Larval development of *Galathea amboinensis* (Decapoda: Anomura: Galatheidae) under laboratory conditions.

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Abstract. –The larval development of *Galathea amboinensis* De Man, 1888, a galatheid symbiotic with comatulid crinoids, is described and illustrated from laboratory-reared material. This species had four zoeal stages and one megalopal stage. The larval morphology of *G. amboinensis* is compared with that of other congeneric species for which the complete larval development is known: *G. inflata* Potts, 1915, *G. rostrata* A. Milne Edwards, 1880 and *G. intermedia* Lilljeborg, 1851. The zoeas of *G. amboinensis* are much like those of *G. inflata*, but distinctive in the absence of small spines on the posterodorsal margin of the second to fifth abdominal segments. The megalop of *G. amboinensis* also resembles that of *G. inflata*, but differs in segmentation of the antennal flagellum and setation of the mandibular palp, and in having circular or subcircular red spots on the carapace and abdomen.

Introduction

During the course of a survey on the crinoid-decapod relationships on the Okinawa Island of the Ryukyu Islands, three symbiotic galatheids, *Galathea amboinensis* De Man, 1888, *G. inflata* Potts, 1915 and *Allogalathea elegans* (Adams & White, 1848), were recorded (Fujita & Baba, 1999; Kogo & Fujita, 2000). Of these, *G. amboinensis* and *G. inflata* often share the same crinoid hosts but are readily distinguished by their color patterns (Fujita & Baba, 1999). In a previous paper (Fujita *et al.*, 2001), the larval morphology of *G. inflata* was reported, and available information on *Galathea* larvae was included. This paper describes the complete larval development of *G. amboinensis* based on the materials reared under laboratory conditions.

Materials and Methods

An ovigerous female of *Galathea amboinensis* was found solitarily on the host crinoid, *Capillaster multiradiatus* (Linnaeus, 1758), at Cape Maeda of Okinawa Island of the Ryukyu Islands on 30 May 2000. Hatched zoeas were mass-cultured in circular plastic tanks (30 cm in diameter) containing 8-liter of filtered seawater. In order to determine the normal number of their larval stages and duration, 20 zoeas were kept individually in 50 ml glass beakers. The salinity and water temperatures of the seawater were 33.5–35.0 ‰ and 24.5–26.5 °C, respectively. Foods given throughout all larval stages were freshly hatched *Artemia* sp. nauplii enriched by "SUPER ARTEMIA (Higashimaru Co., LTD.)." Approximately one-third of the water in the tank was changed daily.

The zoeal and megalopal specimens were fixed and preserved in 50 % ethylene glycol for setal observations. Dissections and measurements were carried out under a Nikon SMZ-10 binocular microscope by using fine entomological needles. Measurements of carapace length (CL), total length (TL), and postorbital carapace length (PCL; measured only in megalops) follow those of Fujita *et al.* (2001). Drawings were made using a NIKON OPTIPHOT-2 microscope equipped

with a drawing tube. Descriptions were based on 6 zoeal larvae of each stage and 5 megalops. Body somites are described from anterior to posterior, appendages from endopod to exopod, and segments and setae from proximal to distal. Terminology generally follows that of Gore (1979) and Ingle (1991), and usage of the terms of "zoeas (the plural)," "megalop (the singular)," and "megalops (the plural)" follow those of Clark *et al.* (1998).

The spent female and complete larval series (undissected samples) were deposited in the Coastal Branch of Natural History Museum and Institute, Chiba, Japan (CMNH) under the following registration numbers: CMNH-ZC 01130 for the spent female, CMNH-ZC 01131-01134 for first to fourth zoeas, CMNH-ZC 01135 for megalops.

Results

Hatching occurred on 2 June 2000, and 268 zoeas were recorded. Two days later (4 June 2000), the female laid eggs again without copulation. The eggs developed normally and 512 zoeas hatched on 15 June 2000.

Galathea amboinensis passed through four zoeal stages before attaining the megalopal (decapodid) stage. However, all the megalops could not metamorphose to the first juvenile stage. The duration of the zoeal stages from hatching to the end of the fourth stage ranged between 13 and 16 days.

Only two of the 20 larvae that were reared solitarily metamorphosed into the megalopal stage. The duration and survival rate of the larval stages are shown in Fig. 1.

Description of larvae

Galathea amboinensis De Man, 1888

Figs. 2–11

First Zoea

Size. CL 1.20–1.33 mm (mean 1.28 mm), TL 2.50–2.70 mm (mean 2.58 mm).

Carapace (Figs. 2A, 3A, B). Typical galatheid: posteriorly produced into acute spine on each side; posterodorsal and posteroventral margins with 16–18 and 20–24 small teeth, respectively. Rostrum broad, with 14–18 lateral teeth; eyes sessile.

Antennule (Fig. 4A). Uniramous, elongated, terminally with 3 aesthetascs plus 1 plumose and 2 simple setae, subterminally with 1 long plumose seta.

Antenna (Fig. 4F). Biramous; protopod with 1 serrated spine at distoventral end, equally long as endopod; endopod fused to protopod, with 1 long plumose seta terminally; scaphocerite ending in long and acute process at distolateral margin, inner margin

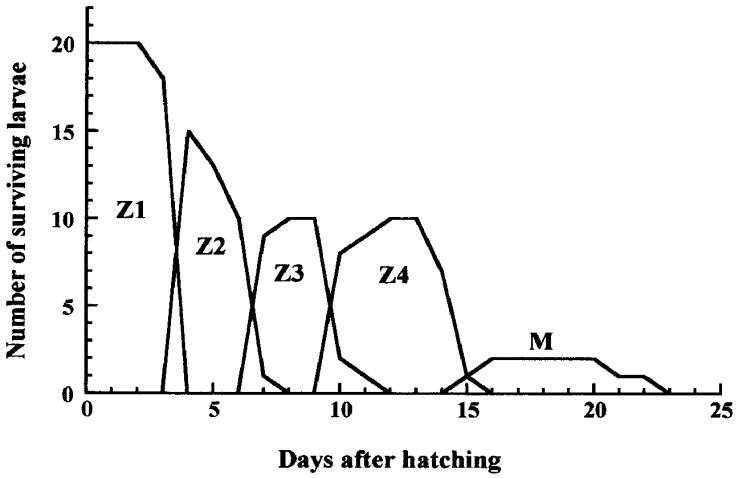

Fig. 1. Relationship between larval survival and molting time of *Galathea amboinensis* De Man, 1888 reared under laboratory conditions. Abbreviations: Z1, first zoea; Z2, second zoea; Z3, third zoea; Z4, fourth zoea; M, megalop.

with 10 plumose setae, dorsal and ventral surfaces each with minute denticles.

Mandible (Fig. 5A). Asymmetrical in dentation; incisor and molar processes distinct, incisor processes with several strong and small teeth, molar processes heavily serrate or spinose; palp absent.

Maxillule (Fig. 6A). Coxal endite with 7 plumodenticulate setae; basial endite with 2 cuspidate and 2–3 (almost 3) plumodenticulate setae; endopod 2-segmented, proximal segment with 1 small seta, distal segment with 1 subterminal and 4 terminal setae (setal formula, 1+4).

Maxilla (Fig. 7A). Coxal and basial endites bilobed, with 8+4 and 5+4 setae, respectively; endopod unsegmented, with 3+2+4 setae; scaphognathite with 4 marginal plumose setae, posteriorly ending in elongate plumose process.

First maxilliped (Fig. 8A). Coxa with 2 setae; basis with 12 ventral setae arranged 3+3+3+3; endopod 5-segmented, with setation of 3, 2, 1, 2, 4+I (I = dorsoproximal plumose seta); exopod incompletely 2-segmented, distally with 4 long plumose natatory setae.

Second maxilliped (Fig. 9A). Coxa naked; basis with 1+2 setae on distoventral margin; endopod 4-segmented, with setation of 2, 2, 2, 4+I ; exopod as in first maxilliped.

Third maxilliped (Fig. 10A). Small uniramous bud.

Pereopods. Not visible.

Abdomen (Figs. 2A, 11A). Five-segmented; each segment covered with numerous very small spines; posterodorsal margins of segments 2–5 each bearing pair of short setae, but without distinct posterodorsal teeth; segments 4 and 5 each with pair of posterolateral spines; pleopods absent.

Telson (Fig. 11A, B). Trigonal in dorsal view, slightly concave on posteromedian margin; dorsal surface covered with numerous very small spines; 7 pairs of processes on posterior margin (telsonal formula, I+ii+3–7), first (lateralmost) immovable acute spine, second short plumose seta (= anomuran hair), third to seventh bearing long, stout plumose setae with very minute spines.

