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# The Complete Larval Development of a Sand Bubbler Crab, *Scopimera bitympana* Shen(Brachyura, Ocypodidae), Reared in the Laboratory

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**The complete larval development of *Scopimera bitympana* Shen was described and illustrated from the larvae reared in the laboratory. *S. bitympana* had five, or occasionally six, zoeal and one megalopal stages. At 25°C, the megalopa and the first crab instar were attained in 24 and 38 days (31 and 48 days in six zoeal series) after hatching respectively.**

***S. bitympana* zoeae can be distinguished from other described zoeae in the genus by the toothed carapace spines and the telson with a dorsal and two ventral spines. Megalopa of this species can be distinguished from other *Scopimera* species by the feature of carapace. Other minor morphological features of *S. bitympana* larvae are compared to the previous descriptions of larvae of the genus and the morphological differences are briefly discussed.**

**KEY WORDS: Larval development, Brachyura, *Scopimera bitympana***

The sand bubbler crab, *Scopimera bitympana* shen, 1930, is known from the Yellow Sea of Korea, the Peichihli Bay and the Shantung Peninsula of North China and Taiwan, and occurs near high tide levels on sand beaches of estuaries or inland sea (Kim, 1973, 1985; Sakai, 1976).

Within the genus *Scopimera*, larval descriptions are available for only four speices: *S. longidactyla* Shen, *S. inflata* H. Milne Edwards, *S. globosa* De Haan and *S. crabricauda* Alcock. Of these, the complete larval development is known for *S. longidactyla, S. inflata* and *S. globosa* (see Jang and Kim, 1989; Fielder and Greenwood, 1985; Terada, 1976), although the first stage zoea and the megalopa of *S. globosa* were previously described by Aikawa (1929) and Gamô (1958) respectively. A detailed description of the first stage zoea of *S. crabricauda* was provided by Rice (1976).

The objective of the present work is to describe all larval stages of *S. bitympana* and to compare them with the known larvae of the genus *Scopimera*.

## Material and Methods

Seven ovigerous females were collected from a sandy beach on Anmyŏn Island in the Yellow Sea (36°4'N, 126°2'E) on 5 June 1988. they were maintained individually in glass containers (300 mm diameter × 200 mm depth) which were provided with wedges of sand of 150 mm depth for a shelter and filled to 60 mm depth with seawater of 33.3‰ salinity. Hatching occurred successfully in all the female crabs but only one brood of zoeae hatched on 8 July 1988 was used for the rearing experiment.

Ten newly hatched larvae were removed into each of 30 glass bowls (containing 80 ml filtered seawater of 33.3‰) and they were kept at 25°C and a light regime of 14 hr light : 10 hr darkness. A mass culture of the larvae were also maintained under the same conditions. *Brachionus* sp. was provided as food in the first to third zoeal stages and freshly hatched *Artemia* nauplii in subsequent stages. Food and seawater were changed daily.

**Table 1.** Measurements of various features of the zoeae and megalopae of *Scopimera bitympana* Shen.

| Features | Zoea I | Zoea II | Zoea III | Zoea IV | Zoea Vu | Zoea Vp | Zoea VI |
|---|---|---|---|---|---|---|---|
| TSL | 1.94[0.04] | 3.02[0.12] | 4.62[0.19] | 6.25[0.17] | 8.50[0.46] | 8.05[0.07] | 10.58[0.33] |
| Randge | 1.88-2.00 | 2.85-3.20 | 4.45-5.05 | 5.90-6.40 | 8.05-9.25 | 8.80-8.10 | 10.20-10.90 |
| CL(A) | 0.57[0.02] | 0.73[0.04] | 0.99[0.03] | 1.18[0.06] | 1.58[0.06] | 1.58 | 2.01[0.07] |
| Range | 0.55-0.60 | 0.68-0.78 | 0.93-1.03 | 1.08-1.25 | 1.50-1.68 | 1.58 | 1.93-2.08 |
| DL(B) | 0.55[0.03] | 0.91[0.05] | 1.43[0.08] | 2.01[0.06] | 2.87[0.20] | 2.73[0.04] | 3.48[0.12] |
| Range | 0.50-0.58 | 0.85-1.00 | 1.33-1.53 | 1.90-2.10 | 2.65-3.20 | 2.70-2.75 | 3.35-3.55 |
| RL(C) | 0.92[0.03] | 1.44[0.09] | 2.30[0.10] | 3.10[0.08] | 4.15[0.20] | 3.90[0.07] | 5.17[0.18] |
| Range | 0.88-0.98 | 1.30-1.58 | 2.18-2.50 | 2.95-3.20 | 3.95-4.30 | 3.85-3.95 | 4.95-5.35 |
| AL(D) | 0.40[0.02] | 0.55[0.03] | 0.66[0.01] | 0.77[0.05] | 0.91[0.04] | 0.88 | 0.95[0.06] |
| Range | 0.38-0.43 | 0.50-0.60 | 0.66-0.68 | 0.68-0.83 | 0.85-0.95 | 0.88 | 0.88-1.00 |
| Ratio B/A | 0.96 | 1.24 | 1.44 | 1.70 | 1.81 | 1.72 | 1.73 |
| Ratio C/A | 1.61 | 1.97 | 2.32 | 2.62 | 2.62 | 2.46 | 2.57 |
| Ratio B/C | 0.59 | 0.63 | 0.62 | 0.64 | 0.69 | 0.70 | 0.67 |
| Ratio D/C | 0.43 | 0.38 | 0.28 | 0.24 | 0.21 | 0.22 | 0.18 |
| | Megalopa(V) | Megalopa(VI) | | | | | |
| CL(E) | 1.78[0.05] | 1.88[0.10] | | | | | |
| Range | 1.73-1.83 | 1.80-2.05 | | | | | |
| CW(F) | 1.53[0.05] | 1.79[0.06] | | | | | |
| Range | 1.48-1.58 | 1.70-1.88 | | | | | |
| Ratio F/E | 0.85 | 0.95 | | | | | |

AL, second antenna length; CL, carapace length; CW, carapace width; DL, dorsal spine length; RL, rostral spine length; TSL, length from rostral to dorsal spine tips; Zoea Vp, penultimate fifth zoea; Zoea Vu, ultimate fifth zoea; Megalopa(V), megalopa from Zoea Vu; Megalopa(VI), megalopa from Zoea VI. Mean values for ten specimens, except Zoea Vp, Zoea VI and Megalopa(VI) measured for two or four specimens. Standard deviations in brackets. All measurements in mm.

Samples of living larvae, plus all exuviae and dead larvae, were preserved in 7% neutral formalin. Larval descriptions were made after examination of at least 10 individuals of each stage, except for a larval series with 6 zoeal stages (Table 1). Drawings and measurements were based on freshly killed larvae and made with the aid of a camera lucida and an ocular micrometer. Measurements of larvae and tabular presentation of appendage setations follow those presented by Fielder and Greenwood (1985).

