

## Larval development of a semiterrestrial mangrove sesarmine crab *Chasmagnathus convexus* (Crustacea: Decapoda: Brachyura: Grapsidae) reared in laboratory

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### Abstract

Four zoeal stages and one megalopal stage were identified in laboratory reared semiterrestrial mangrove sesarmine crab *Chasmagnathus convexus*. At an average salinity and temperature of  $20 \pm 1\%$  and  $19.2 \pm 0.2^\circ\text{C}$ , the megalopa was attained 24 days after hatching. Morphologically, the first zoea of *C. convexus* is very similar to those of other species of the genus *Chasmagnathus* as well as species of the genus *Helice*, in that view all share the following characteristics: lateral spine on the carapace, three pair of setae on the posterior margin of the telson furca, one plus five setae on the endopod of the maxillule, and two plus two setae on the endopod of the maxilla. The differences between the first zoea and megalopa of and those of its congeners are discussed.

**Key words:** Mangrove crab, *Chasmagnathus convexus*, Larval development

### Introduction

*Chasmagnathus convexus* (De Haan) is an estuarine, semiterrestrial sesarmine crab that lives generally in burrows constructed on the river bank or in the reed marshes above the high water mark (Nakasone *et al.* 1982, Islam *et al.* 2000). Like many freshwater or terrestrial taxa that have colonized in land from the marine environment, their larval development is either abbreviated or hatching directly from the eggs (Rabalais and Gore 1985). Baba and Fukuda (1972) described the complete larval development of this species, but the illustrations and descriptions are inadequate for comparison with other species of the genus *Chasmagnathus* as well as species of sesarmine crabs. Boschi *et al.* (1967) and Green and Anderson (1973) described only the first zoea of *C. granulata* and *C. laevis*, respectively. Considering the ecological importance of this species in the estuarine environments as well as mangrove ecosystems, the present study was conducted to illustrate and describe all the larval stages of *C. convexus* in detail, and to compare them with previously studied characters of the larvae of other species of *Chasmagnathus* and other sesarmine crabs.

## Materials and methods

An ovigerous *Chasmagnathus convexus* female measuring 36.7 mm carapace length and 42.3 mm carapace width, was captured from the salty spring of Waku River (bank of this river sparsely covered by mangroves), the northern part of Okinawa Island, Japan, on 25 December'98. The female was brought to the Laboratory and maintained in a plastic trough containing seawater of  $20 \pm 1$  ppt salinity, with moderate aeration to supply air and to circulate the seawater. Seawater temperature ranged from 17.3 to 22.9°C during the experimental period. Water was changed daily until the eggs hatched into the zoeae. The female was fed with the meat of tiger shrimp and short-necked clam.

Hatching occurred within nine days after collection. Among the newly hatched larvae, the 200 most photopositive and active zoeae were transferred into 10-liter capacity plastic bowls covered with black paper on the outside, and then reared under the same conditions as the ovigerous female. The water was aerated and half-renewed daily. Temperature was not controlled, ranged from 16.6 to 21.8°C. Zoeae were fed daily with newly hatched nauplii of *Artemia*. In addition, finely chopped meat of the short-necked clam was fed to the megalopa.

Specimens used for dissection and identification of stages were preserved in 50% ethylene glycol solution. Larvae were dissected under a binocular stereomicroscope (Nikon SMZ-10). Drawings and measurements were made with a profile projector (Nikon Profile projector V-12) and an optical microscope (Nikon FDX-35). At least 10 specimens of each stage were examined. The chromatophore pattern was determined by the observation of living larvae.

