Perotrochus maureri, a New Species of Pleurotomariid from the western Atlantic (Gastropoda: Pleurotomariidae)

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ABSTRACT

Perotrochus maureri, a new species of pleurotomariid, is described from the upper continental slope off northeastern Florida and the Carolinas. It can be distinguished from its sister species, *Perotrochus amabilis* (Bayer, 1963), and from the more remotely related *P. atlanticus* (Rios & Mathews, 1968) by its smaller, lower, more deeply pigmented shell with fewer spiral cords on the selenizone and shell base, as well as on the basis of its radular asymmetry and formula. The emergence of peninsular Florida is hypothesized to have separated the ancestral population into the Carolinian *P. maureri* and *P. amabilis*, which appears to be restricted to the Gulf of Mexico.

Key words: Pleurotomariidae; *Perotrochus*; new species; bathyal; vicariance; radula.

INTRODUCTION

During the course of continuing studies on the ecology and systematics of western Atlantic pleurotomariid gastropods, we had occasion to re-examine a large series of specimens that we collected off Charleston, South Carolina and previously referred to *Perotrochus amabilis* (Bayer, 1963) (Askew, 1988:91; Harasewych *et al.* 1988). Comparison of this material, as well as additional specimens from off Jacksonville, Florida, with the holotype and additional specimens of *P. amabilis* from off northern Cuba and throughout the Gulf of Mexico revealed subtle but consistent differences in size, pigmentation and sculpture. We ascribe these differences to allopatric speciation, and here describe as new the member of the species pair ranging from northern Florida to the Carolinas.

MATERIALS AND METHODS

The type material was collected during four dives aboard the Research Submersible NEKTON DELTA, in the area of the "Charleston Lumps," a region of rugged topography some 90 miles east of Charleston, South Carolina, on May 2–4, 1987. Some of the specimens were fixed in 10% sea water formalin and stored in 70% ethanol for dissection; the remainder were frozen and maintained at −80°C.

Additional specimens of the new species, as well as comparative material of *P. amabilis* and *P. atlanticus* in museum collections were examined, and are identified in the text by the following institutional acronyms:

AMNH—American Museum of Natural History, New York
AMS—Australian Museum, Sydney
ANSP—Academy of Natural Sciences, Philadelphia
BM(NH)—British Museum (Natural History), London
FM—Fernbank Museum of Natural History, Atlanta
FMNH—Field Museum of Natural History, Chicago
FSBC I—Florida Marine Research Institute, St. Petersburg
HBOM—Harbor Branch Oceanographic Museum, Ft. Pierce, Florida
LACM—Los Angeles County Museum of Natural History
MCZ—Museum of Comparative Zoology, Cambridge
MNHN—Muséum National d'Histoire Naturelle, Paris
USNM—National Museum of National History, Smithsonian Institution, Washington, DC

SYSTEMATICS

Perotrochus maureri new species.

Synonymy:

Perotrochus amabilis: Askew, 1988:91; Harasewych *et al.* 1988. (Non *Perotrochus amabilis* (Bayer, 1963)).

Description: Shell (fig. 1) medium-sized (to 52 mm), thin, trochoid, non-umbilicate, of up to 9¾ whorls. Spire coeloconoid, straight for first 5 whorls, becoming increasingly concave thereafter. Protoconch (figs. 2–3), 500 μm wide, of 1 smooth, glossy, translucent whorl. Transition to teleoconch abrupt, delimited by slightly flared protoconch lip, onset of spiral and axial sculpture, selenizone. Selenizone initially nearly abutting suture, descending to mid-whorl by whorl 2, below mid-whorl by whorl 6. Axial sculpture of pronounced prosocyrt riblets

Table 1. Measurements of shell characters in *Perotrochus maureri*, *P. amabilis* and *P. atlanticus*. Linear measurements in mm.

