

First zoeas of two shallow-water galatheids, *Lauriea gardineri* (Laurie, 1926) and *Phylladorhynchus integrirostris* (Dana, 1853) (Crustacea: Decapoda: Anomura: Galatheidae)

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Abstract.—The first zoeas of two shallow-water galatheids, *Lauriea gardineri* (Laurie 1926) and *Phylladorhynchus integrirostris* (Dana 1853), are described and illustrated from laboratory-hatched materials. The first zoeal morphology of *L. gardineri* is very similar to that of *Galathea amboinensis* De Man 1888, and there are only a few minor morphological differences between the two species. The first zoea of *P. integrirostris* is readily distinguished from other known galatheid larvae by the presence of a pair of posterodorsal spines on the fourth and fifth abdominal segments.

Konishi & Saito (2000) recently reviewed the first zoeal morphology of ten galatheid species, all described from laboratory-reared materials. Subsequently, the complete larval series of *Galathea inflata* Potts 1915, *G. amboinensis* De Man 1888, and *Sadayoshia edwardsii* (Miers 1884), and the first zoeas of *Neonida grandis* Baba & de Saint Laurent 1996, *Agononida squamosa* (Henderson 1885), and *Munida javieri* Macpherson 1994 were described from laboratory-reared materials (Fujita et al. 2001, 2003; Fujita & Shokita 2005, Guerao et al. 2006). Larval morphology is now known for 16 species of eight galatheid genera: *Agononida* Baba & de Saint Laurent 1996, *Cervimunida* Benedict 1902, *Galathea* Fabricius 1793, *Munida* Leach 1820, *Munidopsis* Whiteaves 1874, *Neonida* Baba & de Saint Laurent 1996, *Pleuroncodes* Stimpson, 1960, and *Sadayoshia* Baba 1969 (see Gore 1979, Konishi & Saito 2000, Fujita et al. 2001, 2003; Fujita & Shokita 2005, Guerao et al. 2006).

Recently, I obtained ovigerous females of two shallow-water galatheids, *Lauriea gardineri* (Laurie 1926) and *Phyllador-*

hynchus integrirostris (Dana 1853). The genus *Lauriea* Baba 1971 contains two species, *L. gardineri* and *L. siagiani* Baba 1994, which live symbiotically with sponges (Baba 1994, Kato & Okuno 2001). The genus *Phylladorhynchus* Baba 1969 is composed of four Indo-Pacific species: *P. bengalensis* Tirmizi & Javed 1980, *P. ikedai* (Miyake & Baba 1965), *P. integrirostris*, and *P. pusillus* (Henderson 1885) (see Baba 1991). Of these, *P. integrirostris* is commonly found among dead coral rubble in the shallow coastal waters of the Ryukyu Islands (Fujita unpublished data).

The aim of this study is to describe and illustrate the first zoeal morphology of *L. gardineri* and *P. integrirostris* obtained from laboratory-hatched materials and to compare them with known galatheid larvae.

Materials and Methods

Two ovigerous females of *Lauriea gardineri* were found on unidentified sponge hosts at Cape Maeda of Okinawa Island, the Ryukyu Islands on 18 Jul 2001

and 5 May 2002. Two ovigerous females of *Phylladiorhynchus integrirostris* were collected among dead coral rubbles at Cape Zanpa of Okinawa Island on 26 May 2001.

Dissected and undissected larvae, in addition to spent females, are deposited in the Natural History Museum and Institute, Chiba, under the registration numbers of CBM-ZC 8582 (first zoeas of *L. gardineri*), CBM-ZC 8581 (spent females of *L. gardineri*), CBM-ZC 8584 (first zoeas of *P. integrirostris*), and CBM-ZC 8583 (spent females of *P. integrirostris*), respectively.

All ovigerous females of *L. gardineri* and *P. integrirostris* collected were transported to the University of the Ryukyus and maintained in 1.4-liter plastic aquaria, containing filtered seawater, until hatching occurred. After hatching, larvae were fixed and preserved in 50% ethylene glycol. Observations and illustrations were made using a Nikon Optiphot-2 binocular stereomicroscope equipped with a drawing tube. Six specimens were dissected for setal observations. Body segments are described from the anterior to posterior direction, appendages from endopod to exopod, and segments and setae from proximal to distal. The long, plumose natatory setae on the exopods of the first and second maxillipeds are not fully illustrated but are drawn truncated. Methods for measuring carapace length (CL) and total length (TL) follow that of Fujita et al. (2001). Terminology generally follows that of Gore (1979) and Ingle (1991), but usage of the terms of "zoeas" (as plural) follows that of Clark et al. (1998).

