

# Complete Larval Development of the Swimming Crab, *Charybdis bimaculata* (Miers, 1886) (Crustacea, Brachyura, Portunidae), Reared in Laboratory

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The 7 zoeal and 1 megalopal stages of *Charybdis bimaculata* (Miers, 1886) are described and illustrated in detail from larvae reared in laboratory. Under laboratory conditions of 22°C temperature and 33.3‰ salinity, the megalopa was attained in 32 days or more after hatching. The larval morphology of the first zoea of *C. bimaculata* are coincide with those of *Charybdis* species by bearing lateral spines on carapace, B-type antenna, A-type telson, 1,6 setae on the endopod of maxillule, and 6 setae on the endopod of maxilla. Morphological features of *C. bimaculata* larvae were compared to the previous descriptions of larvae of the other species belonging to the same genus.

**KEY WORDS:** Larval Development, *Charybdis bimaculata*, Brachyura, Portunidae, Korea

Most of swimming crabs or portunid crabs are known to occur in waters of the Indo-West Pacific (Stephenson, 1976). The family Portunidae comprise one of the most dominant groups of crabs which support important fisheries along the Pacific, East China Sea, and Japan Sea coast as well as in Korean waters. At least 30 species of the genus *Charybdis* occur in the region extending from the Philippines to Japan and China, of which 5 are reported by Kim (1973) from Korean waters.

*Charybdis bimaculata* (Miers, 1886) is mostly found from Yöng-il Bay of East Sea to Kyönggi Bay of Yellow Sea in Korea and inhabits the bottoms of sand, mud or broken shells of 20 to 430 m deep (Kim, 1973). This species also distributes widely from Japan to the eastern Asia, India, Australia, and east coast of Africa (Sakai, 1976).

Studies on life history of portunid crabs have

been in progress for the last 100 years, but complete larval development are very poorly known. In the genus *Charybdis*, the complete larval descriptions are available for only 4 species: *C. acuta* (A. Milne Edwards) (Kurata and Omi, 1969; Terada, 1979), *C. callianassa* (Herbst) (Hashimi, 1969; Greenwood and Fielder, 1980), *C. feriata* (Linnaeus) (Motoh and Villaluz, 1976 as *C. cruciata* Herbst; Terada, 1979 as *C. cruciata* Herbst; Fielder *et al.*, 1984), and *C. japonica* A. Milne Edwards (Aikawa, 1937 as *C. 6-dentata* Herbst; Yatsuzuka, 1952; Kurata and Nishina, 1975; Terada, 1979; Yatsuzuka *et al.*, 1984). Seven zoeal stages of *C. miles* De Haan and *C. variegata* (Fabricius) are described by Terada (1979) and 3 zoeal stages of *C. truncata* (Fabricius) are described by Kurata (1975). First zoeae have been only described for *C. annulata* (Fabricius), *C. lucifera* (Fabricius) and *C. orientalis* Dana by Hashimi (1969), and *C. miles* by Kurata (1975). Although Aikawa (1937) and Kurata (1975) described zoeal stages IV-V and megalopa

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and 4 zoeal stages of *C. bimaculata* obtained from the planktonic specimens and laboratory culture respectively, their descriptions are very brief, questionable in the accuracy, and not giving setation and figure for some appendages of each larval stage. Therefore, it is necessary to study of more detailed description for complete larval development of the species.

The purpose of this paper is to describe and illustrate complete larval stages of *C. bimaculata* in detail and to compare them with previously known larvae of the other species within the genus *Charybdis*.

## Materials and Methods

On 11 July 1994, ovigerous females of *Charybdis bimaculata* were collected in trawl catches from a depth of 30-40 m at sea off Kadökdo, Pusan, Korea. The obtained females were transported to the laboratory in plastic boxes previously cooled to approximately 10°C. They were placed individually in glass containers (300 mm diameter × 200 mm depth) filled with aerated seawater of 33.3‰ salinity and 21±1°C temperature. A natural photoperiod of 12 h (light intensity = 4,500 lux) was maintained until hatching. Hatching occurred at night and lasted 2 h.

Positively phototactic active larvae were separated into 20 groups of 10 larvae per glass bowl (containing 80 ml filtered seawater of 33.3

‰) and kept in a culture chamber with 14 h light : 10 h dark photoperiod and 22°C temperature. *Brachionus* sp. for the early stages and newly hatched *Artemia* nauplii for the later stages were provided as food daily. Filtered seawater was changed every day. The larvae were examined each day before changing the water for the presence of live or dead larvae and exuviae.

Specimens, dead larvae and exuviae of each developmental stage were preserved in 7% neutral formalin. Larval descriptions were made based on at least 15 individuals of each stage. Drawings and measurements were based on freshly killed larvae and made with the aid of a camera lucida and an ocular micrometer. The chromatophore patterns were determined from the observation of living larvae. Measurements of zoeal and megalopal stages were adapted from Stuck and Truesdale (1988).

## Results

*Charybdis bimaculata* passed through 7 zoeal and 1 megalopal stages before attaining the first crab stage. The megalopa appeared in 32 days or more after hatching. Survival and developmental time from hatching to each larval stage are given in Table 1. Measurements of various features of the larvae are presented in Table 2. The morphology of the first zoeal stage is described in detail, but for the later (2nd-7th) zoeal stages, morphological changes are only described.

**Table 1.** Time required for complete larval development and survival percentage of *Charybdis bimaculata* (Miers) at 22°C (Initial number of larvae = 200, mean based only on larvae attaining next stage).

Stage	Initial number	Survival percentage	Days reached		
			Min.	Max.	Mean/S.D.
Hatch to					
Zoea II	187	93.50	4	6	5.04/0.36
Zoea III	168	84.00	9	11	10.35/0.57
Zoea IV	155	77.50	13	18	15.49/0.98
Zoea V	131	65.50	18	22	20.18/0.90
Zoea VI	117	58.50	22	28	24.90/1.46
Zoea VII	106	53.00	27	33	29.46/1.56
Megalopa	64	32.00	32	39	35.55/1.89

**Table 2.** Measurements of various characteristics of the zoeae and megalopa of *Charybdis bimaculata* (Miers). All measurements are in mm; mean values for 15 specimens of each larval stage are given with standard deviations in brackets.

	Zoea I	Zoea II	Zoea III	Zoea IV	Zoea V	Zoea VI	Zoea VII	Megalopa
TSL	1.06[0.03]	1.20[0.04]	1.40[0.06]	1.68[0.10]	1.96[0.10]	2.47[0.13]	2.92[0.14]	
Range	1.01-1.12	1.14-1.27	1.30-1.48	1.56-1.82	1.82-2.16	2.24-2.65	2.68-3.12	
DL	0.40[0.02]	0.41[0.02]	0.49[0.05]	0.58[0.04]	0.67[0.06]	0.83[0.06]	1.13[0.11]	
Range	0.35-0.43	0.39-0.43	0.43-0.56	0.54-0.65	0.61-0.79	0.76-0.93	1.01-1.30	
RL	0.30[0.01]	0.33[0.02]	0.42[0.02]	0.49[0.03]	0.58[0.03]	0.75[0.05]	0.95[0.07]	
Range	0.28-0.32	0.31-0.36	0.40-0.46	0.45-0.52	0.52-0.62	0.70-0.81	0.83-1.04	
SW	0.53[0.02]	0.59[0.02]	0.76[0.05]	0.84[0.04]	1.04[0.03]	1.26[0.06]	1.55[0.06]	
Range	0.50-0.55	0.56-0.62	0.69-0.83	0.80-0.91	1.00-1.08	1.17-1.35	1.46-1.61	
AL	0.28[0.01]	0.32[0.03]	0.38[0.02]	0.45[0.04]	0.50[0.02]	0.64[0.07]	0.73[0.03]	
Range	0.27-0.31	0.28-0.36	0.35-0.40	0.40-0.50	0.47-0.52	0.54-0.70	0.70-0.78	
CL	0.42[0.02]	0.53[0.03]	0.60[0.02]	0.71[0.04]	0.84[0.05]	1.06[0.04]	1.36[0.05]	1.90[0.16]
Range	0.40-0.45	0.48-0.57	0.58-0.63	0.65-0.77	0.80-0.96	0.98-1.10	1.30-1.43	1.69-2.08
CW								1.62[0.17]
Range								1.43-1.82

AL, second antenna length; CL, carapace length; CW, carapace width; DL, dorsal spine length; RL, rostral spine length; SW, lateral spines width (= length between lateral spine tips); TSL, total spine length (= length from rostral to dorsal spine tips).

