

DESCRIPTIONS OF TEN XANTHOIDEAN (CRUSTACEA: DECAPODA: BRACHYURA) FIRST STAGE ZOEAS FROM INHACA ISLAND, MOZAMBIQUE

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ABSTRACT. – The zoea stage I of seven xanthoidean (sensu Serène, 1984) crab species, collected from Inhaca Island, Mozambique, and hatched in the laboratory are described for the first time, *Epixanthus frontalis* (H. Milne Edwards, 1834), *Lydia annulipes* (H. Milne Edwards, 1834), *Eriphia scabricula* Dana, 1852, *Lybia plumosa* Barnard, 1947, *Pilodius paumotensis* Rathbun, 1907, *Zozymodes xanthoides* (Krauss, 1843) and *Eurycarcinus natalensis* (Krauss, 1843). *Leptodius exaratus* (H. Milne Edwards, 1834), *Pilumnus longicornis* Hilgendorf, 1879 and *Pilumnus vespertilio* (Fabricius, 1793) first stage zoeas are redescribed. A comparative study of all these larvae, especially antennal morphology, is presented.

KEY WORDS. – First stage zoeal description, Xanthoidea, *Epixanthus frontalis*, *Lydia annulipes*, *Eriphia scabricula*, *Lybia plumosa*, *Pilodius paumotensis*, *Zozymodes xanthoides*, *Leptodius exaratus*, *Eurycarcinus natalensis*, *Pilumnus longicornis*, *Pilumnus vespertilio*.

INTRODUCTION

Brachyuran crabs represent one of the major animal groups in coastal ecosystems, being one of the most abundant macroinvertebrates in mangroves and tidal flats in tropical regions. Dispersal and recruitment studies are important in order to understand the role of the various coastal biotopes on the growth of the early stages, the patterns of genetic exchange between separate populations, as well as to assess the magnitude of interchange between coastal ecosystems and possible depletion of species vulnerable to overexploitation. One of the major handicaps to developing such studies is the absence of reliable brachyuran larval descriptions and this has prevented marine biologists from identifying the majority of species in the plankton even to family level. Most crab larvae from the Western Indian Ocean to date are either undescribed or their descriptions by early authors do not meet modern day requirements for accurate comparative studies (Clark et al., 1998). At Inhaca Island, Mozambique, a significant part of zooplankton is composed of decapod crustacean larval stages, mainly brachyurans (Paula et al., 1998), and of these only a restricted number can be assigned to known species (Flores et al., 2003). Accordingly, a programme was developed to obtain and describe hatched larval stages from ovigerous decapod crustaceans from east African coasts. The aim of this project is to produce identification keys for at least most of the

common species. This present paper deals with xanthoidean crabs; other brachyuran and decapod groups are to be treated elsewhere.

Ten species of xanthoidean (sensu Serène, 1984) ovigerous crabs were collected from around Inhaca Island, Mozambique and hatched in the laboratory. Three families (Xanthidae MacLeay, 1838, Eriphiidae MacLeay, 1838 and Pilumnidae Samouelle, 1819) were represented within the Xanthoidea and this is the first time that larvae from the Polydectinae (Xanthidae) are described. Further, the first stage zoea of seven species are described for the first time including *Epixanthus frontalis* (H. Milne Edwards, 1834), *Lydia annulipes* (H. Milne Edwards, 1834), *Eriphia scabricula* Dana, 1852, *Lybia plumosa* Barnard, 1947, *Pilodius paumotensis* Rathbun, 1907, *Zozymodes xanthoides* (Krauss, 1843), and *Eurycarcinus natalensis* (Krauss, 1843). The zoeas of three other species have been reported previously: *Leptodius exaratus* (H. Milne Edwards, 1834) by Aikawa (1929) [as *Xantho exaratus*], Chhapgar (1956), Tufail & Hashmi (1964) [as *L. exaratus*], Saba (1976), Fielder et al. (1979), Terada (1980), Amir (1989) [publication not seen during this present study] and Siddiqui & Tirmizi (1998), *Pilumnus longicornis* Hilgendorf, 1879 by Hashmi (1970a) and *Pilumnus vespertilio* (Fabricius, 1793) by Aikawa, (1929), Hashmi (1970a), Lim & Tan (1981) and Terada (1990); but are here redescribed.

From adult specimens deposited in the collections of The Natural History Museum, London, the distribution of ten xanthoidean species represented in this present study fall into two categories. Three species appear to be restricted to the Western Indian Ocean namely, *Lybia plumosa*, *Zozymodes xanthoides* and *Eurycarcinus natalensis*. The remainder, *Epixanthus frontalis*, *Lydia annulipes*, *Eriphia scabricula*, *Pilodius paumotensis*, *Leptodius exaratus*, *Pilumnus longicornis* and *Pilumnus vespertilio*, have much wider distribution from the East coast of Africa through to Indochina and the Pacific.

The purpose of this present study is to describe and illustrate the first stage zoea of ten xanthoidean crab species collected from Inhaca Island, Mozambique. Abbreviations used: coll. = collected, NHM = The Natural History Museum, London and ZRC = Zoological Reference Collection, Raffles Museum, National University of Singapore.

MATERIAL EXAMINED

- Eriphia scabricula* Dana, 1852, coll. Paul Clark & José Paula, polychaete worm reef, Cabo Inhaca, North East Inhaca Island, Mozambique, 13 Nov.1997 and hatched on 27 Nov.1997, NHM reg. 2003:191, five specimens were examined.
- Epixanthus frontalis* (H. Milne Edwards, 1834), coll. Paul Clark & José Paula, Ponta Ponduine, South West Inhaca Island, Mozambique, 15 Nov.1997 and hatched on 5 Dec.1997, NHM reg. 2003:192, five specimens were examined.
- Lydia annulipes* (H. Milne Edwards, 1834), coll. José Paula, Cabo Inhaca, North East Inhaca Island, Mozambique, 31 Jan.2002 and hatched on 2 Feb.2002, NHM reg. 2003:193, six specimens were examined.
- Pilodius paumotensis* Rathbun, 1907, coll. Paul Clark & José Paula, polychaete worm reef, Cabo Inhaca, North East Inhaca Island, Mozambique, 13 Nov.1997 and hatched on 15 Nov.1997, NHM reg. 2003:194, five specimens were examined.
- Lybia plumosa* Barnard, 1947, coll. Paul Clark & José Paula, Barreira Vermelha, Inhaca Island, Mozambique, 1 Dec.1997 and hatched on 8 Dec.1997, NHM reg. 2003:195, five specimens were examined.
- Leptodius exaratus* (H. Milne Edwards, 1834), coll. Paul Clark & José Paula, off Inhaca Marine Biological Station, Inhaca Island, Mozambique, 11 Nov.1997 and hatched on 12 Nov.1997, NHM reg. 2000:1908, five specimens were examined.
- Zozymodes xanthoides* (Krauss, 1843), coll. Paul Clark & José Paula, polychaete worm reef, Cabo Inhaca, North East Inhaca Island, Mozambique, 13 Nov.1997 and hatched on 25 Nov.1997, NHM reg. 2003:196, five specimens were examined.
- Eurycarcinus natalensis* (Krauss, 1843), coll. Paul Clark & José Paula, Saco Mangrove, Inhaca Island, Mozambique, 12 Nov.1997 and hatched on 17 Nov.1997, NHM reg. 2003:197, five specimens were examined.
- Pilumnus longicornis* Hilgendorf, 1879, coll. Paul Clark & José Paula, off Ponta Raso, Inhaca Island, Mozambique, 27 Nov.1997 and hatched on 28 Nov.1997, NHM reg. 2003:198, five specimens were examined.
- Pilumnus vespertilio* (Fabricius, 1793), coll. Paul Clark & José Paula, Ponta Ponduine, South West Inhaca Island, Mozambique, 15 Nov.1997 and hatched on 5 Dec.1997, NHM reg. 2003:199, five specimens were examined.
- Atergatis floridus* (Linnaeus, 1767), coll. Peter Ng, Singapore, 13 Apr.1982, ZRC reg. 1984.608-4007, six specimens examined.

- Eriphia smithi* MacLeay, 1838, coll. Syed Salahuddin Hashmi, Buleji Rocks, Native Jetty, Manora Island, Karachi, Pakistan, NHM reg. 1986:908, five specimens examined.
- Lophozozymus pictus* (Fabricius, 1798), coll. Peter Ng, Siloso Beach, Setosa Island, Singapore, hatched 29 Jan.1992.

METHODS

First stage zoeas were hatched in the Marine Biological Station of Inhaca Island, Mozambique and preserved in 70% alcohol. The zoeas were dissected using a Wild M5 and drawings were made using an Olympus BH-2 microscope equipped with Nomarski interference contrast plus a *camera lucida*. Setal ambiguities were resolved using a Zeiss Axioskop differential interference contrast microscope. Appendages were mounted in polyvinyl lactophenol and allowed to clear for 24 hrs. Cover-slips were sealed with clear nail varnish. The sequence of the zoeal descriptions is based on the malacostracan somite plan and described from anterior to posterior. Setal armature of appendages was described from proximal to distal segments and in order of endopod to exopod (see Clark et al., 1998). The first stage zoeas were described and fully illustrated. The long antennular aesthetascs, the long plumose natatory setae of the first and second maxillipeds and distal part of the telson furcae in close-up aspect were drawn truncated. The approximate measurement of the antennal exopod (for its ratio with the protopod) was taken from the base to the tip excluding the terminal setae.

LARVAL DESCRIPTIONS

ERIPHIIDAE MACLEAY, 1838

ERIPHIINAE MACLEAY, 1838

Eriphia scabricula Dana, 1852

(Figs. 1-4)

Larval description. – Carapace (Fig. 1a): dorsal spine curved distally, approximately same length as rostral spine; rostral spine slightly longer than antennal protopod and without distal spinulation; lateral spines long and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 1b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 1 long slender, 2 shorter, slender terminal aesthetascs of unequal length and 1 short terminal seta.

Antenna (Fig. 1c): protopodal process distally bilaterally spinulate, slightly short in length than rostral spine and with two small lateral basal spines; endopod absent; exopod ca. 40% length of protopod, possessing 3 (1 long subterminal setae, 2 unequal terminal) setae with small spinules at base.

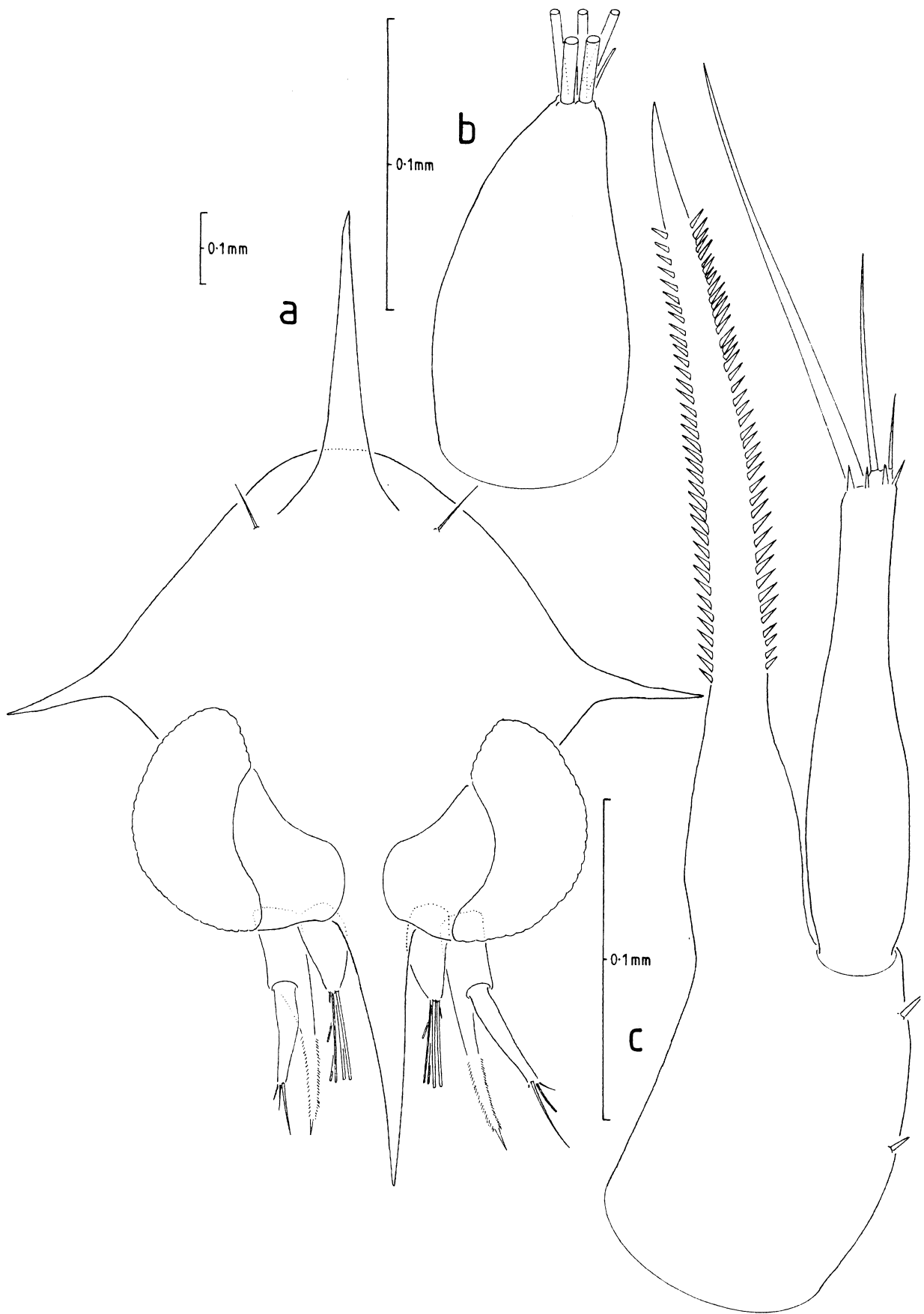


Fig. 1. *Eriphia scabricula* Dana, 1852 first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

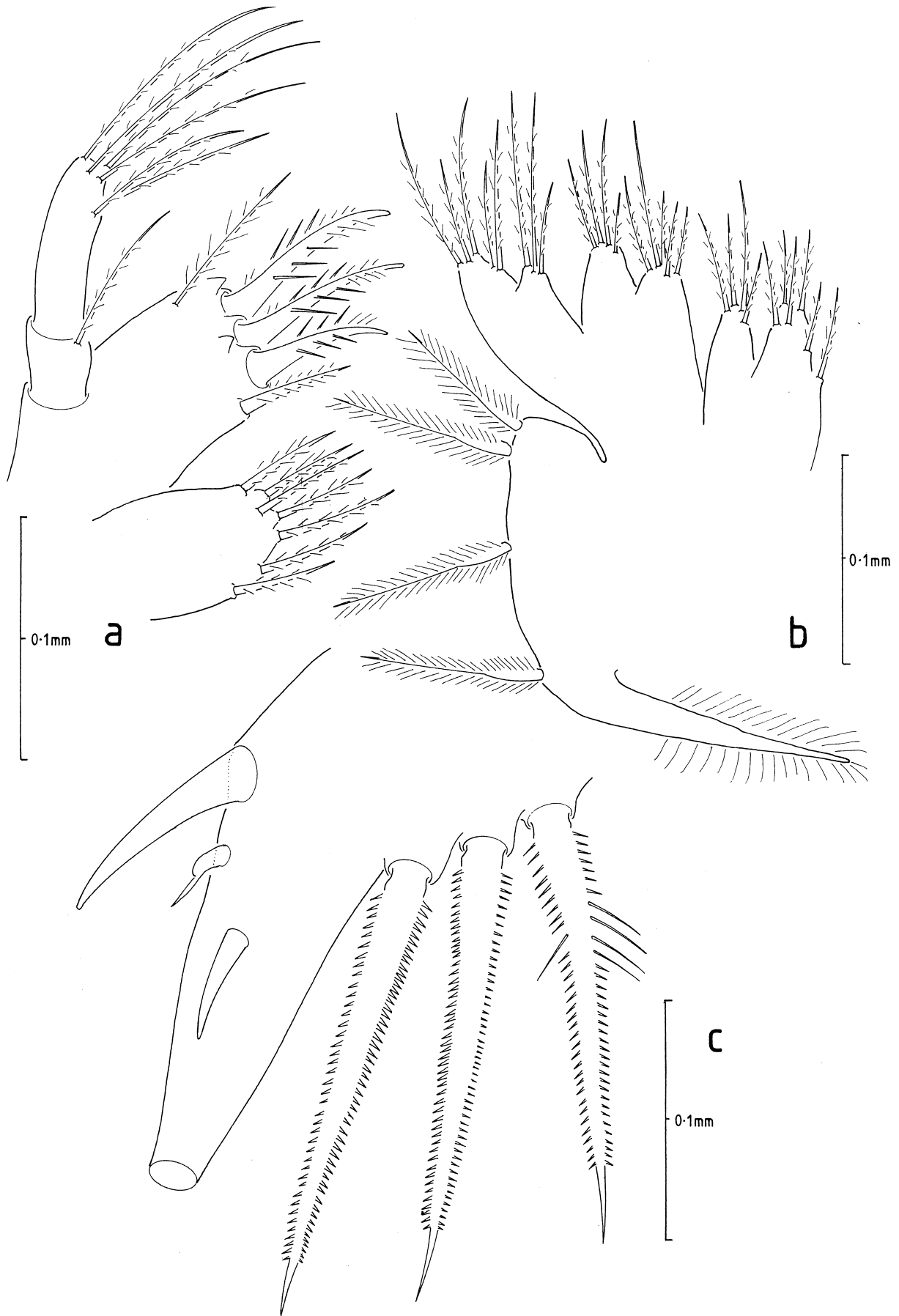


Fig. 2. *Eriphia scabricula* Dana, 1852 first stage zoea; a) maxillule; b) maxilla; c) telson.

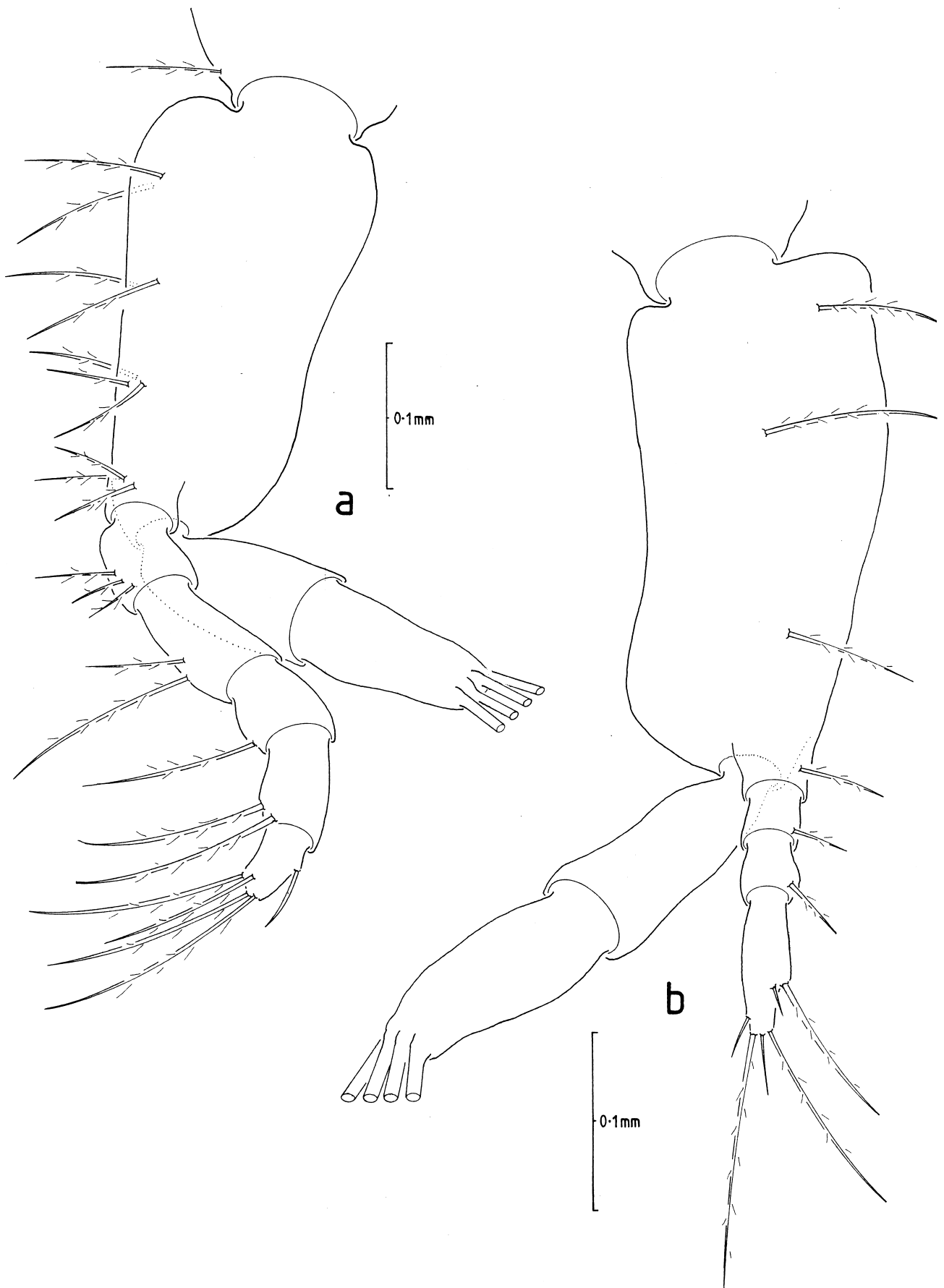


Fig. 3. *Eriphia scabricula* Dana, 1852 first stage zoea; a) first maxilliped; b) second maxilliped.

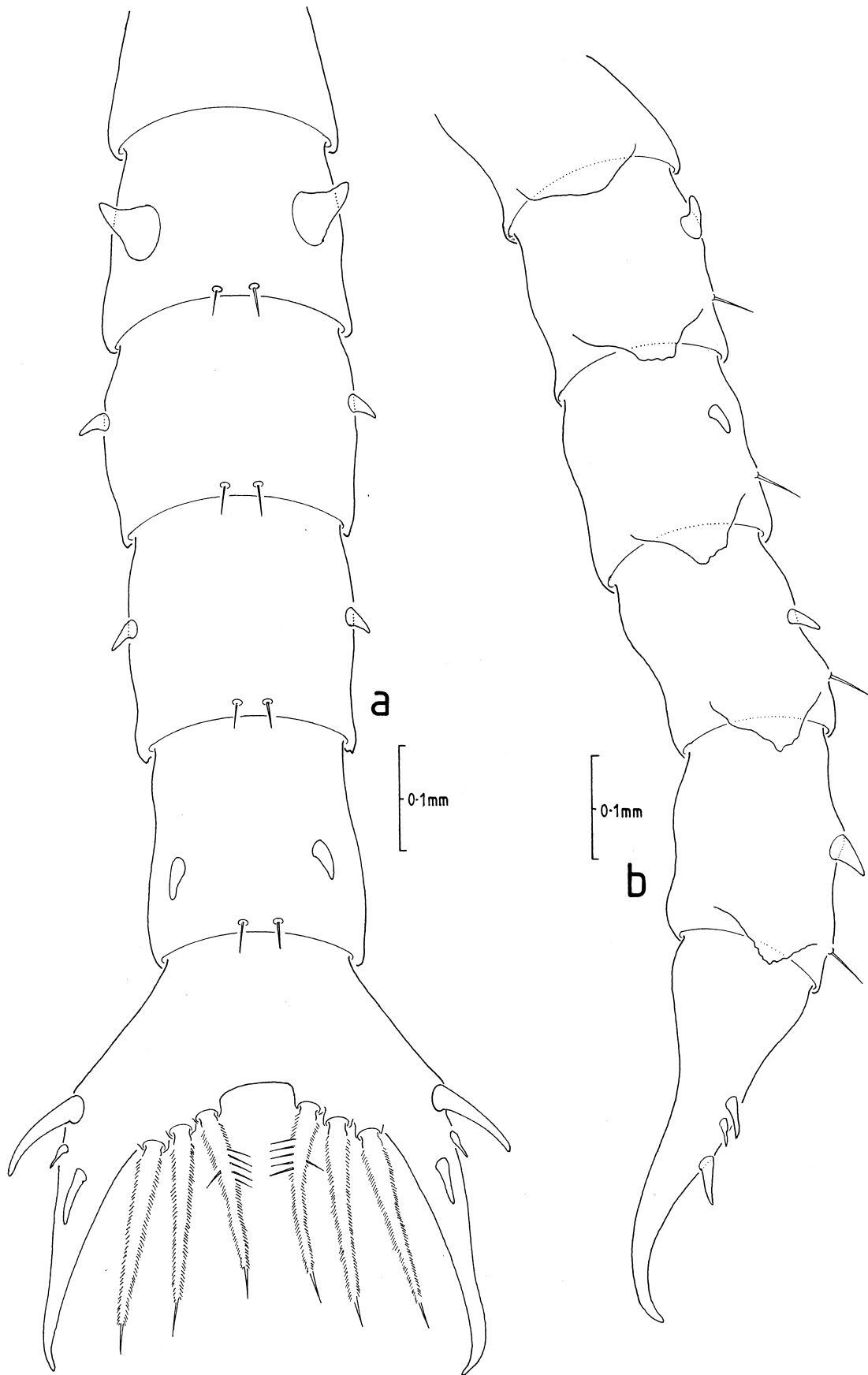


Fig. 4. *Eriphia scabricula* Dana, 1852 first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

Mandible: endopod palp absent.