Color in life. Carapace and abdomen excluding telson generally transparent brown, inside of median gastric region and abdominal segments bright orange; telson and appendages essentially transparent; red chromatophores present on anterior part of telson, proximal part of antennule and basis of first maxilliped; brown chromatophores present on rostrum, lateral margins of carapace, abdominal segments and antenna, and distal to mesial margins of eye.

Second Zoea

Size. CL 1.45–1.55 mm (mean 1.50 mm), TL 2.94–3.00 mm (mean 2.96 mm).

Carapace (Figs. 2B, 3C). Pair of anterodorsal setae newly appeared; posterodorsal and posteroventral margins of carapace with 17–26 and 18–24 teeth, respectively; rostrum with 21–27 lateral teeth; eyes now stalked.

Antennule (Fig. 4B). Protopod with 3 short plumose setae at distal fourth, and 3–4 (almost 4) aesthetascs plus 4 setae (including 1 plumose seta) terminally; endopodal bud slightly developed, with 1 long plumose seta terminally.

Antenna (Fig. 4G). Protopod with additional serrated spine at ventrodistal end; endopodal plumose seta now absent; otherwise unchanged.

Mandible (Fig. 5B). Unchanged.

Maxillule (Fig. 6B). Basial endite with 3–4 (almost 4) cuspidate setae; otherwise unchanged.

Maxilla (Fig. 7B). Distal lobe of basial endite now with 5–6 (almost 6) setae; scaphognathite with 7 marginal plumose setae, posteriorly ending in plumose process; otherwise unchanged.

First maxilliped (Fig. 8B). Exopod with 7 natatory setae; otherwise unchanged.

Second maxilliped (Fig. 9B). Exopod with 7 natatory setae; otherwise unchanged.

Third maxilliped (Fig. 10B). Biramous; endopod with 1 terminal seta; exopod developed, with 6 natatory setae.

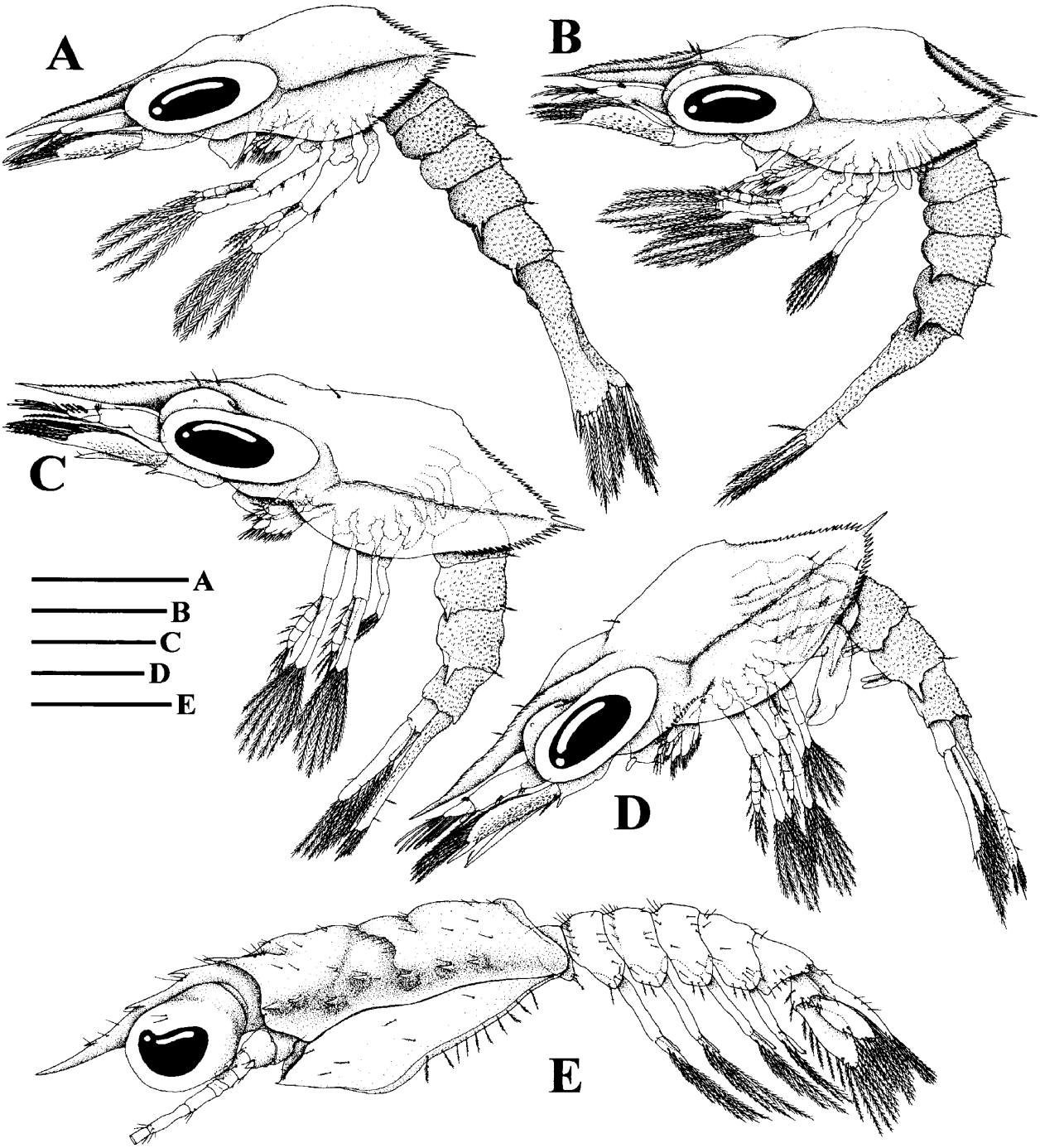

Fig. 2. *Galathea amboinensis* De Man, 1888. A, first zoea, lateral; B, second zoea, lateral; C, third zoea, lateral; D, fourth zoea, lateral E, megalop, carapace, abdomen, telson and pleopods, lateral. Scale bars = 0.5 mm.

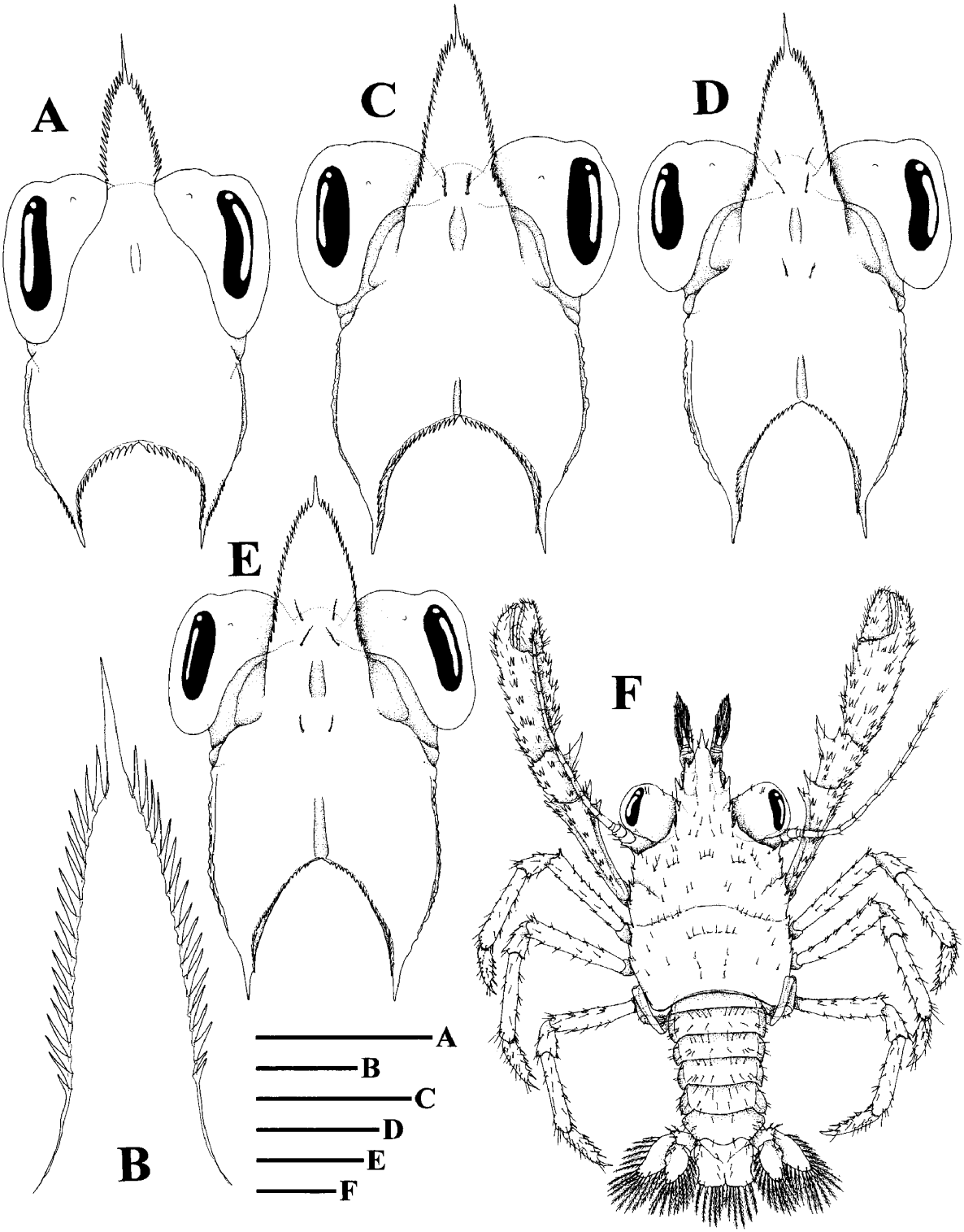

Fig. 3. *Galathea amboinensis* De Man, 1888. A, first zoea, carapace, dorsal; B, first zoea, rostrum, dorsal; C–E, second to fourth zoeas, carapace, dorsal; F, megalop, dorsal view of entire animal. Scale bars = 0.5 mm, except for B (=0.1 mm).

