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First Larvae of *Lebbeus comanthi* and *Thor amboinensis* (Decapoda: Hippolytidae) Hatched in the Laboratory

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The decapodid stage of *Lebbeus comanthi* Hayashi and Okuno and the first zoea of *Thor amboinensis* (De Man) are described based on laboratory-hatched eggs from females collected from Japan. The decapodid stage of *L. comanthi* is readily distinguished from that of *L. groenlandicus* by the carapace without anteroventral denticle and tooth behind rostrum, the absence of the antennal spine, the four-segmented outer flagellum of the antennule, the absence of the palp of the mandible, and the telson with posterior margin concaved medially and without dorsolateral spine. The carapace with anteroventral denticle and the third abdominal somite distinctly curved in lateral view distinguish the first zoea of *T. amboinensis* from that of *T. dobkini* Chace and *T. floridanus* Kingsley. Larval characters of the genus *Thor* are summarized.

Exclusive of several unidentified larvae collected from plankton material (Stephensen, 1916, 1935; Lebour, 1940; Makarov, 1967), the larvae of hippolytid genera *Lebbeus* and *Thor* have been known for two and three species, respectively. For the former genus, the larvae of *L. groenlandicus* (Fabricius, 1775) and *L. polaris* (Sabine, 1882) have been described by previous authors (Krφyer, 1842; Williamson, 1957; Pike and Williamson, 1961; Ivanov, 1971; Haynes, 1978, 1981; Squires, 1993). For the latter genus, the larval descriptions of *T. floridanus* Kingsley, 1878 from Beaufort, *T. dobkini* Chace, 1972 (under the name *Thor* sp.) from Florida, and *T. amboinensis* (De Man, 1888) from Okinawa have been reported (Broad, 1957; Dobkin, 1968; Nagai and Shokita, 2000).

The present study describes the decapodid stage of *Lebbeus comanthi* Hayashi and Okuno, 1997, which is associated with the crinoids, and compares it with that of *L. groenlandicus*. The first zoea of *T. amboinensis* is redescribed since the available information in the previous study is only limited to the pereopods and pleopods development depending on the zoeal stages (Nagai and Shokita, 2000).

Materials and Methods

On 1 October 2003, an ovigerous female of *L. comanthi* was collected from the crinoid *Oxycomanthus japonicus* (Müller, 1841) off Kamogawa, Boso Peninsula, Japan. An ovigerous female of *T. amboinensis* was collected near the sea anemone *Dofleinia armata* Wassilieff, 1908 at a depth of 25 m off Futo, on the east coast of the Izu Peninsula, Japan on 15 December 1995. Newly hatched larvae were preserved in 10% formalin for later observation. Drawings were made with the help of a camera lucida. Measurements and setal counts were based on 10 specimens. Carapace length (CL) was measured from the postorbital margin to the posteromedian margin of the carapace. The setal armature of appendages is described from proximal to distal segments. The larval specimens of the two hippolytids and parent female of *L. comanthi* are deposited at Silla University, Korea. The parent female of *T. amboinensis* is housed at the Coastal Branch of Natural History Museum and Institute, Chiba, Japan, under the catalogue number CMNH-ZC01006.

Results

Lebbeus comanthi Hayashi and Okuno, 1997
Decapodid Stage (Figs. 1, 2)

Size-CL. 0.835 (0.832-0.840) mm.

Description: Carapace (Fig. 1A, B). Rostrum short, not extending beyond eye, broad proximally; supraorbital spine present; antennal and pterygostomian spines absent; anterior and posterior dorsomedian papillae present; ventral margin rounded; eye mobile, without dorsal papilla.

