

Complete Larval Development of *Hemigrapsus sanguineus* (Decapoda, Brachyura, Grapsidae) Reared in Laboratory

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무늬발게 *Hemigrapsus sanguineus*(게 아목, 바위게 과)의 유생발생

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적 요

무늬발게의 유생을 수온 25°C, 염분농도 33.3‰의 해수에서 사육하고, 전체 유생기의 형태적인 특징을 상세히 기술 및 도시하였다. 본 종은 5 zoea와 1 megalopa 유생기를 가지며, 부화시부터 megalopa와 제1기 crab까지는 각각 18일과 31일이 걸렸다. 무늬발게 제1 zoea 유생은 갑측극이 있고, 미절과 제2촉각의 형태가 각각 B형이며, 제1소악과 제2소악의 내지가 각각 1+5, 2+2의 강모를 가지는 점은 이미 보고된 풀게속의 다른 유생들의 특징과 일치하고 있다. 풀게속의 유생 상호간에 구별될 수 있는 형태적인 특징들, 특히 측엽을 가지는 복부마디의 수, 구기 부속지들의 강모식에 대하여 토의하였다.

Key words: Brachyura, *Hemigrapsus sanguineus*, Larval development.

INTRODUCTION

Hemigrapsus sanguineus (De Haan, 1835) occurs in entire coasts of Korea and inhabits between high and low tidal marks on the beaches of stones, pebbles, and rocks (Kim, 1973). This species also is found in Japan, North China, Saghalien, Australia, and New Zealand (Sakai, 1976).

For the genus *Hemigrapsus*, the complete larval development is known for *H. nudus* and *H. oregonensis* by Hart (1935), *H. sanguineus* by Kurata (1968), *H. penicillatus* by Kim (1979), *H. sinensis* by Kim and Moon (1987). The first zoeal stage is known for *H. longitarsis*, *H. penicillatus*, and *H. sanguineus* by Aikawa (1929), *H. crenulatus* and *H. edwardsi* by Wear (1970). Aikawa (1929) and Kurata (1968) described morphological features of *H. sanguineus* larvae, but Aikawa description is questionable in the accuracy. Kurata description is also very brief, superficial and he did not draw some appendages for each larval stage.

Therefore, the purpose of the present paper was to describe all larval stages of *H. sanguineus* in detail and to compare them with the known larvae of the genus *Hemigrapsus*.

MATERIALS AND METHODS

On 23 August 1989, ovigerous females of *Hemigrapsus sanguineus* were collected from crevices of rock or under stones in intertidal zone at Chungsapo, Haeundae, Pusan, Korea. They were placed individually in glass containers (300 mm diameter × 200 mm depth) filled with seawater of 33.3‰ until hatching.

Newly hatched larvae were separated into 20 groups of 15 larvae per glass bowl (containing 80 ml filtered seawater of 33.3‰) and kept in a culture chamber with a light regime of 14:10 hr L:D and at 25°C. *Brachionus* sp. and newly hatched *Artemia* nauplii were provided as food. Filtered seawater and food were changed daily.

Specimens, dead larvae and exuviae of each developmental stage were preserved in 7% neutral formalin. Larval descriptions were made based on at least 10 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 terminology of setal types follows the nomenclature named by Bookhout and Costlow (1974). Direction of setal formulae in the descriptions progresses proximal to distal.

RESULTS

Hemigrapsus sanguineus passed through five zoeal stages and a megalopa stage before attaining the first crab stage. The megalopa and first stage crab appeared in a minimum of 16 and 25 days, respectively. 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. Morphological features of each larval stage are as follows:

First Zoea (Fig. 1)

Carapace (Fig. 1A). With rostral, dorsal, and lateral spines; all spines smooth. Rostral spine straight and dorsal spine slightly curved posteriorly. Lateral spines very short and slightly curved downward. Postero-ventral carapace margin with 8 teeth and smaller ones. A pair of simple hairs flanking base of dorsal spine. Eyes sessile.

Abdomen (Fig. 1A, B). Five somites and telson; somites 2-3 with distinct lateral knobs. Somites 2-5

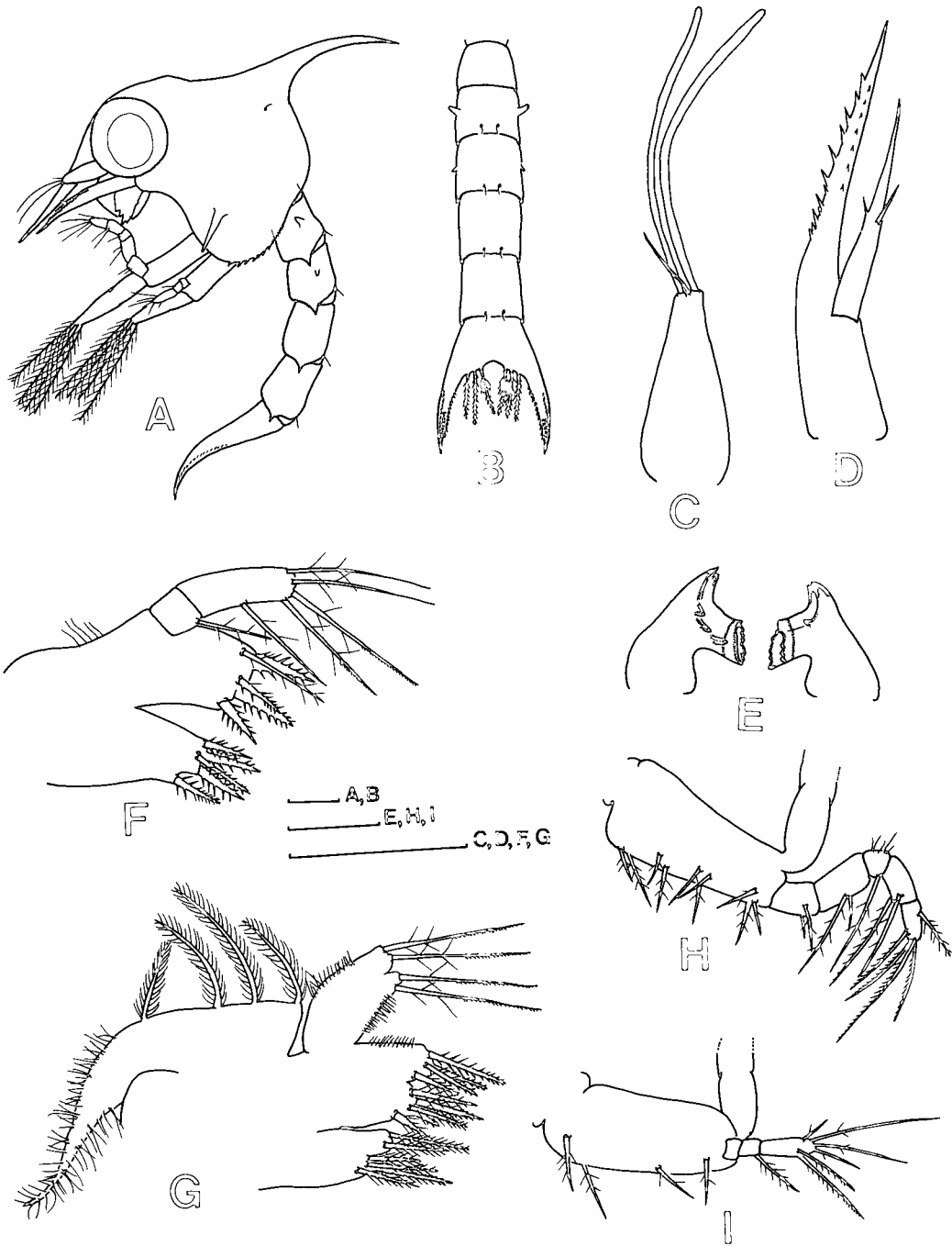


Fig. 1. First zoea of *Hemigrapsus sanguineus*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

each with paired simple setae dorsally and terminating in postero-lateral spines.