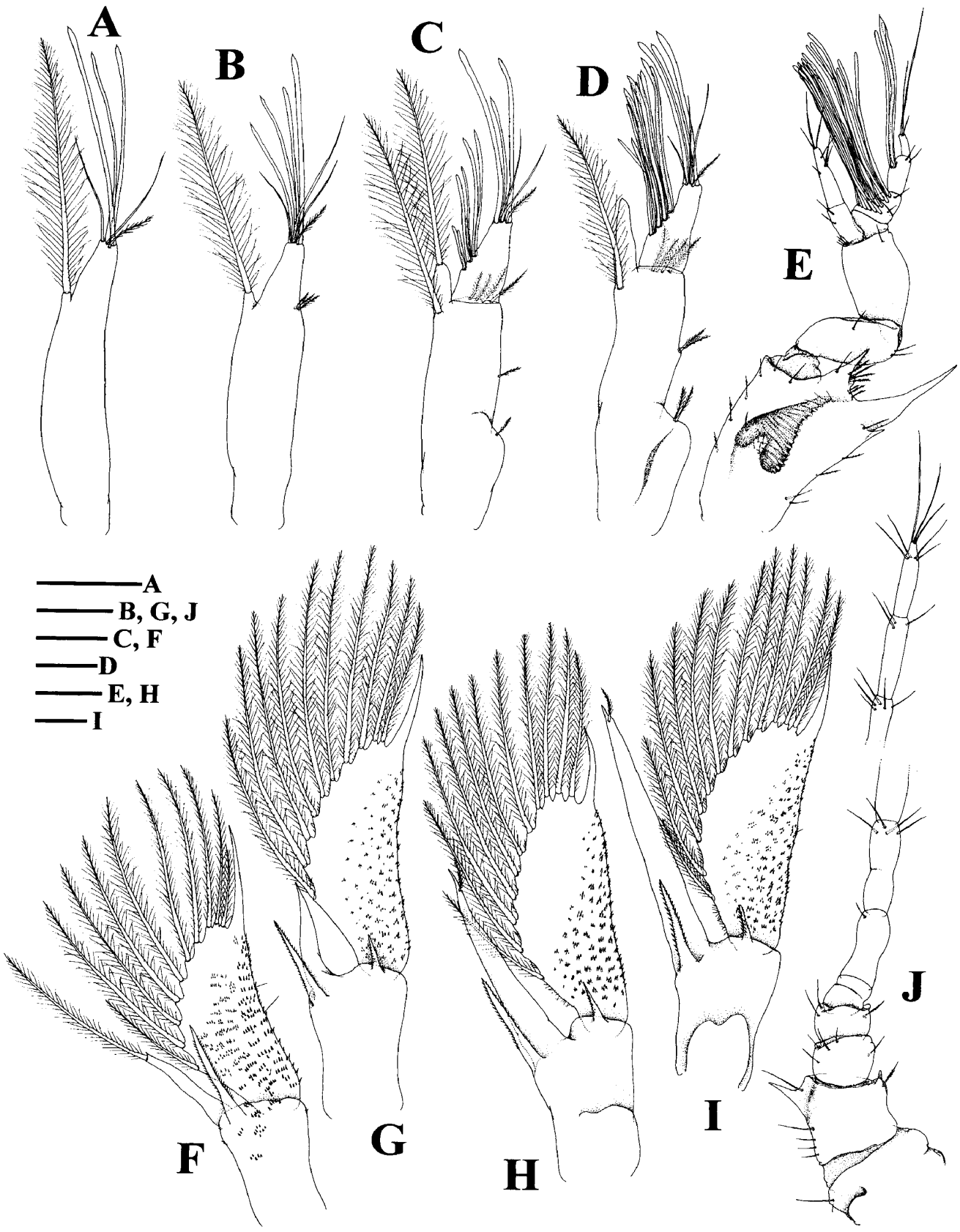

Fig. 4. *Galathea amboinensis* De Man, 1888, antennule (A–E) and antenna (F–J). A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop; F, first zoea; G, second zoea; H, third zoea; I, fourth zoea; J, megalop, middle segments omitted. Scale bars = 0.1 mm.

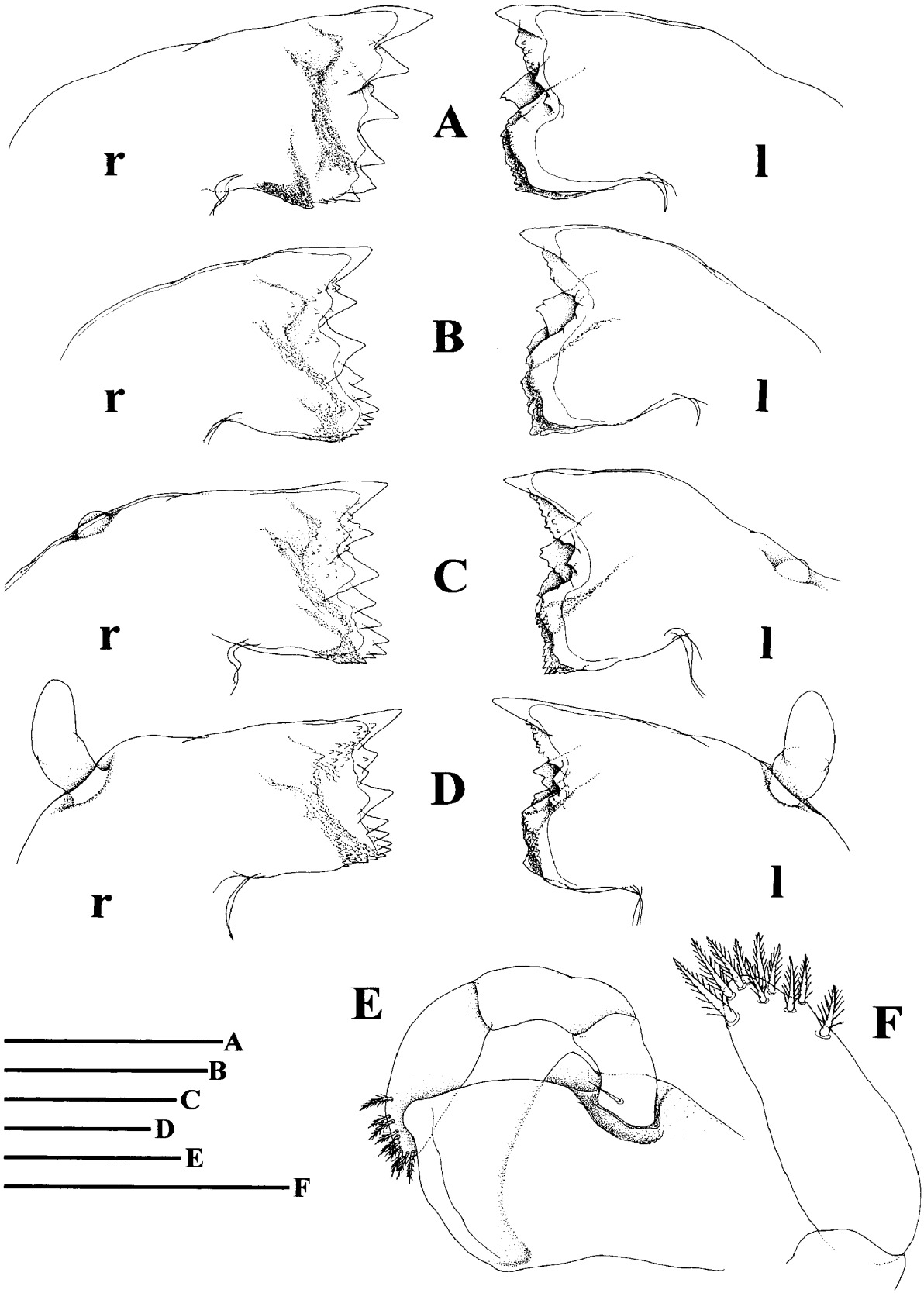

Fig. 5. *Galathea amboinensis* De Man, 1888, mandible (r, right; l, left). A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, right mandible of megalop; F, same, palp. Scale bars = 0.1 mm.