Methods for measurements of larval stages and descriptions of setal arrangements were adapted from Konishi and Shiktani (1998), Clark *et al.* (1998), Ingle (1992), Lago (1989), Hong (1988), Pohle and Telford (1981) and Rice (1979). Measurements taken were: (a) the distance between the tips of the dorsal and the rostral spines for total length (TL) of zoeae, (b) the carapace length (CL) from the base of the rostral spine to the posterior margin of the carapace of zoeae and the distance between the tip of the rostral spine and the posterior margin of the carapace of megalopa, (c) the carapace width (CW) at the widest point of the carapace of megalopa, (d) the dorsal spine length (DL) of zoeae, (e) the rostral spine length (RL) of zoeae, (f) the lateral spine length (LL) of zoeae. Setae of appendages were counted from proximal to distal segments. All features illustrated belong to the same specimen. The illustrations of appendages correspond to the true side from which the appendage was viewed under the microscope. Specimens of all larval stages and the female *C. convexus* have been deposited in the Laboratory of Marine Fisheries, University of the Ryukyus, Okinawa, Japan.

## Results

Hatching of *C. convexus* larvae occurred on the morning of 3 January'99, and the larvae attained the megalopal stage at 24 days (ranged, 22-28 days) after passing through

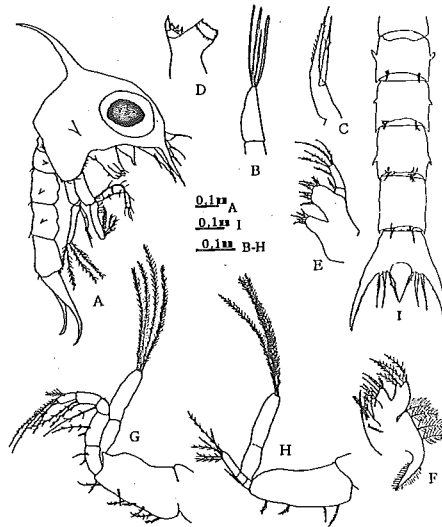
four zoeal stages. Many larvae died during metamorphosis. Measurements of typical zoeal features and larval duration are summarized in Table 1. The morphology of the first zoea is described in detail, but only morphological changes are given for subsequent larval stages.

**Table 1.** Measurement (mm) of various meristic characters with duration (day) of larval stages of *Chasmagnathus convexus*

Characters	1 <sup>st</sup> zoea	2 <sup>nd</sup> zoea	3 <sup>rd</sup> zoea	4 <sup>th</sup> zoea	5 <sup>th</sup> zoea
Carapace length	0.52±0.01	0.61±0.02	0.83±0.03	0.97±0.01	1.73±0.02
Carapace width	-	-	-	-	1.27±0.03
Total length	1.26±0.02	1.32±0.01	1.58±0.02	1.83±0.03	-
Dorsal spine length	0.35±0.01	0.44±0.02	0.63±0.01	0.78±0.02	-
Rostral spine length	0.22±0.03	0.25±0.01	0.38±0.02	0.51±0.01	-
Lateral spine length	0.09±0.02	0.11±0.01	0.15±0.02	0.19±0.01	-
Larval duration	7.42±0.05	6.6±0.05	6.2±0.03	6.09±0.05	6.28±0.01

### First Zoea (Fig. 1)

Color: Brownish or pinkish gray chromatophores on posterior base of dorsal carapace spine, posterolateral surface of carapace, base of antennule, basally on maxillipeds, mandible, base of lateral and dorsal spines, each abdominal segment and telson. This chromatophore pattern applies to all zoeal stages.



**Fig. 1.** First zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1<sup>st</sup> maxilliped, H. 2<sup>nd</sup> maxilliped, I. abdomen and telson (dorsal view).

Carapace (Fig. 1A): Subtriangular, smooth. Dorsal spine stout, smooth, tapering uniformly to a point, extending posteriorly. Rostral spine straight, smooth, tapered, directed downwards. Dorsal and rostral spines shorter than carapace length. Lateral spines present, shorter and more slender than preceding two spines. Posterolateral margin with 7 pairs of minute denticles. Eyes sessile.

Antennule (Fig. 1B): Exopod unsegmented and conical, with 4 terminal aesthetascs. Endopod absent.

Antenna (Fig. 1C): Protopod cylindrical with prolonged spinous process, spinous process terminates at middle of rostrum, 2 rows of denticles internally and externally. Exopod measuring  $2/3$  of spinous process, with 2 short setae placed at distal third. Endopod absent.

