Larval Development of *Cancer oregonensis* Dana (Decapoda: Cancridae) Reared in the Laboratory

Pygmy Crab, *Cancer oregonensis* Dana 의 유생발생 연구

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Abstract

The complete larval development of *Cancer oregonensis* Dana, inhabiting area of protected rocky shore from intertidal to subtidal, is described based on laboratory rearing. The laboratory conditions were 8±1℃ in water temperature and 28.5±0.1‰ in salinity. The reared larvae were feed with newly hatched *Artemia* nauplii. All the larval stages are described and illustrated. Larval morphology of *C. oregonensis* is compared with those of other *Cancer* species.

C. oregonensis has five zoeal and a megalopal stages. The species has four spines on carapace. Coxa of the first maxilliped has one seta from first to fourth zoeal stages, and has one epipod bud in fourth zoeal stages. The numbers of setae increase to three at fifth zoeal stage. One

epipod bud appeared on the coxa of the second maxilliped from fifth zoeal stage. In the first abdominal somite, the numbers of setae increase gradually from 1 to 3 from third to fifth stage. In second zoeal stage, posterior margin on telson has 3 pairs of setae. As zoea develops from third to fourth stage, the setae increases in pairs. The characteristic of megalopal stage is absence of the spine on ischium of the cheliped.

The morphological characters of the genus *Cancer* are summarized.

Introduction

The Pygmy rock crab, *Cancer oregonensis* inhabits protected rocky areas from the intertidal to the subtidal, ca. 400 m, where it is commonly found nestling in holes, empty large barnacle shells, and kelp holdfasts (Kozloff, 1974, 1987; Jensen, 1995; O'Clair and O'Clair, 1998).

The brachyuran crab, genus *Cancer* has a world-wide range of distribution in the temperate zone to mid-latitude in the northern and southern hemispheres (MacKay, 1943). The group is entirely marine and is represented by 25 living species in the Atlantic and Pacific Oceans (Nations, 1979; Quintana and Saelzer, 1986). Its distribution has been reported from the coast of the western and southern Europe, the western North and South America, the Pacific coast of Japan, the Korean coast, the East China Sea, and Australia (Nations, 1979; Ingle, 1980; Dai and Yang, 1991). From east to west of the genus *Cancer*, the following 4 species occur in Southeast Alaska: *C. gracilis* Dana, *C. magister* Dana, *C. oregonensis* Dana, and *C. productus* Randall (O'Clair and O'Clair, 1998).

Of the 25 species of the genus *Cancer*, larval development was described for 17 species from laboratory-reared or plankton samples (Rice, 1980; Quintana and Saelzer, 1986). The complete larval development was reported for the following 12 species: *C. amphioetus* Rathbun (Iwata and

Konishi, 1981), *C. antennarius* Stimpson (Roesijadi, 1976), *C. anthony* Rathbun (Trask, 1974; Anderson, 1978), *C. borealis* Stimpson (Sastry, 1977b), *C. edwardsi* Bell (Quintana, 1983), *C. gracilis* Dana (Ally, 1975), *C. irroratus* Say (Sastry, 1977a), *C. magister* Dana (Poole, 1966), *C. novaezelandiae* Jacquinot (Wear and Fielder, 1985), *C. pagurus* Linnaeus (Ingle, 1981), *C. productus* Randall (Trask, 1970) and *C. setosus* Molina (Quintana, 1984).

Up to now the larva of *C. oregonensis* was known by DeBrosses *et al.* (1989) only for the megalopal stage based on plankton samples, and the complete larval development of this is not known.

This study described the five zoeal and a megalopal stages of *Cancer oregonensis* from specimens reared in the laboratory, and compared morphological characters of the larvae of *C. oregonensis* with those of other *Cancer* species.

Materials and Methods

A berried female of *Cancer oregonensis* was collected on 22 May 2001, by SCUBA diving, from the Auke Bay (58°20 N, 134°27 W), Juneau, Alaska. The crab was transported to the laboratory at Juneau Center of the School of Fisheries and Ocean Science, and reared in a glass jar (ca. 3 ℓ) filled with sea water (8℃, 28.9‰) with aeration. The jar was placed in an aquarium with running natural seawater until the larvae hatching.

On 28 May 2001 larvae hatched. Of these 60 larvae were individually reared in small glass jars (ca. 50 mℓ) with natural sea water, and mass cultures including about 250 larvae were made in four glass jars (ca. 3 ℓ) with sea water. The jars were kept in a tray of running sea water to maintain a constant temperature. During the larval rearing, sea water temperature was kept between 8±1℃, and salinity range was 28.5 ± 0.1‰. The sea water was renewed daily. All larvae were fed with newly hatched brine *Artemia* nauplii daily. To observe mortality and developmental stage of the larvae, exuviae and dead larvae were checked daily.

At least more than 10 specimens as well as the exuviae and the dead larvae were preserved in 5% buffered seawater-formalin solution for observation, measurements and drawings. Drawings of larvae were made with the aid of a microscope equipped with a drawing tube. Liner characters

of each larvae were measured based on at least 10 specimens with an ocular micrometer.

Measurements taken for dimensions of the larvae are as follows: (a) carapace length (CL) from between eyes to posterolateral carapace margin for zoea; from rostral tip to posteromedian carapace margin for megalopa; (b) rostral spine length (RSL) for zoea; (c) dorsal spine length (DSL) for zoea; (d) lateral spine length (LSL) for zoea; (e) distance between tip of dorsal spine and rostral spines of carapace (TT).

The specimens used in the present study, including the berried female, are deposited in the Invertebrate Zoology Laboratory, Pukyong National University, Busan, Korea as PKNU-INVERT number 20010522.

Results

1. Description

In the complete larval development of *Caner oregonensis*, there were five zoeal and a megalopal stages. The major morphological characters of zoeal and megalopal stages are described below.

First Zoea

(Fig. 1)

Size. CL: 0.60 mm (0.58-0.63 mm); RS: 0.63 mm (0.58-0.70 mm); DS: 1.29 mm (1.27-1.30 mm); LS: 0.30 mm (0.25-0.33 mm); TT: 1.95 mm (1.85-2.00 mm).

Duration. 18-21 days (mean: 19 days).

Carapace (Fig. 1A, B). Rostral and dorsal spines well-developed; lateral spine deflected and much shorter than other spines; rostral spine acute distally and longer than antennal protopod; dorsal spine stout and curved backward; anteromedial region without setae; anteromedial process and pair of posterodorsal setae present; posterolateral marginal setae absent;

eyes sessile.

Antennule (Fig. 1C). Uniramous; endopod absent; exopod unsegmented, conical with 2 short terminal setae and 3 aesthetascs of varying size.

Antenna (Fig. 1D). Uniramous; protopodal process about 2.1 times length of exopod and tapered, with 2 rows of spinules on distal half; endopod absent; exopod unsegmented, with 2 unequal setae.

Mandible (Fig. 1E). Asymmetrical; incisor and molar process developed; mandibular palp absent.

