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The complete larval development of *Sadayoshia edwardsii* (Miers, 1884) (Decapoda: Anomura: Galatheidae) described from laboratory-reared material

YOSHIHISA FUJITA & SHIGEMITSU SHOKITA

Department of Chemistry, Biology and Marine Science, University of the Ryukyus, 1 Senbaru, Nishihara-cho, Okinawa 903-0213, Japan

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Abstract
The complete larval development of *Sadayoshia edwardsii* (Miers, 1884) is described and illustrated from laboratory-reared material. The development comprises four zoeal and one megalopal stages. Diagnostic zoeal characters of *Sadayoshia* are provided and these are compared with other galatheid genera for which the larval morphology is known. Zoeas of *S. edwardsii* are readily distinguished from those of other galatheid species by the setation of the maxillular endopod together with the basis and endopod of the first maxilliped. The megalop of *S. edwardsii* has a flattened, triangular-shaped rostrum, which differs remarkably from that of the adult. Although the rostral shape resembles that of *Galathea* megalops, the armature of the lateral margins is different between megalops of the two genera. The present larval study suggests that *Sadayoshia* is more closely allied to *Galathea* than to *Munida*.

Keywords: *Crustacea, Decapoda, Anomura, Galatheidae,* Sadayoshia edwardsii, *larval development*

Introduction

The family Galatheidae contains 28 genera (see Tirmizi and Javed 1980; Baba 1988, 1991, 1993; Baba and de Saint Laurent 1996; Baba and Wicksten 1997; Baba and Williams 1998; Macpherson 1998; Macpherson and Machordom 2000). However, the larvae have been described for only 12 species belonging to six genera as follows: *Agononida* Baba and de Saint Laurent, 1996, *Cervimunida* Benedict, 1902, *Galathea* Fabricius, 1793, *Munida* Leach, 1820, *Munidopsis* Whiteaves, 1874 and *Pleuroncodes* Stimpson, 1960 (see Gore 1979; Konishi and Saito 2000; Fujita et al. 2001, 2003).

Recently, we obtained an ovigerous female of *Sadayoshia edwardsii* (Miers, 1884) from Okinawa Island of the Ryukyu Islands. This species is common on the coral reefs of the Ryukyu Islands, and inhabits dead coral rubble (Kamezaki et al. 1988, as *S. miyakei* Baba,

Correspondence: Yoshihisa Fujita, Department of Chemistry, Biology and Marine Science, University of the Ryukyus, 1 Senbaru, Nishihara-cho, Okinawa 903-0213, Japan

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1969). *Sadayoshia edwardsii* had been referred to as *S. miyakei* Baba, 1969 or *S. acroporae* Baba, 1972, until Baba (1990) considered that *S. edwardsii* was the senior synonym of these two species.

The purpose of this study is to describe and illustrate the complete larval development of *Sadayoshia edwardsii*, provide diagnostic larval characters for the genus and to compare it with the known larvae of other genera within the Galatheidae.

Materials and Methods

An ovigerous specimen of *S. edwardsii* was collected in dead coral branches, at Cape Zanpa of Okinawa Is., the Ryukyu Islands, at a depth of 19.2 m, on 26 May 2001. The female was maintained in 5-litre circular plastic aquaria until hatching occurred. The hatched larvae were mass-cultured in circular plastic tanks containing 8 litres of filtered sea water. In order to determine the normal number of zoeal stages, 20 fourth-stage zoeas were cultured individually in 50-ml glass beakers. The salinity and water temperatures of the sea water were 35.0‰ and 24.0–27.0°C, respectively. Approximately one-third of the water in the tanks and the beakers was changed daily. Food given throughout was newly hatched *Artemia* nauplii.

The zoeal and megalopal specimens were stored in 50% ethylene glycol. Five larvae of each stage were measured and dissected for setal observations. Methods for mounting, drawing and measurement of carapace length (CL), total length (TL) and postorbital carapace length (PCL; measured only in the megalopal stage) followed those of Fujita et al. (2001). The long, plumose natatory setae on the exopods of maxillipeds and pleopodal exopods are drawn truncated. Terminology generally followed that of Gore (1979) and Ingle (1991). Usage of the terms of 'zoeas (the plural)', 'megalop (the singular)', 'megalops (the plural)' and 'basial endite' of appendages followed Clark et al. (1998).

The spent female and undissected larvae are deposited in the Coastal Branch of the Natural History Museum and Institute, Chiba, Japan (CMNH) under the following registration numbers: CMNH-ZC 1146 for the spent female, CMNH-ZC 1147–1150 for first to fourth zoeas and CMNH-ZC 1151 for megalops.

Results

Sadayoshia edwardsii passed through four zoeal stages and the megalop before attaining the first juvenile stage. The megalopal phase appeared 15–20 days after hatching, and the first juvenile stages 24–28 days after hatching. Minimum durations of the first to fourth zoeal stages were 3, 3, 3 and 5 days, respectively.

Five of 20 fourth-stage zoeas that were reared solitarily metamorphosed into the megalop stage. The remaining 15 larvae died, all of them failing to metamorphose.

The morphological characters of the larvae are described below.

Sadayoshia edwardsii (Miers, 1884)
(Figures 1–10)

First zoea

Size. CL 1.29–1.39 mm (mean 1.34 mm), TL 2.41–2.57 mm (mean 2.46 mm).

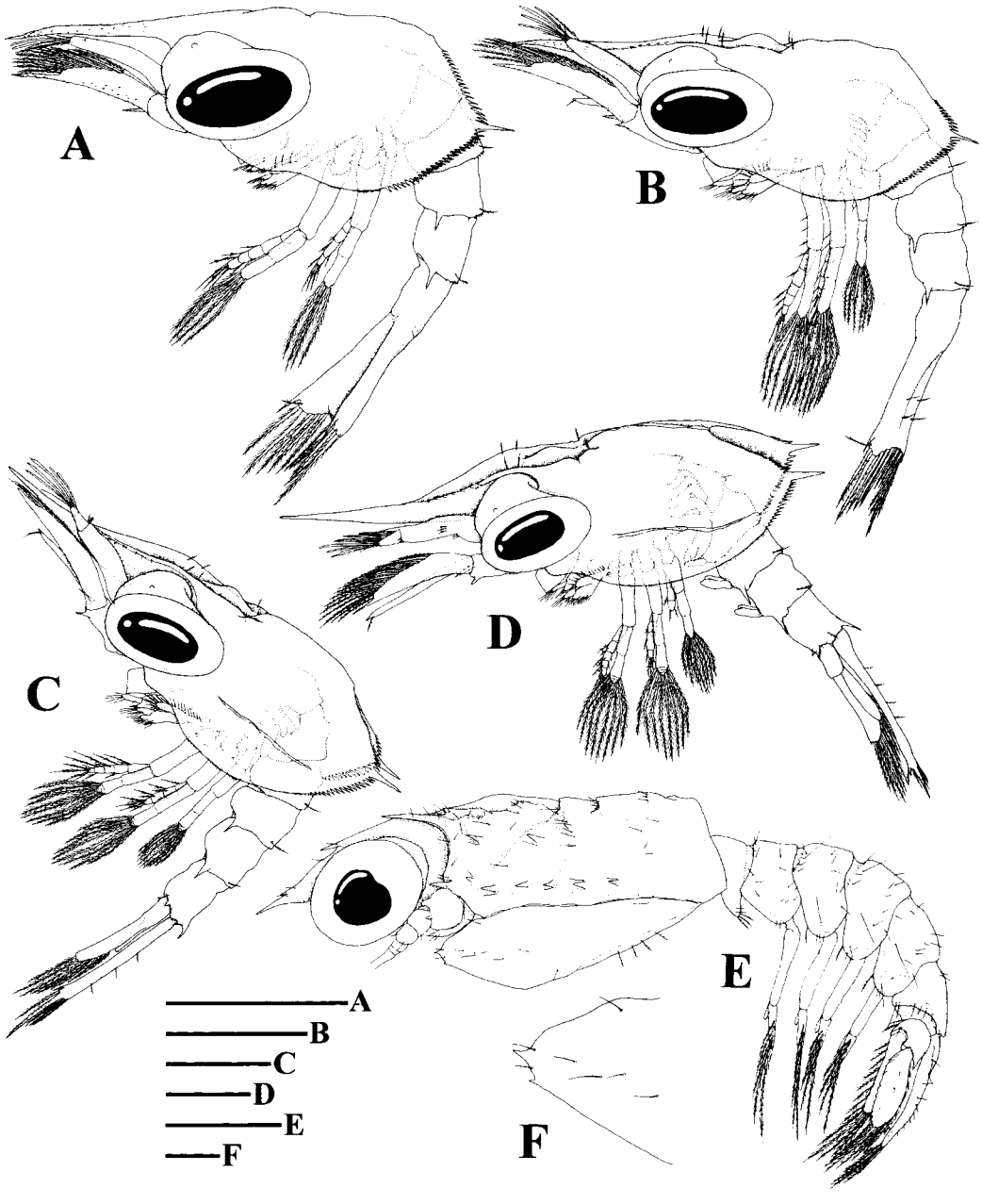

Figure 1. *Sadayoshia edwardsii* (Miers, 1884). (A) First zoea, lateral; (B) second zoea, lateral; (C) third zoea, lateral; (D) fourth zoea, lateral; (E) megalop, carapace, abdomen, telson and pleopods, lateral; (F) megalop, anterior margin of carapace, lateral. Scale bars: 0.5 mm (A, B); 0.1 mm (C–F).

