

The Fossil Cypraeidae of the Pinecrest Member (Unit 7) and Kissimmee River Valley Equivalent, Tamiami Formation of Southern Florida: (Mollusca: Gastropoda: Cypraeidae)

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ABSTRACT Following the disappearance of the seven Buckingham Member (Unit 10) Cypraeidae from the Myakka Lagoon System (Myakka), there was a hiatus represented by two strata at Sarasota (Pinecrest Members 9 & 8) in the early Piacenzian Pliocene, 3.6 million years ago (“mya”), from which no Cypraeidae have been recorded. This was followed by the warmest and most tropical conditions of the entire Pliocene. The sea grass beds and mud flats, which were the preferred habitats of the Pinecrest Cypraeidae, returned in force. The depositional strata which resulted, Pinecrest (Unit 7) and its Kissimmee River Valley Equivalent, were very thick and probably represent a long period of uninterrupted deposition. Eight new species in six genera emerged in Myakka. In the Kissimmee River Valley (Kissimmee), six new species in three genera (one new) emerged as the first and earliest known Cypraeidae species from that area. This represented geographically separate, but parallel, evolutionary tracks. Pinecrest Members 6 & 5 represented a repeat of the conditions experienced during Pinecrest Members 9 & 8, resulting in the disappearance of all Pinecrest (Unit 7) Cypraeidae from Myakka and Kissimmee.

KEYWORDS Tamiami Formation, Buckingham Member, Pinecrest Member (Unit 7), Unit 7 equivalent, Cypraeidae, fossil, *Akleistostoma*, *Siphocypraea*, *Pahayokea*, *Calusacypraea*, *Pseudadusta*, Myakka Lagoon System, Sarasota area, Polk Peninsula, Kissimmee Embayment, Kissimmee River Valley, St. Lucie Peninsula, Caloosahatchee Strait, Loxahatchee Strait, Okeechobee Plains, Everglades Pseudoatoll

Peninsular Florida

During the Piacenzian Pliocene Epoch of about one million years (3.6-2.58 million years ago (hereinafter “mya”)), which lasted until the end of the Pliocene, peninsular Florida was still not yet complete. In the west, the estuarine Myakka was isolated from the south by the Caloosahatchee Strait, which appears to have acted as an absolute barrier to the southward migration of Cypraeidae during the late Zanclean-early Piacenzian Pliocene (3.8-3.6 mya). However, during the Piacenzian, the strait apparently became more of an obstacle rather

than a barrier with at least one species having been recorded in Lee and Collier County.

In the east, the Kissimmee Embayment and its southern sedimentary deposits formed a long and broad river valley (Kissimmee) and represented its southernmost extension. The Kissimmee encompassed the Kissimmee Embayment as well as the sedimentary deposits, which flowed into the embayment from the north and surrounds and southward into what today is the Okeechobee Plains. The plains, north of Lake Okeechobee, are low lying grasslands formed by a fairly continuous deposit of these sediments. Kissimmee habitats were

thereby extended from Okeechobee County in the north, southward to encompass present day Osceola County, eastern Highland County, northeast Glades County and western Indian County where Pinecrest Member (Kissimmee Unit 7 equivalent) Cypraeidae are found. The Everglades Pseudoatoll lay to the south of Myakka and Kissimmee.

The pseudoatoll was bounded by coral reefs and coral reef tracts. In the east southeast, south of the Kissimmee, lay the Palm Beach Reef Tract with the Miami Reef Tract representing a continuation of the former, curving to the southwest along the southeast of the pseudoatoll. The pseudoatoll was bounded on the west by the Immokalee Reef Tract, a broad reef system, which ran south southeast from below Myakka. The Long Pine Key Reefs, a set of small reefs, ran from west to east between the southernmost tips of the Immokalee and Miami Reef Tracts. Experiencing periodic flooding and emergent events, the pseudoatoll grew in fits and starts and would remain separate from peninsular Florida until the Late Pleistocene when sediments would fill the remaining gaps.