Maxillule (Fig. 1F). Coxal endite with 7 setae; basal endite with 2 cuspidate spines and 3 setae; endopod 2-segmented, with setation of 1, 6 (2 subterminal +4 terminal) setae; no exopod on maxillure.

Maxilla (Fig. 1G). Coxal endite bilobed with 3+4 setae; basal endite bilobed with 5+4 setae; endopod bilobed with 3+3 (1 subterminal + 2 terminal) setae; scaphognathite with 4 marginal plumose setae and an apically tapering process fringed with dense fine hairs.

First maxilliped (Fig. 1H). Coxa with 1 seta; basis with 9 medial setae, arranged as 2, 2, 3, 2; endopod 5-segmented, with setation of 2, 2, 1, 2, 5 (1 subterminal + 4 terminal) setae; exopod with 4 terminal plumose natatory setae.

Second maxilliped (Fig. 1I). Coxa without setae; basis with 4 medial setae, arranged as 1, 1, 1, 1; endopod 3-segmented, with setation of 1, 1,

5 (2 subterminal + 3 terminal) setae; exopod with 4 terminal plumose natatory setae.

Third Maxilliped Not developed.

Pereiopods Not developed.

Abdomen (Fig.1J). Five somites plus telson; second somite with a pair of dorsolateral processes directed anterioly; posterolateral magin of second somite with obtuse angle; posterolateral margin of third-fifth somite with a part of spinous processes; a pair of minute setae on posterodorsal margin of second-fifth somites.

Pleopods Not developed.

Telson (Fig. 1J). Bifurcated; each fork long; 1 fused lateral spine, 1 dorsal articulated spine; posterior margin concave, armed with 3 pairs of setae; innermost pair with 4 long interior spinules located proximal quarter of spine; outermost pair with stout tooth-like spinules on distal 2/3 of spine.

Second Zoea

(Fig. 2)

Size. CL: 0.79 mm (0.75-0.83 mm); RS: 0.80 mm (0.73-0.88 mm); DS: 1.60 mm (1.57-1.62 mm); LS: 0.36 mm (0.30-0.40 mm); TT: 2.41 mm (2.30-2.50 mm).

Duration. 14-16 days (mean: 17 days).

Carapace (Fig. 2A, B). Anteromedial region with 2 pairs of anterodorsal setae; posterolateral carapace margin with 4 plumose posterior setae inserted near margin; eyes now stalked and movable; otherwise unchanged.

Antennule (Fig. 2C). Uniramous; endopod absent; exopod unsegmented, with 2 short terminal setae and 6 aesthetascs.

Antenna (Fig. 2D). Enlarged.

Mandible (Fig. 2E). Larger than in first zoea.

Maxillule (Fig. 2F). Basal endite with 4 cuspidate spines and 3 setae; exopod with 1 plumose natatory seta; otherwise unchanged.

Maxilla (Fig. 2G). Scaphognathite (exopod) with 11 plumose setae; apically tapered process in first zoea now blunt and broad; otherwise unchanged.

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

setae; otherwise unchanged.

Second maxilliped (Fig. 2I). Exopod with 6 terminal plumose natatory setae; otherwise unchanged.

Third maxilliped Not developed.

Pereiopod. Not developed.

Abdomen (Fig. 2J). Posterolateral margin of third-fifth somites with spinous processes more developed than in first zoea; otherwise unchanged.

Pleopods Not developed.

Telson (Fig. 2J). Slightly enlarged.

Third zoea

(Fig. 3)

Size. CL: 0.96 mm (0.95-1.00 mm); RS: 1.05 mm (1.00-1.10 mm); DS: 1.92 mm (1.9-1.95 mm); LS: 0.34 mm (0.30-0.38 mm); TT: 2.98 mm (2.95-3.00 mm).

Duration. 14-18 days (mean: 16 days).

Carapace (Fig. 3A). Posterolateral carapace margin with 8 plumose posterior setae inserted near margin; otherwise unchanged.

Antennule (Fig. 3B). Uniramous; endopod absent; exopod unsegmented, with 1 short terminal seta and 7 aesthetascs.

Antenna (Fig. 3C). Endopod now developed as a broad bud; otherwise unchanged.

Mandible (Fig. 3D). Enlarged.

Maxillule (Fig. 3E). Basal endite with 4 cuspidate spines and 4 setae; otherwise unchanged.

Maxilla (Fig. 3F). Basal endite with 6+5 setae; scaphognathite (exopod) with 19 plumose setae; otherwise unchanged.

First maxilliped (Fig. 3G). Exopod with 8 terminal plumose natatory setae; otherwise unchanged.

Second maxilliped (Fig. 3H). Exopod with 8 terminal plumose natatory

setae; otherwise unchanged.

Third maxilliped (Fig. 3I). Biramous with endopod and exopod.

Pereiopods (Fig. 3I). Five small buds; first leg with one gill bud (future arthrobranch) on basocoxal part; second-fourth legs each with one gill bud (future pleurobranch).

Abdomen (Fig. 3J). Six somites; dorsomedial seta on first somite; posterolateral margin of third-fifth somites with well-developed acute processes; otherwise unchanged.

Pleopods Not developed.

Telson (Fig. 3J). Apparent length reduced by formation of six abdominal somite; posterior margin with additional small pair of medial setae; otherwise unchanged.

Fourth Zoea

(Fig. 4)

Size. CL: 1.30 mm (1.25-1.33 mm); RS: 1.23 mm (1.13-1.30 mm); DS: 2.66 mm (2.62-2.69 mm); LS: 0.38 mm (0.33-0.43 mm); TT: 3.85 mm (3.75-3.92 mm).

Duration. 14-17 days (mean: 16 days).

Carapace (Fig. 4A). Posterolateral carapace margin with 11-13 plumose posterior setae; otherwise unchanged.

Antennule (Fig. 4B). Biramous; endopod absent; exopod with 3 subterminal aesthetascs and 8 aesthetascs.

Antenna (Fig. 4C). Endopod elongate bud about 0.5 times length of exopod; otherwise unchanged.

Mandible (Fig. 4D). Teeth on incisor and molar process differentiated and developed.

Maxillule (Fig. 4E). Coxal endite with 8 setae; basal endite 5 with cuspidate spine and 7 setae; epipod seta now present; otherwise unchanged.

Maxilla (Fig. 4F). Coxal endite bilobed with 3+4 setae; basal endite bilobed with 6+5 setae; scaphognathite (exopod) fringed with 27-29 plumose natatory setae; otherwise unchanged.

First maxilliped (Fig. 4G). Coxa with 1 epipod bud and 1 seta; endopod distal segment with 6 setae; exopod with 10 terminal plumose natatory setae; otherwise unchanged.

Second maxilliped (Fig. 4H). Exopod with 10 or 10+ 1 terminal plumose natatory setae; otherwise unchanged.

Third maxilliped (Fig. 4I). Endopod and exopod buds elongate, with 1 epipod bud and 2 gill buds (future arthrobranchs) on basal part.

Pereiopods (Fig. 4I). Incipiently segmented buds; chelipeds bilobed; gill formula unchanged and slight developed.

