Some Upper Miocene and Pliocene(?) Ostracoda of Atlantic Coastal Region for Use in Hydrogeologic Studies
Some Upper Miocene and Pliocene (?) Ostracoda of Atlantic Coastal Region for Use in Hydrogeologic Studies

By FREDERICK M. SWAIN

Descirptions, illustrations, geographic distribution, stratigraphic ranges, and environmental aspects of microfossils
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## ILLUSTRATIONS

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### PLATES 1-13
Upper Miocene and Pliocene (?) Ostracoda.

### FIGURE 1
Location of sample sites
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ABSTRACT

Upper Miocene and Pliocene (?) outcrop samples from North Carolina and Virginia yielded 63 species and seven subspecies of Ostracoda. The stratigraphic distribution of the species indicates the presence of an assemblage, the *Aurila conradi-Thuarcycythere schmidtae* assemblage, that also extends into the Pliocene in southern North Carolina and South Carolina. A subassemblage, the *Radimella confragosa* subassemblage, represents the upper Miocene and Pliocene in southern North Carolina and in South Carolina. *T. schmidtae* appears to represent a cooler water subassemblage of the upper Miocene in northern North Carolina, Virginia, and southernmost Maryland.

Two new genera, two new species, and one new subspecies are described herein. The new genera are *Prodictocythere*, n. gen., and *Shattuckocythere*, n. gen. The new species are *Murrayina macleani*, n. sp., and *Prodictocythere trapezoidalis*, n. sp. The new subspecies is *Pontocythere agricola duopunctata*, n. subsp.

INTRODUCTION

As a part of a U.S. Geological Survey research project dealing with the permeability of sedimentary rocks in the Atlantic Coastal Plain, the Ostracoda have been studied from many surface localities and well samples (fig. 1).

The present paper describes the upper Miocene and Pliocene (?) Ostracoda obtained from outcrops in the Atlantic coastal region in the area extending from North Carolina to Maryland. Other ostracode faunas of the region will be discussed in later papers.

This paper represents the fourth in a series that records the results of the Ostracoda study; the others are Swain and Brown (1964, 1972) on Lower Cretaceous, Upper Jurassic (?), and Triassic Ostracoda, and Swain (1968) on Tertiary Ostracoda.

ACKNOWLEDGMENTS

P. C. Sylvester-Bradley, University of Leicester, kindly arranged for the scanning electron microscope photographs on plates 10–13, and Frederick J. Gunther prepared most of the transmitted light photographs on plates 8 and 9. H. J. Oertli and W. A. van den Bold provided the writer with many helpful suggestions.

The scanning electron microscope and optical microscope photographs on plates 1–7 were made at the University of Delaware with the assistance of Takako Nagase.

STRATIGRAPHIC SUMMARY

The ostracode-bearing deposits of Miocene and Pliocene (?) age in North Carolina, Virginia, and Maryland are represented in part by outcrops of the Yorktown and Duplin Formations and in part by sediments of late Miocene age that do not crop out. These sediments attain a maximum measured thickness of 590 feet in a well in Pamlico County, N.C. They thin to the north, to the south, and to the west of Pamlico Sound.

The Yorktown Formation was named by Clark and Miller (1906) for exposures along the James River at Yorktown, Va. The formation consists of white and light-gray fine- to coarse-grained molluscan sands, in part silty, argillaceous, and glauconitic; white and light-gray sands; argillaceous, coquina, porous, coarsely crystalline limestone, sandy molluscan shell beds (shell marl); and light-gray and brown clay (Swain, 1952; Brown, 1958). The Yorktown Formation thins to a featheredge along the outcrop belt in central North Carolina and in the coastal areas in Virginia and Maryland. The thinning is chiefly erosional, as indicated by the numerous outliers in the inner Coastal Plain and in adjacent areas of the Piedmont province to the west of the dominant Yorktown outcrop belt. North of Maryland, the Yorktown Formation is transitional to the Cohanseay Sand that comprises virtually unfossiliferous beds (Spangler and Peterson, 1950; Owens and Minard, 1960). In North Carolina the Yorktown Formation is underlain chiefly by beds of Cretaceous, Paleocene, Eocene, and middle Miocene age. In the restricted...
UPPER MIocene AND Pliocene (?) Ostracoda, ATLANTIC COASTAL REGION

SAMPLES
1. A1-A6; Maddry's Bluff, Hertford Co., N. C.
2. B1, B2; Meherrin River, Hertford Co., N. C.
3. C1, C2; Suffolk, Nansemond Co., Va.
4. D1, D2; Suffolk, Nansemond Co., Va.
5. E; Tar Ferry Landing, Hertford Co., N. C.
6. H1-H4; Black Rock Landing, Bertie Co., N. C.
8. L1, L2; Petersburg, Dinwiddie Co., Va.
9. M1-M3; Sunken Marsh Creek, Surry Co., Va.
11. P1, P3; Ferguson's Wharf, Isle of Wight Co., Va.
12. R1-R4; Morgan's Beach, Isle of Wight Co., Va.
14. T1; Urbanna, Middlesex Co., Va.
15. U1; Rappahannock River, Middlesex Co., Va.
16. V1; Rappahannock River, Middlesex Co., Va.
17. Z; Chickahominy River, Hanover Co., Va.
18. Meherrin River, Hertford Co., N. C.
19. Meherrin River, Hertford Co., N. C.

FIGURE 1.—Location of sample sites.
OSTRACODA OF THE YORKTOWN FORMATION

Three collections obtained by Thomas G. Gibson are possibly of Pliocene age. These are: (1) in the upper part of a bluff 150 yards south of Colerain Landing on the western bank of Chowan River, Bertie County, N.C. (Gibson’s samples G-1 and G-3 in ascending order), (2) in bluff at a point 200 yards south of Colerain Landing (Gibson’s samples F-1 to F-5 in ascending order), (3) Mount Gould Landing on western bank of Chowan River, Bertie County, N.C. The species of ostracodes from these Pliocene (?) deposits are listed in table 1.

The following species from the Pliocene (?) localities in table 1 have not been recorded in this area in deposits as old as Miocene:

- **Cytherura cf.** C. gibba Müller, 1785
- **Xestoleberis cf.** X. aurantia (Baird, 1838)

The remaining species from the Pliocene (?) also occur in the Miocene of this region. Lithologically the Pliocene (?) beds at the two localities mentioned above are darker brown in color and are more of a shell hash than is the Yorktown Formation in this area.

OSTRACODA OF THE YORKTOWN FORMATION

UPPER YORKTOWN

Two collections provided by Thomas G. Gibson were designated by him as representing the upper part of the Yorktown Formation. These are: (1) in a bluff on the western side of Chowan River at Black Rock Landing, 1 mile north of Highway 17 bridge, Bertie County, N.C. (Gibson’s samples H-1 to H-4 in ascending order), (2) roadcut on south side of road leading to Tar Ferry Landing on Wiccacon Creek from Harrellsville, Hertford County, N.C. (Gibson’s sample E), the exposure of 6 feet of yellow sandy beds is about 100 yards south of the old ferry; megafossils are common, especially Mercenaria and Pectens; sample was taken 3 feet above base of section. The ostracode species obtained from the upper Yorktown localities are listed in table 1.

No ostracode species are restricted to the upper Yorktown in the present collection.

One species occurs in the upper Yorktown, as designated by Gibson, and has been recorded in younger deposits by other workers but is not known to range into middle or lower Yorktown: **Proto-cytheretta sahnii** Puri, 1952.

One species was found in the upper Yorktown or in older deposits but not above the Yorktown: **Paradoxostoma robustum** Puri, 1954.

OSTRACODA FROM DEPOSITS OF PLIOCENE (?) AGE

The Duplin Marl was named by Dall (1898) for exposures in Duplin County, N.C., near Natural Well, southwest of Magnolia (Keroher, 1966). The Duplin consists of shell marl, clay, and sandstone as much as 100 feet thick in North Carolina according to Cooke (1945), but later authors have included the beds with the Yorktown Formation, or have referred to it as upper Miocene, undifferentiated (Swain, 1952; Brown, 1958). For example in the Cape Hatteras well, the deposits in the interval from 160 to 250 feet was found by Gardner (in Swain, 1952, p. 8) to contain faunas "closely allied to those from the Duplin surface outcrops." The upper Miocene in that well extends from 160 to 391 feet. According to Malde (1959) the Duplin in South Carolina is not a well-defined unit lithologically, but is more of a biostratigraphic unit of late Miocene age. From North Carolina, it extends into eastern South Carolina, eastern Georgia, and Florida where it rests on rocks ranging in age from middle Miocene to Late Cretaceous. The Duplin is overlain by Pliocene or by Pleistocene deposits in its areas of occurrence. The Waccamaw Formation of late Miocene to early Pliocene age in southern North Carolina and northern South Carolina (Swain, 1968) is very similar lithologically to the Duplin beds, and the two formations may be in part lateral equivalents.

The upper Miocene deposits of New Jersey, Delaware, and most of Maryland do not commonly contain Ostracoda, except in a few wells near the coast; the upper Miocene has not been found in New York. The upper Miocene ostracode faunas of South Carolina and other southeastern States are being studied. Several papers on these faunas have already appeared, notably those by Howe and others (1935), Puri (1954), and Pooser (1965).
TABLE 1.—Upper Miocene and Pliocene (?) Ostracoda from outcrop samples in North Carolina and Virginia

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MIDDLE YORKTOWN

The localities designated by Gibson as representing the middle Yorktown Formation and which yielded Ostracoda are as follows:

1. (Gibson's samples C-1 and C-2.) A bluff on the south bank of Nansemond River 0.5 mile northeast of Highway 258 bridge in the northern part of Suffolk, Nansemond County, Virginia; the lowermost 2 feet are composed of bluish clayey sand, only sparingly fossiliferous; the upper 9 feet are yellowish clayey sand, fairly fossiliferous throughout but with several concentrated shell bands; sample C-1 is from 1 foot above the base of the section in the lower unit, and sample C-2 is from 5 feet above the base of the upper unit.

2. (Gibson's samples D-1 and D-2.) A bluff on the western bank of Nansemond River 1.5 miles northeast of Highway 258 bridge in the northern part of Suffolk, Nansemond County, Va.; 13 feet of yellow clayey sand are exposed; the lowermost 2 feet are only sparingly fossiliferous, and the upper 11 feet are quite fossiliferous; sample D-1 is from 7 feet above the base, and sample D-2 is from a *Mulinia congesta* bed 8 feet above the base.

3. (Gibson's samples K-1 to K-4.) Along bank of Lieutenant's Run on the southwest side of Petersburg, Dinwiddie County, Va., 0.5 of a mile east of Atlantic Coast Line Railroad; about 15 feet of section are exposed in creek bank; the lowest 4 feet are composed of bluish sand and contain a great number of fossils, mainly Bivalvia; above the lower unit the beds gradually become more clayey and barren of fossils; sample K-1 is from 2 feet up in the section; sample K-2 is from 6 feet above the base; and sample K-3 is from 10 feet above the base, and K-4 is in the barren unit 13 feet above the base.

4. (Gibson's samples P-1 and P-3.) Bluff 0.5 of a mile north of Ferguson's wharf on the west bank of James River, east of Rushmere, Isle of Wight County, Va.

5. (Gibson's samples R-1 to R-4.) Bluff at Morgott's Beach on the south bank of James River, 5 miles north of Smithfield, Isle of Wight County, Va.

6. (Gibson's samples S-1 to S-5.) South bank of Yorktown River about 1 mile downstream from Yorktown at base of Moore House Bluff, James County, Va.

The ostracode species that are restricted to the middle Yorktown as designated by Gibson and represented in the present collection and that are not definitely known to occur in older to younger units in previously described collections are: *Cytheridea* sp. B; *Cytheridea muelleri* (Münster, 1830) subsp.; *Cletocythereis mundorffi* (Swain, 1952) subsp.; *Murrayina macleani*, n. sp.; and *Neocytherideis* sp.

Several species of this or previously recorded collections have been found in the middle Yorktown or younger deposits but not in the pre-middle Yorktown: *Bairdoppilata triangulata* Edwards, 1944; *Leptocythere paracastanea* Swain, 1955; *Loxococoncha wilberti* Puri, 1954; *Costa barclayi* (McLean, 1957); *Campylocythere laeva postopunctata* Edwards, 1944; *Acuticythereis laevissima punctata* Edwards, 1944; *Eucythere triangulata* Puri, 1954; *Puriana mesacostalis* (Edwards, 1944); and *Thaerocythere* sp.

A few species range from older deposits into the middle Yorktown but have not been found in younger beds: *Prodictyocythere trapezoidalis*, n. gen., n. sp.; *Campylocythere* sp.; *Cytheretta burnsi* (Ulrich and Bassler, 1904); *Cytheropteron subreticulatum* van den Bold, 1946; and *Pterygocythereis americana* (Ulrich and Bassler, 1904).

LOWER YORKTOWN

The samples designated as representative of the lower part of the Yorktown Formation in T. G. Gibson's collection are as follows:

1. (Gibson's samples A-1 to A-6.) Maddry's Bluff on the south bank of Meherrin River, 1 mile downstream from the Highway 258 bridge over the river, 1 mile northeast of Murfreesboro, Hertford County, N.C.

2. (Gibson's samples B-1, B-2.) Bluff on the south bank of Meherrin River, 2 miles upstream from Highway 258 bridge over the river, 1 mile northeast of Murfreesboro, Hertford County, N.C.; lower unit is composed of 3.5 feet of bluish clayey sand with many large bivalves and an upper unit of 4 feet of sandy clay; sample B-1 is from 3 feet up in the lower unit, and sample B-2 is from 2 feet up in the upper unit.

3. Bluff on the south side of Meherrin River, 7.5 miles upstream from the Seaboard Air Line Railroad Bridge between Boykins, Va., and Severn, Northampton County, N.C.; 4 feet of bluish clayey sand are exposed at the base of the bluff, and are richly fossiliferous, es-
especially with *Pecten* and *Glycymeris*; sampled 2 feet above the base of section.

4. One mile upstream from the bridge mentioned in the preceding paragraph, sampled in the same unit, 3 feet from the base of the section.

5. (Gibson's samples L-1, L-2.) Just below the outlet of City Pond in a small stream cut on the southwest side of Petersburg, Dinwiddie County, Va.; 20 feet of beds are exposed with the lower 15 feet being bluish-gray sandy clay which contains only a few scattered fossils and the upper 5 feet being bluish clayey sand with a great number of *Mercenaria* and *Turritella*; sample L-1 was taken 2 feet from the top of the lower unit and sample L-2 from 6 inches above the base of the upper unit.

6. (Gibson's samples M-1 to M-3.) Bluff 200 yards upstream from the mouth of Sunken Marsh Creek on the south bank of James River, Surry County, Va.; may include upper St. Marys Formation in lower part of exposure.

7. (Gibson's samples N-1, N-2.) Bluff at Mount Pleasant Plantation on south bank of James River, Surry County, Va.; section is composed of a lower 15-foot unit of bluish-gray clayey sand with scattered fossils and an upper 20-foot unit of yellow sand with extremely abundant fossils; sample N-1 is from 6 feet up in the lower unit and N-2 is from 10 feet up in the upper unit; may include upper St. Marys Formation in lower part of exposure.

8. (Gibson's sample T-1.) Small bluff 0.5 of a mile downstream from the Fishery Building at Urbanna, Middlesex County, Va.; approximately 2 feet of very coarse yellow sand are exposed at the base of the bluff; megafossils are abundant, with *Pecten* and *Chama* being the most common genera; the sample was taken 1 foot above the beach.

9. (Gibson's sample U-1.) Small bluff 0.5 of a mile upstream from Punchbowl on the south shore of Rappahannock River, Essex County, Va.; 1.5 feet of coarse bluish sand is exposed at the base of the bluff, with the sample being taken 1 foot above the beach; megafossils are abundant with *Pecten*, *Vermetus*, and *Ostrea* the most common; possibly represents upper part of St. Marys Formation rather than lower Yorktown.

10. (Gibson's sample V-1.) Small bluff 1.5 miles below Bowlers wharf on the south bank of Rappahannock River, Essex County, Va.; 6 feet of bluish clay are exposed, with mega-

fossils fairly abundant, particularly *Mulinia*, *Andara*, and *Mercenaria*; sample V-1 was taken 3 feet from the base of the section; possibly represents upper part of St. Marys Formation, rather than lower Yorktown.

11. (Gibson's sample Z.) Cut on the east side of U.S. Highway 301, about 200 yards south of the bridge over Chickahominy River, Hanover County, Va.; about 10 feet of bluish clayey sand are exposed, with the lower half containing mostly *Turritella*, together with *Mulinia* and *Dentalium*, and the upper half being barren of megafauna; sample Z was taken 2 feet above the base of the section.

The only species of Ostracoda of the present or previously recorded collections that are restricted to the lower Yorktown or possibly to the uppermost St. Marys in Essex, Hanover, and Surry Counties, Va. are: *Aglaocypris* sp. and *Cytheridea* sp. A. The latter may also occur in Oligocene deposits in the Hatteras Light 1, Dare County, N.C., 1,620–1,630 feet (Swain, 1952, p. 20) where it was recorded as *Haplocytheridea* sp. aff. *H. israelskyi* Stephenson, 1944.

The following Ostracoda were recorded by Ulrich and Bassler (1904) from the Chesapeake Group (mainly Yorktown Formation) at Yorktown and James River, Va.: *Cythere burnsi* Ulrich and Bassler, 1904; *Cythere clarkana* Ulrich and Bassler, 1904; *C. clarkana miniscula* Ulrich and Bassler, 1904; *Cythere martini* Ulrich and Bassler, 1904; *Cythere micula* Ulrich and Bassler, 1904; *Cythere planibasilis* Ulrich and Bassler, 1904; *Cythere plebeia* Ulrich and Bassler, 1904; *Cythere porcella* Ulrich and Bassler, 1904; *Cythere rugipunctata* Ulrich and Bassler, 1904 (types from James River); *Cythere tuomeyi* Ulrich and Bassler, 1904; *Cythere vaughani* Ulrich and Bassler, 1904; (types from James River); *Cythere alaris* Ulrich and Bassler, 1904 (types from James River); *Cythere cornuta americana* Ulrich and Bassler, 1904; *Cytherideis ashernani* Ulrich and Bassler, 1904; and *Cythereopteron nodosum* Ulrich and Bassler, 1904; (types from James River). Of these species (with modern generic assignments given), *Cytheretta burnsi* (Ulrich and Bassler, 1904), *Echinocytheris? clarkana* (Ulrich and Bassler, 1904), *Actinoocythereis exanthemata* (Ulrich and Bassler, 1904), and *Haplocytheridea israelskyi* Stephenson, 1944.
OSTRACODA OF THE YORKTOWN FORMATION

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1904), Muellerina micula (Ulrich and Bassler, 1904), Cytheretta porcella (Ulrich and Bassler, 1904), Purina rugipunctata (Ulrich and Bassler, 1904), Orionina vauhanni (Ulrich and Bassler, 1904), Pterygoocythereis americana (Ulrich and Bassler, 1904), Pantocythere ashormani (Ulrich and Bassler, 1904), and Paracythereidae altila Edwards, 1904 (=Cythereopteron nodosum) Ulrich and Bassler, 1904 occur in the Yorktown Formation in the present collections. Furthermore, among the species that she obtained from the Yorktown; the other six species are: Cushmanidea echolae (Malkin, 1953); Pantocythere ashermani (Ulrich and Bassler, 1904), and Paracythereidae altila Edwards, 1904 (=Cythereopteron nodosum) Ulrich and Bassler, 1904), however, in the pres­

tent collections have been found only in pre­

Yorktown Miocene deposits. Furthermore, among the species that she obtained from the Yorktown Formation, Malkin (1953) did not record H. evax.

Malkin recorded 29 species of Ostracoda from the Yorktown Formation near York­

town and Grove, Va. Twenty-three of these were found in the present collections from the Yorktown; the other six species are: Cushmanidea echolae (Malkin, 1953); Pantocythere subaequalis ulrichi (Howe and Johnson, 1935); Clithroocythereidae virginiensis (Malkin, 1953); Anomocythereidae floridana (Howe and Hough, 1935); Shattuckocythere shattucki (Malkin, 1953) subsp.; and Cytherura wardensis Howe and Brown, 1935. Malkin also recorded Bairdia spp. from the Yorktown.

McLean (1957) obtained species of Ostra­

coda from the Yorktown Formation of the York­

James Peninsula, Va. Eighteen of the species occur in the present collections from the Yorktown. The other six species found by McLean are: Paracypris choctawhatcheensis Puri, 1954; Cythereopteron talquinensis Puri, 1954; Cytherura lumbetonensis Edwards, 1944; Clithroocythereidae virginiensis Malkin, 1953; Eucythere sp.; and Cushmanidea echolae (Malkin, 1953). Among the recorded Yorktown species and subspecies of Ulrich and Bassler (1904), Cythere clarkana minis­

cula Ulrich and Bassler, 1904 is considered by the writer to represent immature molts based on a study of cotypes 35414 from the Calvert Formation at Plum Point, Md., housed in the National Museum. They are apparently molts of Echinocythereis? clar­
kana (Ulrich and Bassler, 1904). “Cyhere martini” Ulrich and Bassler, 1904 as used by authors in recent years, as discussed by Hazel (1967) is for the most part, not congeneric with the types of martini but belong to Muellerina Bassiouni (1965) or a related genus of the Hemicythereidae rather than to the Trachyleberidae to which martini should be referred. The “Cythere martini” of the York­
town Formation should, the present writer believes, be referred to Muellerina micula (Ulrich and Bassler, 1904), rather than to the species “Cythere lienenklausi” Ulrich and Bassler, 1904, as recommended by Hazel (1967). The type of C. lienenklausi in the U.S. National Museum is too badly broken for one to be sure of its characteristics and the reference of Recent North Atlantic speci­

mens to that species (Hazel, 1967) is doubtful.

