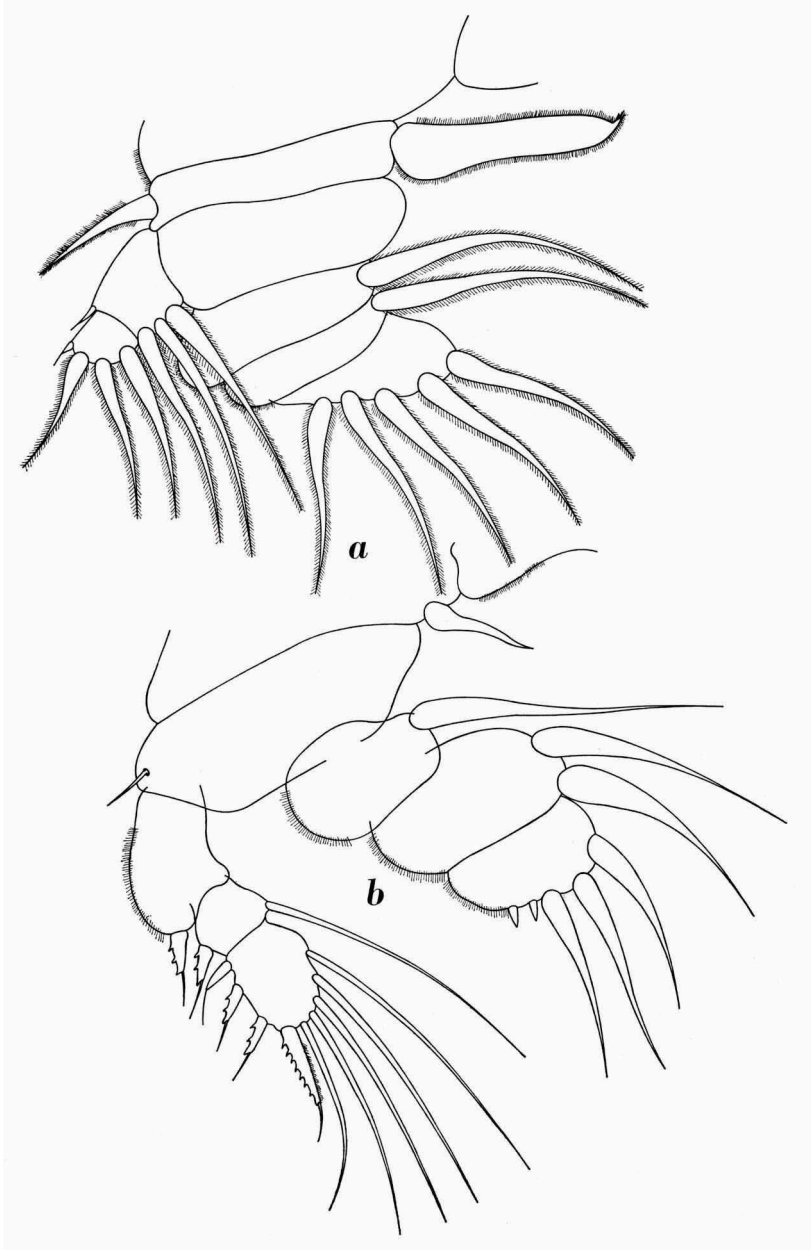

Fig. 5. *Parabomolochus anonymus* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 1; b, leg 2. × 400.

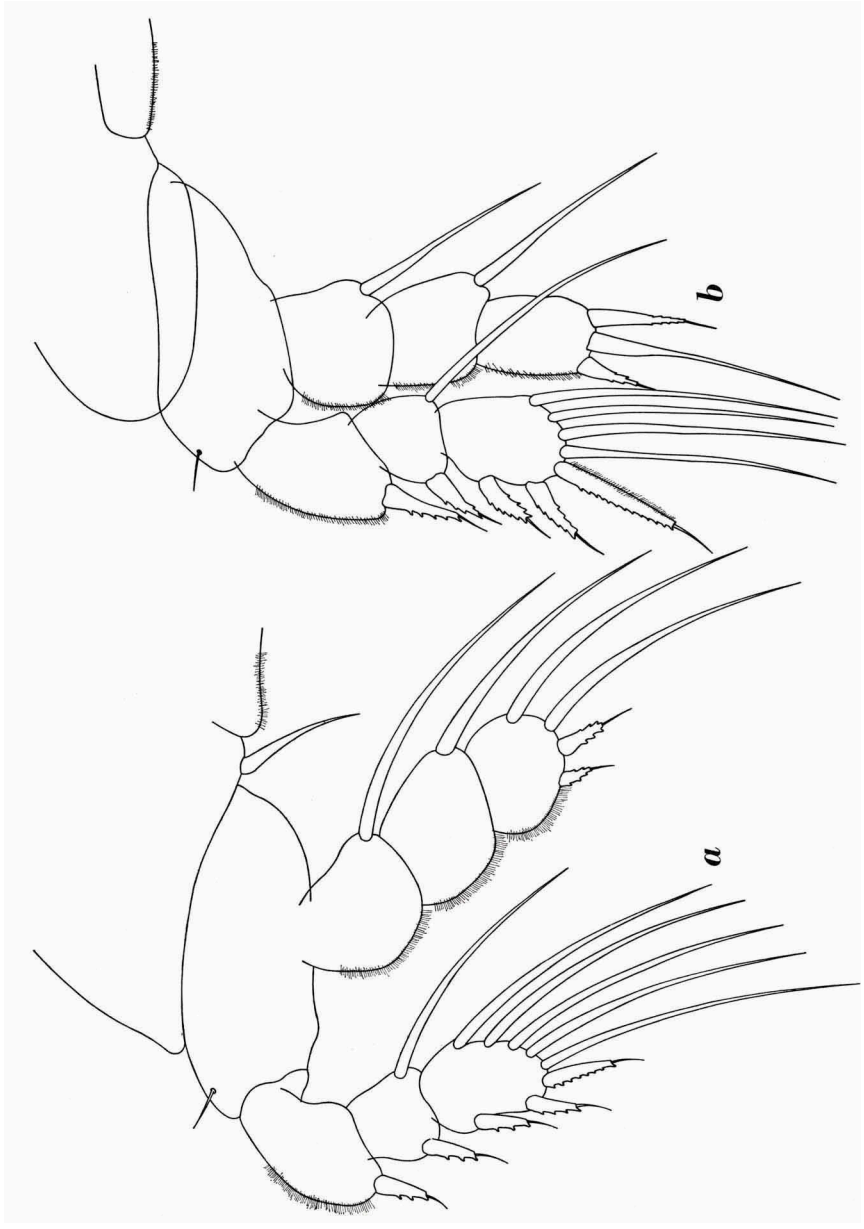

Fig. 6. *Parabomolochus anonymus* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 3; b, leg 4. × 400.

The endopodites of leg 3 (fig. 6a) and leg 4 (fig. 6b) are normally developed; the structure of intercoxal plate, coxa, and basis is as in leg 2, with the exception of the coxa of leg 4, which has no internal seta.

Legs 2 to 4 have strongly haired external margins of the endopodite. The external margin of the first exopodal segment too is strongly haired. The external marginal spines along the exopodite have coarse teeth; in addition each spine has a fine flagellum. The spines on the third endopodal segment of legs 3 and 4 also are set with some coarse teeth.

Leg 5 (fig. 2d) has the usual structure; the intermediate segment is free and has a fine external seta. The external margin of this segment is spinulose. The whole of the external margin and the distal half of the internal margin of the apical segment of leg 5 are haired. In addition there is a spine at the external margin at about halfway its length. The apical portion of the segment has a seta flanked by two spines. All spines of the terminal segment are set with short, prickly hairs and provided with a flagellum.

Remarks. — This is a very distinct though small *Parabomolochus,* easily recognized by the general shape of the cephalothorax and the antennular structure. I have no indications of the incidence of parasitism of this species on its type host, *Euthynnus alleteratus* (Rafinesque), where it occurs together with *Ceratocolax euthynni* nov. spec.; because of its small size it may easily be overlooked. No males have been observed. The specific name, *anonymus,* has been derived from the greek anonymos, nameless, unknown.

Parabomolochus mycterobius nov. spec. (fig. 7-14).

Material examined. — Gulf of Guinea, off Abidjan, Côte d'Ivoire, leg. Dr. J. F. Aldrin, 6 adult females and 2 adult males from the nasal fossae of *Auxis thazard* (Lacépède). The adult females, nearly all ovigerous, measure 1.72, 1.75, 1.85, 2.04, 2.10 and 2.25 mm. The adult ovigerous female of 2.04 mm length has been chosen as the holotype; all remaining females have been labelled as paratypes. The holotype has been used for the description and figures of the external appearance; the 2.25 mm long, non-ovigerous female paratype has been dissected and the appendages figured and mounted. The two males measure 709 and 689 μ total length; the 709 μ long male has been chosen as the allotype; it has been used for a description of the external appearance. The remaining male paratype has been dissected. All specimens and the slides are in the collection of the Rijksmuseum van Natuurlijke Historie, Leiden.

Description. — Adult female, total length 2.04 mm; the greatest diameter, at the cephalic somite, is 1.00 mm. The proportion of lengths of cephalothorax and abdomen is as 29 : 21. The length of the cephalic somite, mea-

sured from the end of the rostral base to the end of the caudal projection of the cephalic somite, is 800 μ, the diameter is 1000 μ. The second thoracic somite is invisible from above; the third thoracic somite has a length of 135 μ (visible part only) and a diameter of 600 μ. For the remaining somites

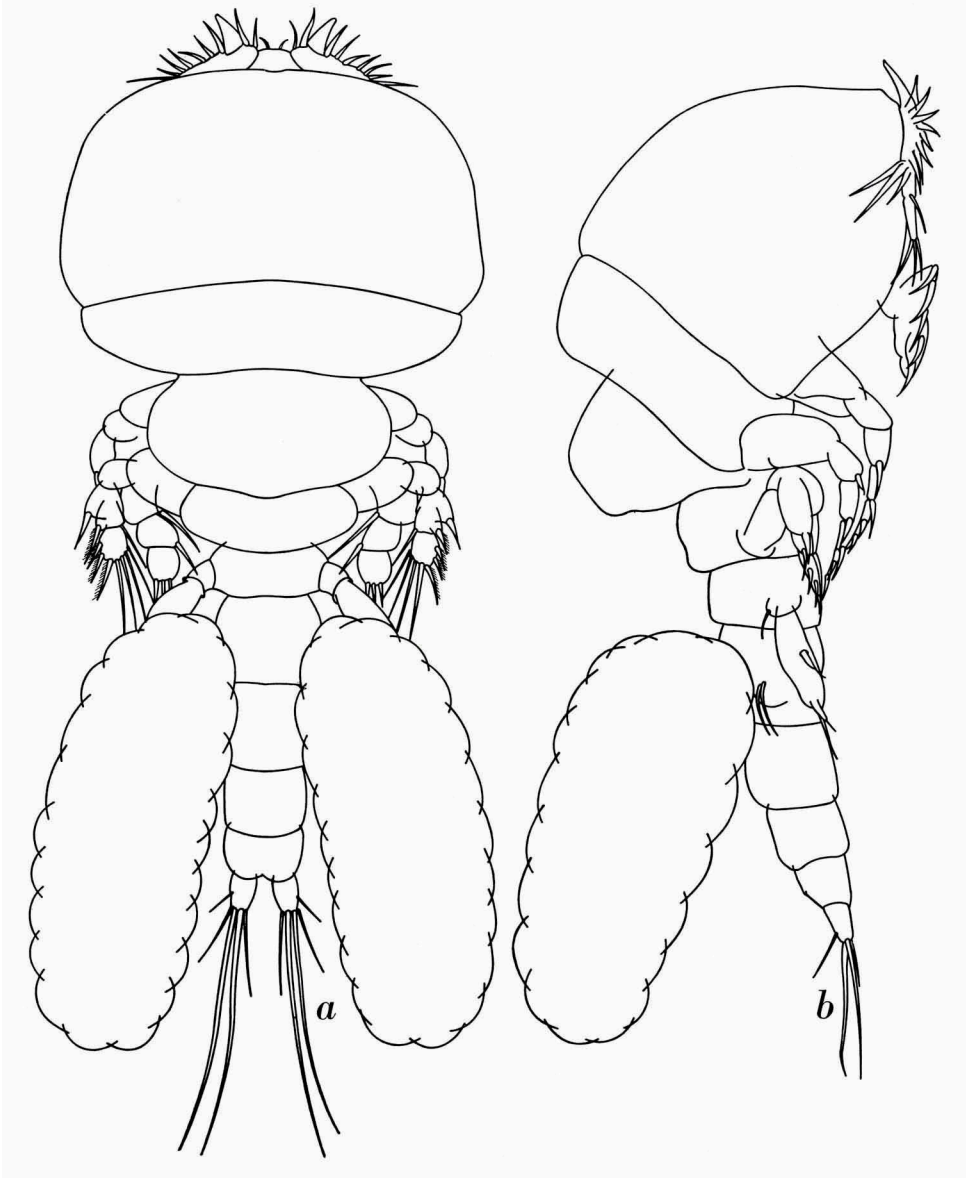

Fig. 7. *Parabomolochus mycterobius* nov. spec., ad. ♀, holotype, Gulf of Guinea. a, whole animal, dorsal view; b, whole animal, lateral view from right side. × 55.

these figures are 108 and 420 μ for the fourth and 110 and 310 μ for the fifth thoracic somite. The genital complex is 216 μ wide and 338 μ long. The remaining abdominal somites have the following lengths and diameters: the third somite 189 and 257 μ; the fourth somite 135 and 230 μ and the fifth somite 135 and 190 μ. The furca is 140 μ long and each ramus basally measures 95 μ. The longest furcal setae are 400 μ long. The egg sacs are 760 μ long and 245 μ wide. They contain about 100 large, round eggs.

