

TWO NEW SPECIES OF *PHASCOLION*
(SIPUNCULA: PHASCOLIONIDAE) FROM TROPICAL
AND SUBTROPICAL WATERS OF THE
CENTRAL WESTERN ATLANTIC

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Abstract.—*Phascolion (Isomya) gerardi*, a new species of Sipuncula, is described from littoral waters of the Bahamas, Belize, and the Yucatan coast of Mexico where it inhabits rubble associated with coral reefs. A new interstitial species, *Phascolion (Phascolion) psammophilum*, is described from depths of 15–19 m off the coast of east central Florida. It is the first sipunculan, documented as an adult rather than juvenile, to be reported as a member of the meiofaunal community. Observations on development, resulting from laboratory spawnings, reveal a typical lecithotrophic trochophore and a short-lived, lecithotrophic pelagosphaera larva that transforms into a crawling juvenile at 4 days of age. Station data for these collections are presented in an appendix at the end of the paper.

In collections of sipunculans from the waters of the southeastern coast of Florida, the Bahamas, and the Caribbean, two new species of *Phascolion* have been discovered. These collections were made for a systematic survey, currently in progress, of the phylum of marine worms, Sipuncula, in the western central Atlantic Ocean. Although a number of authors have described localized collections from these waters (cf. Fischer 1922; ten Broeke 1925, Murina 1967a, 1967b; Rice 1975) a comprehensive survey of the systematics and distribution of sipunculans from south Florida, the Bahamas, and the Caribbean has not been undertaken.

The most recent classification of the phylum Sipuncula is that of Gibbs and Cutler (1987) who defined two classes, four orders and six families. In a separate treatment of the family Phascolionidae, Cutler & Cutler (1985) recognized two genera, *Phascolion* and *Onchnesoma*. In the smaller genus *Onchnesoma* only 4 species are listed, whereas in *Phascolion* 5 subgenera and 23

species are distinguished. The present paper adds two species to the genus *Phascolion*.

Family Phascolionidae Cutler & Gibbs,
1985

Genus *Phascolion* Théel, 1875

Subgenus *Isomya* Cutler & Cutler, 1985

Phascolion gerardi, new species

Fig. 1

Material examined.—Bahamas: Berry Islands (Rice, Sta. 209), 1 specimen, Belize: South Water Cay and Curlew Bank (Rice Sta. 263, 264), 7 specimens. Mexico: Puerto Morelos reef (Rice, Sta. 265, 268), 4 specimens.

Holotype: USNM 160243.

Paratypes: USNM 160244-160248.

Diagnosis.—Total body length averaging 17 mm. Thick trunk sometimes cylindrical, but more often spherical in living specimens. Thin, narrow introvert one to two times the length of trunk. Prominent papillae, mammillate or elongate and cone-shaped, distributed closely over the entire

trunk, largest and most elongate at anterior and posterior extremities; larger papillae often with multiple tips. Less conspicuous, sharply tapered papillae over introvert. Up to 24 digitiform tentacles surround mouth. Nuchal organ forms corrugated band surrounding dorsal half of introvert at base of tentacular crown. Bulbous expansion of introvert beneath tentacles bears numerous, irregularly arranged simple, curved hooks. Ventral retractor muscle divides in mid-trunk, each branch attaching to body wall on either side of ventral nerve cord in posteriormost trunk. Single dorsal retractor muscle attaches posteriorly at same level as ventrals. Dorsal and ventral muscles separate at anterior extremity of introvert, remaining attached by mesenteries to esophagus for length of introvert. Intestine looped, attached to body wall by fixing muscles. Long rectum, ending at anus on mid-introvert. Single right nephridium opening in anterior trunk. Gonad at base of ventral retractor muscles.

Description.—Of the 12 specimens on which this description is based, the tentacles were extended in 10 and the entire introvert was retracted in the others. The digitiform tentacles, having grooves on the inner surfaces leading to the central mouth, numbered 9 to 24 (Fig. 1a–c). The total body length (introvert plus trunk) ranged from approximately 8 to 30 mm; the introvert to trunk ratio ranged from 1.0 to nearly 3. Larger specimens, as a rule, had more tentacles than smaller. Depending on the state of contraction of the specimen, the region of the introvert just posterior to the tentacular crown may be expanded into a bulbous shape. The nuchal organ is a distinctive dorsal band that extends half way around the base of the tentacles, becoming narrower laterally (Fig. 1c). It is distinguished by the numerous irregular folds or longitudinal corrugations. The “neck” or the area anterior to the bulbous expansion is smooth and its posterior border in many specimens appears as an undulating fold. Covering the

