MORPHOLOGICAL STUDY OF DIAGNOSTIC CHARACTERS IN WESTERN ATLANTIC *HEPOMADUS* (CRUSTACEA, DECAPODA, PENAEIDAE)

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ABSTRACT

The collections made during the expeditions of the *Oregon, Oregon II,* and the RV *John Elliott Pillsbury* almost tripled the number of specimens of *Hepomadus* previously recorded from the western Atlantic. The taxonomic status of the material has been assessed through a study of the external morphology and an investigation of variations of morphological, morphometric, and meristic characters. It is demonstrated that intermediates are present between extremes of variations and, consequently, all specimens are assigned to a single species, *Hepomadus tener* Smith.

The gap in our knowledge of the genus *Hepomadus* results from the great paucity of collections taken beyond the continental shelf of America. Although recent material caught in the course of the expeditions of the *Oregon, Oregon II,* and the RV *John Elliott Pillsbury,* in addition to five specimens taken by the *Albatross* in 1885 and 1886 which have not been reported, have almost tripled the number of specimens previously recorded from the western Atlantic (18), the total number of known specimens is only 51.

The purpose of this paper is to demonstrate that all specimens of *Hepomadus* that have been taken in the western Atlantic (including the Sargasso Sea, the Gulf of Mexico, and the Caribbean) belong to a single species, *Hepomadus tener* Smith, 1884. My study has drawn from the works of earlier investigators, and I have corroborated their observations on the great variation in many morphological and a few morphometric and meristic characters within this species. Additional material from a greater number and more widely distributed localities, however, have led me to conclude that features which have been suggested as probably useful in differentiating species of *Hepomadus* in the region are not valid. Similarly, all other characters analyzed here for the first time show a wide range of variation, with intermediate stages present between the extremes. One meristic and two morphological characters, however, have been found reliable for separating *H. tener* and *H. glacialis* Bate, 1881, which is known only from the western Pacific.

PRESENTATION OF DATA

The c.l. (carapace length—linear distance between orbital margin and midposterior margin of carapace) and r.l. (rostral length—linear distance from apex to orbital margin) are measured to the nearest 0.5 mm. The ratios presented in the tables are given to the nearest 0.05. Certain ratios are not given for every specimen because the rostrum is damaged in many of them, and, in some, the spine on the third pleonic somite is broken. The ocean depths have been recorded to the nearest meter. Finally, the scales accompanying the illustrations are in millimeters.

The following abbreviations are used for repositories of specimens: TAMU-Department of Oceanography, Texas A&M University; UMML-Institute of Marine Sciences, University of Miami; USNM-National Museum of Natural History, Smithsonian Institution; and YPM-Peabody Museum of Natural History, Yale University.

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HEPOMADUS TENER SMITH, 1884

Figures 1-10

Hepomadus tener Smith, 1884: 409, pl. 9 fig. 7-8. Holotype: ♂ USNM 5464. Type-locality: off mouth of Chesapeake Bay, 5,394m, 2 October 1883, *Albatross* stn 2099 (lat 37°12'20"N, long 69°30'W).-Smith, 1887:689, pl. 19, fig. 3-3a.-Bouvier, 1908: 57, pl. 1, fig. 5, pl. 13, fig. 1-12.-Burkenroad, 1936:86.-Ramadan, 1938:55.-Roberts and Pequegnat, 1970:43, fig. 3-2D.-Pequegnat and Roberts, 1971:9.

Hepomadus tener?.-Wood-Mason and Alcock, 1891:189.

Aristaeus (Hepomadus) tener?.-Alcock, 1901:42.

Hepomadus glacialis.-A. Milne Edwards and Bouvier, 1909:194, fig. 13-19, pl. 1, fig. 3. [Not *Hepomadus glacialis* Bate, 1881.]

Material

United States

New Jersey: 1 ♀, USNM, off Atlantic City, 2,601 m, 11 August 1885, *Albatross* stn 2563.

Delaware: 1 ♂, USNM, off mouth of Delaware Bay, 3,206 m, 18 September 1886, *Albatross* stn 2715. 1 ♀, USNM, off mouth of Delaware Bay, 2,983 m, 18 September 1886, *Albatross* stn 2716.

Virginia: 1 ♂, holotype, USNM 5464. 1 ♀, USNM, off mouth of Chesapeake Bay, 3,740 m, 10 September 1884, *Albatross* stn 2226. 1 ♂ 1 ♀, YPM, and 1 ♀, USNM, off Back Bay, 2,266 m, 24 October 1886, *Albatross* stn 2727.

North Carolina: 1 ♀, YPM, off Roanoke Island, 1,542 m, 11 November 1883, *Albatross* stn 2115.

Florida: 1 ♀, USNM, S of Santa Rosa Island, 1,463 m, 2 September 1970, *Oregon II* stn 11206.

Alabama: 1 ♂ 1 ♀, USNM, off Mobile Bay, 2,683 m, 2 March 1885, *Albatross* stn 2379. 2 ♀ USNM, off Mobile Bay, 1,555-1,829 m, 28 July 1962, *Oregon* stn 3664. 2 ♂ 1 ♀, USNM, off Mobile Bay, 1,646 m, 28 January 1970, *Oregon II* stn 10897.

Louisiana: 1 ♀, USNM, off Grand Terre Islands, 2,652 m, 28 July 1959, *Oregon* stn 2574.

Texas: 1 ♂, TAMU, off Padre Island, 1,399 m, August 1969, *Alaminos* stn 68-A-11-7.

Mexico

Tamaulipas: 1 ♂, TAMU, of Boca San Rafael, 3,384-3,493 m, November 1968, *Alaminos* stn 68-A-13-10. 1 ♂, TAMU, off Boca San Rafael, 3,658 m, March 1968, *Alaminos* stn 68-A-3-3B. 1 ♂ 1 ♀, TAMU, off Tampico, 1,774 m, August 1969, *Alaminos* stn 69-A-11-87.

