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LARVAL DEVELOPMENT UNDER LABORATORY CONDITIONS OF THE XANTHID MUD CRAB *EURYTIUM LIMOSUM* (SAY, 1818) (BRACHYURA: XANTHIDAE) FROM GEORGIA

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ABSTRACT Larvae of the xanthid mud crab *Eurytium limosum* were reared in the laboratory from hatching to first crab stage. Four zoeal stages and one megalops stage were obtained and are described. Complete larval development required about 15 days under culture conditions of 26.0° to 28.0°C and 25 ppt sea water. A long antenna and short antennal exopods consign *E. limosum* to the Group I xanthid zoeae of Rice (1980). The first stage zoea closely resembles that of *Panopeus herbstii* and is distinguished by having the dorsal spine strongly recurved at the extremity. Stages 2 to 4 are distinguished from *Rhithropanopeus harrisii* and *Neopanope sayi* larvae by having two lateral spines on the telson.

INTRODUCTION

Xanthid larvae have been the subject of more studies than have larvae of any other family within the Brachyura. Wear (1970) in his bibliography of xanthid crab larvae listed 23 references to xanthid larvae, exclusive of the 25 references given by Gurney (1942). More recently, Rice (1980) summarized current knowledge of xanthid larvae and listed 15 references not found in Wear (1970) or published since that time. Not listed by Rice (1980) were the descriptions of larvae belonging to *Pilumnoides perlatus* by Fagetti and Campodonico (1973), and to *Neopanope texana* by McMahan (1967). Since Rice's review, the larvae of *Micropanope barbadensis* have been described by Gore et al. (1981).

Xanthids generally are characterized by having four zoeal stages and a megalops stage, although five species have been shown to have less than four zoeal stages (Hale 1931; Wear 1967, 1968; Saba et al. 1978); the five exceptions are from somewhat restricted habitats. Members of the subfamily Menippinae have five and sometimes six zoeal stages, but there is strong evidence that these crabs constitute a separate family (Scotto 1979). Only one other xanthid crab, *Pilumnoides perlatus* (Poeppig, 1936), has been shown to have five zoeal stages (Fagetti and Campodonico 1973).

The xanthid genus *Eurytium* Stimpson, 1859 is represented in North America by three species, only one of which occurs on the eastern coast of North America (Rathbun 1930). Though primarily a tropical species associated with mangrove habitats, the mud crab *Eurytium limosum* (Say, 1818) is a common member of the *Spartina* salt marsh fauna of coastal Georgia and southern South Carolina (Teal 1959, Williams 1965), and it is probable that its larvae represent an important part of the estuarine meroplankton in those and other regions.

The present study is the first description of larvae within the genus *Eurytium*, and is in part the result of studies conducted at Sapelo Island, Georgia, by Kurata (1970).

MATERIALS AND METHODS

An ovigerous female captured in a *Spartina* marsh adjacent to Sapelo Island, Georgia, on August 16, 1964, was kept at room temperature in a large finger bowl half filled with filtered sea water diluted to 25 ppt until August 21, 1964, when the eggs hatched. Most of the zoeae were placed in three large finger bowls. Later, the first stage zoeae were placed in 10 small 3.5-inch finger bowls in groups of 10 per bowl and maintained at 26.0° to 28.0°C in 25 ppt filtered sea water. Water in the finger bowls was changed daily, and a record was maintained of larval molting and mortality. All zoeal and megalops stages were fed once daily on newly hatched *Artemia* nauplii. Various stages used for the descriptions were removed from the large mass-culture bowls and fixed in 10% formalin; 48 hours later, stages were transferred to 70% ethanol. Drawings were made with the aid of Wild M-5 and M-20 drawing tubes; an ocular micrometer was used for all measurements. Preserved larval stages and the parent currently are in the collection of the senior author.

RESULTS

Rearing

Results of rearing experiments are summarized in Figure 1. Mortality of larvae was negligible during the zoeal stages, but was considerable in the megalops stage. Mean duration of each zoeal stage was 2 to 3 days and that of megalops was about 8 days. Complete larval development required from 8 to 15 days; molting to first crab stage occurred between days 16 and 19.

Larval Stages

Four zoeal stages (Figures 2 and 3) and one megalops stage (Figure 4A–C) are recognized. No additional zoeal stages were observed.

