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THE FIRST LARVAL STAGE OF *MICROPROSTHEMA SEMILAEVE* (VON MARTENS, 1872) (CRUSTACEA: DECAPODA: STENOPODIDEA) OBTAINED IN THE LABORATORY

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ABSTRACT The first larval stage of *Microprosthema semilaeve* (von Martens, 1872) is described from ovigerous females collected off Sombrero Key, Florida Keys, USA, and Guana Island, British Virgin Islands, Caribbean. The larvae are characterized by a broad, triangular telson bearing posterolateral spines and an "anomuran seta," a first maxilliped that differs markedly from the very similar (to each other) second and third maxillipeds, and the presence of the first pereiopod as a swimming appendage upon hatching, as is apparently true of all stenopodidean first stage larvae. Characters of the larvae are compared to those described from the Indian Ocean by Raje and Ranade (1978) and mistakenly attributed to this same species, and to those of stenopodidean larvae described by Lebour (1941) from Bermuda plankton. Problems in identifying adult specimens of *Microprosthema* from the Caribbean are discussed.

INTRODUCTION

The decapod crustacean infraorder Stenopodidea comprises 2 families and 9 genera (see Holthuis1993) of small, lobster-like shrimp, many of which are highly colorful. The affinities of stenopodideans to other groups of decapod crustaceans has been an ongoing source of controversy and interest (e.g., see Abele 1991, Martin and Davis 2001). Despite the uncertainty that has always surrounded the relationships of stenopodideans to other decapods, and despite the recognized value of larval stages in taxonomy and phylogeny of decapods (e.g., see Rice 1980, 1983), there are surprisingly few reports of larval stages of any stenopodideans. Most of the descriptions of stenopodidean larvae are from plankton samples with authors suggesting possible species attribution based on adult zoogeographical distributions (Cano 1892, Gurney 1924, 1936, Gurney and Lebour 1941, Kurian 1956, Bourdillon-Casanova 1960, Williamson 1970, 1976, Seridji 1985, 1990). For example, Lebour (1941) (in Lebour and Gurney 1941) described some stenopodidean larvae from Bermuda plankton and was able, with some uncertainty, to assign most of them to genus level. To our knowledge, the only publications in which stenopodidean larvae have been described in any detail from eggs hatched in the laboratory are the works of Brooks and Herrick (1891) on *Stenopus hispidus* and a more recent paper by Raje and Ranade (1978), who described the larval stages of a species of *Microprosthema* from the Indian Ocean. Raje and Ranade (1978) attributed those larvae to the species *M. semilaeve* (Von Martens, 1872); however, the species could not have been *M. semilaeve*, because that species is restricted to the Caribbean and western Atlantic. Thus, Raje and Ranade described larvae of an undescribed species of *Microprosthema* that one of us (JWG) is describing (see also Goy 1987).

Microprosthema semilaeve is a commonly encountered associate of reefs and rocky areas. The species has been reported throughout the Caribbean and western Atlantic and was thought common enough by Williams et al. (1989) to be assigned the common name "crimson coral shrimp." Below, we provide the first description of the larvae of *M. semilaeve* (von Martens) obtained in the laboratory.

MATERIALS AND METHODS

This study was prompted by the discovery of several small stenopodidean shrimps collected during a survey of the cryptic marine invertebrates of Guana Island, British Virgin Islands (BVI), led by T.L. Zimmerman and J.W. Martin and funded by grants from the US National Science Foundation and the Falconwood Corporation. Although various collecting methods were employed during that survey, the single ovigerous female *M. semilaeve* from which larvae were reared was collected by hand on 18 July 2000 from BVI Station 82, Guana Island, BVI, just off North Beach, central to northeast end, in shallow water (< 1 m), from rock and coral rubble. Collectors were T. Zimmerman, J. Martin, T. Haney, and R. Ware. The ovigerous female was photographed and assigned the photographic voucher number Vc1105; she and all of the first stage larvae (except those dissected and destroyed in the process of describing them) have been deposited in the Natural History Museum of Los Angeles County and assigned catalog number LACM CR 2000-029.1. The live ovigerous female was maintained in seawater about 2 days, with larvae hatching on July 19, one day after capture of

