Rediscovery, range extension, and redescription of *Calliostoma torrei* Clench and Aguayo, 1940 (Gastropoda: Vetigastropoda: Calliostomatidae)

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ABSTRACT

Two living specimens of *Calliostoma torrei* were recently collected feeding on bamboo coral (*Keratoisis ornata* Verrill, 1878) east of Jacksonville, Florida, at a depth of 843 m. This represents a considerable range extension of a species that was previously known only from the holotype, collected dead off Matanzas, Cuba, in 704 meters. A redescription of the shell and first descriptions of the operculum, gross anatomy, and radular morphology are provided; partial sequences of the genes for 16S rDNA and cytochrome c oxidase I have been determined and added to the GenBank database. These new data suggest that *Calliostoma rugosum* Quinn, 1992, from unknown depths in the Straits of Florida is a synonym of *C. torrei*. The radula most closely resembles that of *C. yucatecanum* Dall, 1881, suggesting placement in *Calliostoma* sensu stricto according to the criteria of Clench and Turner, 1960.

INTRODUCTION

A number of unusual and noteworthy gastropods were collected during the NOAA Ocean Exploration Cruise ESTUARY TO ABYSS, EXPLORING ALONG THE LATITUDE 31–30 TRANSECT, conducted 20 August to 1 September, 2004, off the coasts of South Carolina, Georgia, and northeastern Florida. Among these were two exceptionally large specimens of the pleurotomariid *Bayerotrochus midas* (F. M. Bayer, 1965), which extends the range of this species northward from the Little Bahama Bank to off the coast of southern Georgia, and two small calliostomatid trochoideans. The calliostomatids are members of a rare and poorly known group of species, characterized by a stepped spire, that are known to inhabit bathyal depths in the Straits of Florida, throughout the Bahamas and the Antilles, southward to Argentina, and eastward to the Azores and western Africa. Both specimens appear closest in morphology to the *Calliostoma torrei* Clench and Aguayo, 1940, a taxon known only from the dead-collected holotype dredged in 704 m off Matanzas, Cuba; our specimens are smaller and presumed to be immature. To a lesser extent, they resemble *Calliostoma rugosum* Quinn, 1992, a taxon that is also based on a single, dead-collected specimen from the Straits of Florida, but for which neither depth nor exact location are known.

We provisionally consider all four specimens to be conspecific and *Calliostoma torrei* to be the oldest available name for this taxon. Because this species was previously known only from dead and damaged specimens, we provide a detailed description of the shell, operculum, radula, and gross anatomy based on the newly collected specimens. Partial sequences of the mitochondrial genes for 16S rDNA and cytochrome c oxidase I (CO I) have been entered into Genbank, but no sequences for either of these genes from any species of *Calliostoma* were available for comparison at the time of this writing.

Within the fauna of the western Atlantic, the genus *Calliostoma* is unusually diverse, with 94 living species (Quinn, 1992; Rosenberg, 2005) inhabiting principally hard-bottom substrates from intertidal to mid-bathyal depths (0–2000 m) at latitudes ranging from 42° N to 55° S (Rosenberg, 2005). Other species inhabit comparable depths in the Azores and eastern Atlantic. This genus is thus ideally suited for studies of fine-scale biogeography and bathymetric zonation once sufficient data are accumulated to produce a robust phylogenetic framework. Institutional abbreviations are: MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; SERTC/SCDNR: Southeastern Regional Taxonomic Center/South Carolina Department of Natural Resources, Charleston, South Carolina; USNM, National Museum of Natural History, Smithsonian Institution, Washington, DC.

SYSTEMATICS (Follows Bouchet et al., 2005)

Clade Vetigastropoda Salvini-Plawen, 1980
Superfamily Trochoidea Rafinesque, 1815
Family Calliostomatidae Thiele, 1924
Genus *Calliostoma* Swainson, 1840
Calliostoma torrei Clench and Aguayo, 1940
(Figures 1–20)

Calliostoma (Calliostoma) torrei Clench and Aguayo, 1940: 79–80, pl. 14, fig. 5; Clench and Turner, 1960: 59–60, plate 40; Abbott, 1972: 46; Quinn, 1992: 79, figs. 80, 81.
Calliostoma rugosum Quinn, 1992: 102–103, figs. 78–79.