Descriptions of Larvae

Lauriea gardineri (Laurie, 1926)

Figs. 1, 2

First zoea.

Size.—CL 1.04–1.09 mm (\bar{X} = 1.06 mm), TL 2.04–2.15 mm (\bar{X} = 2.12 mm).

Carapace (Fig. 1A–C).—Typical galatheid form, posteriorly produced into acute spine on each side; anterodorsal setae absent; posterodorsal and posteroventral margins with 10–15 and 17–22 small teeth, respectively. Rostrum broad, with 11–16 slender lateral teeth, terminating in long process. Eyes sessile.

Antennule (Fig. 2A).—Uniramous, elongate rod-like, terminally with 3 aesthetascs plus 2 simple setae and 1 plumose seta; subterminal margin with 1 long plumose seta.

Antenna (Fig. 2B).—Biramous; protopod with 1 serrated spine at distoventral margin, slightly shorter than endopod; endopod fused to protopod, with long plumose seta terminally; scaphocerite (exopod) ending in long, acute process at distolateral margin, mesial margin with 10 plumose setae, dorsal and ventral surface with minute denticles.

Mandible (Fig. 2C).—Asymmetrically dentate; incisor and molar processes distinct, incisor processes with strong teeth, molar processes serrate or spinose; palp absent.

Maxillule (Fig. 2D).—Coxal endite with 7 setae; basal endite with 2 cuspidate and 3 (rarely 2) plumodenticulate setae; endopod 2-segmented, proximal segment with 1 small terminal seta, distal segment with 1 subterminal and 4 terminal setae (seta formula 1 + 4).

Maxilla (Fig. 2E).—Coxal and basal endites bilobed, with 8 + 4 and 5 + 4 setae, respectively; endopod unsegmented, with 3 submedian, 2 subdistal, and 4 distal setae (seta formula 3 + 2 + 4); scaphognathite (exopod) with 4 marginal plumose setae, posteriorly ending in elongate plumose process.

First maxilliped (Fig. 2F).—Coxa with 2 distoventral setae; basis with 12 setae (seta formula, 3 + 3 + 3 + 3) on ventral margin; endopod 5-segmented, with setation as 3, 2, 1, 2, 4 + I (I = dorsoproximal plumose seta); exopod indistinctly 2-segmented, distally with 4 long plumose natatory setae.