Telson (Fig. 1B). Bifurcated. Each furca with rows of minute spinules on inner and dorsal region. Three pairs of denticulate setae on inner margin.

Antennule (Fig. 1C). Smooth and conical, with 2 long aesthetascs and a short simple seta.

Antenna (Fig. 1D). Protopod tapered, with 2 rows of spinules on distal half. Exopod about a half of protopod length and with 2 short simple setae at the base of the terminal spine.

Mandibles (Fig. 1E). Asymmetrical. Molar and incisor processes irregularly dentated. Junction of molar and incisor processes with 3 teeth on the right mandible, and a tooth on the left mandible.

Maxillule (Fig. 1F). Endopod two-segmented; proximal segment with a plumose seta, distal segment with 4 terminal and 1 subterminal plumodenticulate setae. Basal and coxal endites each with 5 plumodenticulate setae. Fine hairs on dorsal margin.

Maxilla (Fig. 1G). Unsegmented endopod slightly bilobed, with 4 plumodenticulate setae terminally. Distal and proximal lobes of basal endite each with 4 and 5 plumodenticulate setae. Coxal endite with 2 and 4 plumose setae. Lateral surface of endopod and endites covered with fine hairs. Scaphognathite with 4 plumose setae and terminal process with dense microtrichia.

First maxilliped (Fig. 1H). Basis with 10 plumodenticulate setae, setation 2, 2, 3, 3 distally. Endopod 5-segmented, plumodenticulate setation 2, 2, 1, 2, 5 distally (of these, third segment with several fine hairs on dorsal surface). Exopod with 4 plumose natatory setae.

Second maxilliped (Fig. 1I). Basis with 4 plumodenticulate setae ventrally. Endopod 3-segmented, plumodenticulate setation 0, 1, 6 distally. Exopod with 4 plumose natatory setae.

Chromatophores. Chromatophore patterns fairly consistent throughout zoeal development. Dark brown chromatophores on labrum and mandibles, on basis of first and second maxillipeds, on each ventral side of carapace, on cardiac region and along ventral region of abdominal somites 2-5 and telson. Orange red chromatophores on dorsal surface of abdominal somite 2-5 and distal two-thirds of dorsal and rostral spines.

Second Zoea (Fig. 2)

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

Abdomen (Fig. 2A,B). As in the first stage but somite 1 with a medio-dorsal plumose seta.

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

Antenna (Fig. 2D). As in the first stage.

Mandibles (Fig. 2E). As in the first stage but right mandible with an additional tooth on junction of incisor and molar process.

Maxillule (Fig. 2F). Basal and coxal endites each with 7 and 5 plumodenticulate setae. Plumose seta added on dorsal margin.

Maxilla (Fig. 2G). Distal lobe of coxal endite with an additional plumose seta terminally. Scaphognathite with 8 densely plumose setae.

First maxilliped (Fig. 2H). Exopod with 6 plumose natatory setae.

Second maxilliped (Fig. 2I). Exopod with 6 plumose natatory setae.

Third Zoea (Fig. 3)

Carapace (Fig. 3A). Postero-ventral margin with 5-6 plumose setae. Postero-dorsal arch with a plumose seta. Paired simple hairs added on base of rostral spine, interocular and forehead respectively. Paired simple hairs added on one-fourth base of dorsal spine.