Maxillule (Fig. 2a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 2b): coxal endite bilobed with 6+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 3a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 3b): coxal without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 4a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somites 3-5 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short rounded posterolateral processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 2c, 4a, b): each fork long, gradually curved distally; 1 large and 1 small lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

OZIINAE DANA, 1851

Epixanthus frontalis (H. Milne Edwards, 1834) (Figs. 5-8)

Larval description. – Carapace (Fig. 5a): dorsal spine long and curved distally, longer than rostral spine; rostral spine approximately equal in length to antennal protopod and without spinulation distally; lateral spines present and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 5b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 1 long slender, 2 shorter, slender terminal aesthetascs of unequal length and 1 short terminal seta.

Antenna (Fig. 5c): protopodal process distally, bilaterally spinulate, approximately equal in length to rostral spine; endopod absent; exopod ca. 41% length of protopod, possessing 3 (1 long subterminal, 2 unequal terminal) setae with small spinules at base.

Mandible: endopod palp absent.

Maxillule (Fig. 6a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 6b): coxal endite bilobed with 5+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 7a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 7b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 8a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short rounded posterolateral processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 6c, 8a, b): each fork long, gradually curved distally; 1 large and 1 small lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

Lydia annulipes (H. Milne Edwards, 1834) (Figs. 9-12)

Larval description. – Carapace (Fig. 9a): dorsal spine curved distally, slightly longer than rostral spine; rostral spine approximately the same length as antennal protopod and without distal spinulation; lateral spines long and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

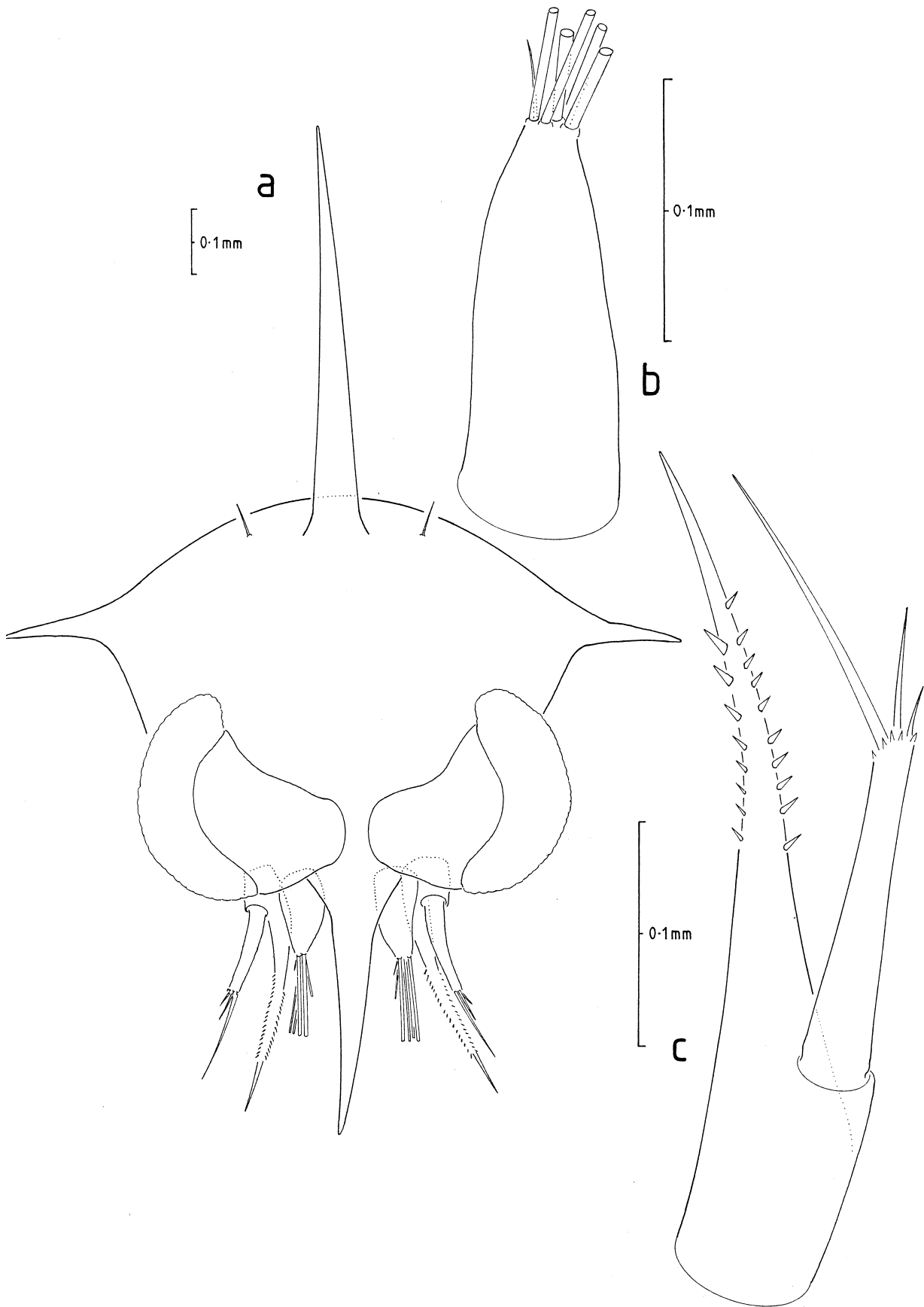


Fig. 5. *Epixanthus frontalis* (H. Milne Edwards, 1834) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

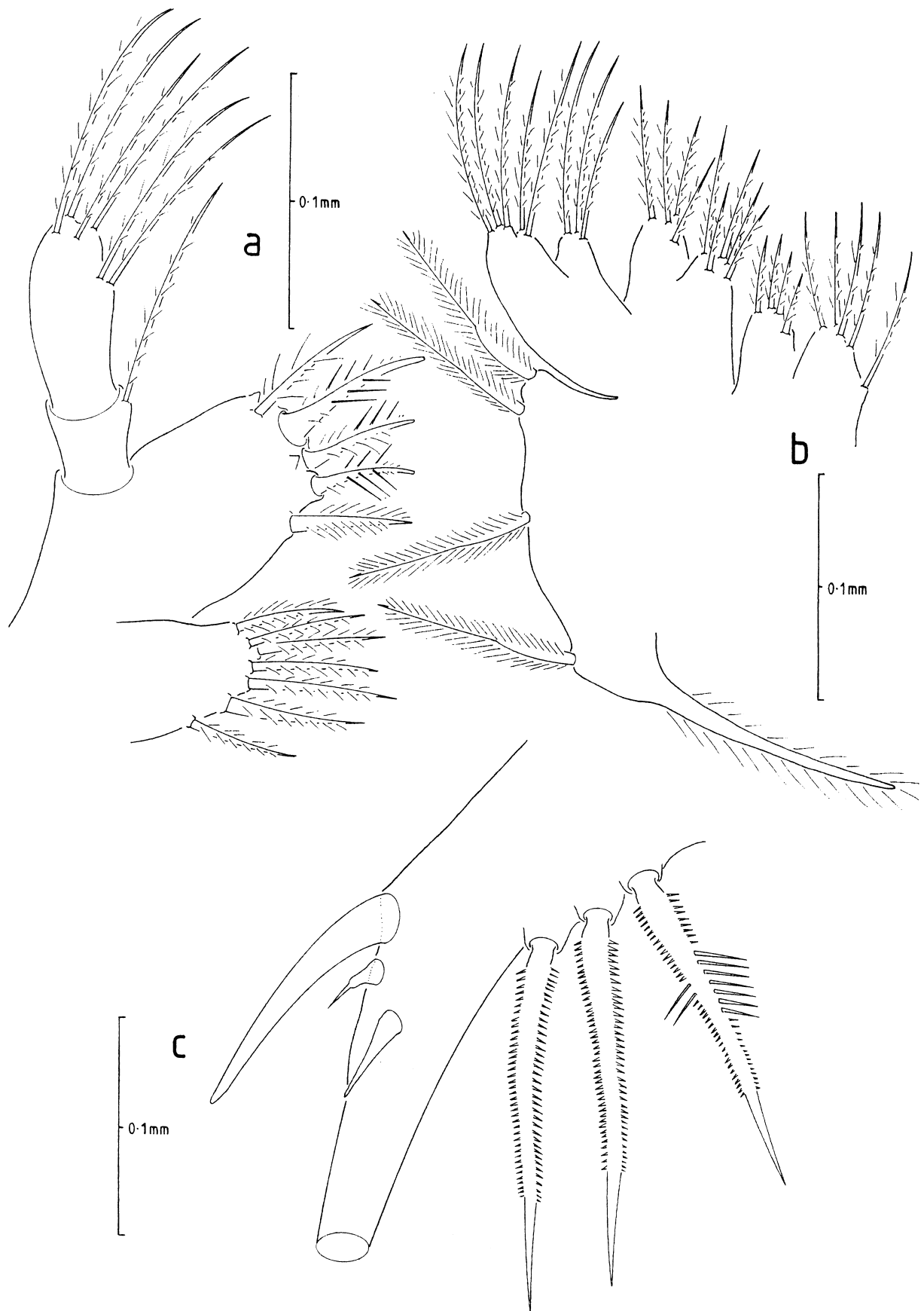


Fig. 6. *Epixanthus frontalis* (H. Milne Edwards, 1834) first stage zoea; a) maxillule; b) maxilla; c) telson.

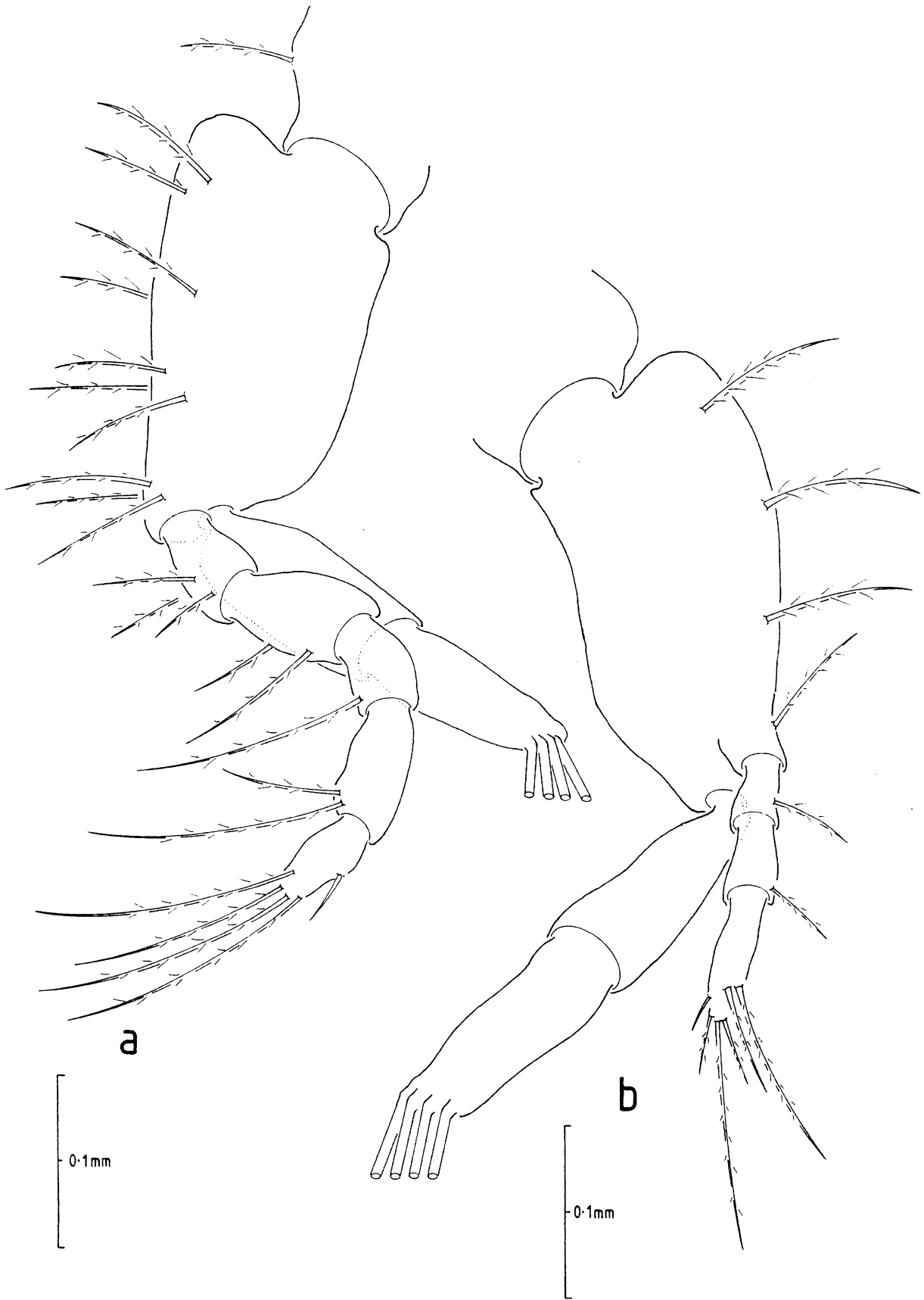


Fig. 7. *Epixanthus frontalis* (H. Milne Edwards, 1834) first stage zoea; a) first maxilliped; b) second maxilliped.

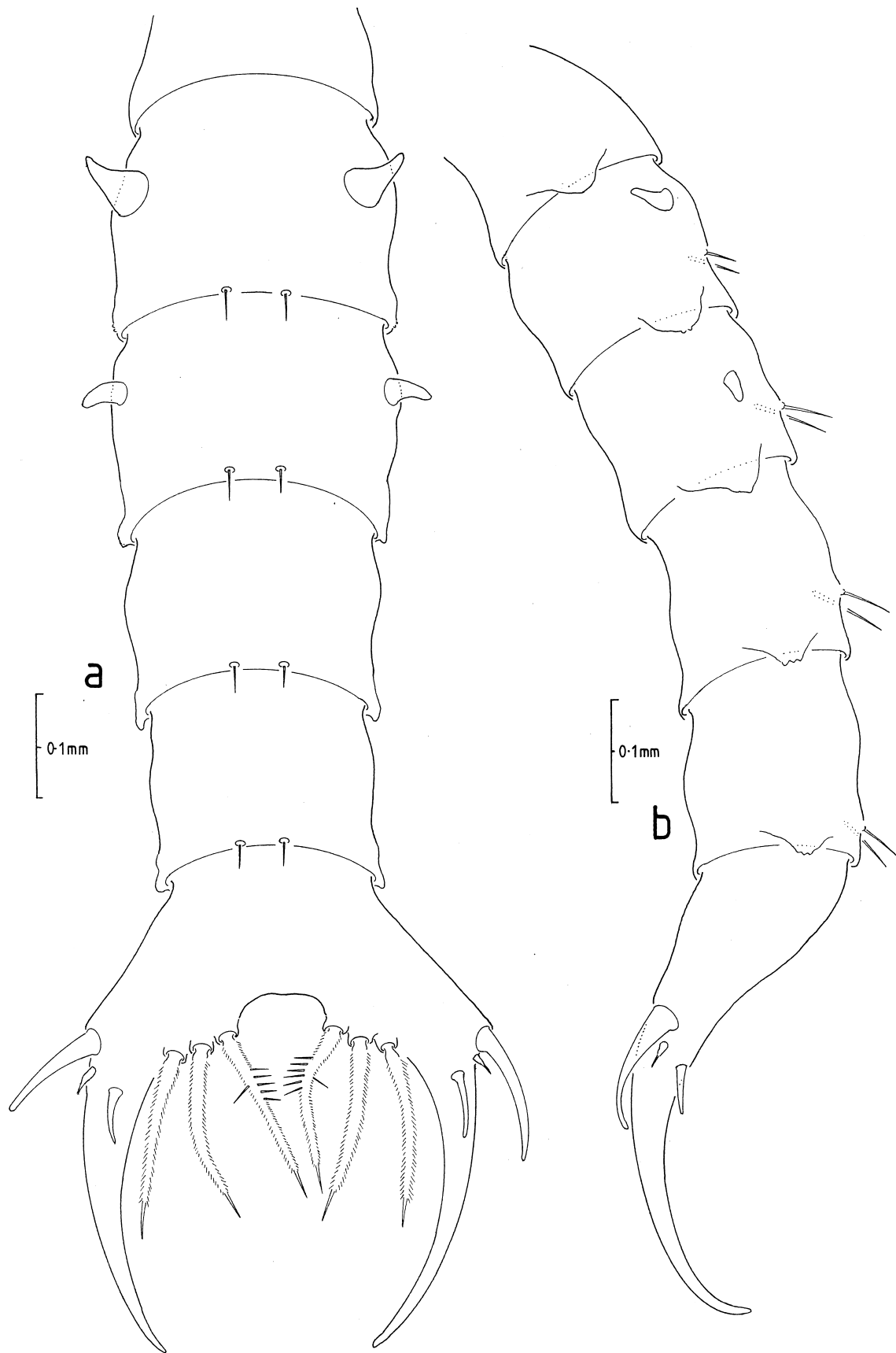


Fig. 8. *Epixanthus frontalis* (H. Milne Edwards, 1834) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

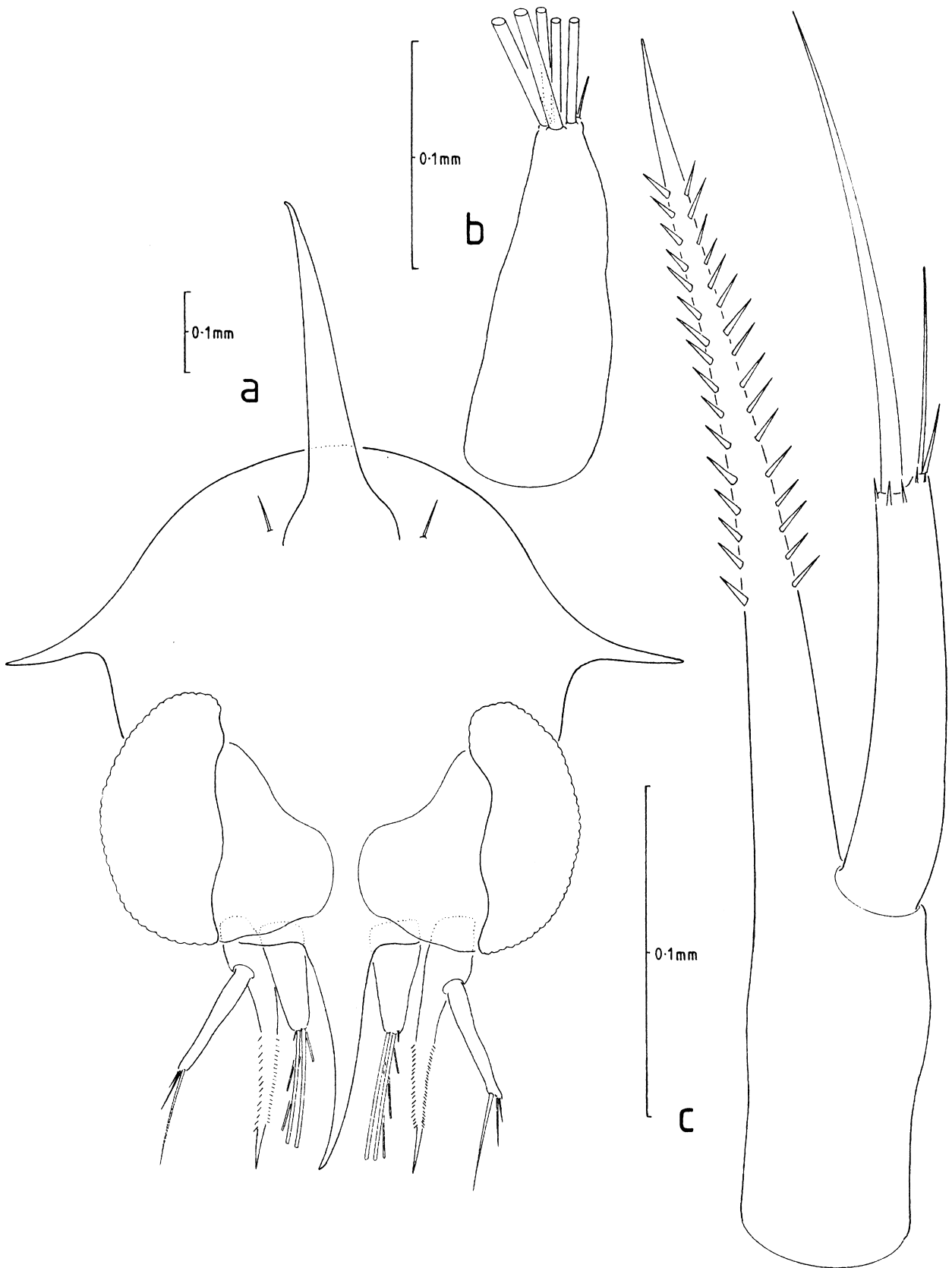


Fig. 9. *Lydia annulipes* (H. Milne Edwards, 1834) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

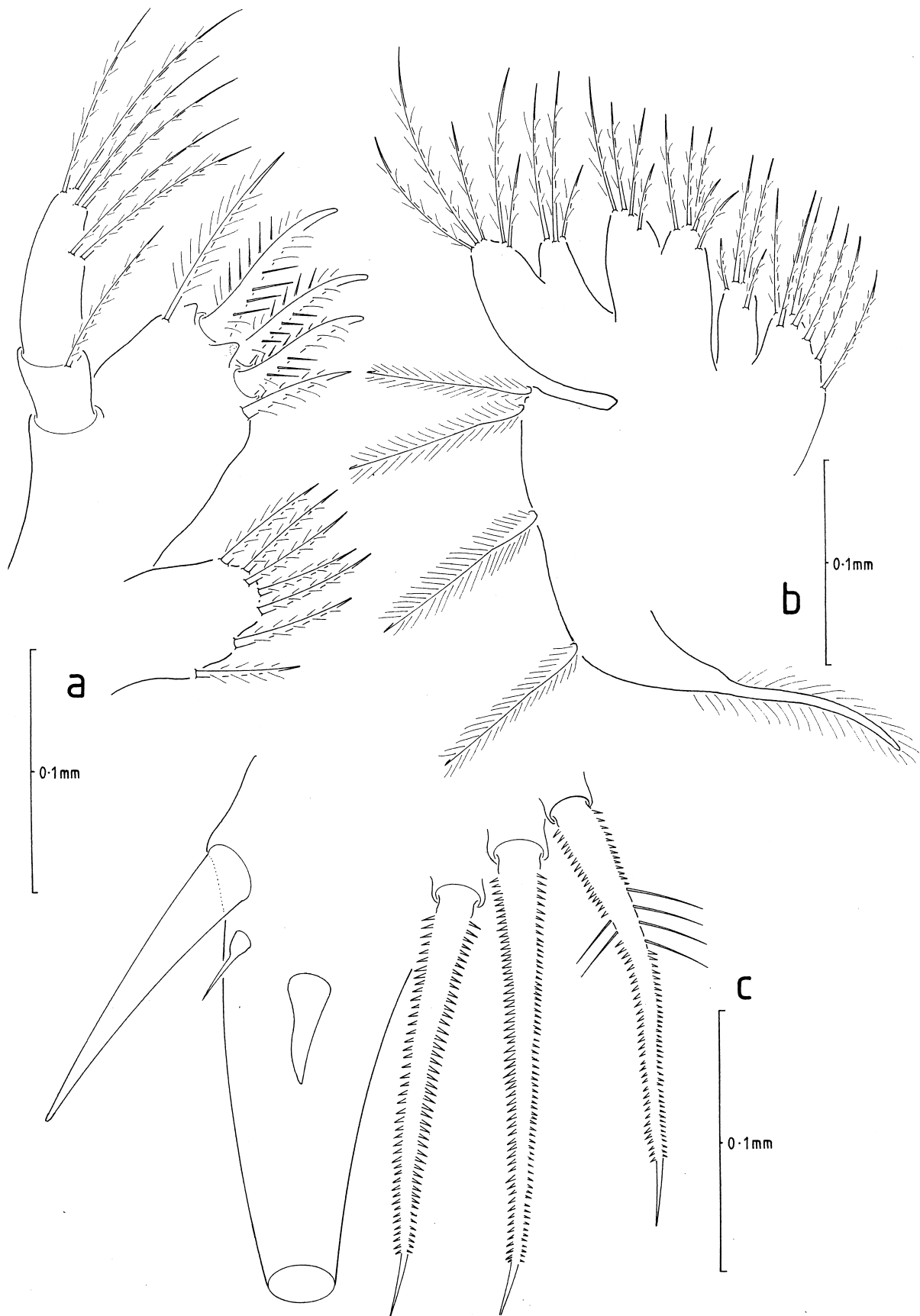


Fig. 10. *Lydia annulipes* (H. Milne Edwards, 1834) first stage zoea; a) maxillule; b) maxilla; c) telson.