Mandible (Fig. 1D): Incisor and molar processes differentiated; incisor process with 3 large teeth; molar process cylindrical; its masticatory surface slightly hollowed. Mandibular palp absent.

Maxillule (Fig. 1E): Coxal endite with 5 plumodenticulate setae. Basial endite with 6 plumodenticulate setae. Endopod 2-segmented : proximal segment with 1 plumodenticulate seta; distal segment with 1 subterminal and 4 terminal sparsely plumose setae. Coxopod naked.

Maxilla (Fig. 1F): Coxal endite bilobed, with 4+3 plumodenticulate setae. Basial endite bilobed, with 5+5 plumodenticulate setae. Endopod bilobed, with 2+2 sparsely plumose setae. Scaphognathite with 4 highly plumose setae and elongate distal process.

First maxilliped (Fig. 1G): Coxopod naked. Basipod with 8 medial plumodenticulate setae; arranged 2, 2, 2 and 2. Endopod 5-segmented: proximal segment with 2 simple setae; segment II with 1 simple seta and 1 sparsely plumose seta; segment III with 1 sparsely plumose seta; segment IV with pair of sparsely plumose setae; distal segment with 1 subterminal simple and 4 terminal sparsely plumose setae. Exopod 2 segmented : proximal segment naked; distal segment with 4 terminal natatory plumose setae. Third maxilliped and pereopod buds: poorly developed beneath the carapace.

Abdomen and telson (Figs. 1A, I): Abdomen consists of 5 somites: somite I almost covered by carapace and naked; somite II with a pair of lateral spine directed anteriorly; somite III with a pair of small lateral spine directed posteriorly; somite IV with a pair of lateral spine directed posteriorly, which is larger than that of somite III; posterolateral margin of somite V with feebly pointed minute spine. Segments II-V each with a pair of minute simple setae. Pleopod and uropod buds absent. Telson bifurcated; forks curved dorsally, cornua slightly curved dorsally on distal section. Posteromedial margin with medial notch and 3 pairs of plumose setae. Inner margin of fork fringed with fine setae.

## Second Zoea (Fig. 2)

Carapace (Fig. 2A): Same as first zoea, but eyes stalked and mobile.

Antennule (Fig. 2B): Exopod with one additional aesthetasc.

Antenna (Fig. 2C) and Mandible (Fig. 2D): Same as first zoea, but different in size.

Maxillule (Fig. 2E): Coxal endite with 6 plumodenticulate setae. Basial endite with 8 plumodenticulate setae. One highly plumose seta added on dorsal margin of coxopod.

Maxilla (Fig. 2F): Coxal endite bilobed, with 5+3 plumodenticulate setae. Basial endite bilobed, with 6+4 plumodenticulate setae. Scaphognathite with 8 highly plumose setae separated into anterior (5 setae) and posterior (3 setae) groups.

First maxilliped (Fig. 2G): Distal segment of exopod with 6 terminal natatory plumose setae.

Second maxilliped (Fig. 2H): Distal segment of exopod with 6 terminal natatory plumose setae.

Abdomen and telson (Figs. 2A, I): One plumose seta added on somite I medially. One pair of plumose setae added on posteromedial margin of telson.

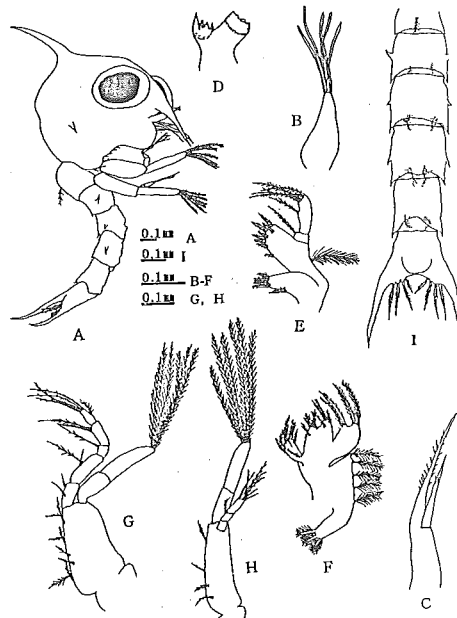


Fig. 2. Second zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1<sup>st</sup> maxilliped, H. 2<sup>nd</sup> maxilliped, I. abdomen and telson (dorsal view).