surface of the bulb are scattered hooks. The hooks are brown, curved, and simple, averaging 30 μm in basal width and 20 μm in height (Fig. 1d). One of the most distinctive external features of this species is the form, prominence and abundance of the papillae (Fig. 1a, e, f). They cover the entire trunk and are commonly largest at the anterior trunk or base of the introvert, and next largest at the posterior extremity. The largest papillae are elongate, often cone-shaped with two to three pores opening on apical protrusions; others have a tapered or rounded apex and a single pore. Small, sharply tapered papillae are closely distributed over the introvert. The anus is situated dorsally in the mid-introvert (Fig. 1a, g). Internally the retractor muscle column separates in the anterior introvert into a ventral and a dorsal retractor of similar diameter (Fig. 1g). The esophagus is enclosed between the two muscles, to which it is attached by mesenteries, for the length of the introvert, separating from the dorsal mesenteric connection slightly above the ventral separation. The ventral retractor muscle splits in mid-trunk into two muscles which attach on either side of the ventral nerve cord close to the posterior extremity. A single dorsal muscle attaches posteriorly at about the same level as the ventrals. In all specimens dissected (6/12) the posterior end of the contractile vessel appears as a prominent bulge along the esophagus, where the latter presumably merges with the intestine. At this level a prominent fixing muscle attaches the esophagus to the dorsal body wall in the mid-trunk. The intestine forms several loose loops which are attached to the body wall by numerous other fixing muscles. The intestine sometimes forms a short spiral of 2 or 3 coils posteriorly. A long rectum extends to the anal opening in the mid-introvert. A single right nephridium opens in the anterior trunk and is attached by mesenteries to the body wall for most of its length. A nodule occurring on the left side at the same level as the right nephridiopore may rep-