the female. Larvae and the spent parental female were preserved in 70% ethanol. Illustrations of the larvae were made using a Wild M5 stereoscope, a Wild M5 APO stereoscope, or a Nikon Labophot compound microscope, all equipped with drawing tubes. Earlier, another ovigerous female of *M. semilaeve* was collected by Tim Green off Sombrero Key, Florida Keys, USA, at a depth of 5 m in coral rubble on 24 June, 1989. This specimen was brought to one of us (JWG) on 26 June, 1989. From this female, 43 eggs hatched in a prezoeal stage in the laboratory, but only 2 of these prezoeae subsequently transitioned into first zoeae.

Other Caribbean material (adults only) was examined during a visit (JWM) to the US National Museum of Natural History in February 2001, including the following specimens: USNM 233997, *Microprosthema manningi* Goy and Felder (holotype); USNM 275993, *Microprosthema granatense* Criales (holotype); and USNM 244439, Bahamas, *M. semilaeve* ovigerous female (non-type specimen).

RESULTS

Prezoeal Stage (based on $n = 10$ larvae from adult female from Sombrero Key, Florida)

Size. Total length (rostral region to tip of telson) 2.1 mm ($n = 10$).

Rostrum turned under carapace, but antennae fully extended. Appendages developed, but with setae not fully extended on any appendage. Telson well formed, similar to that of first zoeal stage (see below).

This prezoeal stage was very feeble and used its antennae to swim. The duration to first molt was less than 6 h, but only 2 of 43 survived this molt.

First Zoeal Stage (based on $n = 10$ larvae from adult female from Guana Island, BVI)

Size. Total length (tip of rostrum to posterior indentation of telson) 2.20 mm ($n = 10$). Carapace length (orbital region at base of rostrum to dorsal posterior indentation of carapace) about 0.56 mm.

Carapace (Figure 1a, b). Extending posteriorly in a more or less straight line from the rostrum. Cervical groove slight but visible just posterior to large, well developed (but sessile) eyes. Dorsally with medial rounded invagination. Minutely punctate and minutely granulate, especially on posterolateral half. Rostrum straight, unornamented, extending to level just short of distal extremity of second peduncular article of antennule.

Antennae (Figure 1d). Antennule (first antenna) biramous, but with inner ramus (endopod) so reduced as to appear as a single thick plumose seta. Outer (lateral) ramus (exopod) short, about 1/3 length of article preceding it, and with 4 plumose distal setae. More proximal articles (1 and 2) unarmed, second longer than first. Antenna (second antenna) inner ramus (endopod) short, approximately half length of exopod, and with 2 long, stout plumose setae; outer ramus (exopod) with curving inner border and nearly straight lateral border, bearing 7–11 setae from midpoint on medial border around tip and on to distolateral edge of lateral border as shown.

Mandible (Figure 2a). Broad, simple, spade-shaped, with slight tooth at dorsodistal corner. Palp lacking. Slightly asymmetrical.

Maxillule (maxilla 1) (Figure 2b). Protopod consisting of 2 lobes; anterior lobe with 2 heavy cuspidate and serrate spines and 3 plumodenticulate setae; posterior lobe with 2 stout spines, 2 plumodenticulate setae, and one heavier seta extending posteriorly from lower margin. Palp lacking.

Maxilla (maxilla 2) (Figure 2c). Endopod 2-segmented with setation 1 + 2 as illustrated. Protopod subdivided into 3 large enditic lobes, with setation 5, 3, and 4 (proximal to distal). Scaphognathite poorly developed, with 2 to 4 plumose setae and usually a stronger setose "posterior process."

Maxilliped 1 (Figure 2d). Endopod weakly 3-segmented, with setation 2, 2, 4. Exopod unsegmented, with 4 distal plumose setae. Protopod weakly 2-segmented; basal article with 2 plumodenticulate setae; distal article subdivided into 3 lobes, with setation 3, 2, 2; some setae distinctly stronger and more spinulose than others, especially noticeable on posteriormost lobe of second article.