### Third Zoea (Fig. 3)

Carapace (Fig. 3A): Eyes fully stalked. Other characters same as second zoea.

Antennule (Fig. 3B): Exopod with one additional aesthetasc.

Antenna (Fig. 3C): Endopod buds 2/3 as long as the protopod.

Mandible (Fig. 3D): Same as second zoea.

Maxillule (Fig. 3E): Coxal endite with 7 plumodenticulate setae. Basial endite with 9 plumodenticulate setae.

Maxilla (Fig. 3F): Coxal endite bilobed, with 6+4 plumodenticulate setae. Basial endite bilobed, with 7+4 plumodenticulate setae. Scaphognathite with 19 highly plumose setae.

First maxilliped (Fig. 3G): Setation patte on endopod changed: segment I with 1 simple seta and 1 sparsely plumose seta; segment II with 1 simple and 2 sparsely plumose setae; 1 plumose seta added on distal segment subterminally. Distal segment of exopod with 8 terminal natatory plumose setae.

Second maxilliped (Fig. 3H): Distal segment of exopod with 8 terminal natatory plumose setae.

Third maxilliped and pereopods (Fig. 3I): Buds of third maxilliped and first-fifth pereopods present underneath the carapace.

Abdomen and Telson (Figs. 3A, J): Consists of 6 somites. Sixth somite shorter than broad with smooth posterolateral margin, and naked. Small pleopod buds present on somites II-V. Apparent length of telson reduced by formation of somite VI.

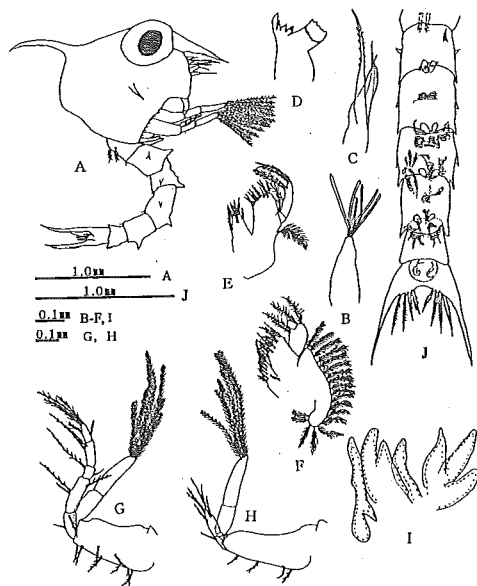


Fig. 3. Third zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1<sup>st</sup> maxilliped, H. 2<sup>nd</sup> maxilliped, I. abdomen and telson (ventral view).

#### Fourth Zoea (Fig. 4)

Carapace (Fig. 4A): Same as third zoea, but different in size, Dorsal spine relatively more short than the previous stage.

Antennule (Fig. 4B): Endopod present as small bud. Exopod with 6 aesthetascs.

Antenna (Fig. 4C): Endopod elongate 4/5 as long as the protopod.

Mandible (Fig. 4D): Mandibular palp present as small bud.

Maxillule (Fig. 4E): Coxal endite with 9 plumodenticulate setae. Basial endite with 11 plumodenticulate setae.