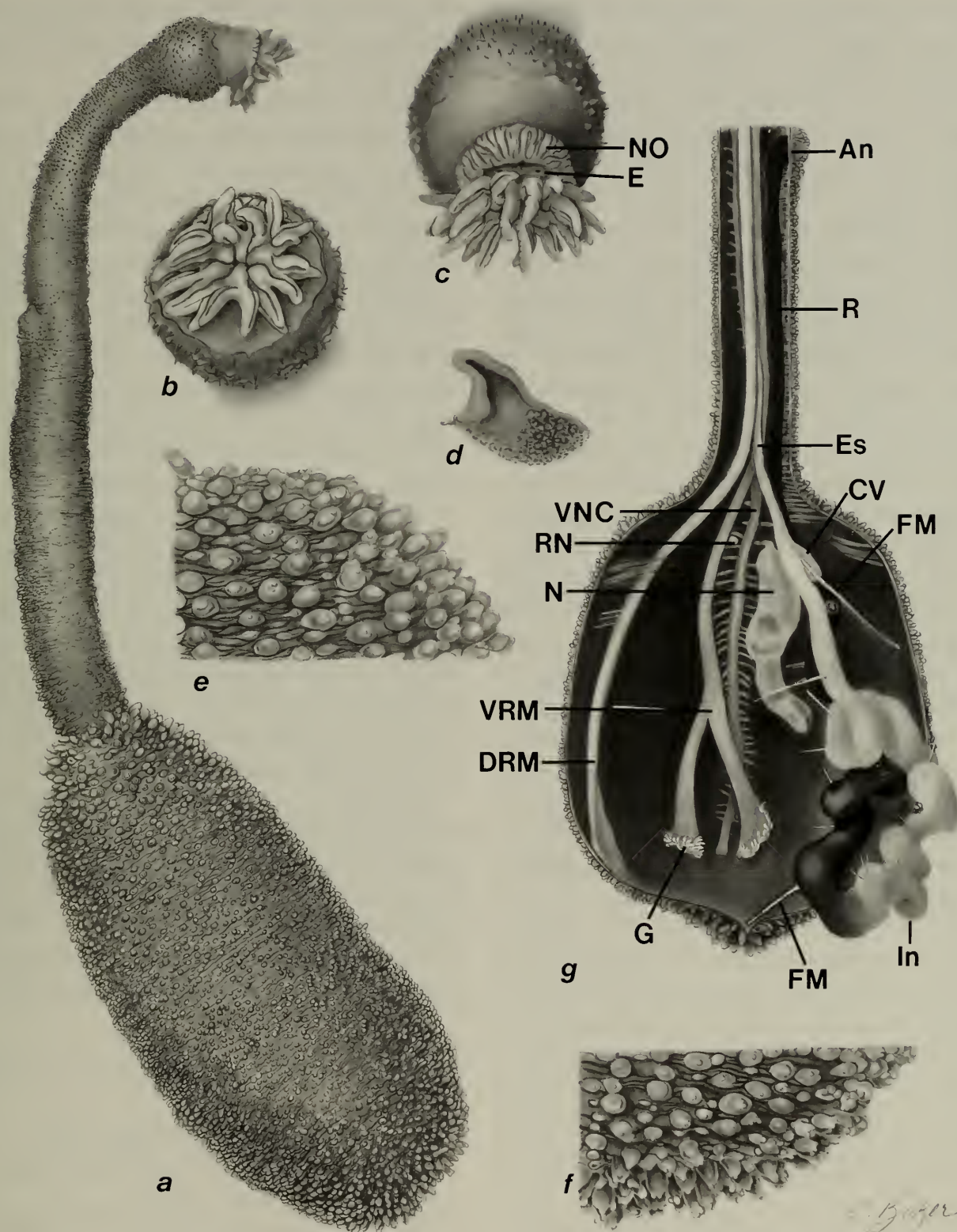


Fig. 1. Illustration of *Phascolion gerardi*, new species. a. External anatomy of the holotype. Note anus (An) in the mid-introvert region. b. Apical view of tentacles surrounding central mouth. c. Dorsal view of head showing nuchal organ (NO) and eyespots (E). d. Introvert hook. e. Enlargement of papillae from anterior trunk. f. Enlargement of papillae from posterior trunk. Note multiple tips. g. Internal anatomy. Abbreviations.—An, anus; CV, contractile vessel; DRM, dorsal retractor muscle; E, eyespot; Es, esophagus; FM, fixing muscle; G, gonad; In, intestine; N, nephridium; NO, nuchal organ; R, rectum; RN, rudimentary nephridium; SB, saccular body; VNC, ventral nerve cord; VRM, ventral retractor muscle. (Illustrator: Charissa Baker)

resent a rudimentary left nephridium. The gonadal fringe at the bases of the ventral retractor muscles has well developed lobules and in some specimens extends as a strand between the two muscles posterior to the end of the ventral nerve cord.

Remarks.—*Phascolion gerardi* is placed in the subgenus *Isomya* recently created by Cutler & Cutler (1985) to include those species in which dorsal and ventral retractors are approximately equal in diameter and in which the esophagus departs from the retractor column posterior to the separation of the muscles. In *Phascolion gerardi* the retractor muscle column divides into dorsal and ventral muscles in the anterior introvert; these two muscles, of similar diameter, are attached by mesenteries to the esophagus, which lies between them, for the length of the introvert. In the anterior trunk or posterior introvert the mesenteric connection ends and the muscles become separate from each other and from the esophagus.

A distinguishing feature of *Phascolion gerardi* is the arrangement and prominence of the papillae. In this character, it most closely resembles *Phascolion tuberculosum* Théel, 1875, which also is in the subgenus *Isomya*. Papillae cover the trunk and are largest at its posterior and anterior extremities. The largest papillae are elongate and may have two to three pores on apical protrusions, whereas those in the mid-body are usually mammillate and rounded, with a single pore. Holdfasts, common in many members of this genus, are lacking in *P. gerardi* and, according to Théel's description (Théel, 1905), also in *P. tuberculosum*. However, Cutler & Cutler (1985), in a re-evaluation of this character, describe papillae in the midsection of the latter species as flattened spheres, resembling holdfasts without chitinization. Such a condition is not apparent in *P. gerardi*. Other differences include the shape of tentacles and position of the anus. The tentacles of *P. tuberculosum* are short and rounded and the anus opens in the anterior trunk, whereas the ten-

tacles of *P. gerardi* are more elongate and digitiform and the anus opens midway along the introvert.

Unlike most species of *Phascolion*, *P. gerardi* does not inhabit shells or construct tubes, nor does it possess the modified papillary holdfasts usually associated with such habitats. Specimens at all stations were found in cavities in coralline limestone. This species differs from many other rock-dwelling sipunculans in that it does not appear to create the burrow in which it lives, but rather inhabits pre-existing holes in the rocks. When the rock is fractured, the specimens, usually contracted and spherical, roll out from their exposed burrows.

Nothing is known about reproductive biology in this species, but on one occasion spawned eggs were observed. A specimen from the Bahamas, Sta. 209, kept alive in the laboratory, spawned eggs 12 days after collection. The eggs were spherical, opaque and white and enclosed by a thin egg envelope. The average diameter ($n = 50$) was 257 μm with a range of 252–263 μm .

Etymology.—This species is named for the Honorable Sumner Gerard in appreciation of his gracious and generous help in our collecting efforts. It was on a cruise aboard his research vessel, *Morning Watch*, in the Berry Islands, Bahamas, that the first specimen of this species was discovered.

Family Phascolionidae Cutler & Gibbs, 1985

Genus *Phascolion* Théel, 1875

Subgenus *Phascolion* (sensu stricto)

Théel, 1875

Phascolion psammophilum, new species

Figs. 2–4.

