A new record of introduced *Cerion* (Gastropoda: Pulmonata: Cerionidae) in southeastern Florida

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ABSTRACT

A large, well-established colony of the land snail genus *Cerion* is reported from Delray Beach, Florida, far north from the range of the only native species in Florida, *Cerion incanum* (Binney, 1851) and its subspecies, and from the well-documented populations introduced by Paul Bartsch during the early 20th Century. Although hurricanes have frequently been proposed as agents of long distance dispersal of *Cerion* species, the Delray Beach Colony is more probably the result of intentional introductions during the mid-20th Century. The morphology of the shells in this colony is uniform except for the degree of pigmentation, yet it does not match precisely any of the fourteen named taxa from the Little Bahama Bank or the Bimini Islands, the nearest and most probable sources of the introduced propagules. Rather, the phenotype appears to combine elements of several taxa from both island groups, suggesting that the Delray Beach Colony may be a result of hybridization among animals from multiple and disparate introductions.

Additional Keywords: Introduced species, land snails, hybridization, Bahamas.

INTRODUCTION

The land snail genus *Cerion* has long been known for its extreme morphological diversity, especially in the faunas of Cuba, the Bahamas, and Cayman Islands (see Woodruff, 1978, and references therein). Although the oldest Cenozoic records of the genus are from the Oligocene of western Florida (Table 1A; Figure 1, ▼), *Cerion* is limited to a single species, *Cerion incanum* (with four subspecies or forms, see Table 1B; Figure 1, ♦) in the Recent fauna of Florida (Pilsbry, 1946: 163, fig. 77). The species inhabits nearshore vegetation from Key Biscayne southward throughout the Florida Keys to Key West. Several authors (e.g., Binney, 1851: 153; Pilsbry, 1902: 213; 1907: 193; 1946: 162; Dall, 1905a: 30) have suggested that *C. incanum* is not directly descended from a Florida Oligocene species but rather from *Cerion* that re-colonized the Florida Keys from Cuba following the interglacial high stands that had completely submerged southern Florida during the Pleistocene (Hearty et al., 1999). Pilsbry (1902: 213) regarded *Cerion incanum* to be most closely related to the Cuban *C. maritinum* (Pfeiffer, 1839).

The *Cerion* fauna of Florida had been significantly increased through a series of well-documented experimental transplantations of non-native species begun by Bartsch in 1912 (see Bartsch, 1912; 1920; 1949, and references therein). Bartsch's initial introductions were confined to two species that he subsequently named *Cerion casablancae* Bartsch, 1920, and *Cerion viaregis* Bartsch, 1920, both from Andros Island, Bahamas. Each of these was introduced to several of the Florida Keys, including the Dry Tortugas that were thought to be devoid of *Cerion incanum* (Table 1C). Bartsch later expanded his experiments to include introductions of an additional dozen species from Cuba, Puerto Rico, Curaçao, and several Bahamian islands, to sites in the Dry Tortugas, especially Fort Jefferson on Garden Key, and Loggerhead Key. He monitored and reported on these introduced colonies for decades. Most of the introduced colonies have since died out, but several (e.g., *Cerion casablancae* on Indian Key) flourish to this day, and some (e.g., *C. viaregis* on Newfound Harbor Key and *C. casablancae* on Bahia Honda Key) have hybridized with the native *C. incanum* (see Bartsch, 1920; Woodruff and Gould, 1987).

We have recently encountered a sizeable colony of *Cerion* in Delray Beach, Florida (Figure 1, ✠), far north of the known distribution of native *Cerion incanum* (Figure 1, ♦) and the sites of Bartsch's introductions (Figure 1, ●). The Delray Beach Colony inhabits vegetation on seaside sand dunes between the Atlantic Ocean and Route A1A, from Atlantic Avenue (26°27.696′ N, 80°03.483′ W) northward to near the northern limit of the Gulfstream Golf Course (26°29.284′ N, 80°03.218′ W), where the dunes and vegetation are replaced by private homes that extend to the beach. These *Cerion* are most abundant just south of George Bush Boulevard (26°28.350′ N, 80°03.373′ W), and near the northern end

Table 1. The family Cerionidae in Florida.

A. Fossil Taxa (all Oligocene, from Balast Point, Tampa Bay)
Cerion (Eostrophia) anodonta Dall, 1890.
Cerion (Eostrophia) anodonta var. *floridanum* Dall, 1890.
Microcerion floridanum Dall, 1915.