Character	*Perotrochus maureri* (n = 10)			*P. amabilis* (n = 8)			*P. atlanticus* (n = 3)		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Maximum diameter (MD)	46.1	34.4–59.5	6.6	72.2	44.9–87.2	12.1	57.0	56.3–58.2	0.9
Shell height (SH)	37.3	34.7–46.9	4.4	60.58	41.7–73.3	6.1	53.7	52.7–54.8	0.9
SH/MD	0.822	.791–.832	0.01	0.858	.840–.929	0.03	0.940	.936–.951	0.00
No. whorls, teleoconch	8.78	8.25–9.75	0.37	9.76	9.0–10.75	0.54	9.33	9.0–9.75	0.31
No. spiral cords on selenizone	1.80	1–3	0.75	2.88	2–4	0.60	3.33	3–4	0.47
No. spiral cords on shell base	19.0	16–22	1.6	28.2	24–31	2.3	27.0	23–31	3.3

(18–20 on whorl 1), above and below selenizone, aligned in early whorls. Riblets decrease in prominence, being reduced to beads on spiral cords by whorl 6. Spiral sculpture initially of fine threads that cross riblets at angle (20–30°) to converge on selenizone from above and below. Single, continuous spiral cord first appears above the selenizone on whorl 2, below the selenizone on whorl 4. Selenizone with opisthocyrt ribs that are more numerous than, and unaligned with, prosocyrt ribs. Spiral sculpture on selenizone of fine radial threads between adjacent ribs on early whorls, single medial spiral cord by whorl 4. Number of spiral cords above/on/ below the selenizone increasing to 3–4/1/2–3 on whorl 6, 6–8/1–3/3–4 on whorl 8. Suture initially grooved, becoming flat by whorl 5, impressed by whorl 7. Aperture horizontally ovately-rhomboidal. Outer lip smooth, portion below slit offset from portion above slit by 30–33°. Slit narrow, extending posteriorly 84–92° from outer lip. Columella spirally coiled, with strong sigmoid flexure near adapical margin. Umbilical region excavate but not perforate. Base convex, with 17–22 even spiral cords between periphery and umbilical region, which is nacreous due to resorption of outer layers of shell. Base color ivory, with broad axial bands of pale brick red, and narrower bands of dark red. Aperture nacreous, iridescent. Operculum (fig.4) small, (spanning 0.6 of minor axis of aperture) multispiral, corneous.

Anatomy: As the anatomy of *P. maureri* agrees in most regards with that of *P. amabilis* as described by Fretter (1964); only supplemental observations on living animals are recorded. The foot, head and tentacles are densely mottled with dark brick red. When the animal is crawling, the posterior portion of the shell is supported on the operculum. Tentacles are long, cylindrical, ventrally directed. Left tentacle bilobed in one of the five specimens dissected. The jaws, inner lips and outer lips are all interconnected, being formed of a single piece of scleroprotein. The heavily papillated mantle edges on either side of the slit abut, sealing the slit except for a small opening along the posterior ⅕ of its length. The ctenidia do not project beyond the mantle edge in living specimens. When the animal is disturbed, the hypobranchial gland rapidly secretes large volumes of a whitish fluid that is immiscible with and denser than seawater. This secretion settles around and adheres to the shell.

