

THE LARVAL STAGES OF THE DEEP SEA RED CRAB,
GERYON QUINQUEDENS SMITH, REARED UNDER
LABORATORY CONDITIONS (DECAPODA: BRACHYRHYNCHA)

HERBERT C. PERKINS¹

ABSTRACT

A prezoal stage, four zoal stages, and one megalopa stage were obtained from eggs of *Geryon quinquedens* Smith hatched in the laboratory. Each zoal stage and the megalopa are discussed and illustrated.

The commercial potential and abundance of the deep sea red crab, *Geryon quinquedens* Smith, are discussed by Schroeder (1959), McRae (1961), and Holmsen (1968). The red crab is obviously an important constituent of the deep-water benthic fauna found on the continental shelf off New England and the middle Atlantic states, and its larvae should therefore occur in considerable numbers in the plankton of that region. Knowledge of the larval stages of this species is apparently totally lacking. Brattegard and Sankarankutty (1967) have described the prezoa and the first zoea of *Geryon tridens* Krøyer from Norway, but I can find no other reference to the larval stages of this genus.

It is the purpose of this paper to describe the larval stages of *Geryon quinquedens* so that they may be identified in plankton collections and thus facilitate the understanding of the early life history of this species and hopefully to shed light on its apparently tenuous taxonomic status within the Brachyrhyncha.

METHODS AND MATERIALS

In February 1971, several berried females of *Geryon quinquedens* were captured in 300 fm of water (bottom temperature was 5.9°C) in the Baltimore Canyon area of the continental shelf (lat 37°56'N, long 73°55'W) off Delaware Bay.

Three of the berried crabs were returned to the Boothbay Harbor Laboratory and maintained in shallow tanks at temperatures that ranged from 5° to 12°C. On 29 April 1971, one of the females died and some of her eggs were removed and placed in beakers of filtered seawater. Temperature in the beakers was 15°C; prezoae were observed the next day and on 1 May first zoeae were apparent. On 10 May, another female's eggs started hatching in one of the tanks. Water temperature in this tank was 10°C. A prezoa stage was noted in the tank also but lasted less than 1 hr. First zoeae from each of these batches were maintained separately in beakers containing 1,000 ml of filtered seawater and 50,000 units of penicillin plus a small amount of streptomycin (some larvae were raised without the antibiotics with no differences noted). Newly hatched *Artemia* nauplii obtained from California eggs were given as food. Small amounts of algae (*Dunaliella*) were also added to sustain the *Artemia* nauplii. Water and food were changed every other day. At the start the zoeae were maintained at a constant temperature of 15°C, but fouling organisms grew on many of the zoeae and it was necessary to maintain them at room temperature (18°-21°C) to accelerate development. Salinity ranged 30 to 31‰ during the study. Zoeae were also put into compartmented plastic trays, one to a compartment, and were maintained as those in the beakers. The zoeae in the compartments were used for the developmental studies. When a zoea molted in a

¹ Northeast Fisheries Center, National Marine Fisheries Service, NOAA, West Boothbay Harbor, ME 04575.

compartment it was preserved, along with its molt, the following day.

Measurements of the larvae were made with an ocular micrometer and are given in millimeters; drawings were made with the aid of a camera lucida. Ten individuals, of each stage, and their molts were examined and measured for the developmental series. Carapace length measurements were made from the anterior edge of the carapace (posterior edge of eye sockets) to the posterior margin, along the midline. Total length represents the distance from the tip of the rostral spine to the tip of the telson along the curves of the dorsal midline. The setae on some appendages have been shortened or deleted in some of the illustrations to ensure clarity, but are given full descriptions in the text.

RESULTS

A prezoaea stage of short duration, four zoeal stages, and a megalopa stage were obtained. The prezoaea measured about 2.8 mm in total length. The following are the average number of days from one stage to the next at temperatures of 18° to 21°C; first stage zoea to second, 7 days; second to third, 6; third to fourth, 5; fourth to megalopa, 7; and megalopa to first crab, 14. Two abnormalities were observed; a first stage zoea with the protopodite of one antenna forked from the base, and a second stage zoea with the large lateral spine on one side of the telson forked from its base. The larvae are usually light reddish brown in gross appearance. Some individuals are quite light in appearance but both phases exhibit numerous melanophores scattered over the entire body, particularly on the cephalothorax and along the outer margins of the abdomen. Small melanophores are often scattered on the basipodite on the maxillipeds.

DESCRIPTION OF THE LARVAE

ZOEA I (Figure 1A)

Carapace length 0.83 mm (0.81-0.86); total length 3.71 mm (3.67-3.73). Carapace with rostral, lateral, and dorsal spines. Rostral spine strongly depressed; slightly longer than anten-

nae and nearly three quarters the length of the dorsal spine. Lateral spines flexed slightly ventrad, broad based, and nearly as long as the rostral spine. Width of the carapace from tip to tip of lateral spines about half the total length of the body. Dorsal spine long and curved slightly posteriad; its length about one-third the total length of the body. A short slender seta is present on each side of the carapace, in line with the posterior margin of the dorsal spine's base. The eyes are not stalked. Abdomen with five somites and the telson (Figure 2H). Abdominal somites two through five with lateral spines (fifth somite in some individuals without spines); those on second somite fairly blunt and directed somewhat anteriorly; spines on somites three through five sharper and hooked posteriad, decreasing in size posteriorly. Posterior lateral margin of somites three through five produced into long, sharp spines. Second somite with two setae on middorsal surface; somites three through five with two setae each on posterodorsal margin. Telson bifurcate with three pairs of setae on the inner side. Each furca with two lateral spines, one long and strong, the other much smaller, and a small dorsal spine. Antennule (Figure 2B) with four unequal aesthetes and a small seta terminally. The antenna (Figure 2A) bears a long protopodite with a row of spinules on the outer margins; the exopodite is about half the length of the protopodite and terminates in a spine and one seta. Mandible (Figure 2C) with two large teeth anteriorly, a medial blade, and a toothed edge posteriorly. The maxillule (Figure 2D) bears a two-segmented endopodite, the short proximal segment bears one long plumose seta, the distal segment with six long plumose setae, two of which are subterminal; the basal and coxal endites each bear six spinous setae. The scaphognathite of the maxilla (Figure 2E) has seven marginal plumose setae and a plumose apical tip; the endopodite is bilobed with five spinous setae on the distal lobe and three on the proximal; basal and coxal endites each bilobed with 5 + 5 and 3 + 3 spinous setae respectively. There is a suggestion of two segments in the exopodite of the first maxilliped (Figure 2F) which bears four, one-jointed, natatory setae terminally; endopodite