Antennule (Fig. 1C). Peduncle with stylocerite, 3-

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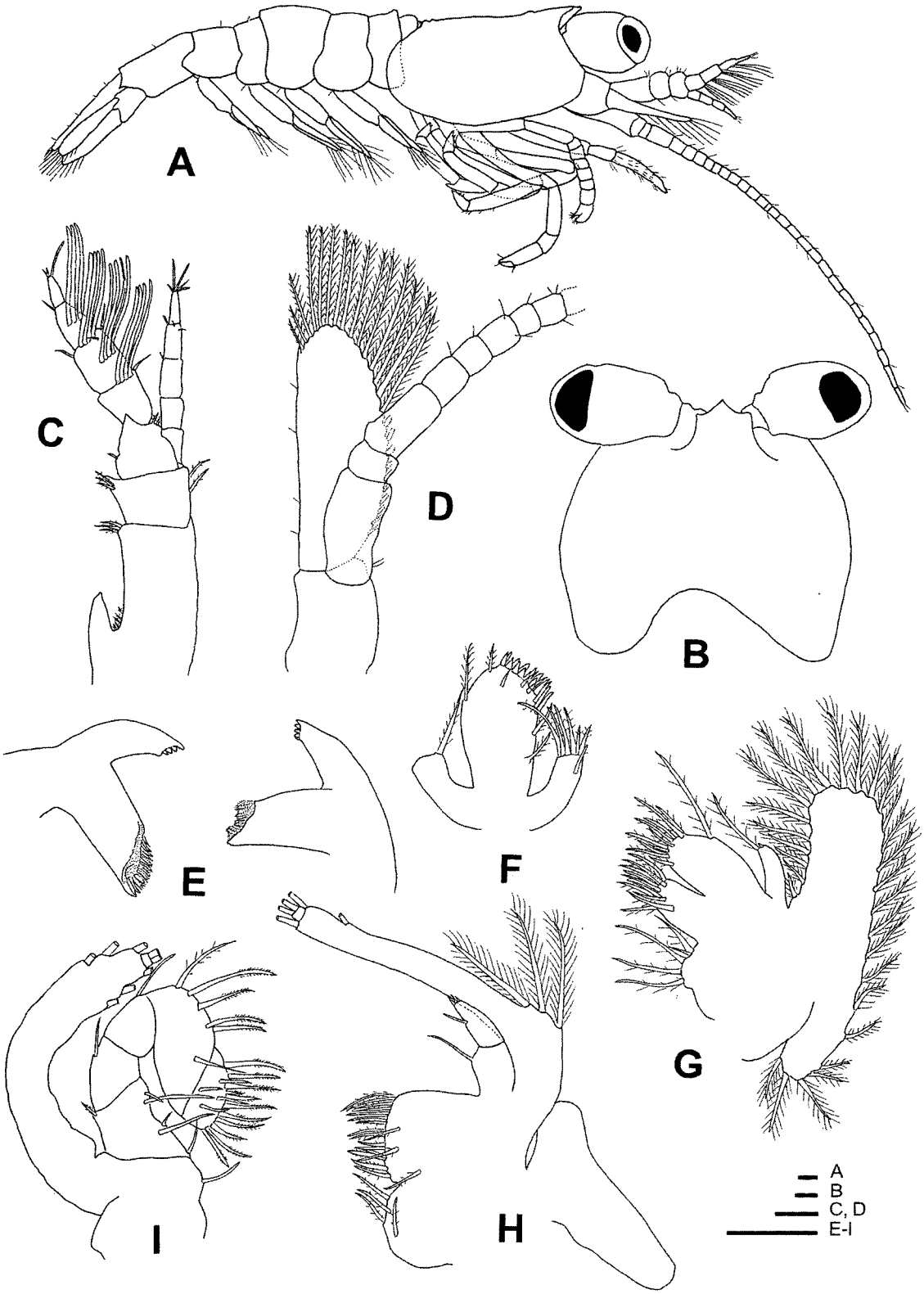

Fig. 1. Decapodid stage of *Lebbeus comanthi* Hayashi and Okuno, 1997. A, Lateral view. B, Carapace, dorsal view. C, Antennule. D, Antenna. E, Mandibles. F, Maxillule. G, Maxilla. H, First maxilliped. I, Second maxilliped. Scale bars = 0.1 mm.