B. Living, Native Taxa (with their type localities).
Cerion incanum incanum (Binney, 1851). Key West.
Cerion incanum fasciatum (Binney, 1859). Key Biscayne.
Cerion incanum saccharimeta 'Blanes' Pilsbry and Vanatta, 1899. Sugarloaf Key.
Cerion incanum vaccinum Pilsbry, 1902. Key Vacca.

C. Non-native species of Cerion introduced intentionally to the Florida Keys and the Dry Tortugas by Bartsch, 1912–1924.
Cerion viaregis Bartsch, 1920. From Andros, Bahamas, introduced to: Second Ragged Key North of Sands Key; Tea Table Key; Duck Key; Newfound Harbor Key; Key West; Boca Grand Key; Garden Key; Loggerhead Key; Man Key; Boy Key.
Cerion casablancae Bartsch, 1920. From Andros, Bahamas, introduced to: First Ragged Key North of Sands Key; Sands Key; Indian Key; Bahia Honda Key; Loggerhead Key.
Cerion (Paracerion) tridentatum Pilsbry and Vanatta, 1895. From Cuba introduced to: Key West; Garden Key, north side of the parapet at Fort Jefferson; Loggerhead Key.
Cerion mumia (Sowerby, 1834). From the point at Miramar, Cuba, introduced to: Garden Key, north side of the parapet at Fort Jefferson, Loggerhead Key.
Cerion chrysalis ("Ferussac" Beck, 1837). From near Cabanas Fort, Cuba, introduced to: Garden Key, north side of the parapet at Fort Jefferson, Loggerhead Key.
Cerion sculptum (Poey, 1858). From near the lighthouse at Mariel, Cuba, introduced to: Garden Key, north side of the parapet at Fort Jefferson.
Cerion "n. sp." Young. From East of the point at Mariel, Cuba, introduced to: Garden Key, north side of the parapet at Fort Jefferson.
Cerion sp. [small, mottled]. From Andros, Bahamas, introduced to: Bird Key.
Cerion sp. Mottled. From New Providence, Bahamas, introduced to: Loggerhead Key.
Cerion crassilabris ("Shuttleworth" Sowerby, 1875). From Puerto Rico, introduced to: Loggerhead Key.
Cerion uva (Linne, 1758). From Curaçao, introduced to: Loggerhead Key.
Cerion "mayori" (not clear if this is a typographical error for *C. mayoi* Maynard and Clapp, 1920, or a manuscript name). From Middle Bight, Andros, introduced to: Loggerhead Key.
Unspecified *Cerion*. From Puerto Rico and "El Salvador," introduced to: Loggerhead Key.
Cerion incanum (Binney, 1951). Source unspecified [Florida Keys], introduced to: Loggerhead Key, Man Key, Boy Key.

of Gulfstream Golf Course (26°29.247′ N, 80°03.229′ W), where densities exceeded 15 individuals per square meter. The snails in this colony are fairly uniform in their shell morphology (Figures 3, 5–8), but vary in degree of pigmentation from pure white (Figure 7) to weakly (Figure 6, 8) or strongly (figures 2, 4) mottled with oblique bands of brown.

Many *Cerion* researchers (e.g., Pilsbry, 1907; Mayr and Rosen, 1956; Clench, 1957; Gould and Woodruff, 1978) accepted the hypothesis that hurricanes play a significant role in the long distance dispersal of *Cerion* species and are a major factor in determining biogeographic patterns within the genus. A review of historical hurricane tracks [http://hurricane.csc.noaa.gov/hurricanes/viewer.html] revealed that the Little Bahama Bank and the Bimini Islands (both within 120 km of Delray Beach) are the closest potential sources for this colony under this dispersal scenario. However, intentional human introduction during the mid-20th Century is, in our view, a more credible explanation for the origin of this colony. Dr. Edward Petuch (personal communication) recounted to us his conversations with the late P. L. and T. L. McGinty, in which they acknowledged introducing at least six different Bahamian populations of *Cerion*, "mostly from West End (Grand Bahama Island) and the Bimini Islands," to the vicinity of their home in Boynton Beach. These second-hand accounts of *Cerion* introductions are given credence by an earlier report of an anomalous population of another land snail, *Liguus fasciatus* (Müller, 1774), from nearby Boynton Beach (Craig, 1973) that was subsequently documented as being the descendents of an intentional introduction by the McGinty brothers (Krieger and Austin, 1975). Whether transported by a hurricane or intentionally introduced, the most probable sources for the Delray Beach colony are the *Cerion* faunas of the Little Bahama Bank or of the Bimini Islands.