**First zoea (Fig. 1)**

Carapace (Figs. 1A, B). Rostral spine smooth, straight, uniformly tapered and shorter than carapace length. Dorsal spine tapering uniformly to posterior curved tip and as long as carapace length. Lateral spines small and directed at right-angles to body. One fine seta flanking each side of base of dorsal spine. Postero-ventral margin of carapace rounded and naked. Antero-medial margin of carapace with slight protuberance behind eyes. Eyes sessile.

Abdomen and telson (Figs. 1A, C). With 5 somites and 1 telson. Somites II-III each with distinct dorso-lateral knobs, somites III-V each with acute postero-lateral processes, and somites II-V each with pair of dorso-marginal simple setae. Telson bifurcated, each furca with strong outer lateral spine and dorsal spine. Three serrate spines present on inner margin of each furca.

Antennule (Fig. 1D). Conical, with 3 long aesthetascs and 1 short simple seta.

Antenna (Fig. 1E). Approximately 3/4 length to dorsal spine. Elongated protopod tapered, with 2 rows of spinules on distal half. Exopod about 1/4 length of protopod, with short simple seta at base of terminal spine.

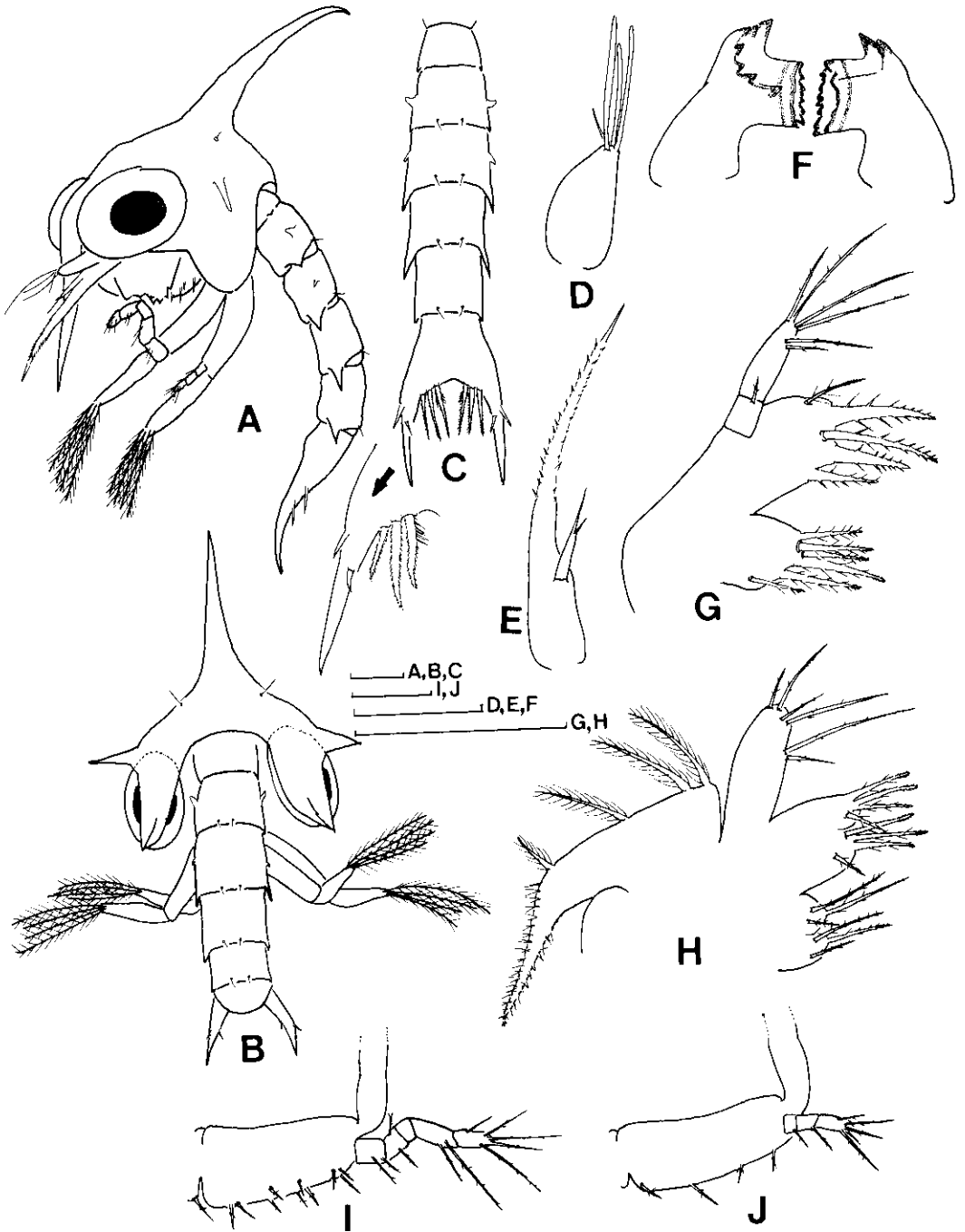
Mandibles (Fig. 1F). Asymmetrical. Molar and incisor processes irregularly dentated. Junction of molar and incisor processes with 4 teeth on right mandible.

Maxillule (Fig. 1G). Endopod 2-segmented, proximal segment with small medial plumose seta, distal segment with 4 terminal and 2 subterminal plumodenticulate setae. Basal and coxal endites with 5 and 6 plumodenticulate setae, respectively.

Maxilla (Fig. 1H). Endopod unsegmented, with 4 terminal and 2 subterminal plumodenticulate setae. Basal endite bilobed, outer and inner lobes each with 4 plumodenticulate setae. Coxal endite bilobed, outer and inner lobes each with 3 plumose setae. Scaphognathite with 4 densely plumose setae and terminal process with dense microtrichia.

Maxilliped I (Fig. 1I). Coxa with plumodenticulate seta. Basis with 2, 2, 3, and 3 plumodenticulate setae. Endopod 5-segmented, with 2, 2, 0, 2 and 4+1 plumodenticulate setae. Exopod with 4 natatory plumose setae.

Maxilliped II (Fig. 1J). Coxa naked. Basis with 4 plumodenticulate setae. Endopod 3-segmented, each of distal margin of proximal 2 segments with plumodenticulate seta, distal segment with 5