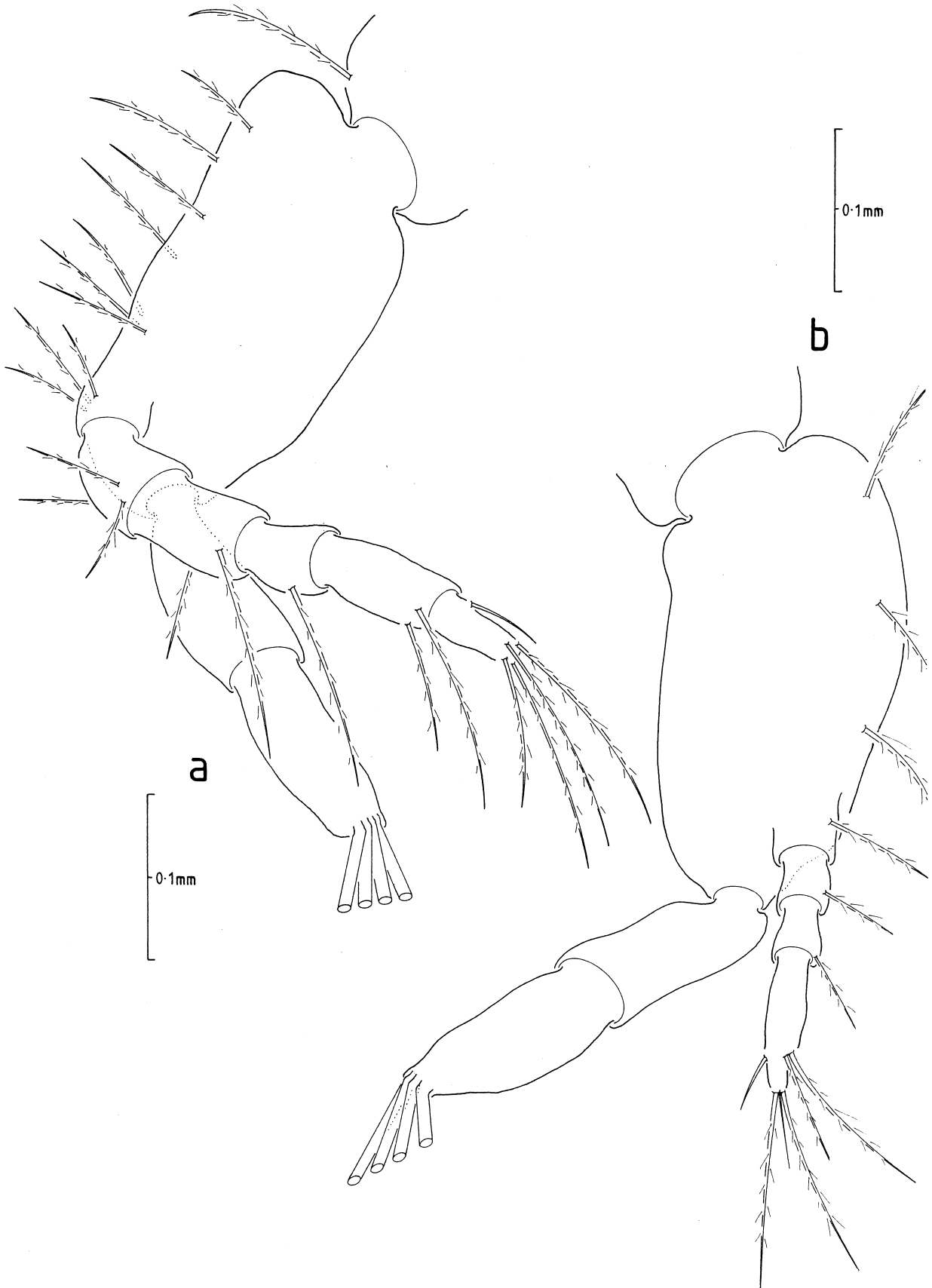


Fig. 11. *Lydia annulipes* (H. Milne Edwards, 1834) first stage zoea; a) first maxilliped; b) second maxilliped.

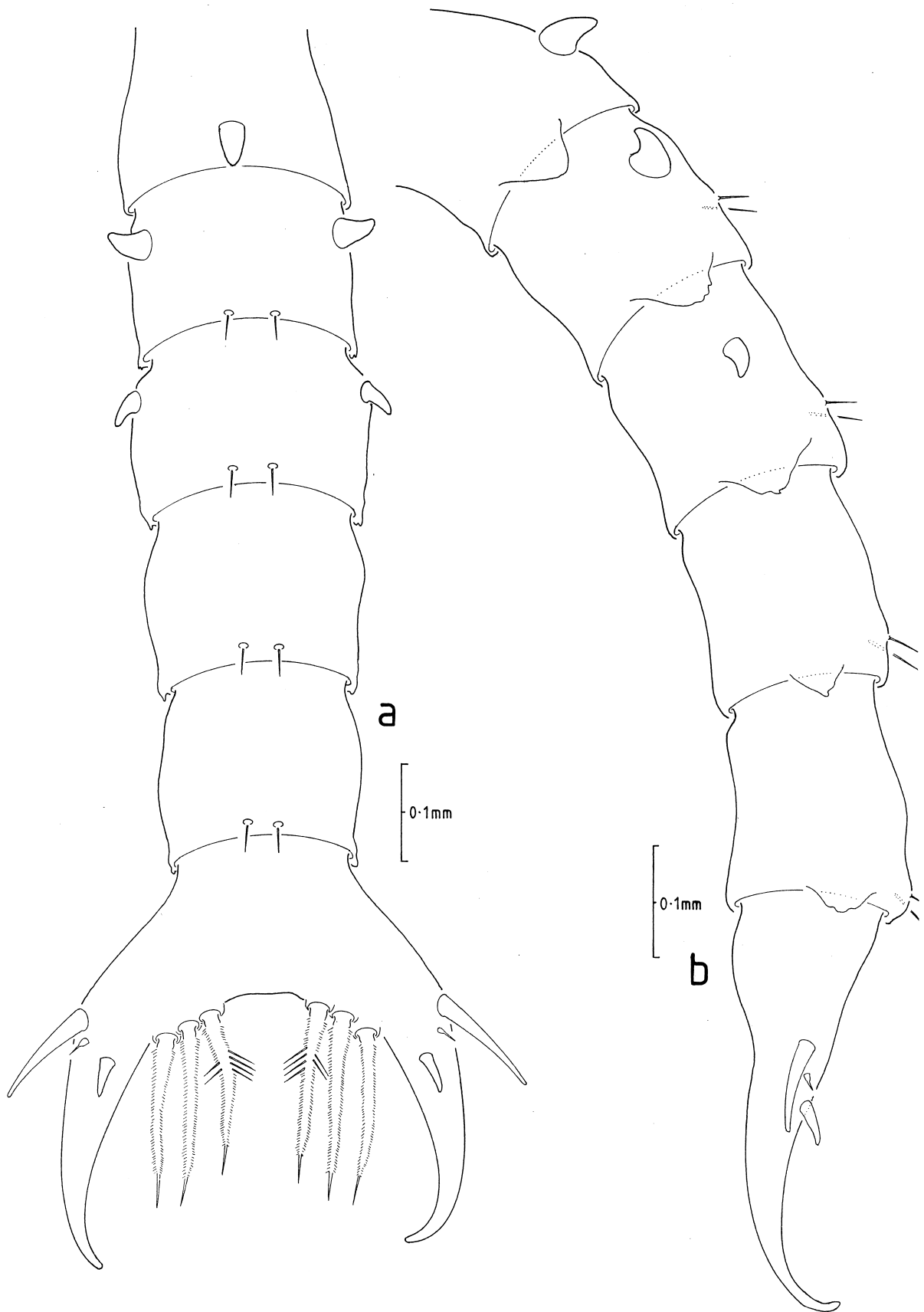


Fig. 12. *Lydia annulipes* (H. Milne Edwards, 1834) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

Antennule (Fig. 9b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 1 long slender, 2 shorter, slender terminal aesthetascs of unequal length and 1 short terminal seta.

Antenna (Fig. 9c): protopodal process distally, bilaterally spinulate, approximately equal in length to the rostral spine; endopod absent; exopod ca. 35% length of protopod, possessing 3 (1 long subterminal, 2 unequal terminal) setae with small spinules at base.

Mandible: endopod palp absent.

Maxillule (Fig. 10a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 10b): coxal endite bilobed with 7+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 11a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 11b): coxal without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 12a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somite 1 with a median dorsal process; somites 1-2 with rounded posterolateral processes and 3-5 with short rounded posterolateral processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 10c, 12a, b): each fork long, gradually curved distally; 1 large and 1 small lateral spine; 1 smaller dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

XANTHIDAE MACLEAY, 1838

CHLORODIINAE ALCOCK, 1898

Pilodius paumotensis Rathbun, 1907
(Figs. 13-16)

Larval description. – Carapace (Figs. 13a, d): dorsal spine

long and curved distally, approximately twice as long as rostral spine; rostral spine much shorter than dorsal spine, shorter in length to protopod of antenna and distally spinulate; lateral spines short and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 13b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 2 shorter, slender terminal aesthetascs and 1 terminal seta.

Antenna (Fig. 13c): protopodal process distally multispinulate, longer in length than rostral spine; endopod spine present; exopod rudimentary ca. 9% length of protopod, possessing 2 unequal terminal setae.

Mandible: endopod palp absent.

Maxillule (Fig. 14a): coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 14b): coxal endite bilobed with 4+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 15a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 15b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 16a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short posterolateral spinous processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 14c, 16a, b): each fork long, gradually curved distally; 1 large and 1 small lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

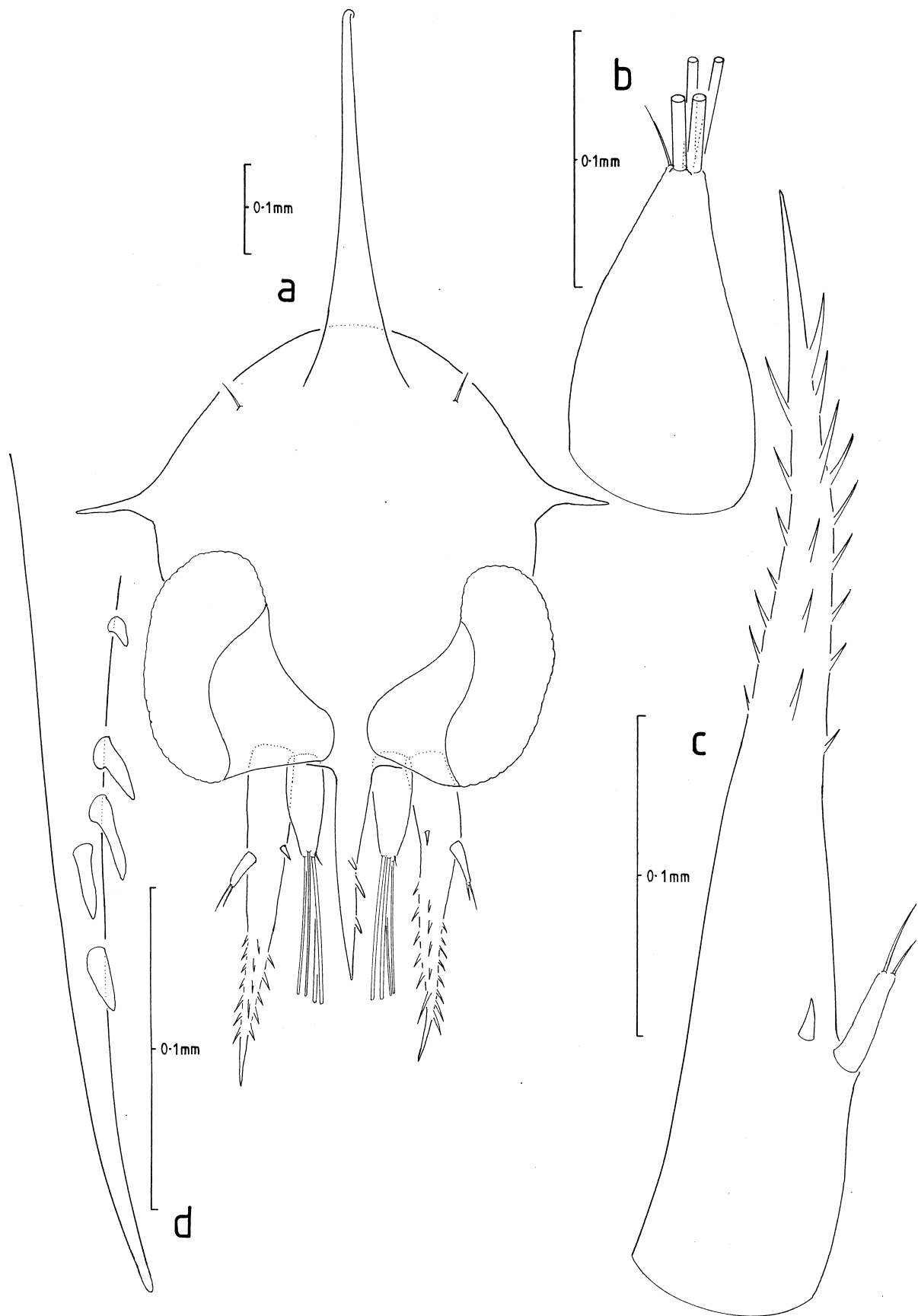


Fig. 13. *Pilodius paumotensis* Rathbun, 1907 first stage zoea; a) anterior view of carapace; b) antennule; c) antenna; d) rostral spine.

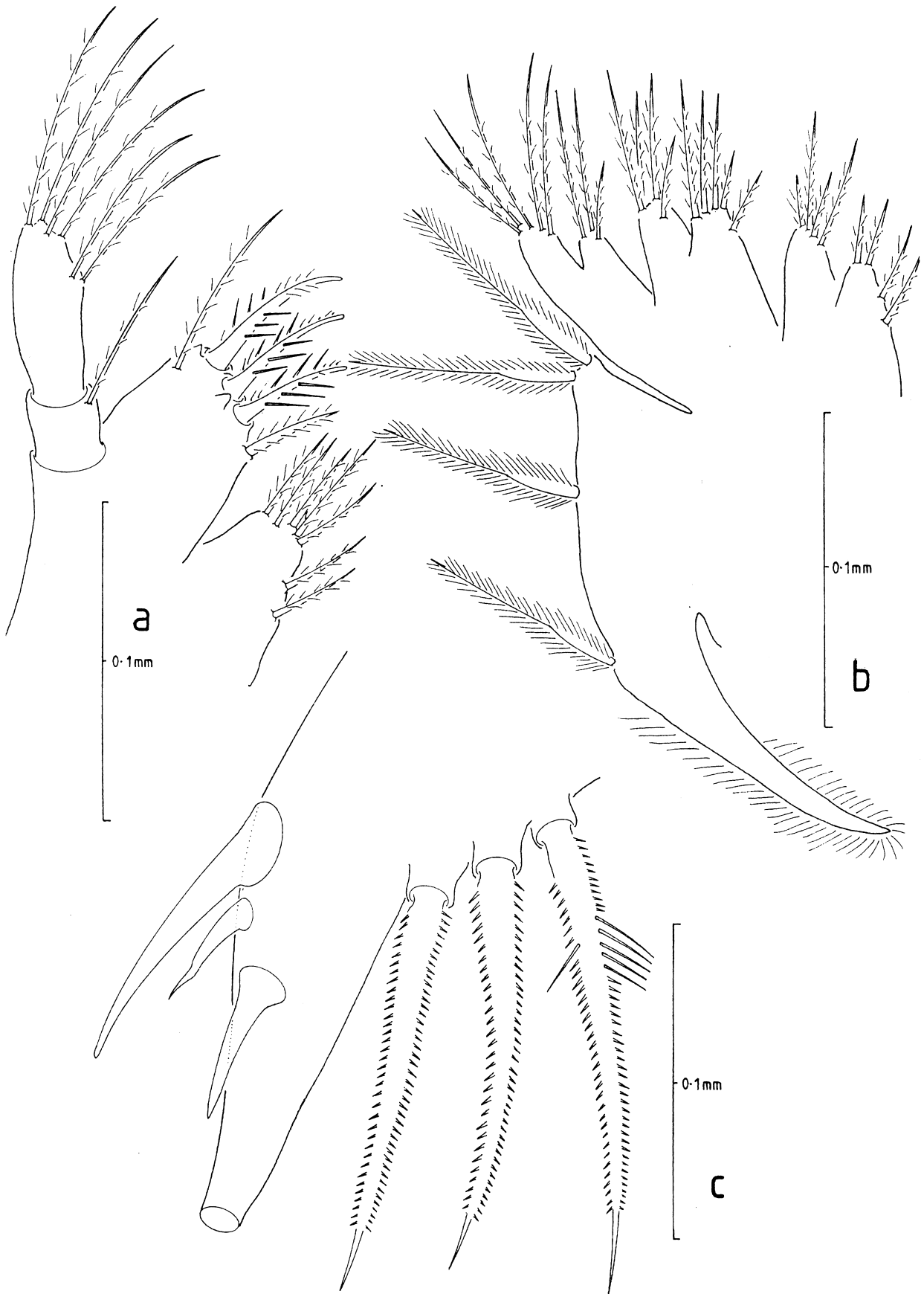


Fig. 14. *Pilodius paumotensis* Rathbun, 1907 first stage zoea; a) maxillule; b) maxilla; c) telson.

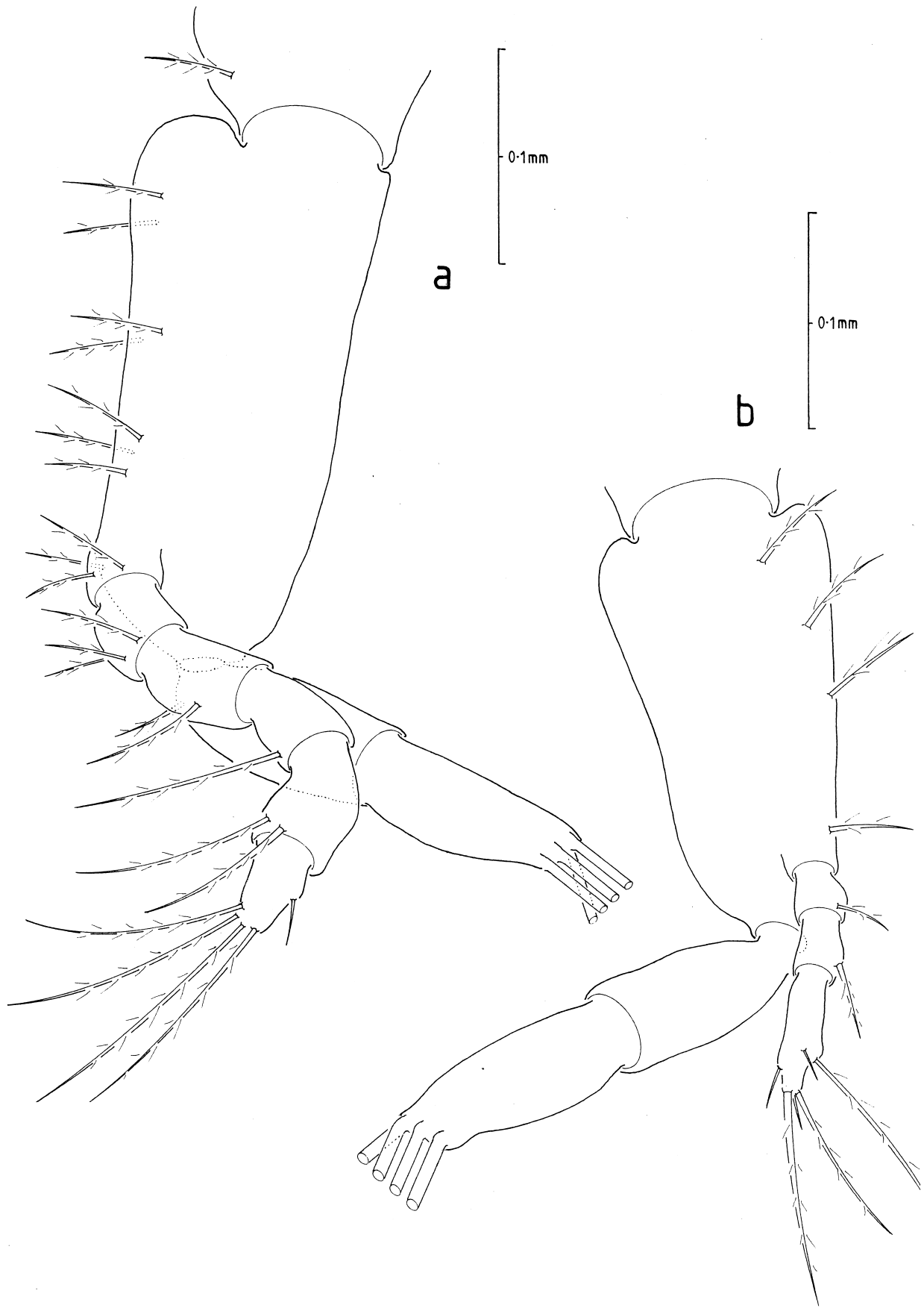


Fig. 15. *Pilodius paumotensis* Rathbun, 1907 first stage zoea; a) first maxilliped; b) second maxilliped.

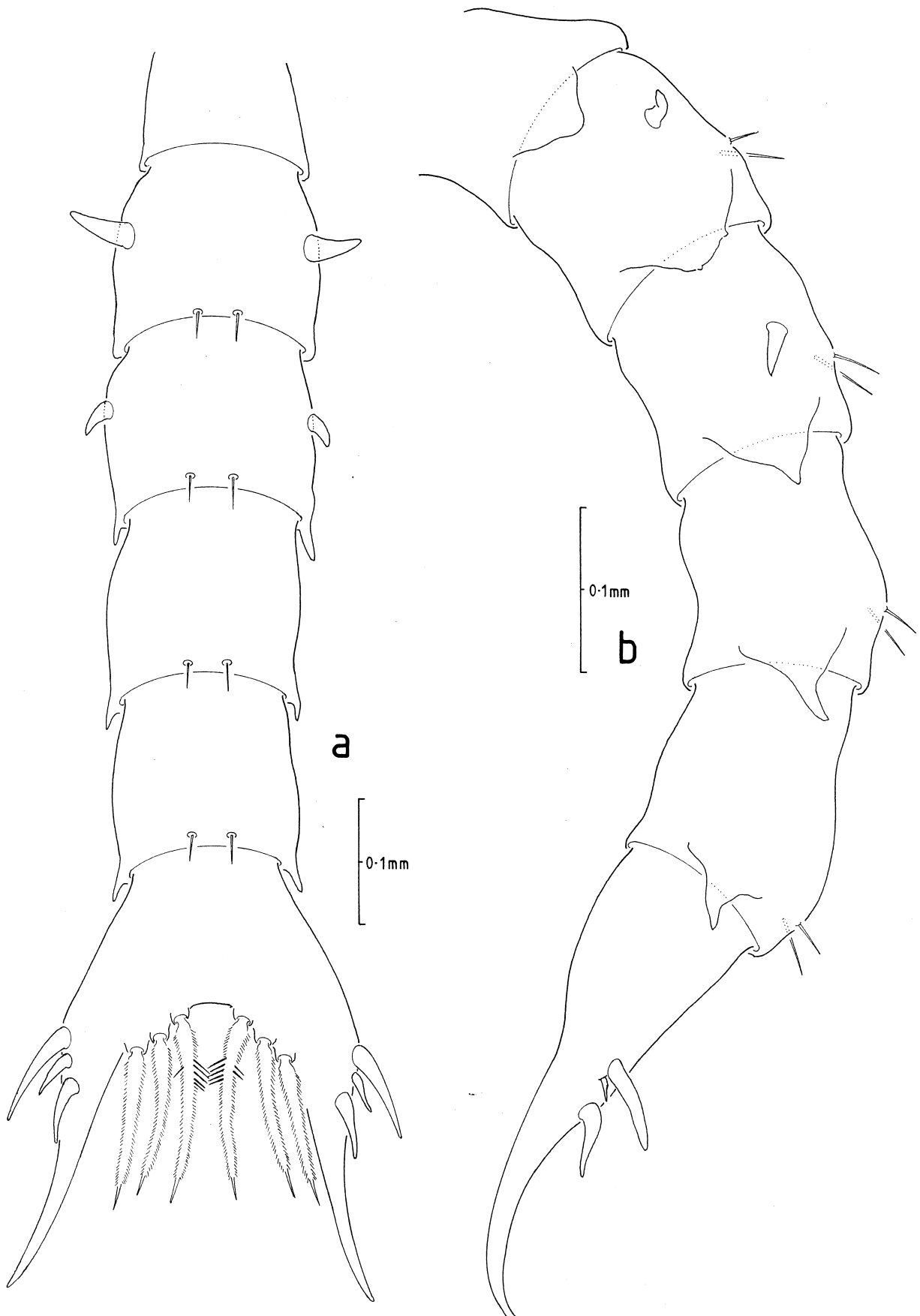


Fig. 16. *Pilodius paumotensis* Rathbun, 1907 first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

POLYDECTINAE DANA, 1851

Lybia plumosa Barnard, 1947

(Figs. 17-20)

Larval description. – Carapace (Figs. 17a, d): dorsal spine long and curved distally, longer than rostral spine; rostral spine shorter than dorsal spine, slightly shorter in length to protopod of antenna and distally spinulate; lateral spines long and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 17b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 2 shorter, slender terminal aesthetascs and 1 terminal seta.

Antenna (Fig. 17c): protopodal process distally multispinulate, slightly longer in length than rostral spine; endopod spine present; exopod ca. 14% length of protopod, possessing 3 (1 long subterminal, 2 terminal unequal) setae.

Mandible: endopod palp absent.

Maxillule (Fig. 18a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 18b): coxal endite bilobed with 4+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 19a): coxa without seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 19b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,5 (2 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 20a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with long posterolateral spinous processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 18c, 20a, b): each fork long, gradually curved

distally; 1 large and 1 smaller lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

XANTHINAE MACLEAY, 1838

Leptodius exaratus (H. Milne Edwards, 1834)

(Figs. 21-24)

Xantho exaratus – Aikawa, 1929: 42-43, Pl. 3, Fig. 18, Pl. Fig. 37, zoea I.

