

MOLLUSCS OF THE NATURAL WELL LOCALITY, DUPLIN STRATOTYPE, NEAR
MAGNOLIA, NORTH CAROLINA, AND REDISCOVERY OF *CARINORBIS*
QUADRICOSTATA (EMMONS, 1858) (GASTROPODA: AMATHINIDAE)

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I. ABSTRACT

The Duplin Formation stratotype at the Natural Well limestone sink near Magnolia, North Carolina, is commonly thought to be the source of one of the most thoroughly documented Pliocene molluscan faunas in the Carolinas. However, few of the 196 species listed by Dall (1903) as from "the Duplin well or the adjacent village of Magnolia" were actually collected from Natural Well. Neither the coding of Dall's lists nor reference in text clearly indicates which specimens were collected from the stratotype section.

A stratigraphically pure Natural Well collection, housed in the Geology Department of the University of North Carolina at Chapel Hill, contains 239 molluscan species (Appendix I). The faunule is low in endemics and high in first appearances of species that continue into the younger Waccamaw faunas. Like the correlative Tearcoat Branch and Muldrow Place faunules, the Natural Well faunule contains only a single pectinid species, the ubiquitous *Carolinapecten eboreus*.

The UNC-CH collections contain a number of rare and unusual species, including a single specimen of *Carinorbis quadricostata* (Emmons, 1858). This is only the third recorded specimen of this rare and endemic species, and the first that permits comparative systematic analysis. The genus *Carinorbis* has been overlooked or inaccurately synonymized in most literature.

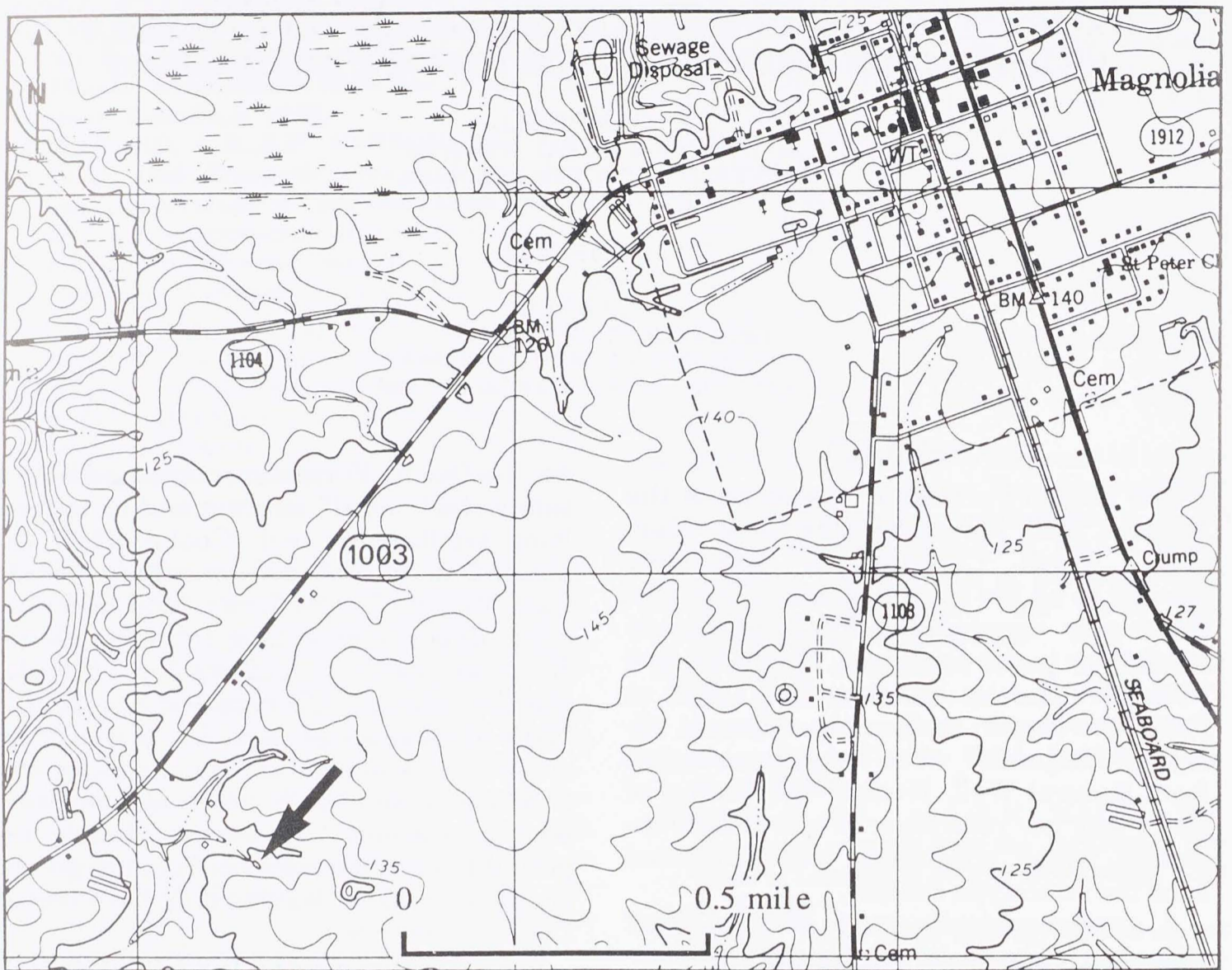
II. INTRODUCTION

The Duplin beds have had a varied history of stratigraphic assignments. Originally defined (Dall and Harris, 1892) in terms of the Hodge (1842) section at Natural Well near Magnolia, North Caroli-

na, the Duplin Formation contained both a sandy shell "marl" stratum and an underlying argillaceous bed. Cooke (1945) expanded the formational concept to include "late Miocene" (now Lower and mid-Pliocene) deposits extending from the Neuse River to northern and western Florida. Huddle (1940, p. 227) reported a section of "5-10' of Pleistocene sand, 3-4' of shell marl and about 14' of light green calcareous and argillaceous sand with interbedded calcareous sandstones." However, Huddle reported Eocene microfossils from the green, argillaceous sand, leaving only 3 to 4 feet of Duplin stratotype.

Berry (1947) included the Duplin within an expanded concept of the Yorktown Formation. Ward *et al.* (1979) abandoned the term "Duplin Formation" in favor of a similarly expanded Yorktown concept, but Bailey (1987) and Ward, Bailey, and Carter (1991) have resurrected the Duplin.

The discovery of at least three transgressive-regressive pulses, each with related but distinctive faunas, in the "Duplin" of South Carolina (M. Campbell, 1992) prompted a reexamination of the reported fauna at Natural Well. Dall (1903, p. 1599-1603) listed approximately 300 species of "Duplin" molluscs, but Dall's list was a composite from several localities and literature citations, including 196 species "authentically collected at the Duplin well or the adjacent village of Magnolia by Burns." The composite nature of this list was soon overlooked in subsequent literature. Clark *et al.* (1912, p. 241) observed: "Many lists of fossils obtained at the Natural Well have been published at various times. The most complete one is that given by W. H. Dall in vol. III of the Transactions of the Wagner Free Institute of Science."



Text-figure 1. Location of Natural Well, near Magnolia, North Carolina. Warsaw South 7.5 minute quadrangle. Figure after Carter *et al.*, 1988.