Veracruz: 1 ♂, USNM, NE of Cabo Rojo, 896 m, 3 June 1970, *Oregon II* stn 10955. 3 ♂, USNM, SE of Cabo Rojo, 1,280 m, 3 June 1970, *Oregon II* stn 10957. 1 ♀, USNM, SE of Cabo Rojo, 1,097 m, 3 June 1970, *Oregon II* stn 10956.

Yucatan: 1 ♂, TAMU, NW of Progreso, 3,841 m, March 1968, *Alaminos* stn 68-A-3-5B.

Bahamas

1 ♂, YPM, Turks Island Passage, 1,646-1,728 m, 12 April 1927 *Pawnee* stn 54.

Haiti

1 ♂ 1 ♀, USNM, Gulf of Gonave, 3,109-3,493 m, 1 July 1970, *Pillsbury* stn 1180.

Tobago

1 ♂, USNM, NW of Charlotteville, 920-1,244 m, 2 July 1969, *Pillsbury* stn 847. 2 ♀, USNM, NE of Man of War Bay, 1,817-1,847 m, 1 July 1969, *Pillsbury* stn 844.

Western Caribbean

2 ♀, USNM, NW of Cayos Hobbies, 933 m, 24 October 1970, *Oregon II* stn 11217.

Panama

1 ♀, USNM, off Punta Manzanillo, 1,639 m, 25 March 1884, *Albatross* stn 2144.

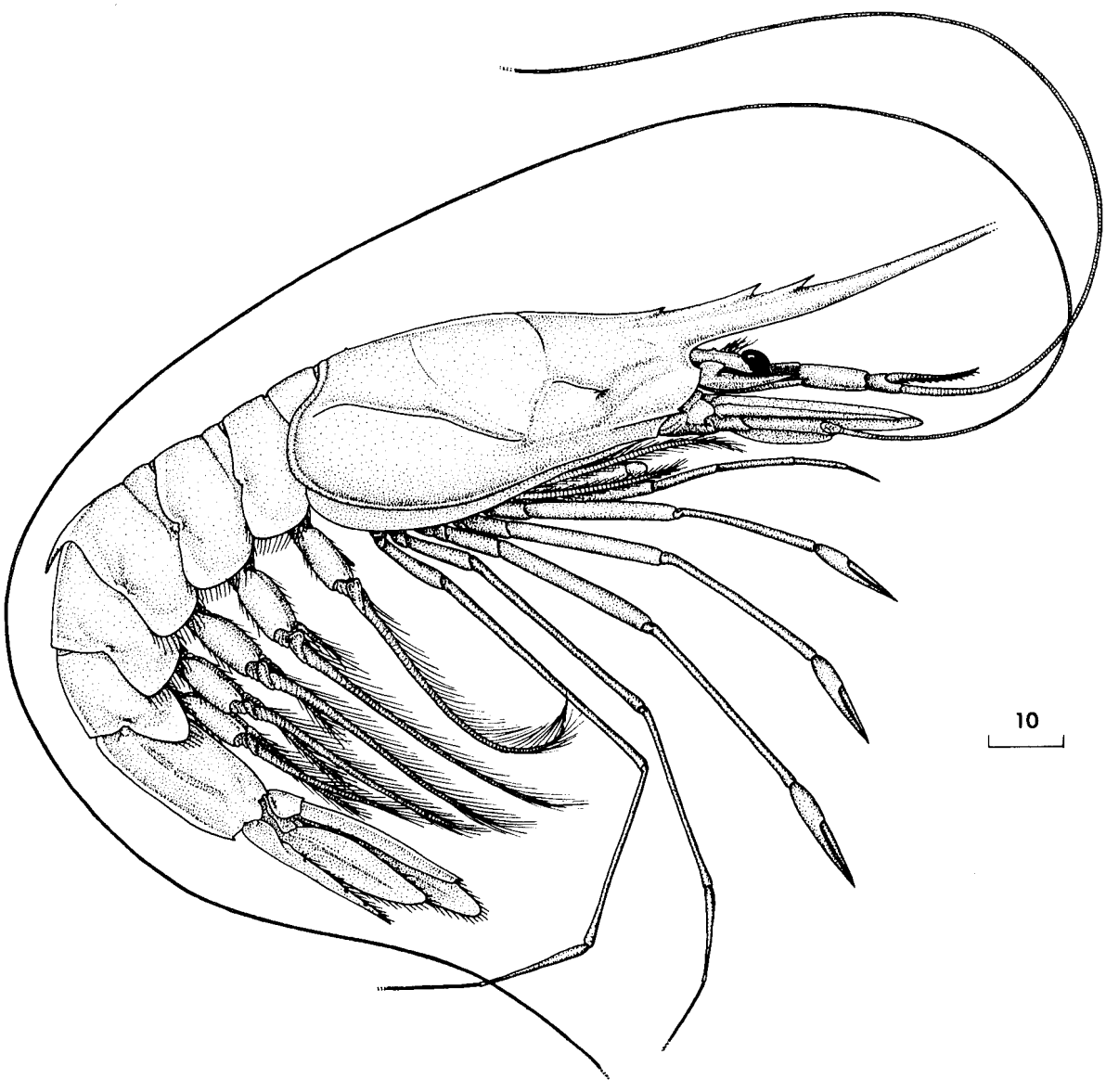

FIGURE 1.—*Hepomadus tener* Smith. Lateral view, ♀ 51 mm c.l., off Mobile Bay, Ala.

Colombia

1 ♂ 1 ♀, UMML, off Islas de San Bernardo, 1,271 m, 4 November 1970, *Oregon II* stn 11240. 3 ♂, USNM, off Isla de Barú, 1,097 m, 5 November 1970, *Oregon II* stn 11242. 1 ♀, USNM, off Puerto Colombia, 1,097 m, 8 November 1970, *Oregon II* stn 11245. 1 ♂ 1 ♀, TAMU, N of Cabo de la Aguja, 4,152 m, 24 July 1970, *Alaminos* stn 70-A-10-48. 1 ♀, USNM, NW of Península de la Guajira, 1,500 m, 27 July 1966, *Pillsbury* stn 454.