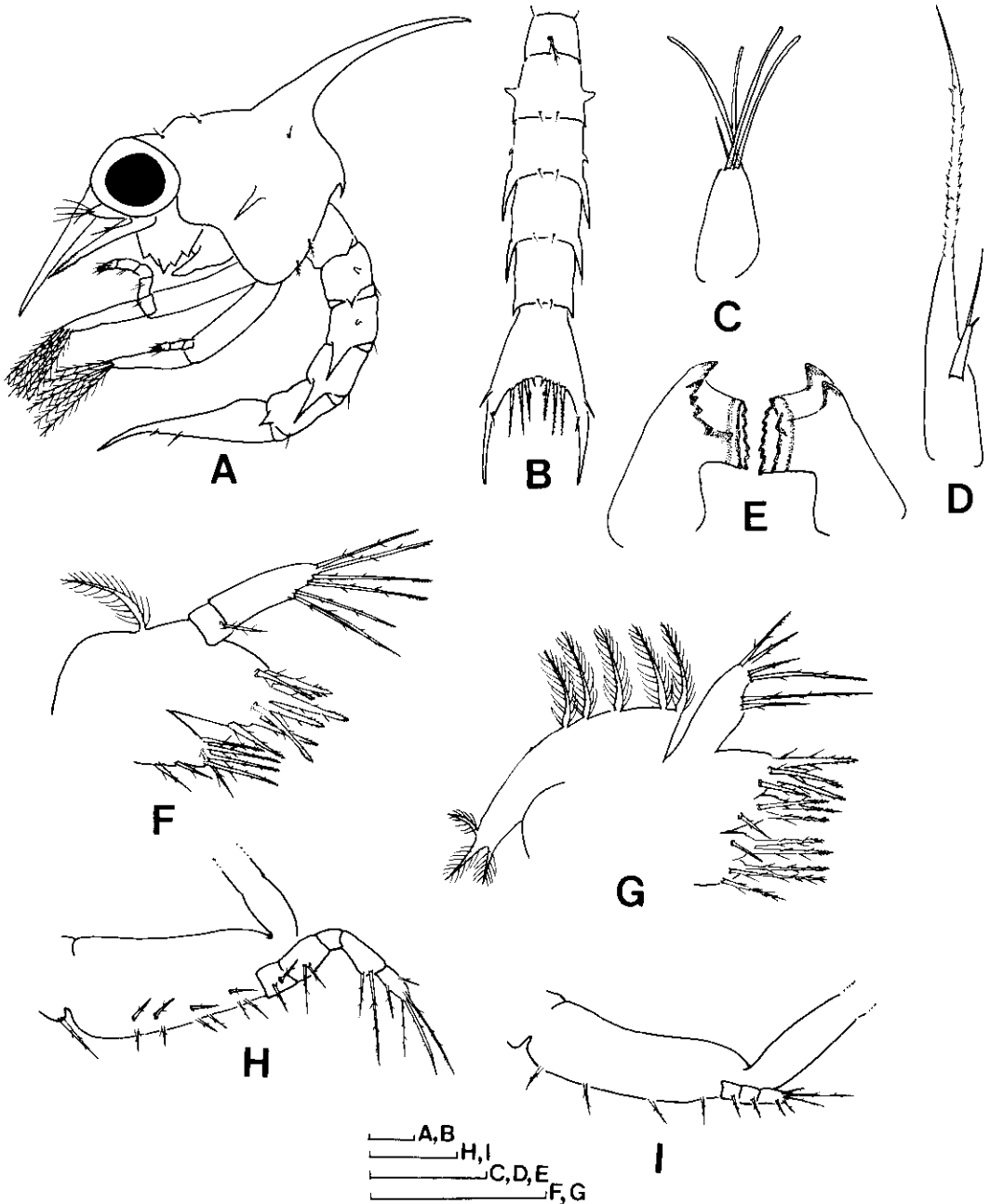


**Fig. 1.** First zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, posterior view; C, dorsal view of abdomen; D, antennule; E, antenna; F, mandibles; G, maxillule; H, maxilla; I, first maxilliped; J, second maxilliped. Scale bars = 0.1 mm.

plumodenticulate setae of different length. Exopod with 4 natatory plumose setae.

Chromatophores. Chromatophore patterns fairly consistent throughout zoeal development.

Light-brown chromatophores present on labrum and mandibles, on basis of first maxilliped, and on postero-ventral side of abdominal somites III-V. Reddish orange chromatophore present on ventral



**Fig. 2.** Second zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

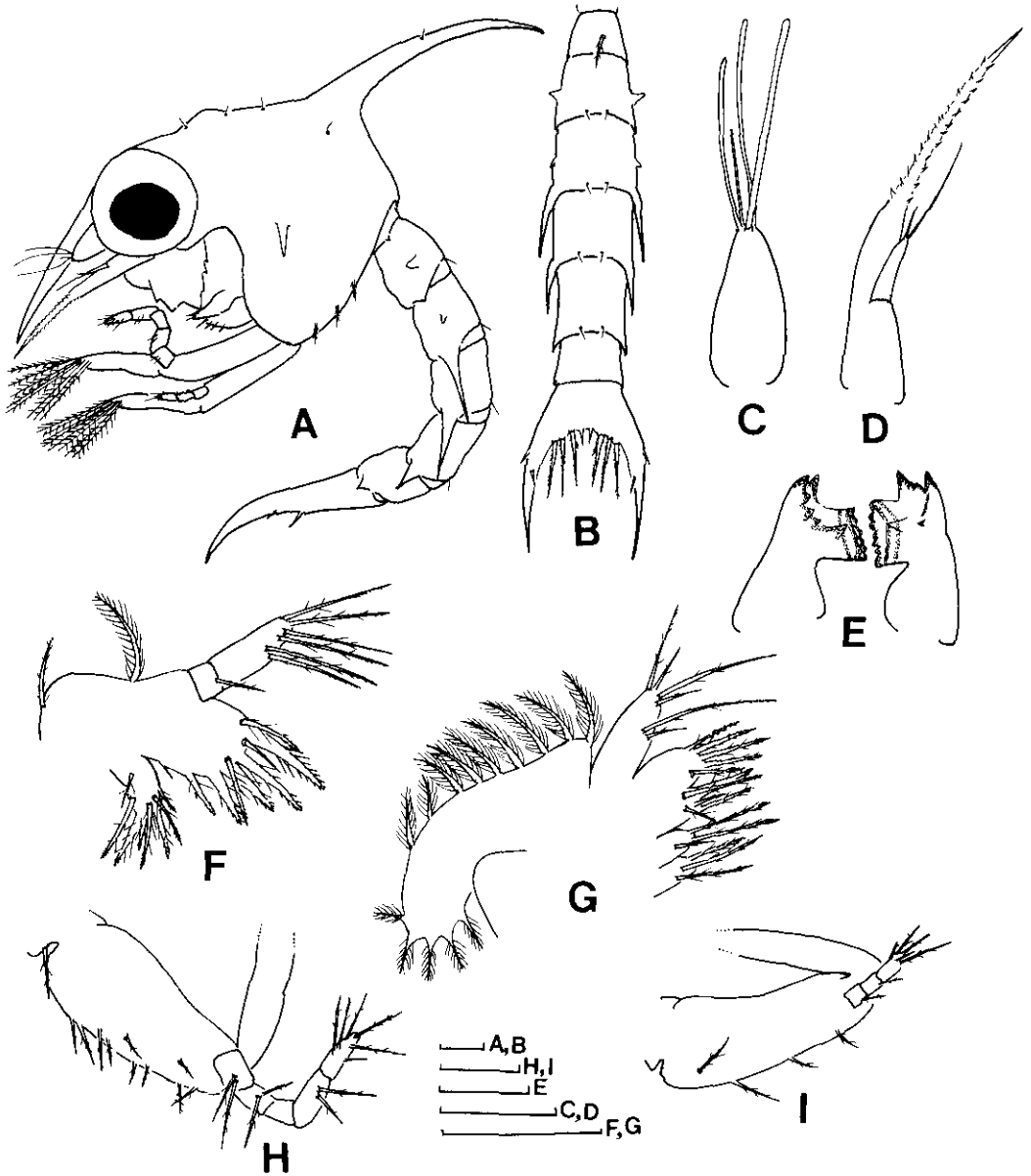
side of abdominal somites III-V.

**Second Zoea (Fig. 2)**

Carapace (Fig. 2A). Postero-ventral margin with 2 pairs of plumose setae. Two pairs of simple setae added on antero-medial margin. Eyes stalked.

Abdomen and telson (Figs. 2A, B). Abdominal somites III-IV each with elongate acute postero-lateral processes. Somite I with dorso-median plumose seta. One pair of small serrate spines added on central arch of telson.

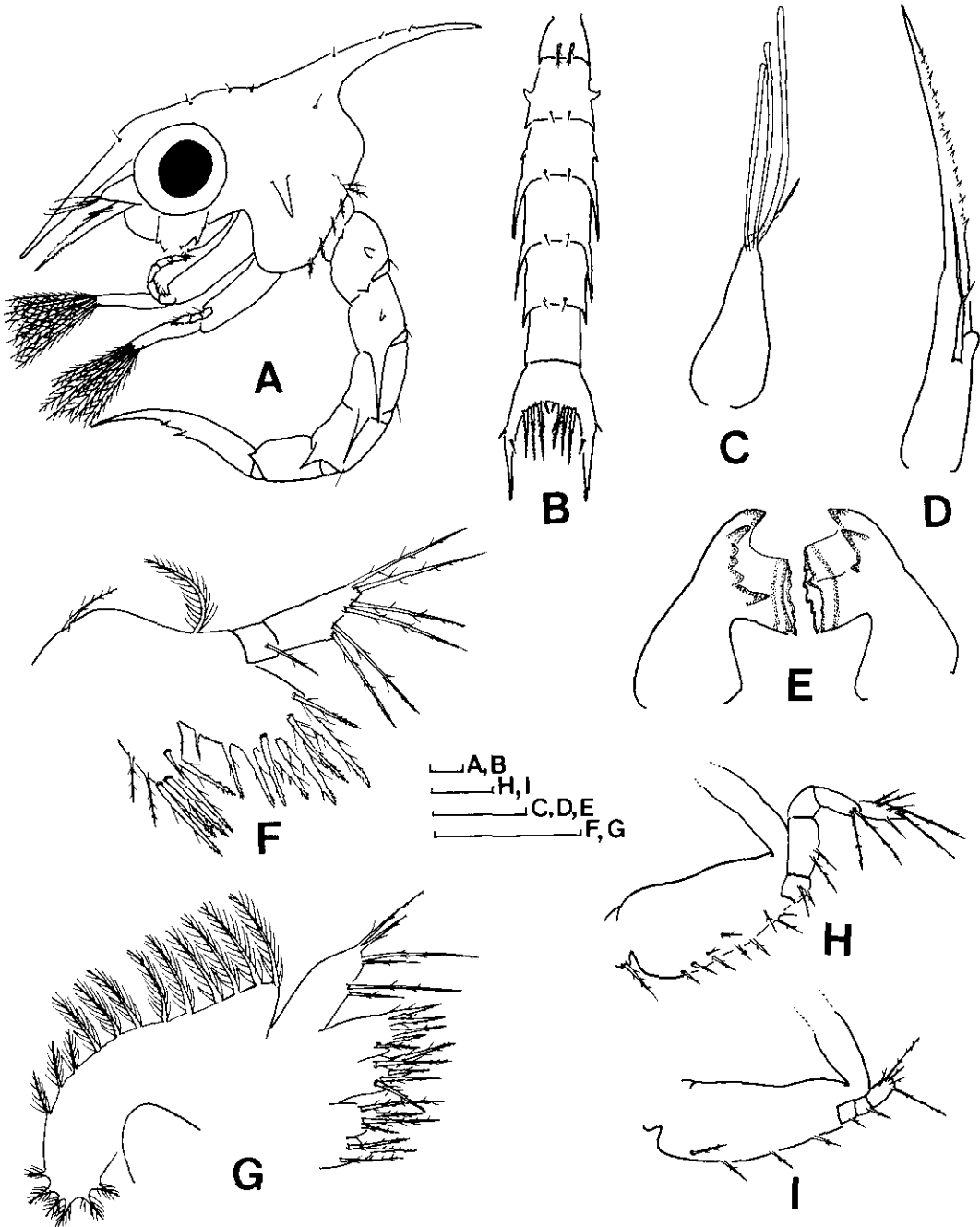
Antennule (Fig. 2C). With 4 aesthetascs and 1 simple seta.