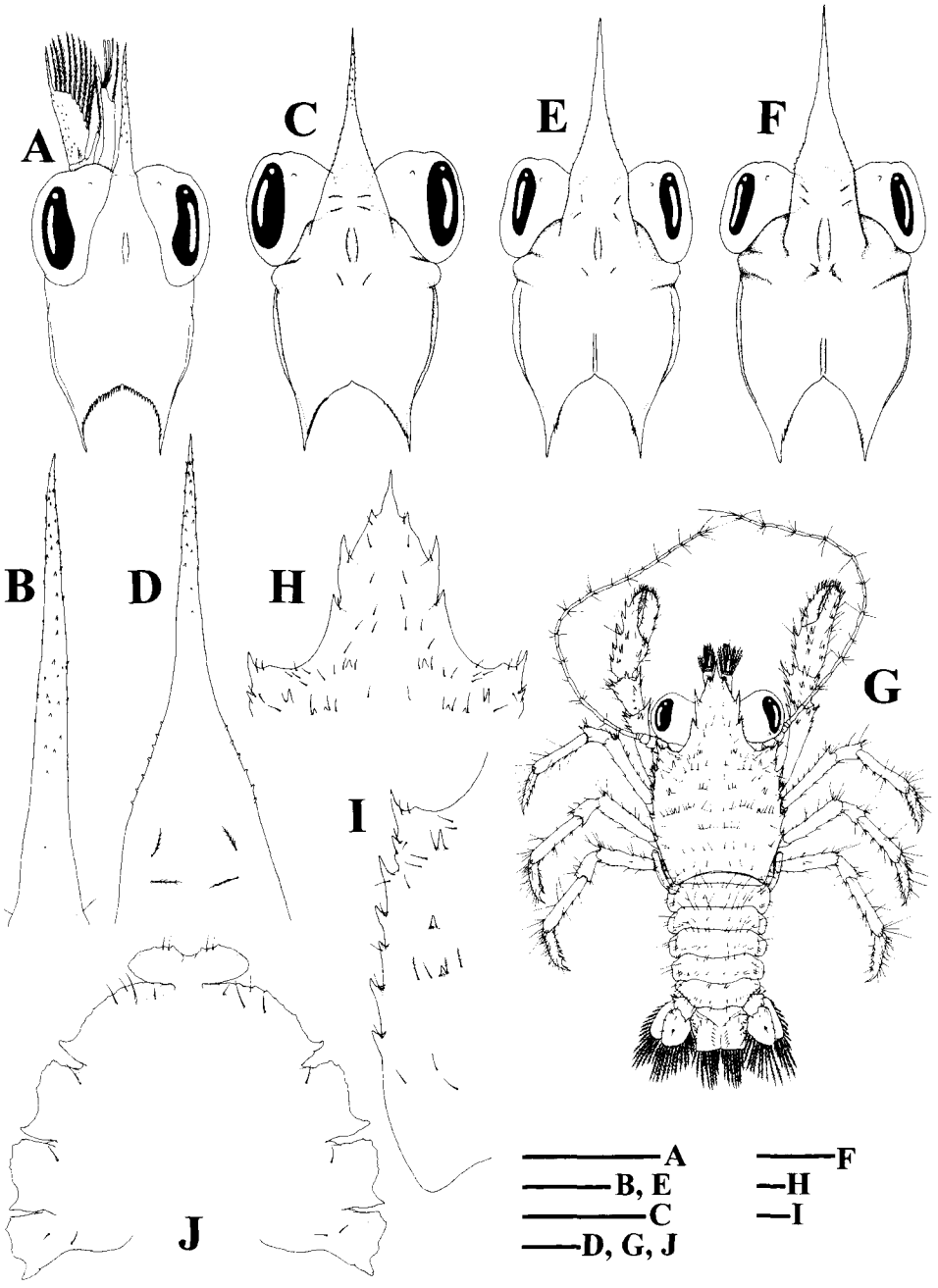

Figure 2. *Sadayoshia edwardsii* (Miers, 1884). (A) First zoea, carapace, dorsal; (B) first zoea, rostrum, dorsal; (C) second zoea, carapace, dorsal; (D) second zoea, rostrum, dorsal; (E) third zoea, carapace, dorsal; (F) fourth zoea, carapace, dorsal; (G) megalop, entire animal, dorsal; (H) megalop, rostrum, dorsal; (I) megalop, lateral margin of carapace, dorsal; (J) thoracic sternites, ventral. Scale bars: 0.5 mm (A, B); 0.1 mm (C–F).

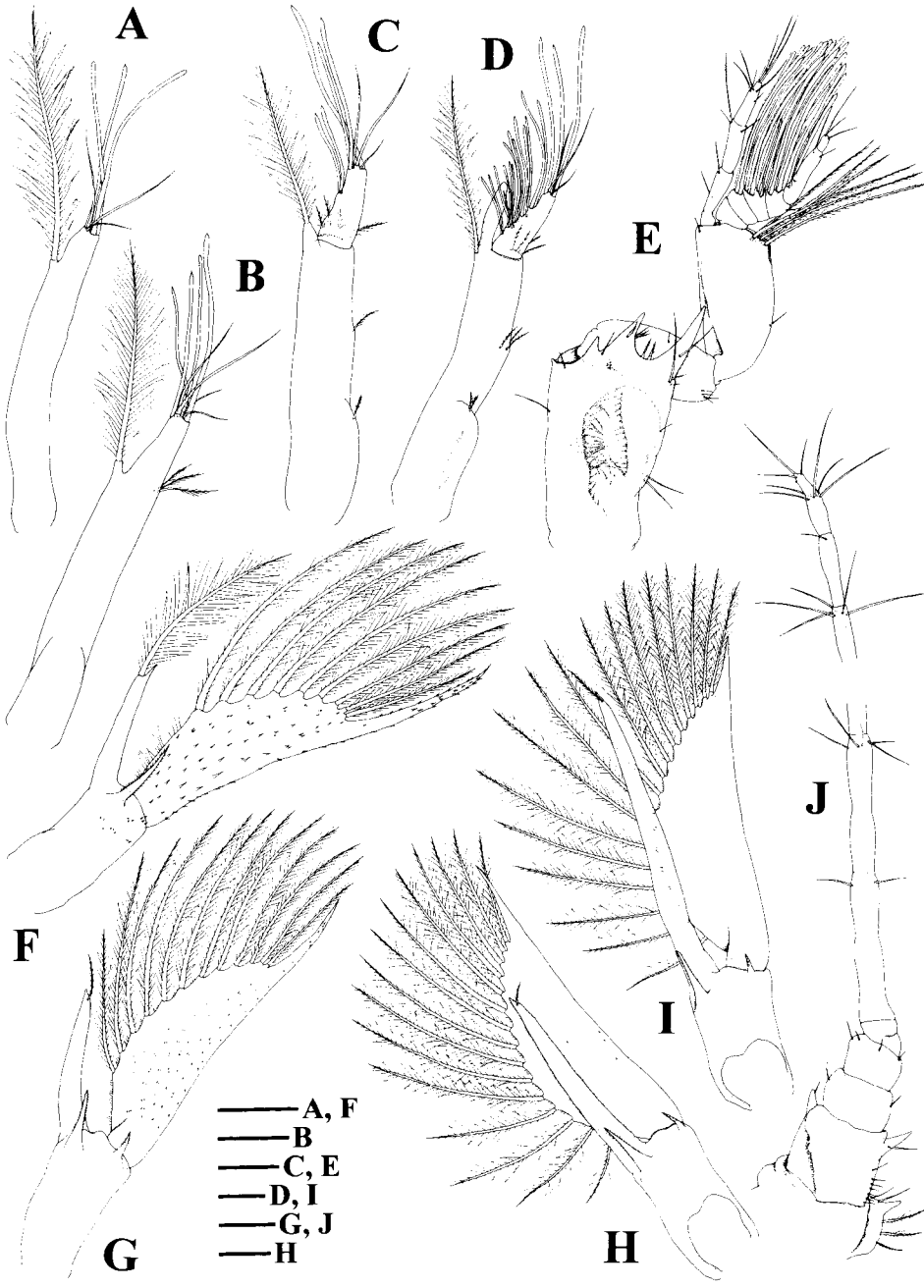

Figure 3. *Sadayoshia edwardsii* (Miers, 1884). (A–E) Antennule: (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop. (F–J) Antenna: (F) first zoea; (G) second zoea; (H) third zoea; (I) fourth zoea; (J) megalop, middle segments omitted. Scale bars: 0.1 mm.