Description

Body slender and lacking setae (Figure 1). Dorsum of carapace almost straight or very slightly convex, convexity extending beyond postcervical sulcus (Figure 3A). Rostrum styliform, straight to slightly upturned in young (Figure 2), pronouncedly inclined dorsad in large individuals of both sexes; in young females and, apparently, in all males length of rostrum not exceeding 0.70 that of carapace, in larger females rostral length increasing with increasing size of shrimp to as much as 1.25 length of carapace, and surpassing antennular peduncle by about 0.3 of its own length. Rostral teeth 3, first tooth located slightly posterior to orbital margin, and rather far from second tooth; second and third teeth separated by interval varying from 0.3 to 0.6 of distance between first and second tooth. Postrostral carina (inconspicuous in young individuals) long, extending to about 0.8 length of carapace, and followed by rather minute dorsal tubercle, located near posterior margin; adrostral carina extending from orbital margin to near tip of rostrum, stronger and sharp basally. Orbital spine absent; antennal spine short, acute; branchiostegal spine produced and sharp; hepatic spine prominent. Cervical sulcus well marked, extending to middorsum of carapace, ending there at about 0.45 length of carapace from orbital margin; postcervical sulcus faint, concave except for almost straight, short, dorsal portion, ending at middorsum of carapace at 0.3 of carapace length from posterior margin; hepatic sulcus almost horizontal; orbitoantennal sulcus short and linear; branchiocardiac sulcus well marked, its length slightly more than half that of carapace, extending from near posterior margin of carapace to posterior end of hepatic sulcus.

Antennular peduncle length about 0.55 that of carapace; stylocerite produced distally into very slender, sharp spine, barely reaching base, or extending to midlength, of acute distolateral spine; first segment bearing minute ventromesial spine in young, occasionally spine persisting in animals of 24 mm c.l.; dorsal flagellum extremely long, about 4.5 times length of carapace, or 1.1 times total length of shrimp.

Scaphocerite 2.0 to 2.1 times as long as broad, and surpassing antennular peduncle by 0.1 to 0.2 of its own length; lateral rib produced distally into sharp spine overreached by lamella; antennal flagella incomplete in all specimens examined.

Labrum (Figure 4A, B) consisting of two

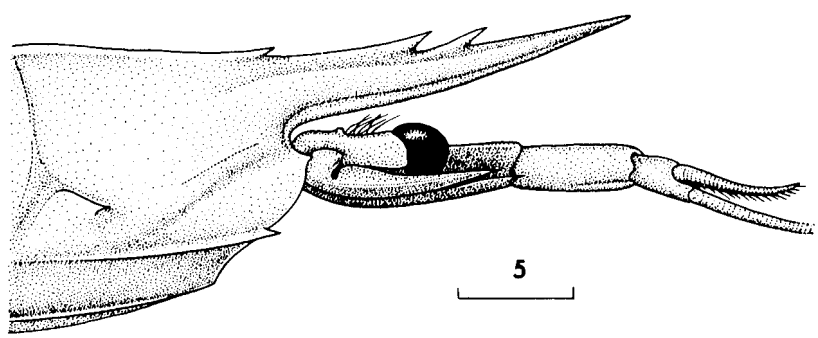

FIGURE 2.—*Hepomadus tener*. Anterior region, ♂ 28 mm c.l., mouth of Delaware Bay, Del.

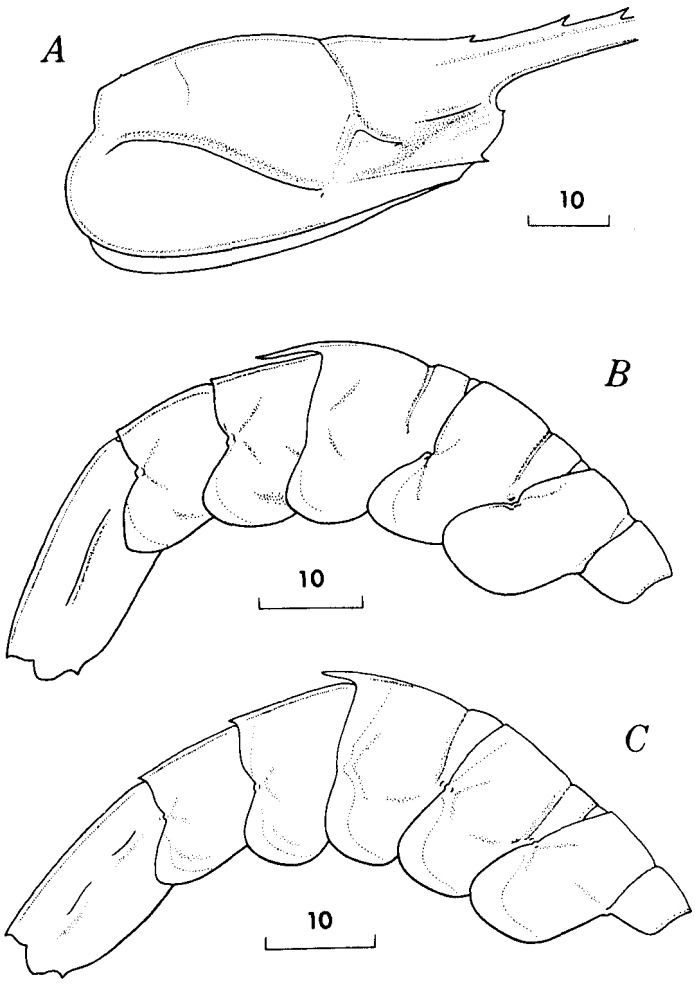

FIGURE 3.—*Hepomadus tener*. A. Lateral view of carapace, ♀ 52 mm c.l., off Back Bay, Va. B. Lateral view of abdomen, ♀ 51 mm c.l., off Atlantic City, N.J. C. Lateral view of abdomen, ♂ 35.5 mm c.l., SE of Cabo Rojo, Veracruz.

lightly sclerotized lobes: 1) anterodorsal lobe, subtriangular in outline, often bearing longitudinal, ventromedian carina, and ending anteriorly in vertical, apical ridge; lateral walls of lobe tapering from apical ridge posteriorly, and ending in caudally divergent, cornified, epistomal bars; and 2) posteroventral lobe, subtrapezoidal, delimited by lateral ribs projecting anteriorly as paired, small convexities on margin of lobe; posterior portions of ribs turning mesially but not meeting in midline.