Dall's Duplin list contained *Terebraspira elegans* (Emmons), *Barbatia centenaria* (Say), and *Mercenaria tridacnoides* (Lamarck). He records several pectinids from "Natural Well and Magnolia," including *Chesapecten septenarius* and *Amusium mortoni*. *Chesapecten edgecombensis* (= *C. madisonius*) was cited as Duplin, but without specific locality.

These species have not been recovered subsequently from Natural Well or equivalent beds, but are characteristic of the older Goose Creek Limestone and Raysor faunas in South Carolina. In southern Florida, *Chesapecten septenarius* and *C. madisonius* (low rib number form) are restricted to the Tamiami Limestone, a pre-Pinecrest (*i.e.*, pre-Duplin) unit, and *Mercenaria tridacnoides* is found only in the Tamiami and the basal Pinecrest. In the Virginia Yorktown Zone 2 faunas,

Chesapecten madisonius (10-16 rib form) is restricted to the basal beds, and *Barbatia centenaria*, *Mercenaria tridacnoides*, and *Chesapecten septenarius* are present only in the lower and middle (pre-Duplin equivalent) Zone 2 beds (L. Campbell, 1993). Typical *Chesapecten madisonius* (16-26 rib form) is found throughout the middle and upper beds of Zone 2 (L. Campbell, 1993). Consequently, both Dall's general "Duplin" list and the specific records in text appear to represent a stratigraphically composite assemblage.

Dall and Harris (1892, p. 72-73) observed of Natural Well:

"This locality has recently been visited by Mr. Frank Burns, of the U. S. Geological Survey, who reports the 'well' or sink to be situated in the midst of a hard-wood 'hammock' covering a few acres.... Much of the marl has been removed for use as a fertilizer and good speci-

mens of fossils are now rare. But better exposures of the marl can be found in the immediate neighborhood of Magnolia, a village about 2 miles northeast from the well. On the farm of Mr. Strickland, 1 1/2 miles northwest from Magnolia, the same bed afforded better preserved fossils than at the well, while on the farm of Mr. Hollingsworth, 2 miles northeast of Magnolia, the marl is cemented into a comparatively solid rock, hard enough to burn for lime."

In other words, few if any of the Burns collection specimens recorded from Natural Well and the vicinity of Magnolia and cited by Dall (1890-1903), Mansfield (1930, 1932) and Gardner (1944, 1948) actually came from Natural Well. Apparently, the Strickland farm is the source of most of Burns' "Natural Well" specimens, but the Hollingsworth farm cemented marl "hard enough to burn for lime" suggests Goose Creek Limestone lithologies, which would provide a credible source for the *Chesapecten* species and other anomalous "Natural Well" pectinids. An abbreviated assemblage from the Strickland farm is preserved in the U. S. Geological Survey stratigraphic collections at the National Museum in Washington, D.C. Hodge (1842, p. 335-336) stated that "the shells [at Natural Well] are of a great variety of species belonging to this formation, and they lie promiscuously together in great confusion." One hundred and fifty years later, the Natural Well faunule continues to lie in a state of unsuspected confusion.

From the 1890's to the early 1950's, access to the Duplin sands at Natural Well was limited by the precipitous nature of the exposure and the undercutting produced from mining the Duplin layer for agricultural lime. In the early 1950's, Charles Locklin had a ramp cut to facilitate collecting (Druid Wilson, 1990, personal communication). The Caloosahatchee and Pinecrest portions of the Locklin collection went to the Academy of Natural Sciences of Philadelphia (Olsson and Harbison, 1953), but we have not located the Locklin Natural Well collection.

An independent and stratigraphically pure collection of Natural Well fossils at the University of North Carolina at Chapel Hill, assembled by John W. Frink, Walter Wheeler, Joseph G. Carter, and their students over the past sixty years, permits a reexamination of the stratotype Duplin

biota. Two hundred and thirty-nine molluscan species can be documented in literature or in the Chapel Hill collection (Appendix I). Preliminary comparisons indicate a strong correlation with the faunule at Tearcoat Branch, Sumter County, South Carolina (S. Campbell, 1974), and with the *Cancellaria* zone fauna of western Florida (Mansfield, 1930, 1932). The nanofossil age of the Natural Well stratotype was given by Cronin *et al.* (1984) as NN 16-18.

We concur with Bailey (1987) that the term "Duplin" should be reinstated, but we suggest that the lithostratigraphic concept should be narrowly restricted to the Natural Well stratotype and lithologically equivalent beds. Owens (1991) mapped the area from Cape Fear to Georgetown, South Carolina, using an expanded concept of the Duplin Formation, while Weems and Lemon (1988) mapped quadrangles in the Charleston area, using a more restricted concept.

Using a narrow lithostratigraphic interpretation of the Natural Well stratotype, the Duplin includes: (1) the Natural Well section; (2) the Strickland Farm; (3) Bed E at the Robeson Farm near Tar Heel, North Carolina (Britt *et al.*, 1992); (4) Tearcoat Branch and Muldrow Place, Sumter County, South Carolina (S. Campbell, 1974); and (5) Kirby's Pond, Timmons ville, Florence County, South Carolina. A total of 453 molluscan species can be documented from these sites. A biostratigraphic statistical summary of the Natural Well faunule is given in Table 1.

The Natural Well faunule includes many tropical and sub-tropical elements. The Duplin fauna, typified by the Natural Well faunule, is low in endemics, being a major transitional fauna in both space and time. Spatially, the subtropical Duplin borrows heavily from the tropical Pinecrest faunas of southern Florida and from the rich, warm temperate faunas of the Yorktown in Virginia and northern North Carolina. Lateral biofacies are admixed at Natural Well, Tearcoat Branch, Muldrow Place, and Timmons ville, each locality blending taxa typical of modern littoral, sublittoral, shallow, mid-, and outer shelf biotopes. Despite the resulting diversity, the Natural Well fauna has yielded only a single pectinid species, the ubiquitous *Carolinapecten*.

TABLE 1
STATISTICAL SUMMARY OF DUPLIN MOLLUSCAN SIMILARITY LEVELS

	R	UW	LW	E	D	RA	UGC	LGC	M
%	18.8	46.0	46.0	64.5	95.8	45.6	38.5	24.3	18.0
Dice	.179	.383	.341	.155	.662	.487	.441	.324	.248

% = Percentage in Common

Dice = Dice Similarity Index $(2 \times C) / (A + B)$

C = species in common, A = species in assemblage A, B = species in assemblage B

R = also Recent; UW = Upper Waccamaw; LW = Lower Waccamaw;

E = beds at Elizabethtown; D = Duplin; RA = Raysor; UGC = Upper Goose Creek Limestone; LGC = Lower Goose Creek Limestone;

M = also Miocene. (For more detailed stratigraphy, see M. Campbell and L. Campbell, this volume).

Note: The Natural Well faunule does not completely equate with the Duplin standard because a small number of taxa from Natural Well were not identified to species.

ten eboreus. The older, less diverse Raysor and Goose Creek faunas have higher rates of endemism and include several pectinid species.

As a time-transitional fauna, the Duplin combines many last-appearance records from the older Raysor and Goose Creek faunas with numerous first-appearances of species continuing into the younger Waccamaw faunas.

The University of North Carolina Natural Well collection contains a number of unusual species, including a single specimen of *Carinorbis quadricostata* (Emmons, 1858), a species which has not been recognized subsequent to its initial discovery. This discovery prompted a review of the genus *Carinorbis* Conrad, 1862, and the two Duplin species in this genus.

