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First stage zoeal descriptions of five Galatheoidea species from Western Pacific (Crustacea: Decapoda: Anomura)

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Abstract

The first zoeal stages of the galatheids *Neonida grandis*, *Agononida squamosa* and *Munida javieri*, and the chirostylids *Eumunida annulosa* and *E. capillata* are described and illustrated from laboratory-hatched material obtained from ovigerous females collected from south western Pacific. The morphologies of the first zoeae are compared with the same larval stage of other known anomuran species. The larval characters of *Agononida squamosa* and *Neonida grandis* are similar to those described for *Agononida incerta*. *Munida javieri* exhibits features not present in other described species of *Munida* such as the setation of the endopod of the maxillule and the antennal morphology. *Eumunida annulosa* and *E. capillata* do not show abbreviated development as in other described chirostylids such as *Uroptychus* and *Gastroptychus*, and its larval morphology is equivalent to the first stage of galatheid zoeae. However, many morphological characters of *Eumunida* species are typically pagurid, such as the two terminal plumose setae of the antennal endopod, the three-segmented endopod of the maxillule, the posterior margin of the carapace without spines, and the scaphognathite with 5 plumose setae and without a posterior lobe.

Key words: Anomura, Galatheoidea, Galatheidae, Chyrostilidae, *Neonida*, *Agononida*, *Munida*, *Eumunida*, first stage zoea, descriptions

Introduction

The Galatheoidea Samouelle, 1819 includes five families of anomuran decapod crustaceans: Aeglidae Dana, 1852; Galatheidae Samouelle, 1819; Chirostylidae Ortmann, 1892; Kiwaidae Macpherson *et al.* 2005 and Porcellanidae Haworth, 1825 (Martin & Davis 2001, Macpherson *et al.* 2005). The Galatheidae is one of the most diverse families of anomuran decapods and many undescribed species have been discovered in the last decades (Baba 1988, 2005, Macpherson 1994, 2004, Ahyong & Poore 2004b, Macpherson & Segonzac 2005). The systematics of the family has not been fully resolved and many groups of galatheids are undergoing revision (Baba & de Saint Laurent 1996, Machordom & Macpherson 2004). Additionally, knowledge of the larval stages of Galatheoidae is scarce. The percentage of available larval descriptions in galatheid genera is about 22%, and the percentage of the species is lower than 4% (Konishi & Saito 2000, Fujita & Shokita 2005). At present, the first stage zoea morphology of galatheids is known for *Agononida* Baba & de Saint Laurent, 1996 (1 species); *Munida* Leach, 1820 (3 species); *Galathea* Fabricius, 1793 (4 species); *Cervimunida* Benedict, 1902 (1 species); *Pleuroncodes* Stimpson, 1860 (2 species); *Munidopsis* Whiteaves, 1874 (2 species) and *Sadayoshia* Baba, 1969 (1 species) (Huus 1934, Fagetti 1960, Fagetti & Campodonico 1971, Samuelsen 1972, Roberts 1973, Gore 1979, Christiansen & Anger 1990, Wilkens *et al.* 1990, Konishi & Saito 2000, Fujita *et al.* 2001, Fujita *et al.* 2003, Fujita & Shokita 2005).

Chirostylidae typically occupy outer shelf and slope habitats. From numerous expeditions across the western Pacific, many unknown species of chirostylids have been

discovered in the last 20 years (de Saint Laurent & Macpherson 1990, de Saint Laurent & Poupin 1996, Baba 2004, Ahyong & Poore 2004a). Furthermore, the knowledge on the larval stages of Chirostylidae is even scarcer than in the Galatheidae. Pike & Wear (1969) described newly hatched first larval stages of *Gastroptychus* Caullery, 1896 and *Uroptychus* Henderson, 1888, and Ogawa & Matsuzaki (1992) described the first zoeal stage of *Chirostylus dolichopus* Ortmann, 1892. De Saint Laurent and Macpherson (1990) described the general aspect of the first zoea of *Eumunida capillata* de Saint Laurent & Macpherson, 1990 and the megalopa of *Eumunida sternomaculata* de Saint Laurent & Macpherson, 1990, *E. capillata* and *E. annulosa* de Saint Laurent & Macpherson, 1990. The complete larval development is unknown for any species of the family.

The reason for the limited information on larvae of galatheids and especially chirostylids may be due to the difficulty in obtaining ovigerous females from the deep-sea. However, during recent cruises carried out in New Caledonia and Vanuatu islands, some ovigerous females of *Agononida squamosa* (Henderson, 1885), *Munida javieri* Macpherson, 1994, *Neonida grandis* Baba & de Saint Laurent, 1996, *Eumunida annulosa* de Saint Laurent & Macpherson, 1990 and *E. capillata* de Saint Laurent & Macpherson, 1990 were collected and maintained in aquaria in order to obtain newly hatched larvae. The galatheid *Neonida grandis* is the only species of the genus, it is closely related to *Bathymunida* Balss, 1914 (Baba & de Saint Laurent 1996) and is a rare species reported from the Vanuatu and Solomon Islands at depths between 135 and 402 m (Baba & de Saint Laurent 1996, Macpherson & Baba 2006). *Agononida squamosa* is recorded along the western Pacific from Japan to New South Wales, Australia, including numerous islands (e.g., Admiralty, New Caledonia, Loyalty islands, Vanuatu, Wallis, Fiji, Tonga) at depths of 156–591 m (Macpherson 2004, Baba 2005). *Munida javieri* is recorded from New Caledonia, Chesterfield Island, Matthew and Hunter Island, at depths of 280–440 m (Macpherson 1994).

The chirostylids *Eumunida annulosa* and *E. capillata* are deep-sea species commonly found in New Caledonia and the Chesterfield Islands, and other localities of the western Pacific (de Saint Laurent & Macpherson 1990, Baba 2005). These species occur on the bottom of Stylasteridae hydrocorallians at depths of around 375–650 m for *E. annulosa* and 356–650 m for *E. capillata*.

The present study aims to describe the first zoeal stage morphology of *Neonida grandis*, *Agononida squamosa*, *Munida javieri*, *Eumunida annulosa* and *E. capillata* and to compare their larval features with those known for other species of Galatheoidea. This represents the first description of the zoea of the genus *Neonida*, the second description for *Agononida*, the fourth description for *Munida*, and the first complete description of the first zoea of the genus *Eumunida* Smith, 1883.

Abbreviations used: The Biological Reference Collection, Institut de Ciències del Mar Barcelona = CSIC; Muséum national d'Histoire naturelle, Paris = MNHN.

Material and methods

Ovigerous females of *Neonida grandis*, *Agononida squamosa*, *Munida javieri*, *Eumunida annulosa* and *E. capillata* were collected during cruises NORFOLK 2 and BOA 1 carried out in New Caledonia and Vanuatu islands, respectively.

Neonida grandis: BOA 1. Stn CP 2479, 16º43.25'S, 167º50.86'E, 350–358 m, 15.09.2005, MNHN reg. no. MNHN-Ga5395.

Agononida squamosa: BOA 1. Stn CP 2479, 16º43.25'S, 167º50.86'E, 350–358 m, 15.09.2005.

Munida javieri: NORFOLK 2. Stn CP 2094, 24°44.19'S, 168°09.76'E, 300 m, 29.10.2003, MNHN reg no. MNHN-Ga5396.

Eumunida annulosa: NORFOLK 2. Stn CP 2089, 24°44.30'S, 168°08.83'E, 230 m, 29.10.2003, MNHN reg no. MNHN-Ga5397, CSIC reg. no. ICMD 4/2006 (first zoea).

Eumunida capillata: NORFOLK 2. Stn CP 2089, 24°44.30'S, 168°08.83'E, 230 m, 29.10.2003, MNHN reg. no. MNHN-Ga5398, CSIC reg. no. ICMD 5/2006 (first zoea).

The females were maintained in aquaria containing natural, cooled, sea water until the eggs hatched. Newly hatched larvae were preserved in 70% alcohol. All *Agononida squamosa* zoeae and some of *Neonida grandis* did not completely extrude setae and spines, and most material showed intermediate characters between prezoea and zoea stages. However, was been possible to study the more important setation features.

A binocular microscope equipped with an ocular micrometer was used for the measurements of individuals (2–4 individuals were measured). A microscope was used for the determination of the setal formula. The zoeas were dissected on glass slides in polyvinyl alcohol using a Wild M8 binocular microscope and the appendages allowed to clear for 24 hours before examination. Cover-slips were sealed with clear nail varnish. Appendages were drawn using an Olympus BH-2 microscope equipped with differential interference contrast (DIC) and a camera lucida.

The following measurements were taken for *Neonida grandis*, *Agononida squamosa* and *Munida javieri*: Carapace length (CL) from the anterior margin of the eyes to the mid-dorsal posterior margin of the carapace; carapace length including rostral spine (CLR) from the tip of the rostral spine to the mid-dorsal posterior margin of the carapace; total length (TL) from the tip of the rostral spine to the posterior margin of the telson, excluding telsonal processes; eye length (EL) length to the longest axis of the eye. The following measurements were taken for *Eumunida* species: carapace length (CL) from the anterior margin of the eyes to the posterior margin of the carapace; carapace length including rostral spine (CLR) from the tip of the rostral spine to the posterior margin of the carapace; total length (TL) from the tip of the rostral spine to the posterior margin of the telson; eye length (EL) length to the longest axis of the eye.