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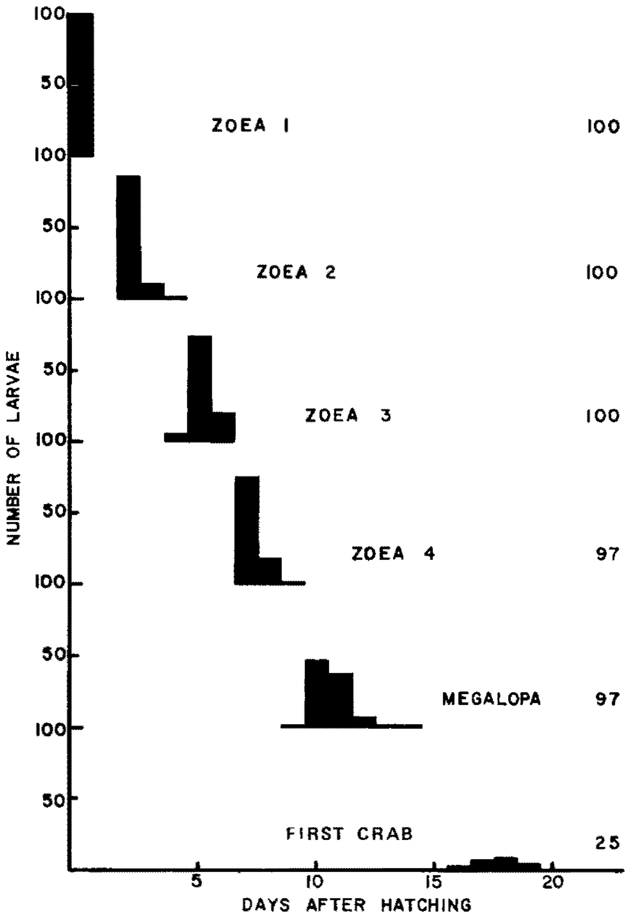

Figure 1. Duration and success of larval stages during development of *Eurytium limosum*. One hundred newly hatched zoeae were reared in 10 small finger bowls at 26.0° to 28.0°C, at 25 ppt. Figures on right hand side of diagram show the total number of larvae successfully reached at each stage.

Zoea

Carapace with 1 dorsal, 1 rostral, and 2 lateral spines. These are all smooth with the rostral spine long and almost straight. Dorsal spine about 3/4 the carapace length (measured from tip of rostral spine to posterior margin of carapace), curving posteriorly at the end. Lateral spines small, about 1/8 length of dorsal spine. Small anterior and posterior protuberances on carapace. Ventral margin of carapace smooth and fringed with up to 10 hairs, increasing in number with the progression of stages. Abdomen (measured from posterior of carapace to tip of telson forks) about 1.1 times longer than carapace, lateral hooks present on segments 2 and 3, those on segment 3 distinctly smaller than those on segment 2. A pair of lateral spines present on segments 3 to 5, these spines all nearly the same size and never reaching the posterior margin of the following segment.

Telson with 1 dorsal and 2 lateral spines, second lateral spine quite small. hairlike and seen only in the first stage. First lateral and dorsal spines distinct in all stages, though the former decreases in size in later stages. Telson forks slender, smooth, and curving dorsally at end. Central indentation on posterior margin wide but shallow. Three pairs of internal spines, the third pair (innermost) longest and slightly longer than 1/2 the length of telson fork.

Antennae nearly equal to or slightly longer than rostral spine; exopod is vestigial and represented by a small process with a short terminal spine (sometimes wanting) at the base of the spinous process. Spinous process furnished distally with several spinules in stage 1, but smooth in later stages.

Stage 1 (Figures 2A, B; 3A, E). Carapace length: 1.13 mm. Eyes sessile. No ventral, marginal setae on carapace. Sixth abdominal segment fused with telson. Telson fork length nearly equal to width of telson (measured at the level of the first internal spine). Antennule represented by a simple conical process with single group of terminal aesthetes. No endopod on antenna, mandible with no palp. No outer setae on maxillule. First and second maxillipeds bear 4 swimming setae on each exopod. No third maxillipeds, pereopods, or abdominal appendages.