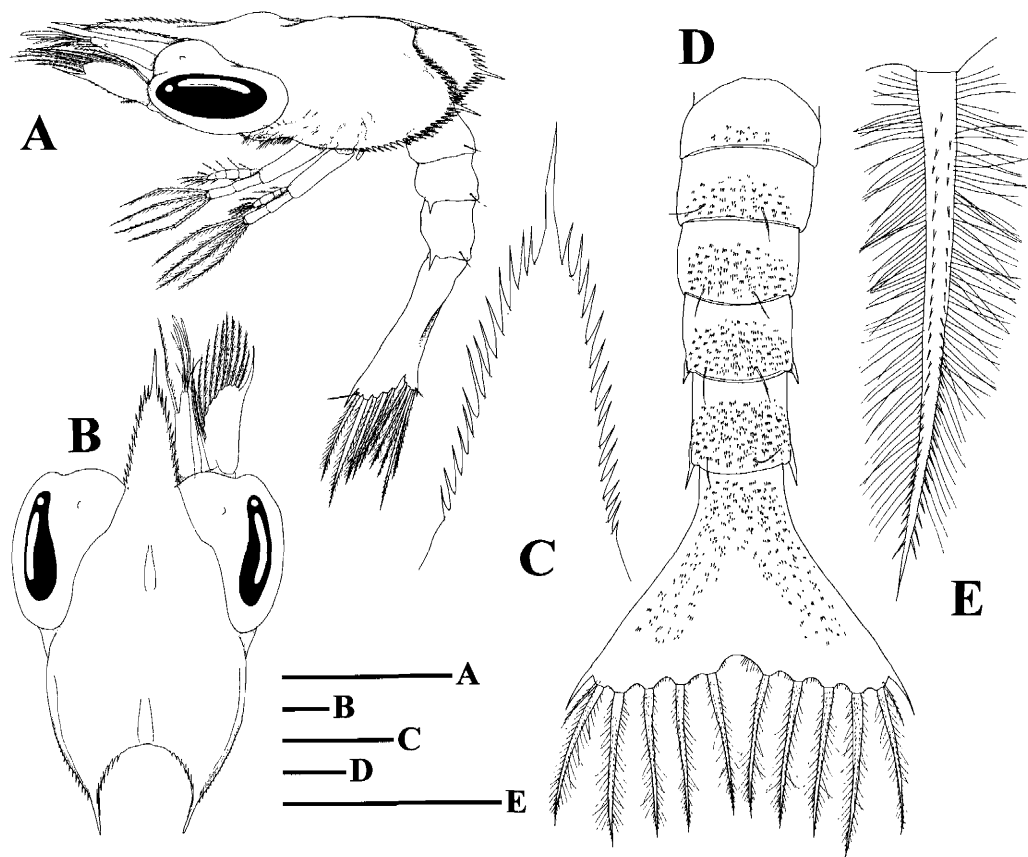


Fig. 1. *Lauriea gardineri* (Laurie, 1926), first zoea. A, entire animal, lateral, very small spines on abdomen and telson omitted; B, carapace, dorsal; C, rostrum, dorsal; D, abdomen and telson, dorsal; E, lateralmost plumose process of telson. Scale A = 0.5 mm; scales B-E = 0.1 mm.

Second maxilliped (Fig. 2G).—Coxa without setae; basis with 1 + 2 distoventral setae; endopod 4-segmented, with setation of 2, 2, 2, 4 + I; exopod as in first maxilliped.

Third maxilliped (Fig. 2H).—Small, biramous but unsegmented bud.

Pereiopods.—Not apparent.

Abdomen (Fig. 1A, D).—Five segments, each segment covered with numerous small spinules; segments 2-5 bearing pair of short setae on posterodorsal margin; segments 4 and 5 each with pair of posterolateral spines; pleopods absent.

Telson (Fig. 1A, D).—Trigonal in dorsal view, slightly concave on posteromedial margin; dorsal surface covered with numerous small spinules; 7 pairs of pro-

cesses on posterior margin (telsonal formula, I + ii + 3-7), lateralmost represented by immovable acute spine (I), second by a short plumose seta (= anomuran hair, ii), third to seventh by long, stout plumose setae (3-7) and small spinules marginally (Fig. 1E).

Color in life.—Carapace and abdomen, including telson and appendages, essentially transparent; median and anterolateral gastric region and lateral to the eyes light brown; red chromatophores present on proximal portion of telson, basis of first and second maxillipeds; brown chromatophores present on the anterior margin of eye, posterolateral margin of carapace, and antennal scaphocerite.