The sequence of zoeal descriptions is based on the malacostracan somite plan and described from anterior to posterior. Setal armature of appendages was described from proximal to distal segments and in order of endopod to exopod (see Clark et al. 1998). The

long antennular aesthetascs and the long plumose natatory setae of the first and second maxillipeds were drawn truncated. Setal terminology follows Ingle (1991).

Description of first zoea

Galatheidae Samouelle, 1819

Neonida grandis Baba & de Saint Laurent, 1996
(Figs 1–4)

Size: CL= 0.76 mm; CLR= 1.62 mm; TL= 2.92 mm; EL= 0.67 mm.

Carapace (Figs. 1A,B). Typical galatheid larval form; without setae; rostrum elongated, extending beyond antennule, surface with spinules; acute spines posteriorly, posterodorsal margin with 17 or 18 teeth and posteroventral margin with 14 or 15 teeth; eyes sessile and long, EL more than 3/4 of CL.

Antennule (Fig. 1C). Uniramous, endopod absent, with 3 aesthetascs and 3 setae terminally, 1 long subterminal plumose setae.

Antenna (Fig. 1D). Biramous; protopod with 1 spinose process with 2 rows of spinules, shorter than endopod (about 32% length of exopod); endopod unsegmented, without setae and with sparsely spines (about 52% length of exopod); exopod (scaphocerite) ending in long and robust process covered with spinules, inner margin with 8 plumose setae and 1 simple seta.

Mandible (Fig. 2A). Left and right mandibles asymmetric well developed molar processes strongly spinose; palp absent.

Maxillule (Fig. 2B). Coxal endite with 7 sparsely plumose setae; basial endite with 5 setae (2 strong prominent cuspidate setae with 3–7 denticles and 3 plumodenticulate setae); endopod 2-segmented with 5 setae on distal segment (1 subterminal simple seta + 3 plumodenticulate and 1 simple terminal setae).

Maxilla (Fig. 2C). Coxal endite bilobed with 8+4 sparsely plumose setae; basial endite bilobed with 5+4 plumodenticulate setae; endopod unsegmented, bilobed, with 3 (1 minute simple and 2 long plumodenticulate) + 4 setae and mat of microtrichia in inner and outer margin; exopod (scaphognathite) with 4 marginal plumose setae and 1 long posterior plumose process.

First maxilliped (Fig. 3A). Coxa with 2 simple setae; basis with 11 sparsely plumose setae (2,3,3,3) on ventral margin; endopod 5-segmented with 3,2,1,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 long terminal plumose setae.

Second maxilliped (Fig. 3B). Coxa without setae; basis with 3 sparsely plumose setae (1,2) on anteroventral margin; endopod 4-segmented with 2,2,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 long terminal plumose setae.

Third maxilliped (Fig. 3C). Small unsegmented bud.

Pereiopods. Absent.

Abdomen (Figs. 4A, B). Five somites plus telson; somites 4 and 5 with posterolateral processes; somites 2–5 with pair of posterodorsal setae and without denticles or teeth on posterodorsal margin; pleopods absent.

Telson (Figs. 4A, C). Forked with median cleft; with 7+7 processes, first (lateralmost) non-movable long spine covered with spinules (longer than plumose setae), second short plumose seta (anomuran hair), third to seventh bearing long, stout plumose setae and minute spinules.

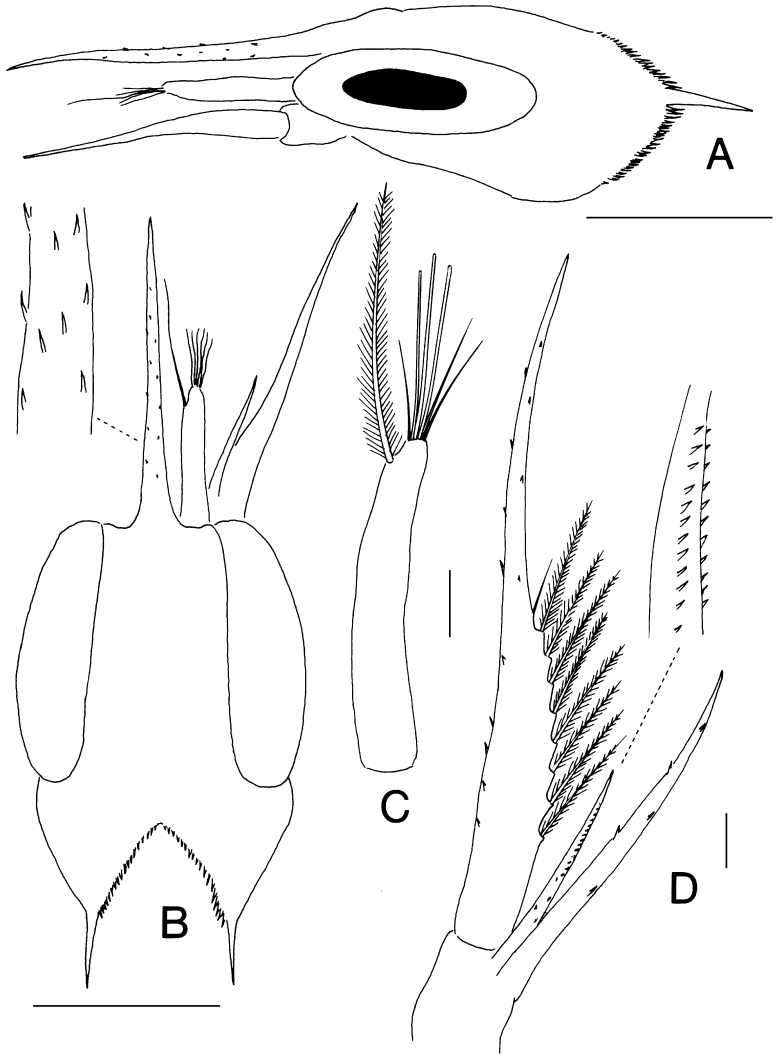

FIGURE 1. *Neonida grandis* Baba and de Saint Laurent, 1996, first zoea. A, lateral view; B, dorsal view; C, antennule; D, antenna. Scale bar of A and B = 0.5 mm; scale bar of C and D= 0.1 mm.

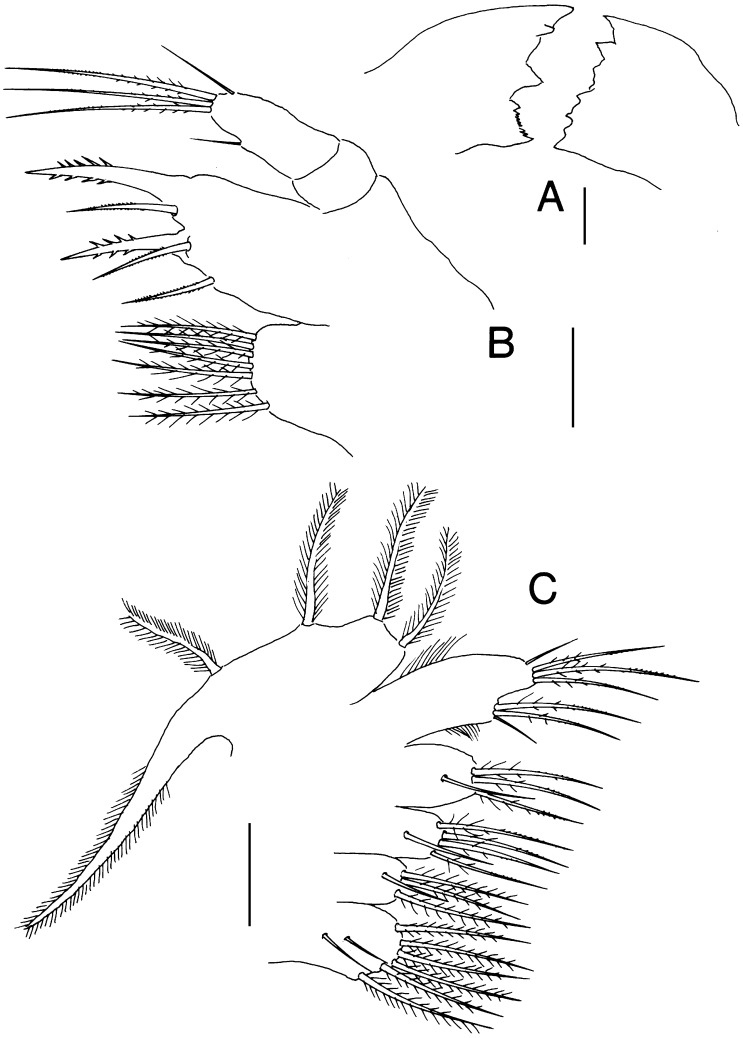

FIGURE 2. *Neonida grandis* Baba and de Saint Laurent, 1996, first zoea. A, mandibles; B maxillule; C, maxilla. Scale bar = 0.1 mm.

Agononida squamosa **(Henderson, 1885)**
(Figs 5–6)

Size: CL= 0.75 mm; EL= 0.60 mm.

Carapace (Figs. 5A,B). Typical galatheid larval form; without setae; rostrum elongated, surface with spinules; acute spines posteriorly, posterodorsal margin with 15 or 16 teeth and posteroventral margin with 17 or 18 teeth; eyes sessile and long, the EL more than 1/2 of CL.