III. SYSTEMATIC PALEONTOLOGY

Class GASTROPODA

Superfamily PYRAMIDELLOIDEA

Family AMATHINIDAE Ponder, 1987

Genus CARINORBIS Conrad, 1862

Carinorbis CONRAD, 1862, Acad. Nat. Sci. Phila., Proc., v. 14, p. 288.

Type species: *Delphinula lyra* Conrad, 1834, here designated.

Original Description: "Suborbicular; spire small, depressed, or but little prominent; shell costate, ribs revolving, distant, prominent; last

whorl flattened above; umbilicus small, and the space beneath it channeled; peristome continuous." (Conrad, 1862, p. 288)

Discussion: Conrad (1862) originally assigned two species to *Carinorbis*: *Delphinula lyra* Conrad, 1834, and *Delphinula quadricostata* Emmons, 1858. No type species was originally or subsequently designated. Conrad (1863, p. 570) then muddled the concept of *Carinorbis* by assigning to it four additional species, a trochid and three very different vitrinellids, none of which are congeneric with *Delphinula lyra* and *Delphinula quadricostata*.

Carinorbis lyra is the first named of Conrad's (1862) cited species, and it is common in some Yorktown faunules. In contrast, *Carinorbis quadricostata* (Emmons) is known from only three specimens including the missing holotype, and is found only at Natural Well. We, therefore, designate *Delphinula lyra* Conrad, 1834 (probable syntypes ANSP 30731) as type of *Carinorbis* Conrad (1862), although the choice does not affect the nature of the genus since the two taxa are congeneric. Dall (1892) synonymized *Carinorbis* with *Fossarus*. However, like many other taxa traditionally placed in or near *Fossarus*, *D. lyra* belongs elsewhere (James McLean, 1988, personal communication). *Carinorbis* Yen (1946), and *Carinorbis* Mandahl-Barth (1954) are homonyms (*vide* Vaught, 1989).

Carinorbis lyra is congeneric with *Clathrella clathrata* (Philippi, 1844), Pliocene of Italy, as illustrated by Cavallo and Repetto (1992, sp. 433, here reproduced as plate 1, figure 9), and with *Clathrella costata* (Brocchi, 1814), Neogene and Recent of Europe, as figured by Ponder (1987). Consequently, *Carinorbis* Conrad (1862) is a senior synonym of *Clathrella* Recluz, 1864 [type species: *Clathrella clathrata* (Philippi)]. Although *Clathrella* was synonymized with *Phasianema* by Wenz (1940), Ponder (1987) has shown them to be distinct. *Phasianema* Wood, 1842 (type species *P. sulcata* Wood, 1842 = *Turbo costulata* Brocchi, 1814) is not congeneric with *Carinorbis* and is morphologically closer to *Iselica*. In a footnote, Cavallo and Repetto (1992, p. 154) synonymized *Clathrella clathrata* with *Phasianema costata* (Brocchi, 1814). Their use of *Phasianema* for *Clathrella costata* is not explained. It may follow the usage of Wenz, or could have easily resulted from the confounding of Brocchi's two very similar species names.

Ponder (1987) erected a new family, the Amathinidae, (superfamily Pyramidelloidea), in which he included seven genera, among them *Clathrella*, *Phasianema*, and *Iselica*. Like *Carinorbis*, *Iselica* had previously been assigned to the Fossaridae by most authors.

CARINORBIS LYRA (Conrad)

Plate 1, figures 5-8

- Delphinula lyra* CONRAD, 1834, Acad. Nat. Sci. Phila., Jour., v. 7, p. 141; CONRAD, 1846, Acad. Nat. Sci. Phila., Proc., v. 3, p. 20, pl. 1, fig. 27.
- Delphinula globulus* H.C. LEA, 1843, Abstract of a paper read before the American Philosophical Society, (privately printed) p. 9; H.C. LEA, 1845, Amer. Philos. Soc., Trans., preprint, ser. 2, v. 9, p. 36, pl. 36, fig. 74.
- Carinorbis lyra* CONRAD, 1862, Acad. Nat. Sci. Phila., Proc., v. 14, p. 288; CONRAD, 1863, Acad. Nat. Sci. Phila., Proc. v. 14, p. 570; MEEK, 1864, Smithsonian Misc. Coll., v. 7, no. 183, p. 14; L. CAMPBELL, 1993, Virginia Div. Min. Resources, Publ. 127, p. 69, pl. 30, fig. 331.
- Fossarus lyra* (Conrad). DALL, 1892, Wagner Free Inst. Sci., Trans., v. 3, pt. 2, p. 322, 347, pl. 18, fig. 3a; CAMPBELL *et al.*, 1975, South Carolina Geol. Notes, v. 19, p. 105, species 907; WARD and GILINSKY, 1993, Virginia Mus. Nat. Hist., Mem. 3, part A, p. 17.

Original Description: "Shell transversely subovate; spire depressed; body whorl with about eight distant very elevated ribs, composed of double laminae; space between the ribs transversely striated; umbilicus small, placed nearer the summit than the base of the shell; aperture dilated; longitudinally suboval. Length, less than half an inch. Locality. Suffolk, Va." (Conrad, 1834, p. 141)

Discussion: *Carinorbis lyra* (Conrad) was illustrated poorly but recognizably by Conrad (1846, pl. 1, fig. 27). The species was more definitively illustrated by Dall (1892, pl. 18, fig. 3a; here reproduced as plate 1, figure 8.) in a figure which inexplicably added an extra rib. The species has five strong and two weaker spiral cords, and about 24 strong, narrow, axial ribs on the adult body whorl, producing a coarsely cancellate sculpture. The shell changes shape with growth, becoming relatively broader because of rapid inflation of the adult body whorl. Adult shells are never common, but immature shells are common in some Yorktown deposits. Specimens are scarce in the Duplin Formation at Natural Well and Tearcoat Branch and rare in the Raysor sands at the Berkeley County Quarry near Cross, South Carolina. Conspecific specimens with high, but thinner, spiral ribs can be found in the Pinecrest beds (bed 8) at the APAC pit, Sarasota, Florida (USGS collections).

CARINORBIS QUADRICOSTATA

(Emmons)

Plate 1, figures 1-4

- Delphinula quadricostata* EMMONS, 1858, Report of the Geol. Surv. of North Carolina, p. 272, fig. 180; DALL, 1892, Wagner Free Inst. Sci., Trans., v. 3, pt. 2, p. 322 (as a synonym of *Fossarus lyra*).
- Carinorbis quadricostata* (Emmons). CONRAD, 1862, Acad. Nat. Sci. Phila., Proc., v. 14, p. 288; CONRAD, 1863, Acad. Nat. Sci. Phila., Proc., v. 14, p. 570.
- Aorotrema gardnerae* OLSSON and HARBISSON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 424, pl. 39, fig. 13; CAMPBELL *et al.*, 1975, South Carolina Geol. Notes, v. 19, p. 99, species 708.
- Original Description*: "Shell small, thin; whorls [*sic*] few, angulated and furnished with four ribs, which are crossed by lines of growth; aperture angular.
- "Found occupying the interior of the large univalve shells of the miocene [*sic*]." (Emmons, 1858, p. 272)

Discussion: *Delphinula quadricostata* is missing from among the Emmons types at the Paleontological Research Institution, Ithaca, New York. Both Emmons' original figure and the illustration of *Aorotrema gardnerae* of Olsson and Harbison lack the detail necessary for defining *C. quadricostata* as distinct from the more coarsely sculptured *C. lyra*. The presence of a definitive specimen in the University of North Carolina at Chapel Hill Natural Well collections allows recognition of *C. quadricostata* as a distinct species. *Carinorbis quadricostata* differs from *C. lyra* in having four rather than five major spiral cords on the body whorl, in having narrower and lower primary and secondary spiral cords, and in having axial sculpture much reduced, consisting of about 30 very low, narrow riblets on the body whorl. The sculpture is not cancellate as in *C. lyra*. The three known specimens of *C. quadricostata* are much smaller than adult *C. lyra*, and may be immature. Based on Olsson and Harbison's (1953) figure of the type, we judge *Aorotrema gardnerae* to be a minute juvenile of *C. quadricostata*. Emmons' type locality for *C. quadricostata* is unstated, but could have been Natural Well. *Carinorbis quadricostata* appears to be rare, local in its distribution, and easily overlooked due to its small size.