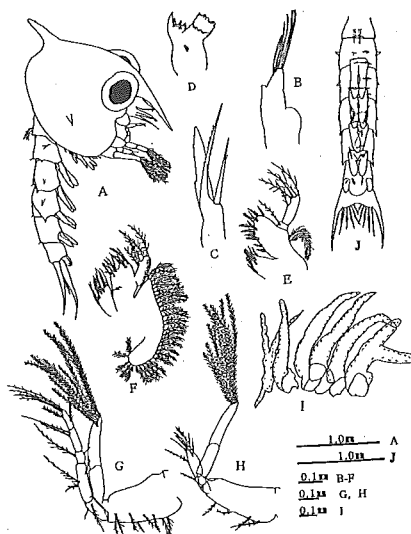
Maxilla (Fig. 4F): Coxal endite bilobed, with 6+4 plumodenticulate setae. Basial endite bilobed, with 7+5 plumodenticulate setae. Scaphognathite with 32 highly plumose setae.

First maxilliped (Fig. 4G): Distal segment of exopod with 10 terminal natatory plumose setae.

Second maxilliped (Fig. 4H): Distal segment of exopod with 10 terminal natatory plumose setae.

Third maxilliped and pereiopods (Fig. 4I): Third maxilliped bud further developed beneath the carapace. Pereiopods buds (first-fifth) more elongate, segmented incompletely. Gill buds of first-third pereiopods appearing beneath the carapace.

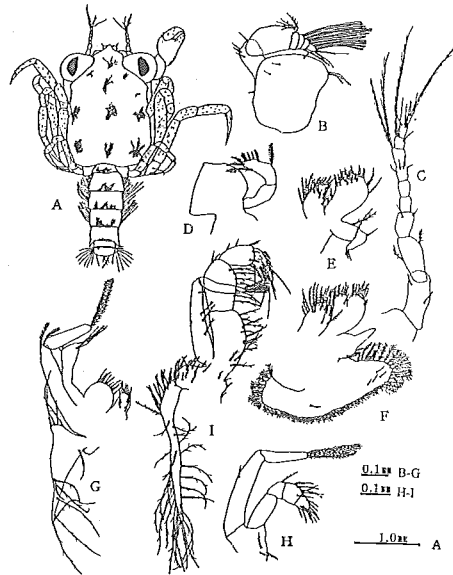
Abdomen and Telson (Figs. 4A, J): Pleopod buds on abdominal somites II-V further developed and partially segmented laterally. Uropod present as small buds on somite VI. One pair of plumose setae added on posteromedial margin of telson.



**Fig. 4.** Fourth zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1<sup>st</sup> maxilliped, H. 2<sup>nd</sup> maxilliped, I. abdomen and telson (ventral view).

### Megalopa (Fig. 5, 6)

Carapace (Fig. 5A): Subrectangular and smooth, longer than broad, narrowing anteriorly, ending in a small rostrum, slightly extended forwards and bent downwards, ordinary sites of lateral and dorsal spines slightly elevated and each with a minute spine. Orbicular edge wide and smooth. A number of small simple setae scattered on dorsal surface and on posterior margin. Eyes larger than the last zoeal stage and stalked.



**Fig. 5.** Megalopa of *Chasmagnathus convexus*. A. dorsal view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1<sup>st</sup> maxilliped, H. 2<sup>nd</sup> maxilliped, I. 3<sup>rd</sup> maxilliped.

Antennule (Fig. 5B): Peduncle 3-segmented: enlarged basal segment with 4 simple and 3 basal sparsely plumose setae; segment II with 4 simple setae; distal segment with 4 sparsely plumose setae. Flagellum 4-segmented: proximal segment naked, segment II with 2 aesthetascs; segment III with 6 aesthetascs and 1 plumose seta; distal segment with 6 aesthetascs

Antenna (Fig. 5C): Consists of 10 segments, with a setation of 2, 2, 2, 0, 0, 4, 2, 3, 3, 3; distal four segments with long setae.

Mandible (Fig. 5D): Molar process with sharp cutting edge. Palp 2-segmented: proximal segment naked; distal segment with 9 short plumose setae.

Maxillule (Fig. 5E): Coxal endite with 20 plumodenticulate, short plumose setae. Basial endite with 22 plumodenticulate, short plumose setae. Endopod unsegmented, with 3 simple and 2 sparsely plumose setae. Basipod naked.