Stage 2 (Figures 2C; 3B, F). Carapace length: 1.43 mm. Eyes stalked and free from carapace. Base of rostral spine slightly expanded laterally just in front of eyes but not produced into distinct spines. Two hairs on inner ventral margin of carapace. Second lateral spine on telson disappears in this stage. Inconspicuous swelling at base of antennal spinous process representing rudimentary endopod. Densely plumose outer setae on maxillule. Six swimming setae on exopod of first maxilliped, 7 setae on exopod of second maxilliped. Third maxilliped and pereopods appear as small buds.

Stage 3 (Figures 2D; 3C, G). Carapace length: 1.90 mm. Sixth abdominal segment articulated from telson. A pair of small setae added between innermost pair of internal spines of telson. Length of telson forks about 1 1/4 times longer than width of telson. Endopod of antenna about 1/8 length of spinous process. First and second maxillipeds each bear 8 swimming setae on exopods. First pereopod bilobed. Pleopods appear as simple conical buds, those on segments 3 and 4 shorter than respective lateral spines of segments.

Stage 4 (Figures 2E-J; 3D, H). Carapace length: 2.17–2.43 mm. Telson usually with 2 pairs of small internal setae between innermost pair of spines. Antennule greatly swollen at base; outer flagellum segmented from protopod and bearing 3 groups of aesthetes, inner flagellum appears as a simple process. Mandible (Figure 2F) well calcified with incisor and molar processes distinctly divided, and with small palp. Endopod of maxillule (Figure 2G) consists of 2 segments with a seta on short proximal segment and 6 setae in 3 groups on long distal segment. A simple outer seta present near base of maxillule. Endopod of maxilla (Figure 2H) unsegmented but divided into 3 indistinct inner lobes with 3, 2, and 3 setae on each respective lobe. Endopod of first maxilliped has on terminal segment a vestigial, outer seta not reaching distal end of terminal segment (Figure 2I). Exopod of first maxilliped with 8 or 9 setae.