Abdomen (Fig. 4J). First somite with 2 dorsomedial setae; posterolateral processes on third-fifth somites longer than in previous stage.

Pleopods (Fig. 4A). Pleopod buds on second-sixth abdominal somites.

Telson (Fig. 4J). Medial length increased compared with previous zoea; posterior margin with 2 pairs of medial setae; otherwise unchanged.

Fifth Zoea

(Fig. 5)

Size. CL: 1.59 mm (1.55-1.63 mm); RS: 1.35 mm (1.33-1.38 mm); DS: 2.94 mm (2.92-2.95 mm); LS: 0.30 mm (0.28-0.33 mm); TT: 4.31mm (4.25-4.33 mm).

Duration. 19-24 days (mean: 23 days).

Carapace (Fig. 5A). Posterolateral carapace margin with 13-15 plumose posterior setae inserted near margin; otherwise unchanged.

Antennule (Fig. 5B). With 2 small setae on proximal part; exopod with 9 subterminal and 6 terminal aesthetascs.

Antenna (Fig. 5C). Spinous process about 2 times length of exopod; endopod elongate, more than 1.2 times length of exopod; otherwise unchanged.

Mandible (Fig. 5D). Mandibular palp present as small bud.

Maxillule (Fig. 5E). Coxal endite with 11 setae; basal endite with 6 cuspidate spines and 10 setae; otherwise unchanged.

Maxilla (Fig. 5F). Coxal endite with 4+4 setae; basal endite with 7+8 setae; scaphognathite (exopod) fringed with 36-38 plumose natatory setae; otherwise unchanged.

First maxilliped (Fig. 5G). Elongate epipod and 3 setae on coxa; exopod

now with 12 plumose natatory setae; otherwise unchanged.

Second maxilliped (Fig. 5H). With epipod bud on coax; exopod now with 12 or 12+2 plumose natatory setae; otherwise unchanged.

Third maxillipod (Fig. 5I). With epipod and 2 gill buds (future arthrobranchs) elongate; endopod bud longer than exopod bud and segmented.

Pereiopods (Fig. 5I). Developing; otherwise unchanged.

Abdomen (Fig. 5J). First somite with 3 dorsomedial setae; otherwise unchanged.

Pleopods (Fig. 5A). Elongate; biramous with endopod buds on pleopods second – sixth; otherwise unchanged.

Telson (Fig. 5J). Medial length increased compared with previous stage; otherwise unchanged.

Megalopa

(Figs. 6, 7)

Size. CL: 2.84 mm (2.75-2.93 mm)

Carapace (Fig. 6A, B). Considerably longer than broad, narrowing anteriorly; rostrum well developed, directed anteriorly; dorsal spine projected posterioly; posteroventral margin with 5 pairs of setae; eyes well developed.

Antennule (Fig. 6C). Peduncle 3-segmented with 7, 5, 1 setae; endopod 2-segmented, distal segment with 3+4 setae; exopod 4-segmented with 0, 11-15, 10-13, 5-7 aesthetascs, fourth segment with 2 setae.

Antenna (Fig. 6D). Peduncle 3-segmented, with 6, 3, 4 setae; 8-segmented flagellum with (from proximal to distal) 0, 0, 4, 0, 5, 0, 4, 4 setae.

Mandible (Fig. 6E). Molar and incisor processes not distinguishable; mandibular palp 2-segmented, distal segment with 10 marginal setae.

Maxillule (Fig. 6F). Coxal endite with 15-17 setae; basal endite with 25-27 setae; endopod 2-segmented, proximal segment with 0 or 1 seta, distal segment with 1 or 2 setae.

Maxilla (Fig. 6G). Coxal endite bilobed with 7+6 setae; basal endite bilobed with 10+8 setae; endopod subacute lobe, with 1 terminal seta,

with 4 setae on out margin; scaphognathite (exopod) margin with 65-69 plumose setae and 4 lateral setae.

First maxiliped (Fig. 6H). Epipod well-developed process, with 14-17 long setae; coxal endite with 23 setae; basal endite with 43 setae; endopod not distinctly segmented, with 5-9 setae; exopod 2-segmented, proximal segmented with 2-4 setae, distal segment with 3-6 terminal plumose natatory setae.

Second maxilliped (Fig. 6I). Epipod with 4-6 setae and 1 gill bud; endopod 4-segmented with 2, 1, 8, 10 setae; exopod 2-segmented, proximal segment with 1 seta, distal segmented with 8 terminal plumose natatory setae.

Third maxilliped (Fig. 6J). Epipod with 21 long setae; endopod 5-segmented, ischium with 27- 30 setae, merus with 11-13 setae, carpus with 16-18 setae, propodus with 12-13 setae, dactylus with 9-10 setae; exopod 2-segmented, proximal segment with 3-5setae, distal with 6 terminal plumose natatory setae.

Pereiopods (Fig. 7A–E). All segmented and sparsely spinous; first preiopods with 2 gill buds (future arthrobranchs) at base of coxa, second pereiopods with 1 gill bud (future pleurobranch) on coxa, third pereiopods with 1 gill bud (future pleurobranch) on coxa, fourth and fifth pereiopods devoid of gill buds; dactylus of fifth pereiopods with 1 long

straight seta and 2 long curved setae.

Abdomen (Fig. 6K, L). Six somites, with 4, 7, 8, 7, 3, 2 pairs of surface setae on somites 1-6; posterolateral margin of second-fifth somites broadly truncate.

Pleopods (Fig. 6A, 7F, G). Somites 2-5 each with pair of biramous pleopods; endopod unsegmented with subterminal hooks on internal margin; exopod fringed with 19 plumose natatory setae on second somite; fifth somite with 15 plumose natatory setae.

Uropod (Fig. 7H). Endopod absent; exopod 2-segmented, proximal segment with 1 seta, distal segment with 9 plumose natatory setae.

Telson (Fig. 7H). Broader than long, subquadrate with 2 pairs of dorsal setae.

Discussion

Morphological characters of *Cancer* species larvae represent those of the family Cancridae, because the family is represented by the genus *Cancer* only. The Cancrid zoeae are similar to Portunid in zoeal general morphology, so that distinguishing of the larvae of the two families is not easy (Rice, 1980; Ingle, 1981). A distinguishable character of the two families is the zoeal morphology of spinules on the posterior margin of the telson. Cancrid larvae have stout tooth-like spinules on the posterior margin of the telson that Portunid larvae lacks. .

Larval development of 17 *Cancer* species has been reported so far in the world ocean (Table 1). Of the 17 *Cancer* species only 4 species (*C. gracilis, C. magister, C. oregonensis*, *C. productus*) occur in Southeast Alaskan coast (O'Clair and O'Clair, 1988).