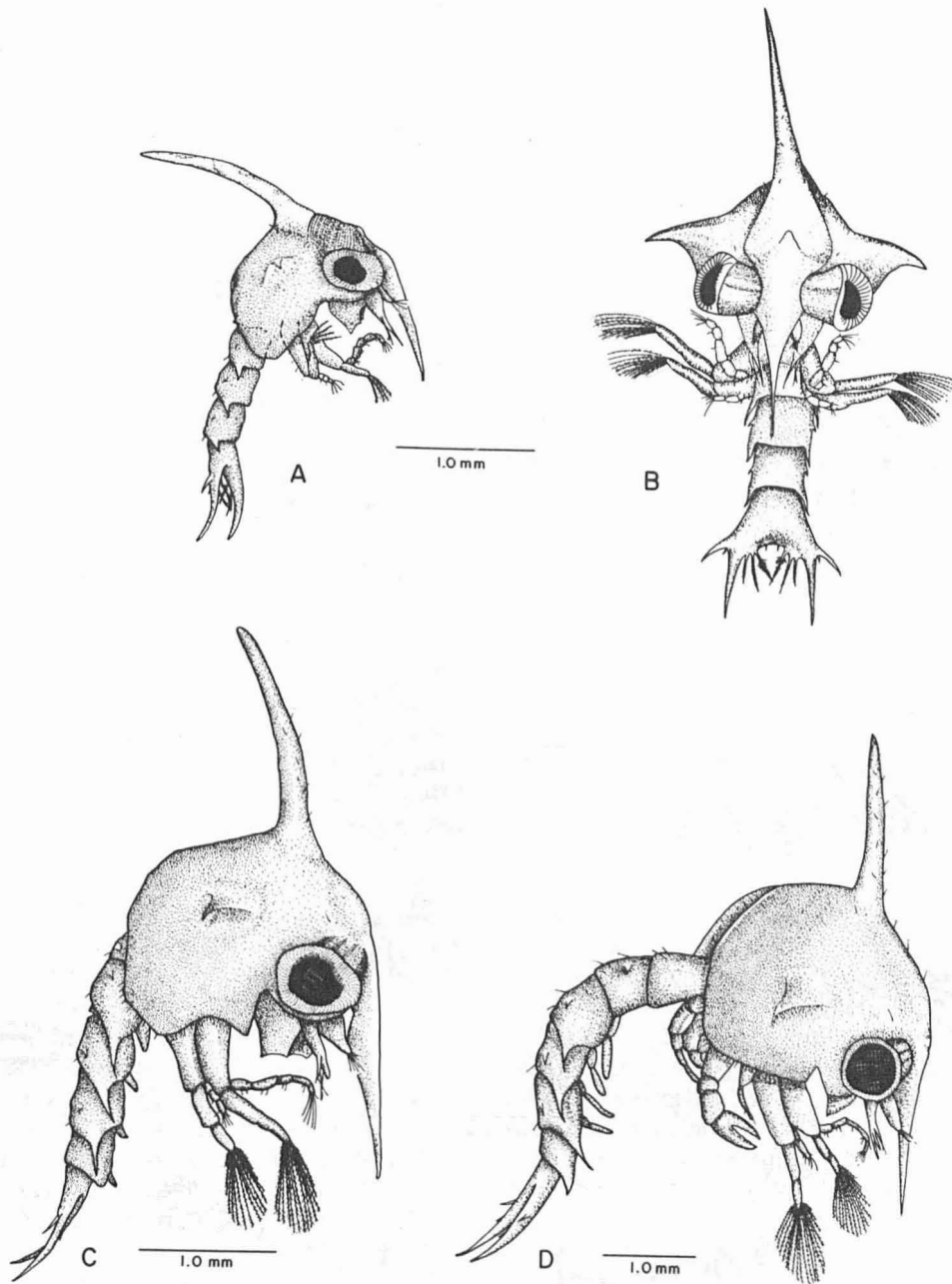


FIGURE 1.—*Geryon quinquedens*. A. Zoea I, B. Zoea II, C. Zoea III, D. Zoea IV.