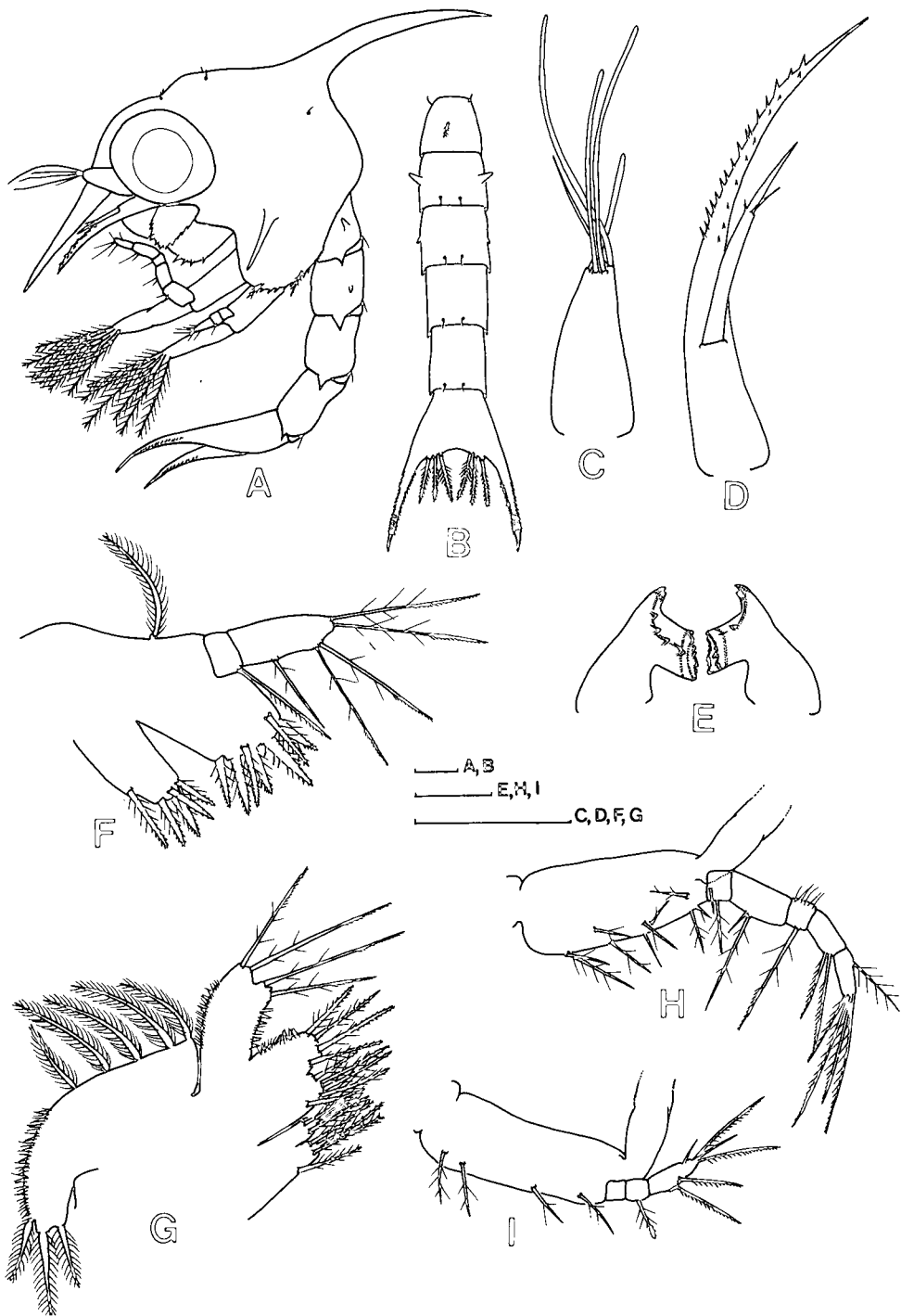


Fig. 2. Second zoea of *Hemigrapsus sanguineus*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

Abdomen (Fig. 3A,B). Somite 6 now present. Somite 1 with 3 medio-dorsal plumose setae. Telson with 4 pairs of plumodenticulate setae on inner margin.

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

Antenna (Fig. 3D). Endopod present as a small bud, and a lateral seta on base of the terminal spine disappeared in this and subsequent stages.

Mandibles (Fig. 3E). As in the second stage.

Maxillule (Fig. 3F). Basal endite with 7 terminal and 1 lateral plumodenticulate setae. A plumodenticulate seta added on proximal margin.

Maxilla (Fig. 3G). Scaphognathite bearing 12-13 plumose setae separated into anterior (7-8 setae) and posterior (5 setae) groups.

First maxilliped (Fig. 3H). Plumose seta added on the third segment of endopod, now setation 2, 2, 2, 5. Exopod with 8 plumose natatory setae.

Second maxilliped (Fig. 3I). Exopod with 8 plumose natatory setae.

Fourth Zoea (Fig. 4)

Carapace (Fig. 4A). Postero-ventral margin with 9-10 plumose setae. Paired simple hairs added on dorsal spine. Buds of thoracic appendages visible through carapace.

Abdomen (Fig. 4A,B). Somite 1 with 5 medio-dorsal setae. Somites 2-6 with pleopod buds.

Antennule (Fig. 4C). With 4 terminal, a subterminal aesthetascs and a simple seta.

Antenna (Fig. 4D). Endopod bud much larger.

Mandibles (Fig. 4E). Right and left mandibles each with an additional tooth on junction of incisor and molar processes.

Maxillule (Fig. 4F). Basal endite with 10 terminal and 2 lateral plumodenticulate setae. Coxal endite with 7 plumodenticulate setae. A plumose seta added on proximo-lateral margin.

Maxilla (Fig. 4G). Distal and proximal lobes of basal endite each with 5 and 6 plumodenticulate setae. Coxal endite with 8 plumose setae. Scaphognathite with 23 plumose setae.

First maxilliped (Fig. 4H). Coxa with a plumodenticulate seta. A plumose seta added on distal segment of endopod, setation now 2, 2, 2, 2, 6. Exopod with 10 plumose natatory setae.

Maxilliped 2 (Fig. 4I). Exopod with 10 plumose natatory setae.

Fifth Zoea (Fig. 5)

Carapace (Fig. 5A). Anterior margin with 7 pairs of simple hairs as illustrated. Postero-ventral margin and postero-dorsal arch each with 15-17 and 2 plumose setae. Dorsal spine now with 3 pairs of simple setae. Thoracic appendages enlarged and chela prominent.

Abdomen (Fig. 5A,B). Somite 1 now with 7 medio-dorsal setae. Pleopod buds much elongated. Telson with paired simple setae on medio-dorsal region and with 5 pairs of plumodenticulate setae on inner margin.

Antennule (Fig. 5C). Aesthetascs arranged in 2 tires: 4 aesthetascs plus a simple seta terminally and 5 aesthetascs subterminally. Basal region swollen and with a simple seta. Endopod bud small, round.

Antenna (Fig. 5D). As in the fourth stage but endopod 2-segmented.

Mandibles (Fig. 5E). As in the fourth stage but an additional tooth on junction of incisor and molar

