18 December 1992
PROC. BIOL. SOC. WASH.
105(4), 1992, pp. 674–682

OBSERVATIONS ON AND REDESCRIPTION OF *MEIOMENIA ARENICOLA* SALVINI-PLAWEN, 1985 (MOLLUSCA: APLACOPHORA), AN INTERSTITIAL SOLENOGASTER FROM FORT PIERCE, FLORIDA

M. Patricia Morse and Jon L. Norenburg

Abstract.—The interstitial solenogaster, *Meiomenia arenicola,* is redescribed and illustrated from material collected in coarse sand sediments off Fort Pierce Inlet, Florida. Included are observations of living organisms and comparisons with other interstitial aplacophorans.

Interstitial solenogasters of the subclass Neomeniomorpha occur as part of a molluscan assemblage in coarse sand environments (Swedmark 1968, Scheltema 1978, Morse & Scheltema 1988). The assemblage includes species of the opisthobranch orders Acochlidiacea and Nudibranchia and is known from temperate zones at Crow Neck, Maine (Morse 1976) and San Juan Island, Washington (Morse 1979) and in tropical habitats at Viti Levu, Fiji (Morse 1987) and Belize, Central America (Morse & Norenburg, personal observations). A similar assemblage was found in a subtropical area in coarse to moderately coarse subtidal sediment at several sites off the Fort Pierce Inlet, Florida. Here the solenogasters are represented by at least three species of the subclass Neomeniomorpha and appear to dominate this molluscan assemblage. The species to be discussed here is similar to a species, *Meiomenia arenicola,* tentatively described by Salvini-Plawen (1985) from two specimens (0.6 mm and 1.2 mm) collected from sand at 40 m off the coast of North Carolina (34°45′N, 75°45′W). The following descriptions include observations on living animals and indicate that members of the genus *Meiomenia* Morse, 1979, have morphologies that facilitate movement among sediment particles and characterize these aplacophorans as interstitial.

Materials and Methods

Five sediment samples were collected with a sled dredge during a 10-year period by the R/V *Tursiops,* R/V *Snook,* or R/V *Sunburst* of the Smithsonian Marine Station at Link Port. Two samples were collected in approximately 16 m of water 9.6 Km off the Fort Pierce Inlet (27°29.13′N, 80°11.65′W) and three in 11 m of water at Capron Shoals (27°26.43′N, 80°14.15′W). The sediment, predominantly biogenic carbonates, might be described as moderately coarse shell sand. Sediment was held in buckets from which subsamples were removed and agitated in fresh seawater. Suspended organisms were collected on a 150-μm nylon screen and then resuspended in seawater in petri dishes.

The solenogasters were studied alive (both intact and squashed) or relaxed in 7.5% magnesium chloride in distilled water for subsequent fixation. They were fixed in 70% ethanol or 3% glutaraldehyde in 2 M cacodylate buffer for use in scanning electron microscopy (SEM). For light microscopy, relaxed specimens were placed in Hollande's fluid, embedded in polyester wax, sectioned at 7 μm and stained with Heidenhain's Azan. Four slides of a single serially-sectioned *Meiomenia arenicola* (USNM 86031) and a whole animal fixed in 70% alcohol (USNM 86032) have been depos-

ited in the Division of Mollusks of the National Museum of Natural History, Smithsonian Institution.

Results

Meiomenia arenicola (Fig. 1) are minute aplacophorans measuring up to 1.5 mm in length with an average size of 1.2 mm long and 0.1 mm wide (n = 16). About forty additional specimens were of similar size. The body is covered by a coat of scales, spines and spicules (Fig. 18C–G). Characteristic of the genus *Meiomenia* are elongate lateral spicules. Posteriorly the body is slightly flattened with elongate spines distributed around the posterior margin of the body.

The most common spicules are the oval body scales (Fig. 2, BS). These scales are overlapping and attach to the underlying epidermis by a ball-and-socket arrangement, the "socket" located on the anterior half of the scale. Elongate oval paddle scales are scattered in small numbers among the common body scales. These have a projecting basal attachment which anchors the scales into the integument (Fig. 2, PS, BA).

