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THE ANADARID SUBGENUS *CALOOSARCA* IN THE WESTERN ATLANTIC REGION

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ILLUSTRATIONS

I. ABSTRACT

Species referable to the anadarid subgenus *Caloosarca* Olsson, 1961, are distinguished by their broadly elongate valves with anteriorly located umbos and, especially in the younger stages of growth, a broadly emarginated posterior end that gives the valves an auriculate or winged outline. The ligament in the young and early mature stages is confined to the posterior portion of the cardinal area, extending anteriorly only to a point directly below the umbo, with the anterior portion of the area bare; in late mature and gerontic stages this an-

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terior portion may also be covered. The teeth on the hinge plate are in two series that meet immediately below a transverse groove on the cardinal plate which marks the anterior end of the normal ligamental structure.

Seven named species, differentiated primarily upon the number and nature of the radial ribs that ornament the valves, are recognized. A probable eighth species is represented by specimens dredged from upper Miocene deposits in the bed of the Caloosahatchee River, near Olga, Lee County, Florida, but present material is inadequate for description.

One species, *Anadara* (*Caloosarca*) *notabilis* (Röding), is living in relatively shallow waters from Florida to southern Brazil and has been reported from Pleistocene deposits from Cape Hatteras to Brazil. The other species are known only from the fossil record, with five of them being confined, so far as is presently known, to peninsular Florida. Two new species, *A.* (*C.*). *notoflorida* and *A.* (*C.*) *hoerleae,* are described from the upper Miocene, Pinecrest Formation; one species, *A.* (*C.*) *crassicosta* (Heilprin) occurs in the Pliocene, Caloosahatchee Formation; and two species, *A.* (*C.*) *aequalitas* (Tucker and Wilson) and *A.* (*C.*) *catasarca* (Dall), are confined to deposits referred to "Unit A" of Olsson and Petit, 1964, an as yet unnamed post-Caloosahatchee formation. The type of the subgenus, *A.* (*C.*) *rustica* (Tuomey and Holmes) is known only from the Pliocene, Waccamaw Formation of South Carolina and adjacent areas of southern North Carolina.

II. Introduction

Among the more abundant elements in the fossil faunas collected from the Pliocene and early Pleistocene deposits of peninsular Florida are representatives of the anadarid subgenus *Caloosarca* Olsson, 1961. The Pliocene specimens, characterized by great divergence in the size of the ribs on the posterior portion of the median segment of the valves, have been almost universally identified in the literature as *Anadara rustica* (Tuomey and Holmes) following Dall's (1898, p. 653) error in placing *Anadara crassicosta* (Heilprin) in the synonymy of that Carolinian species (see Olsson and Petit, 1964, p. 527-528). The later Pliocene and early Pleistocene specimens with ribs on the median area of the valves of more equal strength have usually been referred to *Anadara aequalitas* (Tucker and Wilson).

During December, 1966, specimens of a relatively equi-ribbed species that clearly was different from *A. aequalitas,* were collected from spoil bank material of upper Miocene age that temporarily was available during the construction of the trans-Florida toll road, generally referred to as "Alligator Alley." Subsequently Mrs. R. E. Hoerle, of West Palm Beach, Florida, presented to Tulane University a collection of upper Miocene fossils that had been secured from material dredged from the Kissimmee River north of Lake Okeechobee. This collection included representatives of yet another undescribed species that showed characteristics more or less intermediate between the "Alligator Alley" species and the Pliocene *A. crassicosta.* As study of this material progressed it became evident that a careful review of the Tertiary and Recent species in the western Atlantic region was desirable and would prove a useful tool to students of these faunas.

In the present study the writer recognizes seven named species as being referable to the subgenus *Caloosarca.* In addition, three specimens dredged from the bed of the Caloosahatchee River one mile below Olga appear to represent an eighth species, but the material is not adequate for description. The named species here referred to *Caloosarca* include:

Anadara (*Caloosarca*) *notabilis* (Röding)—Upper Pliocene or lower Pleistocene, Moín Formation, Costa Rica; Pleistocene, Cape Hatteras, North Carolina to Brazil; Recent, Florida to eastern Texas and southward to Ilha Grande, Rio de Janeiro, Brazil.

Anadara (*Caloosarca*) *catasarca* (Dall)—"Unit A" (unnamed post-Caloosahatchee formation), Upper Pliocene or lower Pleistocene, southern Florida.

Anadara (*Caloosarca*) *aequalitas* (Tucker and Wilson)—"Unit A" (unnamed post-Caloosahatchee formation), Upper Pliocene or lower Pleistocene, southern Florida.

Anadara (*Caloosarca*) *crassicosta* (Heilprin)—Pliocene, Caloosahatchee Formation, southern Florida.

Anadara (*Caloosarca*) *rustica* (Tuomey and Holmes)—Pliocene, Waccamaw Formation, North and South Carolina.

Anadara (*Caloosarca*) *notoflorida* H. E. Vokes, new species—Upper Miocene, Pinecrest Formation, Collier, Lee and Charlotte counties, southern Florida.

Anadara (*Caloosarca*) *hoerleae* H. E. Vokes, new species—Upper Miocene, Pinecrest Formation, Kissimmee River, Highlands County, Florida.

III. Acknowledgments

The present report is one of a series of generic studies of Tertiary and Recent Mollusca being supported by National Science Foundation grant GB-6048. The financial assistance and encouragement thus afforded is most gratefully acknowledged. The writer is also indebted to the authorities of the United States National Museum for the loan of numerous specimens, including the holotypes of *Anadara catasarca* (Dall) and *A. prephina* (Woodring). Mr. Druid Wilson of the United States Geological Survey has permitted the writer to draw on his extensive knowledge of the Florida Tertiary deposits and their faunas; Mr. Richard E. Petit of Ocean Drive Beach, South Carolina, made available the many specimens of *Anadara* (*Caloosarca*) *rustica* (Tuomey and Holmes) that he had collected during the construction of the airport facilities at Crescent Beach, South Carolina; Mrs. Robert C. Hoerle of West Palm Beach, Florida, presented to Tulane University extensive collections from southern Florida that included representatives of all of the species of *Caloosarca* here recognized from that area. Their generosity has been of much assistance during the preparation of this report.

IV. Genus *ANADARA* Gray, 1847
Plate 1, figures 1-7

Type species, by original designation: *Arca antiquata* Linnaeus

The genus *Anadara* was established by Gray (1847, p. 198) in the following terms:

"707. Anadara. Arca sp. *Linn., Lamk., Swains.* Pectunculus Anadara, *Adans.* 1757. Arca rhomboides, *Blainv.* Arca antiquata."

The *Arca antiquata* selected as the type is the species so named by Linnaeus (1758, p. 694) with references to illustrations by Buonanni, Rumphius, Sloane, and Gualtieri, and the habitat given as "O. Americano." There has long been uncertainty as to just what species should bear the Linnaean name. As noted by Dodge (1952, p. 149) the original description is "somewhat vague" and "the references, with the possible exception of the figure from Gualtieri, are valueless." Fortunately, however, there is a small, somewhat worn left valve in the original Linnaean collection that bears the specimen number "144" in Linnaeus' handwriting. This is the number assigned the species in the Tenth Edition of the Systema Naturae and the specimen "agrees in all respects with those few characters in the original description that are not too generalized" (Dodge, 1952).

The problem as to the exact identity of the species has stemmed largely from the Linnaeus citation of his form as from the "O. Americano." While there are superficially similar forms in that region, none agrees very closely with the admittedly poor original figures cited, nor with the specimen in the Linnaean collection. Species of *Anadara, sensu lato,* occur in the warmer waters of all parts of the world. Poli (1795, vol. 2, pl. 25, figs. 14, 15), and following him, Lamarck (1819, p. 42) identified as *Arca antiquata* a Mediterranean form now generally referred to *Anadara* (*Diluvarca*) *diluvii* (Lamarck), a species based upon a fossil shell from the same general region. It is to be noted, however, that Lamarck cited for his *Arca antiquata* "Habite l'Océan indien, les côtes d'Afrique, la Mediterranée." Bruguière (1789, p. 103-4) after citing the records of Rumphius ("l'île de Malacca"), Sloane ("Jamaique"), and Adanson ("Sénégal"), adds "je l'ai trouvée abondamment aux îles de France, de Bourbon & de Madagascar; & Forskhaels dans la mer Rouge." Thus even at this comparatively early date the assignment of the species as a member of the fauna of the "O. Americano" was in question.

Hanley (1855, p. 95) and after him, Dodge (1952, p. 150) suggested that Linnaeus was led into error regarding the locality from which his specimen came by "the erroneous figures he cited from Lister and Adanson . . ." (Dodge). Unfortunately Linnaeus did not cite either of these two authors in the original description of the Tenth Edition, adding them only in the Twelfth Edition where, however, he gives the locality as "Habitat in O. Americano, Africano." It seems more probable that the

assignment to the fauna of the "O. Americano" was based upon the citation to Sloane's "Natural History of Jamaica" in which that author states in the description of his *Pectunculus major polyginglymus hirsutus* (vol. 2, p. 257), "I found it in the Sea adjoining to Jamaica." Why that locality was given preference over that of Rumphius —"Amboina"—is of course not now known.

According to Hanley (1855, p. 94) "The original example, being much worn, was accompanied in the cabinet [of the Linnaean Society] by a perfectly fresh-looking specimen that had possibly been introduced by Sir J. Smith, to further illustrate the species." This latter specimen was figured by Hanley (1855, pl. 1, fig. 4) as *Arca scapha* Meuschen, 1781, with which species Hanley clearly initially identified the Linnaean specimen. "The type, however, having been subsequently pronounced by that eminent naturalist Mr. Cuming to be the *maculosa* of Reeve [1844, Conch. Icon., pl. 4, sp. 24] it has been thought desirable to give an engraving of it likewise (pl. 4, fig. 3)." A comparison of these figures with due allowance being made for the worn condition of the original Linnaean specimen, reveals the very close relationship of the two forms. Dodge (1952, p. 149-150) appears to believe that they are but varietally different, while Olsson (1961, p. 85) after a comparison of the specimens in question "supplemented by a few other shells at the British Museum (Nat. Hist.) believed to represent the same species" concluded that *A. scapha* and *A. maculosa* are synonyms, both of each other and of *A. antiquata* Linnaeus.

The Hanley figure of the Linnaean specimen represents an external view. Woodring (1925, pl. 4, figs. 1, 2) has given figures of its interior and dorsal aspects.

It is of interest to note that Chemnitz (1783, vol. 7, p. 201-205) included: "LINNAEI Syst. Nat. Edit. 10. no. 144. pag. 694." as one of the references to his discussion of his illustration, pl. 55, fig. 548. "Das Paquetboot. Arca Scapha . . . " His other citations include all of the references given by Linnaeus for his *Arca antiquata* in both the 10th and 12th editions of the Systema. Chemnitz cites the locality references of many of the authors listed, but states that the original of his figure came from the Red Sea.

Collections made during the ninth cruise of the RV *Anton Bruun* in the western

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PLATE 1

Figures Page

Anadara (*Anadara*) *antiquata* (Linnaeus) 3

1, 2, 3, 5, 7. USNM 694045, paired valves, length 49.8 mm, height 38.7 mm, diameter 30 mm. Locality, Pamanzi Island, near Mayotta, Comorro Group, Indian Ocean. 1. Exterior of right valve; 2. Oblique view of anterior end, right valve; note median grooves on ribs. 3. Exterior, left valve; 5. Hinge and interior of right valve; note weakening of marginal denticulations toward anterior end of ventral margin. 7. Dorsal view of conjoined valves.

4, 6. USNM 694046, paired valves, length 77.6 mm, height 60 mm, diameter 58 mm. Locality, between West and Polymnie Islands, Aldabra Group, Indian Ocean. 4. Dorsal view of gerontic specimen; note irregular ligament grooves. 6. hinge view.

Anadara (*Caloosarca*) *notabilis* (Röding) 30

8. USNM 694047, left valve, length 52.5 mm, height 39 mm. Locality TU R-109.

9, 10. USNM 694049, paired valves, length 33 mm, height 26.1 mm, diameter 21.5 mm. Locality TU R-109. 9. Exterior of right valve with preserved remnants of periostracum; 10. Dorsal view of conjoined valves; note smooth anterior end of cardinal margin.

11, 12. USNM 694048, right valve, length 47.8 mm, height 35.8 mm. Locality TU R-109. 11. Hinge and interior of valve; 12. Exterior of right valve; note grooved anterior ribs.

Figure 2 slightly enlarged, all others approximately natural size.

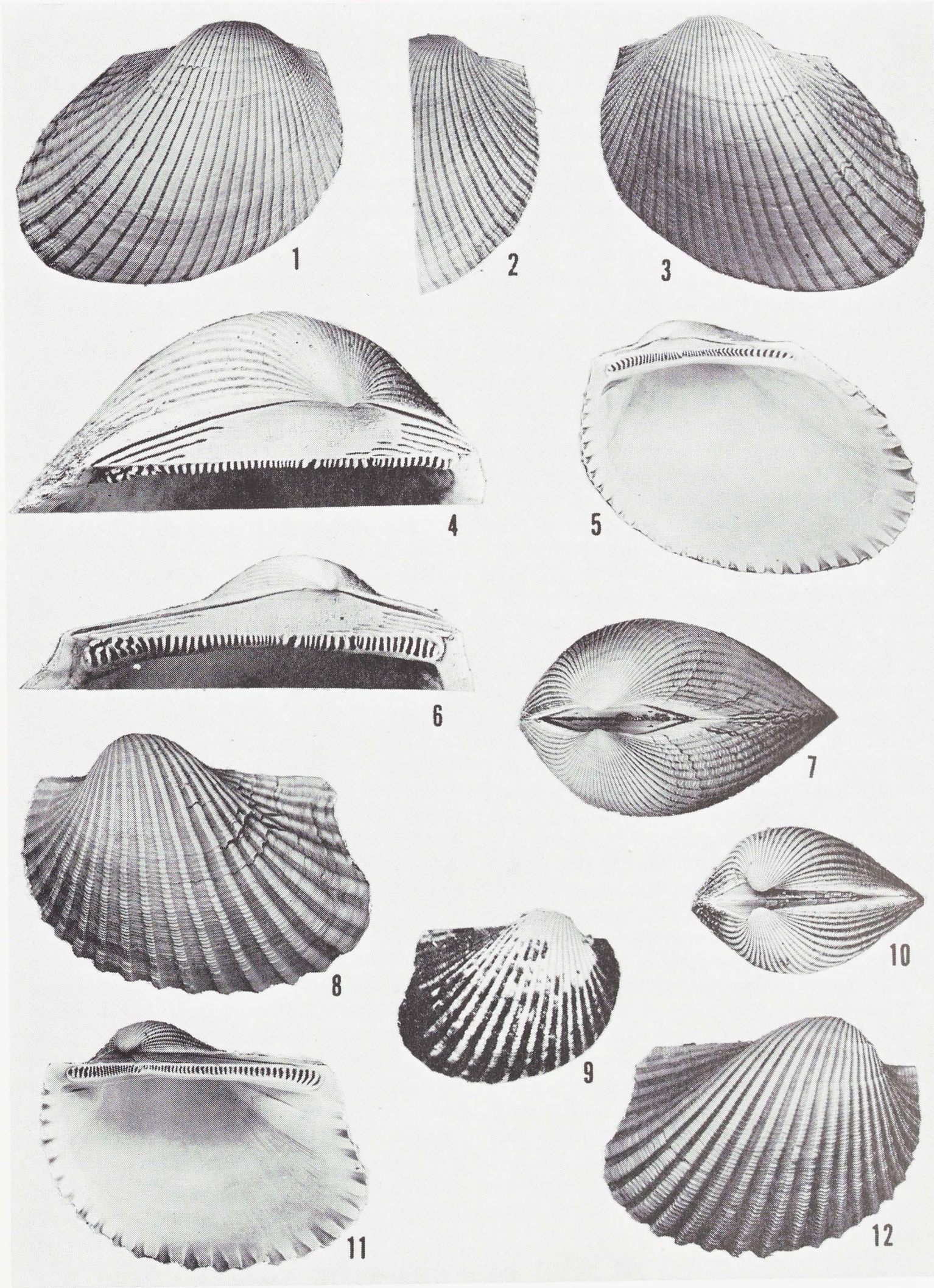


PLATE 1

part of the Indian Ocean contain numerous specimens from the coast of Kenya and Tanzania, as well as from the islands of the Seychelles and Comorro Groups. It is also common in collections that I made in 1952-53 in the Philippines, and is listed by Smith *in* Gardiner (1906, p. 597) from the Maldive and Laccadive Archipelagos. Reeve's type of his *Arca maculosa* was cited as from "North coast of New Holland" while Rippingale and McMichael (1961, p. 167) cite "*Anadara maculosa* Reeve (= *antiquata* olim)" as ranging from "Melanesia and Queensland to the Northern Territory" [of Australia]. Kira (1962, p. 124, pl. 44, fig. 12) indicates the range as "south of Amami Islands to the Philippines, in shallow waters." The species thus seems to range throughout the warmer waters of the western Pacific Ocean and the Indian Ocean to the Red Sea.

The recognition of the fact that the name *Arca antiquata* Linnaeus, 1758, is to be applied to the species that has generally been denominated *Arca scapha* Meuschen, 1781 (an invalid name having been published in a non-binomial work, see Opinion 261, Int. Comm. on Zool. Nomenclature) or *Arca maculosa* Reeve, 1844, permits a more precise definition of the genus *Anadara, sensu stricto.* The shell is of medium to relatively large size, equivalved, inequilateral, and rather strongly inflated. The largest specimen in the Indian Ocean collections, a somewhat worn pair of valves from the lagoon at Aldabra atoll in the western Indian Ocean, has the following dimensions: length, 77.6 mm, height, 60 mm, diameter (paired valves), 58 mm. Measurements of a number of adult specimens show a height : length ratio varying between 1:1.23-1.29, and a height : diameter (paired valves) ratio between 1:.72 (in younger individuals)-.96 (in larger, more or less gerontic specimens). The small, prosogyrate umbones are situated just slightly behind the anterior fourth of the total length of the valve, but are slightly posterior to the anterior third of the length of the cardinal area. The length of this structure varies from slightly more than one-half the total length of the valve in relatively oblique specimens, being .57 of the length in the specimen illustrated (Plate 1, fig. 5) to three-fourths of the total length in the larger, more gerontic forms. The ratio of total length to the length of the cardinal area in the large specimen from Aldabra, mentioned above, is 1:.756 (Plate 1, fig. 6).

The cardinal area in living specimens is always completely covered by a thick, dark brown to black ligament which tends to exhibit transverse striations. It is set into deep grooves that are located at the outer margins of the area. In specimens of average size these marginal grooves are the only insertion structures on the area, which is smooth except for faint striations that appear to represent remnant patterns induced by the growth of the hinge teeth. Older specimens occasionally develop ligament insertion grooves that may be parallel to the outer margins of the area as incomplete chevrons, or, more commonly, are parallel to the hinge plate as short, disjunct lines (Plate 1, fig. 4).

The sculpture is essentially similar in both valves and consists of numerous, close-set ribs. A count of 50 valves in the collections from the Indian Ocean area gives the following result:

No. of ribs:	33	34	35	36	37	38	39	
No. of specimens:								
Right valves	1	2	5	7	5	4	1	= 25
Left valves	0	4	5	6	5	4	1	= 25
Total	1	6	10	13	10	8	2	= 50

Initially the ribs are simple, separated by interspaces that are about one-half the width of the adjacent rib, relatively flat-bottomed, but ornamented by raised threads that under the microscope appear as the projecting portions of shingled growth increments. These same lirations also cross the radial ribs but are much subdued and inconspicuous except on the anterior end of the shell where they may, on well-preserved specimens, appear as narrow transverse beading. Early in the development of the valve a median groove develops on the tops of the ribs. This first appears on the anterior portion of the valve (Plate 1, fig. 2), then, usually, on the posterior portion, developing on the median surface of the shell only in relatively late adult stages. Subsequent to the development of the median grooves secondary grooves may appear on each side of them giving the ribs a quadripartite appearance. These first tend to develop on the ribs that mark the area of the margin between the posterior

and ventral surfaces of the shell and appear on the anterior ribs only late in development. The time of appearance of the median grooving is variable. Thus one specimen from near Mayotta in the Comorro Island group that is but 7.7 mm long has such grooves on two millimeters of the length of the anterior ribs; while another from the same locality with a length of 20.4 mm shows no trace of such grooving. The median grooves show quite well on the figure of the Linnaean type specimen given by Hanley (1855, pl. 4, fig. 3).