The general shape of the body (fig. 7), though distinctly cyclopoid, is characterized in dorsal aspect by the very wide cephalic somite, followed by thoracic and abdominal somites of much reduced width; in lateral view the great, sac-shaped backward protrusion of the cephalic somite and the backward produced third thoracic somite are very prominent features. The third and fourth pairs of legs, by the reduced width of thoracic somites 3 and 4, are completely visible from above.

The head and the first thoracic somite are completely fused to form the cephalic somite; this is first of all characterized by a backward produced, sac-shaped part, covering the second thoracic somite and part of the third thoracic somite. The exact shape of this part appears clearly in figure 7. The rest of the cephalic somite is distinctly kidney-shaped, with a broadly rounded frontal zone, leaving the antennules free for observation from above. Laterally, as also appears from figure 7a, the cephalic somite has a distinct fold on each side. The frontal portion of the cephalic somite, as appears in figure 7b, has a low, rounded ridge, so that the rostral plate is invisible from above. The exact structure of the rostral plate is best visible in a ventral aspect of the animal (fig. 9d); it is only very moderately developed and shaped as a short plate with rounded edge, flanked on both sides by the basal plates of the antennules. The extreme corners of this rostral plate each bear a short, conical rostral prominence, covered by the first of the plumose setae of the antennules.

The second thoracic somite, as stated above, is completely hidden from observation by the cephalic prominence; it is a short, narrow, ring-shaped somite wedged between the cephalic somite and the third thoracic somite. The third thoracic somite is much better developed and, although partly covered by the produced part of the cephalic somite, it is in itself produced backward and largely covers the fourth thoracic somite. This fourth somite is narrower and shorter than the third but still distinctly visible from above. The fifth thoracic somite is more or less trapezoidal, with slightly produced sides for the insertion of the fifth legs.

The genital complex (fig. 9b), composed of the fused first two abdominal somites, has the usual shape; the genital orifices are placed dorso-laterally

Fig. 8. *Parabomolochus mycterobius* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, left part of ventral aspect of cephalothorax; b, anal somite and furca, dorsal view; c, antennula, ventral view; d, antenna. a, × 80; b, × 125; c, d, × 365.

and are covered by almost circular plates. In the non-ovigerous females three setae project from the genital orifice. The abdominal somites 3 and 4 have no salient details; the fifth (anal) somite narrows caudally; the anal plate is very thin and scarcely visible. Each caudal ramus has 5 marginal setae and 1 appendicular (dorsal) seta. The setae 1, 4, 5 and the appendicular seta are fine and short; the setae 2 and 3 are lengthened and thickened; the structure of the setae appears in figure 8b.

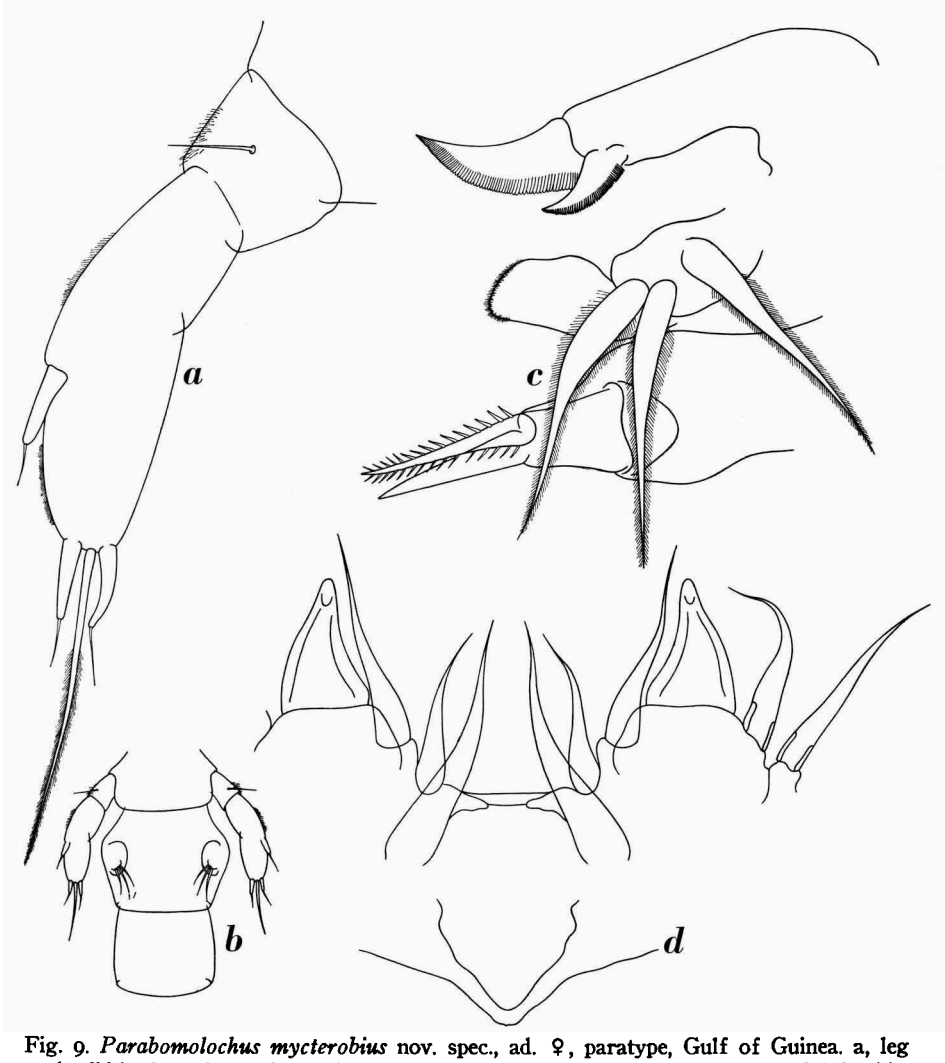

Fig. 9. *Parabomolochus mycterobius* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 5; b, fifth thoracic somite and genital somite, dorsal view; c, oral parts of left side, ventral view; d, rostral plate and basal parts of antennules, ventral view. a, × 220; b, × 55; c, × 550; d, × 400.

The antennules (fig. 8c) have the structure characteristic of the genus *Parabomolochus*; they are composed of an apparently 3-segmented basal part and a 3-segmented apical part (flagellum). There are the usual plumose, sensory setae on the basal part, of which 14 are more or less unmodified, whilst the fourth seta on each side is completely modified and represented by a highly chitinized, slightly curved hook. The first two segments of the basal portion of each antennule are reinforced with chitinized, basal plates. In contradistinction to the other species of *Parabomolochus* these plates enter into the free part of the plumose setae to a much inferior degree; the rostral parts only of setae 5 to 13 shows the presence of a chitinized part. The total number of plumose setae is 14; the modified, hook-like seta not included. In addition there are some non-plumose setae on the antennule. The structure of this appendage can best be judged from figures 8c and 9d; the hook and the majority of the plumose setae can be seen in dorsal view of the animal.

The antenna (fig. 8d) has the usual shape, with the endopodite folded over the coxa. The endopodite, which I think is composed of two fused segments, is covered by longitudinal rows of needle-shaped spinules. As some of the spinules at times are placed between the rows the arrangement is slightly confused. I observed only 5 setae on the endopodite, 3 of which are hooked. In addition there is a hooked seta near the insertion of the lamelliform process. This process has a longitudinal row of fine, long spinules, continuing for only a short distance on the endopodite.

The cutting edge of each mandible (fig. 9c) has one very big and one much smaller tooth; the cutting edge of each tooth is set with scale-shaped teeth. On the mandible, distinctly visible in my slides as well as in the undissected females, I observed only three setae. The paragnaths are short and club-shaped; the apex is haired. The maxilla has two very big teeth, only one of which is covered with acute spinules. The maxillipedes, that have the structure characteristic of the Bomolochidae, have a large curved claw without additional tooth. In addition there are on each maxillipede 3 plumose setae; the position is clearly indicated in figure 10a.

The legs 1 to 4 have the following setal and spinal formula:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5	6 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 6 + III
leg 3	1 + 0 . 1 + 0 . 2 + II	0 + I . 1 + I . 6 + II
leg 4	1 + 0 . 1 + 0 . I + 1 + I	0 + I . 1 + I . 6 + II

The exo- and endopodites of leg 1 (fig. 10b) are strongly flattened, all setae are strongly plumose. There is a haired appendage on the internal

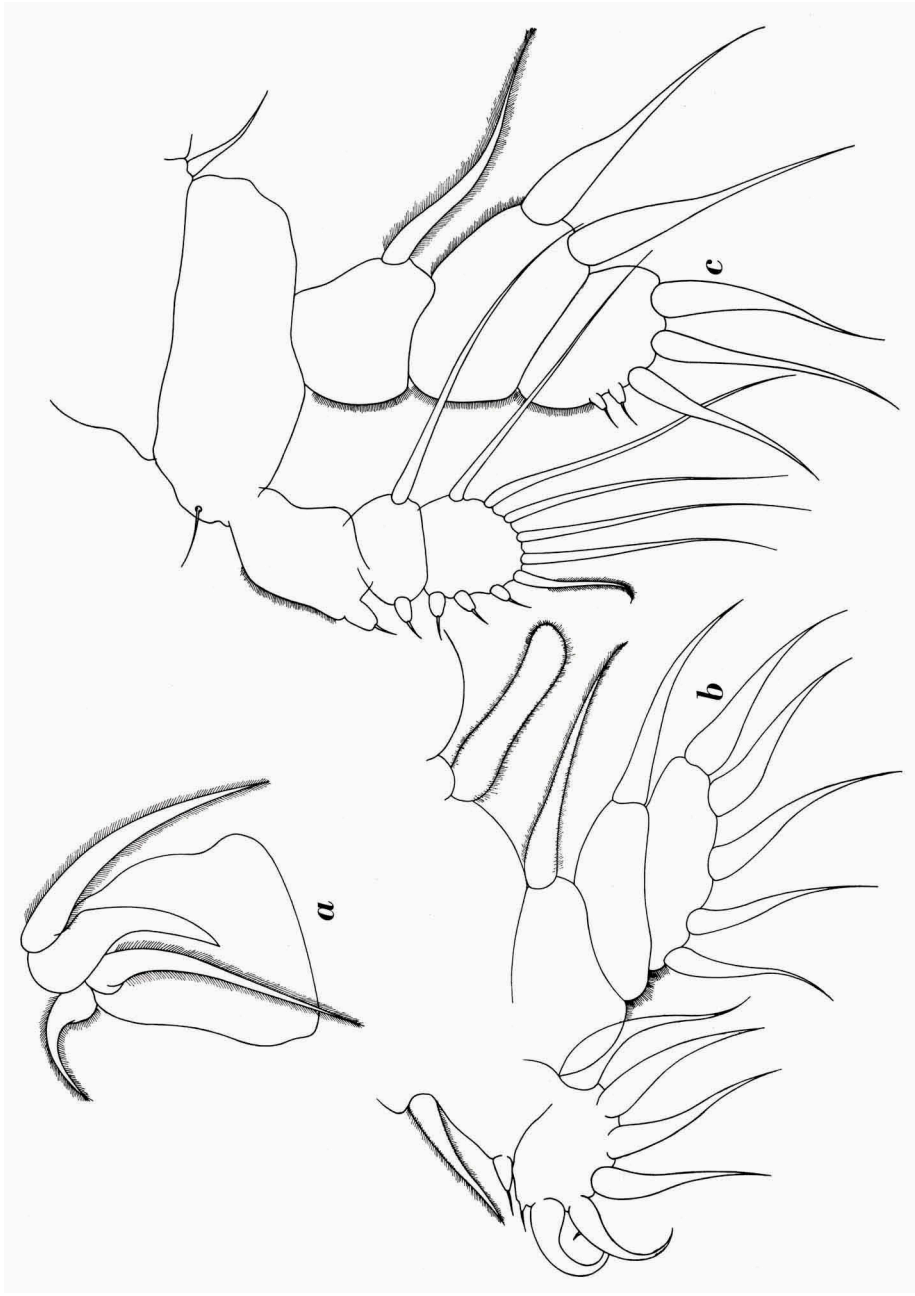

Fig. 10. *Parabomolochus mycterobius* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, maxillipede; b, leg 1; c, leg 2. a, × 400; b, c, × 220.