Radula: Radulae of 5 specimens (39–52 mm maximum diameter) were examined. Radula (figs. 5–10, table 2) long (75–82% maximum shell diameter), asymmetrical, left-skewed, bifid posteriorly, composed of 92–104 inverted V-shaped rows of teeth. Hickman's (1984) terminology for the six tooth types is used herein and correlated to other terminologies in table 2. Rachidian Tooth (figs. 6, 8) with dorsal surface laterally expanded, forming flanges that apparently serve to maintain alignment between lateral teeth. Two long, Inner Lateral Teeth, with laterally expanded dorsal surfaces and broad, strongly curved distal ends (fig. 8, arrows) flank the rachidian tooth on each side. Adjacent are 24–26 (number increasing with shell size) Outer Lateral Teeth (figs. 6–8) that are shortest opposite Inner Lateral Teeth of adjacent row (fig. 7), and become progressively broader and stouter, with the long axis of the basal plates of the outermost Outer Lateral Teeth nearly perpendicular (≈70°) to that of the innermost Outer Lateral Teeth and to the radular axis (fig. 8). These in turn are flanked by 21 large, curved Sickle Teeth (figs. 5–7). As in *P. amabilis*, the innermost teeth are tricuspid (fig. 7, arrow), but the cusp on the concave surface is lost in subsequent teeth (Fretter, 1964: 181). The transition from Sickle Teeth to Filament-Tipped Teeth is gradual,the first Filament-Tipped Tooth discerned by the presence of two minute bristles on either side of the proximal cusp (Woodward, 1901:250). The bristles increase in number and become larger, while the cusps diminish in size (fig. 9) and ultimately are lost in the outermost Filament-Tipped teeth. The outermost 8–9 teeth (fig. 10), referred to as Paddle-Shaped Teeth, are broad, flat, and blunt ended, the preceding 1–2 teeth are transitional from Filament-Tipped teeth to Paddle-Shaped Teeth and retain vestiges of a filaments along the inner distal ends. The Paddle-Shaped Teeth of one row overlap the outer Filament-Tipped Teeth of the adjacent, more proximal row, forming a telescoping mar-