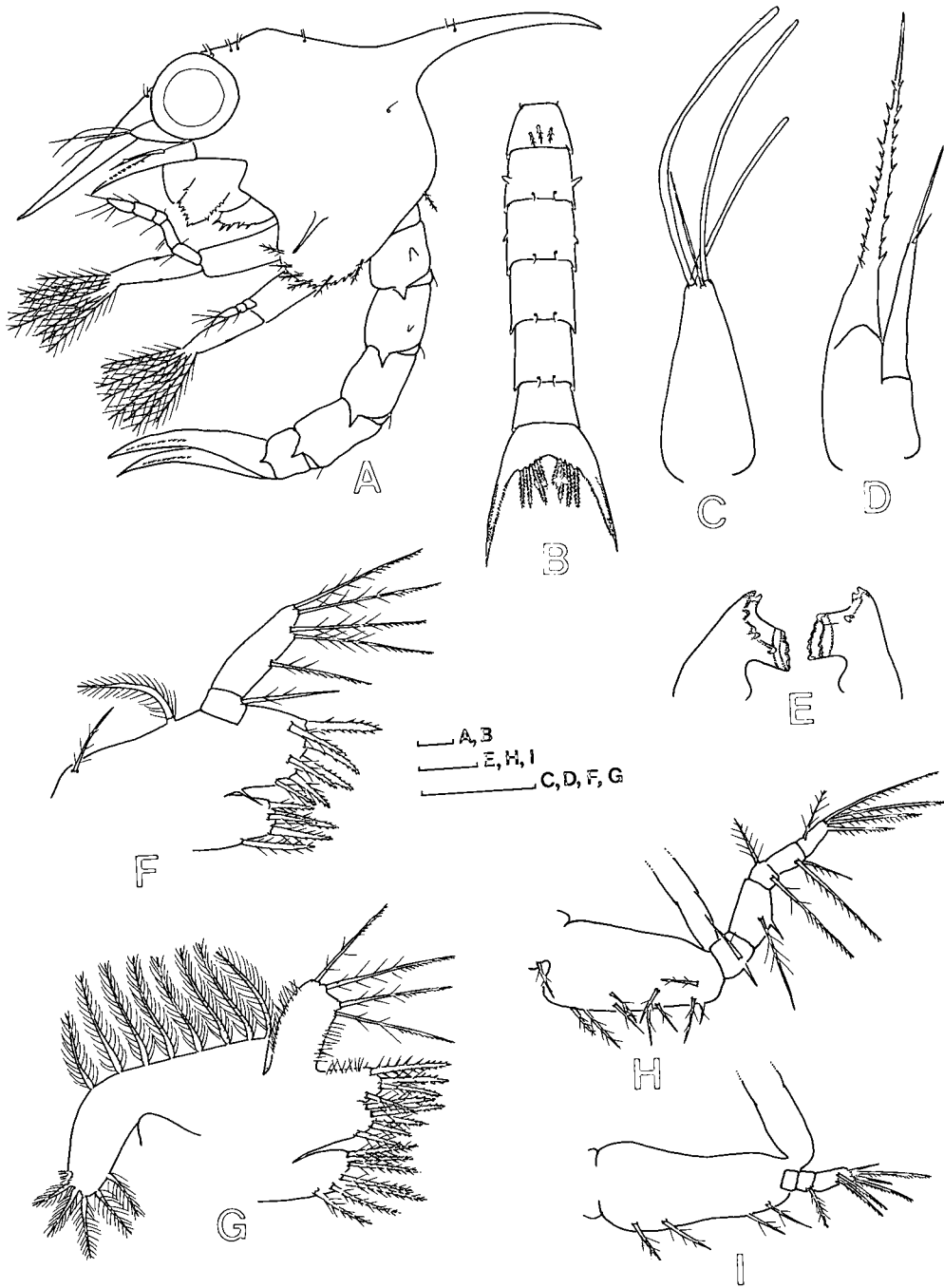


Fig. 3. Third zoea of *Hemigrapsus sanguineus*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

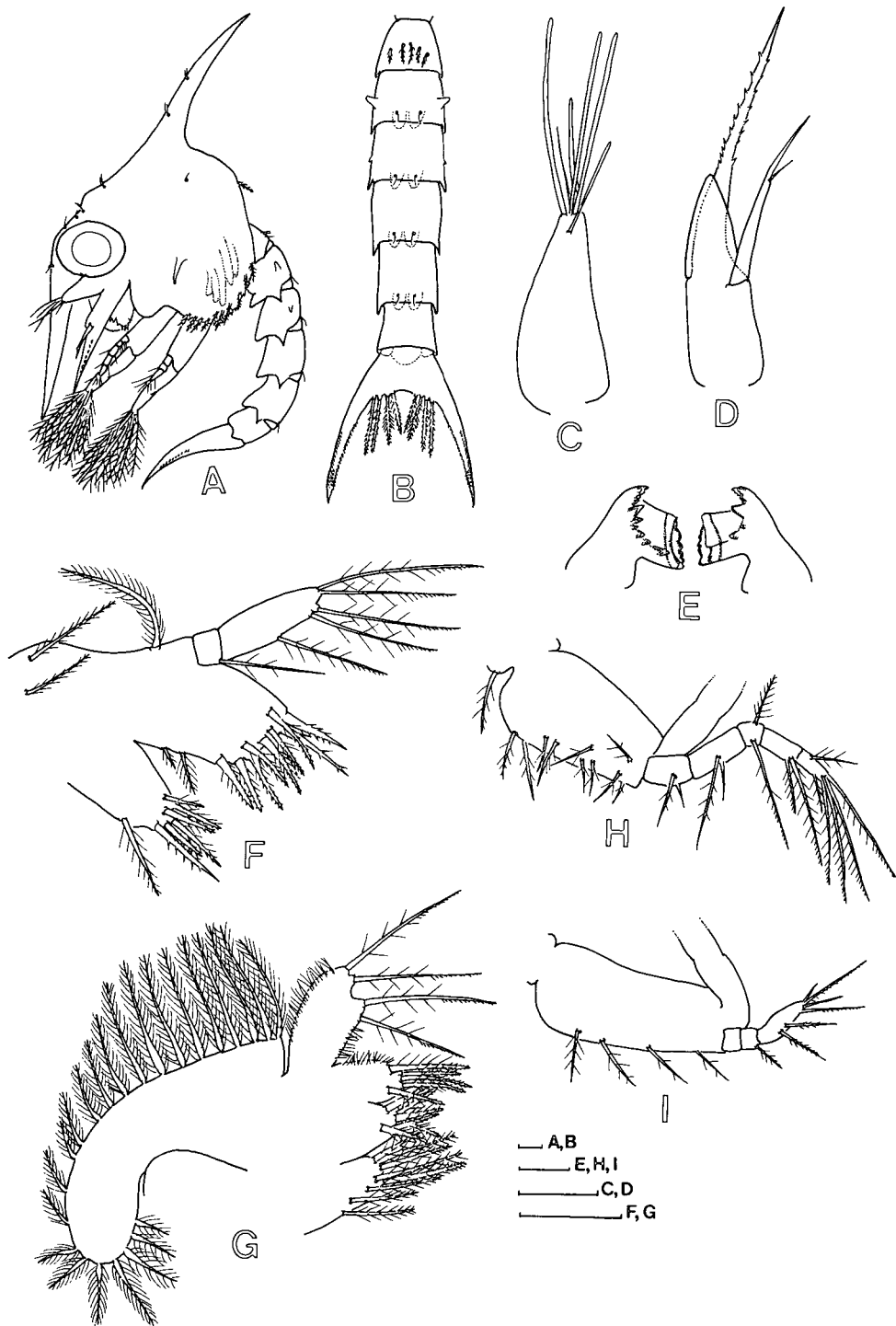


Fig. 4. Fourth zoea of *Hemigrapsus sanguineus*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