Nine species or subspecies of *Cerion* have been described from the Little Bahama Bank (Clench, 1957) (Table 2, Figures 9–18). Gould and Woodruff (1978) reduced these taxa to two semispecies, *C. abacoensis* Pilsbry and Vanatta, 1895, and *C. bendalli* Pilsbry and Vanatta, 1896, based on morphometric and allozyme studies, but noted that the various shell morphotypes could be localized to specific regions on the Little Bahama Bank.

Clench (1935: 50) conjectured that *Cerion milleri* (Pfeiffer, 1867), described from Duck Key, Exuma

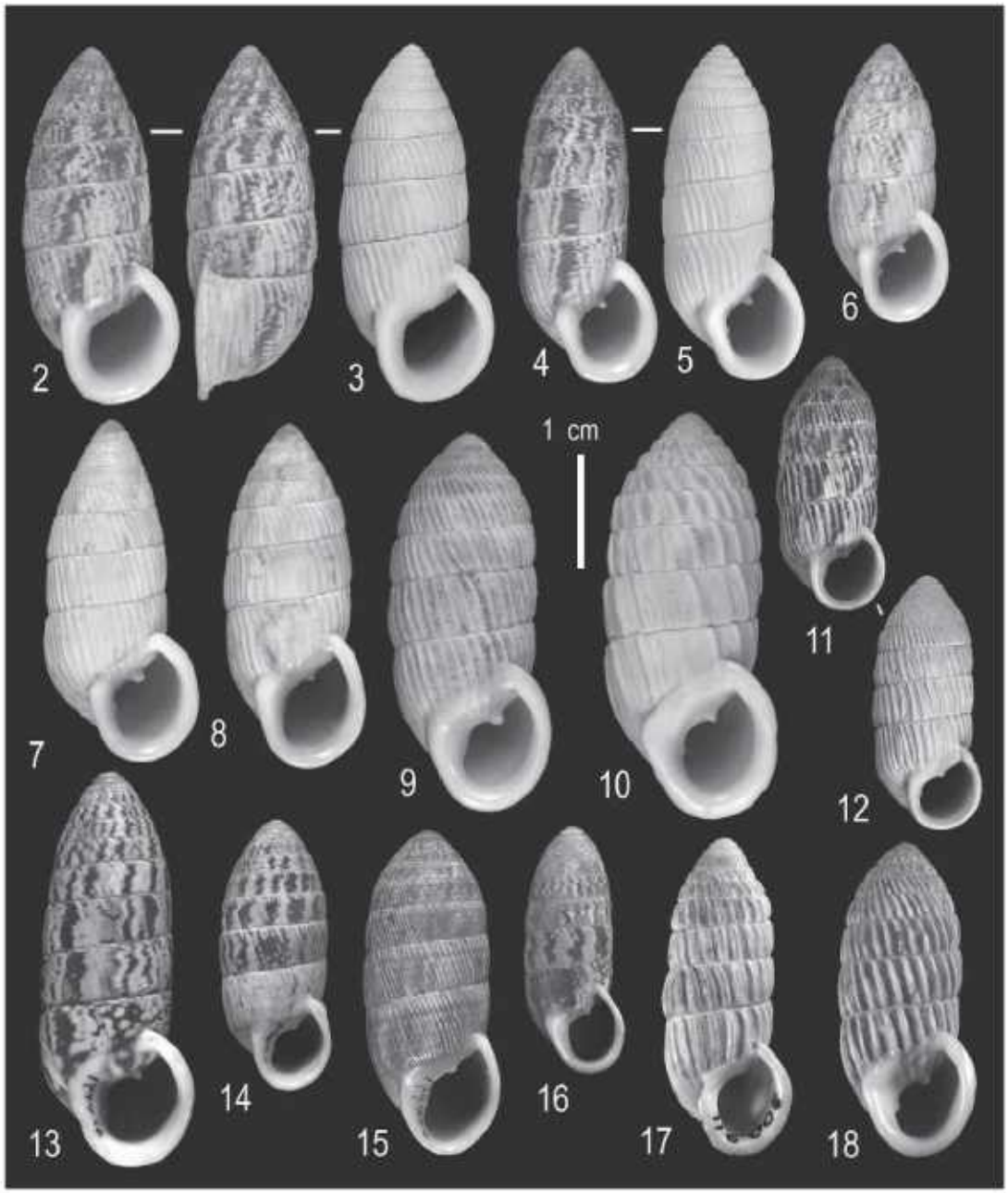
Figure 1. Distribution of the Genus *Cerion* in Florida. Late Oligocene-Early Miocene species (triangle, ▼). Recent, native species, *Cerion incanum* and subspecies (diamonds, ♦). Non-native species of *Cerion* intentionally introduced to the Florida Keys and the Dry Tortugas by Bartsch, 1912–1924 (circles, ●). New record of introduced *Cerion* (cross, ✠). Probable sources of the introduction are the Little Bahama Bank and/or the Bimini Islands. Satellite image modified from that available at http://visibleearth.nasa.gov.