Maxilla (Fig. 5F): Coxal endite bilobed, with 10+4 plumodenticulate, short plumose setae. Basial endite bilobed, with 8+9 plumodenticulate, short plumose setae. Endopod unsegmented, with 3 short plumose setae basally. Scaphognathite with 55 highly plumose setae on marginal and 5 simple setae on external surface.

First maxilliped (Fig. 5G): Coxal endite with 13 plumodenticulate, short plumose setae. Basial endite with 10 plumodenticulate, short plumose setae. Endopod unsegmented, with 2 simple setae subterminally and 3 sparsely plumose setae distally. Exopod 2-segmented: proximal segment with 2 highlyplumose setae distolaterally; distal



segment with 4 long plumose setae terminally. Epipod triangular, with 12 sparsely plumose setae.

Second maxilliped (Fig. 5H): Basally with 2 plumose setae. Endopod 4-segmented: proximal segment with 8 plumose setae. Exopod 2-segmented: proximal segment with 1 simple seta; distal segment with 5 long plumose setae terminally. Epipod absent.

Third maxilliped (Fig. 5I): Endopod 5-segmented: proximal segment with 13 short plumose setae; segment II with 2 simple and 7 short plumose setae; segment III with 3 simple and 3 plumose setae; segment IV with 4 simple and 8 plumose setae; distal segment with 4 plumose setae terminally. Exopod 2-segmented: proximal segment with 2 simple and 3 plumose setae; distal segment with 4 highly plumose setae terminally. Coxa and basis fused. Basipod with 19 plumodenticulate setae. Epipod elongate, with 28+13 sparsely plumose setae. Podobranch well developed, with gill filaments.

Pereiopods (Figs. 6A-E): Chelipeds (pereiopod I) subequal, with spine directed ventrally on ischium, chela with frontal tooth and irregular cutting edge. Pereiopods II-IV similar in structure, dactylis tapering distally, slightly curved ventrally, with several scattered plumose, plumodenticulate, denticulate and simple setae on surfaces. Dactylis of pereiopod V with 3 long terminal serrate setae, surface with several scattered plumose, plumodenticulate, denticulate and simple setae.

Abdomen (Figs. 6K): Consists of 6 somites: somites III-V each with posterior sharp pointed ventrolateral projections, in somite V its reaching 2/3 length of somite VI. Posterior margin of somite VI smooth. Somites I-VI with 3, 4, 6, 6, 6 and 3 pairs of simple setae on dorsal surface, respectively.

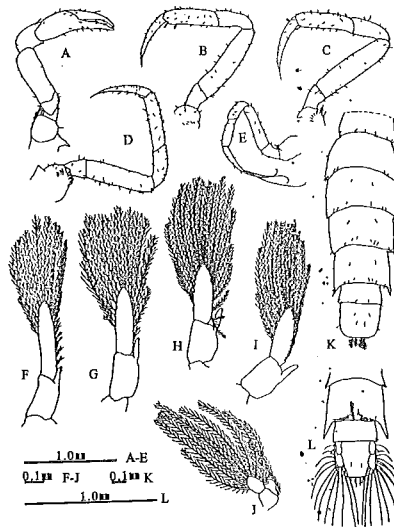


Fig. 6. Megalopa of *Chasmagnathus convexus*. A-E. pereiopods, F-I. 1<sup>st</sup>-4<sup>th</sup> pleopods, J. uropod, K-L. abdomen and telson (dorsal view).

Pleopods (Figs. 6F): Two-segmented, developed to main natatorial appendages. Endopod of pleopods I-IV each with 3 cincinnuli distolaterally. Exopod of pleopods I-IV, with 20, 19, 19 and 18 plumose setae, respectively.

Uropod (Figs. 6J, L): Uropods 2segmented : proximal segment with one external plumose seta laterally; distal segment with 11 plumose setae.

Telson (Figs. 6K, L): Posterior margin oval shaped and smooth, distinctly longer than somite VI, with 6 simple and 4 plumose setae medially on posterior margin.