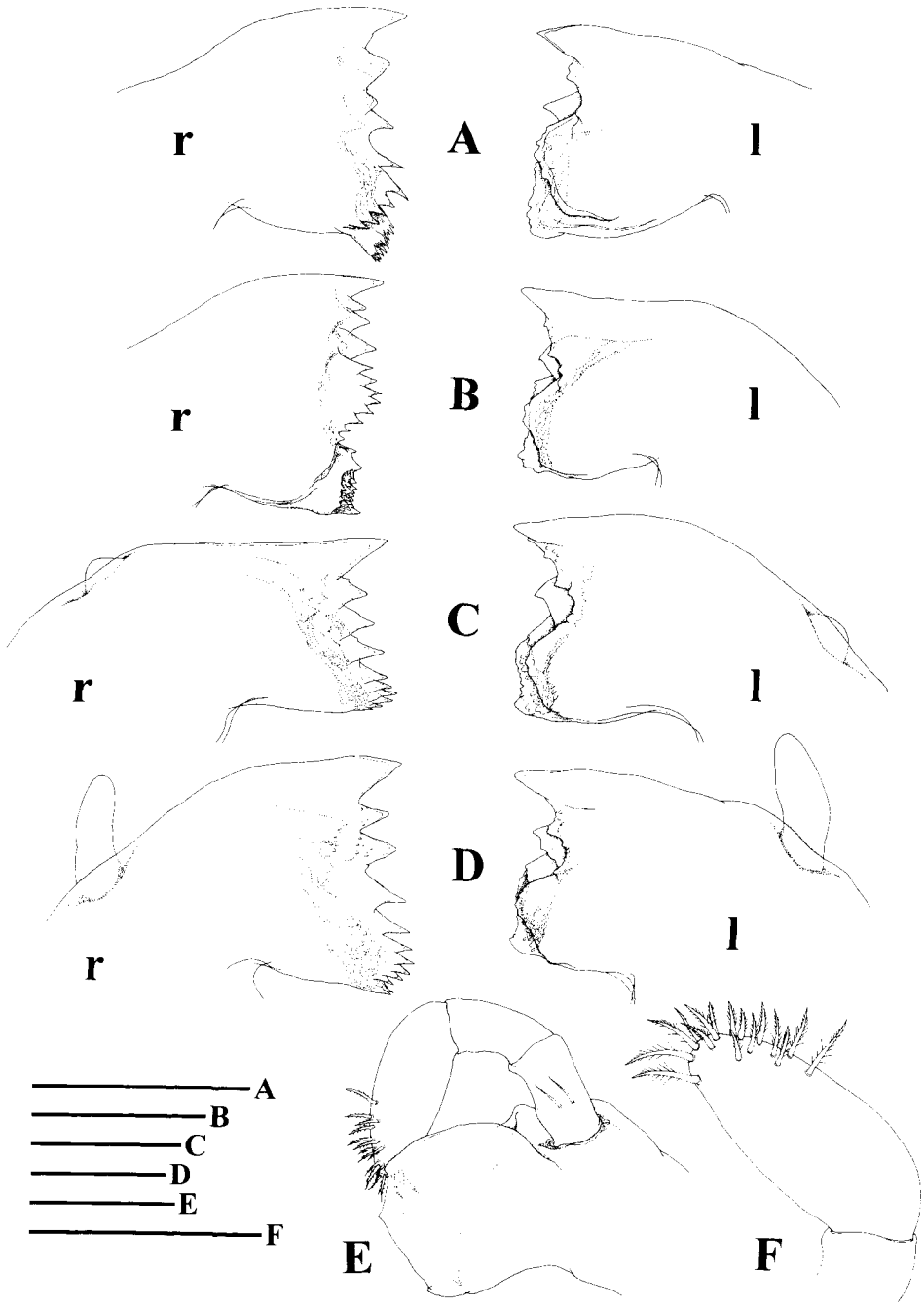

Figure 4. *Sadayoshia edwardsii* (Miers, 1884), mandible (r, right; l, left). (A) first zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) left mandible of megalop; (F) same, palp. Scale bars: 0.1 mm.

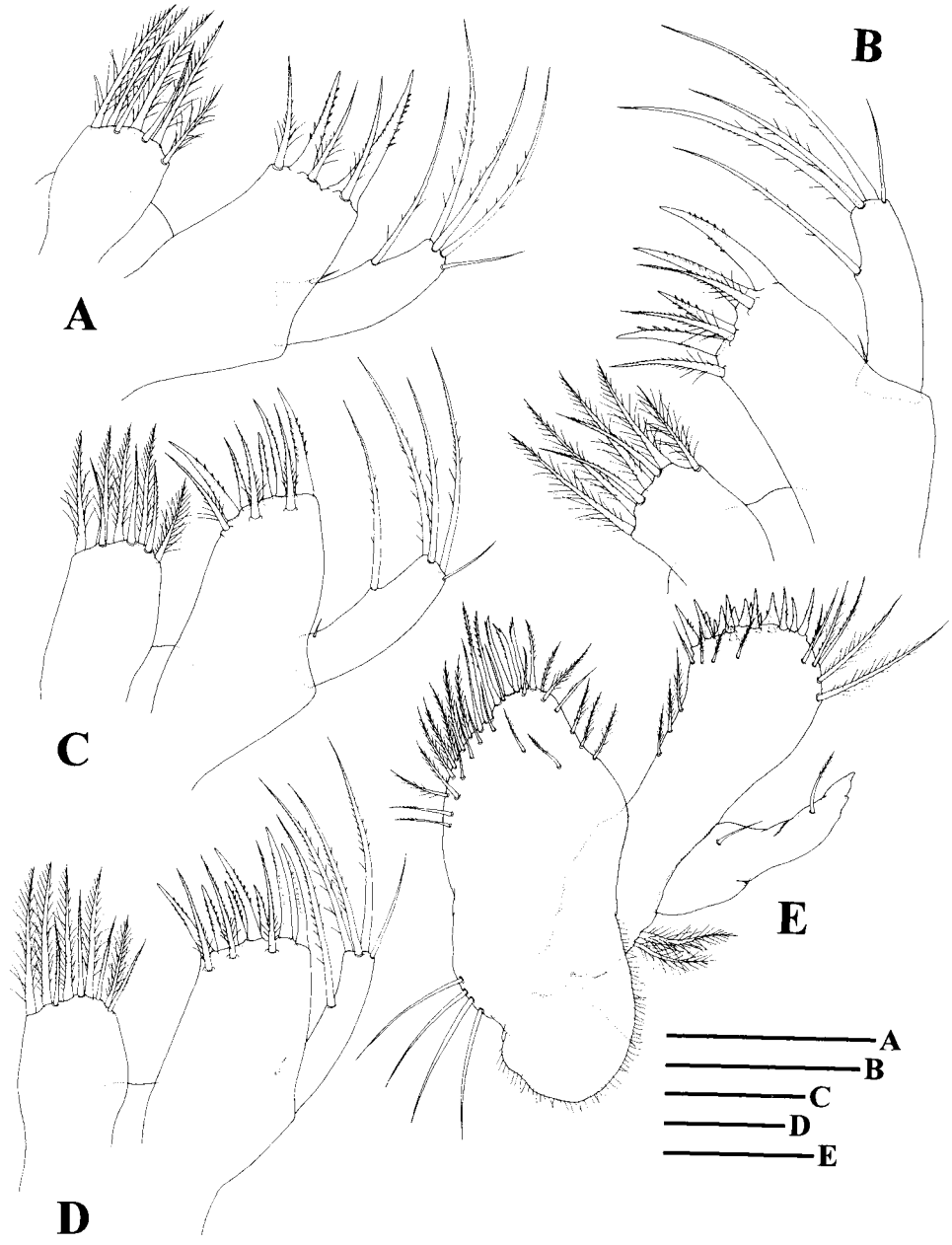

Figure 5. *Sadayoshia edwardsii* (Miers, 1884), maxillule. (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop. Scale bars: 0.1 mm.