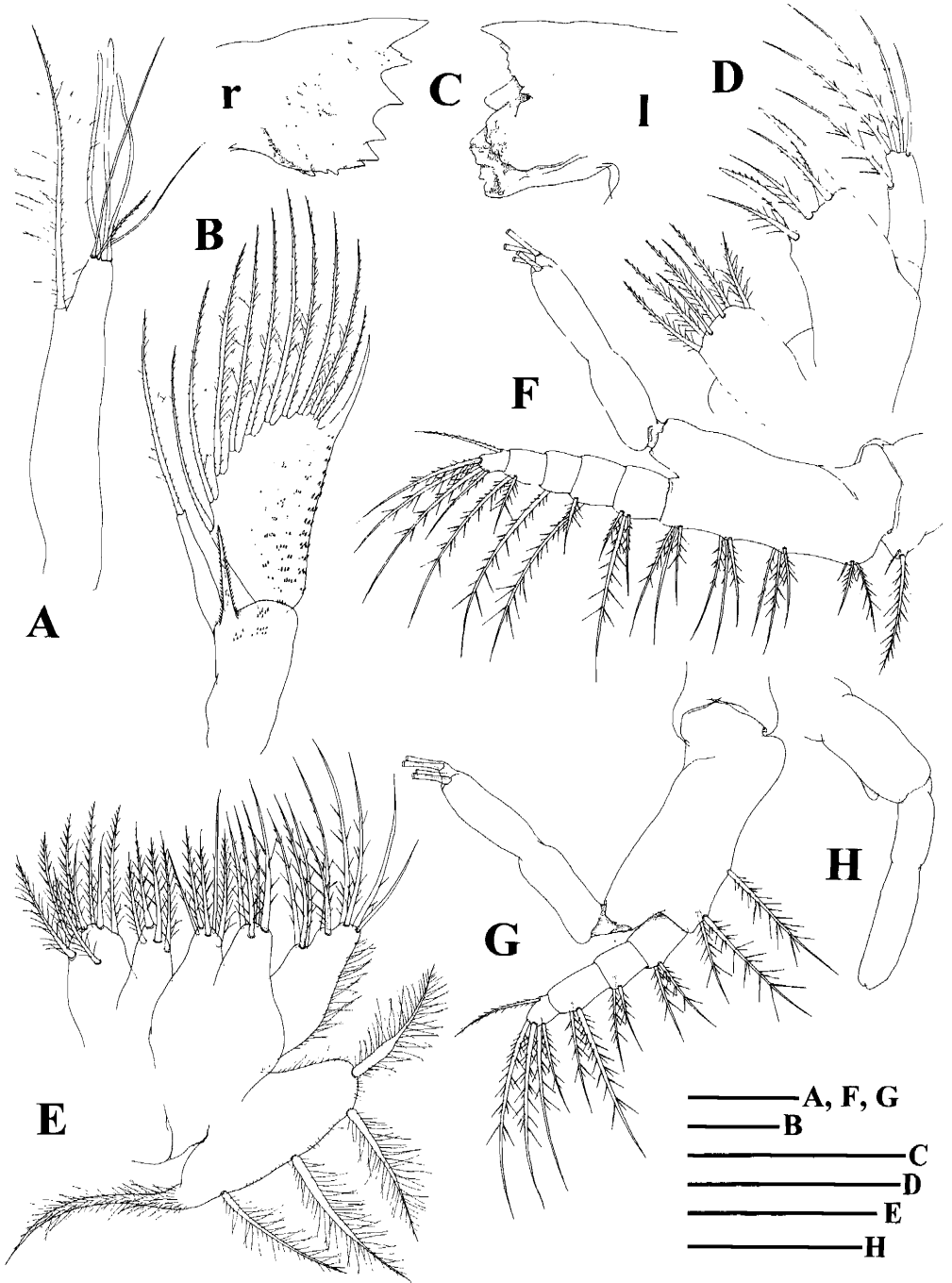


Fig. 2. *Lauriea gardineri* (Laurie, 1926), first zoea. A, antennule; B, antenna; C, mandible (r, right side; l, left side); D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped. Scales = 0.1 mm.

