スナモグリ(甲殻綱: アナジャ科下目: スナモグリ科)の人工飼育による全幼生期の記載

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A Complete Description of Larval Stages of the Ghost Shrimp
*Callianassa petalura* Stimpson (Crustacea: Thalassinidea: Callianassidae) under Laboratory Conditions

Kooichi Konishi*1, Rodolfo Quintana, R.*2), and Yasushi Fukuda*3)

(Received January 8, 1990)

Larvae of the ghost shrimp *Callianassa petalura* Stimpson were reared in the laboratory, and the complete series of development was observed and illustrated for the first time from Japan, based on laboratory-rearing. This species has six zoeal stages and one decapodid, and development to the decapodid took 15–16 days at a water temperature of 22–28°C; this larval duration is the shortest in the previously known *Callianassa* larvae, except for the development of abbreviated type. The decapodid of *C. petalura* bears an *appendix interna* on pleopodal endopod, showing close affinity to the Axiidae among thalassinid families.

*Key words:* *Callianassa*, culture, larva, systematics

Ghost shrimps of the family *Callianassidae* represent a great ecological interest, such as bioturbating activity on benthos of intertidal flat (e.g. Tamaki, 1988). These shrimps are also used as good fishing baits for sea breams both in Japan and other localities. However, as in the other thalassinid families, the life cycle of these ghost shrimps has been poorly studied including their larval development, since the early callianassid larvae usually show high mortality under laboratory conditions.

The *Callianassidae* includes 9 species belonging to 3 genera from Japan (Sakai, 1969; Miyake, 1982). The larval stages of this family have been documented only in *C. japonica* Ortmann from Japan: the laboratory-hatched zoea 1 stage by Miyazaki (1937) and the planktonic zoea 1–4 stages reconstructed by Kurata (1965). Thus, no complete larval development of callianassids has been described yet in Japan (see Table 1).

This paper gives: 1) a description of complete larval stages of *C. petalura* Stimpson obtained from laboratory-rearing, and 2) a comparison of larval development of this species, especially in decapodid stage, with those of previous works.

*1 National Research Institute of Aquaculture, Nansei, Mie 516-01, Japan
*2 Mitsubishi Corporation, Sucursal Chile para Construccion y Proyectos, Teatinos 220, Casilla 1693, Santiago, Chile
*3 Faculty of Education, Kumamoto University, Kumamoto 860, Japan
Table 1. Larval descriptions in the genus Callianassa

<table>
<thead>
<tr>
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<td>U.S.A., Virginia</td>
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<td>biformis</td>
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<td>plankton</td>
<td>U.S.A., Virginia</td>
<td>Sandifer, 1973</td>
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<tr>
<td>garthi</td>
<td>Z1–5, D</td>
<td>laboratory-reared</td>
<td>Chile, Penco</td>
<td>Aste &amp; Retamal, 1983</td>
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<tr>
<td>uncinata</td>
<td>Z1–5</td>
<td>laboratory-reared</td>
<td>Chile, Penco</td>
<td>Aste &amp; Retamal, 1984</td>
</tr>
<tr>
<td>stebbingi</td>
<td>Z1–2</td>
<td>laboratory-reared</td>
<td>Mediterranean Sea</td>
<td>Heegaard, 1963</td>
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<tr>
<td>kraussi</td>
<td>Z1–2, D*</td>
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<td>Forbes, 1973</td>
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<td>japonica</td>
<td>Z1</td>
<td>laboratory-reared</td>
<td>Japan, Honshu</td>
<td>Miyazaki, 1973</td>
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<tr>
<td>japonica</td>
<td>Z1–4</td>
<td>plankton</td>
<td>Japan, Hokkaido</td>
<td>Kurata, 1965</td>
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<tr>
<td>petalura</td>
<td>Z1–6, D</td>
<td>laboratory-reared</td>
<td>Japan, Kyushu/Hokkaido</td>
<td>this study</td>
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D: decapodid (megalopa), Z: zoea, * abbreviated development