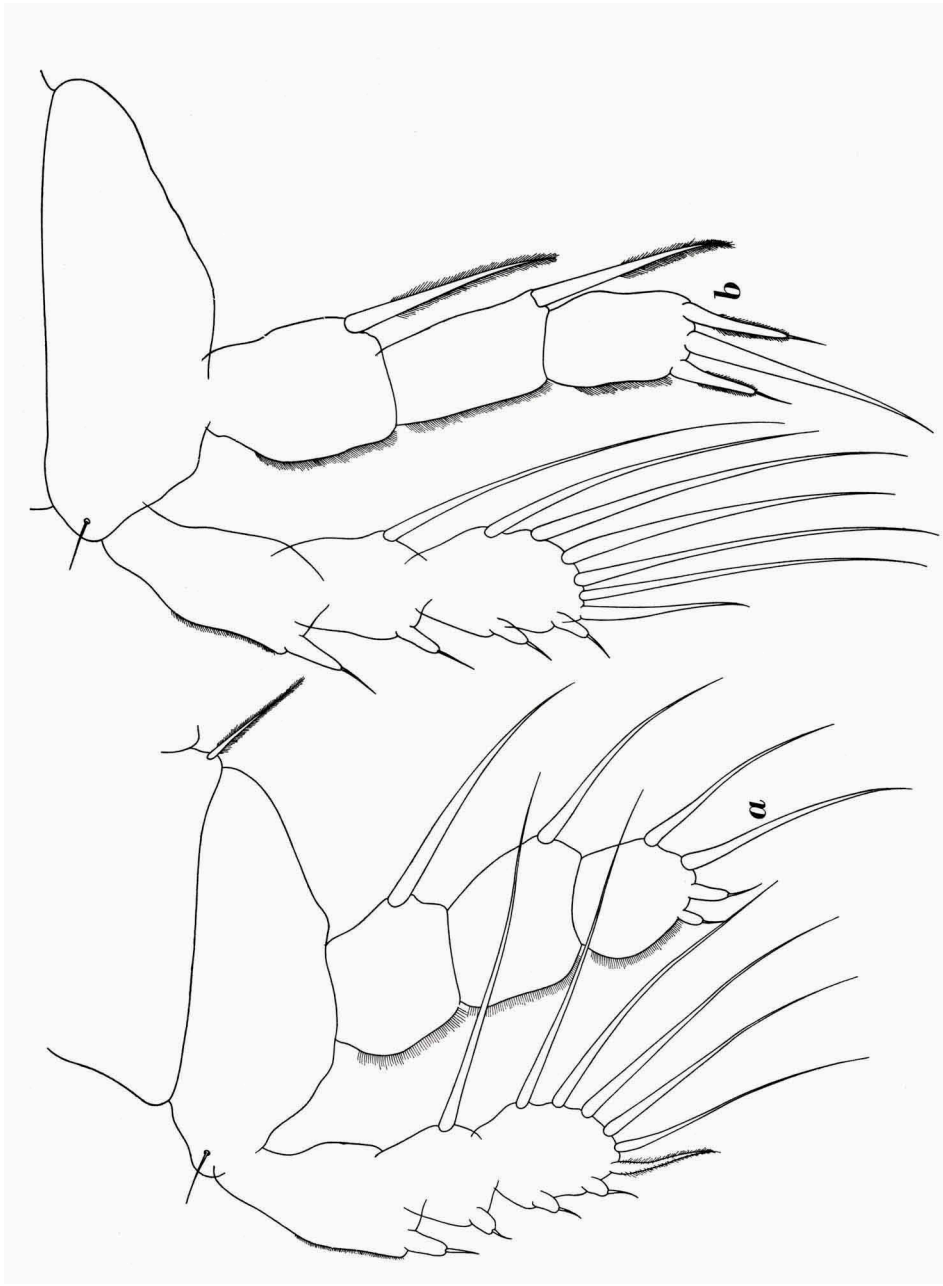

Fig. 11. *Parabomolochus mycterobius* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 3; b, leg 4. × 220.

margin of the coxa; the external margin of the basis has a haired seta. The segmentation between the exopodal segments is incomplete; there are two spines at the external margin.

The endopodite of leg 2 (fig. 10c) is strongly flattened. There are two internal setae on the second endopodal segment and three of such setae and 2 spines on the third endopodal segment.

The endopodite of leg 3 (fig. 11a) too is slightly flattened; the second endopodal segment has a single internal seta; the third endopodal segment has 2 setae and 2 spines.

The setae at the internal margin of the endopodal segments 1 and 2 of leg 4 are short and almost spiniform. The third endopodal segment has an apical seta flanked by two spines (fig. 11b).

All spines, those of the exopodite as well as those of the endopodite are composed of a short, usually more or less squat, conical part and a fine flagellum. The apical "spine" on the third exopodal segment of legs 2 to 4 is shaped as a slightly curved, haired seta.

Leg 5 (fig. 9a) is composed of a short intermediate segment and a large, slightly reniform apical segment. The intermediate segment is haired externally and carries a fine seta. The apical segment is haired along the external margin, this margin also bears a spine, slightly under the middle. The apex has a plumose seta flanked by two spines. The spines of leg 5 too have the flagellated structure referred to above.

Adult male, total length 709 μ. The greatest diameter is 338 μ. The cephalic somite has a total length of 336 μ and a diameter of 154 μ. For the remaining somites these figures are 270 and 66 μ for the second thoracic somite; 226 and 61 μ for the third thoracic somite; 171 and 61 μ for the fourth thoracic somite and 165 and 39 μ for the fifth thoracic somite. The genital somite into which the second abdominal somite is completely telescoped, is 182 μ long and 116 μ wide. For the remaining abdominal somites these figures are 110 and 44 μ for the third abdominal somite, 83 and 55 μ for the fourth and 77 and 50 μ for the fifth. The furcal rami are 28 μ long and basally 22 μ wide. The longest furcal seta is 155 μ.

The general appearance of the male is quite different from that of the female; the body is distinctly cyclopoid, with gradually narrowing somites without backward produced parts (fig. 12a, b). All thoracic somites are free for observation and not covered by parts of other somites.

The head and the first thoracic somite are fused and form the cephalic somite; this in dorsal view is broadly rounded anteriorly. The basal parts of the antennules are covered by the cephalic somite and are not visible from above. The base of the rostral plate is visible as a rounded eminence of the anterior

portion of the cephalic somite. The rostral plate curves forward and terminates in a slightly thickened ridge between the proximal parts of the antennules; no rostral points have been observed. The thoracic somites 2 to 4

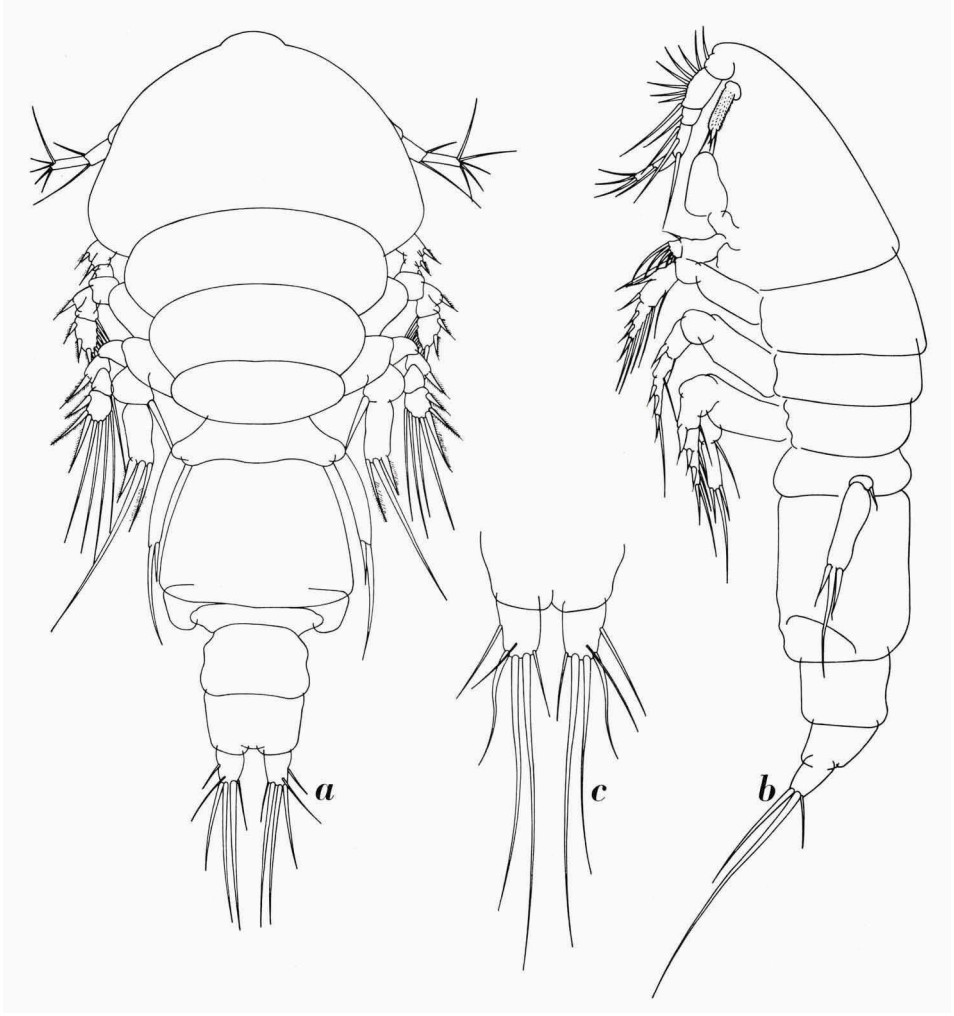

Fig. 12. *Parabomolochus mycterobius* nov. spec., ad. ♂, Gulf of Guinea. a, allotype, whole animal, dorsal view; b, allotype, whole animal, lateral view from left side; c, paratype, furca, dorsal view. a, b, × 135; c, × 220.

gradually diminish in diameter; their shape appears clearly in figure 12a.

The epimeral plates are poorly developed so that the coxae of the legs are distinctly visible laterally and dorsally. The fifth thoracic somite has distinct "shoulders" because of fusion with the intermediate segment of leg 5.