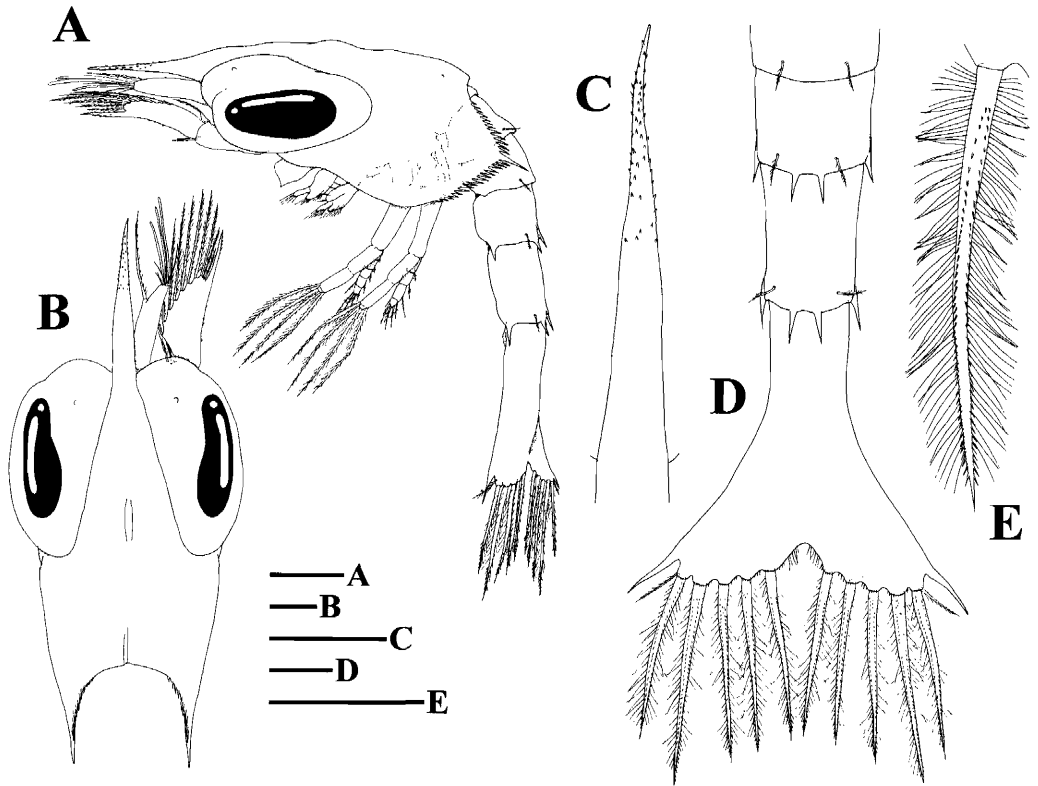


Fig. 3. *Phylladorhynchus integrirostris* (Dana 1853), first zoea. A, entire animal, lateral; B, carapace, dorsal; C, rostrum, dorsal; D, abdomen and telson, dorsal; E, lateralmost plumose process of telson. Scales = 0.1 mm.

Phylladorhynchus integrirostris
(Dana, 1853)

Figs. 3, 4

First zoea.

Size.—CL 1.06–1.15 mm (\bar{X} = 1.10 mm), TL 2.20–2.38 mm (\bar{X} = 2.29 mm).

Carapace (Fig. 3A–C).—Typical galatheid form, posteriorly produced into acute spine on each side; anterodorsal setae absent; posterodorsal and posteroventral margins with 9–12 and 15–19 small teeth, respectively. Rostrum elongate, spine-like, with very small distal spinules, reaching to level of the tip of antennal scaphocerite. Eyes sessile.

Antennule (Fig. 4A).—Uniramous, elongate and rod-like, with 3 terminal aesthetascs plus 2 simple setae and 1 plumose seta; 2 simple setae distinctly unequal in length, longer seta not reaching distal

end of aesthetasc; subterminal margin with 1 long plumose seta.

Antenna (Fig. 4B).—Biramous; protopod with 1 serrated spine on distoventral margin, approximately twice as long as endopod; endopod fused to protopod, with long terminal plumose seta; scaphocerite ending in slender, serrated process at distolateral margin, mesial margin with 10 plumose setae, ventral surface with minute denticles.

Mandible (Fig. 4C).—Asymmetrically dentate; incisor and molar processes distinct, incisor processes with strong teeth, molar processes serrate and/or spinose; palp absent.

Maxillule (Fig. 4D).—Coxal endite with 7 setae; basal endite with 2 cuspidate and 3 plumodenticulate setae; endopod unsegmented, with 1 + 4 setae.