Materials and Methods

Two ovigerous females of Callianassa petalura were caught by digging pebbly sand flat at Takamoku-Jima, Ariake Bay, Kyushu, the southern part of Japan (ca. 32°30'N), on 12 June 1980. The female shrimps were kept in an aquarium with filtered sea water until hatching occurred on 26 and 27 July 1980, respectively. Active zoeas were selected and reared in a polycarbonate tank containing 30 l of sea water. Water temperature ranged from 22 to 28°C. Cultured Brachionus and newly-hatched Artemia nauplii were given as food, and the rearing was checked daily. For comparison of materials of different locality, we also examined zoea 1 specimens which were hatched on 3 August 1984 from an ovigerous female from Kikonai, Hokkaido, the northern part of Japan (ca. 41°30'N). Larvae and exuviae of each stage were fixed with 5% formalin, rinsed briefly in distilled water, and then preserved in 70% ethanol; a number of larvae were fixed with 50% ethylene glycol. These specimens were transferred to 50% glycerin solution before dissections. Some specimens were treated with 2% KOH in order to make them translucent and exuviae were stained with methylene blue. The appendages were dissected with fine insect pins. Drawings and measurements were made with a drawing tube attached to a microscope and ocular micrometer, respectively.

The terminology used in this paper is the same as in the previous papers (Konishi and Quintana, 1988; Konishi, 1989). All setal arrangement is listed from proximal to distal. Carapace length (CL) given in the descriptions was measured from the tip of the rostral spine to the posterior border of the carapace mesially.

The specimens used in this study have been deposited at the Zoological Institute, Faculty of Science, Hokkaido University under accession numbers ZIHU 661 and ZIHU 869–882.

Description of Larval Stages

Prezoea stage was not observed in the present study. Table 2 summarizes the dimensions and
Fig. 1 Callianassa petalura Stimpson. A-G, lateral view of zoea 1–6 and decapodid. Scale bar = 1.0 mm.
rearing data of each larval stage. The CL of zoea 1 specimens from Hokkaido is slightly smaller than that from Kyushu specimens.

**Zoea 1**

**CARAPACE** (Figs. 1A, 2A): Longer than broad, anterolateral margin denticulated; rostral spine pointed, fringed with denticules and setules. Eyes fused with anterior portion of carapace.

**ANTENNULE** (Fig. 3A): Unsegmented process with 3 long thick aesthetascs and a thin seta terminally; a long plumose subterminal seta on future endopodal bud.

**ANTENNA** (Fig. 4A): Protopod with a stout serrated spine near the base of exopod; endopod with a long apical plumose seta; exopod (=scaphocerite) tip pointed, bearing 8 plumose setae along inner
margin, and a simple short seta on outer margin.

MANDIBLES: Symmetrical, but different in dentition on each side; incisor process smaller than molar process, but processes not clearly defined. No palp.

MAXILLULE (Fig. 6A): Coxal endite with 7 setae; basal endite with 2 stout serrated spines and 3 setae; endopod 3-segmented, with 3, 2, 4 setae distally.

MAXILLA (Fig. 7A): Coxal and basal endite 2-lobed, 10 + 4 and 8 + 6 setae, respectively; endopod incompletely 4-segmented, bearing 3, 2, 2, 5 setae, respectively; scaphognathite with 4 marginal plumose setae and a long posterior plumose seta.

MAXILLIPED 1 (Fig. 8A): Coxa with 3 + 2 + 2 setae; basis, slightly longer than coxa, with 3 + 3 + 3 + 3 setae; endopod 4-segmented, providing with 3, 2, 2, 3 + I (Roman numeral denoting dorsolateral plumose seta) setae on each segment; exopod incompletely 2-segmented, bearing 4 long natatory setae terminally.

MAXILLIPED 2 (Fig. 9A): Coxa without setae; basis with 1 + 1 + 1 + 2 setae on lateral portion; endopod 4-segmented, with 2, 2, 2, 4 + I setae, respectively. Exopod as in maxilliped 1.

MAXILLIPED 3 (Fig. 10A): Coxa with no seta; basis with 2 distal setae; endopod 3-segmented with 0, 2, 3 + I setae respectively; exopod with 5 long natatory setae distally.