Description: Shell (specimen in Figures 9–12) 22.2 mm high, 23.0 mm in maximum diameter, rather thin, with very narrow umbilicus nearly sealed by parietal fold. Spire stepped, weakly concave, spire angle 76.5°. Color whitish, pale golden yellow between peripheral keel and suture, iridescence of aragonitic nacre visible through thin calcitic outer layer. Protoconch (Figures 14–15) paucispiral, smooth, glassy, translucent, increasing from 150 to 500 μm in diameter in about ¾ whorl (270° rotation). Transition to teleoconch marked by flared terminal varix. Teleoconch of 7 1/8 whorls. Step between peripheral cord and suture concave in first teleoconch whorl, becoming angular, then progressively more convex with increasing whorl number. Base inflated, convex, evenly rounded. First teleoconch whorl with 21 well-defined axial ribs and two strong spiral cords (Figure 15, P2 + P3; following cord terminology of Marshall, 1995) that produce reticulate sculpture at their intersections. Axial ribs decrease in prominence by 4th teleoconch whorl, replaced by increasingly prominent beads at intersections with spiral cords. Adapical cord (Figures 14, 15, P1) begins as spiral thread in first teleoconch whorl, ¾ whorl after the onset of spiral cord P2, expands to form cord by second teleoconch whorl. Cord P3 remains at periphery. Fine spiral threads appear between adjacent spiral cords at onset of whorl 4, expanding to form beaded cords by the next whorl. The process repeats, increasing the number of broad, beaded cords between P1 and P3 on the body whorl to 6, in addition to 2 fine and 2 weakly beaded threads. Region between peripheral cord (P3) and suture smoothly concave in teleoconch whorls 1–3, with fine thread appearing at onset of whorl 4 and expanding to form beaded cord by the next whorl, the process repeating to produce 2 beaded cords and 2 fine threads on penultimate whorl, and 4 beaded cords and 2 threads on body whorl. A single, smooth cord appears between suture and P1 near end of teleoconch whorl 7. Base with 21 smooth cords between umbilicus and periphery. Cords broad near umbilicus, becoming narrower towards periphery. Aperture tangential, with plane offset from coiling axis by 32°, 11.1 mm wide, 9.6 mm high, outer lip symmetrically elliptical, inner lip with thickened columella forming an angle of 87° with the base of previous whorl and 17° with the coiling axis of the shell. Columella rounded, nacreous inductura nearly seals very narrow umbilicus.

Operculum: Corneous, thin, transparent, yellowish amber in color, multispiral, with thin growing edge. Maximum diameter 8.8 mm.