Maxilliped 2 (Figure 2e). Basis with 4 setae arranged 1, 1, 2. Endopod 5-segmented, with setation 2, 1, 0, 2, 1 + 5. Exopod 2-segmented, with setation 1, 5.

Maxilliped 3 (Figure 2f). Very similar to maxilliped 2. Basis with 3 setae occurring singly. Endopod 5-segmented, with setation 2, 1, 0, 1, 4. Exopod weakly 2-segmented, with setation 1, 4.

Pereiopod 1 (Figure 2g). Endopod small, bearing 3 terminal, 1 subterminal, and 1 basal plumose setae. Exopod with numerous crenulations and bumps, 2-segmented, with 2 setae on proximal article and 4 setae (arranged 2 + 2) on distal article. Other pereiopods absent.

Abdomen and Telson (Figure 1b, c). Abdomen with minute teeth on posterolateral borders of somites 3 and 4, and with sharp spine extending ventrally from sternal region of somite 5 (Figure 1c). Sixth abdominal somite not distinguishable from (fused to) telson. Telson (Figure 1e, f) broadly triangular in dorsal view. Lateral corners ending in acute tooth, followed immediately by a stout, setose artic-

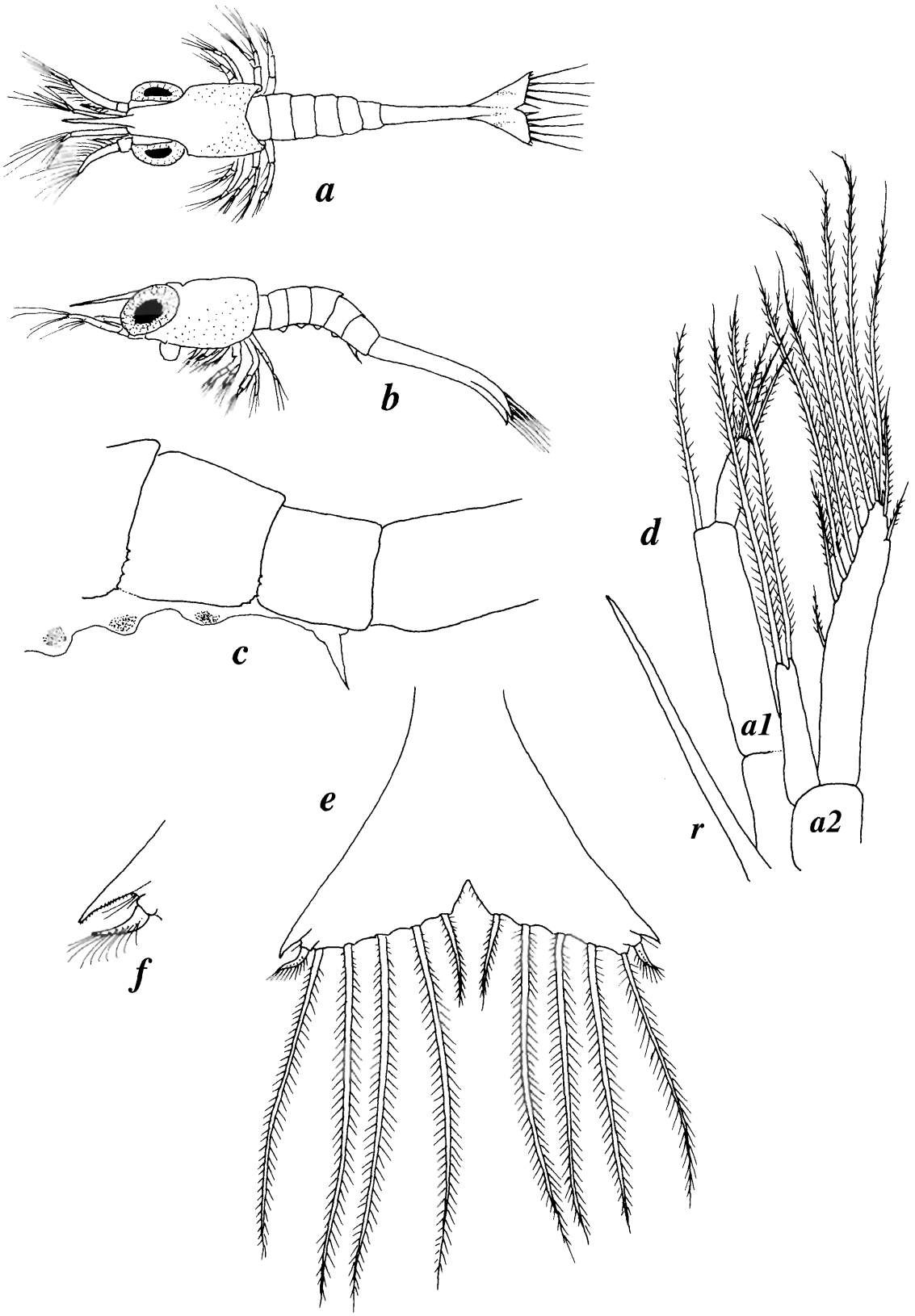

Figure 1. First zoeal stage of the stenopodidean shrimp *Microprosthema semilaeve* (von Martens, 1872) from an ovigerous female collected off Guana Island, BVI, Caribbean Sea. a, entire larva, dorsal view. b, same, lateral view. c, higher magnification of abdominal somites 3–5 and anterior of somite 6 (still fused to telson at this stage), showing acute spine extending from sternum of somite 5. d, rostrum (r), antennule (first antenna) (a1), and antenna (second antenna) (a2) in dorsal view, drawn in situ. e, telson, dorsal view. f, higher magnification of posterolateral spines of telson, dorsal view.