The Piacenzian Pliocene of Southern Florida (Pinecrest Time)

Following a drop in sea levels, which occurred during the late Zanclean/early Piacenzian crossover period, southern Florida commenced a warming trend, which progressively produced the warmest and most tropical conditions of the entire Pliocene. This was manifested in rising sea levels, the expansion of sea grass bed habitats and mangrove forests and, in the Kissimmee, the formation of the mud and clay sedimentary strata, which would provide the habitat for Kissimmee equivalent Cypraeidae. The contemporaneous Golden Gate Member of the Everglades Pseudoatoll saw the commencement of the richest tropical hard coral

fauna ever found in the Neogene western Atlantic.

Pinecrest and Contemporary Members, Tamiami Formation

In 1964, Olsson and Petit named the "Pinecrest Beds", as a molluscan biozone for the fauna contained in its sandy units, after the old Pinecrest settlement on the Everglades Road off U.S. Route 41 on the Dade-Collier County line. Pinecrest Index fossils were found throughout the Everglades region, including canal digs in Highlands and Glades Counties, *i.e.* Kissimmee. In 1968, Hunter provided the first lithographic description of the widespread shell beds and their fauna. This was further refined in Petuch's 1982 work. In 1992, Missimer gave a more detailed description of the areal extent of what he called the "Pinecrest Sand Beds". The name has been shortened to the Pinecrest Member and aligned with other southern Florida members.

Within the Piacenzian of southern Florida, there were three relevant Tamiami Formation members: the Pinecrest Member, the Golden Gate Member and the Fruitville Member. The Pinecrest is the oldest while the Golden Gate is roughly contemporaneous with both the Pinecrest and the younger Fruitville. The Pinecrest contemporaneous Ochopee Member of the southwestern Everglades area contains only Cypraeidae casts, leaving a void in our knowledge of the species in that member.

Similar to the Buckingham Member, the Pinecrest Member covered all of the Tamiami Formation of southern Florida. The focus of this paper is on Unit 7 of the Pinecrest Member along with its Kissimmee equivalent. It will discuss the two preceding units (9 and 8) as well as the ending units (6 and 5). It will also touch briefly on the Golden Gate Member.

Hiatus (Pinecrest Units 9 and 8)

Two thin (one meter thick each) depositional units overlay the quartz sand and mud of Unit 10 in the Myakka, suggesting short depositional periods. Unit 9 represented a dramatic change with oyster shell beds (*Hytissa meridionalis* Heilprin, 1886) dominating. They formed in subtidal/surface areas in quiet lagoon areas and were so tightly packed that only small amounts of sand were present among these beds. Unit 8, overlaying Unit 9, also represented a further dramatic change with gastropod worm reefs (*Vermicularia recta* Olsson & Harbison, 1953) overlaying the oyster beds. The large size of the worms and their solid beds implies a significant high nutrient riverine input into the lagoon in support.

Such conditions imply that the climax of the late Zanclean Age cooling period extended into the earliest Piacenzian causing reduced sea levels. This would have reduced the sea grass beds and mud flats, which so dominated Unit 10, such that no Cypraeidae have been recorded in either the Unit 9 or 8 strata. That does not mean that there were no Cypraeidae populations extant during these periods. The presence of small, isolated populations may be inferred by the emergence of new species in Unit 7 of the Pinecrest. These would have existed outside the recent quarries and collection sites in those areas.

Pinecrest (Unit 7) Myakka Lagoon System

In the Myakka, habitats, which were virtually identical to those which existed in Buckingham (Unit 10), returned. Composed of quartz sand, often mixed with variable (gradational) amounts of lime muds, the five meters thick strata represent a long depositional period and is considered the main bed of the Pinecrest. Eight new species in five genera emerged.

The shallow water, low salinity mud flats associated with river mouths supported the emergence of two estuarine species in the neotenic *Calusacypraea* (Petuch, 2004) genus. Neoteny is defined as the retention in adults of certain juvenile features, either delayed or permanent, which represent an advantage to the species. With *Calusacypraea* species, it is a likely a permanent adaptation to the environment of its habitat. The genus is considered neotenic when all species within the genus are neotenic. Separately, *Akleistostoma patula* Petuch and Drolshagen, 2011 is associated with mud flats near mangrove forests. The small, intertidal sea grass beds served as perfect habitats for emergent weed eating Cypraeidae species.