The hinge line is straight; the teeth arranged in a series that may or may not be interrupted near the middle of the hinge-length posterior to the umbones. Immature specimens show a slight arching of the tooth-row, with the posterior series tending to override the anterior one. In these forms the teeth in the middle portion of the valve are transverse to the hinge plate, with the lateral teeth being divergent. Very small specimens, up to about 5 mm in length, show a small notch in the ventral side of the hinge plate immediately below the median interruption of the two series. In the right valve figured (pl. 1, fig. 5) the anterior series has 20 teeth, the posterior 38. The median nine or ten teeth in each series are relatively thin and transverse in position, but the lateral teeth become more chevron-shaped with the apex of the chevron pointing toward the median tooth elements. This chevron structure is first achieved by a lateral bending of the dorsal portion of the tooth elements such that in those teeth adjacent to the central part of the hinge plate only about the upper fourth of the tooth length is at an angle. The point of angulation tends progressively to become more ventral in location and the most distal elements on either end of the toothrow have the chevron angulation at approximately the middle of the tooth height. Tooth number is moderately constant, but shape is very plastic and variable. Thus, though almost all adult specimens of average size show 19 to 21 teeth in the anterior series and 26 to 29 in the posterior one, approximately one-half of the same specimens will lose the chevron fold in the outer six to eight teeth of the posterior series. In the majority of specimens these tend to be essentially transverse, although with a slight slope such that the dorsal end of a given tooth is somewhat more lateral in position than is the ventral end. Most gerontic specimens have the majority of the teeth directly transverse in position, with only those teeth at the anterior and posterior ends of the hinge plate modified, usually to a chevron-shape. In the largest specimen, mentioned above, the anteriormost teeth are not greatly altered, but the posterior lateral teeth are exceedingly irregular in shape (Pl. 1, fig. 6).

The anterior and posterior adductor scars are of moderate size and not strongly delimited in specimens of average size. Older individuals, however, show a strong tendency towards a thickening of the shell in the region of the anterior adductor until, in truly gerontic individuals there is a definite platform upon which this adductor is attached. The pallial line is entire and not strongly marked except for the fact that there is, near the postero-ventral end, a series of irregular raised ridges separated by rounded grooves that trend normal to the pallial line and extend inward from that structure toward the median portion of the valve.

The ventral margin of the shell is crenulated on its inner side. These crenulations are most strongly developed along the postero-ventral margin but are also well represented on the anterior and posterior ends of the valve. They become weak and relatively inconspicuous toward the anterior end of the ventral margin. This is well shown on the illustration of the Linnaean type given by Woodring (1925, pl. 4, fig. 1) who interpreted it as indicating that the species represented must have had a byssal gape (1925, p. 41); Dodge (1952, p. 149) appears to have interpreted it as a feature resultant from excessive wear in the specimen concerned. It is, however, to be observed in all specimens examined in the present study, including those that were taken alive with full, unworn periostracum. None of these same specimens show more than an exceedingly narrow linear gape in this area (0.3 mm wide in the smaller specimen figured) and none of the preserved animals in the collections reveal any byssal development. It is of interest to note that the weakening of the crenulations in the antero-ventral position is less pronounced on the specimens in the collections

from the Philippine Islands than it is in those from the western part of the Indian Ocean. Indeed this seems to be the one relatively constant character upon which the specimens from the two areas could be distinguished. It suggests that the original Linnaean type must have been from an Indian Ocean or Red Sea locality.

The reason for this weakening of the crenulations in the area in which a byssal gape would occur if present may possibly be taken as suggesting that the modern *Anadara antiquata* was evolved from a byssiferous ancestral species. This suggestion receives some added support in the fact that the umbones of many specimens reveal weak fold-depressions similar to those found in byssiferous species. These are often quite pronounced in shells of 5 to 10 mm total length, but even here, no trace of a true byssal gape can be detected.

Rumphius (1711) states that the species indicated in his pl. 44, fig. 1, which he denominated as *Pecten virgineus* was known among the Malaccans as *"Bia Anadara."* This statement was noted by Chemnitz (1783, p. 202) ". . . a Maleicensibus Bia Anadara vocatur." In the meantime Adanson (1757, 248, pl. 18, fig. 7) used the vernacular "Anadara" for a similar species that was cited by Linnaeus in his synonymy of *Arca antiquata* in the 12th edition of the Systema Naturae and the term appears to have achieved rather wide acceptance as a vernacular name for species of this general form, particularly among the French conchologists. Thus Bruguière (1789, p. 103) uses the heading:

> "12. ARCHE anadara.
> Arca antiquata; LINN."

while also stating (p. 104) that the species is known as "Anadara, *coeur en arche de Noé*; par les Francois." Lamarck (1819, p. 42) used "26. Arche anadara. *Arca antiquata."* It remained for Gray (1847, p. 198) to use the name in a formal scientific sense.

Dimensions:

Figured Specimen, USNM 694045: length 49.8 mm; height 38.7 mm; diameter (paired valves) 30 mm. Locality: Reef flat southwest of Pamanzi Island, near Mayotta, Comorro Group, Indian Ocean.

Figured Specimen, USNM 694046: length 77.6 mm; height 60 mm; diameter (paired valves) 58 mm. Locality: Reef flat at main channel between West and Polymnie Islands, Aldabra Group, Indian Ocean.

V. Subgenus *CALOOSARCA* Olsson, 1961

Type species, by original designation: *Anadara rustica* (Tuomey and Holmes). Pliocene, North and South Carolina.

Olsson's (1961, p. 98) original description of this subgenus was as follows:

"Shell broadly elongate, moderately heavy, equivalve, convex. Cardinal area elongate, rather low or narrow, not covered fully by the ligament, the small portion anterior to the beaks usually bare. Posterior side deeply impressed, often winged or emarginated. Ribs simple, plain or heavily noded and often differing considerably in size, the anterior set sometimes mesially grooved. Hinge teeth small, numerous and in a continuous series.

"In the average specimen of *A. rustica,* the cardinal area in front of the beak is bare, but in gerontic specimens the anterior area may be partly covered or furrowed with ligamental grooves. In *A. notabilis* of the Caribbean, the cardinal area has essentially the same characters as in *A. rustica."*

There has existed in the literature a considerable degree of misunderstanding as to the distribution of the species selected by Olsson to typify his subgenus. This stems from the work of Dall (1898, p. 653) who synonymized the Florida Caloosahatchee species, *Arca crassicosta* Heilprin, with the Carolinian Waccamaw form, *Arca rustica* Tuomey and Holmes, stating (p. 654): "The collection of more material since Professor Heilprin's publication leaves no doubt whatever as to the identity of this splendid species with that of Tuomey and Holmes." The original Tuomey and Holmes description was based upon very inadequate material, and the species is generally rare, becoming well known only after a considerable number of specimens became available through dredging for fill at the airport at Crescent Beach, South Carolina. Study of this material re-establishes the identity of *A. crassicosta* as a species distinct from the Waccamaw form (Olsson & Petit, 1964, p. 527-8).

At the time of the original publication

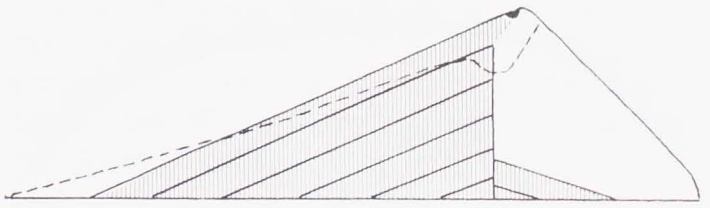
of the name *Caloosarca* Olsson clearly accepted Dall's conclusions as stated above, and gave the range of his *Anadara rustica* as "Pliocene of South Carolina and Florida." This fact, together with the selection of the subgeneric name *Caloosarca,* obviously based upon the name of the Florida, Pliocene, Caloosahatchee Formation, has raised some question as to whether or not this might be considered as a genus based upon a misidentified type species with consequent referral to the International Commission on Zoological Nomenclature (see International Code of Zoological Nomenclature articles 65 (b) and 70 (a)). This seems an unnecessary complication in the present case since there can be no doubt whatsoever but that the two species concerned are congeneric. However, Olsson's reference to the occurrence of the type species in the Pliocene of Florida should be deleted.

The subgenus first occurs in the western Atlantic faunas in the Upper Miocene of Florida and is represented in the Pliocene of North and South Carolina and Florida, the Pleistocene of North Carolina to Brazil, and in the Recent faunas from Florida to southern Brazil. Olsson also refers to this subgenus the Recent Panamic species *Arca biangulata* Sowerby (1833, p. 21), with which is synonymized *Arca gordita* Lowe (1935, p. 16, pl. 1, fig. 1).

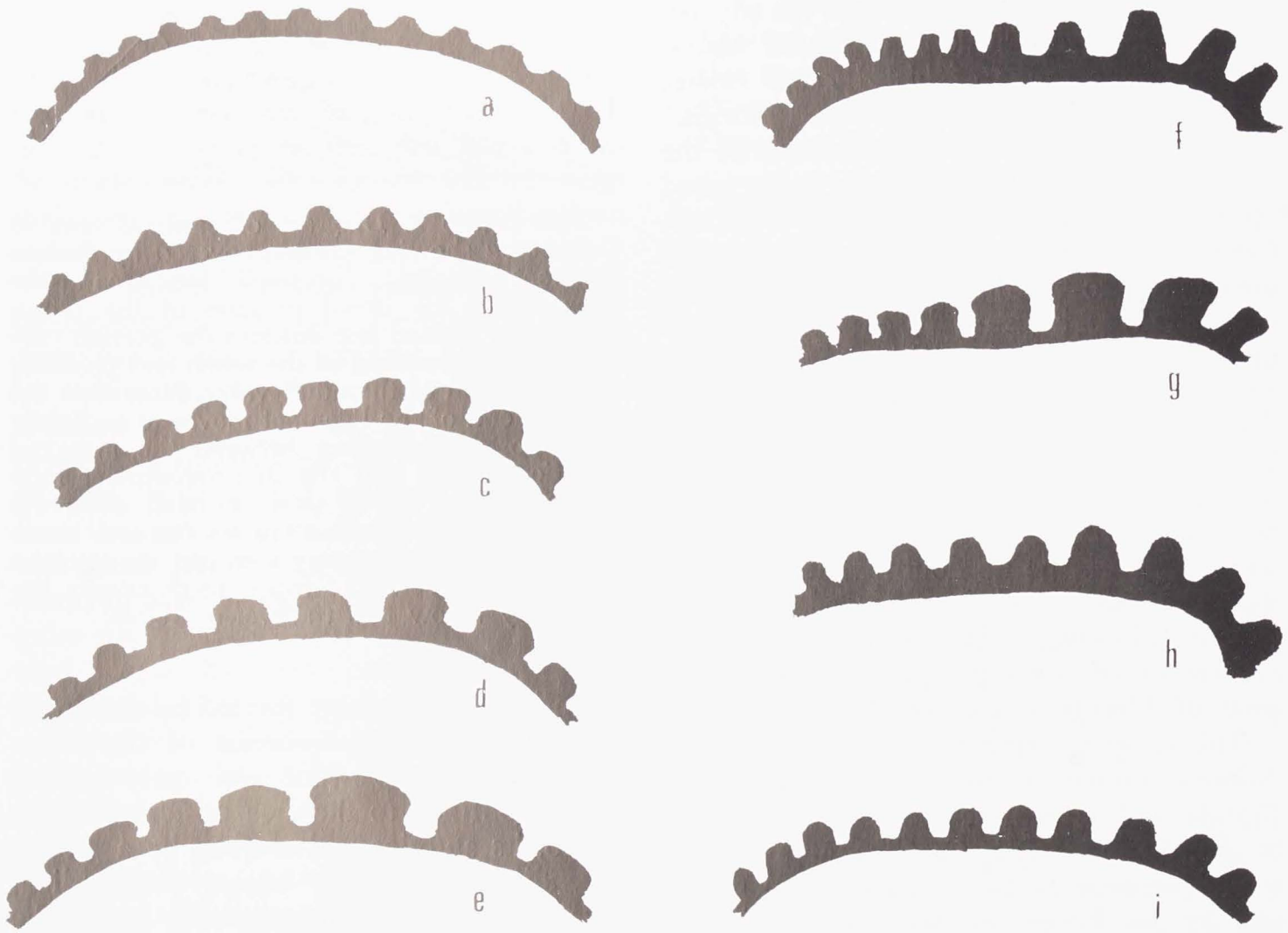
On the basis of the present study of the type and other species here referred to the subgenus *Caloosarca* the following revised description may be given for the subgenus:

Shell broadly elongate, moderately heavy, equivalve, strongly inequilateral with the relatively high, usually inflated umbos situated at, or in front of, the anterior fourth of the total length. Posterior side deeply impressed, winged or emarginate, especially in the earlier stages of growth. Ribs alternate in position on the two valves, simple, usually high, in some species differing considerably in size, especially near the posterior end of the median portion of the valve. Anterior ribs sometimes mesially grooved. All ribs more or less noded by raised growth increments which occur at regular intervals and are present on both ribs and interspaces.

Cardinal area elongate, moderately narrow, widest immediately in front of the umbones and sharply delimited posterior to them by a strong ridge formed by the dorsal margin of the main portion of the valve. Ligament in adolescent and early mature stages confined to the area posterior to the umbo, its anterior end marked by a groove extending transversely across the cardinal area from a position immediately below the umbo to a point immediately above the junction of the anterior and posterior tooth series on the hinge plate (see text fig. 1). Ligament apparently present over the entire posterior area at all stages of development, inserted in a groove immediately below the posterior dorsal ridge and with secondary grooves more or less irregularly parallel with the margin of the area. In late adult and gerontic stages the ligament tends also to occupy the anterior portion of the area, inserted into grooves that make essentially the same relative angle with the hinge line as do those of the posterior series and are never subparallel with the outer margin of the cardinal area as are those of the posterior series. On some specimens the anterior grooves are confluent posteriorly with the anterior end of the posterior grooves to form chevron-shaped structures, in others the anterior ones may terminate posteriorly at a position intermediate between the anterior ends of adjacent posterior grooves. While the time of development of the anterior segment of the ligament varies, in most species there are three to five posterior grooves prior to the first of the anterior ones.



Text figure 1. Diagram of cardinal area in *Caloosarca* showing portion covered by fibrous ligament (shaded). The small black area at the apex marks the initial position of the protoconch, the dashed line outlines the portion covered by the overhang of the umbo and posterior dorsal margin of the adult valve. Note that the anterior end of the ligament moves to a slightly more posterior position between the marginal insertion groove and the first subsequent ligamental groove and is then bounded anteriorly by a shallow groove that crosses the area transversely. The discontinuity between the anterior and posterior series of hinge teeth occurs immediately below this transverse groove.



Text figure 2. Profiles of the ribs on the median area of left valves of species referred to *Anadara* (*Caloosarca*).

a. *A.* (*C.*) *notabilis* (Röding).
b. *A.* (*C.*) *catasarca* (Dall).
c. *A.* (*C.*) *aequalitas* (Tucker and Wilson), typical form.
d. *A.* (*C.*) *aequalitas* (Tucker and Wilson), specimen transitional to *A.* (*C.*) *crassicosta* (Heilprin).
e. *A.* (*C.*) *crassicosta* (Heilprin).
f. *A.* (*C.*) *rustica* (Tuomey and Holmes), typical form.
g. *A.* (*C.*) *rustica* (Tuomey and Holmes), specimen with broad posterior ribs similar to those on *A.* (*C.*) *crassicosta* (Heilprin).
h. *A.* (*C.*) *hoerleae* H. E. Vokes, new species.
i. *A.* (*C.*) *notoflorida* H. E. Vokes, new species.

Hinge line straight, the teeth in two series with the anterior end of the posterior series dorsal to the termination of the anterior one and immediately below the position of the transverse groove of the cardinal plate. The longer posterior series with two and one-half to three times as many teeth as the shorter anterior series. Teeth generally transverse to the hinge plate, narrow, with their sides irregularly grooved. The distal teeth in the posterior series often show a tendency to develop a weak chevron-shape, usually with the apex of the chevron pointing anteriorly, but modification of individual teeth, including partial abortion may occur at any position in either series.

Inner margins of the valves strongly crenulated by the external radial ornamentation, the crenulations usually terminating near the well-marked, entire, pallial line. Interior of the valve pectinated by regularly spaced grooves that are most strongly developed just above the pallial line and immediately anterior to the posterior adductor scar. Adductor scars large, well marked, the anterior subtriangular in shape, the posterior more elongate, situated on a thickened smooth "plate" which is separated from the ventral side of the hinge plate by a distinct anal groove. Pedal retractor and/or diductor scars localized on the ventral side of the hinge plate, well marked.

On the basis of this redefinition of the subgenus, seven (possibly eight) species

present in the upper Miocene to Recent faunas of the western Atlantic area are here referred to *Caloosarca.* Two of these, *Anadara* (*Caloosarca*) *hoerleae,* n. sp., and *A.* (*C.*) *notoflorida,* n. sp., are from the upper part of the Pinecrest Formation, upper Miocene, of peninsular Florida. *A. hoerleae* occurs in deposits that Olsson (*in* Olsson and Petit, 1964, p. 517) has termed "The Brighton Facies" north of Lake Okeechobee, while *A. notoflorida* has been collected only from beds at Acline, Charlotte County, and from spoil bank material temporarily available during the construction of the new trans-Florida toll road that has been termed "Alligator Alley." In both areas the species is associated with *Vasum* (*Hystrivasum*) *locklini* Olsson and Harbison, suggesting that *A.* (*C.*) *hoerleae* and *A.* (*C.*) *notoflorida* are approximately of contemporaneous occurrence. The possible eighth species, in this report designated as "*Anadara* (*Caloosarca*), new species?," occurs in association with a specimen of *A.* (*C.*) *notoflorida* in a collection from material dredged from the bed of the Caloosahatchee River one mile below Olga, Lee County, Florida. It appears, in some characters, to be intermediate in position between the two described upper Miocene forms and *A.* (*C.*) *rustica* (Tuomey and Holmes), from the Waccamaw Formation, Pliocene, of South Carolina and adjacent areas of southern North Carolina, and *A.* (*C.*) *crassicosta* (Heilprin) from the essentially contemporaneous Caloosahatchee Formation of peninsular Florida.

Anadara (*Caloosarca*) *aequalitas* (Tucker and Wilson) is most abundant in collections made in the vicinity of the present Lake Okeechobee from strata that have been termed "Unit A" by Olsson and Petit (1964, p. 521) representing an as yet unnamed post-Caloosahatchee formation which is of uppermost Pliocene or early Pleistocene age. In its earliest occurrences it may be contemporary with *A.* (*C.*) *crassicosta* with which it occurs in collections from Tulane University localities 79 and 529. Unfortunately these are spoil bank collections that may represent more than one stratigraphic unit. The specimens in these two collections, however, are transitional between the two species and seem clearly to establish the evolution of *A.* (*C.*) *aequalitas* from *A.* (*C.*) *crassicosta.* Within the deposits as-

Anadara (*Caloosarca*)	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Number of Specimens Counted
notabilis (Röding)	–	–	–	–	–	–	–	–	–	7	42	82	41	25	3	200
catasarca (Dall)	–	–	2	14	37	45	38	38	20	3	3	–	–	–	–	200
aequalitas (Tucker & Wilson)	12	32	54	43	33	20	6	–	–	–	–	–	–	–	–	200
crassicosta (Heilprin)	–	1	22	80	72	21	3	1	–	–	–	–	–	–	–	200
rustica (Tuomey & Holmes)	–	–	–	–	–	–	4	6	16	14	4	1	–	–	–	45
new species ?	–	–	–	–	2	–	–	–	1	–	–	–	–	–	–	3
notoflorida new species	–	–	–	–	–	8	18	16	8	–	–	–	–	–	–	50
hoerleae new species	–	–	–	–	–	1	–	3	–	–	–	–	–	–	–	4
															Total number of specimens counted:	902

TABLE 1. Number of radial ribs on species of *Anadara* (*Caloosarca*) recognized in this report. All true ribs are counted, but the thickened anterior and posterior rim of the cardinal area is not included.

signed to "Unit A," *A. (C.) aequalitas* occurs most abundantly at localities where the matrix contains a fairly high lime mud content. At those localities where the lime mud element is reduced in amount and the matrix is generally a relatively fine-grained sand we find *Anadara (Caloosarca) catasarca* (Dall) to be the dominant species with *A. (C.) aequalitas* usually rare or absent.