IV. LITERATURE CITED

- BAILEY, R.H., 1987, Stratigraphy and depositional history of the Yorktown Formation in northeastern North Carolina: Southeastern Geology, v. 28, p. 1-20.
- BERRY, E.W., 1947, Marls and limestones of eastern North Carolina: North Carolina Geol. Survey, Bull. v. 54, p. 1-16.
- BRITT, R.J., L.D. CAMPBELL, M.R. CAMPBELL, and J.G. CARTER, 1992, Molluscan biostratigraphy of the Tar Heel Robeson Farm Site, Bladen County, North Carolina in J.M. DENNISON and K.G. STEWART (eds.), Geologic field guides to North Carolina and vicinity: University of North Carolina-Chapel Hill, North Carolina Geologic Guidebook No. 1, p. 153-157.
- CAMPBELL, L.D., 1993, Pliocene molluscs from the Yorktown and Chowan River Formations in Virginia: Virginia Div. Min. Resources, Publ. 127, 259 p.
- CAMPBELL, M.R., 1992, Molluscan biostratigraphy of the Pliocene beds of eastern South Carolina and southeastern North Carolina in J.M. DENNISON and K. G. STEWART (eds.), Geologic field guides to North Carolina and vicinity: University of North Carolina-Chapel Hill, Geologic Guidebook No. 1, p. 145-151.
- CAMPBELL, S.C., 1974, Duplin Formation, Sumter County, South Carolina; a new locality: South Carolina Geol. Notes, v. 18, p. 75-97.
- CARTER, J.G., P.E. GALLAGHER, R.E. VALONE, and T.J. ROSSBACH, 1988, Fossil col-

PLATE 1

Carinorbis species from Virginia, North Carolina, and Italy.

Figures

- 1-4. *Carinorbis quadricostata*, 4 mm, UNC-15152, Natural Well, near Magnolia, North Carolina.
1. Adapertural view showing reduced axial sculpture and four prominent keels.
 2. Apertural view.
 - 3, 4. Apical view showing reduced sculpture and heterostrophic protoconch.
- 5, 7. *Carinorbis lyra*, 5.9 mm, UNC-15230, Rock Wharf, south bank of James River, west of Smithfield, Virginia.
5. Adapertural view showing prominent axial sculpture and seven spiral keels.
 6. Apertural view.
 7. Apical view showing prominent sculpture and heterostrophic protoconch.
8. *Carinorbis lyra* (Conrad) (*Fossarus lyra* of Dall, 1892, pl. 18, fig. 3a). 4 mm, locality not given. An artistic error added an extra rib to the body whorl for a total of eight. The aperture is correctly depicted.
9. *Carinorbis clathrata* (Philippi, 1844) (*Clathrella clathrata* of Cavallo and Repetto, 1992, p. 154-5, fig. 433).