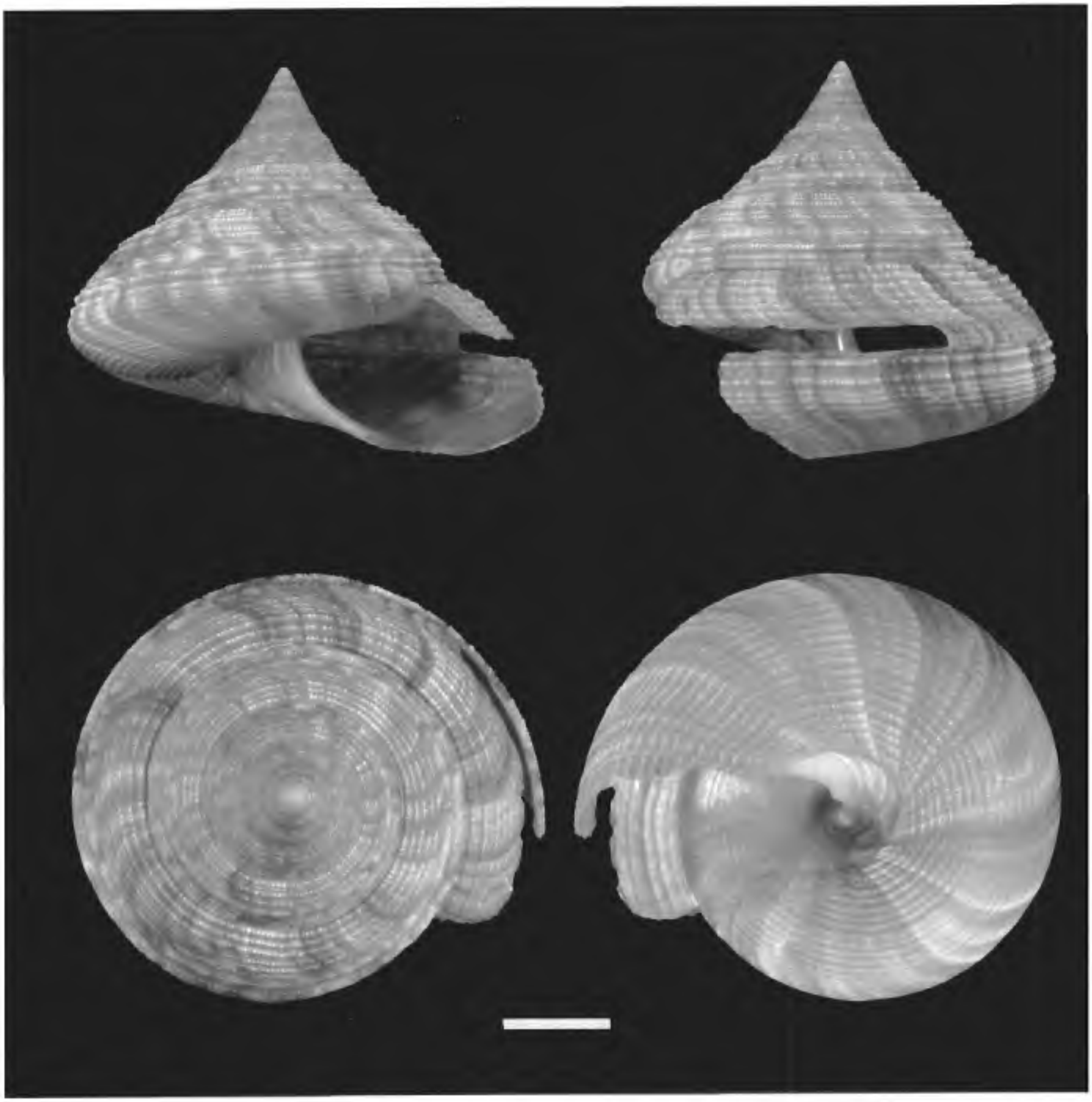


Figure 1. *Perotrochus maureri*, new species. Apertural, lateral, ventral and dorsal views of holotype (USNM 860320). Off Charleston, South Carolina, USA (32°43'57"W, 78°05'41"W) in 195–204 m. Scale bar = 1.0 cm.

gin that envelops the Filament-Tipped Teeth and facilitates smooth motion of the radula within its sheath on the rasping stroke. The blunt ends of the Paddle-Shaped Teeth may also dislodge entangled sponge tissue and spicules from the radula and free them to pass into the esophagus.

Type locality: 90 nautical miles E of Charleston, South Carolina, USA (32°43'54"N, 78°06'00"W, to 32°44'02"N, 78°05'22"W), in 195–213 m.

Range: *Perotrochus maureri* occurs on the upper continental shelf off Charleston, South Carolina and Jacksonville, Florida, in depths of 193–366 m.

Type specimens: Holotype, USNM 860320; Paratypes 1–9, USNM 875218; Paratype 10, AMS C.169400; Paratype 11, BM(NH); Paratype 12, MNHN, Paratype 13, FMNH; Paratype 14, FSBC I; all from R/V NEKTON DELTA dive 561, (32°43'57"N, 78°05'41"W) in 195–204 m, 4 May 1987. Paratypes 15–17, LACM 2629; Paratype

Table 2. Comparison of formulae and asymmetries of pleurotomariiid radula. Sources of data footnoted. ? indicates that the character could not be inferred from cited text or figure.

		A: Rachidian	Lateral teeth		Marginal teeth			
		B: Rachidian	Central	Lamellate	Hooked	Brush	Flabelliform	
Taxon	N	C: Rachidian	Inner laterals	Outer laterals	Sicle	Filament-tipped	Paddle-shaped	Skew*
Mikadotrochus beyrichi[1]	4?	1	3	20–21	17–22	63–65	7–12	R[1]
Perotrochus quoyanus[2]	1?	1	3	24	13	63	6	R[9,10]
P. caldedonicus[3]	1	1	1	22	14	53	7	R[11]
P. notialis[4]	1	1	2	29	13	63	10	?
P. amabilis[5]	1	1	3	24	21	63	8	R[12]
P. maureri[6]	5	1	2	24–26	21	61–63	8–9	L[6]
P. midas[7]	1	1	3	26	13	63	6	L[9,10]
P. lucaya[7]	1	1	3	25	13	61	6	?
P. africana[8]	1	1	4	25	12	50	6	?