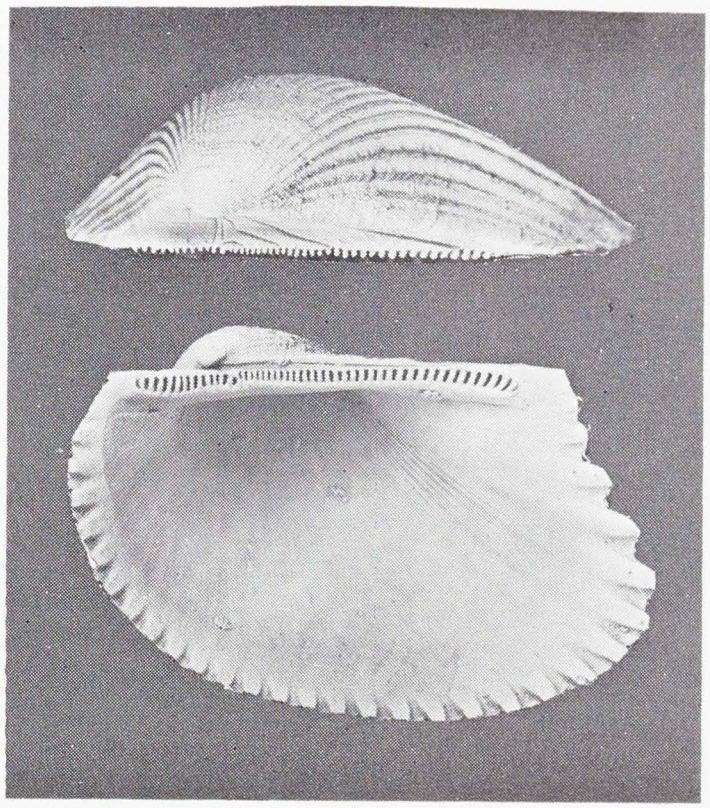
Anadara (Caloosarca) notabilis (Röding) is the only representative of the subgenus that is yet living in the waters of the western Atlantic area, ranging from Florida to southern Brazil. The oldest certain record of its occurrence seems to be from the Moín Formation of Costa Rica which appears to be contemporaneous with "Unit A" of the Florida section.

While there is some recognizable variation within these species in the expression of the characteristic hinge and cardinal area structures, as well as in the degree of inflation of the valves, the most useful characters for specific identification are to be found in the number of radial ribs (see Table 1) and in the variation in their size and shape on the median area of the valves, as well as in the size and shape of the interspaces that separate them (see Text fig. 2).

There are a number of superficially similar species, particularly in the middle and upper Miocene deposits of the western Atlantic region. These forms tend, like *Caloosarca,* to have the anterior end of the cardinal margin smooth in the younger stages of development, and the teeth in two series. But in all cases the anterior termination of the earlier, posterior portion of the ligament is situated well behind the umbos, usually only slightly in advance of the midlength of the area, and there is no transverse groove marking the anterior end of the early ligament growth. The two series of teeth, which overlap in a manner similar to that of the species of *Caloosarca,* meet below the anterior termination of the early posterior portion of the ligament and hence only slightly in advance of the midlength of the hinge plate. Furthermore, they are as a result more nearly equal in the number of teeth present in each series, the posterior usually having but one and one-quarter to one and one-half times as many teeth as the anterior. The outer, terminal teeth in the posterior series often tend to be somewhat inclined, rather than transverse in position as they are in *Caloosarca.* Exteriorly the shells are transversely elongate, ornamented by radial ribs that are never as high and strongly developed as in *Caloosarca;* the posterior end is not as deeply emarginate, the postero-ventral umbonal ridge never as strongly developed, and the shell is but slightly, if at all auriculate posteriorly. The ventral margin tends, in most of these species, to be broadly rounded, rather than relatively straight.

Included in this group of Miocene species are: *Anadara campsa* (Dall) (1898, p. 656, pl. 32, fig. 21) from the upper Miocene, Jackson Bluff Formation of northern Florida; *A. inaequilateralis* (Guppy) (1866, p. 293, pl. 18, fig. 2), *A. halidonata* (Dall) (1898, pl. 646, pl. 33, fig. 24), and (?) *A. dasia* (Woodring) (1925, p. 44, pl. 4, fig. 7) from the upper (?) Miocene, Bowden Formation of Jamaica; *A. istmica* Perrilliat Montoya (1960, p. 12, pl. 1, figs. 3-5) and *A. woodringi* Perrilliat Montoya (1960, p. 13, pl. 2, figs. 3-10) from the upper Miocene, Agueguexquite Formation of the Isthmus of Tehuantepec area of Mexico; *A. actinophora* (Dall) (1898, p. 185, pl. 33, fig. 26) and an apparently undescribed species in the Tulane University collections from the middle Miocene, Gatun Formation of Panama; and *A. guayubinica* (Maury) (1917, p. 170, pl. 28, fig. 4; pl. 29, fig. 1), and *A. riogurabonica* (Maury) (1917, p. 170, pl. 29, fig. 4) from the middle Miocene, Gurabo Formation of Santo Domingo. The Recent species, *A. hemidesmos* (Philippi) (1845, vol. 2, p. 31, *Arca,* pl. 2, fig. 5) from Cuba and Martinique (*fide* d'Orbigny, 1845, p. 345-6, as *hemidermos*), and *A. baughmani* Hertlein (1951, p. 487, pl. A, figs. 1-7) from 40 fathoms off the coast of Texas appear to be descendants of this Miocene group.

It seems most probable that the species referable to *Caloosarca* have been derived from among the Miocene species of this group. Structurally the Bowden species *Anadara prephina* (Woodring) (1925, p. 44, pl. 4, fig. 8) is almost intermediate in position, having the external shape with rounded ventral margin, weaker posterior umbonal ridge, and but slight posterior



Text figure 3. Dorsal and interior views of holotype right valve (USNM 352754) of *Anadara prephina* (Woodring). Note the *Caloosarca*-like nature of the hinge and cardinal area.

emargination, plus numerous, lower, radial ribs such as characterize the typical Miocene forms mentioned above. The hinge and ligamental areas are, however, very similar to those found in *Caloosarca.* The ligament, while confined to the region posterior to the umbos, extended anteriorly to a position almost directly beneath the beaks, with a well-developed transverse groove marking its anterior termination (text fig. 3). The junction between the anterior and posterior tooth series is similarly more anterior in position than is typical of the Miocene species cited above, and almost identical with the location found in *Caloosarca.* The anterior series, in the holotype specimen, has 14 teeth while the longer posterior series has 34 (text fig. 2), a 1:2.5 ratio that agrees more closely with that observed in typical species of *Caloosarca* than it does with the 1:1.25 to 1:1.5 ratio noted in the Miocene species mentioned above.

VI. Tertiary and Recent Species of *CALOOSARCA*

Anadara (Caloosarca) notoflorida H. E. Vokes, n. sp.

Plate 2, Figures 1-7, Text Figure 1i

1939 *Arca catasarca* Dall, Mansfield, Florida Geol. Surv. Bull. 18, p. 12 (dredged, Caloosahatchee River, 1 mile below Olga) (NOT p. 23, 32).

Diagnosis: Shell elongate, subrhomboidal, with moderately inflated, prosocoelus umbos located at or slightly anterior to the anterior fourth of the total length of the cardinal margin. Anterior end of the valve broadly rounded, passing gradually into the gently concave ventral edge, which is rather sharply rounded into the auriculate posterior end. The degree of auriculation varies, being usually most pronounced in the younger individuals, but the posterior margin is always more or less convex in its median portion and projecting in its dorsal segment. The cardinal margin is straight, but the dorsal margin of the main portion of the valve exterior to the cardinal area rises above it to form a rather sharp ridge, especially strong posterior to the umbos, giving the valves when viewed from their lateral aspects a distinctly higher posterior dorsal segment than the short anterior one. Surface of the valves ornamented by 21 to 24 (usually 22 to 23) relatively high radial ribs which are rounded on top but almost straight-sided; the interspaces between them being approximately two-thirds as wide as the adjacent ribs, very gently concave, almost flat-bottomed, and subangulate at their lateral junctions with the ribs. Ribs on the anterior and median portions of the valve almost equal in width; those on the posterior becoming progressively somewhat lower and narrower, with interspaces of approximately equal width. Surface of the ribs and interspaces marked by rather elevated growth increments which occur at regular intervals and cause the tops of the ribs to appear to be nodulous.

The cardinal area is typical of the subgenus, straight and obscurely lozenge-shaped, widest immediately in front of the beaks. Ligament confined to the area posterior to the umbo in the earlier stages of development, appearing on the area anterior to the umbo only in large adult or gerontic specimens. Usually three to four, occasionally five, ligamental grooves (including the outer, marginal one) on the posterior portion prior to the appearance of any anterior one. Anterior end of the ligament in the earlier stages marked by a rounded groove extending transversely across the cardinal area from a point immediately beneath the umbo to a position directly above the junction of the anterior and posterior series of hinge teeth. Usually one or more short incipient transverse grooves anterior to this major one.

Hinge line straight, shorter than the length of the valve, with an anterior and a posterior series of relatively long and very narrow, markedly irregular teeth, generally transverse to the hinge line, but occasionally, especially toward the posterior end of the anterior series, tending to become oblique in position. At times adjacent teeth will unite for a portion of their length then divide to form two segments in a sort of parallel-sided "Y." The anterior series is always shorter than the posterior, usually with 18 to 20 teeth, but variations from 16 to 24 have been noted; the longer posterior series with

approximately two and one-half to three times as many teeth as the anterior one. Tooth counts on adult specimens reveal the following number of anterior/posterior teeth: 16/40, 18/47, 19/52, 20/45, 20/60, 21/51, 24/61. The anterior end of the posterior series is dorsal to the posterior end of the anterior one.

Interior of valve as in other species of the subgenus, with large well-marked adductor scars, the anterior one subtriangular in shape, the posterior more elongate, situated on a thickened smooth plate that is separated from the ventral side of the cardinal area and hinge plate by a distinct groove. Pedal retractor muscle scars moderately large, situated on the ventral side of the cardinal plate. Ventral margin strongly crenulated by the radial ribbing, the crenulations extending inward almost to the pallial line, inside of which are many shallow radial grooves.

Discussion: *Anadara* (*Caloosarca*) *notoflorida* occurs most abundantly in the Tulane University collections from three spoil bank localities that were bared during the course of the construction of the new trans-Florida highway extending from Naples to Fort Lauderdale—popularly known as "Alligator Alley." Mr. Druid Wilson of the United States Geological Survey loaned the writer specimens from the upper Miocene beds at Acline, Florida. The associated fauna at the Tulane localities also indicates an upper Miocene Pinecrest age for the species.

Although only a relatively few specimens were available for the present study, this species appears to be more stable and less variable in its general characters than are the succeeding forms referable to the subgenus *Caloosarca.* This feature is well shown in the rib counts. Fifty specimens reveal the following distribution:

No. of ribs:	21	22	23	24	
No. of specimens:					
Right valves	3	11	5	2	= 21
Left valves	5	7	11	6	= 29
Total	8	18	16	8	= 50

This distribution over four rib number units may be contrasted with that observed for *rustica* (6), *crassicosta* (7), *aequalitas* (8), *catasarca* (9), and *notabilis* (6). It is interesting to note the increase in variability in this factor throughout the Pliocene and Pleistocene species, although the Recent *A. notabilis* proves less variable than its Pleistocene congeners.

Comparison: *Anadara* (*Caloosarca*) *notoflorida,* new species, most closely resembles *A.* (*C.*) *aequalitas* (Tucker and Wilson) in its overall aspect. It may be distinguished from that species, however, by its generally larger number of radial ribs, which are separated from each other by distinctly narrower interspaces. The valves tend to be more elongate in proportion to their height,

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PLATE 2

Figures

All specimens from Pinecrest Formation, upper Miocene, Florida. All figures approximately natural size.

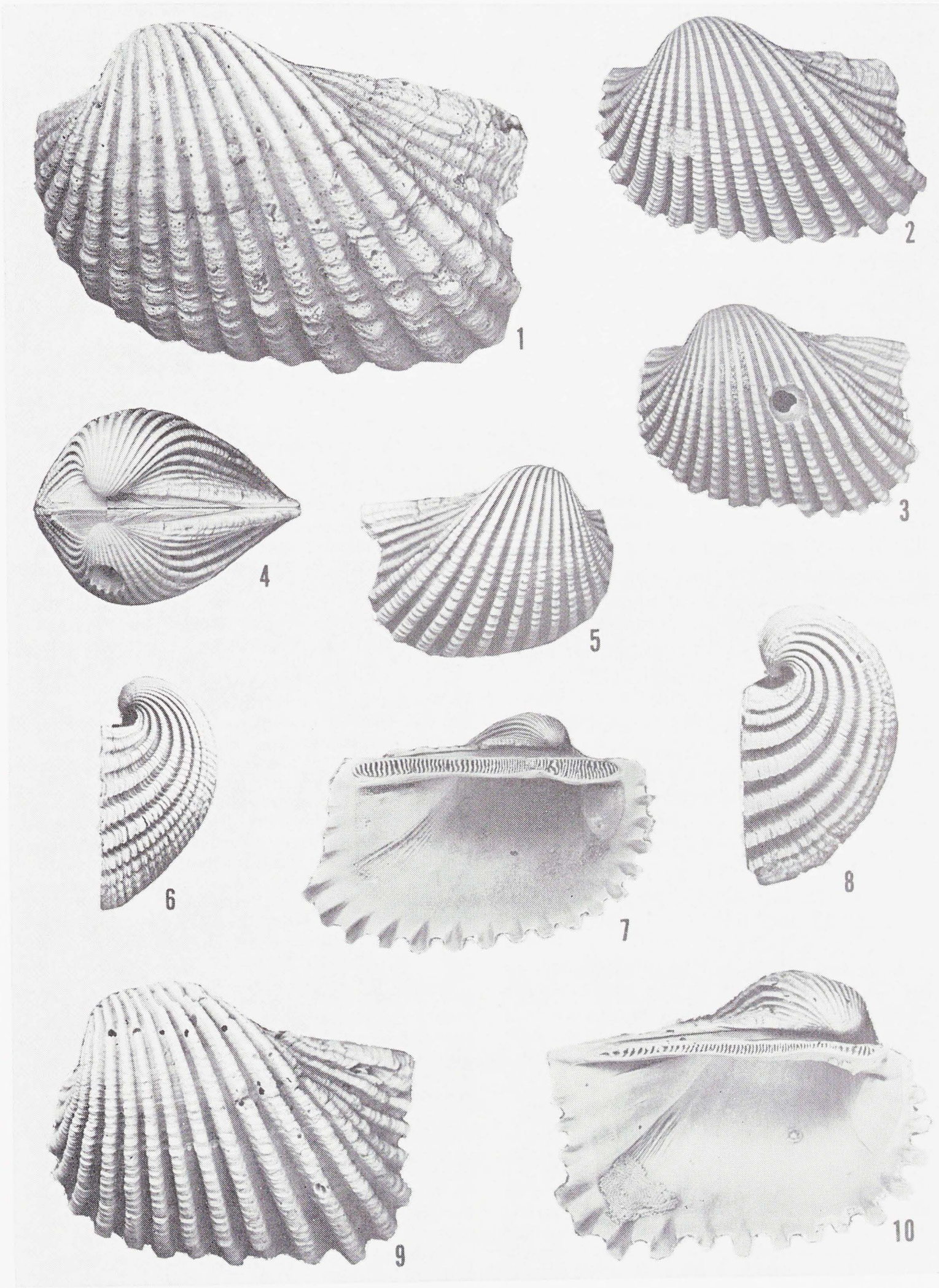

PLATE 2

and the ventral margin less broadly convex than in *A. aequalitas.*

Some of the variants of *A.* (*C.*) *rustica* (Tuomey and Holmes) are superficially similar in general aspect, particularly in the immature stage of development, but none of the specimens of *A. notoflorida* have the ribs near the posterior umbonal ridge as strongly developed in contrast to those more anteriorly situated nor as high in proportion to their width as are those in the Waccamaw form. Furthermore, the ribs on the posterior portion of the valve are sharply delimited and straight-sided on both their dorsal and ventral edges, in contrast to the ventrally sloping sides of those present on *A. rustica.*

Anadara (*Caloosarca*) *crassicosta* (Heilprin) and *A.* (*C.*) *catasarca* (Dall) may readily be distinguished by the respective characteristics of the ornamentation in the two species. *A.* (*C.*) *notabilis* (Röding) differs in overall shape of the valves, number of ribs, and the fact that the ribs are much lower, lacking the straight sides that are so noticeable in *A. notoflorida.*

Holotype, USNM 645912: length 49.4 mm; height 34 mm; diameter (left valve) 17.3 mm. Locality TU 797.

Paratype, USNM 645913: length 74.8 mm; height 49.2 mm; diameter (left valve) 26.7 mm. The largest specimen in the collections. Locality TU 797.

Paratype, USNM 645914: length 42.7 mm; height 31.8 mm; diameter (left valve) 14.9 mm. Locality TU 797.

Paratype, USNM 645915: length 38.3 mm; height 28 mm; diameter (paired valves) 28.2 mm. Locality TU 797.

Collections studied: Tulane University localities 796, 797, 933; USGS 14075, 21257, 21907, 22298, 22299, 22445.

Anadara (Caloosarca) hoerleae H. E. Vokes, n. sp.

Plate 2, Figures 8-10; Text Figure 1h

Diagnosis: Shell of average size for the subgenus *Caloosarca,* marked by broadly inflated and strongly enrolled umbos whose beaks are situated at or slightly anterior to the anterior fifth of the total length of the cardinal margin. Anterior margin of the valve broadly rounded and passing gradually into the almost straight ventral margin which, in turn, is rather sharply rounded into the auriculate to almost straight posterior margin. No young individuals are present in the available collection, but judging from the growth lines, the degree of posterior auriculation is most pronounced in the younger growth stages, as is characteristic of the subgenus. Cardinal margin straight, anteroposteriorly, but distinctly curved and rising laterally to the high dorsal margin of the main portion of the valve, which is exceptionally strong posterior to the umbos where it projects over the lateral portions of the cardinal surface. Surface of the valve ornamented by 21 to 23 relatively high radial ribs that are rounded on top and almost straight on their lateral margins. The interspaces between the ribs are approximately two-thirds as wide as the adjacent ribs, gently concave, almost flat-bottomed, and subangulate at their junctions with the ribbing. Ribs on the anterior end and the anterior and median portions of central area of the valve are almost equal in strength and width. The four or five ribs adjacent to the postero-ventral angulation are somewhat higher and broader, while the four or five on the posterior slope are lower and relatively narrower than those toward the anterior end. Surface of all ribs and interspaces are marked by rather elevated growth increments that occur at regular intervals and cause the tops of the ribs to appear to be nodulated.

Cardinal area essentially similar to that of other species of the subgenus, lozenge-shaped, widest anterior to the umbos and progressively narrowing posteriorly. However, the curved upper surface and the strong overhang of the main valve area results in the posterior portion, when viewed from above appearing to be rather narrow and almost linear. Ligament confined to the area posterior to the umbo throughout most of the development of the individual, appearing on the anterior portion only in late, gerontic stages. Anterior portion of the area with three or more shallow transverse grooves, the posteriormost of which extends from immediately below the beak to a position immediately above the junction of the anterior and posterior series of the hinge teeth.

Hinge line straight, shorter than the length of the cardinal area, with an anterior and a posterior series of transverse teeth. The anterior series is always shorter than the posterior, with 9 to 12 teeth that are usually relatively wider and stronger than the majority of the teeth in the posterior series. The longer posterior series has 57 teeth on the holotype specimen, the only one in the collection in which the entire toothrow is preserved. Its anterior end rides dorsally above the posterior end of the anterior series. The anterior four or five teeth of this series are relatively wide and strong, similar to those of the anterior series; the succeeding 35 to 40 teeth are erect and strikingly narrower and closer together, with the posteriormost teeth becoming again relatively wider and heavier and on the holotype tending to become somewhat irregular, usually with a distinct postero-ventral slope.

Interior of the valve typical of the subgenus. Anterior adductor large, separated from the ventral side of the hinge plate by a distinct groove, dorsal and ventral sides subparallel, slightly curved, the inner end broadly rounded. The posterior scar more elongate, also separated

from the ventral side of the hinge plate by a well-marked groove and somewhat undercut ventrally by a gutter-like depression that marks the inner side of the postero-ventral angulation. Pedal retractor scars moderately large, raised, and situated on the ventral side of the cardinal plate. Ventral margin strongly crenulated by the radial ribbing, the crenulations extending inward almost to the pallial line. The gutter-like depression ventral to the posterior adductor scar marked by irregular, elongate grooves. In two of the four specimens available, the inner margin of the pallial area is marked also by numerous short radial grooves.