## Results

The larvae of *Scopimera bitympana* reared in the laboratory passed through five or occasionally six zoeal stages before metamorphosis to megalopa (Fig. 1). In the late zoeal stage, this species showed two series of larval development *i.e.*, one series of normal (ultimate) fifth stage zoeae molted directly to megalopal stage; another series of penultimate fifth stage zoeae molted to an additional sixth zoeal stage before molting to megalopa. Both of ultimate and penultimate fifth stage zoeae appeared in the same day (day 18). However there was a gap of 7 days between developmental times to two types of megalopae. This is a result of the intercalation of an extra zoeal instar. The delay in developmental time of the 6 zoeal series occurred in the first crab stage, too. Morphological differences between the corresponding larval stages of the two developmental series are obvious and described in the text. Measurements of larvae and setations of appendages are summarized in Tables 1-3. Gross morphological features of each larval stage are as follows:

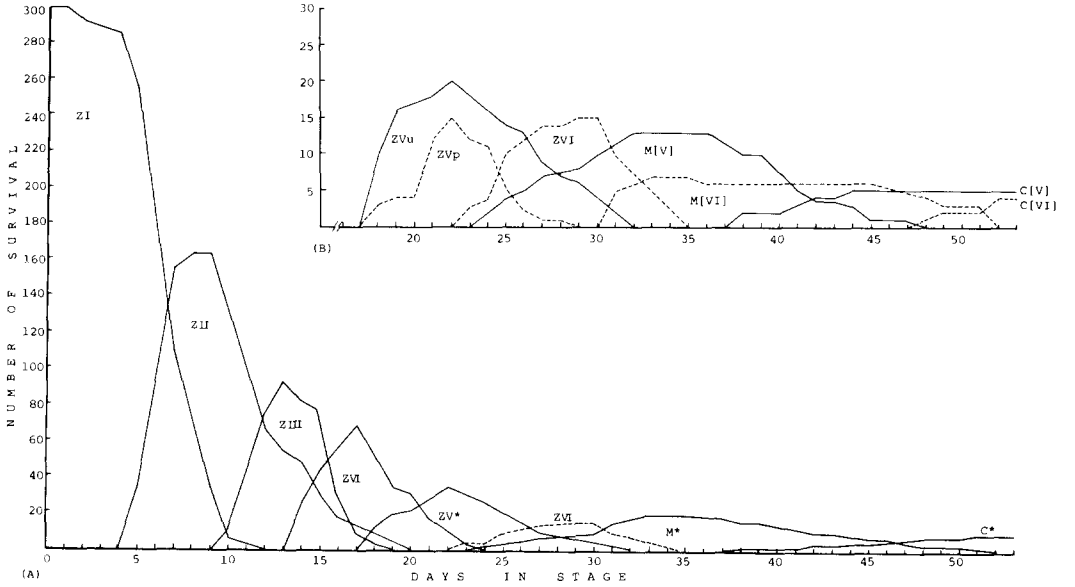


**Fig. 1.** Number of survival and duration of larval stages in *Scopimera bitympana* reared in 33.3‰, 25°C and 14L:10D photoperiod. *, combined stages; ZI-ZVI, first to sixth zoeal stages; ZVp, penultimate fifth zoea; ZVu, ultimate fifth zoea; M[V] and M[VI], megalopae molting from ZV and ZVI; C[V] and C[VI], first crab molting from M[V] and M[VI] respectively. After the fourth zoeal stage, two courses of development are separately given in (B).

**First zoea(Fig. 2)**

Carapace with well-developed dorsal and rostral spines; denticles present on both spines. Lateral carapace spines short and naked. A pair of simple setae flanking base of dorsal spine. Postero-ventral margin of carapace round and naked. Eyes sessile. Abdomen composed of five somites and a telson; somite 1 with a mid-lateral process; somites 2-5 each with a pair of dorsal simple setae and terminating in postero-lateral spines; somites 2 and 3 with paired mid-lateral knobs. Telson bifurcated, with 3 pairs of plumodenticulate setae on inner margin; fork with a dorsal and 2 ventral spines.

Dark brown chromatophores present on mouthparts, posterior to eyes, ventro-lateral region of carapace, center of rostral carapace spines and ventral region of abdominal somites 2-5 and telson; orange red chromatophores also on distal half of rostral and dorsal carapace spines.

**Secend zoea(Fig.3)**

Eyes movable. Very small dorsal spine added on telson fork. Paired simple setae added on forehead of carapace; postero-ventral margin of carapace with 2-3 plumose setae. Several dark brown chromatophores present on dorsal carapace spine; orange red chromatophore posterior to lateral carapace spine. This pattern of chromatophores consistent in the subsequent zoeal stages.

**Third zoea(Fig.4)**

Dorsal carapace spine now vertical with no posterior slope. Third maxilliped and pereiopods present as small buds, covered by carapace. Additional simple and plumose setae on carapace given in Table 2.

**Fourth zoea(Fig.5)**

Abdominal somites 2-5 with small pleopod buds; somite 6 now separate from telson. Telson with paired dorsal simple setae proximally. Third maxilliped buds trilobed.

**Fifth zoea(Ultimate, Fig.6)**

Telson with paired small denticles proximally. Uropods absent. Third maxilliped and pereiopods incompletely segmented, still covered by carapace.

**Fifth zoea(Penultimate, Fig.7)**

This stage zoea molted to sixth zoeal stage before metamorphosis to megalopa and readily dis-

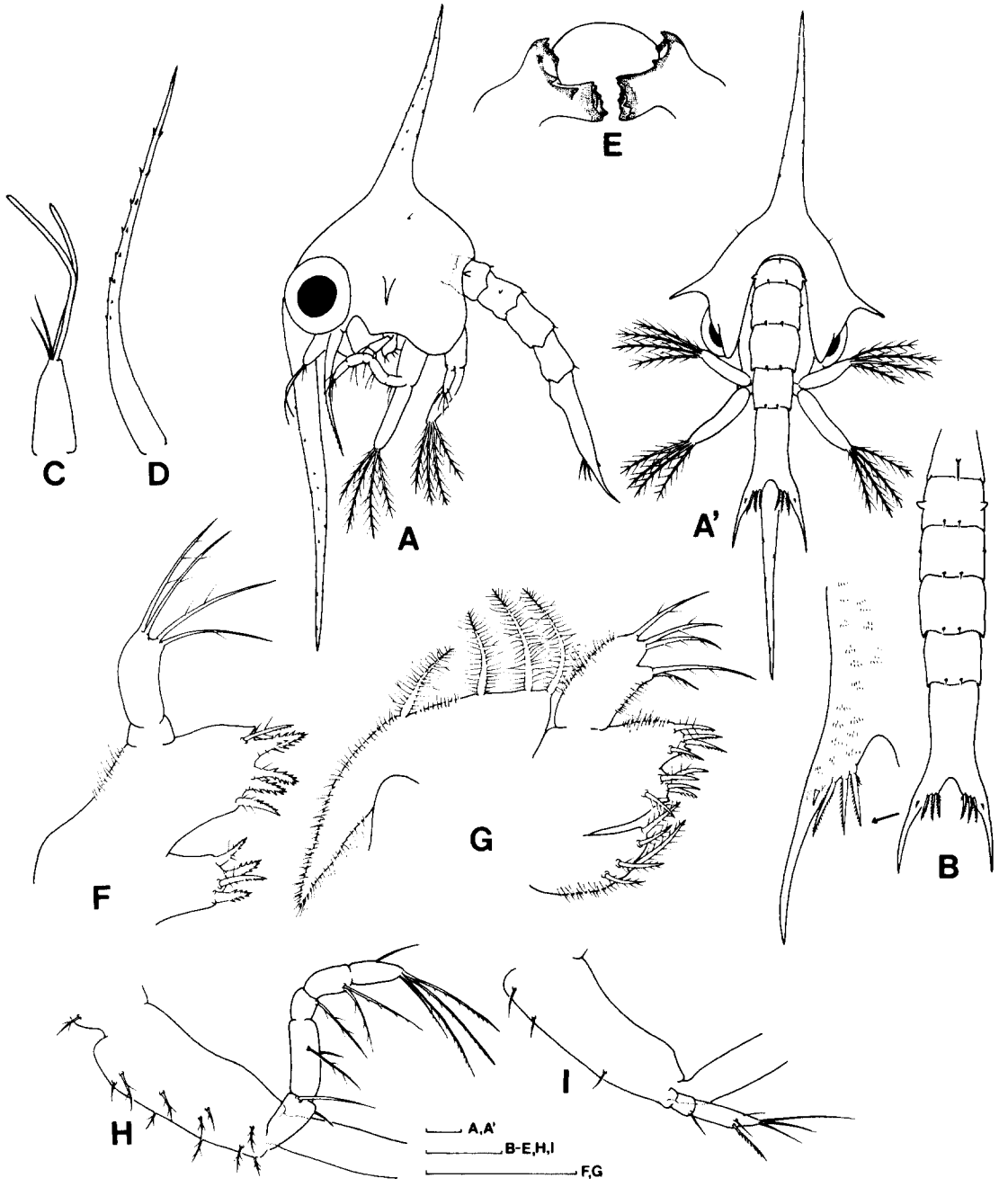


**Fig. 2.** First zoea of *Scopimera bitympana*. A, lateral view; A', posterior view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars= 0.1 mm.