PEREIOPODS: Not developed.

ABDOMEN (Figs. 1A, 13A, 13A'): 5 somites plus a triangular telson; somite 2 with a long dorsal spine posteriorly; somite 3–5 with 9 or 11 dorsal denticules; each somite without lateral spine. Telson with a median and a pair of the outermost unarticulated processes and 5 + 5 articulated processes posteriorly; the outermost process 1 with inner spinules; process 2, so-called ‘anomuran hair’, reduced to a thin plumose seta, situated between processes 1 and 3, and about 2/3 of process 1 length (occasionally equal in length); processes 3–7 with plumose setae. Posterior margin of telson bearing numerous plate-like spinules. Anal spine not recognizable.

PLEOPODS: Not developed.

UROPOD: Not developed.

Zoea 2

CARAPACE (Figs. 1B, 2B): Eyes now stalked; rostral spine flattened, denticulated laterally, with subterminal setules (Fig. 2B'): anterodorsal carina evident.

ANTENNULE (Fig. 3B): Protopod with 4 aesthetascs and a thin seta terminally; a long subterminal plumose seta also present.

ANTENNA (Fig. 4B): Exopod with 10 inner plumose setae, of which distal seta simple and much smaller than the remainder; endopod unchanged.

MANDIBLES (Fig. 5A): Larger, but generally as in zoea 1.

MAXILLULE (Fig. 6B): Basal endite with 5 stout serrated spines and 3 setae; setation of coxal endite and endopod unchanged.

MAXILLA (Fig. 7B): Coxal endite with 10–13 setae on proximal lobe, and 4 setae on distal lobe; basal endite bearing 7–8 and 6–7 setae on each lobe; endopod setation as in zoea 1; scaphognathite with 7 marginal plumose setae and a long posterior plumose seta.
Fig. 3 Callianassa petalura Stimpson. A–G, antennule of zoea 1–6 and decapodid. Scale bar = 0.1 mm.
MAXILLIPED 1 (Fig. 8B): Exopod bearing 5 natatory setae, but otherwise unchanged from zoea 1.

MAXILLIPED 2 (Fig. 9B): Endopod with 2+1, 2, 2, 4+1 setae; exopod as in maxilliped 1. No other unchanged.

MAXILLIPED 3 (Fig. 10B): Endopod with 0, 2+1, 3+1 setae; exopod as in zoea 1 stage.

Fig. 4 Callianassa petalura Stimpson. A–G, antenna of zoea 1–6 and decapodid. Scale bar = 0.1 mm.
PEREIOPODS 1–2 (Figs. 11A, 11F): Biramous bud.
PEREIOPODS 3–5: Not recognizable.
ABDOMEN (Figs. 1B, 13B): Telson with a pair of additional posterior articulated processes beside median process.
PLEOPODS: Not developed.
UROPOD: Not developed.

Zoea 3

CARAPACE (Figs. 1C, 2C): No remarkable changes.
ANTENNULE (Fig. 3C): Biramous; coxa with a simple distal seta; basis with 2 long plumose setae distally; exopod with 5 aesthetascs and a thin seta; endopod with a long apical plumose seta.
ANTENNA (Fig. 4C): Coxa and basis incompletely separated; endopod setation unchanged, but occasionally lacking distal plumose seta as shown in figure; exopod with 11 inner plumose setae and a short distal simple seta.
MANDIBLES (Fig. 5B): No remarkable change.
MAXILLULE (Fig. 6C): Coxal endite with 9–10 setae; basial endite with 7 stout spines and 4 setae; endopod unchanged.
MAXILLA (Fig. 7C): Coxal endite with 12 and 4 setae on each lobe; proximal and distal lobes of basial endite with 8 and 7 setae, respectively; scaphognathite with 11 soft plumose setae and a long posterior plumose process.
MAXILLIPED 1 (Fig. 8C): Setal groups in coxa and basis not clear unlike the previous stages; coxa with 8 setae; basis with 17 setae; setation of endopod 3+1, 2, 2, 3+1; exopod unchanged.
MAXILLIPED 2 (Fig. 9C): Endopod setation 2+1, 2, 2+1, 4+1; exopod as in maxilliped 1.
MAXILLIPED 3 (Fig. 10C): Endopod 4-segmented, with 0, 1+1, 2, 3+1 setae; exopod unchanged.