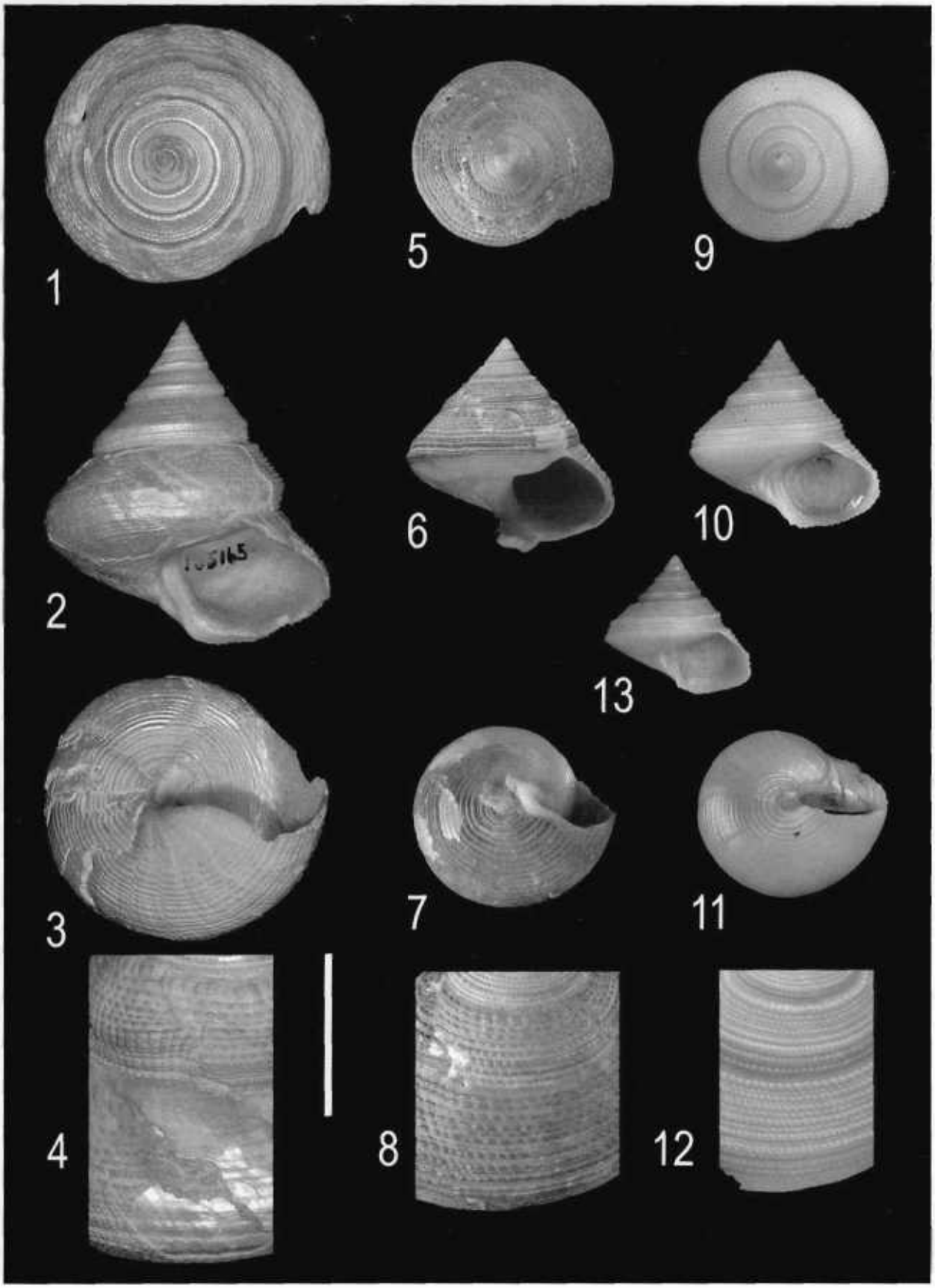
Gross Anatomy: Exposed portions of animal yellowish tan. Foot long, narrow, posteriorly tapering; epipodium broad, with broad, scalloped, inhalant and narrow, tapering, enrolled, exhalant neck lobes; 4 epipodial tentacles per side. Cephalic lappets small, simple, cephalic tentacles long, eye stalks short, with very large, black eyes. Snout large, cylindrical, papillate ventrally, with split ventral lip.

Radula (Figures 16–20): Radular ribbon 8.65 mm long, 1.6 mm wide, with 97 rows of teeth. Rachidian teeth (Figure 18, **r**) simple, triangular, with very finely serrated edges. Lateral teeth (Figure 18, **l**) 7 per side, with broad attachment area and narrow, simple, curved, finely serrated along entire outer edges, with or without fewer, more widely spaced cusps along distal portion of inner edge. Innermost marginal teeth (Figures 18, 19, **imm**) broad, thick, with 5 short, conical cusps along the inner distal edge. Marginal teeth become progressively longer and narrower toward the outer edge of the radular ribbon, with an increasing number of fine cusps along the inner, distal portions of the scythe-shaped teeth. Compare inner marginal teeth (Figure 19, **im**) with outer marginal teeth (Figure 20, **om**).

Jaws large, broadly rounded, anterior ends broadly rounded with short fringe.

Material Examined: Holotype of *Calliostoma torrei* Clench and Aguayo, 1940, Atlantis Station 3985, off Matanzas, Matanzas Province, Cuba (23°13′ N, 81°22′ W), in 385 fathoms [704 m], MCZ 135165; Holotype of *Calliostoma rugosum* Quinn, 1992, James M. Gillis Cruise 7307, Station 13, Straits of Florida, depth and exact location unknown, USNM 860262; Johnson-Sea-Link II Dive 3470, Cutthroat Cliff, about 220 km E of Jacksonville, Florida, (30°17.147′ N, 79°20.147′ W), in 863 m (SCDNR Collection Number T10041060), larger specimen (Figures 9–12) USNM 1069300, smaller specimen (Figure 13) SERTC/SCDNR collection S1005.