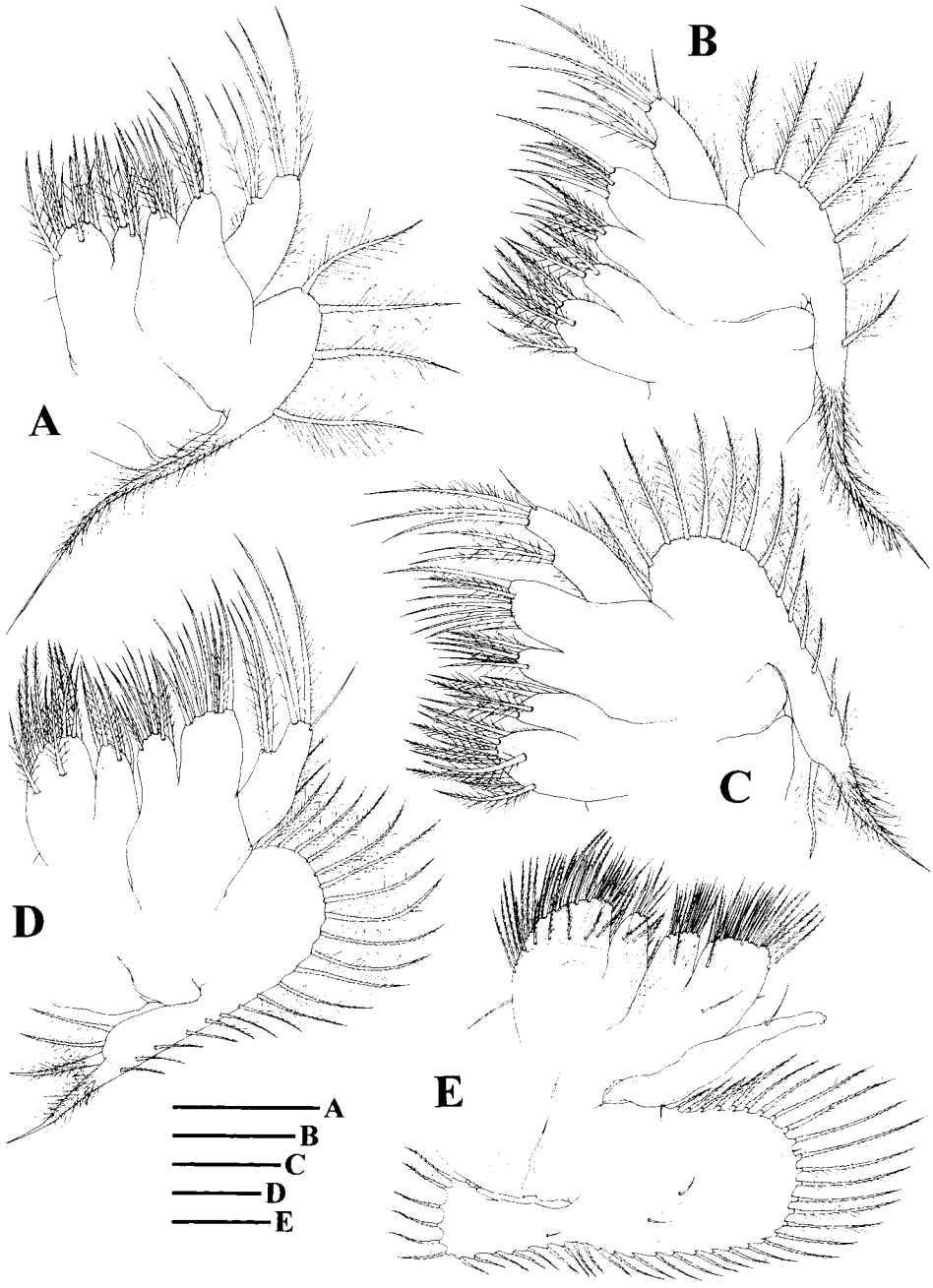

Figure 6. *Sadayoshia edwardsii* (Miers, 1884), maxilla. (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop. Scale bars: 0.1 mm.

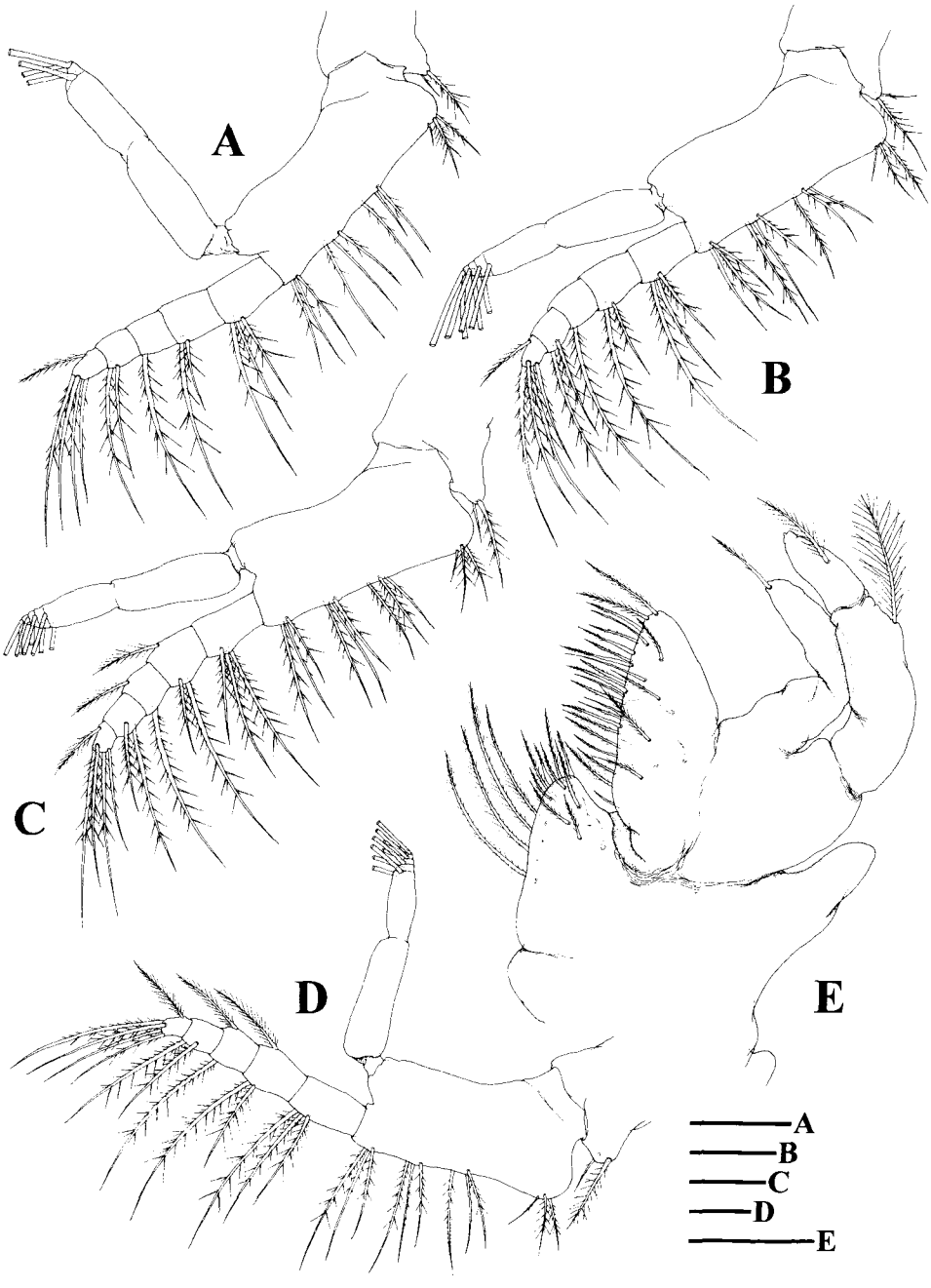

Figure 7. *Sadayoshia edwardsii* (Miers, 1884), first maxilliped (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop. Scale bars: 0.1 mm.