**Table 2.** Setations on carapace and appendages of zoeae of *Scopimera bitympana* Shen.

| Appendages | Zoea I | Zoea II | Zoea III | Zoea IV | Zoea Vu | Zoea Vp | Zoea VI |
|---|---|---|---|---|---|---|---|
| CARAPACE | | | | | | | |
| Antero-dorsal | 1 pair S | 2 pair S | 4 pair S | 5 pair S | 6 pair S | 8 pair | 11 pair S |
| Postero-ventral | 0 | 2-3P | 5-7P | 7-9P | 12-13P | 11-12P | 17-18P |
| ANTENNULE | | | | | | | |
| Terminal | 2A,2S | 4A,1S | 3A,1S | 3A,1S | 3A,1S | 3A,1S | 3A,1S |
| Subterminal | 0 | 0 | 0 | 1A | 3A | 3A | 3A |
| ANTENNA | | | | | | | |
| Exopod | – | – | – | – | – | – | – |
| Endopod | – | – | – | small bud | present | present | 2S |
| ABDOMEN | | | | | | | |
| Seg. 1 | 1S | 1P | 1P | 3P | 3P | 3P | 3P |
| MANDIBLE | | | | | | | |
| Palp bud | – | – | – | – | present | – | present |
| MAXILLULE | | | | | | | |
| Coxa | 0 | 1HP | 1HP,1PD | 1HP,2PD | 1HP,2PD | 1HP,2PD | 1HP,2PD |
| Coxal end. | 4PD | 5PD | 6PD | 9PD | 13PD | 11-13PD | 16-18PD |
| Basal end. | 5PD,1Pr | 7PD | 7+1PD | 13-14PD | 20-21PD | 18-19PD | 24-27PD |
| Endopod seg. prox. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| seg. 2 | 4PD | 4PD | 4PD | 4PD | 4PD | 4PD | 4PD |
| MAXILLA | | | | | | | |
| Coxal end. prox. | 3PD | 3PD | 4PD | 7PD | 9-11PD | 9-11PD | 14-17PD |
| dist. | 2PD | 3PD | 3PD | 3+1PD | 3+1PD | 3+1PD | 3+1PD |
| Basal end. prox. | 5PD | 6PD | 8PD | 10PD | 12-13PD | 12-13PD | 16PD |
| dist. | 4PD | 5PD | 6PD | 8-9PD | 9-11PD | 9-11PD | 11-14PD |
| Endopod | 5PD | 5PD | 5PD | 5PD | 5PD | 5PD | 5PD |
| Scaphognathite | 4+1HP | 8HP | 13-15HP | 23-26HP | 34-35HP | 34-35HP | 46-49HP |
| MAXILLIPED I | | | | | | | |
| Coxa | 1PD | 1PD | 1PD | 1PD | 2PD | 2PD | 3PD |
| Basis | 1S,9PD | 2S,8PD | 10PD | 10PD | 10PD | 10PD | 10-12PD |
| Endopod seg. prox. | 2S | 1S,1PD | 1S,1PD | 1S,1PD | 1S,1PD | 1S,1PD | 1S,1PD |
| seg. 2 | 1S,1PD | 1S,1PD | 1S,1PD | 1S,1P,1PD | 1S,1P,1PD | 1S,1P,1PD | 1P,2PD |
| seg. 3 | 1PD | 1PD | 1P,1PD | 1P,1PD | 1P,1PD | 1P,1PD | 1P,1PD |
| seg. 4 | 2PD | 2PD | 2PD | 2PD | 2PD | 2PD | 2PD |
| seg. 5 | 1S,4PD | 1P,4PD | 1S,1P,4PD | 1P,6PD | 1P,7PD | 1P,6-7PD | 1P,7-8PD |
| Exopod | 4N | 6N | 8N | 10N | 12N | 12N | 14N |
| MAXILLIPED II | | | | | | | |
| Coxa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basis | 3S | 3PD | 3PD | 3PD | 3PD | 3PD | 3PD |
| Endopod seg. prox. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| seg. 2 | 1S | 1S | 1PD | 1PD | 1PD | 1PD | 1PD |
| seg. 3 | 5S,1PD | 5S,1PD | 5S,1PD | 5S,1PD | 5S,1PD | 5S,1PD | 1-2S,5PD |
| Exopod | 4N | 6N | 8N | 10N | 12N | 12N | 14N |

A, aesthetascs; HP, highly plumose; N, natatory; P, plumose; PD, plumodenticulate; Pr, process; S, simple; end., endite; dist., distal; prox., proximal; seg., segment. Zoea Vp and Zoea Vu, penultimate and ultimate fifth zoeal stages.