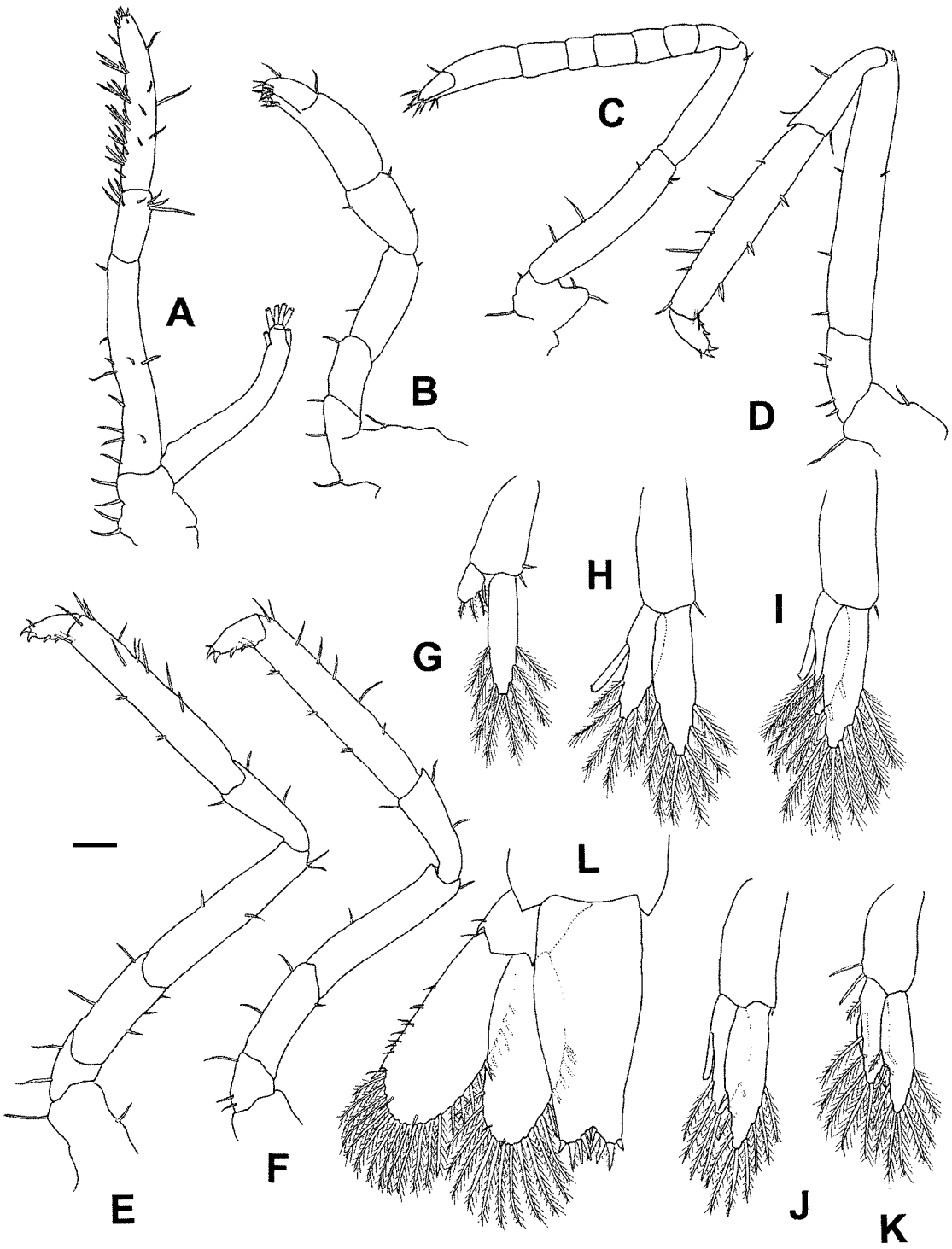

Fig. 2. Decapodid stage of *Lebbeus comanthi* Hayashi and Okuno, 1997. A, Third maxilliped. B, First pereopod. C, Second pereopod. D, Third pereopod. E, Fourth pereopod. F, Fifth pereopod. G, First pleopod. H, Second pleopod. I, Third pleopod. J, Fourth pleopod. K, Fifth pleopod. L, Telson and uropod. Scale bar=0.1 mm.

segmented; first segment with 5 proximal plumose setae and 3 distal plumose setae; second segment with outer distal tooth and 5 plumose setae; third segment with distal tooth and 3 setae; inner flagellum 5-segmented, with 0,0,1,3,5 setae; outer flagellum 4-segmented; first segment with 4 aesthetascs and seta; second segment

with 8 (4 subterminal, 4 terminal) aesthetascs and 3 setae; third segment with 3 subterminal aesthetascs and terminal seta; fourth segment with 3 distal setae.