Elongate spines occurring along the lateral surfaces of the body are especially conspicuous on the anterior third of the body. They are slightly flattened and have a characteristic proximal bend and a circular basal attachment (Figs. 3, 4). These lateral spines vary considerably in number, independent of body size, from 5 to 30 or more along the anterior third of the body, and from 0 to 30 or more along the posterior two-thirds of the body. Most commonly there are about 30 in each region. In contrast with the lateral spines of the anterior third, the more posterior spines taper to a point (Fig. 9), and like the anterior spines, are flattened and have a circular basal attachment (Figs. 10, 11). There are usually 5–10 of these pointy spines fringing the caudal margin.

At the anterior end of the crawling animal two protuberances project forward (Fig. 5) as well as bundles of elongate cilia forming three anteriorly projecting bristles. The protuberances can be withdrawn into the vestibule (Fig. 1). Associated with the protuberances are vestibular scales (Figs. 6–8). These minute triangular scales are thickened along their proximal edges and have elaborate basal attachments into the integument. The distal surface is serrated, with some variation in appearance (Figs. 7, 8). The variation may be a result of wear as the smaller scales (Fig. 8) have more elongate serrations. These scales are associated with surfaces that are usually everted as the animal crawls on a slide. Thus the distal margins of these scales would be in constant contact with surrounding sediments.

A dorsoterminal organ (dorsoterminal sense organ auctt.), located close to the posterior margin of the body, is surrounded by a variable number (7–10) of small spicules (Figs. 9, 10, 12). On contraction, the organ is directed posteriorly so that it may not be observable. The spicules are approximately triangular, with a point directed medially and often upward, resulting in a crown-like appearance when seen laterally (Fig. 12).

The pedal groove (Fig. 14), which contains the ciliated foot, is along the ventral side, beginning just behind the oral vestibule. The pedal groove is lined on both sides by projecting and overlapping pedal scales (Fig. 13) attached by a ball-and-socket arrangement like that of the body scales. The pedal scales are flattened and elongate with a slight rounding and thickening at the "socket," the point of attachment to the pedal furrow.

The digestive system (Fig. 5) begins at the mouth opening where a long oral tube leads into the buccal mass that contains the radula (Fig. 5). The radula (Fig. 18A, B) is distichous and consists of eight to twelve (more often 11 or 12) rows of teeth but these are difficult to count with certainty. Each tooth has four denticles. Paired salivary glands (Fig. 5, SG) empty into the buccal cavity, from which the esophagus (Fig. 5) leads pos-

associated with the presence of recognizable testes as they have not been observed in specimens without recognizable gametes, and a specimen with immature ova had no copulatory spicules. Immature ova have been observed anterior to the copulatory spicules and, in one specimen, a large presumably mature ovum was positioned medially immediately posterior to the copulatory spicules. Large vitellogenic eggs (Fig. 17) often are seen. Packages of minute tubes that might represent packets of sperm were observed associated with the spicules (Fig. 16) but this needs to be verified by further ultrastructural examination.

Meiomenia arenicola is an active aplacophoran that continuously changes its shape while being observed in a glass dish (Fig. 17). The animals move by ciliary gliding or in an inch-worm fashion, contracting and elongating their body, while routinely changing direction and probing with the anterior protuberances as they move. Living animals exhibit a distinct, albeit somewhat weak, adhesive response at the posterior end when disturbed, but a terminal adhesive gland has not been identified.

Discussion

The initial description of *Meiomenia arenicola* by Salvini-Plawen (1985) tentatively placed it in the genus *Meiomenia*. In that paper, the author rediagnosed the genus and noted "without dorsoterminal sense organ." Neither presence nor absence of this organ was part of the original generic diagnosis (Morse 1979) nor is there currently evidence that the dorsoterminal organ found in *M. arenicola* is a sense organ. More studies are needed to determine the functional cytomorphology of the dorsoterminal organs in neomenioids and their relationship to sense organs of other aplacophorans as described by Haszprunar (1987). Usually this organ can be observed only at the relatively high magnification of the compound light microscope or scanning electron microscope, and it was only definitively identified in slightly less than half the specimens