Antennule (Fig. 5C). Uniramous, endopod absent, with 6 setae terminally (not completely extruded) and 1 long subterminal plumose setae.

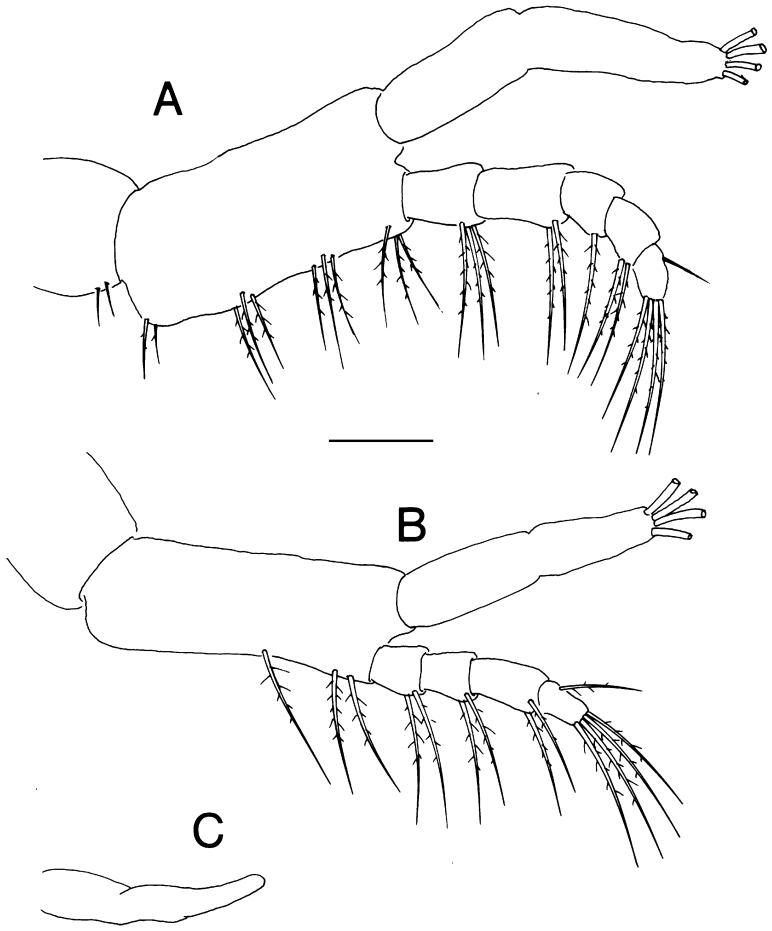

FIGURE 3. *Neonida grandis* Baba and de Saint Laurent, 1996, first zoea. A, 1st maxilliped; B, 2nd maxilliped; C, 3rd maxilliped . Scale bar = 0.1 mm.

Antenna (Fig. 5D). Biramous; protopod with 1 spinose process with 2 rows of spinules, probably shorter than endopod; endopod unsegmented, without setae and with sparse spines; exopod (scaphocerite) ending in process not completely extruded in any examined individuals, inner margin with 8 plumose setae and 1 simple seta.

Mandible. Similar to *Neonida grandis*, left and right mandibles developed molar processes strongly spinose; palp absent.

Maxillule (Fig. 5E). Setae not completely extruded, but clearly observable. Coxal endite with 7 sparsely plumose setae; basial endite with 5 setae (2 strong prominent cuspidate setae); endopod 2-segmented with 5 setae on distal segment (1 subterminal simple seta + 4 terminal setae).

Maxilla (Fig. 6A). Setae not completely extruded, but clearly observable. Coxal endite bilobed with 8+4 setae; basial endite bilobed with 5+4 setae; endopod unsegmented,

bilobed, with 3 +4 setae and mat of microtrichia in outer margin; exopod (scaphognathite) lobe developed anteriorly only and with 4 marginal plumose seta and 1 long posterior plumose process.

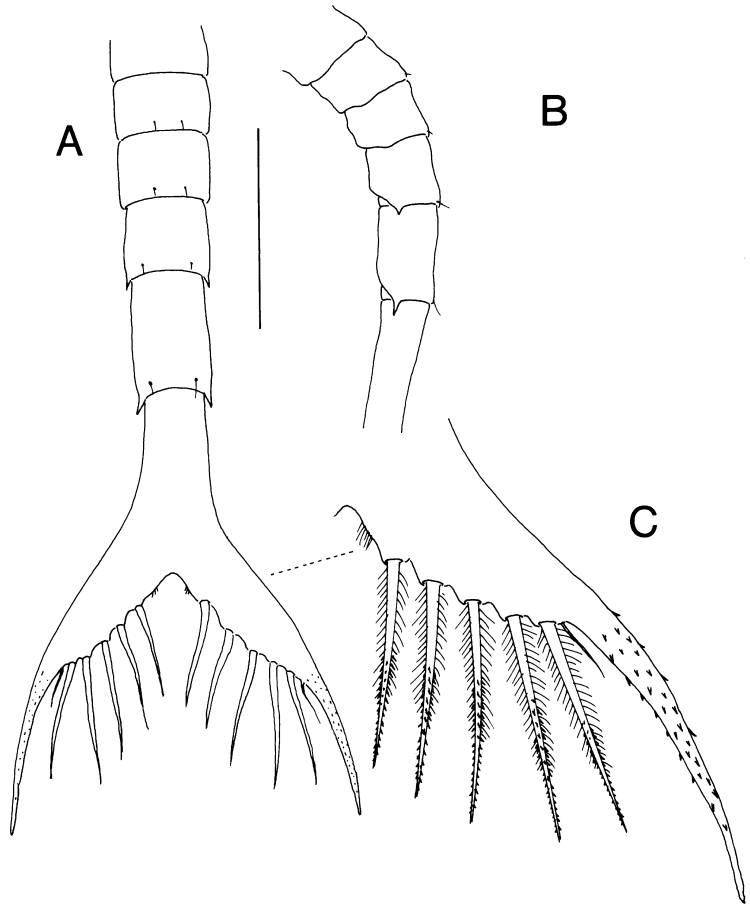

FIGURE 4. *Neonida grandis* Baba and de Saint Laurent, 1996, first zoea. A, abdomen, dorsal view; B, abdomen, lateral view; C, telson. Scale bar = 0.5 mm.

First maxilliped (Fig. 6B). Setae not completely extruded, but clearly observable. Coxa with 2 setae; basis with 11 (2,3,3,3) sparsely plumose setae on ventral margin; endopod 5-segmented with 3,2,1,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 terminal setae.

Second maxilliped (Fig. 6C). Setae not completely extruded, but clearly observable. Coxa without setae; basis with 3 sparsely plumose setae (1, 2) on anteroventral margin; endopod 4-segmented with 2,2,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 terminal setae.

Third maxilliped. Small unsegmented bud .

Pereiopods. Absent.

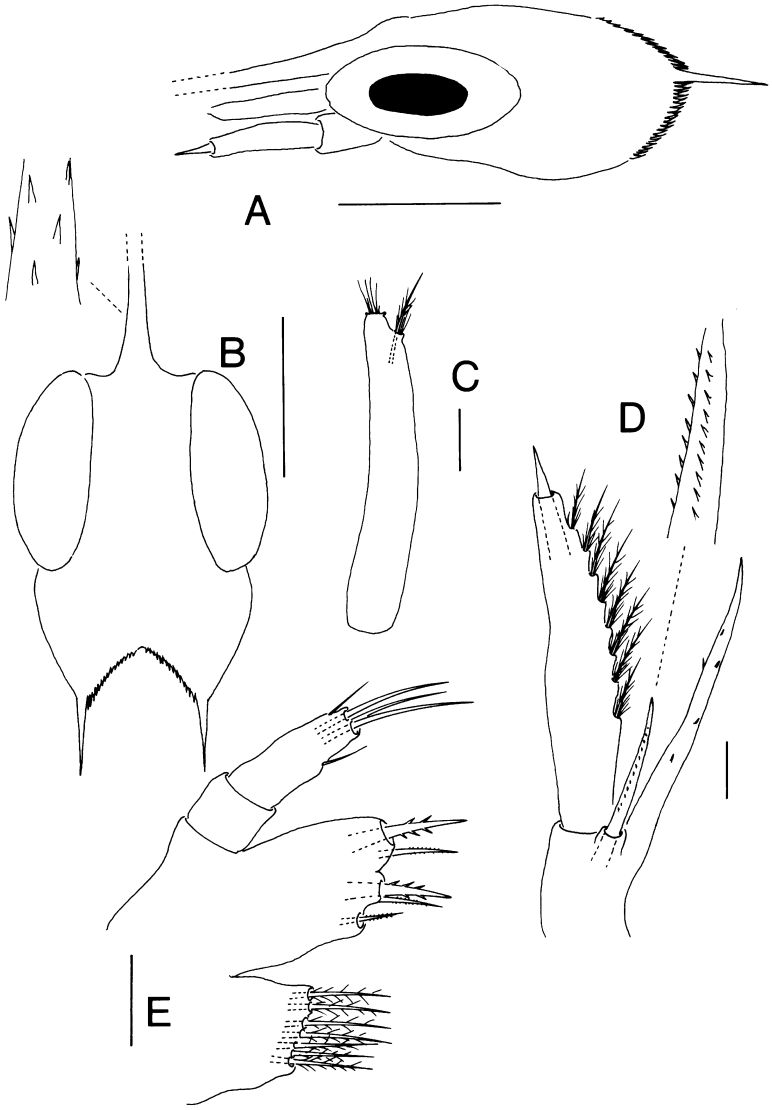

FIGURE 5. *Agononida squamosa* (Henderson, 1885), first zoea. A, lateral view; B, dorsal view; C, antennule; D, antenna; E, maxillule. Scale bar of A and B = 0.5 mm; Scale bar of C-E = 0.1mm.