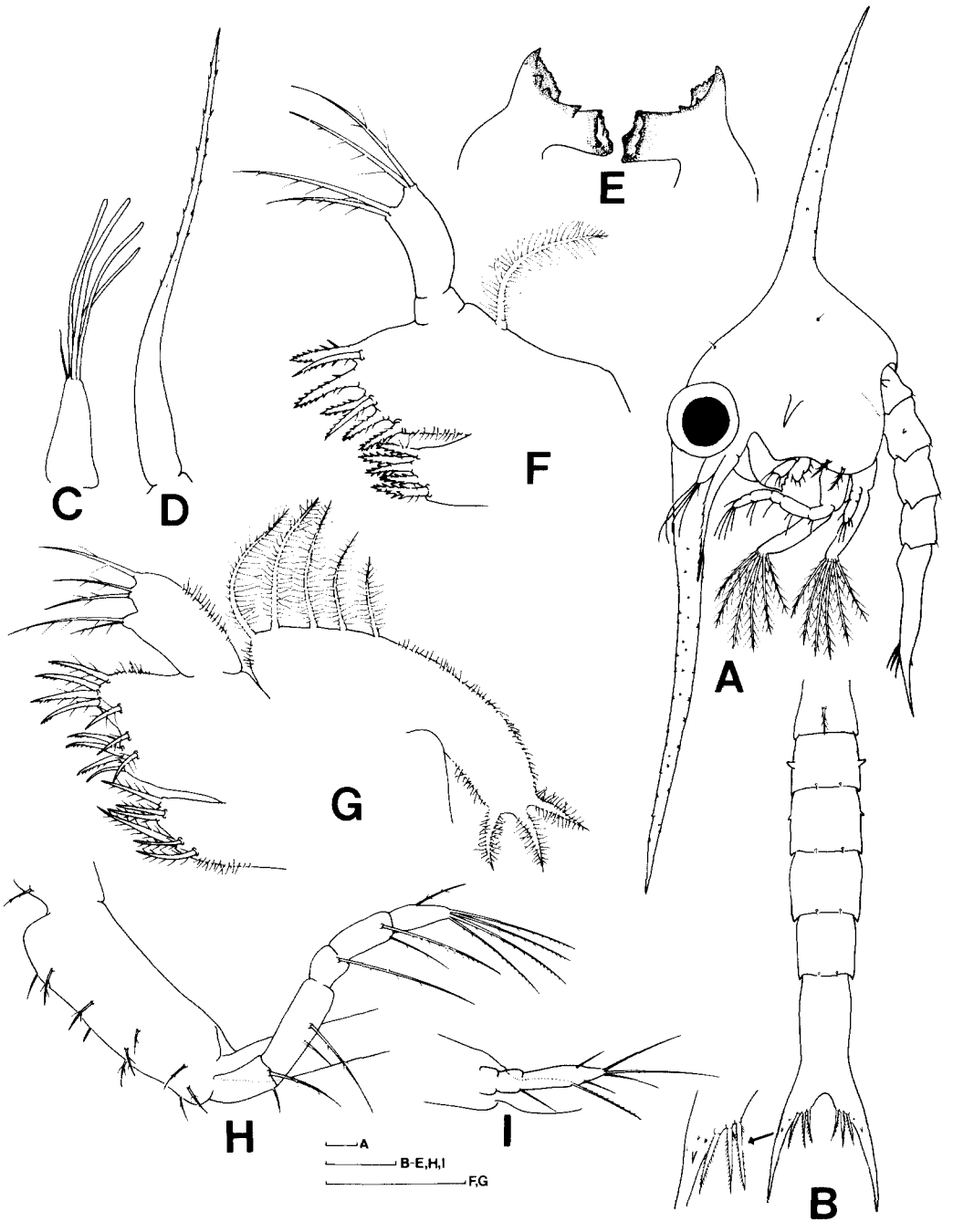


**Fig. 3.** Second zoea of *Scopimera bitymapana* A, lateral view; B. dorsal view ot abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I. maxilliped 2. Scale bars= 0.1 mm.

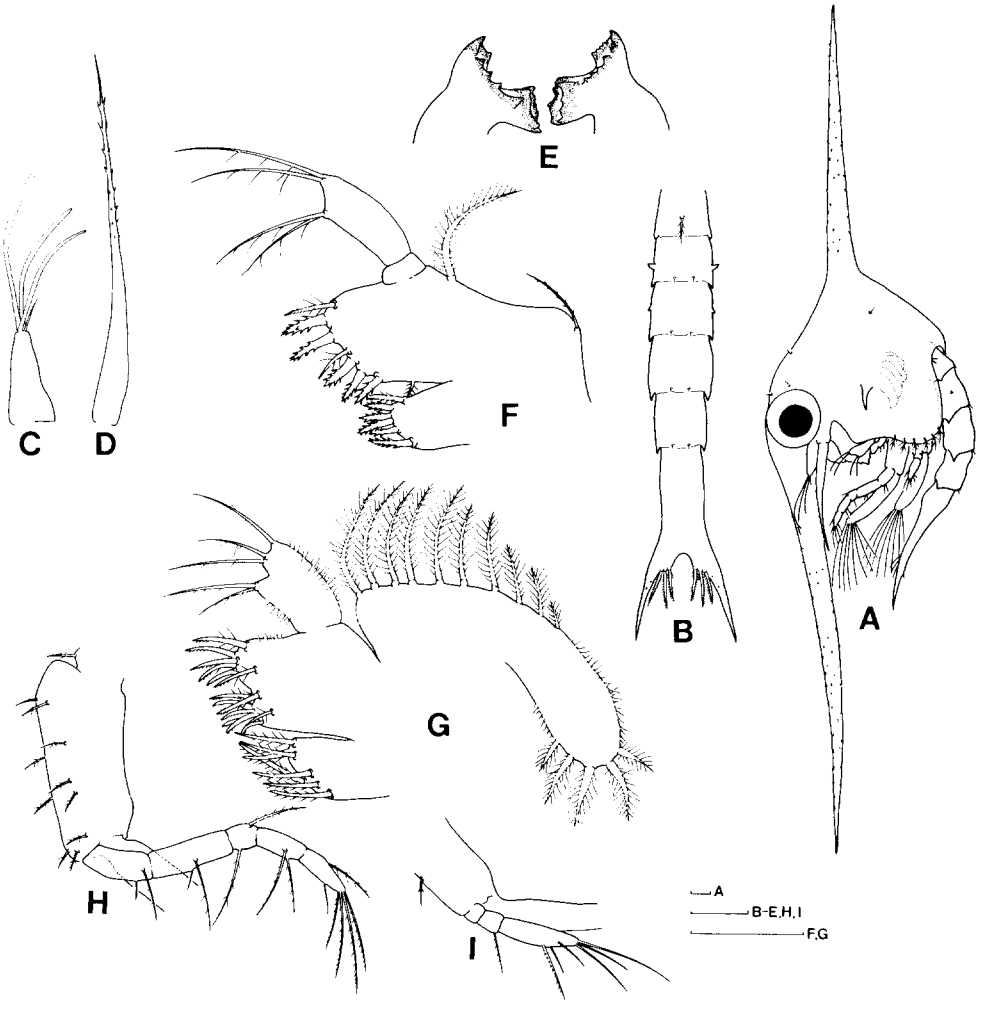


**Fig. 4.** Third zoea of *Scopimera bitympana*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2. Scale bars= 0.1 mm.

tinguished from both fourth and normal fifth zoeae by carapace size, lenght of pleopods, absence of mandibular palp and appendage setation(Table 2).

**Sixth zoea(Additional, Fig.8)**

Pleopods longer than typical fifth stage, with several (variable in number) simple setae marginally. Antenna exopod incompletely three-segmented, with 2 terminal setae. Third maxilliped with 3-4 simple or plumose setae on epipod. Pereiopods segmented; chela with several simple setae.

**Megalopa(Molting from fifth zoea, Figs.9 and 10)**

Two types of megalopae molting from boty fifth and sixth zoeal stages are very similar in form. Detailed setations distinguishing between them are given in Table 3.

Carapace subquadrate, with undulations marginally; small, round tubercles present behind eyestalks and on mid-lateral region; approximately 20 stout plumodenticulate setae antero-laterally; many simple setae antero-dorsally; long plumose setae fringed along postero-lateral margin. Ros-

**Table 3.** Setations on appendages of the megalopa of *Scopimera bitympana* Shen. (Setations of the megalopa molting from sixth stage zoea are placed in brackets; abbreviations as in Table 2)

| Appendages | Setation | Appendages | Setation |
|---|---|---|---|
| ANTENNULE | | MAXILLIPED I | |
| Peduncle seg. prox. | 1S,9P[1S,10P] | Basis | c.13S,4P[1P,many S] |
| seg. 2 | 1S[1S,1P] | Endopod | 4S[3S] |
| seg. 3 | 1S[1S] | Exopod seg. prox. | 4HP[4HP] |
| Lower ramus | 2P[2P] | seg. 2 | 1S[1S] |
| Upper ramus | 2S,6A[2S,7A] | Epipod | 5S[8S] |
| ANTENNA | | MAXILLIPED II | |
| Flagellum seg. prox. | 1S,1P[1S,1P] | Endopod seg. prox. | 3PD[3PD] |
| seg. 2 | 0[0] | seg. 2 | 1PD[0] |
| seg. 3 | 2S[2S] | seg. 3 | 0[6S] |
| seg. 4 | 0[0] | seg. 4 | 4PD,4S[5PD,4S] |
| seg. 5 | 0[0] | seg. 5 | 10-12S[11PD,4S] |
| seg. 6 | 2S[2S] | Exopod seg. prox. | 0[3P] |
| seg. 7 | 2S[2S] | seg. 2 | 2-3S[1S] |
| MANDIBLE | | MAXILLIPED III | |
| Palp seg. prox. | 6-9S[c.13P] | Endopod seg. prox. | 21PD[c.33PD] |
| seg. 2 | 1-7S,2-4P[c.18S,5P] | seg. 2 | 32PD[c.35PD] |
| MAXILLULE | | seg. 3 | 17PD[c.25PD] |
| Coxa | 1HP,2PD[1HP,2PD] | seg. 4 | 3PD[3PD] |
| Coxal end. | 41-45PD[c.60PD] | seg. 5 | 3PD[5PD] |
| Basal end. | 40-43S[c.55S] | Exopod seg. prox. | 1S[1HP, 3P] |
| Endopod | 3S[3S] | seg. 2 | 2HP[3HP] |
| MAXILLA | | Epipod prox. | c.36PD[c.55PD] |
| Coxal end. prox. | 9S,13PD[11S,20PD] | dist. | 20-21PD[20-23PD] |
| dist. | 2S,10PD[2S,10PD] | PLEOPOD I | 21-23N[24-25N] |
| Basal end. prox. | c.19S,1PD[c.23S] | II | 21-22N[23N] |
| dist. | c.20S,3PD[c.40S,3PD] | III | 18-21[22N] |
| Endopod | 1P[1P] | IV | 17N[18N] |
| Scaphognathite | c.76HP,4-5P[c.97HP,4P] | | |