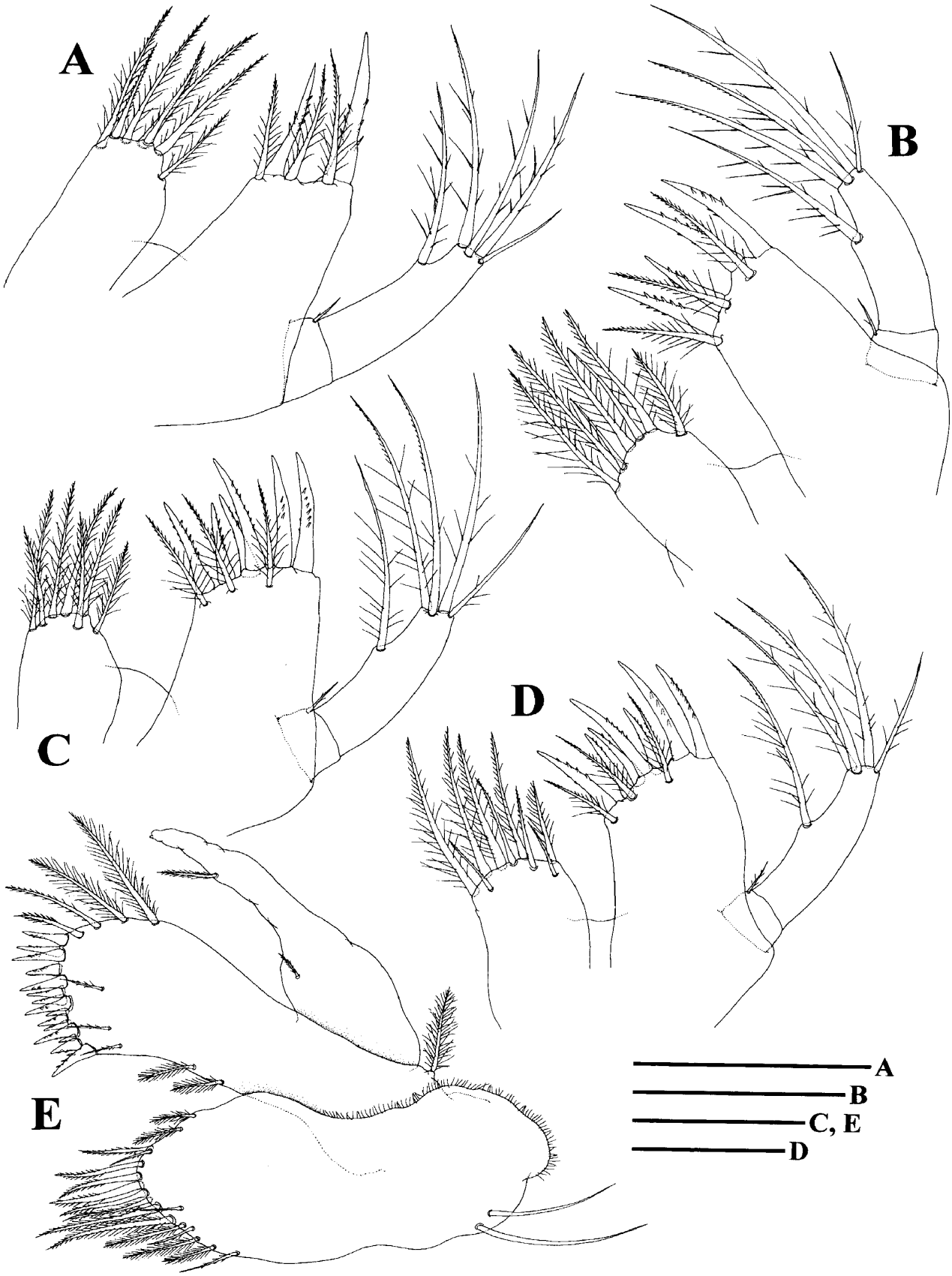

Fig. 6. *Galathea amboinensis* De Man, 1888, maxillule. A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop. Scale bars = 0.1 mm.

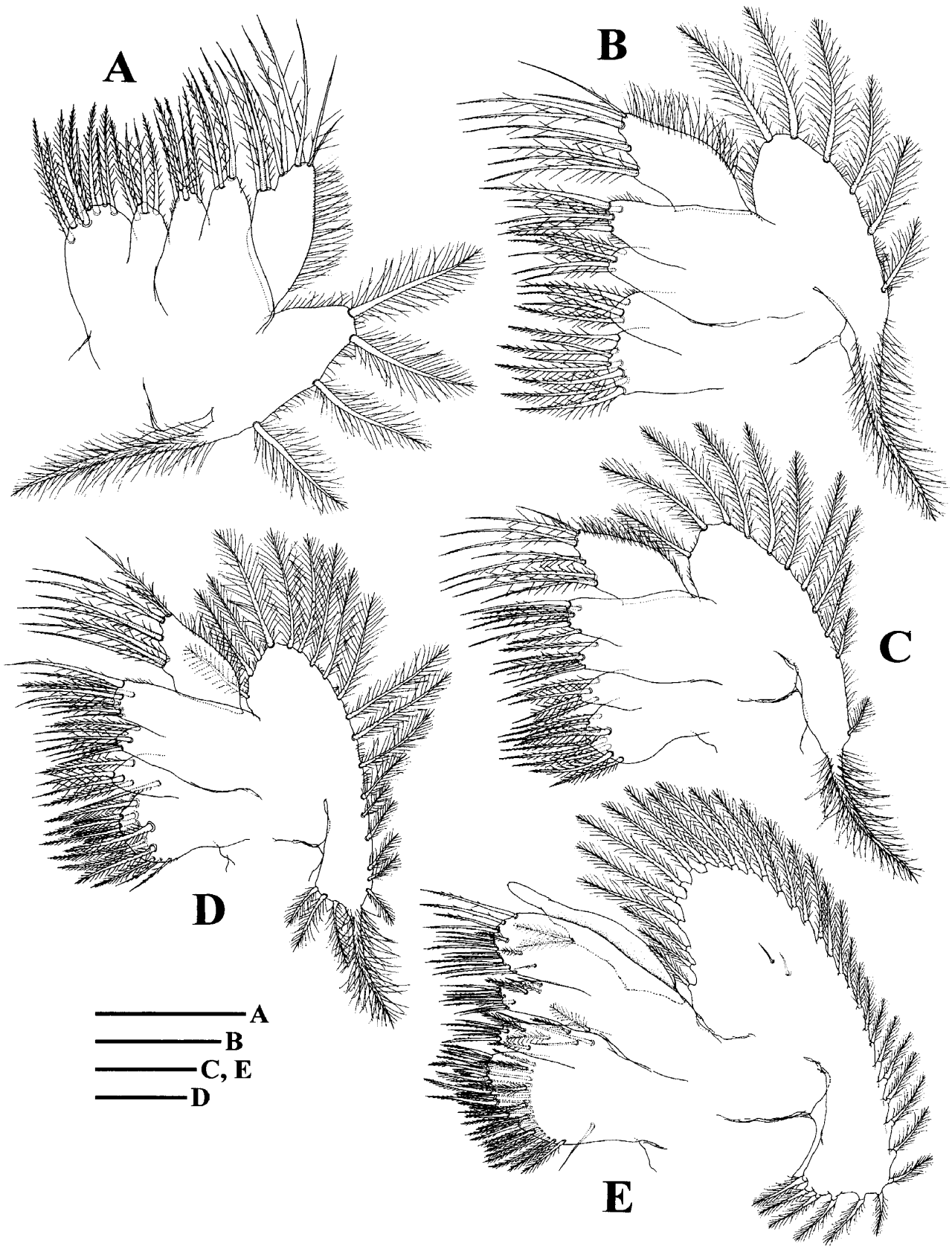

Fig. 7. *Galathea amboinensis* De Man, 1888, maxilla. A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop. Scale bars = 0.1 mm.