Group, might actually be from Duck Key in Cherokee Sound, off Abaco, noting that he could not find any "Duck Key" in the Exuma Group on modern maps. Gould and Woodruff (1978: 381) commented that if Clench were correct, *C. milleri* would become the senior synonym of *C. bendalli*, but noted that they could not verify Pfeiffer's locality, and that similar mottled *Cerion* occur throughout the Bahamas, including the Exumas. Perusal of Nautical Chart 26-D (Department of the Navy Hydrographic Office, 1965) reveals Duck Cay to be located west of the southern end of Great Exuma Island (23°27.22′ N, 76°02.60′ W), supporting Pfeiffer's original type locality and excluding this taxon from the fauna of the Little Bahama Bank.

The *Cerion* fauna of the Bimini Islands consists of five named taxa (Table 3, Figures 19–23). Clench (1942) had synonymized three of the taxa (*Cerion pillsburyi* Pilsbry and Vanatta, 1897, *C. canonicum* Dall, 1905, and *C. northropi* Dall, 1905), but later (Clench, 1956) he named another taxon. Mayr and Rosen (1956) concluded that it was not possible to classify the existing colonies simply in terms of three nominal species, and noted that some colonies formed highly variable hybrid populations.

The transplantation experiments of Bartsch (1920) documented that colonies resulting from single introductions retain the morphology of their parental stock for multiple generations following transplantation. However, most *Cerion* "species" hybridize freely when commingled. In the short term, such hybrid populations produce morphological and molecular features not evident in either parent population (Bartsch, 1920; Woodruff, 1989). Over a period of decades, the hybrid phenotype and genotype may be gradually assimilated into that of the numerically dominant taxon (Woodruff and Gould, 1987), yet even after millennia, traces of past hybridization may persist as area effects (Goodfriend and Gould, 1996).

Shells from the Delray Beach colony do not resemble precisely any of the fourteen named taxa from either the Bimini Islands or the Little Bahama Bank as might be expected if this colony were the result of a single introduction. Rather, Delray Beach colony *Cerion* exhibit at-



Figures 2–8. Five specimens of introduced *Cerion* from northern end of Delray Park, Delray Beach, Florida (26°28.23′ N, 80°03.39′ W), USNM 1086626. **2.** Specimen A. **3.** Specimen A coated with ammonium chloride to show sculptural details. **4.** Specimen B. **5.** Specimen B coated with ammonium chloride to show sculptural details. **6–8.** Specimens C-E, weakly pigmented or unpigmented specimens.

Figures 9–18. *Cerion* taxa from the Little Bahama Bank. **9.** *Cerion abacoensis* Pilsbry and Vanatta, 1895, lectotype, ANSP 25337, Abaco, Bahamas. **10.** *Cerion maynardi* Pilsbry and Vanatta, 1895, lectotype, ANSP 25338, Abaco, Bahamas. **11–12.** *Cerion abacoensis bendalli* Pilsbry and Vanatta, 1896, **11.** Lectotype, ANSP 25343, Great Abaco, Bahamas. **12.** Lectotype coated with ammonium chloride to show sculptural details. **13.** *Cerion oweni oweni* Dall, 1905, lectotype, USNM 179436, Little Abaco, opposite Marsh Harbor and Riding Point, Grand Bahama. **14.** *Cerion oweni reticulatum* Dall, 1905, lectotype, USNM 179443, Sugar Loaves, Abaco. **15.** *Cerion oweni incisum* Dall, 1905, lectotype, USNM 179440, Stranger Cay, NW of Little Abaco. **16.** *Cerion oweni vermiculum* Dall, 1905, lectotype, USNM 179442, Mathews Point, south side of Great Abaco Bahamas. **17.** *Cerion chrysaloides* Plate, 1907, MCZ 116008, Eight Mile Rock, Grand Bahama Island. **18.** *Cerion lucayanorum* Clench, 1938, paratype, MCZ 116018. NW portion of Mores Island, 32 miles NW of Southwest Point, Great Abaco Island, Bahama Islands. Scale bar = 1 cm for all specimens.