**Fig. 3.** Third zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

Antenna (Fig. 2D) and Mandibles (Fig. 2E). As in zoeal stage I.  
Maxillule (Fig. 2F). Basal and coxal endites each

with 7 plumodenticulate setae. Plumose seta added on dorsal margin.  
Maxilla (Fig. 2G). Scaphognathite with 8 densely



**Fig. 4.** Fourth zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

plumose setae separated into anterior (5 setae) and posterior (3 setae) groups.

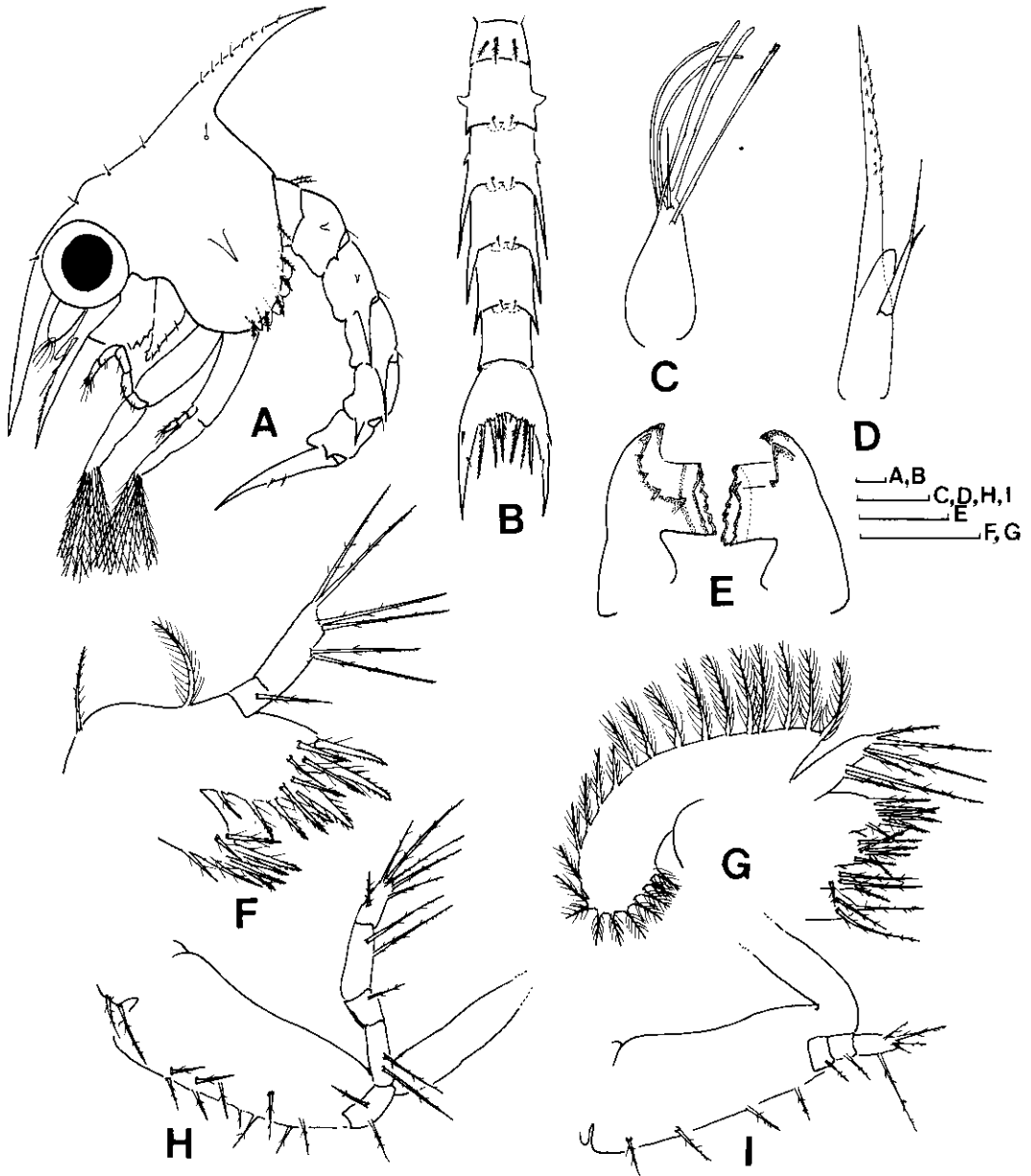
Maxilliped I (Fig. 2H). Exopod with 6 natatory plumose setae.

Maxilliped II (Fig. 2I). Exopod with 6 natatory plumose setae.

### Third Zoea (Fig. 3)

Carapace (Fig. 3A). Postero-ventral margin with 3 pairs of plumose setae. Paired simple setae added on anterior margin and dorsal spine.

Abdomen and telson (Figs. 3A, B). Somite VI present. Postero-lateral processes of somites III-IV



**Fig. 5.** Fifth zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.



each overlapped with 3/4 length of succeeding somites.

Antennule (Fig. 3C). With 3 aesthetascs and 1 simple seta.

Antenna (Fig. 3D). As in zoeal stage II.

Mandibles (Fig. 3E). Left mandible with additional tooth on junction of incisor and molar process.

Maxillule (Fig. 3F). Basal and coxal endites with 8+1 and 8 plumodenticulate setae, respectively. Plumodenticulate seta added on proximal margin.

Maxilla (Fig. 3G). Outer and inner lobes of basal endite each with 5 plumodenticulate setae. Scaphognathite with 14-15 densely plumose setae separated into anterior (9 setae) and posterior (5-6 setae) groups.

Maxilliped I (Fig. 3H). Plumose seta added on distal segment of endopod, setation 2, 2, 0, 2 and 6. Exopod with 8 natatory plumose setae.

Maxilliped II (Fig. 3I). Exopod with 8 natatory plumose setae.

#### **Fourth Zoea (Fig. 4)**

Carapace (Fig. 4A). Postero-ventral margin with 4-5 pairs of plumose setae. Paired simple setae added on basis of rostral spine. Dorsal spine with 3 pairs of simple setae.

Abdomen and telson (Figs. 4A, B). Somite I with 2 dorso-median plumose setae.

Antennule (Fig. 4C). As in zoeal stage III.

Antenna (Fig. 4D). Endopod present as shape of small bud.

Mandibles (Fig. 4E) and Maxillule (Fig. 4F). As in zoeal stage III.

Maxilla (Fig. 4G). Outer and inner lobes of coxal endite with 4,3 plumose setae, respectively. Scaphognathite with 17-19 densely plumose setae.

Maxilliped I (Fig. 4H). Exopod with 10 natatory plumose setae.

Maxilliped II (Fig. 4I). Exopod with 10 natatory plumose setae.