trum ending in pointed tip, curved ventrally. Abdominal somites 1-6 each with 8, 14, 12, 12, 20 and 4 simple setae dorsally. Telson subquadrate, with 2 posterior, 2 mid-dorsal and 2 mid-ventral simple setae, plus 6 dorsal setules. Sometimes, abnormal telson found: slightly bifurcated, with 6 plumodenticulate setae terminally and 2 simple setae subterminally(Fig. 10, L'). Unsegmented endopods on pleopods with 2-3 teeth on cutting margin. Pereiopods 2-4 similar in form, with long plumose setae marginally; pereiopod 5 with 5 long plumose setae, instead of brachyuran feelers.

Dark brown chromatophores present between and posterior to eyestalks; on antero-lateral and mid-posterior region and center of carapace; on all segments of pereiopods 1-5, and ventral region of abdominal somites 1-5 and telson.

## Discussion

### Number of Larval Stages

Partial or complete larval descriptions of the family Ocypodidae are available for about 40 species but the number of zoeal stages occurring in a larval series is only known for 40% of them. Most species usually have five zoeal stages, but some have two (*Uca subcylindrica;* Rabalais and Cameron, 1983) or six (*Macrophthalmus japonicus* and

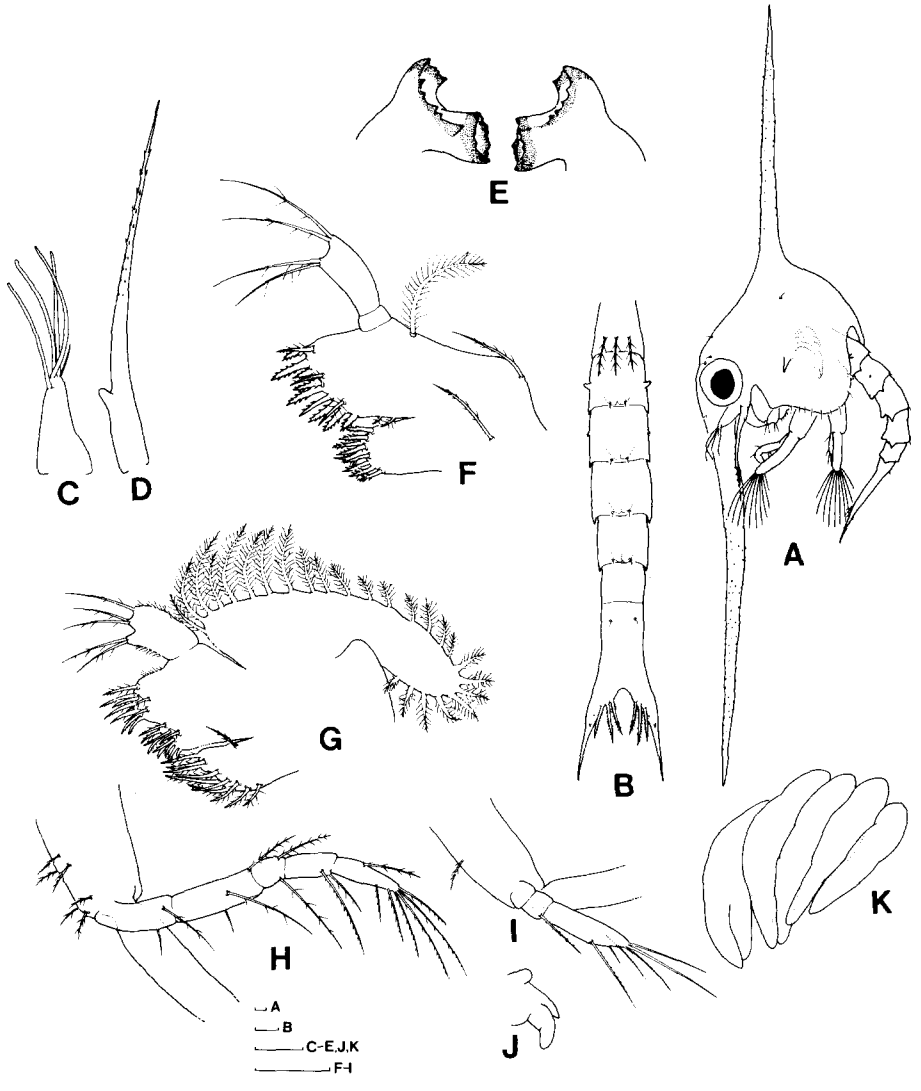


**Fig. 5.** Fourth zoea of *Scopimera bitympana*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K, pereiopods. Scale bars=0.1 mm.

*M. dilatatus;* Terada, 1979) zoeal stages. Of these, however, no species are known to attain extra instars except *U. subcylindrica*. Even if Rabalais and Cameron (1983) found an extra zoeal instar in the mass culture of the larvae of *U. subcylindrica*, they reported that the extra stage did not differ morphologically from the normal stage nor did its occurrence affect the normal timing of the other stages or survivorship. Moreover *U. subcylindrica* exhibits an abbreviated larval development which has two zoeal stages and a megalopa.

In the present study, *Scopimera bitympana* attained an extra instar in the late zoeal development. The occurrence of extra instars has been reported in the larval development of other brachyuran families, including Grapsidae (Yatsuzuka, 1962; Fukuda and Baba, 1976; Wilson, 1980; Gore and Scotto, 1982; Kim and Jang, 1987), Xanthidae (Porter, 1960; Scotto, 1979) and Portunidae (Costlow, 1965; Yatsuzuka, 1962). Although many workers have studied extensively the variability of decapod larval development -addition or