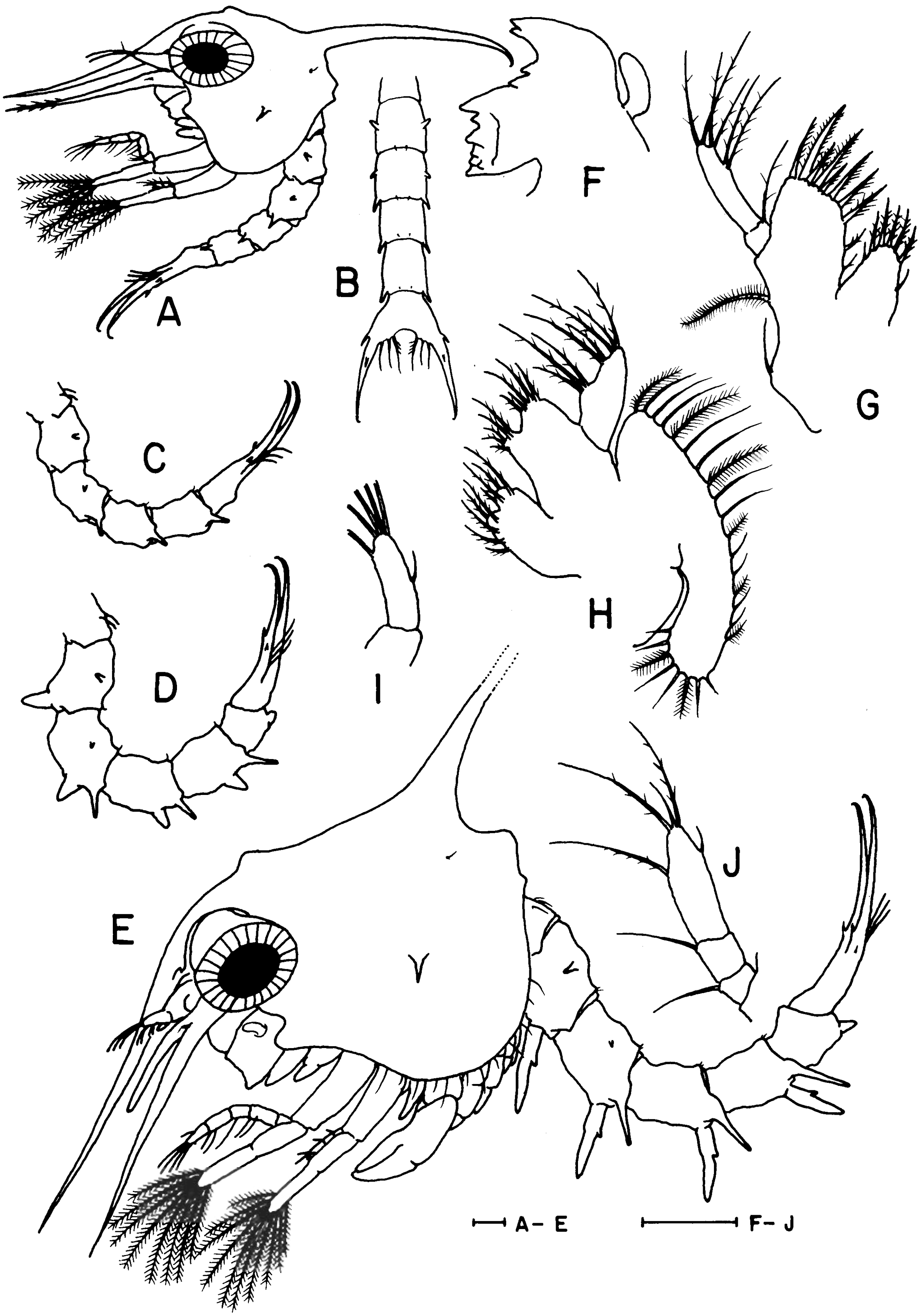

Figure 2. *Eurytium limosum*, zoeal stages 1 to 4. Stage 1 zoea: A, lateral view; B, dorsal view of abdomen. Stage 2 zoea: C, lateral view of abdomen. Stage 3 zoea: D, lateral view of abdomen. Stage 4 zoea: E, lateral view; F, mandible; G, maxillule; H, maxilla; I, terminal segment of maxilliped 1; J, endopod of maxilliped 2. (0.1 mm indicated.)

