

The Complete Larval Development of *Eriocheir japonicus* De Haan (Crustacea, Brachyura, Grapsidae) Reared in the Laboratory

Chang Hyun Kim and Sang Gu Hwang

Department of Biology, College of Natural Sciences, Pusan National University, Pusan 609-735, Korea

The complete larval development of *Eriocheir japonicus* De Haan reared in the laboratory is described and illustrated. *E. japonicus* passes through 5 zoeal stages before metamorphosis to the megalopal stage. The megalopa and crab I instar are attained in 17 and 27 days after hatching, respectively. The culture was carried out under a photoperiod of 14 h light and 10 h dark and a constant temperature of 25°C.

Morphological characteristics of each larval stage of this species are compared with those of *E. japonicus* from Japan. Morphological features between zoea I of the Varuninae are briefly discussed.

KEY WORDS: Larval development, Brachyura, *Eriocheir japonicus*,

Eriocheir japonicus De Haan, 1835, very commonly inhabits the rivers and streams adjacent to the Korea Strait and the East Sea of Korea, but ovigerous crabs migrate to the river mouths in a spawning season (Kim, 1973). The species also occurs in Japan, Vladivostok, Taiwan and Hong Kong (Sakai, 1976).

The larval development of the Varuninae has been relatively well studied among the crabs of the Grapsidae, although the larvae of many other genera as well as the *Eriocheir* are comparatively little known of their development. Zoeal stage I is known for *Hemigrapsus longitarsis*, *H. penicillatus*, *H. sanguineus* and *Gaetice depressus* by Aikawa (1929), *H. edwardsi* and *H. crenulatus* by Wear (1970). Zoea I and megalopal stages of *E. sinensis* are briefly described by Peters and Panning (1933) from specimens obtained in the plankton. Complete larval stages are known for *Acmaeopleura parvula* by Kurata (1968a) and Kim and Jang

(1987), *Eriocheir leptognatus* by Lee (1988), *Euchirograpsus americanus* by Wilson (1980), *G. depressus* by Kim and Lee (1983), *Hemigrapsus nudus* and *H. oregonensis* by Hart (1935), *H. sanguineus* by Kurata (1968b), *H. penicillatus* by Kim (1979), *H. sinensis* by Kim and Moon (1987). In addition to these, Aikawa (1929) and Morita (1974) described only zoea I and all larval stages of *E. japonicus* respectively. Their descriptions, however, are very brief and questionable in the accuracy, not giving setation and description on some appendages.

It is the purpose of the present study to describe the complete larval stages of *E. japonicus* in details and to compare the zoea I of *E. japonicus* with other known zoea I of the Varuninae in morphological characteristics.

Materials and Methods

On 5 May 1989, ovigerous females of *E. japonicus* were collected from crab pots off the estuary

This work was supported by grant from the Korea Research Foundation (1988) to Dr. C. H. Kim.

of the Sömjin River, Kyöngsangnam-do. In the laboratory, they were placed in plastic containers containing filtered seawater with 33.3‰ salinity and room temperature (mean 21.5°C). When the larvae hatched, they were separated into 20 groups of 15 larvae per glass bowl and some of them were fixed immediately. Megalopae obtained in bowls were transferred into 18-compartmented polystyrene trays. Bowls and trays were maintained in a 25°C constant temperature cabinet with a light regime of 14 h : 10 h, L : D. Filtered seawater (33.3‰ salinity) was changed daily. Larvae were fed daily with the following diets: *Brachionus plicatilis* in zoeae I-IV; a mixture of *B. plicatilis* and freshly hatched *Artemia* nauplii in zoea V; only *Artemia* nauplii in megalopal and crab stages.

All dead larvae, exuviae, and representative live specimens were preserved in 7% neutral formalin to check setation of appendages. At least 10 specimens were measured and dissected for each larval stage. Drawings and measurements were made with a camera lucida and an ocular micro-

meter. The chromatophore patterns were determined from the observation of living larvae.

Results

There are 5 zoeal stages and a megalopal stage in the complete larval development of *E. japonicus*. The megalopal and crab I stages were attained in 17 and 27 days after hatching respectively.

Measurements of various features of the larvae are given in Table 1. The major morphological characteristics of each larval stage are as follows:

Zoea I (Fig. 1)

Carapace (Fig. 1A). Dorsal and rostral spines with several teeth scattered over length, dorsal spine nearly straight and rostral spine straight. Lateral spines naked, slightly curved downward. Postero-ventral margin with 10-13 teeth and smaller ones. Cardiac region with pair of minute

Table 1. Morphometric measurements of various features of the zoeae and megalopa of *Eriocheir japonicus*. All measurements are in mm; mean values, for 10 specimens of each larval stage, are given with standard deviations in brackets

Feature	Zoea I	Zoea II	Zoea III	Zoea IV	Zoea V	Megalopa
TSL	1.18(0.05)	1.46(0.02)	1.99(0.05)	2.66(0.14)	3.35(0.12)	
Range	1.12-1.28	1.43-1.48	1.93-2.08	2.50-2.88	3.25-3.50	
CL	0.50(0.02)	0.62(0.03)	0.78(0.05)	1.02(0.05)	1.31(0.05)	1.86(0.10)
Range	0.47-0.52	0.60-0.68	0.75-0.86	0.95-1.08	1.25-1.35	1.75-2.00
CW	0.40(0.01)	0.49(0.01)	0.60(0.03)	0.91(0.04)	1.14(0.05)	1.34(0.10)
Range	0.38-0.41	0.48-0.50	0.58-0.65	0.85-0.98	1.08-1.23	1.25-1.50
DSL	0.40(0.02)	0.49(0.03)	0.65(0.06)	0.75(0.05)	1.05(0.06)	
Range	0.37-0.44	0.45-0.55	0.58-0.71	0.68-0.80	1.00-1.15	
RSL	0.34(0.04)	0.49(0.03)	0.66(0.04)	0.90(0.04)	1.21(0.04)	
Range	0.28-0.39	0.45-0.55	0.65-0.72	0.88-0.95	1.15-1.28	
LSL	0.15(0.01)	0.16(0.02)	0.17(0.03)	0.19(0.03)	1.21(0.02)	
Range	0.12-0.17	0.14-0.18	0.14-0.23	0.15-0.23	0.18-0.23	
AL	0.25(0.01)	0.33(0.01)	0.39(0.03)	0.49(0.02)	0.57(0.03)	
Range	0.23-0.26	0.31-0.34	0.34-0.40	0.45-0.50	0.53-0.63	
TLSL	0.68(0.03)	0.77(0.06)	0.95(0.10)	1.26(0.09)	1.46(0.08)	
Range	0.65-0.75	0.71-0.81	0.83-1.08	1.10-1.40	1.38-1.58	

AL, second antenna length; CL, carapace length; CW, carapace width; DSL, dorsal spine length; LSL, lateral spine length; TLSL, total lateral spine length (= distance between lateral spine tips); RSL, rostral spine length; TSL, total spine length (= distance between the tip of rostral and tip of dorsal spines).