PEREIOPOD 1 (Fig. 11B): Coxa without setae; basis bearing a distal seta; endopod unsegmented with 2 terminal and a subterminal setae; exopod with 5 natatory setae distally.
PEREIOPOD 2 (Fig. 11G): Coxa and basis with no setae; endopod unsegmented with 2 terminal and a subterminal setae; exopod as in pereiopod 1.
PEREIOPODS 3–4 (Figs. 12A, 12F): Biramous bud.
PEREIOPOD 5 (Fig. 12K): Uniramous bud.
ABDOMEN (Figs. 1C, 13C): Abdominal somite 6 separated from telson, bearing uropods. Telson elongated trapezoid from, with a median and eight pairs of posterior processes as in zoea 2 stage, but processes 1, 3 and 4 spinulose.
PLEOPODS: Not recognizable at this stage.
UROPOD (Fig. 13C): Biramous; endopod without setae; exopod with 7 marginal plumose setae.

Zoea 4

CARAPACE (Figs. 1D, 2D): No remarkable changes.
ANTENNULE (Fig. 3D): Coxa with a short seta and a distal plumose seta; basis with 4 plumose
and 4–5 short setae distally; exopod with 5–6 aesthetascs and a seta; endopod with a distal plumose seta and a minute seta.

ANTENNA (Fig. 4D): Endopod elongated with a fine seta near tip; exopod with 13–14 inner plumose setae, and an outer short seta.

MANDIBLES (Fig. 5C): Palp recognizable as rudimentary buds.

MAXILLULE (Fig. 6D): Coxal endite with 11–12 setae; basial endite with 8 stout spines and 4 setae; endopod unchanged.

MAXILLA (Fig. 7D): Coxal endite with 15–16 and 5 setae on each lobe; proximal and distal lobes of basial endite with 7 and 8–9 setae, respectively; scaphognathite with 14–15 soft plumose setae and a long posterior plumose process.

MAXILLIPED 1 (Fig. 8D): Coxa with 8 setae; basis with 18–20 setae; setation of endopod 3+1, 2, 2(3), 3+1; exopod with 5 natatory setae.

MAXILLIPED 2 (Fig. 9D): Endopod 5-segmented with 2+1, 2+1, 1, 2, 4(3)+1 setae; exopod as in maxilliped 1.

MAXILLIPED 3 (Fig. 10D): Endopod setation 2+1, 1+1, 2, 4+1; exopod as in the previous stage.

PEREIOPOD 1 (Fig. 11C): Coxa with a short seta; basis with 2 distal setae; endopod subchelate, 4-segmented with 0, 2, 2, 2+1 setae; exopod with 5 natatory setae distally.

Fig. 5 *Callianassa petalura* Stimpson. A–E, mandibles of zoea 2–5 and decapodid. Scale bar = 0.1 mm.
PERIOPOD 2 (Fig. 11H): Coxa without seta; basis with a seta; endopod 4-segmented with 0, 2, 2, 2+1 setae, forming subchelate shape; exopod as in pereiopod 1.

PERIOPOD 3 (Fig. 12B): Biramous; coxa and basis without seta; endopod 4-segmented with 2 terminal and a subterminal setae; exopod with 4 natatory setae.

PERIOPOD 4 (Fig. 12G): Biramous; coxa and basis with no seta; endopod unsegmented with 2 terminal setae; exopod as in pereiopod 3.

PERIOPOD 5 (Fig. 12L): Uniramous, incompletely 7-segmented, with 2 terminal setae on distal segment.
Fig. 7 *Callianassa petalura* Stimpson. A–F, maxilla of zoea 1–5 and decapodid. Endites and endopod are omitted in zoea 2–5. Scale bar = 0.1 mm.
ABDOMEN (Figs. 1D, 13D): Rudimentary buds of pleopod recognizable; the process 2 of telson stout from; spine evident.