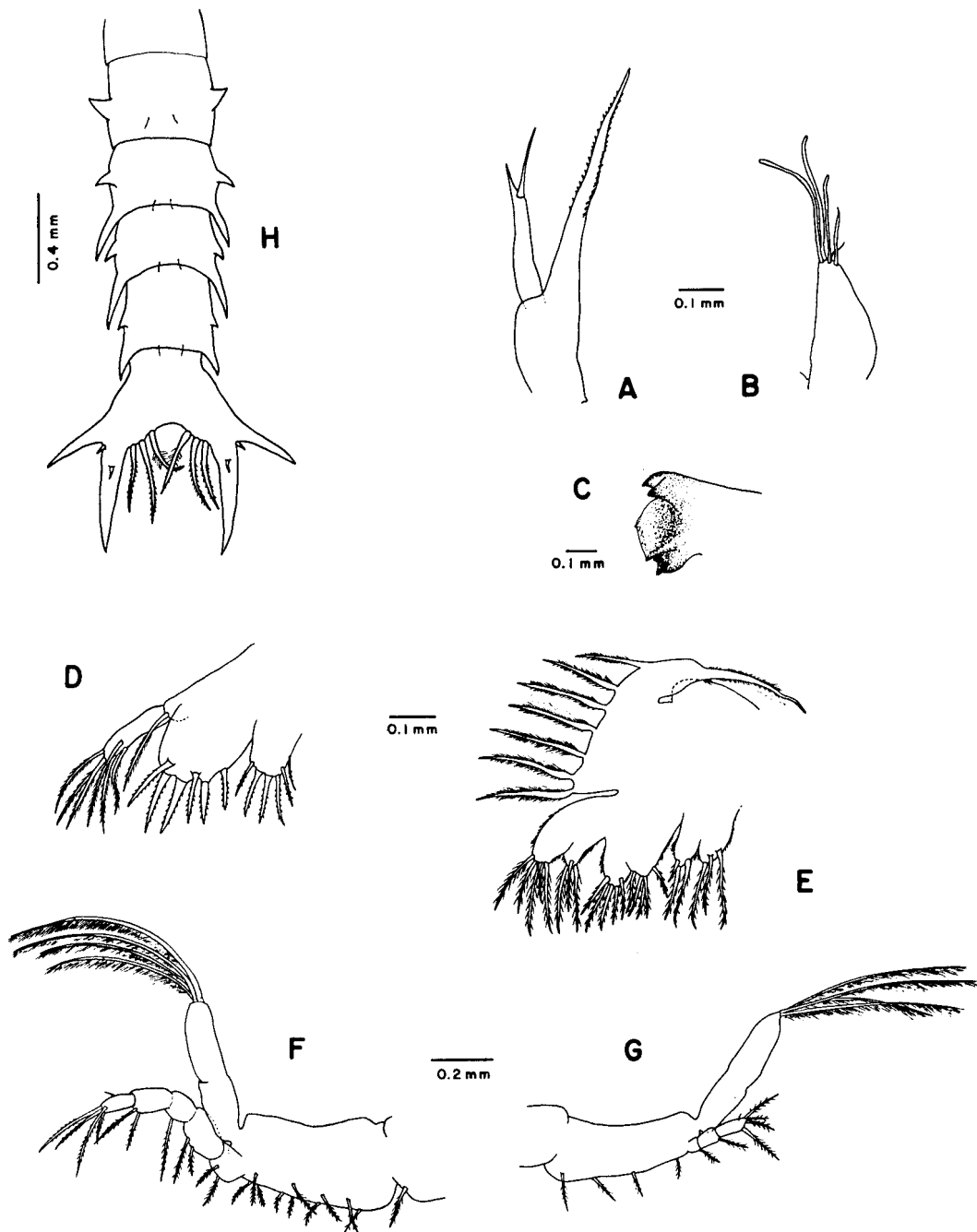


FIGURE 2.—*Geryon quinquedens*, Zoea I. A. antenna, B. antennule, C. mandible, D. maxillule, E. maxilla, F. first maxilliped, G. second maxilliped, H. dorsal view of abdomen and telson.

five-segmented with 2, 2, 1, 2, 5 setae on the segments (proximally to distally); basipodite with 10 setae, coxa with 1 seta. The exopodite of the second maxilliped (Figure 2G) bears four, one-jointed natatory setae terminally; endopodite three-segmented with 1, 1, 5 setae; basipodite with four setae; coxa naked.

ZOEA II (Figure 1B)

Carapace length 1.07 mm (1.00-1.13), total length 4.97 mm (4.89-5.02). Spines on carapace as in Zoa I. The rostral spine is nearly as long as the dorsal spine. Width of carapace from tip to tip of lateral spines about four-tenths the total length of the body. A short, slender seta is present at each side of the posterior margin of the dorsal spine's base. One to four small setae are scattered along the anterior edge of the proximal half of the dorsal spine; a small seta is present slightly above and in line with the base of each eye. Eyes stalked. Posteroventral edge of carapace finely serrate with three of four short, slender setae on the inner margin. Abdomen with five free somites (sixth fused with telson) (Figure 3H). Spination and setation as in Zoa I except an additional pair of short setae has been added proximally on the inner margin of the telson. The spines on the abdomen are somewhat more pronounced than in Zoa I. The antennule (Figure 3A) bears four aesthetes, plus one short and one long setae terminally. Protopodite of the antenna (Figure 3B) as in Zoa I; the exopodite terminates in two unequal setae and the endopodite is evident as a bud. Mandible as in Figure 3C. Endopodite of the maxillule (Figure 3D) as in Zoa I; a single, long plumose seta is present on the protopodite; basal endite with 12 spinous setae, coxal endite with 11. The scaphognathite of the maxilla (Figure 3E) bears 22 marginal plumose setae; endopodite bilobed with five setae on the distal lobe, three on the proximal; basal endite with seven setae on the distal lobe, five on proximal; coxal endite with four setae on each lobe. The two-segmented exopodite of the first maxilliped (Figure 3F) now bears 10 or 11 articulated natatory setae terminally; endopodite, basipodite, and coxa as in Zoa I. The exopodite of

the second maxilliped (Figure 3G) bears 11 articulated natatory setae; endopodite, basipodite, and coxa as in Zoa I. The third maxillipeds, chelipeds, and pereopods are evident as minute buds.

ZOEA III (Figure 1C)

Carapace length 1.42 mm (1.35-1.48); total length 6.13 mm (5.75-6.48). The lateral spines are more ventrally flexed and the number of small setae on the anterior edge of the dorsal spine has increased from the previous stage. There are 15 small setae along the inner margin of each side of the posteroventral and posterior edge of the carapace. Abdomen with six somites and the telson (Figure 4I). The spination and setation of somites two through five is the same as in the previous stage. The first somite now bears two small setae on the middorsal surface; sixth segment naked. Telson with five pairs of setae on the inner portion. The pleopods are evident as buds on somites 2 through 5; uropods as buds on the sixth. Antennule (Figure 4A) with four aesthetes and three setae terminally, plus three aesthetes subterminally; basal portion swollen and the endopod occurs as a small bud. The protopodite and exopodite of the antenna (Figure 4B) as in the previous stage; the endopodite is now about the same length as the exopodite. The mandible (Figure 4C) now bears a simple palp, evident as a bud. The endopodite of the maxillule (Figure 4D) has five or six long plumose setae on the distal segments; the basal and coxal endites each bear about 17 spinous setae. The scaphognathite of the maxilla (Figure 4E) bears about 31 marginal plumose setae; endopodite and basal endite as in previous stage; coxal endite with five spinous setae on distal lobe, and nine on the proximal lobe. The exopodite of the first maxilliped (Figure 4F) bears about 14 articulated natatory setae terminally; the distal segment of the endopodite now bears six setae; setation of other segments as in the previous stages, as is that of the basipodite; coxa with three setae. The exopodite of the second maxilliped (Figure 4G) bears about 14 articulated natatory setae; setation of endopodite segments as in the previous stages; basipodite with