Cythere plebeia (Ulrich and Bassler, 1904) of the Yorktown is here included with Cytheretta porcella (Ulrich and Bassler, 1904) as a junior objective synonym. Cythereis alaris (Ulrich and Bassler, 1904) of the Yorktown is an immature molt of Pterygo­
cythereis americana (Ulrich and Bassler, 1904) (Pooser, 1965).

The total number of ostracode species re­
corded herein from the Yorktown Formation is 75 of which 63 were found in the present collections and 12 others were obtained by Malkin (1953) and McLean (1957). Hazel (1971) states that 230 species of Ostracoda occur in the Yorktown Formation as delineated by him.

An important group of species in the pre­

cent collection deserve mention as not being known to occur in pre-Yorktown or pre­

Duplin Miocene deposits in the area studied; these are: Aglaiocypris sp.; Aurila conradi (Howe and McGuirt, 1935); Bairdopilata triangulata Edwards, 1944; Proteoconcha gigantica (Edwards, 1944); Campylocythere laeva Edwards, 1944; Campylocythere laeva posteropunctata Edwards, 1944; Acuticythereis laevisissima punctata (Edwards, 1944); Proteoconcha multipunctata (Edwards, 1944); Campylocythere sp.; Caudites sp.; Caudites sellardsi (Howe and Neill, 1935); Caudites choctawhatcheensis Puri, 1954; Costa barclayi (McLean, 1957); Cytherelloidea umbonata Edwards, 1944; Cytheridea sp. B.; Cytheridea muelleri (Mün­
OSTRACODA OF THE DULPIN MARL

The ostracode species obtained from the Dulpin Marl in the collections studied are listed in table 1. The Dulpin localities sampled by Thomas Gibson are as follows:

1. Marl pit on the Barwick Farm, southwest of Kenansville, Duplin County, N.C.; 4 feet of yellow clayey sand are exposed, the sample being taken 3 feet above the base of the section; megafossils are abundant at this locality.

2. Natural Well, 2 miles west of Magnolia, Duplin County, N.C.; 4 feet of bluish clayey sand are exposed; the sample was taken 3 feet above the base of the section; megafossils are fairly abundant.

3. A small bluff on the northern bank of Lumber River about 1.5 miles southeast of Lumberton, Robeson County, N.C.; 100 yards upstream from the point where Highway 74 crosses the river; 10 feet of yellow clayey sand are exposed; megafossils are abundant, with *Glycymeris* being the most numerous form; sample was taken 8 feet above the base of the section.

4. A small marl pit on the Duvar Farm 1 mile east of Tar Heel, Robeson County, N.C.; 3 feet of yellow clayey sand are exposed, and the sample was taken in the upper foot; megafossils are fairly abundant, with *Mulinia* being the most numerous form.

5. A small roadcut on the O. H. Allen farm, 0.5 of a mile east of Tar Heel, Robeson County, N.C.; 4 feet of yellow coarse sand are exposed, with the sample being taken 3 feet above the base of the section. *Glycymeris* is the most abundant megafossil.

6. Walkers Bluff on the southern bank of Cape Fear River, 9 miles below Elizabethtown, Bladen County, N.C.; 5 feet of beds are exposed; the lowermost 2 feet are composed of yellow sand with much shell hash; sample 6–1 is from 1 foot above base of section, and 6–2 is from 4 feet above the base.

The Dulpin Ostracoda are for the most part represented also in the Yorktown Formation, but the following Dulpin species were not found in the Yorktown in this collection: *Haplocytheridea bradyi* (Stephenson, 1938), *Proteoconcha gigantica* (Edwards, 1944), *Caudites choctawatcheensis* (Puri, 1954), *C. sellardsi* (Howe and Neill, 1935), *C. sp.* *Cushmanidea agricola* (Howe and Hough, 1935), *Proteoconcha multipunctata* (Edwards, 1944), *Cytherelloidea umbonata* (Edwards, 1944), *Cytheromorpha curta* Edwards, 1944, *Paracytheridea mucra* Edwards, 1944, and *Xestoleberis? ventrostriata* Swain, 1952.

Edwards (1944) described 35 species and four subspecies from the Dulpin Marl of North Carolina of which 29 species and three subspecies were new. The previously described species and subspecies are *Anomocytheridea floridana* Howe and Hough, 1935, *Pontocythere ashermani* Ulrich and Bassler, 1904, *Aurila conradi* (Howe and McGuirt, 1935), *Actinocythereis exanthemata gomillionensis* (Howe and Ellis, 1935), *Orionina vaughani* (Ulrich and Bassler, 1904), *Puriana rugipunctata* (Ulrich and Bassler, 1904), and *Cytherura wardensis* Howe and Brown, 1935. Subsequently, most of the Dulpin species have been found in the Yorktown, except those listed in the preceding paragraph.

Several species recorded from the Yorktown have not been found in the Dulpin. *Prodictyocythere trapezoidalis* n. gen., n. sp.; *Aglaiocypris* sp.; *Cushmanidea ulrichi* (Howe and Johnson, 1935); *C. fabula* (Howe and Dohm, 1935); *Cytherella burnsi* (Ulrich and Bassler, 1904); *Cytherella porcella* (Ulrich and Bassler, 1904); *Cytheridea* sp. B.; *C. muelleri* (Münster, 1830) subsp.; *C. sp. A.; Leptocythere paracastanea* Swain, 1955;
Cythereopteron subreticulatum van den Bold, 1946; Loxoconcha sp.; Shattuckocythere similis (Malkin, 1953); Luvula? sp.; Murrayina maculata, n. sp.; Neocytherideis sp.; Paradozoaella robusta Puri, 1954; Pontocythere agricola dupunctata, n. subsp.; Pterygocythereis americana (Ulrich and Bassler, 1904); Thaerocythere schmidtae (Malkin, 1953); and T. sp.

Pooser (1965), however, obtained Pterygocythereis americana from the Duplin Marl of South Carolina. He also recorded five other species from the Duplin, including the following forms that were not recorded from the Duplin by Edwards (1944) or in the present paper: Munseyella subminuta (Puri, 1954); Cytherura johnsoni Mincher, 1941; Cytherelloidea leonensis Howe; Haplocytheridea bassleri Stephenson, 1943; and Protocytheretta karlana (Howe and Pyeatt, 1935).

**UPPER MIocene OSTRACOA FROM WELLS IN THE ATLANTIC COASTAL PLAIN**

The presumed upper Miocene Ostracoda from several wells in the Atlantic Coastal Plain of eastern North Carolina recorded by Swain (1952) represented 42 species. Of those species only Basselerites cf. *B. miocenicus* Howe, 1935, is not represented in the surface upper Miocene deposits discussed above.

In a discussion of subsurface stratigraphy of the North Carolina coastal plain, Brown (1958) listed 25 species of upper Miocene Ostracoda all but one of which had been found previously in outcrops or wells in the upper Miocene. The one species is *Henry­howellae evax* (Ulrich and Bassler, 1904) which the present writer considers as being restricted to pre-upper Miocene deposits of the Atlantic coastal area.

Hall (1965) has recently studied reworked upper Miocene Ostracoda from cores in the Pleistocene and Holocene on Sapelo Island, Ga. Twenty-one of the species he identified were considered to be restricted to the upper Miocene and younger. The ranges of some of the species cited by Hall differ from those found by the present writer in the coastal plain farther north, and additional study in the intervening area is necessary to verify the true ranges of these forms.

**SUMMARY OF OSTRACODA DISTRIBUTION IN UPPER MIocene AND Pliocene OF ATLANTIC COASTAL PLAIN BASED ON COLLECTIONS STUDIED HEREIN**

Most of the abundant upper Miocene ostracode species of the Atlantic Coastal Plain also range into younger deposits. The Pliocene Waccamaw Formation of North and South Carolina contains many ostracode species in common with the Duplin and Yorktown Formations (Swain, 1968). Some geologists have suggested that the Duplin and Yorktown may be in part Pliocene based on the modern aspect of their faunas compared with those of the underlying St. Marys, Choptank, and Calvert Formations (Hazel, 1971). The Pleistocene of the Atlantic coastal region is relatively scarce in Ostracoda, but the Holocene contains a relatively large fauna on the continental shelf and in some of the more southerly bays.

As stated above, about 47 species of subspecies of ostracodes that occur in the Yorktown or Duplin Formations or in younger deposits are not known to be present in pre-upper Miocene rocks. The upper Miocene and Pliocene of the area studied are represented by the *Aurila conradi–Thaerocythere schmidtae* assemblage. Radimella confragosa (Edwards, 1944) is abundant in the upper Miocene Duplin Marl and Pliocene Waccamaw Formation of southern North Carolina and northern South Carolina, but is uncommon in the Yorktown Formation. It is selected to represent the *Radimella confragosa* sub­ assemblage of the *A. conradi–T. schmidtae* assemblage that characterizes the uppermost Miocene and Pliocene in southern North Carolina and northern South Carolina. Van den Bold (1966) also recognized the stratigraphic usefulness of *R. confragosa* in the uppermost Miocene. *Thaerocythere schmidtae* (Malkin, 1953) on the other hand is rare or absent in the Duplin Marl and Waccamaw Formation, but is relatively abundant in the Yorktown Formation of northern North Carolina, Virginia, and Maryland (that is, the southern Virginian province of Dana, 1853). *Thaerocythere schmidtae* thus characterizes the upper Miocene of the northern part of the area discussed, that is northern North Carolina, Virginia, and southernmost Maryland. This presumably represents a cooler water subassemblage of the upper Miocene than does *R. confragosa* subassemblage. At present *Thaerocythere* (that is, *T. crenulata* (Sars, 1866)) is found in the North Atlantic region (Hazel, 1967) while *R. confragosa* is living in the Gulf of Mexico (Puri, 1960). The upper Miocene ostracodes are marine and generally represent an open shelf sub littoral environment. Some of the forms, such as *Cytheromorpha warneri* Howe and Spurgeon, 1935, and *C. curta* Edwards, 1944, and *Leptocythere para­ castanea* Swain, 1955, may indicate local lagoonal or estuarine conditions.

The middle Miocene, underlying the Yorktown
and Duplin Formations in the area studied is represented by an assemblage of *Murrayina gunteri* (Howe and Chambers, 1935); *M. howei* Puri, 1954; *Cytheretta spencerensis* Smith, 1941; *C. inaequivalvis* (Ulrich and Bassler, 1904) and other species. The middle Miocene assemblage consists of marine species that mostly suggest an open shelf sublittoral environment.

Valentine (1971) has recently recorded an upper Pleistocene (Sangamon) ostracode assemblage of 82 species from the Norfolk Formation as used by Oaks and Coch (1963) of southeastern Virginia. He finds that 70 of the species are still living. When the Norfolk assemblage is compared with present day ostracode assemblages from the continental shelf, none of the modern assemblages is comparable to that of the Norfolk Formation. The latter contains some species that today are found only north or south of Cape Hatteras. When compared to the distribution of modern forms it appears that the late Pleistocene assemblage lived in waters that were warmer and more equable than now prevail off southeastern Virginia.

The living ostracodes of bays and estuaries in North Carolina and Georgia include upper Miocene species that seem to represent a warm-water assemblage of Floridian and Carolinian origins (Darby, 1965; Grossman and Benson, 1967). The living ostracodes of Chesapeake Bay, however, include species that have not been found in the fossil assemblages, that is, *Cytheridea papillosa* Bosquet, 1852 (auct.); *Heterocythereis alboconica* (Baird, 1838), (auct.); and *Hemicythere strandentia* Tressler and Smith, 1948, (Tressler and Smith, 1948). The ostracodes recorded by Hulings (1966) from the Atlantic continental shelf off Virginia also are mainly represented by North Atlantic forms. In a recent study of western Atlantic ostracodes, Hazel (1970) found distinctive differences in the ostracode assemblages in the region from Nova Scotia to Long Island. About 50 percent of the species are of European occurrence, but less than 25 percent of species from the Virginian mild-temperate province are known to have reached European waters. The comparative sparsity of amphiatlantic species passing Cape Cod from the north as compared to endemic thermophilic species passing the Cape from the south is interpreted by Hazel as caused by seasonal isothermal variations.

Hazel (1971) has proposed a zonation of the Yorktown Formation of Virginia and North Carolina based on ostracodes, and utilizing binary similarity coefficients and cluster analysis to establish his zones. Without going into a discussion of the method itself, comments herein are restricted to the data used to establish the zonation.

A critical locality in Hazel’s study is that of the Texas Gulf Sulphur Co. open-pit phosphate mine at the mouth of Lees Creek near Aurora, N.C. Hazel states (1971, p. 7) that the lowest of his three ostracode zones, the *Pterygoocythereis inexpectata* Zone, occupies the lower 10 feet of sands, phosphate pebbles, and quartz pebbles overlying the phosphatic sands and diatomaceous clays of the middle Miocene Pungo River Formation. The upper Pungo River here contains an abundant microfauna of middle Miocene ostracodes in collections obtained by the writer and by P. M. Brown and James Miller. In collections of the lower Yorktown, in which reworked phosphatic pebbles and nodules are common, there are also abundant middle Miocene ostracodes, which the writer also interprets as reworked, together with Yorktown species of ostracodes. The middle Miocene forms include *Murrayina gunteri* (Howe and Chambers, 1935); *M. howei* Puri, 1954; *Cytheretta spencerensis* Smith, 1941 and other forms. The upper Miocene species represented in the lower part of the Yorktown here include *Aurila coronata* (Howe and McGurk, 1935); and *Radimella confragosa* (Edwards, 1944). The presence of *R. confragosa* here suggests that the oldest Yorktown beds in the Lees Creek pit may represent middle or upper parts of the formation in the other sections studied, as this species is most common in upper Yorktown-age deposits elsewhere. Thus the numerous species which Hazel (1971, table 1) records from the Yorktown Formation in the Lees Creek pit (his samples 2–5) are thought by the present writer to include many forms that have been reworked from the middle Miocene. Because he lists a great many of his species with open nomenclature, it is not possible to decide which ones are of middle Miocene affinity. In the present writer’s collection, the Pungo River species are mainly those that occur in the Calvert, Choptank, and St. Marys Formation of the Chesapeake Bay region. Although many of the forms range into the overlying Yorktown Formation, certain ones, including those mentioned above do not occur in the Yorktown, and several of the Yorktown species do not range down into the pre-Yorktown deposits.

One of the species used by Hazel in establishing his second Yorktown zone is *Orionina vaughani*, a form that the present writer considers to be long-ranging in the lower, middle, and upper Miocene and to be unsuitable to serve as a zone indicator within
the Miocene. Similarly, the species indicator of his lower zone, *Pterygoocythereis inexpectata* is recorded as living in the Atlantic Ocean and does not appear to be useful to establish an early upper Miocene zone. The records of this species in the Lees Creek pit, the writer furthermore believes, may be based on specimens reworked from the middle Miocene.

As an example of the problems that may arise from local reworking of older microfaunas into younger beds, one may refer to the recognition by Hazel himself (1971, p. 7) that such reworking at Yadkin, Va. has brought together in the same bed younger beds, one may refer to the recognition by of the Duplin, but it does contain many upper Miocene fossils. Evidence has yet been cited for the post-Miocene age of the containing deposits. No definitive rock, the writer furthermore believes, may be based on specimens reworked from the middle Miocene.

**SYSTEMATIC DESCRIPTIONS**

**Family PARACYPRIDIDAE** Sars, 1923

**Genus AGLAIOCYPRIS** Sylvester-Bradley, 1947


See Moore and others (1961, p. 245) for diagnosis of the shell of the genus. Type species, *Aglaia pulchella* Brady, 1868. Geologic range, Miocene to Holocene.

*Aglaioocypris* sp.

Plate 1, figure 2

Shell elongate-subelliptical in side view, highest medially; dorsal margin gently convex; ventral margin nearly straight to slightly convex; terminal margins nearly equally rounded, the anterior slightly the narrower. Valves moderately convex, the left slightly the larger; surface smooth. Hinge of right valve consists of narrowed valve edge. Inner lamellae of moderate width and with broad vestibules terminally; radial canals few or absent; adductor muscle scar a median compact group of four or five spots.

Length of figured right valve specimen 0.88 mm., height 0.38 mm., convexity 0.18 mm.

*Relationships.*—The elongate-subelliptical outline, hingement and other internal shell structures relate this species to *Aglaiocypris*. The present species is more elongate than living form *A. pulchella* (Brady, 1868), the type species, and has a less convex dor­sum than *A. complanata* Brady and Robertson, both from the North Atlantic and a less concave venter than *A. virgenensis* Swain, 1967 from the Gulf of California.

*Occurrence.*—The species is rare in the lower part of the Yorktown Formation, locality U–1, Essex County, Va.

*Number of specimens studied.*—Two.

*Ecology.*—Only a few species are associated with *A. sp.* and they suggest a sublittoral marine environment.

*Zoogeographic derivation.*—*Aglaiocypris* is of North Atlantic origin and the present species possibly originated in the western North Atlantic region off eastern North America, in the Virginian, Nova Scotian, or Arctic Faunal Provinces.

*Figured specimen.*—USNM 179512.

**Family PONTOCYPRIDIDAE** Muller, 1894

**Genus PROPONTOCYPRIS** Sylvester-Bradley, 1947


The shell of the genus was described by Sylvester-Bradley (1947) and was summarized by Moore and others (1961, p. 247). Type species, *Pontocypris trigonella* Sars, 1866. Geologic range, Miocene to Holocene.

*Propontocypris howei* (Puri)

Plate 1, figures 3, 15

*Bythocypris howei* Puri, 1954, Florida Geol. Survey Bull. 36, p. 226, pl. 1, figs. 14–16, text figs. 2e–g.

*Propontocypris howei* (Puri), Hulings, 1966, Chesapeake Sci., v. 7, p. 46, figs. 1a–c, 6a.

*Occurrence.*—The species was obtained from the lower and middle parts of the Yorktown Formation, upper Miocene, in the present collection.1 Puri (1954) described it from the *Area*, *Ephora*, and *Cancellaria* facies of the Choctawhatchee Formation (of former usage) upper Miocene. Hulings recorded the species 1Detailed lists of occurrences not presented herein are available in open­file reports of the Geological Survey.
living in the Atlantic Ocean off the Virginia coast, and by means of a study of the appendages was able to demonstrate a closer affiliation for *Propontocypris* Sylvester-Bradley than for *Bythocypris* Brady.

**Number of specimens studied.**—Four.

**Ecology.**—The species occupied, in Miocene time, an open marine shelf at neritic depths judging from living occurrences.

**Zoogeographic derivation.**—This group of Ostracoda seems to have originated in the Boreal or Arctic Faunal Provinces of the North Atlantic area.

**Figured specimen.**—USNM 179513.

**Family BAIRDIIDAE Sars, 1888**

**Genus BAIRDOPPILATA Coryell, Sample, and Jennings, 1935**


See Moore and others (1961, p. 205) for diagnosis of the shell. The shell and appendages of the genus were discussed recently by Maddocks (1969) who has extended its range to the Holocene Epoch. Type species, *B. martyni*, Coryell, Sample, and Jennings (1935). Geologic range, Lower Cretaceous to Holocene.

**Bairdoppilata triangulata Edwards**

Plate 1, figure 1

*Bairdoppilata triangulata* Edwards, 1944, Jour. Paleontology, v. 18, p. 507, pl. 85, figs. 5, 6; Puri, 1954, Florida Geol. Survey Bull. 36, p. 223, pl. 1, figs. 3, 4; text figs. 1a, b; Swain, 1968, U.S. Geol. Survey Prof. Paper 573-D, p. 6, pl. 1, figs. 2a, b, text figs. 2, 3; Benson and Coleman, 1963, Kansas Univ. Paleont. Contr., Arthropoda, Art. 2, p. 20, pl. 3, figs. 1–3, text fig. 9.

**Occurrence.**—In the Atlantic Coastal region the species has been found from the middle Yorktown Formation (upper Miocene) to the Waccamaw Formation (Pliocene, Swain, 1968; Hazel, 1971), and in the eastern Gulf of Mexico region it occurs in the eastern Gulf of Mexico-southeastern United States area, that is in the Caribbean or Carolinian Faunal Provinces.

**Figured specimen.**—USNM 179514.

**Family CYTHERIDEIDAE Sars, 1925**

**Subfamily CYTHERIDEINAE Sars, 1925**

**Genus HAPLOCYTHERIDEA Stephenson, 1936**


*Phraectocytheridea* Sutton and Williams, 1939, Jour. Paleontology, v. 13, p. 571. [Considered a valid genus by Hazel, 1968.]

A diagnosis of the shell of the genus is provided in Moore and others (1967, p. 276) and the possible distinction between *Haplocytheridea* and *Phraectocytheridea* is given by Hazel (1968, p. 131). The latter probably should be a subgenus of *Haplocytheridea* because of their similarity in hingement. Type species, *Cytheridea montgomeryensis* Howe and Chambers, 1935. Geologic range, Upper Cretaceous to Holocene.

**Haplocytheridea setipunctata (Brady)**

Plate 9, figure 16

*Cytheridea setipunctata* Brady, 1869, Les Fonds de la Mer, v. 1, p. 124, pl. 14, figs. 15, 16.

*Cytheridea* (Haplocytheridea) *ponderosa* Stephenson, 1938, Jour. Paleontology, v. 12, p. 133, pl. 23, fig. 10; pl. 24, figs. 1, 2.


*Cyprideis floridana* Puri, 1960, Gulf Coast Assoc. Geol. Socs. Trans., v. 10, p. 100, pl. 2, fig. 5; text figs. 1–3 [not *Cytheridea floridana* Howe and Hough, 1935].