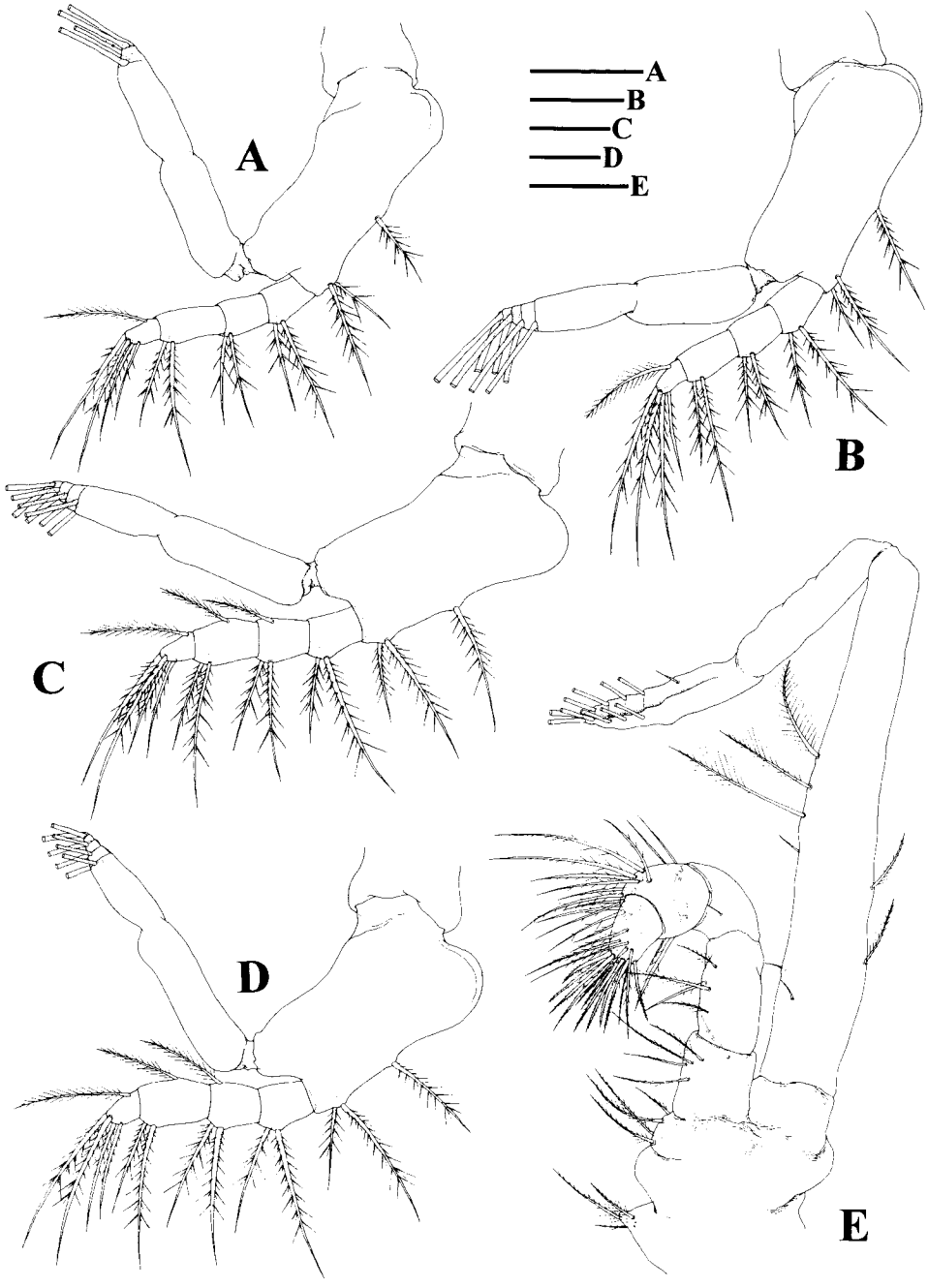

Figure 8. *Sadayoshia edwardsii* (Miers, 1884), second maxilliped. (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop. Scale bars: 0.1 mm.

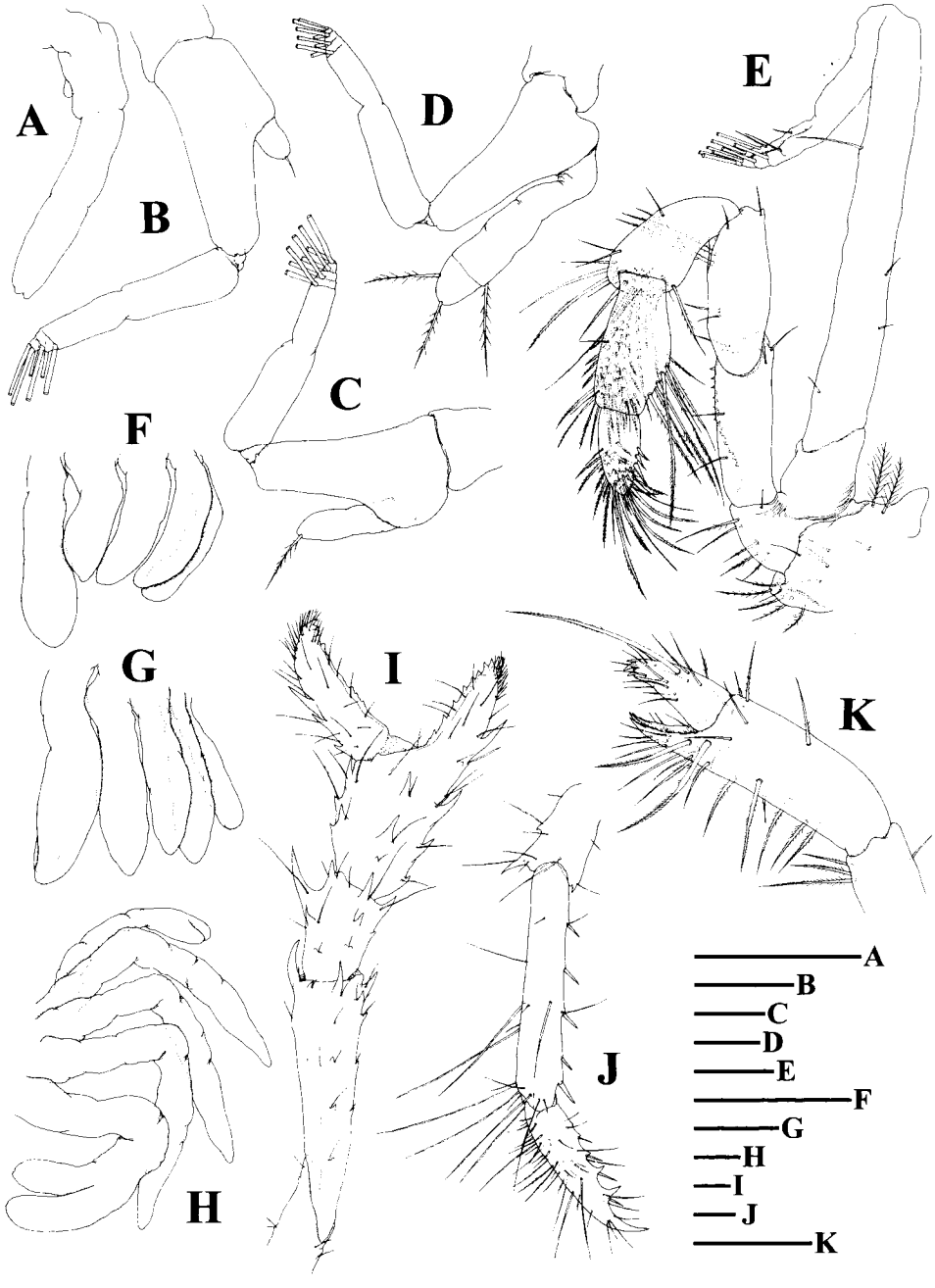

Figure 9. *Sadayoshia edwardsii* (Miers, 1884). (A–E) third maxilliped: (A) First zoea; (B) second zoea; (C) third zoea; (D) fourth zoea; (E) megalop (F–K) Pereiopods: (F) Second zoea; (G) third zoea; (H) fourth zoea; (I) megalop, first pereiopod; (J) megalop, second pereiopod, carpus, propodus and dactylus; (K) megalop, fifth pereopod, propodus and dactylus. Scale bars: 0.1 mm.