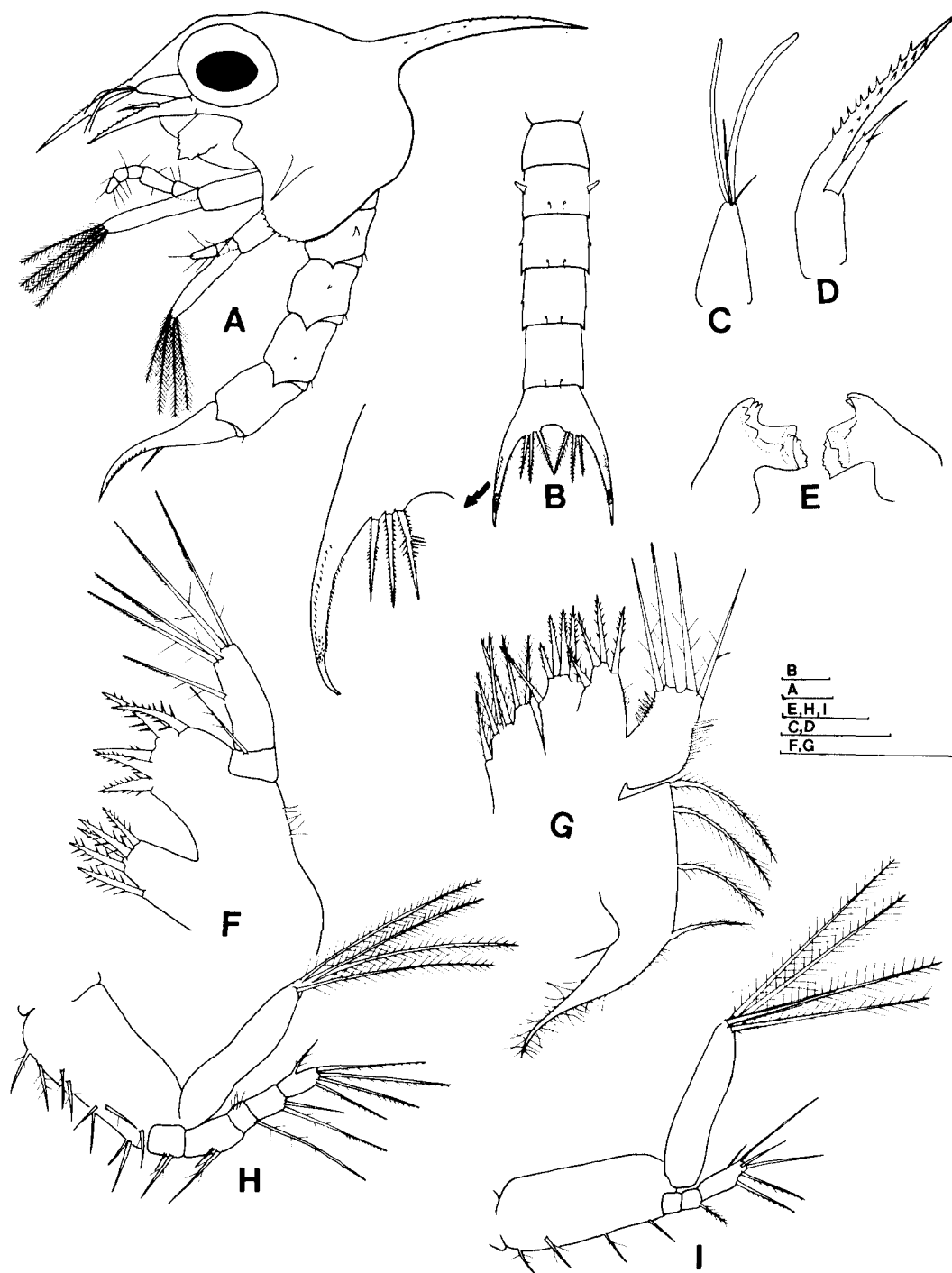


Fig. 1. Zoea I. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars = 0.1 mm

simple setae. Round protuberance on forehead in all zoeal stages. Eyes unstalked.

Abdomen (Figs. 1A, B). Five somites and telson; somites 2-5 each with 2 short simple setae on postero-dorsal margin and terminating in postero-lateral spines; somite 1 naked, somites 2-4 each with pair of lateral knobs (smallest on somite 4).

Telson (Fig. 1B). Bifurcated; furcal shaft long and slender, covered with 2 rows of fine spinules and with cluster of spinules distally; inner margin with 3 pairs of serrate spines of similar length.

Antennule (Fig. 1C). Smooth and conical; with 2 terminal aesthetascs and 2 smaller simple setae.

Antenna (Fig. 1D). Protopodite tapered, with 2 rows of teeth on distal half. Exopodite about one-third length of protopodite, with 2 unequal short simple setae and longer terminal spine.

Mandibles (Fig. 1E). Asymmetrical. Molar process irregularly dentated; 4 prominent teeth between molar and incisor processes on right mandible, tooth on left mandible.

Maxillule (Fig. 1F). Endopodite 2-segmented; proximal segment with sparsely plumose seta, distal segment with 4 terminal and a subterminal plumodenticulate setae. Basal and coxal endites each with 5 plumodenticulate setae. Microtrichia on dorsal margin.

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

Maxilliped 1 (Fig. 1H). Coxopodite naked; basis with 10 sparsely plumodenticulate setae, prograding distally 2, 2, 3, and 3; endopodite 5-segmented, each segment with 2, 2, 1, 2, and 5 plumodenticulate setae distally; exopodite with 4 natatory plumose setae.

Maxilliped 2 (Fig. 1I). Coxopodite naked; basis with 4 sparsely plumodenticulate setae ventrally; endopodite 3-segmented, with plumodenticulate seta on middle segment and 2 plumodenticulate setae plus 4 simple setae on distal segment; exopodite with 4 natatory plumose setae.

Chromatophores. The majority of chroma-

tophores dark brown and present on base of antennule, antenna and maxilliped 1, on labrum and mandibles, on dorsal region of cephalothorax and along ventral region of abdominal somites 2-5 and telson. Red chromatophores on dorsal and lateral carapace spines. This pattern consistent for all zoeal stages.

Zoea II (Fig. 2)

Carapace (Fig. 2A). Two pairs of simple setae added on forehead. Postero-lateral margin with 3-4 plumose setae, postero-dorsal arch with 2 sparsely plumose setae. Eyes stalked.

Abdomen (Fig. 2B). somite 4 disappeared pair of lateral knobs and somite 1 with medio-dorsal plumose seta.

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

Antenna (Fig. 2D). lateral seta on exopodite disappeared in this and subsequent stages.

Mandibles (Fig. 2E). As in zoea I.

Maxillule (Fig. 2F). Basal endite with 7 plumodenticulate setae. Plumose seta added on dorsal margin of basis.

Maxilla (Fig. 2G). Distal and proximal lobes of coxal endite with 3, 4 plumodenticulate setae, respectively. Scaphognathite with 5 marginal and 3 terminal plumose setae.

Zoea III (Fig. 3)

Maxilliped 1 and 2 (Figs. 2H, I). Exopodite with 6 natatory plumose setae.

Carapace (Fig. 3A). Pair of simple setae added on base of rostral spine and eyestalk respectively. Dorsal spine with pair of simple setae. Postero-ventral margin with 7-9 plumose setae. Maxilliped 3 and pereopods present as rudimentary buds.

Abdomen (Fig. 3B). Now with 6 somites; somite 1 with 1 or 3 medio-dorsal plumose setae; inner margin of telson with 4 pairs of serrate spines,

Antennule (Fig. 3C). With 3 long aesthetascs and short simple seta plus hair terminally.

Antenna (Fig. 3D). Endopodite present as small bud.