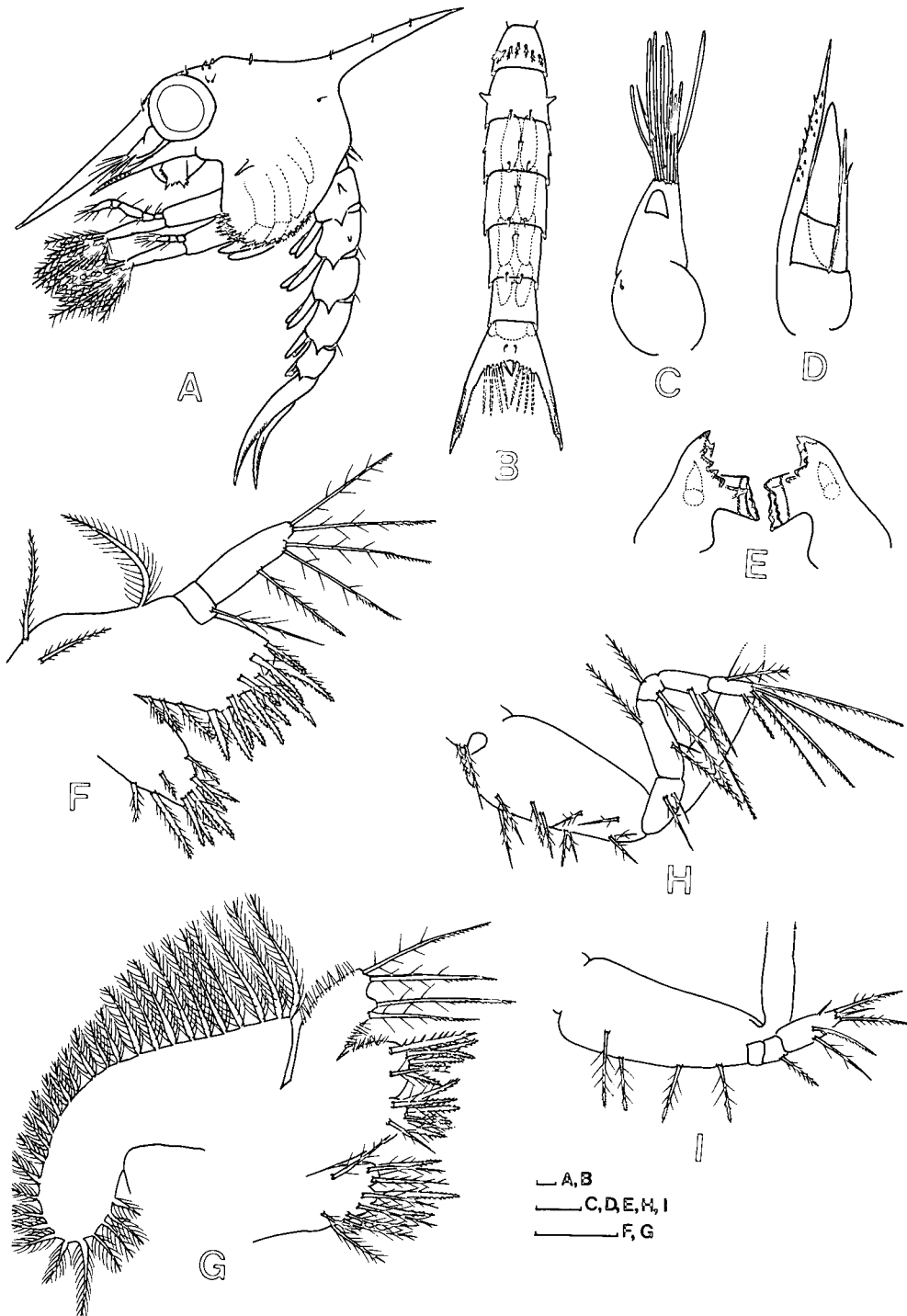


Fig. 5. Fifth zoea of *Hemigrapsus sanguineus*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped. Scale bars = 0.1 mm.

processes at the left mandible. Mandibular palps present as small buds.

Maxillule (Fig. 5F). Basal endite with 13 terminal and 3 lateral plumodenticulate setae. Coxal endite with 10 plumodenticulate setae.

Maxilla (Fig. 5G). Distal and proximal lobes of basal endite each with 7, 8 plumodenticulate setae. Coxal endite with 12 plumose setae. Scaphognathite with 30-32 plumose setae marginally.

First maxilliped (Fig. 5H). Coxa with 2 plumodenticulate setae. A plumose seta added on second segment of endopod, now setation 2, 3, 2, 2 and 6. Exopod with 12 plumose natatory setae.

Second maxilliped (Fig. 5I). Exopod with 12 plumose natatory setae.

Megalopa (Figs. 6, 7)

Carapace (Fig. 6A). Subquadrate in dorsal view. Rostrum ending in a pointed tip, curved ventrally. Simple hairs scattered on dorsal surface. Plumose setae fringed along lateral and posterior margin. Smooth undulation laterally.

Abdomen (Fig. 6A). Six somites and telson. All somites with simple setae as illustrated. Telson semicircular in shape, with 3 plumose setae on posterior margin and 4 dorsal simple setae.

Antennule (Fig. 6B). Peduncle 3-segmented: basal segment with 3 plumose and 6 simple setae, second with 3 plumose setae, third with a simple seta laterally. Lower ramus with 3 terminal and 1 lateral simple setae. Upper ramus 4-segmented: first segment unarmed, second with 7 aesthetascs, third with 7 aesthetascs plus a plumose seta, fourth with 5 aesthetascs plus a plumose seta.

Antenna (Fig. 6C). Ten-segmented: segments with setation on proceeding distally 2-3, 2, 3, 0, 0, 4, 2, 2+2, 2+1, 2+1 simple or plumodenticulate setae.

Mandible (Fig. 6D). Symmetrical. Palp 2-segmented: proximal naked, distal segment with 7 multidenticate and a plumose seta.

Maxillule (Fig. 6E). Endopod with 4 short simple setae plus 2 long plumose setae. Basal endite with 13 plumodenticulate plus 11 simple setae terminally and 5 plumodenticulate setae laterally. Coxal endite with 26 plumodenticulate setae. Proximal region with 4 plumose setae.

Maxilla (Fig. 6F). Endopod unsegmented, naked. Distal and proximal lobes of basal endite each with 12-14, 11-12 plumodenticulate setae. Coxal endite with 27-28 plumose setae. Scaphognathite with 56-60 plumose setae on margin and 6 simple setae on blade.

Pleopods (Figs. 6G 1-5). Well developed on somites 2-6. Exopods on somites 2-6 each with 20-21, 19-20, 17-18, 16-17 and 12-13 plumose natatory setae. Endopods on pleopods 1-4 with 3 appendix internae. Pleopod 5 lacking endopod and with a plumose seta on basal segment.

First maxilliped (Fig. 7H). Unsegmented endopod with 2 terminal simple setae. Exopod 2-segmented: proximal and distal segments each with 2 and 4 plumose setae. Basal endite with 11 plumodenticulate and 6 simple setae. Coxal endite with 11 plumodenticulate and 7 simple setae. Epipod triangular in shape, with 8 plumodenticulate setae and 9-10 aesthetascs.

Second maxilliped (Fig. 7I). Four-segmented endopod with 3, 1, 7 and 8 plumodenticulate or simple setae, progressing distally. Exopod 2-segmented: proximal segment with a simple seta, distal segment with 5 plumose setae. Epipod with a plumodenticulate seta and 7-8 aesthetascs. Basis with 5 simple setae.