Leptodius exaratus – Chhapgar, 1956: 40-41, Text-Fig. 5, zoea I; Saba, 1976: 58-63, Text-Figs. 1-2, pls. 5-7, zoeas I-IV & megalop; Fielder et al., 1979: 117-119, Tab. 1, Figs. 1-6, zoeas I-IV & megalop; Terada, 1980, Fig. 1A1-A2, Fig. 2A'1-A'3, Fig. A1-A4, zoeas I-IV; Amir, 1989 [publication not seen]; Siddiqui & Tirmizi, 1998, Tab. 2, Figs. 1-7, zoeas I-V & megalop.

Leptodius exaratus – Tufail & Hashmi, 1964: 208-210, Pls. 1-2, zoeas 1-2.

Larval description. – Carapace (Figs. 21a, d): dorsal spine long and curved distally; rostral spine shorter than dorsal spine, approximately equal in length to protopod of antenna, distally spinulate; lateral spines present and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 21b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 2 shorter, slender terminal aesthetascs and 1 terminal seta.

Antenna (Fig. 21c): protopodal process distally multispinulate, approximately equal in length to rostral spine; endopod spine present; exopod small, ca. 7% length of protopod with 1 terminal seta.

Mandible: endopod palp absent.

Maxillule (Fig. 22a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 22b): coxal endite bilobed with 4+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 23a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 23b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,5 (2 subterminal, 3 terminal) setae respectively; exopod 2-

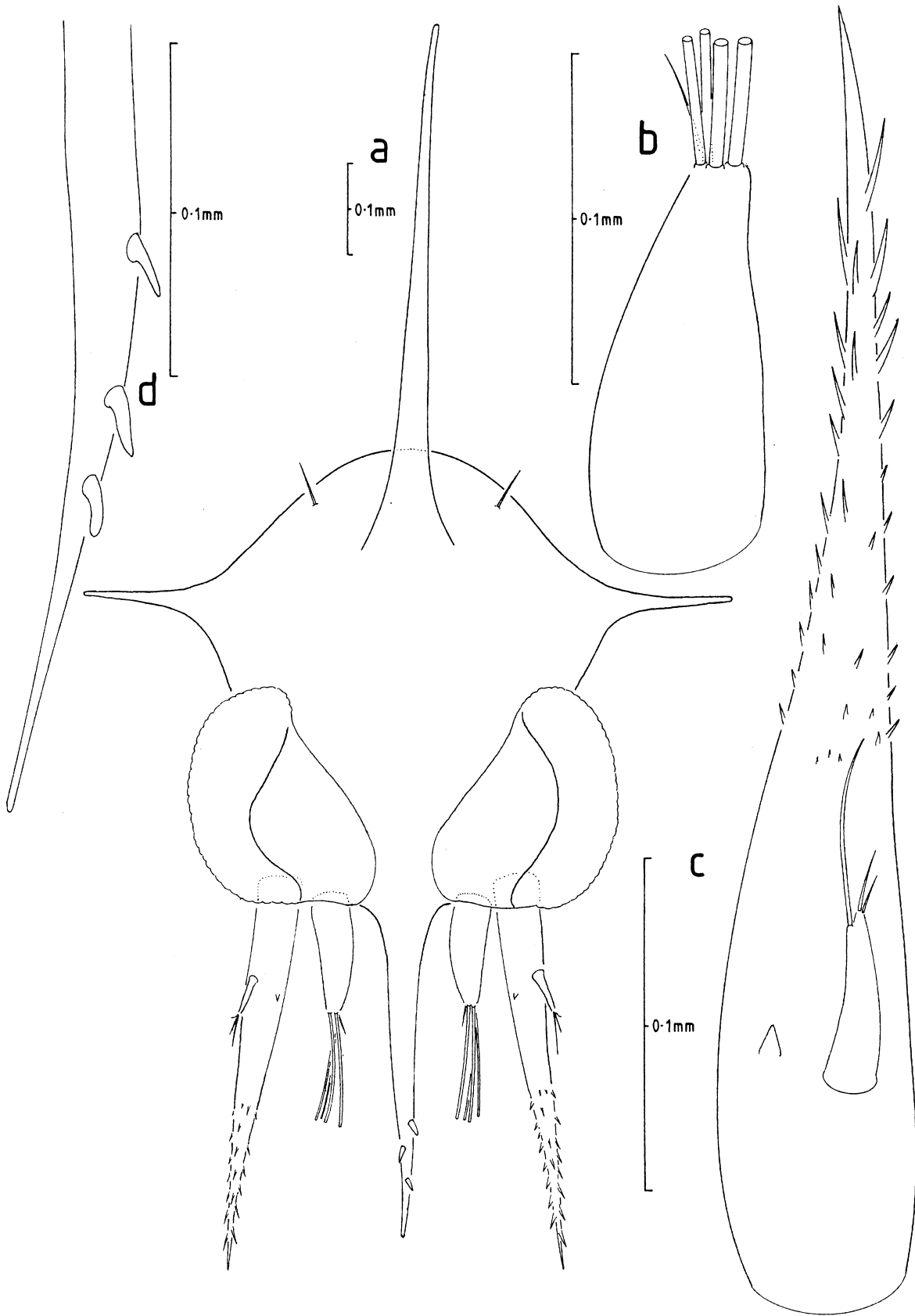


Fig. 17. *Lybia plumosa* Barnard, 1947 first stage zoea; a) anterior view of carapace; b) antennule; c) antenna; d) rostral spine.

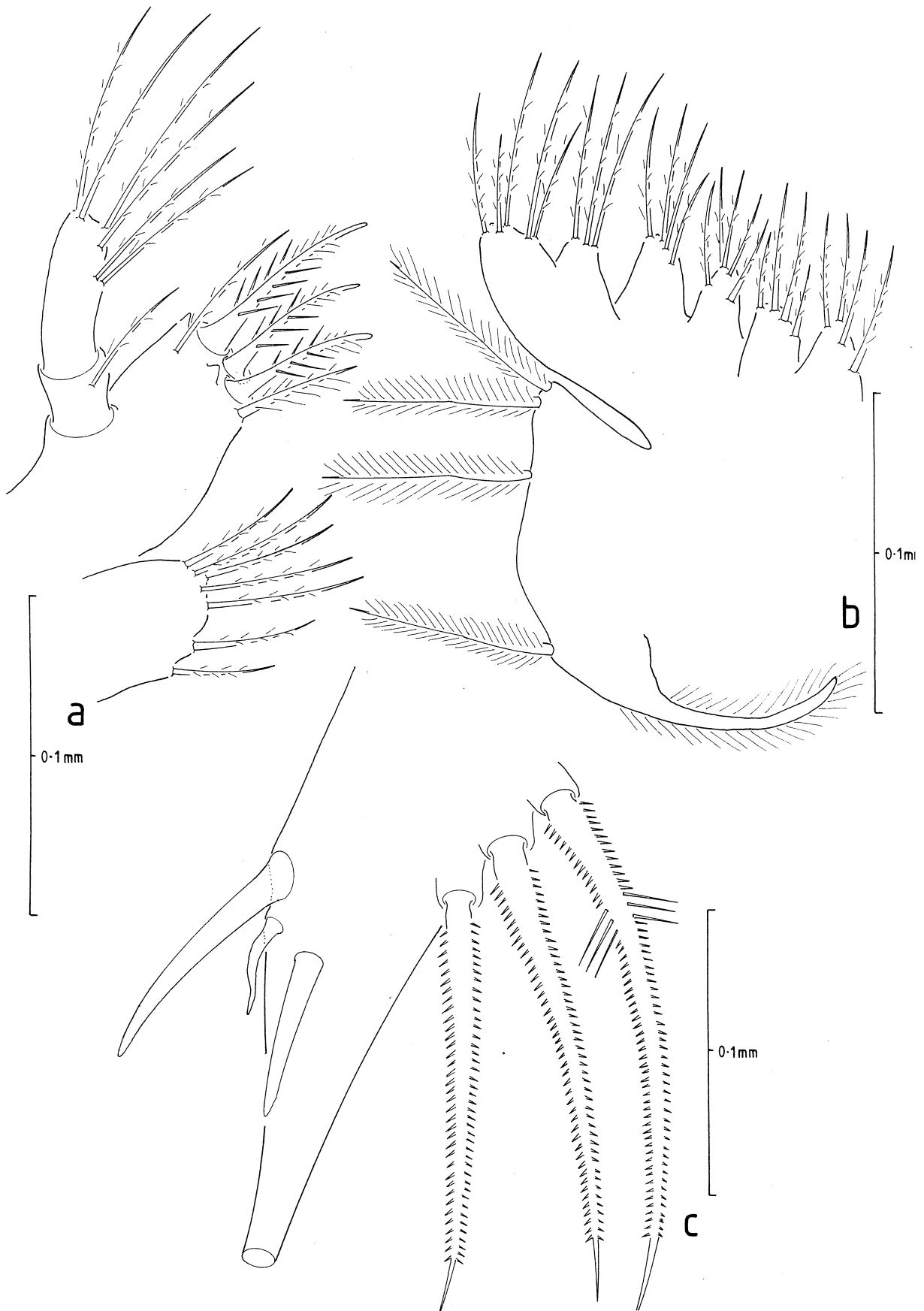


Fig. 18. *Lybia plumosa* Barnard, 1947 first stage zoea; a) maxillule; b) maxilla; c) telson.

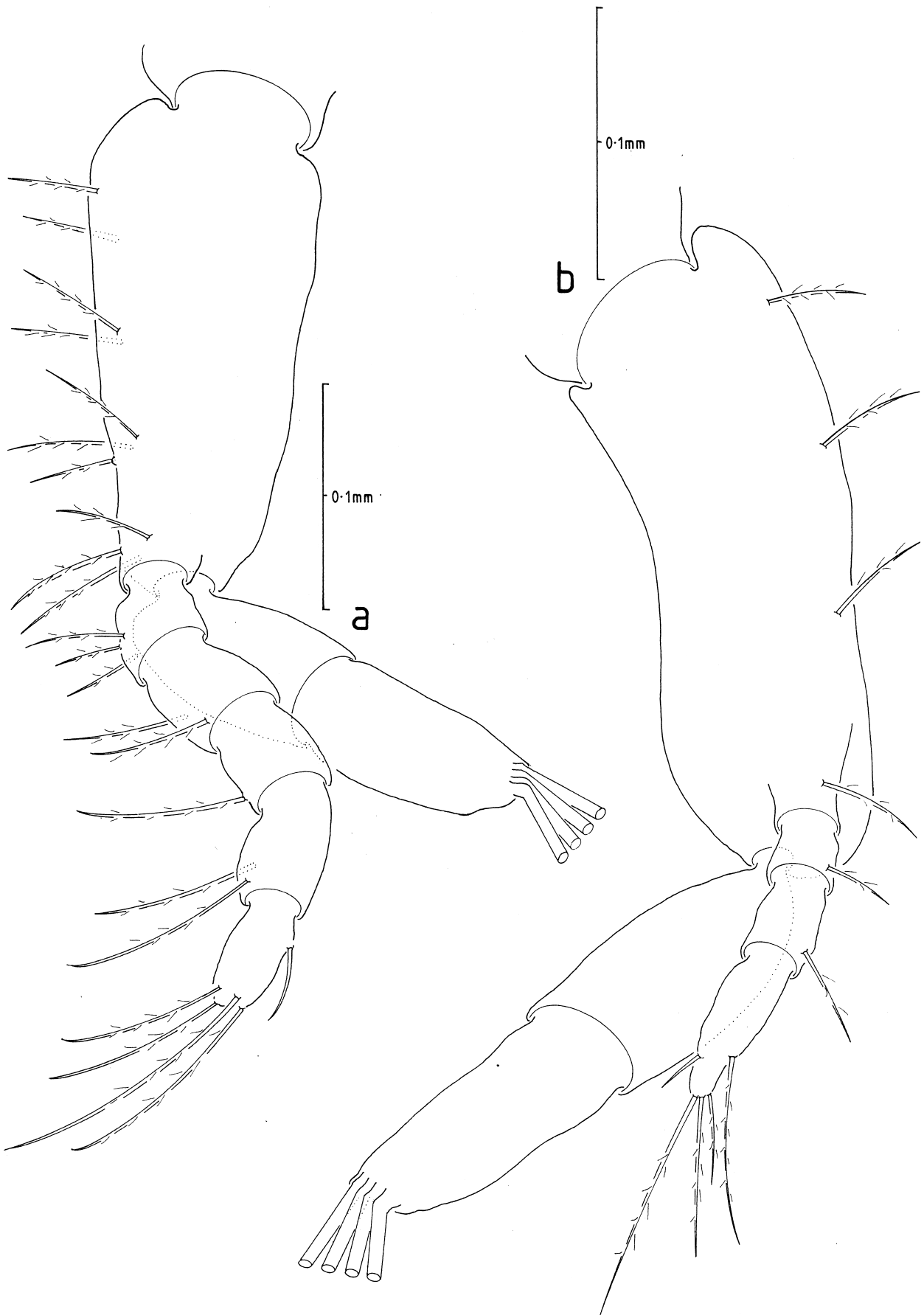


Fig. 19. *Lybia plumosa* Barnard, 1947 first stage zoea; a) first maxilliped; b) second maxilliped.

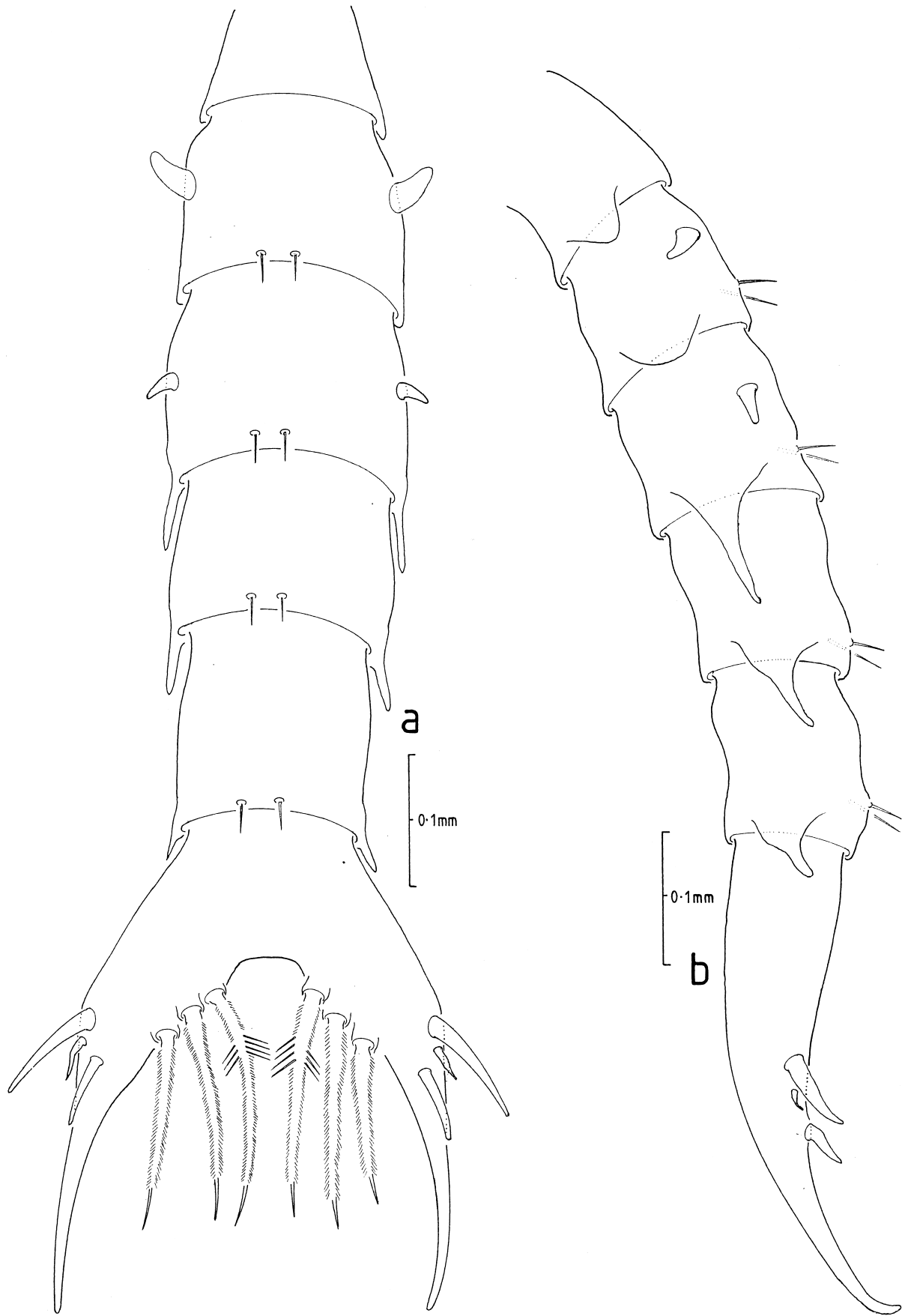


Fig. 20. *Lybia plumosa* Barnard, 1947 first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

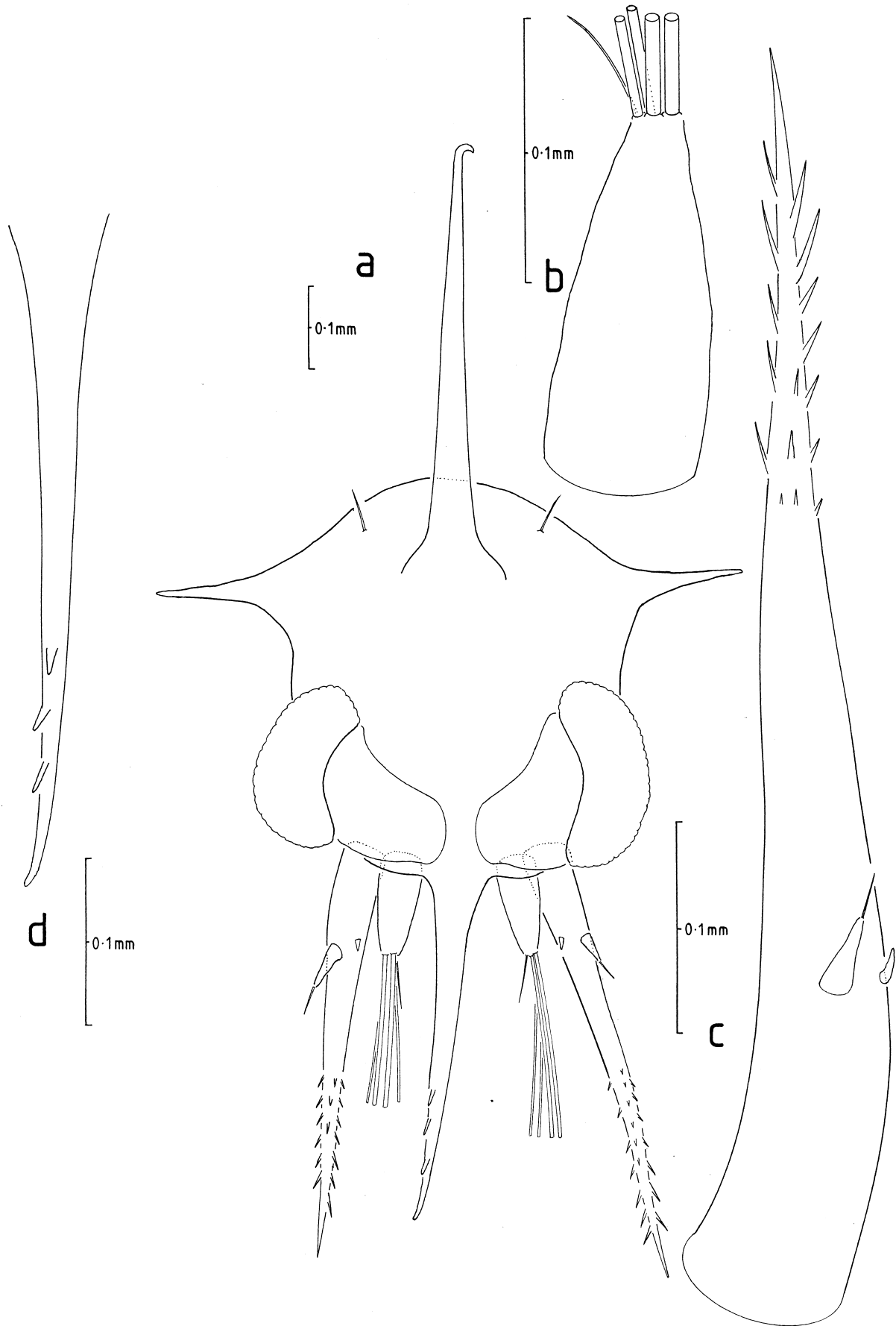


Fig. 21. *Leptodius exaratus* (H. Milne Edwards, 1834) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna; d) rostral spine.

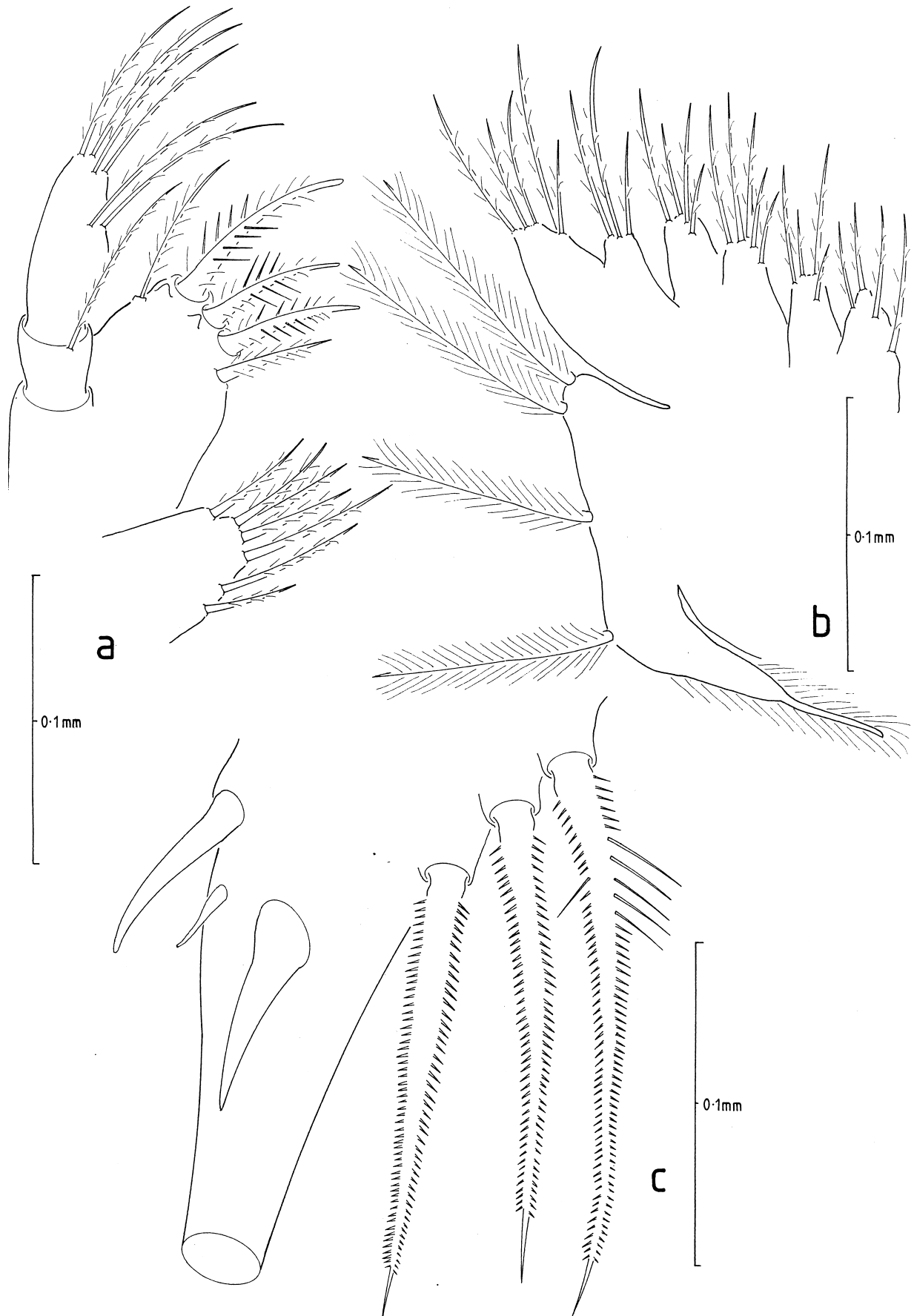


Fig. 22. *Leptodius exaratus* (H. Milne Edwards, 1834) first stage zoea; a) maxillule; b) maxilla; c) telson.