Mandibles (Fig. 3E). As in zoea II but additional tooth between molar and incisor processes on

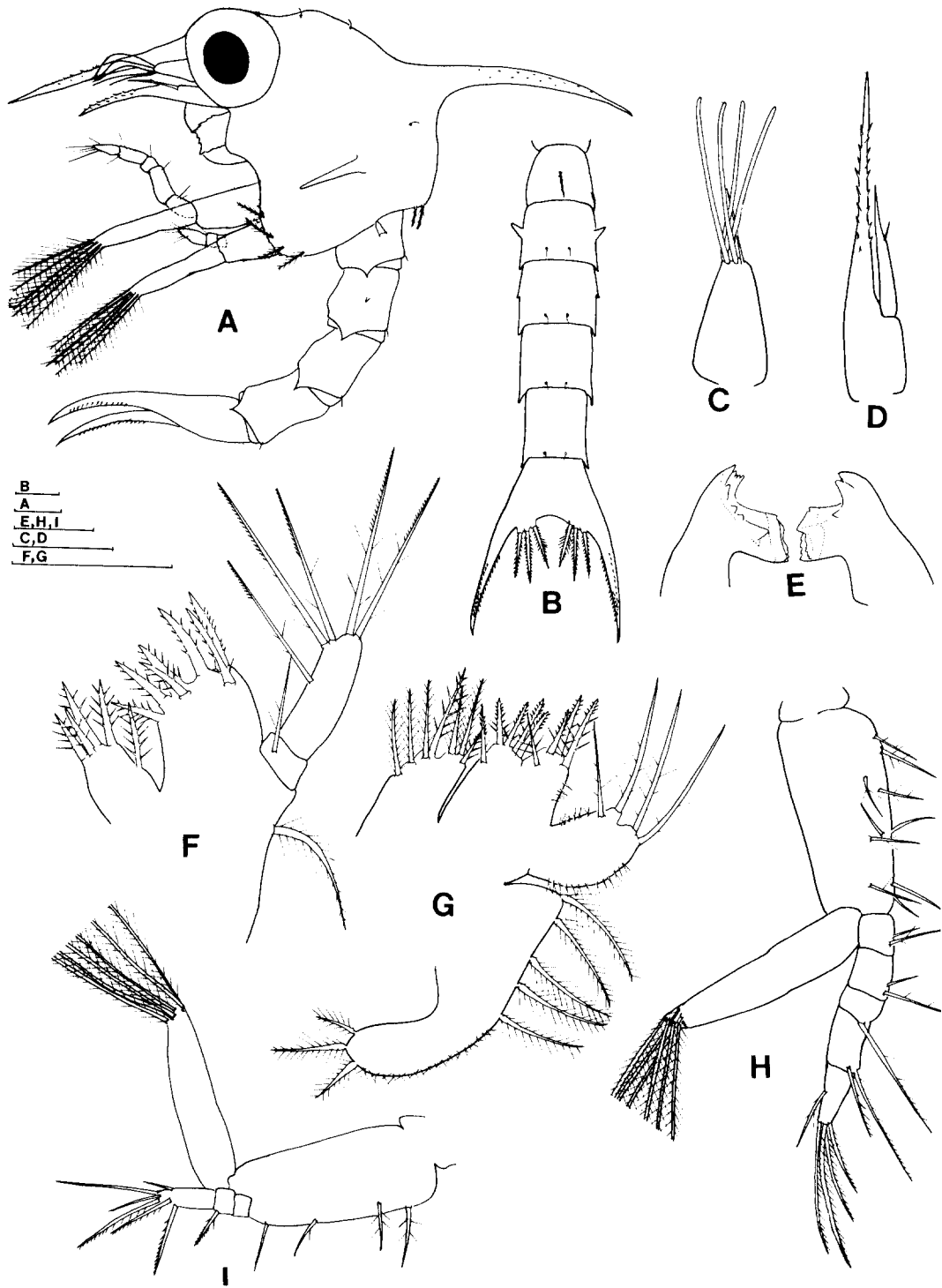


Fig. 2. Zoea II. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars = 0.1 mm

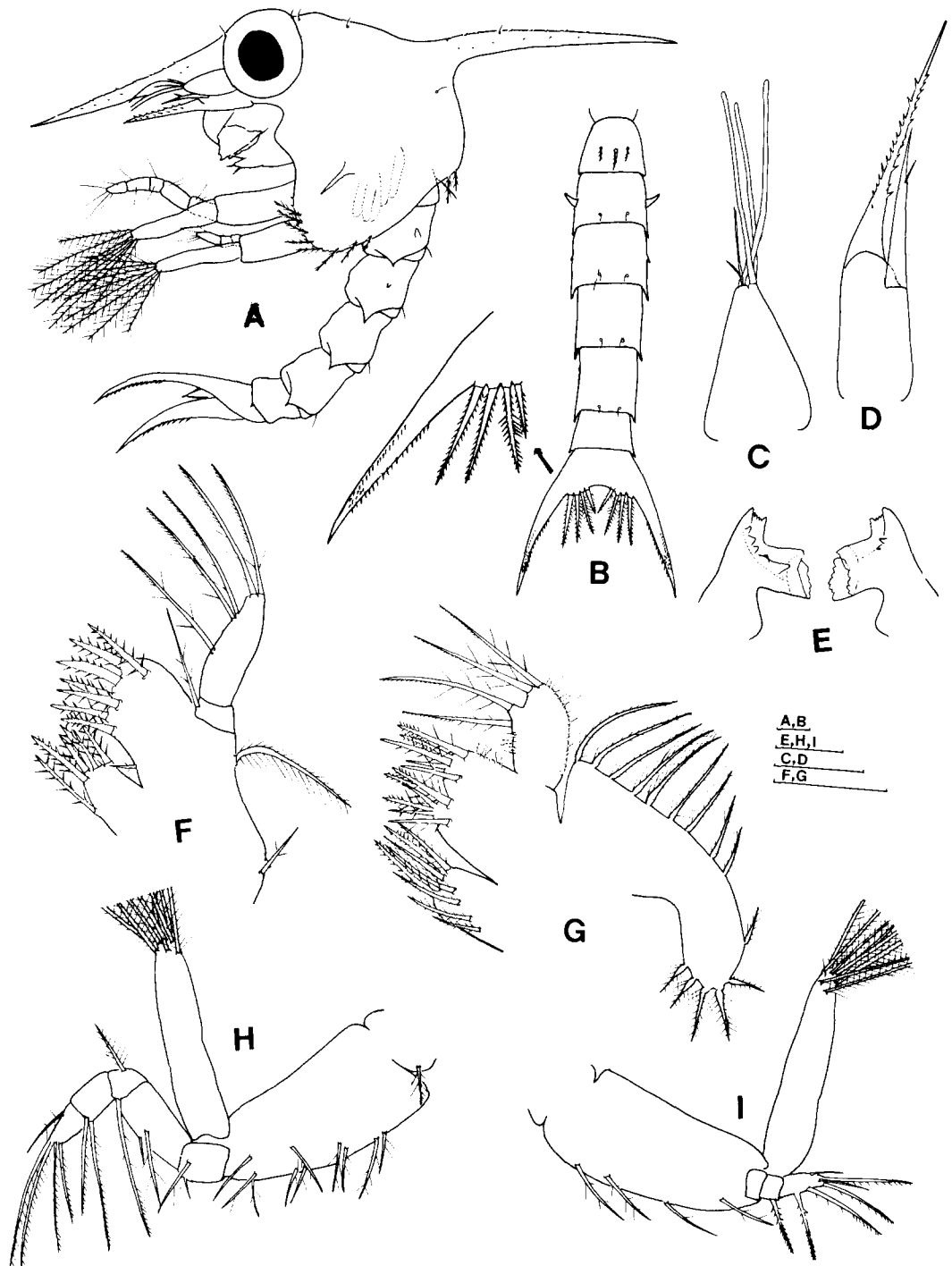


Fig. 3. Zoea III. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars = 0.1 mm

right and left mandibles respectively.