Table 2. *Cerion* taxa described from the Little Bahama Bank, listed chronologically, together with their type localities, primary type specimens, and subsequent notes on distribution.

Cerion abacoensis Pilsbry and Vanatta, 1895. Abaco, Bahamas. Lectotype, ANSP 25337a (Baker, 1963: 206), now ANSP 25337, 4 paralectotypes ANSP 411926. Gould and Woodruff (1978: 379, fig. 1) report that this phenotype is restricted to the Crossing, Great Abaco.

Cerion maynardi Pilsbry and Vanatta, 1895. Abaco, Bahamas. Lectotype, ANSP 25338a (Baker, 1963: 206), now ANSP 25338, 4 paralectotypes ANSP 411925. Gould and Woodruff (1978: 379) reported finding this phenotype only near Hole-in-the-Wall Light, on Great Abaco.

Cerion abacoensis bendalli Pilsbry and Vanatta, 1896. Great Abaco, Bahamas. Lectotype, ANSP 25343a (Baker, 1963: 206), now ANSP 25343. Gould and Woodruff (1978: figs. 1–3) report that this phenotype is broadly distributed on Grand Bahama Island, Little Abaco, and northern and central Great Abaco.

Cerion oweni oweni Dall, 1905. South side of Little Abaco, Bahamas. Lectotype, USNM 179436 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 12) is here designated as the lectotype], 17 paralectotypes, USNM 1086731. Dall (1905b: 443) reported the typical form to occur on Little Abaco, Great Abaco, and Grand Bahama Island. The type locality is that of the lectotype.

Cerion oweni reticulatum Dall, 1905. Sugar Loaves Rocks, NW of Elbow Cay, Great Abaco, Bahamas. Lectotype, USNM 179443 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 8) is here designated as the lectotype], 13 paralectotypes, USNM 1086732.

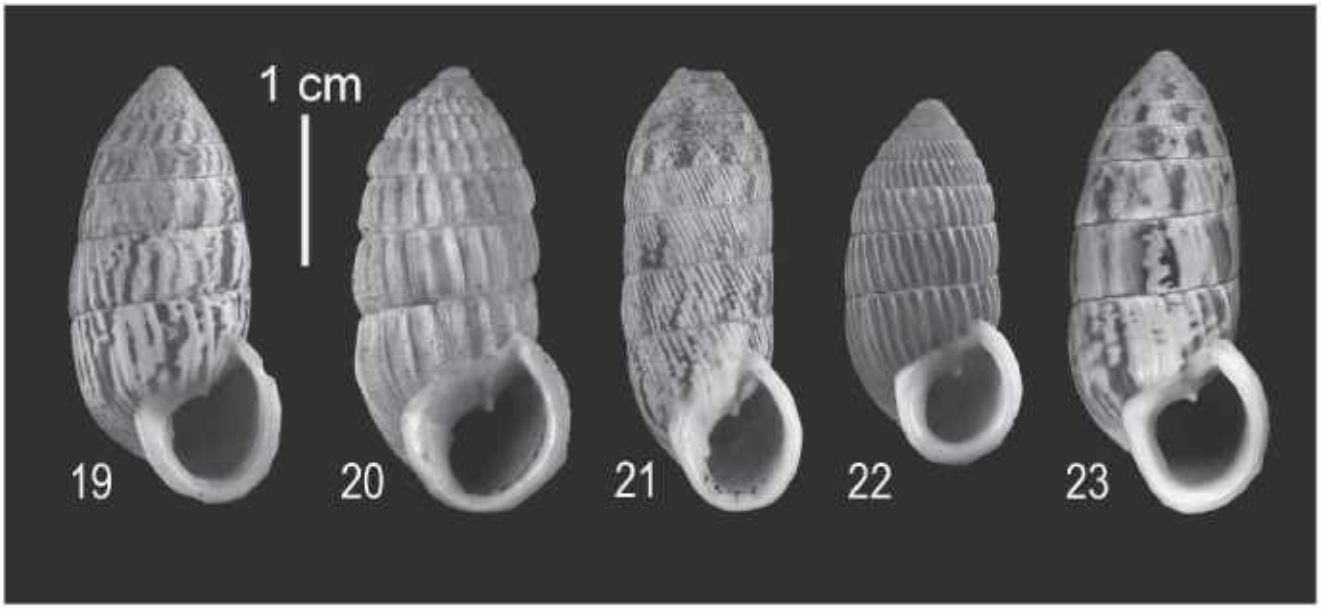
Cerion oweni incisum Dall, 1905. Stranger Cay Beach, NW of Little Abaco. Lectotype, USNM 179440 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 10) is here designated as the lectotype], 4 paralectotypes, USNM 1086733.