#### **Fifth Zoea (Fig. 5)**

Carapace (Fig. 5A). Postero-ventral margin with 6 pairs of plumose setae. Dorsal spine with 8 pairs of simple setae. Buds of thoracic appendages visible through carapace.

Abdomen and telson (Figs. 5A, B). Somite I

with 3 dorso-median plumose setae. Pleopod buds present on postero-ventral margin of somites II-VI.

Antennule (Fig. 5C). With 4 terminal plus 1 subterminal aesthetascs and 1 simple seta.

Antenna (Fig. 5D). Endopod bud slightly enlarged.

Mandibles (Fig. 5E). As in zoeal stage IV.

Maxillule (Fig. 5F). Basal and coxal endites with 10+2 and 8 plumodenticulate setae, respectively.

Maxilla (Fig. 5G). Outer and inner lobes of basal endite each with 6 plumodenticulate setae. Scaphognathite with 24-27 densely plumose setae.

Maxilliped I (Fig. 5H). Plumodenticulate seta added on coxa. Plumose seta added on segment III of endopod, setation 2, 2, 1, 2 and 6. Exopod with 12-13 natatory plumose setae.

Maxilliped II (Fig. 5I). Exopod with 12-13 natatory plumose setae.

#### **Sixth Zoea (Fig. 6)**

Carapace (Fig. 6A). Postero-ventral margin with 8 pairs of plumose setae. Paired simple setae added on anterior margin and posterior to eyes. Dorsal spine with 10 pairs of simple setae. Thoracic appendages slightly enlarged and chela not prominent.

Abdomen and telson (Figs. 6A, B). Pleopod buds slightly enlarged. Postero-lateral processes of somites III-IV extending to posterior margin of succeeding somites.

Antennule (Fig. 6C). With 4 terminal plus 2 subterminal aesthetascs and 1 simple seta. Basal region slightly swelling.

Antenna (Fig. 6D). Endopod bud much elongated.

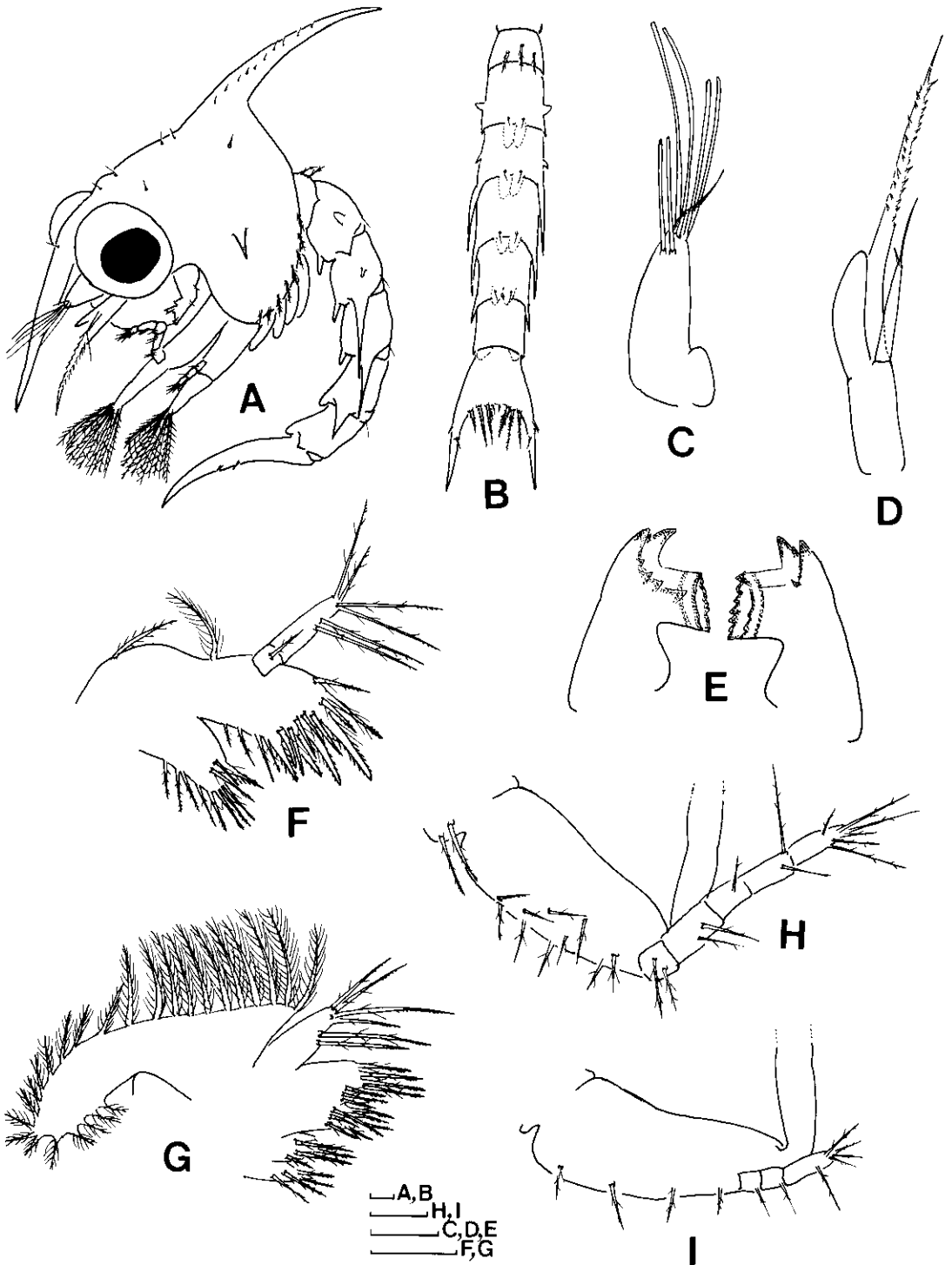
Mandibles (Fig. 6E). As in zoeal stage V.

Maxillule (Fig. 6F). Basal and coxal endites with 14+2 and 11 plumodenticulate setae, respectively.

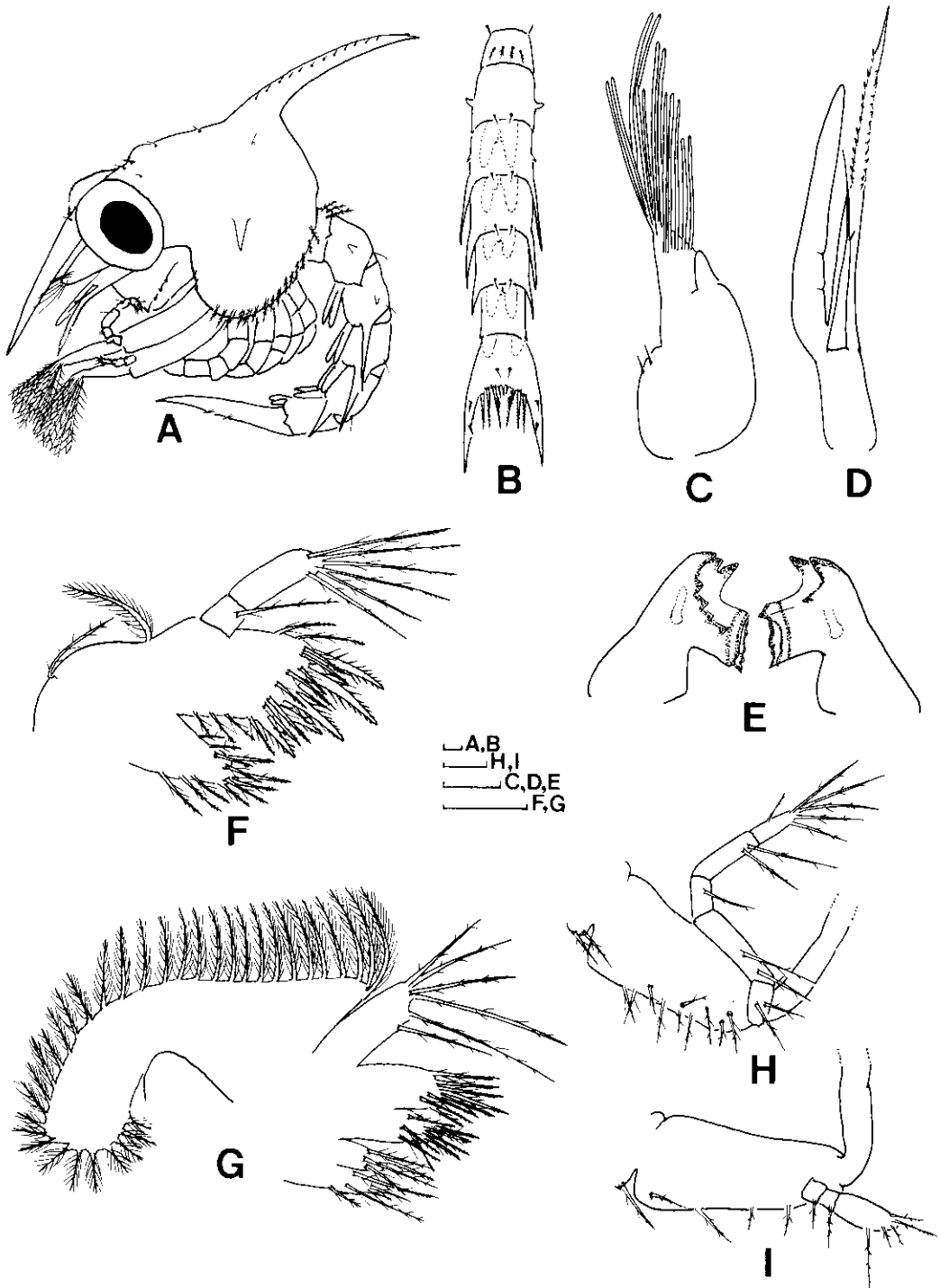
Maxilla (Fig. 6G). Outer and inner lobes of basal and coxal endites with 7, 7 and 4, 4 plumodenticulate setae, respectively. Scaphognathite with 26-30 densely plumose setae marginally.