Holotype: USNM 160249.

Paratypes: USNM 160250–160253.

Material examined.—Florida: off Fort Pierce, central east coast (Rice, Stas. 162, 230, 230A, 236, 237, 254, 255, 255A, 256), 221 specimens.

Diagnosis.—An interstitial sipunculan,

averaging 4 mm in length. Introvert approximately twice the length of trunk. Tentacular crown having two to eight elongate tentacles, followed by bulbous expansion bearing 1–4 irregular rings of curved hooks. Rounded papillae over surface of trunk; smaller and more pointed papillae on introvert. Anus on posterior 20% of introvert. Retractor muscle column divides in anteriormost trunk into thick dorsal retractor and thin ventral retractor, both of which attach to body wall near posterior end of trunk. Ventral retractor splits in posterior extremity before attachment. Esophagus remains attached for short distance to ventral retractor before continuing into loosely looped intestine. Single right nephridium. Pair of saccular bodies on either side of ventral nerve cord near level of nephridiopore.

Description.—Unlike most sipunculans in which the concave curvature of the body is ventral, this species manifests a dorsal concave curvature. The introvert is elongate and slender, whereas the trunk, depending on its state of contraction, is thickened and has a rounded posterior end. The anus opens on the introvert at a point about 20% of the total length of the introvert from its base. Measurements of total body lengths of 65 specimens from 10 stations, with introverts and tentacles extended, averaged 4 mm (± 1.0) with minimum and maximum lengths of 1.5–7 mm; the average ratio of introvert to trunk was 1.7:1 (1.0:1–2.4:1). The width varied depending on the state of contraction, but the maximum body width of the largest specimens was 0.5 mm. The elongate introvert terminates in a tentacular crown with central mouth and 2–8 tentacles (Fig. 2a–e). In smaller specimens, under 2 mm, the number of tentacles is from two to four, whereas in those 3 mm and over the number may range from three to eight. As seen in the smallest specimens, the single pair of tentacles is dorsal, whereas in those specimens with four tentacles there is, in addition, a ventral pair (Fig. 2b, c). In specimens with six tentacles, there are four dor-

sals and two ventrals and in those with eight tentacles there are two additional ventrals (Fig. 2d, e). On the dorsal side of the tentacular crown at the terminal extremity of the animal, there is a flattened pad, revealed by SEM to be heavily ciliated, that is presumed to be the nuchal organ (Fig. 3a, b). SEM also shows the inner surfaces of the tentacles to be grooved and ciliated (Fig. 3b). Posterior to the tentacles, a short neck region is followed by a bulbous expansion of the anterior introvert which bears from two to four irregular rows of large curved hooks, the largest of which are 30 μm in height and 30 μm in basal width. In smaller specimens there may be only one row. The hooks are brownish in color, strongly curved and bluntly pointed (Fig. 2f). Scattered among the hooks are small dome-shaped papillae (Fig. 3c). The papillae on the remainder of the introvert are more pointed and prominent. Scanning electron micrographs reveal a central, apical pore through which ciliary extensions sometimes protrude. Larger, more rounded papillae cover the surface of the trunk, being most concentrated in the anterior trunk (Fig. 3d). Apical regions of papillae often appear to be differentiated as knobs or caps (Fig. 3c, d). Papillary caps are present on some of the trunk papillae, but in those without caps or apical elevations two to three central pores are occasionally visible. Demarcation between introvert and trunk is usually indicated by a constriction and in SEMs by a decrease in the circular undulations of the cuticle of the trunk. Holdfast papillae, present in most species of *Phascolion*, are absent.

Internally, the undivided retractor muscle column extends for the length of the introvert and separates in the anterior third of the trunk, usually close to the base of the introvert, into dorsal and ventral branches. These two branches attach to the body wall near the posterior extremity at approximately the same level (Fig. 2g). The thickness of the dorsal muscle is two to four times