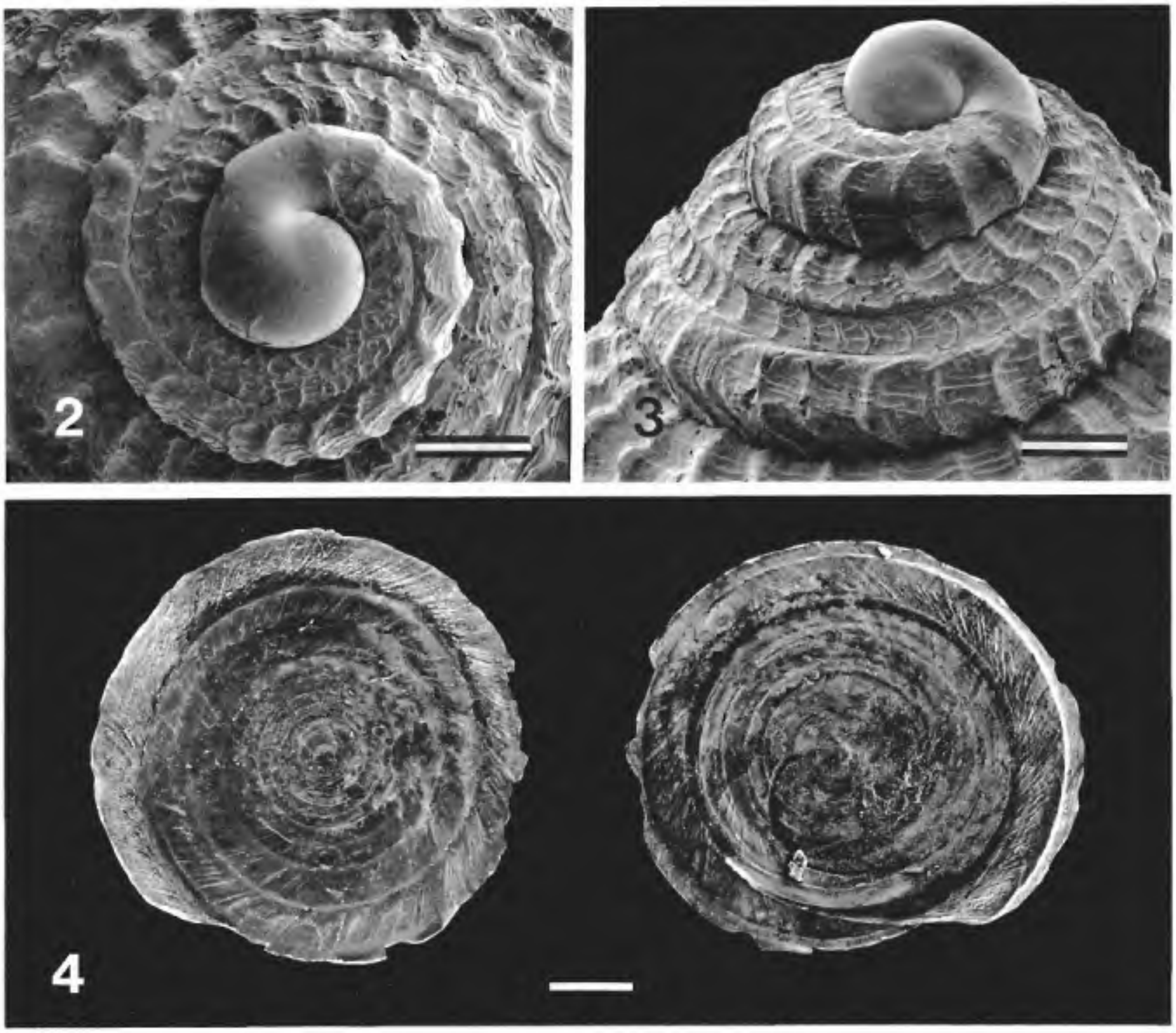
A = Standard terminology (*e.g.*, Fretter & Graham, 1962:169). B = Terminology of Woodward, 1901, and other authors. C = Terminology of Hickman, 1984.
* R = Right-skewed asymmetry. L = Left-skewed asymmetry.
[1] The radular formula given by Woodward (1901:252) and subsequently cited by other authors, is an incorrect summation of the data contained in his paper. His report that there are 223 teeth per row (p. 247), and explicit statement that there are 21 lamellate teeth (p. 249) indicate that the correct radular formula is (R-3-21-17-63-7), at least for the three specimens that he examined. Bouvier and Fischer (1902) report a radular formula of (R-3-20-22-65-12) for this species.
[2] Bouvier and Fischer, 1899.
[3] Bouchet and Metivier, 1982:310.
[4] Leme and Penna, 1969:227.
[5] Fretter, 1964:181.
[6] Herein.
[7] Fretter, 1966:608.
[8] Barnard, 1963:157. Listed as approximate counts.
[9] Hickman, 1981:190.
[10] Hickman, 1984:30.
[11] Bouchet and Metivier, 1982:fig. 2.
[12] Herein, n = 2.