Cerion oweni vermiculum Dall, 1905. Mathews Point, south side of Great Abaco Bahamas. Lectotype USNM 179442 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 3) is here designated as the lectotype], 3 paralectotypes, USNM 1086734.

Cerion chrysaloides Plate, 1907. Eight Mile Rock, Grand Bahama Island, MCZ 116008.

Cerion lucayanorum Clench, 1938. NW portion of Mores Island, 32 miles NW of Southwest Point, Great Abaco Island, Bahama Islands, paratype, MCZ 116018.

tributes of several of the potential source populations. The broad shells with fewer, taller whorls, a longer, more acute conical portion of the spire, and thin parietal callus are most similar to *C. pillsburyi* and *C. eximium lerneri* from the Bimini Islands. However, the strong ribbing, patterns of pigmentation, as well as the shape, size, and orientation of the aperture and columella more closely resemble taxa from the Little Bahama Bank, particularly



Figures 19–23. *Cerion* taxa from the Bimini Islands, Bahamas. **19.** *Cerion pillsburyi* Pilsbry and Vanatta, 1897, lectotype, ANSP 72136a. Gun Cay. **20.** *Cerion canonicum* Dall, 1905, lectotype, USNM 127460. Gun Key. **21.** *Cerion northropi* Dall, 1905, lectotype, USNM 125135. One of the westernmost islets near Gun Cay. **22.** *Cerion biminiense* Henderson and Clapp, 1913, lectotype, USNM 252849. Southern end of North Bimini Cay. **23.** *Cerion eximium lerneri* Clench, 1956, holotype, MCZ 186830. East Bimini.

Table 3. *Cerion* taxa described from the Bimini Islands, listed chronologically, together with their type localities, primary type specimens, and subsequent notes on distribution.

Cerion pillsburyi Pilsbry and Vanatta, 1897. Gun Cay, Bahamas. Lectotype, ANSP 72136a (Baker, 1963: 207), now ANSP 72136, 3 paralectotypes ANSP 411921.
Cerion canonicum Dall, 1905. Gun Cay, Bahamas. Lectotype, USNM 127460 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 13) is here designated as the lectotype], 4 paralectotypes, USNM 1086735.
Cerion northropi Dall, 1905. Bahamas, probably one of the westernmost islets near Gun Cay. Lectotype, USNM 124135 [originally illustrated specimen (Dall, 1905b: pl. 58, fig. 11) is here designated as the lectotype], 2 paralectotypes USNM 1086736.
Cerion biminiense Henderson and Clapp, 1913. Southern end of North Bimini Cay, Bahamas. Lectotype, USNM 252849 [originally illustrated specimen (Henderson and Clapp: 1913, pl. 4 fig. 10) is here designated as the lectotype], 158 paralectotypes, USNM 1086737.
Cerion eximium lerneri Clench, 1956. Holotype, MCZ 186830. Southern tip of East Bimini, Bimini Islands, Bahamas.

C. abacoensis and *C. oweni oweni*. Shell morphology suggests that the Delray Beach colony may be the result of hybridization of snails from two or more populations introduced from the northern Bahamas some time near the middle of the twentieth century. Future genetic analyses may aid in the identification of the source Bahamian population or populations for the Delray Beach colony.

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