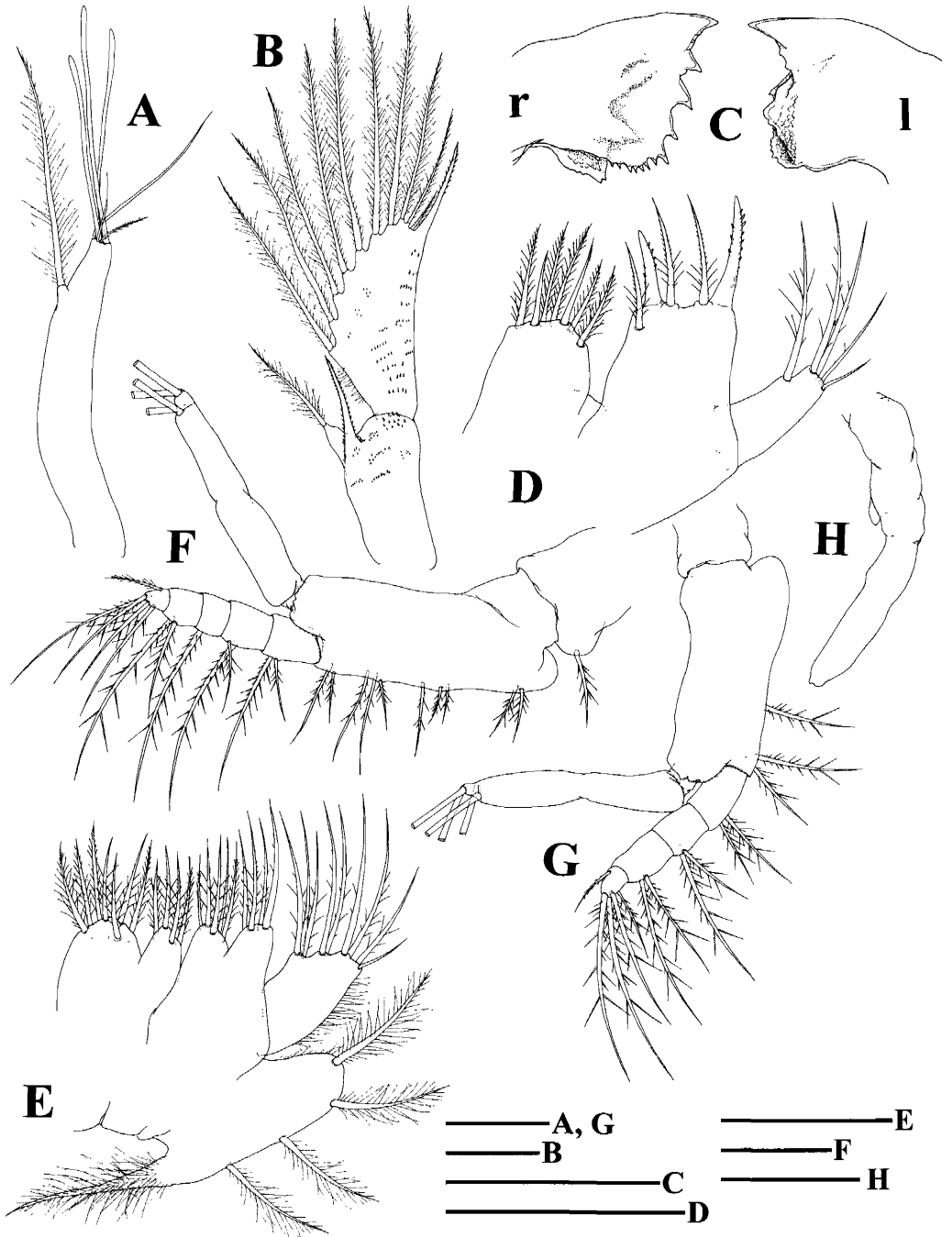


Fig. 4. *Phylladorhynchus integrirostris* (Dana, 1853), first zoea. A, antennule; B, antenna; C, mandible (r, right side; l, left side); D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped. Scales = 0.1 mm.

Maxilla (Fig. 4E).—Coxal and basal endites bilobed, with 7 + 4 and 5 + 4–5 (usually 5 + 4) setae, respectively; endopod unsegmented, with 3 + 2 + 4 setae; scaphognathite with 4 marginal plumose setae, posteriorly ending in an elongate plumose process.

First maxilliped (Fig. 4F).—Coxa with 1 distoventral seta; basis with 2 + 3 + 3 + 2 ventral setae; endopod 5-segmented, with setation of 2, 2, 1, 2, 4 + I; exopod indistinctly 2-segmented, distally with 4 long plumose natatory setae.

Second maxilliped (Fig. 4G).—Coxa naked; basis with 1 + 2 distoventral setae; endopod 4-segmented, with 2, 2, 2, 4 + I setae; exopod as in first maxilliped.

Third maxilliped (Fig. 4H).—Small, biramous but unsegmented bud.

Pereiopods.—Not apparent.

Abdomen (Fig. 3A, D).—Five segments; segments 2–5 smooth on dorsal surface; posterodorsal margins of segments 2–5 bearing pair of short setae; segments 4 and 5 with pair of posterolateral and posterodorsal spines; pleopods absent.

Telson (Fig. 3A, D, E).—Trigonal in dorsal view, distinctly concave on posteromedial margin; posterior margin with 7 + 7 processes (telsonal formula; I + ii + 3–7).

Color in life.—Carapace, abdomen, including telson and appendages, generally transparent; median region of first to third abdominal segments bright red; red chromatophores present on proximal part of telson and mandibles.

Discussion

The zoeas of *Lauriea gardineri* and *Phylladorhynchus integrirostris* described in the present study agree with the typically galatheid larval form proposed by Gurney (1942) and Konishi & Saito (2000), having a carapace that possesses a pair of posterolateral spines and posterodorsal and posteroventral teeth, and a maxillar scaphognathite that bears

a long plumose process on the posterior margin.