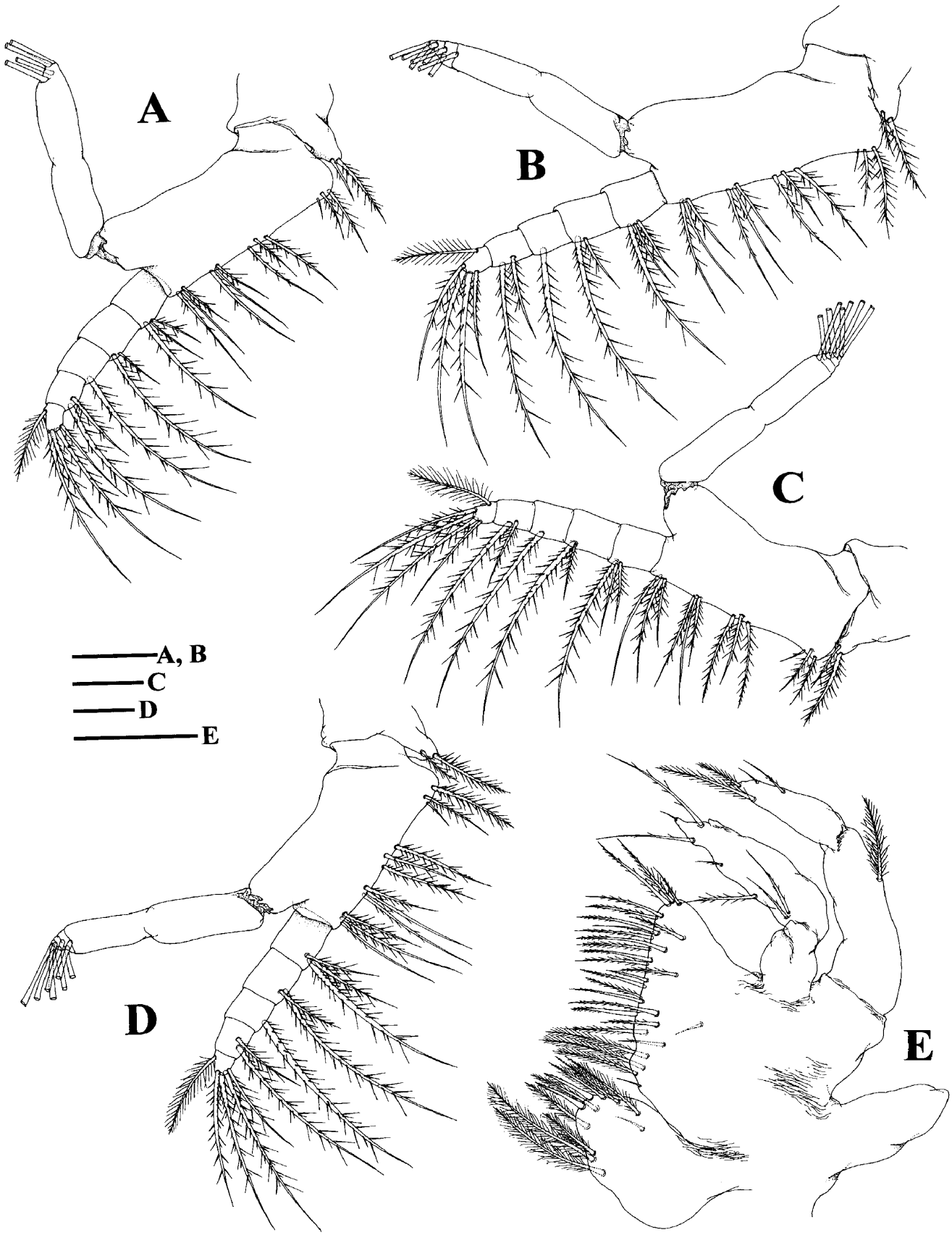

Fig. 8. *Galathea amboinensis* De Man, 1888, first maxilliped. A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop. Scale bars = 0.1 mm.

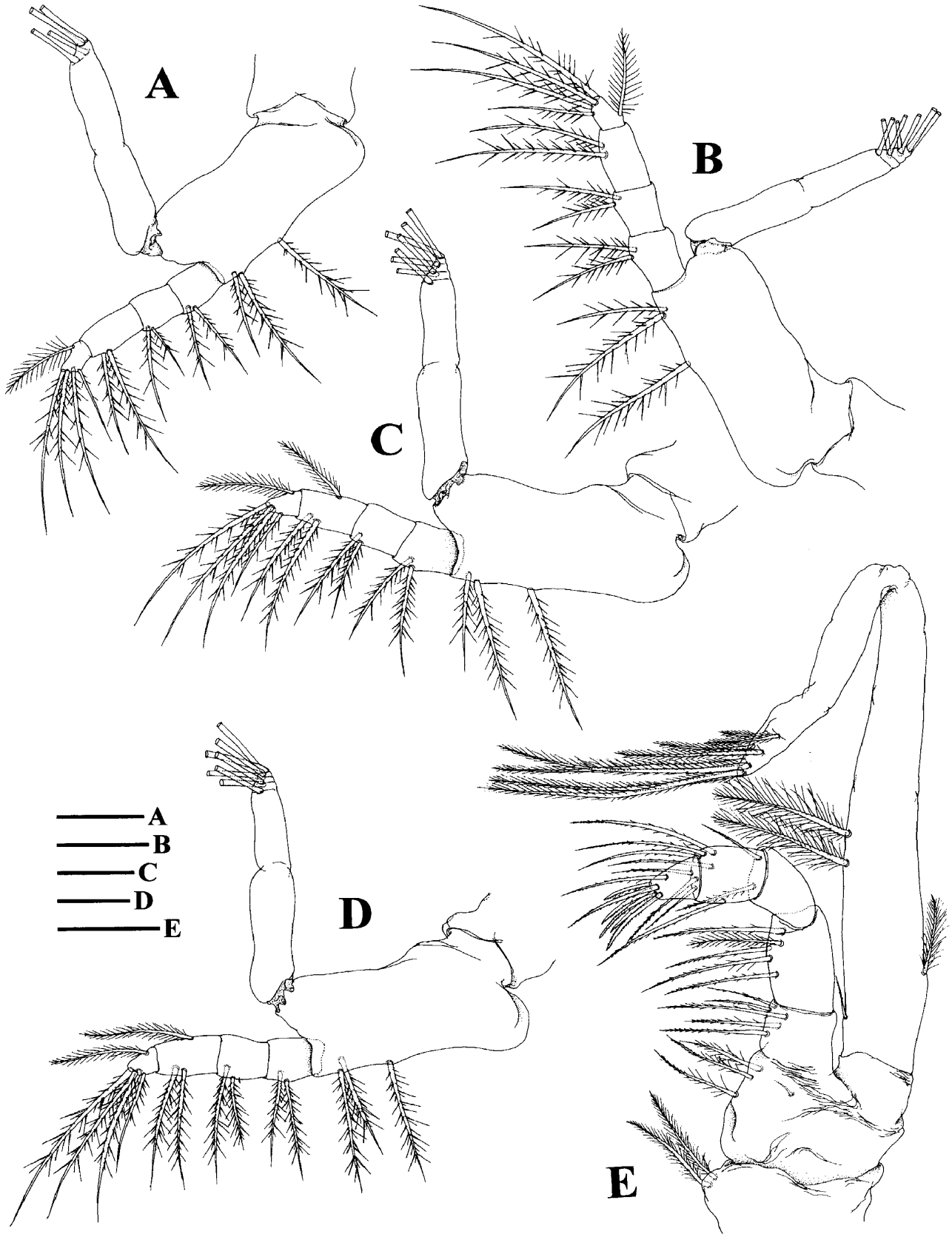

Fig. 9. *Galathea amboinensis* De Man, 1888, second maxilliped. A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop. Scale bars = 0.1 mm.