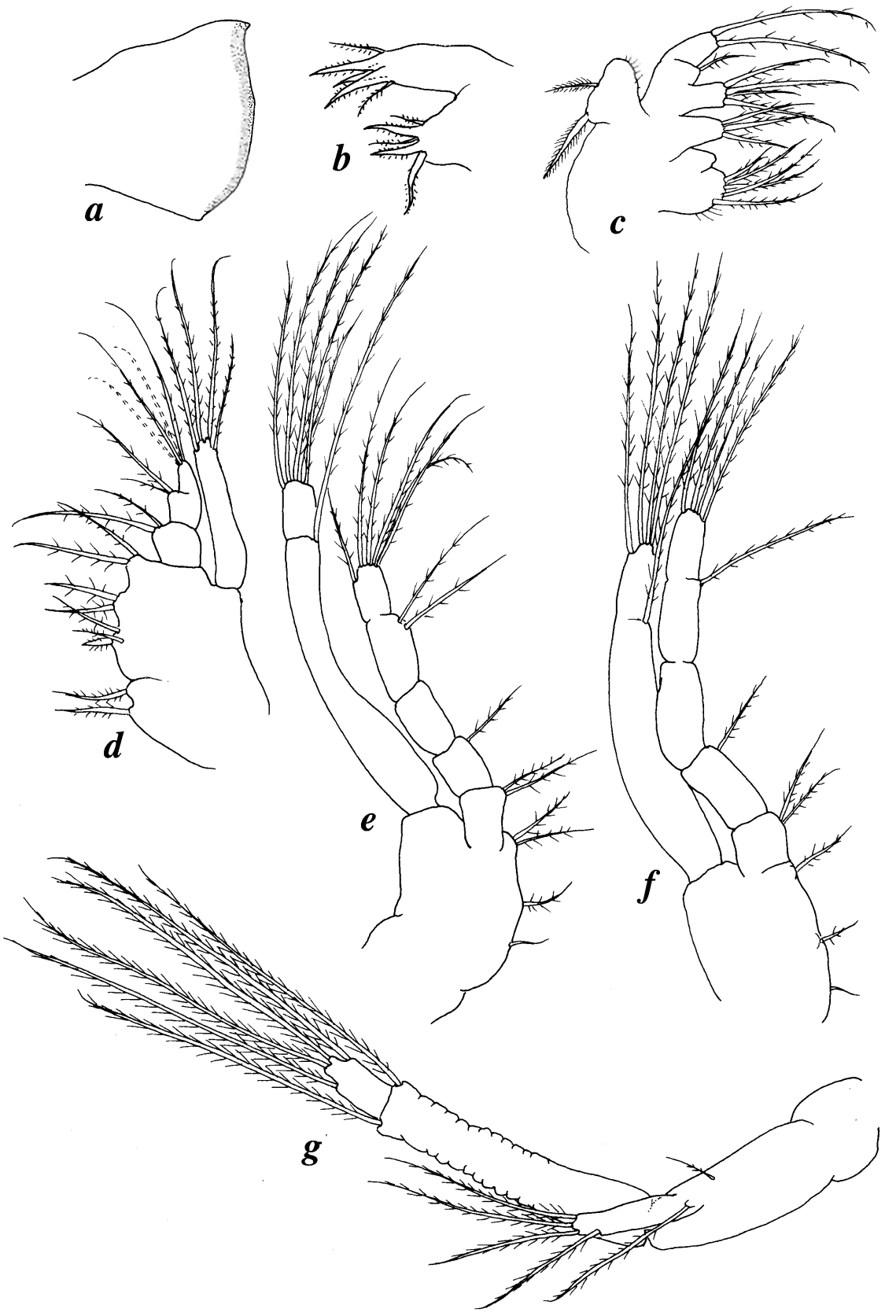

Figure 2. First zoeal stage of the stenopodidean shrimp *Microprosthema semilaeve* (von Martens, 1872), mouthparts and first pereiopod. a, mandible. b, maxillule (first maxilla). c, maxilla (second maxilla). d, first maxilliped (2 setae broken on distal article of endopod of illustrated specimen indicated by dashed lines). e, second maxilliped. f, third maxilliped. g, first pereiopod.

ulating spine that curves dorsally and laterally. Area between tooth and spine harboring single "anomuran seta," which in some cases is actually 2 or 3 thin setae (Figure 1f). Posterior border of telson with shallow sharp indentation medially, and with 4 long plumodenticulate setae and 1 considerably shorter plumodenticulate seta on each side of medial indentation.

First Zoeal Stage (based on $n = 2$ larvae from adult female from Sombrero Key, Florida)

Size. Total length (tip of rostrum to posterior indentation of telson) 2.25 mm ($n = 2$); carapace length not measured.

Antennae, maxillule, mandible, and maxilliped 1 same as described above for Guana Island specimens.

Abdominal somites 2 and 3 ending in bluntly pointed pleural spines. Telson same as above.