Mandibular palp with proximal lobe of second segment ranging from blunt to acute. Second maxilla with endite of basis, "maxillary palp," bearing 2 to 4 strong and 1 to 4 weak setae [occasionally none according to A. Milne Edwards and Bouvier (1909) on a specimen identified as "*H. glacialis*"] on upper side of distolateral portion; and 2 to 5 strong and 1 to 4 weak setae, or none, on the lower side; in addition, 1 to 6 long, plumose, distal setae often present on upper side (Figure 5B, C). Number of setae on endite of right and left maxilla often different in same individual of this species as in holotype of *H. glacialis* (Figure 5D, E, left second maxilla). Exopod of first maxilliped with proximomesial border bearing 4 to 7 long, rigid setae.

Third maxilliped reaching base to distal end of third antennular segment, its dactyl with mesial side broadening abruptly at distal end

of proximal fourth forming excavation bearing strong setae on its proximal side, and tapering distally; first pereopod extending as far as, or very slightly beyond, third maxilliped; second pereopod reaching midlength of third antennular segment or surpassing it by tip of dactyl; third pereopod reaching distal end of antennular peduncle or exceeding it by almost 0.5 length of dactyl; fourth pereopod surpassing antennular peduncle by length of dactyl and 0.2 to 0.5 that of propodus; fifth pereopod overreaching antennular peduncle by length of dactyl and 0.5 or entire length of propodus—last two pairs of pereopods, especially their dactyls, slender. Ischium of third maxilliped bearing minute distomesial spine; merus of first and second pereopods with ventral distomesial spine movable, and rather stout. In females, coxae of last three pairs of pereopods produced mesially into plates covered with long setae and bearing anteriorly prominent, blunt tooth. In males, coxae of fifth pair of pereopods with large, obtuse to strongly acute tooth on anteromesial margin.

Abdomen with middorsal carina extending from about midlength of third somite through sixth, carina rounded on third, sharp from fourth posteriorly; posterodorsal margin of third somite bearing broad-based, prominent spine, its length 0.3 of, to equivalent to, distance between transverse sulcus and posterior margin of somite; posterodorsal margin of fourth and fifth somites varying from straight (Figure 1) to armed with well-developed, small spine (Figure 3B, C); sixth somite bearing small spine at posterior end of dorsal carina, paired posteroventral teeth, and two pairs of prominent lateral cicatrices; latter occasionally almost fused into one. Telson with four pairs of lateral minute, movable spines, posteriormost pair flanking very small terminal portion; median sulcus short, disappearing well anterior to terminal portion, mesial ramus of uropod longer than telson, and lateral ramus considerably overreaching mesial.

Petasma (Figure 6A, B) with median lobe tapering distolaterally from distal extremity of row of cincinuli (hooklike structures along mesial margin of median lobes of petasma that serve to interlock its two halves), and with elongate, subelliptical, sclerotized lapel on inner surface, extending along distomesial margin; lateral lobe very broad proximally, narrower and rounded distally; ventral costa with distal 0.4-0.5 of its length free from adjacent portion of ventrolateral lobule, and strongly curved

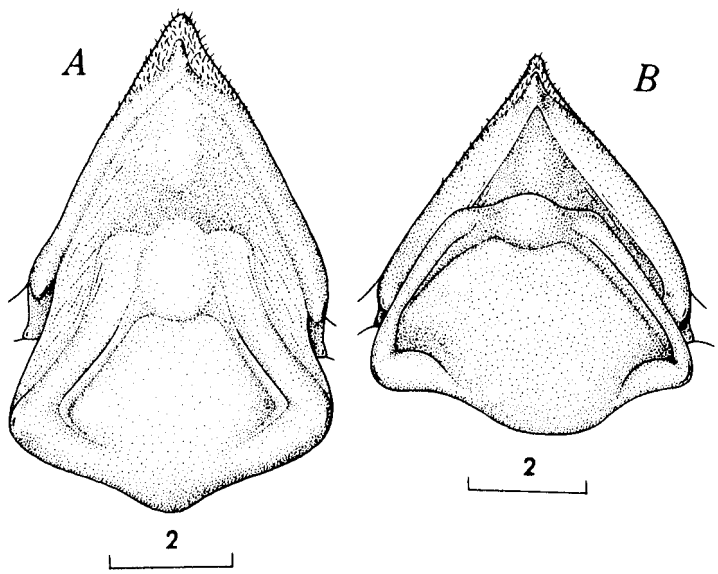

FIGURE 4.—*Hepomadus tener*. Ventral views of labra: A. ♀ 43.5 mm c.l., S of Santa Rosa Island, Fla. B. ♀ 44 mm c.l., off Back Bay, Va.