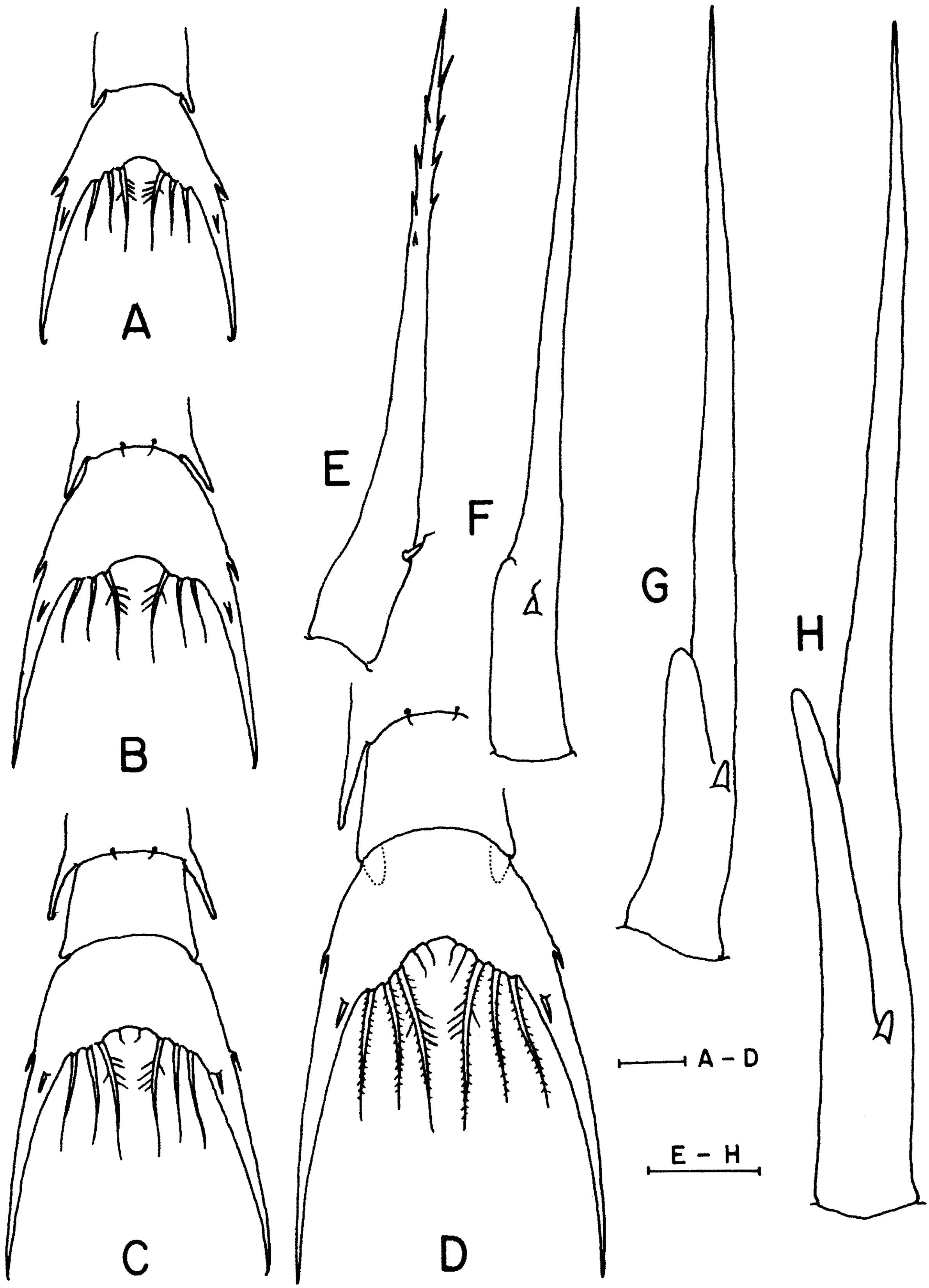

Figure 3. *Eurytium limosum*, zoeal stages 1 to 4, A–D, dorsal view of telson: A, stage 1; B, stage 2; C, stage 3; D, stage 4. E–H, antenna: E, stage 1; F, stage 2: G, stage 3; H, stage 4. (0.1 mm indicated.)