Maxillule (Fig. 3F). Basal endite with 7 terminal and a lateral plumodenticulate setae; coxal endite with 6 (rarely 7) plumodenticulate setae. Sparsely plumodenticulate seta now present on proximal margin.

Maxilla (Fig. 3G). Distal and proximal lobes on basal and coxal endites each with 5, 6, and 3, 5 plumodenticulate setae. Scaphognathite with 9 marginal and 6 terminal plumose setae.

Maxilliped 1 (Fig. 3H). Coxopodite with a plumodenticulate seta; long plumose seta added on segment 3 of endopodite, now setation 2, 2, 2, and 5; exopodite with 8 natatory plumose setae.

Maxilliped 2 (Fig. 3I). Exopodite with 8 natatory plumose setae.

Zoea IV (Fig. 4)

Carapace (Fig. 4A). Paired simple setae added on dorsal spine. Postero-ventral margin with 11-14 plumose setae, postero-dorsal arch with 4 sparsely plumose setae. Maxilliped 3 and pereopod buds visible through carapace.

Abdomen (Fig. 4B). Somite 1 with 5 medio-dorsal plumose setae. Small, round pleopod buds on somites 2-5.

Antennule (Fig. 4C). With 4 aesthetascs plus simple seta terminally and aesthetascs subterminally.

Antenna (Fig. 4D). Endopodite bud much larger, but shorter than half length of protopodite process.

Mandibles (Fig. 4E). As in zoea III.

Maxillule (Fig. 4F). Basal endite with 11 terminal and 2 lateral plumodenticulate setae; coxal endite with 8 plumodenticulate setae. Additional sparsely plumodenticulate seta added on proximo-lateral margin.

Maxilla (Fig. 4G). Distal and proximal lobes of basal and coxal endites each with 7-8, 8 and 3, 8 plumodenticulate setae. Scaphognathite with 24-27 plumose setae.

Maxilliped 1 (Fig. 4H). Plumodenticulate seta added on coxopodite. Short plumose seta added on distal segment of endopodite, now setation 2, 2, 2, 2, and 6. Exopodite with 10 natatory plumose setae.

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

Zoea V (Fig. 5)

Carapace (Fig. 5A). Two pairs of simple setae added on forehead. Pair of simple setae added on dorsal spine, carapace now with 10 pairs of simple setae. Postero-ventral margin with 16-17 plumose setae. Maxilliped 3 and pereopods extending slightly below postero-lateral margin of carapace.

Abdomen (Fig. 5B). Somite 1 with 7 medio-dorsal plumose setae. Pleopod buds much more elongated. Telson with pair of medio-dorsal simple setae; 5 pairs of serrate spines on inner margin.

Antennule (Fig. 5C). Basal regions swollen, with simple seta. Endopodite bud small, round. With 4 aesthetascs plus simple seta terminally and 5 aesthetascs subterminally.

Antenna (Fig. 5D). Endopodite 2-segmented, about 3/4 length of protopodite process.

Mandibles (Fig. 5E). As in zoea IV but mandibular palps present as small buds.

Maxillule (Fig. 5F). Basal endite with 14 terminal and 3 lateral plumodenticulate setae. Coxal endite with 10 terminal plumodenticulate and 4 subterminal simple setae.

Maxilla (Fig. 5G). Distal and proximal lobes of basal endite each with 11, 9 plumodenticulate setae; each lobe of coxal endite with 4 and 11 plumodenticulate setae. Scaphognathite with 37-41 densely plumose setae marginally.

Maxilliped 1 (Fig. 5H). Coxopodite now with 2 plumodenticulate setae. Plumose seta added on second segment of endopodite, now setation 2, 3, 2, 2, and 6. Exopodite with 12 natatory plumose setae.

Maxilliped 2 (Fig. 5I). Exopodite with 12 natatory plumose setae.

Megalopa (Figs. 6, 7)

Carapace (Fig. 6A). Subquadrate, lacking dorsal and lateral spines; rostrum very short and curved downward. Plumose setae fringed along lateral and posterior margins. Anterior and medio-dorsal surface bearing 6 and 16 simple setae as illustrated.