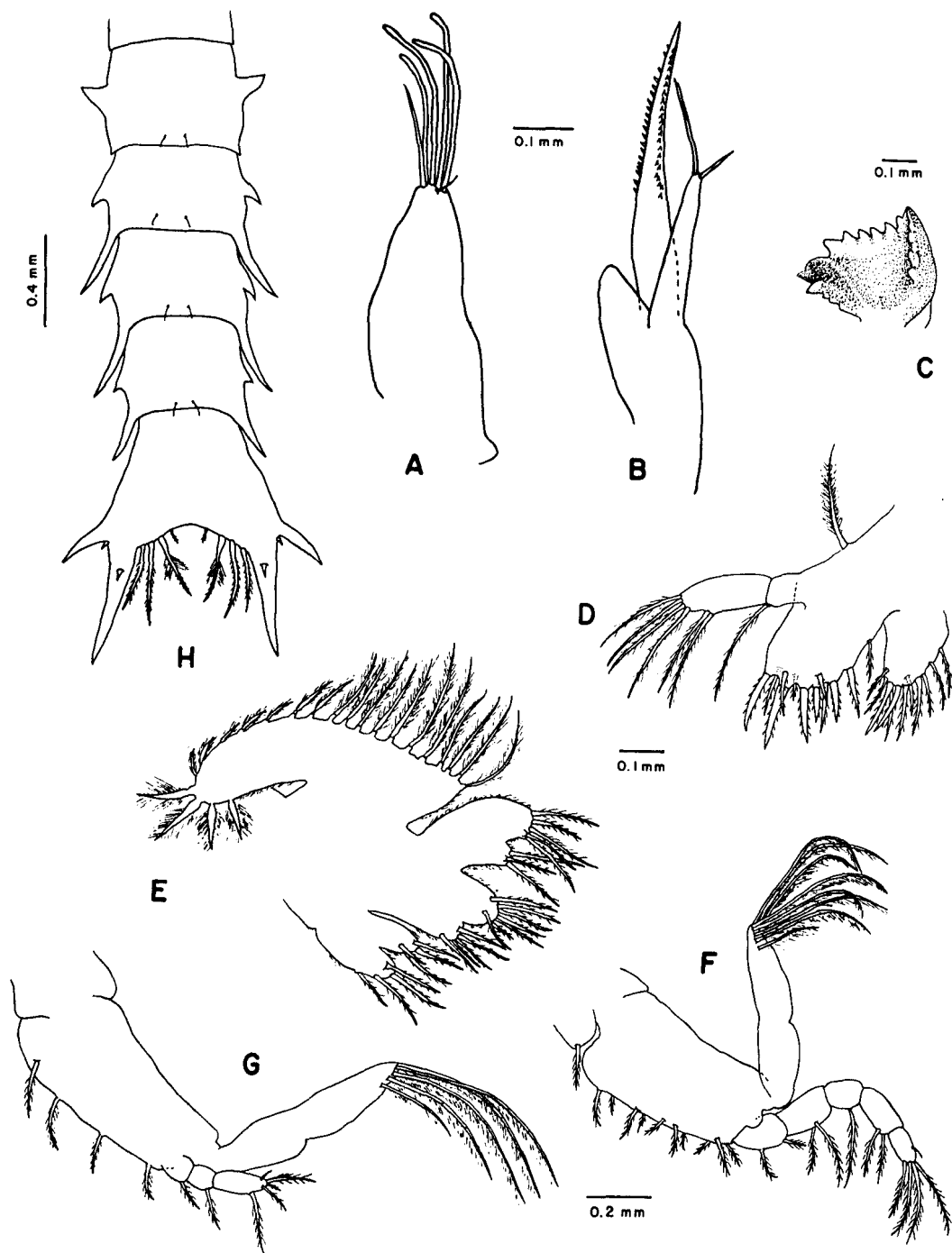


FIGURE 3.—*Geryon quinquedens*, Zoea II. A. antennule, B. antenna, C. mandible, D. maxillule, E. maxilla, F. first maxilliped, G. second maxilliped, H. dorsal view of abdomen and telson.