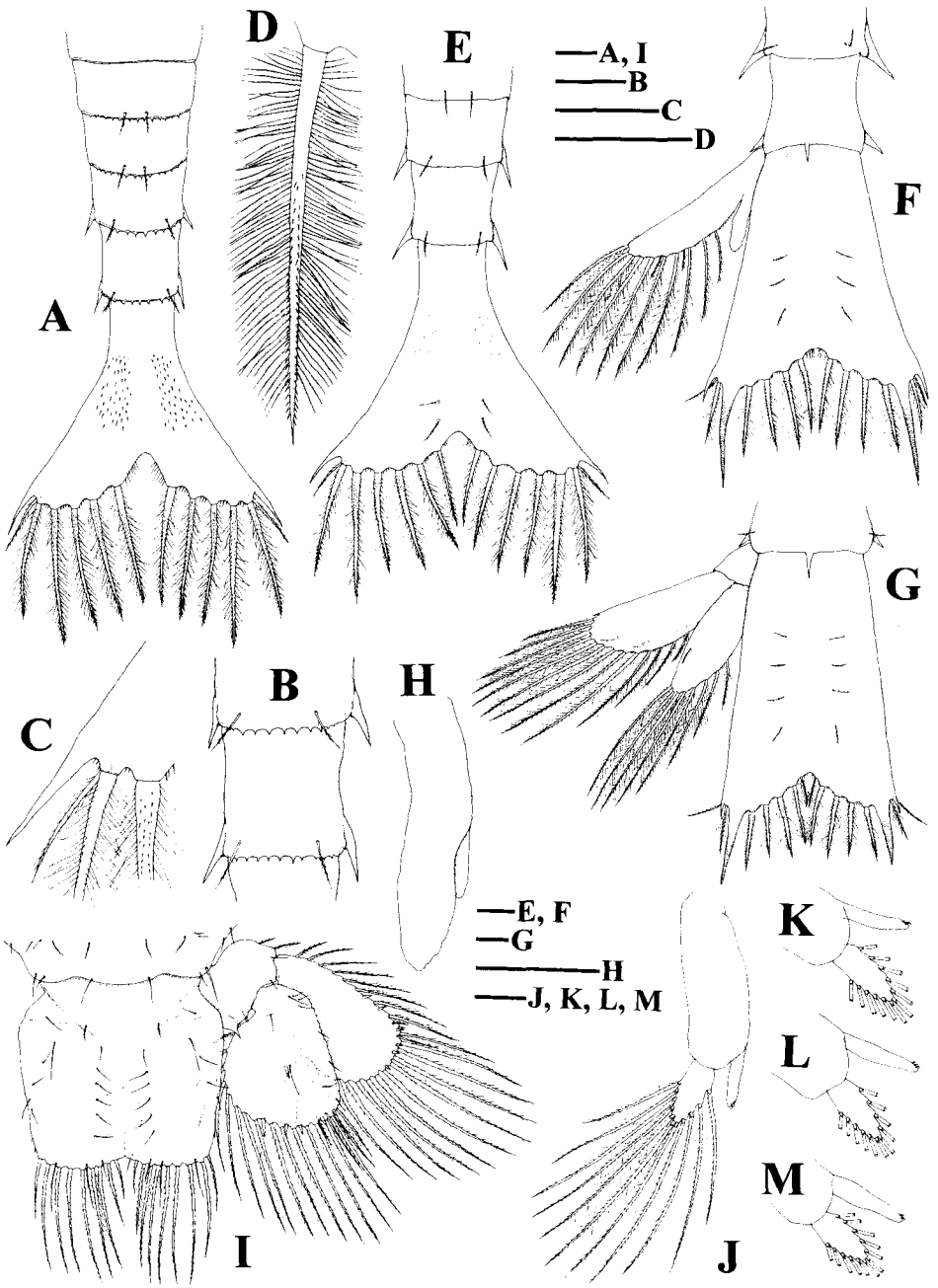

Figure 10. *Sadayoshia edwardsii* (Miers, 1884), abdomen and telson. (A) First zoea, abdomen and telson, dorsal; (B) first zoea, posterodorsal margins of fourth and fifth segments, dorsal; (C) first zoea, posterolateral margin of telson, dorsal; (D) first zoea, innermost plumose seta, dorsal; (E) second zoea, fourth and fifth abdominal segments and telson, dorsal; (F) third zoea, sixth abdominal segment, uropod and telson, dorsal; (G) fourth zoea, uropod and telson, dorsal; (H) fourth zoea, first pleopod, ventral; (I) megalop, tail fan, dorsal; (J–M) megalop, first to fourth pleopods, ventral, exopodal plumose setae of second to fourth pleopods truncated. Scale bars: 0.1 mm.

Carapace (Figures 1A, 2A, B). Typical galatheid larval form; anterodorsal setae absent; anterolateral spine absent; pair of produced, acute spines present posteriorly; posterodorsal margin with 17 or 18 small teeth, posteroventral margin with 20–25 small teeth; rostrum elongated and spine-like, extending to level of anterior apex of the antennal scaphocerite, without distinct lateral teeth but covered with minute denticles; eyes sessile.

Antennule (Figure 3A). Uniramous; elongated, with three aesthetascs and three setae terminally and one long plumose seta subterminally.

Antenna (Figure 3F). Biramous; protopod with one robust serrated spine at distoventral end; endopod fused to protopod, terminally ending in acute spine and with a long plumose seta; scaphocerite with produced, acute spine on distolateral margin, mesial margin with nine plumose setae, ventral and dorsal surfaces with sparse minute denticles.

Mandibles (Figure 4A). Asymmetrically dentate; incisor processes each with some strong teeth and few small teeth; molar processes strongly serrate or spinose; palp buds absent.

Maxillule (Figure 5A). Coxal endite with seven plumodenticulate setae; basial endite with two cuspidate and three plumodenticulate setae; endopod unsegmented, with one small proximal seta, one subterminal seta and four terminal setae (setal formula, 1+1+4).

Maxilla (Figure 6A). Coxal endite bilobed with 8+4 setae; basial endites with 5+4 setae; endopod unsegmented but bilobed, with three distomesial and four distolateral setae (setal formula, 3+4); scaphognathite (exopod) with four marginal plumose setae, posteriorly ending in elongate plumose process.

First maxilliped (Figure 7A). Coxa with two terminal setae; basis with 12 ventral setae arranged 3+3+3+3; endopod five-segmented, with setation 3, 2, 1, 2, 4+I (I=dorsal plumose setae); exopod two-segmented, distally with four long plumose natatory setae.

Second maxilliped (Figure 8A). Coxa naked; basis with three setae arranged 1+2, on distoventral margin; endopod four-segmented, with 2, 2, 2, 4+I setae, respectively; exopod as in first maxilliped.

Third maxilliped (Figure 9A). Small biramous bud; endopod bud sometimes absent.

Pereiopods. Absent.

Abdomen (Figures 1A, 10A, B). Five segments; posterodorsal margins of segments 2–5 each with small but distinct teeth and pair of short plumose setae; segments 4 and 5 each with pair of posterolateral spines; pleopods absent.

Telson (Figures 1A, 10A, C, D). Trigonal form in dorsal view; dorsal surface covered with numerous, minute denticles; posterior margin deeply concave medially, with 7+7 processes (telsonal formula; I+ii+3–7), first (lateralmost) immovable spine, second short plumose seta (=anomuran hair), third to seventh bearing long, stout plumose setae with minute denticles.

Colour in life. Carapace, abdomen including telson and appendages essentially transparent; median gastric region and ventral side of abdominal segments bright orange; red or bright-orange chromatophores present on lateral margin of carapace, eyes, mandibles, maxillule, maxilla, and basis and endopod of first and second maxillipeds.

Second zoea

Size. CL 1.53–1.70 mm (mean 1.63 mm), TL 3.04–3.23 mm (mean 3.14 mm).

Carapace (Figures 1B, 2C, D). Posterodorsal and posteroventral margins with 8–12 and 26–29 teeth, respectively; three pairs of setae present on proximal part of rostrum and median part of carapace; basal part of rostrum swollen; eyes now stalked; otherwise unchanged.

Antennule (Figure 3B). Protopod with two or three plumose setae present at distal one-quarter, distally with four aesthetascs and three or four simple setae; endopodal bud slightly developed, with a terminal plumose seta.

Antenna (Figure 3G). Protopod with additional serrate spine at distoventral end; endopod developed, with one short plumose seta; scaphocerite with 11 or 12 (usually 12) plumose setae on mesial margin.

Mandible (Figure 4B). Unchanged.

Maxillule (Figure 5B). Basial endite with four cuspidate and three plumodenticulate setae; otherwise unchanged.

Maxilla (Figure 6B). Distal lobe of basial endite with five or six (usually six) setae; scaphognathite with six or seven (usually seven) plumose setae on anterior margin and one elongate plumose process at posterior apex; otherwise unchanged.

First maxilliped (Figure 7B). Exopod with seven natatory setae; otherwise unchanged.

Second maxilliped (Figure 8B). Exopod with seven natatory setae; otherwise unchanged.

Third maxilliped (Figure 9B). Endopod more developed than in previous stage, naked or with one terminal seta; exopod with six natatory setae.

Pereiopods (Figure 9F). Unsegmented buds.

Abdomen (Figures 1B, 10E). Posterodorsal minute teeth disappeared; otherwise unchanged.

Telson (Figures 1B, 10E). Posterior margin with 8+8 processes (telsonal formula, I+ii+3–8); two pairs of short setae present at posterodorsal surface.

Colour in life. Similar to first zoea, but antennule and third maxilliped with red or bright-orange chromatophores.

Third zoea

Size. CL 2.00–2.15 mm (mean 2.06 mm); TL 3.90–4.13 mm (mean 3.97 mm).

Carapace (Figures 1C, 2E). Posterodorsal and posteroventral margins of carapace with four to nine and 15–18 teeth, respectively; otherwise unchanged.

Antennule (Figure 3C). Protopod swollen proximally, with one short plumose seta, one lateral plumose seta present at mid-length of lateral margin, four plumose setae present at junction with exopod; endopod developed, but still fused to protopod, bearing one long plumose seta terminally; exopod articulated, with two lateral aesthetascs, terminally with three aesthetascs and three setae.