Maxilliped I (Fig. 6H). Exopod with 14-15 natatory plumose setae.

Maxilliped II (Fig. 6I). Exopod with 14-15 natatory plumose setae.



**Fig. 6.** Sixth zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.



**Fig. 7.** Seventh zoea of *Charybdis bimaculata* (Miers). A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

### Seventh Zoea (Fig. 7)

Carapace (Fig. 7A). Postero-ventral margin with 15-16 pairs of plumose setae. Dorsal spine with 12 pairs of simple setae. Thoracic appendages very enlarged and chela prominent.

Abdomen and telson (Figs. 7A,B). Somite I with 4 dorso-median plumose setae. Pleopod buds well developed. Telson with paired simple setae on medio-dorsal region and with 3 small serrate spines on central arch.

Antennule (Fig. 7C). With 4 aesthetascs plus 1 simple seta terminally and 9 aesthetascs subterminally. Basal region swelling, with 2 simple setae. Endopod bud small, round.

Antenna (Fig. 7D). Endopod bud incompletely 3-segmented, extending to 3/5 length of protopod.

Mandibles (Fig. 7E). Mandibular palps present as small buds.

Maxillule (Fig. 7F). Basal and coxal endites with 16+3 and 12 plumodenticulate setae, respectively.

Maxilla (Fig. 7G). Outer and inner lobes of basal and coxal endites with 8, 8 and 4, 5 plumodenticulate setae, respectively. Scaphognathite with 35-39 densely plumose setae marginally.

Maxilliped I (Fig. 7H). Exopod with 16-18 natatory plumose setae.

Maxilliped II (Fig. 7I). Plumodenticulate seta added on coxa. Exopod with 16-18 natatory plumose setae.

### Megalopa (Figs. 8, 9)

Carapace (Fig. 8A). Narrowing anteriorly, with swelling above gastric region. Rostrum ending in shape of pointed tip, projected forward. Simple setae scattered on protogastric and antero-lateral regions. Plumose setae fringed along lateral and posterior margin. Smooth undulation present on protogastric, metagastric, and mesobranchial regions.

Abdomen and telson (Fig. 8A). With 6 somites and 1 telson. All somites with simple setae. Somite V with large postero-lateral projection extending beyond posterior margin of somite VI. Telson with slightly convex distal border, lacking spines or setae.

Antennule (Fig. 8B). Peduncle 3-segmented:

basal segment with 7 plumose and 1 simple setae, segment II with 2 plumose setae, and segment III naked. Lower ramus with 4 terminal simple setae. Upper ramus 5-segmented: segment I unarmed, segment II with 6 aesthetascs, segment III with 4 aesthetascs plus 1 plumose seta, segment IV with 3 aesthetascs plus 1 plumose seta, and segment V with 4 aesthetascs plus 2 plumose setae.

Antenna (Fig. 8C). Consisting of 11 segments, segments with setation of 3, 2, 3, 0, 0, 4, 2, 5, 1, 3 and 4 simple or plumodenticulate setae.

Mandible (Fig. 8D). Symmetrical. Cutting surface with distinct medial tooth. Palp 2-segmented: proximal segment with plumose seta, distal segment with 10 multidenticulate and 1 plumose seta.

Maxillule (Fig. 8E). Endopod with 3 short simple setae plus 3 long plumose setae. Basal endite with 16 plumodenticulate plus 9 simple setae. Coxal endite with 16 plumodenticulate setae. Proximal and dorsal region with 4 plumose setae.

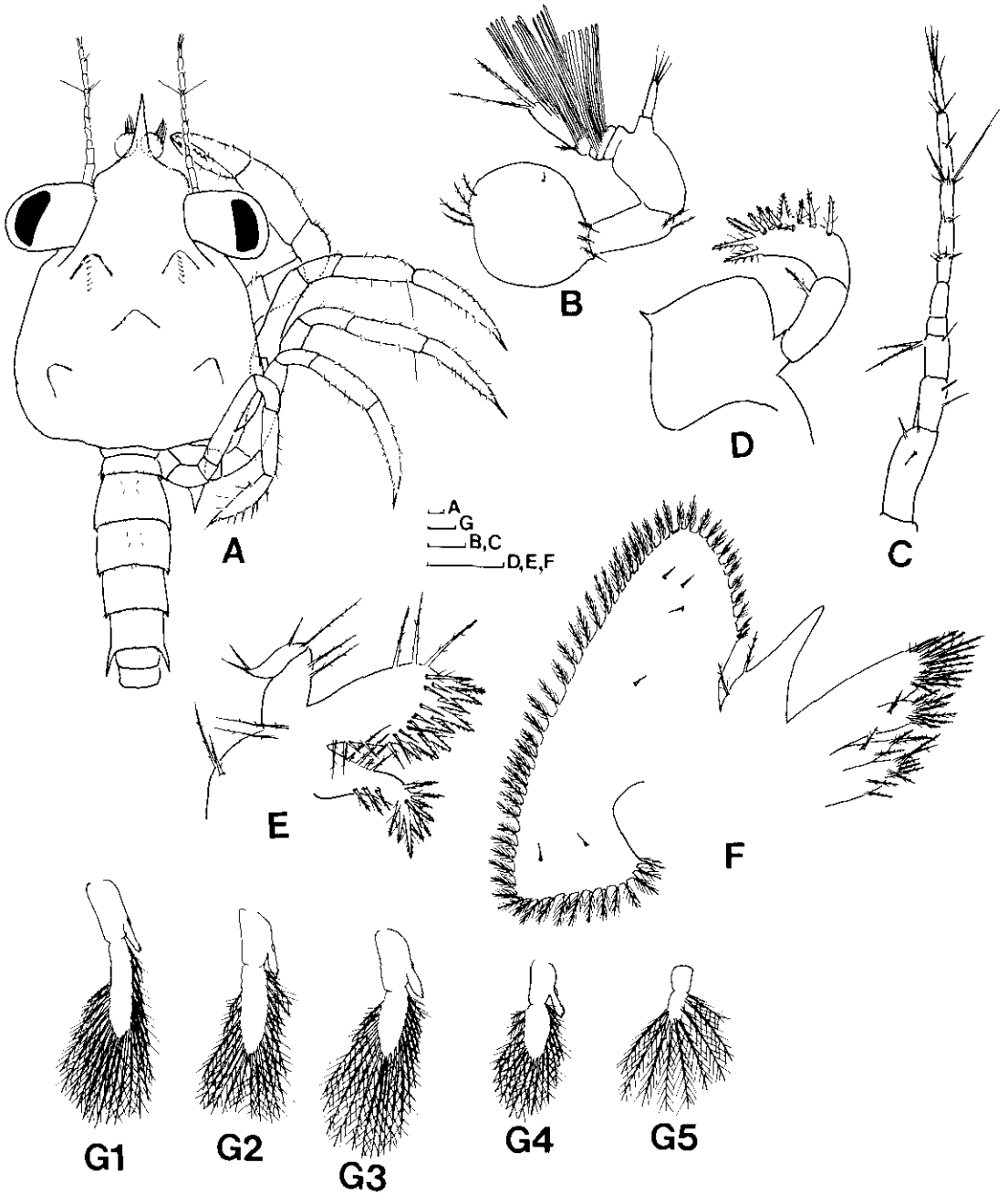
Maxilla (Fig. 8F). Endopod unsegmented, with 2 plumose setae. Outer and inner lobes of basal and coxal endites with 12, 7 and 4, 8 plumodenticulate setae, respectively. Scaphognathite with 56-61 densely plumose setae on margin and 6 simple setae on blade.