Antenna (Fig. 1A, D). Peduncle unarmed; endopod flagellate, markedly elongated; scale with 25 inner plumose and 4 outer setae, distal tooth not overreaching scale.

Mandibles (Fig. 1E). Incisor and molar processes developed, without palps; left mandible without lacinia mobilis below incisor process; right mandible without spinules or teeth between incisor and molar parts.

Maxillule (Fig. 1F). Coxal endite with 7 plumodenticulate setae; basal endite with 22 setae; endopod with long plumodenticulate seta.

Maxilla (Fig. 1G). Coxal endite with 5 plumodenticulate setae; basal endite bilobed, with 10 and 11 plumodenticulate setae; endopod with long plumodenticulate seta and short spiniform seta; scaphognathite with 28 marginal plumose setae.

First maxilliped (Fig. 1H). Coxa with 4 plumodenticulate setae; basis with 18 plumodenticulate setae; endopod 2-segmented, with 1,1+3 setae; exopod with 3 plumose setae on caridean lobe and 5 (1 subterminal, 4 terminal) natatory setae; bilobate epipod large.

Second maxilliped (Fig. 1I). Coxa unarmed; basis with plumodenticulate seta; endopod 5-segmented, with 5+1, 0+1, 0+1, 6, 15 setae; exopod with 8 (4 subterminal, 4 terminal) natatory setae.

Third maxilliped (Fig. 2A). Coxa with 2 plumodenticulate setae; basis with 2 plumodenticulate setae; endopod 3-segmented: first segment with 11 setae; second segment with 7 setae; third segment with 27 setae and 7 distal spines; exopod with 6 (2 subterminal, 4 terminal) natatory setae.

Pereopods (Fig. 2B-F). All pereopods uniramous, without exopods; first and second pereopods chelate; second pereopod with carpus 6-segmented; third to fifth pereopods each with dactylus biunguiculate, with 2 spines on inner margin.

Abdomen (Fig. 1A). Composed of 6 somites; fifth and sixth somites with pleura pointed posteriorly; all somites without spines; third somite moderately curved in lateral view; fourth somite with tuft of dorsomedian setae.

Pleopods (Fig. 2G-K). First to fifth pleopods biramous, each endopod and exopod setose; second to fifth pleopods with appendices internae.

Telson and uropod (Fig. 2L). Telson with posterior width greatly narrower than anterior width, posterior margin with deep median concavity; 5+5 posterior setae present; base of all setae without row of minute spinules; anal spine absent. Uropod developed; endopod with 18 marginal plumose and 2 submarginal setae; exopod with 26 (23 marginal, 3 submarginal) inner setae, 10 outer setae, and distolateral spine.

Remarks: Of the larval descriptions of *L. groenlandicus* and *L. polaris*, decapodid stage is only known for *L. groenlandicus* (see Haynes, 1978, 1981). Newly hatched larvae of *L. comanthi* are similar to decapodid stage of *L. groenlandicus* by the following characteristics: carapace with anterior and posterior dorsomedian papillae; supraorbital spine present; peduncle of antennule 3-segmented, bearing stylocerite; inner flagellum of antennule 5-segmented; endopod of antenna flagellate; endopod of maxillule reduced; third maxilliped with exopod; first and second pereopods chelate; carpus of second pereopod 6-segmented; all pleopods with setose endopods and exopods; appendices internae with a few retinacula; fourth and fifth abdominal somites without posterolateral spines; and uropod with setose endopod and exopod. Several different morphological characteristics in the decapodid stage of *L. comanthi* from that of *L. groenlandicus*, however, are noted. In *L. groenlandicus*, the carapace is armed with anteroventral denticle and tooth behind rostrum. In addition, the antennal spine is present, and the outer flagellum of the antennule is 6-segmented. In contrast, the carapace is devoid of the anteroventral denticle, tooth behind rostrum and the antennal spine, and the outer flagellum of the antennule is 4-segmented in *L. comanthi*. Moreover, the mandible bears unsegmented palp and the telson has straight posterior margin with a pair of dorsolateral spines in *L. groenlandicus*, whereas in *L. comanthi*, the mandible is devoid of the palp, and the telson has medially concaved posterior margin without dorsolateral spine.