PLEOPODS: Not recognizable at this stage.

UROPOD (Fig. 13D): Endopod with 7 seta and exopod with 11 marginal plumose setae.

Fig. 8 Callianassa petalura Stimpson. A–G, maxilliped 1 of zoea 1–6 and decapodid. Exopod is omitted in zoea 2–6. Scale bar = 0.1 mm.
**Zoea 5**

CARAPACE (Figs. 1E, 2E): No remarkable changes.

ANTENNULE (Fig. 3E): Coxa with 4 setae and a long distal plumose seta; basis with 4 long plumose, and 4–5 short setae distally; endopod with a long distal plumose seta and 2 setules; exopod with 6 terminal, and a subterminal aesthetascs, and a short seta subterminally.

ANTENNA (Fig. 4E): Endopod more elongated with 2 terminal setules; exopod with 13–14 inner and an outer setae.

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**Fig. 9** *Callianassa petalura* Stimpson. A–G, maxilliped 2 of zoea 1–6 and decapodid. Exopod is omitted in zoea 2–6. Scale bar = 0.1 mm.
MANDIBLES (Fig. 5D): Bud of palp elongated.

MAXILLULE (Fig. 6E): Coxal endite with 13 setae; basial endite with 8 short spines and 5 setae; setation of endopod unchanged.

MAXILLA (Fig. 7E): Coxal endite with 14 and 5 setae on each lobe; proximal and distal lobes of

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**Fig. 10** *Callianassa petalura* Stimpson. A–G, maxilliped 3 of zoea 1–6 and decapodid. Exopod is omitted in zoea 2–6. Scale bar = 0.1 mm.
basial endite with 9 and 10 setae, respectively; scaphognathite with 16–17 soft plumose setae and a long posterior plumose process.

MAXILLIPED 1 (Fig. 8E): No remarkable changes.

Fig. 11  *Callianassa petalura* Stimpson.  A–E, pereiopod 1 of zoea 2–4, 6 and decapodid; F–J, pereiopod 2 of zoea 2–4, 6 and decapodid.  Scale bar = 0.1 mm.
Fig. 12  *Callianassa petalura* Stimpson.  A–E, pereiopod 3 of zoea 3–6 and decapodid; F–J, pereiopod 4 of zoea 3–6 and decapodid; K–O, pereiopod 5 of zoea 3–6 and decapodid.  Scale bar = 0.1 mm.
MAXILLIPED 2 (Fig. 9E): Endopod setation 2+I, 2+I, I, 2+I, 5+I; otherwise no remarkable changes.

MAXILLIPED 3 (Fig. 10E): Coxa and basis with a short seta; endopod with 2+I, 1+I, 2+I, 4+I setae.

PEREIOPOD 1: Endopod setation 1, 3, 5, 2+I.

PEREIOPOD 2: Endopod setation 0, 2, 3, 2+I.

PEREIOPOD 3 (Fig. 12C): Endopod 4-segmented with 0, 2, 2, 2 setae; exopod with 5 natatory setae distally.

PEREIOPOD 4 (Fig. 12H): Endopod 4-segmented with 0, 2, 2, 2 setae; exopod as in pereiopod 3.

PEREIOPOD 5 (Fig. 12M): Penultimate segment with a distal seta; ultimate with 2 terminal seta.

ABDOMEN (Figs. 1E, 13E): A dorsoposterior spine remarkable in somite 6.

PLEOPODS: Bud emerged.

UROPODS (Fig. 13E): Endopod and exopod with 9 and 13 marginal setae, respectively.

Zoea 6

CARAPACE (Figs. 1F, 2F): No remarkable change.

ANTENNULE (Fig. 3F): Coxa with a proximal seta and long distal plumose setae, 4–5 short setae also found; basis with 6 long plumose seta and 4 short setae; exopod with 7 terminal and 2 subterminal aesthetasc.

ANTENNA (Fig. 4F): Endopod more elongated; exopod with 15 inner and a outer setae.