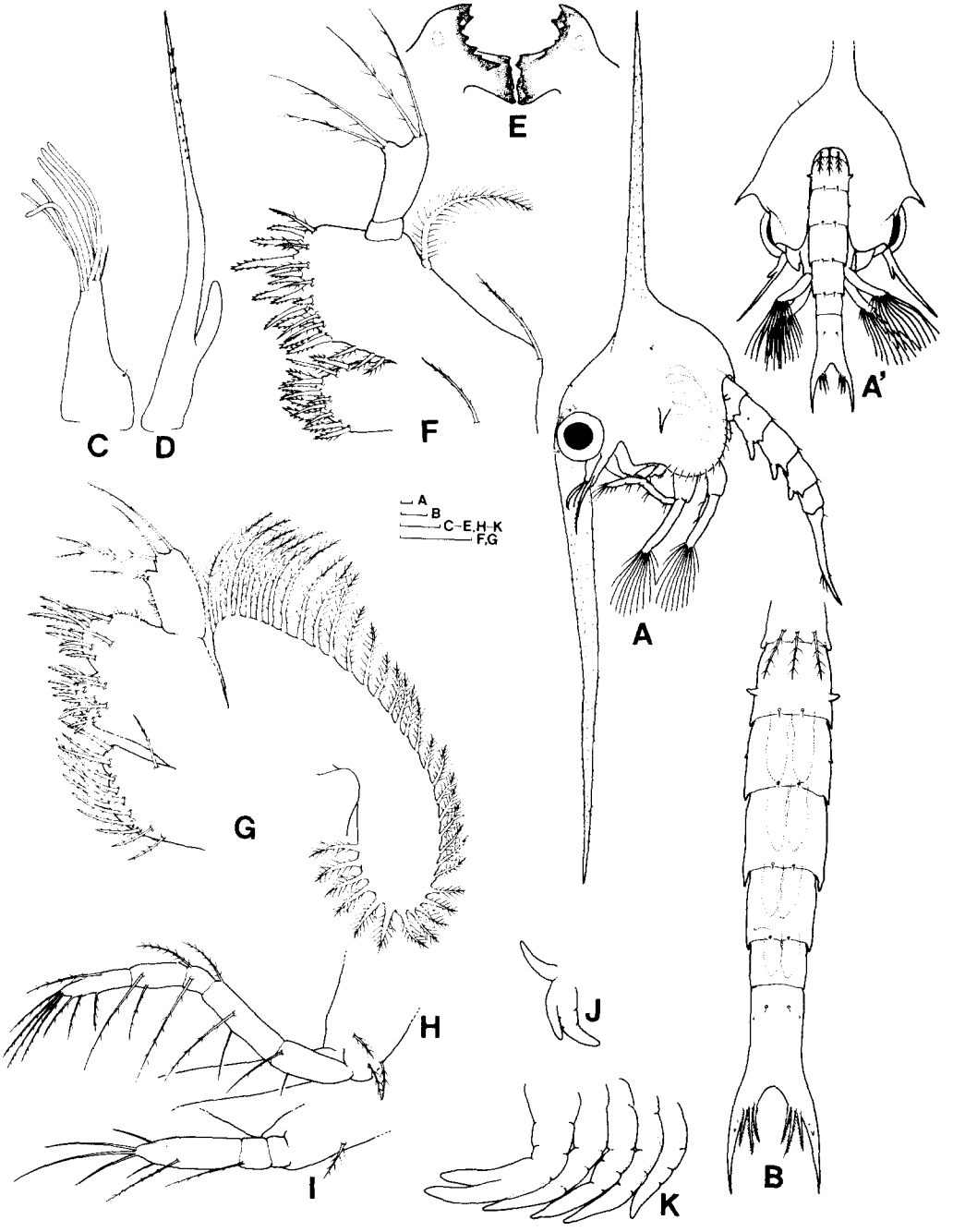


**Fig. 6.** Fifth zoea (ultimate) of *Scopimera bitympana*. A, lateral view; A', posterior view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K, pereiopods. Scale bars = 0.1 mm.

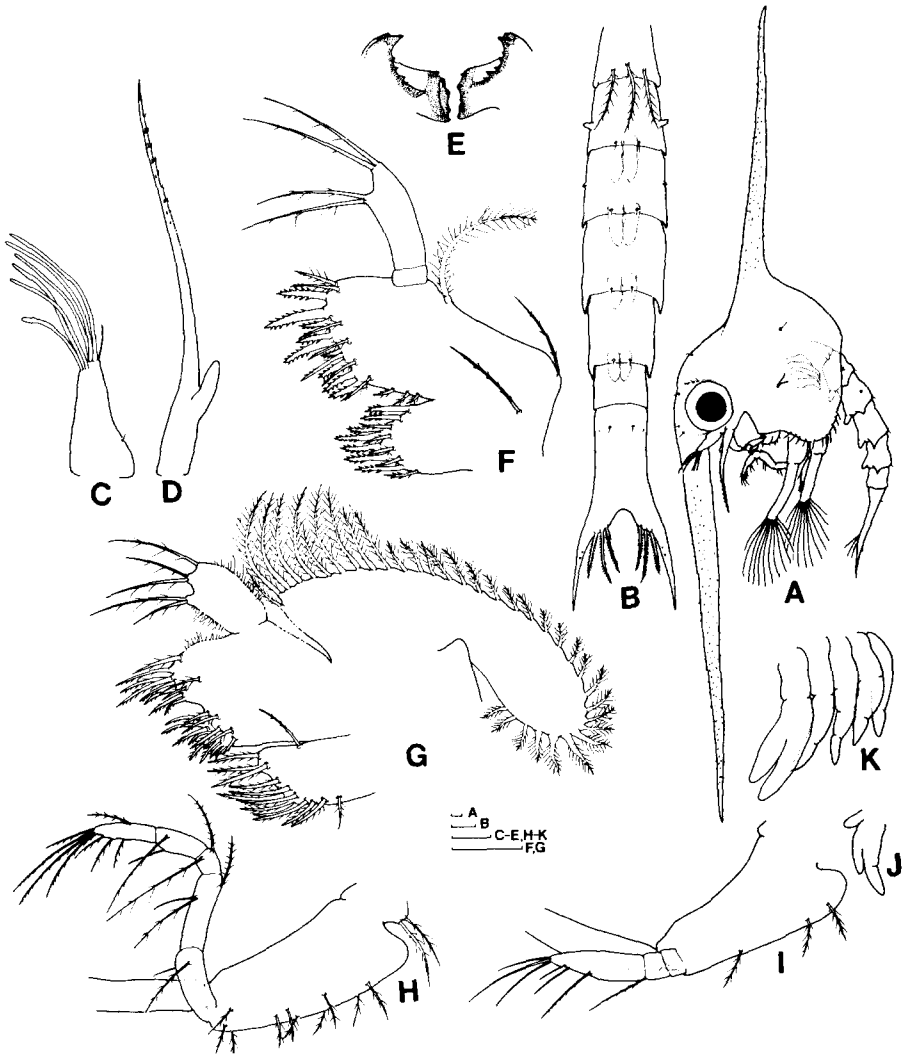


**Fig. 7.** Fifth zoea (penultimate) of *Scopimera bitympana*. A, lateral view; B, dorsal view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K, pereiopods. Scale bars= 0.1 mm.

suppression of larval stages-, the reason is not fully understood. As suggested by the previous authors (Costlow *et al.*, 1960; Sandifer, 1973; Knowlton, 1974; Scotto, 1979; Kim and Jang, 1987; Diaz and Bevilacqua, 1987; among others), several factors including temperature, salinity, diet, genetic differences and temporal variation of the environment in nature as well as laboratory conditions, may affect the number of moults in a larval life history.

**Comparison of Larval Morphology**

In grouping the ocypodid larvae at the subfamily level, setation of mouthparts (*i.e.*, endopods of maxillule, maxilla and second maxilliped) proposed by Rice (1975) plus the setation of second maxilliped basis and the type of second antenna seem to be much more helpful than other characters (Jang *et al.*, in press). On this basis, the zoeal characters of *Scopimera bitympana* conform unequivocally to those of the subfamily Scopimerinae,