The caridean decapodid stage generally has both the larval and juvenile morphological characteristics (Felder et al., 1985). There are a large number of juvenile characteristics in the decapodid stage of *L. comanthi*. However, the following four characteristics are typical of larva: 1) carapace with anterior and posterior dorsomedian papillae; 2) tuft of dorsomedian setae on fourth abdominal somite; 3) mandible without palp; and 4) third maxilliped with exopod. Hayashi and Okuno (1997) reported that the mandible has two-segmented palp and the exopod of the third maxilliped is absent in the adult of *L. comanthi*. Also, there are no anterior and posterior dorsomedian papillae on the carapace and tuft of dorsomedian setae on the fourth abdominal somite (Hayashi and Okuno, 1997). Thus, it is certain that dorsomedian papillae on the carapace and tuft of dorsomedian setae on the fourth abdominal somite as well as the exopod of the third maxilliped will disappear, and two-segmented palp will appear in the mandible after the decapodid stage of *L. comanthi*.

The distribution of *L. comanthi* is restricted to the middle part of the Pacific coast of Honshu, mainland of Japan (Hayashi and Okuno, 1997). The authors regard that the newly hatched larvae of *L. comanthi* as decapodid stage influence the dispersal of its narrow distribution.

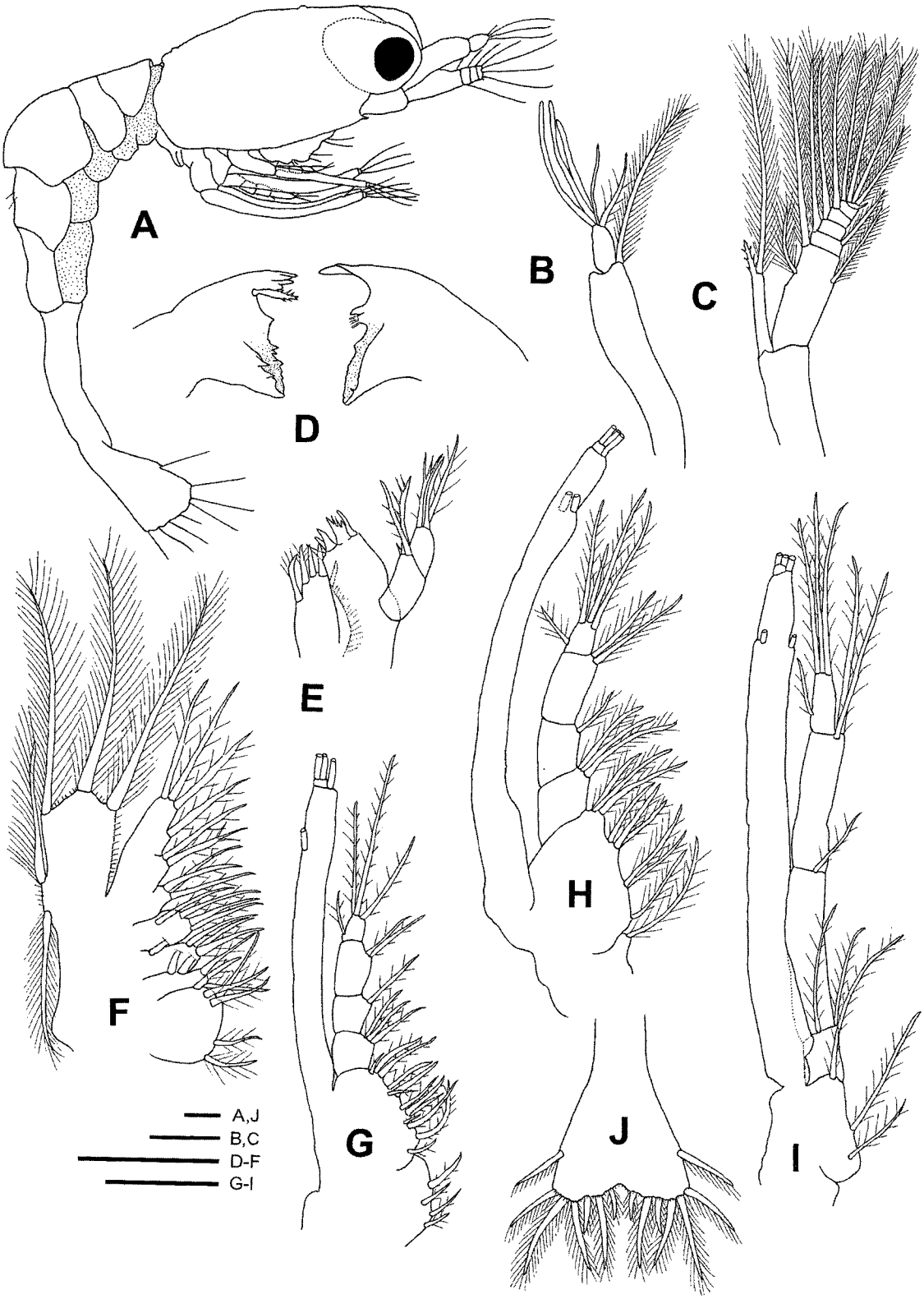

Fig. 3. First zoea of *Thor amboinensis* (De Man, 1888). A, Lateral view. B, Antennule. C, Antenna. D, Mandibles. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Telson and uropod. Scale bars=0.1 mm.

Thor amboinensis (De Man, 1888)
First Zoea (Fig. 3)

Size. CL. 0.420 (0.404-0.432) mm.