Third maxilliped (Fig. 7J). Five-segmented endopod with 20, 12, 7, 12 and 10 plumodenticulate or simple setae. Exopod 2-segmented: proximal segment with 3 plumose and 3 simple setae, distal

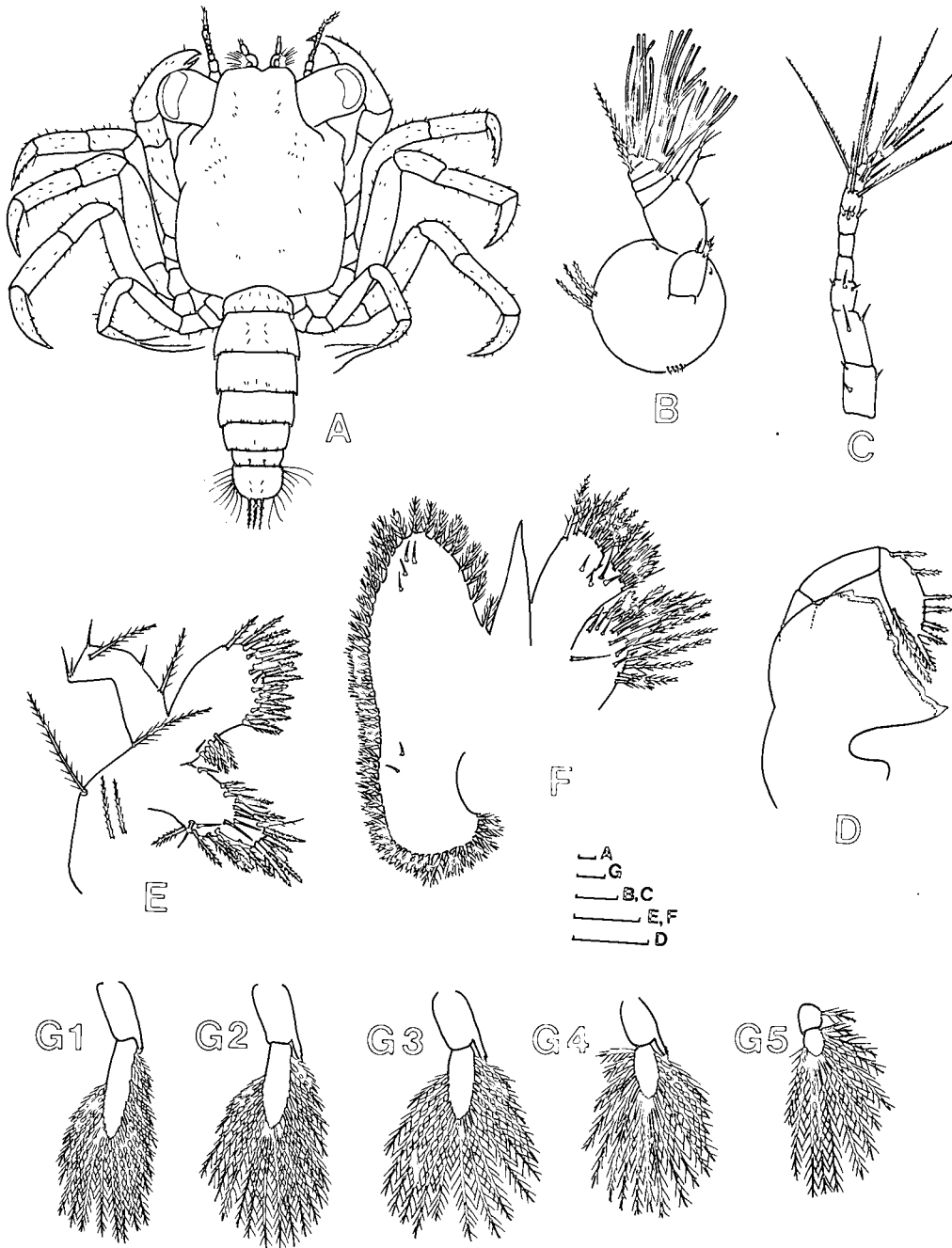


Fig. 6. Megalopa of *Hemigrapsus sanguineus*. A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G1-5, pleopods 1-5. Scale bars = 0.1 mm.

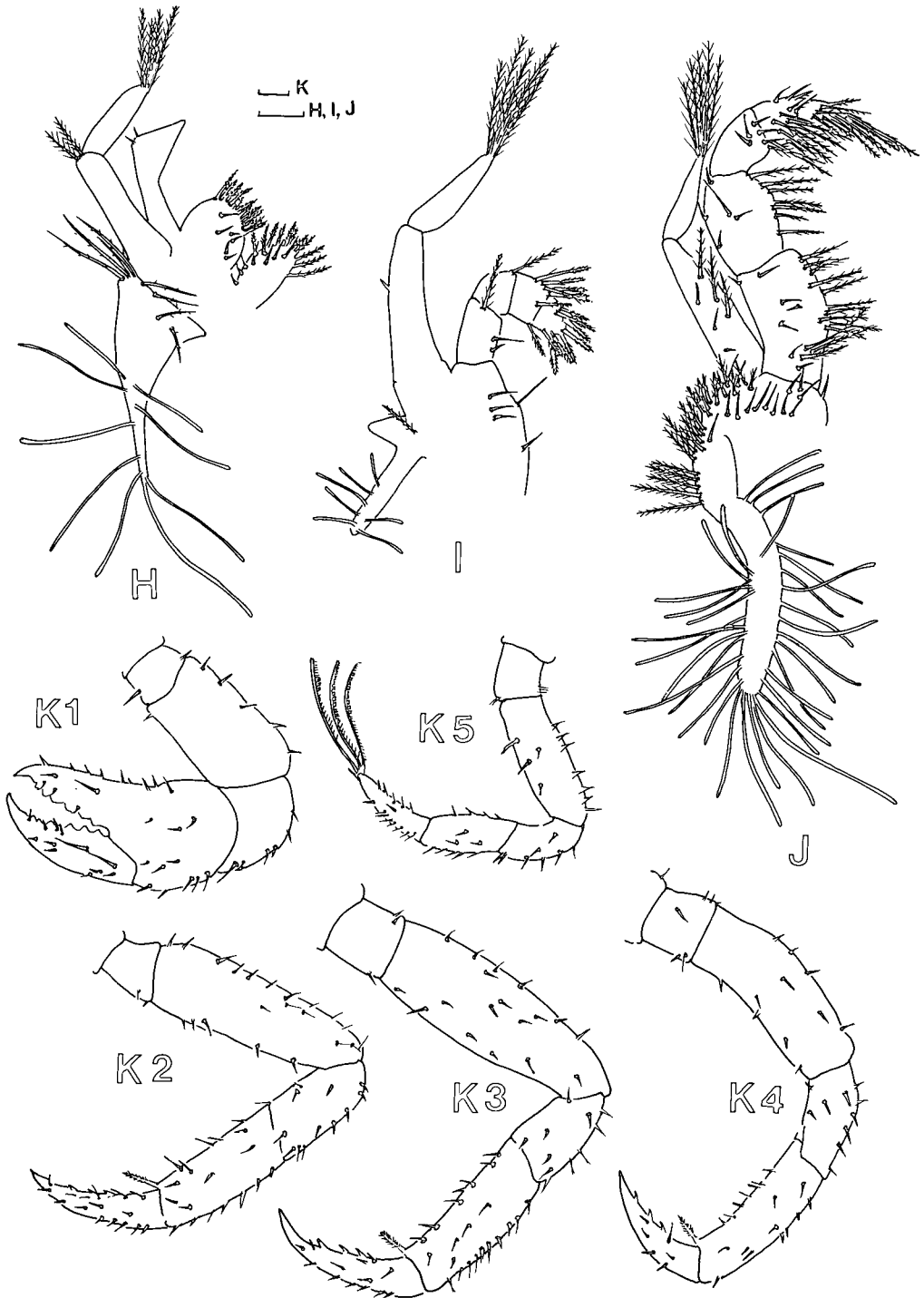


Fig. 7. Megalopa of *Hemigrapsus sanguineus*. H, first maxilliped; I, second maxilliped; J, third maxilliped; K1-5, pereopods 1-5. Scale bars = 0.1 mm.

segment with 5 plumose setae. Epipod with 12 plumodenticulate setae and 33 aesthetascs. Basis with 24 plumose or simple setae.