The major morphological characteristic of *C. oregonensis* zoea is the possesion of process on posterolateral margin of the abdominal somites 2-5 that discriminate *C. oregonensis* from the other *Cancer* species. (Table 2). Rice (1975, 1980) and Quintana and Saelzer (1986) categorized the Cancrid species into 2 groups ("a" and "b") based on the larval morphology of the zoea, particularly on the armature of appendages. The group "a" has the basal segment with 2 setae of the endopod of the first maxilliped, the

endopod of antenna with 2 setae, the two maxillular endopod segments armed with 1, 4-5 setae respectively, and the endopod of the maxilla with 6 setae. The group "b" has the basal segment with 3 setae of the endopod of the first maxilliped, the endopod of antenna with 3 setae, the two maxillular endopod segments armed with 1, 6 setae respectively, and the endopod of the maxilla with 7-8 setae. According to their grouping *C. amphioetus, C. gibbosulus, C. porteri*, and *C. oregonensis* do not belong to neither the group "a" nor "b", because the 4 species partially share the zoeal characters of the both groups, although *C. oregonensis* is closely related to the group "a". The closely relating zoeal characters in *C. oregonensis* are the basal segment with 2 setae of the endopod of the first maxilliped, the endopod of antenna with 2 setae, the endopod of the maxilla with 6 setae as characters of the former group, and the two maxillular endopod segments armed with 1, 6 setae respectively as characters of the latter group. There are 3 additional zoeal characters to categorize the *Cancer* species, described so far, in addition to the previous 4 zoeal characters proposed by Rice (1980) and Quintana and Saelzer (1989). The additional characters are the followings: the setations of the distal segment of antennal exopod, the setation of the coxa of the maxillule, and existence of spinose on posterolateral margin of abdominal segments (Table 2). As mentioned above, the zoeal characters of *C. oregonensis* is closer to those of the group

"a" than the group "b", even though *C. oregonensis* shares the zoeal characters of the group "a" and "b". Comparison of the zoeal characters of *C. oregonensis* with those of the species, which belong to the group "a", revealed that *C. oregonensis* is the most closely related with sympatric *C. gracilis* in the number of sharing character.

In megalopa of *C. oregonensis,* there was no morphological difference between the laboratory-reared specimens (the present study) and the plankton specimens (DeBrosse *et al.*, 1989) (Table 3).

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Pygmy Crab, *Cancer oregonensis* Dana의 유생발생 연구

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요 약

Family Cancridae에 속하는 *Cancer oregonensis* Dana의 포란한 암컷으로부터 부화시킨 zoea 유생을 실험실에서 수온 8±1℃와 염분 28.5±0.1‰ 조건으로 개별 사육하여 각 유생기의 탈피기간, 형태학적 특징을 기재하였다.

*C. oregonensis*는 5기의 zoea기와 1기의 megalopa기를 가진다. 갑각에 4개의 가시를 가지며 1기에서 4기의 zoea 유생에 있어서 첫 번째 턱다리의 바닥마디에 2개

의 강모를 가지며, 5기 zoea에 가면 3개로 증가한다. 그리고 4기의 zoea 유생에서는 외지가 나타난다. Zoea 5기에서는 두 번째 턱다리의 바닥마디에 1개의 외지가 생긴다. Zoea가 1기에서 3기로 발생함에 따라 첫번째 복부 마디에 강모 수가 1개에서 3개로 점차 증가한다. Zoea 2기까지 꼬리 마디의 뒤 가장자리에 3 쌍의 강모를 가지다가 유생이 발달하면서 그 수가 점차 1개씩 증가함을 보인다. Megalopa의 특질은 집게다리의 자리마디에 강모가 부재하는 것이다.

C. oregonensis 유생들의 특징을 다른 은행게 유생들의 특징과 비교, 고찰하였다.

Tables and Figures

Table 1. Larval description studies of *Cancer* species in the world

	Species	Authors	Larval stages reared	Plankton material	Sampling areas
North-Eastern Pacific (Pacific coasts of North America)	*C. antennarius*	Mir (1961) Roesijadi (1976)	Zoea I Prezoea, Zoea I ~ V, Megalopa		Eureka and Oregon border, USA South Humboldt Bay, USA
	C. anthonyi	Mir (1961) Trask (1974) Anderson (1978)	Zoea I Zoea I ~ V, Megalopa Prezoea, Zoea I ~ V, Megalopa		Eureka and Oregon border, USA ? Mission Bay, California, USA
	C. gracilis	Ally (1975)	Prezoea, Zoea I ~ V, Megalopa		San Pedro Bay, California, USA
	C. magister	Mackay (1934) Mir (1961) Poole (1966) Roesijadi (1976) DeBrosse *et al.* (1989)	Prezoea, zoea? Zoea I Zoea I ~ V, Megalopa Prezoea	 Megalopa	? Eureka and Oregon border, USA Eureka, California, , USA Coast of Humboldt country, California, USA Puget Sound Basin, USA
	C. oregonensis	DeBrosse *et al.* (1989)		Megalopa	Puget Sound Basin, USA
	C. productus	Trask (1970) Roesijadi (1976) DeBrosse *et al.* (1989)	Zoea I ~ V, Megalopa Prezoea	 Megalopa	South Humboldt Bay, USA South Humboldt Bay, USA Puget Sound Basin, USA
North-Western Pacific (Pacific coasts of South America)	*C. amphioetus*	Iwata (1973) Iwata and Konishi (1981)	Zoea I Zoea I ~ V, Megalopa		? Abuta, Hokkaido, Japan
	C. gibbosulus	Aikawa (1937) Terada (1987)	Zoea I Zoea I ~ II		? Chilean coast
North-Eastern Atlantic (European coasts)	*C. pagurus*	Lebour (1928) Rice (1975) Ingle (1981)	Zoea I ~ V, Megalopa, Crab I -IV Zoea I Zoea I ~ V, Megalopa, Crab I -III		? Lulworth Cove, Doset, England Shoalstone point, Devon, England
	C. bellianus	Rice and Williamson (1977)	Zoea V		?

North-Western Atlantic (Atlantic coasts of North America)	*C. amoenus* *C. irroratus*	Smith (1873) Faxon (1882) Connolly (1923) Sastry (1977a)	Zoea (?), Post-larval stage Megalopa Prezoea, Zoea I ~IV Prezoea, Zoea I ~ V , Megalopa	Megalopa	Atlantic Canada Narragansett Bay, Rhode Island, USA
	C. borealis	Sastry (1977b)	Prezoea, Zoea I ~ V , Megalopa		Narragansett Bay, Rhode Island, USA
South-Eastern Pacific (Pacific coasts of South America)	*C. edwardsi*	Quintana (1983) Quintana (1984)	Prezoea, Zoea I ~ V , Megalopa Prezoea		Coliumo Bay, Chile Coliumo Bay, Chile
	C. setosus	Quintana (1984) Quintana and Saelzer (1986)	Zoea I ~ V , Megalopa, Crab I Prezoea		Coliumo Bay, Chile Coliumo Bay, Chile
	C. coronatus	Quintana (1984) Quintana and Saelzer (1986)	Prezoea Prezoea, Zoea I		Coliumo Bay, Chile Coliumo Bay, Chile
	C. porteri	Fagetti (1960)	Zoea I		Chilean coast, Chile
Coasts of New Zealand	*C. novaezelandiae*	Wear (1965) Wear and Fielder (1985)	Megalopa Zoea I ~ V , Megalopa		New Zealand