Description: Carapace (Fig. 3A). Rostrum absent; supraorbital and antennal spines absent; anterior and posterior dorsomedian papillae present; anteroventral denticle present; eyes sessile, without dorsal papilla.

Antennule (Fig. 3B). Peduncle unsegmented, with long plumose seta; inner flagellum not differentiated; outer flagellum with 3 aesthetascs, simple seta, and plumose seta.

Antenna (Fig. 3C). Peduncle with distal spine; endopod with long terminal plumose seta, about distal one third length denticulate; scale 6-segmented, with 11 plumose setae and papilla, distal tooth minute, overreaching scale.

Mandibles (Fig. 3D). Incisor and molar processes developed, without palps; left mandible with lacinia mobilis below incisor process; right mandible with cluster of several spinules and tooth between incisor and molar processes.

Maxillule (Fig. 3E). Coxal endite with 5 plumodenticulate setae; basal endite with 5 cuspidate setae; endopod 2-segmented: proximal segment with short simple seta and 2 long plumodenticulate setae; distal segment with 3 plumodenticulate setae.

Maxilla (Fig. 3F). Coxal endite bilobed, with 6 and 4 plumodenticulate setae; basal endite bilobed, each with 4 plumodenticulate setae; endopod with 9 plumodenticulate setae arranged 3,2,1,3; scaphognathite with 5 marginal plumose setae.

First maxilliped (Fig. 3G). Coxa with 4 plumodenticulate setae; basis with 13 plumodenticulate setae; endopod 4-segmented, with 3,1,2,3+1 setae; exopod with 4 (1 subterminal, 3 terminal) natatory setae; caridean lobe and epipod not differentiated.

Second maxilliped (Fig. 3H). Coxa with plumodenticulate seta; basis with 9 plumodenticulate setae, arranged 1,2,3,3; endopod 4-segmented, with 3,1,2,4+1 setae; exopod with 5 (2 subterminal, 3 terminal) natatory setae.