Abdomen. Five somites plus telson; somites 4 and 5 with posterolateral processes; somites 2–5 each with pair of posterodorsal setae and without denticles or teeth on posterior margin; pleopods absent.

Telson. Forked with median cleft; with 7+7 processes not completely extruded, first (lateralmost) immovable spine, second short plumose seta (anomuran hair), third to seventh bearing long, stout plumose setae and minute spinules.

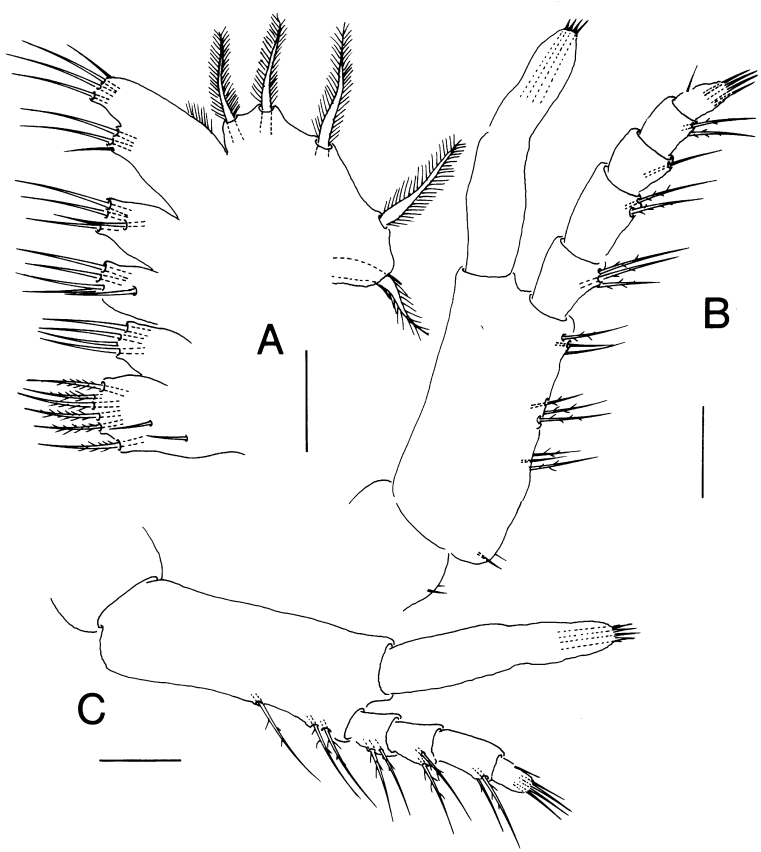

FIGURE 6. *Agononida squamosa* (Henderson, 1885), first zoea. A, maxilla; B, 1st maxilliped; C, 2nd maxilliped. Scale bar = 0.1 mm.

***Munida javieri* Macpherson, 1994**
(Figs. 7–11)

Size: CL= 0.97–1.00 mm; CLR= 2.44–2.47 mm; TL= 3.97 mm; EL= 0.65 mm.

Carapace (Figs. 7A–C). Typical galatheid larval form; without setae; rostrum elongated, extending beyond what of antennule, with spines on distal half of surface; acute spines posteriorly, posterodorsal margin with 15–17 teeth and posteroventral margin with 16-19 teeth; eyes sessile, EL approximately 1/2 of CL.

Antennule (Fig. 8A). Uniramous, endopod absent, with 3 aesthetascs and 3 setae terminally, 1 long subterminal plumose setae.

Antenna (Fig. 8B). Biramous; protopod with 1 spinose process with 2 rows of spinules, shorter than endopod (20% length of exopod), spinose process bifurcated observed only in one case (see Fig. 8B); endopod unsegmented, without setae and with sparse spines (43% length of exopod); exopod (scaphocerite) long ending in inflated and

robust process covered with spines, inner margin with 8 plumose setae and 1 simple seta.

Mandible (Fig. 8C). Left and right mandibles with well developed strongly spinose molar processes; palp absent.

Maxillule (Fig. 9A). Coxal endite with 7 sparsely setose setae; basial endite with 5 setae (2 strong prominent cuspidate setae with 3–7 denticles and 3 plumodenticulate setae); endopod unsegmented with 1 short simple seta on inner proximal margin and 5 setae on distal margin (1 subterminal simple seta + 3 long plumodenticulate and 1 simple terminal setae).

Maxilla (Fig. 9B). Coxal endite bilobed with 8+4 sparsely plumose setae; basial endite bilobed with 5+4 plumodenticulate setae; endopod unsegmented, bilobed, with 3 + 4 setae; exopod (scaphognathite) with 4 marginal plumose setae and 1 long posterior plumose process.

First maxilliped (Fig. 10A). Coxa with 2 setae; basis with 12 (3,3,3,3) sparsely plumose setae on ventral margin; endopod 5-segmented with 3,2,1,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 long terminal plumose setae.

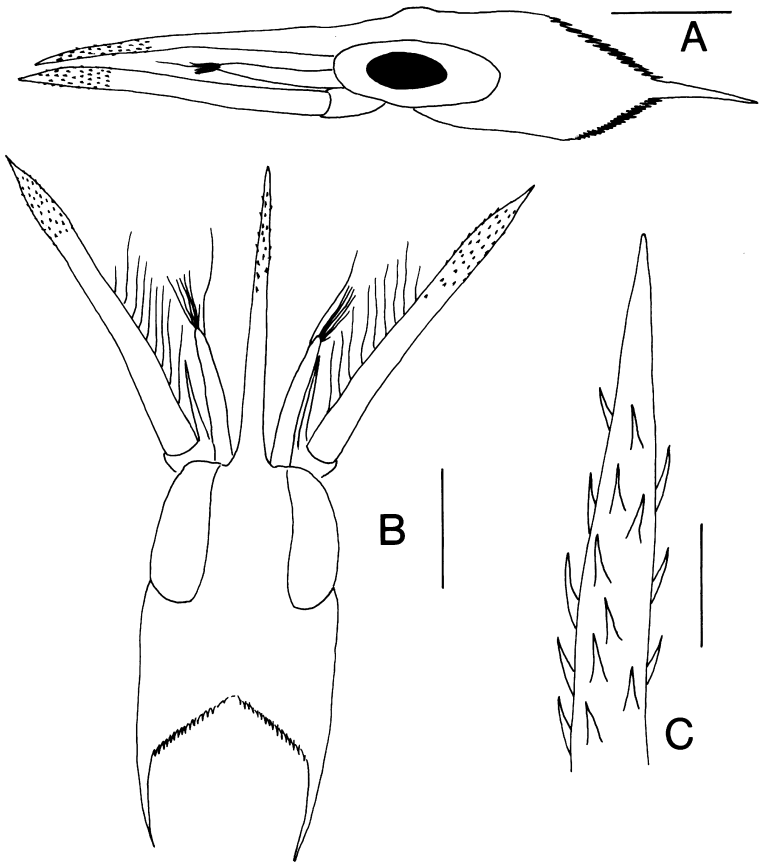

FIGURE 7. *Munida javieri* Macpherson, 1994, first zoea. A, carapace, lateral view; B, carapace, dorsal view; C, tip of rostral spine. Scale bar of A and B = 0.5 mm; scale bar of C = 0.1 mm.

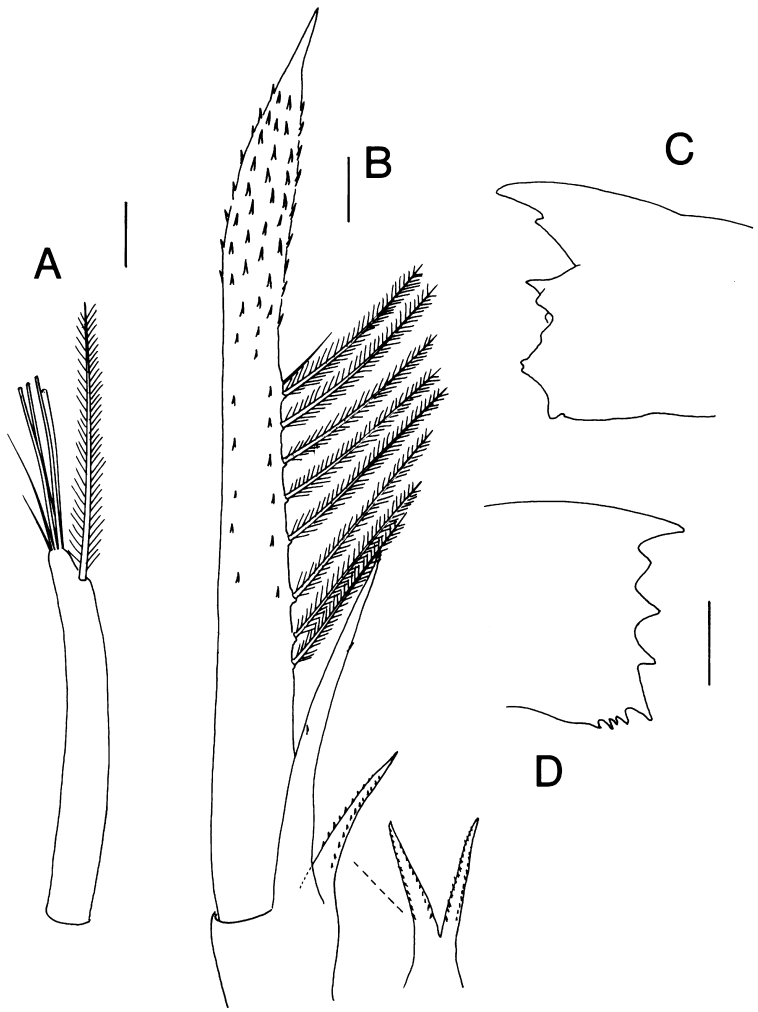

FIGURE 8. *Munida javieri* Macpherson, 1994, first zoea. A, antennule; B, antenna; C, left mandible; D, right mandible. Scale bar of A-D = 0.1 mm.