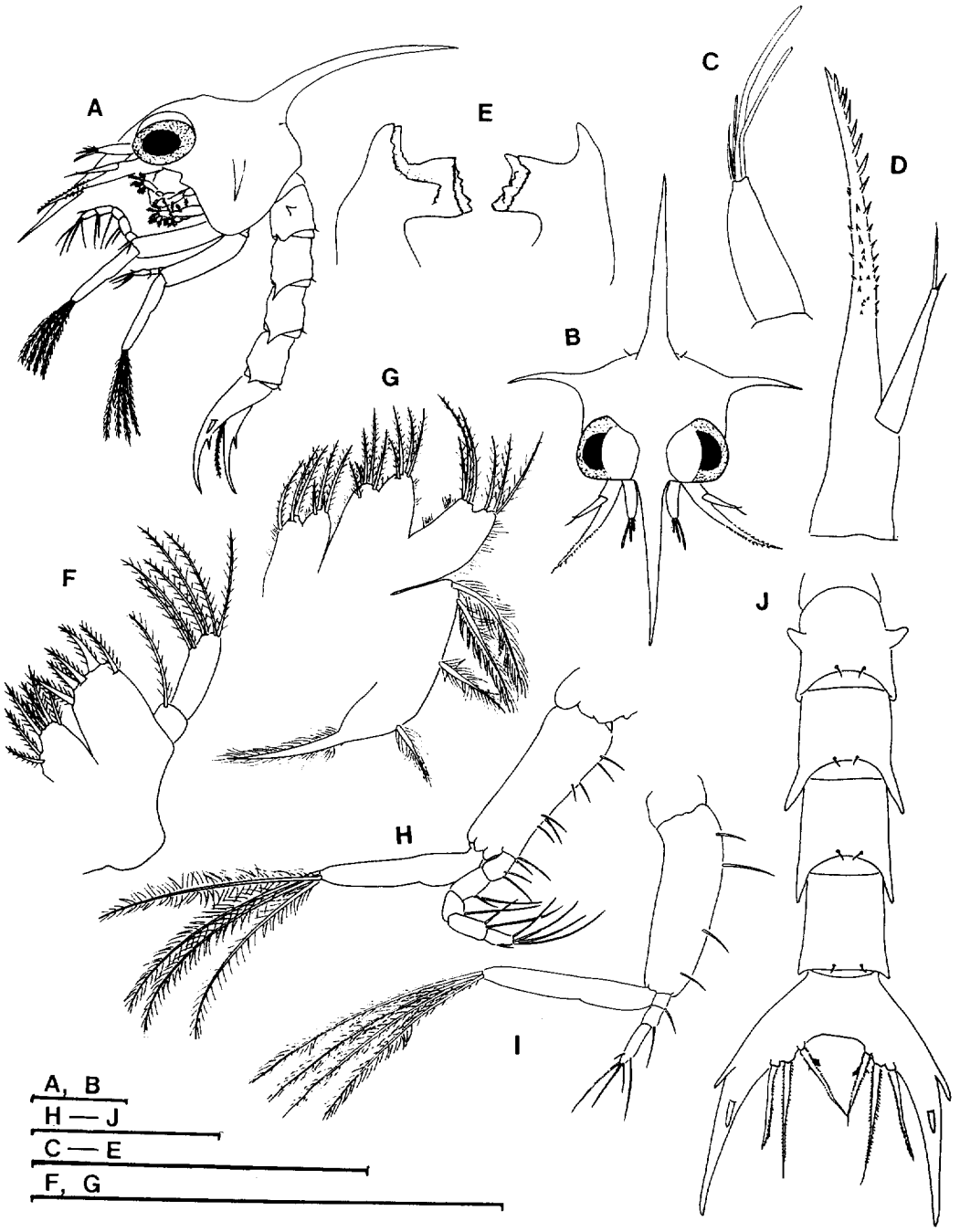
Table 2. Comparative features of first zoeal stage of twelve *Cancer* species after: (1) Present material: (2) Ingle 1981 and Rice 1975: (3) Connolly 1923: (4) Sastry 1977a: (5) Sstry 1977b: (6) Fagetti Guaita 1960: (7) Terada 1987: (8) Mir 1961:(9) Poole 1966: (10) Roesijadi 1976: (11) Trask 1974: (12) Anderson 1978: (13) Rice 1975: (14) Trask 1970: (15) Ally 1975: (16) Iwata and Konishi 1981: (17) DeBrosse *et al.* 1989.

	C. oregonensis (1)	*C. gracilis* (15)	*C. magister* (8), (9)	*C. productus* (14)	*C. pagurus* (2)	*C. irroratus* (3), (4)
Antennule, aesthetascs-setae	3	5	3	3	4	5 [(3)], 4 [(4)]
Antenna, exopod distal setae	2	2	3	3	3	3
Maxillule, endopod setae	1, 6	1, 5	1, 6	1, 6	1, 6	1, 6
Maxillule, basis; coax setae	5, 7	5, 7	5, 6	5, 6	5, 7	5, 7
Maxilla, endopod; basis; coxa setae	3+3, 4+5, 4+3	3+3, 4+5, 3+3	4+3, 4+5, 4+3	4+3, 4+5, 4+3	5+3, 4+3, 3+3	4+3, 3+5, 3+3 [(3)] 5+3,4+5, 4+3 [(4)]
Maxilla scaphognathite	4+1	4+1	3+1	4+1	4+1	4+1
First maxilliped basis setae	9	9	9	10	10	5 [(3)], 9 [(4)]
First maxilliped endopod setae	2, 2, 1, 2, 4+1	2, 2, 1, 2, 4+1	3, 2, 1, 2, 4+1	3, 2, 1, 2, 4+1	3, 2, 1, 2, 4+1	3, 2, 1, 2, 4+1
Abdominal segments, posterolateral margin	2-5 pair of minutely setae	2-5 slightly, spinose	1-5 spinose	1-5 slightly, spinose	3-4 obtuse minutely spinose	2-4 obtuse

	C. borealis (5)	*C. porteri* (6)	*C. gbbosulus* (7)	*C. antennarius* (8), (10)	*C. anthonyi* (8), (12), (13)	*C. amphioetus* (16)
Antennule, aesthetascs-setae	4	4	?	3-4	3	3
Antenna, exopod distal setae	3	3	2	2	2	2
Maxillule, endopod setae	1, 6	1, 5	1, 6	1, 4	1, 5	1, 6
Maxillule, basis; coax setae	5, 6	5, 4	5, 7	5, 6	5, 6	5, 6
Maxilla, endopod; basis; coxa setae	5+3, 4+5, 3+3	4+3, 4+4, 3+3	3+3, 4+4, 3+3	3+3, 4+5, 5 [8] or 3+3 [10]	4+2, 4+4, 3+3 [8] 6, 3+3, 3+3 [12] 3+3, 4+4, 3+3 [13]	3+3, 4+4, 3+4
Maxilla scaphognathite	4+1	4+1	4+1	3+1	4+1	4+?1
First maxilliped basis setae	9	9	?	9	8	8
First maxilliped endopod setae	3, 2, 1, 2, 4+1	3, 2, 1, 2, 4+1	?	2, 2, 1, 2, 4+1	2, 2, 1, 2, 4+1	2, 2, 2, 2, 4+1
Abdominal segments, posterolateral margin	1-5 obtuse	3-5 spinose	4-5 slightly spinose	3-5 slightly spinose	3-5 [12] slightly spinose, 1-5 [13] slightly, spinose	3-5 obtus

Table 3. Comparative features of megalopae of *Cancer oregonensis*.