MANDIBLES: No remarkable changes.

MAXILLULE: Coxal endite with 14 setae; basial endite and endopod with no remarkable changes.

MAXILLA: Scaphognathite with 19 soft plumose setae and a long posterior plumose seta. Otherwise no remarkable changes.

MAXILLIPED 1 (Fig. 8F): No remarkable changes.

MAXILLIPED 2 (Fig. 9F): Unchanged from the previous stage.

MAXILLIPED 3 (Fig. 10F): Endopod setation 6+I, 1+I, 3+I, 5+I.

PEREIOPOD 1 (Fig. 11D): Endopod chelate shape, and larger than exopod with 3, 2, 5, 2 setae.

PEREIOPOD 2 (Fig. 11I): Coxa with a seta; endopod chelate shape, with 3, 2, 3, 2 setae.

PEREIOPOD 3 (Fig. 12D): Basis with a distal short seta; endopod setation 0, 1+I, 2, 2.

PEREIOPOD 4 (Fig. 12I): No remarkable changes.

PEREIOPOD 5 (Fig. 12N): Penultimate segment with 3 distal and a subdistal setae.

ABDOMEN (Figs. 1F, 13F): Anal spine elongated.

PLEOPODS: Buds more elongated.

UROPODS (Fig. 13F): Endopod with 13–14 setae; exopod bearing 14–15 setae.

Decapodid

CARAPACE (Figs. 1G, 2G): Rostral spine reduced, with setose blunt end; *linea thalassinica* obscure at this stage.

ANTENNULE (Fig. 3G): Peduncle 3-segmented, proximal segment with 4 simple setae, and 12–
Fig. 13 *Callianassa petalura* Stimpson. A–G, telson of zoea 1–6 and decapodid from dorsal (A–B, E, G) and ventral (C–D, F) view; A', distal part of telson of zoea 1, enlarged. Scale bar = 0.5 mm.
15 setae on penultimate segment, and distal segment bearing 12–14 short terminal setae; inner flagellum (=endopod) slender, 5-segmented, with 0, 3, 2+1, 2+1, 3 setae, respectively; outer flagellum (=exopod) 4-segmented, with 4 aesthetasc and 8 subterminal setae on distal segment.

ANTENNA (Fig. 4G): Peduncle 3-segmented; flagellum composed of 24–25 segments; distal segment with 3 terminal setae; rudimentary exopod observed on the proximal peduncular segment.

MANDIBLES (Fig. 5E): Incisor and molar processes distinct; basal part with a proximal seta; palp 3-segmented with 10–11 short spinules or setae on distal segment, but segmentation between proximal and penultimate segment inconspicuous; penultimate segment of palp with 2 long setae.

MAXILLULAE (Fig. 6F): Coxal and basial endites spatulated, providing numerous spines and setae; endopod unilobed, with 2 subterminal setae; outer side of proximal portion with a seta.

MAXILLA (Fig. 7F): Proximal and distal lobes of endites flattened, with numerous setae; endopod reduced, 2-segmented with 2 distal setae on each segment; scaphognathite with 39–41 soft plumose marginal setae.

MAXILLIPED 1 (Fig. 8G): Coxal and basial endite with 8 and 19–24 setae, respectively; endopod simply unsegmented without setae; exopod with 11 plumose setae on outer side; epipod roughly triangular.

MAXILLIPED 2 (Fig. 9G): Endopod 4-segmented with numerous setae on proximal, 2 long setae on penultimate, and numerous setae on distal segment, respectively; exopod unsegmented, with 6–8 terminal setae.

MAXILLIPED 3 (Fig. 10G): Coxa with a seta; basis with 2 setae; 4-segmented endopod with numerous long setae.

PEREIOPOD 1 (Fig. 11E): Chelate and setose as in adult form; exopod reduced, lacking setae.
PEREIOPOD 2 (Fig. 11J): Similar to pereiopod 1, but exopod rudimental with 4 terminal setae.

PEREIOPOD 3 (Fig. 12E): Uniramous; endopod 5-segmented with numerous setae, penultimate segment with a short stout spine distally.