Pereiopods (Figs. 7K 1-5). Cheliped covered with short simple setae; fingers with a few teeth on each cutting margin. Pereiopods 2-4 similar in shape, each with a disto-ventral tooth on propodus and 3 ventral teeth on dactylus. Pereiopod 5 with 3 long brachyuran feelers.

Chromatophores. Spidery dark brown and red chromatophores on eyestalks, on mid-lateral, postero-lateral, posterior and gastric region of carapace, on each abdominal somite and pereiopods.

DISCUSSION

The first zoeal stage of *H. sanguineus* has already been described by Aikawa (1929). There are, however, some differences between Aikawa's description and the present study. Aikawa (1929) described that (1) the antennule has two aesthetascs plus two hairs, (2) the second maxilliped has a setation of 0-1-5 on endopod, (3) each of all abdominal somites has a hair on dorsal margin, and (4) postero-ventral margin of carapace is naked. Whereas our specimen showed that (1) the antennule has two aesthetascs plus a simple seta, (2) the second maxilliped has a setation of 0-1-6 on endopod throughout the zoeal stages, (3) abdominal somites 2-5 have two simple setae on postero-dorsal margin respectively, and (4) postero-ventral margin of carapace has several teeth. Therefore, we assume that Aikawa made mistake in observation of some appendages and described inaccurately these morphological features. Otherwise, Aikawa may be made an error in identification of the species and thus described the larvae of other species.

Although the larval development of *H. sanguineus* was reported by Kurata (1968), we are not able to compare them with those of other known *Hemigrapsus* species because his description was very limited. For example, Kurata did not described mouthparts setations and very common morphological characters of brachyuran larvae in all zoeal stages. In the megalopal stage, morphological features of antennule, mandible, maxillule, maxilla, pleopods and maxillipeds were not described and illustrated, either. Comparison in the first zoeal stage of *H. sanguineus* between the present study and Kurata

Table 1. Time required for development and percentage survival of *Hemigrapsus sanguineus* under laboratory conditions (Original number of larvae = 150, mean values based only on larvae attaining next stage).

Stage	Initial number	Survival percentage	Days reached		
			Minimum	Mean / S.D.	Maximum
Hatch to					
Zoea II	141	94.0	3	3.72/0.74	5
Zoea III	135	90.0	5	7.40/1.99	13
Zoea IV	130	86.6	8	10.61/2.27	16
Zoea V	126	84.0	11	14.12/2.38	20
Megalopa	119	79.3	16	17.64/2.30	24
Crab I	115	76.6	25	30.95/2.76	41
Crab II	109	72.6	32	37.32/3.68	45

Table 2. Measurements of various features of the zoeae and megalopa of *Hemigrapsus sanguineus*. All measurements are in mm; mean values, from ten individuals of each stage, are given with standard deviation in brackets.

Features	Zoea I	Zoea II	Zoea III	Zoea IV	Zoea V	Megalopa
TSL	0.93(0.02)	1.24(0.07)	1.69(0.04)	2.55(0.09)	3.12(0.18)	
Range	0.91-0.95	1.10-1.35	1.63-1.74	2.38-2.68	2.93-3.43	
DSL(A)	0.31(0.01)	0.42(0.02)	0.55(0.04)	0.87(0.04)	0.99(0.06)	
Range	0.29-0.33	0.40-0.45	0.47-0.60	0.83-0.95	0.93-1.08	
RSL(B)	0.24(0.01)	0.39(0.02)	0.54(0.03)	0.85(0.04)	1.08(0.08)	
Range	0.23-0.25	0.37-0.43	0.51-0.60	0.78-0.90	0.93-1.15	
LSL(C)	0.09(0.01)	0.12(0.01)	0.15(0.01)	0.17(0.02)	0.22(0.02)	
Range	0.08-0.11	0.11-0.13	0.13-0.16	0.15-0.20	0.18-0.23	
AL(D)	0.22(0.01)	0.26(0.02)	0.38(0.03)	0.45(0.03)	0.57(0.04)	
Range	0.20-0.24	0.24-0.30	0.35-0.42	0.40-0.50	0.53-0.63	
CL(E)	0.49(0.01)	0.60(0.02)	0.72(0.02)	1.02(0.05)	1.27(0.03)	1.74(0.07)
Range	0.47-0.51	0.56-0.62	0.70-0.76	0.98-1.15	1.23-1.30	1.63-1.83
CW						1.54(0.13)
Range						1.38-1.75

AL, second antenna length; CL, carapace length; CW, carapace width; DSL, dorsal spine length; LSL, lateral spine length; RSL, rostral spine length; TSL, total spine length (= length from rostral to dorsal spine tips)

(1968) is given in Table 3.

Hyman (1924) has explained that the zoeae of the family Grapsidae were remarkably uniform in morphological structure, but recently described grapsid larvae including known species thereafter were much more variable in morphological features (Aikawa, 1929; Costlow and Bookhout, 1960; Rajabai, 1961; Hartnoll, 1964; Wear, 1970; Fagetti and Campodonico, 1971; Fukuda and Baba, 1976; Terada, 1982; Fielder and Greenwood, 1983; Kim and Jang, 1987; Paula, 1987; Kim and Hwang, 1990). Therefore it is difficult to find single morphological character separating the grapsid larvae from other families. However, the known *Hemigrapsus* larvae are well-characterized by B-Type antenna, B-Type telson, possession of lateral spines on carapace, 2+2 setae on maxillule endopod and 1+5 setae on maxilla endopod. In this respect, zoea of *H. sanguineus* is morphologically similar to those of seven species of *Hemigrapsus* reported by the previous workers.

In the first zoeal stage, the number of abdominal somites with lateral knobs is not always the same for eight species of this genus. For instance, lateral knobs are present on somite 2 in *H. oregonensis* (Hart, 1935), *H. crenulatus* and *H. edwardsi* (Wear, 1970), on somites 2-3 in *H. longitarsis* (Aikawa, 1929), *H. nudus* (Hart, 1935), *H. penicillatus* (Kim, 1979) and *H. sanguineus* (the present study), and on somites 2-4 in *H. sinensis* (Kim and Moon, 1987). Also, significant differences in structure of the first zoeae among *Hemigrapsus* species are apparent in mouthparts setations. For

Table 3. Comparison of morphological features of the first zoea larvae in eighth species of the genus *Hemigrapsus*.