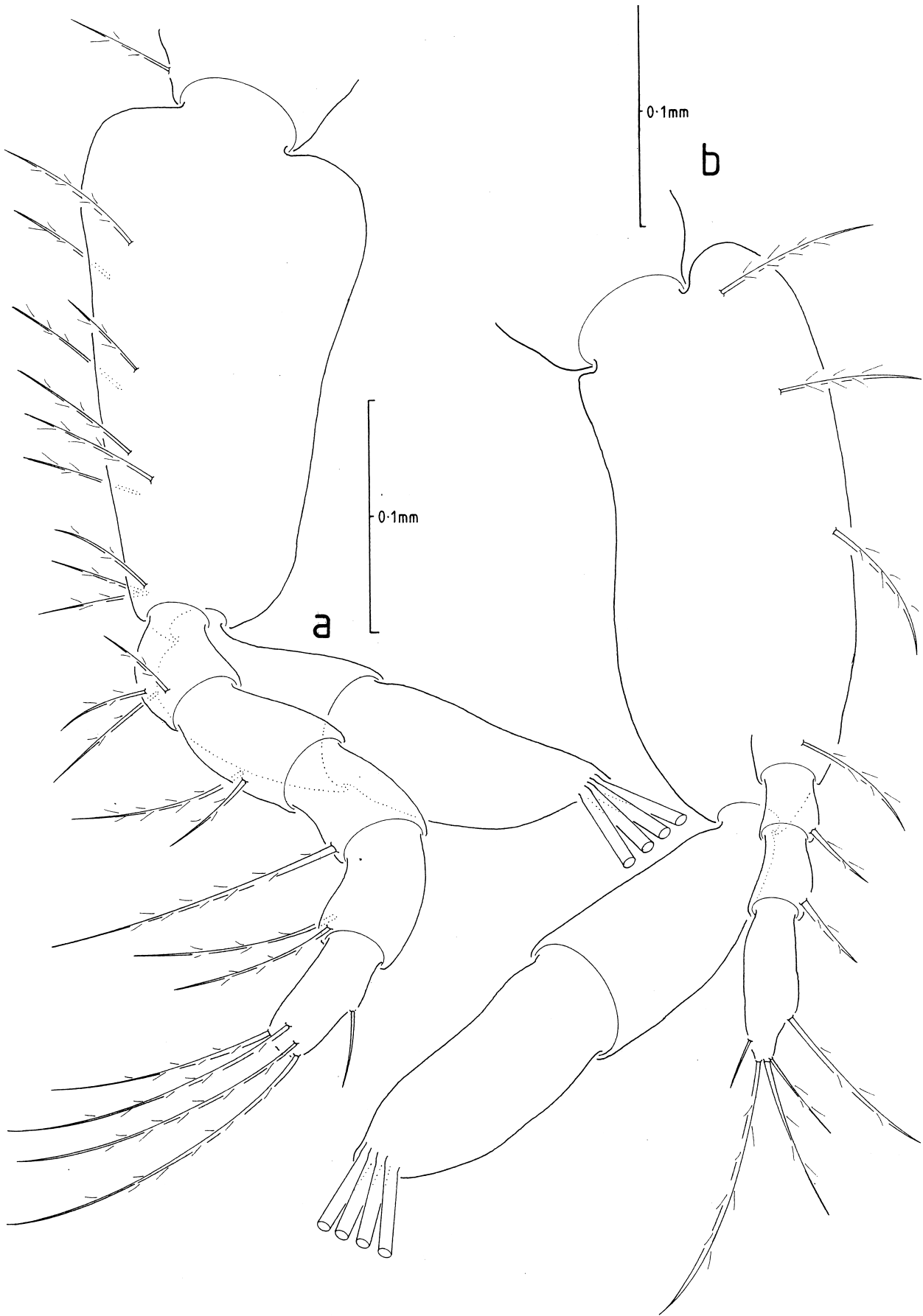


Fig. 23. *Leptodius exaratus* (H. Milne Edwards, 1834) first stage zoea; a) first maxilliped; b) second maxilliped.

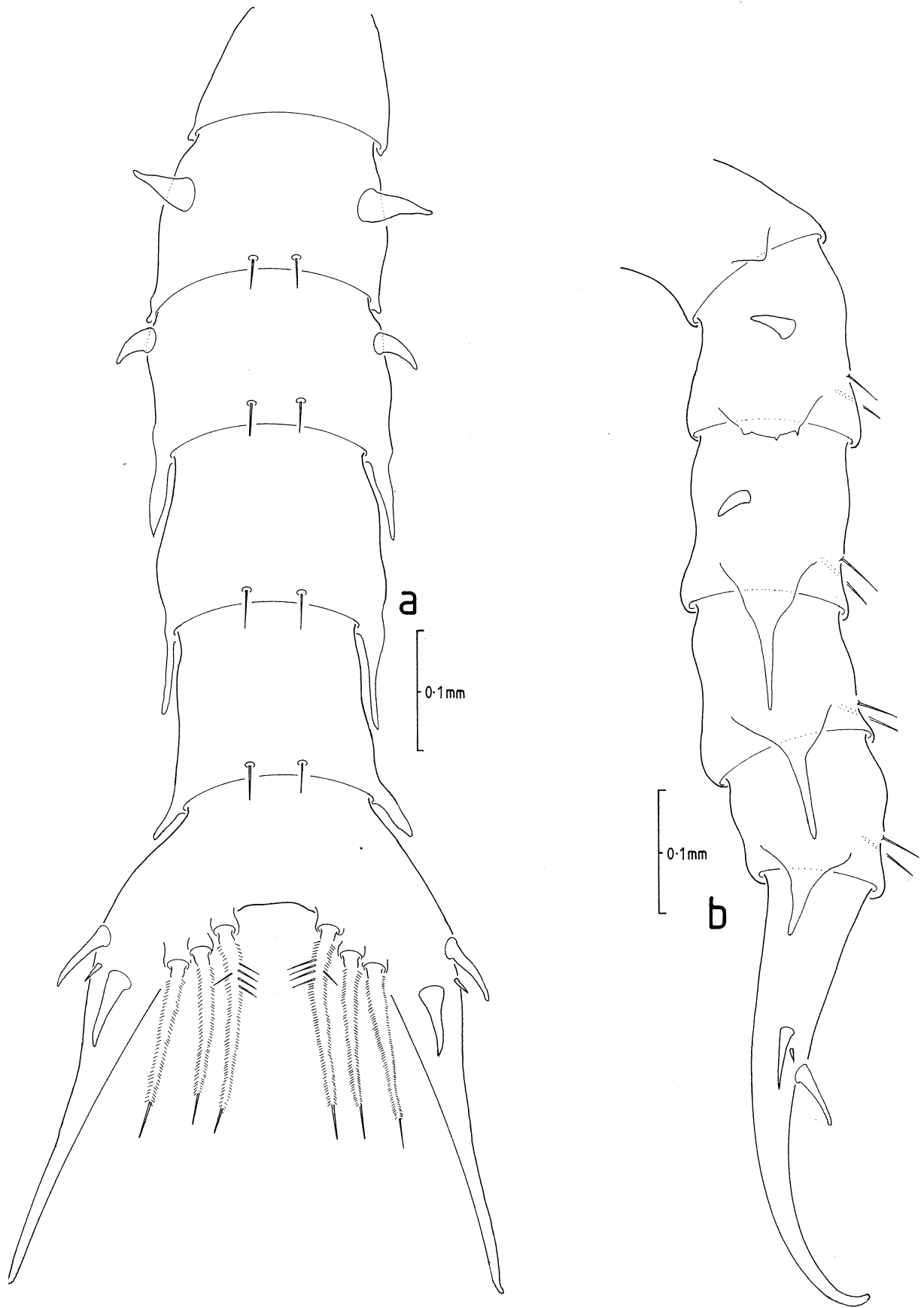


Fig. 24. *Leptodius exaratus* (H. Milne Edwards, 1834) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 24a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with long posterolateral spinous processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 22c, 24a, b): each fork long, gradually curved distally; 1 large and 1 smaller lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

ZOSIMINAE ALCOCK, 1898

Zozymodes xanthoides (Krauss, 1843)

(Figs. 25-28)

Larval description. - Carapace (Figs. 25a, d): dorsal spine long and curved distally and approximately equal in length to rostral spine; rostral spine approximately equal in length to protopod of antenna and distally spinulate; lateral spines long and straight; 1 pair of posterodorsal setae; ventral margin without setae; eyes sessile.

Antennule (Fig. 25b): uniramous, endopod absent; exopod unsegmented with 2 broad, long, 2 shorter, slender terminal aesthetascs and 1 terminal seta.

Antenna (Fig. 25c): protopodal process distally multispinulate, approximately equal in length to rostral spine; endopod spine present; exopod rudimentary ca. 13% length of protopod, possessing 3 (1 long subterminal, 2 unequal terminal) setae.

Mandible: endopod palp absent.

Maxillule (Fig. 26a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 26b): coxal endite bilobed with 4+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed, with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 27a): coxal segment with 1 seta; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively;

exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 27b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 28a, b): 5 somites; somite 2 with 1 pair of dorsolateral processes directed anteriorly; somite 3 with 1 pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short posterolateral spinous processes; somite 1 without setae; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Figs. 26c, 28a, b): each fork long, gradually curved distally; 1 large and 1 smaller lateral spine; 1 large dorsal medial spine; posterior margin with 3 pairs of stout spinulate setae.

PILUMNIDAE SAMOUELLE, 1819

PILUMNINAE SAMOUELLE, 1819

Eurycarcinus natalensis (Krauss, 1843)

(Figs. 29-32)

Larval description. - Carapace (Fig. 29a): dorsal spine smooth, curved distally, approximately three times as long as rostral spine; rostral spine smooth, shorter than dorsal and antennal protopod; lateral spines short and unarmed; 1 pair of posterodorsal setae; ventral margin without setae, eyes sessile.

Antennule (Fig. 29b): uniramous, endopod absent; exopod unsegmented with, 2 broad and long, 2 shorter and slender aesthetascs plus 2 terminal setae of unequal length.

Antenna (Fig. 29c): protopod distally bilaterally spinulate, longer in length than rostral spine but equal in length to the exopod; endopod bud present; exopod equal to length of protopod, unsegmented, distally spinulate with 1 long and 1 smaller medial setae unequal in length.

Mandible: endopod palp absent.

Maxillule (Fig. 30a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 terminal setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 30b): coxal endite bilobed with 6+4 setae;

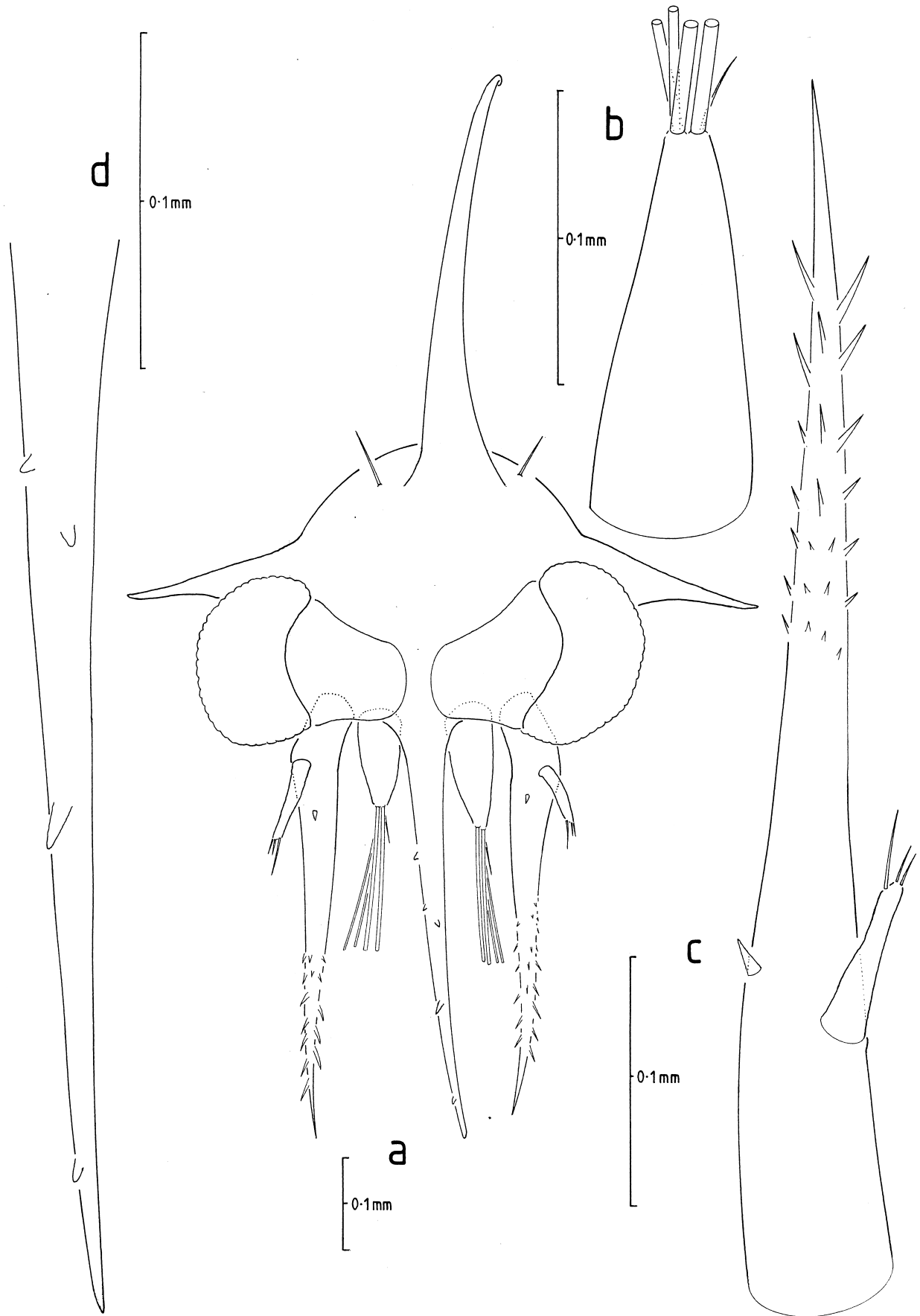


Fig. 25. *Zozymodes xanthoides* (Krauss, 1843) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna; d) rostral spine.

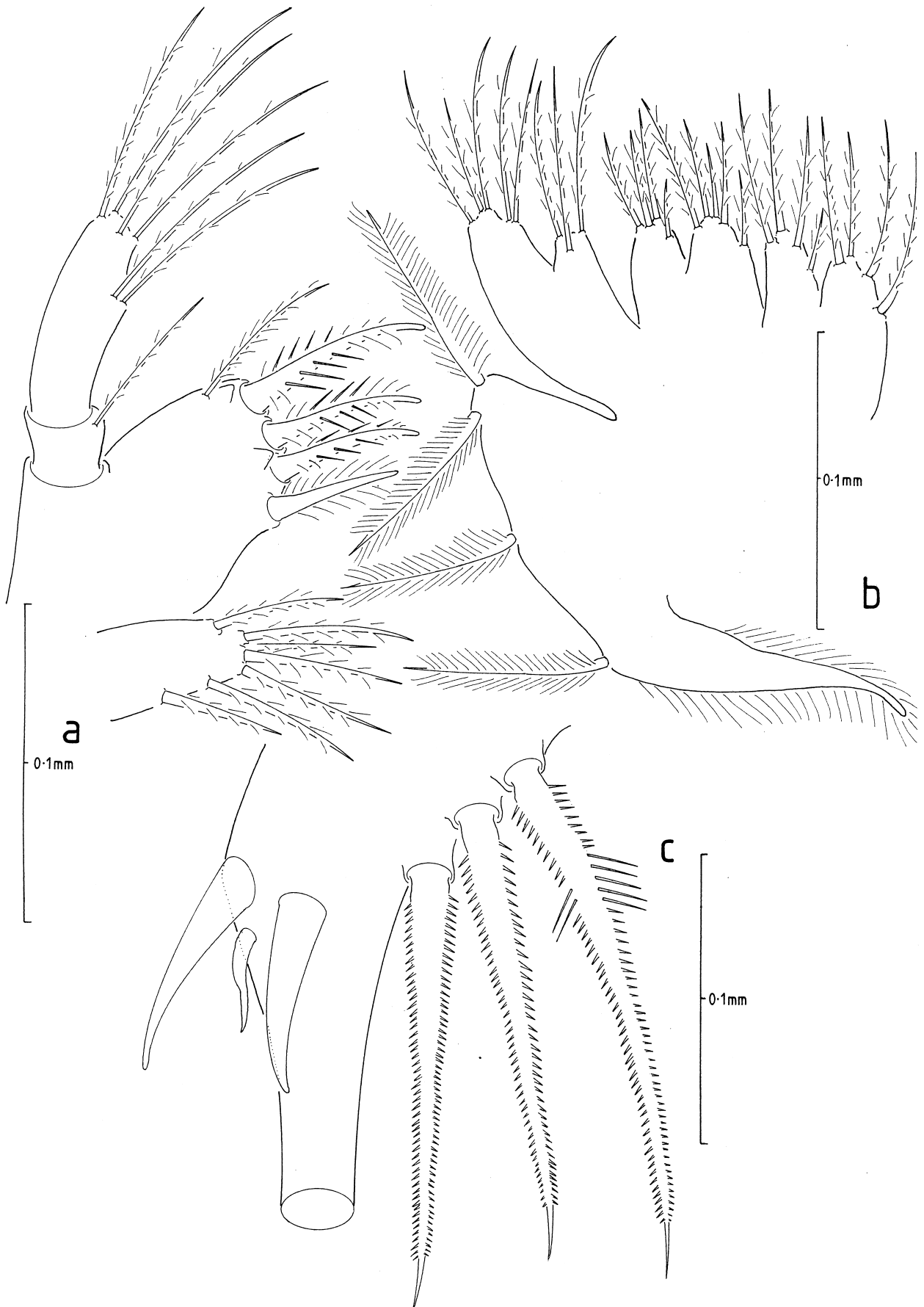


Fig. 26. *Zozymodes xanthoides* (Krauss, 1843) first stage zoea; a) maxillule; b) maxilla; c) telson.

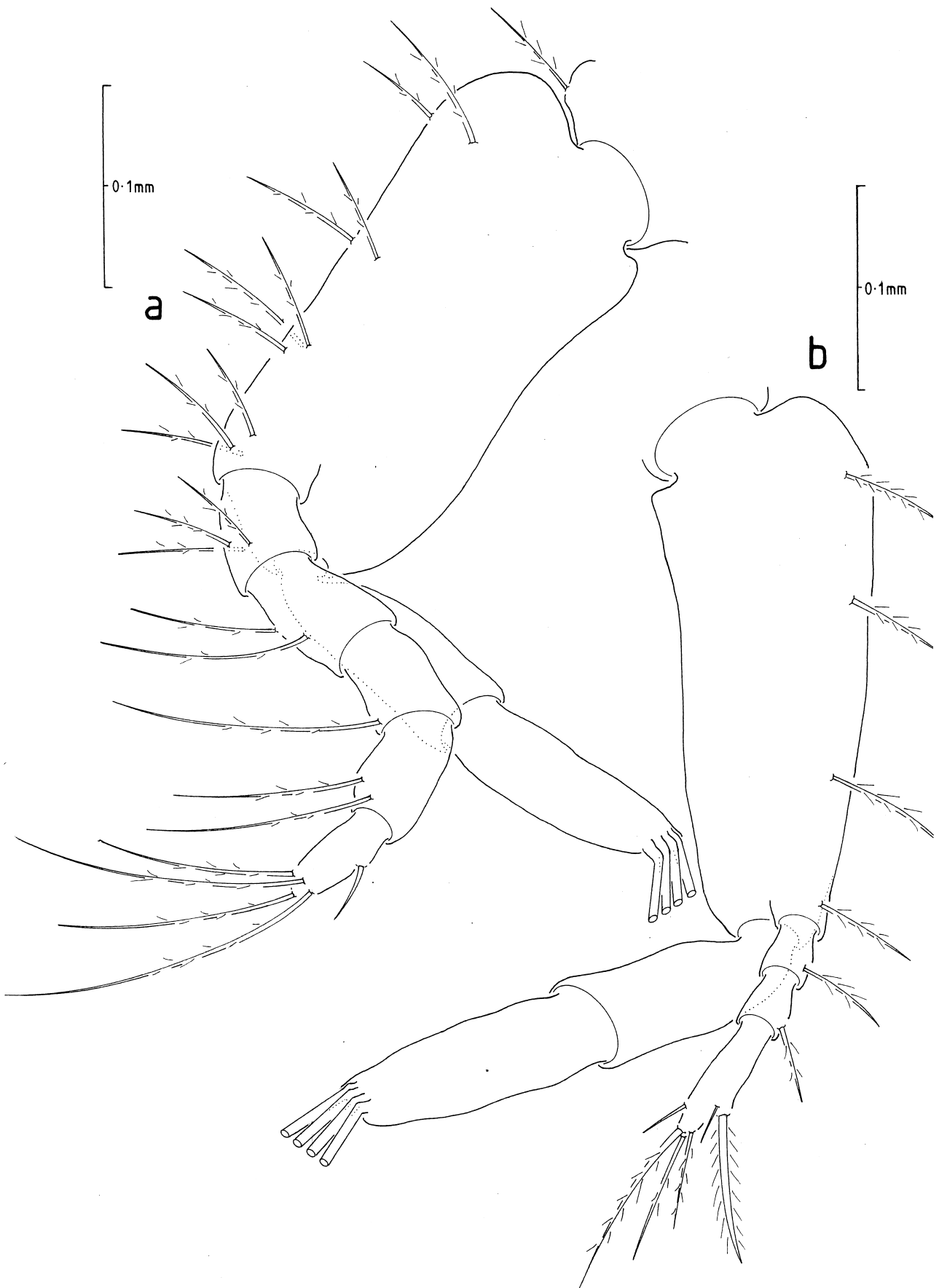


Fig. 27. *Zozymodes xanthoides* (Krauss, 1843) first stage zoea; a) first maxilliped; b) second maxilliped.

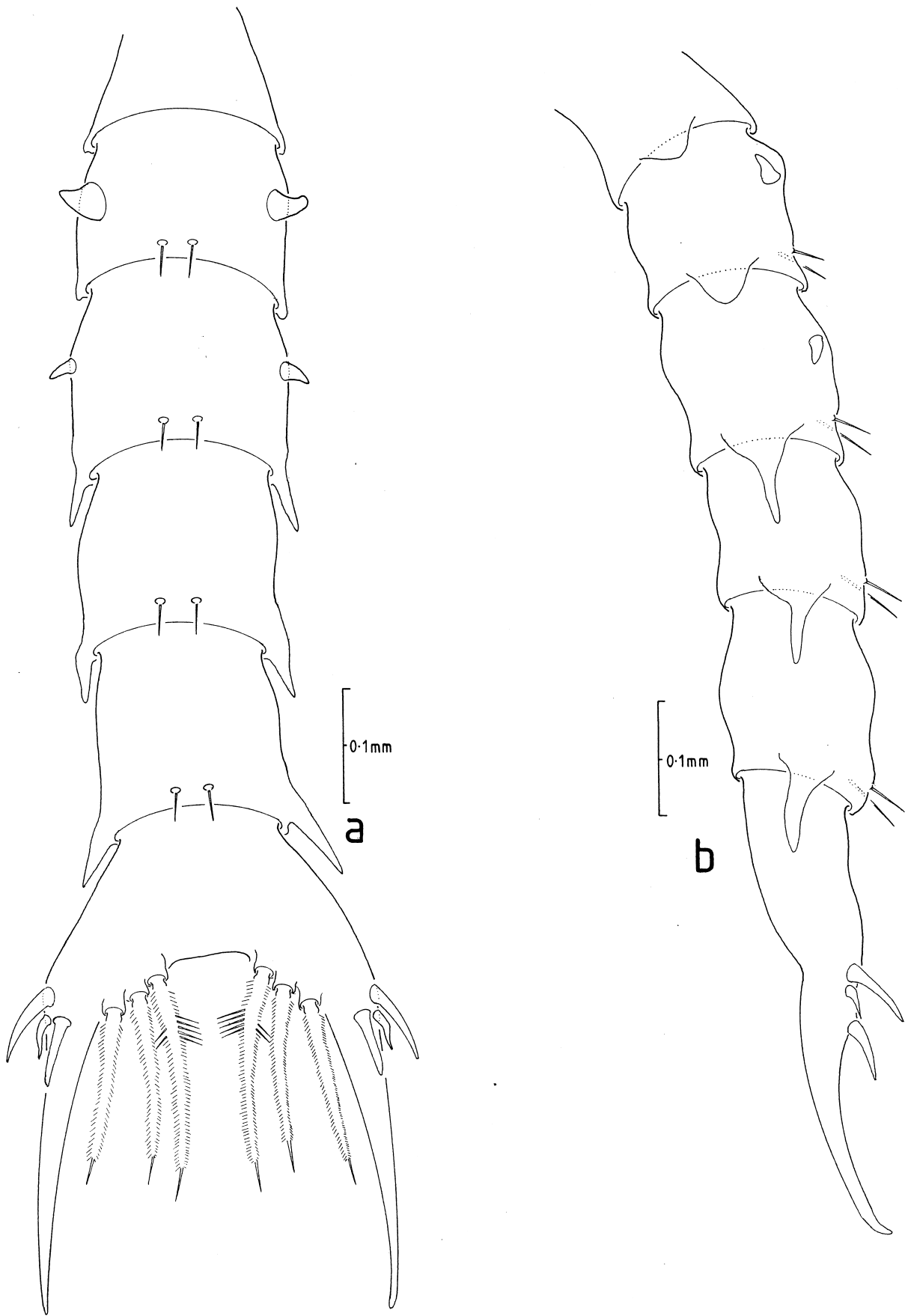


Fig. 28. *Zozymodes xanthoides* (Krauss, 1843) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