Second maxilliped (Fig. 10B). Coxa without setae; basis with 3 sparsely plumose setae (1,2) on anteroventral margin; endopod 4-segmented with 2,2,2,5 (1 subterminal + 4 terminal) setae; exopod 2-segmented with 4 long terminal plumose setae.

Third maxilliped (Fig. 10C). Small unsegmented bud.

Pereiopods. Absent.

Abdomen (Figs 11A, B). Five somites plus telson; somite 3 with blunt posterolateral processes; somites 4 and 5 with posterolateral spiniform processes; somites 2–5 each with pair of posterodorsal setae (sparsely plumose on somites 4 and 5) and without denticles or teeth on posterodorsal margin; pleopods absent.

Telson (Figs 11B, C). Forked with median cleft; with 7+7 processes, first (lateralmost) non-movable long and inflated process covered with spines (longer than plumose setae),

second short plumose seta (anomuran hair), third to seventh bearing long, stout plumose setae with minute spinules in distal half of setae.

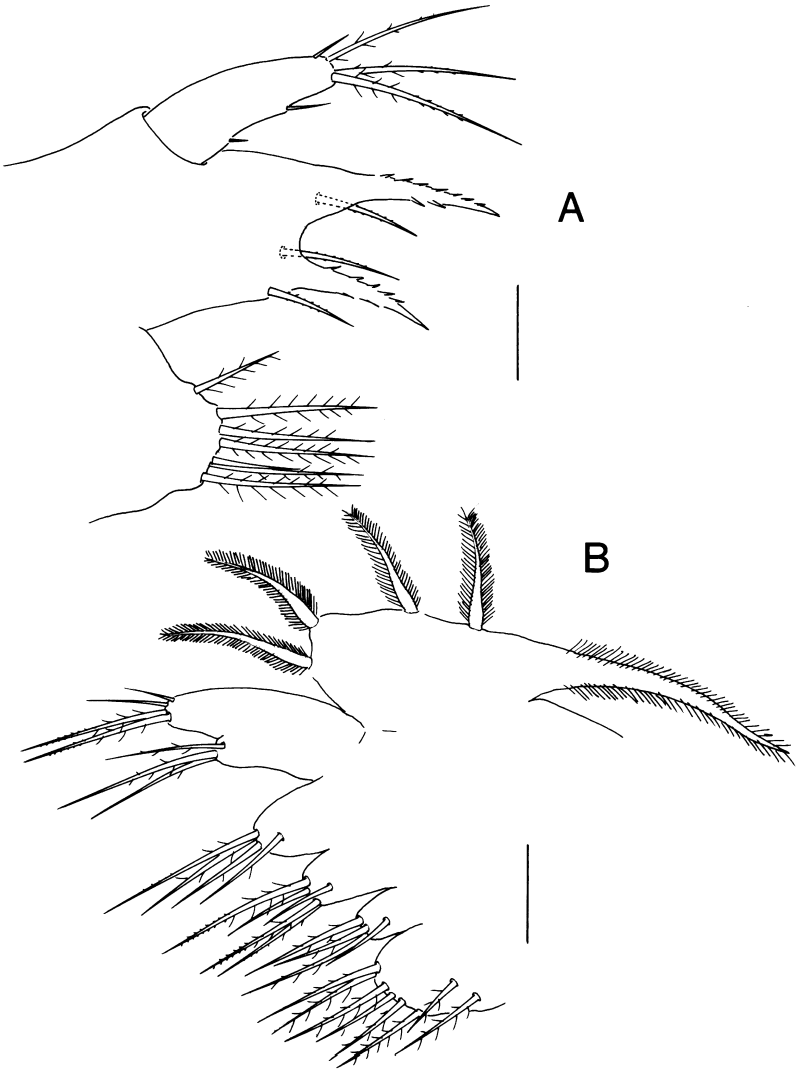

FIGURE 9. *Munida javieri* Macpherson, 1994, first zoea. A, maxillule; B, maxilla. Scale bar = 0.1 mm.

Chirostylidae Ortmann, 1892

***Eumunida annulosa* de Saint Laurent & Macpherson, 1990 and *E. capillata* de Saint Laurent & Macpherson, 1990**
(Figs. 12–17)

The morphology of the first zoeae of *Eumunida annulosa* and *E. capillata* are similar and

display few variations between species. The following description is based on *E. annulosa* but also applies to *E. capillata* except where noted.

Size: TL 2.9–3.1 mm, CL 1.1–1.2 mm, CLR 1.7–1.8 mm.

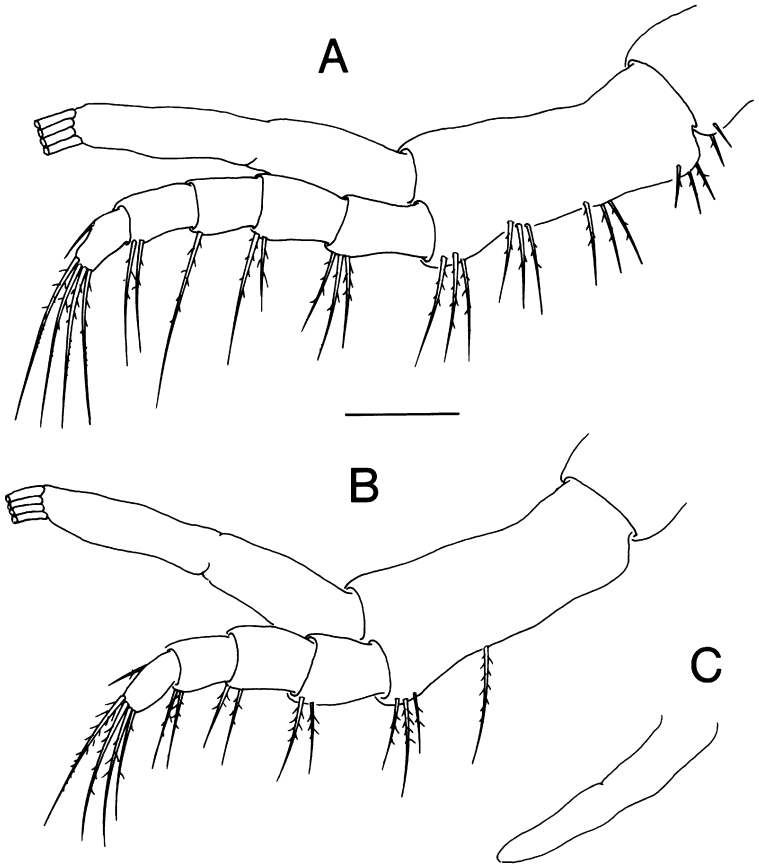

FIGURE 10. *Munida javieri* Macpherson, 1994, first zoea. A, 1st maxilliped; B, 2nd maxilliped; C, 3rd maxilliped. Scale bar = 0.1 mm.

Carapace (Figs. 12A, B). Rostrum well developed, extending beyond of scaphocerite spine and shorter than CL; posterolateral margins rounded, without spines and denticles or teeth; without setae; eyes sessile, EL less than 1/2 of CL.

Antennule (Fig. 13A). Unirramous, endopod absent, with 6 terminal aesthetascs and 1 long subterminal plumose seta.

Antenna (Fig. 13B). Biramous; protopod with 1 spinose process covered with spines, slightly longer than endopod; endopod unsegmented, fused to protopod, with 2 long terminal plumose setae unequal in length; exopod (scaphocerite) ending in robust process at distal margin, inner margin with 9-10 plumose setae and 1 simple seta.

Mandible (Fig. 14A–C). Left and right mandibles developed and asymmetrically dentate, with 1 and 2 strong incisor processes respectively, and few small processes; in *E. capillata* inner processes shorter than in *E. annulosa* (see Fig. 14B and C); molar

processes strongly spinose; palp absent.

Maxillule (Fig. 15A). Coxal endite with 7 setae (5 plumose and 2 simple setae); basal endite with 4 setae (2 strong prominent cuspidate setae with 3-7 denticles and 2 plumodenticulate setae); endopod 3-segmented with 2 small simple setae on proximal segment, 1 seta on second segment and 3 setae on distal segment.