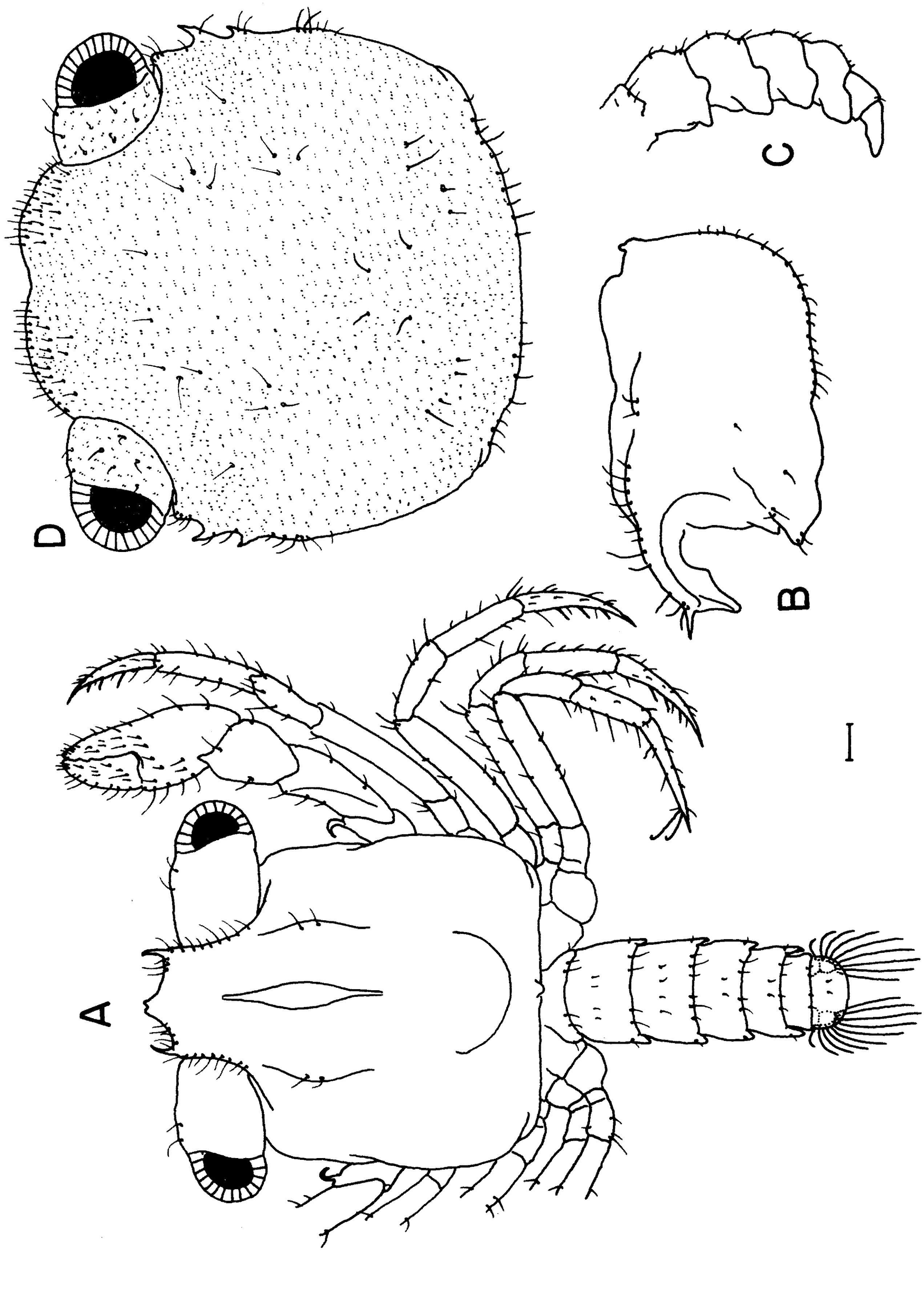

Figure 4. *Eurytium limosum*, megalopa and first crab. A–C, megalopa: A, dorsal view; B, lateral view of carapace; C, lateral view of abdomen. D, dorsal view of carapace of first crab stage. (0.1 mm indicated.)

Endopod of second maxilliped consists of 3 segments, the second slightly longer than the first, the third (terminal) segment about 1 1/2 times length of combined proximal 2 segments (Figure 2J). Proximal 2 segments bear 1 seta each, terminal segment bears 3 apical, 1 inner, and 1 outer setae. Exopod of second maxilliped with 10 or 11 setae. Pereopod buds exposed from ventral margin of carapace. Carapace fringed with up to 10 setae. Pleopods with rudimentary endopods, those on segments 3 and 4 longer than respective lateral spines.

Megalops (Figures 4A-C). Carapace length: 1.06 mm. Total length: 2.01 mm. Carapace slightly longer than wide, without conspicuous dorsal protuberances. Gastric and cardiac regions distended dorsally. Small process at center of posterior margin. Eyes extend somewhat beyond lateral margin of carapace; cornea not wider than stalk.

Rostrum bent obliquely down and terminates as slightly bifid, blunt central process with pair of pointed lateral spines that extend almost horizontally forward, curving inwardly like horns.

Abdomen slightly shorter than carapace. Lateral plate of segment 5 nearly reaching posterior end of segment 6. Telson about 2/3 as long as wide and slightly longer than segment 6, with rounded posterior margin. Uropod bears 1 seta on proximal segment (protopod) and 8 or 9 setae on distal segment (exopod).

Protopod of antenna with 4 segments and a flagellum of 7 segments. Mandible with 3-segmented palp. Cheliped with large curved hook on ischium. No other spines or hooks present on any pereopod segments, except dactyli of pereopods 2 to 4 which bear 3 short spines. Dactyli of pereopods 2 to 5 about 1 1/2 times longer than their propodi. Fifth pereopod bears 2 short aesthetasc-like hairs on dactyl.

First Crab (Figure 4D). Carapace length: 1.33 mm. Body covered throughout with numerous minute hairs and sparsely with long hairs. Carapace nearly as long as wide, with a slightly bilobed front. Two lateral spines on either side of carapace in hepatic region just posterior to orbit. No hooks on ischium of chelipeds.