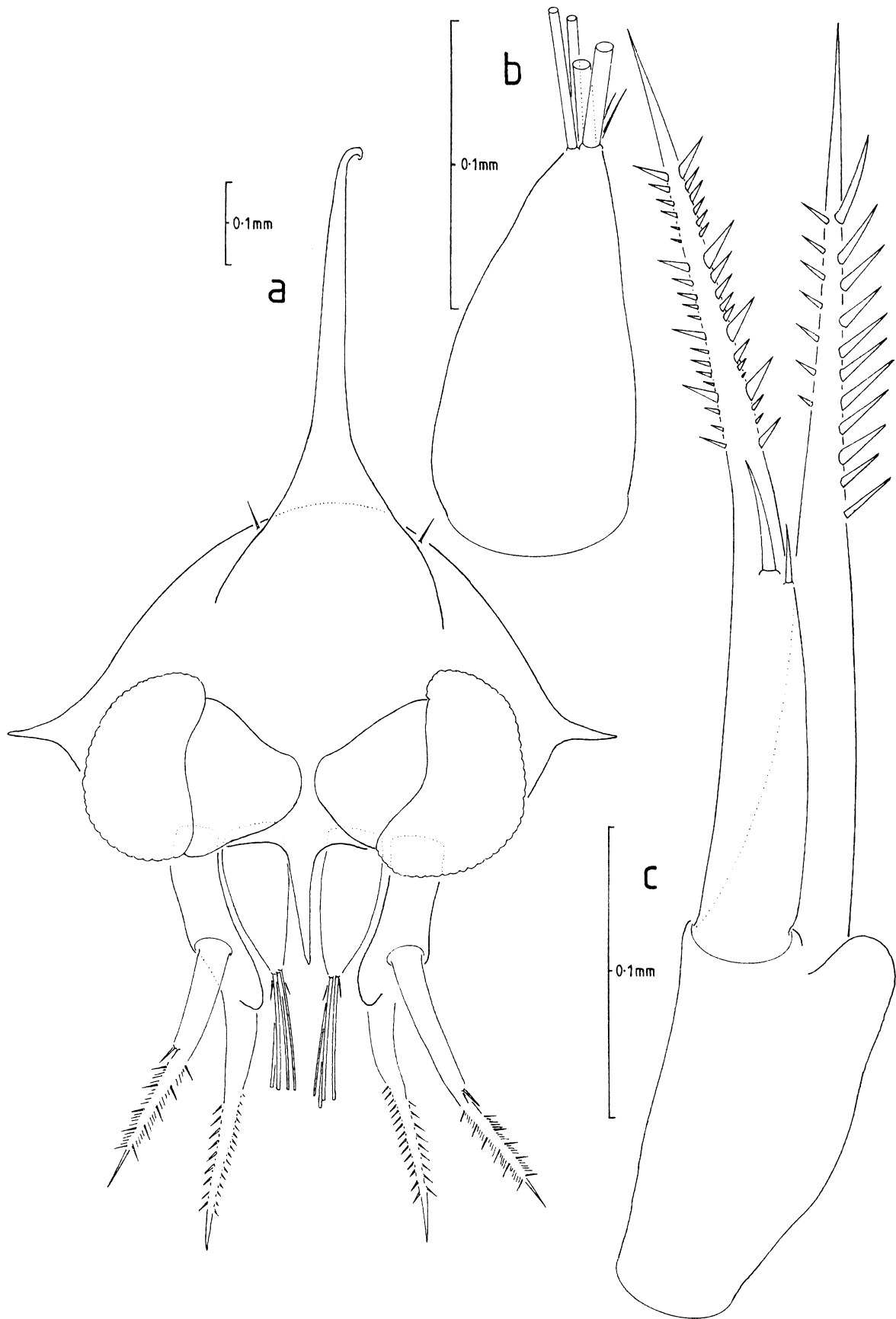


Fig. 29. *Eurycarinus natalensis* (Krauss, 1843) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

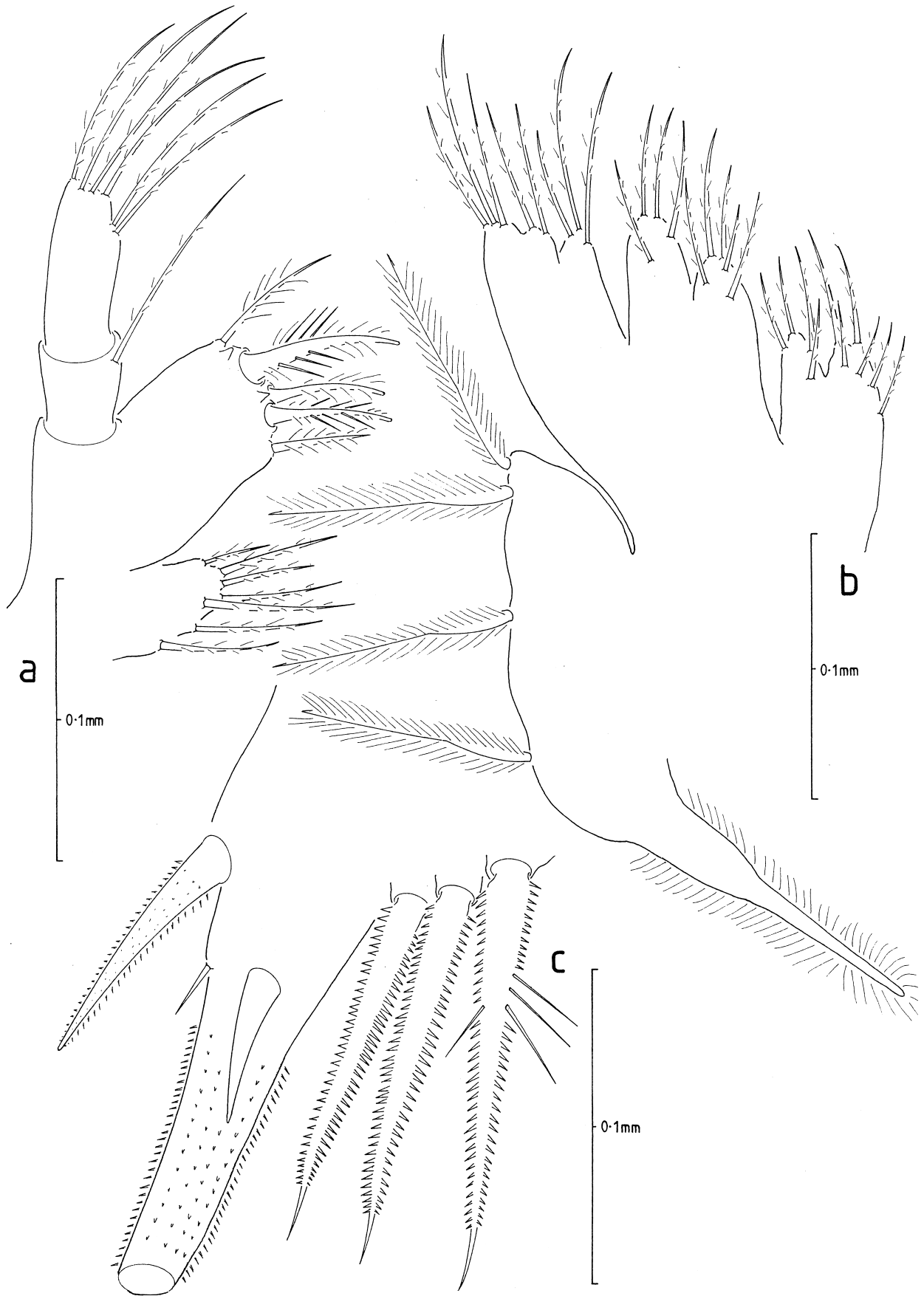


Fig. 30. *Eurycarcinus natalensis* (Krauss, 1843) first stage zoea; a) maxillule; b) maxilla; c) telson.

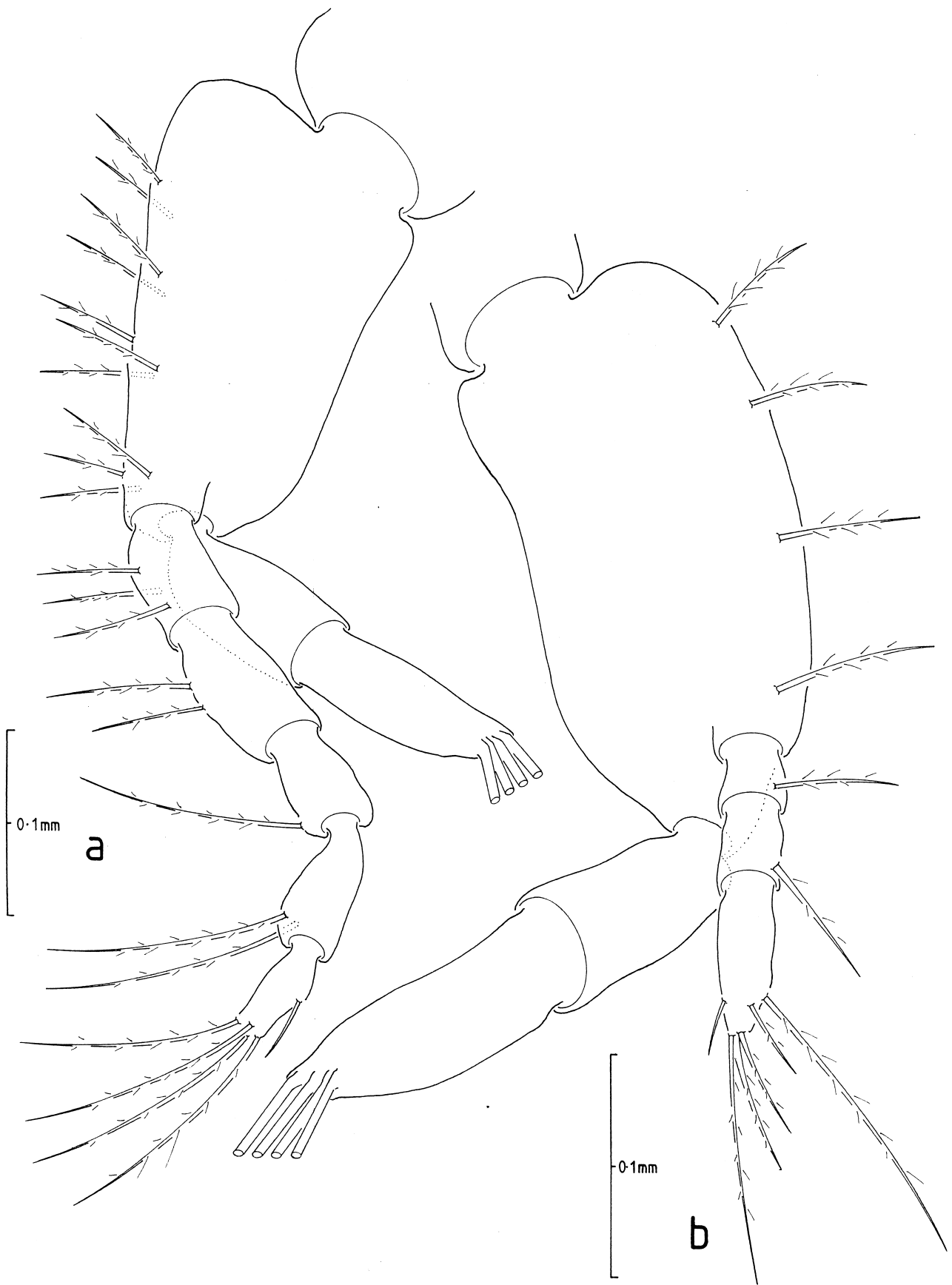


Fig. 31. *Eurycarinus natalensis* (Krauss, 1843) first stage zoea; a) first maxilliped; b) second maxilliped.

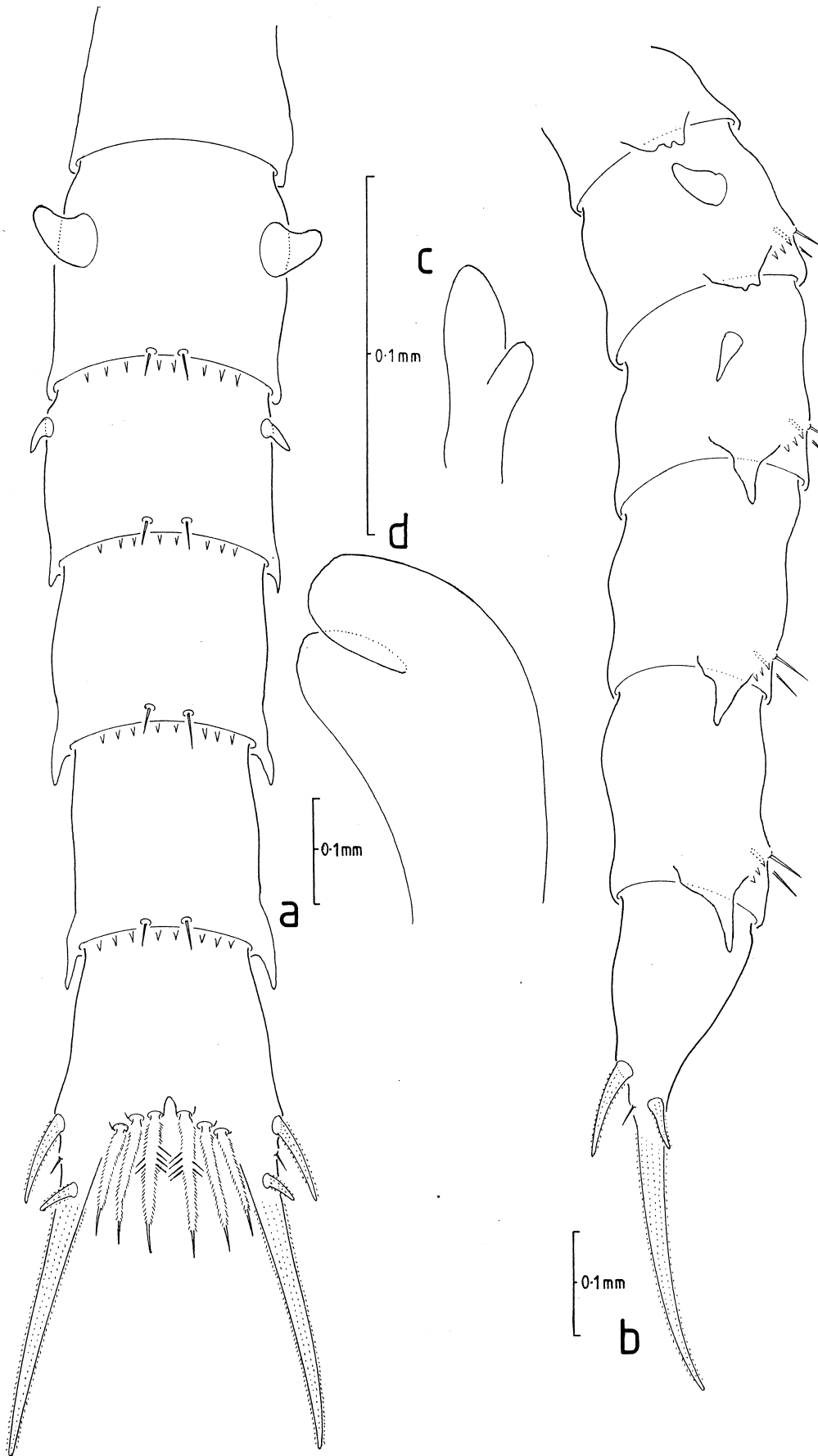


Fig. 32. *Eurycarcinus natalensis* (Krauss, 1843) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

basal endite bilobed with 5+4 setae; endopod bilobed with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 31a): coxa without setae; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 31b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped (Fig. 32c): present and biramous.

Pereiopods (Fig. 32d): present and chela bilobed.

Abdomen (Figs. 32a, b): 5 somites; somite 2 with a pair of dorsolateral processes directed anteriorly; somite 3 with a pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short posterolateral spinous processes; somite 1 without dorsal setae; somites 2-5 with 1 pair of posterodorsal setae; posterior margin of somites 2-5 spinulate; pleopod buds absent.

Telson (Figs. 30c, 32a, b): each telson fork long, spinulate and gradually curved distally; 1 long and 1 fine lateral spine; dorsal medial spine present; posterior margin with 3 pairs of stout spinulate setae.

***Pilumnus longicornis* Hilgendorf, 1879**
(Figs. 33-36)

Pilumnus longicornis – Prasad & Tampi, 1957: 26-28, Fig. 3a-h, zoea I.?

Pilumnus longicornis – Hashmi, 1970a: 423-424, Figs. 8-10, zoea I.

Larval description. – Carapace (Fig. 33a): dorsal spine smooth, curved distally, slightly longer than rostral spine; rostral spine smooth, slightly shorter than dorsal and antennal protopod; lateral spines long and unarmed; 1 pair of posterodorsal setae; ventral margin without setae, eyes sessile.

Antennule (Fig. 33b): uniramous, endopod absent; exopod unsegmented with 2 broad and long, 2 shorter and slender aesthetascs plus 2 terminal setae of unequal length.

Antenna (Fig. 33c): protopod distally bilaterally spinulate, longer in length than rostral spine but equal in length to exopod; endopod absent; exopod equal in length to the protopod, unsegmented, distally spinulate with 1 long and 1 smaller medial setae unequal in length.

Mandible: endopod palp absent.

Maxillule (Fig. 34a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 terminal setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 34b): coxal endite bilobed with 6+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 35a): coxa without setae; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 35b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Abdomen (Figs. 36a, b): 5 somites; somite 2 with a pair of dorsolateral processes directed anteriorly; somite 3 with a pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short posterolateral spinous processes; somite 1 without dorsal setae; somites 2-5 with 1 pair of posterodorsal setae; posterior margin of somites 2-5 spinulate; pleopod buds absent.

Telson (Figs. 34c, 36a, b): each telson fork long, spinulate and gradually curved distally; 1 long and 1 small lateral spine; dorsal medial spine present; posterior margin with 3 pairs of stout spinulate setae.

***Pilumnus vespertilio* (Fabricius, 1793)**
(Figs. 37-40)

Larval description. – *Pilumnus vespertilio*; Aikawa, 1929: 41, pl. III, Fig. 14, zoea I; Hashmi, 1970a: zoea I-III; Lim & Tan, 1981: 71-88, Figs. 1-5, zoea I-III & megalop and Terada, 1990: 29-31, Figs. 6-7, zoea I-III.

Carapace (Fig. 37a): dorsal spine smooth, curved distally, short, approximately three times as long as rostral spine; rostral spine smooth, short and distinctively shorter than antennal protopod; lateral spines short and unarmed; 1 pair of posterodorsal setae; ventral margin without setae, eyes sessile.

Antennule (Fig. 37b): uniramous, endopod absent; exopod unsegmented with 2 broad and long, 2 shorter and slender aesthetascs plus 2 terminal setae of unequal length.

Antenna (Fig. 37c): protopod distally bilaterally spinulate, much longer in length than rostral spine; endopod bud

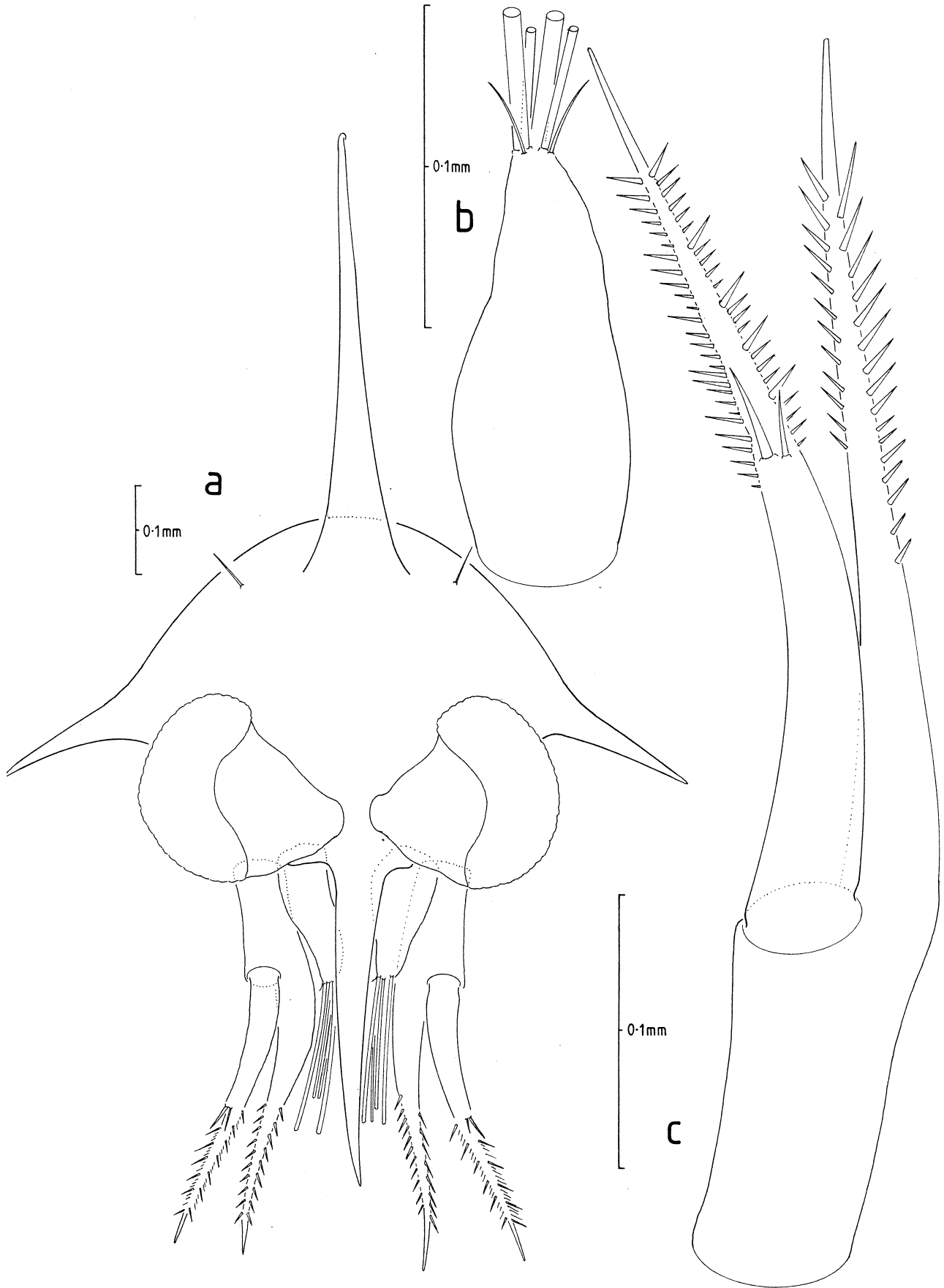


Fig. 33. *Pilumnus longicornis* (Hilgendorf, 1878) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

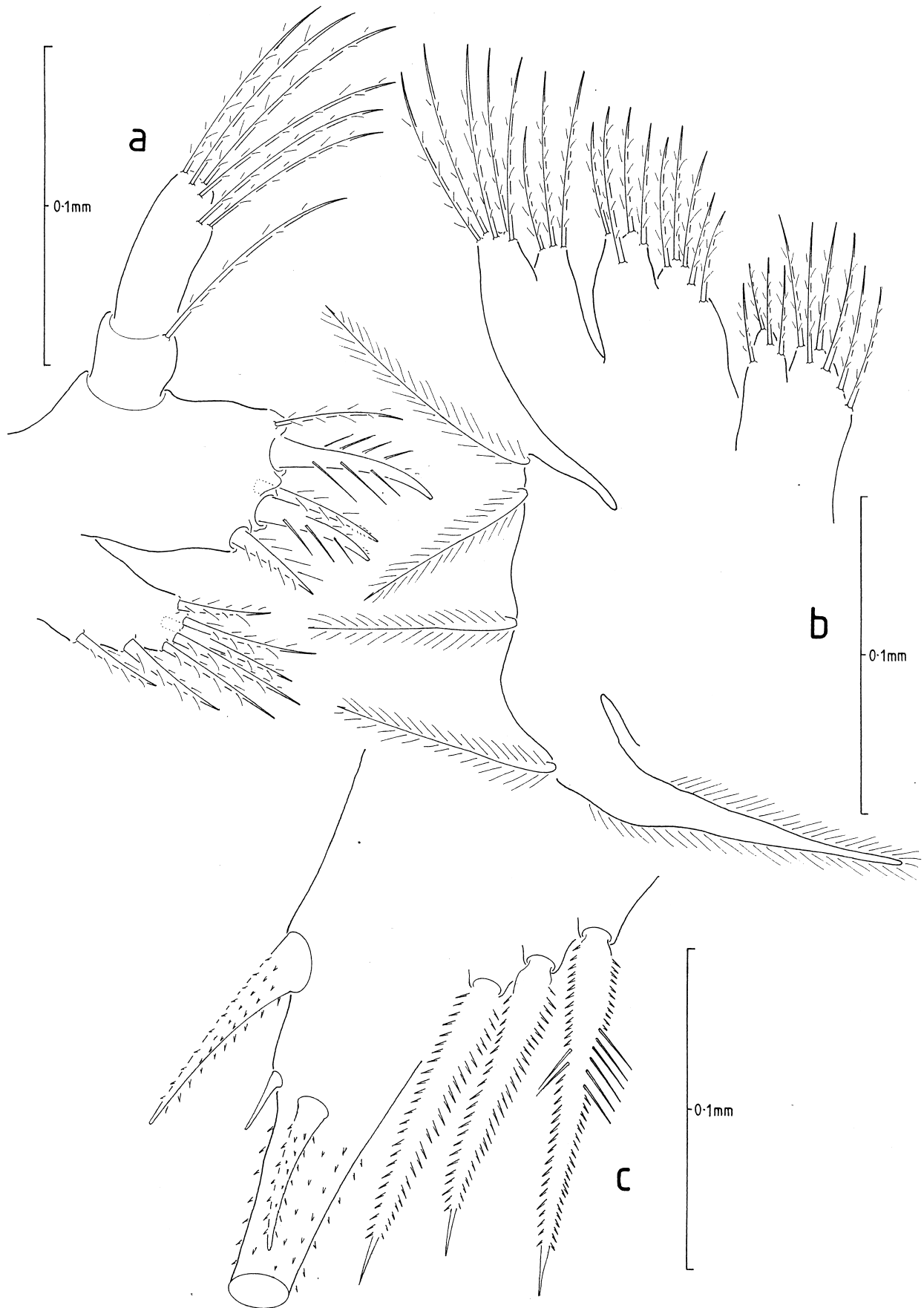


Fig. 34. *Pilumnus longicornis* (Hilgendorf, 1878) first stage zoea; a) maxillule; b) maxilla; c) telson.