*Haplocytheridea bassleri* Stephenson. Swain, 1955 [part], Jour Paleontology, v. 29, p. 617, pl. 59, fig. 9a [not fig. 9b = *Cyprideis ovata* (Mincher), fide Sandberg, 1964]. See Sandberg, 1964, Micropaleontology, v. 10, p. 361, for other questionable references to this species.


*Cytheridea puncticillata* Brady, Tressler and Smith, 1948, [part], Chesapeake Biol. Lab. pub., v. 71, pl. 1, fig. 2 [fide Sandberg, 1964].

SYSTEMATIC DESCRIPTIONS

Haplocytheridea bradyi

The species occurs in the lower Yorktown Formation at locality 3, as well as in the underlying Miocene formations of the area. It has previously been found throughout the Miocene of the Atlantic Coastal Plain, in the Pliocene Waccamaw Formation, and in the Holocene of Chesapeake Bay and the Gulf of Mexico region.

Number of specimens studied.—25+.

Ecology.—The species lives at present in lagoonal and near-shore sublittoral typically euryhaline but perhaps also oligohaline environments.

Zoogeographic derivation.—Its known occurrences indicate that the species originated in the Caribbean or Carolinian Faunal Provinces and has remained relatively restricted in distribution since early Miocene time.

Figured specimen.—USNM 179515.

Haplocytheridea sp. aff. H. israelskyi (Stephenson)

Plate 1, figures 6-8

Cytheridea characterized by elongate-subovate outline, blunt ends in edge view; surface with large pits and intervening ridges, arranged concentrically on marginal third of surface, but not medially.

The shell of this species was described previously (Swain, 1952) but was not given definite assignment. It now appears that the elongate-subovate outline, blunt ends in edge view, and “entomodont” hinge ally the species more with Cytheridea than with Haplocytheridea.

Length of figured specimen 0.80 mm., height 0.44 mm., convexity 0.36 mm. (pl. 1, figs. 6-8).

Occurrence.—The species occurs in the lower
Yorktown Formation, at Madry's Bluff (localities A-1 and A-6), Hertford County, N.C. It was also recorded previously from the upper Miocene at Washington, N.C., and questionably from the Oligocene in a well located at Cape Hatteras, N.C. (Swain, 1952).

**Number of specimens studied.**—Two.

**Ecology.**—The species probably represents a marine shelf environment. This is indicated from species with which it is associated, such as *Thaerocythere schmittdae* (Malkin, 1953).

**Zoogeographic derivation.**—*Cytheridea* of this general type occurred in Western Europe and the Mediterranean region in earlier Tertiary times and are suggested as having migrated to the western North Atlantic in the middle Tertiary.

**Figured specimens.**—USNM 179522, 179523.

*Cytheridea muelleri* subsp.

*Plate 1, figure 5*

Shell subovate in side view, highest anteromedially; dorsal margin moderately convex; ventral margin slightly sinuous, with posteromedian weak concavity; anterior margin broadly curved with four or five small spines ventrally; posterior margin more curved, strongly extended below and with one ventroterminal small spine on right valve and two or three small ventral spines on left valve. Left valve slightly larger than right, overlapping and extending beyond right along dorsal slope and part of terminal and ventral regions; valves moderately convex with convexity extending toward ends and providing a blunt-ended aspect to shell, greatest convexity submedian. Valves ornamented by numerous rather large pits, the interspaces vary from equal to two times diameter of pits; in ventral and terminal areas, pits are roughly arranged in curving rows parallel to valve margins and there is a slight tendency for pits to occupy weak concentric furrows ventrally and anteriorly in right valve.

Hinge heteromerodont, that of right valve consists of terminal elongate crenulate teeth, having about eight crenulae on the anterior and seven on the posterior element, and an interterminal more finely crenulate element that changes from a furrow anteriorly to a low ridge posteriorly and is slightly longer than terminal tooth; hinge of left valve the antithesis of right. Inner lamellae rather narrow, broadest anteriorly; vestibules narrow; radial canals short, numerous, and apparently simple. Adductor muscle scar an anteromedian slightly curved, subvertical row of four closely spaced spots and two additional more anterior spots both U-shaped, open dorsally, the upper of which is larger.

Length of figured specimen 0.83 mm, height 0.47 mm, convexity 0.42 mm.

**Relationships.**—The general shape, ornamentation, and internal shell structures of this subspecies are closely similar to those of *C. muelleri* (Münster, 1830) from the upper Oligocene ( Chattian) of Europe. The present subspecies is less elongate and has wider surface interspaces than is typical of *C. muelleri* s. s.

**Occurrence.**—Yorktown Formation, middle part, locality C-1, Nansemond County, Va.

**Number of specimens studied.**—Two.

**Ecology.**—The habitat of the subspecies is believed by the author to have been an open marine shelf in sublittoral to neritic depths.

**Zoogeographic derivation.**—The forms of this type are believed by the writer to have originated in the Mediterranean or eastern North Atlantic region in Paleogene time and to have migrated to the western North Atlantic in the Neogene.

**Figured specimens.**—USNM 179524.

*Cytheridea* sp. B

*Plate 1, figures 4, 11, 12*

*Cytheridea* is characterized by fine punctuation of surface, the punctae averaging 0.025 mm in diameter with interspaces ranging from two to three times diameter of pits; outline elliptical-subovate.

Shell elongate, subelliptical-subovate in side view, highest about one-fourth from anterior end; dorsal margin nearly straight, slightly more convex in right than in left valve; ventral margin slightly concave medially; anterior margin broadly curved, slightly extended below and with five to six small spines ventrally; posterior margin more narrowly curved, also slightly extended below and with small posteroventral spines in right valve. Valves not strongly convex, greatest convexity median; left valve slightly larger than right. Valve surface of illustrated specimen somewhat worn, but bears numerous medium-sized pits, averaging 0.025 mm in diameter and variably spaced; the interstices range from the same as to more than three times the diameter of the pits.

Hinge heteromerodont, that of right valve consists of anterior elongate hinge element having about eight denticles, a posterior element also containing seven or eight denticles, and an interterminal structure that consists of a shallow crenulate groove anteriorly which passes posteriorly into a low crenulate bar; interterminal structure is somewhat longer...
than either of the terminal teeth; hinge of left valve is the antithesis of that of right valve. Inner lamellae of moderate width, broadest anteriorly and with narrow vestibules terminally; radial canals numerous and simple; adductor muscle scar is an anteromedian subvertical row of four small spots, and there are two, more anterior, large spots, the upper spot is crescentic and points dorsally, the lower spot is elongate.

Length of figured specimen 0.87 mm, height 0.45 mm, convexity 0.37 mm.

Relationships.—This species is similar in shape to C. pernota Oertli and Key, 1955 from the Chattian and Rupelian Stages (Upper Oligocene) of Europe, but that form is more coarsely punctate than the present species. Clithrocytheridea virginensis Malkin, 1953 is similar in shape and ornamentation but as described by Malkin (1953) has an interterminal groove in hinge of right valve typical of Clithrocytheridea rather than the combined right valve groove passing posteriorly into a bar as in the present species and in Cytheridea.

Occurrence.—The species is rare in the middle part of the Yorktown Formation, locality C-1, Nansemond County, Va.

Number of specimens studied.—Two.

Ecology.—The species probably represents a neritic or sublittoral shallow open-shelf environment.

Zoogeographic derivation.—This group of species, including that referred to from the Chattian and Rupelian Stages of Europe are believed by the writer to have originated in western Europe in the Paleogene and to have migrated to North America in the Neogene.

Figured specimen.—USNM 179525.

Subfamily EUCYTHERINAE Puri, 1954

Genus EUCYTHERE Brady, 1868

Cytherops Sars, 1866, Oversigt af Norges Marine Ostracoder, p. 57 [non M'Coy, 1849].


Eucythere triangulata Puri

Plate 1, figure 16


Occurrence.—Rare in middle part of Yorktown Formation, locality D-1, Suffolk, Nansemond County, Va. The species was described from the Arca and Ecphora facies of the Choctawhatchee Formation (of former usage) of Florida (Puri, 1954); it has also been recorded from the Holocene of Georgia (Hall, 1965).

Number of specimens studied.—Two.

Ecology.—The species is associated at locality D-1 with numerous other forms that, judging from living representatives, are now found on the open continental Atlantic shelf off the Middle Atlantic States in the neritic and sublittoral environment.

Zoogeographic derivation.—The origin of this species is not known. Close relatives occur in the North Atlantic, Mediterranean, and Gulf of Mexico-Caribbean region at the present time and fossil representatives are present in the Late Cretaceous and early and late Tertiary of the Gulf of Mexico region and the Atlantic Coastal Plain, and in the Jurassic, Cretaceous, and Tertiary of Europe.

Figured specimen.—USNM 179526.

Subfamily NEOCYTHERIDEIDINAE Puri, 1957

Genus CUSHMANIDEA Blake, 1933

Cytheridea Auctorum, not Jones, 1856, Forbes' Tert. Fluv.-Mar. Fm. Isle of Wight, Great Britain Geol. Survey Mem., 157 [= Cypridea Bosquet].

Cushmanidea Blake, 1933, in W. Procter, 1933, Biological Survey of the Mount Desert region, pt. 5, p. 232.


A diagnosis of the genus was given by Moore and others (1961, p. 290). Type species, Cytheridea seminuda Cushman, 1906. Geologic range, Eocene to Holocene.

Cushmanidea fabula (Howe and Dohm)

Plate 1, figure 20; plate 8, figures 4a, b


Occurrence.—In the present collection the species was obtained from the lower Yorktown Formation, locality N-1, Surry County, Va. It was described from the Arca Zone of the Choctawhatchee Formation (of former usage) of Florida (Howe and others, 1935), and was also recorded from the Chipola Formation and Oak Grove member of the Shoal River
Formation of Florida (Puri, 1954). Its range is interpreted as lower to upper Miocene.

Number of specimens studied.—Two.

Ecology.—The species probably inhabited a sublittoral inner marine shelf environment judging from the species with which it is associated.

Zoogeographic derivation.—The origin of the species is not known but judging from its occurrence may have originated in the eastern Gulf of Mexico or adjacent Atlantic Ocean, in the Caribbean or Carolinian Faunal Provinces.

Figured specimen.—USNM 179527.

*Cushmanidea ulrichi* (Howe and Johnson)


Remarks.—As seen by transmitted light (pl. 1, fig. 25) the radial canals of the species are numerous terminally and are fewer and more widely spaced ventrally; the line of concrescence and inner margin are well separated anteriorly; the adductor muscle scar consists of a curved row of four spots; there are two “frontal spots” the dorsal of which is roughly V-shaped.

Occurrence.—The species is present throughout the Yorktown Formation in the area studied. It was described from the Chipola Formation, the Oak Grove member of the Shoal River Formation and the Choctawhatchee Formation (of former usage) in Florida (Howe and others, 1935; Puri, 1954), middle and upper Miocene. It has also been recorded from the Holocene of Pamlico Sound. It is here considered to be a subgenus of *Pontocythere* in which the shell is more strongly punctate or pustulose and more angulated posteriorly than in typical *Pontocythere*. Type species *H. tuberculata* Puri, 1958. Geologic range, Miocene to Holocene.

*Cytheridea ashermani* (Ulrich and Bassler), 1904, Maryland Geol. Survey, Miocene volume, p. 128, pl. 37, figs. 21–27; Swain, 1948, Maryland Dept. Geology, Mines, and Water Resources Bull. 2, p. 195, pl. 13, fig. 2.


Remarks.—As observed by transmitted light (pl. 9, figs. 12a, b) the radial canals of the species terminate just within outer margin of valve; canals continue along venter but are fewer and more widely spaced than terminally.

Occurrence.—In the present collection the species ranges throughout the Yorktown and Duplin Forma-
tions and is also present in the Middle Miocene and in the Pliocene Waccamaw Formation (also see Hazel, 1971). It has previously been recorded also in the Miocene of Florida (Puri, 1954) and is living in the Atlantic Ocean off Virginia (Hulings, 1966). A report of living representatives off the west coast of Florida (Hulings and Puri, 1965) is less well substantiated (Swain, 1968). According to van den Bold (1968), this group of species does not range south of Guatemala either in living or in fossil forms.

**Number of specimens studied.**—100+.

**Ecology.**—The species is characteristic of an open marine shelf habitat in sublittoral to neritic depths.

**Zoogeographic derivation.**—The species evidently appeared in the Middle Atlantic region in early Neogene time and is of Boreal or Arctic North Atlantic origin, but its ancestral relationships are uncertain.

**Figured specimens.**—USNM 179529–179537.

**Figured specimens.**—USNM 179538.

**Neocytherideis agricola duopunctata, n. subsp.**

Plate 1, figure 18; plate 2, figures 4–7.

**Cytherideis rugipustulosa** Edwards, 1944, Jour. Paleontology, v. 18, p. 514, pl. 86, figs. 5–7.


**Remarks.**—The writer (Swain, 1968) referred to this species a form that is ornamented by linearly arranged rows of nodes. This form is somewhat atypical in that the species commonly seems to have surface ridges on which lie nodes. At present, the relationship between *P. wilberti* (Puri, 1952) which is ornamented by linearly arranged but more widely spaced nodes and *P. rugipustulosa* is not entirely clear. This immature form resembles molt valves of *P. ashermani* (Ulrich and Bassler, 1908) but the surface bears longitudinal and concentric ridges and few or no pits which suggests *P. rugipustulosa*.

**Occurrence.**—Rare in beds of Pliocene (?) age, locality G–3, Bertie County, N.C. (also see Hazel, 1971). The species has also been found in the Duplin Marl (Edwards 1944), the Chocotawhatchee Formation (of former usage) of Florida (Puri, 1952, 1954), the Yorktown Formation of Virginia and North Carolina (Malkin, 1953; Hazel, 1971), and the subsurface middle (?) and upper Miocene of North Carolina (Swain, 1952). It was recorded from the Pleistocene of Virginia by Valentine (1971).

**Number of specimens studied.**—Four.

**Ecology.**—The species probably lived in a sublittoral inner neritic marine shelf environment judging from the species with which it is associated.

**Zoogeographic derivation.**—The species apparently originated in the western Atlantic Ocean in the Carolinian or Caribbean Faunal Provinces off the southeastern United States or nearby western Gulf of Mexico based on its distribution.

**Pontocythere (Hulingsina) agricola duopunctata, n. subsp.**

Plate 1, figure 22; plate 2, figures 8–10.

**Diagnosis.**—*P. agricola* (Howe and Hadley, 1935) in which surface pitting on posterior part of shell is finer than that on anterior and ventral parts of shell.

This subspecies differs from *P. agricola agricola* Howe and Hadley, 1935 in that the surface pitting of the posterior part of the shell is considerably coarser than that lying in concentric rows in the anterior and ventral parts of the shell.

Length of holotype specimen (pl. 2, fig. 8–10) 0.87 mm, height 0.60 mm, convexity 0.37 mm; type horizon and locality, Upper Yorktown Formation, locality K–4, Dinwiddie County, Va.

**Occurrence.**—In the present collection the new subspecies occurs in the lower part of the Yorktown Formation at locality A–1, Hertford County, N.C., and in the middle part of the Yorktown Formation, locality C–1, Nansemond County, Va.; locality K–4, Dinwiddie County, Va.; and in beds of Pliocene (?) age, locality G–3, Bertie County, N.C.

**Number of specimens studied.**—Five.

**Ecology.**—The subspecies probably inhabited an open marine shelf at sublittoral to neritic depths judging from the other ostracodes with which it is associated.

**Zoogeographic derivation.**—The subspecies apparently originated in the western Atlantic Ocean in the Carolinian Faunal Province.

**Figured specimens.**—USNM 179539–179543.

**Genus NEOCYTHERIDEIS Puri, 1952**


A diagnosis of the shell features was given by Moore and others, (1961, p. 290). Type species *N. elongatus* (= *Cytherideis subulata* var. *fasciata*; Brady and Robertson, 1874). Geologic range, Miocene to Holocene.

**Neocytherideis sp.**

Plate 3, figure 23.

Shell elongate, subquadrate-subelliptical in side view, highest about one-third from anterior end; dorsal margin nearly straight, about two-thirds of shell length, with broadly obtuse anterior cardinal
marginal bend; ventral margin nearly straight, longer than dorsal margin, and subparallel to it; anterior margin rounded and strongly extended below; posterior margin more broadly curved and extended medially. Valves compressed, subequal, the left slightly the larger; greater convexity postero-median. Valve surface finely and densely pitted.

Hinge of left valve consists of an anterior elongate socket, open ventrally and bearing a few transverse marks, an interterminal faintly crenulate hinge surface formed of valve edge, and a posterior elongate socket, open ventrally; adductor muscle scar consists of a median compact group of four sub-parallel elongate spots and a more anterior crescentic ("frontal") spot; between these two areas is another spot that may represent the mandibular pivot site rather than the so-called mandibular muscle scar itself. Inner lamellae broad anteriorly, less broad elsewhere, line of concrescence and inner margin separated, especially anteriorly; line of concrescence scalloped due to funnellike inner terminations of radial canals; these canals are rather few, straight, and widely spaced, but continue along all the free margin.

Length of figured left valve 0.44 mm, height 0.19 mm, convexity of valve 0.11 mm.

Relationships.—The general shape, hingement, musculature, and marginal structures relate this species to Neocytherideis Puri, 1952; the subquadrate shape and musculature are reminiscent of Cypytus Skogsberg, 1939 but that genus has a weaker hinge and a less scalloped line of concrescence.

Occurrence.—Rare in Yorktown Formation, middle part, locality S–1, James County, Va.

Number of specimens studied.—Two.

Ecology.—The species represents an open-shelf marine environment judging from the associated ostracodes.

Zoogeographic derivation.—Unknown, but possibly arose in the western Atlantic Ocean in the Carolinian Faunal Province.

Figured specimen.—USNM 179544.

Family CYTHERURIDAE Muller, 1894
Genus CYTHERURA Sars, 1866

Cytherura Sars, 1866, Oversigt af Norges Marine Ostracoder, p. 69.

A brief description of the shell characteristics of the genus was provided by Moore and others (1961, p. 292). Type species, Cytherea gibba O. F. Müller, 1785. Geologic range, Cretaceous to Holocene.


Occurrence.—Rare in beds of Pliocene (?) age, locality G–3 Bertie County, N.C. The species is living in brackish waters in Great Britain, Scandinavia, Holland, and Germany; and is fossil in the Pleistocene of Scotland, Norway (Brady and Norman, 1889), Eastern United States and Baja California.

Number of specimens studied.—One.

Ecology.—The modern representatives of the species inhabit brackish waters (Brady and Norman, 1889). The upper Yorktown specimen was obtained from a sample that includes Cytheromorpha varneri Howe and Spurgeon, 1935, another possible brackish-water form. The other associated species, however, do not necessarily imply brackish water conditions, that is, Actinoeuthereis exanthemata (Ulrich and Bassler, 1904); Costa borclayi (McLean, 1957) and others. The forms illustrated by Tressler and Smith (1948) from Chesapeake Bay may not be this species (Benson, 1959) but were found most abundantly in late summer at water temperatures of 20°–25°C, as well as in small numbers throughout the year.

Zoogeographic derivation.—The species may have originated in the Atlantic region off North America in the Neogene and from there migrated to northwestern Europe.

Figured specimen.—USNM 179545.

Cytherura forulata Edwards
Plate 2, figure 22; Plate 3, figures 5, 6


Occurrence.—The species was found in the present collection to be rare in the beds of Pliocene (?) age at localities G–3 and Mount Gould; rare in upper Yorktown Formation at localities H–1 and H–3, Bertie County, N.C.; rare to frequent in the middle Yorktown at localities S–3 and S–4, James County, Va., C–1 and C–2, Nansemond County, Va.; rare to frequent in the lower Yorktown Formation at localities A–1, A–3, and A–5, Hertford County, N.C., and locality U–1, Essex County, Va.
The species also occurs in the upper Miocene Duplin Marl of North Carolina (Edwards, 1944), the Pliocene Waccamaw Formation of South Carolina (Swain, 1968), in the Pleistocene of Virginia (Valentine, 1971), and is reported to be living off the west coast of Florida (Puri, 1960; Hulings and Puri, 1965).

In the present collection it also ranges down into the upper St. Marys Formation of Maryland.

**Number of specimens studied.**—29.

**Ecology.**—The species at present in the western Florida area lives in both normal-salinity sublittoral environments and in reduced-salinity sublittoral environments but is more abundant in the former. It also shows a preference for sand-mud bottoms.

**Zoogeographic derivation.** The species seems to have originated in the Carolinian or Caribbean Faunal Provinces in late Miocene time.

**Figured specimens.**—USNM 179546, 179547.

**Cytherura elongata Edwards**

Plate 3, figures 1–3; plate 8, figures 7a, b; plate 9, figure 2


**Remarks.**—The radial canals of the species are relatively few, as seen by transmitted light (pl. 8, figs. 7a, b; pl. 9, fig. 2), do not reach outer margin and tend to occur in pairs ventrally.

**Occurrence.**—The species was found in this collection: rare in the lower Yorktown, at localities A–1 and A–2, Hertford County, N.C.; locality M–1, Surry County, Va.; rare to frequent in the middle Yorktown at localities S–1 and S–3, James County, Va. and C–1, C–2, D–1 and D–2, Nansemond County, and R–3, Isle of Wight County, Va. It was described from the Miocene of Cuba (van den Bold, 1946) and was recorded from the subsurface of North Carolina (Swain, 1952). The species also occurs in the upper Choptank Formation, middle Miocene of Calvert County, Md.