Figures 1–13. *Calliostoma torrei* Clench and Aguayo, 1940. **1–4.** Holotype, MCZ 153165, off Matanzas, Cuba, 23°13′ N, 81°22′ W, in 385 fms. [704 m], Harvard-Havana Expedition, Atlantis Station 3485. **1.** Apical, **2.** apertural, and **3.** basal views. **4.** Detail of sculpture on last two whorls. **5–8.** *Calliostoma rugosum* Quinn, 1992, holotype, USNM 860262, Straits of Florida, James M. Gillis Cruise 7307, Station 13, depth and exact location unknown. **5.** Apical, **6.** apertural, **7.** basal views. **8.** Detail of sculpture on last two whorls. **9–12.** *Calliostoma torrei*, larger of two specimens of collected at Cutthroat Cliff, about 135 miles E of Jacksonville, Florida, 30°17.0547′ N, 79°20.2514′ W, in 870 m, Johnson–Sea–Link II Dive 3470. **9.** Apical, **10.** apertural, **11.** basal views. **12.** Detail of sculpture on last two whorls. **Figure 13.** Apertural view of smaller specimen from the same locality. Scale bars = 2 cm for entire shells, 3 cm for images of sculptural details.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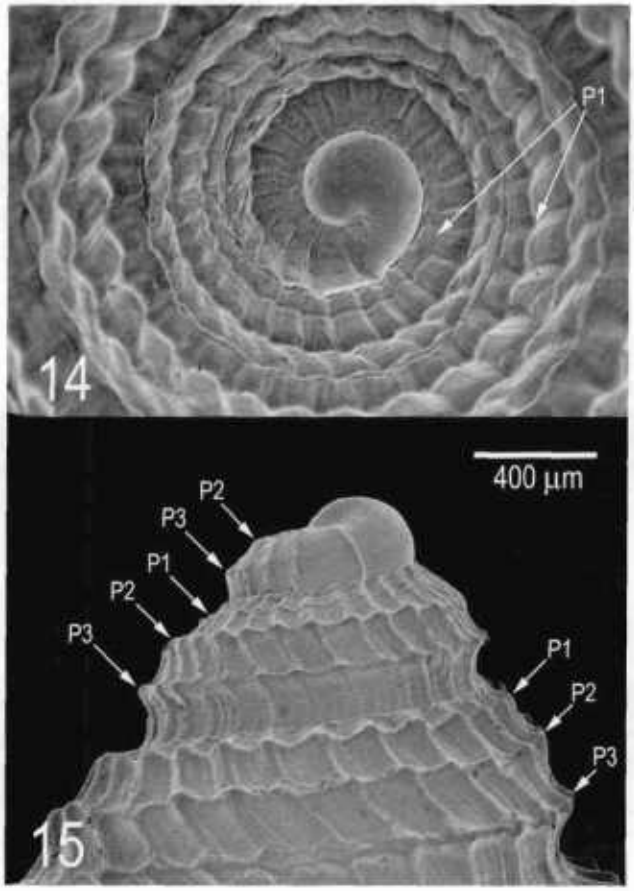


Figures 14–15. *Calliostoma torrei*. **14.** Apical, and **15.** lateral views of protoconch of specimen in Figures 9–12.

Habitat and Ecology: The bottom at the Cutthroat Cliff collection site was sloping at approximately 20°, and was composed mostly of hard, broken, pavement-like rock, some carbonate sand and coral rubble in mound formations (up to 10 m high) composed of loosely aggregated coral fragments and rubble. Scattered dark broken manganese-phosphorite pavement and rocks (Popenoe and Manheim, 2001) were frequently encountered. Bottom temperature was 7.7°C; currents were 0.1–0.2 knots from the south (180°).

The *Calliostoma torrei* specimens were living on, and apparently grazing on, a bamboo coral, *Keratoisis ornata*. The coral was attached to a small (20 × 30 cm) manganese-phosphorite rock or outcrop that protruded through light-colored carbonate sand. Stalked crinoids, small globular and encrusting sponges, and small erect hard corals (*Lophelia* spp.) were common on the dark rocks. A few cutthroat eels (*Synaphobranchus* spp.) swam nearby. The coral branches on which the snails were found (and some adjacent branches) were devoid of polyps, which were abundant and exposed on other branches of the colony.