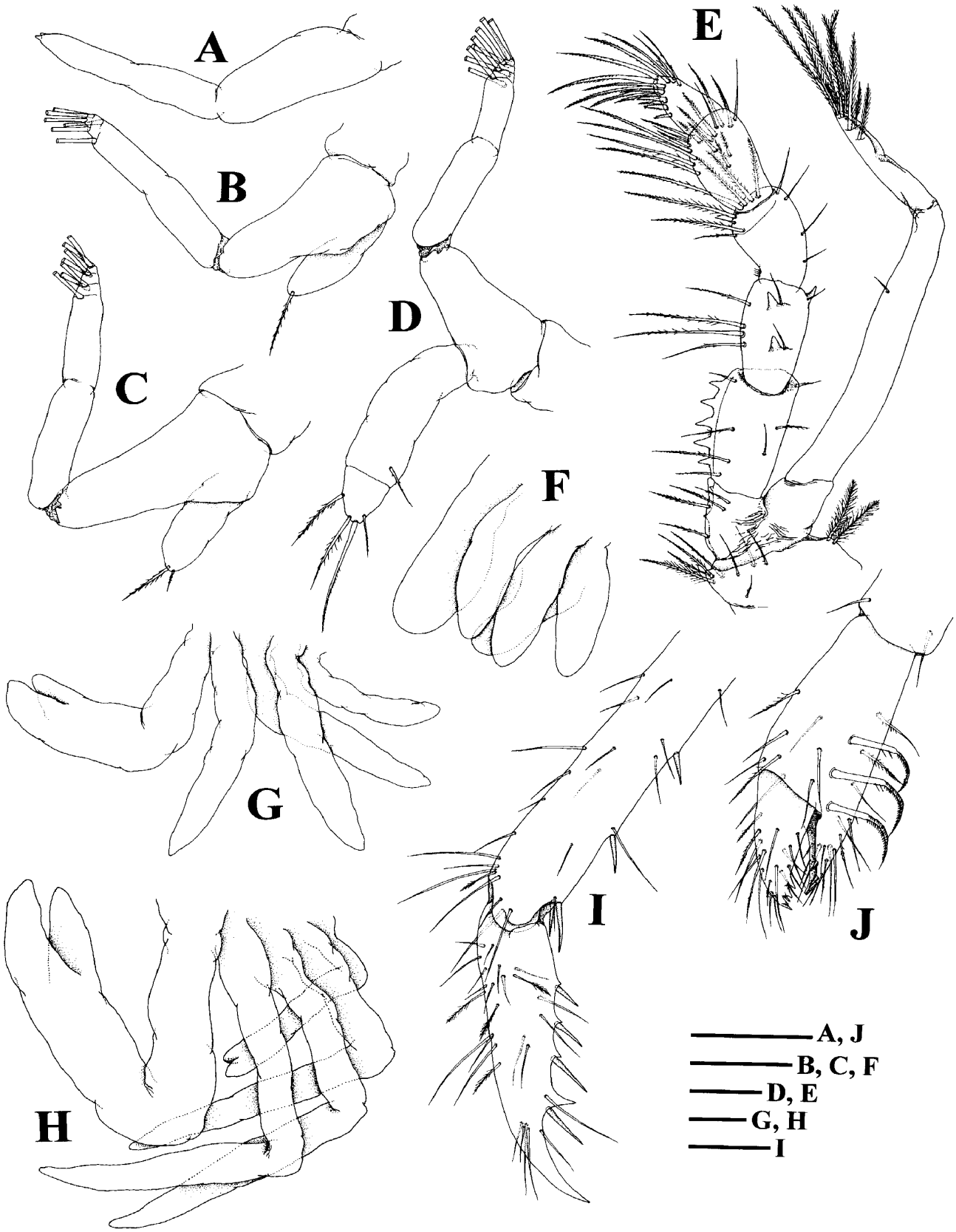

Fig. 10. *Galathea amboinensis* De Man, 1888, third maxilliped (A–E) and pereopods (F–J). A, first zoea; B, second zoea; C, third zoea; D, fourth zoea; E, megalop; F, second zoea; G, third zoea; H, fourth zoea; I, megalop, third pereopod; J, megalop, fifth pereopod. Scale bars = 0.1 mm.

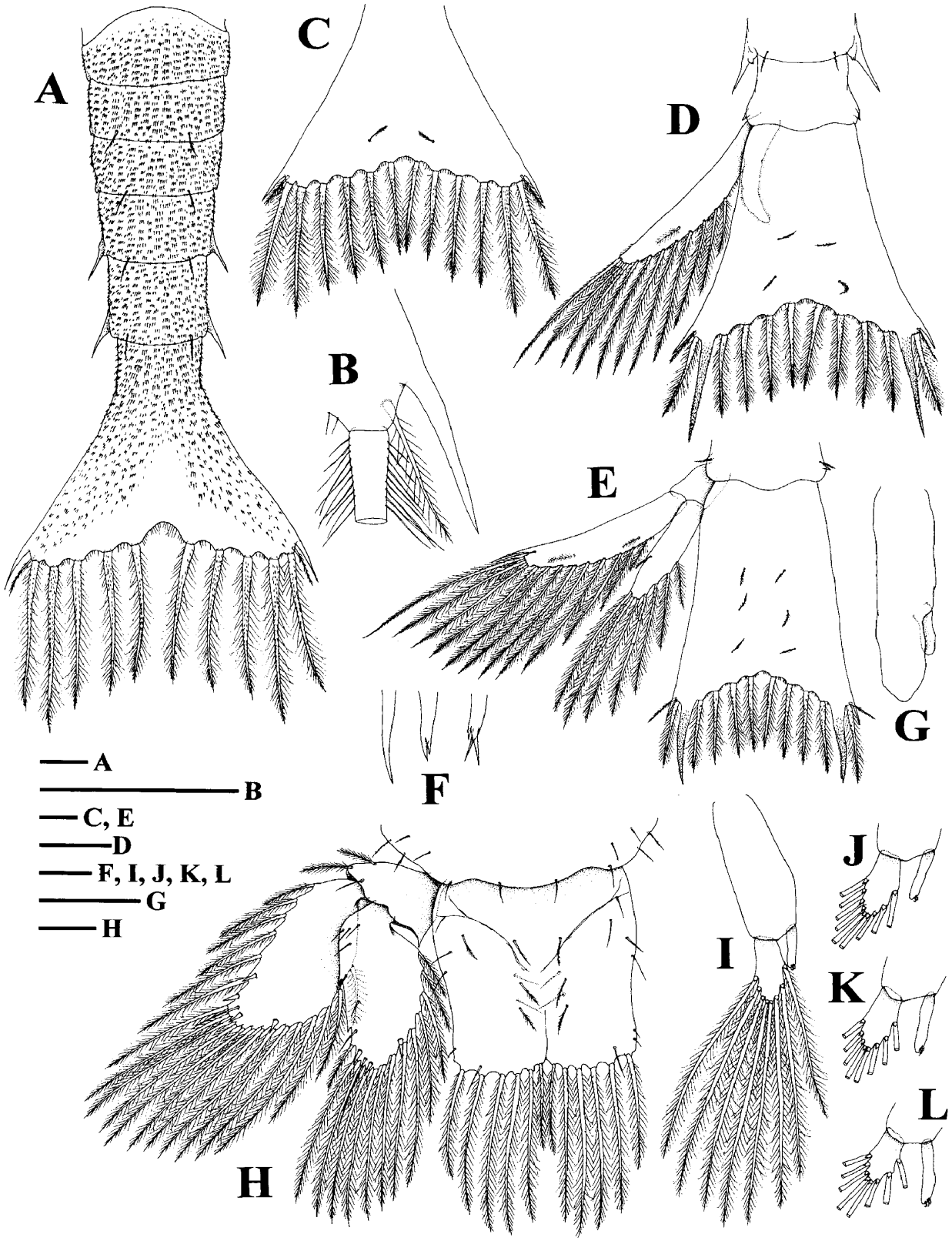

Fig. 11. *Galathea amboinensis* De Man, 1888, abdomen and telson. A, first zoea, abdomen and telson, dorsal; B, first zoea, posterolateral margin of telson, dorsal; C, second zoea, telson, dorsal; D, third zoea, sixth abdominal segment, uropod, and telson, dorsal; E, fourth zoea, uropod and telson, dorsal; F, fourth zoea, variation of tip of the fourth telsonal processes; G, fourth zoea, pleopod on fourth segment; H, megalop, tail fan, dorsal; I-L, megalop, first to fourth pleopods, ventral. Scale bars = 0.1 mm.

Pereopods (Fig. 10F). Unsegmented, small buds.

Abdomen (Fig. 2B). Unchanged.

Telson (Fig. 11C). Posterior margin with 8+8 processes (telsonal formula, I+ii+3–8); pair of small setae present on posterodorsal surface.

Color in life. Similar to first zoea, but red chromatophores on basis of first maxilliped absent.

Third Zoea

Size. CL 1.65–1.85 mm (mean 1.77 mm); TL 3.45–3.70 mm (mean 3.60 mm).

Carapace (Figs. 2C, 3D). Three pairs of anterodorsal setae present; posterodorsal and posteroventral margins of carapace with 19–29 and14–19 teeth, respectively; rostrum with 23–27 lateral teeth, otherwise unchanged.

Antennule (Fig. 4C). Protopod swollen proximally, with 1 short plumose seta at proximal part, 1 lateral plumose seta about at mid-length of lateral margin, 4 plumose setae at junction with exopod, and 1 long plumose seta directly proximal to endopod; endopod more developed than in previous stage but still unarticulated, terminally with 1 long plumose seta; exopod now articulated, with 3 rows of marginal aesthetascs numbering 2, 1–3, 2 from proximal to distal, terminally with 3 aesthetascs and 3–4 setae (including 1 plumose seta).

Antenna (Fig. 4H). Endopod well developed, bearing 1 subterminal plumose seta; scaphocerite with 11 plumose setae; otherwise unchanged.

Mandible (Fig. 5C). Small bud of palp newly appeared.

Maxillule (Fig. 6C). Coxal endite with 7–8 simple/plumodenticulate setae; basial endite with 5–6 cuspidate and 3 plumodenticulate setae; otherwise unchanged.