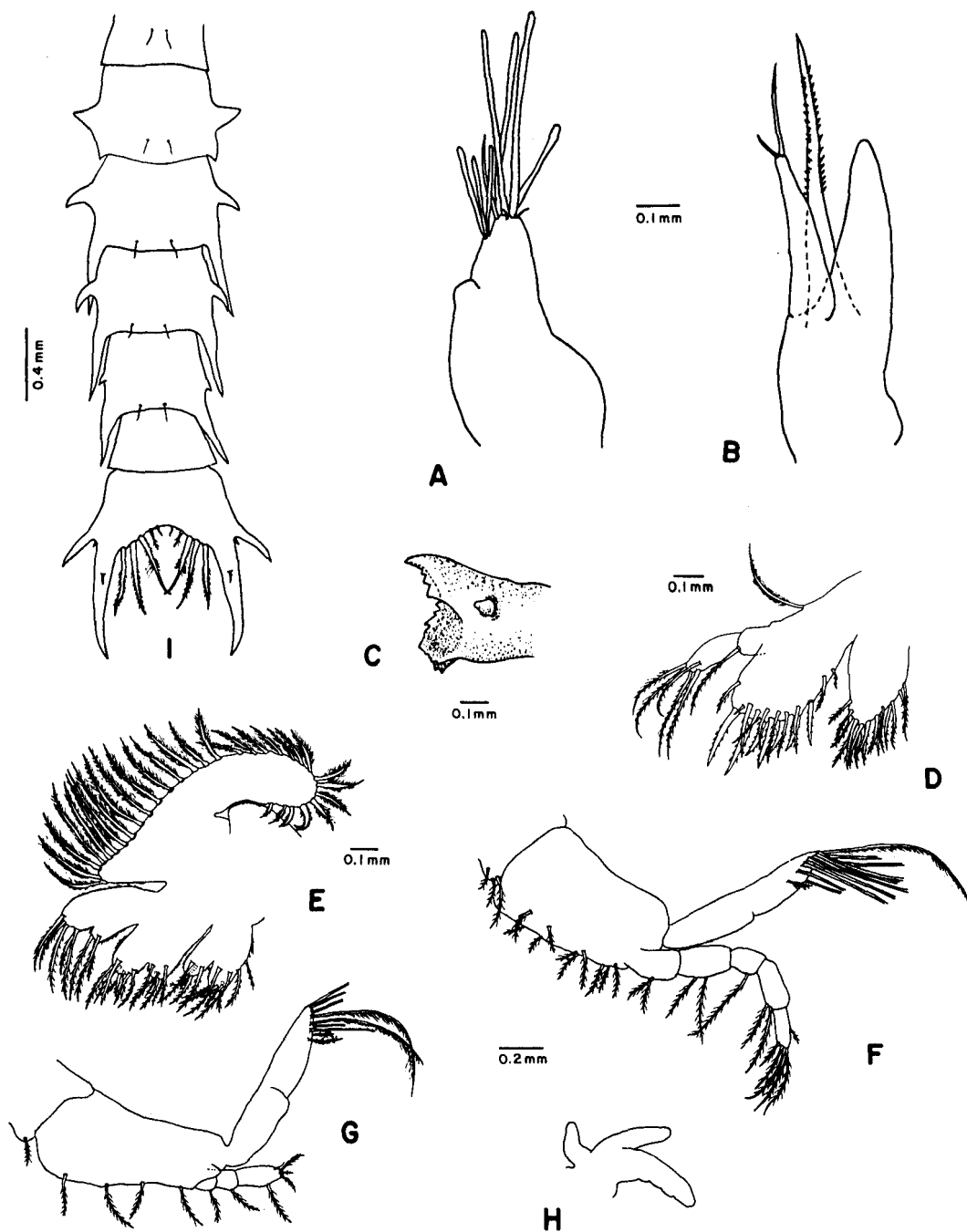


FIGURE 4.—*Geryon quinquedens*, Zoea III. A. antennule, B. antenna, C. mandible, D. maxillule, E. maxilla, F. first maxilliped, G. second maxilliped, H. third maxilliped, I. dorsal view of abdomen and telson.

three or four setae; coxa with one seta. The rudimentary third maxilliped as in Figure 4H. Chelipeds and pereopods about twice as large as in previous stage.

ZOEA IV (Figure 1D)

Carapace length 1.94 mm (1.89-1.97); total length 8.31 mm (7.62-8.95). There is an indication that the considerable range in total and dorsal spine length is due to the nearness of a particular animal to its next molt. In some individuals a relatively short, blunt dorsal spine was observed; these individuals showed the greatest total length, while on shorter individuals a relatively long, slender dorsal spine was observed. Dorsal spine from 20 to 30% of the total length, with small setae scattered along its entire anterior edge; rostral spine usually as long or longer than the dorsal spine. Lateral spines flexed ventrally; carapace width, from tip to tip of lateral spines, about one-third of the total length of the body. A few additional setae occur between the anterior edge of the dorsal spine and the base of the rostral spine; 20 to 25 slender setae mid-ventrally to posteriorly on the inner margin of the carapace. Abdomen with six somites and the telson (Figure 5I). The blunt lateral spines on the second somite now directed slightly posteriad; spines on other somites more pronounced than in the previous stage. The first somite bears four setae on the middorsal surface; the second somite with two setae anterior and four setae posterior to the midline; the third somite with two setae mid-dorsally and two on the posterodorsal margin; somites 4 and 5 each with a pair of setae on the posterodorsal margin, sixth somite naked; telson as in previous stage but with the proximal setae on the inner portion larger; pleopods and uropods considerably enlarged from the previous stage. Antennule (Figure 5A) with four aesthetes and two setae terminally, one group of six aesthetes and another of two subterminally; bud of endopod enlarged from previous stage; basal portion with five setae. Antenna (Figure 5B) as in previous stage but with the endopodite considerably enlarged and longer than the protopodite. Mandibular palp (Figure 5C) simple and

much enlarged from the previous stage. The endopodite of the maxillule (Figure 5D) the same as in the previous stages; basal endite with about 22 spinous setae, coxal endite with 17. Scaphognathite of the maxilla (Figure 5E) with about 54 marginal plumose setae; endopodite the same as in the previous stages; distal lobe of the basal endite with 12 spinous setae, proximal lobe with nine; coxal endite as in the previous stage. The exopodite of the first maxilliped (Figure 5F) bears 17 setae; endopodite and basipodite as in the previous stage; coxa with six setae. The exopodite of the second maxilliped (Figure 5G) with 19 setae; the terminal segment of the endopodite with six setae, other segments as in the previous stages; basipodite with three setae; coxa with one. Exopodite of the third maxilliped (Figure 5H) with slight articulation; endopodite faintly five-segmented, the two distal segments each with one spine. Chelipeds and pereopods considerably enlarged from previous stage.

MEGALOPA (Figures 6A and 7A)

Carapace length 3.16 mm (3.02-3.26); total length 6.46 mm (6.32-6.60). Rostrum one-fifth the length of the carapace, strongly depressed and bifid at the tip; a medial groove present from interorbital position nearly to the distal end of the rostrum. Eye stalks with a few small setae on the anterior and dorsal surfaces. A carina is present on each side of the mesogastric midline (highest points on carapace) and another prominence is present in the cardiac region of the carapace; hepatic and branchial lobes rounded; setation sparse, occurring along the margins of the rostrum, a few in the postorbital region, and a few tufts on the mesogastric prominences; numerous setae are present along the mid-ventral to posterior margin of the carapace. Abdomen with six somites and the telson; setation sparse and as figured; pleopods with about 28 long natatory setae each (Figure 7D); uropods with about 15 each (Figure 7H). The peduncle of the antennule (Figure 6B) is three-segmented, the proximal segment with one plumose seta, the middle segment with five setae subterminally, and the distal segment has two setae; inner