18–20, USNM 875221; Paratype 21, MCZ, Paratype 22, ANSP, Paratype 23, AMNH, R/V Nekton Delta dive 557 (32°43′54″N, 78°06′00″W) in 198–213 m, 2 May 1987. Paratypes 24–26, USNM 846900 (reported in Harasewych *et al.* 1988:94 as *Perotrochus amabilis*), R/V Nekton Delta Dive 560, (32°43′58″N, 78°05′43″W) in 198–210 m, 3 May 1987. Paratypes 27–33, USNM 860321, Paratypes 34–35, FM 92.15. 1–2, R/V Nekton Delta Dive 562 (32°44′02″N, 78°05′22″W) in 204–213 m, 4 May 1987. Paratype 36, HBOM 65:1988 Johnson-Sea-Link-1-1455, about 80 n miles off Charleston, South Carolina, USA 32°44.0′N, 78°05.6′W, in heavy rubble zone of rocks and sand, 193 m. September 6, 1983.

Other material examined: HBOM 65:2017 Off Charleston, SC circa 1982; AMNH 226434, AMNH 226435, AMNH 226436, and USNM 869531, all from Off Jacksonville, Florida, in 366 m.

Comparative material examined: *Perotrochus amabilis* (F.M. Bayer, 1963): Holotype USNM 635625, S.E. of Sombrero Light, Florida (24°29′N, 80°53′W–24°30′N, 80°50′W), trawled in 220 m, R/V Gerda Cruise 6333, haul G–135; USNM 801707, 100 miles NNE of Sagua La Grande, Cuba (23°35′N, 79°34′W), in 183–238 m, R/V Silver Bay sta. 2460; USNM 846648, W of Tampa, Florida, rubble bottom, 210 m; USNM 858215, Green Canyon, 100 miles S of Atchafalaya Bay, Louisiana (27°44′35″N, 91°07′54″W), in 170 m, Johnson-Sea-Link-I–2385, 17.6°C; AMNH 183151, WNW of Ft. Myers, Florida, in 220 m; AMNH 244316, Dry Tortugas, Florida (no depth); FSBC I 30812, About 97 nautical miles W. of Mullet Key, Pinellas County, Florida (27°39′N, 84°33′W), in 126.2–128.0 m. R/V Hernan Cortez; FSBC I 33146, About 95 nautical miles W. of Anna Maria Island, Manatee County, Florida (27°31′N,84°31′W) in 135.6–126.5 m. R/V Hernan Cortez; HBOM 65:02190, About 100 nautical miles SE of Galveston, Texas, in 268.2 m. Johnson-Sea-Link-II–933. *Perotrochus atlanticus* (Rios & Mathews, 1968): USNM 846647, Off Rio Grande, Rio Grande do Sul, Brazil, in 260 m; AMNH 181294, Off Rio Grande, Rio Grande do Sul, Brazil, in 164 m, sand & mud; AMNH 244317, Solidao, Brazil.