Abdomen (Fig. 6A). Six somites and telson; all

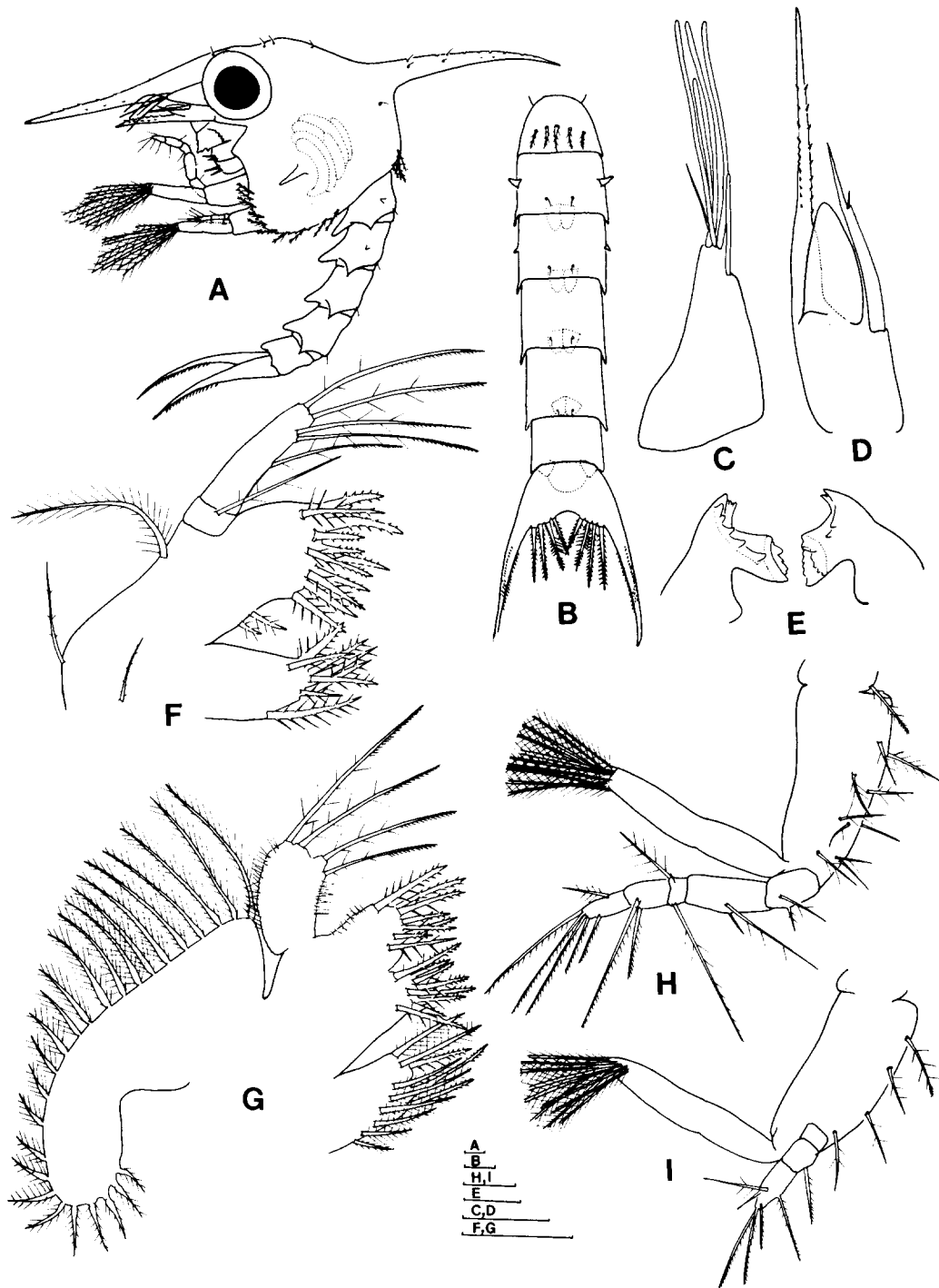


Fig. 4. Zoea IV. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars = 0.1 mm

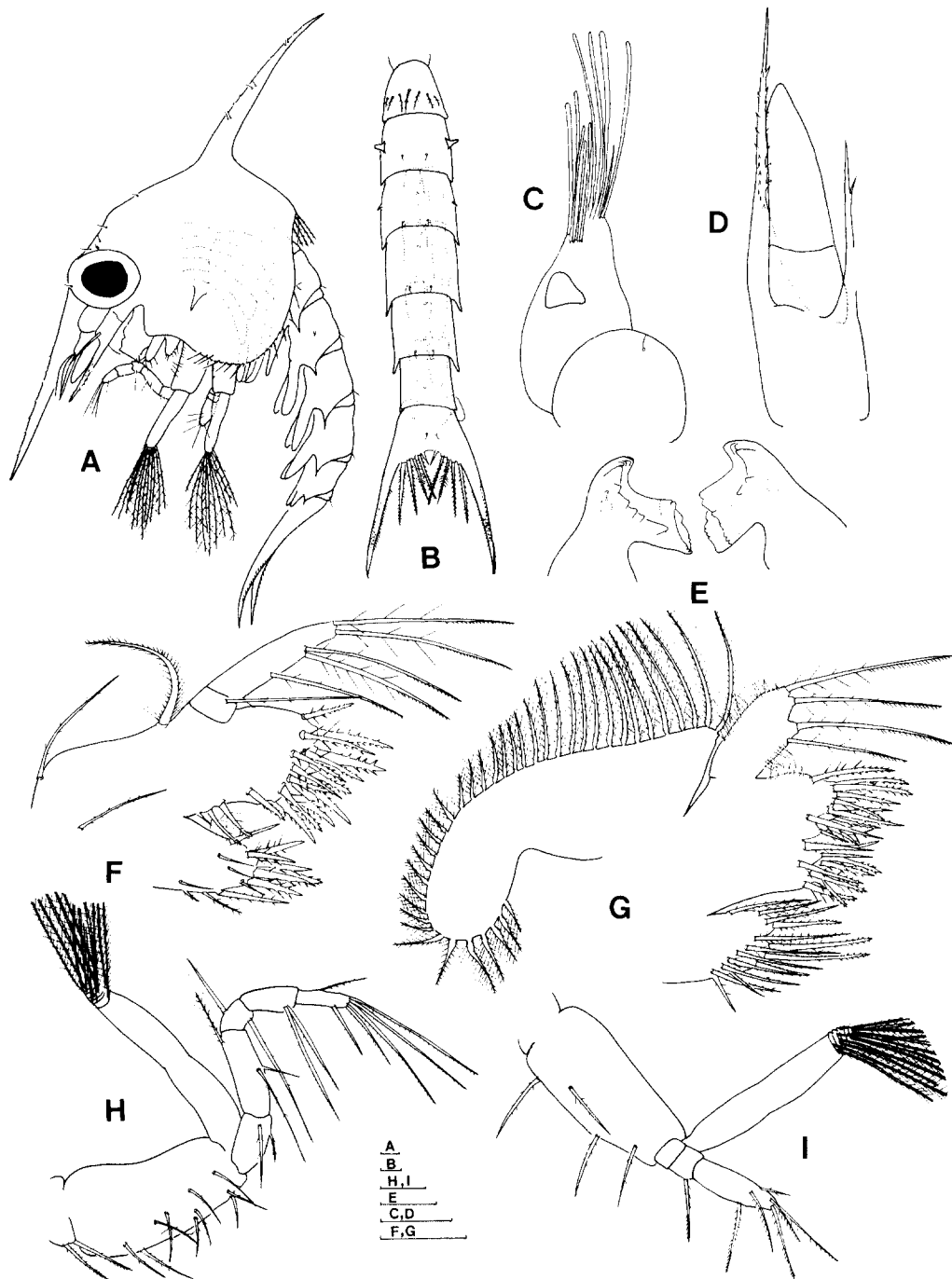


Fig. 5. Zoea V. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1, I, maxilliped 2. Scale bars = 0.1 mm