**Number of specimens studied.**—13.

**Ecology.**—The species apparently lived in sublittoral or neritic marine environments.

**Zoogeographic derivation.**—This species seems to have originated in the Caribbean Faunal Province but several related species occur in western Europe.

**Figured specimens.**—USNM 179551–179553.

**Genus CYTHEROPTERON Sars, 1866**

*Cytheropteron* Sars, 1866, Oversigt af Norges Marine Ostracoder, p. 79.


A diagnosis of the shell of the genus was given by Moore and others (1961, p. 292). Type species, *Cythere latissima* Norman, 1865 (= *Cytheropteron convexum* Sars, 1866). Geologic range, Upper Jurassic to Holocene.

**Cytheropteron subreticulatum van den Bold**

Plate 3, figures 7, 8; plate 9, figure 3

*Cytheropteron subreticulatum* van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 113, pl. 14, fig. 6.


**Remarks.**—As shown in transmitted light view, the species has few radial canals and anteriorly these tend to open funnel-shaped on line of concrescence.

**Occurrence.**—The species was found in this collection: rare in the lower Yorktown, at localities A–1 and A–2, Hertford County, N.C., locality M–1, Surry County, Va.; rare to frequent in the middle Yorktown at localities S–1 and S–3, James County, Va. and C–1, C–2, D–1 and D–2, Nansemond County, and R–3, Isle of Wight County, Va. It was described from the Miocene of Cuba (van den Bold, 1946) and was recorded from the subsurface of North Carolina (Swain, 1952). The species also occurs in the upper Choptank Formation, middle Miocene of Calvert County, Md.

**Number of specimens studied.**—13.

**Ecology.**—The species apparently lived in sublittoral or neritic marine environments.

**Zoogeographic derivation.**—This species seems to have originated in the Caribbean Faunal Province but several related species occur in western Europe.

**Figured specimens.**—USNM 179551–179553.

**Genus HEMICYTHERURA Elofson, 1941**


A diagnosis of the shell features of the genus was given by Moore and others (1961, p. 293). Type species, *Cythere cellulosa* Norman, 1865. Geologic range, Miocene to Holocene.

**Hemicytherura howei** (Puri)
Plate 3, figures 16-21; plate 9, figures 4a, b

*Kangarina howei* Puri, 1954, Florida Geol. Survey Bull. 36, 346, pl. 4, fig. 7; text fig. 6i, j.


**Remarks.**—The zone of concrescence in this species is very broad anteriorly as seen by transmitted light (pl. 9, figs. 4a, b) and the outer terminations of the canals occur along a scalloped submarginal zone.

**Occurrence.**—The species in the present collection was found abundantly at locality G–3, Bertie County, N.C., beds of Pliocene (?) age; rarely at locality H–1, Bertie County, N.C., upper Yorktown Formation; rare to frequent at localities R–1, R–3, and R–4, Isle of Wight County, Va., C–1, C–2, D–1 and D–2, Nansemond County, and S–1, James County, Va., middle Yorktown; rare to common at localities M–1, Surry County, Va., 1 mile above Seaboard Airline Railroad Bridge on Meherrin River, Northampton County, Va. and localities A–1 to A–5, Hertford County, N.C., lower Yorktown (also see Hazel, 1971).

Elsewhere the species occurs in the middle and upper Miocene Chocotawatchee Formation (of former usage) of Florida (Puri, 1954), the Duplin Marl of North Carolina (Pooser, 1965), and the Pliocene Waccamaw Formation of North Carolina and South Carolina (Swain, 1968). It also is rare in the Choptank Formation, middle Miocene, of Maryland.

**Number of specimens studied.**—25+.

**Ecology.**—The species probably inhabited sublittoral nearshore perhaps lagoonal and oligohaline environments judged from associated species such as *Cytheromorpha warneri* Howe and Spurgeon, 1935, *Cytherura forulata* Edwards, 1944, and others.

**Zoogeographic derivation.**—This form is closely related to other species of the Caribbean Faunal Province and may have originated in that area.

**Figured specimens.**—USNM 179562–179566.

**Genus PARACYTHERIDEA** Muller, 1894


**Paracytheridea mucra** Edwards
Plate 1, figure 23

**Paracytheridea mucra** Edwards, 1944, Jour. Paleontology, v. 18, p. 512, pls. 85, figs. 22, 23.

**Occurrence.**—Rare in beds of Pliocene (?) age, locality G–3, Bertie County, N.C. The species was described from the Duplin Marl at Natural Well, Duplin County, N.C. (Edwards 1944). It was also recorded by Hazel (1971) from the Yorktown Formation of Virginia and North Carolina.

**Number of specimens studied.**—One.

**Ecology.**—Members of this genus typically occur in lagoonal environments in waters of reduced salinity.

**Zoogeographic derivation.**—Related forms are so widely distributed on both sides of the Atlantic Ocean and in the Gulf of Mexico, Caribbean Sea, and eastern Pacific Ocean that it is not possible at present to surmise the origin of this species.

**Figured specimen.**—USNM 179567.

*Paracytheridea altita Edwards
Plate 1, figure 17

*Cytheropteron nodosum* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 129, pl. 38, figs. 37–40 [not *Cytheropteron nodosum* Brady, 1868].


*Paracytheridea altita* Edwards, 1944, Jour. Paleontology, v. 18, p. 512, pl. 85, figs. 20, 21; van den Bold, 1968, Bulls. Am. Paleontology, v. 54, no. 239, p. 76, pl. 7, figs. 1a–d;
Valentine, 1971, U.S. Geol. Survey Prof. Paper 688-D, pl. 3, figs. 31-34.

Remarks.—van den Bold (1968) has recently assembled all these forms under the name P. altiia on grounds that they represent a variable series all belonging to one species.

Occurrence.—This species occurs in the Yorktown and Duplin Formations (upper Miocene) of Virginia and North Carolina (also see Hazel, 1971). It also occurs in the Waccamaw Formation (Pliocene) of North and South Carolina (Swain, 1968); the Choctawatchee Formation, Arca facies (middle and upper Miocene of Florida (Puri, 1954), the upper Miocene of the Caribbean Region (van den Bold, 1946, 1968), the Pleistocene of Virginia (Valentine, 1971) and the Holocene of the Gulf of Mexico region (Swain, 1955, Morales, 1966).

Number of specimens studied.—23.

Ecology.—The species characteristically occurs in lagoons and estuaries that have brackish waters at least part of the year but which may also approach normal sea water salinity. Thus the species appears to inhabit mixohaline (0.5-30 parts per mil) to euhaline (30-40 parts per mil) waters but seems to prefer the former.

Zoogeographic derivation.—As in the case of the preceding species the related forms are so widely distributed that the origin of this species is difficult to determine, but its main area of distribution seems to have been the Caribbean Faunal Province.

Figured specimen.—USNM 179568.

Genus SHATTUCKOCYTHE Swain, n. gen.

Diagnosis.—Cytherurid genus having subtrapezoidal to subovate outline, overhanging ventral surface, smooth to finely ornamented surface, and antimerodont hinge.

Description.—Shell trapezoidal in side view, dorsal margin relatively short and straight; ventral margin longer than and subparallel to dorsum; terminal margin narrowly rounded to subacuminate, extended below, truncate above. Left valve larger than right. Valves moderately to strongly convex with ventral surface swollen and tending to overhang ventral margin especially posteromedially. Surface smooth, pitted, papillate, or reticulate.

Hinge antimerodont, that of left valve consists of terminal elongate crenulate sockets and interterminal finely crenulate ridge; that of right valve has terminal crenulate ridges and an interterminal crenulate furrow. Inner lamellae rather narrow, broadest anteriorly; line of concrescence and inner margin separated anteroventrally but nearly coincide elsewhere. Radial canals relatively few and widely spaced.

Type-species, Cythere? shattucki Ulrich and Bassler, 1904. Geologic range, Miocene to Recent.

Relationships.—The subtrapezoidal outline, ventral subalate expansion of the valve surfaces and antimerodont hingement are distinguishing features of the genus. It is placed tentatively in the Cytheruridae although its hinge is unlike the entomodont type which is characteristic of the more definite members of that family. The forms previously referred to as Eocytheropteron yorktownensis Malkin, 1953, and Cytheropteron ventrokurtosa Swain, 1967, I now believe should be placed in Shattuckocythere. Nipponocythere Ishizaki, 1971, from the Holocene of Japan is similar to the present genus, but has a ventral longitudinal ridge on the valve surface.

Shattuckocythere shattucki (Ulrich and Bassler)

Plate 1, figure 14; plate 8, figure 9

Cythere? shattucki Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 121, pl. 38, fig. 10.


Remarks.—The shell characteristics of the type species were described recently by Hall (1965).

Occurrence.—In the present collections the species has been obtained at locality P–1, Isle of Wight County, Va., middle Yorktown, and locality C–1, Nansemond County, Va., Gibson’s localities FP–1 (0.5 of a mile south of Flag Pond, Calvert County, Md.) and Y–2 (Drum Cliff, near Jones Wharf, St. Marys County, Md.) from the Choptank Formation, middle Miocene, from which it has been recorded previously by Ulrich and Bassler (1904) and by Malkin (1953). A form that probably represents the same species was obtained from the subsurface middle Miocene of North Carolina (Swain, 1952) and referred to Cythere wetherelli Jones, 1854. The writer now doubts that Jones’ species occurs in the North Carolina Miocene. It has not been possible in the present work to verify Malkin’s (1953) subspecies curta in the Yorktown Formation of this region. The species has also been recorded from the Holocene of Georgia (Hall, 1965), as reworked material.
UPPER MIocene AND PIocene (?) OSTRACODA, ATLANTIC COASTAL REGION

Number of specimens studied.—Five.

Ecology.—The associated species indicate that this species inhabited an open marine shelf, sublittoral and neritic environment.

Zoogeographic derivation.—This species is believed to have originated in Paleogene time in the Arctic or Boreal Atlantic Faunal Provinces. “Cythere” wetherelli Jones, 1854 of the Eocene of Western Europe may represent one of the primitive members of this group.

Figured specimens.—USNM 179569-179570.

*Shattuckocythere similis* (Malkin)  
Plate 1, figure 19a, b; plate 9, figure 14


Occurrence.—This form, which is somewhat more elongate and with longer hinge line and coarser surface reticulations than *S. shattucki* (Ulrich and Bassler, 1904) was obtained from Mount Gould Landing, Bertie County, N.C., in the beds of Pliocene (?) age. It was first described from the upper Yorktown Formation (Malkin, 1953).

Number of specimens studied.—Seven.

Ecology.—This form appears to represent an open shelf marine environment at sublittoral to neritic depths.

Zoogeographic derivation.—The species like the preceding one apparently originated in Paleogene time in the Arctic or Boreal Atlantic Faunal Provinces.

Figured specimen.—USNM 179571, 179572.

*Shattuckocythere yorktownensis* (Malkin)  
Plate 3, figures 9-15; plate 9, figures 9a, b


*Cytheropteron yorktownensis* (Malkin). Swain, 1968, U.S. Geol. Survey Prof. Paper 573-D, p. 13, pi. 4, figs. 7a-c, text fig. 11.

Remarks.—On the basis of its hingement and surface ornamentation, this species is here transferred to *Shattuckocythere*. As viewed by transmitted light, the normal canals of the species are widely spaced and of fairly large size (pl. 9, figs. 9a, b). The radial canals are few and widely spaced.

Occurrence.—In the samples studied here, the species was found to be rare in beds of Pliocene (?) age at Mount Gould Landing and in the upper Yorktown Formation at locality H-1, Bertie County, N.C.; rare to frequent in the middle Yorktown at localities S-3, James County, Va., P-1, R-1 and R-2, Isle of Wight County, Va., C-1 and C-2, Nansemond County, Va.; rare in the lower Yorktown at localities A-1, A-2, and A-5, Hertford County, N.C. (also see Hazel, 1971). It also is present in samples from the Duplin Marl at Kenansville, Duplin County, N.C. and at Walkers Bluff, Bladen County, N.C.

It previously was recorded from the Yorktown Formation of Virginia (Malkin, 1953), from the Pliocene Waccamaw Formation of North Carolina, and from the Pleistocene of South Carolina (Swain, 1968).

Number of specimens studied.—26.

Ecology.—S. yorktownensis is associated with abundant *Aurila conradi* Howe and McGuirt, 1935, *Cytherura* spp., *Campylocythere* spp. and others that indicate sublittoral to neritic environments.

Zoogeographic derivation.—The species is of uncertain derivation because of its unique shell form. It may have originated in the Carolinian or Caribbean Faunal Provinces as closely related forms occur in the Miocene of Florida (*Cytheropteron leonensis* Puri, 1954). Another similar form is presently living in the Gulf of California (*S. ventrokurtosa* Swain, 1967) and other Pacific coast localities (Swain, 1967; McKenzie and Swain, 1967).

Figured specimens.—USNM 179554-179561.

Family BRACHYCYTHERIDAE Puri, 1954  
Subfamily PTERYGOCYTHERINAE Puri, 1957  
Genus *PTERYGOCYTHEREIS* Blake, 1933

*Fimbria* Neviani, 1928, Pontif. Acad. Sci., Rome, Mém. Ser. 2, v. 11, p. 72 [not Bohadsch, 1761; or Risso, 1826; or Cobb, 1894; or Belon, 1896].

*Cythereis* (Pterygocythereis) Blake, 1933, in W. Procter, 1933, Biological Survey of the Mount Desert region, pt. 5, p. 239.

*Pterygocythereis* van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 29 [error].


Hazel (1967) pointed out the relationships between the pterygocytherid ostracodes and the Brachycytheridae and Trachyleberididae. He placed both the Pterygocytherinae and Brachycytherinae as subfamilies of the Trachyleberididae on the basis of muscle scar patterns.

The present writer prefers to retain the Family Brachycytheridae on the basis of distinctive shell form as well as of internal shell structure.

The Pterygocytherinae perhaps should be retained as a subfamily of Brachycytheridae rather than suppressed as was done in Moore and others (1961).
**SYSTEMATIC DESCRIPTIONS**

**Pterygocythereis americana** (Ulrich and Bassler)

Plate 2, figure 11; plate 9, figure 5; plate 13, figures 2a–c.

*Cythereis cornuta* var. *americana* (Ulrich and Bassler), 1904, Maryland Geol. Survey, Miocene volume, p. 122, pl. 37, figs. 28–33.

*Cythereis alaris* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 123, pl. 38, figs. 34–36.


[not] *Pterygocythereis americana* (Ulrich and Bassler).


Remarks.—Hill (1954) placed the forms referred to *P. americana* by Swain (1948) in his *P. howei* without giving reasons but *P. howei* is stated to have an unbroken smooth dorsal marginal ridge not an interrupted en echelon sharp-edged ridge as in Swain’s specimen from the subsurface Miocene of Maryland.

Hazel (1967, pl. 4, figs. 14, 15) has placed in *P. americana* a form from the Gulf of Maine that Blake (1929, 1933) named *Cythereis* (**Pterygocythereis** *inexpectata* and which differs from *P. americana* in having pronounced fluting on the inner side of its dorsal alar ridge. Fluting of this ridge is less prominent in the specimens of *P. americana* in the collection being considered herein.

Hazel (1971) refers the specimens he found in the Yorktown Formation of North Carolina to *P. inexpectata* Blake. The present writer believes that the middle and upper Miocene *Pterygocythereis* of North Carolina are less fluted in the dorsal ridge and tend to be less pointed posteriorly than *P. inexpectata* and are more correctly placed in *P. americana*.

The records of *P. americana*-like forms with en echelon dorsal ridges from the eastern Gulf of Mexico (Benson and Coleman, 1963) are difficult to evaluate. Only seven (which they consider juveniles) out of 103 of their specimens were constructed like *P. americana*, whereas the others more closely resemble *P. howei* Hill, but are more coarsely spinose terminally.

In the present writer’s opinion the Holocene occurrence of *B. americana* has not been demonstrated for the Gulf of Mexico.

**Occurrence.**—The species occurs in the Miocene of the middle Atlantic region in the Calvert, Choptank, St. Marys, and lower and middle Yorktown Formations (also see Hazel, 1971). It was not found definitely in the upper Yorktown or Duplin Formations. In the Pliocene Waccamaw Formation a form with smooth dorsal ridge occurs (Swain, 1968). The species also is reported to occur in the Chipola, Shoal River, and Choctawhatchee 2 Formations of Florida (Puri, 1954). Its principal occurrence seems to be middle Miocene in the Atlantic coastal region. A striking example of its presence in marine bottom samples is in “Onslow Bay” off North Carolina where the Pungo River Formation crops out on the sea floor. Many specimens of *P. americana* were obtained from these samples.

**Number of specimens studied.**—25+.

**Ecology.**—The species represents an open marine shelf habitat at sublittoral to neritic depths.

**Zoogeographic derivation.**—This form seems to have had its origins in the Arctic or Boreal Atlantic Faunal Provinces in Paleogene time and to have extended its range into the Carolinian and Floridian Faunal Provinces in the Neogene.

**Figured specimens.**—USNM 179573.

**Family CYTHERETTIDAE** Triebel, 1952

**Genus CYTHERETTA** Muller, 1894

*Cytheretta* G. W. Müller, 1894, Fauna u. Flora des Golfes von Neapel, 21 Mon., p. 382.


*Cylindratus* Neviani, 1928, Pontif. Acad. Sci., Rome, Mém. Ser. 2, v. 11, p. 72, 106 [not Deshayes, 1824; or Fitzinger, 1833; or Hermannsen, 1852].


*Cytheretta burnsi* (Ulrich and Bassler)

Plate 2, figures 12–15, 16–18. Plate 8, figures 11a–c.

*Cythere burnsi* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 36, figs. 34–39.

*Cytheretta burnsi* (Ulrich and Bassler). Howe, 1935, Florida Dept. Conserv., Geol. Bull. 13, p. 33, pl. 2, figs. 12–14, 17, pl. 4, figs. 14, 21; Malkin, 1153, Jour. Paleontology, v. 27, p. 789, pl. 81, figs. 7, 8, 10, 11; Puri, 1952, Jour. Paleontology, v. 26, p. 205, pl. 39, figs. 5, 6; Puri, 1954,

2 Of former usage.
Florida Geol. Survey Bull. 36, p. 282, pl. 7, figs. 1, 2; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 91, pl. 12, figs. 1a–d.

*Cythere nitidula* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 107, pl. 36, figs. 21–28 (juv. fide Malkin, 1953).


*Cythere panceipunctata* Ulrich and Bassler, 1904, Maryland Geol. Survey Miocene volume, p. 105, pl. 38, figs. 7–9 (fide Malkin, 1953).

Remarks.—The zone of concrescence is broad, especially anteriorly, and the vestibule is developed only posteriorly where line of concrescence is strongly scalloped; radial canals numerous and closely spaced.

Occurrence.—In the present collections the species was found in the middle part of the Yorktown Formation and in beds of Pliocene (?) age. It was previously reported from the Choptank and Calvert Formations of the Chesapeake Group of Maryland and Virginia (Ulrich and Bassler, 1904), from the upper Calvert, Choptank, and Yorktown Formations of Maryland and Virginia and the Kirkwood Formation of New Jersey (Malkin, 1953), and from the Yorktown Formation of Virginia (McLean, 1957). The present writer is unable to verify its occurrence other than in the Yorktown Formation and in beds of Pliocene (?) age.

Number of specimens studied.—25+.

Ecology.—The species is considered by the writer to have inhabited an open marine shelf at sublittoral to neritic depths.

Zoogeographic derivation.—The species represents ostracodes that today are more characteristic of tropical and subtropical than of boreal or arctic habitats, and it may have originated in the Caribbean Faunal Province.

Figured specimens.—USNM 179575–179581.

*Cytheretta porcella* (Ulrich and Bassler)

Plate 2, figures 19, 20

*Cythere plebeia* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 102, pl. 35, figs. 20–29. [Not *Cythere* (Bairdia) *plebeia* (Reuss), Jones, in Kirby, 1860.]

*Cythere plebeia* var. *capax* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 35, figs. 30–33.

*Cythere plebeia* var. *modica* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 35 figs. 18, 19.

*Cythere porcella* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 106, pl. 36, figs. 26–33.

*Cytheretta plebeia* (as *plebia*) (Ulrich and Bassler), Swain, 1948, Maryland Dept. Geology, Mines, and Water Re-

sources Bull. 2, p. 212, pl. 14, figs. 3, 4; Malkin, 1953, Jour. Paleontology, v. 27, p. 790, pl. 81, figs. 1–6, 9.

*Cytheretta ulrichi* Puri, 1952, Jour. Paleontology, v. 26, p. 204, pl. 39, fig. 3, text figs. 5–7; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 92, pl. 12, figs. 3a–d.


The name *porcella* is used for this species following Puri's (1953) statement that his species name *ulrichi* should be suppressed in favor of *porcella*.

Occurrence.—The species occurs in the present collections in the Calvert, St. Marys, and Yorktown Formations and in beds of Pliocene (?) age. It previously was obtained from the Calvert Formation of Maryland and from the Chesapeake Group of Virginia (Ulrich and Bassler, 1904) and from the Yorktown Formation of Virginia and Maryland (McLean, 1957). It was also recorded from the Pleistocene (?) of North Carolina (Swain, 1952), but that occurrence may represent reworking of older material.

Number of specimens studied.—Six.

Ecology.—Judging from the associated species, such as *Pterygoecythereis americana* (Ulrich and Bassler, 1904) and *Actinocythereis exanthemata* (Ulrich and Bassler, 1904), this species inhabited an open marine shelf at sublittoral to neritic depths.

Zoogeographic derivation.—The absence of this and related species in the Neogene of the Caribbean Faunal Province suggests that its derivation was the Arctic or Boreal Atlantic Faunal Provinces, perhaps from Western Europe. Related forms such as *C. posticalis* Triebel, 1952 and *C. tenuisstrata* (Reuss, 1853), (see Oertli, 1956) occur in the Oligocene Chattian and Rupelian Stages of Switzerland.