Maxilla (Fig. 15B). Coxal endite bilobed with 8+4 plumose setae; basial endite bilobed with 5+4 plumodenticulate setae; endopod unsegmented, bilobed, with 3 (1 minute and 2 long)+6 (2+4) setae; exopod (scaphognathite) lobe developed anteriorly and with 5 marginal plumose setae, without long posterior process.

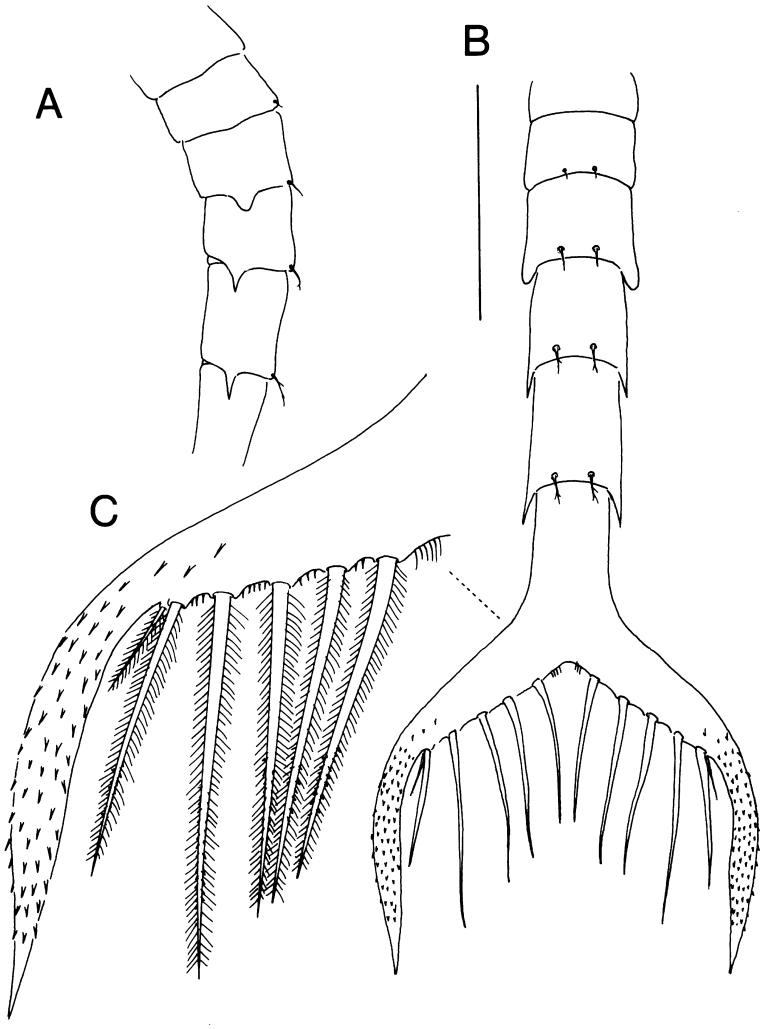

FIGURE 11. *Munida javieri* Macpherson, 1994, first zoea. A, . A, abdomen, lateral view; B, abdomen, dorsal view; C, telson. Scale bar = 0.5 mm.

First maxilliped (Fig. 16A). Coxa without setae; basis with 11 (2,3,3,3) sparsely plumose setae on ventral margin; endopod 5-segmented with 3,2,1,2,5 (1 subterminal + 4

terminal) setae, mat of long microtrichiae on segments 2 and 3; exopod 2-segmented with 4 long terminal plumose setae.

Second maxilliped (Fig. 16B). Coxa without setae; basis with 3 sparsely plumose setae (1,2) on ventral margin; endopod 4-segmented with 2,2,2 (1 strong spine with spinules + 1) setae, 5 (1 subterminal + 4 terminal) setae, mat of long microtrichiae on segment 2-3; exopod 2-segmented with 4 long terminal plumose setae.

Third maxilliped (Fig. 17A). Small unsegmented bud.

Pereiopods. Absent

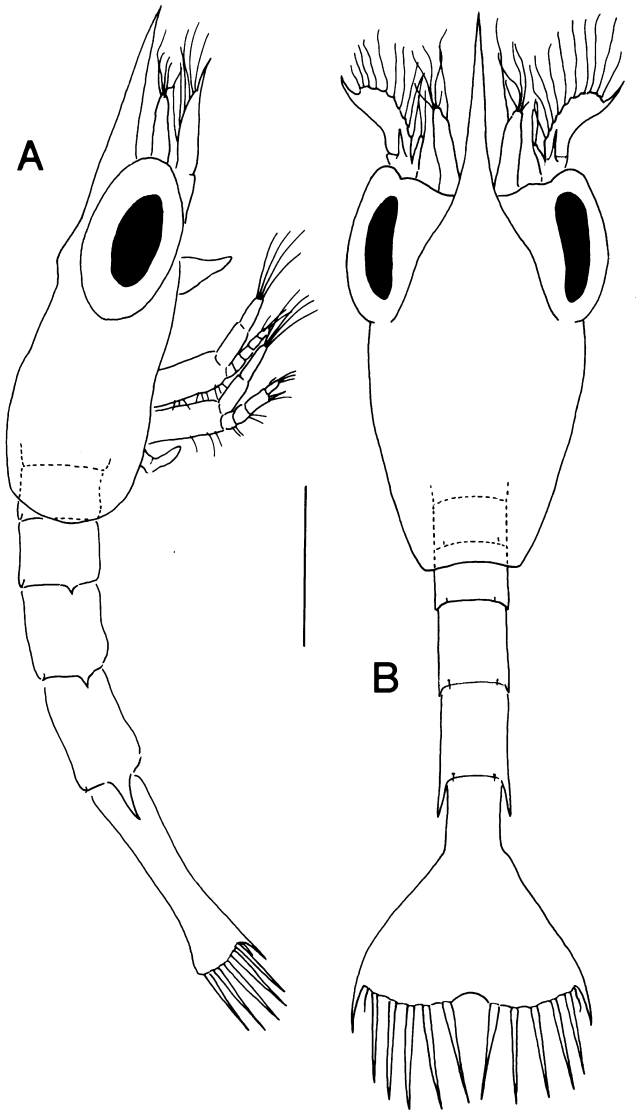

FIGURE 12. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, lateral view; B, dorsal view. Scale bar = 0.5 mm.

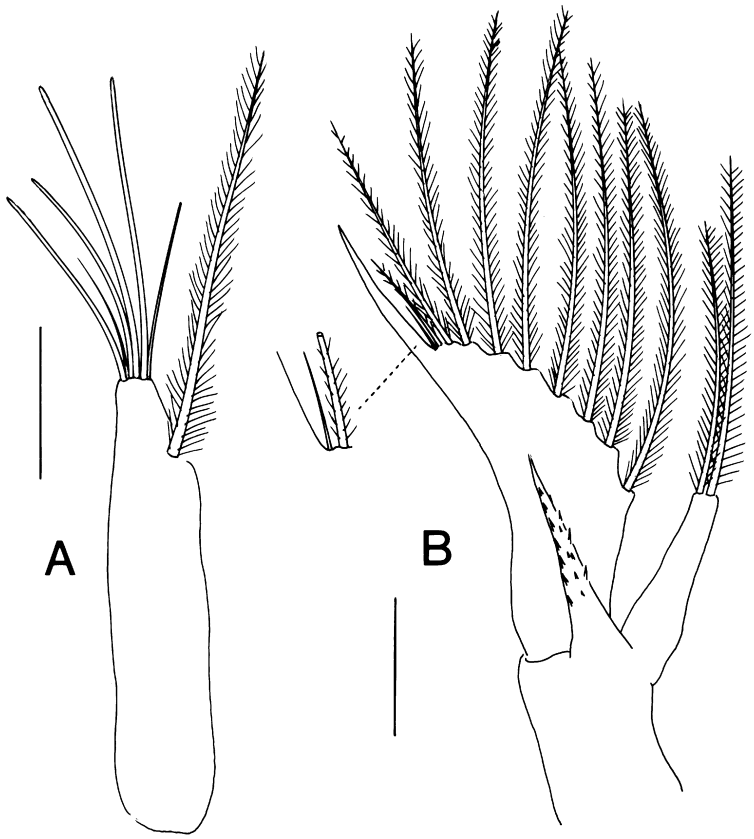

FIGURE 13. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, antennule; B, antenna. Scale bar = 0.1 mm.

Abdomen (Figs 12A, B). Five somites plus telson; segments 3–5 with posterolateral processes; segments 2–5 each with pair of posterodorsal setae; without denticles or teeth on posterior margin; pleopods absent.

Telson (Figs 12B, 17B). Trigonal in dorsal view, posterior margin slightly convex, median gap slightly notched, and with non-articulated spine (shorter than plumose setae), 1 short plumose seta (anomuran hair), shorter than spine, and 5 long plumose setae with spinules on each side.