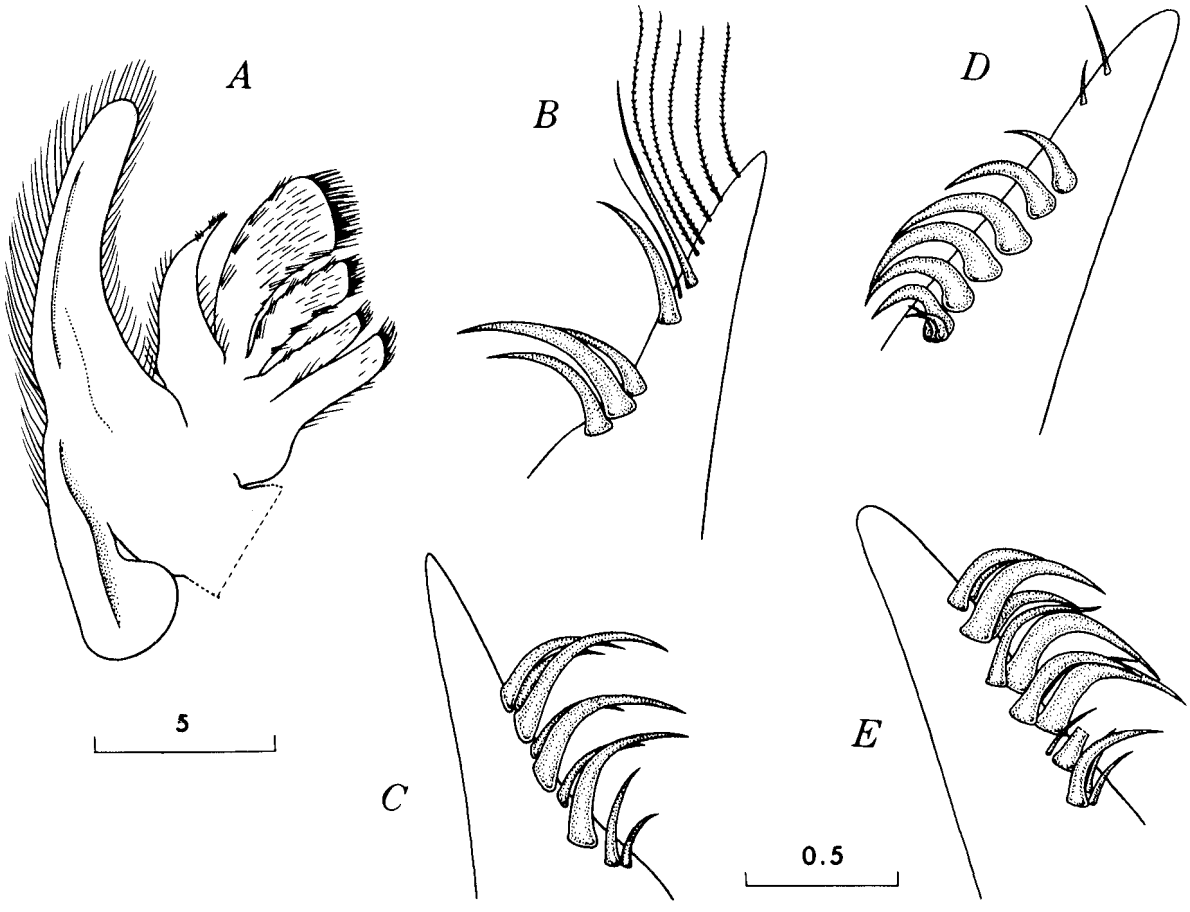

FIGURE 5.—*Hepomadus tener*. A. Dorsal view of left second maxilla, ♀ 51 mm c.l., off Atlantic City, N.J. B. Distalmost part of upper side of left endite, same specimen. C. Lower side of same endite. *Hepomadus glacialis* Bate, holotype, ♀ 65 mm c.l., near Yokohama, Japan. D. Distalmost part of upper side of endite of left second maxilla. E. Lower side of same endite.

laterally forming short, sinuous projection; articular sclerite produced proximomesially into strong, subrectangular spur situated immediately distal to large, platelike, mesially directed projection of basis of pleopod.

Appendix masculina (Figure 7A, B) broad, subfoliaceous, bearing long marginal setae on distal portion and secondary row along short rib, latter delimiting dorsal extremity of ventrally inclined distomesial portion of appendix. Appendix interna narrow, elongate, gently tapering distally to rounded extremity, and extending almost as far as, or somewhat beyond, appendix masculina.

Sternite XIII in males bearing lanceolate, median plate; sternites VIII through XII with high median ridge produced anteriorly into acute spine in males as well as in females.

Thelycum (Figure 8) with median plate on sternite XIII very elongate, reaching between midlength and anterior margin of sternite XII, roughly lanceolate, with gently undulate, or irregular, lateral margins, and rather abruptly tapering anteriorly forming usually obtuse, occasionally acute, triangular projection; sternite XIV weakly convex ventrally, convexity often embraced posteriorly by semicircular groove.