Figured specimens.—USNM 179582–179584.

Genus PROTOCYTHERETTA Puri, 1958

*Protocytheretta* Puri, 1958, Gulf Coast Assoc. Geol. Socs., Trans., v. 8, p. 188.

A diagnosis of this genus is provided in Moore and others (1961, p. 273). Type species, *Cythere danaiana* Brady, 1869. Geologic range, Oligocene to Holocene.

*Protocytheretta sahnii* (Puri)

Plate 2, figure 21

*Cytheretta sahnii* Puri, 1952, Jour. Paleontology, v. 26, p. 206 pl. 39, figs. 7, 8, text figs. 1, 2; 1954, Florida Geol. Survey Bull. 36, p. 284, pl. 8, figs. 7, 8.

Univ. Paleont. Contr., Arthropoda, Art. 2, p. 25, pl. 5, figs. 4, 6, 8, and 12.

Protoocytherea sahnii (Puri). Puri, 1958, Gulf Coast Assoc. Geol. Soc. Trans., v. 8, p. 188.

Occurrence.—The species was obtained from the upper part of the Yorktown Formation, locality H-4, Bertie County, N.C. It was described from the Doolin Marl, upper Miocene, of Florida and also occurs in the Choctawhatchee Formation (of former usage) of Florida (Puri, 1952).

Number of specimens studied.—One.

Ecology.—The species is believed to represent an open marine shelf sublittoral habitat. It is found living in the eastern Gulf of Mexico (Benson and Coleman, 1963) at depths of 20–63 feet and 36.2–37.84 parts per mil salinity.

Zoogeographic derivation.—The species seems to have originated in the Caribbean Faunal Province, possibly from a form like Cytheretta inaequalvis (Ulrich and Bassler).

Figured specimen.—USNM 179585.

Family BYTHOCYTHERIDAE Sars, 1926
Genus JONESIA Brady, 1866


A diagnosis of the shell features of this genus was given by Moore and others (1961, p. 268). Type species, Cythere simplex Norman, 1865 [not Cythere auriculata simplex Cornuel, 1848, = Bythocytthera acuminata Sars, 1866]. Geologic range, Miocene to Holocene.

Jonesia? sp.

Plate 2, figure 23

Shell elongate sublanceolate to subtrapezoidal in side view, highest posteriorly; dorsal margin convex, sloping more steeply behind than in front of position of greatest height; ventral margin slightly concave, curving abruptly into posterior margin and projecting downward at anteroventral marginal bend. Valves compressed. Surface smooth.

Length of figured specimen 0.42 mm, height 0.20 mm, convexity 0.20 mm.

Remarks.—The shape and other shell features of this form indicate a relationship to Luvula Coryell and Fields of the Miocene. That genus was referred to Jonesia Brady by Howe (in Moore and others, 1961), but Jonesia is more acuminate posteriorly, and the present form is only questionably referred to the latter genus. Too few specimens of the present form are available for further taxonomic treatment.

Occurrence.—The species is rare in the middle Yorktown Formation at locality C-1, Nansemond County, Va., and locality S-4, James County, Va.

Number of specimens studied.—Two.

Ecology.—The associated species indicate that this form lived in neritic open-shelf environments.

Zoogeographic derivation.—A somewhat similar species Jonesia palmerae (Coryell and Fields, 1937) occurs in the Miocene of Florida (Puri, 1954) as well as in Panama, and the generic stock may have originated in the Caribbean Faunal Province.

Figured specimen.—USNM 179586.

Family XESTOLEBERIDAE Sars, 1928
Genus XESTOLEBERIS Sars, 1866

Xestoleberis Sars, 1866, Oversigt af Norges marine Ostracoder, p. 66.

A summarized description of the genus was given by Moore and others (1961, p. 343). Type species, Cythere aurantia Baird, 1838. Geologic range, Cretaceous to Holocene.

Xestoleberis cf. X. aurantia (Baird)
Plate 2, figures 24, 25

Xestoleberis aurantia (Baird). Brady, 1868, Linnean Soc. London Trans., v. 26, p. 437. pl. 27, figs. 34–37, pl. 39, fig. 6.

Occurrence.—In the present collection, the species was obtained from beds of Pliocene (?) age, Mount Gould Landing locality, Bertie County, N.C. It was previously recorded from the Holocene of Europe, the North Atlantic, the Arctic Ocean, Hongkong, and Ceylon.

Number of specimens studied.—One.

Ecology.—The species represents estuarine to marine open shelf habitat at littoral to neritic depths judging from associated species. At present (Elofson, 1941), it lives in waters ranging from 0°–22°C, and its salinity tolerance is 3–30 parts per mil (Neale, 1964).

Zoogeographic derivation.—The origin of this ubiquitous form is unknown; it has close relatives in the Eocene and younger Cenozoic (Neogene) deposits of France and Belgium, the Holocene of northern Europe, the Caribbean Faunal Province, and the Pacific coast of North America.

Figured specimen.—USNM 179587.

Xestoleberis? ventrostriata Swain

Occurrence.—In the present collection the species was obtained from beds of Pliocene (?) age at Mount Gould Landing and Colerain Landing localities, Bertie County, N.C.

Number of specimens studied.—Three.

Ecology.—The associated species suggest that this form inhabited an open-shelf marine environment at sublittoral depths.

Zoogeographic derivation.—The species seems to have originated in the Carolinian Faunal Province.

Unfigured specimen.—USNM 179729.

Family LEPTOCYTHERIDAE Hanai, 1957
Genus LEPTOCYTHE Sars, 1925

Remarks.—The outline, ornamentation, and internal structures of this species seem identical with those given for L. paracastanea Swain, 1955, and its range is extended back to the upper Miocene. The line of concrescence is scalloped posteriorly as seen in transmitted light (pl. 9, figs. 6a, b.).

Occurrence.—Previously the species was recorded living in San Antonio Bay, Tex., and near Sapelo Island, Ga., in brackish waters. In this collection, the species was obtained from the middle part of the Yorktown Formation, locality K–4, Dinwiddie County Va.

Ecology.—The species lives at present in brackish water lagoonal and tidal marsh environments.

Zoogeographic derivation.—This group of Ostracoda is widespread in modern North Atlantic brackish water habitats but its site of origin is uncertain.

Figured specimens.—USNM 179593–179598.

Family LOXOCONCHIDAE Sars, 1925
Genus CYTHEROMORPHA Hirschmann 1909

The shell of the genus was described briefly by Moore and others (1961, p. 313). Type species, C. albula Hirschmann, 1909 (= Cythere fuscata Brady, 1869).


Remarks.—This species is very similar to C. apheles van den Bold, 1963 from the Morne l’Enfer and Springvale Formations, upper Miocene, of Trinidad. That species, according to van den Bold (1963), is smaller than C. warneri and has a more carinate marginal rim anteriorly.

Occurrence.—In the collections studied, the species is most characteristic of the Yorktown Formation but ranges downward to the St. Marys and Calvert Formations where it is generally rare (also see Hazel, 1971). It was not noted in the Choptank collections. It was previously recorded from the Choctawhatchee Formation (of former usage) of Florida (Howe and others, 1935; Puri, 1954), the Calvert and Yorktown Formations of the Middle Atlantic region (Malkin, 1953; McLean, 1957), the upper Miocene of North Carolina (Swain, 1952), the Miocene of Cuba (van den Bold, 1946), and the Holocene of the Gulf of Mexico and Pamlico Sound (Puri and Hulings, 1957; Puri, 1960; Benda and Puri, 1962; Grossman, 1964; Hulings and Puri, 1964).

Number of specimens studied.—50+.

Ecology.—The species is typical of oligohaline lagoonal and estuarine environments.

Zoogeographic derivation.—The species is apparently native to the Carolinian and Caribbean Faunal Provinces. It does not extend into the more northerly provinces.

Figured specimens.—USNM 179574, 179588–179592.
Genus LOXOCONCHA Sars, 1866

Loxoconcha Sars, 1866, Oversigt af Norges Marine Ostracoder (1865), p. 61.
Loxoleberis Sars, 1866, Oversigt af Norges Marine Ostracoder (1865), p. 130 (error).
Normania Brady, 1866, Zool. Soc. London Trans., v. 5, p. 832 [not Bowerbank, 1869; or Boeck, 1871].

The shell features of the genus are diagnosed in Moore and others (1961, p. 313). Type species, Cythere impressa Baird, 1850 (= C. rhomboiacea Fischer, 1855). Geologic range, Cretaceous to Holocene.

Loxoconcha sp.
Plate 4, figure 9; plate 9, figure 7

Shell subquadrate in side view, highest posteroventrally; dorsal margin nearly straight, anter or cardinal angle somewhat more obtuse than that at posterior end; ventral margin slightly concave anteromedially; anterior margin broadly rounded, somewhat extended below; posterior margin also broadly rounded, extended above. Valves subequal, the left slightly larger than right, males moderately convex; females strongly convex in posterior half.

Terminal and all but incurved part of venter bears a narrow marginal rim and shell is compressed in marginal zone; general surface finely pitted, superimposed on which is a weakly reticulate pattern of low narrow ridges which in terminal and ventral parts of shell are strongest in a concentric pattern.

Hinge of left valve gongylodont, with two small teeth and intervening yolk-groove at each end of hinge and an interterminal very weakly crenulate bar formed of valve edge, and dorsoadjacent narrow accommodation groove; adductor muscle scar a curved subvertical group of four closely spaced spots, and two more anterior spots, the upper or "frontal" spot is oval, the lower or "mandibular" spot is obliquely elongate or double. Two dorsal muscle spots the posterior of which is elongate lie just below dorsal margin. Inner lamellae of moderate width; line of concrescence most widely separated from inner margin anteriorly; radial canals rather few and widely spaced, in part with funnel-shaped inner ends, terminally.

Length of female shell (pl. 4, fig. 9) 0.63 mm, height 0.34 mm, convexity 0.33 mm.

Relationships.—In its combined pitted and reticulate surface ornamentation this species is like L. caudata Puri, 1954 from the Ecphora facies of the Chocawhatchee Formation (of former usage) of Florida, but that form is shorter and higher and has a posteroverentral flange of the shell margin unlike the present species.

Occurrence.—The species is rare in occurrence in the lower Yorktown Formation at locality A–5, Hertford County, N.C.; in the upper Yorktown at locality H–4, and in beds of Pliocene (?) age, locality G–3, Bertie County, N.C.

Number of specimens studied.—Three.
Ecology.—The species lived in an open marine shelf environment judging from associated species.

Zoogeographic derivation.—This group of ostracodes occurs abundantly in the Paleogene and Neogene of the Gulf of Mexico region but also in western Europe. Similar forms are widespread in the Cretaceous which indicates that the group attained its ubiquitous shallow marine distribution in later Mesozoic time.

Figured specimens.—USNM 179599–179601.

Loxoconcha purisubrhomboidea (Edwards)
Plate 4, figure 10


Occurrence.—In the present collections this species occurs in beds of Pliocene (?) age in the Choptank, Yorktown, Duplin, and Waccamaw Formations, but is rare and somewhat questionable below the Yorktown. It previously has been found in the Duplin Marl of North Carolina (Edwards 1944), the Miocene of Florida (Puri, 1954) the middle and upper Miocene and Pliocene of North and South Carolina (Swain, 1952, 1968) and the Holocene of the Gulf of Mexico (Hulings, 1967).

Number of specimens studied.—25+.
Ecology.—The species is characteristic of estuarine environments (Hulings, 1958) at depths ranging up to 30 meters, salinity range 16–37 percent, temperature range 24°–25°C on sand, silt, and clay bottoms.

Zoogeographic derivation.—The species seems to have originated in the Caribbean Faunal Province. Similar forms occur living along the Pacific Coast
of Central America and southern North America to where they probably migrated in pre-Holocene time.

**Figured specimens.**—USNM 179603-179605.

**Loxoconcha wilberti** Puri

Plate 4, figure 13; plate 9, figure 15

**Loxoconcha wilberti** Puri, 1954, Florida Geol. Survey Bull. 36, p. 274, pl. 10, figs. 1, 2, text figs. 10a, b; Puri and Hulings, 1957, Gulf Coast Assoc. Geol. Soc. Trans., p. 187, fig. 11; Puri, 1960, Gulf Coast Assoc. Geol. Soc. Trans., v. 10, p. 114, pl. 4, figs. 18, 19; Hulings, 1966, Contr. Marine Sci., v. 12, p. 93; Swain, 1968, U.S. Geol. Survey Prof. Paper 573-D, p. 24, pl. 3, figs. 6a-c, pl. 7, fig. 6, text figs. 10a, b.

**Remarks.**—The inner lamellae are fairly broad but line of concrescence and inner margin nearly coincide (pl. 9, fig. 15); radial canals few and widely spaced.

**Occurrence.**—In the present collections the species was obtained from beds of Pliocene (?) age, locality G-3; from the upper part of the Yorktown Formation, locality H-1, Bertie County, N.C.; and from locality S-5, James County Va., middle Yorktown Formation. It was previously recorded from the Choctawhatchee Formation (of former usage), upper Miocene, of Florida (Puri, 1954), the Waccamaw Formation, Pliocene, of North Carolina (Swain, 1968) and in living collections in the Gulf of Mexico (Puri and Hulings, 1957; Puri, 1960; Hulings, 1966).

**Number of specimens studied.**—Four.

**Ecology.**—The species was found in Holocene carbonate beach sands in southern and western Florida and presumably is a eulittoral species.

**Zoogeographic derivation.**—This species of *Loxoconcha* seems to have originated in the Carolinian Faunal Province in the Late Miocene and to have spread into the Caribbean Faunal Province by Holocene time.

**Figured specimens.**—USNM 179606-179607.

**Loxoconcha reticularis** (Edwards)

Plate 4, figures 11, 12


**Occurrence.**—In the collections studied here the species was common in the middle part of the Calvert Formation at Gibson’s locality PPN-1 (lowest of four samples in bluff 1 mile north of Plum Point), Calvert County, Md.; the lower part of the Choptank Formation at Gibson’s locality FP-3 (in bluff 0.5 of a mile south of Flag Pond), Calvert County, Md.; the upper part of the St. Marys Formation at Gibson’s localities CPS-1-2 (0.25 of a mile southeast of Chancellor Point), St. Marys County, Md.; the lower part of the Yorktown Formation, locality B-2, Hertford County, N.C., and locality U-1, Essex County, Va.; the middle part of the Yorktown Formation, localities S-3, S-4, James County, Va., and R-1, Isle of Wight County, Va.; Duplin Marl, at Natural Well, Duplin County, N.C., Lumberton, Robeson County, N.C. and Allen Farm, Robeson County, N.C. (also see Hazel, 1971). The species has also been found in the Waccamaw Formation, Pliocene, of North and South Carolina (Swain, 1968), in the subsurface upper Miocene of North Carolina (Swain, 1952), in the Yorktown Formation of Virginia (Malkin, 1953; McLean, 1957), in the Choctawhatchee Formation (of former usage) upper Miocene, of Florida (Puri, 1954), in the Kirkwood Formation, middle Miocene of New Jersey (Malkin, 1953). It was also reported living by Benda and Puri (1962) from the eastern Gulf of Mexico.

**Number of specimens studied.**—25+.

**Ecology.**—At present (Benda and Puri, 1962) the species is living in the open shelf of the eastern Gulf of Mexico, and its fossil associations suggest that it typifies a sublittoral to neritic open shelf habitat.

**Zoogeographic derivation.**—The species seems to have originated in the continental shelf areas of the southeastern United States in the early or middle Miocene.

**Figured specimens.**—USNM 179608, 179609.

**Family PARADOXOSTOMATIDAE** Brady and Norman, 1889

**Subfamily PARADOXOSTOMATINAE** Brady and Norman, 1889

**Genus PARADOXOSTOMA** Fischer, 1855


**SYSTEMATIC DESCRIPTIONS**

**Paradoxostoma robustum** Puri

*Plate 4, figures 14, 15*

*Paradoxostoma robusta* Puri, 1954, Florida Geol. Survey Bull. 36, p. 289, pl. 15, fig. 1, text figs. 12d, e.


**Occurrence.**—The species was found to be rare in occurrence in the upper part of St. Marys Formation, middle Miocene and throughout the Yorktown Formation, upper Miocene, in the present collection. Puri (1954) recorded it from the lower Miocene Chipola Formation and the upper Miocene Choctawhatchee Formation, Ecphora Facies (of former usage) in Florida.

**Number of specimens studied.**—Six.

**Ecology.**—The species apparently can occur either in the euhaline inner neritic to sublittoral marine shelf environment or in mixohaline lagoonal or estuarine environments judged from its associated species.

**Zoogeographic derivation.**—This type of *Paradoxostoma* may have originated in the North Atlantic Boreal Realm in some form like *P. variabile* (Baird, 1850) which is similar to, but less elongate than, *P. robusta.*

**Figured specimens.**—USNM 179610, 179611.

*Family TRACHYLEBERIDIDAE* Sylvester-Bradley, 1948

*Subfamily TRACHYLEBERIDINAE* Sylvester-Bradley, 1948

**Genus MURRAYINA** Puri, 1954


A brief description of the shell features of the genus was given by Moore and others (1961, p. 333).

**Type species,** *Murrayina howei* Puri, 1954. Geologic range, Miocene.

*Murrayina macleani,* n. sp.

*Plate 4, figures 16-21; plate 8, figures 8a-c; plate 9, figure 13*

**Diagnosis.**—*Murrayina* having elongate shell, weak submarginal rims and furrows, and ventrally deflected narrow longitudinal ridges in posterior part of shell.

**Description.**—Shell subquadrate in side view, strongly dimorphic, the presumed male shells (pl. 4, fig. 16) lower with respect to length than females (pl. 4, fig. 17), highest about one-fourth from anterior end; dorsal margin nearly straight to slightly sinuous, anterior cardinal angle more obtuse than posterior cardinal angle; ventral margin nearly straight to gently convex, converging toward posterior with respect to dorsum; anterior margin broadly curved, somewhat extended and bears about 10 short spines, below; spines are backwardly curved in well-preserved specimens; posterior margin much narrower than anterior, extended above, and has several small short spines medially. Valves of male shells compressed, with straightened sides as viewed dorsally; female valves more convex, greatest convexity posteromedian. Left valve larger than right, overreaching right most noticeably at cardinal angles.

Anterior marginal one-sixth of each valve is ornamented by two narrow ridges subparallel to margin; anterodorsally is a small rounded eye tubercle; a low broad oblique anterodorsal sulcus-like depression defines eye tubercle behind and below; general valve surface bears longitudinally arranged narrow curving ridges that are bent posterolaterally in posterior part of shell; somewhat weaker crossbars lie between ridge and provide a reticulate ornamental pattern; width of ridges and crossbars is one-fourth to one-half width of interspaces; anteromedially is a rounded area, which represents site of adductor muscle scar on valve interior; posterior sixth of valves smooth or with irregular continuations of surface ridges.

Hinge of right valve consists of an anterior high pointed tooth, posterojacent small socket, interterminal narrow faintly crenulate furrow, and posterior bluntly pointed tooth; hinge of left valve an anterior deep rounded socket passing downward into an ocular sinus and defined ventrally by a curving ocular ridge. A posterojacent tooth, interterminal weakly and finely notched bar and a posterior oblong socket, not completely enclosed ventrally.

Adductor muscle scar consists of a slightly curved, vertical row of four small spots and an additional more anterior spot. Inner lamellae of moderate width, having an unusual post-midventral broad spot; vestibule present terminally and anteromedially; radial canals numerous and are in part paired and with bulbous median expansions.

Length of holotype male left valve (pl. 4, fig. 20) 0.78 mm, height 0.38 mm, convexity of left valve 0.20 mm; type locality and horizon, locality P-2, Isle of Wight County, Va., middle Yorktown Formation.

**Relationships.**—As compared to *Murrayina howei* Puri, 1954 this species has more evenly convex valve surfaces, and particularly lacks the deep furrow that defines the anterior marginal rim on its inner flank, in that species. *M. gunteri* (Howe and Chambers, 1935) also has a more rugose surface than *M. macleani.*

**Occurrence.**—The species was obtained from the middle Yorktown Formation at localities C-1 and C-2, Nansemond County, Va., and P-2, Isle of Wight County, Va. It is not known to occur outside the Yorktown Formation, but a similar though more
elliptical form Murrayina sp was recorded in the Waccamaw Formation of North Carolina (Swain, 1968).

Number of specimens studied.—12.

Ecology.—The species represents a marine open shelf environment as judged from species with which it is associated.

Zoogeographic derivation.—As nearly as can be determined, this form originated in the western North Atlantic Subtropical Realm.

Named after.—James D. McLean, Jr.

Figured specimens.—USNM 179612-179624.

Genus ACTINOCYTHEIS Puri, 1953


The shell characteristics of the genus were diagnosed by Moore and others (1961, p. 334). Type species, Cythere exanthemata Ulrich and Bassler, 1904. Geologic range, Eocene to Holocene.

Actinocythereis exanthemata exanthemata (Ulrich and Bassler)
Plate 4, figures 23, 24; plate 5, figures 1, 2; plate 10, figures 1a-g

Cythere exanthemata Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 117, pl. 36, figs. 1-5.

Cythereis exanthemata (Ulrich and Bassler). van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 88, fig. 2; Swain, 1948, Maryland Dept. Geology, Mines, and Water Resources Bull. 2, p. 204, pl. 12, figs. 14, 15.

Cythereis exanthemata var. marylandica Howe and Hough, 1935, Florida Geol. Survey Bull. 13, p. 18, pl. 1, figs. 1-5; pl. 4, fig. 7.