Discussion: *Anadara* (*Caloosarca*) *hoerleae,* n. sp., is a rare form, represented in the collections only by four left valves from the upper Miocene deposits from the lower course of the Kissimmee River (locality TU 729). The associated fauna at this locality clearly indicates an upper Miocene, Pinecrest age for the species.

All specimens are strongly consistent in their general characteristics, including number of ribs, relative strength and shape of the ribs of the different areas of the valve surface, the strongly enrolled, inflated umbos, the curved surface of the cardinal area and the details of the varying strength of the hinge teeth. So far as can be determined from the small hypodigm available, there is less variability in these features in this species than in any other of the species here referred to the subgenus.

Comparison: In the characteristics of the surface ornamentation *A. hoerleae,* n. sp., is almost intermediate in position between *A. notoflorida,* n. sp., and the more regularly ribbed variants of *A. rustica* (Tuomey and Holmes). It may readily be distinguished from the former by its more anteriorly situated much more inflated and enrolled umbos (compare Plate 2, figures 6 and 8), more strongly developed ribs on the posterior umbonal area, its strongly curved cardinal area and the relatively narrower hinge with shorter anterior tooth series. The ribbing on the posterior end is heavier, and the ribs are broader, fewer in number and more sharply delimited, especially on their ventral slopes than are those of *A. rustica.* In that species the umbos are about equally as inflated as in the present form, but are situated somewhat more posteriorly, at or near the anterior fourth of the total length, and are not as strongly enrolled, the cardinal plate is not as notably curved, and the hinge series, while equally narrow as compared with that of *notoflorida,* differs in all details of the number and relative strength of the tooth elements present in the two series.

It gives me much pleasure to be able to dedicate this species to Mrs. Robert C. Hoerle of West Palm Beach, Florida, who collected the type specimens and donated them, together with a large collection of associated species to the paleontological collections of Tulane University.

Holotype, USNM 645916: Length 54.6 mm; height 41.7 mm; diameter (left valve) 21.0 mm. Locality TU 729.

Paratype, USNM 645917: Length 64.0 mm; height 42.0 mm; diameter (left valve) 23.3 mm. Locality TU 729.

Collections studied: Tulane University locality 729.

ANADARA (CALOOSARCA) new species?

1939 *Arca rustica* Tuomey and Holmes, MANSFIELD, Florida Geol. Surv., Bull. 18, p. 12 (dredged from Caloosahatchee River one mile below Olga).

1939 *Arca aequalitas* Tucker and Wilson, MANSFIELD, Florida Geol. Surv., Bull. 18, p. 12 (dredged from Caloosahatchee River one mile below Olga).

Material dredged from the bed of the Caloosahatchee River one mile below Olga, Lee County, Florida (USNM 14075) contains a specimen of *Anadara* (*Caloosarca*) *notoflorida,* new species, identified by Mansfield as *Arca catasarca* Dall, together with representatives of an undescribed species that Mansfield identified, in part, as *Arca rustica* Tuomey and Holmes and in part, as *Arca aequalitas* Tucker and Wilson. Mansfield recognized that this collection included material from more than one stratigraphic horizon, noting: "Some of the shells are clean and appear to have come from a sand (many of the shells are believed to be Pliocene); others from an indurated light gray limestone (probably also Pliocene); and others from a light tan argillaceous limestone (probably Buckingham limestone)." The specimen that is here identified with *A.* (*C.*) *notoflorida* is clean and white in color and apparently came from the sand unit. The specimens identified as *"Arca" aequalitas* and *rustica* all show adherent pieces or masses of a gray, lime-cemented shell sand and are presumed to have come from the "light gray limestone" unit. They cannot be identified with either of the two species to which Mansfield re-

ferred them, nor do they fall within the range of variation of any of the described species here recognized in the subgenus *Caloosarca.* In certain of the observable characters the form appears to be essentially intermediate in position between *Anadara* (*Caloosarca*) *hoerleae,* new species, and the Pliocene species *A.* (*C.*) *rustica* (Tuomey and Holmes) and *A.* (*C.*) *crassicosta* (Heilprin), but all specimens are worn, broken, or covered by the intractable limy matrix to the point that they comprise a hypodigm that is not adequate for formal description.

The ribs upon the anterior end and the anterior portion of the median part of the valve are similar in general to those that may be observed in *A.* (*C.*) *hoerleae* and *A.* (*C.*) *rustica,* while those on the posterior portion of the median area are quite like those of *A. rustica* in being somewhat broader and higher than those more anterior in position, but do not approach the extreme width presented by the posterior ribs of *A. crassicosta* (Heilprin) [= *rustica* of earlier Florida students]. The ribbing on the posterior end of the valve is similar to that on *A. hoerleae* and *A. crassicosta* in being as sharply raised on the ventral sides of the ribs as on the dorsal sides, a feature that contrasts with development of these ribs on specimens of *A. rustica.* Two of the three specimens upon which the number of ribs may be determined show but 20 ribs, the third has 24. None of the 45 specimens of *A. rustica s.s.* upon which the number of ribs could be determined had as few as 20 ribs, while none of the 200 specimens of *A. crassicosta* that were used in determining the range of rib number variation in that species had as many as 24. Thus in this character also, these specimens appear to occupy a position more or less intermediate between *A. hoerleae* and the two Pliocene species.

On the other hand the valves differ from those of all three species mentioned above in general proportions, being considerably more elongate relative to valve height, with lower and less inflated umbos that are more like those present in *A.* (*C.*) *notoflorida,* new species (see Pl. 6, fig. 6).

Material examined: USGS loc. 14075.

Anadara (Caloosarca) rustica (Tuomey and Holmes)

Plate 3, Figures 1-9; Text Figures 1f, g.

1857 *Arca rustica* Tuomey and Holmes, Pleiocene Fossils South Carolina, p. 39, pl. 15, fig. 1 (described, "Waccamaw").

1863 *Scapharca* (*Arca*) *rustica* Tuomey and Holmes, Conrad, Acad. Nat. Sci., Phila.,

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Plate 3

Figures Page

Anadara (*Caloosarca*) *rustica* (Tuomey and Holmes) 18

1. USNM 645918, left valve, length 74 mm, height 54 mm. Locality TU 558. Exterior view of gerontic left valve; ribs on posterior portion of median area of valve are but slightly wider than those immediately anterior, but have noticeably wider interspaces.
2, 8. USNM 645920, right valve, length 53.7 mm, height 44 mm. Locality TU 558. 2. Exterior view of valve with ribbing similar to that found in *A.* (*C.*) *crassicosta* (Heilprin). 8. Hinge view of same specimen.
3. USNM 645921, right valve, length 50.6 mm, height 41 mm. Locality TU 558. Exterior view of strongly auriculate specimen with posterior ribbing but slightly stronger than that on the more anterior part of valve.
4, 5, 9. USNM 645919, right valve, length 66.9 mm, height 52.6 mm. Locality TU 558. 4. Exterior view; 5. Hinge and interior of valve; 9. Dorsal view.
6. USNM 645922, right valve (× 1½), length 25 mm, height 16 mm. Locality TU 558. Strongly auriculate immature right valve with wide ribs on posterior half of median portion of valve.
7. USNM 645923, left valve (× 1½), length 21.8 mm, height 16 mm. Locality TU 558. Auriculate immature left valve with ribbing of almost equal strength over entire valve surface.

All specimens from Waccamaw Formation, Pliocene, at Crescent Beach, South Carolina, airport. All figures, except 6 and 7, of approximately natural size.

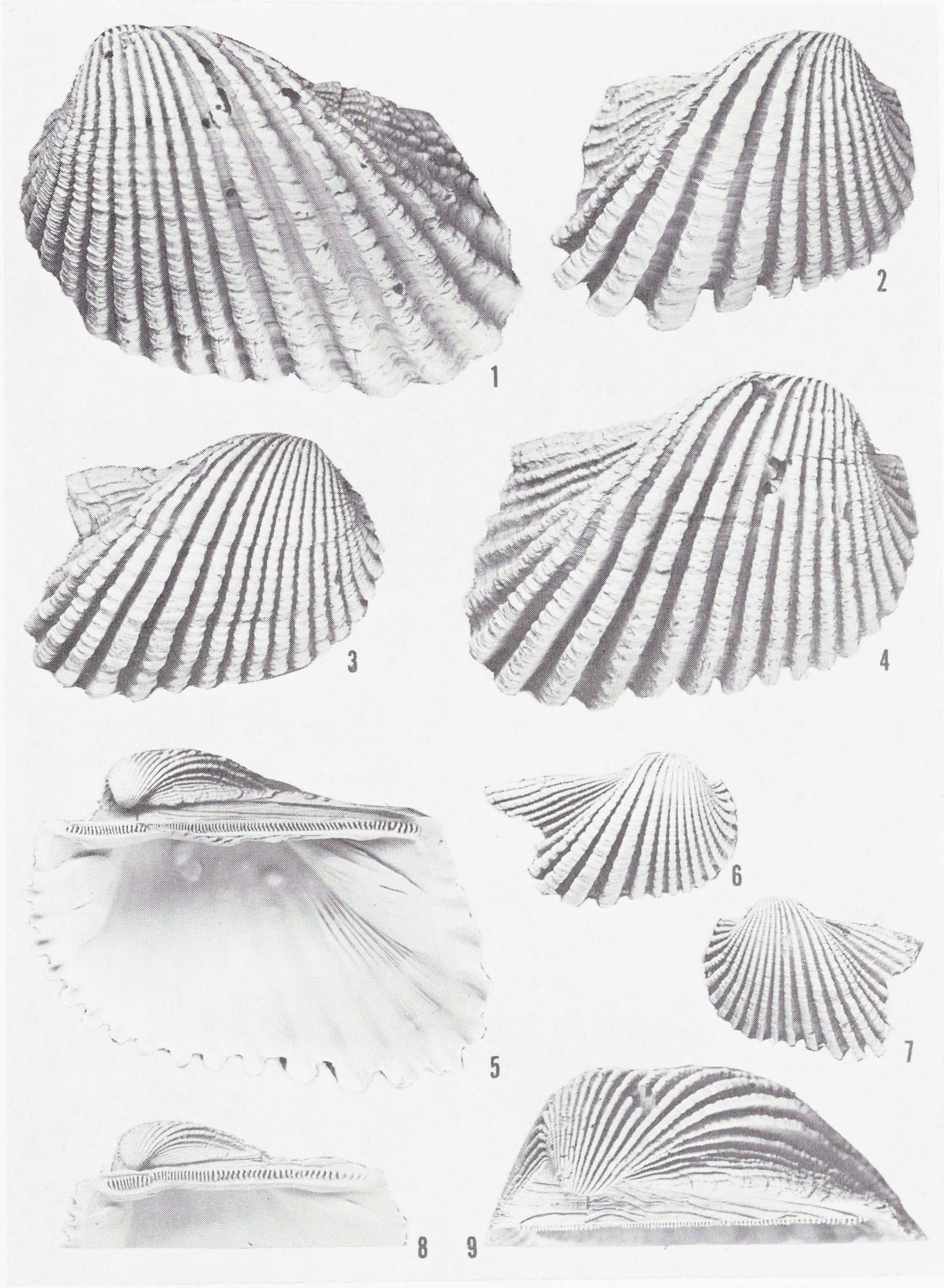

PLATE 3

Proc. for 1862, p. 580 (listed, Miocene [sic] fossils of Atlantic Slope).

1898 *Scapharca* (*Anadara*) *rustica* Tuomey and Holmes, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 653 (part, NOT pl. 31, figs. 6, 9) (*A. crassicosta* Heilprin placed in synonymy).

1912 *Arca rustica* Tuomey and Holmes, MILLER in W. B. Clark, *et al.*, North Carolina Geol. and Econ. Survey, vol. 3, pt. 1, p. 256 listed (Neill's Eddy Landing), 257 (Walker's Bluff), 323 & 324 (Waccamaw Formation).

1916 *Arca rustica* Tuomey and Holmes, SHELDON, Paleont. Americana, vol. 1, no. 1, p. 55 (part, NOT pl. 13, figs. 4, 5).

1937 *Arca rustica* Tuomey and Holmes, MANSFIELD AND MACNEIL, Jour. Wash. Acad. Sci., vol. 27, no. 1, p. 9 (Intercoastal Waterway near Little River, South Carolina).

1961 *Anadara* (*Caloosarca*) *rustica* (Tuomey and Holmes), OLSSON, Panamic-Pacific Pelecypoda, p. 98 (type of *Caloosarca*, n. subgen.) [South Carolina record only].

1962 *Anadara rustica* (Tuomey and Holmes), DUBAR, Geologic Notes, South Carolina Div. Geol., vol. 6, no. 3, p. 28 (listed Waccamaw Formation, North and South Carolina).

1963 *Anadara rustica* (Tuomey and Holmes) DUBAR AND HOWARD, Southeastern Geol., vol. 5, no. 1, p. 36, 63 (listed, Waccamaw Formation, Horry Co., South Carolina).

1964 *Anadara* (*Caloosarca*) *rustica* (Tuomey and Holmes), OLSSON AND PETIT, Bull. Amer. Paleontology, vol. 47, p. 527, pl. 77, figs. 4, 4a, 4b.

1965 *Anadara rustica* Tuomey and Holmes, DUBAR AND FURNBUNCH, Geol. Notes, South Carolina Div. Geol., vol. 9, no. 1, p. 22 (listed, Waccamaw Formation, Intercoastal Waterway, Horry Co., South Carolina).

The original description of Tuomey and Holmes, inadequate and based upon very imperfect material, was as follows:

"*A. testa crassa, sub-quadrata, radiatim costata; costis sub-squamosis; latere buccali brevioribus, costis crenatis; latere anali carinato, angulato, truncato, costis majoribus; umbonibus inter se fere contingentibus.*

"DESCRIPTION. Shell thick, somewhat square, radiately, and unequally ribbed; ribs almost squamose; buccal side very short, ribs crenate; anal side carinate, angular, truncate, ribs very large; ligament area narrow, umbones nearly touching.

"This fossil is readily distinguished by the coarse ribs and deeply excavated interspaces on the anal side. The margin is strongly crenulated. Only a single perfect valve has been found, with a fragment of a larger individual which is presented in Fig. 1.

"PLATE XV., FIG. 1. *Fragment of the only specimen in our possession. The outline is correct. A perfect shell, though much smaller, was lost after the outline of Fig. 1 had been taken.*

"LOCALITY. Waccamaw."

As earlier noted, the species has been rare in collections previous to the dredgings at the Crescent Beach, South Carolina, airport. This plus the inadequate nature of the original material has resulted in confusion as to the limits of the species. Dall's action (1898, p. 653) placing the Caloosahatchee species *A. crassicosta* Heilprin in synonymy with the present form, while obviously a result of the inadequate knowledge of *A. rustica* at the time, nevertheless was peculiarly unfortunate in that *A. crassicosta* is abundant in the collections and *A. rustica* became identified primarily on the basis of the characters exhibited by the Florida species.

Olsson and Petit (1964, p. 527) add the following supplementary descriptive notes:

"The shell becomes large and heavy at maturity, the umbones and beaks near the anterior one-fourth, the posterior side showing a tendency to become winged and is often deeply sinuated especially in the juvenile stage, while the umbones become more or less sulcated along the middle. The ribs number about 18 from the anterior slope to the umbonal angle, and about six more on the posterior slope, the anterior and middle ones are large, high, and coarsely noded, as narrow as their interspaces, except those along the umbonal slope which are somewhat larger; the posterior set becomes progressively smaller towards the [dorsal] margin. In small specimens, the cardinal area is narrow behind the beaks and bears a few ligamental lines, the space anterior and under the beaks bare. In the larger gerontic specimens, the cardinal area may be high and completely covered with ligamental lines, only a small space under the inrolled, prosogyrate beaks remaining bare. The ventral margin is deeply fluted by the ends of the external ribs."

Forty-five relatively complete valves, 21 right and 24 left, plus a few fragmentary specimens were available for the present study. It is of interest to note that 18 of the right valves and 20 of the left ones are from the Crescent Beach airport locality; all other Tulane collecting had yielded but seven valves. A count of the number of ribs in these specimens shows the following distribution:

No. of ribs:	22	23	24	25	26	27	
No. of specimens:							
Right valves	3	1	8	7	1	1	= 21
Left valves	1	5	8	7	3	0	= 24
Total	4	6	16	14	4	1	= 45

The ribs on the anterior half of the valve, including the anterior end, are round-topped, rather coarsely noded, higher than wide, and straight-sided, separated by flat-bottomed interspaces that are slightly narrower than the adjacent ribs (see Text fig. 1f).

The junction of the rib base with the interspace is very sharply rounded, almost forming a 90 degree angle. The most posterior rib in this series tends to be a little more strongly developed than the rest and usually is followed, posteriorly, by four or five ribs that ornament the posterior half of the median area of the valve, the posterior umbonal ridge and on to the posterior end of the valve. The posterior umbonal ridge usually occurs approximately at the position of the fourth, or between the third and fourth of these ribs. They constitute the most variable portion of the ornament. In the majority of the specimens they differ from the ribs of the more anterior series primarily in size, agreeing in all relative proportions with the relationship of rib height to width, and of width of rib to that of the adjacent interspaces. In some of the specimens (Plate 3, figs. 3 and 4) the size difference is not great and the resultant ornament superficially resembles that of *Anadara* (*Caloosarca*) *aequalitas* (Tucker and Wilson) and *A.* (*Caloosarca*) *hoerleae,* new species. In the majority of specimens, however, there is a noticeable difference, and one extreme, a right valve with 22 ribs (Plate 3, fig. 2) even has the anterior two or three ribs of this series noticeably wider than their interspaces, more or less undercut on their sides, especially the anterior one, and as a result comes to have a rather close resemblance to *A.* (*Caloosarca*) *crassicosta* (Heilprin).

A. rustica may, however, be readily separated from both of the above named species by the nature of the ribbing on the posterior end of the valve. In this area on mature specimens the rib that immediately follows the stronger ones adjacent to the umbonal ridge is usually rather similar to these, being stronger than any of those postero-dorsal to it but agrees with them in having a distinctly sloping antero-ventral side and a straight to undercut postero-dorsal slope. Immature specimens tend to have well-developed, raised, noded ribs on this area that are, with the exception of one or two ribs immediately adjacent to the dorsal margin, usually only about one-half as wide as their adjacent interspaces; the dorsally situated ribs may be slightly wider than the interspace between them. In adult specimens, however, the majority of the ribs tend to lose their strength and to assume the appearance of irregular, noded threads, asymmetrical in section with a distinct antero-ventral slope and a steep postero-dorsal one. In both *A. aequalitas* and *A. crassicosta* these posterior ribs maintain their identity, their sides being essentially vertical in all but the most gerontic specimens. Furthermore, the ribs on the median portions of the valves of *A. rustica* are much higher in proportion to their width than are those of either of the two other species (see Text fig. 1).

The umbones are well inflated, the beaks rounded and prosogyrate, situated well in front of the anterior fourth of the total length, usually about at the anterior fifth in average specimens, but often are as far forward as the anterior sixth of the total length in large, gerontic forms. The cardinal area is broad, widest immediately under the anteriorly situated beak. The dorsal margin of the valve distinctly curves over and above the outer margin of the ligamental area posterior to the umbo but does not project anterior to that structure. The result is that the area appears to be much narrower posterior to the umbos than anterior to them. The ligament was confined to the area posterior to the umbo during the earlier stages of growth. It was inserted in a rather deep groove at the outermost edge of the cardinal area and appears to have completely covered the portion posterior to the umbones at all stages of growth. The portion anterior to the umbones was free of ligament during the period up to relative maturity but was invaded by that structure in later stages. Diagonally situated ligamental grooves, more or less parallel with the outer margin of the cardinal area, mark the posterior portion of that structure during the interval when the ligament was wholly posterior in position. These tend to become irregular chevrons when the ligament is also present on the anterior portion of the area. Of the 14 larger specimens with chevron-shaped grooves on the inner margin of the area, 4 have three diagonal posterior grooves before the appearance of any anterior limb, 5 have four, and another 5 have five such grooves. Five specimens show four posterior grooves with no trace of any anterior grooving. All of the specimens show a narrow, linear depressed

line trending more or less transversely across the cardinal area from a position immediately beneath the umbone. The posteriorly situated ligamental grooves terminate at this line, and when chevrons are developed, the apex of the chevron angle occurs there. Presumably this marks the anterior edge of the ligament during the period when this structure was confined to a position behind the beaks. The groove is not strictly transverse in position, showing a slight tendency to move more anteriorly as the beaks assume a relatively more anterior position.