Maxilla (Fig. 7C). Coxal and basial endites with 9–10+4 and 6+6–7 setae, respectively; endopod unchanged; scaphognathite with 11–12 marginal plumose setae, posteriorly ending in plumose process.

First maxilliped (Fig. 8C). Unchanged.

Second maxilliped (Fig. 9C). Third segment of endopod with 1 plumose seta at dorsomesial margin; otherwise unchanged.

Third maxilliped (Fig. 10C). Endopod with 2 terminal setae; exopod with 7 natatory setae; otherwise unchanged.

Pereopods (Fig. 10G). More developed than in previous stage, first pereopod bifid.

Abdomen (Figs. 2C, 11D). Six-segmented; without pleopods; biramous uropods newly appeared, endopods small, naked, exopods well developed, with 10–12 marginal plumose setae plus 1 short plumose seta on ventral surface.

Telson (Fig. 11D). Posterior processes still 8+8, but fourth pair of processes changed to robust spines fused to telson (telsonal formula, I+ii+3+IV+5–8); 2 pairs of short setae on posterodorsal surface.

Color in life. Similar to second zoea, but sixth abdominal segment with bright orange chromatophores; uropod transparent.

Fourth Zoea (Figs. 6, 7)

Size. CL 1.90–2.10 mm (mean 2.00 mm); TL 3.90–4.15 mm (mean 4.02 mm).

Carapace (Figs. 2D, 3E). Rostrum with 22–29 lateral teeth; posterodorsal and posteroventral margins of carapace with 21–28 and 9–17 small teeth, respectively; otherwise unchanged.

Antennule (Fig. 4D). Protopod with 2 plumose setae at proximal part, 2 lateral plumose seta on middle part, 4 dorsodistal plumose setae at junction with exopod, and 1 long plumose seta directly proximal to endopod; endopod more developed than in previous stage, terminal plumose seta now absent; exopod with 4 rows of lateral aesthetascs numbering 4–5 on proximal first row, 3–4 on second, 3 on third, 2 on fourth, distal end with 3 aesthetascs plus 3–4 setae (including 1 plumose seta).

Antenna (Fig. 4I). Endopod well developed, 3 times as long as ventrodistal spine of protopod, bearing subterminal plumose seta; scaphocerite with 12 marginal plumose setae; otherwise unchanged.

Mandible (Fig. 5D). Palp more developed

than in third zoea, but still unsegmented.

Maxillule (Fig. 6D). Coxal endite with 9–10 plumodenticulate setae; basial endite with 7 cuspidate setae; otherwise unchanged.

Maxilla (Fig. 7D). Coxal endite with 13–15+4–6 setae; basial endite with 7+9–10 setae; scaphognathite with 17–18 plumose setae on lateral margin, 2–3 plumose setae on mesial margin, and 1 posterior plumose process; otherwise unchanged.

First maxilliped (Fig. 8D). Unchanged.

Second maxilliped (Fig. 9D). Unchanged.

Third maxilliped (Fig. 10D). Endopod well developed, completely or incompletely 2-segmented, with 3–6 setae; exopod with 7–8 natatory setae.

Pereopods (Fig. 10H). More developed than in previous stage, fifth pereopod now bifid.

Abdomen (Figs. 2D, 11E, G). Biramous pleopods (Fig. 11G) now present on segments 2–5; endopod of uropod with 5–7 marginal plumose setae plus 1 short seta on dorsal surface, exopod laterally ending in acute spine, mesially with 11–13 marginal plumose setae, ventrally with 2 short setae.

Telson (Fig. 11E, F). Much longer than broad; telsonal formula I+ii+3+IV+5–8, fourth pair of processes ending in simple, bifid or trifid tip (Fig. 11F); 3 pairs of small setae present on dorsal surface.

Color in life. Almost as in previous stage.

Megalop (Decapodid)

Size. CL 1.80–1.95 mm (mean 1.89 mm); PCL 1.00–1.15 mm (mean 1.08 mm); TL 3.25–3.45 mm (mean 3.37 mm).

Carapace (Figs. 2E, 3F). Carapace longer than broad, numerous short setae scattered on dorsal surface; lateral margin with 7 small spines, 5 of these situated behind anterior cervical groove; no spine on gastric region; rostrum triangular, with 4 lateral spines.

Antennule (Fig. 4E). Biramous, peduncle 3-segmented, proximal segment with 1 small and 2 large spines distally; endopod 2-segmented, proximal segment with 2 setae, distal segment with 3–4 subterminal and 3–4 terminal setae; exopod 5-segmented, proximal segment naked, second to third segments with 6 rows of marginal aesthetascs arranged 6–7+4, 3+3, 2+1 (from proximal to distal), distal segment with 2–3 simple setae.

Antenna (Fig. 4J). Peduncle 4-segmented, flagellum with 11–14 segments, each with 0–5 distal setae, terminal segments with 6–8 setae.

Mandible (Fig. 5E, F). Symmetrically scoop-like process; palp 3-segmented, basal segment with 1 short seta, second segment naked, third segment with 9–10 (almost 10) stout serrate setae distally.

Maxillule (Fig. 6E). Coxal endite with 17–18 setae, proximal part of coxa with 2 long setae; basial endite with 13–15 cuspidate setae and 9–11 plumose setae, 1 plumose seta directly proximal to endopod; endopod unsegmented, with 1 subterminal and 1 proximal seta.

Maxilla (Fig. 7E). Coxal and basial endites bilobed, with 34–37+12–13 and 11–12+17–19 setae, respectively; endopod unsegmented, with 3–6 setae; scaphognathite with 32–41 (mostly 34–38) plumose setae marginally and with 2 short simple setae on surface.

First maxilliped (Fig. 8E). Coxal and basial endites with 9–12, 26–29 setae, respectively; endopod unsegmented, setal number varying from 0 to 7; exopod with 4–8 terminal setae plus 1 plumose seta on lateral margin.

Second maxilliped (Fig. 9E). Coxa with 1–2 setae; basis with 8–9 setae on ventral margin; endopod 4-segmented, with setation of 5, 2, 7–8, 6–10 (including stout serrate setae on distal 2 segments); exopod incompletely 2-segmented, proximal segment with 3 plumose setae and 1 simple seta as illustrated, distal segment with 8–9 terminal plumose setae.

Third maxilliped (Fig. 10E). Coxa with 8–11 setae; basis with 3–4 (almost 4) setae and 1–2 small spines on mesial margin; endopod 5-segmented, ischium with 4–6 denticles and 6–7 setae; merus with 3 strong

spines (2 on flexor margin, 1 on extensor distal margin) and 3–4 long and 3 small setae; carpus, propodus and dactylus with 8–13, 14–19, 14–17 setae (including stout serrate setae), respectively; exopod with 8–9 (almost 8) terminal plumose setae.

Pereopods (Figs. 3F, 10I, J). All pereopods fully developed; first pereopod (cheliped) robust, sparsely setose and spinose, carpus with 1 large acute spine on mesial margin, merus with 2 stout spines on distomesial margin; second to fourth pereopods (ambulatory legs) slender, propodus with 4–5 movable spines on flexor margin, dactylus with 3–4 movable and 3–4 fixed spines on flexor margin; fifth pereopods chelate, short and subcylindrical, propodus with 3 long, robust, serrate setae and scattered, short simple/plumose setae, as illustrated; no male/female gonopores.

Abdomen (Figs. 2E, 3F, 11I–L). Six segments, sparingly setose on dorsal surface; fifth segment with small posterolateral spines on each side; biramous pleopods present on segments 2–5 (Fig. 11I–L), endopods increasing in length toward telson, each with 2–3 small hooks distally, exopods bearing terminal plumose setae, setal formulae progressing posteriorly with 7–9, 8–9, 8, 8.

Tail Fan (Fig. 11H). Telson as long as broad, incompletely divided into 5 plates with faint demarcations; posterior margin nearly transverse, bearing 12–13 (usually 6 pairs) long plumose setae; dorsal surface with scattered short setae as illustrated; uropods biramous, endopods with 12–13 long plumose setae on mesial and distal margins, fixed spines on lateral margin, and 2–3 movable spines dorsal to posterior margin and 8 simple setae dorsomesial to lateral margin, exopods with 19–20 long plumose setae on lateral and posetrior margins, 3–4 spines dorsal to posterolateral margins, and 1–2 simple setae on surface.

Color in life (specimens just after metamorphosed). Carapace and abdomen generally transparent, with scattered bright orange and/or red chromatophores, bearing large, circular or subcircular red spots in midline and along lateral margin; telson transparent overall. Cheliped generally transparent, with scattered dark red or/and brown chromatophores on carpus and merus; palm with dense orange and red chromatophores; fixed and movable fingers with scattered dark brown chromatophores. Ambulatory legs generally transparent, with scattered red, orange and dark brown chromatophores. Other appendages essentially transparent, but red and/or bright orange chromatophores present on antennule, antenna, mandible, third maxilliped and protopod of pleopods.