The first zoea of *L. gardineri* is diagnosed by the following characteristics: 1) broad rostrum armed with distinct lateral teeth; 2) maxillular endopod consists of two segments, with 1, 1 + 4 setae; 3) maxillar endopod bears 3 + 2 + 4 setae; 4) first maxilliped bears two setae on the coxa, 3 + 3 + 3 + 3 setae on the basis, and 3, 2, 1, 2, 4 setae on ventral margin of the endopod, respectively; 5) abdominal segments lack a median spine on the dorso-posterior margin; and 6) the lateral immovable spine of the telson is much shorter than telsonal plumose processes (Table 1). These characteristics are shared with four species of *Galathea* described from laboratory-reared materials: two Indo-West Pacific species, *G. amboinensis* and *G. inflata*, and two Atlantic species, *G. intermedia* Liljeborg 1851 and *G. rostrata* (A. Milne Edwards 1880) (see Gore 1979, Christiansen & Anger 1990, Fujita et al. 2001, 2003). Of these, the zoeal morphology of *L. gardineri* most closely resembles that of *G. amboinensis*, especially in having a broad rostrum armed with lateral teeth, and there are only a few minor morphological differences between *L. gardineri* and *G. amboinensis* (Fujita et al. 2003; Table 2): 1) posterodorsal margins of carapace with 10–15 teeth in *L. gardineri* (16–18 teeth in *G. amboinensis*), and 2) the small spinules on the dorsal surface of the abdominal segments and telson are fewer for *L. gardineri* than *G. amboinensis*. However, Baba (1994) noted that the adult morphology of *Lauriea* differs markedly from that of the other galatheid genera by having the ordinary lateral margin of the uropod endopod being posterior in position, no continuous transverse carapace ridges, biunguiculate dactyli of the walking legs, and no first gonopods in males. Further descriptive studies of larval development are required to accurately assess relationships among *Lauriea* and *Galathea*.

Table 1.—Morphological differences in first zoeae among ten galatheid genera for which larval morphology has been described in the laboratory. Abbreviations: s, seta. References: *1, Konishi & Saito (2000), Guerao et al. (2006); *2, Fagetti (1960); *3, Gore (1979), Christiansen & Anger (1990), Fujita et al. (2001, 2003); *4, Huus (1934), Roberts (1973), Konishi & Saito (2000), Guerao et al. (2006); *5, Sars (1889), Samuelsen (1972); *6 Guerao et al. (2006); *7, Boyd (1960), Fagetti & Campodonico (1971); *8, Fujita & Shokita (2005).

Species References	<i>Laureia</i> present study	<i>Phylladorhynchus</i> present study	<i>Agononida</i> *1	<i>Cervinunida</i> *2	<i>Galathea</i> *3	<i>Munida</i> *4	<i>Munidopsis</i> *5	<i>Neonida</i> *6	<i>Pleuroncodes</i> *7	<i>Sadaposhia</i> *8
Rostrum:										
lateral teeth	present	absent	absent	absent	present/absent	absent	absent	absent	absent	absent
Carapace:										
anterolateral spine	absent	absent	absent	absent	absent	absent	present	absent	absent	absent
Maxillular endopod:										
number of segment	2 segments	1 segment	2 segments	1 segment	2 segments	1 segment	1 segment	2 segments	1 segment	1 segment
setation	1s, (1+4)s	(1+4)s	0, (1+4)s	(1+1+4)s	(0-1)s, (1+3-4)s	(1+4)s or (1+1+4)s	1s	0, (1+4)s	(1+4)s	(1+1+4)s
Maxillar endopod	(3+2+4)s	(3+2+4)s	(3+4)s	(3+4)s	(3+2-3+3-4)s	(3+4)s or (3+2+4)s	1s	(3+4)s	(3+4)s	(3+4)s
First maxilliped:										
coxa	2s	1s	2s	no data	2s	2s	no data	2s	1s	2s
basis	(3+3+3+3)s	(2+3+3+2)s	(2+3+3+3)s	(2+3+3+3)s	(2-3+3+3+3)s	(2-3+3+3+3)s	naked	(2+3+3+3)s	(2+3+3+2)s	(3+3+3+3)s
Endopod (ventral margins)	(3, 2, 1, 2, 4)s	(2, 2, 1, 2, 4)s	(3, 2, 1, 2, 4)s	(2, 2, 1, 2, 4)s	(3, 2, 1, 2, 4)s	(3, 2, 1, 2, 4)s	(0, 1, 2, 3)s	(3, 2, 1, 2, 4)s	(2, 2, 1, 2, 4)s	(3, 2, 1, 2, 4)s
Abdomen:										
segments	absent	4th-5th	absent	absent	absent	absent	absent	absent	absent	absent
with dorsal-posteromedian spine										
Telson:										
posterior processes	7+7	7+7	7+7	7+7	7+7	7+7	13-15+13-15	7+7	7+7	7+7
lateral spine	short	short	long	long	short	long	short	long	long	short