Discussion

The first zoeae of *Neonida grandis*, *Agononida squamosa* and *Munida javieri* bear recognized diagnostic features of galatheid species: presence of spines and teeth on the posterolateral margin of the carapace, and presence of a long plumose process on the posterior margin of the scaphognathite (Gurney 1942, Van Dover *et al.* 1982, Konishi & Saito 2000). The morphology of the first larva of *Agononida squamosa* is similar to the

previously described species *A. incerta* (Henderson, 1888) (Table 1). Both species of *Agononida* have a two-segmented endopod on the maxillule, with 0 and 5 setae, respectively; the basal segment of the endopod of the first maxilliped bears 3 setae, and the antennal endopod is long, without long plumose setae (Konishi & Saito 2000). Konishi and Saito (2000) reported a minute simple seta at the tip of the antennal endopod, but this seta is not observed in *A. squamosa*; these authors indicated that the posterodorsal margin of the abdominal somites bore teeth, but no teeth appear in a figure of the dorsal view of the abdomen (Konishi & Saito 2000; Fig. 1). *Agononida squamosa* agrees with the figure provided by Konishi and Saito, in lacking spines or teeth on the posterior margin of the abdomen, with the exception of the posterolateral processes of somites 4 and 5.

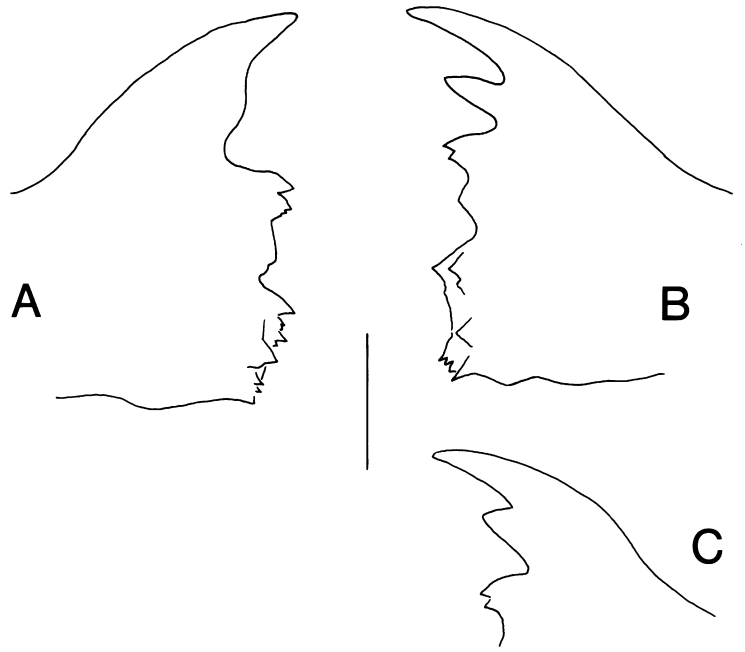

FIGURE 14. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, rigth mandible; B left mandible. *Eumunida capillata* de Saint Laurent and Macpherson, 1990, first zoea. C, incisor process of the left mandible. Scale bar = 0.1 mm.

The morphology of the first zoea of the *Neonida grandis* resembles the first larval stage of *Agononida* species, showing a similar setation (Table 1). *Neonida grandis* zoeae have larger eyes (longest axis longer than 3/4 of CL) than other described galatheid zoeas.

The similarity in larval morphology between *Agononida* and *Neonida*, both differing from species of *Munida*, agrees with the phylogenetic structure of the group. The former two genera are clearly separated from the *Munida* clade, and they are characterized by the presence of only one pair of gonopods in adult males instead of two (Baba & de Saint Laurent 1996, Machordom & Macpherson 2004). The morphological differentiation of the adult *Agononida* and *Neonida* is not reflected in the first larval stages, as it has been

observed in other decapods, for example, Brachyura (Rice 1980). It will be interesting to compare the morphological characteristics of the first stages of the other genera of the *Agononida-Neonida* clade (e.g., *Bathymunida*, *Anoplonida* Baba & Saint Laurent, 1996, *Heteronida* Baba & Saint Laurent, 1996, *Onconida* Baba & Saint Laurent, 1996, *Plesionida* Baba & Saint Laurent, 1996, *Paramunida* Baba, 1988 and *Crosnierita* Macpherson, 1998) to confirm the lack or presence of early differentiation.

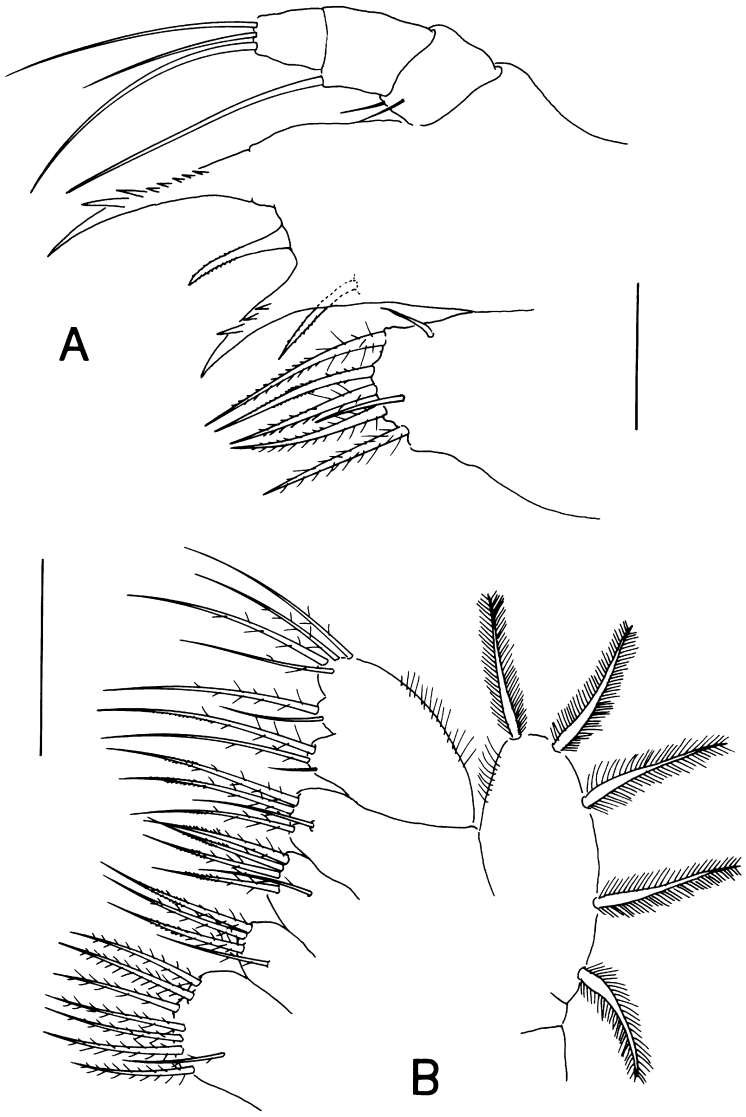

FIGURE 15. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, maxillule; B, maxilla. Scale bar = 0.1 mm.

Munida javieri possesses characters not previously described for any larva of *Munida*: the morphology of the distal process of the antennular exopod, the presence of a robust posterolateral processes on abdominal somite 3 and the setation of the endopod of the

maxillule (Table 1). The presence of 1+1+4 setae on endopod of the maxillule has been previously described in *Cervimunida johni* and *Sadayoshia edwarsii* (see Fagetti 1960, Fujita & Shokita 2005). These significant differences support the genetic and morphological differentiation of *M. javieri* that, together with other closely allied species (*M. callista* Macpherson 1994, *M. hystrix* Macpherson & de Saint Laurent 1991), seem to belong to another genus (Machordom & Macpherson 2004).

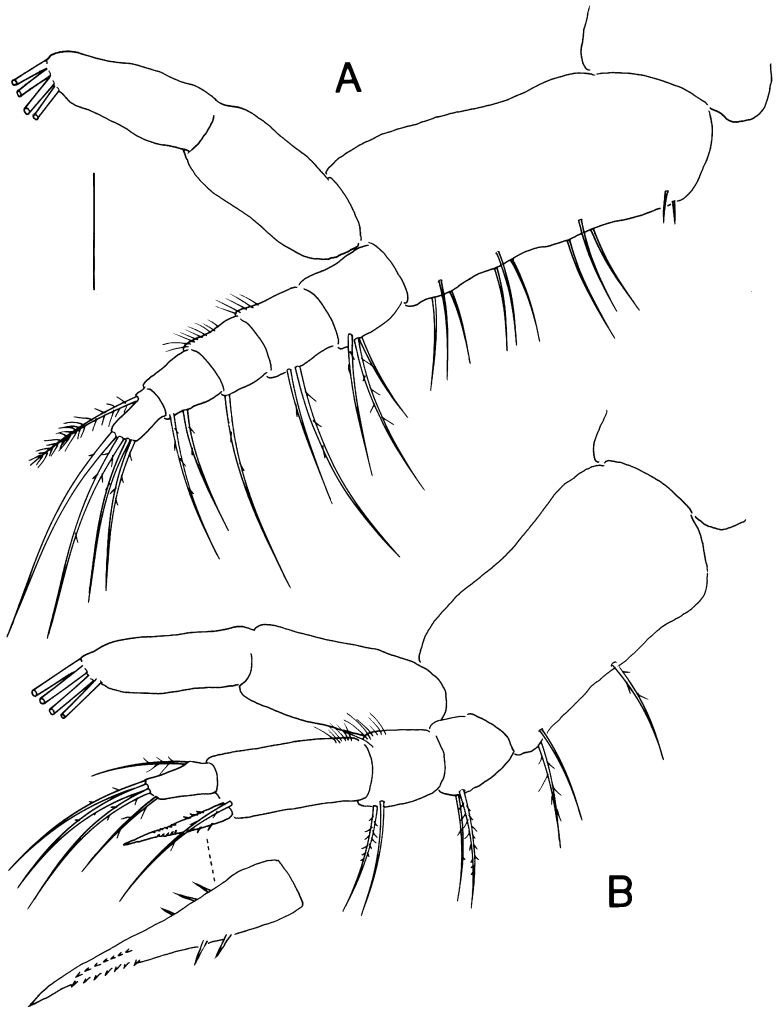

FIGURE 16. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, 1st maxilliped; B, 2nd maxilliped. Scale bar = 0.1 mm.