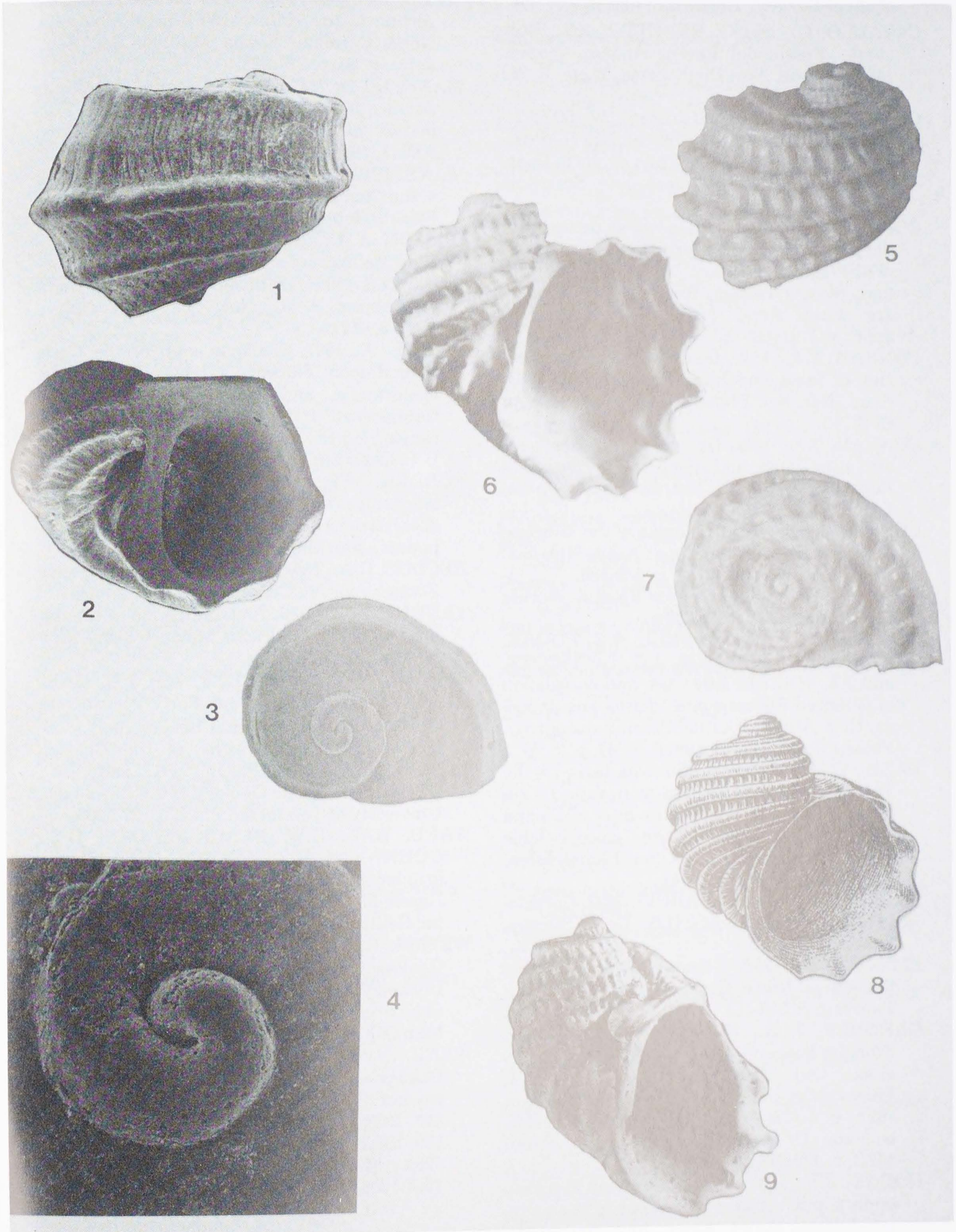


PLATE 1

- lecting in North Carolina: North Carolina Geological Survey, Bulletin 89, 89 p.
- CAVALLO, O., and G. REPETTO, 1992, Conchiglie Fossili del Roero, Atlante, Iconografico: Assoc. Nat. Piemontese, Mem. 2, 251 p.
- CLARK, W.B., B.L. MILLER, L.W. STEPHENSON, B.L. JOHNSON, and H.N. PARKER, 1912, The Coastal Plain of North Carolina: North Carolina. Geol. and Economic Survey, v. 3, 540 p.
- CONRAD, T.A., 1834, Observations on the Tertiary and more recent formations of a portion of the southern states. Appendix, descriptions of new Tertiary fossils from the southern states: Acad. Nat. Sci. Philadelphia, Jour., v. 7, p. 116-157.
- CONRAD, T.A., 1846, Descriptions of new species of fossil and Recent shells and corals: Acad. Nat. Sci. Philadelphia, Proc., v. 3, p. 19-27.
- CONRAD, T.A., 1862, Descriptions of new genera, subgenera, and species of Tertiary and Recent Shells: Acad. Nat. Sci. Philadelphia, Proc., v. 14, p. 285-291.
- CONRAD, T.A., 1863, Catalogue of the Miocene shells of the Atlantic Slope: Acad. Nat. Sci. Philadelphia, Proc., v. 14, p. 549-586.
- COOKE, C.W., 1945, Geology of Florida: Florida Geol. Survey, Bull. 29, 339 p.
- CRONIN, T.M., L.M. BYBELL, R.Z. POORE, B.W. BLACKWELDER, J.C. LITTICOTT, and J.E. HAZEL, 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U. S. Atlantic Coastal Plain: Palaeogeog., Palaeoclimatol., Palaeoecol., v. 47, p. 21-51.
- DALL, W.H., 1890-1903, Contributions to the Tertiary Fauna of Florida, with especial reference to the Miocene Silex-beds of Tampa and the Pliocene beds of the Caloosahatchie River: Wagner Free Inst. Sci. Philadelphia, Trans., v. 3, pts. 1-6, 1654 p.
- DALL, W.H., and G.D. HARRIS, 1892, Correlation Papers Neocene: U.S. Geol. Survey, Bull., v. 84, 349 p.
- EMMONS, E., 1858, Report of the Geological Survey of North Carolina. Raleigh, North Carolina, p. 246-315.
- GARDNER, J. A., 1943 [1944]-1948, Mollusca from the Miocene and Lower Pliocene of Virginia and North Carolina, Part 1, Pelecypoda: U. S. Geol. Survey, Prof. Paper 199A, p. 1-178; Part 2, Scaphopoda and Gastropoda: U. S. Geol. Survey, Prof. Paper 199B, p. 179-310.
- HODGE, J.T., 1842, Observations on the Secondary and Tertiary formations of the southern Atlantic States: Amer. Jour. Sci., v. 41, p. 332-344.
- HUDDLE, J.W., 1940, Notes on the geological section at the Natural Well near Magnolia, North Carolina: Elisha Mitchell Sci. Soc., Jour., v. 56, p. 227-228.
- MANSFIELD, W.C., 1930, Miocene Gastropods and Scaphopods of the Choctawhatchee Formation of Florida: Florida Geol. Survey, Bull. 3, 189 p.
- MANSFIELD, W.C., 1932, Miocene Pelecypoda of the Choctawhatchee Formation of Florida: Florida Geol. Survey, Bull. 8, 240 p.
- OLSSON, A.A., and A. HARBISON, 1953, Pliocene Mollusca of southern Florida, with special reference to those from North Saint Petersburg: Acad. Nat. Sci. Philadelphia, Mon. 8, 457 p.
- OWENS, J., 1991, Geologic map of the Cape Fear Region, Florence 1 degree by 2 degree Quadrangle and northern half of the Georgetown 1 degree by 2 degree Quadrangle, North Carolina and South Carolina: U.S. Geol. Survey, Map I-1948-A.
- PONDER, W.F., 1987, The anatomy and relationships of the Pyramidellacean limpet *Amalthina tricarinata* (Mollusca: Gastropoda): Asian Marine Biology, v. 4, p. 1-34.
- RECLUZ, C.A., 1864, Observations sur le genre Fossar: Jour. de Conchyl., v. 12, p. 247-251.
- VAUGHT, K.C., 1989, A classification of the living Mollusca. American Malacologists, Melbourne, Florida, 195 p.
- WARD, L.W., R.H. BAILEY, and J.G. CARTER, 1991, Pliocene and Early Pleistocene stratigraphy, depositional history, and molluscan paleobiogeography of the Coastal Plain in J.W. HORTON, JR. and V.A. ZULLO (eds.), The Geology of the Carolinas. University of Tennessee Press, p. 274-289.
- WARD, L.W., B.W. BLACKWELDER, G.S. GOHN, and R.Z. POORE, 1979, Stratigraphic revision of Eocene, Oligocene, and Lower Miocene Formations of South Carolina: South Carolina Geol. Notes, v. 23, p. 2-32.
- WEEMS, R.E., and E.M. LEMON, JR., 1988, Geologic map of the Ladson Quadrangle, Berkeley, Charleston, and Dorchester Counties, South Carolina: U. S. Geol. Survey, Map GQ-1630, 1 sheet.
- WENZ, W., 1938-1960, Handbuch der Paläozoologie. Berlin, Gebrüder Borntraeger. Vol. 6, Gastropoda, pt. 1, p. viii + 240, 1938; pt. 2, p. 241-480, 1938; pt. 3, p. 481-720, 1939; pt. 4, p. 721-960, 1940; pt. 5, p. 961-1200, 1941; pt. 6, p. 1201-1506, 1943; pt. 7, p. 1507-1639, 1944; Vol. 6, Pt. 2, Euthyneura, p. xii + 600, 1959; p. 601-834, 1960.