Maxilla. Palp bearing 2 terminal plumose setae. Protopod subdivided into 3 large endites, with setation 3, 4, and 5 (proximal to distal). Scaphognathite weak, with 5 plumose setae.

Maxilliped 2 same as above, except exopod with setation 2, 4.

Maxilliped 3 same as above, except exopod with setation 2, 4.

Pereiopod 1 same as above, except endopod with 2 basal plumose setae and exopod lacking crenulations and with setation 2, 4.

DISCUSSION

There are currently 5 described species of *Microprosthema* reported from the Caribbean and/or western Atlantic: *M. semilaeve* (von Martens, 1872); *M. manningi* Goy and Felder, 1988; *M. looensis* Goy and Felder, 1988; *M. granatense* Criales, 1997; and *M. jareckii* Martin, 2002 (see reviews by Criales 1997, Martin, 2002). The species *Microprosthema inornatum*, described by Manning and Chace (1990) from Ascension Island, South Atlantic, could potentially be in the Caribbean as well, because species of stenopodideans tend to have a relatively long larval duration (J. Goy, unpublished data) and as many as 9 larval stages (Gurney and Lebour 1941), though possibly fewer in species of *Microprosthema* (e.g., Raje and Ranade 1975). Additionally, we are aware of another undescribed species of *Microprosthema* from the Dry Tortugas, Florida (J. Goy, unpublished data).