Pleopods (Figs. 8G 1-5). Well developed on somites II-VI. Exopods of pleopods I-V with 20-21, 21-22, 20, 17 and 8-9 natatory plumose setae, respectively. Endopods of pleopods I-IV each with 3 hooked spines. Pleopod 5 lacking endopod.

Maxilliped I (Fig. 9H). Endopod unsegmented, with 5 simple setae on broad distal margin. Exopod 2-segmented: proximal segments with 3 small plumose setae, distal segment with 4 long plumose setae terminally. Basal and coxal endites with 24 and 10 plumodenticulate setae, respectively. Epipod triangular in shape, with 14 long sparsely plumose setae.

Maxilliped II (Fig. 9I). Endopod 4-segmented, each segment with 4, 1, 7 and 9 plumodenticulate or simple setae. Exopod 2-segmented: proximal segment with simple seta laterally, distal segment with 3 plumose setae terminally. Basis with 3 plumodenticulate setae.

Maxilliped III (Fig. 9J). Endopod 5-segmented,

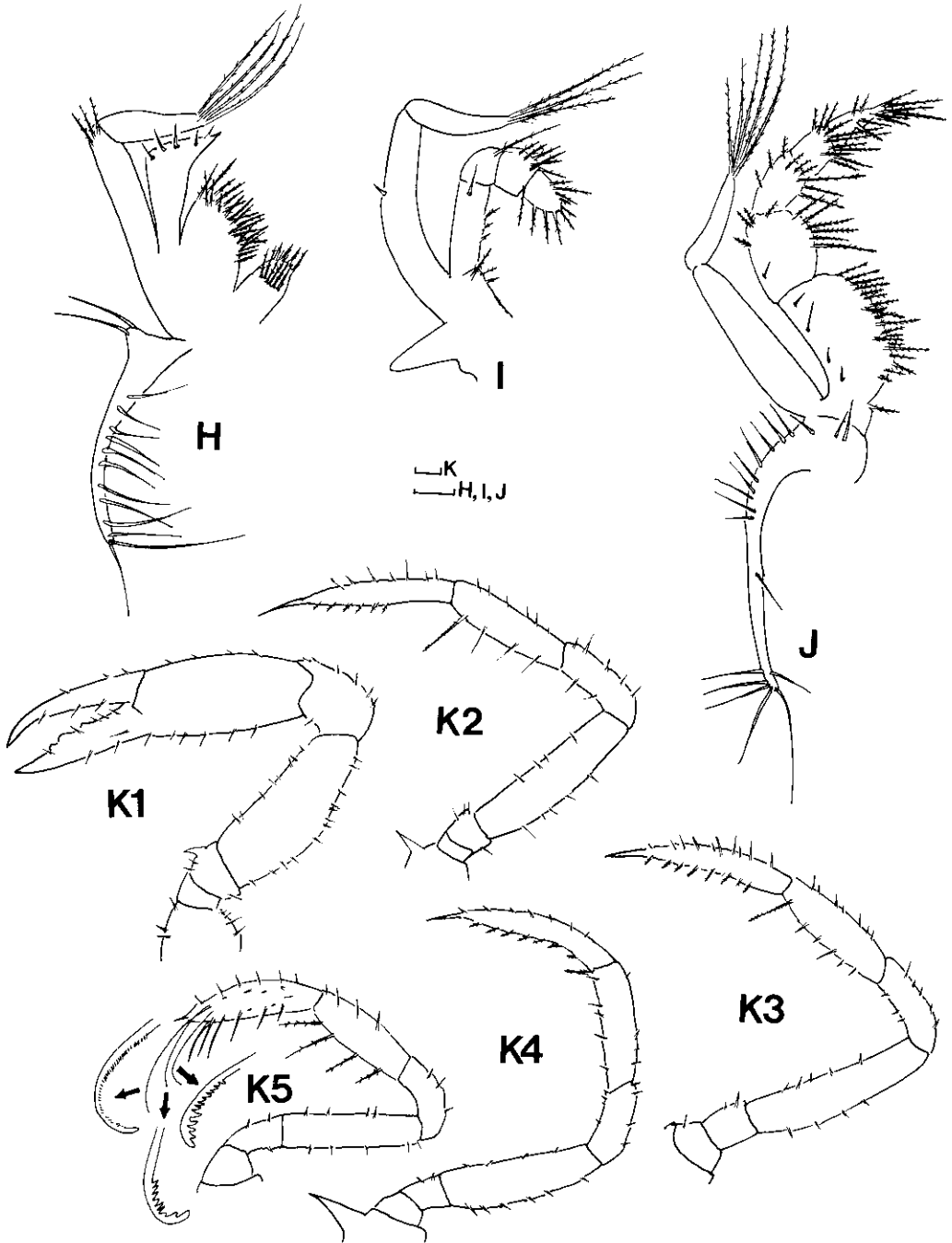


**Fig. 8.** Megalopa of *Charybdis bimaculata* (Miers). A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G1-5, pleopods 1-5. Scale bars = 0.1 mm.

each segment with 25, 11, 9, 11 and 10 plumodenticulate or simple setae. Exopod 2-segmented: proximal segment naked, distal segment with 5 plumose setae terminally. Epipod

with 12 proximal and 7 distal sparsely plumose setae.

Pereiopods (Figs. 9K 1-5). Cheliped (= pereiopod 1) with thorn-shaped spine directed



**Fig. 9.** Megalopa of *Charybdis bimaculata* (Miers). H, first maxilliped; I, second maxilliped; J, third maxilliped; K1-5, pereopods 1-5. Scale bars = 0.1 mm.

ventrally on distal region of ischium; fingers with several teeth on each cutting margin. Pereiopod II with spine on coxa, pereiopod IV with well developed sternal cornua on coxa, and pereiopod V with peddle-shaped dactylus bordered by 2 long hooked serrate and 1 long modified hooked serrate setae.

Chromatophores. Dark brown chromatophores present on mandible, on basis of antennule, on frontal, metagastric and mesogastric regions of carapace, on abdominal somites II-V, on coxa of pereiopods II-IV and on dactyla of cheliped. Red chromatophores present on coxa of pereiopods II-IV and on eye stalk.

**Discussion**

Aikawa (1937) briefly described zoeal stages IV-V and megalopa of *Charybdis bimaculata*

obtained from the planktonic samples. There are, however, some differences between Aikawa's description and that of the present study. Aikawa described that the exopod of antenna longer than 1/2 of peduncle in the zoeal stage V, whereas that of our specimen is 1/5 as long as peduncle in all zoeal stages. Aikawa also recognized 2 different groups of megalopa in this species, but he did not describe the differences between the 2 stages in detail, except the lengths of carapace and abdomen, and the uropod setation. While our specimen has 1 megalopal stage before molting to the crab I instar. Therefore, the authors assume that Aikawa made a mistake in the identification of the species and thus described the megalopa of other species rather than different stages of the same species.