Ecology: Specimens were observed *in situ* at the type locality, an area of rugged terrain consisting of steep, large (3–30 m) hill crests and valleys. *Perotrochus maureri* was largely confined to hard substrates, composed of slabs or fragments of relithified phosphorite, that lined



Figures 2–4. *Perotrochus maureri*, new species. **2.** Apical and **3.** oblique views of protoconch. Scale bars = 250 μm. **4.** Outer and inner views of operculum. Scale bar = 1.0 mm.

the tops and sides of the hill crests (see Askew, 1988:90, fig. 2). Water temperature was 9.6–9.8°C. *Perotrochus maureri* occurs in considerable densities at the type locality, with distances between specimens ranging from 10 to 30 meters. The diet of *P. maureri* [as *P. amabilis*] was reported by Harasewych *et. al.*, (1988) to consist on sponges of the orders Poecilosclerida, Choristida or Spirophorida, and the genus *Strongylophora*. Most specimens have 7–12 repaired shell breaks, indicating frequent, unsuccessful predation, probably by crustaceans.

Etymology: This species is named in honor of Mr. Richard S. Maurer in recognition of his long and devoted interest in, and support of Malacology.

Discussion: *Perotrochus maureri* is most closely related to *P. amabilis*, and more remotely related to *P. atlan-*

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Figures 5–10. Radular ribbon of *Perotrochus maureri*. **5.** Dorsal view of critical-point dried buccal mass, showing alternating arrangement of hooked teeth. Scale bar = 500 μm. **6.** Anterior view of extended, critical-point dried radula. Radula is seen to be asymmetrical and left-skewed. Scale bar = 500 μm. **7.** Left side of radula. Scale bar = 500 μm. **8.** Rachidian, inner and outer lateral teeth. Teeth to the left of the rachidian are further anterior than their homologues on the right. Scale bar = 250 μm. **9.** Filament-tipped teeth from two adjacent rows. Scale bar = 100 μm. **10.** Paddle-shaped teeth. Transition from filament-tipped to paddle shaped teeth discernible on teeth 9–10 (arrows). Scale bar = 250 μm.