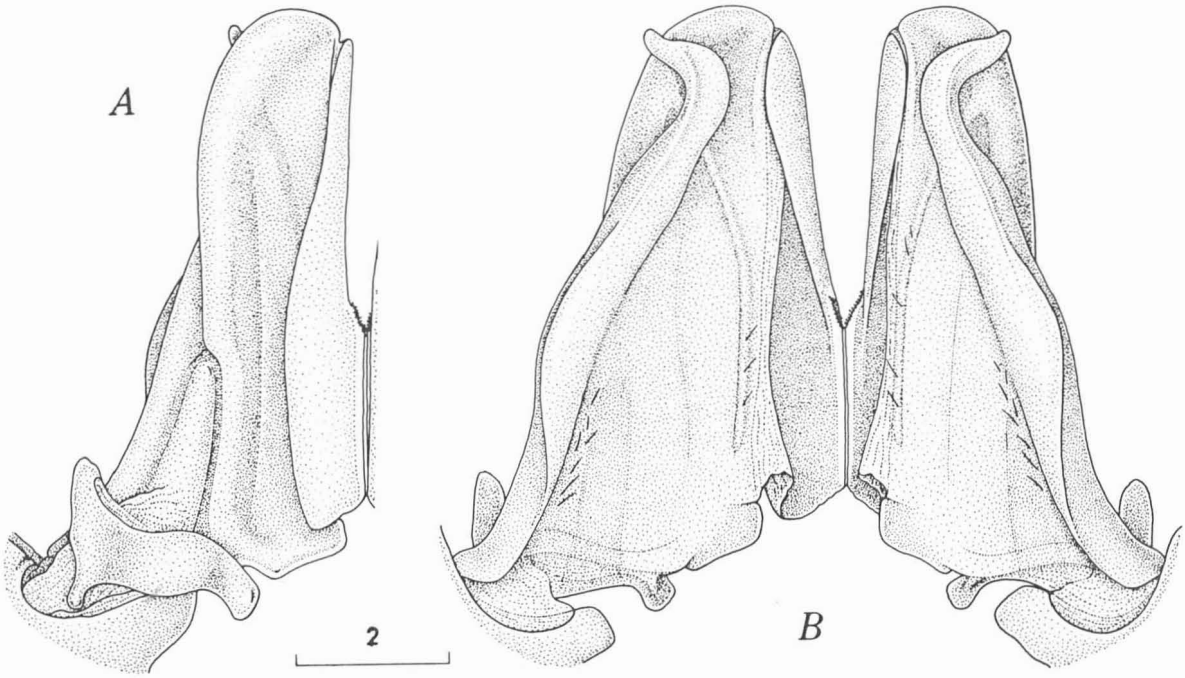

FIGURE 6.—*Hepomadus tener*. Petasma: A. Dorsal view of left half, ♂ 35.5 mm c.l., SE of Cabo Rojo, Veracruz. B. Ventral view of same petasma.

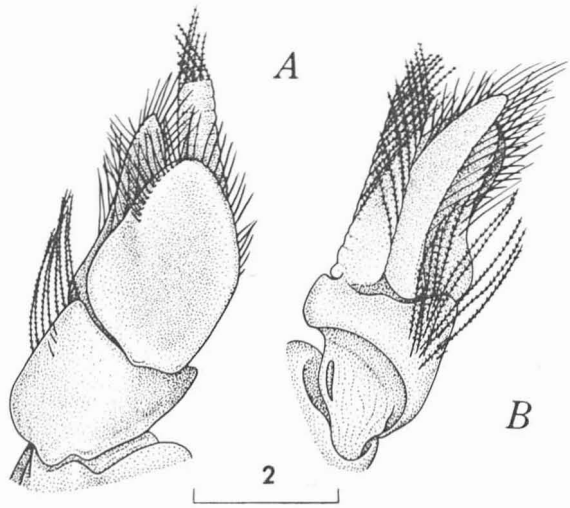

FIGURE 7.—*Hepomadus tener*. Appendices masculina and interna: A. Dorsal view of right appendix masculina and proximal part of endopod, ♂ 35.5 mm c.l., SE of Cabo Rojo, Veracruz. B. Ventral view, inclined slightly mesad, of appendices interna and masculina of same specimen.

Distribution

Off the Atlantic coast of the United States, from New Jersey southward, through the Sargasso Sea, to the Gulf of Mexico and Caribbean Sea, *H. tener* has been found at depths from 765 m (Roberts and Pequegnat, 1970) to about 5,400 m. This is the first time this species has been reported from the Caribbean, where it is widely distributed.

There are only two records of *H. tener* from localities outside the western Atlantic. Wood-Mason and Alcock (1891) questionably identified a much damaged female from the Bay of Bengal in 2,396 m. Later, Alcock (1901) apparently referring to the same specimen stated that the depth was 2305 m, and indicated that the epipod of the somite XIII consists of a tiny filament. This identification needs confirmation because the epipod is small, subrectangular and lamelliform in the western Atlantic material, as Burkenroad (1936) observed.

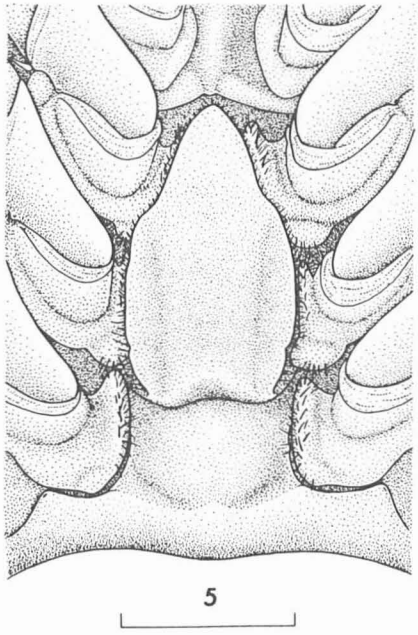

FIGURE 8.—*Hepomadus tener*. Thelycum, ♀ 47 mm c.l., off Back Bay, Va.

The other record is that of a female reported by Ramadan (1938) from off Zanzibar [Tanzania], in 2,930 m; this record leaves no doubt as to the presence of *H. tener* in the western Indian Ocean.

DISCUSSION

Previous authors (Smith, 1886; Bouvier, 1908; Burkenroad, 1936; Roberts and Pequegnat, 1970) who have reported *H. tener* from the western Atlantic have cited a number of differences between their material and specimens that had been described earlier. In addition to these western Atlantic records of this species, Milne Edwards and Bouvier (1909) identified a male from SW of Dry Tortugas Islands as *H. glacialis* on the basis of several features, including the presence of a well-defined spine on the midposterior margin of the fourth and fifth pleonic terga but, at the same time, pointed out other characters that distinguish their specimen from the type of *H. glacialis*.

Burkenroad (1936) presented a detailed discussion of the differences in various characters (e.g., shape of the proximal projection, "inner lobe," of the second segment of the mandibular palp, relative lengths of the stylocerite and the scaphocerite, development of the postrostral carina, length of the spine at the midposterior margin of the third pleonic tergum) among known specimens of *H. tener*, and interpreted the differences as individual variations or those due to differential growth rates. He also noted that the small male assigned to *H. glacialis* by Milne Edwards and Bouvier differs from *H. tener* (according to their description), in possessing a larger rostrum, a smaller interval between the last two rostral teeth, a shorter spine on the third pleonic tergum, an obtuse posteroventral tooth on each side of the sixth pleonic somite, and in lacking setae on the upper side of the endite of the basis of the second maxilla. He concluded that if such differences exist, the small male belongs to a species other than *H. tener*. Furthermore, Burkenroad stated that his specimens had no trace of a spine at the midposterior margin of the fourth and fifth pleonic terga, and that the presence of those spines in the male reported by Milne Edwards and Bouvier is the strongest reason for identifying the latter as *H. glacialis*. Later, Ramadan (1938) after examining the type of *H. glacialis*, cited three features by which Milne Edwards' and Bouvier's specimen differs from the type, and suggested that it probably represents an undescribed species.