However, the areal extent of the Pinecrest sea grass beds was not limited to the Myakka. To the south of Myakka lay the Everglades Pseudoatoll and its Golden Gate Member. The Golden Gate, contained within the pseudoatoll, was defined based on its coral reefs, coral reef tracts and coralline habitats. However, sand flats covered with sea grass also interfingered with the reefs and reef tracts providing substantially the same habitat as the sand and sea grass beds at Myakka. As evidence, *Akleistostoma floridana* (Mansfield, 1931), commonly found in Unit 7 of the Sarasota quarries, has been recorded in the quarries of Lee and Collier Counties to the south of Sarasota. While *A. floridana* existed in the Pinecrest, only specimens collected from the Sarasota area are designated Unit 7.

This suggests that the Caloosahatchee Strait was no longer an absolute barrier to southward migration of Cypraeidae species and it is possible, if not probable, that other species may have breached the strait.

Pinecrest (Unit 7) Kissimmee River Valley Equivalent

Buckingham Member Unit 10 was extant in the upper reaches of Kissimmee. However, in its lower reaches, sediments have been leached leaving only riverine rocks/stones intermixed with broken mollusk fragments. No Buckingham Cypraeidae have been recorded from Kissimmee. Units 9 & 8 are not present in the valley as the estuarine habitats of Myakka did not exist in Kissimmee. However, the presence of Cypraeidae extant during these periods is inferred as the emergence of six species in three genera in Unit 7 equivalent supports their prior existence.

In the Kissimmee, the sedimentary facies differ from other areas of the Pinecrest in general and Myakka in particular. The strata, formed in its estuaries, shallow banks and tidal channels, consists of mud, clay minerals, organic particulate matter mixed with sand and shell bioclasts in mud flats and mangrove tree forests. Hence, fossil Cypraeidae collected in the river valley have been designated equivalent members. Fossil Cypraeidae have been collected in what would have been sea grass beds, and mud flats in tidal channels near Black and Red Mangrove forests.

In addition to *Calusacypraea* (see above), a neotenic genus also emerged in the Kissimmee, *i.e.* *Okeechobea* (Petuch, 2004). The more delicate, bubble like species preferred muddy estuarine and mangrove habitats which were exposed at low tide and represent a likely adaptation to their environment. Two species of *Okeechobea* emerged in Unit 7 equivalent. The other Kissimmee Cypraeidae are associated with sea grass beds and mud flat habitats. The Kissimmee Unit 7 equivalent facies remained constant throughout the Pinecrest. As a result, the well defined Pinecrest units (strata)

of Sarasota do not exist. Rather the strata represent a continuum throughout the Pinecrest, *i.e.* only Unit 7 equivalent existed in Kissimmee during Pinecrest time. The equivalent unit is inferred based upon Index shell fossils from other known, well defined fossil sites.

Hiatus (Pinecrest Units 6 and 5)

The end of Pinecrest time was marked by Units 6 and 5, representing the return of the Unit 9 and 8 conditions at Sarasota. The strata were of similar thickness, one meter each, and were dominated by the same oyster beds and gastropod worm reefs. During this period, all Unit 7 and equivalent Cypraeidae species disappeared. New species would only emerge during the subsequent Fruitville Member.

Pinecrest Member Species

Myakka Lagoon System (Sarasota) Unit 7
Akleistostoma floridana (Mansfield, 1931) - Figure 2A

Akleistostoma patula Petuch and Drolshagen, 2011 - Figure 2B

Akleistostoma (Mansfieldicypraea) rugostoma Petuch and Drolshagen, 2011 - Figure 2C

Siphocypraea (Seminolecypraea) trippeana Parodiz, 1988 - Figure 2D

Pahayokea (Gardnericypraea) mansfieldi (Petuch, 1998) - Figure 2E

Calusacypraea globulina Petuch, 2004 - Figure 2F

Calusacypraea (Myakkacypraea) briani (Petuch 1996) - Figure 2G

Pseudadusta hertweckorum (Petuch, 1991) - Figure 2H

Kissimmee River Valley restricted (Unit 7 equivalent)

Akleistostoma (Ingramicypraea) highlandensis Petuch and Drolshagen, 2011 - Figure 1A

Akleistostoma (Olssonicypraea) hughesi (Olsson and Petit, 1964) - Figure 1B

Pahayokeya kissimmeensis (Petuch, 1994) - Figure 1C

Pahayokeya (Kissimmecypraea) transitoria (Olsson and Petit, 1964) - Figure 1D

Okeechobea osceolai Petuch and Drolshagen, 2011 - Figure 1E

Okeechobea (Yeeshawcypraea) bartoni Petuch and Drolshagen, 2011 - Figure 1F

Altogether, 14 species in six genera have been collected in Pinecrest Unit 7 deposits and its equivalent.