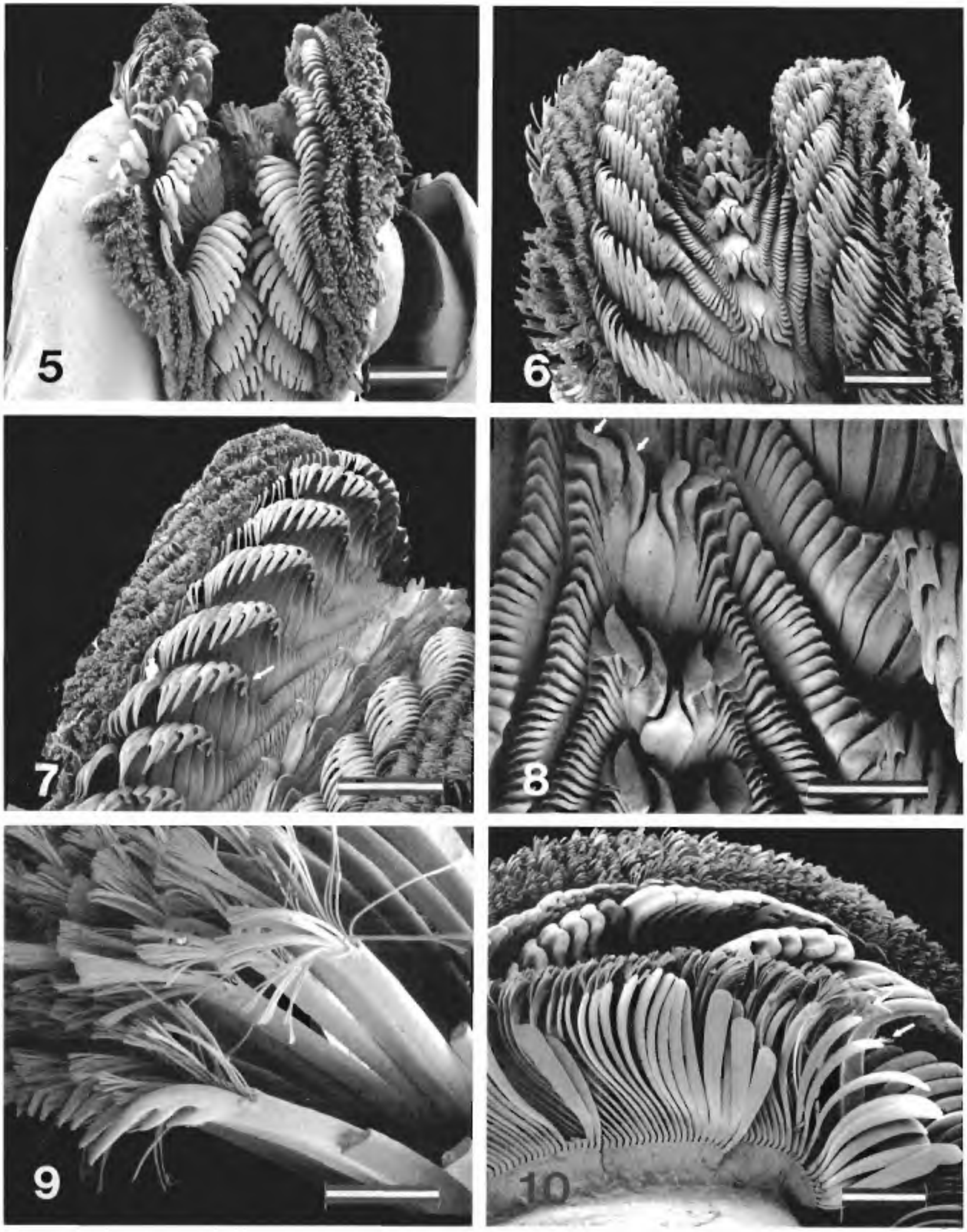
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Figure 11. Map showing distribution of *Perotrochus amabilis* (Bayer) (dots) and *P. maureri* n. sp. (open circles). Solid and open stars denote respective type localities.

ticus. It can be distinguished from both these species by its smaller size, lower spire, and its more darkly pigmented shell with fewer spiral cords on the selenizone and base (Table 1). The radula of *P. maureri* differs from that of *P. amabilis* in being left-skewed rather than right-skewed, and in having one fewer Inner lateral Teeth, an equal or greater number of Outer Lateral Teeth, an equal or lesser number of Filament-tipped Teeth and an equal or greater number of Paddle-shaped Teeth (Table 2). The utility of minor differences in radular formulae for distinguishing taxa is questionable, as most reports to date are based on a single radula per species. Intraspecific variation in the numbers of Outer Lateral, Sickle, Filament-tipped and Paddle-shaped teeth has been encountered when multiple radulae have been examined (Table 2). As the transitions between the types of teeth are gradual (especially in the Marginal Teeth), it is also possible that different investigators may have assigned one or more transitional teeth to different tooth types, thus further obscuring the discriminating value of radular formulae. Radular asymmetry, however, appears to be constant within a species (*P. maureri*, left-skewed, $n = 5$; *P. amabilis*, right-skewed, $n = 2$), and is tentatively regarded as a useful distinguishing criterion.

Perotrochus maureri is known only from the upper continental slope off northeastern Florida and the Carolinas, where it occurs below the 10°C thermocline. Its sister species, *P. amabilis*, is limited to the Gulf of Mexico and the Straits of Florida (Fig. 11). A single temperature record from Louisiana (17.6°C) indicates that this species lives substantially above the 10°C thermocline. We surmise that the emergence of peninsular Florida separated the ancestral population during the Neogene, with *P. amabilis* evolving in the Gulf of Mexico, while *P. maureri* was isolated on limited areas of hard substrate off the Carolinas, and subsequently adapted to colder temperatures.

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