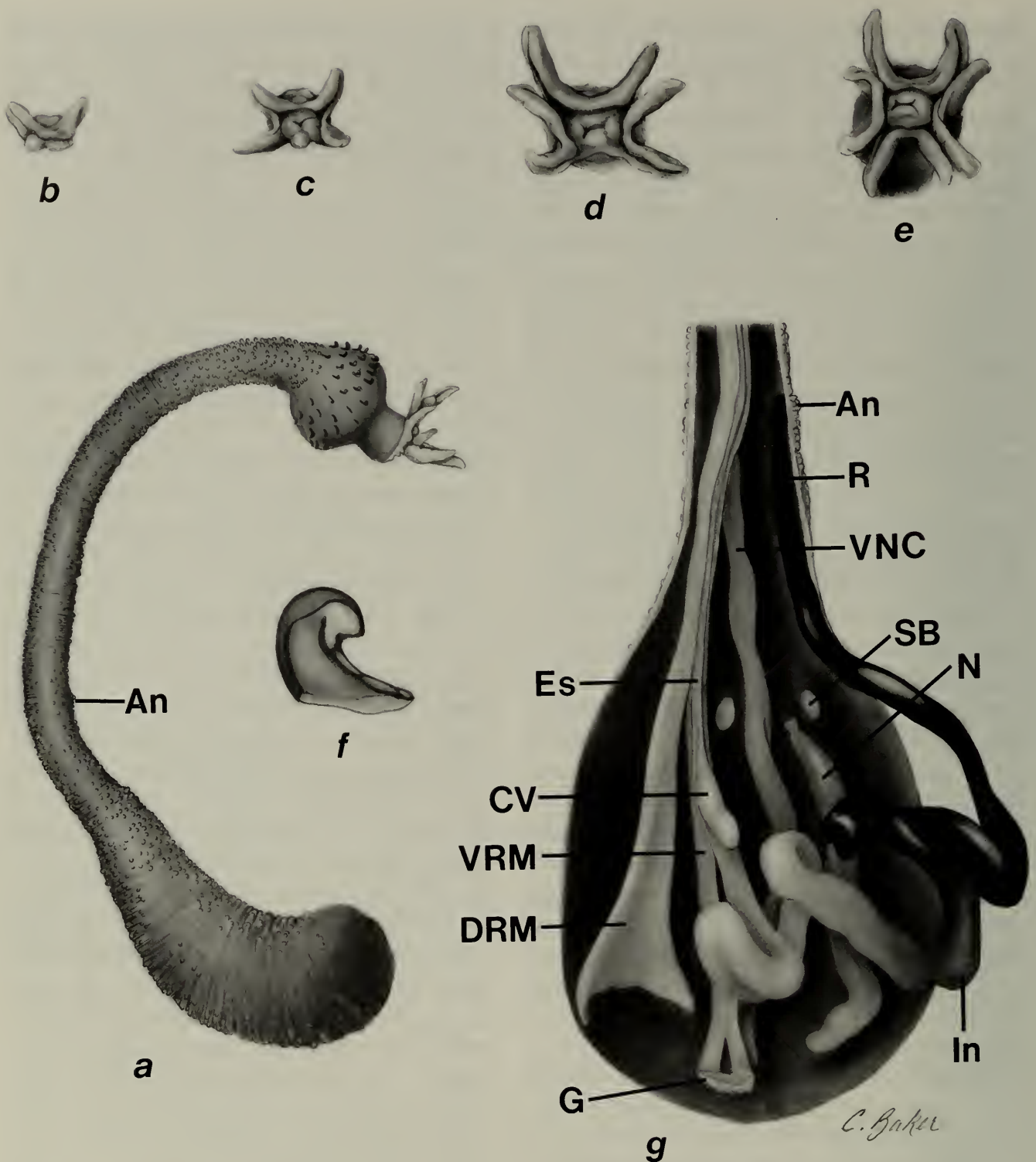


Fig. 2. Illustration of *Phascolion psammophilum*, new species. a. External anatomy. b-e. Ontogenetic sequence of tentacle development from two to eight tentacles. Apical view; dorsal side at top. f. Introvert hook. g. Internal anatomy. Abbreviations.—See Fig. 1. (Illustrator: Charissa Baker)

greater than that of the ventral. The ventral muscle usually splits near its point of attachment, straddling the end of the thick nerve cord. Gonadal tissue extends across the base of the ventral muscles. The esophagus is attached to the anterior ventral re-

tractor muscle for a short distance posterior to its separation from the dorsal retractor. The swollen posterior end of the contractile vessel is apparent along the esophagus near its position of separation from the muscle. The intestine is not coiled, but is loosely