The shape of the genital somite appears best in figure 13a; the somite, in dorsal view, is slightly trapezoidal; the sides are thickened. No genital slits have been observed. The second abdominal somite apparently is completely

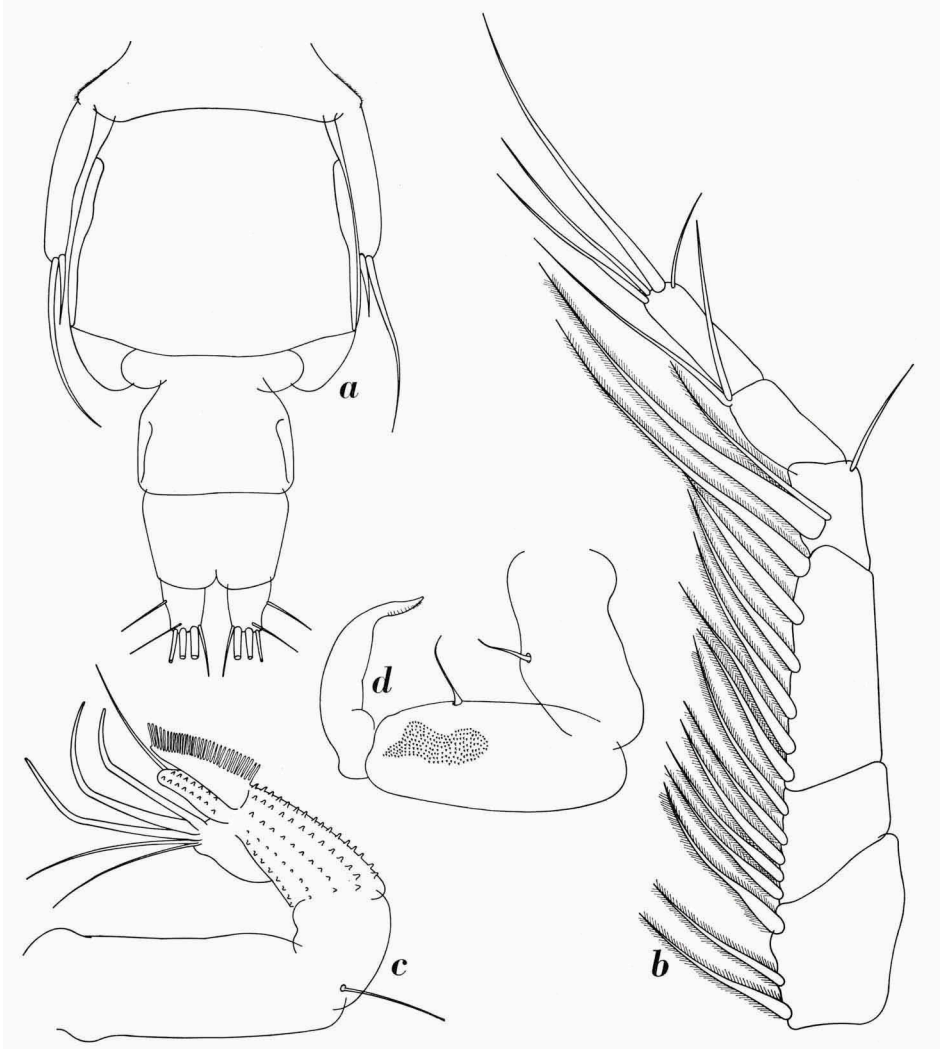

Fig. 13. *Parabomolochus mycterobius* nov. spec., ad. ♂, paratype, Gulf of Guinea. a, fifth thoracic somite and abdomen, dorsal view; b, antennule, ventral view; c, antenna; d, maxillipede. a, × 220; b, c, × 550; d, × 400.

telescoped into the genital somite, so that only its distal parts are visible. The third abdominal somite too is almost hidden by the genital somite, though its distal parts protrude caudally from the genital somite. The sides of the fourth abdominal somite are also thickened. The fifth (anal) somite has a

very obscure anal plate. The furca is exactly as in the female (fig. 12c).

The antennules are not reinforced by chitinized plates; the structure is shown in figure 13b. There are 15 plumose sensory setae, increasing in size distally, distributed over 4 distinctly separate segments. In addition there are two distal segments that make an obtuse angle with the basal part of the antennule.

The antenna (fig. 13c) is almost as in the female but smaller. There are 5 longitudinal rows of thick spines on the endopodite, two of which continue on the apical segment. The lamelliform process has a pectinate row of fairly slender spines. A continuation of this row on the endopodite, as contrasted with the female, could not be observed here. As in the female there are 4 hooked, spiniform setae and two straight setae. The remaining oral appendages, with the exception of the maxillipedes, are as in the female, but are correspondingly smaller.

The maxillipede (fig. 13d) is a chelate structure; the short coxa has a single internal seta. The basis is only moderately swollen, with a large patch of fine spinules on the "palm". In addition there is one internal seta. The endopodite is a fairly short claw with curved apex. The internal margin of that apex is set with lamelliform teeth.

The structure of legs 1 to 4 appears from the setal and spinal formula, figure 14, and from the following notes.

Setal and spinal formula:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5	0 + I . 6 + I
leg 2	1 + 0 . 1 + 0 . 3 + II	0 + I . 1 + I . 5 + III
leg 3	1 + 0 . 1 + 0 . 2 + II	0 + I . 1 + 0 . 5 + III
leg 4	1 + 0 . I + 1 + I	0 + I . 1 + 0 . 4 + III

Leg 1 (fig. 14a) is remarkable by the fact that it resembles the first leg of the female. In nearly all known males of Bomolochinae the difference between the legs of both sexes is greatest in the first pair. Here the female structure has more or less been retained.

The legs of the second pair (fig. 14b), of the third pair (fig. 14c), and of the fourth pair (fig. 14d) are characterized by the strongly spinulose spines along the external margin of the exopodite. In legs 3 and 4 the spines of the endopodite too are strongly spinulose.

The intermediate segment of leg 5 (fig. 14e) is fused with the fifth thoracic somite; a small seta occurs on that somite near the insertion of the free segment of the leg. This segment is four times as long as wide and apically it carries an internal spine and an external seta. The internal margin is haired; some spinules occur near the insertion of the apical seta.

Remarks. — This new *Parabomolochus* differs in some respects from the other well described species of this genus (*P. bellones* (Burmeister), *P.*

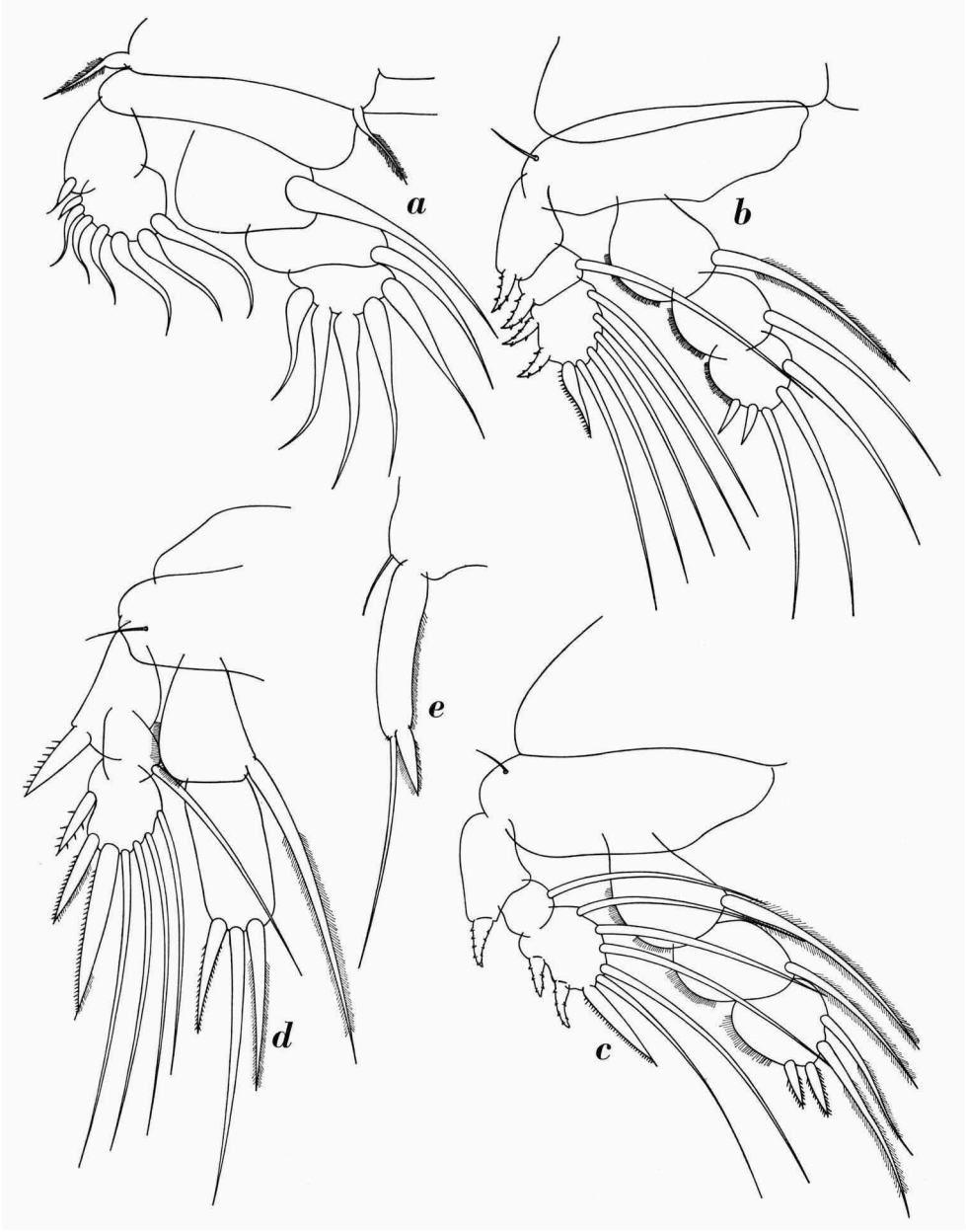

Fig. 14. *Parabomolochus mycterobius* nov. spec., ad. ♂, paratype, Gulf of Guinea. a, leg 1; b, leg 2; c, leg 3; d, leg 4; e, leg 5. a-d, × 400; e, × 240.

decapteri (Yamaguti), *P. tumidus* (Shiino), *P. hyporhamphi* (Yamaguti & Yamasu), *P. psettobius* Vervoort and *P. cuneatus* (Fraser)). The fourth plumose seta of the antennule is completely modified in *P. mycterobius*, whilst in the other species, though at times greatly chitinized, it can still be recognized as one of the plumose setae. There are only 3 setae on the maxillule and no auxiliary tooth occurs on the sigmoid spine of the maxillipede. In *Parabomolochus*, where the number of setae on the maxillule usually numbers 4, one of the setae is much smaller and a complete disappearance of this seta in some species could only be expected. In *Nothobomolochus* species with and without auxiliary tooth on the sigmoid claw of the maxillipede are known; it is not surprising to find a similar condition in *Parabomolochus*. In such species of *Parabomolochus* that have been sufficiently described, the antenna usually has a long row of acicular teeth on its endopodite, forming a continuation of those observed on the lamellar process. A comparison of the length of this row on the endopodite proper shows that its length varies according to species: some have a very long row, terminating at the articulation between endopodite and basis, some have a slightly shorter row. In *P. mycterobius* this row of acicular teeth seems to be rather short, approaching the condition observed in *Nothobomolochus*, where as a rule it is very short.

As mentioned in the description, the male of this species of *Parabomolochus* differs from previously described males in the structure of leg 1, the structure of which shows many affinities to that of the female.

The incidence of parasitism in *Auxis thazard* (Lacépède) seems to be high. Dr. Aldrin informs me, that the parasite usually occurs in both nostrils. Amongst a total of 72 specimens examined 63 proved to be parasitized. Of the remaining 9 specimens some may have carried parasites which because of their small size could have been overlooked. The host does not appear to be greatly affected by the presence of Bomolochid parasites.

Ceratocolax nov. gen.