Antenna (Figure 3H). Endopod more developed than in previous stage; mesial margin of scaphocerite with 14 or 15 plumose setae; otherwise unchanged.

Mandible (Figure 4C). Appearance of palp bud; otherwise unchanged.

Maxillule (Figure 5C). Coxal endite with eight plumodenticulate setae; basial endite with five cuspidate and three plumodenticulate setae; otherwise unchanged.

Maxilla (Figure 6C). Coxal endite with 9–10+5 setae; basial endite with 6–7+8–9 setae; scaphognathite with 12–14 plumose setae on lateral margin, one plumose seta on inner margin and one posterior plumose process; otherwise unchanged.

First maxilliped (Figure 7C). Setation of endopod 3, 2+I, 1+I, 2, 4+I; exopod with eight natatory setae; otherwise unchanged.

Second maxilliped (Figure 8C). Setation of endopod 2, 2+I (dorsal plumose seta rarely absent), 2+I, 4+I; exopod with eight natatory setae; otherwise unchanged.

Third maxilliped (Figure 9C). Endopod more developed than in previous stage, with one terminal seta; exopod with seven or eight (usually eight) natatory setae.

Pereiopods (Figure 9G). Chela bilobed; more developed than in previous stage.

Abdomen (Figures 1C, 10F). Six segments; segment 6 with one dorsal and one ventral posteromedian spine, and with pairs of posterolateral spines; appearance of biramous uropods, endopods naked, exopods well developed, with nine or 10 plumose setae marginally and two small setae at ventral surface.

Telson (Figures 1C, 10F). Posterior processes still 8+8, but fourth paired processes now robust, fused spines, with numerous minute spinules on surface (telsonal formula, I+ii+3+IV+5–8); three pairs of short setae on posterodorsal surface.

Colour in life. Almost as in previous stage, but chromatophores on antennule sometimes absent.

Fourth zoea

Size. CL 2.40–2.70 mm (mean 2.54 mm), TL 4.85–5.15 mm (mean 4.98 mm).

Carapace (Figures 1D, 2F). Posterodorsal and posteroventral margins of carapace with three to six and 8–20 (mostly 9–11) small teeth, respectively; otherwise unchanged.

Antennule (Figure 3D). Protopod with two short plumose setae at proximal part, two or three lateral plumose setae on middle part, four plumose setae at junction with exopod, and one long plumose seta directly proximal to endopod; endopod developed, terminal plumose seta disappeared; exopod with five rows of lateral aesthetascs, numbering proximal to distal 2–3, 5, 3, 3, 2, respectively, distal apex with three aesthetascs and two or three setae.

Antenna (Figure 3I). Endopod well developed; mesial margin of scaphocerite with 16–18 plumose setae; otherwise unchanged.

Mandible (Figure 4D). Palp developed, but unsegmented.

Maxillule (Figure 5D). Coxal endite with nine plumodenticulate setae; basial endite with seven cuspidate and three plumodenticulate setae; otherwise unchanged.

Maxilla (Figure 6D). Coxal endite with 10–12+5 setae; basial endite with 8–10+10–12 setae; scaphognathite with 20–23 plumose setae on lateral margin, three or four plumose setae on mesial margin and one posterior plumose process; otherwise unchanged.

First maxilliped (Figure 7D). Unchanged.

Second maxilliped (Figure 8D). Unchanged.

Third maxilliped (Figure 9D). Endopod well developed, indistinctly two-segmented, with two or three setae; otherwise unchanged.

Pereiopods (Figure 9H). Well formed, but unsegmented; first and fifth pereiopods bilobed as chelipeds.

Abdomen (Figures 1D, 10G, H). Segment 6 with pair of small dorsal-posterolateral setae; appearance of biramous pleopods on segments 2–5; uropods segmented, endopod with seven to nine marginal plumose setae plus one dorsal short seta, exopod with 11–14 plumose setae and one spine marginally, four short setae on ventral surface; otherwise unchanged.

Telson (Figures 1D, 10G). Longer than broad; posterior processes 9+9 (telsonal formula, I+ii+3+IV+5–9); four pairs of short setae present on dorsal surface.

Colour in life. Similar to third zoea.

Megalop (decapodid).

Size. PCL 1.05–1.18 mm (mean 1.11 mm), CL 1.88–2.14 mm (mean 2.02 mm), TL 3.60–3.95 mm (mean 3.80 mm).

Carapace (Figures 1E, F, 2G, H, I, J). Longer than broad; dorsal surface with numerous setae, lateral margin with six or seven (usually seven) small spines, three sublateral spines

on hepatic to epibranchial regions, pair of epigastric spines present; transverse striae indistinct. Rostrum triangular, broad proximally, with three lateral teeth, anterior tooth distinctly smaller than the posterior teeth. Pterygostomian flap differentiated from the carapace by faint demarcations, anterior margin armed with two spines. Thoracic sternites as illustrated; third thoracic sternite approximately three times as wide as long, anteromedian margin concave; following sternites expanded laterally, without distinct transverse striae or ridges, sparsely setose as illustrated.

Antennule (Figure 3E). Biramous; peduncle three-segmented, proximal segment with three large, acute spines, penultimate segment with some short setae, ultimate segment with three pairs of long plumose setae terminally; endopod three-segmented, proximal segment with one or two setae, penultimate segment with three setae, ultimate segment with four or five subterminal and three terminal setae; exopod six-segmented, first segment naked, second to fifth segments with seven rows of marginal aesthetascs arranged 5–6, 5–6+5–6, 3+3, 2+1 (from proximal to distal), ultimate segment with two or three setae.

Antenna (Figure 3F). Peduncle four-segmented; flagellum with 21–25 articles, each with zero to five setae distally, terminal segment with five subterminal and three terminal setae.

Mandible (Figure 4E, F). Subsymmetrically scoop-like process; palp three-segmented, proximal segment with two setae, ultimate segment with 14–16 stout, serrate setae distally.

Maxillule (Figure 5E). Coxal endite with 30–33 plumodenticulate setae, lower part with four long setae; basial endite with 16–20 cuspidate and 11–15 setae, and two plumose seta and one long seta externally proximal to endopod; endopod unsegmented, with one or two setae.

Maxilla (Figure 6E). Coxal and basial endites bilobed, setation highly variable, with 43–47+14–18 and 17–23+28–32 setae, respectively; endopod unsegmented, with one or two small proximal and one or two subterminal setae; scaphognathite with 43–48 plumose setae marginally plus six or seven setae on surface.

First maxilliped (Figure 7E). Coxal and basial endites with 14–18, 29–32 setae on ventral margin, respectively; endopod unsegmented, naked or with one terminal seta; exopod with one or two plumose setae on lateral median part and one to five subterminal/terminal setae.

Second maxilliped (Figure 8E). Coxa with three setae; basis with five or six setae; endopod five-segmented (proximal segment fused to basis), with setation 4–6, 4–5, 4–5, 12–14, 15–19 (including stout serrate setae on distal segment); exopod segmented, proximal segment with six to nine simple/plumose setae marginally, distal segment with 10–13 terminal simple/plumose setae.

Third maxilliped (Figure 9E). Coxa and basis with 12 or 13 and four to six setae, respectively; endopod five-segmented, ischium with crista dentata of 12–17 small teeth and four to seven setae; merus with five to seven setae; carpus, propodus and dactylus with 20–24, 41–48, 29–36 setae (including stout serrate setae), respectively; exopod segmented, proximal segment with three or four setae marginally, distal segment with 10–12 terminal simple/plumose setae.

Pereiopods (Figure 9I, J, K). All pereiopods fully developed, segmented. Cheliped (first pereiopod) robust, approximately as long as carapace, sparsely setose and spinose as illustrated; carpus with one large acute spine on mesial margin. Ambulatory legs (second to fourth pereiopods) slender, sparsely setose as shown; merus with row of small teeth on extensor and flexor margins; carpus with one large, acute spine and few small spines on extensor margin; propodus with four to six movable spines on flexor margin, distal pair largest; dactylus with four to five movable spines and four to six teeth. Fifth pereiopod short, subcylindrical, chelate; palm with three to five long and some short serrate setae. No male/female gonopores.

Abdomen (Figure 1E, 2G). Six segments, sparsely setose on dorsal surface as illustrated; biramous pleopods present on segments 2–5 (Figure 10J–M), endopods increasing in length posteriorly, with two to four small terminal hooks, exopods well developed, bearing terminal plumose setae, setal formulae progressing posteriorly with 11–12, 11–12, 11–12, 11–12.