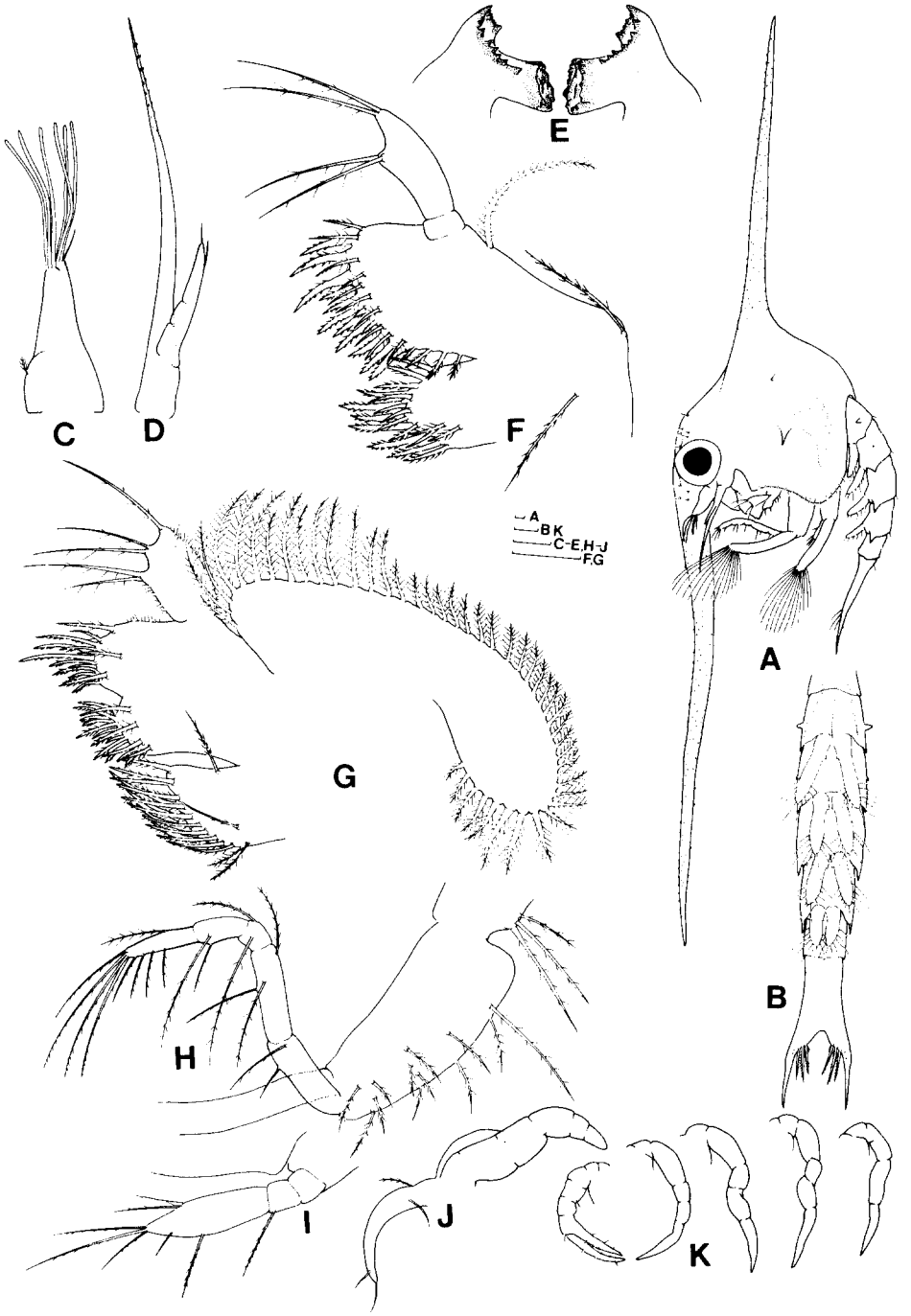


**Fig. 8.** Sixth zoea (additional) of *Scopimera bitympana*. A, lateral view; B, ventral view of abdomen; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla; H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K, pereiopods. Scale bars=0.1 mm.

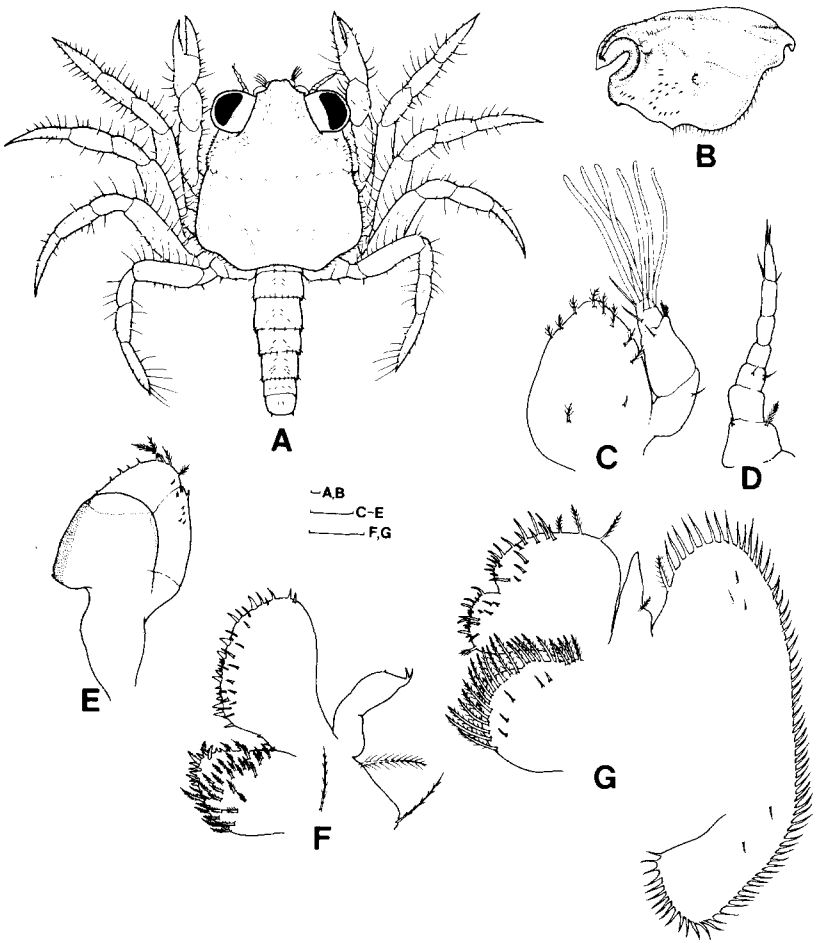


**Fig. 9.** Megalopa of *Scopimera bitympana*. A, dorsal view; B, lateral view of carapace; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla, Scale bars= 0.1 mm.

*i.e.*, 0,4 setae on maxillule endopod, 5 setae on maxilla endopod, 3 and 0,1,6 setae on basis and endopod of second maxilliped respectively, and C-type of second antenna [=exopod reduced to very short spine or simple seta; Aikawa, 1929].

Within the Scopimerinae, the *Scopimera* zoeae can be readily differentiated from those of *Ilyoplax* and *Dotilla* by the relative ratio of rostral carapace spine length to carapace length (=R/C) (Jang and Kim, 1989). The ratio is always $R/C > 1.5$ in the known first zoeae of the *Scopimera*, but $1.0 < R/C < 1.5$ and $R/C < 1.0$ in those of the *Ilyoplax* and *Dotilla* respectively.

Fielder and Greenwood (1985) described in detail the zoeal stages of *S. inflata* and compared them with those of *S. globosa* and *S. crabricauda* previously described by Terada (1976) and Rice (1976) respectively. Therefore the zoeal characters of *S. bitympana* (present study) are added to the Table IV presented by Fielder and Greenwood (1985) as follows: dorsal and rostral carapace spines sparsely toothed; dorsal carapace spine < tiwce carapace length; rostral carapace spine about twice carapace length; antenna 0.43 × rostral carapace spine and with about 17 spines; abdomen with postero-lateral spines on somites 3-4 from first zoeal stage and without tufted setules; telson with a dorsal spine plus 2 ventral denticles in first stage and an additional denticle in the subsequent zoeal stages; telson twice rami length and