The hinge line is straight, with the teeth in two series that meet approximately at the position of the transverse groove noted above, with the posterior series thus being much longer than the anterior one, its anterior end being located dorsal to the posterior end of the anterior series. In very large gerontic specimens this separation into series may become obscured. The number of teeth in each series is variable. A count of the teeth in each gave the following numbers of anterior/posterior teeth: 11/29; 13/38; 13/44; 14/48; 17/59; 17/64; 18/53; 18/58; 22/71. The individual teeth are usually narrow and transverse to the hinge plate. Variation, when present, tends to occur near the posterior end of the longer series, and in most cases is indicated by the development of broadly chevron-shaped teeth that have the apex of the chevron pointed posteriorly. In some gerontic specimens the posterior teeth may break down to form small nodose denticles; these appear at times to represent the dorsal and ventral ends of chevrons in which the median apex has failed to develop.

The anterior and posterior adductor scars are prominent and relatively large, the posterior being situated on an elongately thickened platform that has a relatively narrow but well-marked channel dorsal to it, separating it from the projecting ventral side of the cardinal margin. This latter area bears four or more rather well-defined diductor and pedal retractor muscle scars.

Figured Specimen, USNM 645918: length 74 mm; height 54 mm; diameter (left valve) 29.6 mm. Locality TU 558.

Figured Specimen, USNM 645919: length 66.9 mm; height 52.6 mm; diameter (right valve) 25 mm. Locality TU 558.

Figured Specimen, USNM 645920: length 53.7 mm; height 44 mm; diameter (right valve) 19.4 mm. Locality TU 558.

Figured Specimen, USNM 645921: length 50.6 mm; height 41 mm; diameter (right valve) 19.4 mm. Locality TU 558.

Figured Specimen, USNM 645922: length 25 mm; height 16 mm; diameter (right valve) 7.3 mm. Locality TU 558.

Figured Specimen, USNM 645923: length 21.8 mm; height 16 mm; diameter (left valve) 7 mm. Locality TU 558.

Distribution: Tulane University localities 558, 559, 870. USGS localities, 4276 (Neill's Eddy Landing), and Tilly's Lake, Waccamaw River. Waccamaw Formation, North and South Carolina.

ANADARA (CALOOSARCA) CRASSICOSTA (Heilprin)

Plate 4, Figures 1-7; Text Figure 1e

1887 *Arca crassicosta* HEILPRIN, Trans. Wagner Free Inst. Sci., vol. 1, p. 96, pl. 13, figs. 30, 30a (described, Caloosahatchee River).

1895 *Arca crassicosta* Heilprin, DANA, Man. Geology, ed. 4, p. 900, fig. 1508.

1898 *Scapharca (Anadara) rustica* Tuomey and Holmes, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 653 (part) (?, pl. 31, figs. 6, 9) (*crassicosta* placed in synonymy).

1916 *Arca rustica* Tuomey and Holmes, SHELDON, Paleont. Americana, vol. 1, no. 1, p. 55 (part), pl. 13, figs. 4, 5. (Dall's discussion reprinted; figured from Shell Creek, Fla.)

1929 *Arca rustica* Tuomey and Holmes, COOK AND MOSSOM, Florida Geol. Survey, 20th Ann. Rept., p. 156, pl. 9, fig. 1. (Caloosahatchee Marl).

1939 *Arca rustica* Tuomey and Holmes, MANSFIELD, Florida Geol. Survey, Bull. 18, p. 18 (3/4 mi. above Fort Denaud), 24 (Myakka River), 27 (Caloosahatchee Fauna).

1945 *Anadara rustica* (Tuomey and Holmes), COOK, Florida Geol. Survey Bull. 29, p. 216, fig. 28(1) (characteristic of Caloosahatchee Marl).

1953 *Anadara (Anadara) rustica* (Tuomey and Holmes), OLSSON AND HARBISON, Acad. Nat. Sci., Phila., Mon. 8, p. 37, pl. 3, figs. 1, 1a. ("Common at St. Petersburg and most other Pliocene localities in Florida.")

1958 *Anadara (Anadara) rustica* (Tuomey and Holmes), DUBAR, Florida Geol. Survey, Bull. 40, p. 156 (part), pl. 1, fig. 9 (NOT figs. 2, 3). ("Common in the Caloosahatchee formation.")

1962 *Anadara rustica* (Tuomey and Holmes), DUBAR, Florida Geol. Survey, Bull. 43, p. 23, 26 (listed, Shell Creek), 34 (listed, Alligator Creek), 40 (listed "Pliocene" and "Caloosahatchee"), 60 (general faunal list).

1964 *Anadara (Caloosarca) crassicosta* (Heilprin), OLSSON AND PETIT, Bull. Amer. Pale-

ontology, vol. 47, p. 520 (Caloosahatchee fauna), 528 (removed from synonymy of *A. rustica*).

1965 *Anadara* (*Cara*) *rustica* (Tuomey et Holmes, 1857), GLIBERT AND VAN DE POEL, Inst. Roy. Sci. Nat. de Belgique, ser. 2, fasc. 77, p. 53 (Pliocene, Shell Creek, "De Soto Co." [= Charlotte Co.] Florida, U.S.A.).

1968 *Anadara crassicosta* Heilprin, OLSSON, Miami Geol. Soc., Guidebook, 2nd. Ann. Field Trip, pl. 2, fig. 8 (index fossil for Caloosahatchee Formation).

Heilprin's original description of this species was as follows:

"Shell subquadrangular, ventricose, ponderous, ornamented with about twenty, coarse, elevated, transversely barred, terete ribs, which are somewhat irregular and crowded on the anterior half of the shell, becoming widely separated and profoundly elevated on the posterior half; beaks nearly anterior, looking forward, separated from each other by a fairly broad interval; hingeline almost as long as the greatest length of the shell, pectinated with numerous, narrow, nearly vertical teeth; ligamental area narrow, elongated, with about six longitudinal lines, which rise toward the apex of the beak; interior of the shell coarsely rugated; base ascending anteriorly, profoundly crenated.

"Length, 2.7 inches: height, two inches."

Heilprin was not absolutely certain that his species was indeed distinct from Tuomey and Holmes' *A. rustica,* stating that: "It closely resembles *Arca rustica* of Tuomey and Holmes . . . and may, indeed, be that shell. . . . Their figure, drawn from a mere fragment, does not represent the profound ribs seen in the Florida fossil; the posterior interspaces are apparently also much narrower, nor does there appear to be any marked variation either in the disposition or the size of the costae. Still, the differences here indicated, which are based upon figure and description only, may be more apparent than real, and the two forms, as above intimated, may in reality represent a single species. . . ." As earlier noted, it was Dall who synonymized *A. crassicosta* with *A. rustica,* leading to the misinterpretation that has been prevalent concerning these two forms. And, it may be noted, that the specimen figured by Dall as from the "Caloosahatchee beds" is not a typical representative of *A. crassicosta* as developed in the Caloosahatchee Formation, but appears to be a variant towards *A. aequalitas* (Tucker and Wilson). The distinctive characters given by Heilprin are yet valid in the separation of *A. rustica* and *A. crassicosta.*

In general, typical specimens of *A. crassicosta* have fewer radial ribs than are to be found on typical forms of *A. rustica* (see table 1). A count of the ribbing on 200 specimens (100 right and 100 left valves) of *A. crassicosta* reveals the following distribution:

No. of ribs:	17	18	19	20	21	22	23	
No. of specimens:								
Right valves	1	13	37	35	11	2	1	1 = 100
Left valves	0	9	43	37	10	1	0	0 = 100
Total	1	22	80	72	21	3	1	1 = 200

A comparison of these counts with those made, of fewer specimens, for *A. rustica* shows that while the majority of the specimens of *A. crassicosta* have 19 or 20 ribs, the majority in *A. rustica* have 24 or 25. There is, it is true, a slight overlapping in the 22 to 23 rib range, however, only a few specimens in each species group fall into this interval and these may be rather easily separated on other grounds. Typical forms of *A. rustica* may be distinguished by the fact that in that species the interspaces between the ribs are deeper than they are in *A. crassicosta,* the ribbing along the region of the posterior umbonal slope is not as strikingly delimited from that on the more anterior portions of the valve, and the radials on the posterior end of *A. crassicosta* are persistent as defined ribs well delimited from their interspaces, not reduced in strength with sloping anteroventral margins such as are to be found in true *A. rustica.*

There is considerable variation in the relative height/length proportions of the valves as well as in the degree of inflation in the umbonal region. In general those specimens with a high inflated umbone tend to be relatively shorter and more quadrate in outline when viewed from the hinge side than are those with less inflated, and hence lower, umbones (compare figs. 4 & 5, Plate 4).

The basic features of the ligamental structure are the same as those discussed for *A. rustica.* The principal differences in the cardinal area lie in the tendency for the ligamental grooves to be more irregularly developed and in general more numerous in the present species, with, as a result, a larger number of grooves posterior to the umbo prior to the first appearance of the anterior grooving to form the true chevron-shaped structures. Of 20 specimens counted, only one had as few as 3 posterior grooves before the appearance of the chevron; 9

specimens had four grooves; 5 had five, 4 had 6, and one particularly gerontic looking specimen had eight posterior grooves with no trace of any on the anterior end.

Similarly, the hinge structures appear to be basically the same in the two species. The anterior and posterior tooth series are well delimited, with the anterior end of the posterior series passing dorsally above the posterior end of the anterior one and reaching a point coincident with the termination of the transverse groove on the hinge plate that marked the anterior end of the fibrous ligamental structure. The number of teeth in the two series are equally as variable in *A. crassicosta* as they are in *A. rustica* and the principal difference between the species appears to lie in the fact that in the former it is the teeth of the anterior series that are most subject to variation, often breaking down into small denticles situated near the dorsal and ventral sides of the toothrow, with the adjacent teeth of the opposite valves often bridging across the intervening socket to form a somewhat crude "H" structure. While this same tendency has been noted to occur sporadically along the posterior tooth series, it is never as commonly developed in this area as it is among the teeth of the anterior series.

The nature and position of the adductor and diductor scars is the same as that to be observed in *A. rustica*, as are the other features of the interior of the valves.

Distribution: *Anadara crassicosta* appears to be confined to the fauna of the Caloosahatchee Marl as restricted by Olsson and Petit (1964, p. 519) to the strata below the *Crassostrea virginica labellensis* Olsson and Harbison zone. It is abundant at almost all Caloosahatchee localities. A few specimens occur in spoil bank collections from Levee 28 in the western part of Broward County, Florida, associated with a fauna that is dominated by Pinecrest species. Since these are spoil bank collections, however, it is probable that a thin remnant of Caloosahatchee strata overlies the upper Miocene in this area.

Figured Specimen, USNM 645924: length 69.7 mm; height 56.7 mm; diameter (right valve) 29.6 mm. Locality TU 767.

Figured Specimen, USNM 645925: length 57 mm; height 46.1 mm; diameter (paired valves) 48.5 mm. Locality TU 767.

Figured Specimen, USNM 645926: length 25.2 mm; height 17.1 mm; diameter (paired valves) 14.6 mm. Locality TU 767.

Figured Specimen, USNM 644317: length 58.3 mm; height 48.1 mm; diameter (left valve) 26.3 mm. Locality TU 975.

Collections studied: Tulane University localities 79, 202, 203, 519, 523, 527, 529, 532, 536, 539B, 541, 579, 583, 736, 740, 741, 742, 749, 755, 767, 768, 770, 792, 801, 802, 816, 975; USGS 23722.

Anadara (Caloosarca) aequalitas (Tucker and Wilson)

Plate 5, Figures 1-8; Text Figure 1c,d

→

Plate 4

Figures — Page

Anadara (Caloosarca) crassicosta (Heilprin) 22

1. USNM 645924, right valve, length 69.7 mm, height 56.7 mm. A large, somewhat gerontic specimen. Locality TU 767.
2, 4, 6, 7, 8. USNM 645925, paired valves, length 57 mm, height 46.1 mm, diameter 48.5 mm. Locality TU 767. 2. Exterior, left valve; 4. Hinge and interior, left valve; 6. Exterior, right valve; 7. Dorsal view, conjoined valves; 8. Ventral view, conjoined valves.
3. USNM 645926, left valve, length 25.2 mm, height 17.1 mm. Locality TU 767. Exterior, left valve to show strongly auriculate immature stage.
4. USNM 644317, left valve, length 58.2 mm, height 48.1 mm. Locality TU 975. Specimen with strongly inflated umbone; note more quadrate outline of valve.

All specimens from Caloosahatchee Formation, Pliocene, of Florida. All figures approximately natural size.

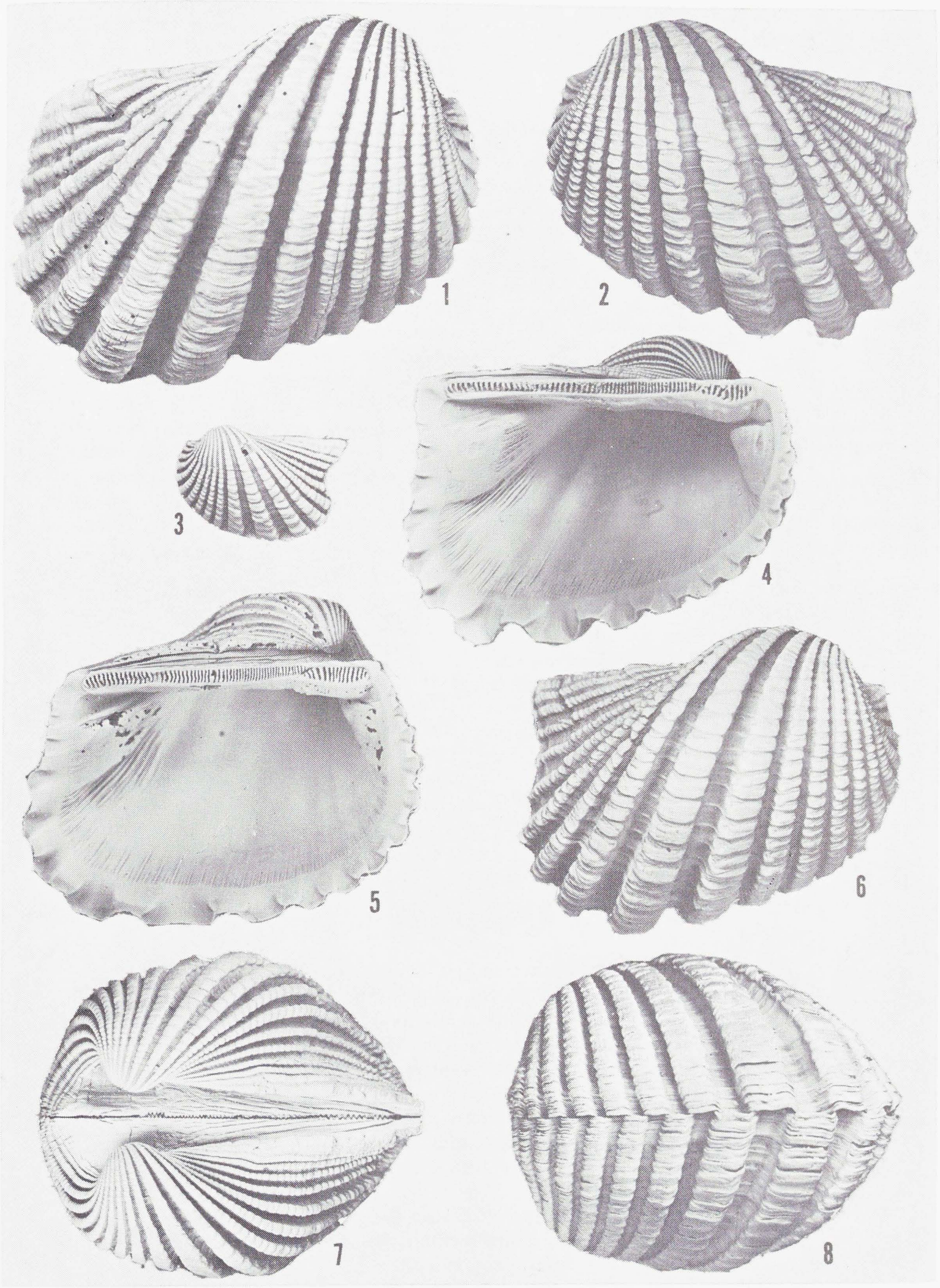

PLATE 4

? 1898 *Scapharca* (*Anadara*) *rustica* Tuomey and Holmes, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 653 (part), pl. 31, figs. 6, 9.

1932 *Arca aequalitas* TUCKER AND WILSON, Bull. Amer. Paleontology, vol. 18, p. 41, pl. 5, fig. 2; pl. 6, fig. 6; pl. 7, fig. 7; pl. 9, fig. 1 (described Port Mayaca, Florida, listed as also at Prairie Creek and LaBelle, Florida).

1939 *Arca aequalitas* Tucker and Wilson, MANSFIELD, Florida Dept. Conserv., Geol. Bull. 18, p. 25 (listed, 1 mi. N. of Bermont, Charlotte Co.), 32 (listed, Bermont and St. Lucie Canal). (NOT p. 12, "dredged from Caloosahatchee River one mile below Olga" [= new species?]).

1953 *Anadara* (*Anadara*) *aequalitas* (Tucker and Wilson), OLSSON AND HARBISON, Acad. Nat. Sci. Phila., Mon. 8, p. 38 (NOT pl. 3, figs. 2, 2a).

1958 *Anadara* (*Anadara*) *rustica* (Tuomey and Holmes), DUBAR, Florida Geol. Surv. Bull. 40, p. 156 (part), pl. 1, fig. 3 (NOT figs. 2, 9).

1964 *Anadara* (*Caloosarca*) *aequalitas* (Tucker and Wilson), OLSSON AND PETIT, Bull. Amer. Paleontology, vol. 47, p. 521 (listed, "Unit A").

"Arca" aequalitas was described by Tucker and Wilson in terms of a comparison with "typical *A. rustica* Tuomey and Holmes from the Waccamaw of South Carolina." Their reference to the marked increase in the width of the posterior ribs makes it clear, however, that the actual comparison was with Florida specimens that are to be identified as *A. crassicosta.* Their description follows:

"Shell somewhat thicker than typical *A. rustica* Tuomey and Holmes from the Waccamaw of South Carolina. Beaks only slightly elevated, sulcus absent. Auriculation well developed in young specimens. Usually only sixteen ribs. Interspaces deeply excavated, usually same width as interspaces [= ribs]. None of the posterior ribs increase as markedly in width as do those in *A. rustica.* Height 51; width 39 mm."

Anadara (*Caloosarca*) *aequalitas* appears to be a late Pliocene or early Pleistocene descendant of *A. crassicosta,* having essentially the same number of radial ribs, but differing in their relative strength and spacing. The ribs on the anterior portion of the valve are more widely separated from each other in the present species and those on the posterior portion of the median surface are not markedly greater in width than those on the anterior part. In this latter characteristic the present species resembles *A. rustica,* from which it may be distinguished by the lesser number of radial ribs and, as earlier noted (p. 21) by the nature of the ribs on the posterior end of the valve.

A count of the number of ribs on 200 valves, 100 right and 100 left, reveals the following distribution:

No. of ribs:	16	17	18	19	20	21	22	
No. of specimens:								
Right valves	5	14	27	23	20	8	3	= 100
Left valves	7	18	27	20	13	12	3	= 100
Total	12	32	54	43	33	20	6	= 200

The statement of the original description, "Usually only sixteen ribs" suggests that the three or four relatively fine ribs of the posterior slope were not included in the counts. All are included in the figures given above.

The cardinal area and the details of the hinge structure are similar to those observed in *A. crassicosta.* The greatest varia-

PLATE 5 →

Figures

Anadara (*Caloosarca*) *aequalitas* (Tucker and Wilson) ..... Page 24

1, 2, 4, 7, 8. USNM 645927, paired valves, length 56.4 mm, height 45.1 mm, diameter 43 mm. Locality TU 580. 1. Exterior, right valve; 2. Exterior, left valve; 4. Dorsal view, conjoined valves; 7. Hinge and interior of left valve; 8. Ventral view of conjoined valves of adult individual with but 17 ribs on each valve.

3. USNM 645930, left valve, length 44 mm, height 27.7 mm. Locality TU 201. Note the strong auriculation resulting from the unusually elongated dorsal margin, a characteristic of the immature specimens of this species (see also fig. 6).