Trachyleberis exanthemata (Ulrich and Bassler). Swain, 1952, U.S. Geol. Survey Prof. Paper 234-A, p. 37, pl. 6, fig. 5; Malkin, 1953, Jour. Paleontology, v. 27, p. 791, pl. 81, figs. 16, 19, 20; van den Bold, 1964, Geol. no. 11, p. 8.


Remarks.—The adductor muscle scar consists of four slightly raised spots (pl. 10, fig. 1g); “frontal” spot lying near dorsal end of main group also a raised spot. A. exanthemata marylandica (Howe and Hough, 1935) probably represents females of the species as shown on plate 4, figure 23, whereas the males are represented by plate 4, figure 24.

Occurrence.—This species was found throughout the Miocene in the collections studied in the lower part of the Calvert Formation, middle Miocene Gibson’s locality PPN-1 (highest of samples in bluff, 1 mile north of Plum Point), Calvert County, Md.; middle part of Calvert Formation, localities PPS-1 (lower of four samples) PPS-1 (lower of two samples in bluff 1 mile south of Plum Point), and PC-1 (lower of three samples in bluff 0.5 of a mile south of Parker Creek), Calvert County, Md.; lower part of Choptank Formation, middle Miocene, locality Y-1 (lower of two samples in Drum Cliff near Jones Wharf), St. Marys County, Md. It also occurs in the Pungo River Formation that is exposed on the sea floor in Onslow Bay, Atlantic Ocean. The species was not found in collections from the St. Mary’s Formation. In the lowest part of the Yorktown Formation, upper Miocene, it was found at localities A-6, B-2, Hertford County, N.C., and 1 mile above Seaboard Air Line Railroad Bridge on Meherrin River, Northampton County, N.C.; middle part of Yorktown Formation, locality C-2, D-1 and D-2, Nansemond County, Va.; K-3, Dinwiddie County, Va., P-1, R-1, R-3 and R-4, Isle of Wight County, Va.; S-3 and S-4, James County, Va.; upper part of Yorktown Formation, localities H-1, H-2, and H-3, Bertie County, N.C.; Duplin Marl, upper Miocene, Barwick Farm, Duplin County, N.C. In the undivided Yorktown Formation in core hole BE-C13-63, Beaufort County, N.C., the species was recorded at depths of 178 feet to 185 feet 9 inches. The species has been recorded previously from the Calvert and Choptank Formations of Maryland and the Chesapeake Group of Virginia (Ulrich and Bassler, 1964); the Calvert and Choptank Formations of Maryland (Malkin, 1953), but not the Yorktown Formation which Malkin believed contains A. exanthemata gomillionensis (Howe and Ellis, 1935) rather than A. exanthemata exanthemata (Ulrich and Bossier, 1904); subsurface upper Miocene of North Carolina (Swain, 1952); Chipola Formation, the Oak Grove Member of the Shoa River Formation, and Choctawhatchee Formation (of former usage) of Florida Panhandle area (Puri, 1954); Waccamaw Formation of North and South Carolina (Swain, 1968) and Holocene of Gulf of Mexico (Hulings, 1967). Forms related to the species were reported from the Miocene Agua Clara Formation of Venezuela (van den Bold, 1964).

Number of specimens studied.—50+.

Ecology.—The species ranges in distribution from lagoons and bays, generally the open and lower parts, to the open shelf sublittoral and neritic en-
vornaments and in a wide variety of bottom conditions.

Zoogeographic derivation.—The species and genus evidently evolved in the marine environment off the southeastern United States in early Miocene time from the Oligocene “Trachyleberis” rosefieldensis Howe and Law, 1935 or similar species.

Figured specimens.—USNM 179627–179631.

Actinocythereis exanthemata var. gomillionensis (Howe and Ellis) Plate 4, figure 22

Cythereis exanthemata var. gomillionensis (Howe and Ellis, 1935, Florida Geol. Survey Bull. 13, p. 19, pl. 1, figs. 6–12; pl. 4, fig. 3; Edwards, 1944, Jour. Paleontology, v. 18, p. 521, pl. 87, figs. 31, 32; van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 88, pl. 9, fig. 19; van den Bold, 1950, Jour. Paleontology, v. 24, p. 83.


Trachyleberis exanthemata var. gomillionensis (Howe and Ellis). Malkin, 1953, Jour. Paleontology, v. 27, p. 792, pl. 81, figs. 17 [not figs. 15, 18=Cletocythereis mundorffi (Swain)].


Occurrence.—The species was found in the present collection in the beds of Pliocene (?) age, locality G–3, Bertie County, N.C. It was described and recorded earlier from the Choctawhatchee Formation (of former usage) Area zone, upper Miocene, of Florida (Howe and others, 1935; Puri, 1953, 1954); the Duplin Marl, upper Miocene of North Carolina (Edwards, 1944), the Yorktown Formation, upper Miocene of Virginia (Malkin, 1953; McLean, 1957) and the Miocene of the Caribbean region (van den Bold, 1946).

Number of specimens studied.—Four.

Ecology.—The associated species suggest that this form lived in sublittoral to neritic open-shelf habitats.

Zoogeographic derivation.—The species apparently originated in the southeastern United States shelf area in late Miocene time as an ecologic variant of A. exanthemata exanthemata (Ulrich and Bassler, 1904).

Figured specimens.—USNM 179632–179634.

Genus CLETOCYTHEREIS Swain 1963

Cletocythereis Swain, Jour. Paleontology, v. 37, p. 823.

A trachyleberidid genus characterized by dimorphic male shell having a posteroventral flangelike expansion of shell which is weaker in the relatively higher female shells, posterodorsal subvertical short ridge, reticulate and nodose surface and prominent anteromedian node. Type species, Cythereis rastromarginata Brady, 1880. Geologic range, Pleistocene to Holocene.

Cletocythereis mundorffi (Swain) Plate 5, figures 3, 4; plate 11, figures 1a–d

Trachyleberis mundorffi Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 36, pl. 5, fig. 19; pl. 6, fig. 4.

Actinocythereis exanthemata gomillionensis (Howe and Ellis). Malkin, 1953, Jour. Paleontology, v. 27, p. 729, pl. 81, figs. 15, 18 [not fig. 17].


The characteristics of the present species were described previously (Swain, 1952, 1968) and are further illustrated herein.

Occurrence.—In this collection the species was obtained from the lower and middle parts of the Yorktown Formation and from the Duplin Marl (also see Hazel, 1971). In the lower Yorktown Formation it was found at locality A–1, Bertford County, N.C., at locality Z, Hanover County, Va. and 1 mile above Seaboard Air Line Railroad Bridge on Meherrin River, Northampton County, Va. In the middle Yorktown it occurs at locality C–1, Nansemond County, Va., locality K–3, Dinwiddie County, Va., locality R–2, Isle of Wight County, Va., and locality S–2, James County, Va. In the Duplin Marl it was obtained at the Barwick Farm locality, Duplin County, N.C. It was previously recorded from the middle and upper Miocene, from wells in North Carolina (Swain, 1952) and from the Waccamaw Formation of North Carolina, Swain, 1968).

The forms identified by Hazel (1967) as Actinocythereis dawsoni (Brady, 1870) from the Gulf of Maine, Vineyard Sound, Gulf of St. Lawrence, Browns Bank, and Atlantic Ocean Continental Shelf off northeastern North America, and in the Pleistocene of Maine and Quebec, and Actinocythereis vineyardensis (Cushman, 1906) from Vineyard Sound, Gulf of Maine, Georges Bank, and Atlantic Shelf are very similar to C. mundorffi mundorffi although somewhat less reticulate, and may be descended from it.

Number of specimens studied.—15.

Ecology.—In its fossil associations and its relationships to modern forms this species apparently
lived in sublittoral to neritic open shelf and open bay habitats.

Zoogeographic derivation.—This form seems to have originated in the North American Atlantic area.

**Figured specimens.—** USNM 179635–179640.

*Cletocythereis mundorffi* subs. 
Plate 5, figures 5–8

This subspecies is characterized by narrower median longitudinal and associated ridges on the shell surface than in *C. mundorffi mundorffi* (Swain, 1952). Only the short, high forms, presumably females, have been found for this subspecies.

Length of figured shell 0.67 mm, height 0.43 mm, convexity 0.36 mm.

**Occurrence.**—The subspecies occurs in the middle Yorktown Formation, locality C-1, Nansemond County, Va.

**Number of specimens studies.**—Three.

**Ecology.**—The subspecies is associated with abundant *Cytheretta burnsi* (Ulrich and Bassler, 1904), *Loxoconcha pirusubrhomboida* Edwards, 1953, *Murrayina mcleani* n. sp., and *Muellerina micula* (Ulrich and Bassler 1904) and other forms that suggest an open-shelf marine environment.

Zoogeographic derivation.—This form apparently originated in the North American Atlantic area from *C. mundorffi* as a localized subspecies.

**Figured specimens.**—USNM 179641–179643.

**Genus COSTA Neviani 1928**


**Costa barclayi** (McLean)

Plate 5, figures 9–12, plate 9, figures 10a, b, 11


**Remarks.**—The shape, hingement, general surface ornamentation of the shell, and particularly the longitudinal ridge downturned at the posterior end, relate this species to *Costa* Neviani, 1928 rather than to *Murrayina* Puri, 1954.

The inner lamellae are of moderate width; line of concrescence and inner margin separated to form narrow vestibule anteriorly (pl. 9, fig. 11); radial canals numerous and closely spaced terminally, fewer ventrally.

**Ecology.**—The species is rare to frequent in the Yorktown Formation undivided, locality O-1, Surry County, Va.; in the middle part of the Yorktown Formation, localities C-1 and D-1, Nansemond County, Va., and K-4, Dinwiddie County, Va. and is rare in beds of Pliocene (?) age, locality G-3, Bertie County, N.C. (also see Hazel 1971). Elsewhere the species has been found in the Yorktown Formation at Moore House Beach, Va. (McLean, 1957) and from the Duplin Marl near Cameron, S.C. (Pooser, 1965).

**Number of specimens studied.**—Ten.

**Ecology.**—The species with which it is associated suggest that this form inhabited littoral to sublittoral marine environments.

Zoogeographic derivation.—This species seems to have been indigenous to the western Atlantic shelf area of the southeastern United States. Related species of *Costa* occur in the Mediterranean Sea Realm.

**Figured specimens.**—USNM 179644–179654.

**Subfamily ECHINOCYTHEREIDINAE Hazel, 1967**

*Genus ECHINOCYTHEREIS* Puri, 1954


The shell characteristics of the genus were diagnosed by Moore and others (1961, p. 336). The appendages were discussed by Hazel (1967) from the viewpoint of their relationships to both the Hemi­cytheridae and the Trachyleberididae. Type species, *Cythereis garretti* Howe and McGuir, 1935. Geologic range, Upper Cretaceous to Holocene.

**Echinocythereis? clarkana** (Ulrich and Bassler)

Plate 5, figures 13–15

*Cythere clarkana* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 98, pl. 35, figs. 1–10.

*Cythere calverti* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 100, pl. 38, figs. 11–13.

*Cythere clarkana* var. *miniscula* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene, volume, p. 99, pl. 35, figs. 11–14.


*Trachyleberis clarkana* (Ulrich and Bassler). Malkin, 1953, Jour. Paleontology, v. 27, p. 792, pl. 82, figs. 1–5.

**Remarks.**—*Echinocythereis? ligula* (Lienenklaus, 1897) as illustrated by Oertli (1956) from the Ru-
pelian Stage (Oligocene) of Switzerland is similar to E.? clarkana but is somewhat more spinose.

Occurrence.—The species is rare in the present collection at locality U–1, Essex County, Va., locality A–1, Hertford County, N.C., and localities M–2 and M–3, Surry County, Va., lower Yorktown; and at localities S–1, James County, Va. and C–2, Nansemond County, Va., middle Yorktown. It was also found in the Calvert Formation, but not in the overlying Choptank and St. Marys Formations in the present collection. It was described originally from the Calvert Formation of Maryland (Ulrich and Bassler, 1904) and has since been recorded from the Calvert Formation, subsurface, of Maryland (Swain, 1948), the Calvert and Kirkwood Formations of Maryland (Malkin, 1953), the lower, middle, and upper Miocene, subsurface, of North Carolina (Swain, 1952), the pre-Yorktown Miocene of Virginia (McLean, 1957) and the Cooper Marl, Oligocene, of South Carolina (Foose, 1965). The range of the species is known to be Oligocene to upper Miocene, middle Yorktown Formation, of the middle Atlantic States. It does not seem to range into the upper Yorktown or younger deposits. It has been found in offshore samples in the Atlantic Ocean (“Onslow Bay”) where it occurs in the Pun go River Formation.

Number of specimens studied.—Nine.

Ecology.—The species lived in a nearshore littoral to sublittoral environment judged from associated species that are still living such as Aurila conradi (Howe and McGuirt, 1935) and Cytherura forulata, Edwards, 1944, and may have ranged into lower-than-normal salinity environments (Hulings and Puri, 1965).

Zoogeographic derivation.—The species has close relatives among European Oligocene Ostracoda, as for example E.? ligula (Lienenklaus, 1897) of the Rupelian of Switzerland, and may have originated either there or in its American area of occurrence.

Figured specimens.—USNM 179655–179657.

Family CAMPYLOCYTHERIDAE Puri, 1960

In a recently published paper on the ostracode subfamily Campylocytherinae, Plusquellec and Sandberg (1969) retained Campylocythere Edwards, 1944 and Acuticythereis Edwards, 1944 as distinct genera and proposed a new genus Proteoconcha. These three genera, probably together with Bensonocythere Hazel, 1967 are arranged by Plusquellec and Sandberg in the Family Hemicytheridae, Subfamily Campylocytherinae. The present writer believes that the more strongly developed “amphidont”-type hinge elements and the general tendency toward well-developed splitting of the adductor muscle scar spots of the Hemicytheridae are features that would exclude the weaker hinged mainly unsplitt-adductor scar Acuticythereis and Campylocythere. Enough variation in appendage structures occurs in both hemicytherid and campylocytherid ostracodes, despite their general similarity, to discourage their grouping in the same family. For these reasons the family Campylocytheridae is retained in this paper.

Genus BENSOCYTHE Hazel, 1967


The genus was described fully by Hazel (1967). Type species, Leguminocythereis whitei Swain, 1952.

Geologic range, Oligocene (?) Miocene to Holocene.

Bensocythere whitei (Swain)

Plate 5, figures 16, 17; plate 11, figures 2a–e; plate 12, figures 1a–f


Remarks.—The adductor muscle scar lies on the edge of a median pit and consists of four spots in a curved vertical row (pl. 12, fig. 1d); each spot is marked by a ridge on the posterior side and a furrow on the anterior side; these features are believed by the writer to result from the angle at which the adductor muscle strands are attached to the shell, those along the posterior side of each bundle of muscle strands arise at an acute angle from a ridge owing to higher stress requirements whereas those arising at a steeper angle from the anterior side have lower stress requirements and originate in furrows.

Occurrence.—The species has been obtained from the lower part of the Choptank Formation, middle Miocene, to the Holocene and is believed (Hazel, 1967) to be still living in the Atlantic Ocean (also see Hazel, 1971 and Valentine, 1971). It was recorded dubiously from the Oligocene, subsurface, of North
UPPER MIocene AND PLIOcene(? ) OSTRACODA, ATLANTIC COASTAL REGION

Carolina (Swain, 1952), but that record is questionable.

**Number of specimens studied.**—25 +.

**Ecology.**—The species inhabited an open marine shelf at sublittoral to neritic depths judging from modern representatives.

**Zoogeographic derivation.**—These ostracodes apparently originated in the Boreal Realm in the western North Atlantic shelf area of North America.

**Figured specimens.**—USNM 179658–179663.

**Genus CAMPYLOCYthere Edwards, 1955**


The shell of the genus was diagnosed by Plusquellec and Sandberg (1969). Type species, *C. laeva* Edwards, 1944. Geologic range, Miocene to Holocene.

*Campyllocythere laeva* posteropunctata Edwards

Plate 5, figures 21–24; plate 8, figure 3

*Campyllocythere laeva* posteropunctata Edwards, 1944, Jour. Paleontology, v. 18, p. 515, pl. 86, figs. 15, 16.

**Remarks.**—The subspecies was placed in synonymy with *C. laeva* Edwards, 1944 by Plusquellec and Sandberg (1969), on the basis that all degrees of ornamentation occur, but their illustrations show only a smooth form (*laeva* laeva) and a coarsely and (or) minutely pitted punctate form (*laeva* posteropunctata).

**Occurrence.**—The subspecies is rare in the middle Yorktown Formation locality C–1, Nansemond County, Va., and in beds of Pliocene (?) age, locality G–3, Bertie County, N.C. It was originally described from the Duplin Marl, upper Miocene of North Carolina.

**Number of specimens studied.**—Three.

**Ecology.**—The associated species as well as modern representatives suggest that this form inhabits sublittoral open-shelf habitats, typically on a clean sandy bottom.

**Zoogeographic derivation.**—The species originated in the southeastern United States-Gulf of Mexico marine realm in late Miocene time.

**Figured specimens.**—USNM 179667–179669.

**Genus ACUTICYthereis Edwards, 1944**


Shell shorter and more unequal-ended than *Campyllocythere* and right valve tends to be subangulate posteriorly, internally like *Campyllocythere*. Type species, *A. laevissima* Edwards, 1944. Geologic range, Miocene–Holocene. The genus is retained on the basis of Plusquellec and Sandberg's study (1969). In recent years *Acuticythereis* had been placed in synonymy with *Campyllocythere*.

*Acuticythereis laevissima* punctata Edwards

Plate 6, figures 2, 3

*Acuticythereis laevissima* punctata Edwards, 1944, Jour. Paleontology v. 18, p. 520, pl. 87, figs. 12, 13.

**Occurrence.**—This subspecies was found rarely at locality S–3, James County, Va. in the middle Yorktown and at locality G–3, Bertie County, N.C. in beds of Pliocene (?) age. It was originally described from the lower part of the Duplin Marl at Natural Well, near Magnolia, N.C. (Edwards, 1944).

**Number of specimens studied.**—Two.

**Ecology.**—Judging from associated species, this form lived in sublittoral to neritic open shelf environments.
Zoogeographic derivation.—This form is apparently indigenous to the southeastern United States area.

Figured specimens.—USNM 179671, 179672.

*Acuticythereis* laevissima laevissima Edwards

Plate 6, figures 4–6; plate 8, figures 1, 5, 12

*Acuticythereis* laevissima Edwards, 1944, Jour. Paleontology, v. 18, p. 519, pl. 87, figs. 4–11. (See Plusquellec and Sandberg, 1969, for complete synonomy.)

Occurrence.—The species was found in the present collection in rare occurrence in beds of Pliocene (?) age at locality G–3 and in the upper Yorktown Formation at localities H–1 and H–2, Bertie County, N.C.; in rare to frequent occurrence in the middle Yorktown at localities S–1 to S–4, James County, Va.; localities P–1, R–1, and R–4, Isle of Wight County, Va., K–1, D–1, and D–2, Nansemond County Va.; and frequent occurrence in the lower Yorktown at the locality 1 mile above Seaboard Airline Railroad bridge on Meherrin River, Hertford County, N.C. The species also occurs in the upper Miocene Duplin Marl (Edwards, 1944) of North Carolina, the Pliocene Waccamaw Formation of North and South Carolina (Swain, 1968), and is living off the west coast of Florida (Puri, 1960; Hulings and Puri, 1965). It was reported earlier from the Yorktown Formation of Virginia (Malkin, 1953; McLean, 1957), and from the Choptank Formation of Maryland (Malkin, 1953). In the present collection it is rare in the upper St. Marys Formation of Maryland.

Number of specimens studied.—29.

Ecology.—This subspecies is found at present in sublittoral shallow water environments of normal to slightly reduced salinity.

Zoogeographic derivation.—The species originated in the western Atlantic or Gulf of Mexico realm of the southeastern United States.

Figured specimens.—USNM 179673, 179674.

*Acuticythereis*? sp., immature

Plate 6, figure 7

Shell subreniform in side view, highest about one-fourth from anterior end; dorsal margin strongly convex, sloping more steeply anteriorad of than posteriorad of position of greatest height; ventral margin concave anteriomedially; anterior margin broadly curved, extended below, posterior margin narrowly curved also extended below. Valves somewhat compressed, most convex medially; left valve slightly larger than right. Surface smooth. Internal shell features mostly not observed. Adductor muscle scar consists of about four spots in an anteromedian vertical row.

Length of figured specimen 0.48 mm, height 0.24 mm, convexity 0.17 mm.

Remarks.—This form is more compressed and more reniform in outline than the mature specimens of *Acuticythereis* in the collection, but its general form suggests that it may represent this genus. It is illustrated here to show the difference in shape from that of mature *Acuticythereis*.

Occurrence.—Rare in middle Yorktown Formation, locality R–2, Isle of Wight County, Va.; and in lower Yorktown, locality A–5, Hertford County, N.C.

Number of specimens studied.—Five.

Ecology.—The associated species suggest that this form lived in shallow sublittoral waters of normal to slightly reduced salinities.

Figured specimens.—USNM 179675.

Family LEGUMINOCYTHEREIDIDAE Howe, 1961

Genus PRODICTYOCYTHERE Swain, n. gen.

Diagnosis.—A leguminocytheeidid genus having a trapezoidally outlined shell, reticulate or pitted surface, and flattened or overhanging venter.

Description.—Shell subtrapezoidal in lateral outline; hinge margin shorter than but subparallel to ventral margin; terminal margins extended below, truncate above. Surface reticulate or pitted. Left valve slightly larger than right; valves more or less compressed but venter flattened and somewhat expanded. Hinge amphidont, that of right valve consists of an anterior rounded tooth, postjacent socket that passes into interterminal furrow and posterior rounded tooth. Adductor muscle scar a vertical row of four spots and one or two additional, more anterior spots. Inner lamellae of moderate width and with narrow vestibules terminally. Radial canals fairly numerous and closely spaced.