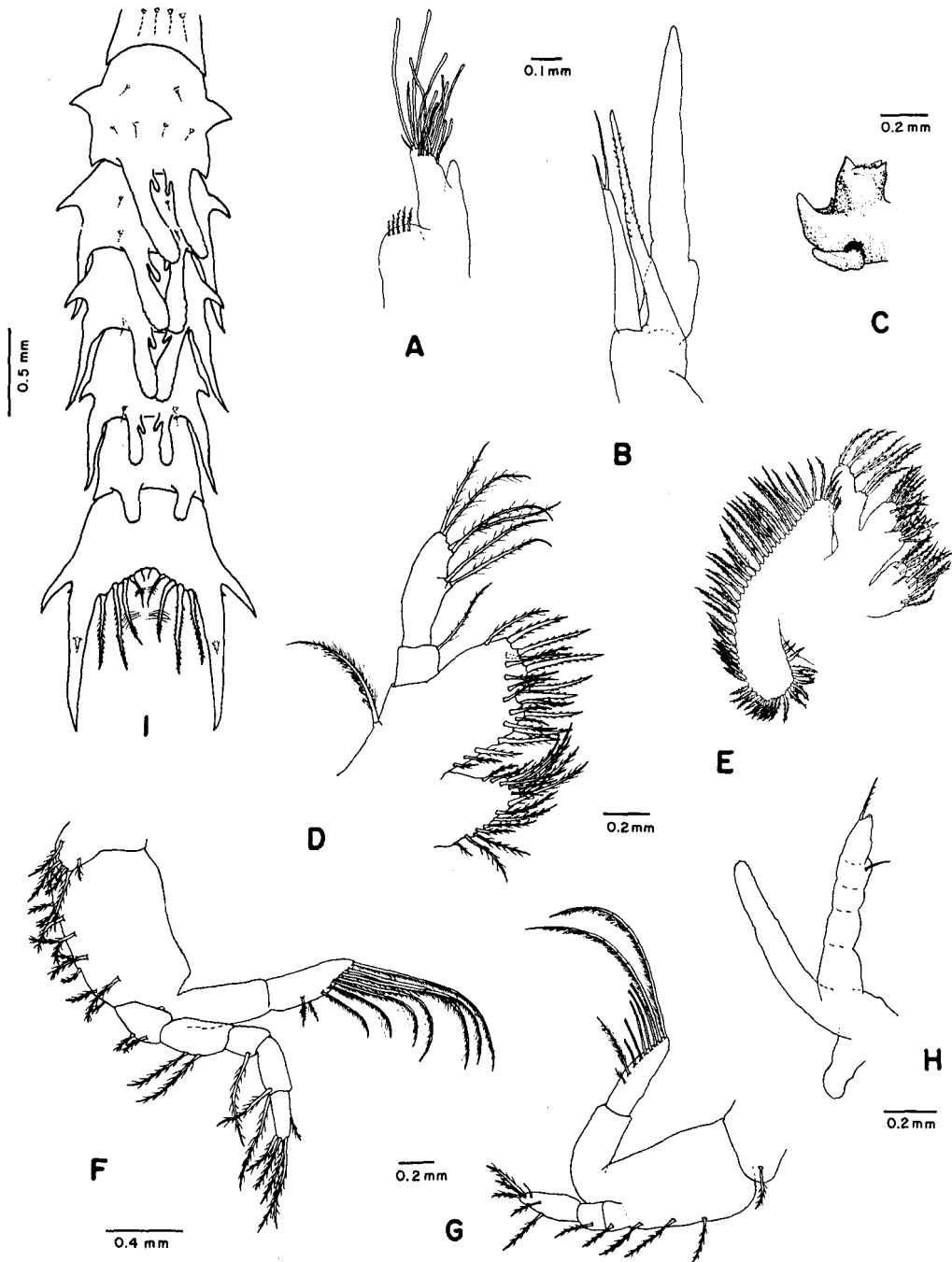


FIGURE 5.—*Geryon quinquedens*, Zoea IV. A. antennule, B. antenna, C. mandible, D. maxillule, E. maxilla, F. first maxilliped, G. second maxilliped, H. third maxilliped, I. ventral view of abdomen and telson.