Table 2.—Comparisons of morphological characters of first zoeas of *Lauriea gardineri* (Laurie 1926) and two *Galathea* species. Abbreviations: a, aesthetascs; cs, cuspidate seta; ps, plumose seta; s, seta, except for cs and ps; sp, spine; I, subterminal long plumose seta on the antennule, or posterior plumose process of the maxillar scaphognathite, or dorsoproximal plumose seta on the endopods of maxillipeds. Telsonal formula follows that of Gore (1979).

Species References	<i>L. gardineri</i> Present study	<i>G. amboinensis</i> Fujita et al. (2003)	<i>G. inflata</i> Fujita et al. (2001)
Rostrum: lateral teeth	11–16	14–18	absent
Carapace:			
posterodorsal teeth	10–15	16–18	12–15
posteroventral teeth	17–22	20–24	17–21
Antennule: protopod	3a+3s+I	3a+3s+I	3a+3s+I
Antenna:			
protopod	1sp	1sp	1sp
scaphocerite	10ps	10ps	10ps
Maxillule:			
coxal endtite	7s	7s	7s
basal endite	2cs+3s	2cs+(2–3)s	2cs+3s
endopod	1s, (1+4)s	1s, (1+4)s	1s, (1+4)s
Maxilla:			
coxal endtite	(8+4)s	(8+4)s	(8+4)s
basal endite	(5+4)s	(5+4)s	(5+4)s
endopod	(3+2+4)s	(3+2+4)s	(3+2+4)s
scaphognathite	4ps+I	4ps+I	4ps+I
First maxilliped:			
coxa	2s	2s	2s
basis	(3+3+3+3)s	(3+3+3+3)s	(3+3+3+3)s
endopod	3s, 2s, 1s, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I	3s, 2s, 1s, 2s, 4s+I
Second maxilliped:			
coxa	naked	naked	naked
basis	(1+2)s	(1+2)s	(1+2)s
endopod	2s, 2s, 2s, 4s+I	2s, 2s, 2s, 4s+I	2s, 2s, 2s, 4s+I
Abdomen:			
segment with			
posterolateral spines	4th–5th	4th–5th	4th–5th
posterodorsal teeth	absent	absent	2nd–5th
Telson:			
telsonal formula	I+ii+3–7	I+ii+3–7	I+ii+3–7
lateral spine	short	short	short

The diagnostic characters of *P. integrirostris* zoea are as follow: 1) rostrum is elongate and spine-like; 2) maxillule endopod is unsegmented with 1 + 4 setae; 3) maxilla endopod bears 3 + 2 + 4 setae; 4) first maxilliped is armed with one seta on the coxa, 2 + 3 + 3 + 2 setae on the basis, and 2, 2, 1, 2, 4 setae on ventral margin of the endopod; 5) the fourth and fifth

abdominal segments are each armed with a pair of posterodorsal spines; and 6) the lateral immovable spine of the telson is obviously shorter than telsonal plumose processes. Such setation of the first maxilliped has been described only in two species of *Pleuroncodes* Stimpson 1860, *P. planipes* Stimpson 1860 and *P. monodon* (H. Milne Edwards 1837) (Boyd

1960, Fagetti & Campodonico 1971; Table 1). However, *P. integrirostris* can be easily distinguished from these conspecifics by the shape of the rostrum, armature on the posterodorsal margins of the abdominal segments and telsonal lateral spine, and setation of antenna and maxilla. The possession of paired posterodorsal spines on the fourth and fifth abdominal segments of *P. integrirostris* is unique among galatheid species for which larval morphology is known, although some species possess small teeth on the posterodorsal margins of these abdominal segments. Gurney (1942: fig. 103, H) reported that zoea of *Galathea* sp., described from a plankton sample collected at Melbourne Harbor in Australia, have a pair of posterodorsal spines on the second to fifth abdominal segments. The morphology of the first zoea of *P. integrirostris* suggests that Gurney's larvae may be from a species in a genus related to *Phylladorhynchus* rather than a species of *Galathea*.

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