Type species, *P. trapezoidalis*, n. sp. Geologic range upper Miocene.

Relationships.—The genus resembles *Dictocythere* Sylvester-Bradley, 1955 of the Jurassic and Lower Cretaceous but has a more strongly developed holamphidont hinge and a more uniformly convex surface than that genus. The hingement, musculature, and general shape of the genus suggest that it belongs in the Leguminocythereididae.

*Prodicythecythere trapezoidalis*, n. gen., n. sp.

Plate 6, figures 8–10; plate 8, figure 6

Diagnosis.—*Prodicythecythere* having surface marked by a coarse pattern of reticulating ridges.

Description.—Shell elongate-subtrapezoidal in outline, highest about one-fourth from anterior end;
dorsal margin nearly straight, about three-fifths of shell length, with obtuse cardinal angles, the anterior less so than the posterior; ventral margin nearly straight, converging slightly toward dorsum posteriorly; anterior margin extended and rounded below, truncate above; posterior margin narrower than anterior; strongly extended below, truncate above, and extending farther beyond end of hinge than anterior. Valves somewhat compressed, greatest convexity median, lateral margins straightened medially in edge view. Left valve slightly larger than right, overlapping right terminally and in cardinal areas.

Surface bears strongly reticulating ridges that are arranged concentrically in free-marginal zone; anteromedially is a rounded only partly ornamented median node; ridges and pits are of about equal width.

Hinge holamphidont, consisting in left valve of an anterior rounded deep socket, posterio-adjacent rounded tooth, interterminal bar slightly enlarged at its posterior end, and a posterior rounded socket. Inner lamellae of moderate width; line of concrescence and inner margin slightly separated terminally.

Length of holotype shell (pl. 6, figs. 8–10) 0.76 mm, height 0.34 mm, convexity 0.36 mm. Type horizon and locality, middle Yorktown Formation, locality C–1, Nansemond County, Va.

Relationships.—The general shape and hingement are similar to Dictyocythere retirugata (Jones, 1885) of the Jurassic, but the present species is more evenly convex and has a more clearly holamphidont hinge than that of Dictyocythere Sylvester-Bradley, 1956.

Occurrence.—The species is rare in the middle Yorktown Formation at locality C–1, Nansemond County, Va., and in the lower Yorktown at locality A–1 Hertford County, N.C.

Number of specimens studied.—Four.

Ecology.—The species occurs with abundant Aurila conradi (Howe and McGuirt, 1935) and probably represents a shallow sublittoral marine shelf habitat.

Zoogeographic derivation.—This form appears to be indigenous to the western Atlantic Ocean area of the southeastern North America realm.

Figured specimens.—USNM 179676–179678.

Family HEMICY TherIDAE Puri, 1953
Subfamily HEMICY TherINAE Puri, 1953
Genus RADIMELLA Pokorny, 1968

Diagnosis.—“Carapace rather varying in shape, hemicytheroid, elongate-oval or subquadrato, reticulate. Eye tubercle interrupts regular arch formed by anterior marginal and anterodorsal ridges, the latter of which fuses in anterodorsal region with frontal keel. Ventral surface bordered by ventrolateral ridge. Hinge amphidont. Right valve with high anterior tooth bordered dorsally by lower elongate step; median element consists of anterior socket and finely structured groove; auxiliary denticles cross the groove in front of ventrally incised posterior tooth. Three frontal muscle scars. Dorso- median and ventromedian adductor scars divided. Lateral canals of sieve type accompanied in some species by simple, lateral canals visible even under low magnification. Vestibule inconspicuous or absent. Some 60 to more than 100 simple marginal pore canals present in front of ventral concavity. Length/ height ratios of males larger, their mean length usually smaller than that of females.” (Pokorny, 1968)

Type species.—R. dictyon Pokorny, 1968.

Geologic Range.—Upper Miocene to Holocene.

Hemicythere confragosa (Edwards)
Plate 6, figures 11–13.


Mutilus confragosa (Edwards). Puri, 1960, Gulf Coast Assoc. Geol. Soc. Trans., v. 10, p. 130; Swain, 1967, Geol. Soc. America Mem. 101, p. 83, pl. 6, figs. 1a, b, text fig. 52a; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 21, pl. 4, figs. 8a–e, pl. 5, figs. 5a–c, pl. 7, figs. 3a–c.

Aurila confragosa (Edwards). van den Bold, 1963b, Micropaleontology, v. 9, p. 385, pl. 8, fig. 1.


Occurrence.—In the present collection the species is rare in the upper Yorktown at locality H–3, and in the beds of Pliocene (?) age, Mount Gould Landing, Bertie County, N.C. (also see Hazel, 1971). It was described from the upper Miocene Duplin Marl of North Carolina (Edwards, 1944) and has also been recorded from the upper Miocene of Florida (Puri, 1954) and the Caribbean region (van den Bold, 1963), and the Pliocene Waccamaw Formation of South Carolina (Swain, 1968) and is living...
off the south coast of Florida (Puri, 1960). Forms recorded from the Gulf of California (Swain, 1967) I now believe are a different species.

Number of specimens studied. — 25 +.

Ecology.—The species lives at present in warm shallow sublittoral carbonate environments in Florida.

Zoogeographic derivation.—The species apparently originated in the southeastern United States-Gulf of Mexico region in the late Miocene. With respect to the genus itself, Pokorny (1969) has found 16 Holocene species in the Galapagos Islands. He states that Radiinella underwent strong insular radiation in the shallow waters around the Galapagos to which it probably migrated from Central America.

Figured specimens.—USNM 179681, 179682.

Genus AURILA Pokorny, 1955


The shell characteristics of Aurila were summarized by Howe in Moore and others (1961, p. 302). Type species, Cythere punctata Baird, 1850 (= Cythere punctata Münster, 1830). Geologic range, Oligocene to Holocene.

Aurila conradi (Howe and McGuirt)

Plate 6; figures 14–18; plate 13, figures 1a–g


Remarks.—The elevated rounded adductor muscle scar has furrows around the two sets of divided spots (pl. 13, fig. 1c); the three “frontal” scars are rounded and elevated and the dorsal two have furrows as illustrated.

Occurrence.—The species was found in the present collection in the upper Yorktown, rare to frequent at localities H–2 and H–3, Bertie County, N.C.; rare to abundant in the middle Yorktown at localities S–1 to S–5, James County, Va., P–1, P–3, R–1 to R–4, Isle of Wight County, Va., K–3 and K–4, Dinwiddie County, Va., C–1, C–2, D–1 and D–2, Nansemond County, Va.; in the lower Yorktown, rare to common at localities A–1 and B–1, Hertford County, N.C. and 1.5 miles upstream from Seaboard Airline Railroad Bridge on Meherrin River, Northampton County, N.C. (also see Hazel, 1971).

The species previously has been obtained from the upper Miocene of Florida (Howe and McGuirt, 1936; Puri, 1954), the upper Miocene Duplin Marl of North and South Carolina (Edwards, 1944, Pooser, 1965), the subsurface upper Miocene of North Carolina (Swain, 1952), the Yorktown Formation of Virginia (Malkin, 1953; McLean, 1957) the Pliocene Waccamaw Formation of North and South Carolina (Swain, 1968), and the Holocene of the Gulf of Mexico region (Swain, 1955; Puri, 1960; Hulings and Puri, 1965). Records of pre-upper Miocene subsurface occurrences in North Carolina (Swain, 1952) are believed by the writer to be displaced specimens.

Number of specimens studied. — 100 +.

Ecology.—In the Gulf of Mexico region the species is living in sublittoral shallow bays or nearshore bays where salinities may range from subnormal to above normal for sea water.

Zoogeographic derivation.—This late Miocene species seems to have originated in the Gulf of Mexico-Caribbean region but there are closely related forms in the Oligocene of the same area and in the Oligocene and Miocene of the Mediterranean region and southern Europe. Either area may have served as the origin of this group of species.

Figured specimens.—USNM 179684–179692.

Genus CAUDITES Coryell and Fields, 1937


The shell of the genus was diagnosed by Howe in Moore and others (1961, p. 302). Type species, C. medialis Coryell and Fields, 1937. Geologic range, Eocene to Holocene.

Caudites? sp.

Plate 6, figure 20

Caudites? sp. Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 22, pl. 5, figs. 6a, b; pl. 6, fig. 13; pl. 7, figs. 8a–c.
Shell subquadrate-subreniform in side view, highest one-fourth from anterior end; cardinal angles broadly obtuse, not well defined; dorsal margin slightly convex; ventral margin concave; anterior margin broadly curved, extended below; posterior margin angulated ventromedially, prominently truncated above, more weakly truncated below. Left valve slightly larger than right, over-reaching right along terminal-dorsal slope. Valves compressed, greatest convexity median to posteromedian.

Free margins provided with narrow submarginal rim that posteriorly lies farthest from margin; a small oblique eye tubercle lies anterodorsally; general median surface bears several longitudinal wrinkle-like low ridges (especially an oblique anteroventral one) and furrows but is nearly smooth; posterior end compressed.

Hinge of right valve consists of an anterior high pointed tooth, posterojacent rounded socket, interterminal and subjacent rabbet-groove formed in edge of valve, and a posterior pointed tooth; inner lamellae are of moderate width; vestibule is present terminally but is narrow; radial canals are very numerous but closely spaced; there are three large pillars anteriorly on inner valve surface adjacent to inner margin; adductor muscle scar not clearly seen but apparently consists of a median vertical row of spots and two more anterior "frontal spots."

Length of figured specimen 0.47 mm, height 0.26 mm, convexity 0.17 mm.

Relationships.—This species has the general shape, ornamentation, and internal structures of Caudites but is less sharply extended posteriorly than are most members of that genus. Its relatively smooth surface and low oblique anteroventral ridge also help to distinguish it from other species of the genus.

Occurrence.—The species is rare in beds of Pliocene (?) age at locality G-3, Bertie County, N.C. It was previously recorded in the Duplin Marl, upper Miocene of North Carolina, and the Pliocene Waccamaw Formation, North Carolina (Swain, 1968).

Number of specimens studied.—Four.

Ecology.—The associated species suggest that the species lived in an open shelf neritic environment.

Zoogeographic derivation.—The species has several similarly appearing relatives in the southeastern United States, Gulf of Mexico-Caribbean region and apparently originated there in late Miocene time.

Figured specimen.—USNM 179695.

Genus MUELLERINA Bassioumi, 1965


The characteristics of the genus were diagnosed by Bassioumi (1965, p. 509), and were discussed in further detail by Hazel (1967). Type species, Cythere latimarginata Speyer, 1863. Geologic range, Oligocene to Holocene.

Muellerina micula (Ulrich and Bassler)

Plate 7, figures 1-8

Cythere micula Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 116, pl. 36, figs. 18-20.


Trachyleberis martini (Ulrich and Bassler). Malkin, 1953, Jour. Paleontology, v. 27, p. 793, pl. 82, figs. 6-13.


Mue1lerina lienenklausi (Ulrich and Bassler). Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 21, pl. 3, figs. 3-6, 11, pl. 7, figs. 1, 4, 5, 7; Swain, 1952, U.S. Geol. Survey Prof. Paper 573-D, p. 16, pl. 3, figs. 2a-b, 3a-b, 4a, text fig. 15.

Remarks.—The confused status of this species was reviewed by Hazel (1967) who concluded that Cythere lienenklausi Ulrich and Bassler, 1904 is the species to which should be referred the forms identified by Murrayina martini (Ulrich and Bassler 1904) by authors in recent years. The present writer has since studied the broken left valve type specimen of lienenklausi in the U.S. National Museum and, while recognizing the value of Hazel's work on the genus, concludes that the form is too incompletely known to serve as the name for "Murrayina martini" particularly because the original illustration of lienenklausi matches the broken type only in a general way. The types of Cythere micula (Ulrich and Bassler, 1904) are represented by two immature left valves that to the writer are more representative of "Murrayina martini" than is the lienenklausi type, especially in the presence in the latter of a stronger ventral longitudinal ridge than occurs in micula. Williams (1966) has referred Holocene forms of this type to Murrayina micula. Muellerina micula seems to be the best available name for the forms illustrated here.

Occurrence.—In the present collection the species is rare in the upper Yorktown Formation, localities...
H–1 and H–3, Bertie County, N.C.; rare in the middle Yorktown at localities S–1, S–3, S–4, and S–5, James County, Va.; P–1, P–3, R–1, R–3, and R–4, Isle of Wight County, Va.; K–3 and K–4, Dinwiddie County, Va.; and common to abundant at C–1, C–2, D–1, and D–2, Nansemond County, Va. In the lower Yorktown the species is rare to common at localities M–1, Surry County, Va., B–1, B–2, A–1 to A–6, Hertford County, N.C. The species also ranges into the middle Yorktown at localities S–1, S–3, S–4, and S–5.

Previously the species was recorded from the Calvert and Yorktown Formations of Maryland and Virginia (Ulrich and Bassler, 1904), the Yorktown, Choptank, Kirkwood, and Calvert Formations of Maryland, Virginia, and New Jersey (Malkin, 1953; Swain, 1948; McLean, 1957), the subsurface middle and upper Miocene of North Carolina (Swain, 1952), the upper Miocene Duplin Marl of South Carolina (Pooser, 1965), the upper Miocene of Florida (Puri, 1954), the Pliocene of North and South Carolina (Swain, 1968), the Pleistocene of Georgia (Hall, 1965), and the Holocene of the Atlantic Ocean off the northern United States (Hazel, 1967; Williams, 1966). Records of pre-Miocene occurrences of the species in wells in North Carolina (Swain, 1952) are believed by the writer to be displaced specimens.

Number of specimens studied.—100+.

Ecology.—The forms identified as *Muellerina lieneklansi* were obtained by Hazel (1967) from the Gulf of Maine, Browns Bank, Georges Bank, and other localities on the Atlantic Ocean shelf off northeastern United States at depths ranging from 37 to 165 meters. Those forms appear to be the same as the ones here referred to *M. micula*.

Zoogeographic derivation.—The species appears to be of North Atlantic origin.

Figured specimens.—USNM 179696–179703.

**Genus ORIONINA Puri, 1954**


The shell characteristics of the genus were diagnosed by Howe in Moore and others (1961, n. 339), and the musculature and anterior internal pillars were discussed by van den Bold (1963) and Swain (1968).

Howe in Moore and others (1961, p. 339) referred *Jugosocythereis* Puri (1957) to *Orionina*, but in the writer’s opinion the shell structure and musculature of the two genera are distinct enough to require separation.

Type species, *Cythere vaughani* Ulrich and Bassler, 1904 (considered by Pooser, 1965 to be a synonym of *Cythere bermudae* Brady, 1880, = *Cythere serrulata* Brady, 1869, not Bosquet, 1854). Van den Bold (1963), however, cites the variation in the marginal zone and the more extended anterior end of *O. serrulata* as basis for keeping the two species separate. Geologic range, Miocene to Holocene.

*Orionina vaughani* (Ulrich and Bassler)

Plate 7, figure 17; plate 12, figures 2a–h

*Cythere vaughani* Ulrich and Bassler, 1904, Maryland Geol. Survey Miocene volume, p. 109, pl. 38, figs. 25–27.


*Trachyleberis vaughani* (Ulrich and Bassler). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 37, pl. 6, figs. 6, 7; Malkin, 1953, Jour. Paleontology, v. 27, p. 794, pl. 82, fig. 14.

*Orionina vaughani* (Ulrich and Bassler). Puri, 1954, Florida Geol. Survey Bull. 36, p. 254, pl. 12, figs. 15, 16, text figs. 8a–c; McLean, 1957, Bulls. Am. Paleontology, v. 38, p. 88, pl. 11, figs. 6a, b; Brown, 1958, North Carolina Dept. Conserv. and Devel. Bull. 72, p. 64, pl. 3, fig. 2; van den Bold, 1963a, Jour. Paleontology, v. 37, p. 44, pl. 4, figs. 1–6, text fig. 5, 6–8; 1963b, Micropaleontology, v. 9, p. 386, pl. 6, fig. 7; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 21, pl. 4, figs. 4a–e, text fig. 19; Hall, 1965, Michigan Univ., Natl. Sci. Found. Project GB–26, Rept. 4, p. 35, pl. 7, figs. 4, 5, 7; van den Bold, 1965, Micropaleontology, v. 11, p. 394.


Remarks.—The adductor muscle scar (pl. 12, fig. 2f) consists of two upper nearly square spots with submarginal furrows and a lower dorso-ventrally elongate spot. The three “frontal” scars (pl. 12, fig. 2e) also have bordering or submarginal furrows.

Occurrence.—The species is rare to common in the middle Yorktown Formation at localities S–4, James County, Va., P–3, R–2, R–3 and R–4, Isle of Wight County, Va., K–4, Dinwiddie County, Va., C–1, C–2, D–1, and D–2, Nansemond County, Va.; in the lower Yorktown it is rare to frequent 1 mile and 1.5 miles above Seaboard Airline Railroad Bridge on Meher-
rin River, Hertford County, N.C. (also see Hazel, 1971). It is also rare to frequent at several localities in the Duplin Marl in the present collection.

It has been recorded previously from the Chesapeake Group of Virginia (Ulrich and Bassler, 1904), the lower (?) and upper Miocene and Pliocene of Florida (Howe and others, 1935; Puri, 1954; Puri and Vernon, 1959), the upper Miocene Duplin Marl of North Carolina (Edwards, 1944), the upper and middle Miocene of the North Carolina subsurface (Swain, 1952), the uppermost lower Miocene and lower upper Miocene of Trinidad, the lower and middle Miocene of Venezuela, the middle Miocene and possibly lowermost Miocene of Colombia, the Miocene of Guatemala, and the middle and upper Miocene of Cuba (van den Bold, 1963). Thus the species seems to have begun in early Miocene time in northern South America but did not inhabit the Middle Atlantic States region until middle Miocene time.

**Number of specimens studied.**—25+.

**Ecology.**—The species lives in neritic open sea and perhaps bay environments of normal salinity and at depths of 4.5 to 4.35 fathoms.

**Zoogeographic derivation.**—The species originated in the Caribbean region evidently in the early Miocene and spread northward to the Gulf of Mexico and the western middle Atlantic region where it or closely related forms O. bradyi van den Bold, 1963 and O. serrulata (Brady, 1869), are still living.

**Figured specimens.**—USNM 179704–179707.

**Subfamily THAEROCYTHERINAE Hazel, 1967**

**Genus THAEROCYTHERE Hazel, 1967**


A diagnosis of the genus has been provided by Hazel (1967, p. 25). Type species, *Cythereis crenulata* Sars, 1866. Geologic range, Miocene to Holocene.

**Thaerocythere schmidtiae** (Malkin)

Plate 6, figure 19; plate 7, figures 9–15; plate 9, figures 1a–d


**Remarks.**—Inner lamellae, as seen in transmitted light (pl. 9, figs. 1a–d) of moderate width; line of concrescence and inner margin nearly coincide; radial canals terminally are closely spaced, in places occurring in pairs; along venter they are fewer in number.

**Occurrence.**—In this collection the species was found in beds of Pliocene (?) age at locality G–3; in the upper Yorktown at localities H–1 to H–3, Bertie County, N.C. and locality E, Hertford Co., N.C.; in the middle Yorktown at localities S–1 to S–5, James County, Va.; locality P–1, Isle of Wight County, Va.; locality R–3, Isle of Wight County, Va.; and in the lower Yorktown at A–1 and A–6, Hertford County, N.C.; B–1, Hertford County, N.C. and 1.5 miles above Seaboard Air Line Railroad Bridge on Meherrin River, Northampton County, Va. (also see Hazel, 1971). The species was described from the Yorktown Formation of Virginia (Malkin, 1953), and was recorded from the upper Miocene in the North Carolina subsurface (Swain, 1952).

**Number of specimens studied.**—25+.

**Ecology.**—The species inhabited a restricted sub-littoral to open-shelf environment judging from associated abundant *Cytherura*, *Aurila*, and *Cythero-morpha*.

**Zoogeographic derivation.**—The species is related to *Thaerocythere angulata* (Sars 1866) and *T. crenulata* (Sars 1865) from the North Atlantic region and seems to have been ancestral to one or both of those species.

**Figured specimens.**—USNM 179543, 179574, 179584, 179602, 179639, 179640, 179670, 179680, 179709, 179710.

**Thaerocythere sp.**

Plate 7, figure 16


A *Thaerocythere* that is characterized by a smoothed area anterior to median node and an irregularly punctate surface.

The shell features of this species were for the most part described in a preceding publication (Swain, 1952).

**Relationships.**—Close relationship of the species to *Thaerocythere angulata* (Sars) is shown by its general almondlike outline, marginal ridges and median node. It differs from Sars' species in having a smoother area anterad of the median node, lacking a smooth anteromedian patch, and in having a more irregularly punctate general surface. The species lacks the regularly punctate general surface of *T. schmidtiae* (Malkin 1953) with which it is associated.
Length of figured shell 0.69 mm, height 0.42 mm, convexity 0.35 mm.

Occurrence.—The species was obtained rarely at localities G–3, in beds of Pliocene(?) age, Bertie County, N.C. and S–5, James County, Va., middle Yorktown. It was recorded previously from the upper Miocene of the North Carolina subsurface (Swain, 1952).

Number of specimens studied.—Three.

Ecology.—The species inhabited an open shelf sublittoral environment judging from associated forms.

Zoogeographic derivation.—The form is believed by the writer to have originated in the North Atlantic realm.