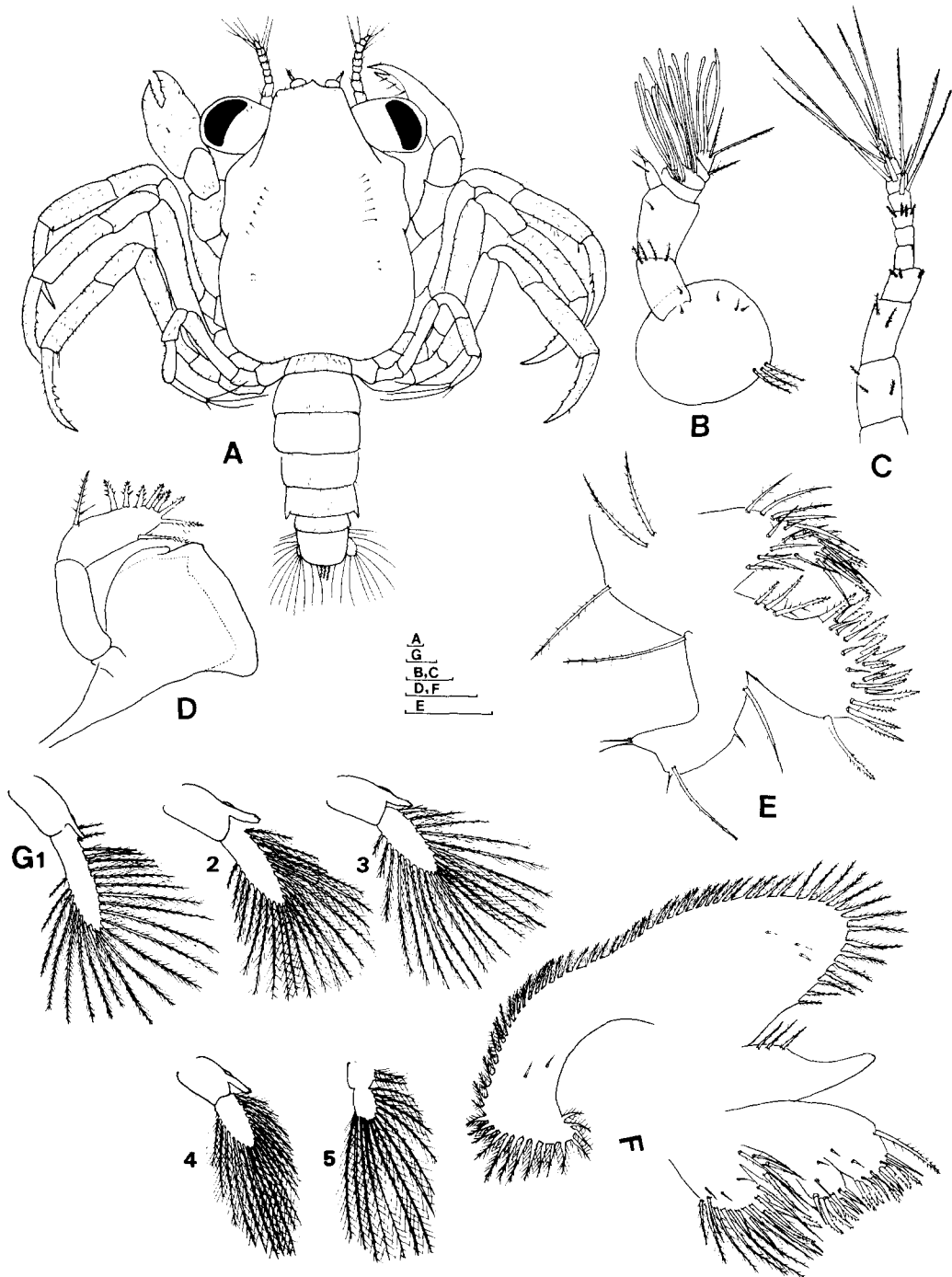


Fig. 6. *Megalopa*. A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G1-5, pleopods 1-5. Scale bars = 0.1 mm

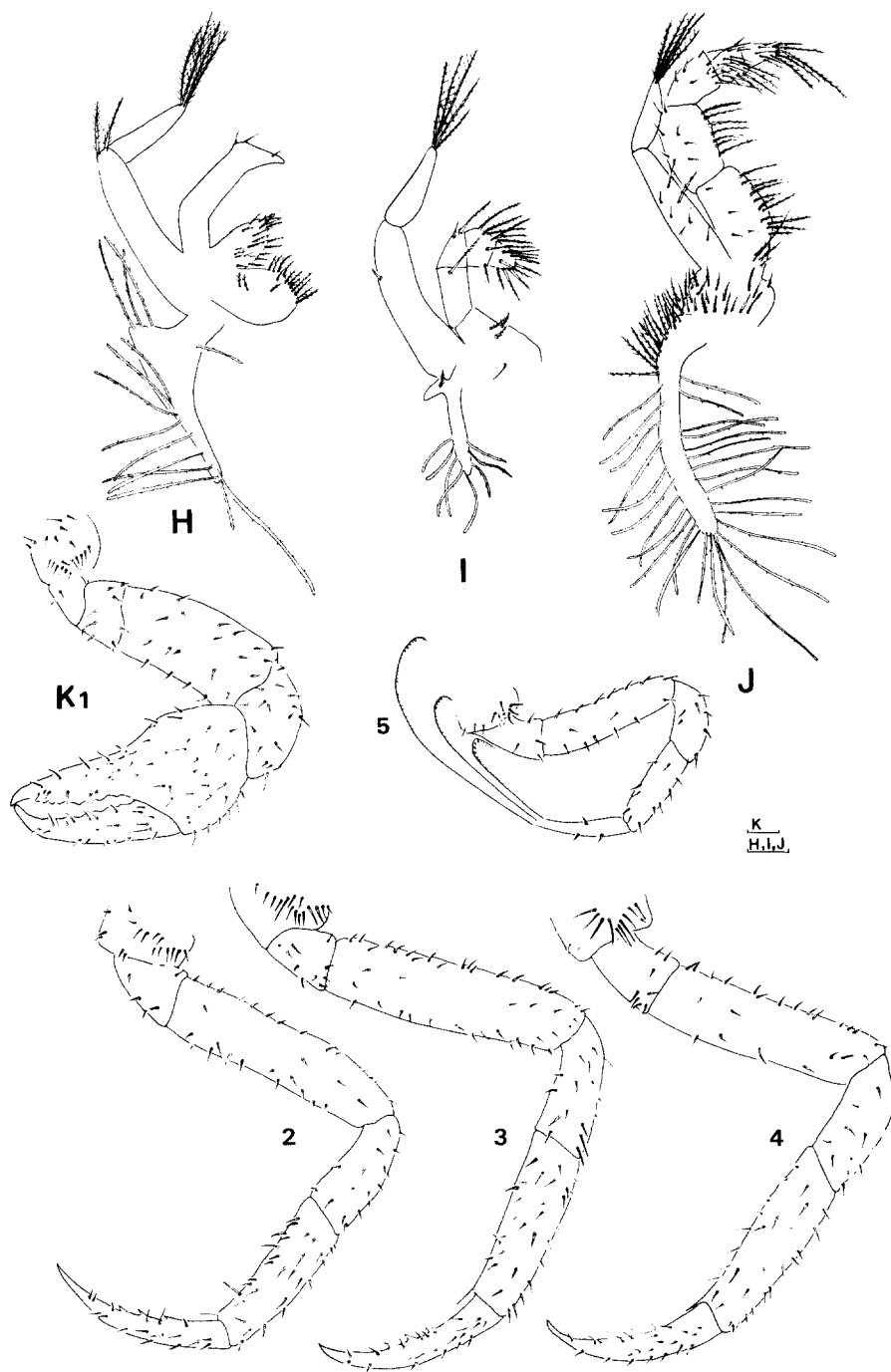


Fig. 7. Megalopa. H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K1-5, pereopods 1-5. Scale bars = 0.1 mm

somites with dorsal simple setae as illustrated; telson with 3 plumose setae on postero-medial margin.

Antennule (Fig. 6B). Peduncle 3-segmented: basal segment with 3 sparsely plumose and 5 simple setae, segment 2 with 4 plumose setae, segment 3 with simple seta. Segmented lower ramus with 3 terminal and a subterminal simple setae. Upper ramus 4-segmented: segment 1 naked, segment 2 with 5 aesthetascs, segment 3 with 5 aesthetascs and lateral plumose seta, segment 4 with 4 aesthetascs and 2 terminal plumodenticulate setae.

Antenna (Fig. 6C). Ten-segmented; setation progressing distally 3, 2, 3, 0, 0, 4, 2, 4, 3, 3.

Mandible (Fig. 6D). Symmetrical, cutting margin smooth. Palp 2-segmented, distal segment with 8 plumodenticulate and a plumose setae.

Maxillule (Fig. 6E). Unsegmented endopodite with 4 terminal and 2 lateral setae. Basal endite with 24-26 terminal and 3 lateral plumodenticulate setae. Coxal endite with 22-24 plumodenticulate setae. Dorsal margin with 4 long sparsely plumodenticulate setae.

Maxilla (Fig. 6F). Unsegmented endopodite with 2-3 plumose setae on lower lateral margin. Distal and proximal lobes of basal and coxal endites each with 15-18, 10-12 and 6, 19-20 plumodenticulate setae. Scaphognathite with 65-72 plumose marginal setae and 5 simple setae on blade.