5. USNM 645928, right valve, length 46.5 mm, height 39.1 mm. Locality TU 580. Although not much more elongate than the specimen shown in fig. 3, this individual has attained adult proportions.

6. USNM 645929, right valve, length 36.5 mm, height 22.8 mm. Locality TU 580.

All specimens from "Unit A," unnamed post-Caloosahatchee formation, late Pliocene or early Pleistocene in age, Florida. All figures approximately natural size.

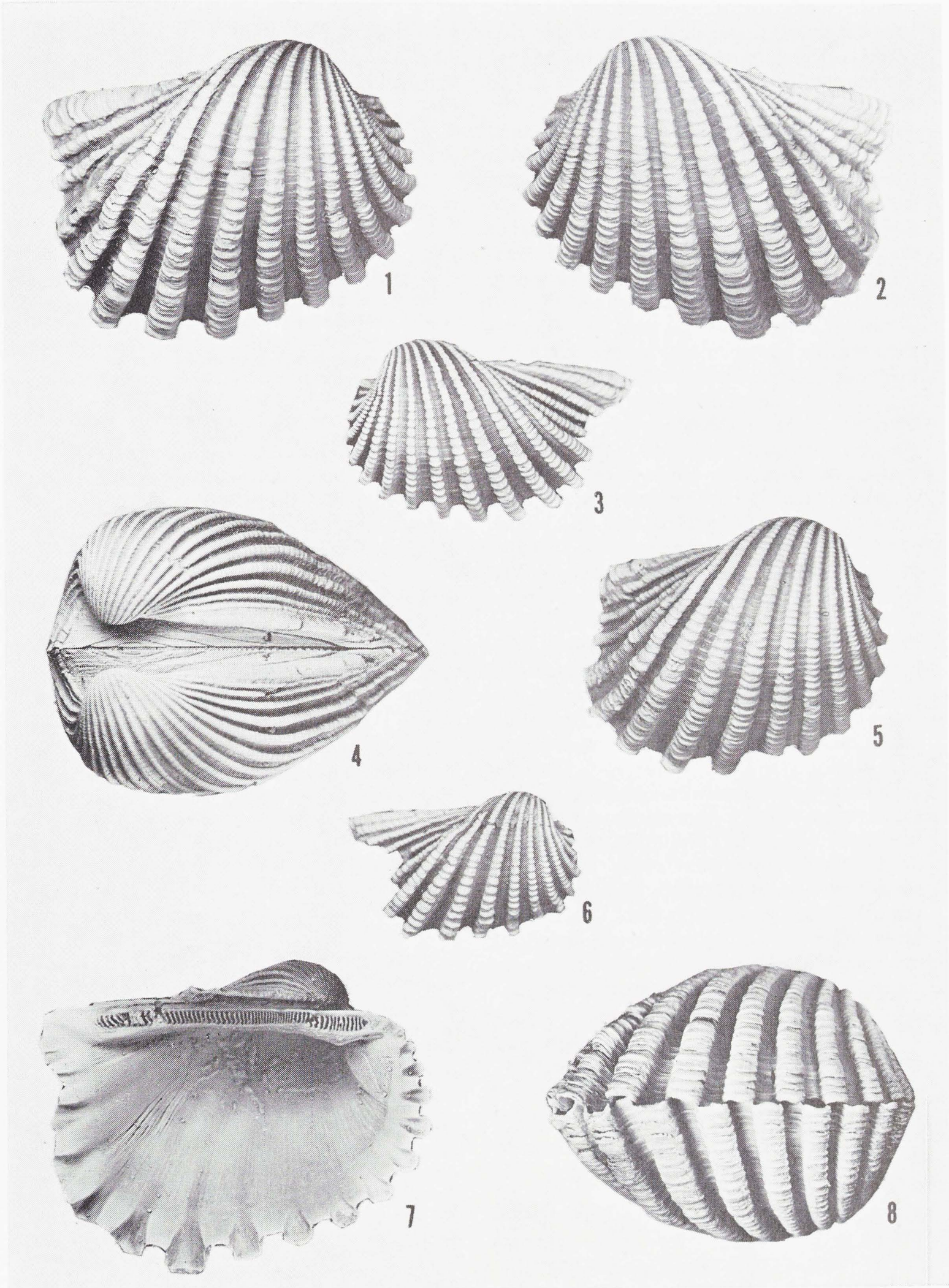

PLATE 5

tion in tooth structure occurs in the short anterior series, although occasionally weakly chevron-shaped teeth may be observed in the latter third of the length of the posterior series.

The specimen figured by Olsson and Harbison (1953, pl. 3, figs. 2, 2a) from Clewiston, Florida, one of only two in their collections has the straighter ventral margin and narrower, more regular, beaded ribbing that marks *A. catasarca* (Dall); it does not represent the present species. However, their identification of this specimen as *A. aequalitas* led them to suggest (p. 38) that this species has a more rectangular form than does *A. rustica* [=*crassicosta*]. In the majority of the specimens in our collections the general convexity of the ventral margins of the valves of the latter two species is about the same. However, the general tendency, so marked in *A. crassicosta,* for the ventral margin to "slope" toward the posterior with the greatest width of the valve interior being located in the region dorsal to that portion of the ventral margin of the shell marked by the termination of the strong posterior umbonal ribbing, is not as pronounced in *A. aequalitas,* the result being that the interior of the valve appears to be relatively more elongately quadrangular than that of the typical *A. crassicosta.*

Distribution: *Anadara aequalitas* appears to have preferred an environment with a fine chalky shell-marl type of bottom. Many of the specimens are encrusted with bryozoan, coral or calcareous algal materials, serpulid worm tubes commonly occur and holes made by boring molluscs and worms are frequently present. All would attest to an environment of slow deposition.

Figured Specimen, USNM 645927: length 56.4 mm; height 45.1 mm; diameter (paired valves) 43.0 mm. Locality TU 580.

Figured Specimen, USNM 645928: length 46.5 mm; height 39.1 mm; diameter (right valve) 19.0 mm. Locality TU 580.

Figured Specimen, USNM 645930: length 44.0 mm; height 27.7 mm; diameter (left valve) 13.2 mm. Locality TU 201.

Figured Specimen, USNM 645929: length 36.5 mm; height 22.8 mm; diameter (right valve) 10.7 mm. Locality TU 580.

Collections studied: Tulane University localities 79, 201, 283b, 529, 580, 583, 725, 727, 732, 733, 746, 747, 748, 749, 751, 759, 978; USGS, 11152, 13835, 21982, 21984, 22038, 22039, 22853 and 22855.

Anadara (Caloosarca) catasarca (Dall)

Plate 6, Figures 1-10; Text Figure 1b

1898 *Scapharca* (*Anadara*) *catasarca* Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 654, pl. 32, fig. 20 (described, Alligator Creek, Florida).

1916 *Arca catasarca* Dall, Sheldon, Palaeontogr. Americana, vol. 1, no. 1, p. 56, pl. 13, fig. 6 (orig. descr. and fig. reprinted).

1939 *Arca catasarca* Dall, Mansfield, Florida Geol. Surv. Bull. 18, p. 23 (Alligator Creek), 32 (Table of occurrences adding west side Lake Okeechobee, Coffee Mill Hammock, Caloosahatchee R. at Ortona Locks) [NOT p. 12, Caloosahatchee River 1 mile below Olga = *notoflorida* n. sp.].

1953 *Anadara* (*Anadara*) *aequalitas* (Tucker and Wilson), Olsson and Harbison, Acad. Nat. Sci. Phila., Mon. 8, pl. 3, figs. 2, 2a (Clewiston, Florida).

1958 *Anadara* (*Anadara*) *rustica* (Tuomey and Holmes) Dubar, Florida Geol. Surv. Bull. 40, p. 156 (part), pl. 1, fig. 2 (NOT figs. 3, 9).

1962 *Anadara catasarca* (Dall), Dubar, Florida Geol. Surv. Bull. 43, p. 60 (checklist, Charlotte Harbor area, Florida).

1968 *Anadara aequalitas* Tucker and Wilson, Olsson, Miami Geol. Soc. Guidebook, 2nd. Ann. Field Trip, pl. 2, fig. 7 (index fossil for Unit A).

Dall's "*Scapharca*" *catasarca* has been rather generally overlooked by students of the Tertiary faunas of Florida since its original description. Much of this stems from the fact that the original illustration represented only the hinge and interior of the holotype valve, there being no figure showing the exterior with its distinctive ornamentation.

The original description was as follows: "Shell elongate, solid subrhomboidal, with very anterior, high prosocoelus beaks; right valve with twenty-three strong, narrow, rounded ribs, separated by wider, very deeply channelled interspaces; concentric sculpture of incremental lines, which are slightly elevated at regular intervals, and cause over much of the valve the tops of the ribs to appear obscurely nodulous; the ribs on the anterior end, though simple in the young, are sharply mesially sulcate in the adult, those on the posterior dorsal slope lower and more rude than those on the body of the shell; the hinge-line is straight, the cardinal area differs from that of *A. rustica* [= *crassicosta*] only by having but a single transverse groove anteriorly between the beaks; both valves are

similarly sculptured, but no adult left valve was collected; the hinge-line is straight and shorter than the shell; there are about fifteen anterior and four times as many similar posterior vertical teeth, the proximal ends of the series slightly overlapping; the hinge-line in the specimen figured is forty-six millimeters long, the vertical of the beak falls at 8.5 millimeters from the anterior end; inner margins thickened, with short flutings. Long. 55, alt. 36, diam. 45 mm.

"This fine species appears to be rare, and was found only at Alligator Creek, where two adult right valves, one young pair, and some fragments were obtained. The young has much the outline of *A. auriculata* [= *notabilis*], but is not markedly auriculate. It is proportionately shorter than the adult. The species belongs in the same subordinate group as *A. rustica* [= *crassicosta*], as shown by the minor characters."

This species appears to be rare in the "Unit A" (late Pliocene or early Pleistocene) deposits exposed in the more western portions of the Florida peninsula. Dall's original hypodigm included the few specimens from Alligator Creek and a single broken valve, "probably of this species," from Shell Creek. Apparently later collecting has added to the USNM collections 2 small valves from the Alligator Creek and 2 from the Shell Creek localities. In addition, there are 3 valves collected by Mansfield and MacNeil from Acline, Charlotte Co. It is not present in the Tulane University collections from either of these localities. We have four valves, two right and two left, from the Cecil M. Webb Wildlife Management Area in Charlotte County, south of Punta Gordo, Florida (TU-816). In contrast, the species is abundant in material recently dredged in the widening and deepening of the Caloosahatchee Canal at, and up to about five and one-half miles eastward from the Ortona Locks. Our collections from this area contain more than 200 valves. It also is moderately abundant at a number of localities in Palm Beach County, southeastward from Lake Okeechobee.

A count of the ribbing on 200 specimens, 100 right and 100 left valves, reveals the following distribution:

No. of ribs:	18	19	20	21	22	23	24	25	26	
No. of specimens:										
Right valves	2	10	18	22	15	21	9	1	2	= 100
Left valves	0	4	19	23	23	17	11	2	1	= 100
Total	2	14	37	45	38	38	20	3	3	= 200

The mesial sulcation of the anterior ribs, remarked by Dall as a characteristic feature of the species, proves on examination of a series of specimens to be a variable feature and not reliable for specific identification. As may be noted in the illustration of Plate 6, Fig. 9, the anterior ribs are simple and more or less rounded on top in the earlier stages of development, the mesial sulcation when present appearing only in the more adult stage. Many specimens, probably a majority of those in the collections, do not show a sulcation, the adult ribs tending instead to assume a relatively subtriangular section with a relatively ridged, non-sulcate top. Sulcations, when present are most strongly impressed into the third, fourth, and fifth ribs from the dorsal margin; the first and second ribs are seldom, if ever, modified in any way.

The features of the hinge and cardinal area are typical of the subgenus. A majority of the specimens show at least three posterior ligamental grooves prior to their appearance on the anterior area. The hinge, as in *A. crassicosta* and *A. aequalitas,* shows the greatest tendency for the modification of the teeth in the area of the short anterior series. The development of a weak chevron-shape in the teeth of the median part of the longer posterior series is almost always to be observed, with the apex of the chevron pointing anteriorly. Those teeth anterior and posterior to the chevrons are directly transverse.

Muscle scars and interior of the valve show no features unique to the species.

Anadara catasarca appears to be descended from *A. aequalitas* and some specimens are assignable with difficulty to one species or the other. The typical forms, however, may be rather readily distinguished by the more triangular shape of the ribs in *A. catasarca* and the resultant appearance of greater width of the interspaces. The steep-sided ribs of *A. aequalitas* often show a tendency to be grooved just below their crests making the crests the widest part of the rib, rather than the narrowest as in *catasarca.* Furthermore the ribs on the main portion of the valve are all of approximately equal strength with no tendency toward greater width posteriorly.

Holotype, USNM 107713: length 56.7 mm; height 36 mm; diameter (right valve) 22 mm. Alligator Creek, Charlotte Co., Florida.

Figured specimen, USNM 645931: length

56.1 mm; height 39 mm; diameter (both valves) 41.4 mm. Locality TU 759.
Figured specimen, USNM 645934: length 56.3 mm; height 38.7 mm; diameter (right valve) 22.5 mm. Locality TU 803.
Figured specimen, USNM 645932: length 37.4 mm; height 28 mm; diameter (left valve) 13.4 mm. Locality TU 759.
Figured specimen, USNM 645935: length 32 mm; height 24.9 mm; diameter (right valve) 12.8 mm. Locality TU 803.
Figured specimen, USNM 645933: length 20 mm; height 13.8 mm; diameter (right valve) 6.5 mm. Locality TU 759.
Figured specimen, USNM 645939: length 74 mm; height 52.5 mm; diameter (right valve) 26.5 mm. Locality TU 201.

Collections studied: Tulane University localities 79, 201, 579, 580, 725, 727, 731, 746, 749, 759, 767, 768, 802, 803, 816, 939; USGS 22038, 22444, 22855, 13975, 22742, 23089, 22853.

Anadara (Caloosarca) notabilis (Röding)

Plate 1, Figures 8-12, Text Figure 1a

1783 Varietas notabilis praecedentis speciei [*Arca scapha* = *antiquata*], Chemnitz, Neues Systematisches Conchylien-Cabinet, vol. 7, p. 166, 205, pl. 55, fig. 549.
1798 *Arca Notabilis* Röding, Mus. Boltenianum, p. 173.
1843 *Arca Deshayesii* Hanley, An Illustrative and Descriptive Catalogue of Recent Bivalve Shells, p. 157 (fft.).
1843 *Arca Deshayesii* Reeve, Philippi, Abbild. u. Beschr. Conch., vol. 1, p. 30, *Arca*, pl. 2, fig. 3.
1844 *Arca Deshayesii* Hanley, Reeve, Conch. Icon., vol. 2, *Arca*, pl. 7, sp. 47.
1845 *Arca auriculata* (Lamarck), D'Orbigny, *in* de la Sagra, Historia fisica, politica y natural de la Isla de Cuba, vol. 5, Moll., p. 345 [p. 321 in French ed., *fide* Dall, 1885, p. 25] (NOT *A. auriculata* Lamarck, 1819, p. 43, Red Sea species).
1853 *Anadara natabilis* [sic] Bolten [=] *A. Deshayesii* Hanl. Reeve, Moerch, Cat. Conch. Comes de Yoldi, fasc. 2, p. 41 ("Antill.").
1858 *Arca Deshayesii* Hanley, Beau, Cat. cog. rec. a la Guadaloupe . . . , p. 22.
1864 "*Arca notabilis* Bolt. (*Anodara* Gray. *A. Deshayesii* Hanley)" Krebs, The West Indian Marine Shells, p. 125 ("Habitat: Antillae, . . . Guadalupe . . . Virgin-Islands.")
1878 *Arca notabilis* Bolten = *A. Deshayesii* Hanley, Moerch, Cat. West India shells . . . coll. . . . Poulsen, p. 16 (*fide* Dall, 1885, p. 28).
1879 *Arca auriculata* Lamarck, Arango y Molina, Contr., fauna malac. Cubana, p. 262.
1881 *Arca* (*Andara*) *deshaysii* [sic] Hanley, Gabb, Acad. Nat. Sci., Phila., Jour., ser. 2, vol. 8, p. 378 ("Pliocene," Costa Rica).
1886 *Arca auriculata* Lamarck, Dall, Harvard Mus. Comp. Zoology, Bull., vol. 12, no. 6, p. 191, 241 (27 fthms., Flannegan's Passage [Virgin Isls.]; 35 fthms., off Havana).
NOT 1889 *Arca* aff. *Deshayesii* Hanley, Lorie, Samml. Geol. Reichs.-Mus. Leiden, ser. 2, vol. 1, p. 116-118, 141, pl. 1, fig. 9 (Pleistocene, Curacao) [prob. = *hemidesmos* (Philippi)].

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Plate 6

Figures

Anadara (*Caloosarca*) *catasarca* (Dall) ..... Page 28

1. USNM 107713 (holotype), right valve, length 56.7 mm, height 36 mm. Locality, Alligator Creek, Charlotte Co., Florida.
2, 6, 7, 9. USNM 645931, length 56.1 mm, height 39 mm, diameter (paired valves) 41.4 mm. Locality, TU 759. 2. Left valve; 6. Ventral view of conjoined valves; 7. Hinge and interior of left valve; 9. Anterior view of conjoined valves, note median grooving of some of the ribs.
3. USNM 645934, right valve, length 56.3 mm, height 38.7 mm. Specimen with relatively narrow, straight-sided ribs. Locality, TU 803.
4. USNM 645939, right valve, length 74 mm, height 52.5 mm. Largest specimen in Tulane University collections, note the subtriangular, crested ribs. Locality TU 201.
5. USNM 645933, right valve, length 20 mm, height 13.8 mm. Note the strongly auriculate outline and rounded ventral margin of immature specimens. Locality TU 759.
8. USNM 645932, left valve, length 37.4 mm, height 28 mm. Locality TU 759.
10. USNM 645935, right valve, length 32 mm, height 24.9 mm. Locality TU 759.

All specimens from "Unit A," unnamed post-Caloosahatchee formation, late Pliocene or early Pleistocene in age, Florida. All figures approximately natural size.

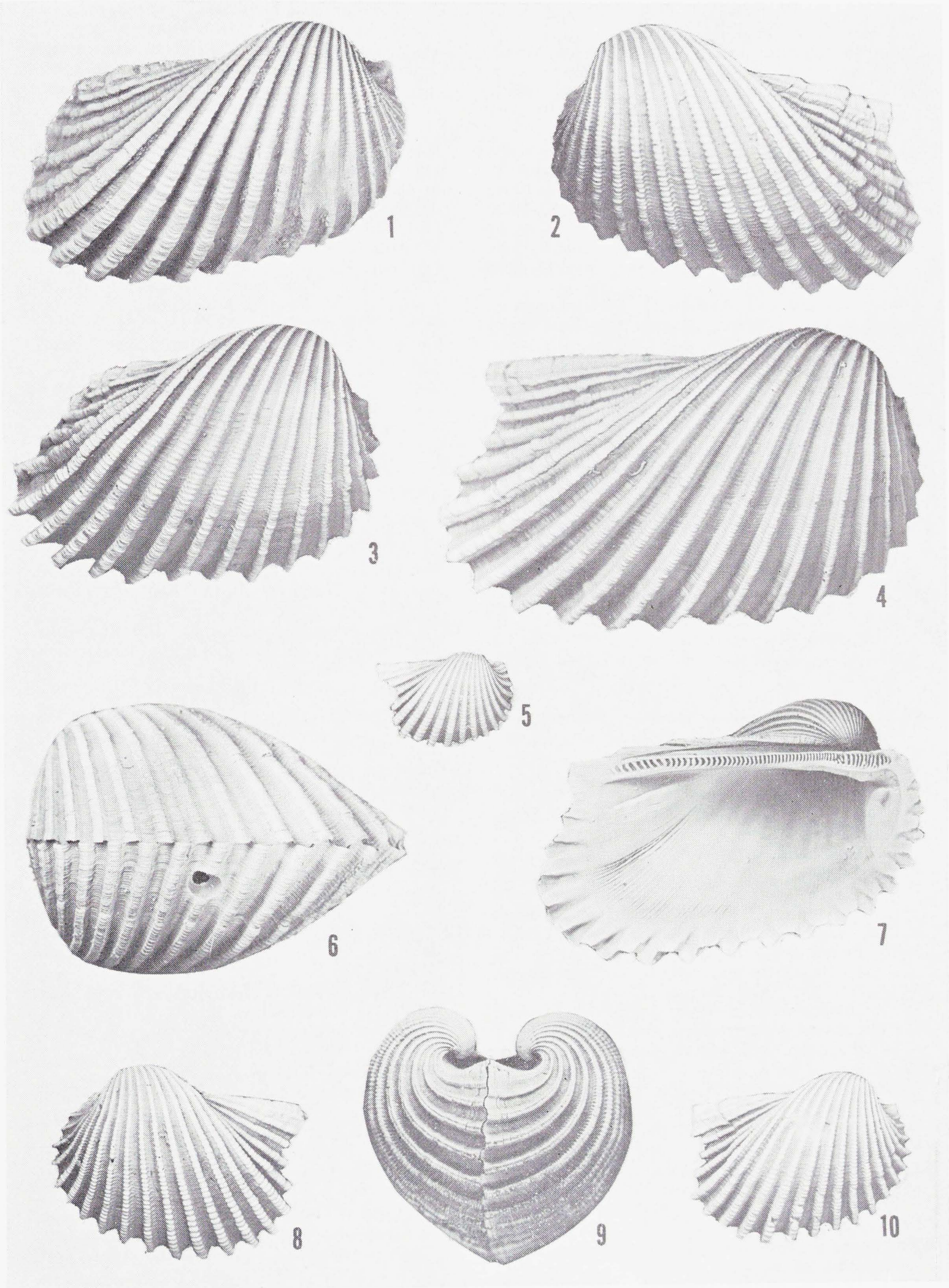

PLATE 6

1889 *Arca* (*Scapharca*) *auriculata* Lamarck, DALL, U. S. Natl. Mus. Bull. 37, p. 40 (15 to 40 fathms., Texas, Key West to Martinique).