DISCUSSION

The zoea of *E. limosum*, like other typical xanthid zoeae, is characterized by a long antenna with a reduced exopod. It is distinguishable from other known xanthid zoeae by stages 2 to 4 having a smooth antennal spinous process and two distinct outer spines on the telson. However, as the first stage zoea of *E. limosum* has a serrated antennal spinous process and three outer spines (2 lateral, 1 dorsal), it is difficult to distinguish from the first zoea of *Panopeus herbstii* Milne-Edwards, 1834. Only the strongly recurved extremity of the dorsal carapace spine in *Eurytium limosum* appears to distinguish the first zoeal stages of these two species.

Rathbun (1930) reported 18 species of crabs in the family Xanthidae from the coasts of Georgia and the Carolinas. Williams (1965), and Williams et al. (1968) added 8 more species, and Williams (1974) reported a new genus and species, *Allactaea lithostrota.* Thus, 27 species of xanthids belonging to 16 genera are now known to occur along the eastern coast of Georgia and the Carolinas. Larval stages of 12 species belonging to the genera *Leptodius, Panopeus, Neopanope, Hexapanopeus, Eurypanopeus, Micropanope, Rhithropanopeus, Menippe, Lobopilumnus, Pilumnus,* and *Eurytium* are now known from the eastern coast of North America. Larvae of the remaining genera (*Glyptoxanthus, Actaea, Domecia, Eriphia,* and *Allactaea*) known from this region remain undescribed. However, information on the larvae of *Eriphia* is available from other geographical areas (see Gurney 1942).

Wear (1970) concluded that the most important character of Lebour (1928) separating xanthid zoeae into recognizable groups was the length of the antennal exopod relative to the length of the protopodite. Scotto (1979) agreed with Wear (1970) in that a well-developed antennal exopod indicated a more primitive condition, and she mentioned the extra zoeal stage and the placement of male and female genital openings on the adults (after Guinot 1977) as evidence for the apparent "primitive" placement of the genus *Menippe.* If the antennal exopod is indeed a good character for placement within the family Xanthidae, *Eurytium limosum* is an advanced xanthid and is more closely allied to the genera *Hexapanopeus, Heteropanope, Neopanope, Lophopanopeus,* and *Rhithropanopeus.* Aikawa (1937) placed much phylogenetic significance on the antennal exopod and expanded the two xanthid zoeal groupings of Hyman (1925) into three groups. Rice (1980) has separated the known xanthid zoeae into four groups, employing the setation of the mouthparts as additional characters. The first of these groups, into which *Eurytium limosum* falls, contains the most advanced xanthids, with antennal exopods greatly reduced or absent.

The antenna of the first stage zoea of *E. limosum* is furnished distally with several spinules, but is smooth in later stages. This character, plus the presence of three outer spines on the telson of stage 1 zoea, indicates a not too distant relationship to less advanced xanthids such as *Panopeus herbstii.* The first stage zoea is similar to that of *Panopeus herbstii* Milne-Edwards, 1834 as described by Costlow and Bookhout (1961), but can be distinguished by the more strongly recurved distal portion of the dorsal carapace spine in *E. limosum.* The later stages resemble the zoea of *Rhithropanopeus harrisii* (Gould, 1841) as described by Connolly (1925), Chamberlain (1962), and Hood (1962), and the zoea of *Neopanope sayi* (Smith, 1869) as described by Hyman (1925, after Birge 1883) and Chamberlain (1957, 1961). However, the zoeae of *Eurytium limosum* have two outer spines on the telson in contrast to the single outer spine on the telson of *R. harrisii* and *N. sayi.*

Available data indicate that *Eurytium* may have originated from *Panopeus* stock but advanced along a separate line from those genera that have undergone a reduction in telsonal armature. There is, however, still some doubt as to the phylogenetic significance of many decapod larval characters. For example, according to the scheme of Aikawa (1937) and to the categorization of xanthid larvae by Rice (1980), *Panopeus bermudensis* Benedict and Rathbun, 1891 would rank as extremely primitive among the Xanthidae on the basis of its first stage zoea (Lebour 1944); it would likely deserve recognition under a separate genus were larval characters considered as phylogenetically significant as the adult morphology upon which its generic placement is presently based. This was noted by Wear (1970) and by Rice (1980).

Detailed descriptions of additional genera and species likely will clarify questionable phylogenetic relationships among the many members of the Xanthidae. Future studies employing the larval characters given by Rice (1980) should, in particular, further clarify the phylogenetic significance of such larval characters as armature of the antennal exopod and telson within this group.

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