	The present study	DeBrosse *et al.* (1989)
Antennule exopod, aesthetascs-setae	26-35	13-22
Antennule endopod, setae	7	5-7
Antenna segments	11	11
Antennal setae, proximal to distal	6, 3, 4, 0, 0, 4, 0, 5, 0, 4, 4	3-6, 2-3, 4-5, 0, 0-1, 3-4, 0, 3-5, 0-1, 4, 3-4
Mandibular palp, setae	10	9-11
Maxillule endopod, setae	0-1, 1-2	1, 1-2
Maxillule basis; coxa, setae	18, 13	23-29, 13-16
Maxilla scaphognathite	65-69	68-85
Second maxilliped endopod, setae of three distal segments	1, 8, 10	1-2, 6-9, 8-11
Third maxilliped exopod, setae	3-5, 6	3-5, 4-8
Abdominal segments	6	6
Uropods exopod, setae	1, 9	1, 11-13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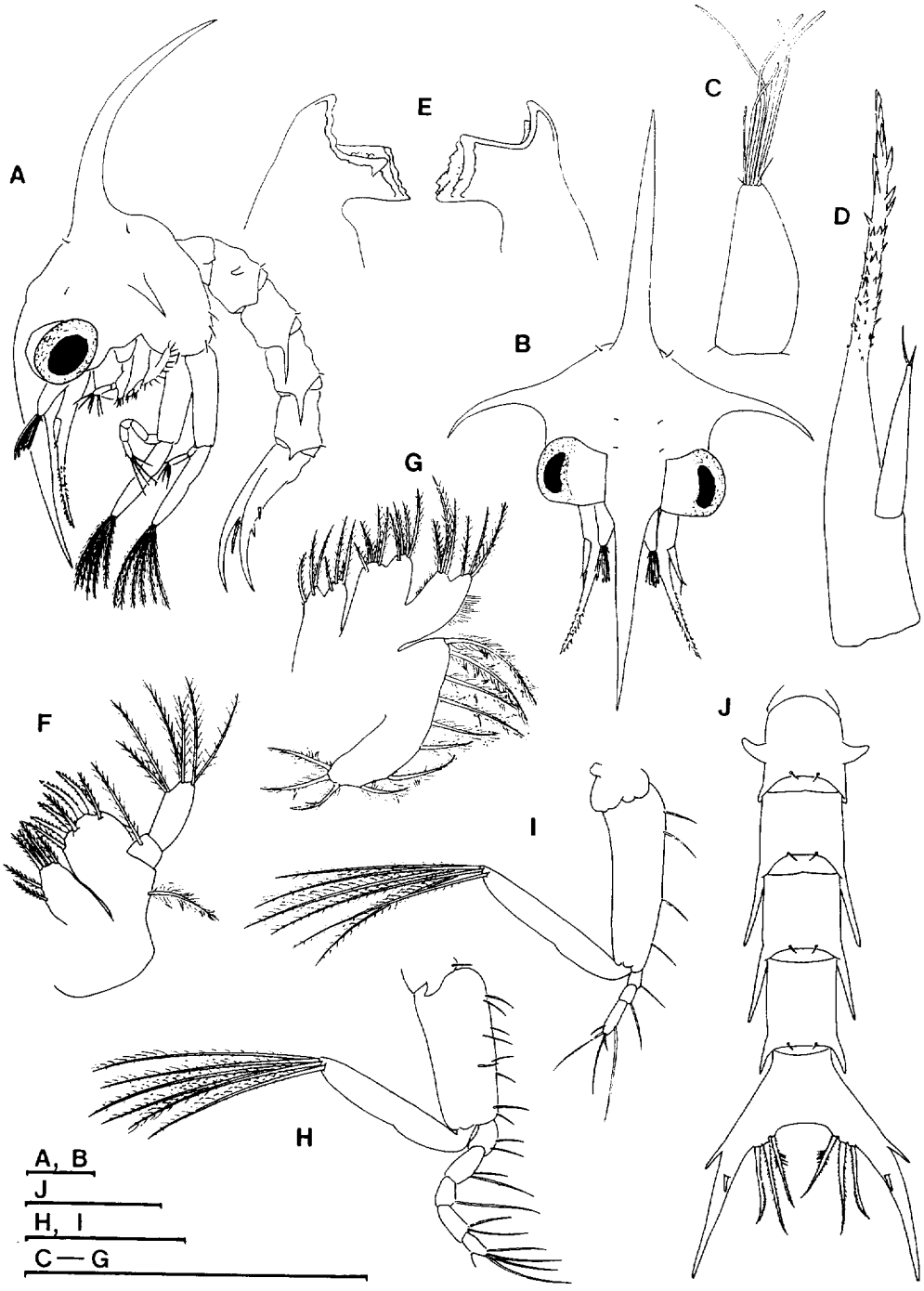
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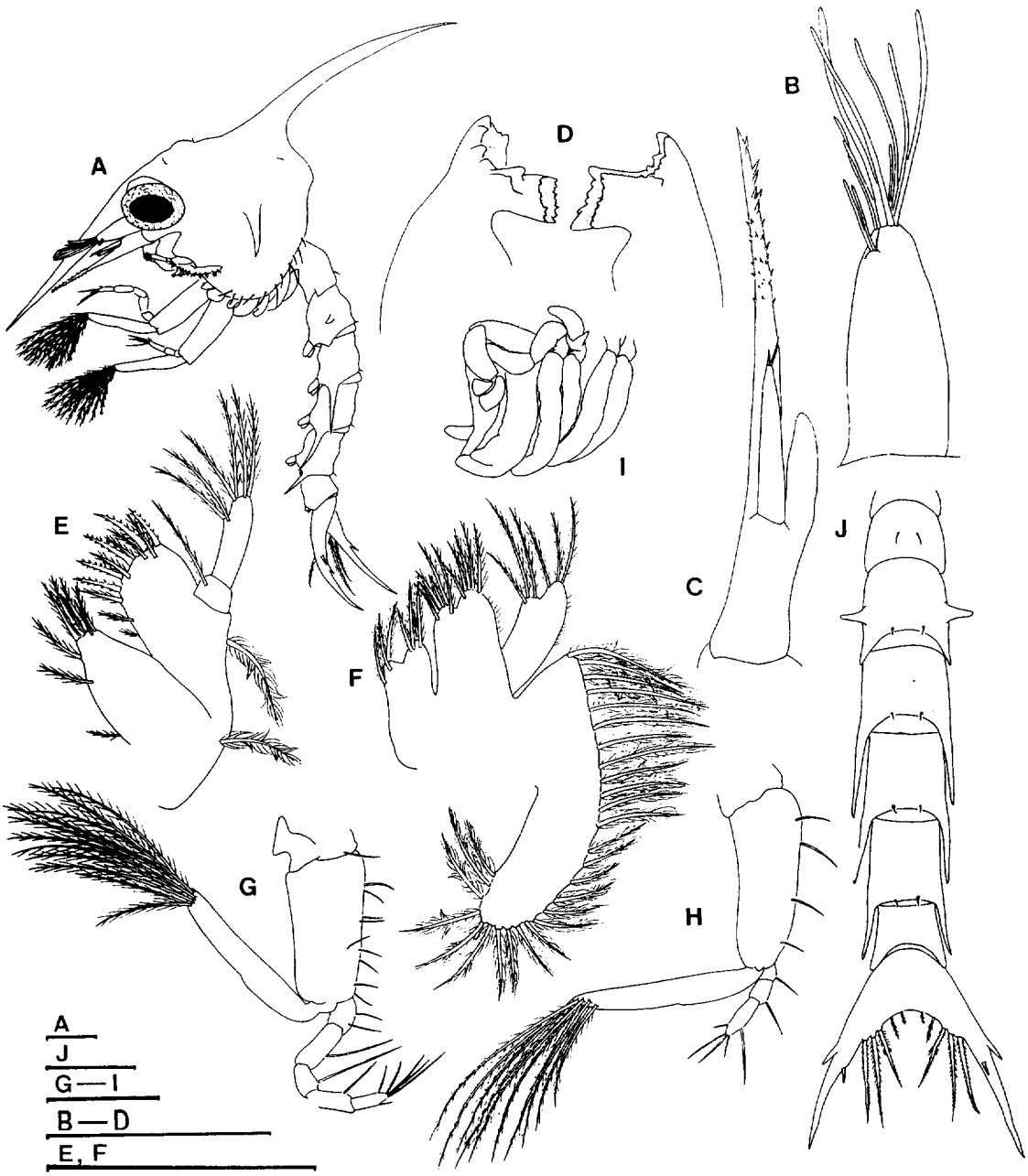