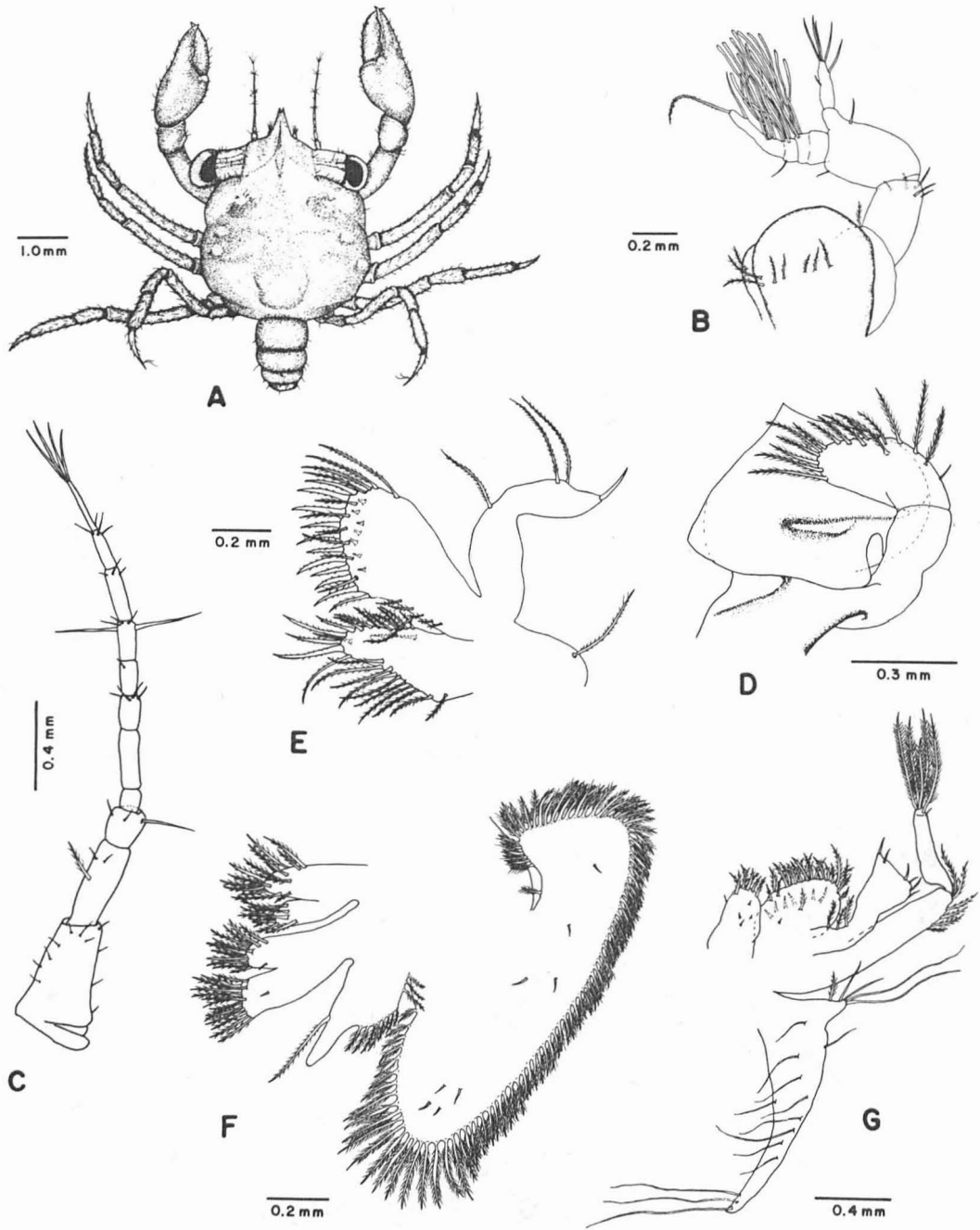


FIGURE 6.—*Geryon quinquedens*, megalopa. A. dorsal view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. first maxilliped.

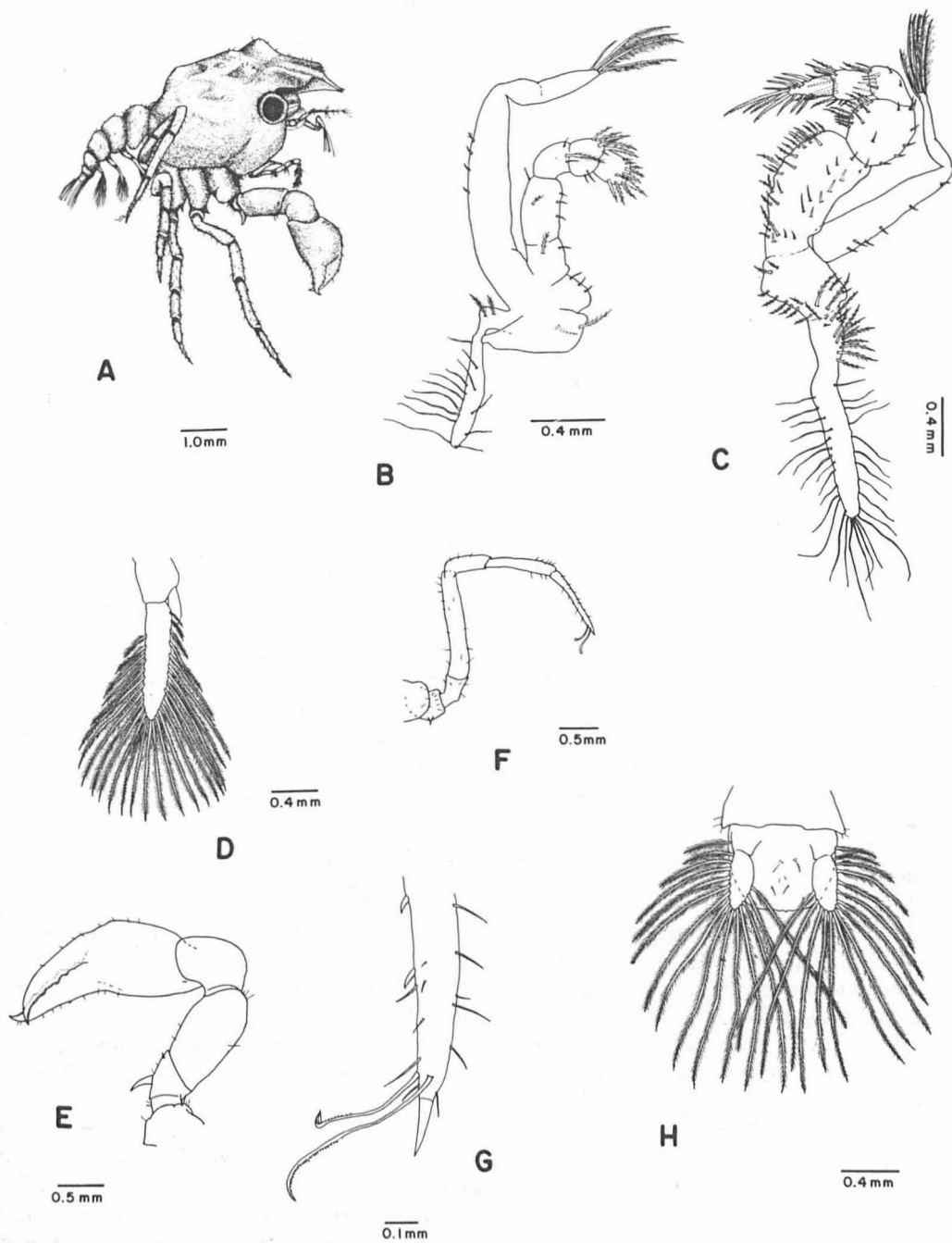


FIGURE 7.—*Geryon quinquedens*, megalopa. A. lateral view, B. second maxilliped, C. third maxilliped, D. pleopod of second abdominal somite, E. cheliped, F. last pereopod, G. dactyl of last pereopod, H. ventral view of telson and uropods.