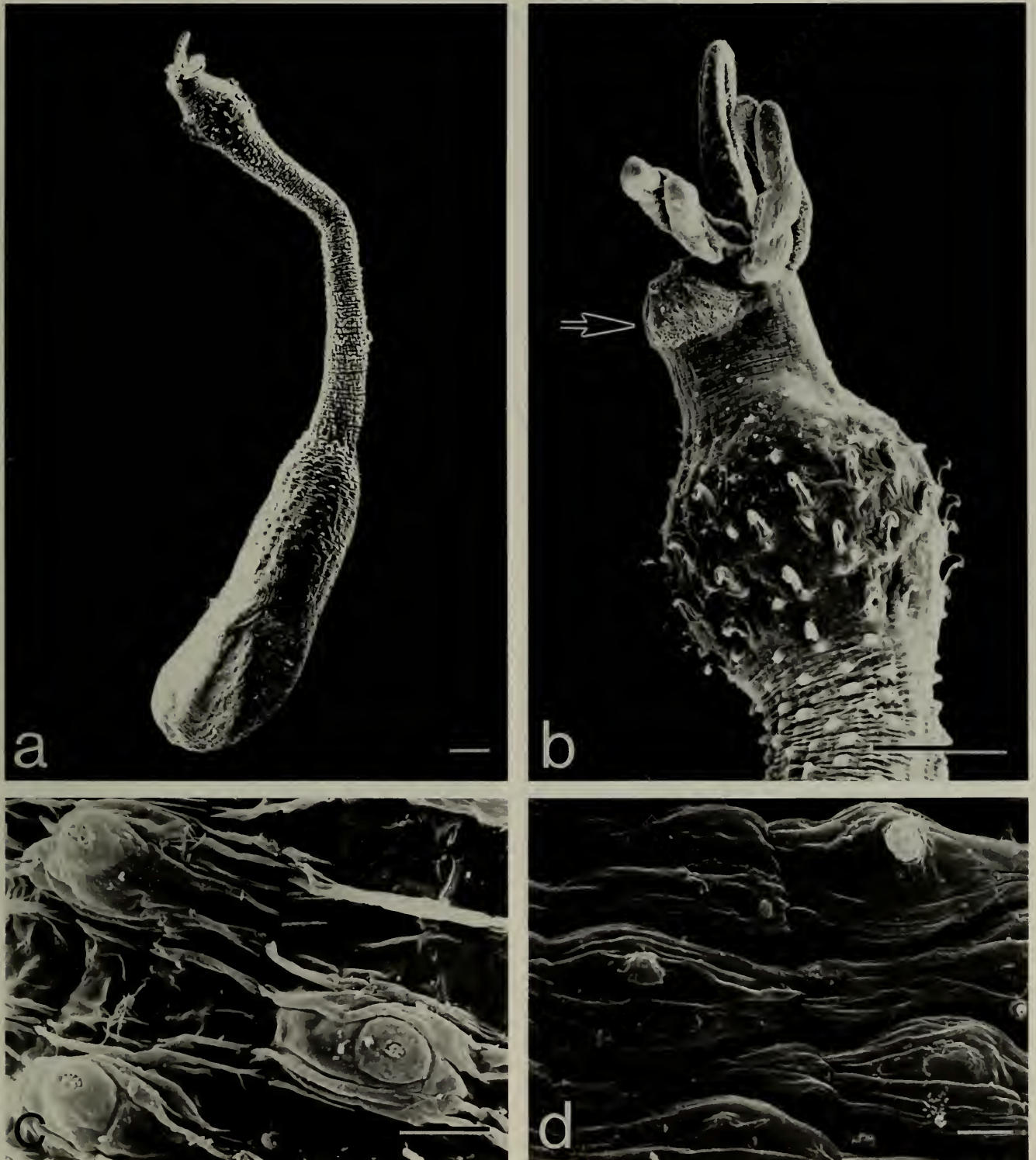


Fig. 3. Scanning electron micrographs of *Phascolion psammophilum*, new species. a. Whole animal. Left side is dorsal. Scale bar, 150 μm . b. Lateral view of anterior introvert showing 6 tentacles, dorsal nuchal organ (arrow), and hooks on bulbous introvert. Scale bar, 150 μm . c. Papillae from anterior introvert. Note central pores. Scale bar, 10 μm . d. Papillae from mid-trunk. Some have papillary cap. Scale bar, 10 μm .

looped and attached to the body wall by a few fine fixing muscles. A caecum is present at the end of the intestine, and a long rectum extends into the introvert where it opens in a dorsal anus. A single right nephridium,

free from the body wall for most of its length, attaches at the level of the nephridiopore in the anterior one-third of the trunk. Slightly anterior to this attachment is a pair of sac-ciform bodies on either side of the ventral