Discussion

Larval morphology of *Galathea amboinensis* can be compared with that of *G. inflata*, *G. rostrata* and *G. intermedia*, for which the complete larval development is known (see Gore, 1979; Christiansen & Anger, 1990; Fujita et al., 2001). *Galathea amboinensis* zoeas agree well with diagnostic features of galatheid larvae, proposed by Gurney (1942) and Konishi & Saito (2000), in particular, the carapace possessing a pair of posterolateral spines and posterodorsal and posteroventral teeth, and the maxillar scaphognathite bearing a long plumose process on posterior margin. Zoeas of *G. amboinensis* are easily distinguished from two Atlantic species, *G. rostrata* and *G. intermedia*, by having the following characters through the zoeal phase: (1) the rostrum has distinct lateral teeth (no lateral teeth in *G. rostrata* and *G. intermedia*); (2) the proximal segment of the maxillular endopod bears a short seta (without seta in *G. rostrata* and *G. intermedia*); (3) the abdomen and telson are covered with numerous minute spines (Table 1). On the other hand, the zoeal morphology of *G. amboinensis* closely resembles that of *G. inflata*, except for their abnormal fifth-stage zoeas (see Fujita *et al.*, 2001). In *G. amboinensis*, however, the posterodorsal margins of the second to fifth abdominal segments are unarmed through the zoeal

Table. 1. Differences and similarities in zoeal characters among *Galathea* species, hitherto described the larval development. Abbreviations: a , aesthetasc; ps , plumose seta; pp, posterior process of maxilla scaphognathite; s, seta except for ps; sp, spine; I, dorsal plumose seta on maxilliped endopod. References: *1, Fujita *et al.*(2001); *2, Gore (1979); *3, Christiansen & Anger (1990).

	G. amboinensis Present study	*G. inflata* *1	*G. rostrata* *2	*G. intermedia* *3
First Zoea				
Rostrum: lateral teeth	present	absent	absent	absent
Antenna: scaphocerite	10ps	10ps	9ps	(9–10)ps
Maxillule: endopod	1s, (1+4)s	1s, (1+4)s	0, (1+3)s	0, (1+4)s
Maxilla:				
coxal endtite	(8+4)s	(8+4)s	(8+4)s	(6–7+3)s
basial endite	(5+4)s	(5+4)s	(4+4)s	(4+4)s
First maxilliped: basis	(3+3+3+3)s	(3+3+3+3)s	(2+3+3+3)s	(2+3+3+3)s
Abdomen:				
segments with lateral spines	4–5	4–5	4–5	5
posterodorsal teeth	absent	present	present **1	absent **5
Second Zoea				
Rostrum: lateral teeth	present	present	absent	absent
Maxillule: endopod	1s, (1+4)s	1s, (1+4)s	0, (1+4)s	0, (1+4)s
Maxilla: basial endite	(5+5–6)s	(5+6)s	(4–5+6)s	(4–5+4)s
First maxilliped:				
basis	(3+3+3+3)s	(3+3+3+3)s	(2+3+3+3)s	(2+3+3+3)s
endopod	3s, 2s, 1s, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I	3s, 2s+I, 1s+I, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I
Second maxilliped:				
endopod	2s, 2s, 2s, 4s+I	2s, 2s, 2s, 4s+I	2s, 2s+I, 2s, 5s+I	2s, 2s+I, 2s, 4s+I
Abdomen:				
segments with lateral spines	4–5	4–5	4–5 **2	5
posterodorsal teeth	absent	present	present **1	absent **5
Third Zoea				
Rostral lateral teeth	present	present	absent	absent
Antenna: scaphocerite	11ps	(12–13)ps	(9–11)ps	(10–11)ps
Mandible: palp	present	present	absent	absent
Maxillule: endopod	1s, (1+4)s	1s, (1+4)s	0, (1+4)s	0, (1+4)s
Maxilla:				
coxal endtite	(9–10+4)s	(8+4)s	(8+4)s	(8+4)s
basial	(6+6–7)s	(6+7)s	(4–5+6)s	(4–5+6)s
scaphognathite	(11–12)ps+pp	(10–11)ps+pp	10ps+pp	(9–10)ps+pp
First maxilliped:				
basis	(3+3+3+3)s	(3+3+3+3)s	(2+3+3+3)s	(2+3+3+3)s
endopod	3s, 2s, 1s, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I	3s, 2s+I, 1s+I, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I
exopod	7ps	7ps	7ps	8ps
Second maxilliped:				
endopod	2s, 2s, 2s+I, 4s+I	2s, 2s, 2s, 4s+I	2s, 2s+I, 2s, 5s+I	2s, 2s+I, 2s+I, 4s+I
exopod	7ps	7ps	7ps	8ps
Abdomen:				
segments with lateral spines	4–5	4–5	5	5
posterodorsal teeth	absent	present	present **3	absent **5
Telson: dorsal setae	2 pairs	2 pairs	2 pairs	1 pair

Table. 1. Continued.

	G. amboinensis Present study	*G. inflata* *1	*G. rostrata* *2	*G. intermedia* *3
Fourth Zoea				
Rostrum: lateral teeth	present	present	absent	absent
Antenna: scaphocerite	12ps	(13–14)ps	(10–12)ps	(11–12)ps
Maxillule:				
coxal endite	(9–10)s	(9–10)s	(8–9)s	8s
endopod	1s, (1+4)s	1s, (1+4)s	1s, (1+4)s **4	0, (1+4)s
Maxilla:				
coxal endtite	(13–15+4–6)s	(11–13+4–6)s	(11+5)s	(8–11+4)s
basial endtite	(7+9–10)s	(8–9+9–10)s	(7–8+8)s	(4–6+5–7)s
scaphognathite	(19–21)ps+pp	(19–22)ps+ pp	(17–20)ps+ pp	(12–16)ps+pp
First maxilliped:				
basis	(3+3+3+3)s	(3+3+3+3)s	(3+3+3+3)s	(2+3+3+3)s
endopod	3s, 2s, 1s, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I	3s, 2s+I, 1s+I, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I
exopod	7ps	(7–8)ps	8ps	8ps
Second maxilliped:				
endopod	2s, 2s, 2s+I, 4s+I	2s, 2s, 2s, 4s+I	2s, 2s+I, 2s+I, 5s+I	2s, 2s+I, 2s+I, 4s+I
exopod	7ps	(7–8)ps	8ps	8ps
Third maxilliped:				
exopod	(7–8)ps	(7–8)ps	8ps	8ps
Abdomen:				
segments with lateral spines	4–5	4–5	5	5
posterodorsal teeth	absent	present	absent	absent **5

**1, much reduced in size and number (see Gore, 1979)
**2, spines on somite 4 reduced, even vestigal (see Gore, 1979)
**3, vestigal, ragged and irregular (see Gore, 1979)
**4, seta on the proxiaml segment of the endopod may be present (see Gore, 1979)
**5, not described in the text, estimated from figures (see Christiansen & Anger, 1990)

phase (with distinct teeth in *G. inflata*). Other characters to distinguish zoeas of the two species are summarized in Table 1.

Galathea amboinensis seem to be unique among the Galatheidae in having a row of distinct teeth along the rostral lateral margin in the first zoea. According to Gurney (1938), this character is possessed by *G. longimana* Paulson, 1878 through all zoeal stages of plankton samples from the Red Sea. The two species can be distinguished by the endopod of the maxillule; it is two-segmented in *G. amboinensis*, whereas unsegmented in *G. longimana*.

In the Ryukyu Islands, *G. amboinensis* and *G. inflata* are sympatric, often sharing the same crinoid hosts (Fujita & Baba, 1999). Megalops of these two species are readily distinguished with the naked eyes by their coloration: circular red spots or flecks are visible on the carapace and abdomen in *G. amboinensis*, absent in *G. inflata*. Morphologically, megalops of all known species of the genus are much alike but the following characters may differentiate *G. amboinensis* from the others: the antennal flagellum consists of 11–14 segments (more than 16 segments in *G. inflata*, *G. rostrata* and *G. intermedia*); the mandibular palp bears only one seta on the proximal segment (two setae in *G. inflata*, *G. rostrata* and *G. intermedia*).

The female of *G. amboinensis*, reared solitarily after spawning, laid a further clutch of eggs that developed normally. This fact shows that sperm from the original mating

must have remained viable, inside spermatophores on or around the female gonopores. At present little is known about galatheid mating patterns and even less about sperm retention. The present observations show that a female galatheid can fertilize more than one clutch of eggs after a single mating episode. More extensive studies of sperm transfer and storage in galatheids would be desirable.

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