V. APPENDIX I: MOLLUSCS AND ECHINODERMS OF THE DUPLIN
STRATOTYPE LOCALITY AT NATURAL WELL

BIVALVIA

- Nucula proxima* Say, 1822
UNC 15051
- Nuculana acuta* (Conrad, 1832)
UNC 15052
- Anadara carolinensis* (Dall, 1897)
Gardner, 1943 [1944]
- Anadara callicestosa* (Dall, 1898)
UNC 15053
- Anadara improcera* (Conrad, 1845)
UNC 15054
- Anadara improcera bucua* (Conrad, 1845)
UNC 15055
- Anadara lienosa* (Say, 1832)
UNC 15056
- Noetia incile* (Say, 1824)
UNC 15057
- Noetia trigintinaria* (Conrad, 1862)
UNC 6477
- Glycymeris americana* (Defrance, 1826)
UNC 1777
- Glycymeris duplinensis* Dall, 1898
UNC 15058
- Glycymeris subovata* (Say, 1824)
UNC 1778, 6457, 7534
- Perna conradinus* (Orbigny, 1852)
UNC 1756
- Modiolus inflatus* (Tuomey and Holmes, 1856)
UNC 15059
- Carolinapecten eboreus* (Conrad, 1833)
UNC 15060
- Lima carolinensis* Dall, 1898
UNC 15061
- Plicatula marginata* Say, 1824
UNC 1753, 3589, 15062
- Ostrea compressirostra* Say, 1824
UNC 15063
- Ostrea sculpturata* Conrad, 1840
UNC 1762
- Placuanomia plicata* Tuomey and Holmes, 1855
UNC 15064
- Parvilucina trisulcata* (Conrad, 1841)
UNC 15065
- Parvilucina multilineata* (Tuomey and Holmes, 1856)
UNC 15066
- Parvilucina crenulata* (Conrad, 1840)
UNC 15067
- Callucina keenae* Chavan, 1971
UNC 15068
- Ctena speciosa* (Rogers and Rogers, 1837)
Gardner, 1943 [1944]
- Ctena microimbricata* Gardner, 1943 [1944]
Gardner, 1943 [1944]
- Pseudomiltha anodonta* (Say, 1824)
UNC 15069
- Diplodonta conradi* McGavock, 1944
Gardner, 1943 [1944]
- Diplodonta nucleiformis* (Wagner, 1838)
UNC 15070
- Chama congregata* Conrad, 1833
UNC 1781
- Chama corticosa* Conrad, 1833
Gardner, 1943 [1944]
- Chama emmonsii* Nicol, 1953
UNC 1781a
- Erycina carolinensis* Dall, 1900
Gardner, 1943 [1944]
- Aligena rhomboidea* Gardner, 1943 [1944]
Gardner, 1943 [1944]
- Bornia triangula* Dall, 1900
UNC 15071
- Mysella stantoni* (Dall, 1900)
Gardner, 1943 [1944]
- Sportella constricta* (Conrad, 1841)
UNC 15072
- Ensitellops protexta* (Conrad, 1841)
UNC 15073
- Carditamera arata* (Conrad, 1832)
UNC 1775, 6478
- Pleuromeris tridentata* (Say, 1826)
UNC 15074
- Pleuromeris tridentata decemcostata* Conrad, 1867
UNC 15075
- Pteromeris perplana* (Conrad, 1841)
UNC 15076
- Pteromeris perplana abbreviata* (Conrad, 1841)
UNC 15077
- Astarte concentrica* Conrad, 1834
UNC 15078
- Astarte undulata* Say, 1824
UNC 15079
- Eucrassatella speciosa* (A. Adams, 1852)
UNC 15080
- Eucrassatella virginica* (Gmelin, 1791)
UNC 1755
- Crassinella dupliniana* (Dall, 1903)
UNC 15081
- Crassinella lunulata* (Conrad, 1834)
UNC 15082
- Trigoniocardia (Americardia) media* (Linnaeus, 1758)
UNC 15083
- Clinocardium (Planicardium) acutilaqueatum* (Conrad, 1839)
UNC 15084
- Laevicardium sublineatum* (Conrad, 1841)
UNC 15085
- Laevicardium (Dinocardium) robustum* (Lightfoot, 1786)
UNC 15086
- Spisula duplinensis* Dall, 1898
Gardner, 1943 [1944]
- Mulinia congesta* (Conrad, 1833)
UNC 1765

Note: The UNC collection contains two small *Mulinia* specimens among thousands present that have an adult *Mulinia lateralis* (Say, 1822) morphology. How-

ever, that species is typical of younger deposits, and the highly variable *M. congesta* can converge with it. Therefore, we do not believe the material in hand constitutes a certain record of *M. lateralis* from the Natural Well site.

- Ervilia lata* Dall, 1898
Gardner 1943 [1944]
- Ensis directus* (Conrad, 1843)
UNC 15087
- Ensis ensiformis* (Conrad, 1843)
UNC 15088
- Tellina declivis* Conrad, 1834
UNC 15089
- Tellina dupliniana* Dall, 1900
UNC 15090
- Tellina macilenta* Dall, 1900
Gardner, 1943 [1944]
- Tellina umbra* Dall, 1900
UNC 15091
- Hemimetis magnoliana* (Dall, 1900)
UNC 1715
- Donax cuneola* Gardner and Aldrich, 1919
UNC 15092
- Donax emmonsii* Dall, 1892
Gardner, 1943 [1944]
- Semele carinata* (Conrad, 1830)
UNC 15093
- Semelina nuculoides* (Conrad, 1841)
UNC 15094
- Solecortus cumingianus* (Dunker, 1861)
UNC 15095
- ? *Corbicula densata* (Conrad, 1844)
UNC 15096 (shell preservation different from remaining collection.)
- Mercenaria corrugata* (Lamarck, 1818)
UNC 1760, 1774
- Mercenaria* sp.
UNC 1760a
- Chione cribraria* (Conrad, 1843)
UNC 1779, 6463, 6464
- Chione latilirata* (Conrad, 1841)
UNC 15097
- Chione grus* (Holmes, 1858)
UNC 15098
- Gouldia metastriata* (Conrad, 1838)
UNC 15099
- Transanella carolinensis* Dall, 1903
UNC 15100
- Macrocallista greeni* Ward and Blackwelder, 1987
UNC 15101
- Gemma magna* Dall, 1903
UNC 15102
- Cooperella parilis* (Conrad, 1875 [1873])
Gardner, 1943 [1944]
- Sphenia dubia* (H.C. Lea, 1843)
UNC 15103
- Corbula inaequalis* Say, 1824
UNC 15104
- Corbula contracta* Say, 1824
UNC 15105
- Corbula retusa* Gardner, 1943 [1944]
UNC 15106
- Corbula* sp.
UNC 15107
- Gastrochaena ligula* H.C. Lea, 1843
UNC 15108
- Panopea reflexa* Say, 1824
UNC 15109
- Margaritaria abrupta* (Conrad, 1832)
UNC 15110
- Verticordia emmonsii* Conrad, 1862
Gardner, 1943 [1944]
- SCAPHOPODA
- Dentalium eboreum* Conrad, 1846
UNC 15111
- Cadulus* new species
UNC 15112
- GASTROPODA
- Diodora carolinensis* Conrad, 1875 [1873]
Gardner, 1948
- Diodora nucula* (Dall, 1892)
UNC 15113
- Calliostoma* sp., cf. *C. bella* (Conrad, 1834)
UNC 15114
- Calliostoma labrosa* (Conrad, 1834)
UNC 15115
- Calliostoma virginica* Conrad, 1875 [1873]
UNC 15116
- Tegula exoluta* (Conrad, 1843)
UNC 751
- Arene tricateneria* (Stearns, 1872)
UNC 15117
- Arene* sp.
UNC 15118
- Skenea harrisi* (Olsson, 1916)
UNC 15119
- Skenea smithfieldensis* (Olsson, 1916)
UNC 15120
- Omalogyra* sp.
UNC 15121
- Alvania lipeus* (Dall, 1892)
UNC 15122
- Cyclostremiscus obliquistriatus* (H.C. Lea, 1843)
UNC 15123
- Cyclostremiscus schmidtii* (Olsson, 1916)
UNC 15124
- Aorotrema cistronium* (Dall, 1889)
UNC 15125
- Parviturboides* sp.
UNC 15126
- Teinostoma alexanderi* (Olsson, 1916)
Olsson, 1916
- Teinostoma bushi* (Olsson, 1916)
UNC 15127
- Teinostoma caloosaense* Dall, 1892
UNC 15128
- Teinostoma miocenica* Olsson, 1916
Olsson, 1916
- Teinostoma nana* (I. Lea, 1833)
UNC 15129