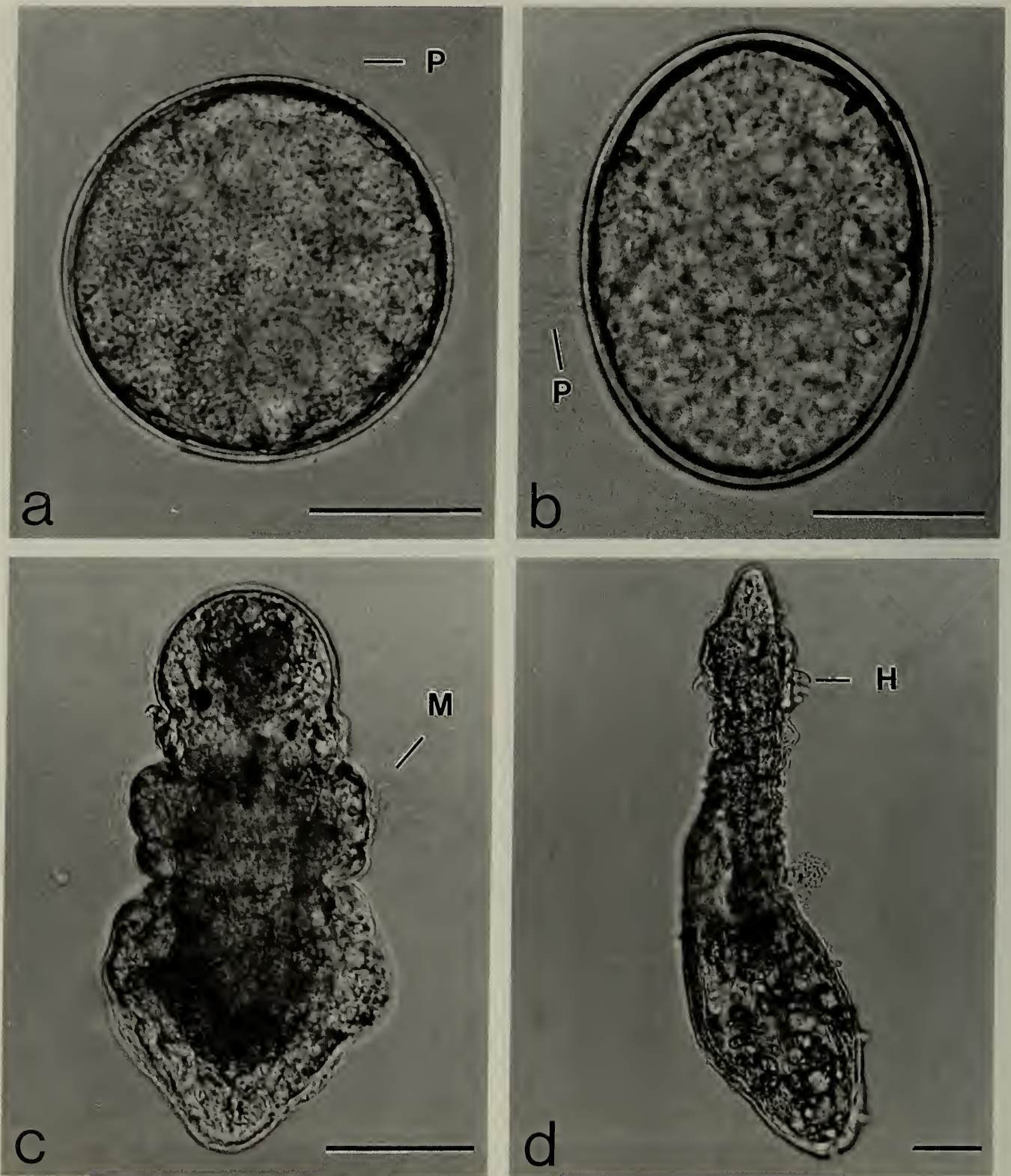


Fig. 4. Developmental stages of *Phascolion psammophilum*, new species. a. Gastrula. b. Trochophore. c. Pelagosphera larva, 1½ days. d. Juvenile, 4½ days. Abbreviations.—P, prototrochal cilia; M, metatrochal cilia; H, hook. Scale bars, 50 μ m.

nerve cord, the right member of the pair being lateral to the nephridium. Histological sections demonstrate that these bodies are glandular and open to the exterior by

pores. The thick, prominent nerve cord ends posteriorly just above the attachment of the ventral retractor muscle.

Reproduction and development.—The

presence of mature gametes in the coelomic fluid is evidence that these specimens are adults rather than juveniles, as might be suggested by their small size. The population is dioecious. Spawnings of eggs and sperm have been observed in the laboratory in the months of April, May, August and December.

Recently spawned, unfertilized eggs are slightly elongate, averaging $124 \times 111 \mu\text{m}$ ($n = 40$), and enclosed by relatively thin egg envelopes that, as is true for all sipunculan eggs, are perforated by fine pores (Fig. 4a). Within 24 hours after fertilization a typical trochophore, having a wide band of prototrochal cilia, apical tuft, and dorsal eyespots, develops within the egg envelope (Fig. 4b). By 36 hours the trochophore has transformed into an elongated pelagosphaera larva with a well-developed band of metatrochal cilia (Fig. 4c). The larva swims near the bottom of the laboratory container or moves along on the bottom in a geometrid pattern of locomotion, similar to that of an inchworm. Within 4 days the pelagosphaera larva metamorphoses into a juvenile worm with fully formed gut. The presence of numerous yolk granules in the coelomic cavity suggests that the larva is lecithotrophic. The young juvenile has the shape characteristic of the adult, with elongate retractable introvert and anterior hooks (Fig. 4d).