The female *M. semilaeve* from Sombrero Key was confirmed by one of us (JWG) after examination of 80 specimens of *M. semilaeve* in the holdings of various US museums. Confirming the identification of the adult parental female from Guana Island from which larvae were obtained proved more difficult than we anticipated. The coloration of the adult was a striking red and white, matching closely with the color description of *M. semilaeve* provided by Manning (1961) and befitting the common name "crimson coral shrimp" bestowed on it by Williams et al. (1989). However, the chelipeds of the parental female from Guana Island are more delicate and lack the large dactylar tooth as compared to "typical" *M. semilaeve* in the holdings of the USNM. Additionally, the chelae possessed a layer of fine, short, plumose setae on the inner face of the propodus. Comparison with specimens or illustrations of "true" *M. semilaeve* proved to be difficult, as that species has not been illustrated other than by Rankin (1898, side view of whole animal), Holthuis (1946, scaphocerite only), and Rodriguez (1980, partial views of carapace and abdomen). Thus, although commonly reported in the literature, this species lacks a thorough modern description. For the purposes of this report we are assuming that the crimson and white coloration is specific to this species, and thus we are referring our Guana Island specimen and its larvae to *M. semilaeve*.

The prezoeal stages obtained from the female collected at Sombrero Key are similar to the prezoeae of *Stenopus hispidus* described by Brooks and Herrick (1891). Those authors noticed a bent rostrum and underdeveloped appendages, but their prezoeal stage was non-natatory. In the present study, *M. semilaeve* prezoeae swam feebly with their antennae. It is not known if the larvae hatch as prezoea in the wild or if this was an artifact of rearing them in the laboratory, although we saw no other indications that anything was abnormal, and the ovigerous female did not appear stressed.

First stage larvae of *M. semilaeve* described herein are morphologically very similar to the larvae described by Raje and Ranade (1978) for an Indian Ocean species of *Microprosthema* (which was erroneously attributed to *M. semilaeve*). Differences include the mandible, which in *M. semilaeve* appears broadly rounded and not as toothed as in the figure provided by Raje and Ranade (1978, their figure 1d), and overall less setose appendages in the Indian Ocean larva. The first and second abdominal somites of the Indian Ocean species bear ventral projections not evident in our specimens. Finally, there are slight differences in the setal counts of some of the articles of the mouthparts and of the endopod of the first pereiopod. Although there is no doubt that the species dealt with by Raje and Ranade (1975) was not *M. semilaeve*, the slight discrepancies in the 2 larval descriptions might be simply differences in perceiving or illustrating the appendages. Such minor variation can also be attributable to variations within or

between populations of the same species or even within a single batch from one female. Interestingly, the differences noted between the description of larvae of *Microprosthema* sp. from the Indian Ocean (Raje and Ranade 1975) and our Guana Island larvae are not appreciably larger than the differences between the Guana Island (BVI) specimens and those from Sombrero Key, Florida, which we are assuming are conspecific.

Of the various stenopodidean larvae described from Bermuda plankton by Lebour (1941), their larvae A, B, and C are most similar to ours. Raje and Ranade (1978) also felt that larvae A and B of Gurney and Lebour were most similar to their description of *Microprosthema* larvae from the Indian Ocean and noted that B was "closer to *Microprosthema* than any other species described." However, Raje and Ranade also noted differences between their Indian Ocean larvae and both larvae A and B of Lebour (1941). Lebour (1941) thought that larva B, the most common larval type encountered by her off Bermuda, was possibly an undescribed species of the genus *Stenopus* (recall that the genus *Microprosthema* was not established at that time), and later in the paper she stated that "it seems probable that species A, B, C, E, and F do not belong to the genus Stenopus." Our description of larvae of *M. semilaeve* (Von Martens) differs from her larvae A and B in having a shorter rostrum, a straight (rather than recurved) spine on the sternum of abdominal somite 5, and no postorbital spines.

There was some variation observed in the first zoeae of *M. semilaeve* in the present study. Similar variation has been seen in the first zoeae of *Stenopus spinosus* (Cano 1892, Kurian 1956, Bourdillon-Casanova 1960, Seridji 1990), *S. hispidus*, *S. pyrsonotus*, and *S. cyanoscelis* (JWG, unpublished data). Lebour (1941) described a postlarva of her Stenopodid B (total length 5.0 mm) that is very similar to 3 juveniles of *M. semilaeve* (total length 7.6–8.3 mm) examined by one of us (JWG). Taking these facts into consideration, we feel that the larvae of Gurney (1936—Stenopodid I) and Lebour (1941—Stenopodid B) represent planktonic larvae of *M. semilaeve*.

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