## Discussion

The overall morphology of the first zoea of *C. convexus* agrees very closely with the other species of the genus *Chasmagnathus* as well as the genus *Helice* having lateral spine on the carapace (Boschi *et al.* 1967, Green and Anderson 1973, Mia and Shokita 1996, 1997). In comparison with larvae of two subspecies of *Helice*, which are the most related, the fourth abdominal somite has a lateral spine in *C. convexus* and in *H. tridens*, but it is lacking in *H. wuana* (Baba and Moriyama 1972). Only a distinct character between zoeae of this species and the two subspecies of *Helice* is the presence of a paired or single setae near the distal portion of the exopod of the antenna; the setae are single in the two subspecies but paired in *C. convexus*. In the setation on the telson, the first and final zoeae of both *C. convexus* and the subspecies of *Helice* show the same formulae, 3+3 and 5+5 respectively; but in the second zoea the setation remains as 3+3 in *Helice* subspecies whereas it advances to be 4+4 in *C. convexus* (Baba and Moriyama 1972). The zoeae of *Chasmagnathus* species are readily distinguished from those of other species of the genus *Perisesarma*, *Neosarmatium* and *Sesarma* by having lateral spines on the carapace (Islam and Shokita 2001, Lago 1987, 1989).

The zoea larvae of the family Grapsidae have been divided into four groups on the basis of their morphological characters (Wear and Fielder 1985, Rice 1980). The first two groups are relatively homogeneous and well defined, and correspond roughly to the subfamilies Grapsinae and Plagusiinae (Lago 1993a, b). The other two groups comprise a rather heterogeneous array of morphological characteristics (Wilson 1980), and include genera from the subfamilies Sesarminae and Varuninae (Wear and Fielder 1985). From the study of New Zealand larval grapsid representatives, Wear and Fielder (1985) concluded that separation of the latter two larval groups could not be justified, and lumped all larval sesarminae and varunine together into a single subfamilial division. Lago (1993a) arrived at the same conclusion from the analysis of mouth parts setation patterns in 37 sesarminae and varunine species.

Lago (1993a,b) classified the genera *Sesarma*, *Aratus*, *Metasesarma*, (including here within *Sesarma* Serene and Soh's, 1970 genera *Perisesarma*, *Sesarmops* and *Bresedium*), and possible *Neosarmatium* (revised by Davie 1994) into a distinct larval subgroup within the sesarminae-varunin group. A second larval subgroup identified by Rice (1980) within the sesarminae-varunine group includes the genera *Chasmagnathus*, *Helice*, *Cyclograpsus*,

*Hemigrapsus*, *Helograpsus*, *Heterograpsus* and *Eriocheir*. This indicates the same degree of homogeneity as that observed in *Helice*, *Sesarma* and allied genera (Lago 1993a, b).

The detailed megalopal descriptions of species within the sesarmine-varunine group have been described poorly, and intergeneric comparisons are premature. However, given the known characteristics of megalopa of the genera *Sesarma*, *Perisesarma*, *Neosarmatium* and *Helice*, a tentative definition of the megalopa of *C. convexus* may be based on the following characters: antennule lacking inner flagellum; antennal seventh segment always with two, stout denticulate terminal setae; distal segment of the mandibular palp with more than eight setae; scaphognathite of the maxilla with about 55 highly plumose and 2-4 simple setae; second maxilliped lacking epipod, and endopod almost always with 3,1,6,8 setae; and distal segment of uropods with ten or eleven setae.

In the megalopa stage no distinct differences are noted in the member of *Chasmagnathus*, *Helice*, *Sesarma*, *Perisesarma* and *Neosarmatium* of the sesarmine-varunine group (Mia and Shokita 1996, 1997, Islam and Shokita 2000, 2001). The setation of pleopods of *Chasmanathus* is near to that of *Helice* species. The megalopa of *C. convexus* of be readily distinguished from other sesarmine crabs by the setal formula of the following structures: endopod of the first maxilliped; exopod of the first and third maxillipeds. The present results do not support the use of larval description of the subfamilies Sesarminae and Varunine, at least with their present generic composition.

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