1891 *Arca Deshayesii* Hanley, BAKER, Acad. Nat. Sci. Phila., Proc., vol. 43, p. 47 (Recent, north coast Yucatan).

1896 *Arca Deshayesii* [Hanley], HEILPRIN, *in* SAPPER, Bol. Inst. Geol. de Mexico, no. 3; partial translation by Maury and Harris, Jour. Geology, vol. 4, no. 8, p. 938-947, see p. 945. ("Pliocene," Merida, Yucatan).

1897 *Arca* (*Anomalocardia*) *auriculata* Lamarck, VON IHERING, Rev. Mus. Paulista, vol. 2, p. 82. (Brazil).

1898 *Scapharca* (*Scapharca*) *auriculata* Lamarck, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 649 (part), 659. (Pliocene, Costa Rica; Pleistocene, Antilles; Recent, Key West to Martinique, in 15 to 40 fathms.) [NOT Bowden, Jamaica (= *"Barbatia* (*Diluvarca*)" *prephina* Woodring)].

1898 *Scapharca Deshayesii* Hanley, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 659 (Pliocene of Costa Rica; Recent, southern coasts of U. S.).

1901 *Arca deshayesii* Hanley, DALL, Wash. Acad. Sci., Proc., vol. 3, p. 141 (Recent, Pernambuco, Brazil).

1901 *Arca deshayesii* Hanley, DALL AND SIMPSON, U. S. Fish Comm., Bull., vol. 20, pt. 1, p. 461, 510 (Recent, Mayaguez & San Juan, Porto Rico; Vieques Isl.).

1907 *Arca deshayesii* Hanley, LAMY, Jour. Conchyl., vol. 55, p. 218-221. (Recent, in coll. Mus. d'Hist. Nat., Paris).

1913 *Arca deshayesii* Hanley, BROWN AND PILSBRY, Acad. Nat. Sci. Phila., Proc., vol. 65, p. 496 (Pleistocene, Canal Zone).

1913 *Arca* (*Cunearca*) *deshayesii* Hanley, JENKINS, Amer. Philos. Soc., Proc., vol. 52, no. 211, p. 457 (Quaternary, Rio Grande do Norte, Brazil).

1916 *Arca Deshayesii* Hanley, SHELDON, Palaeontogr. Americana, vol. 1, no. 1, p. 50, pl. 11, figs. 15-18 (Recent, West Indies; fossil, mainland of southern North America; fig'd. from Guadalupe and Jamaica).

1916 *Arca auriculata* Lamarck, SHELDON, Palaeontogr. Americana, vol. 1, no. 1, p. 50, pl. 11, fig. 19 (fig'd., Recent, Florida).

1917 *Scapharca auriculata* Lamarck, MAURY, Bull. Amer. Paleontology, vol. 5, p. 339, pl. 54, fig. 3; p. 445. (Santo Domingo—see discussion below).

1919 *Arca deshayesii* Hanley, VAUGHAN, U. S. Natl. Mus. Bull. 103, p. 564 (common in Pleistocene near Mt. Hope, Panama Canal Zone).

1920 *Scapharca* (*Scapharca*) *auriculata* Lamarck, MAURY, Bull. Amer. Paleontology, vol. 8, p. 50 (repeats Dall, 1889, distribution information).

1922 *Arca deshayesii* Hanley, REMINGTON, Nautilus, vol. 35, no. 4, p. 121.

1922 *Arca auriculata* Lamarck, OLSSON, Bull. Amer. Paleontology, vol. 9, p. 362, pl. 25, fig. 3 ("Gatun Stage," Costa Rica [see below]).

1925 *Scapharca* (*Scapharca*) *auriculata* Lamarck, MAURY, Bull. Amer. Paleontology, vol. 10, p. 201, pl. 15, fig. 2 (Recent, Erin Point, Trinidad; "We have gathered recent specimens on the Texas coast and on the beach at Monte Cristi, Dominican Republic.")

1925 *Scapharca* (*Scapharca*) *dehayesi* [sic] Hanley, MAURY, Bull. Amer. Paleontology, vol. 10, p. 201, pl. 15, fig. 3 [as *deshayesii* in pl. desc.] (Recent, Guadalupe; Quaternary, Curacao).

1926 *Arca* (*Scapharca*) *auriculata* Lamarck, WEISBORD, Nautilus, vol. 39, no. 3, p. 82 (Recent, Progreso and Sabancuy, Yucatan).

?, 1927 *Arca* (*Scapharca*) *auriculata* Lam., ANDERSON, California Acad. Sci., Proc., ser. 4, vol. 16, no. 3, p. 89 (listed, Stage "M," lower Miocene, Tubera Mountain, near Puerto Colombia, Colombia).

?, 1929 *Arca* (*Scapharca*) *auriculata* Lamarck, ANDERSON, California Acad. Sci., Proc., ser. 4, vol. 18, no. 4, p. 149-150 (Miocene, northern Colombia).

NOT 1933 *Scapharca* cf. *Deshayesii* Hanley, TRECHMANN, Geol. Mag., vol. 70, no. 823, p. 34, pl. 4, fig. 1 (Pleistocene, Barbados) [= *hemidesmos* (Philippi)].

1934 *Arca auriculata* Lamarck, 1819 (*A. deshayesii* Hanley 1843), JOHNSON, Boston Soc. Nat. Hist., Proc., vol. 40, no. 1, p. 19 (Recent, Florida Keys and West Indies).

1935 *Arca auriculata* Lamarck, RICHARDS, Jour. Paleontology, vol. 9, p. 256 (Pleistocene, western Cuba).

1936 *Arca auriculata* Lamarck, MCLEAN, Soc. Cubana Hist. Nat. "Felipe Poey," Mem., vol. 10, no. 1, p. 39 (Recent, Santa Clara Prov., northern Cuba).

1936 *Arca auriculata* Lamarck, CLENCH AND MCLEAN, Soc. Cubana Hist. Nat. "Felipe Poey," Mem., vol. 10, no. 3, p. 159 (Recent, Cat, Little Salvador and New Providence Islands, Bahamas).

1936 *Arca auriculata* Lamarck, MCLEAN, Nautilus, vol. 49, no. 4, p. 116 (Recent, Bahama Is.).

1936 *Arca auriculata* Lamarck, RICHARDS, Nautilus, vol. 39, no. 4, p. 133-4 (North Carolina "Banks").

1937 *Arca auriculata* Lamarck, SMITH, East Coast Marine Shells, p. 26, pl. 3, figs. 8a, b.

1938 *Arca auriculata* Lamarck, PERRY, SCHWENGEL AND DRANGA, Nautilus, vol. 52, no. 1, p. 27 (dredged, Sanibel Isl., Florida).

1938 *Arca auriculata* Lamarck, RICHARDS, Geol. Soc. America, Bull., vol. 49, p. 1290 (Pleistocene, near Fort Lauderdale, Florida).

1940 *Arca auriculata* Lamarck, PERRY, Bull. Amer. Paleontology, vol. 46, no. 95, p. 29, pl. 1, figs. 6a, b (dredged in 3 to 6 fathoms, southwest Florida).

1942 *Anadara auriculata* Lamarck, JAUME AND PÉREZ FARFANTE, Soc. Cubana Hist. Nat. "Felipe Poey," Mem., vol. 16, no. 1, p. 38 (Pleistocene, Mariel, Matanzas and Guantanamo, Cuba).

1945 *Arca auriculata* Lamarck, VAN BENTHEM JUTTING, Geolog.-Mijnbouwk. Genootschap

Nederland en Kolonien, Geol. ser., vol. 14, p. 77 (Quaternary, northern South America).

1946 *Arca* (*Scapharca*) *auriculata* Lamarck, Jaume, Soc. Malac. "Carlos de La Torre," Rev., vol. 4, no. 3, p. 98. (Recent, Progreso and Sabancuy, Yucatan).

1949 *Arca* (*Arca*) *auriculata* Lamarck, Lange de Morretes, Arq. Mus. Paranaense, vol. 7, art. 1, p. 9 (Brazil).

1951 *Arca* (*Scapharca*) *auriculata* Lamarck, McLean, Sci. Surv. Porto Rico and Virgin Islands (N. Y. Acad. Sci.), vol. 17, pt. 1, p. 16, pl. 2, fig. 9.

?, 1953 *Arca* (*Arca*) *deshayesii* Hanley, Haas, Fieldiana—Zoology, vol. 34, no. 20, p. 203 (listed, Ilha Grande, Rio de Janeiro, Brazil).

1953 *Arca* (*Scapharca*) *auriculata* Lamarck, Haas, Fieldiana—Zoology, vol. 34, no. 20, p. 203 (listed Ilha Grande, Rio de Janeiro, Brazil).

1954 *Anadara* (*Larkinia*) *notabilis* (Röding), Abbott, American Seashells, p. 344, pl. 37, fig. p. ("Rare in Florida; common in the West Indies").

1955 *Anadara* (*Scapharca*) *notabilis* (Röding) (*A. auriculata* Lam.), Perry and Schwengel, Marine Shells of the Western Coast of Florida, p. 35, pl. 1, figs. 6a, b (reprints descr. and figs. of Perry, 1940).

1955 *Anadara notabilis* Röding, Hulings, Invest. benthic mar. invert. fauna from shallow waters off Texas coast (unpubl. M. A. thesis, Texas Christian Univ.), p. 21 (sta. 25, sandy shell debris, 40 feet, dead), 23 (sta. 27, Sabine Bank, shell debris, 42 feet, dead), 31 (sta. 46, sandy mud at 42 feet, live), 54 (not previously recorded from Texas coast), 70.

1958 *Anadara notabilis* (Röding), Olsson and McGinty, Bull. Amer. Paleontology, vol. 39, no. 177, p. 19 (Bocas Isl., northwest coast of Panama).

1958 *Anadara* (*Larkinia*) *notabilis* Röding, Abbott, Acad. Nat. Sci., Phila., Mon. 11, p. 111 (alive, North Sound and Duck Pond, Grand Cayman Isl., in 5 to 15 feet water on sand and grass bottom).

1959 *Anadara notabilis* Röding, Nowell-Usticke, Check List Marine Shells of St. Croix, U. S. Virgin Islands, p. 1 ("not common—Altona Bay and Lagoon. Sugar Bay" St. Croix).

1959 *Anadara notabilis* (Röding), Newell, Imbrie, Purdy and Thurber, Amer. Mus. Nat. Hist. Bull., vol. 117, art. 4, p. 218, 222, [Great Bahama Bank, "*Strombus samba* community (outer platform, unstable sand bottom, generally deeper than 2 fathoms)" and "*Strombus costatus* community, (shelf lagoon and marginal lagoons, stable sand bottom, generally less than 1.5 fathoms)."]

1961 *Arca* (*Anadara*) *notabilis* Roeding, van Regteren Altena, Konikl. Nederl. Akad. Wetensch.-Amsterdam, Proc., ser. b, vol. 64, no. 2, p. 298 (Post-Miocene, probably Pleistocene, St. Kitts and St. Eustatius Isl.).

1961 *Anadara* (*Larkinia*) *notabilis* Röding, Warmke and Abbott, Caribbean Seashells, p. 159, pl. 30, fig. h (Florida to the Caribbean and Brazil, "very common . . . in shallow water on mud and grass").

1961 *Anadara* (*Caloosarca*) *notabilis* (Roeding), Olsson, Panama-Pacific Pelecypoda, p. 98, pl. 8, fig. 3 (referred to subgenus *Caloosarca* with fig. of hinge of specimen from Pass-a-Grille, Florida).

1961 *Anadara notabilis* (Roeding), Weber, Nautilus, vol. 75, no. 2, p. 58 (Water Is., Virgin Isls. Group).

1962 *Anadara notabilis* (Röding), Richards, Amer. Philos. Soc., Trans., vol. 52, pt. 3, p. 52, pl. 1, figs. 31, 32 (Pleistocene, Cape Hatteras, North Carolina, Recent, northern Florida to Brazil; fig'd. Recent, Snipe Key, Florida).

1962 *Anadara notabilis* (Röding), Rehder, Jour. Paleontology, vol. 36, no. 3, p. 585 (Pleistocene, Grand Cayman Isl.).

1964 *Anadara* (*Larkinia*) *notabilis* (Röding), Weisbord, Bull. Amer. Paleontology, vol. 45, p. 69-72, pl. 5, figs. 7, 8 (NOT figs. 9, 10) (extended bibliography and discussion; fig'd., Recent, Venezuela).

1965 *Anadara* (*Cara*) *auriculata* (Lamarck, 1819), Glibert and van de Poel, Inst. Roy. Sci. Nat. de Belgique, ser. 2, fasc. 77, p. 52 (Pleistocene, Port Limon, Costa Rica).

1967 *Anadara notabilis* (Röding, 1798), Hebard, Nautilus, vol. 81, no. 2, p. 41 (Pleistocene, New Providence Isl., Bahamas).

This species was originally named by Röding (1798, p. 173) without description, but with a reference to a figure in Chemnitz (1783, pl. 55, fig. 549), denominated as a "Varietas notabilis praecedentis speciei," which was said to represent *Arca scapha,* a species now referred to *A. antiquata* Linnaeus. In his discussion of the "varietas" Chemnitz noted that it had only 24 to 26 ribs in contrast to the 35 to 36 ribs present on *A. scapha.* The only locality mentioned is through a reference to Favart d'Herbigny "Dict. tom 1. pag. 250" who states that it is "trouvé dans les mers de l'Amérique."

Early authors confused this species with *Arca antiquata* Linnaeus. Judging from the locality and the inadequate description accompanying them, the very poor figures given by Sloane (1725, tab. 241, figs. 14-16) cited by Linnaeus in the original description of his *A. antiquata,* probably represent the present species, although they were interpreted by d'Orbigny (1845, p. 345) as "*Hemidermos*" Philippi [= *hemidesmos*], a much rarer species in collections. Similarly, the figure given by Lister (1692 (?), vol. 2, pl. 236, fig. 70) of a specimen from Jamaica which was cited by Linnaeus in the synonymy of *A. antiquata* in the 12th edition of the Systema, is a good representation of

the present species, while the figure in Chemnitz, cited by Röding at the time he named *A. notabilis,* is listed by Lamarck (1819, p. 42) in his synonymy of *A. antiquata* with, however, an Old World distribution.

Weisbord (1964, p. 71) describes this species in the following terms:

"Shell inflated, oblong-rhomboidal, slightly tapering anteriorly, auriculate behind. Anterior end rounded, base gently curved, posterior margin concave above. Beaks high, well forward, separated by a moderately wide lanceolate cardinal area which is scored with several long, irregular, obtusely angled ligamental grooves. Hinge line fairly straight, the hinge itself bearing numerous comb-like teeth of which there are 15 to 18 anterior and 35 to 39 posterior. The posterior teeth are smaller than the anterior at the point of divergence of the hinge and tend to over-ride the initial anterior one. The anterior teeth at the point of divergence of the hinge may be larger than the ones immediately forward but they are longest at the distal end; the posterior teeth, on the other hand, enlarge gradually and regularly toward the posterior end. The teeth do not reach the basal margin of the hinge which is thick and smooth. Inner margin broadly corrugated. Exterior sculptured by 27 or 28 straight radial ribs crossed by numerous, more or less equally spaced concentric threads which are sharp in the interspaces but form crenations on the crest of the ribs, particularly on the lower half of the disk and on the ends. The interspaces on the disk are as wide as, or in places a trifle wider, than the ribs themselves. The color of the Recent shell is whitish, and such of the periostracum that remains is brown and silky."

The above description is somewhat incomplete in failing to note that the anterior ribs tend to be medially grooved. The most dorsally situated of these ribs seems never to be so ornamented, the grooving generally, but not always, first appearing on the second rib below the cardinal margin. The number of ribs bearing these grooves is variable. A count on 25 specimens revealed a variation between 3 and 9, with an average of 5 or 6. The total number of ribs is also variable, but there is no observable correlation between the number of ribs bearing grooves and the total number of ribs on the valve. A count of ribs on 200 specimens reveals the following distribution:

No. of ribs:	25	26	27	28	29	30	
No. of specimens:							
Right valves	5	19	38	16	8	3 =	89
Left valves	2	23	44	25	17	0 =	111
Totals	7	42	82	41	25	3 =	200

The individual ribs (see Text-fig. 1a) are lower and usually more round-topped than are those of the other species referred to *Caloosarca.* They are, however, relatively variable; in some specimens almost straight-sided and relatively flat-topped, in others the sides are sloping and the tops proportionately narrowed until they are almost triangular in profile. Even the flat-topped ones generally tend to become notably rounded in later, gerontic stages. Interspaces between the ribs are approximately as wide as the adjacent ribs.

The shape of the valve varies with age. Younger individuals tend to be more produced and auriculate posteriorly and higher in proportion to total length. Measurement of a number of smaller specimens, 15 to 20 mm in length, reveals an average height that is 85.6 percent of the length, while specimens more than 50 mm in length tend to average 72.4 percent. The specimen figured by Perry (1940, pl. 1, fig. 6b) and by Perry and Schwengel (1955, pl. 1, fig. 6b) is unusually elongate, more so than any represented in the collections presently available for this study. As measured on their illustration, the height of this specimen is but 65.7 percent of total length.

The cardinal area is typical of that shown by other species referable to *Caloosarca.* The majority of specimens show two posterior ligamental grooves before their first appearance anteriorly. There are, however, specimens in the collections that reveal as many as five posterior grooves with no trace of any anterior ones. Hinge and interior of the valve are typical in every respect.

Distribution: *Anadara* (*Caloosarca*) *notabilis* has been reported, under various names,* from the Miocene to the Recent

* The genus *Larkinia* Reinhart, 1935, to which Abbott and some other recent authors have referred this species is characterized by a high, subtrigonal and non-auriculate valve, a somewhat curved hinge line on which the cen-

in the Antillean-Caribbean region. The Miocene records from Jamaica, Santo Domingo, Costa Rica and Colombia, are, however, all highly suspect and probably none represent the present species. The Bowden, Jamaica, record given by Dall (1898, p. 649) was based upon the form subsequently named by Woodring (1925, p. 44, pl. 4, fig. 8) as *Barbatia (Diluvarca) prephina.* The Dominican record is based on a single valve reported by Maury (1917, p. 339, pl. 54, fig. 3) from Sabaneta "(loose, not *in situ*)" and (p. 445) as "lying loose on top of [bed] 3 [the uppermost Tertiary bed in the section]. [Its] origin is unknown." The specimen from Costa Rica figured by Olsson (1922, p. 362, pl. 25, fig. 3) as being from the "Gatun Stage" at "Old Man Sam Creek, one mile south of the beach," agrees in all details with similar small specimens in our collections from the Moín Formation at Moín and Puerto Limon (TU locs. 953 and 954). Olsson also reported the occurrence of the species at Hone Walk Creek. Since both these Olsson localities occur high in the Costa Rican section, and since *Anadara notabilis* is unknown in the fauna of the true Gatun deposits, either in Panama or in Costa Rica, it seems probable that Olsson's specimens were of Moín age. Anderson's record (1927, p. 89; 1929, p. 149) from the Miocene of northern Colombia is based upon unfigured material and cannot be evaluated at this time.