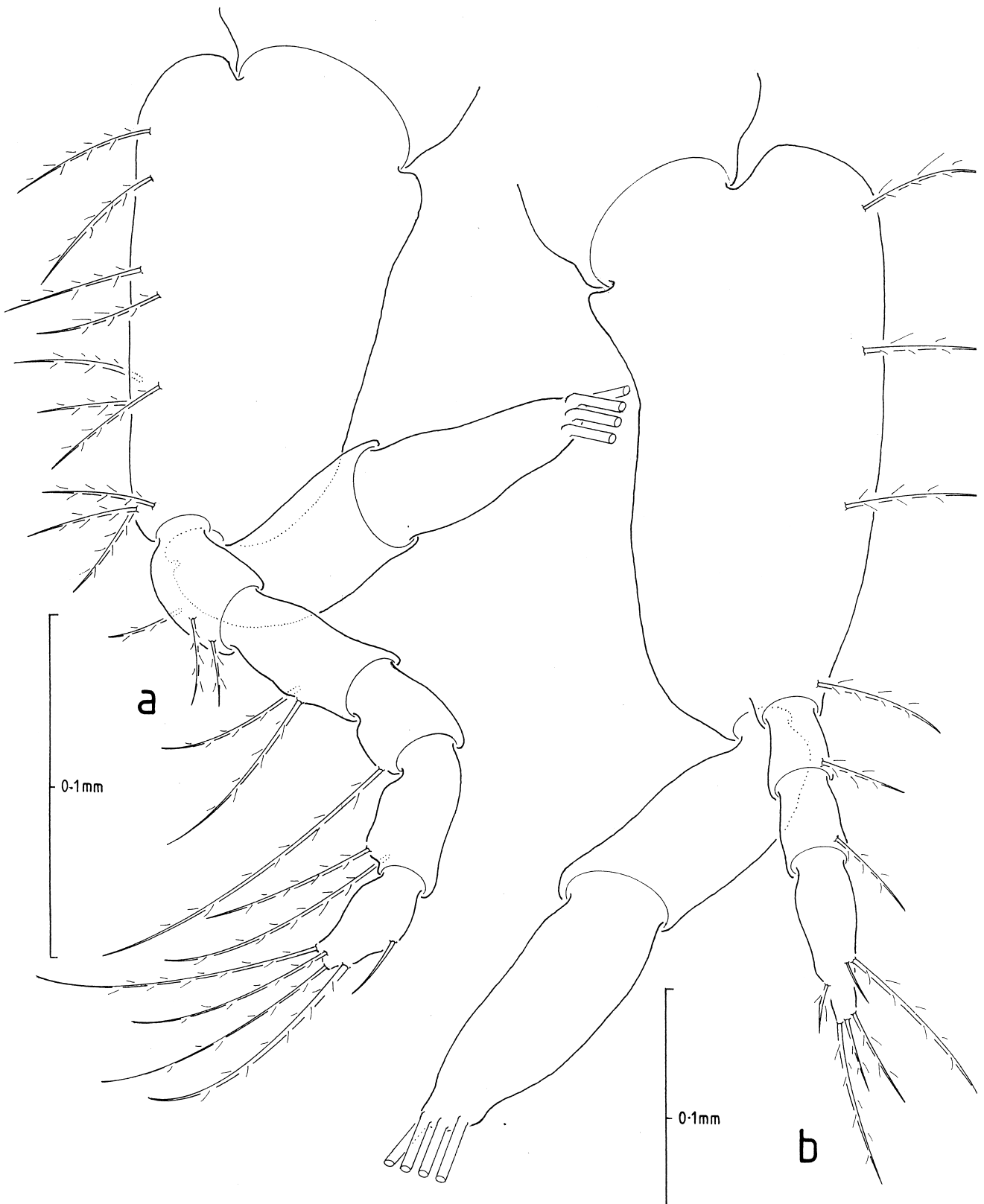


Fig. 35. *Pilumnus longicornis* (Hilgendorf, 1878) first stage zoea; a) first maxilliped; b) second maxilliped.

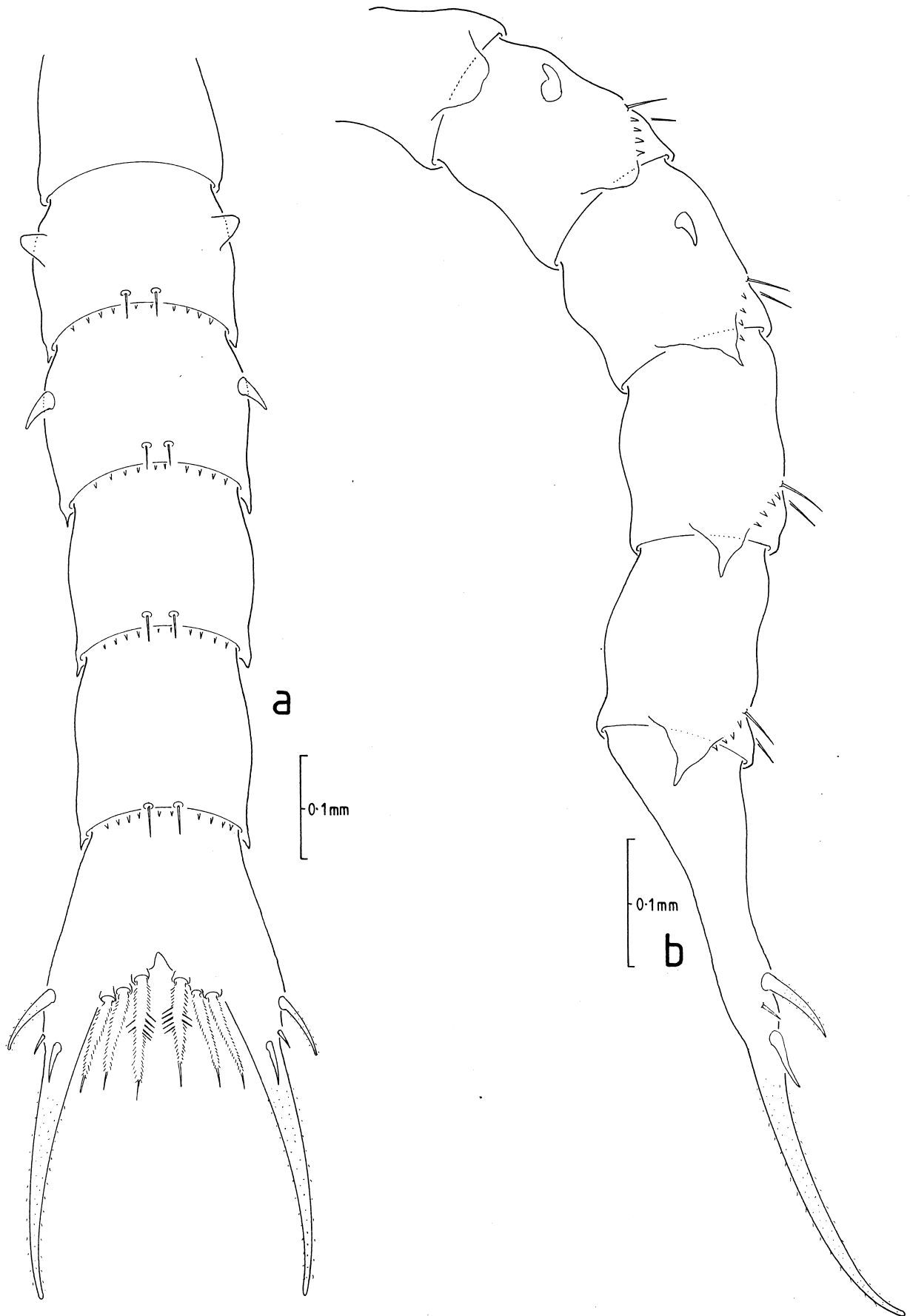


Fig. 36. *Pilumnus longicornis* (Hilgendorf, 1878) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

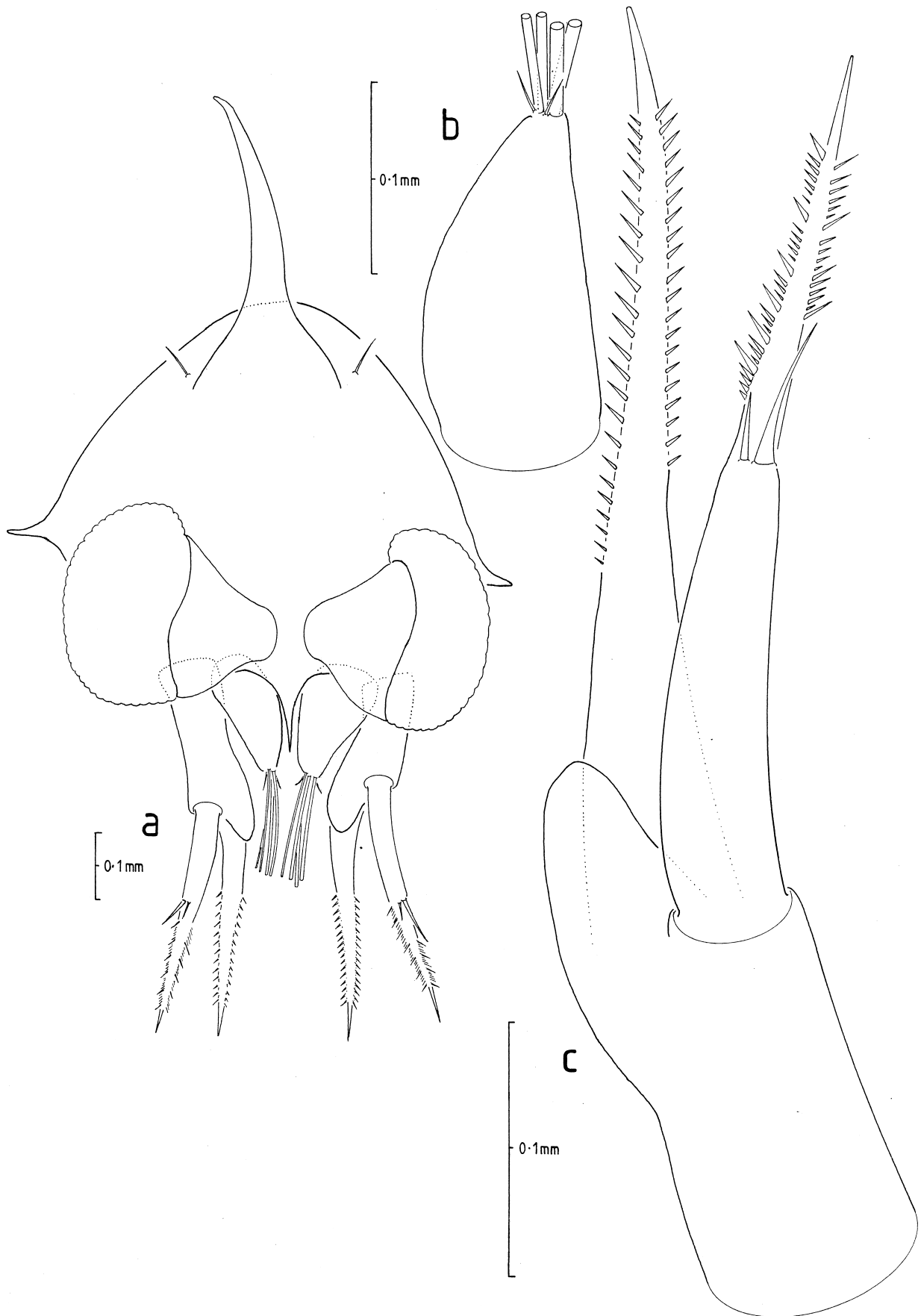


Fig. 37. *Pilumnus vespertilio* (Fabricius, 1793) first stage zoea; a) anterior view of carapace; b) antennule; c) antenna.

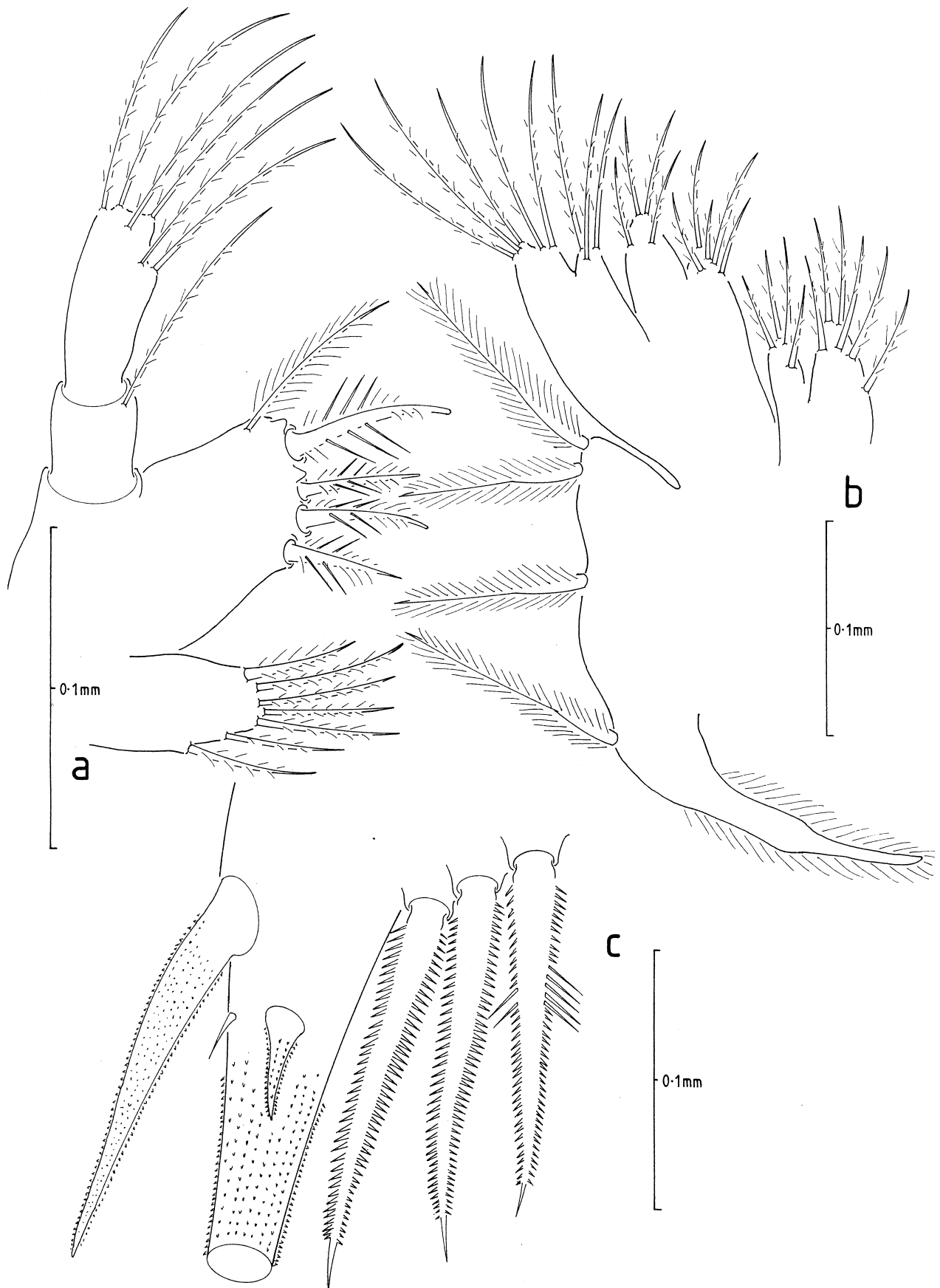


Fig. 38. *Pilumnus vespertilio* (Fabricius, 1793) first stage zoea; a) maxillule; b) maxilla; c) telson.

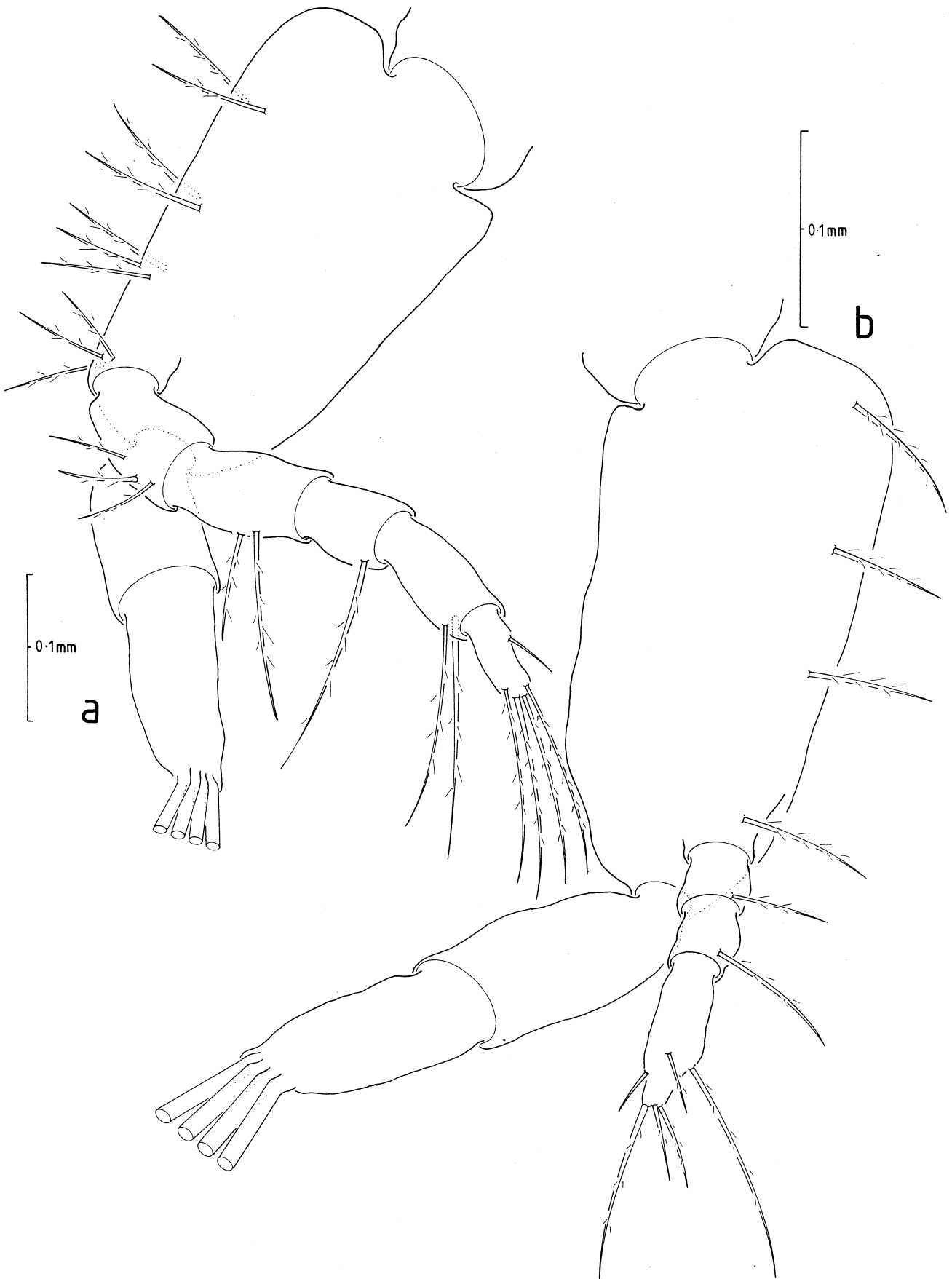


Fig. 39. *Pilumnus vespertilio* (Fabricius, 1793) first stage zoea; a) first maxilliped; b) second maxilliped.

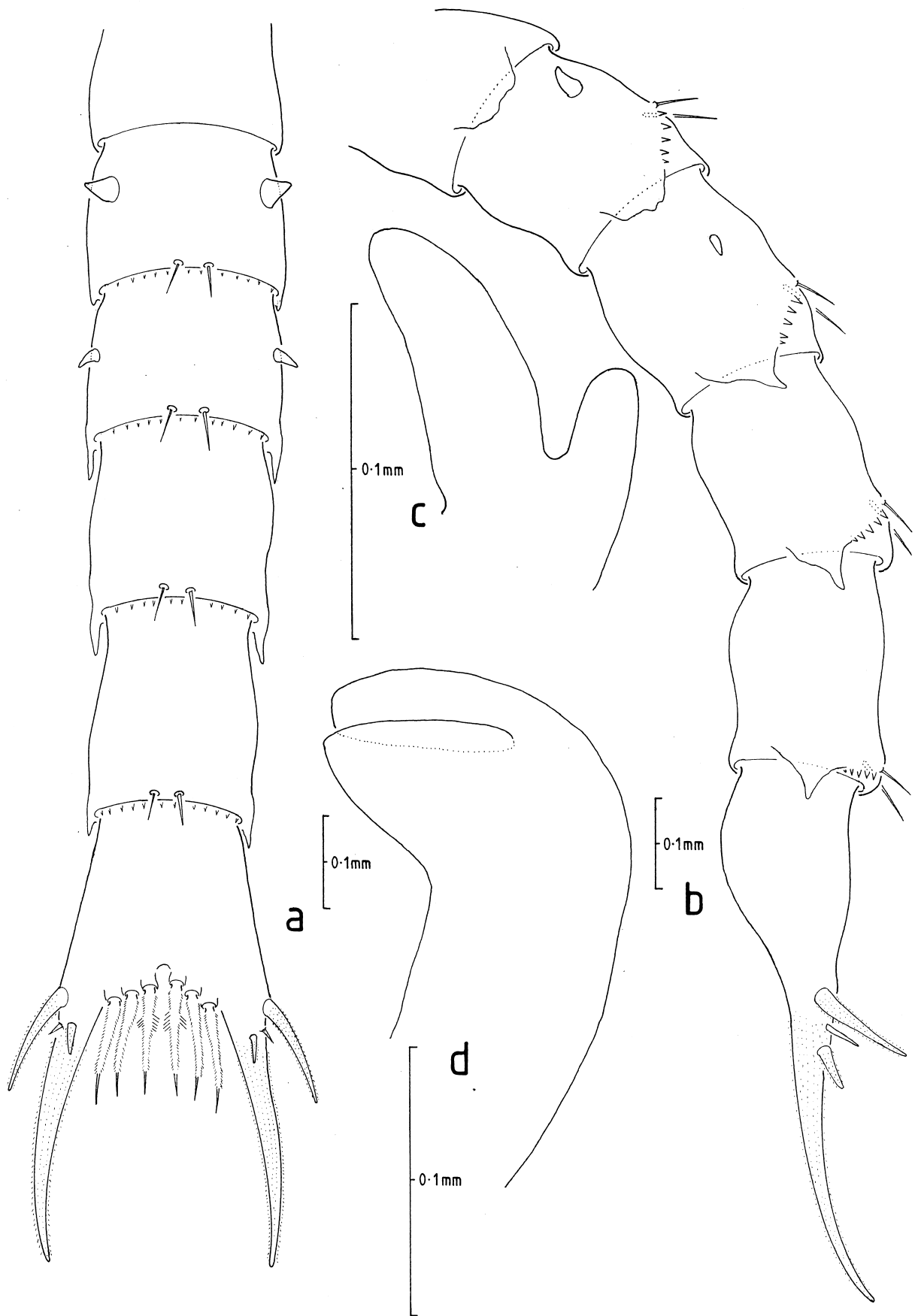


Fig. 40. *Pilumnus vespertilio* (Fabricius, 1793) first stage zoea; a) dorsal view of abdomen; b) lateral view of abdomen.

Table 1. A comparison between the first stage zoeas of *Eriphia smithi* [as *Eriphia laevimana smithii*] as described by Hashmi (1970b) and a re-examination of this material for the present study.

Character	<i>Eriphia smithi</i> (by Hashmi, 1970b)	<i>Eriphia smithi</i> (this present study)
CARAPACE	Fig. 9a	
1 pair of posterodorsal setae	Absent	Present
ANTENNULE	Fig. 10a	
Number of aesthetascs and setae	2 aesthetascs and 1 terminal seta	5 aesthetascs and 1 small terminal seta
ANTENNA	Fig. 10b	
Pair of small proximal lateral spines	Absent	Present
MAXILLA	Fig. 10f	
Setation of coxal endite	5+4	6+4
Setation of basal endite	4+4	5+4
FIRST MAXILLIPED	Fig. 10g	
Setation on basis	8(2,2,2,2)	10 (2,2,3,3)
Setation on endopod	2,1,1,2,5	3,2,1,2,5

present; exopod unsegmented, distally spinulate with 1 long and 1 smaller medial setae unequal in length.