- Teinostoma subconica* (H.C. Lea, 1843)
 UNC 15130
Teinostoma thompsoni Olsson, 1916
 Olsson, 1916
Teinostoma umbilicata (H.C. Lea, 1843)
 UNC 15131
Macromphalina aperta (H.C. Lea, 1843)
 Gardner, 1948
Caecum compactum Dall, 1892
 UNC 15132
Caecum cooperi S. Smith, 1862
 UNC 15133
Caecum ibex Dall, 1892
 UNC 15134
Caecum new species
 UNC 15135
Turritella burdeni (Tuomey and Holmes, 1856)
 UNC 1312
Turritella etiwanensis (Tuomey and Holmes, 1856)
 UNC 1780
Turritella fluxionalis Rogers and Rogers, 1837
 UNC 15136
Turritella holmesi Dall, 1892
 UNC 1312a
Turritella virginica Campbell, 1993
 UNC 15137
Serpulorbis granifera (Say, 1824)
 UNC 15138
Petalocochnus sculpturatus H.C. Lea, 1843
 UNC 6475
Cerithiopsis bicolor (C.B. Adams, 1845)
 UNC 15139
Cerithiopsis scariphus Dall, 1892
 UNC 15140
Cerithiopsis smithfieldensis Olsson, 1916
 UNC 15141
Seila adamsi (H.C. Lea, 1845)
 UNC 15142
Triphora bartschi (Olsson, 1916)
 UNC 15143
Triphora submonilifera (Orbigny, 1852)
 UNC 15144
Epitonium aciculum (H.C. Lea, 1843)
 UNC 15145
Epitonium duplinianum (Olsson, 1916)
 Olsson, 1916
Epitonium fasciatum Gardner, 1948
 Gardner, 1948
Epitonium junceum Gardner, 1948
 Gardner, 1948
Epitonium magnolianum (Olsson, 1916)
 Olsson, 1916
Epitonium micropleurum (H.C. Lea, 1843)
 UNC 15146
Melanella laevigata (H.C. Lea, 1843)
 UNC 15147
Melanella angulata (H.C. Lea, 1843)
 UNC 15148
Melanella conchita Olsson and Harbison, 1953
 UNC 15149
Strombiformis biconica Gardner, 1948
 Gardner, 1948
Strombiformis lina Gardner, 1948
 Gardner, 1948
Strombiformis migrans (Conrad, 1846)
 UNC 15150
Strombiformis spatula Gardner, 1948
 Gardner, 1948
Carinorbis lyra (Conrad, 1834)
 UNC 15151
Carinorbis quadricostata (Emmons, 1858)
 UNC 15152
Calyptraea centralis (Conrad, 1841)
 UNC 744
Crucibulum auriculum spinosum (Sowerby, 1824)
 UNC 746
Crucibulum grande (Say, 1824)
 UNC 15153
Crucibulum scutellatum (Wood, 1828)
 UNC 15154
Crepidula aculeata (Gmelin, 1791)
 UNC 758
Crepidula cymbaeformis (Conrad, 1844)
 UNC 15155
Crepidula fornicata (Linnaeus, 1758)
 UNC 1761
Crepidula plana (Say, 1822)
 UNC 15156
Siphocypraea carolinensis (Conrad, 1841)
 UNC 1769
Erato maugeriae Gray, 1832
 UNC 15157
Euspira interna (Say, 1824)
 UNC 1754b
Euspira sayana Campbell, 1993
 UNC 1754a
Neverita duplicatus (Say, 1822)
 UNC 1771
Natica plicatella Conrad, 1863
 UNC 15158
Tectonatica psila (Say, 1822)
 UNC 15159
Sconsia hodgei (Conrad, 1841)
 UNC 6472
Murexiella shilohensis (Heilprin, 1888)
 UNC 15160
Urosalpinx lepidota (Dall, 1890)
 UNC 15161
Urosalpinx trossula (Conrad, 1832)
 UNC 15162
Pterorytis umbrifer (Conrad, 1832)
 UNC 15163
Typhis harrisi Olsson, 1914
 UNC 15164
Anachis styliola Dall, 1892
 UNC 15165
Anachis obesa (C.B. Adams, 1845)
 Gardner, 1948
Anachis parvulus (H.C. Lea, 1843)
 UNC 15166

- Strombina anomala* (Gardner and Aldrich, 1919)
 Gardner, 1948
Mitrella communis (Conrad, 1862)
 UNC 15167
Mitrella edenensis Richards and Harbison, 1947
 UNC 15168
Mitrella matsoni (Mansfield, 1924)
 UNC 15169
Aesopus ithitoma (Dall, 1890)
 UNC 15170
Aesopus stearnsi (Tryon, 1883)
 UNC 15171
Juliamitrella gardnerae (Blackwelder and
 Ward, 1987)
 UNC 15172
Ptychosalpinx multirugata (Conrad, 1841)
 Gardner, 1948
Tritonoharpa floridensis Tucker and Wilson,
 1932
 Gardner, 1948
Celatoconus nux (Dall, 1892)
 UNC 15173
Busycon canaliferum Conrad, 1863
 UNC 15174
Busycon incile (Conrad, 1833)
 UNC 15175
Busycon maximum (Conrad, 1839)
 UNC 15176
Busycon excavatum (Conrad, 1840)
 UNC 15177
Busycon contrarium (Conrad, 1840)
 UNC 15230
Nassarius consenoides (Olsson, 1916)
 Olsson, 1916
Nassarius cornellianus (Olsson, 1916)
 UNC 15178
Nassarius quadrulatus (H.C. Lea, 1843)
 UNC 15179
Nassarius smithianus (Olsson, 1916)
 Olsson, 1916
Nassarius vibex (Say, 1822)
 UNC 15180
Ilyanassa granifera (Conrad, 1868)
 UNC 15181
Ilyanassa harpuloides (Conrad, 1844)
 Gardner, 1948
Ilyanassa johnsoni (Dall, 1892)
 Gardner, 1948
Ilyanassa scalaspira (Conrad, 1868)
 UNC 15182
Ilyanassa sexdentata (Conrad, 1843)
 Gardner, 1948
Trajana pyta Gardner, 1948
 Gardner, 1948
Fasciolaria rhomboidea Rogers and Rogers,
 1839
 UNC 15183
Terebraspira sparrowi Emmons, 1858
 Gardner, 1948
Triplofusus gigantea (Kiener, 1840)
 UNC 1759
Fusinus equalis (Emmons, 1858)
 UNC 15184
Hesperisternia filicata (Conrad, 1843)
 UNC 15185
Oliva canaliculata H.C. Lea, 1843
 UNC 1750b
Oliva carolinensis (Conrad, 1863)
 UNC 15186
Olivella ancillariaeformis (H.C. Lea, 1843)
 UNC 15187
Olivella carolinae Gardner, 1948
 UNC 15188
Olivella mutica (Say, 1822)
 UNC 745
Olivella sp.
 UNC 15189
Pleioptygma carolinensis (Conrad, 1841)
 UNC 15190
Vexillum elaboratum (H.C. Lea, 1843)
 UNC 15191
Vexillum reticulatum (Emmons, 1858)
 UNC 15192
Scaphella trenholmi (Tuomey and Holmes, 1856)
 UNC 15193
Aurinia obtusa (Emmons, 1858)
 Gardner, 1948
Bullata antiqua (Redfield, 1852)
 UNC 15194
Bullata oliviformis (Tuomey and Holmes, 1856)
 Gardner, 1948
Dentimargo aureocincta (Stearns, 1872)
 UNC 15195
Dentimargo eburneola (Conrad, 1834)
 UNC 15196
Dentimargo schmidtii (Olsson, 1916)
 UNC 15197
Prunum limatulum (Conrad, 1834)
 UNC 743
Prunum virginianum Conrad, 1868
 UNC 743a
Prunum precursor (Dall, 1890)
 UNC 15198
Granula lavalleeana (Orbigny, 1842)
 UNC 15199
Persicula ovula Conrad, 1870
 UNC 743b
Granulina virginica Campbell, 1993
 UNC 15200
Granulina new species, aff. *G. hadra* (Dall, 1889)
 UNC 15201
Volvarina tersa (Mansfield, 1930)
 UNC 15202
Conus adversarius Conrad, 1841
 UNC 1768
Conus marylandicus Green, 1830
 UNC 1768a
Terebra carolinensis (Conrad, 1841)
 UNC 15203
Terebra indenta Conrad, 1863
 UNC 15204
Terebra unilineata (Conrad, 1841)