Tail fan (Figures 1E, 10I). Telson incompletely divided into five plates with faint demarcations; anterolateral plate more distinctly marked than others; posterior margin with 16–19 long plumose setae (frequently eight or nine pairs, but sometimes asymmetrical) on posterior margin and one or two spinules on each posterolateral margin, dorsal and ventral surfaces with short plumose setae as illustrated; uropods biramous, endopod with 17–19 plumose setae marginally, dorsal surface with 9–11 short setae and four to six small spines, exopod with 17–29 (mostly 21–24) long plumose setae marginally, dorsal surface with two short setae and four to seven small spines on posterior part.

Colour in life. Carapace and abdomen generally transparent, with scattered, orange or/and red chromatophores; telson with red chromatophores on posterolateral margin; appendages essentially transparent, red or bright-orange chromatophores present on eye stalk, antennal peduncle, second and third maxillipeds, chela of first pereiopod, dactyli and propodi of second to fourth pereiopods, and uropods.

Discussion

Sadayoshia edwardsii zoeas agree well with diagnostic features of the galatheids proposed by Gurney (1942) and Konishi and Saito (2000); in particular in that the carapace possesses a pair of posterolateral spines and posterodorsal and posteroventral teeth, and that the maxillar scaphognathite bears a long plumose process on the posterior margin.

As shown in Table I, *Sadayashia* zoeas are diagnosed by the following characters: (1) the anterolateral spine of the carapace is absent; (2) the maxillular endopod is unsegmented, with 1+1+4 setae; (3) the maxillar endopod bears 3+4 setae; (4) the first maxilliped bears two setae on the coxa and 12 (3+3+3+3) setae on the basis, respectively; (5) the endopod of the first maxilliped bears 3, 2, 1, 2, 4 setae each on ventral margins of the first to fifth segments; (6) the sixth abdominal segment armed with a posterodorsal spine in the third and fourth zoeas; (7) telsonal formulae in the first and second zoeas are I+ii+3–7, I+ii+3–8, respectively, and in the third and fourth zoeas I+ii+3+IV+5–8, I+ii+3+IV+5–9, respectively; and (8) lateral spines of the telson are much shorter than the posterior plumose processes through the zoeal stages. Among these characteristics, the setation of the maxillular endopod is an uncommon character and known only in *Cervimunida johni* Porter 1903 (see

Table I. Morphological differences in zoeal stages among seven galatheid genera, for which larval morpology has been described.

	Sadayoshia (present study)	*Agononida* (1)	*Cervimunida* (2)	*Galathea* (3)	*Munida* (4)	*Munidopsis* (5)	*Pleuroncodes* (6)
Carapace							
Anterolateral spine	Absent	Absent	Absent	Absent	Absent	Present	Absent
Maxillular endopod							
Number of segment	1 segment	2 segments	1 segment	2 segments	1 segment	1 segment	1 segment
Setation	(1+1+4)s	0, (1+4)s	(1+1+4)s	(0–1)s, (1+3–4)s	(1+4)s	1s [z1] 2s [z2]	(1+4)s
Maxillar endopod	(3+4)s	(3+4)s	(3+4)s	(3+2–3+3–4)s	(3+4)s or (3+2+4)s	1s [z1] 3s [z2]	(3+4)s
First maxilliped							
Coxa	2s	2s	No data	2s	2s	No data	1s [z1–2] 2s [z3–5]
Basis	(3+3+3+3)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+2)s
Endopod (ventral margins)	(3, 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	(2, 2, 1, 2, 4)s
Abdomen							
Segments with dorsal-posteromedian spine	Absent [z1–z2] 6th segment [z3–z4]	Absent	Absent	Absent	Absent [z1–z2] 6th segment [z3–z4]	Absent	Absent [z1–z2] 6th segment [z3–z4]
Telson							
Posterior processes	7+7 [z1] 8+8 [z2–z3] 9+9 [z4]	7+7 [Z1]	7+7 [Z1]	7+7 [z1] 8+8 [z2–z5]	7+7 [z1] 8+8 [z2] 10+10 [z3] 11–12+11–12 [z4] 12–13+12–13 [z5]	13–15+13–15 [z1] 14–16+14–16 [z2]	7+7 [z1] 8+8 [z2] 9+9 [z3] 10–12+10–12 [z4] 12+12 [z5]
Lateral spine	Short	Long	Long	Short	Long [z1–z2] Short [z3–z5]	Short	Long [z1–z2] Short [z3–z5]

References: 1, Konishi and Saito (2000); 2, Fagetti (1960); 3, Gore (1979), Christiansen and Anger (1990), Fujita et al. (2001, 2003); 4, Huus (1934), Roberts (1973), Konishi and Saito (2000); 5, Sars (1889), Samuelsen (1972); 6, Boyd (1960), Fagetti and Campodonico (1971).

Fagetti 1960). However, *Sadayoshia* zoeas differ considerably from *C. johni* by the setation of the basis and endopod of the first maxilliped (see Table I). Therefore, *Sadayoshia* zoeas can be distinguished from the other genera through the zoeal stages by the combination of setation of the maxillular endopod and of the first maxillipedal basis and endopod.

With regard to the adult systematics, Baba and de Saint Laurent (1996) and Baba and Wicksten (1997) suggested that the Galatheidae could be separated into two groups by the presence or absence of first pleopods in males. The genera having the pleopods are as follows: *Alainius* Baba, 1991, *Allogalathea* Baba, 1969, *Allomunida* Baba, 1988, *Anomoeomunida* Baba, 1993, *Cervimunida*, *Fennerogalathea* Baba, 1988, *Galathea*, *Janetogalathea* Baba and Wicksten, 1997, *Leiogalathea* Baba, 1969, *Munida*, *Munidopsis*, *Pleuroncodes*, *Raymunida* Macpherson and Machordom, 2000, *Sadayoshia* Baba, 1969 and *Shinkaia* Baba and Williams, 1998. Among these genera, *Sadayoshia* is allied to *Anomoeomunida*, *Cervimunida*, *Pleuroncodes* and *Munida* by having a spiniform rostrum (Baba and Wicksten 1997). Although the *Anomoeomunida* zoea is still unknown, *Sadayoshia* also resembles *Cervimunida*, *Pleuroncodes* and *Munida* in the following zoeal characters (Table I): (1) the maxillular endopod is unsegmented through the zoeal stages and (2) the posterior margin of the telson bears more than 9+9 processes in the fourth zoea. Moreover, *Sadayoshia* has a dorsal-posteromedian spine on the sixth abdominal segment in the third and fourth zoeas, the character is also shared in *Pleuroncodes* and *Munida*. The abdominal armature is not known for *Cervimunida*, because the complete larval development remains undescribed.

Sadayoshia larvae have short lateral spines on the telson that are much shorter than the posterior plumose processes through the zoeal stages and this character has also been described for *Galathea* larvae (see Gore 1979; Christiansen and Anger 1990; Fujita et al. 2001, 2003). Although the larvae of *Munidopsis* are also known to possess short lateral spines, the general larval morphology is remarkably different from those of the other genera due to the abbreviated larval life (Sars 1889; Samuelsen 1972; Wilkens et al. 1990). The larvae of *Cervimunida*, *Pleuroncodes* and *Munida* possess lateral spines extremely longer than the posterior processes of the telson, which bears numerous marginal spinules in the first and second zoeal stages, and become shortened in the subsequent larval stages (Huus 1934; Boyd 1960; Fagetti and Campodonico 1971; Pike and Williamson 1972; Roberts 1973). From the viewpoint of the shape of the lateral spines of the telson, *Sadayoshia* zoeas seem to be allied to *Galathea* rather than to *Cervimunida*, *Pleuroncodes* and *Munida*.

Although zoeas of six galatheid genera have been identified to date, knowledge of megalopal morphology is restricted only to *Galathea* and *Munida* (Sars 1889; Lebour 1930, 1931; Huus 1934; Al-Kholy 1959; Pike and Williamson 1972; Roberts 1973; Gore 1979; Christiansen and Anger 1990; Fujita et al. 2001, 2003). *Sadayoshia edwardsii* megalop has a flattened, triangular-shaped rostrum, which is clearly different from that of the adult (Figure 2H). This shape of the rostrum resembles that of *Galathea* megalops rather than *Munida*, although the adult of *S. edwardsii* has a spiniform rostrum as in *Munida*. The *Munida* megalop has a long, spine-like rostrum (but subterminally with very small lateral teeth) and two proximal short spines (see Sars 1889; Lebour 1930; Pike and Williamson 1972; Roberts 1973). However, the *S. edwardsii* megalop is easily distinguished from *Galathea* megalops by the rostrum with three lateral small teeth (with four teeth in *Galathea* megalops).

Baba (1969) stated that *Sadayoshia* was placed between *Munida* and *Galathea* when he established the genus *Sadayoshia*. The present larval evidence agrees well with his opinion, and suggests closer relationships between *Sadayoshia* and *Galathea* than between

Sadayoshia and *Munida*. In order to discuss accurate relationships between *Sadayoshia* and its related galatheid genera, further descriptive studies of larval development are required.

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