PEREIOPOD 4 (Fig. 12): Uniramous; endopod 5-segmented with numerous setae, penultimate segment with a subterminal stout spine.

PEREIOPOD 5 (Fig. 12O): Each segment with numerous setae; penultimate segment with a distal strongly curved spine.

ABDOMEN (Figs. 1G, 13G): 5 somites and a quadrate telson; each somite with well-developed pleopods; margin of telson bearing 18–20 posterior spines and many short setae on dorsal surface.

PLEOPODS (Figs. 14A, 14B, 14C): Biramous on somite 3–5; inner margin of protopod, endopod and exopod with 8–10, 21–23 and 34–35 long plumose setae, respectively; appendix interna of endopod (= stylamblys) bearing 4–5 distal hooks (Fig. 14D).

UROPOD (Fig. 13G): Endopod providing a spine, and 18 plumose and 8–9 simple setae marginally; exopod with a short spine, and 31–34 plumose and 20–21 simple setae on its margin.

Discussion

Laboratory-rearing of the callianassid larvae is difficult because of unusual high mortality of zoeas caused by adhesion to water surface as found in rhizocephalan nauplius larvae (cf. Yanagimachi, 1961): we observed that in non-circulating water condition, most of newly-hatched zoea 1, which show intensive phototaxis, were left floating on the surface of water and eventually died within a few hours. It seems that some physical nature of larval cuticle such as the strong water-repellent surface, together with their strongly active swimming behaviour, brings this fatal adhesion. This property is remarkable in zoea 1–2 larvae, but weak in the successive stages; later zoeal larvae were rarely trapped by the water surface. Sankolli and Shenoy (1975) also noted this floating condition of larvae in other callianassids of the genus Callichirus. Biological significance of their repellent cuticle is unclear, but apparently the callianassid

Table 2. Rearing data and dimensions of Callianassa petalura Stimpson larvae (water temperature = 22–28°C)

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<th>Stage</th>
<th>Days after hatching</th>
<th>Duration (days)</th>
<th>CL (mm) range</th>
<th>CL (mm) mean</th>
<th>CL growth (CL&lt;sub&gt;n&lt;/sub&gt;/CL&lt;sub&gt;n-1&lt;/sub&gt;)</th>
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<tr>
<td>Zoea 1</td>
<td>—</td>
<td>3–4</td>
<td>1.21–1.26</td>
<td>1.24</td>
<td>—</td>
</tr>
<tr>
<td>Zoea 1*</td>
<td>—</td>
<td>—</td>
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<td>1.11</td>
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</tr>
<tr>
<td>Zoea 2</td>
<td>3–4</td>
<td>2–3</td>
<td>1.33–1.46</td>
<td>1.38</td>
<td>1.11</td>
</tr>
<tr>
<td>Zoea 3</td>
<td>5–6</td>
<td>1–2</td>
<td>1.68–1.86</td>
<td>1.76</td>
<td>1.27</td>
</tr>
<tr>
<td>Zoea 4</td>
<td>6–7</td>
<td>2–3</td>
<td>2.04–2.30</td>
<td>2.20</td>
<td>1.25</td>
</tr>
<tr>
<td>Zoea 5</td>
<td>8–9</td>
<td>2–3</td>
<td>2.35–2.48</td>
<td>2.41</td>
<td>1.09</td>
</tr>
<tr>
<td>Zoea 6</td>
<td>10–11</td>
<td>3–4</td>
<td>2.55–2.77</td>
<td>2.67</td>
<td>1.11</td>
</tr>
<tr>
<td>Decapodid</td>
<td>15–16</td>
<td>—</td>
<td>1.47–1.54</td>
<td>1.50</td>
<td>—</td>
</tr>
</tbody>
</table>

* material from Kikonai, Hokkaido, CL: carapace length
zoeas avoid the fatal adhesion in natural condition. In the present study, continuous water agitation by
gentle aeration reduced capturing by the water surface.