- UNC 1751b
Mitrolumna mitrodita (Gardner and Aldrich, 1919)
 UNC 15205
Drillia ecphorae Olsson, 1916
 Olsson, 1916
Drillia emmonsii Olsson, 1916
 Gardner, 1948
Drillia gastrophila Olsson, 1916
 Olsson, 1916
Drillia mcgrawensis Olsson, 1916
 Olsson, 1916
Drillia magnoliana Olsson, 1916
 Olsson, 1916
Drillia precursor Gardner and Aldrich, 1919
 UNC 15206
Drillia sumterensis Gardner and Aldrich, 1919
 UNC 15207
Crassispira (Crassispirella) virginiana (Conrad, 1834)
 UNC 15208
Cerodrillia simpsoni (Dall, 1887)
 UNC 15209
Splendrillia tiara (Gardner, 1948)
 UNC 15210
Cymatosyrinx lunata (H.C. Lea, 1843)
 UNC 15211
Cymatosyrinx ziczac Gardner, 1948
 Gardner, 1948
Cryoturris magnoliana (Olsson, 1916)
 UNC 15212
Glyphostoma zoster Gardner, 1948
 Gardner, 1948
Longchaeus suturalis (H.C. Lea, 1843)
 UNC 15213
- Odostomia (Odostomia) turbinopsis* (H.C. Lea, 1843)
 UNC 15214
Odostomia (Chrysallida) granulata (H.C. Lea, 1843)
 UNC 15215
Odostomia (Menestho) milium (H.C. Lea, 1843)
 UNC 15216
Odostomia (Evalea) diaphana (H.C. Lea, 1843)
 UNC 15217
Odostomia spp. 1-3
 UNC 15218-15220
Turbonilla spp. 1-3
 UNC 15221-15223
Cyclostremella magnoliana Olsson, 1916
 Olsson, 1916
Ringicula floridana Dall, 1889
 UNC 15224
Acteocina candei (Orbigny, 1842)
 UNC 15225
Acteocina lepta Woodring, 1928
 UNC 15226
Cylichna duplinensis (Dall, 1896)
 Gardner, 1948
- ECHINODERMATA
Arbacia species (spine)
 UNC 15227
Mellita species (fragments)
 UNC 15228
Echinocardium orthonotum (Conrad, 1843)
 UNC 15229

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- ZULLO, V.A., and G.R. BAUM, 1981, *Euscalpellum* Hoek (Cirripedia, Scalpellidae) from the Eocene of North and South Carolina: South Carolina Geol., v. 25, no. 1, p. 33-41.
- ZULLO, V.A., 1982, *Arcoscalpellum* Hoek and *Solidobalanus* Hoek (Cirripedia, Thoracica) from the Paleogene of Pacific County, Washington, with a description of a new species of *Arcoscalpellum*: Los Angeles County Mus. Nat. Hist., Cont. in Sci. 336, 9 p.
- ZULLO, V.A., 1982, Cirripedia, in Synopsis and Classification of Living Organisms. McGraw-Hill, New York, p. 220-228.
- HARRIS, W.B., and V.A. ZULLO, 1982, Rb-Sr glauconite isochron of the Eocene Castle Hayne Formation, North Carolina – Reply: Geol. Soc. Amer., Bull. v. 93, no. 2, p. 182-183.
- ZULLO, V.A., 1982, A new species of the turtle barnacle *Chelonibia* Leach, 1817 (Cirripedia, Thoracica) from the Oligocene Mint Springs and Byram Formations, Mississippi: Mississippi Geol., v. 2, no. 3, p. 1-6.
- ZULLO, V.A., and R.B. GURUSWAMI-NAIDU, 1982, Late Miocene Cirripedia from the basal Wilson Ranch Beds ("Merced" Formation). Sonoma County, northern California: California Acad. Sci., Proc., (ser. 4) v. 42, no. 21, p. 525-535.
- ZULLO, V.A., 1982, A new species of *Balanus* Da Costa, 1778 (Cirripedia) from the upper Oligocene Chickasawhay Formation of Mississippi and Alabama: Mississippi Geol., v. 3, no. 1, p. 9-14.
- ZULLO, V.A., R.H. WILLOUGHBY, and P.G. NYSTROM, 1982, A late Oligocene or early Miocene age for the Dry Branch Formation and Tobacco Road Sand in Aiken County, South Carolina?, in P.G. NYSTROM and R.H. WILLOUGHBY, eds., Geological investigations related to the stratigraphy in the kaolin mining district, Aiken County, South Carolina: 1982 Field Trip Guidebook, Carolina Geol. Soc., Columbia, South Carolina, p. 34-45.
- ZULLO, V.A., and J.D. STANDING, 1983, Sponge-inhabiting barnacles (Cirripedia, Archaeobalanidae) of the Carolinian Province, southeastern United States, with the description of a new species of *Membranobalanus* Pilsbry: Biol. Soc. Washington, Proc., v. 96, no. 3, p. 468-477.
- ZULLO, V.A., 1984, New genera and species of balanoid barnacles from the Oligocene and Miocene of North Carolina: Jour. Paleontology, v. 58, no. 5, p. 1312-1338.
- ZULLO, V.A., 1984, Cirriped assemblage zones of the Eocene Claibornian and Jacksonian Stages. southeastern Atlantic and Gulf Coastal Plains: Paleogeog., Paleoclim., Paleoecol., v. 47, nos. 1-2, p. 167-193.
- ZULLO, V.A., 1984, Barnacles from the Old Church Formation, Pamunkey River region, Virginia, in L.W. WARD and K. KRAFFT, eds., Stratigraphy and paleontology of the outcropping Tertiary beds in the Pamunkey River region, central Virginia Coastal Plain: 1984 Field Trip Guidebook, Atlantic Coastal Plain Geol. Assoc., p. 192-199.
- ZULLO, V.A., and L.E. KITE, 1985, Barnacles of the Jacksonian (upper Eocene) Griffins Landing Member, Dry Branch Formation in South Carolina and Georgia: South Carolina Geol., v. 28, no. 1, p. 1-21.
- ZULLO, V.A., and N.F. SOHL, 1985, Scalpelloid barnacles from the Upper Cretaceous of southeastern North Carolina: Biol. Soc. Washington, Proc., v. 98, no. 3, p. 636-643.

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