Diagnosis. — Female. The body is elongate, i.e., the somites of the body narrow gradually. The thorax is curiously shaped because of the constriction of the frontal part of the third thoracic somite. The head and the first thoracic somite are fused; the resulting cephalic somite is fairly short and broad, with a deep, longitudinal groove, terminating anteriorly between the basal parts of the antennules into a distinctly depressed part, flanked on each side by a distinct knob. The caudo-median part of the cephalic somite is produced backward and upwards, covering part of the second thoracic

somite, which somite is almost as broad as the cephalic somite. The third thoracic somite is greatly constricted anteriorly and much swollen dorsally. The fourth thoracic somite, though smaller than the third, is also produced backward and dorsally. The fifth thoracic somite has "shoulders", but the fifth legs have a free intermediate segment. The genital complex, resulting from fusion between abdominal somites 1 and 2, has some rounded lateral plates, covering the genital orifices, that give the somite a curious appearance. The rest of the abdomen, including the furca, is as in *Parabomolochus*. The rostrum is 2-pointed.

The antennule is remarkable by the presence of a large chitinized plate, inserted between the antenna and the frontal edge of the cephalic somite; this plate is frontally produced into a very strong hook, distinctly visible in dorsal aspect of the animal. In addition there are, on the antennule, 15 plumose sensory appendages, none of which is fused with the hook.

The antennae have a large number of small, stubby spines, placed in longitudinal rows along the endopodite. The lamelliform process has a pectinate row of short spines, which row continues for some distance on the endopodite. There are 3 hooked setae, two strong straight setae and 3 smaller setae.

The remaining mouthparts are as in *Parabomolochus*; in the type of *Ceratocolax* there are 3 strong setae and one very small seta on the maxillule. The maxillipede has a very strong, sigmoid claw with a small auxiliary tooth; in addition there are 3 setae.

The legs are almost as in *Parabomolochus*, with the exceptions listed below.

The setal and spinal formala, based exclusively on the type, is:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5	6 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 5 + IIII
leg 3	1 + 0 . 2 + 0 . 2 + II	0 + I . 1 + I . 5 + III
leg 4	1 + 0 . 1 + 0 . I + 1 + I	0 + I . 1 + I . 4 + III

Leg 1. There is no haired lamella at the internal margin of the coxa. In- and external margins of the basis carry a strong, plumose seta each; in addition there is a transverse row of spinules on the frontal aspect of the basis.

Legs 2 to 4 have strongly spinulose external margins of both endo- and exopodites. The endopodite of leg 2 is moderately flattened; that of leg 3 is normally developed. The exopodite of leg 4 is styliform and lengthened; it surpasses the exopodite.

Leg 5, though strongly spinulose, is normally developed; there is one spine at the external margin and 3 spines of varying size occur near the apex.

Males. The males show the same morphological differences from the females as have been observed in *Parabomolochus*. The general shape of the body is distinctly more cyclopoid than in the female, with gradually narrowing thoracic somites. The genital complex is large and apparently comprises the genital somite and abdominal somites 2 and 3. One of the furcal setae on each side is lengthened and thickened. The anal somite has some spinules on its ventral surface.

The structure of the antennule is normal, i.e., there are no chitinized plates or hooks. The spines on the endopodite of the antenna are fairly long and slender. The claw of the maxillipede is long and slender; the basis is greatly swollen and internally covered with small spines with thickened bases.

The legs show the usual modifications; the setal and spinal formula is:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5 + I	0 + I . 1 + I . 5 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 5 + III
leg 3	1 + 0 . 1 + 0 . 2 + II	0 + I . 1 + I . 5 + III
leg 4	1 + 0 . I + 1 + I	0 + I . 1 + 0 . 4 + III

As in the female the external margins of the exopodites are strongly spinulose.

The intermediate segment of leg 5 is fused with the fifth thoracic somite. The free segment of leg 5 has a strongly spinulose external margin, whilst the apex has an external seta and an internal spine.

Parasites of the oral fossae of fishes. The type of the genus is *Ceratocolax euthynni* nov. spec. The name of the genus *Ceratocolax* (gender masculine) has been derived from the greek keras, -atos, horn, and kolax, -akos, flatterer or fawner.

Ceratocolax euthynni nov. spec. (fig. 15-22)

Material examined. — Gulf of Guinea, off Abidjan, Côte d'Ivoire, leg. Dr. J. F. Aldrin, 8 adult females and 4 adult males along with some copepodites, from the nasal fossae of *Euthynnus alleteratus* (Rafinesque). The adult females, nearly all ovigerous, measure 3.10, 3.10, 3.40, 3.50, 3.68, 3.70, 4.00 and about 4.2 mm. The adult males measure 1.35, 1.38, 1.40 and 1.47 mm. The adult, ovigerous female of 3.68 mm has been chosen as the holotype; the 1.47 mm long male as the allotype. All remaining specimens are labelled as paratypes. All specimens and slides of this species are in the collection of the Rijksmuseum van Natuurlijke Historie, Leiden.

Description. — The following description is based on the holotype and

a 4.2 mm long female paratype for the adult female stage, and the allotypic male and a 1.40 mm long male paratype for the adult male stage. These paratypes have been dissected and the appendages mounted. The holo- and allotype have been figured and used for the description of the external appearance.

Adult female, total length 3.68 mm. The length of the cephalothorax, mea-

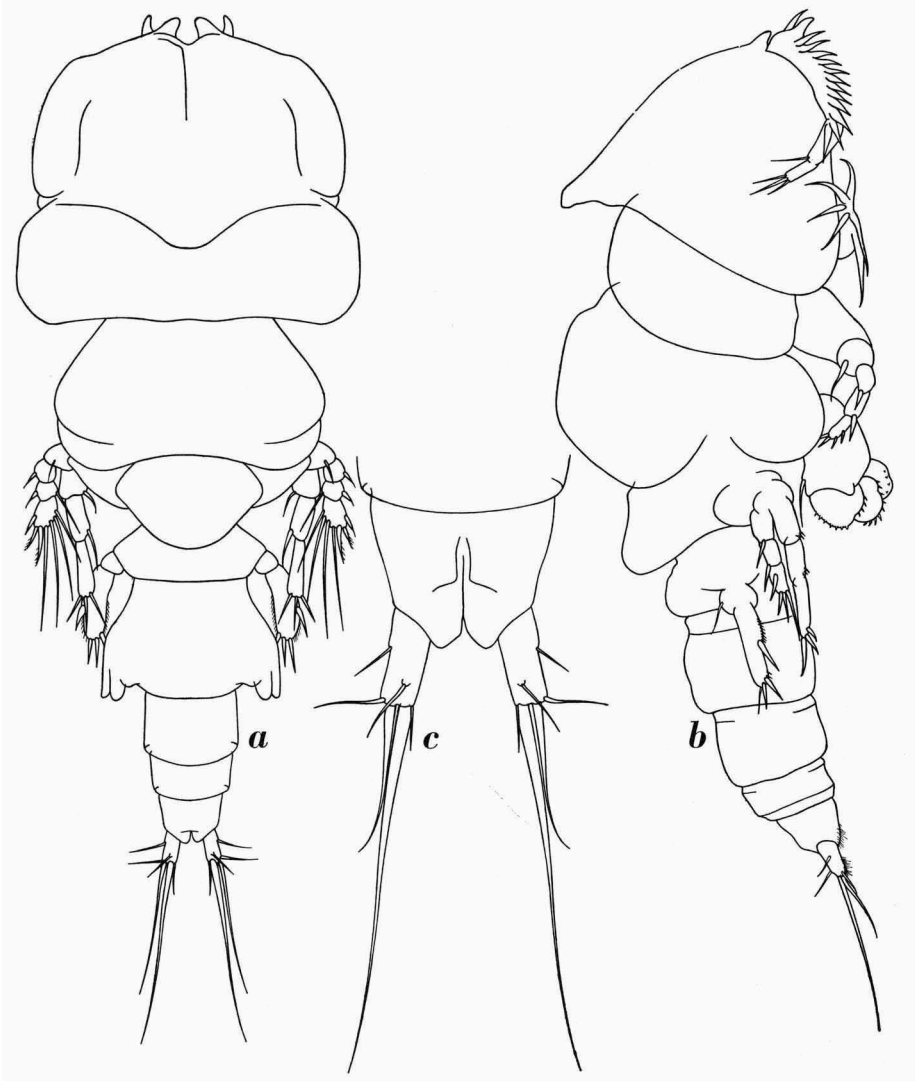

Fig. 15. *Ceratocolax euthynni* nov. spec., ad. ♀, Gulf of Guinea. a, holotype, whole animal, dorsal view; b, holotype, whole animal, lateral view from right side; c, paratype, anal somite and furca. a, b, × 30; c, × 85.

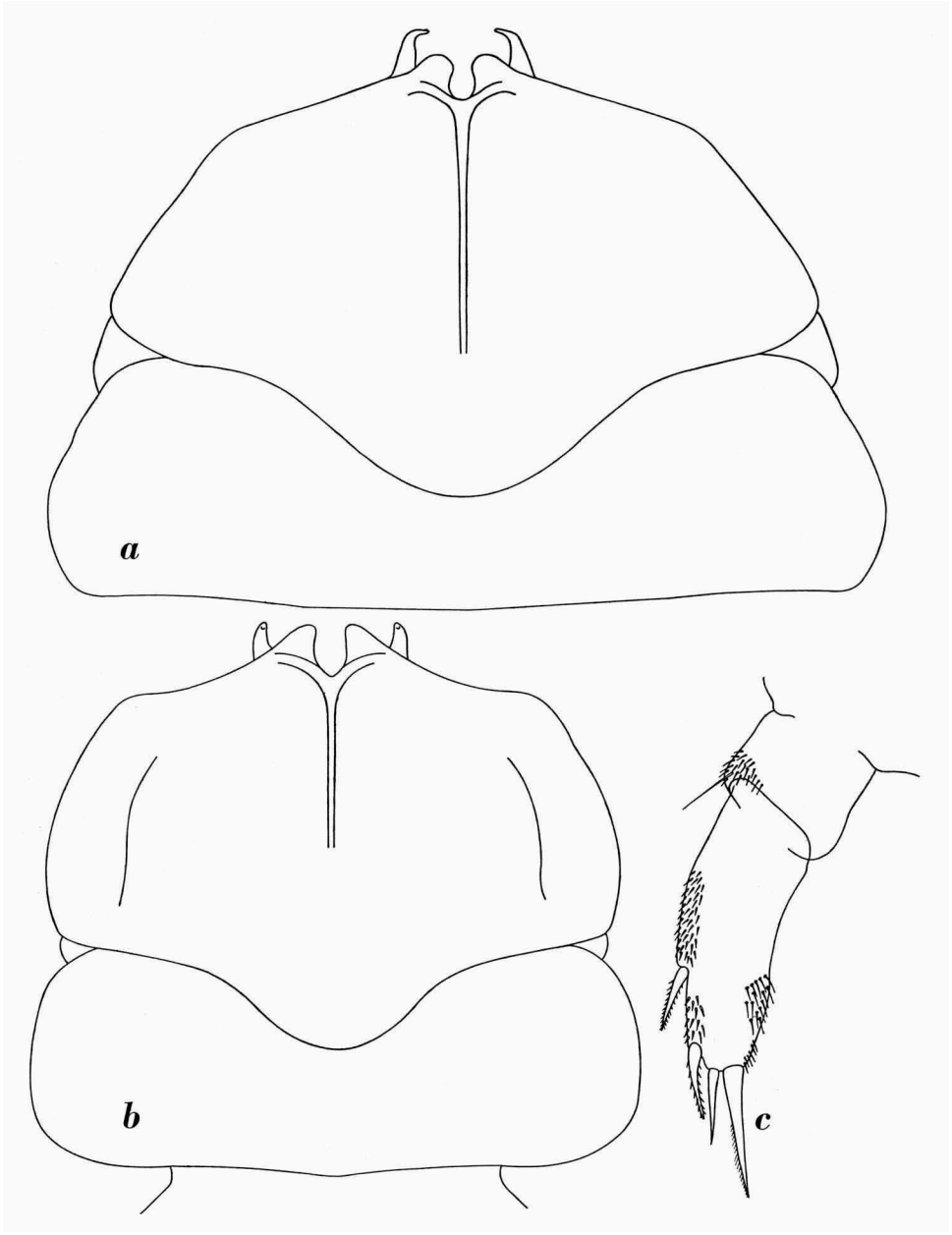

Fig. 16. *Ceratocolax euthynni* nov. spec., ad. ♀, Gulf of Guinea. a, paratype, anterior part cephalothorax in dorsal view; b, holotype, anterior part cephalothorax, dorsal view; c, leg 5. a, b, × 55; c, × 85.

sured from the end of the frontal prominences to the articulation between fourth and fifth thoracic somites, is 2.45 mm; the length of the abdomen, including the fifth thoracic somite, is 1.23 mm. The length of the cephalic somite, from the apex of the frontal prominences to the end of the dorsal hump, is 920 μ, the diameter is 1,300 μ. The length of the second thoracic somite is 360 μ, the greatest diameter 1,400 μ; for the remaining somites these figures are 600 and 1,240 μ for the third, 480 and 960 μ for the fourth and 280 and 680 μ for the visible part of the fifth somite. The genital complex is 440 μ long and 800 μ wide. The remaining abdominal somites have the following lengths and diameters: the third somite 360 and 380 μ; the fourth somite 220 and 320 μ; the fifth somite 230 and 280 μ. The furca is 120 μ long and each ramus basally has a diameter of 63 μ. The longest furcal setae are 400 μ long. The eggs sacs in all specimens are slightly damaged; they are sausage-shaped and slightly curved, twice or three times as long as the abdomen. They contain a very large number of small eggs.