Gabb (1881, p. 378) reported *A. notabilis* [as "*Arca (Andara) Deshaysii,* Hanley"] from "the Pliocene Clay Beds between Limon and Moen, Costa Rica." These deposits, which are now referred to the Moín Formation, contain *Arcohelia limonensis* Vaughan and *Acrosterigma declive* (Gabb), species that were considered by Olsson and Petit (1964, p. 521) as among the forms characteristic of their "Unit A" which lies unconformably upon the Caloosahatchee Formation and is thought to be of later Pliocene (Emerson, 1964, p. 8) or earliest Pleistocene age.

Similarly the limestones exposed in the immediate vicinity of Merida, Yucatan, which had been referred to the Pliocene are now known to be of Pleistocene age (Dr. A. E. Weidie, personal communication).

Anadara notabilis is widely distributed in the Pleistocene, ranging from Cape Hatteras, North Carolina (Richards, 1962, p. 52) to Brazil (Jenkins, 1913, p. 457) being reported from Florida and the Bahama Islands, Cuba, Grand Cayman Isl., Central America (Yucatan, Costa Rica, and Panama), Antilles (Barbados, St. Kitts and St. Eustatis, Curacao) and from northern South America. It is represented in the Recent faunas from both sides of the peninsula of Florida westward to eastern Texas and south at least as far as Ilha Grande, Rio de Janeiro, Brazil. It appears, however, not to occur in the more western parts of the Gulf of Mexico between eastern Texas and the Yucatan Peninsula. It is abundant in the Tulane collections from the northern shores of Yucatan as well as in those made from the northwestern extremities of the peninsula as far south as Isla Arenas, about 16 miles south of Celestun, but is absent in our collections southward from this point, and westward along the Campeche, Tabasco and Vera Cruz coasts. However, the much more extensive collections of Dr. E. Wyllys Andrews of Merida, Yucatan, contain one or two isolated valves from Chenkan and Isla Aguada, on the southwestern Campeche coast.

Figured Specimen USNM 694047: Length 52.5 mm; height 39 mm; diameter (left valve) 18.6 mm. Locality TU R-109.

Figured Specimen USNM 694048: Length 47.8 mm; height 35.8 mm; diameter (right valve) 17.0 mm. Locality TU R-109.

Figured Specimen USNM 694049: Length 33 mm; height 26.1 mm; diameter (paired valves) 21.5 mm. Locality TU R-109.

Collections studied: Tulane University localities 953, 954, R-9, R-18, R-35, R-36, R-69, R-71, R-74, R-76, R-78, R-79, R-82 R-100, R-105, R-109, R-110, R-115, R-124, R-127, R-128, R-130, R-132, R-164, R-171, R-172.

VII. Paleoecological Observations

As may be noted from the annotations to the synonymy of *Anadara (Caloosarca) notabilis,* that species has been reported

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tral teeth are vertical and the lateral teeth divergent, and, more importantly, a triangular cardinal area on which the ligament covered the anterior as well as the posterior portions from the earliest stage of development.

from depths as shallow as 5 feet (Abbott, 1958, p. 111) to 40 fathoms (Dall, 1889, p. 40; 1898, p. 649). Off the Florida coast, the general latitude in which most of our fossil species are found, it has been reported as occurring from 3 to 6 fathoms (Perry, 1940, p. 29; Perry and Schwengel, 1955, p. 35). In the Tulane University collections it is represented by a fresh valve dredged in 4 to 5 fathoms off Long Boat Key, near Sarasota, and by a worn valve from 18 fathoms off Highland Point, Monroe County. It is reported to prefer muddy to limy sand or pure sand bottoms occurring in most profusion in areas where marine grasses are growing (Hulings, 1955, p. 31; Abbott, 1958, p. 111; Warmke and Abbott, 1961, p. 159).

Anadara biangulata (Sowerby) [+ *Arca gordita* Lowe], the eastern Pacific species referred to *Caloosarca* by Olsson (1961, p. 98), has a rather similar bathymetric distribution. As reported by Hertlein and Strong (1943, p. 155-156) it ranges from 7 fathoms (Sowerby's type specimen) to 61 fathoms (off Costa Rica), being found in mud, sandy mud, shelly mud, muddy sand, sand, gravelly sand, crushed shells, and weeds. The majority of the records appear to be in the interval between 20 and 45 fathoms.

There is no evidence that could be interpreted as indicating any marked deviation from this general type of environmental preference for any of the fossil species referred to *Caloosarca* in this report. The matrix at all localities where the fossils are abundant consists predominantly of sand, usually with a small admixture of argillaceous or calcareous material. As noted in the discussion of *A. aequalitas* that species apparently preferred a somewhat larger lime content in the bottom sediments than did the contemporaneous *A. catasarca* which is most abundant in collections from localities in which the sediment is of a more pure sand composition. Furthermore, the associated molluscan faunas all accord well with a depth of water in the 5 to 40 fathom range.

VIII. Locality Data

The following are Tulane University fossil locality numbers:

79. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks north and south side of Caloosahatchee River, at Ortona Lock (Sec. 27, T42S, R30E), Glades Co., Florida.
201. Unnamed post-Caloosahatchee formation, spoil banks at pit just south of Belle Glade, Palm Beach Co., Florida.
202. Caloosahatchee Fm., south bank of Caloosahatchee River, about two miles west of La Belle (SE ¼ Sec. 12, T43S, R28E), Hendry Co., Florida.
203. Caloosahatchee Fm., north bank of Caloosahatchee River, about two miles east of Fort Denaud (SW ¼ Sec. 11, T43S, R28E), Hendry Co., Florida.
283. Pinecrest Beds and unnamed post-Caloosahatchee formation mixed, spoil banks on cross canal 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock), on Florida Highway 771 (Sec. 12, T40S, R21E), Charlotte Co., Florida.
519. Caloosahatchee Fm., Harney Pond Canal spoil banks, at Florida Highway 78, northwest side of Lake Okeechobee (NW ¼ Sec. 18, T40S, R33E), Glades Co., Florida.
523. Uppermost Pinecrest Beds (Brighton facies), and basal Caloosahatchee Fm., Harney Pond Canal spoil banks, six miles northwest of Florida Highway 78, Brighton Indian Reservation (NW ¼ Sec. 22, T39S, R32E), Glades Co., Florida.
527. Caloosahatchee Fm., north shore Lake Okeechobee, Pumping Station no. 127 (NE ¼ Sec. 35, T39S, R33E), Glades Co., Florida.
529b. Caloosahatchee Fm., north bank of Caloosahatchee River, about two miles west of La Belle (SE ¼ Sec. 12, T43S, R28E), Hendry Co., Florida.
532. Pinecrest Beds and Caloosahatchee Fm., mixed, spoil banks on cross canal 1¾ miles south of Florida Highway 771, 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock) (SE ¼ Sec. 24, T40S, R21E), Charlotte Co., Florida.
536. Caloosahatchee Fm., south bank of Caloosahatchee River about one mile east of La Belle (Sec. 3 & 4, T43S, R29E), Hendry Co., Florida. (Designated as type locality of the Caloosahatchee Formation by Olsson *in* Olsson and Petit, 1964, p. 519.)
539B. Caloosahatchee Fm., Shell Creek (lower beds), about eight miles east of Cleveland (Sec. 30, T40S, R25E), Charlotte Co., Florida.
541. Caloosahatchee Fm., Miami Canal spoil banks, two miles north of pumping station at Broward County line, Palm Beach Co., Florida.
558. Waccamaw Fm., borrow pits at north end of Crescent Beach Airport, Crescent Beach, Horry Co., South Carolina.
559. Waccamaw Fm., "Neill's Eddy Landing," south bank Cape Fear River near Acme, North Carolina.
579. Caloosahatchee Fm., Miami Canal spoil banks, four miles north of pumping station at Broward County line, Palm Beach Co., Florida.
580. Unnamed post-Caloosahatchee formation,

North New River Canal spoil banks, one mile south of South Bay, Palm Beach Co., Florida.

583. Caloosahatchee Fm., Miami Canal spoil banks, seven miles north of pumping station at Broward County line, Palm Beach Co., Fla.

725. Unnamed post-Caloosahatchee formation, North New River Canal spoil banks, three miles south of South Bay, at Okeelanta, Palm Beach Co., Florida.

727. Unnamed post-Caloosahatchee formation, borrow pits 2.2 miles east of U. S. Highway 27, 15 miles south of South Bay, Palm Beach Co., Florida.

729. Pinecrest Beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, approximately ½ mile south of U. S. Corps of Engineers Structure 65-D, (S ½ Sec. 33, T36S, R33E), Okeechobee Co., Florida.

731. Unnamed post-Caloosahatchee formation, West Palm Beach Canal spoil banks, at junction of U. S. Highway 441 and 98, seven miles west of Loxahatchee, Palm Beach Co., Florida.

732. Unnamed post-Caloosahatchee formation, borrow pits on Florida Highway 715, four miles north of Hillsborough Canal, at Belle Glade, Palm Beach Co., Florida.

733. Unnamed post-Caloosahatchee formation, North New River Canal spoil banks, one mile north of Florida Highway 80, at South Bay, Palm Beach Co., Florida.

736. Pinecrest Beds (Brighton facies), and Caloosahatchee Fm., mixed, spoil banks on south side of Florida Highway 70 and east side of Kissimmee River, Okeechobee Co., Florida.

740. Pinecrest Beds, levee fill, canal L-28, 3.6 miles west and 2.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.

741. Pinecrest Beds and Caloosahatchee Fm., mixed, levee fill, canal L-28, 3.6 miles west and 3.6 miles south of pumping station on Miami Canal at Palm Beach county line, Broward Co., Florida.

742. Pinecrest Beds and Caloosahatchee Fm., mixed, levee fill, canal L-28, 3.6 miles west and 5.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.

746. Unnamed post-Caloosahatchee formation, North New River Canal spoil banks, 5.3 miles north of pumping station at Broward county line on U. S. Highway 27, Palm Beach Co., Florida.

747. Unnamed post-Caloosahatchee formation, North New River Canal spoil banks, two miles south of South Bay, Palm Beach Co., Florida.

748. Unnamed post-Caloosahatchee formation, Lake Okeechobee levee, two miles north of South Bay, Palm Beach Co., Florida.

749. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, borrow pits on south side of "Glades Airport," 1.3 miles south of Pahokee south city limits on Florida Highway 715, Palm Beach Co., Florida.

751. Unnamed post-Caloosahatchee formation, North New River Canal spoil banks, 1½ miles south of South Bay, Palm Beach Co., Florida.

755. Caloosahatchee Fm., Miami Canal spoil banks, 17.4 miles north of pumping station at Broward County line, Palm Beach Co., Florida.

759. Unnamed post-Caloosahatchee formation, spoil banks north side of Caloosahatchee River, two miles west of Ortona Lock (NE ¼ Sec. 29, T42S, R30E), Glades Co., Florida.

767. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks north side of Caloosahatchee River, five miles west of Ortona Lock (NW ¼ Sec. 36, T42S, R29E), Glades Co., Florida.

768. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks north side of Caloosahatchee River, 5½ miles west of Ortona Lock (NW ¼ Sec. 35, T42S, R29E), Glades Co., Florida.

770. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks west side of Kissimmee River, 1½ to 3½ miles north of Florida Highway 70 (Secs. 10, 14, 15, and 28, T37S, R33E), Highlands Co., Florida.

788. Pinecrest Beds, Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks at U-shaped canal, north side Florida Highway 771, 3.4 miles southwest of U.S. Highway 41 at Port Charlotte Railroad station (formerly Murdock, Fla.) (Sec. 15, T40S, R21E), Charlotte County, Florida.

792. Caloosahatchee Fm., borrow pits just west of Florida Highway 80, about two miles southwest of La Belle (SW ¼ Sec. 7, T43S, R29E), Hendry Co., Florida.

796. Pinecrest Beds, material exposed during construction of "Alligator Alley," 12.8 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

797. Pinecrest Beds, material exposed during construction of "Alligator Alley," 13.3 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

801. Caloosahatchee Fm., spoil banks south side of Caloosahatchee River, 2¾ miles west of Ortona Lock (NW ¼ Sec. 29, T42S, R30E), Glades Co., Florida.

802. Pinecrest Beds and Caloosahatchee Fm., mixed, spoil banks south side of Caloosahatchee River, 4¼ miles west of Ortona Lock (SE ¼ Sec. 25, T42S, R29E), Glades Co., Florida.

803. Unnamed post-Caloosahatchee formation, spoil banks south side of Caloosahatchee River, two miles west of Ortona Lock (NE ¼ Sec. 29, T42S, R30E), Glades Co., Florida.

816. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, borrow pits, Cecil M. Webb Wildlife Management Area, 1.8 miles east of U. S. Highway 41 and 7.2 miles north of the Lee county line, Charlotte Co., Florida.

870. Waccamaw Fm., pits on east side of North Carolina Highway 130, 2.8 miles

north of Old Dock School, Old Dock, Columbus Co., North Carolina.
933. Pinecrest Beds, material exposed during construction of Alligator Alley, 21.5 miles east of Florida Highway 29, Collier County, Florida.
939. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation (mixed), south side of Caloosahatchee River, 5.2 miles west of Ortona Lock (NW ½ Sec. 36, T42S, R29E) Glades Co., Florida.
953. Moín Fm. (type locality)—Moín Hill, in railroad cut and on side of adjacent road to Sandoval, Costa Rica. Locality is about 4.5 km west of Limón, Costa Rica.
954. Moín Fm., in hill cut immediately behind Standard Fruit Company box factory, just west of cemetery at Pueblo Nuevo, Costa Rica. Locality is about 2 km west of Limón, Costa Rica.
975. Pinecrest Beds and Caloosahatchee Fm., mixed, levee on north side of Caloosahatchee Canal, 0-.5 mile west of middle of former Lake Hicpochee, T42S, R32E (unmapped); Glades Co., Florida.
978. Unnamed post-Caloosahatchee formation, pit south of waterworks at South Bay, Palm Beach Co., Florida. Pit is approximately one mile north of Atlantic Coast Line Railroad.

Tulane University, Department of Geology, Recent localities:

R-9. Dredged in 3 to 5 fathoms off Longboat Key, Sarasota, Florida.
R-18. Beach collection, Virginia Key, Florida, near University of Miami Marine Laboratory.
R-35. Midden, near Jerico, Puerto Castilla, north of Trujillo, Honduras.
R-36. Beach collection, Atlantic side of Long Key, Florida Keys.
R-69. Beach and shallow water collection, Celestún, Yucatan, west side Yucatan Peninsula.
R-71. Beach collection, Punta Palmas, the northwest "corner" of Yucatan Peninsula.
R-74. Beach and shallow water collection, Isla Arenas, Campeche, about 16 miles south of Celestún, Yucatan.
R-76. Isla Cancun, Quintana Roo, first island south of Isla Mujeres. Beach and shore collection.
R-78. Chevihau, Yucatan (east of Telchac). Beach collection.
R-79. Telchac, Yucatan, beach collection [also known as Telchac Puerto].
R-82. Dzilam Bravo, Yucatan; beach and salt marsh coll.
R-100. *Anton Bruun* Cruise 10. Dredged off Duarte Cays, northwest of Porto Bello, Panama, 9°36.9′ N., 79°40.8′ W., from 140 to 160 feet. (42-49 meters)
R-105. *Hernan Cortez* Cruise 17, dredged off Highland Point, Monroe County, Florida, 81°23′ N., 25°33′ W., 18 fathoms.
R-109. Fill for refinery, Bahia las Minas, Isla Payardi, Panama. (Radiocarbon dated at 7000 years B. P.)
R-110. Whites Beach, near Porto Bello, Panama, beach coll.
R-115. Punta Ualakpich, north of Bahia de la Ascensión, Quintana Roo, Mexico. Beach and shallow water coll.
R-124. Bonacca (Guanaja) Island, Bay Islands, Honduras, beach collection, west side near south end of island (west of West Peak).
R-127. Bonacca (Guanaja) Island, Bay Islands, Honduras, beach and shallow water collection off "Columbus Beach," Pine Ridge Bight, northwest side of island.
R-128. Bonacca (Guanaja) Island, Bay Islands, Honduras, beach and shallow water coll. from west side of Michael Rock, northwest side of island.
R-130. Bonacca (Guanaja) Island, Bay Islands, Honduras, beach and shallow water coll., from area just west of Dunbar Rock, southeast side of island.
R-132. Bonacca (Guanaja) Island, Bay Islands, Honduras, beach collection from Shean Cays (village of Guanaja).
R-164. Isla Contoy, off Cabo Catoche, Quintana Roo, Mex. (second island north of Isla Mujeres). Beach and shallow water coll.

U. S. Geological Survey Tertiary Fossil Localities:

USGS 4275: Waccamaw Fm., Neill's Eddy Landing, Cape Fear River, 28 miles above Wilmington, North Carolina, at B. F. Keith's fertilizer plant.
USGS 4276: Waccamaw Fm., pit at B. F. Keith Fertilizer Plant, on Cape Fear River, North Carolina, 28 miles above Wilmington.
USGS 11152: Spoil bank, West Palm Beach Canal, 2 to 3 miles above Loxahatchee Post Office, Palm Beach Co., Florida.
USGS 13835: Marl pit one mile north of Bermont, Charlotte County, and about three miles south of Prairie Creek.
USGS 13975: Alligator Creek, Charlotte County, Florida about one-half mile above the railroad bridge.
USGS 14075: Material dredged from Caloosahatchee River, one mile west of Olga, Lee County, Florida (upper Miocene).
USGS 21257: Pinecrest beds, U. Miocene float near Acline pit; Sec. 29, T41S, R23E, about 1 mile southwest of Acline Station (Pit C. of Schroeder and Hoy sketch map, 1952, p. 73).
USGS 21907: Pinecrest beds, U. Miocene, same as loc. 21257.
USGS 21982: Unnamed post-Caloosahatchee formation, north of Moore Haven, Glades Co., Florida; float from road metal pits on west side of Fla. 78 about 4.5 miles north of intersection with U. S. 27.
USGS 21984: Unnamed post-Caloosahatchee formation, north of Moore Haven, Glades Co., Florida; east wall of pit at USGS loc. 21982.
USGS 22038: Unnamed post-Caloosahatchee formation, Port Mayaca, Martin Co., Florida. Float on south bank of St. Lucie Canal between U. S. 441 and Fla. East Coast Railroad bridge.
USGS 22039: Unnamed post-Caloosahatchee

formation, Port Mayaca, Martin Co., Florida, float from south bank of St. Lucie Canal at eastern boundary of Port Mayaca (east of loc. 22038).

USGS 22040: Unnamed post-Caloosahatchee formation, St. Lucie Canal, Martin Co., Florida; float from south bank about 2.5 miles east of Port Mayaca, north of cemetery.

USGS 22298: Pinecrest beds, U. Miocene pit at Acline, Charlotte Co., Florida (see loc. 21257) from 3.8 feet of shell marl exposed at base of section in west wall.

USGS 22299: Pinecrest beds, U. Miocene, base of bed at Acline Pit (see loc. 22298).

USGS 22445: "Caloosahatchee River, La Belle, Florida. Collected by J.L.M., May, 1928." (An old collection at U.S.N.M. Locality is probably in error. Fauna is in the main of Acline species, and of same preservation, but include some admixture of Pleistocene and Caloosahatchee material.

USGS 22742: Unnamed post-Caloosahatchee formation, South Prong of Alligator Creek, Charlotte Co., Florida. Float apparently from outcrops in stream northwest of bridge in NE ¼, Sec. 26, T40S, R23E, Cleveland quad.

USGS 22853: Unnamed post-Caloosahatchee formation, Shell Creek, Charlotte Co., Florida; outcrop of upper bed in gully cut into south bank of creek in extreme east side of Sec. 30, or west side of Sec. 29, T40S, R25E, Bermont quad.

USGS 22855: Unnamed post-Caloosahatchee formation, Shell Creek, Charlotte County, Florida; float from pits and cut on south side of creek in same area as loc. 22853.

USGS 23089: Unnamed post-Caloosahatchee formation, Shell Creek, Charlotte Co., Florida; first outcrops upstream from Mr. Washington's place.

USGS 23722: Caloosahatchee Fm., spoil bank, west side of Miami Canal, about 9.3-9.9 miles south of Lake Harbor, Palm Beach Co., Florida (= TU 755).

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