Remarks.—Previous to the collections and observations of *Phascolion psammophilum* reported in this paper, sipunculans have been generally considered as only temporary inhabitants of the meiofaunal community, represented by numerous unidentifiable juveniles. However, as demonstrated by the above observations on gametes and reproduction, this species, in its adult stage, is an integral member of the meiofaunal community. It has been previously referred to as an unidentified interstitial species (Rice 1988, 1993). Only one other sipunculan, *Aspidosiphon exiguus*, has been reported as a member of the interstitial community (Edmonds 1974, 1982). Although specimens

were presumed to be adults, gametes were not observed.

Phascolion psammophilum was discovered during studies of sediments on the continental shelf off the central east coast of Florida. It occurs at depths from 15 to 19 meters in sediments characterized as medium to coarse sand and shell hash. Unlike most species of this genus, *P. psammophilum* does not occupy shells or tubes, but is found moving among the sand grains.

The arrangement and fusion of retractor muscles and their relation to the esophagus are characteristic of the subgenus *Phascolion*, as defined by Cutler and Gibbs (1985). In two other species of this genus, *P. hupferi* and *P. gerardi*, the anus opens on the introvert; however, these species differ in many other characters and are placed in two other subgenera, respectively, *Lesenka* and *Iso-myia*.

Etymology.—The name *psammophilum* refers to the sand habitat in which this species is found. (Gr. psammos, sand; Gr. philos, having affinity for.)

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Watch for collections in the Bahamas. Smithsonian Marine Station at Link Port Contribution #327. Caribbean Coral Reef Ecosystems Program Contribution #388.

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Appendix: Station Data

Station numbers listed below are from the station records of Mary E. Rice for her collections in Florida and the Caribbean.

Station 162—27°31.0'N, 80°08.3'W, 8.7 miles E from Fort Pierce, FL, collected by pipe dredge on Aquarius Cruise 7 at 15 m depth, 9 May 1978

Station 209—Frazer's Hog Cay, Berry Islands, Bahamas, Morning Watch Cruise, collected by hand at 1 m depth, 3 March 1982, in calcareous sandstone and coralline limestone

Station 230—27°29.9'N, 80°11.4'W, 5.6 miles E from Fort Pierce, FL, collected by anchor dredge on Tursiops Cruise 24 at 15 m depth, 6 Dec 1982, in coarse sand with shell fragments

Station 230A—27°30.9'N, 80°12.2'W, 5.4 miles NE from Fort Pierce, FL, collected by anchor dredge on Tursiops Cruise 25 at 15 m depth, 31 Jan 1983, in coarse sand with shell fragments

Station 236—27°30.5'N, 80°12.0'W, 5.3 miles NE of Fort Pierce, FL, collected by sled dredge on Snook Cruise 80 at 15 m depth, 24 Feb 1983, in crushed shell and fine quartz sand

Station 237—27°30.3'N, 80°12.0'W, 5.3 miles E of Fort Pierce, FL, by sled dredge on Snook Cruise 80 at 15 m depth, 24 Feb 1983, in crushed shell and fine quartz sand

Station 254—27°33.3'N, 80°10.8'W, 7.8 miles NE of Fort Pierce, FL, collected by anchor dredge on Tursiops Cruise 30 at 19 m depth, 6 Dec 1983, in medium sand and shell hash

Station 255—27°32.3'N, 80°10.6'W, 7.3 miles NE of Fort Pierce, FL, collected by anchor dredge on Tursiops Cruise 30 at 18 m depth, 6 Dec 1983, in sand and shell hash

Station 255A—27°32.3'N, 80°10.7'W, 7.3 miles NE of Fort Pierce, FL, collected by anchor dredge on Tursiops Cruise 31 at 15 m depth, 6 Mar 1984, in sand and shell hash

Station 256—27°31.2'N, 80°10.1'W, 7.2 miles NE of

Fort Pierce, FL, collected by anchor dredge on Tur-
siops Cruise 30 at 17 m depth, 6 Dec 1983, in shell
hash

Station 263—north of South Water Cay, west of To-
bacco Reef, Belize, collected by sled dredge at 1 m
depth, 26 June 1985, in rubble on sandy backreef
area

Station 264—Curlew Bank, Belize, collected by hand
in less than 1 m depth, 26 June 1985, in coral rubble

Station 265—Puerto Morelos, Quintana Roo, Mexico,
collected by hand while snorkeling at 1 m depth, 3
July 1985, in coral rubble taken from reef crest area

Station 268—Cabeza Reef, Puerto Morelos, Quintana
Roo, Mexico, collected by hand while scuba diving
at 9 m depth, 5 July 1985, in coral rubble from reef