The general shape of the body (fig. 15a, b) is characterized by the fairly broad cephalic somite and second thoracic somite; the remaining body somites are distinctly separated and gradually diminish in diameter. Both the cephalic somite and the third thoracic somite are of a very curious shape, particularly in lateral view; along with the presence of frontal prominences on the cephalic somite they afford highly characteristic features.

The head and the first thoracic somite are completely fused; the resulting cephalic somite, in dorsal view, is a fairly broad structure with a deep median longitudinal fossa with the internal chitinized ridge distinctly visible through the tegument. The anterior end of the fossa is deeply excavated between a chitinized frontal prominence on each side, the exact shape of which appears clearly from figure 16a, b. The anterior portion of the cephalic somite is strongly curved and hides the basal parts of the antennules completely from view; the hook-shaped prolongations of the dorsal plates of the antennules only are visible besides the frontal prominences of the head. The lateral portions of the cephalic somite are slightly depressed and set off from the rest of the somite by a shallow groove. In the middorsal line the cephalic somite is strongly backward produced; the produced part has the shape of a wedge-like sac covering a part of the second thoracic somite (fig. 15b). The rostral plate is only visible in ventral view; it is slightly produced backward between the basal parts of the antennules and terminates in the two-pointed rostrum. The rostral points are placed closely together and are bluntly pointed (fig. 17a).

The second thoracic somite, in dorsal view, is slightly broader than the cephalic somite; the epimeral plates are badly developed and the caudal border

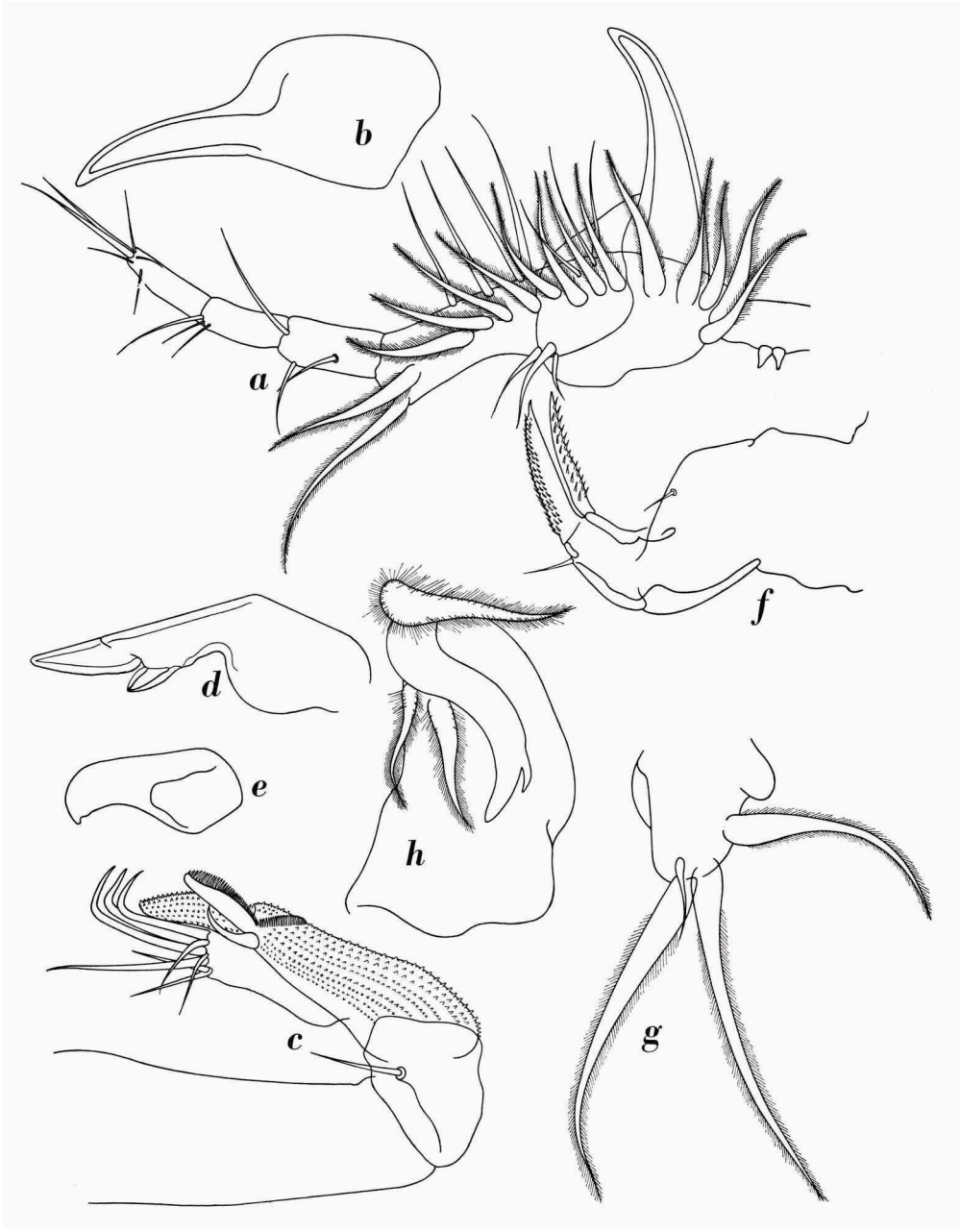

Fig. 17. *Ceratocolax euthynni* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, antennule, ventral view; b, dorsal plate; c, antenna; d, mandible; e, paragnath; f, maxilla; g, maxillule. a, b, × 135; c, × 240; d-g, × 220.

is straight. The shape of the third thoracic somite can best be judged from figure 15a, b. It is caudally and caudo-laterally produced and covers a part of the fourth thoracic somite. The caudo-lateral parts of this somite, in dorsal view, are slightly bilobated; the epimeral plates are well developed and rounded. The fourth thoracic somite is much smaller than the third and slightly backward produced to cover a part of the fifth thoracic somite; it has no epimeral plates. The fifth thoracic somite in dorsal view is more or less trapezoidal; the "shoulders", distinctly visible in dorsal view, serve as place of attachment for the fifth legs.

The first and second abdominal somites are completely fused to form the genital complex; this, by the peculiar development of the genital slits, is a very characteristic structure, the shape of which appears best in figure 15a. The genital slits, found latero-caudally on each side of the complex, are covered by three flap-like structures, completely hiding the small sixth feet. The three strong, haired setae found on each sixth foot do not protrude beyond the flaps (fig. 18c). The abdominal somites 3 to 5 gradually diminish in diameter; the anal somite is deeply cleft. The furcal rami are only slightly tapering and each has 5 marginal setae. The setae 1, 4 and 5 are short; seta 2 is greatly, seta 3 moderately lengthened. In addition there is a dorsal (appendicular) seta on each ramus (fig. 15c).

The antennular structure in this species is different from that observed in other Bomolochids. Each antennule is composed of a flattened and slightly chitinized proximal part, resulting apparently from the fusion of 3 segments, and a 3-segmented "flagellum". In addition there is, on each side, a dorsal chitinized plate, interposed between the antennule and the ventral wall of the cephalic somite. These highly chitinized dorsal plates are very firmly attached to the system of chitinized ridges of the ventral wall of the cephalic somite and to a much lesser degree to the chitinized structures of the proximal antennular portion. On dissection the antennules can easily be removed from the ventral wall of the cephalic somite but the dorsal plate then remains attached to the ventral wall and can only be removed at the cost of complete fragmentation of the cephalic somite. Each dorsal plate is produced into a fairly long, outwardly curved horn-shaped tooth, the development of which varies slightly in the various individuals, but it is always slightly longer than the frontal prominences of the cephalic somite and distinctly visible in dorsal aspect of each female. None of the 15 plumose setae of the ventral part of each antennule is fused with the rostral plate or its horn. In addition there are some "normal" setae on the antennule, the position of which appears from figure 17a. In some females the extreme part of the antennule may be visible protruding besides the cephalic somite in dorsal view.

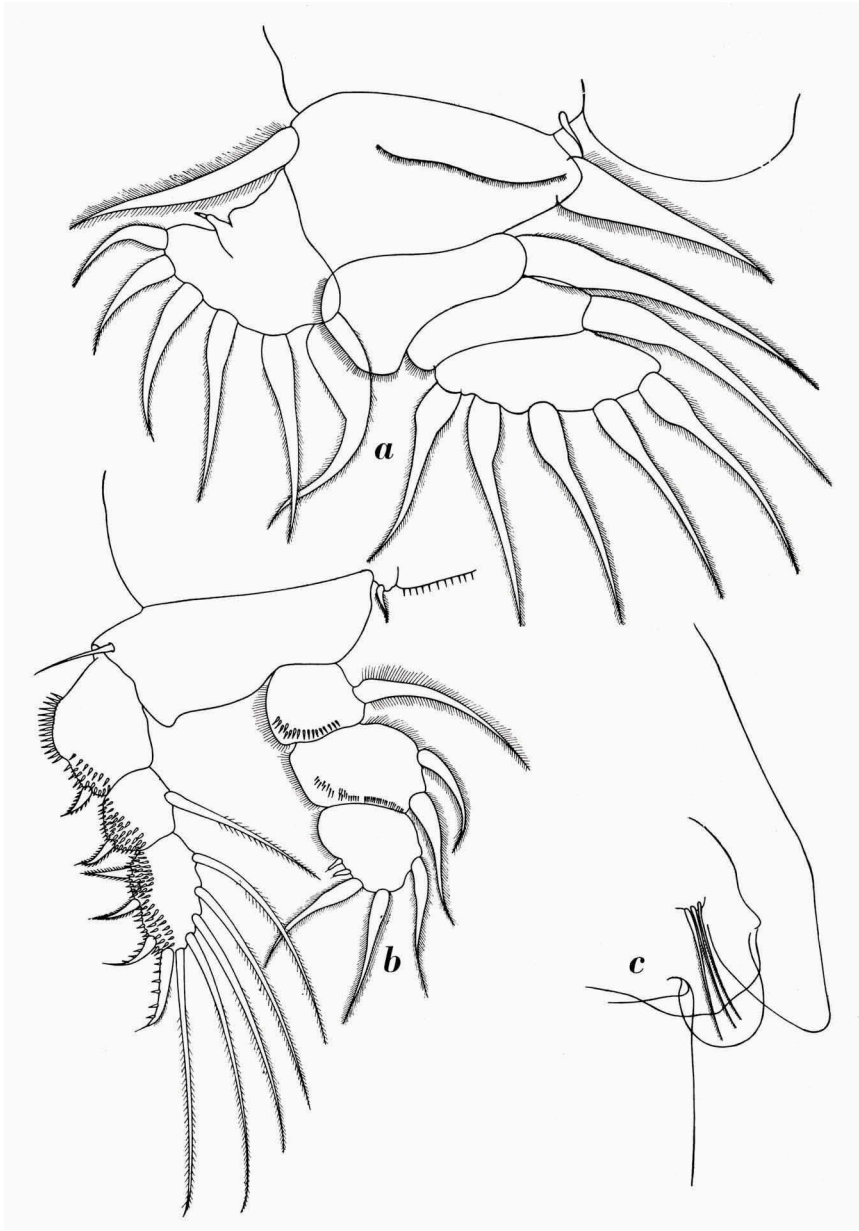

Fig. 18. *Ceratocolax euthymni* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 1; b, leg 2; c, right aperture of genital somite. a, × 135; b, c, × 85.