DNA Sequences: Partial sequences of the mitochondrial genes for cytochrome c oxidase I (CO I) (Genbank DQ 314293) and 16S rDNA (Genbank DQ 314294) have been determined using standard protocols for DNA extraction, amplification and sequencing.

A search of the Entrez nucleotide database revealed that only a single sequence for any species of *Calliostoma* was present in the database, that for a 302-bp fragment of the 28 S rDNA gene of *Calliostoma zizyphinum* Linnaeus, 1758.

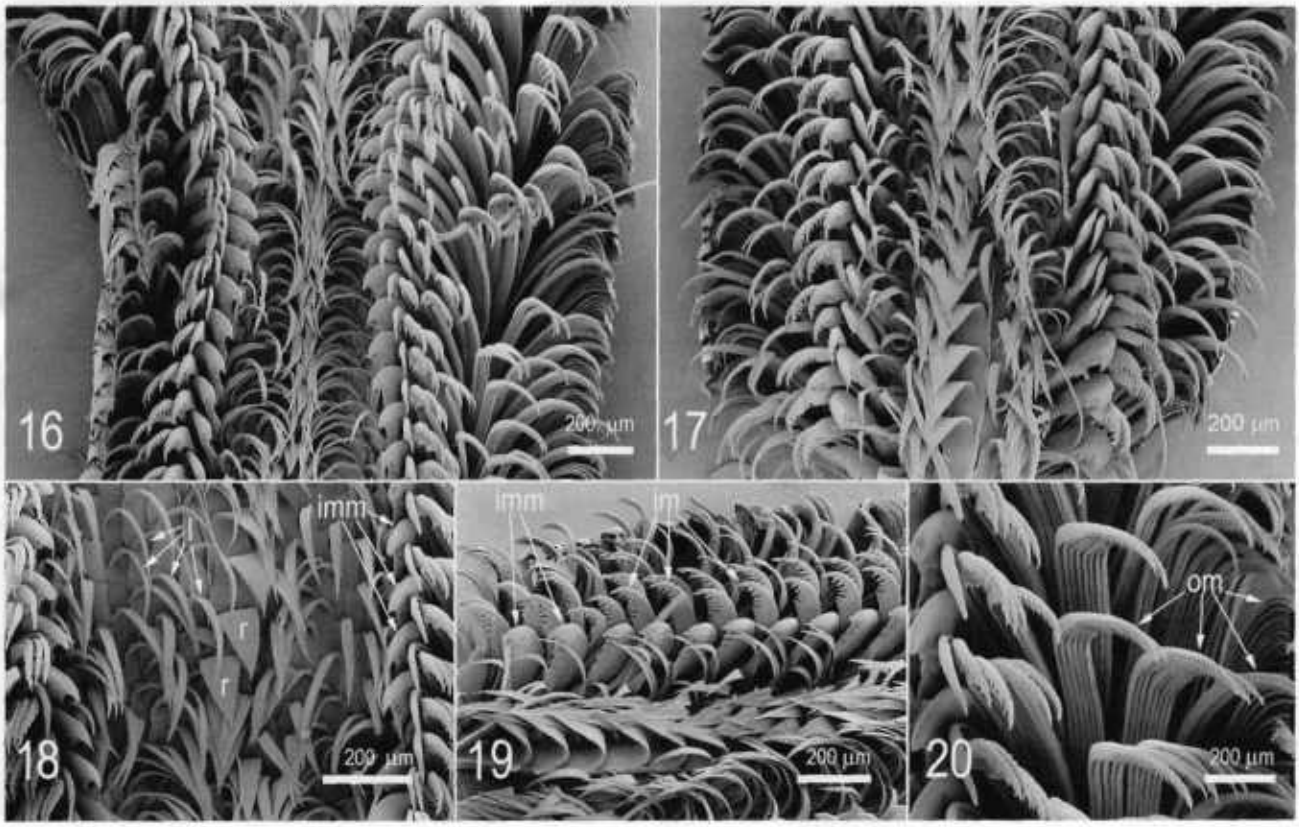
Remarks: *Calliostoma torrei* was described on the basis of a single, very large (41 mm) but dead-collected specimen, that has deteriorated over time, primarily through delamination of the outer, calcareous shell layers from the inner nacreous layers (compare Clench and Turner, 1960: pl. 40; Quinn, 1992: figs. 80, 81; with Figures 1–4 herein). Clench and Turner (1960: 60) commented that this species was among the largest in the western Atlantic and was not closely related to any other species in the region. They suggested that it was perhaps closest to the large (to 35 mm), shallow water (30–65 m), South American species *Calliostoma militare* Ihering, 1907 [as *C. amazonicum* Finlay, 1930] (Rosenberg, 2005), and, to a lesser extent, to *Calliostoma atlantis* Clench and Aguayo, 1940, from comparable depths (603 m) off Mariel, Cuba.