Little detailed information on larvae of callianassids, especially in later developmental stages has been
published, including plankton studies (e.g. Lebour, 1938; Kurata, 1965; Sandifer, 1973). Heegaard
(1963) reared zoea 1–2 of C. stebbingi Borradaile under laboratory conditions, but no later stages were
obtained. In previous larval works on Callianassa species, only one successful case of complete larval
development has been reported: Aste and Retamal (1983) described 5 zoeal and a decapodid stages in C. 
garthi Retamal. Forbes (1973) also reared C. kraussi Stebb, but gave no morphological descriptions.

Previous studies (e.g. Hailstone and Stephenson, 1961; Aste and Retamal, 1983, 1984) have shown
that the larval period of Callianassa is more than one month. Hailstone and Stephenson (1961) reported
that C. australiensis spend 4–5 months in the plankton. Under laboratory condition, the total larval
duration of C. petalura and C. garthi are 15–16 and 48 days respectively, although morphology of the
latter shows some feature of abbreviated development such as the setation of maxillar scaphognathite and
the telsonal processes. The instar number of C. garthi (=5) is also smaller than of C. petalura (=6).
Another example of zoal development of Callianassa was studied in C. uncinata Milne-Edwards (Aste
and Retamal, 1984), of which zoal features are similar to those of the present species: it took 32 days at
17–20°C from hatching to zoea 5. As shown in Table 2, duration of zoea 1–5 ranges 1–4 days in C. 
petalura, while that of C. garthi is 8–9 days. Although it is possible that this difference derived from the
lower water temperature, 17–20°C, in culture of those two Chilean species, the development of C. 
petalura is the shortest among previously known examples of Callianassa larvae in laboratory-cultured
condition, except the abbreviated development found in C. kraussi (Forbes, 1973) which passed larval
phase within 3–5 days at 20°C. The growth rate of CL in successive instars, i.e. CLn/CLn−1 shown in
Table 2, is the highest at the second mouling, and then gradually reduces from zoea 3 through the
decapodid stage. This tendency is also recognized in C. garthi and C. uncinata.

We could not distinguish the two batches of zoal specimens from different locality by morphological
characters except their dimensions (Table 2). The setations of maxillular and maxillar endopods are
stable characters during larval development. It is conspicuous feature that the pleopodal endopod, 
 already in decapodid stage, bears appendix interna normally; this small projection is also figured in Aste 
and Retamal’s paper (1983) and described in Callichirus (Sankolli and Shenoy, 1975). In other known
decapodids of the thalassinid families, pleopod of the family Axiidae exhibits this structure (Kurata, 1965),
while that of the families Upogebiidae and Laomediidae are lacking (Shenoy, 1967; Ngoc-Ho, 1977; Goy
and Provenzano, 1979; Andryszak, 1986; Konishi, 1989). In this respect callianassid and axiid decapos-
dids resemble each other as pointed out by Gurney (1942).

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スナモグリ（甲殻綱：アナジャコ下目：スナモグリ科）の人工飼育による全幼生期の記載

小西光一・ロドルフォ・クィンタナ, R・福田 靖

*Callianassa* 属に代表されるスナモグリ類は干潟砂泥域のベントスとして生態学上重要な位置を占め、釣り餌としても重要であるが、その初期生活史は不明な点が多い。この生活史研究の基礎となる幼生発生に関して、変態完了までの幼生期を完全に把握したのは今までの所チリ産の *C. garthi* での1例のみで極めて少ない。これは主として初期ソエア幼生の飼育の難しさによるものである。本邦のスナモグリ科は3属9種が知られているが、全幼生期の記載報告はまだない。本研究においては本邦に広く分布するスナモグリ *C. petalura* の全幼生期を人工飼育により得て、その形態を中心とした記載を行った。

本種は水深22〜28℃の条件で孵化後15〜16日でデカポディッドに変態する。この幼生期間はそれぞれの鰭期の長さも含め、本科の既知例の中では短縮型発生の種を除いて最も短い。デカポディッドは腹肢内肢に内部付属葉（appendix interna）をすぐに有しており、この点でアナジャコ下目ではアナエビ科のものに最も近い。