The antennae are like those of *Nothobomolochus*; the 2-segmented endopodite is folded over the coxa, which has a single seta. Both endopodal segments are covered with short, knob-like spines, arranged in longitudinal rows. The first endopodal segment has a total of 8 setae, 3 of which are hook-shaped. The arrangement of the setae appears from figure 17c. In addition there is a lamelliform process, set with a longitudinal row of fine spines, and a curved hook near its articulation with the first endopodal segment. The row of spines on the lamelliform process continues for some distance on the first endopodal segment as a pectinate row of spines.

The mandibles of both sides are partly covered by the broadly rounded, haired posterior margin of the labrum. The cutting edge of the mandible (fig. 17d) has one strong and big, and one much smaller tooth; the posterior, hyaline and sharp margins of both teeth are crenulated. The maxillule (fig. 17g), which is distinctly discernable, has 3 strong, plumose setae and a much smaller, nude seta. The paragnaths (fig. 17e) are short, club-shaped structures with an indistinctly hooked apex; the hook is directed backward. Both teeth-shaped appendages of the maxilla (fig. 17f) are covered by flat spinules. In addition there are two short setae on the maxilla, the position of which appears from figure 17f. The maxillipedes have the usual structure; the claw is strongly sigmoid and has a very distinct auxiliary tooth. In addition there are 3 setae, the position of which appears in figure 17h.

The legs 1 to 4 have the following setal and spinal formula:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5	6 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 5 + IIII
leg 3	1 + 0 . 2 + 0 . 2 + II	0 + I . 1 + I . 5 + III
leg 4	1 + 0 . 1 + 0 . I + 1 + I	0 + I . 1 + I . 4 + III

The endo- and exopodites of leg 1 (fig. 18a) are strongly flattened. There is a short internal seta on the coxa. The basis has a strong, plumose external and internal seta; in addition there is a transverse row of spinules on the anterior aspect of the basis. There is no haired appendage at the internal margin of the basis, its place being taken by the large seta. The exopodal segments are all fused; there is one external marginal spine with a short flagellum. The three endopodal segments are all separate. All setae of leg 1 are slightly thickened at the base and densely plumose.

The endo- and exopodites of legs 2 to 4 are 3-segmented. The legs 2 and 3 have a small seta at the internal margin of the coxa; the intercoxal plate is spinulose. In leg 2 (fig. 18b) the endopodite is strongly flattened; there are rows of spinules on the anterior surface of the endopodal segments 1

and 2. On the third endopodal segment there are 3 plumose setae and, at the external margin, 2 short, stubby spines with a short flagellum. The spines at the external margins of the exopodites of legs 2 to 4 are strongly spinulose, as also appears from the figures 18b and 19. The external margin of the exopodite is set with strong spinules; the spinules spread over a portion of

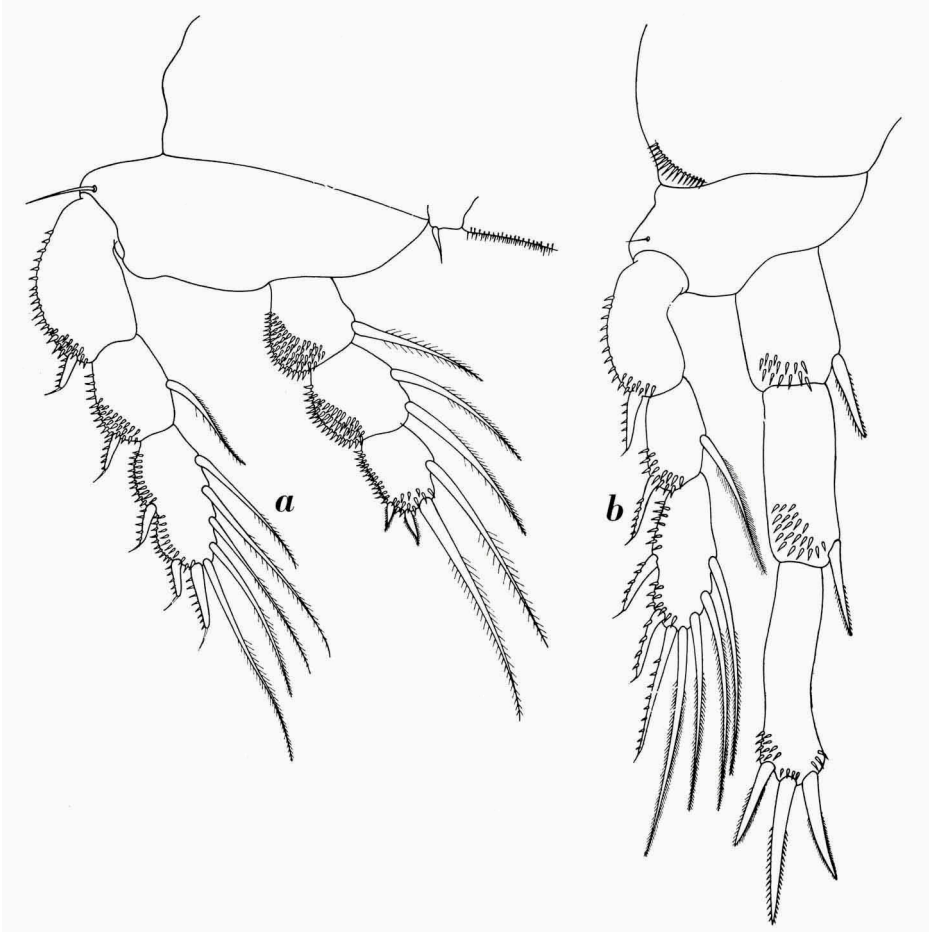

Fig. 19. *Ceratocolax euthynni* nov. spec., ad. ♀, paratype, Gulf of Guinea. a, leg 3; b, leg 4. × 85.

the anterior surface of the exopodal segments. A similar condition occurs along the external margin of the endopodite of leg 3 (fig. 19a); the third endopodal segment of leg 2 has 2 setae at the internal margin and two short spines at the external margin. Leg 4 (fig. 19b) is remarkable by the great length of the endopodite, which surpasses the exopodite. There are

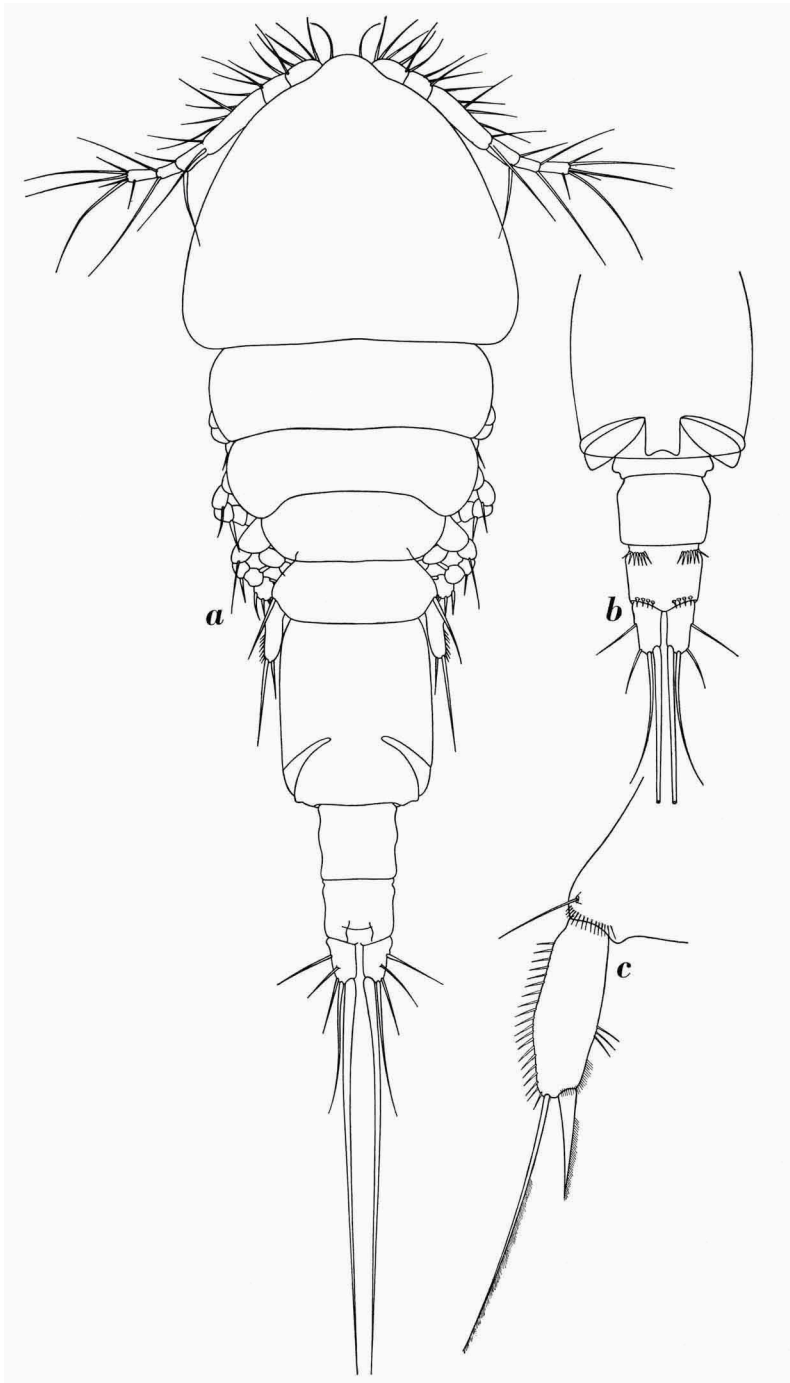

Fig. 20. *Ceratocolax euthynni* nov. spec., ad. ♂, Gulf of Guinea. a, allotype, whole animal, dorsal view; b, paratype, abdomen, ventral view; c, paratype, leg 5. a, b, × 80; c, × 220.

patches of large spinules on the distal part of the anterior surface of the endopodal segments; the third endopodal segment has 3 apical spines, the median being slightly longer.

In the fifth legs the intermediate and terminal segments are distinctly separate. The intermediate segment is a short, tube-shaped structure with a seta and a patch of spiniform hairs at the distal part of the external margin. The terminal segment is slightly curved; it has an external spine and 3 apical spines, the position of which appears in figure 16c. In addition there are some patches of hair-like spinules on the anterior surface.

Adult male, total length 1.47 mm. The greatest diameter is 0.51 mm. The cephalic somite has a total length of 446 μ and a diameter of 513 μ. For the remaining somites these figures are 149 and 432 μ for the second thoracic somite; 95 and 378 μ for the third thoracic somite; 108 and 270 μ for the fourth thoracic somite; 95 and 243 μ for the fifth thoracic somite; 297 and 243 μ for the genital complex; 122 and 135 μ for the fourth abdominal somite and 95 and 108 μ for the fifth abdominal somite. The length of the longest furcal seta is 880 μ. The length of the furca is 77 μ; the greatest diameter of each ramus is 44 μ.

The general appearance of the male is quite different from that of the female (fig. 20a); the body is cyclopoid, with the thoracic and abdominal somites gradually diminishing in size; none of the thoracic somites is backward produced, so that in dorsal aspect of the male all thoracic somites can clearly be observed. The head and the first thoracic somite are fused to form the cephalic somite. The frontal part of the cephalic somite is slightly produced between the bases of the antennules, the apex of this produced part is rounded. No rostrum has been observed. The lateral portions of the thoracic somites 2 to 4 are rounded; the coxae of the legs are visible from above. The thoracic somite 5 is distinctly shouldered on both sides; the shoulders support the fifth legs and have a lateral seta on each side in addition to some small spinules (fig. 20c).

The genital complex is a large, barrel-shaped structure; in ventral aspect the genital flaps are distinctly visible; their shape appears in figure 20b. The third abdominal somite is either fused with or completely telescoped into the genital complex: I could not observe it in the specimens at my disposal. The abdominal somites 4 and 5 are much narrower than the genital complex. The anal somite has a distinct anal flap; ventrally there are short rows of big spinules near the insertion of the furcal rami and near the articulation with somite 4. The setation of the furca is as in the female.