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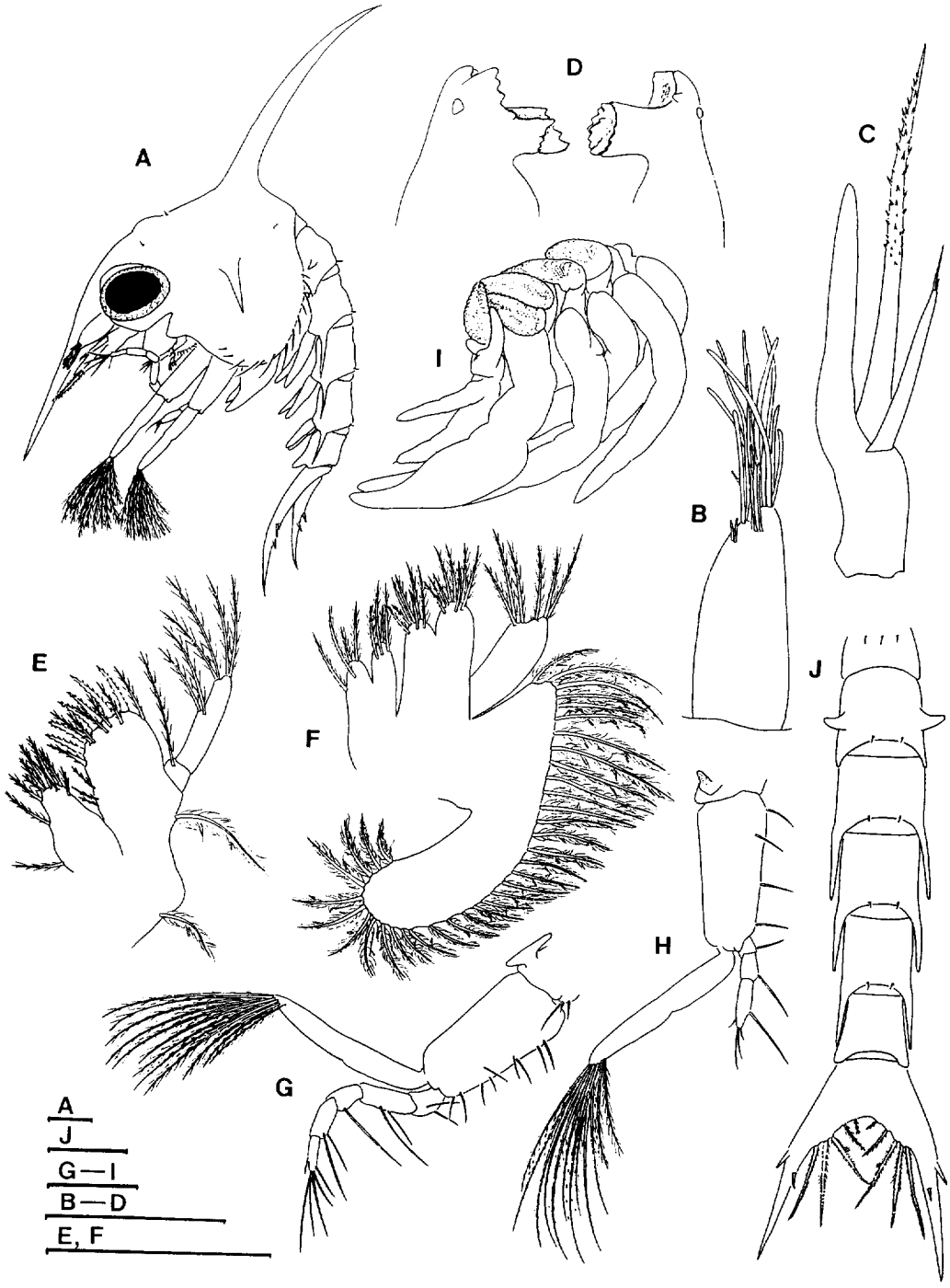
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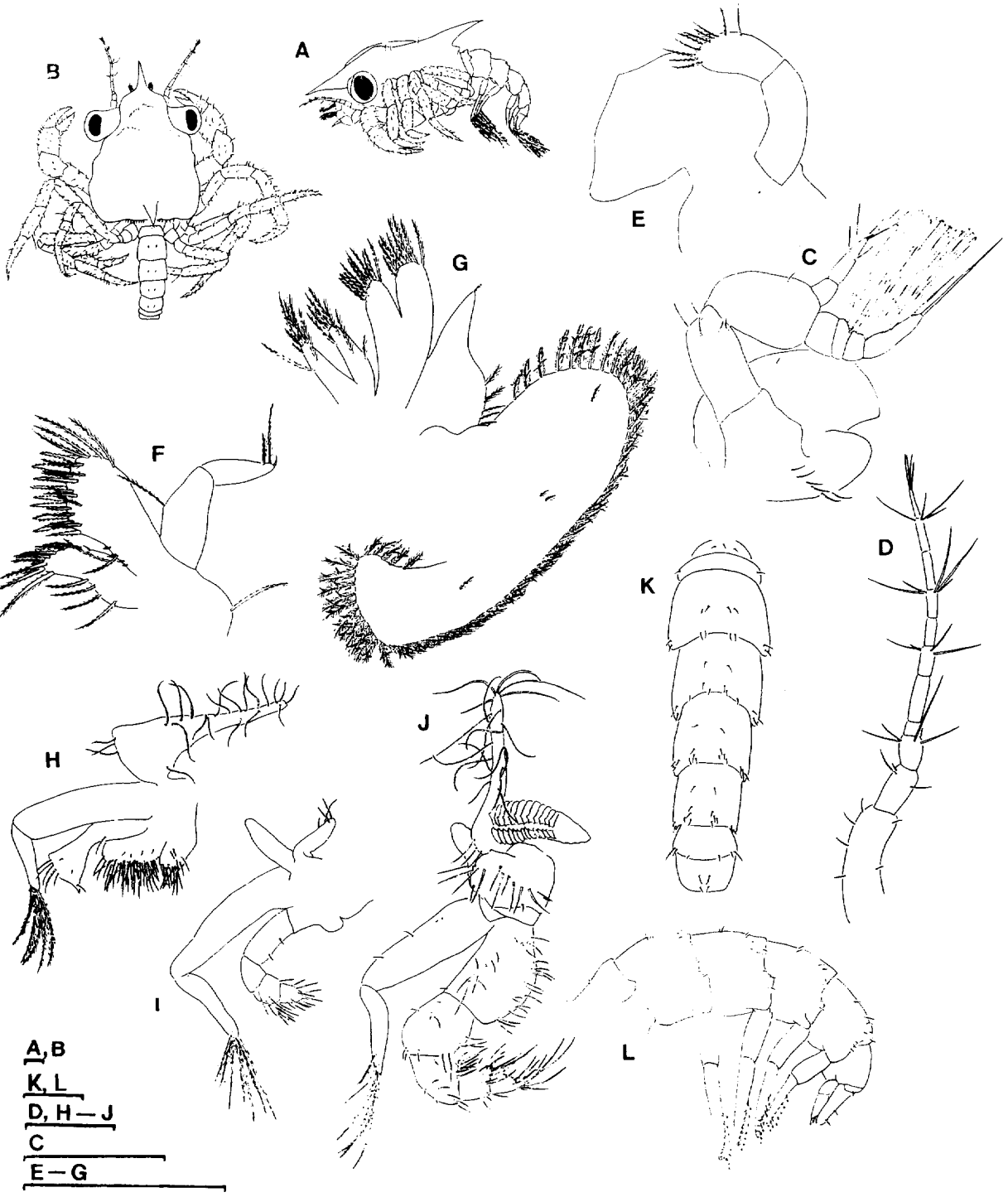
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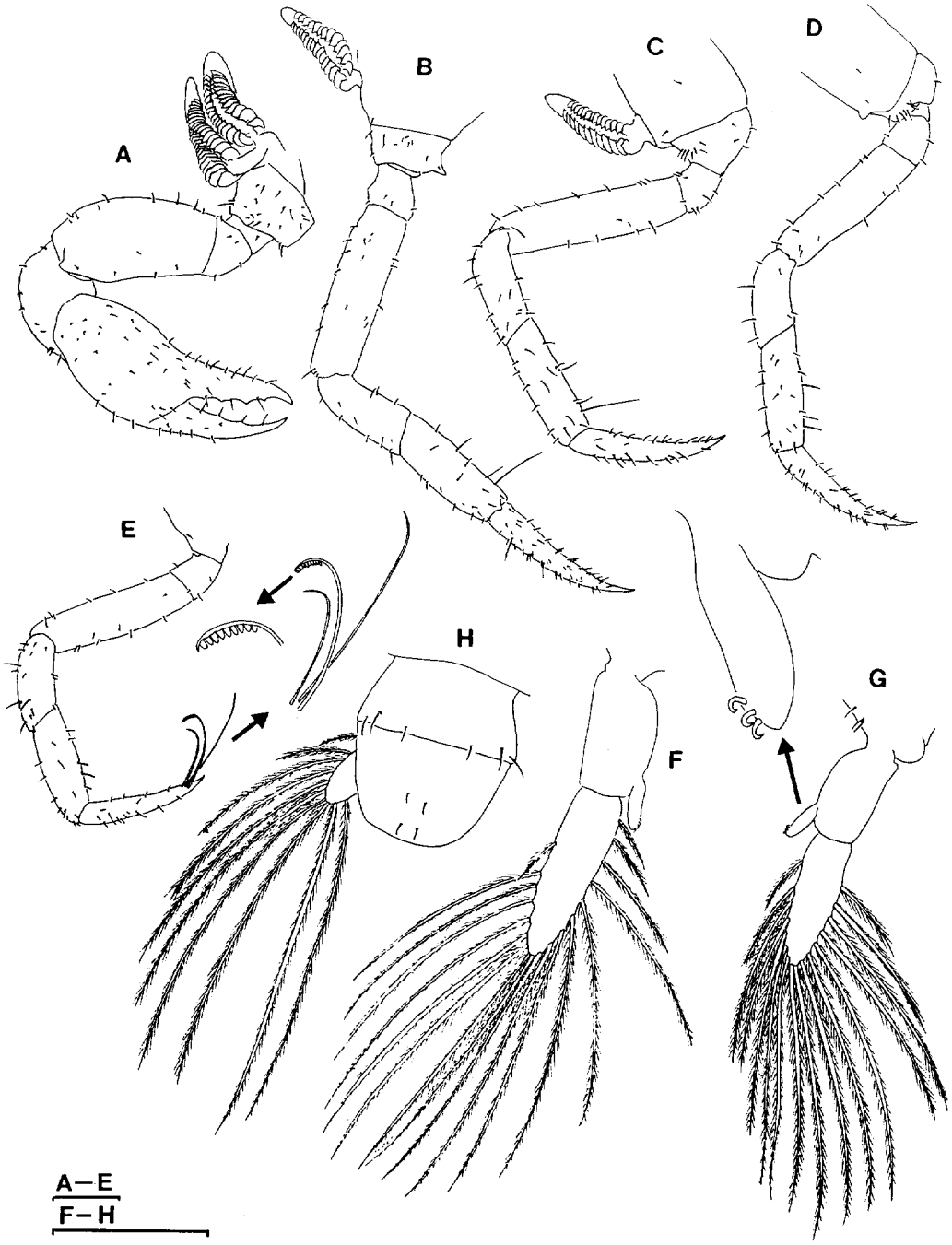
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