Kurata (1975) also described early zoeal stages of this species and used the length of some appendages as a supporting character for

**Table 3.** Comparison of the first zoeal characteristics in eleven species of *Charybdis*.

	TSL (mm)	CL (mm)	Antennule Telson		Maxillule		Maxilla		Maxilliped I		Maxilliped II		
			setation	fork	BE	CE	EN	BE	CE	Basis	EN	Basis	EN
<i>C. acuta</i> (Kurata and Omi, 1969)	1.23	0.45*	2A,1S	2L,1D	5	6	6	4,5	4,4	-	2,2,0,2,5*	-	1,1,5
<i>C. annulata</i> (Hashimi, 1969)	0.95	-	2A,1S	2L,1D	5	6	5	4,5	2,3	8	2,2,0,2,5	3	1,1,5
<i>C. bimaculata</i> (present study)	1.06	0.42	3A,1S	1L,1D	5	6	6	4,4	3,3	2,2,3,3	2,2,0,2,5	4	1,1,5
<i>C. callianassa</i> (Greenwood and Fielder, 1980)	0.98	0.51	2A,2S	2L,1D	5	7	6	5,3	4,3	8	2,2,0,2,5	3	1,1,5
<i>C. feriata</i> (Fielder et al., 1984)	1.21	0.42*	2A,1S	1L,1D	5	6	5	4,4	2,3	2,2,3,3	2,2,0,2,5	4	1,1,4
<i>C. japonica</i> (Yatsuzuka et al., 1984)	-	0.48	3A,1S	1L,1D	5	6	6	4,4	2,2	6	2,1,0,1,4	4	1,1,5
<i>C. lucifera</i> (Hashimi, 1969)	1.54	-	2A,2S	2L,1D	5	6	6	3,4	3,2	8	3,2,0,2,5	4	1,1,5
<i>C. miles</i> (Terada, 1979)	1.22	0.40	-	2L,1D	5	6	-	-	-	2,2,3,3	2,2,0,2,5	4	1,1,5
<i>C. orientalis</i> (Hashimi, 1969)	1.54	-	2A,3S	1L,1D	5	6	5	4,5	3,3	12	3,2,0,2,5	4	1,1,5
<i>C. truncata</i> (Kurata, 1975)	1.11-1.20	-	-	2L,1D	-	-	6	-	-	-	-	-	-
<i>C. variegata</i> (Terada, 1979)	0.76	0.31	-	2L,1D	-	-	6	4,4	3,3	2,2,3,3	2,2,0,2,5	4	1,1,5

\* data from Terada (1979); A, aesthetascs; BE, basal endite; CE, coxal endite; CL, carapace length; D, dorsal spine; EN, endopod; S, simple seta; L, lateral spine; TL, total spine length; -, no data.

distinguishing *Charybdis* from other genera. Unfortunately, such a simple factor which excludes appendage setations can not be used to establish the differences among the species of *Charybdis*.

Portunid species have at least 3 zoeal stages (Fielder and Greenwood, 1979; Greenwood and

Fielder, 1979; Thomas *et al.*, 1980) and even up to 8 zoeal stages (Costlow and Bookhout, 1959; Bookhout and Costlow, 1977; Wear and Fielder, 1985; Stuck and Truesdale, 1988) before molting to the megalopa. Particularly, there are considerably more variations in the rate of

**Table 4.** Comparison of morphological features of the megalopa in three species of the genus *Charybdis*.

	<i>C. bimaculata</i> (present study)	<i>C. callianassa</i> (Greenwood and Fielder, 1980)	<i>C. feriata</i> (Fielder <i>et al.</i> , 1984)
Carapace			
length/width	1.90/1.62 mm	1.20/1.35 mm	1.61-1.75/1.70-2.40 mm
Antennule			
peduncle	3-segmented; 7P+1S, 2P, 0	2-segmented; 9S, 1HP+3S	3-segmented; 1S+5P, 5P, 2S+1P
lower ramus	4S	5S	2S+2PD
upper ramus	0; 6A; 4A+1P; 3A+1P; 4A+2P	0; 8-9A; 7-10A; 7A; 4A+1HP	0; 11A; 11A+1S; 9A+1S; 4A+1S+1P
Antenna			
flagellum	11-segmented; 3, 2, 3, 0, 0, 4, 2, 5, 1, 3, 4	10-segmented; 3, 3, 4, 0, 2, 1, 3, 0, 3, 4	11-segmented; 2, 3, 4; 0; 0, 4; 3, 4; 2; 4; 5
Mandible			
palp	2-segmented; 1P, 10MD+1P	3-segmented; 0, 0, 12PD	2-segmented; 0, 16PD
Maxillule			
coxal endite	16PD	19PD	23PD
basal endite	16PD+9S	21PD+6K	28PD
endopod	2P; 1S+1P; 2S	3PD; 1P; 3P	3PD; 1PD; 2P
Maxilla			
coxal endite	4PD dist.; 8PD prox.	5PD dist.; 9PD prox.	10PD dist.; 13PD prox.
basal endite	12PD dist.; 7PD prox.	10PD+1S dist.; 9PD+1S prox.	12PD dist.; 12PD prox.
endopod	2P	2HP	1S+3HP
scaphognathite	56-61HP, 6S on face	50-54HP, 9S on face	69HP, 9S on face
Maxilliped I			
coxal endite	10PD	14PD	24PD
basal endite	24PD	33PD	36-42PD
endopod	5S	5S	1S+5PD
exopod	3P; 4P	3HP; 5HP+1S	2S; 5HP
epipod	14SP	15SP	31SP
Maxilliped II			
basis	3PD	2PD+3S	3P
endopod	4S; 1PD; 7PD; 9PD	5S; 1S+1PD; 7S+2PD; 9PD	4S; 1S+1PD; 9PD; 11PD
exopod	1S; 3P	1K; 5HP	2S; 6HP
epipod	0	10SP	0
Maxilliped III			
basis	0	15S	0
endopod	21PD+4S; 6PD+5S; 9PD; 11PD; 10PD	6S+21PD+6P; 6S+9PD; 5S+4PD; 12PD; 8PD+2K	39PD; 19PD; 10PD; 12PD; 10PD
exopod	0; 5P	3S; 5HP	3S; 7HP
epipod	19SP	4S+9SP	16HP+19SP

A, aesthetascs; dist., distal lobe; HP, highly plumose; K, cuspidate; MD, multidenticulate; P, plumose; PD, plumodenticulate; prox., proximal lobe; S, simple; SP, sparsely plumose.



development in the Portuninae than that in either Polybiinae or Carcininae. Therefore, meaningful comparisons can only be made between the larvae of many species at the first and last zoeal stages and the megalopal stage.

*C. bimaculata* zoeae are well-characterized by B-type antenna [= exopod about half or a little more than half as long as the peduncle], A-type telson [= telson with a dorsal tooth at the middle of fork and a lateral tooth near the base], well-developed lateral carapace, dorso-lateral knobs on the abdominal somites II-III, 1,6 setae on the maxillule endopod, 6 setae on the maxilla endopod and 1,1,5 setae on the maxilliped II endopod. In this respect, the zoeal stages of this species possess all characters of the family Portunidae and subfamily Portuninae listed by Rice (1980).

Significant differences in the structure of the zoeae I among the *Charybdis* species are apparent in the mouthparts setations. In particular, *C. bimaculata* can be easily distinguished from other known species of the same genus by the setation of the basal endite (4+4) and the coxal endite (3+3) of the maxilla. The present species has a setation pattern of 2,2,0,2,5 on the endopod of the maxilliped I and this feature differs from 3,2,0,2,5 in *C. lucifera* and *C. orientalis*. This species also can be separated from *C. callianassa* and *C. annulata* by the setation patterns on the basis of the maxillipeds I-II and differ from other known *Charybdis* species, except *C. japonica*, by the antennule setation. Beside these, other characteristics allowing distinction among these species are given in Table 3.

Currently, the megalopal descriptions of the *Charybdis* are available for *C. acuta*, *C. bimaculata* (the present study), *C. callianassa*, *C. feriata* and *C. japonica*. However, descriptions of the megalopae of *C. acuta* and *C. japonica* collected from Japan are too brief to be used in comparison them with those of other known species of the same genus. The megalopa of *C. bimaculata* can be easily separated from that of *C. feriata* by the presence of a thornlike spine on the ischium of cheiliped and straight thoracic cornua, whereas they are curved in *C. feriata*.

The postero-lateral projections of abdominal segment V of *C. bimaculata* are also large, whereas those of *C. feriata* are small. Comparison of morphological features separating megalopa of *C. bimaculata* from those of *C. callianassa* and *C. feriata* are given in Table 4.

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두점박이민꽃게(갑각강, 단미목, 꽃게과)의 유생발생  
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두점박이민꽃게(*Charybdis bimaculata*)의 유생을 수온 22°C, 염분농도 33.3‰의 해수에서 사육하고, 전체 유생기의 형태적인 특징을 상세히 기재 및 도시하였다. 본 종은 7 단계의 zoea 유생기와 1 단계의 megalopa 유생기를 가지며, 부화로부터 megalopa까지는 최저 32일이 걸렸다. 두점박이민꽃게의 제1 zoea 유생은 갑측극이 있고, 미절과 제2측각의 형태가 각각 A와 B형이며, 제1소악과 제2소악의 내지가 각각 1+6, 6의 강모식을 가지는 점에서 이미 보고된 민꽃게속(*Charybdis*) 내의 다른 종들의 유생들의 특징과 일치하고 있다. 두점박이민꽃게의 유생들과 이미 보고된 민꽃게 속의 다른 종들의 zoea 및 megalopa 유생 사이에 서로 구별될 수 있는 형태적인 특징들에 대하여 토의하였다.