For detailed genera and species descriptions, background information and discussion, see *Jewels of the Everglades, The Fossil Cowries of Southern Florida, 2018*, by Edward J. Petuch, David P. Berschauer and Robert F. Myers.

Origins - Myakka

Two Myakka *Akleistostoma* species appear to be offshoots of *Akleistostoma carolinensis* (Conrad, 1841), with *A. floridana* inhabiting sea grass beds while *A. patula* represented an adaptation to mud flat environments. *Akleistostoma rugostoma* represents a larger and more inflated version of *Akleistostoma crocodila* (Petuch, 1994). The more well developed extremities of *S. (S.) trippeana* separate it from *Siphocypraea (Seminolecypraea) micanopy* Petuch and Drolshagen, 2011 and presage the coiled apical sulcus of later *Siphocypraea* Heilprin, 1886. *Pahayokeya (G.) mansfieldi* most closely resembles its predecessor, *Pahayokeya (Gardnericypraea) erici* (Petuch, 1998). A steinkern cast of *Calusacypraea polkensis* Petuch and Drolshagen, 2011 of the late Miocene was collected in a quarry north of Sarasota in what would have been the western fringes of the Polk Peninsula. It is similar to *C. globulina* and is its probable predecessor. *Calusacypraea (M.) briani* is a more slender and less inflated version of the older

Calusacypraea duerri (Petuch, 1996). *Pseudadusta hertweckorum* is a more oval version of the older *Pseudadusta buckinghamensis* Petuch and Drolshagen, 2011.

Origins - Kissimmee

The origins of the Kissimmee species are more speculative due to the absence of known fossil shell beds below the Pinecrest beds and the limited number of collecting sites over a very large area. In addition, the Polk Peninsula, as well as the Caloosahatchee and Loxahatchee Straits acted as an intervening barrier between Myakka and Kissimmee, resulting in a large degree of genetic separation. Nevertheless, possible, if not probable, connections can be posited.

Given its wide range, *Akleistostoma (Ingramicypraea) pilsbryi* (Ingram, 1939) was probably extant in the Kissimmee prior to the Pinecrest. It most closely resembles *A. (I.) highlandensis* and is its probable predecessor. Likewise, *A. (O.) hughesi* resembles a large, depressed *A. pilsbryi* and is probably a highly localized evolutionary offshoot restricted to the sea grass beds, mangrove forest and mud flats. The two *Pahayokeya* species (*P. kissimmeensis* and *P. (K.) transitoria*) are evolutionary offshoots of an unknown species.

Okeechobea represents an entirely new genus. Like the *Calusacypraea*, they retain certain juvenile features into adulthood. While the coiled apical sulcus present to a greater or lesser extent in all its species would suggest a *Siphocypraea* Heilprin, 1886 offshoot, there does not appear to be a predecessor in that genera, which would serve as rootstock for the genus. In *Okeechobea* species, the apical sulcus is open; the species are mostly inflated, fragile and have varying aperture widths. They appear to be more closely aligned with *Calusacypraea*,

in which case, *C. polkensis* could plausibly be considered the possible predecessor.