The study of collections at my disposal as well as data presented in previous descriptions of other material indicate that all known western Atlantic *Hepomadus* are different from *H. glacialis*. During the course of the investigation it also has become evident that a considerable degree of variation exists among specimens from the region. In each of the characters considered, however, there is a broad range of variation, which seems to indicate that all the specimens belong to a single species, *Hepomadus tener*.

The principal differences between *H. glacialis*, the holotype of which has been made available to me, and *H. tener* are given in Table 1.

To analyze the various characters considered by previous authors to be of possible diagnostic

TABLE 1.—Characteristics distinguishing *Hepomadus glacialis* (holotype) from *H. tener*.

Feature	*H. glacialis* (holotype)	*H. tener*
Dorsum of carapace	Strongly arched to postcervical sulcus	Almost straight or very slightly arched, convexity extending beyond postcervical sulcus
Postrostral carina	Interrupted, disappearing on cardiac region, becoming distinct again and extending almost to posterior margin of carapace	Uninterrupted, extending posteriorly about 0.8 length of carapace
Setae on endite of basis of second maxilla		
Upper side	5 and 6 strong, 10 and 4 weak (right and left endite, respectively)	0; 2-4 strong, 1-4 weak
Lower side	5 and 9 strong, 3 and 5 weak	0; 2-5 strong, 1-4 weak

value in differentiating two species of western Atlantic *Hepomadus*, I have divided the material into three somewhat arbitrary groups based on the shape of the midposterior margin of the fourth and fifth pleonic terga: Group 1, straight; Group 2, slightly produced into a short, sometimes barely perceptible, projection; and Group 3, produced into a conspicuous spine. Intermediate stages (Group 2) between the two extremes (Groups 1 and 3) have not been discussed previously, although Bouvier (1908), in his description of a male *H. tener* from the Sargasso Sea, indicated that the dorsal carina of the fourth and fifth pleonic terga is produced into a small projection.

As stated above, Burkenroad indicated that in the specimen reported by Milne Edwards and Bouvier, which fits into Group 3, the interval between the last two rostral teeth is smaller than in the specimens with straight margins (Group 1) he had studied. I have found that this tooth interval varies considerably, from 0.30 to almost 0.60 of the distance between the first and the second tooth, and that the variations are not correlated with the shape of the posterior margin of the pleonic terga (Figure 9). It is true that according to the figure of Milne Edwards and Bouvier, in their Group 3 male (17 mm c.l.), the interval is 0.30, whereas in the Group 2 male described by Bouvier, the interval is 0.55 [according to his Figure 2, on plate 13], and in the female with 47 mm c.l., from off Virginia, belonging to Group 1, which Burkenroad had studied, the interval is 0.50. However, in the male holotype of *H. tener* (17.5 mm c.l., Group 1), which Burkenroad had not seen, the interval is 0.30, as in the 17 mm c.l. male of Group 3. Furthermore, among the material I have examined, two females of Group 3 of about same size (36 mm c.l. and 37 mm c.l.) possess a tooth interval of 0.40 and 0.60. Finally, in a small female of 14.5 mm c.l. and in another of 47 mm c.l., both belonging to Group 2, the tooth interval is about the same, 0.35 and 0.40, respectively. The data presented herein demonstrate that there are no significant differences in the tooth interval between the three groups.

The available information is too meager—particularly on animals of Group 1—to determine whether or not a clear correlation exists between the relative length of the rostrum and the shape of the midposterior margin of the fourth and fifth pleonic terga. Nevertheless, the ratio of the length of the rostrum to the length of the carapace in the specimens examined by me are presented in Table 2.

The relative length of the posteromedian spine on the third pleonic tergum varies greatly, from 0.3 of, to equivalent to, the distance between the transverse groove and the posterior margin of the tergum (adjacent to base of spine). The correlation of this ratio with increase in size of the animals seems obscure, and the correlation of the relative length of the spine with the shape of the midposterior margin of the fourth and fifth pleonic terga does not appear to indicate the presence of more than

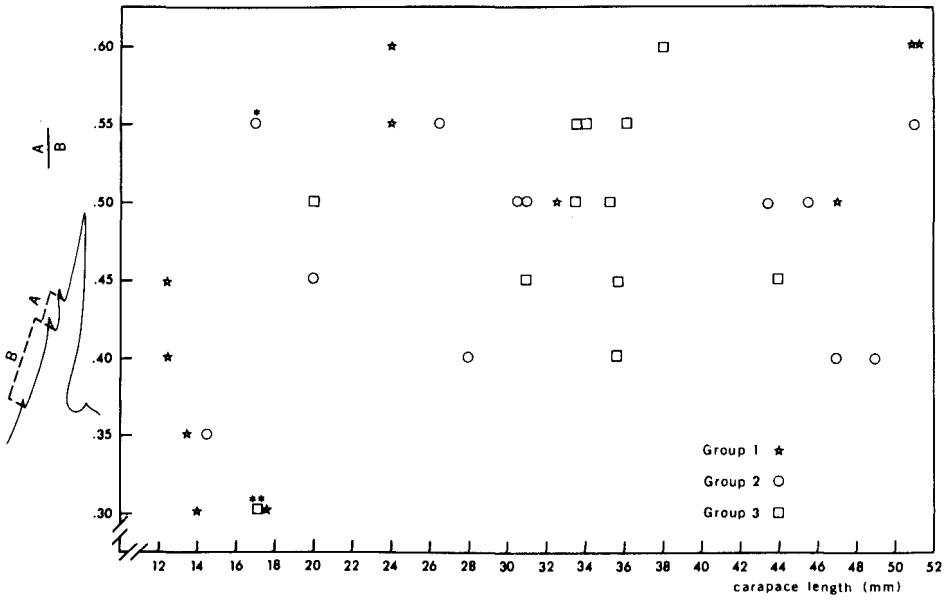

FIGURE 9.—Ratio of interval between last two rostral teeth (A) to interval between first two teeth (B) plotted against carapace length in the three groups (see text) of *Hepomadus tener*.