Third maxilliped (Fig. 3I). Coxa unarmed; basis with 3 plumodenticulate setae; endopod 4-segmented, with 2,1,2,3+1 setae; exopod with 5 (2 subterminal, 3 terminal) natatory setae.

Pereopods (Fig. 3A). First pereopod present, biramous as rudiment; other pereopods absent.

Abdomen and pleopods (Fig. 3A). Composed of 5 somites; sixth somite not differentiated; all somites without spines; third somite distinctly curved in lateral view; fourth somite with pair of dorsal setae.

Pleopods (Fig. 3A). Absent.

Telson and uropod (Fig. 3J). Telson triangular; posterior margin with deep median concavity; 7+7 posterior setae present; base of all setae except outermost with row of minute spinules; outermost 2 pairs plumose only on inner side; anal spine absent. Uropod absent.

Remarks: Broad (1957) described eight zoeal and one post-larval stages of *T. floridanus*. Dobkin (1968) reported the abbreviated larval development of *T. dobkini* consisting of two zoeal stages before metamorphosed into post-larvae. Morphological comparison of the first zoea of *T. amboinensis* with that of *T. dobkini* and *T. floridanus* reveals that the carapace with anteroventral denticle and the third abdominal somite distinctly curved in lateral view distinguish *T. amboinensis* from *T. dobkini* and *T. floridanus*. Four anteroventral denticles are present in the carapace and the third abdominal somite is moderately curved in lateral view in *T. dobkini* and *T. floridanus*. The scale of the antenna is armed with a papilla in *T. amboinensis*, but lacking in *T. dobkini* and *T. floridanus*. A recent study on redescription of the caridean first zoeas indicates that a papilla on the scale of the antenna is overlooked in the previous descriptions (Ito et al., 2003). Therefore, it is desirable to recheck the first zoeas of *T. dobkini* and *T. floridanus* to confirm the presence or absence of the papilla for distinguishing among the three *Thor* species.

The first zoeas of *T. amboinensis* and *T. floridanus* resemble each other in having the following combination of features: rostrum absent; carapace with anterior and posterior dorsomedian papillae as well as anteroventral denticle; exopods of second and third maxillipeds with three terminal natatory setae; and all abdominal somites without spines. Broad (1957) described four terminal natatory setae on the exopod of the first maxilliped in *T. floridanus*. However, there are three terminal natatory setae of the exopod of the first maxilliped in *T. amboinensis* and *T. dobkini* (see Dobkin, 1968). The number of terminal natatory setae of the exopods of the three pairs of maxillipeds in the first hippolytid zoeas appears to be homogeneous at the generic level (Gurney, 1942). It is thus likely that three terminal natatory setae are probably present in the exopod of the first maxilliped of the first zoea of *T. floridanus*.

Based on the larval descriptions of *T. floridanus* by Broad (1957) and *T. amboinensis* in the present study, the larvae of *Thor* can be characterized as the following: rostrum (absent in first zoea) broadly triangular, minute, not extending beyond eye; carapace with anterior and posterior dorsomedian papillae, without midventral or posteroventral denticles; scale of antenna segmented terminally in first zoea; endopod of maxillule 2-segmented, distal segment with three setae; proximal coxal endite of maxilla present; basis of second maxilliped with nine setae arranged 1,2,3,3 in first zoea; exopods of maxillipeds with three terminal natatory setae, disposed asymmetrically in first zoea; first and second pereopods with exopods. Detailed description of other larvae of *Thor* is needed for further characterization. Recently Bruce (1997, 1998) transferred *Thor maldivensis* Borradaile, 1915 to his new monotypic genus *Thinora*, on the basis of morphological differences of the rostrum and male

second pereopod, and the marked sexual dimorphism of the first pereopod in the adult. This characterization of the larvae of *Thor* may be helpful in elucidation of systematic relationships between *Thor* and *Thinora*, if new larval data of *Thinora maldivensis* (Borradaile, 1915) are obtained.

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