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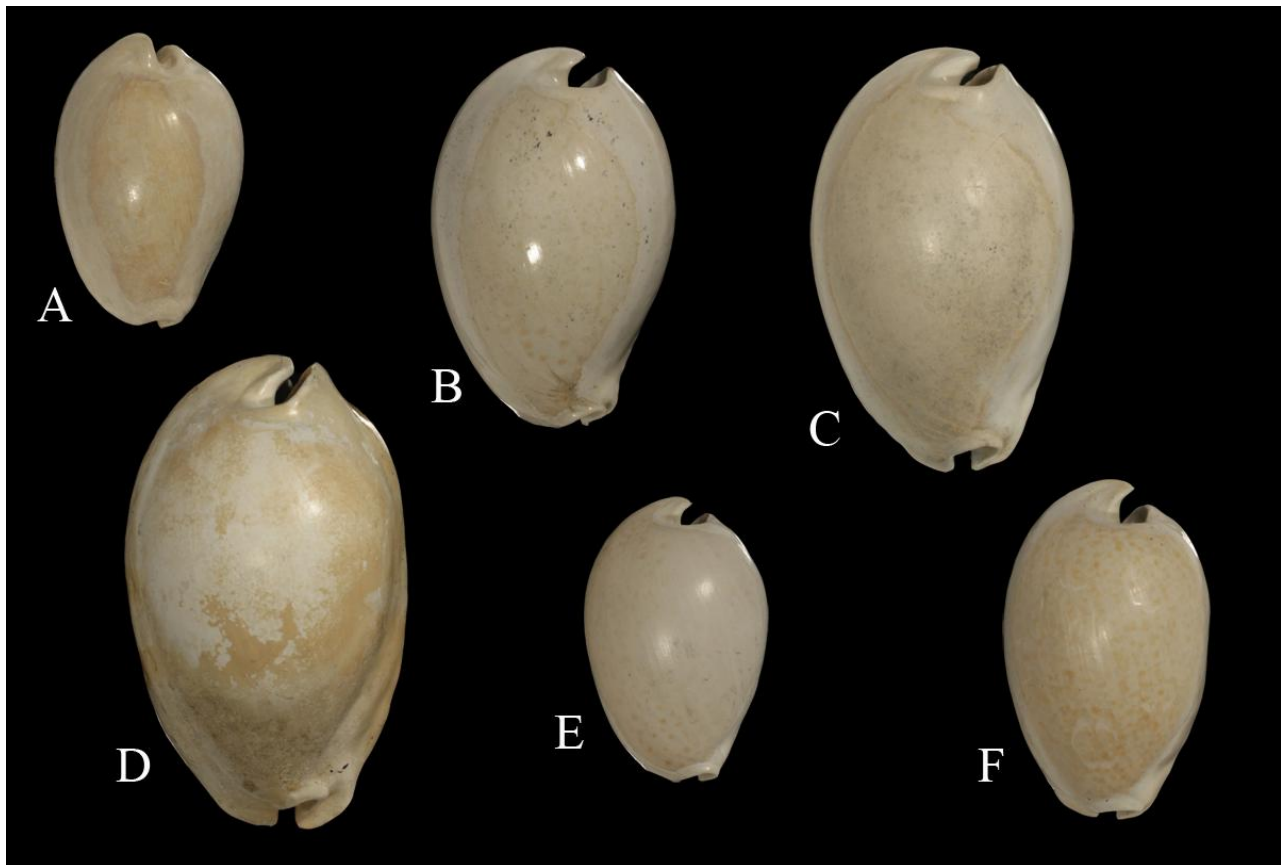


Figure 1. Kissimmee River Valley restricted (Unit 7 equivalent). A = *Akleistostoma (Ingramicypraea) highlandensis* Petuch and Drolshagen, 2011, length 50.9 mm; B = *Akleistostoma (Olssonicypraea) hughesi* (Olsson and Petit, 1964), length 64.6 mm; C = *Pahayokea kissimmeensis* (Petuch, 1994), length 71.5 mm; D = *Pahayokea (Kissimmecypraea) transitoria* (Olsson and Petit, 1964), length 81.4 mm; E = *Okeechobea osceolai* Petuch and Drolshagen, 2011, length 48.3 mm; F = *Okeechobea (Yeehawcypraea) bartoni* Petuch and Drolshagen, 2011, length 57.9 mm.