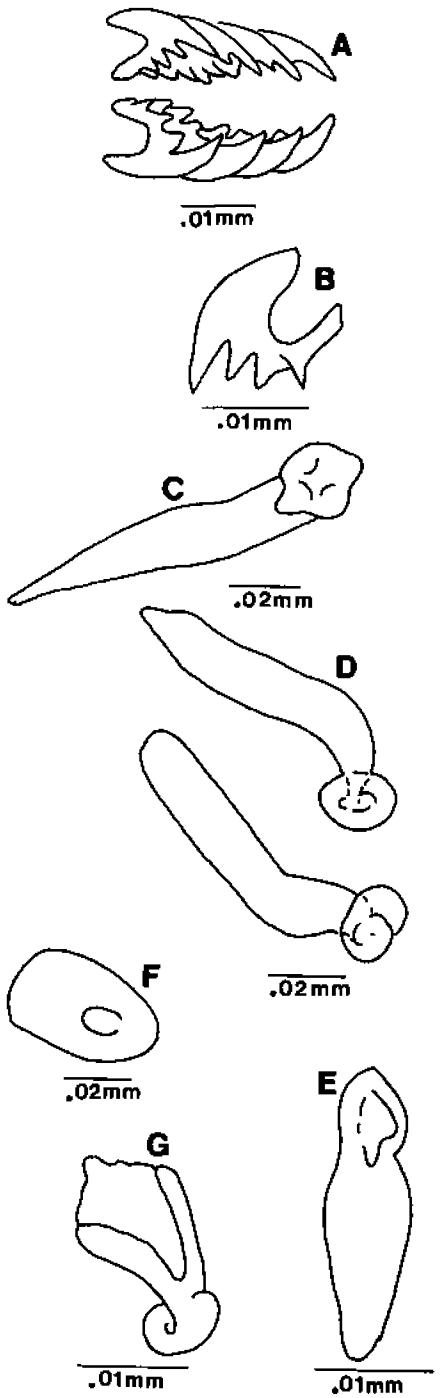

Fig. 18. Diagrams of spicules, spines and radula of *Meiomenia arenicola* A, Group of radular teeth of distichous radula; B, Single radular tooth with four denticles; C, Posterior elongate spine; D, Lateral body spines; E, Pedal spicule; F, Oval body scale; G, Vestibular scale.

so examined. We consider reports of its absence a dubious diagnostic character in the absence of adequate numbers of specimens and therefore by the original genus designation (Morse 1979) this species can be placed in the genus *Meiomenia*.

Meiomenia arenicola can easily be distinguished from *M. swedmarki* Morse, 1979 by the radula. The distichous radula in *M. arenicola* has up to 12 rows and each tooth has four denticles, whereas *M. swedmarki* has 26 rows and each tooth has six denticles. Both of these organisms have elongate body scales with an elaborate basal attachment that may aid in movement through the sediment pore spaces. A single nematocyst was found in a squash preparation of *M. arenicola*, which would suggest that they feed on cnidarians.

Acknowledgments

The authors wish to thank Dr. M. E. Rice, Director of the Smithsonian Marine Station at Link Port for providing support and facilities, H. Reichardt and W. Lee for their excellent field work, and Dr. N. W. Riser and B. Fowle for helpful discussions. We thank Dr. A. Scheltema for her thorough review of the manuscript and helpful discussions. This is contribution #299 from the Smithsonian Marine Station and contribution #195 from the Marine Science Center, Northeastern University.

Literature Cited

Haszprunar, G. 1987. The fine morphology of the osphradial sense organs of the mollusca. IV. Caudofoveata and solenogastres.—Philosophical Transactions of the Royal Society of London B 315:63–73.

Morse, M. P. 1976. *Hedylopsis riseri* sp. n., a new interstitial mollusc from the New England coast (Opisthobranchia, Acochlidiacea).—Zoologica Scripta 5:221–229.

———. 1979. *Meiomenia swedmarki*, gen. et sp. n., a new interstitial solenogaster from Washington, USA.—Zoologica Scripta 8:249–253.

———. 1987. Distribution and ecological adaptations of interstitial molluscs in Fiji.—American Malacological Bulletin 5:281–286.

———, & A. H. Scheltema. 1988. Aplacophora. Pp. 447–450 *in* R. P. Higgins & H. Thiel, eds., Introduction to the study of Meiofauna. Smithsonian Press, Washington, 488 pp.

Salvini-Plawen, L. v. 1985. New interstitial solenogastres (Mollusca).—Stygologia 1:101–108.

Scheltema, A. H. 1978. Position of the class Aplacophora in the phylum Mollusca.—Malacologia 17:99–109.

Swedmark, B. 1968. The biology of interstitial Mollusca.—Symposium of the Zoological Society of London 22:135–149.

(MPM) Marine Science Center and Biology Department, Northeastern University, Nahant, Massachusetts 01908, U.S.A.; (JLN) Department of Invertebrate Zoology, National Museum of Natural History, Washington, D.C. 20560, U.S.A.