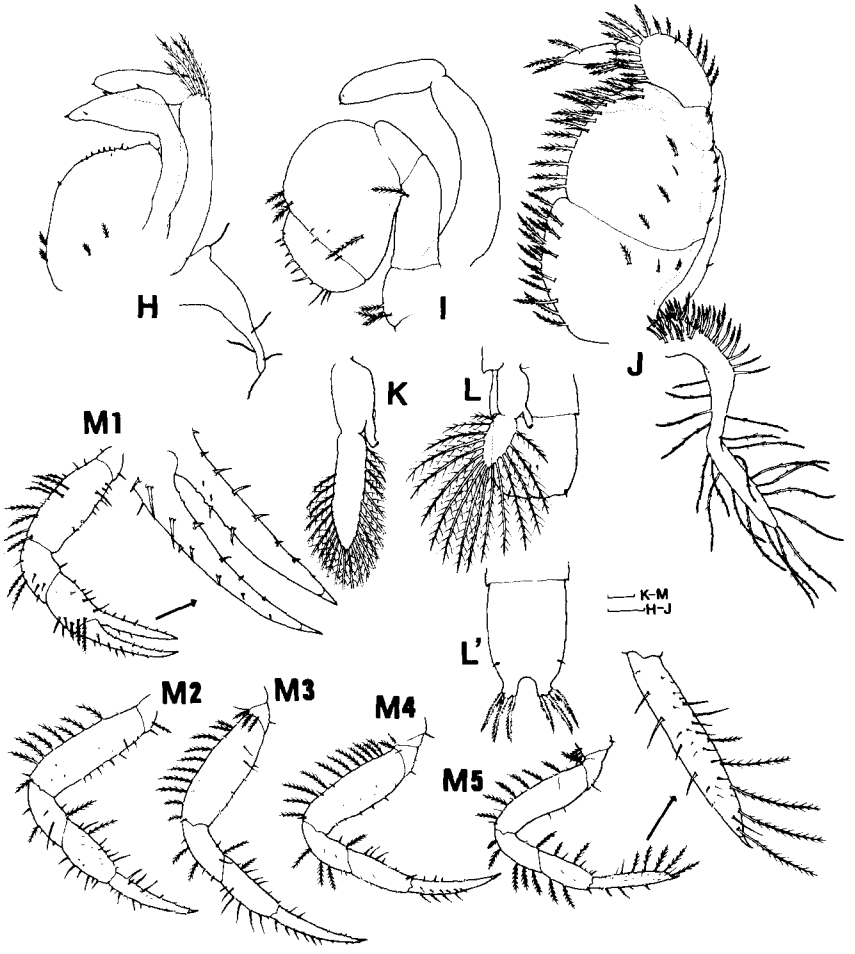


**Fig. 10.** Megalopa of *Scopimera bitympana*. H, maxilliped 1; I, maxilliped 2; J, maxilliped 3; K, pleopod 1; L, pleopod 4 and telson; L', abnormal telson; M1-5, pereiopods 1-5. Scale bars= 0.1 mm.

covered with tufted setules. *S. bitympana* zoeae can be discriminated from the other known *Scopimera* zoeae by one or more of the above characters. Minor features of mouthparts setations listed in Table 2 will also aid in distinguishing them.

It seems noteworthy that the additional sixth zoea of *S. bitympana* shows considerable variation in the number of setae on the first maxilliped basis and the second maxilliped endopod, when compared to the normal zoeal stages (Table 2). Based on the literature available, however, both brachyuran and ocypodid larvae generally have the constant number of setae on these appendages throughout all zoeal stages in a given species. However, extra instars tend to have variable setation on these appendages. For example, the extra sixth zoea of a grapsid crab, *Cyclograpsus integer*, has 9-11 setae on the first maxilliped basis and 0-1, 1,6 setae on the second maxilliped endopod, instead of 9 and 0,1,6 setae on the corresponding appendages of the normal zoeal stages 1-5 (Gore and Scotto, 1982). Such setal variation is also found in the extra instars of *Euchirograpsus americanus* and *Menippe nodifrons* (Wilson, 1980; Scotto, 1979). Similarly, the fifth stage zoea of *S. inflata* exhibits 17-20 setae on the first maxilliped basis and 0,1,7 setae on the second maxilliped

endopod instead of 10 and 0,1,6 setae respectively, in the first to fourth zoeal stages. However Fielder and Greenwood (1985) did not report the extra instar in the larval study of *S'o inflata*. Although *S. inflata* shows the variation in this setation in the last zoeal stage, we cannot confirm whether it indicates the presence of an extra instar or not. To this setal variation of *S. inflata*, however, Fielder (personal communication) suggests an inference as follows: "We did not see an extra instar in *S. inflata* that you saw in *S. bitympana*. Time gaps between zoeal stages gave no indications of a series other than the one we described. Moreover our stage V zoeae had the expected 12, not 14, terminal setae on the exopods indicating they were in an expected series. *S. inflata* larval series of 5 zoeal stages, however, may be a compromise between 5 and 6 zoeal series of *S. bitympana*. In *S. inflata* it appears that a high level of zoeal development is always necessary before metamorphosis to megalopa. In *S. bitympana* such high level zoeal development is only required sometimes. It is almost as if *S. inflata* bypasses *S. bitympana's* stage V altogether."

Other than the present study, descriptions of the *Scopimera* megalopae are available for *S. longidactyla, S. globosa* and *S. inflata* (Jang and Kim, 1989; Terada, 1976; Fielder and Greenwood, 1985). Because Jang and Kim (1989) compared in detail the megalopal features among the three species, megalopal features of *S. bitympana* are summarized in Table 3 without futher comparison. The most important megalopal feature distinguishing each species is the carapace armature: *S. bitymapna* has two pairs of lateral round tubercles on the carapace while *S. longidactyla* has one pair of spines posterior to eyestalks, *S. inflata* has one pair of 'obvious hepatic spines' and *S. globosa* lacks them; *S. bitympana* and *S. longidactyla* have many simple setae on the carapace surface but *S. inflata* and *S. globosa* are smooth and naked dorsally. Other minor features allowing distinction among the megalopae include the setation, segmentation and sometimes setal types of antennule, antenna, mouthparts appendages and telson (Table 3).

Both of *S. bitympana* and *S. inflata* megalopae show very unusual features in the setal types on some appendages and the telson armature which are not found in other brachyuran megalopae. *S. bitympana* (Figs. 9, 10) and *S. inflata* (Fielder and Greenwood, 1985, Figs. 5, 6) have short simple (developing or reduced) setae on mandibular palp, basal endites of maxillule and maxilla, and basis of first maxilliped, as opposed to longer plumose or plumodenticulate setae in other described megalopae. The telson morphology of the two species is also very characteristic. Fielder and Greenwood (1985) found that unusual telson extensions (bearing three biplumose spines and one highly plumose seta) of *S. inflata* were present in most megalopae (80%) and were consistently present in individuals from several broods, and suggested that the function of the telson extensions is probably to holdfast effectively and to dig the initial burrow after megalopal lodgement. Interestingly, the telson of *S. bitympana* (Fig. 10, L') is very similar to that of *S. inflata*, although the majority of *S. bitympana* megalopae had the typical "brachyuran telson" (Fig. 10, L). However, whether these unusual telsons of *S. bitympana* as well as *S. inflata* can function actually in nature, as suggested by Fielder and Greenwood (1985), remains speculative at present.

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## 실험실에서 사육된 눈콩게 *Scopimera bitympana*(달랑게과)의 유생발생

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실험실에서 사육된 눈콩게의 전 유생발생단계를 기술, 도시하였다. 눈콩게는 5 zoea (가끔 6 zoea)와 1 megalopa 유생기를 가졌다. 수온 25°C에서, megalopa와 제1기 crab은 부화후 각각 24일과 38일만에 나타났으나 extra zoea 유생기를 갖는 경우에는 31일과 48일만에 나타났다.

눈콩게의 zoea유생은 거치상의 갑각가시와 배측에 하나, 복측에 두개의 작은 가시가 있는 미설에 의하여 엽낭게속의 타종과 구분되며, megalopa 유생은 갑각의 특징에 의하여 구분될 수 있다. 그밖의 미세한 형태적 특징들이 앞서 보고된 엽낭게속의 유생들과 비교되고 차이점이 간단히 논의되었다.