Pleopods (Figs. 6G 1-5). Well developed on abdominal somites 2-6; exopodite of pleopods 1-4 with 23, 22-23, 20-22, 19-20 long natatory plumose setae respectively; endopodite of pleopods 1-4 with 3 hooked spines. Pleopod 5 lacking endopodite, with 2 plumose setae on basal segment and 12-13 plumose setae on exopodite.

Maxilliped 1 (Fig. 7H). Basal and coxal endite each with 22-25, 16-17 plumodenticulate setae. Unsegmented endopodite with 3 terminal simple setae. Exopodite 2-segmented, with 2 short plumose setae on proximal segment and 4 longer plumose setae on distal segment. Epipodite with 13-15 sparsely plumodenticulate setae on marginal.

Maxilliped 2 (Fig. 7I). Endopodite 4-segmented, each segment with 1, 2, 7-8, 10-11 plumodenticulate setae distally. Exopodite 2-segmented:

proximal segment with simple seta laterally; distal segment with 5 terminal plumose setae. Epipodite with 8-9 sparsely plumodenticulate setae distally and plumodenticulate seta proximally. Basis with 3-5 plumodenticulate setae.

Maxilliped 3 (Fig. 7J). Endopodite 5-segmented, each with 18-20, 14, 9-10, 17-19, 10-11 plumodenticulate setae distally. Exopodite 2-segmented: proximal segment with 7 plumodenticulate setae, distal segment with 5 terminal plumose setae. Epipodite with 13-15 plumodenticulate setae proximally and 28-30 long sparsely plumodenticulate setae distally. Basis with 25-27 plumodenticulate setae.

Pereiopods (Figs. 7K 1-5). Cheliped covered with short simple setae as illustrated; cutting margins of finger with several small teeth. Pereiopods 2-4 similar in form each other; each with distro-ventral tooth on propodus and 3 ventral teeth on dactylus. Pereiopod 5 with 3 long modified hooked serrate setae (= brachyuran feelers) on dactylus.

Chromatophores. Dark brown chromatophores present on eyestalk, medio-lateral, postero-lateral, posterior and gastric regions of carapace, basis of pereiopods 2-4, each abdominal somite and telson. Red chromatophores present on eyestalk and all segments (except dactylus) of pereiopods 2-4.

Discussion

Zoeal stage I and all larval stages of *Eriocheir japonicus* have already been described by Aikawa (1929) and Morita (1974) respectively. There are, however, many differences between their descriptions and the present study. Aikawa (1929) described that the exopodite of the second antenna has two rows of small teeth and is nearly equal in length to the protopodite process. Whereas those of Morita's (1974) and our specimens lack two rows of teeth and are much shorter than protopodite process. Aikawa (1929) also described the telson as A-Type [= telson with a dorsal tooth at middle of fork and a lateral tooth near base], while both Morita's and our specimens show B-Type telson [= telson fork without outer teeth]

Therefore, it seems that Aikawa made a mistake in identification of species and described charac-

teristics of different species.

Based on overall morphology and mouthparts setation considered by previous authors (Aikawa, 1937; Rice, 1980; Wilson, 1980) as a subfamilial characters, the zoeal features of the present material are well similar to those of the subfamily Varuninae. However, Morita's (1974) description and illustration are very questionable as larval characteristics of the Varuninae. For example, (1) most of the varuninid zoeae have 10 or 12 and 4 setae on basis of maxillipeds 1 and 2 respectively in all zoeal stages, whereas Morita's specimen shows quite different setations on basis of maxillipeds 1 and 2 through development (Table 2), (2) endopodite of maxilliped 2 is always 3-segmented and each segment has 0-1, 1 and 5-6 setae distally in typical varuninid zoeae, while that of Morita's

specimen is 3-segmented in only zoea V (Table 2), (3) Morita (1974) did not describe very common morphological characters in some appendages of brachyuran larvae: antennule of all zoeal stages lacking simple setae and abdominal somite 1 missing medio-dorsal plumose setae, (4) Morita (1974) also did not illustrate the following setae on some appendages: sparsely plumodenticulate setae on proximal and proximo-lateral margins of maxillule; plumodenticulate setae on coxopodite of maxilliped 1; simple and plumose setae on carapace and dorsal spine; 3 hooked spines on endopodite of pleopods 1-4 in the megalopal stage. In addition, differences of appendage setation in zoeal and megalopal stages between the present study and Morita's (1974) are listed in Tables 2 and 3. It seems these discrepancy be-

Table 3. Differences in setations of the megalopa appendages of *Eriocheir japonicus* between the present study and Morita's (1974)

	Feature	Present study	Morita (1974)
Antennule	peduncle	3P+5S, 4P, 1S	5+10,0,2,0
	lower ramus	4S	3S
	upper ramus	0,5,5+1S,4+2S	0,5,5,5
Antenna		3,2,3,0,0,4,2,4,3,3	0,4,2,0,0,2,2,3,3,3
Mandible	palp	0,9	0,0,9
Maxillule	coxa	4	0
	coxal endite	26	7
	basal endite	27-29	12
Maxilla	coxal endite	6, 19-20	3, 8
	basal endite	15-18, 10-12	11, 9
	endopodite	2-3	0
	scaphognathite	65-72 mar.+5 lat.	44-46 mar.+0 lat.
Maxilliped 1	coxa	16-17	15
	basis	22-25	12
	endopodite	3	5
	exopodite	2, 4	2, 3
	epipodite	13-15	12
Maxilliped 2	basis	3-5	2
	endopodite	1,2,7-8,10-11	0,1,6,10
	exopodite	1, 5	1, 4
	epipodite	8-9 mar.+1 prox.	11 mar.+1 prox.
Maxilliped 3	basis	25	0
	endopodite	18-20,14,9-10,17-19,10-11	9,9,4,11,7
	exopodite	7, 5	3, 4
	epipodite	28-30 mar.+13-15 prox.	20-22 mar.+18 prox.
Pleopods 1-5		23,22-23,20-22,19-20,14-15	23,24,22,19,13

lat., lateral seta; mar., marginal seta; prox., proximal seta

Table 4. Differences of zoeae I features in known larvae of the Varuninae. (Abbreviations as in Table 2)