The antennules are very distinctly visible from above; they are not reinforced by chitinized plates. Each antennule has 6 free segments; the setation

appears in figure 21a. The number of plumose (sensory) setae on each antennule is 15.

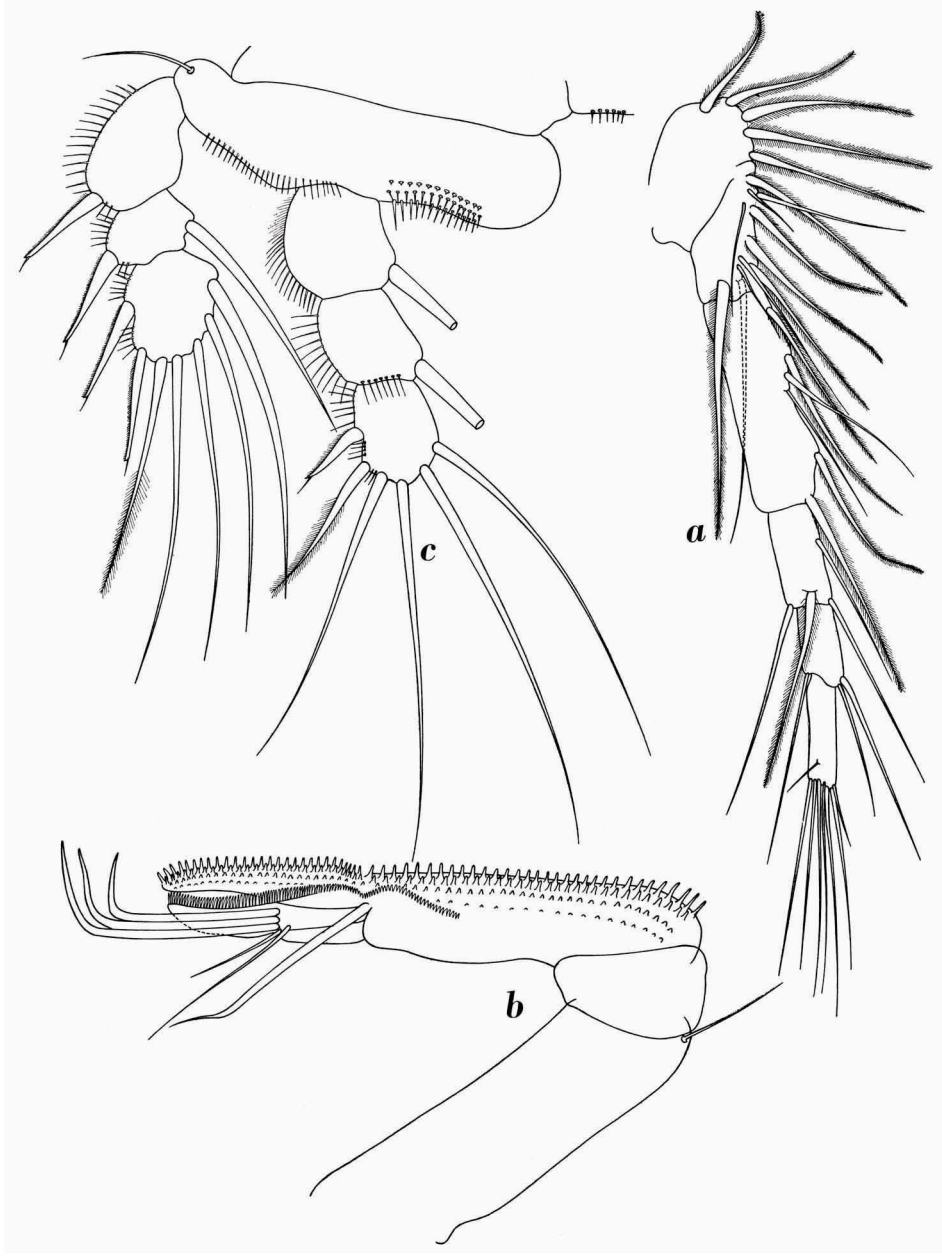

Fig. 21. *Ceratocolax euthynni* nov. spec., ad. ♂, paratype, Gulf of Guinea. a, antennule, ventral aspect; b, antenna; c, leg 1. a, × 240; b, c, × 400.

The antenna (fig. 21b) has the same structure as in the female, but it is correspondingly smaller. The spines, composing the longitudinal rows on the endopodite, are longer and slenderer than in the female; the pectiniform row of spinules on the lamelliform process, and its continuation on the endopodite, is composed of finer and shorter teeth, though it still represents a very characteristic structure on the antenna.

I have obtained a very satisfactory preparation of the oral appendages. The mandibles, maxillules, paragnaths and maxillae, though smaller, are as in the female. The maxillipedes are completely transformed, compared with those of the female, and represented by strongly developed, chelate structures on each side. Each maxillipede (fig. 22d) is composed of a short coxa, apparently without seta. The basis is strongly swollen; its internal surface is covered with some longitudinal rows of spinules. In addition there are two fine setae on the basal third of the basis. The endopodite is a single, claw-shaped segment, about as long as the basis and slightly curved. It has a longitudinal row of scale-shaped teeth; the basal part of the endopodite has a single seta.

The structure of legs 1 to 4 appears from the setal and spinal formula, the figures 21c, 22a-c, and from the following notes.

Setal and spinal formula:

	endopodite	exopodite
leg 1	1 + 0 . 1 + 0 . 5 + I	0 + I . 1 + I . 5 + II
leg 2	1 + 0 . 2 + 0 . 3 + II	0 + I . 1 + I . 5 + III
leg 3	1 + 0 . 2 + 0 . 2 + II	0 + I . 1 + I . 5 + III
leg 4	1 + 0 . I + 1 + I	0 + I . 1 + 0 . 4 + III

All legs are characterized by the strongly spinulose external marginal spines of the exopodite; the basis has a distinct external seta. The intercoxal plate of legs 1 to 4 is spinulose.

Leg 1 (fig. 21c) has the internal part of the basis strongly spinulose.

Leg 2 (fig. 22a) has two internal setae on the second endopodal segment. The external margin of the coxa is spinulose. The two spines on the third endopodal segment are strongly spinulose.

Leg 3 (fig. 22b) has two setae at the internal margin of the second endopodal segment. The two spines at the apex of the third endopodal segment are strongly spinulose. The external margin of the coxa is covered with some spinules.

The internal seta of the first endopodal segment of leg 4 (fig. 22c) is very strong. The apex of the second endopodal segment has two unequal spines flanking a slender seta. The external margin of the coxa is spinulose.

The fifth leg is composed of a single segment, the shape of which appears from fig. 20c. The apex has a strong spine, placed at the internal part of the

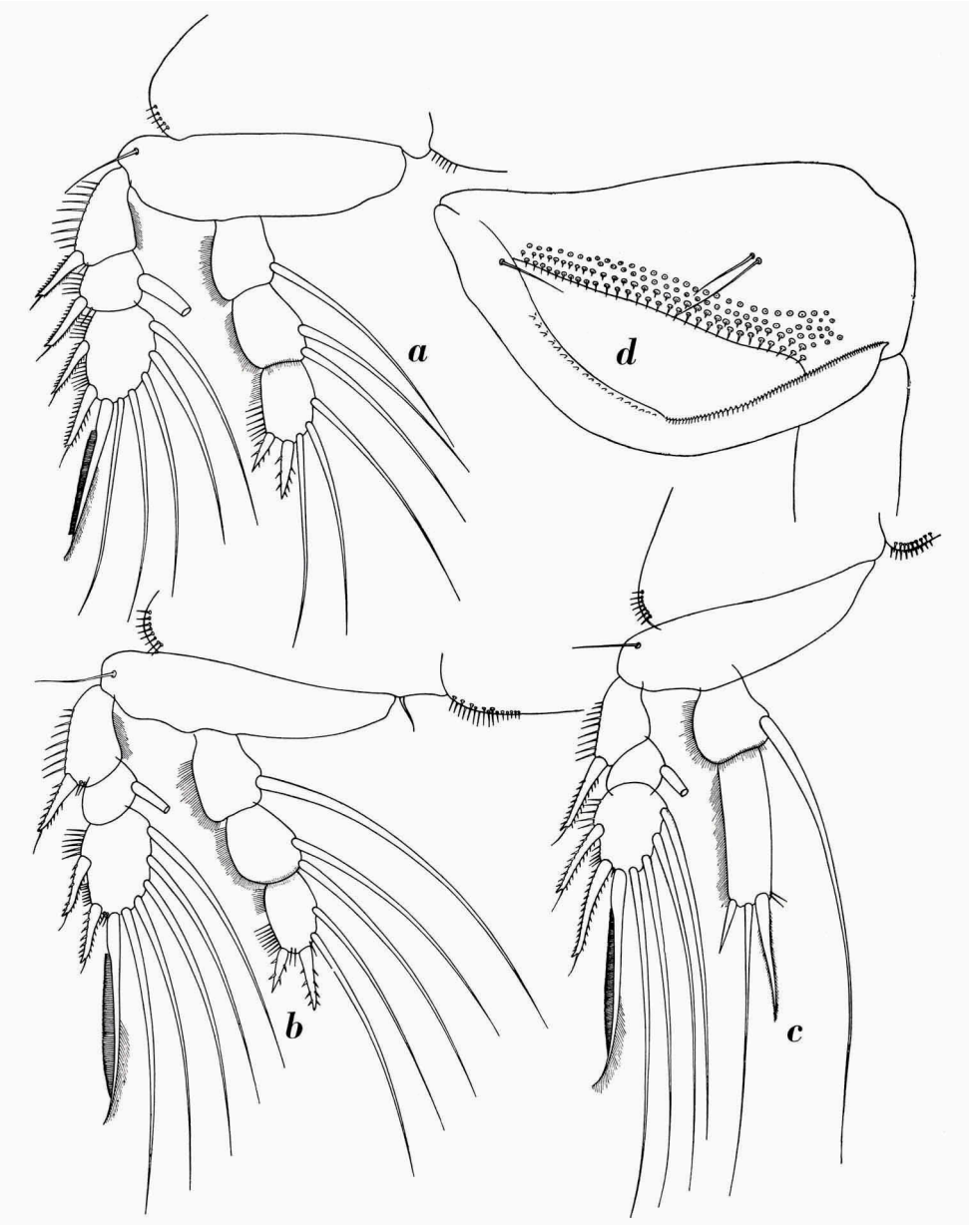

Fig. 22. *Ceratocolax euthynni* nov. spec., ad. ♂, paratype, Gulf of Guinea. a, leg 2; b, leg 3; c, leg 4; d, maxillipede. × 240.

apex, and a long, slender seta. The external margin of the segment is completely spinulose; the internal margin has some hairs and a patch of spines about halfway its length. The "shoulder" of the fifth thoracic somite, in addition to the seta, has a row of fine spines near the insertion of leg 5.

From information supplied by Dr. J. F. Aldrin it appears that almost every specimen of *Euthynnus alleteratus* (Rafinesque) from the Gulf of Guinea area carries parasites in both nasal fossae. This at least appeared to be the condition in 226 fishes inspected for the presence of Bomolochid parasites, all of which appeared to carry this species in both nasal fossae, without any trace of damage to the fish. The smallest specimen of *Euthynnus alleteratus* inspected measured 28 cm. In several instances *Ceratocolax euthynni* occurred together with a second species, *Parabomolochus anonymus,* a much smaller species, of which the incidence of parasitism appears to be much less.

Though in the samples at my disposal females and males occur separately there is little doubt that the large maxillipedes of the males are used to clasp the females, probably at or near the fifth thoracic somite.

References

VERVOORT, W., 1962. A review of the genera and species of the Bomolochidae (Crustacea, Copepoda), including the description of some old and new species. Zool. Verhandel. Leiden **56**: 1-111, fig. 1-12.

——, 1964. Notes on Bomolochidae (Copepoda), I. A redescription of Parabomolochus cuneatus (Fraser, 1920) and notes on its synonymy. Crustaceana **6**: 291-302, fig. 1-7.

YAMAGUTI, S., 1963. Parasitic Copepoda and Branchiura of fishes: i-ix, 1-1104, pl. 1-333.