	R-D spines length	Lateral carapace spines	Lateral knobs abdomen	Telson type	Antenna type	Antennule form
<i>Hemigrapsus crenulatus</i> (Wear, 1970)	1.05	+	2	B	B3	2A+1S
<i>Hemigrapsus edwardsi</i> (Wear, 1970)	1.20	+	2	B	B3	2A+1S
<i>Hemigrapsus longitarsus</i> (Aikawa, 1929)	0.76	+	2-3	B	B2	2A+1S
<i>Hemigrapsus nudus</i> (Hart, 1935)	1.20	+	2-3	B	B3	2A+1S
<i>Hemigrapsus oregonensis</i> (Hart, 1935)	1.10	+	2	B	B3	2A+1S
<i>Hemigrapsus penicillatus</i> (Kim, 1979)	0.75	+*	2-3	B	B2	2A+2S
<i>Hemigrapsus sanguineus</i> (Kurata, 1968)	0.88	+	2-3	B	B3	—
<i>Hemigrapsus sanguineus</i> (the present study)	0.93	+	2-3	B	B3	2A+1S
<i>Hemigrapsus sinensis</i> (Kim and Moon, 1987)	0.85	+	2-4	B	B3	2A+2S

Maxillule			Maxilla				Maxilliped 1		Maxilliped 2	
Endopod	Bas.E.	Cox.E.	Endopod	Bas.E.	Cox.E.	Sca.	Endopod	Basis	Endopod	Basis
1,5	5	4	2,2	3,3	2,4	3	1,1,1,2,5	3,3,3,3	1,1,6	1,1,1,1
1,5	6	4	2,2	4,4	2,4	5	2,2,2,2,6	—	1,1,6	1,1,1,1
1,5	5	5	4	8	6	4	2,2,1,2,5	2,2,3,3	—	1,1,1,1
1,5	6	5	4	7	6	4	2,2,1,2,5	2,1,3,3	0,1,5	4
1,5	6	5	4	7	6	4	2,2,1,2,5	2,1,3,3	0,1,5	4
1,5	5	5	2,2	5,4	2,4	4	2,2,1,2,5	2,2,3,3*	0,1,5	4*
1,5	—	—	2,2	—	—	—	—	—	0,1,6	—
1,5	5	5	2,2	4,5	2,4	4	2,2,1,2,5	2,2,3,3	0,1,6	1,1,1,1
1,5	5	5	2,2	4,5	3,4	4	2,2,1,2,5	2,2,3,3	0,1,6	1,1,1,

A, aesthetascs; Bas.E., basal endite; Cox.E., coxal endite; S, simple seta; Sca., scaphognathite; telson and antenna types following Aikawa's scheme (1929, 1933); *data from Aikawa (1929); +, presence; —, no description.

example, most species of this genus usually have 5+5 setae on basal and coxal endites of maxillule (Aikawa, 1929; Kim, 1979; Kim and Moon, 1987; the present study); *H. crenulatus* and *H. edwardsi* have 5+4 and 6 + 4 setae respectively; both *H. nudus* and *H. oregonensis* have 6+5 setae. In the maxilla, the number of setae on basal endite is variable by species (Table 3), but coxal endite has 6 setae in most species except for only *H. sinensis* which has 7 setae on coxal endite. In addition, comparative numbers of setae on the basis of the first maxilliped are as follows: *H. crenulatus* 3, 3, 3, 3; both *H. nudus* and *H. oregonensis* 2, 1, 3, 3; *H. longitarsis*, *H. penicillatus*, *H. sinensis* and *H. sanguineus* (the present study) 2, 2, 3, 3. Besides these, some minor features in the first zoeal stage among *Hemigrapsus* species are given in Table 3. As a result, the first zoea of *H. sanguineus* can be easily distinguished from those of other known species within *Hemigrapsus* by the combination of abdominal somites which have lateral knobs and setations of maxillule, maxilla and the first maxilliped.

Although the megalopae of *H. nudus* and *H. oregonensis* collected from British Columbia have been described previously (Hart, 1935), both descriptions and illustrations are too brief and superficial to be used in comparison them with those of other known species of the same genus. Currently, the megalopal descriptions of the *Hemigrapsus* are available for *H. penicillatus*, *H. sinensis*, and *H. sanguineus* (the present study). Comparison of morphological features separating megalopa of *H. sanguineus* from those of *H. penicillatus* and *H. sinensis* are given in Table 4, but there is still a need for more detailed descriptions in order to make comparisons among the megalopae of *Hemigrapsus* species.

ABSTRACT

The larval stages of *Hemigrapsus sanguineus* were reared in the laboratory and described with illustrative figures. Five zoeal and one megalopal stages were found in the complete larval development. At 25°C, the megalopa and the first crab instar were attained in 18 and 31 days after hatching, respectively.

The first zoeal larva of *H. sanguineus* showed the characteristics which coincide with those of the same genus by bearing lateral spines on carapace, B-types of telson and antenna, 1+5 setae on the endopod of maxillule, and 2+2 setae on the endopod of maxilla. Morphological features of *H. sanguineus* larvae were compared to the previous descriptions of larvae of the same genus and morphological differences among them were discussed.

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

		<i>H. sanguineus</i> (present study)	<i>H. sinensis</i> (Kim and Moon, 1987)	<i>H. penicillatus</i> (Kim, 1979)
Carapace	Length/Width	1.74/1.54 mm	1.14/0.92 mm	1.68/1.45 mm
Antennule	Upper ramus	0;7A;7A+1P;5A+1P	0;6;7;6	0;12A;10A+1P;7A+1P
	Lower ramus	4S	4	4
Antenna	Flagellum	2S;2S;3S;0;0;4S;2PD ;2PD;2PD+2S;2PD+1S	1-3;1-2;1-2;0;0;0-3 ;1;3+2;1+2;2+1	
Mandible	Palp	2-segmented	2-segmented	3-segmented
		0;7MD+1P	0;7	0;0;10
Maxillule	Endopod	unsegmented	2-segmented	
		4S+2P	2;4	
		Basal endite	18P+11S	20-23
	Coxal endite	26P	13-16	31
Maxilla	Endopod	0	2	2
	Scaphognathite	56-58P + 6S	31-41P + 4-5S	57P
Maxilliped I	Endopod	2S	2	6
	Exopod	2P;4P	2P;4P	2;5
	Epipod	8PD+9A	7	10
Maxilliped II	Endopod	2S+1P;1P;7PD;8PD	0;1;4-5;8	1;0;4;16
	Exopod	1S;5P	1;5	1;5
	Epipod	1PD+7A	4	4
Maxilliped III	Endopod	13P+7S;7P+5S;2P+5S ;6P+6S;10-11PD	14;10;7;9-11;7-8	22;11;9;0;16
	Exopod	3P+3S;5P	2S;5P	1;5
	Epipod	12PD+33A	8P+14	21+33A
Pleopod	Exopod	20-21;19-20;17-18 ;16-17;12-13	14;14;13;11-12;7	

A, aesthetascs; MD, multidenticulate seta; P, plumose seta; PD, plumodenticulate seta; S, simple seta.

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