Quinn (1992: 103) described *Calliostoma rugosum* from a single, dead-collected and damaged specimen dredged in the Straits of Florida from unknown depths, differentiating this from *C. torrei* based on its smaller size, broader shell, and differences in the sculpture of the cords.

The two juvenile, live-collected specimens are intermediate in morphology between the holotypes of *C. torrei* and *C. rugosum*. The spire angle of both is closer to that of *C. rugosum*, but the sculpture is closer to that of *C. torrei*. Distinctions between the four specimens appear to lie primarily in the relative coarseness of spiral sculpture, especially when compared at corresponding whorls. We provisionally consider these specimens to be conspecific, recognizing that additional material will be required to better delineate intraspecific variation over a range of sizes.

In their review of western Atlantic *Calliostoma*, Clench and Turner (1960) did not assign *C. torrei* to any subgenus, as neither the morphology of the jaws nor the radula were known. When compared to the few species for which radular morphology has been published, the radula of *C. torrei* appears most similar to that of *C. yucatecanum* Dall, 1881 (see Clench and Turner, 1950: pl. 4, fig. 4), especially in having rachidian teeth without a broad basal area, narrow lateral teeth, and similarities in the morphology of the innermost and inner marginal teeth. Radular and jaw morphology of *C. torrei* suggest an affinity with *Calliostoma* sensu stricto.

Quinn (1992: 103) suggested that both *C. rugosum* and *C. torrei* were closely related to the Pliocene *C. caribbeanum* Weisbord, 1962, from the Mare Formation of Venezuela. Based on shell characters, he (Quinn,1992: 99) hypothesized that the species *C. atlantis* (603–628 m,



Figures 16–20. *Calliostoma torrei*. Radula of specimen in Figures 9–12. **16.** Radular ribbon near mid-length. **17.** Radular ribbon anterior to section in Figure 16. Marginal teeth reflected to better reveal rachidian, lateral, and inner marginal teeth. **18.** Detail of rachidian and finely serrated lateral teeth. **19.** Lateral view of radular ribbon, showing details of innermost lateral and inner lateral teeth. **20.** Scythe-like outer lateral teeth. **im,** inner marginal teeth; **imm,** innermost marginal teeth; **l,** lateral teeth; **om,** outer marginal teeth; **r,** rachidian teeth.

off Mariel, Cuba and Great Inagua), *C. torrei* (including *C. rugosum* synonymized herein) (704–870 m, NE Florida to Cuba), *C. dnopherum* (Watson, 1879) (640 m, Recife, Brazil), *C. atlantoides* Quinn, 1992 (417–589 m, St. Lucia), *C. rota* Quinn, 1992 (20–30 m, Brazil), and *C. coronatum* Quinn, 1992 (768–805 m, Brazil) form a distinctive species group. In this group, he also provisionally included *C. cubanum* Clench and Aguayo, 1940 (896 m, Cardenas, Cuba) and the central and eastern Atlantic species *C. grimaldii* Dautzenberg and Fisher, 1896 (1250–2165 m, Azores, Morroco), *C. leptophyma* Dautzenberg, 1927 (550–845 m, Azores), *C. normani* Dautzenberg, 1927 (599–1600 m, Azores) and *C. caroli* Dautzenberg, 1927 (1250 m, Azores). With the exception of *C. rota*, all members of this diverse and widespread group inhabit bathyal depths, most in the 500–1000 m range, with depths increasing eastward.

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