Mandible: endopod palp absent.

Maxillule (Fig. 38a): epipod seta absent; coxal endite with 7 setae; basal endite with 5 terminal setal processes and 2 small teeth; endopod 2-segmented, proximal segment with 1 seta; distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 38b): coxal endite bilobed with 6+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed with 3+5 (2 subterminal, 3 terminal) setae; exopod (scaphognathite) margin with 4 setae and 1 long distal stout process.

First maxilliped (Fig. 39a): coxa without setae; basis with 10 setae arranged 2,2,3,3; endopod 5-segmented with 3,2,1,2,5 (1 subterminal, 4 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second Maxilliped (Fig. 39b): coxa without setae; basis with 4 setae arranged 1,1,1,1; endopod 3-segmented, with 1,1,6 (3 subterminal, 3 terminal) setae respectively; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped (Fig. 40c): present and biramous.

Pereiopods (Fig. 40d): present and chela bilobed.

Abdomen (Figs. 40a, b): 5 somites; somite 2 with a pair of dorsolateral processes directed anteriorly; somite 3 with a pair of dorsolateral processes directed ventrally; somites 1-2 with rounded posterolateral processes and 3-5 with short posterolateral spinous processes; somite 1 without dorsal setae; somites 2-5 with 1 pair of posterodorsal setae; posterior margin of somites 2-5 spinulate; pleopod buds absent.

Telson (Figs. 38c, 40a, b): each telson fork long, spinulate and gradually curved distally; 1 long and 1 small lateral spine; dorsal medial spine present; posterior margin with 3 pairs of stout spinulate setae.

COMPARATIVE MORPHOLOGY

ERIPHIIDAE MACLEAY, 1838

ERIPHIINAE MACLEAY, 1838

Remarks. – Four species of *Eriphia* have had their larval stages described, *E. caribbaea* [this is a *nomen nudum* but may be *E. gonagra*] by Thompson (1836); *Eriphia smithii* [as *E. laevimana smithii*] by Hashmi (1970b); *E. spinifrons* by Cano (1892), Paolucci (1910), Boraschi (1921), Hyman (1925) and Bourdillon-Casanova (1960), and *E. verrucosa* by Lumare & Gozzo (1972). Hashmi (1970b) deposited some of his first stage zoeas in the NHM and this material was re-examined for the present study. A comparison of the two studies is made in Table 1. The first stage zoeas of *E. verrucosa* [by Lumare & Gozzo (1972)], *E. smithii* [by this present study] are compared those of *E. scabricula* [by this present study] (see Table 2).

OZIINAE DANA, 1851

Remarks. – Although this is the first description of *Epixanthus frontalis* (H. Milne Edwards, 1834) zoea the larvae of this genus are known for *E. dentatus* (White, 1848) from Saba et al. (1978). A comparison between the two first stage zoeas is presented in Table 3. The differences between the two species is of interest because according to Saba et al. (1978) *E. dentatus* has only two zoeal stages and is an example of abbreviated development zoeal development. The first zoeal stage of *E. dentatus* has hatched in a far more developed state than that of its congener *E. frontalis*. For *E. dentatus* the following characters have had an accelerated appearance (see Clark, 2001), the well developed antennal

Table 2. A comparison between the first stage zoeas of *Eriphia verrucosa* by Lumare & Gozzo (1972), *Eriphia smithi* and *Eriphia scabricula* from this present study.

Character	<i>Eriphia verrucosa</i> (see Lumare & Gozzo, 1972)	<i>Eriphia smithi</i> (this present study)	<i>Eriphia scabricula</i> (this present study)
CARAPACE	Fig. 1a		Fig. 1a
1 pair of posterodorsal setae	Absent	Present	Present
ANTENNULE	Fig. 1d		Fig. 1b
Number of aesthetascs and setae	3 aesthetascs	5 aesthetascs and 1 small terminal seta	5 aesthetascs and 1 small terminal seta
Pair of small proximal lateral spines	Absent	Present	Present
ANTENNA	Fig. 1e		Fig. 1c
Ratio of exopod to protopod length	ca. 50%	ca. 41%	ca. 40%
MAXILLA	Fig. 1g		Fig. 2b
Setation of coxal endite	5+4	6+4	6+4
FIRST MAXILLIPED	Fig. 1h		Fig. 3a
Setae on basis	4 (1,1,1,1)	10(2,2,3,3)	10 (2,2,3,3)
Number of setae on endopod segment 1	2	3	3

Table 3. A comparison between the first stage zoeas of *Epixanthus dentatus* described by Saba et al. (1978) and *Epixanthus frontalis* from this present study.

Character	<i>Epixanthus dentatus</i> (see Saba et al., 1978)	<i>Epixanthus frontalis</i> (this present study)
CARAPACE	Fig. 1A	Fig. 5a
1 pair of posterodorsal setae	Absent	Present
ANTENNULE	Fig. 1B	Fig. 5b
Number of aesthetascs and setae	3 aesthetascs	5 aesthetascs and 1 small terminal seta
ANTENNA	Fig. 1C	Fig. 5c
Ratio of exopod to protopod length	ca. 60%	ca. 41%
Endopod	Present	Absent
MAXILLULE	Fig. 1D	Fig. 6a
Exopod seta	Present	Absent
Number of setae on coxal endite	8	7
Setal processes on basal endite	7	5
MAXILLA	Fig. 1E	Fig. 6b
Setation of basal endite	5+5	5+4
Setation of scaphognathite (exopod)	17 setae and 1 long distal stout process	4 setae and 1 long distal stout process
FIRST MAXILLIPED	Fig. 1F	Fig. 7a
Seta on coxa	Not shown	Present
Number of setae on endopod segment 5	6 (2 subterminal, 4 terminal)	5 (1 subterminal, 4 terminal)
ABDOMEN	Fig. 1H	Figs 8a,b
Dorsolateral processes on somites 4 & 5	Present	Absent
Pleopods	Present	Absent
TELSON	Fig. 1H	Fig. 6c
Number of lateral spines on fork	1 fine spine	1 large and 1 small lateral spine
Number of setae on inner margin	1 pair	Absent

Table 4. A comparison between eriphid first stage zoeas of *Eriphia scabricula*, *Epixanthus frontalis*, and *Lydia annulipes* all described in this present study

Character	<i>Eriphia scabricula</i>	<i>Epixanthus frontalis</i>	<i>Lydia annulipes</i>
ANTENNA	Fig. 1c	Fig. 6c	Fig. 9a
Pair of small proximal lateral spines	Present	Absent	Absent
MAXILLA	Fig. 2b	Fig. 6b	Fig. 10b
Coxal endite setal formula	6+4	5+4	7+4
ABDOMEN	Figs 4a,b	Figs 8a,b	Figs 12a,b
Dorsal medial spine on somite 1	Absent	Absent	Present
Lateral process on somite 4	Present	Absent	Absent
Lateral process on somite 5	Present	Absent	Absent

endopod; the appearance (instead of absence) of the exopod seta and the 8 (instead of 7) setae on the coxal endite of the maxillule; the 17 (instead of 4) marginal setae on the scaphognathite and possibly the setal formula of the basal endite 5+5 (instead of 5+4) of the maxilla; the appearance of an extra seta (5 in total instead of 4 setae) on the distal endopod segment of the first maxilliped and a pair of medial setae (instead of being absent) on the posterior margin of the telson. *Epixanthus frontalis* first stage zoeas are distinguished from those of *Lydia annulipes* and *Eriphia scabricula* by possessing a maxilla with a coxal endite setal formula of 5+4 setae and an abdomen where the dorsal medial spine is absent on somite 1 and lateral processes are absent from somites 4 & 5 (see Table 4).

This is the first description of *Lydia* zoea and the differences between the first stage zoeas of *L. annulipes*, *Epixanthus frontalis* and *Eriphia scabricula* are summarised in Table 4.

XANTHIDAE MACLEAY, 1838

CHLORODIINAE ALCOCK, 1898

Remarks. – The zoeal description of *Pilodius paumotensis* is the first for this species. However Ng & Clark (2000) described the first stage zoea of two species for *Pilodius*, *P. areolatus* (H. Milne Edwards, 1834) and *P. pugil* Dana, 1852, and a comparison of *P. paumotensis* larval morphology with their figures revealed no differences in setal or spinature characters. Furthermore Ng & Clark (2000) also described two other larvae from the Chlorodiinae, *Phymodius monticulus* Dana, 1852 and *Chlorodiella nigra* (Forskål, 1775) and *Pilodius paumotensis* first stage zoeal characters appear to be identical to these two species. Therefore differentiating Chlorodiinae first stage zoeas to species level from plankton samples may not be possible.

POLYDECTINAE DANA, 1851

Remarks. – The description in this present study of *Lybia plumosa* first stage zoea is the only one known for the Polydectinae Dana, 1851.

XANTHINAE MACLEAY, 1838

Remarks. – The first stage zoeal descriptions of *Leptodius exaratus* by Saba (1976), Fielder et al. (1979), Terada (1980) and Siddiqui & Tirmizi (1998) were not consistent and are compared with material hatched from Inhaca Island (see Table 5).

ZOSIMINAE ALCOCK, 1898

Remarks. – This is the first description of *Zozymodes xanthoides* zoea and a first for the genus. Other larval descriptions for this subfamily are known for *Atergatis reticulatus* De Haan, 1835, by Terada (1980); *Lophozozymus pictor* (Fabricius, 1798) by Clark & Ng, 1998; *Zosimus aeneus* (Linnaeus, 1758) by Tanaka (1999); and *Atergatis floridus* (Linnaeus, 1767) by Tanaka & Koonishi (2001). The antenna of *L. pictor* was re-examined for this present study and Clark & Ng, 1998 overlooked the small endopod spine. For the present study the first stage zoeas of *Atergatis floridus* from Singapore were examined and compared with the work of Tanaka & Koonishi (2001) (see Table 6). A comparison between the known Zosiminae first stage zoeas is listed (see Table 7). The zoeas of *L. pictor* differ from the other Zosiminae larvae on a number of characters including a smooth rostral spine, a smooth antennal protopod and two fine lateral spines on the telson fork.

PILUMNIDAE SAMOUELLE, 1819

PILUMNINAE SAMOUELLE, 1819

Remarks. – Prasad & Tampi (1957) described the first stage zoea of *Pilumnus longicornis* but their description does not meet with modern standards because they overlooked many characters. For example their figure of the first maxilliped scores 0,1,1,0,3 setae for the endopod segments respectively while this present study found 3,2,1,2,5 setae for the same appendage. There are also problems with the description by Hashmi (1970a) of *P. longicornis* first stage zoea (see Table 8). This present study did not observe an endopod on the antenna (see Hashmi 1970a: Fig. 9b), a bilobed chela with walking legs (see Hashmi 1970a: Fig. 10d) and an abdomen with pleopod buds (see Hashmi, 1970a: Fig. 8a). These

Table 5. A comparison of the first stage zoeal descriptions of *Leptodius exaratus* by Saba, (1976), Fielder, et al. (1979), Terada (1980) and Siddiqui & Tirmizi (1998) with material hatched in Mozambique and examined for this present study.

Characters	Saba (1976)	Fielder et al., (1979)	Terada (1980)	Siddiqui & Tirmizi (1998)	This present study
CARAPACE	Text fig. 1	Fig. 1A	Fig. A1	Fig. 1A	Fig. 21a
Pair of posterodorsal setae	Absent	Present	Absent	Absent	Present
ANTENNULE	Text p. 59; Pl. 5A	Fig. 2A	Fig. A1	Fig. 1D	Fig. 21b
Terminal setation	text = 2 aesthetascs, 1 seta; pl. = 3 aesthetascs, 1 seta	2 aesthetascs, 1 seta, 1 small spine	3 aesthetascs, 1 seta	2 aesthetascs, 1 seta	4 aesthetascs, 1 seta
ANTENNA	Pl. 5E	Fig. 2B	Fig. 2 A'1	Fig. 1E	Fig. 21c
Endopod spine	Absent	Absent	Absent	Present	Present
Exopod terminal seta	Absent	Present	Present	Absent	Present
MAXILLULE	Pl. 6A	Fig. 2D	Text p. 138	Fig. 1G	Fig. 22a
Distal endopod segment setation	6(2 subterminal + 4 terminal)	6(2 subterminal + 4 terminal)	6(2 subterminal + 4 terminal)	5(2 subterminal + 3 terminal)	6(2 subterminal + 4 terminal)
MAXILLA	Pl. 6E	Fig. 2E	Fig. 2, D''1	Fig. 1H	Fig. 22b
Coxal endite setation	4+4	4+4	4+4	5+3	4+4
Scaphognathite setation	4+1	4+1	4+1	6+1	4+1
FIRST MAXILLIPED	Text p. 59	Fig. 2F		Fig. 1I	Fig. 23a
Coxal setation	Not figured	Not figured	Not figured	0	1
Basial setation	8-10	9 (2,2,3,2)	10 (2,2,3,3)	8(2,2,2,2,)	10 (2,2,3,3)
Setation of endopod	2,2,1,2,5	3,2,1,2,5	3,2,1,2,5	3,2,1,2,6	3,2,1,2,5
SECOND MAXILLIPED	Pl. 7A	Fig. 2G	Text p. 140	Fig. 1J	Fig. 23b
Basial setation	3	4	4	3	4
ABDOMEN	Text p. 59, Pl. 5I	Fig. 1A	Fig. 3A1	Fig. 1C	Figs 24a,b
Dorsal setation on somites 2-5	text = present 2-5; pl. = present on 2-4	Present	Present	Absent	Present
TELSON	Text p. 59; Pl. 5I	Fig. 1H	Fig. 3A1	Fig. 1C	Fig. 22c
Armature	text = 2 lateral spine, 1 dorsal spine; pl. = absent	Lateral spine and seta, 1 dorsal spine	Lateral spine and seta, 1 dorsal spine	Lateral spine and small spine, 1 dorsal spine	Lateral spine and small spine, 1 dorsal spine

Table 6. A comparison between the first stage zoeal descriptions of *Atergatis floridus* by Tanaka & Konishi (2001) and the re-examination by this present study.

Character	<i>Atergatis floridus</i> (see Tanaka & Konishi, 2001)	<i>Atergatis floridus</i> (this present study)
CARAPACE	Fig. 2A	
Rostral spine distally spinulate	Absent	Present
ANTENNULE	Fig. 3A	
Terminal setation	4 aesthetascs	4 aesthetascs, 1 seta
ANTENNA	Fig. 3F, F'	
Endopod spine	Absent	Present
Exopod terminal setation	Two	Three

Table 7. A comparison between known Zosiminae first stage zoeal descriptions; *Atergatis reticulatus* by Terada (1980), *Zosimus aeneus* by Tanaka (1999), *Lophozozymus pictor* by Clark & Ng (1998), *Atergatis floridus* examined for this present study and *Zozymodes xanthoides* from this present study.

Character	<i>Atergatis reticulatus</i> (see Terada 1980)	<i>Zosimus aeneus</i> (see Tanaka, 1999)	<i>Lophozozymus pictor</i> (see Clark & Ng, 1998)	<i>Atergatis floridus</i> (this present study)	<i>Zozymodes xanthoides</i> (this present study)
CARAPACE	Fig. 1.D1	Fig. 1A	Fig. 1A		Fig. 25a, d
Pair of posterodorsal setae	Absent	Absent	Present	Present	Present
Rostral spine distally spinulate	Absent	Absent	Absent	Present	Present
ANTENNULE	Fig. 1.D1	Fig. 2A	Fig. 2A		Fig. 25b
Terminal setation	4 aesthetascs, 1 seta	2 aesthetascs, 1 seta	4 aesthetascs, 1 seta	4 aesthetascs, 1 seta	4 aesthetascs, 1 seta
ANTENNA	Fig. 2 D'1	Fig. 2E	Fig. 8A, B		Fig. 25c
Protopod spinulation	Present	Present	Absent	Present	Present
Endopod spine	Absent	Absent	Present	Present	Present
Exopod terminal setation	three	three	three	three	three
Protopod – exopod %	6%	21%	10%	15%	13%
TELSON	Fig. 3 D1	Fig. 1E	Fig. 15A		Fig. 26c
Lateral spines	2 fine spines	1 large + 1 smaller spine	2 fine spines	1 large + 1 smaller spine	1 large + 1 smaller spine

Table 8. A comparison between the first stage zoea of *Pilumnus longicornis* described by Hashmi (1970a) and this present study.

Character	<i>Pilumnus longicornis</i> (see Hashmi 1970a)	<i>Pilumnus longicornis</i> (this present study)
CARAPACE	Fig. 8a	Fig. 33a
1 pair of posterodorsal setae	Absent	Present
ANTENNULE	Fig. 9a	Fig. 33b
Terminal setation	4 aesthetascs, 1 seta	4 aesthetascs, 2 setae
ANTENNA	Fig. 9b	Fig. 33c
Endopod	Present	Absent
PEREIOPODS	Fig. 10d	Not figured
Chela and walking legs	Bilobed chela with walking legs present	Absent
ABDOMEN	Fig. 8a	Fig. 36a
Pleopod buds	Present	Absent

characters suggest that the pilumnid species of Hashmi (1970a) only had two zoeal stages. [PFC discussed this anomaly with Peter K. L. Ng and his comments were as follows: The taxonomy of *Pilumnus longicornis* is uncertain and it may be a complex of several species together with its ally *P. cursor* A. Milne-Edwards, 1873 (see Ng, 1988). Alcock (1898: 193, 194) reported *P. longicornis* and the closely allied *P. andersoni* De Man, 1888, from Pakistan. Balss (1933), however, synonymised *P. andersoni* with *P. longicornis*, but all indications are that they are different species (Ng, 1988: 295), the two differing in the form of the anterolateral teeth and degree of carapace granulation (see also Alcock, 1898: 194). The Mozambique specimen on which the zoeae have been obtained here is *P. longicornis* s. str., agreeing very well with the holotype male in the Berlin Museum, which I (Ng) have examined (also from Mozambique). In view of the substantial differences in zoeal morphology (including the likelihood that it has two zoeal stages) between the account of Hashmi (1970a) and the present one by Clark & Paula, it is likely that Hashmi had in fact misidentified his specimen. From Pakistan, a two-zoeal

stage larva is known, *P. kempfi* (see Siddiqui & Tirmizi, 1992) but it seems unlikely that such a misidentification could have been made as *P. kempfi* and *P. longicornis* are markedly different in appearance. It is also possible that Hashmi (1970a) had specimens of the related *P. andersoni*, which can be mistaken for *P. longicornis*. In lieu of rechecking the identity of Hashmi's specimen, it seems best to disregard his zoeal account for "*P. longicornis*" and just treat it as an incerta sedis for the time being (Peter K. L. Ng, pers. comm.).

The larval stages of *P. vespertilio* have previously been described by Aikawa (1929), Hashmi (1970a), Lim & Tan (1981) and Terada (1990). Only the descriptions of the last three authors are comparable with the present study (see Table 9).

The first stage zoeas of three pilumnid species were hatched for this present study, *Eurycarcinus natalensis*, *Pilumnus longicornis* and *Pilumnus vespertilio*. Distinguishing the three zoeas appears relatively easy; the antennal endopod is

Table 9. A comparison between the first stage zoea of *Pilumnus vesperilio* described by Hashmi (1970a), Lim & Tan (1981), Terada (1990) and this present study.

Character	Hashmi (1970a)	Lim & Tan (1981)	Terada (1990)	This present study
CARAPACE	Fig. 1a	Fig. 1A	Fig. 6 AI	Fig. 37a
1 pair of posterodorsal setae	Absent	Absent	Absent	Present
ANTENNULE	Fig. 2a	Fig. 1D	Fig. 6 BI	Fig. 37b
Terminal setation	4 aesthetascs, 2 setae	3 aesthetascs, 2 setae	3 aesthetascs, 1 seta	4 aesthetascs, 2 setae
MAXILLE	Fig. 2f	Fig. 1G	Fig. 6 DI	Fig. 38a
Number of setae on coxal endite	6	7	6	7
MAXILLA	Fig. 3a	Fig. 1H	Fig. 7 EI	Fig. 38b
Number of setae on basal endite	5+3	3+4 (Text) 4+4 (Fig.)	5+4	5+4
FIRST MAXILLIPED	Fig. 2g, h	Fig. I	Fig. 7 FI	Fig. 39a
Number of setae on basis	9(1,1,1,1,2,3)	9 (2,2,3,2)	10 (2,2,3,3)	10 (2,2,3,3)
Number of setae on first endopod segment	3	2	3	3
Number of setae on fourth endopod segment	3	2	2	2
THIRD MAXILLIPED	Fig. 3f	Fig. 1K	Not figured	Fig. 40c
Biramous	Present	Present		Present
CHELIPED	Fig. 3e	Fig. 1L	Not figured	Fig. 40d
Bilobed	Present	Present		Present
TELSON	Fig. 1c	Fig. 1B	Fig. 6 HI	Fig. 38c
Number of lateral spines	2	1	2	2

Table 10. A comparison between the xanthid first stage zoeas of *Leptodius exaratus*, *Lybia plumosa*, *Pilodius paumotensis* and *Zozymodes xanthoides* all described in this present study.

Character	<i>Leptodius exaratus</i>	<i>Lybia plumosa</i>	<i>Pilodius paumotensis</i>	<i>Zozymodes xanthoides</i>
ANTENNA	Fig. 13c	Fig. 17c	Fig. 21c	Fig. 25c
Setation of exopod	1 seta (1 terminal)	3 unequal setae (1 subterminal + 2 terminal)	2 unequal setae (2 terminal)	3 unequal setae (1 subterminal + 2 terminal)
SECOND MAXILLIPED	Fig. 15b	Fig. 19b	Fig. 23b	Fig. 27b
Setation of endopod segment 3	5 (2 subterminal + 3 terminal)	5 (2 subterminal + 3 terminal)	6 (3 subterminal + 3 terminal)	6 (3 subterminal + 3 terminal)
TELSON	Fig. 14c	Fig. 18c	Fig. 22c	Fig. 26c
Lateral spines	1 large + 1 small	1 large + 1 smaller	1 large + 1 smaller	1 large + 1 smaller

absent in *P. longicornis* (Fig. 33c), but present in *E. natalensis* (Fig. 29c) and *P. vesperilio* (Fig. 37c). The appearance of a biramous third maxilliped (Fig. 40c) and bilobed cheliped (Fig. 40d) have been accelerated in *P. vesperilio*, but they are absent in *E. natalensis* and will appear in this species at a later zoeal stage. Other zoeal characters do separate the three species such as length of carapace and telson spines, but these characters are difficult to quantify. For example when compared with the other two first stage zoeas, the rostral spine of *P. longicornis* (Fig. 33a) is the longest and that of *P. vesperilio* (Fig. 37a) the shortest. However, quantifying the rostral spine length of *E. natalensis* (Fig. 29a) which is intermediate between the other two species, as a diagnostic character is difficult. This rostral spine example also applies to the carapace dorsal and lateral spines, and telson spines.

ANTENNAL MORPHOLOGY

ERIPHIIDAE MACLEAY, 1838

Remarks. – The first stage zoeas of three Menippidae species are described in this present study, *Epixanthus frontalis*, *Lydia annulipes* and *Eriphia scabricula*. The antenna of these zoeas appear to correspond to that of the group III described by Martin (1984: 228, Fig. 1J). He described the antennal exopod as robust, about _ length of the protopod, armed with three unequal setae. This definition may be revised to a protopod with distal bilateral spinulation and a robust exopod about 33% (or greater) of the length of the protopod with 3 (one long subterminal and 2 unequal terminal) setae.

XANTHIDAE MACLAHEY, 1838

Remarks. – The present study examined four xanthid species, *Leptodius exaratus*, *Lybia plumosa*, *Pilodius paumotensis* and *Zozymodes xanthoides* and a comparison of their differences is listed (see Table 10). Martin's (1984: 221, Fig. 1A) antennal definition for his group I appears to fit these four species and he states; antennal exopod reduced, less than $\frac{1}{4}$ length of protopod (=spinous process), never armed with more than 2 short terminal setae, these sometimes absent, antennal protopod approximately the same length as rostrum. A number of antennal characters have been overlooked and consequently this definition may be revised. For example the protopod of a xanthid zoea is distally multispinulate, many larvae workers have overlooked the endopod spine and the protopod of *Pilodius paumotensis* described in this present study appears to be longer than the rostral spine. Of interest is the exopod armature description by Martin as: never armed with more than 2 short terminal setae. This account of the exopod does not take into account the three (1 subterminal + 2 terminal) exopod setae described in this present study for *Lybia plumosa* and *Zozymodes xanthoides*. Perhaps a revised definition should read: protopod distally multispinulate, antennal exopod reduced to less than $\frac{1}{4}$ the protopodal length, never armed with more than three setae.

PILUMNIDAE SAMOULLE, 1819

Remarks. – The pilumnid antenna is a conservative character and defines all species attributed to the taxon. According to Martin's (1984: 228, Fig. 1H) xanthid group II, pilumnids are characterised by an antennal exopod acutely tipped, about equal in length to or slightly longer than protopod, armed with small spinules distally and with a prominent outer seta about halfway along its length; antennal protopod usually longer than rostrum. However, Martin overlooked a second smaller medial seta on the exopod (see present study Figs. 25c, 29c, 33c). Two medial setae on the antennal exopod are characteristic of this family. Furthermore the exopod is distally bilaterally spinulate as is the protopod.

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