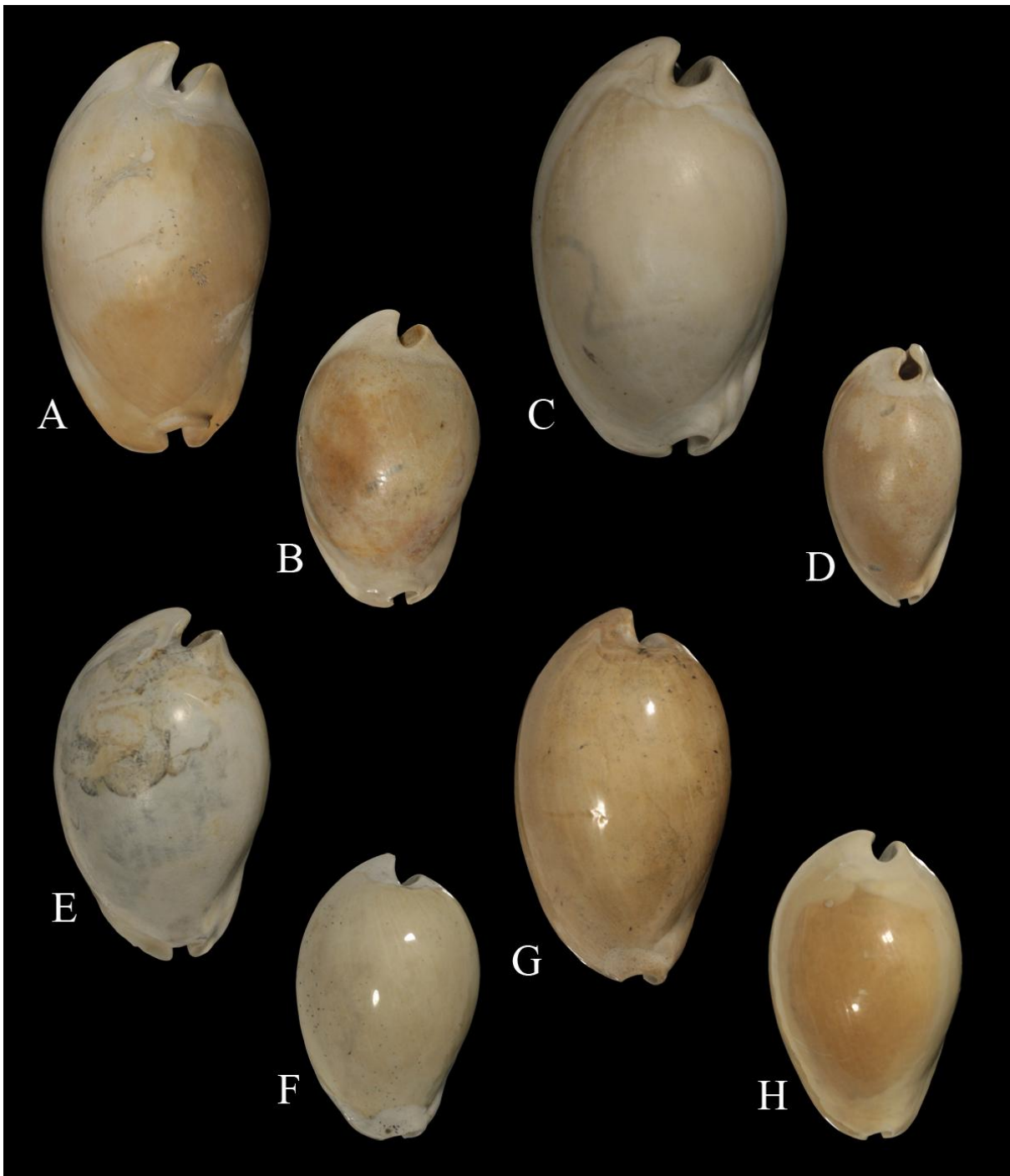


Figure 2. Myakka Lagoon System (Sarasota) Unit 7. A = *Akleistostoma floridana* (Mansfield, 1931), length 78.5 mm; **B =** *Akleistostoma patula* Petuch and Drolshagen, 2011, length 57.3 mm; **C=** *Akleistostoma (Mansfieldicypraea) rugostoma* Petuch and Drolshagen, 2011, length 79.4 mm; **D =** *Siphocypraea (Seminolecypraea) trippeana* Parodiz, 1988, length 50.7 mm; **E=** *Pahayokea (Gardnericypraea) mansfieldi* (Petuch, 1998), length 67.3 mm; **F =** *Calusacypraea globulina* Petuch, 2004, length 54.3 mm; **G =** *Calusacypraea (Myakkacypraea) briani* (Petuch 1996), length 71.1 mm; **H =** *Pseudadusta hertweckorum* (Petuch, 1991), length 58.6 mm.