* Bouvier, 1908, pl. 13, fig. 2.
** A. Milne Edwards and Bouvier, 1909, pl. 1, fig. 3.

TABLE 2.—Ratio of rostrum length to carapace length at various carapace lengths (c.l.) in the three groups (see text) of *Hepomadus tener*.

c.l.	Group 1	Group 2	Group 3
12.5	♀ 0.45	—	—
	♀ 0.55	—	—
14	♂ 0.55	—	—
14.5	—	♀ 0.60	—
17.5	♂ 0.45	—	—
20	—	—	♂ 0.65
24	♂ 0.70	—	—
28	—	♂ 0.50	—
30.5	—	♀ 0.60	—
31	—	—	♂ 0.55
33.5	—	—	♀ 1.00
34	—	—	♂ 0.60
35.5	—	—	♂ 0.60
36	—	—	♀ 1.10
37	—	—	♀ 1.10
43.5	—	♀ 0.90	—
44	—	—	♀ 0.90
45.5	—	♂ 0.70	—
51	—	♀ 1.25	—

one species. In the specimens of Group 1, the ratio varies from 0.55 to 0.90 (Figure 10), in those of Group 2, from 0.30 to 1.0, and finally, in specimens of Group 3 the ratio varies from 0.30 to 0.45, except for a single individual in which the ratio is 0.55. It thus seems as if the specimens of Group 1 possess a longer spine on the third pleonic tergum than those of Group 3, but in specimens of Group 2 that spine may be as long as, or even longer, than in the specimens of Group 1, or as short as in those of Group 3.

The setation of the endite of the basis of the second maxilla varies within the same limits in the three groups, i.e., 0, or 2 to 4 strong and 1 to 4 weak setae on the upper side; and 0, or 2 to 5 strong and 1 to 4 weak setae on the lower side. Inasmuch as setae are found in many combinations and are lacking on the lower side in a few of the specimens examined by me, it seems highly probable that the absence of setae from the upper side of the endite in the specimen reported by Milne Edwards and Bouvier (1909) may very well fall within the range of individual variation within the species. I have not seen this specimen which is neither in the collection nor is it registered in the card catalog of the Museum of Comparative Zoology (Herbert W. Levi, pers. comm.).

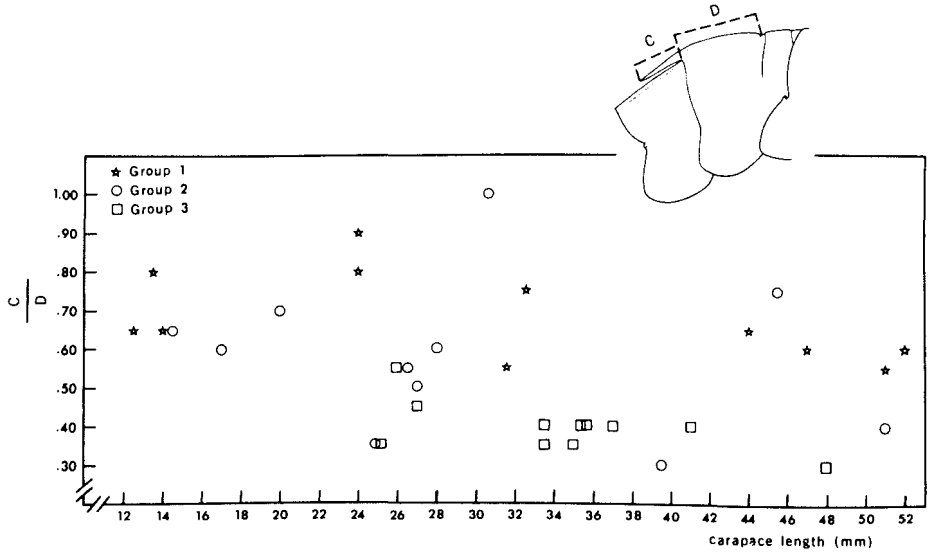

FIGURE 10.—Ratio of length of spine (C) on third pleonic tergum to distance between transverse groove and posterior margin of tergum (D) plotted against carapace length in the three groups (see text) of *Hepomadus tener*.

The differences which earlier authors have pointed out in the labrum, "epistome," among *Hepomadus*, seem to be due to changes in the relative position of its two lobes in preserved specimens. The posteroventral lobe may be only slightly raised and continuous with the anterodorsal lobe, or the posteroventral lobe may be thrust over the anterodorsal so that the two lobes become distinctly delimited.

Another character that has been cited as supposedly useful in differentiating species of *Hepomadus* in the western Atlantic is the shape of the posteroventral teeth of the sixth pleonic somite; however, it is variable, ranging from broadly triangular to subspiniform, in all three groups.

In addition to the features which have been studied by previous workers and discussed above, I have found that the length of the third pair of maxillipeds and five pairs of pereopods shows individual variation, but no consistent differences occur between the three groups; furthermore, the appendix interna may fall short or overreach the appendix masculina within each group, and also the two cicatrices on the sixth abdominal somite not only may be widely separated or almost fused within each group, but also both extremes are found in specimens of a single lot (e.g., 1 ♂ 1 ♀ taken off Alabama, at *Albatross* stn 2379).

The three groups of *H. tener* are not geographically isolated, but Groups 1 and 2 have been found off the east coast of the United States, the former ranging southward to the Bahamas and the latter to the Sargasso Sea. All three groups live in the Gulf of Mexico and the Caribbean Sea.

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