The morphology of the first zoeae of *Eumunida annulosa* and *E. capillata* is similar in structure, size and setation. Therefore, they are difficult to differentiate from one another. Only the mandible presents a slightly different morphology between the two species (see Fig. 14). The first zoeal stage of *Eumunida annulosa* and *E. capillata* differs clearly from the first larval stages of *Gastroptychus* sp., *Uroptychus* cf. *politus* and *Chirostylus*

dolichopus (Pike & Wear 1969, de Saint Laurent & Macpherson 1990, Ogawa & Matsuzaki 1992). The larvae of *Gastroptychus* and *Uroptychus* hatch at an advanced developmental stage and are morphologically equivalent to fourth or fifth stage zoeae of the galatheids: the antennular protopod and the antennal endopod are segmented, the mandibular palp is present, the pereiopods are developed (first chelate), the abdomen has six somites, the pleopod buds are present on somites 2–5, and the posterior margin of the telson has more than 7+7 processes or setae (Pike & Wear 1969).

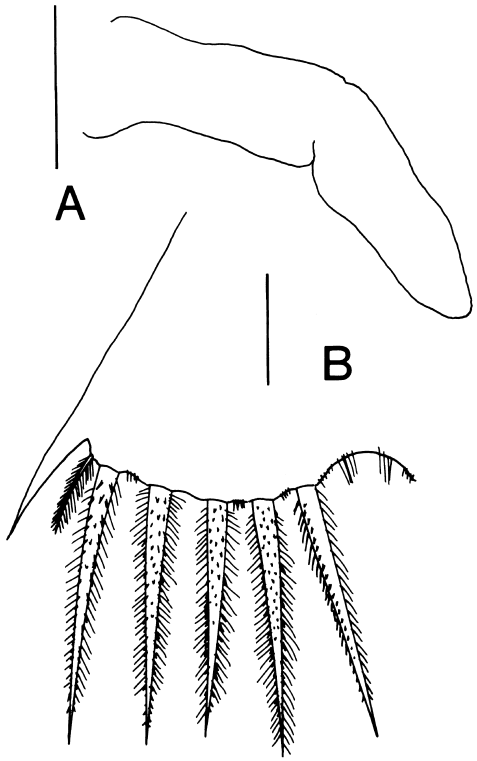

FIGURE 17. *Eumunida annulosa* de Saint Laurent and Macpherson, 1990, first zoea. A, 3rd maxilliped; B, telson. Scale bar = 0.1 mm.

The first larvae of *Eumunida annulosa* and *E. capillata* do not show characters of the typical abbreviated development observed in other Anomura, including the morphology and setation of the mouthparts (Samuelsen 1972, Wilkens *et al.* 1990, Cormie 1993, Konishi & Taishaku 1994). The stage of development is equivalent to a first zoea of a galatheid larva (Lebour 1931, Huus 1934, Fagetti & Campodonico 1971, Roberts 1973, Gore 1979, Christiansen & Anger 1990, Fujita *et al.* 2001, Fujita & Shokita 2005). However, the first zoeae of *Eumunida annulosa* and *E. capillata* do not agree with the diagnostic features of the galatheids proposed by Gurney (1942) and Konishi & Saito (2000). In particular, first larval stage of *Eumunida* differs clearly from the galatheids and other Galatheoidea zoeae by the absence of spines and teeth on the posterolateral margin of the carapace and the absence of the posterior lobe and a long plumose process or setae

on the posterior margin of the scaphognathite (Gurney 1942, Wear 1965, Knight 1970, González-Gordillo *et al.* 1996, Fujita *et al.* 2002, Konishi & Saito 2000, dos Santos & González-Gordillo 2004, Fujita & Shokita 2005). The maxillary scaphognathite of *E umunida* agrees with the type 1 classification of Van Dover *et al.* 1982: posterior lobe absent and, usually, with 5 marginal plumose setae. This scaphognathite is found in pagurids, diogenids, coenobitids and lithodids (Van Dover *et al.* 1982, Konishi & Taishaku 1994, Hebling & Mansur 1995, Brodie & Harvey 2001, McLaughlin *et al.* 2003). In these anomurans, the posterior lobe first appears in the last zoeal stage or in the first postlarval stage (Van Dover *et al.* 1982). Moreover, the *Eumunida annulosa* and *E. capillata* zoeae possess other features frequently present in many pagurid larvae, which are not found in galatheids: (1) the endopod of the antenna has two terminal long plumose setae (1 in galatheids), (2) the basial endite of the maxillule ends in 2 stout cuspidate setae, with 2 additional setae (3 in galatheids) which are present (or not) in pagurid and hippid species (Gurney 1942, Knight 1970, Gore & Scotto 1983, Ingle 1990, Bidle & McLaughlin 1992, McLaughlin & Gore 1992, Shenoy & Sankolli 1993), (3) the endopod of the maxillule is 3-segmented (1- or 2-segmented in galatheids); the same setation of the maxillular endopod in *Eumunida annulosa* and *E. capillata* (2,1,3) is also observed in some pagurids as *Phimochirus holthuisi* (Provenzano, 1961) (Gore & Scotto 1983) and *Pagurus constans* (Stimpson, 1858) (Hong & Kim 2002, as *Parapagurodes constans*); (4) the coxa of the first maxilliped is devoid of setae (usually 2 setae in galatheids). An interesting feature is the presence of the strong spine on the third segment of the endopod of the second maxilliped in *Eumunida* zoeae (see Fig. 16 B). Many pagurids show a similar spine on segments 1–3 of the endopod and on the basis of the same appendage (e.g., McLaughlin *et al.* 1991, Bidle & McLaughlin 1992). De Saint Laurent & Macpherson (1990) indicated the possibility for confusion of the first larval stage of *E. capillata* collected from plankton with pagurid larvae. The morphology of the endopod of the second maxilliped is a useful character for differentiation.

Different phylogenetic hypotheses have been proposed to explain the relationship between galatheoid families (Martin & Abele 1986, Morrison *et al.* 2001, Pérez-Losada *et al.* 2002, Ahyong & O'Meally 2004). The morphology of the first zoeae of *Eumunida annulosa* and *E. capillata* agrees with the spermatological phylogeny suggested by Tudge (1997). Tudge, considered chirostylids more closely related to a variety of paguroids than to other galatheoids. However, later (or subsequent) molecular and morphological studies do not support Tudge's (1997) view. These studies suggest that the chirostylids are closely related to porcellanids (Pérez-Losada *et al.* 2002, Ahyong & O'Meally 2004) or galatheids (Morrison *et al.* 2001) and form the monophyletic galatheoid clade. Therefore, it will be necessary to have more morphological, larval and molecular studies to improve our knowledge of the phylogenetic relationships among chirostylid genera and between chirostylids and the other galatheoid families.

TABLE 1. Morphological differences among first zoeal stages of *Agononida*, *Neonida* and *Munida*: *Agononida incerta* (see Konishi & Saito 2000); *Agononida squamosa* (present study); *Neonida grandis* (present study); *Munida subrugosa* (see Roberts 1973); *Munida tenuimana* (see Huus 1934); *Munida striola* (see Konishi & Saito 2000); *Munida javieri* (present study). Abbreviations: s, setae; a, aesthetascs; ps, plumose seta; PLP, posterolateral process; -, without; +, with; nd, no data.

feature	*Agononida incerta*	*Agononida squamosa*	*Neonida grandis*	*Munida subrugosa*	*Munida tenuimana*	*Munida striola*	*Munida javieri*
CL (mm)	0.90–1.05	0.75	0.76	nd	nd	0.73–0.91	0.97–1.00
CLR (mm)	1.68–2.07	nd	1.60–1.64	1.25–1.78	nd	1.43–1.73	2.44–2.47
Antennula (a/s+ps)	6+1	6+1	6+1	5+1	4+1	6+1	6+1
Antenna							
s on endopod	0	0	0	0	0	1	0
s on exopod	9	9	9	8	8	9	9
Maxillule							
s on coxal end.	7	7	7	6	5	7	7
enpodod segments	2	2	2	1	1	1	1
s on endopod	0,1+4	0,1+4	0,1+4	1+4	1+4	1+4	1+1+4
Maxilla							
s on coxal end.	8+4	8+4	8+4	6+4	5+3	8+4	8+4
s on basial end.	5+4	5+4	5+4	4+4	3+4	5+4	5+4
First maxilliped							
s on basis	2+3+3+3	2+3+3+3	2+3+3+3	3+3+3+3	2+3+3+3	2+3+3+3	3+3+3+3
Abdomen (PLP)							
somite 3	-	-	-	-	-	-	+

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