	Ant. type	Tel. type	Lat. spine	Abdo. lat. kn.	Max. 1		Max. 2		Bas.	Maxi. 1		Maxi. 2	
					BE	CE	BE	CE		End.	End.	End.	End.
<i>Acmaeopleura parvula</i> (Kurata, 1968; Kim & Jang, 1987)	B3	B	-	2-3	5	5	4,5	3,4	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	0,1,6
<i>Eriochair japonicus</i> (present study)	B3	B	+	2-4	5	5	4,5	2,4	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	0,1,6
<i>E. leptognathus</i> (Lee, 1988)	B7	B	+	2-3	5	6	4,5	3,3	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	0,1,6
<i>Euchirograpsus americanus</i> (Wilson, 1980)	C	A	+	2-5	5	5-6	4,5	3,5	3-4	2,2,2,2	2,2,1,2,5	2,2,1,2,5	0,1,6
<i>Gaetice depressus</i> (Kim & Lee, 1983)	B3	B	-	2-3	5	5	4,5	3,3	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	0,1,6
<i>Hemigrapsus crenulatus</i> (Wear, 1970)	B3	B	+	2	5	4	3,3	2,4	3	3,3,3,3	1,1,1,2,5	1,1,2,5	1,1,6
<i>H. edwardsi</i> (Wear, 1970)	B3	B	+	2	4	4	4,4	2,4	5	3,3,3,3	2,2,1,2,5	2,2,1,2,5	1,1,6
<i>H. longitarsis</i> (Aikawa, 1929)	B2	B	+	2-3	5	5	8	6	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	?
<i>H. nudus</i> (Hart, 1935)	B2	B	+	2-3	6	5	7	6	4	2,1,3,3	2,2,1,2,5	2,2,1,2,5	0,1,5
<i>H. oregonensis</i> (Hart, 1935)	B2	B	+	2	6	5	7	6	4	2,1,3,3	2,2,1,2,5	2,2,1,2,5	0,1,5
<i>H. penicillatus</i> (Kim, 1979)	B2	B	+	2-3	5	5	5,4	2,4	4	2,2,3,3*	2,2,1,2,5	2,2,1,2,5	0,1,5
<i>H. sanguineus</i> (Kurata, 1986b)	B3	B	+	2-3	5*	5*	9*	6*	4*	2,2,3,3*	2,2,1,2,5*	2,2,1,2,5*	0,1,6
<i>H. sinensis</i> (Kim & Moon, 1987)	B3	B	+	2-4	5	5	4,5	3,4	4	2,2,3,3	2,2,1,2,5	2,2,1,2,5	0,1,6

Ant. and Tel., type of the second antenna and telson (by Aikawa, 1929, 1937); *, data from Aikawa (1929); ?, no description; + and -, the presence and absence.

tween these two studies come from the following reasons: Firstly, Morita perhaps made some mistakes in description of morphological characteristics of each larval stage. Secondly, the differences between Morita's description and the present study may be partly due to geographical variations. Thirdly, *E. japonicus* of Korea and Japan may be subspecies in their phylogenetic relationship.

Zoea I within the various genera of the Varuninae may be provisionally distinguished by using differences of characters noted in Table 4, and are synopsised as follows. The Varuninae are usually typified by a B-Type telson, B-Type antenna, and possession of lateral carapace spines. There are, however, several exceptions: *Euchirograpsus americanus* by Wilson (1980) exhibit a A-Type (occasionally B) telson and C-Type antenna; both *Acmaeopleura parvula* and *Gaetice depressus* lack lateral spines on the zoeal carapace (Table 4). Setations in basipodite (2, 2, 3, 3) and endopodite (2, 2, 1, 2, 5) of maxilliped 1 and endopodite (0, 1, 6) of maxilliped 2 are consistent in most known varuninid zaeae. However, those of *H. crenulatus* and *H. edwardsi* by Wear (1970) from New Zealand and *H. nudus* and *H. oregonensis* by Hart (1935) from British Columbia are considerably different (Table 4). Zoea I of *E. japonicus* is readily distinguished from those of *E. leptognatus* by differences in armature of abdomen, setations of coxal endites of maxillule and maxilla, and type of the second antenna (Table 4).

References

- Aikawa, H., 1929. On larval forms of some Brachyura. *Rec. Oceanogr. Wks. Japan* **2**:1-55.
- Aikawa, H., 1937. Further notes on brachyuran larvae. *Rec. Oceanogr. Wks. Japan* **9**:87-162.
- Hart, J. F. L., 1935. The larval development of British Columbia Brachyura. I. Xanthidae, Pinnotheridae and Grapsidae. *Canadian J. Res.* **12**:411-432.
- Kim, C. H., 1979. Complete larval development of *Hemigrapsus Penicillatus* (De Haan) reared in the laboratory and its taxonomic significance. *Pusan Natl. Univ. Natural Science Series* **18**:43-54.
- Kim, C. H. and I. K. Jang, 1987. The complete larval development of *Acmaeopleura parvula* Stimpson (Brachyura, Grapsidae) reared in the laboratory. *Bull. Korean Fish. Soc.* **20**:543-560.
- Kim, C. H. and H. J. Lee, 1983. Zoeal development of *Gaetice depressus* (De Haan)(Decapoda, Grapsidae) reared in the laboratory. *J. Sci. Pusan Natl. Univ.* **35**:195-206.
- Kim, C. H. and D. Y. Moon, 1987. Complete larval development of *Hemigrapsus sinensis* Rathbun (Brachyura, Grapsidae) reared in the laboratory. *Korean J. Zool.* **30**:227-291.
- Kim, H. S., 1973. Illustrated Encyclopedia of Fauna and Flora of Korea, Vol. 14, Anomura and Brachyura. Samhwa Publishing Co., Seoul, pp. 694.
- Kurata, H., 1968a. Larvae of Decapoda Brachyura of Arasaki, Sagami Bay-I. *Acmaeopleura parvula* Stimpson (Grapsidae). *Bull. Tokai Reg. Fish. Res. Lab.* **55**:259-263.
- Kurata, H., 1968b. Larvae of Decapoda Brachyura of Arasaki, Sagami Bay-II. *Hemigrapsus sanguineus* (De Haan). *Bull. Tokai Reg. Fish. Res. Lab.* **56**:161-165.
- Lee, H. J., 1988. The larval development of four species of grapsid crabs (Decapoda, Grapsidae) reared in the laboratory. Ph. D. Thesis, Pusan Natl. Univ. pp. 78.
- Morita, J., 1974. Morphological observation on the development of *Eriocheir japonicus* De Haan. *Zool. Jap.* **83**:24-81.
- Peter, N. and A. Panning, 1933. Die chinesische wolhand krabbe (*Eriocheir sinensis* H. Milne Edwards) in Deutschland. *Zool. Anz.* **104**:1-180.
- Rice, A. L., 1980. Crab zoeal morphology and its bearing on the classification of the Brachyura. *Trans. Zool. Soc. Lond.* **35**:271-424.
- Sakai, T., 1976. Crabs of Japan and the adjacent seas. Kodansha Ltd., Tokyo, pp. 773.
- Wear, R. G., 1970. Life history studies on New Zealand Brachyura. 4. Zoeal larvae hatched from crabs of the family Grapsidae. *N. Z. Jl mar. Freshwat. Res.* **4**:3-35.
- Wilson, K. A., 1980. Studies on Decapod Crustacea from the Indian River region in Florida. XV. The larval development under laboratory conditions of *Euchirograpsus americanus* A. Milne Edwards (Crustacea, Decapoda, Grapsidae) with notes on grapsid subfamilial larval characters. *Bull. Mar. Sci.* **30**:756-776.

(Accepted July 10, 1990)

동남참게 *Eriocheir japonicus*의 유생 발생

김창현 · 황상구(부산대학교 자연과학대학 생물학과)

실험실에서 사육된 동남참게(참게아과) 전체 유생기의 형태적인 특징을 상세히 기술하고 도시하였다. 동남참게는 5 zoea기를 거쳐 megalopa기로 탈피하였다. 수온 25°C, 염분 농도 33.3‰, 광주기 14 h light : 10 h dark의 조건하에서 실험이 진행되었다. 부화로부터 megalopa기와 제 1 crab기까지는 각각 17일과 27일이 걸렸다. 각 유생기의 형태적인 특징들이 이미 기재된 일본산 동남참게의 유생 특징들과 비교되었으며, 참게아과 내의 Zoea I기의 형태적 특징에 관하여 간단히 논의하였다.