flagellum two-segmented with four setae terminally and two subterminally; outer flagellum with four segments; proximal segment naked, the antepenultimate segments with six aesthetes, penultimate with five aesthetes and one seta, distal segment with five aesthetes near its base and one seta subterminally, terminating in a long, plumose seta. The basal portion of the antenna (Figure 6C) is two-segmented with small setae scattered on the distal segment; peduncle two-segmented with three setae on each segment; the flagellum is eight-segmented, the setation as figured. Mandibular palp two-segmented with 16 setae on the distal segment (Figure 6D). The endopodite of the maxillule (Figure 6E) is unsegmented, has one lateral and two subterminal setae, and terminates in a spine; the basal endite bears about 35 spinous setae; the coxal endite with about 25. The scaphognathite of the maxilla (Figure 6F) with about 100 marginal plumose setae, with a few setae scattered on the dorsal and ventral surfaces; endopodite produced into a narrow lobe, with three setae on the distal margin of the base, eight setae laterally on the same margin, and one long setae on the proximate lateral edge; basal endite with about 14 spinous setae on the distal lobe, 11 on the proximal; coxal endite with eight spinous setae on the distal lobe and 16 on the proximal. The exopodite of the first maxilliped (Figure 6G) now terminates in but five plumose setae and one naked seta; the endopodite is unsegmented and bladelike; basal endite with about 37 spinous setae along the margin; coxal endite with 12; epipodite with about 16 nonplumose hairs and 1 seta; setation of other portions as figured. A well-developed epipodite is present on the second maxilliped (Figure 7B) and bears about 14 nonplumose hairs and 2 setae; the exopodite terminates in four plumose and one nonplumose setae, and there are four short setae on the outer lateral margin; the endopodite with four segments, the distal segment with about 13 spinous setae terminally; other setation as figured. The exopodite of the third maxilliped (Figure 7C) terminates in six plumose setae; the endopodite is five-segmented, its spination and setation variable as is that of the epipodite and is approximately as figured. Chelipeds (Fig-

ure 7E) with a strong hooked spine on ventral portion of ischium. Spines on coxa of pereopods one through three and another blunt spine subterminally on the posterior margin of the same articulation, decreasing in size posteriorly. Dactyl of last pereopod with two curved, toothed setae (Figure 7F and G).

DISCUSSION

The prezoa and first zoea stages of *Geryon quinquedens* appear to be quite similar in structure to the corresponding stages of *G. tridens* described by Brattegard and Sankarankutty (1967). The most trenchant differences are the larger size of the zoea of *G. quinquedens* and the lack of posterolateral spines on the fifth abdominal somite in *G. tridens*. Brattegard and Sankarankutty give the length of the first zoea as 2.0 mm but no mention is made as to how they arrived at this measurement. The large size of the larvae of *G. quinquedens* should help to distinguish them from other sympatric Brachy-rhyncha, with the possible exception of its congener, *G. affinis*.

The family Geryonidae was erected in 1930 by Beurlen (original reference not obtained, information from Christiansen, 1969), but since then *Geryon* has been placed in various families: Rathbun (1937) places *Geryon quinquedens* in the subfamily Carcinoplacinae of the family Goneplacidae; Bouvier (1940) placed *Geryon* in the family Xanthidae; Gurney (1939) lists the genus under the subfamily Menippinae of the family Xanthidae; and more recently Christiansen (1969) reassigned the genus to the family Geryonidae.

I have found few references dealing with the larvae of goneplacid genera. Lebour (1928) discussed the larval stages of *Gonoplax rhomboides*; Kurata (1968) described the larvae of *Carcinoplax longimanus*. Both of these species agree generally with *Geryon* in the number of larval stages, the spination of the carapace and abdomen, and the spination and setation of the telson. The relative length of the exopodite to the protopodite of the antenna in *Geryon* is apparently similar to that in *Carcinoplax* but different from that in *Gonoplax*. Megalopa of both *Gonoplax*

and *Carcinoplax* bear spines on the carapace, while megalopa of *Geryon* do not.

The exopodite of the antenna in zoeae of *Geryon quinquedens* is about one-half the length of the protopodite; in *Gonoplax* (Lebour, 1928) the exopodite is about the same length as the protopodite, and bears two short setae medially, rather than terminally as in *Geryon*. On the basis of the relative length of these two structures, *Geryon* would not align with *Gonoplax* in Lebour's key to the zoeae. The configuration and relative length of the antennal exopodite and protopodite in *Geryon* are more like those of *Cancer* (Poole, 1966), some portunids (Lebour, 1928; Roberts, 1969) and certain grapsids (Diaz and Ewald, 1968). Boyden (1943) and Leone (1951) discuss the serological relationships of *Geryon quinquedens* to other members of the Brachyura. Each found *Geryon* to be closer to the Xanthidae than to other families tested, with certain affinities noted to the Cancridae and Portunidae. However, neither of these workers tested other members of the Goneplacidae against *Geryon*. The zoeae of *Geryon quinquedens* are similar to most xanthid zoeae (Lebour, 1928; Costlow and Bookhout, 1968) in the number of zoeal stages, the spines on the carapace, and the armature of the telson. However, there are differences in the latter two characters within the Xanthidae alone (Costlow and Bookhout, 1966). The structure of the zoeal antennae of *Geryon* is decidedly different from the antennae of xanthid zoeae; in xanthid zoeae the exopodite of the antenna is very short in relation to the length of protopodite.

The number of terminal setae on the exopodite of the first and second maxillipeds of Zoea II through IV apparently distinguish the larvae of *Geryon quinquedens* from other members of the Brachyryhyncha. In this group the exopodite of the first maxillipeds consistently bear four terminal setae in the first zoeal stage and six in the second stage. The same number is usually associated with the second maxilliped. *G. quinquedens* bears 4 setae in the first stage and 10 or 11 in the second. Knight (1968) reports that the raninid species, *Raninoides benedicti* Rathbun, has nine setae on the exopodite of the

second maxilliped (six on the first) of Zoea II. Only members of the rather diverse and remote Anomura apparently bear as many terminal setae on the maxillipeds of stages subsequent to Zoea I as does *G. quinquedens*. The lithodid species, *Cryptolithodes typicus* Brandt, bears four setae on the exopodite of the first maxilliped in the first zoeal stage and eight in the second stage (Hart, 1965). The porcellanid genera *Polyonyx* (Knight, 1966; Gore, 1968), *Pachycheles*, and *Petrolisthes* (Greenwood, 1965) bear from 11 to 14 terminal setae on the exopodite of the first maxillipeds in Zoea II. All bear four setae on this structure in Zoea I.

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