Figured specimens.—USNM 179679, 179683, 179693.

Genus PURIANA Coryell and Fields, 1953


A description of the shell of this genus was given by Swain (1968) and some of the appendages of one species P. pacifica Benson were described by Swain (1967). Type species, Favella puella Coryell and Fields, 1937. Geologic range, Oligocene to Holocene.

The family position of the genus was recently revised by Hazel (1967) who has placed it in the Hemi-tyine, 1971, U.S. Geol. Survey Prof. Paper 683-D, pl. 2, figs. 31, 36.


Occurrence.—In the middle Yorktown Formation of the present collection the species is rare to common at localities P–3 and R–4, Isle of Wight County, Va., K–4, Dinwiddie County, Va.; C–1, C–2, D–1, and D–2, Nansemond County, Va.; and in the lower Yorktown Formation at locality A–5, Hertford County, N.C. (also see Hazel, 1971).

Previously the species was recorded in the upper Miocene Yorktown Formation of Virginia (Ulrich and Bassler, 1904; Malkin, 1953; McLean, 1957), the Duplin Marl of North and South Carolina (Edwards, 1944; Pooser, 1965), the middle and upper Miocene, sublittoral environment of North Carolina (Swain, 1952; Brown, 1958), the middle (?) and upper Miocene of Florida (Howe and others, 1935; Puri, 1954), the lower to upper Miocene of Cuba, Guatemala, British Honduras, Trinidad (van den Bold, 1946, 1963), the Pliocene of North and South Carolina (Swain, 1968), the Pleistocene of Virginia (Valentine, 1971) and the Holocene of Florida (Puri, 1965; Hulings and Puri, 1965; Benson and Coleman, 1965), Georgia (Hall, 1965), and North Carolina (Grossman, 1967).

Number of specimens studied.—25+

Ecology.—The species is living at present in Pamblico Sound and nearby Atlantic Ocean near Okracoke Inlet, N.C. in water 10 feet to more than 30 feet deep, salinity 25 to 35 parts per mil and on sand or silty sand substrate, associated with P. mesacostalis (Edwards, 1944) (Grossman, 1967). It also occurs in the eastern Gulf of Mexico in water 19 to 239 feet deep, but most commonly shallower than 50 feet and in water having a salinity range from 35 to 40 parts per mil (Benson and Coleman, 1963).

Zoogeographic derivation.—The species seems to have originated in the Gulf of Mexico-Caribbean region or in the southeastern United States area in early Miocene time. Its relatives have since migrated...
to the Pacific coast of central and southern North America where they are now living (Benson, 1959; Swain, 1967).

Figured specimens.—USNM 179694, 179703, 179708, 179711.

_Puriana mesacostalis_ (Edwards)
Plate 7, figure 18


_Puriana rugipunctata_ (Ulrich and Bassler) (part), Benson and Coleman, 1963, Kansas Univ. Paleont. Contr., Arthropoda, Art. 2, p. 43, pl. 8, fig. 5 [not figs. 1, 2=P. rugipunctata, fige Hall, 1965].


Occurrence.—This species is rare in the middle Yorktown Formation, locality K–4, Dinwiddie County, Va. Hazel (1971) has recorded additional occurrences in the Yorktown Formation. It was described from the upper Miocene Duplin Marl of North Carolina (Edwards, 1944) and also occurs in the upper Miocene, subsurface of North Carolina (Swain, 1952), the Pliocene Waccamaw Formation of South Carolina (Swain, 1968), and in the Holocene of Georgia (Hall, 1965) and Florida (Benson and Coleman, 1963).

Number of specimens studied.—Five.

Ecology.—The species is associated with other ostracodes, such as _Pontocythere ashermani_ (Ulrich and Bassler, 1904) that suggest an open shelf neritic habitat.

_Zoogeographic derivation._—This form apparently evolved from _P. rugipunctata_ which had its origin in the southeastern United States–Gulf of Mexico region in late Miocene time.

Figured specimens.—USNM 179712.

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PLATES 1-13

Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225.
FIGURE 1. *Bairdopilata triangulata* Edwards (p. 17).
   Right side of shell; locality S-5, James County, Va., × 32, Yorktown Formation, middle part.

2. *Aplaoocypris* sp. (p. 11).
   Interior of right valve; locality U-1, Essex County, Va., × 45, Yorktown Formation, lower part.

   3. Exterior of a poorly preserved right valve; locality A-5, Hertford County, N.C., × 45, Yorktown Formation, lower part.
   15. Right side of a shell, broken dorsally; locality A-5, Hertford County, N.C., × 69, Yorktown formation, lower part.

   4. Interior of left valve; locality PPN-1, Plum Point, 1 mile north of, Calvert County, Md., × 37.5, Calvert Formation, middle Miocene.
   11. Exterior of right valve; locality C-1, Nansemond County, Va., × 70.5, Yorktown Formation, middle part.
   12. Interior of left valve; locality C-1 Nansemond County, Va., × 70.5, Yorktown Formation, middle part.

   Right side of shell; locality C-1, Nansemond County, Va., × 69, Yorktown Formation, middle part.

   6. Exterior of left valve; locality C-1, Nansemond County, Va., × 69, Yorktown Formation, middle part.

9, 10, 13. *Haplocytheridea bradyi* (Stephenson) (p. 13).
   Reversal of valve size and hingement is shown in these specimens.
   10. Interior of right valve; Mount Gould Landing locality, Bertie County, N.C., × 64, beds of Pliocene (?) age.
   13. Interior of left valve; Mount Gould Landing locality, Bertie County, N.C., × 69, beds of Pliocene (?) age.

   Left side of shell; locality P-1, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

   Right side of shell; locality D-1, Nansemond County, Va., × 69, Yorktown Formation, middle part.

   Exterior of right valve; locality P-3, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

   Right side of shell; locality G-3, Bertie County, N.C., × 69, beds of Pliocene (?) age.

19a, b. *Shattuckocythere similis* (Malkin) (p. 22).
   Left side and dorsal views of a shell; Mount Gould Landing locality, Bertie County, N.C., × 75, beds of Pliocene (?) age.

20. *Cushmanidea fabula* (Howe and Dohm) (p. 15).
   Right side of shell; locality N-1, Surry County, Va., × 69, Yorktown Formation, lower part.

   21. Interior of male left valve; locality G-3, Bertie County, N.C., × 72, beds of Pliocene (?) age.
   24. Exterior of immature left valve; locality K-4, Dinwiddie County, Va., × 72, Yorktown Formation, middle part.

22. *Pontocythere* (*Hulingsina*) *agricola* *duopunctata* n. subsp. (p. 17).
   Right side of paratype shell; locality C-1, Nansemond County, Va., × 36, beds of Pliocene (?) age.

   Right side of shell; locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.

25. *Cushmanidea ulrichi* (Howe and Johnson) (p. 16).
   Right side of shell; locality S-5, James County, Va., × 69, Yorktown Formation, middle part.
BAIRDOPILATA, AGLAIACYPRIS, PROPONTOCYPRIS, CYTHERIDEA, HAPLOCYTHERIDEA, SHATTUCKOCYTHERE, EUCYTHERE, PARACYTHERIDEA, PONTOCYTHERE, AND CUSHMANIDEA
FIGURES 1–3. *Pontocythere (Hulingsina) ashermani* (Ulrich and Bassler) (p. 16).
1. Right side of a poorly preserved male shell; locality C–1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
2. Right side of a male shell; locality G–3, Bertie County, N.C., × 72, beds of Pliocene (?) age.
3. Dorsal View of female shell; locality C–1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

4. Right side of male? shell; locality K–4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
5. Right side of immature shell; locality G–3, Bertie County, N.C., × 74, beds of Pliocene (?) age.
6. Right side of immature shell; locality K–4, Dinwiddie County, Va., × 72, Yorktown Formation, middle part.
7. Left side of immature shell; locality K–4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.

8–10. *Pontocythere (Hulingsina) agricola duopunctata* n. subs. (p. 17).
8. Right side of holotype female? shell; locality K–4, Dinwiddie County, Va., × 72, Yorktown Formation, middle part.
9, 10. Right side of two paratype male? shells; locality C–1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

Exterior of immature right valve; locality U–1, Essex County, Va., × 75, St. Marys (?) Formation.

12. Right side of shell; locality D–2, Nansemond County, Va., × 37.5, Yorktown Formation, middle part.
13. Interior of right valve; Mount Gould Landing locality, Bertie County, N.C., × 37.5, beds of Pliocene (?) age.
15. Right side of female? shell; locality C–1, Nansemond County, Va., × 37.5, Yorktown Formation, middle part.

Shells in which surface ornamentation is confined to posterior half of valve, either because of abrasion or as an original feature; if the latter, these forms may represent a distinct species or subspecies. Left side of two males? and one female? shell respectively; locality C–1, Nansemond County, Va., × 37.5, Yorktown Formation, middle part.

19. Left side of shell; Mount Gould Landing locality, Bertie County, N.C., × 37.5, beds of Pliocene (?) age.
20. Interior of right valve; Mount Gould Landing locality, Bertie County, N.C., × 37.5, beds of Pliocene (?) age.

Right side of shell; locality H–4, Bertie County, N.C., × 37.5, Yorktown Formation, upper part.

Left side of shell; locality G–3, Bertie County, N.C., × 71, beds of Pliocene (?) age.

23. *Jonesia?* sp. (p. 25).
Right side of shell, locality C–1, Nansemond County, Va., × 150, Yorktown Formation, middle part.

Exterior views of left valve and right valve, respectively; Mount Gould Landing locality, × 75, beds of Pliocene (?) age.

26, 27. *Cytheromorpha warneri* (Howe and Spurgeon) (p. 26).
Exterior of right valve and interior of left valve, locality K–3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
PONTOCYTHERE, PTERYGOCYTHEREIS, CYTHERETTA, PROTOCYTHERETTA, CYTHERURA, JONESIA?, XESTOLEBERIS, AND CYTHEROMORPHA
PLATE 3

[Scanning electron microscope and optical microscope photographs]

1. Right side of poorly preserved shell; Texas Gulf Sulfur phosphate pit, Beaufort County, N.C., × 75, Yorktown Formation, 30 feet above base.
2. Left side of a weakly ornamented shell, locality G–3, Bertie County, N.C., × 45, beds of Pliocene (?) age.
3. Interior of right valve; locality A–1, Hertford County, N.C., × 144, Yorktown Formation, lower part.

4a, b. Cytherura cf. C. gibba (Müller) (p. 18).
Left side, × 45, and dorsal, × 45, views of shell; locality G–3, Bertie County, N.C.; beds of Pliocene (?) age.

5, 6. Cytherura forulata (Edwards) (p. 18).
5. Right side of a shell; locality G–3, Bertie County, N.C., × 45, beds of Pliocene (?) age.

7, 8. Cytheropteron subreticulatum (van den Bold) (p. 19).
7. Right side of shell; locality A–1, Hertford County, N.C., × 71, lower part of Yorktown Formation.
8. Ventral view of shell; locality R–3, Isle of Wight County, Va., × 91, Yorktown Formation, middle part.

10. Dorsal view of female shell; locality A–1, Hertford County, N.C., × 150, lower part of Yorktown Formation.
11. Left side of female shell; locality A–1, Hertford County, N.C., × 150, lower part of Yorktown Formation.
12. Left side of male shell; locality P–1, Isle of Wight County, Va., × 150, middle part of Yorktown Formation.
13. Interior of left valve; locality P–1, Isle of Wight County, Va., × 150, middle part of Yorktown Formation.
14. Right side of female shell; locality A–1, Hertford County, N.C., × 150, lower part of Yorktown Formation.
15. Dorsal view of female shell; locality P–1, Isle of Wight County, Va., × 150, middle part of Yorktown Formation.

16. Left side of male shell; locality G–3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
17. Interior of right valve; locality G–3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
18. Right side of female shell; locality S–1, James County, Va., × 75, middle part of Yorktown Formation.
19. Dorsal view of shell; locality S–1, James County, Va., × 75, middle part of Yorktown Formation.
20. Right side of female shell; locality A–5, Hertford County, N.C., × 150, lower part of Yorktown Formation.
21. Left side of male shell; locality A–5, Hertford County, N.C., × 150, lower part of Yorktown Formation.

22. Cytheromorpha warneri (Howe and Spurgeon) (p. 26).
Right side of male shell; locality G–3, Bertie County, N.C., × 75, beds of Pliocene (?) age.

23. Neocytherideis sp. (p. 17).
Left side of shell; locality S–1, James County, Va., × 45, Yorktown Formation, middle part.
CYTHERURA, CYTHEROPTERON, SHATTUCKOCYTHERE, HEMICYTHERURA, CYTHEROMORPHA, AND NEOCYTHERIDEIS
PLATE 4

[Scanning electron microscope and optical microscope photographs]

1. Interior of immature left valve; locality K-3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
2. Exterior of immature left valve; locality K-4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
3. Exterior of female right valve; locality K-3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
4. Interior of immature right valve; locality K-3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.

5. Interior of female right valve; questionably representing this species, locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
7. Right side of a male shell; locality R-3, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
8. Left side of male shell; locality R-3, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

9. *Loxoconcha* sp. (p. 27).


16-21. *Murrayina macleani* n. sp. (p. 28).
16. Exterior of holotype male right valve; locality P-2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
17. Exterior of paratype female right valve; locality P-2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
18. Exterior of paratype female left valve; locality P-2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
19. Interior of paratype female left valve; locality P-2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
20. Interior of paratype male? right valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
21. Exterior of a paratype male right valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

22. *Actinocythereis exanthemata gomillionensis* (Howe and Ellis) (p. 31).

23. Exterior of right valve; locality P-1, Isle of Wight County, Va., × 37.5, Yorktown Formation, middle part.
24. Exterior of left valve; locality P-1, Isle of Wight County, Va., × 37.5, Yorktown Formation, middle part.
CYTHEROMORPHA, LEPTOCYHERE, LOXOCONCHA, PARADOXOSTOMA, MURRAYINA, AND ACTINOCYHEREIS
PLATE 5

[Scanning electron microscope and optical microscope photographs]

Figures 1, 2. Actinocythereis exanthemata exanthemata (Ulrich and Bassler) (p. 30).
1. Dorsal view of shell; locality P-1, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
2. Right side of shell; locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.

3, 4. Cletocythereis mundorffi (Swain) (p. 31).
3. Exterior of left valve; locality A-1, Hertford County, N.C., × 75, Yorktown Formation, lower part.
4. Interior of right valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

5, 6. Cletocythereis mundorffi (Swain), subsp. (p. 32).
5. Exterior of right valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
6. Dorsal view of left valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

7, 8. Cletocythereis mundorffi (Swain) subsp. (p. 32).
Exterior views of left valve and right valve respectively; locality C-1, Nansemond County, Va., × 45, Yorktown Formation, middle part.

9-12. Costa barclayi (McLean) (p. 32).
9. Exterior of female left valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
10. Ventral slightly oblique view of shell; locality K-3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
11. Exterior of male right valve; locality D-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
12. Interior of male left valve; locality D-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

13. Exterior of immature left valve; locality C-2, Nansemond County, Va., × 75, Yorktown Formation, middle part.
14. Interior of immature right valve; locality C-2, Nansemond County, Va., × 75, Yorktown Formation, middle part.
15. Exterior of left valve, having a somewhat abraded surface; locality C-2, Nansemond County, Va., × 75, Yorktown Formation, middle part.

16, 17. Bensonocythere whitei (Swain) (p. 33).
17. Dorsal view of shell; Mount Gould Landing locality, Bertie County, N.C., × 75, beds of Pliocene (?) age.

18-20. Campylocythere laeva laeva (Edwards) (p. 34).
18. Exterior of immature left valve; locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
19. Right side of shell; locality G-3, Bertie County, N.C., × 76.5, beds of Pliocene (?) age.
20. Right side of shell with dorsum tilted slightly toward observer; locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.

21. Exterior of right valve; locality C-1, Nansemond County, Va., × 76, Yorktown Formation, middle part.
22. Interior of left valve; locality C-1, Nansemond County, Va., × 76, Yorktown Formation, middle part.
23, 24. Dorsal and ventral views respectively of two shells; locality G-3, Bertie County, N.C., × 76.5, beds of Pliocene (?) age.
ACTINOCYHEREIS, CLETOCYHEREIS, COSTA, ECHINOCYHEREIS?, BENSONOCYHERE, AND CAMPYLOCYHERE
Figure 1. *Campylocythere laeva laeva* (Edwards) (p. 34). Interior of left valve; locality G-3, Bertie County, N.C., × 76.5, beds of Pliocene (?) age.

2, 3. *Acuteicythereis laevissima punctata* (Edwards) (p. 34).
   2. Right side of shell; locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
   3. Interior of left valve; locality S-3, James County, Va., × 75, Yorktown Formation, middle part.

   4. Exterior of left valve; locality G-3, Bertie County, N.C., × 76.5, beds of Pliocene (?) age.
   5, 6. Interior views of left and right valves, respectively of a specimen; Lumberton, N.C., × 76.5, Duplin Formation.

7. *Acuteicythereis?* sp. (p. 35).
   Exterior of a right valve; locality A-5, Hertford County, N.C., × 75, Yorktown Formation, lower part.

8–10. *Prodictyocythere trapezoidalis*, n. gen. n. sp. (p. 35).
   8. Exterior of holotype left valve; locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
   9. Exterior of paratype right valve; locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
   10a, b. Exterior of left valve, × 100, and enlargement of dorsal surface, × 375, showing normal pores; locality A-1, Hertford County, N.C., Yorktown Formation, lower part.

   Right sides and ventral view of three shells; Mount Gould Landing locality, Bertie County, N.C., × 75, beds of Pliocene (?) age.

   All are from locality K-4, Dinwiddle County, Va., Yorktown Formation, middle part.
   14, 15, 17. Right sides of three shells in which greatest height is well anterior to midlength, × 75.
   18. Right side of shell in which greatest height is near midlength, × 75.

   Interior of right valve; locality A-1, Hertford County, N.C., × 75, Yorktown Formation, lower part.

20. *Caudites* sp. (p. 37).
   Right side of shell; locality G-3, Bertie County, N.C., × 150, beds of Pliocene (?) age.
1. Left side of immature shell; locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
2. Right side of shell, locality C-1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
3. Interior of left valve; locality A-1, Hertford County, N.C., × 76.5, Yorktown Formation, lower part.
4. Interior of right valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
5. Interior of left valve; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
6. Left side of shell; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
7. Right side of shell; locality C-1, Nansemond County, Va., × 76, Yorktown Formation, middle part.
8. Dorsal view of shell; locality C-1, Nansemond County, Va., × 75, Yorktown Formation, middle part.

9. Left side of female shell; locality S-5, James County, Va., × 75, Yorktown Formation, middle part.
11. Right side of male shell; locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
13. Left side of female shell; locality A-1, Hertford County, N.C., × 76.5, Yorktown Formation, lower part.
15. Interior of female left valve; locality A-1, Hertford County, N.C., × 76.5, Yorktown Formation, lower part.
   Left side of shell; locality G-3, Bertie County, N.C., × 75, beds of Pliocene (?) age.
17. *Orionina vaughani* (Ulrich and Bassler) (p. 39).
   Exterior of left valve; K-4, Dinwiddie County, Va., × 76.5, Yorktown Formation, middle part.
   Exterior of immature right valve; locality K-4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
19. Exterior of left valve; locality K-4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
20. Exterior of right valve; locality K-4, Dinwiddie County, Va., Yorktown Formation, middle part.
MUELLERINA, THAEROCYTHERE, ORIONINA, AND PURIANA
PLATE 8
[Transmitted light photographs]

FIGURES 1. *Acuticythereis laevissima laevissima* Edwards (p. 35).
Interior of right valve of a complete shell, Lumberton, N.C., locality, \(\times 95\), Duplin Marl.

2a, b. *Cytheromorpha warneri* Howe and Spurgeon (p. 26).
Interior views of right valve at two levels of focus, locality E, Hertford County, N.C., \(\times 77\), Yorktown Formation, upper part.

3. *Campylocythere laeva postercopunctata* Edwards (p. 34).
Interior of left valve, locality G–3, Bertie County, N.C., beds of Pliocene(?) age, \(\times 77\).

4a, b. *Cushmannidea fabula* (Howe and Dohm) (p. 15).
Interior of left valve, \(\times 77\), and muscle scar, \(\times 220\), locality E, Hertford County, N.C., Yorktown Formation, lower part.

5, 12. *Acuticythereis laevissima laevissima* Edwards (p. 35).
Muscle scar, \(\times 220\), and detail of anterior margin, \(\times 220\), of left valve of same shell shown on Plate 8, figure 1.

Interior of paratype right valve, locality C–1, Nansemond County, Va., \(\times 150\), Yorktown Formation, middle part.

7a, b. *Cytherura elongata* Edwards (p. 19).
Interior of left valve, \(\times 77\), and detail of anterior margin \(\times 220\), locality K–3, Dinwiddie County, Va., Yorktown Formation, middle part.

8a–c. *Murrayina macleani*, n. sp. (p. 29).
Interior views of right valve at different levels of focus, \(\times 75\), and detail of anterior margin \(\times 220\), locality P–2, Isle of Wight County, Va., Yorktown Formation, middle part.

9. *Shattuckocythere shattucki* (Ulrich and Bassler) (p. 21).
Interior of left valve, locality P–1, Isle of Wight County, Va., \(\times 105\), Yorktown Formation, middle part.

10a, b. *Haplocythereidea bradyi* (Stephenson) (p. 13).
Interior of right valve, \(\times 77\), and detail of anterior margin, \(\times 220\), Mount Gould Landing locality, Bertie County, N.C., beds of Pliocene(?) age.

11a–c. *Cytheretia burnsi* (Ulrich and Bassler) (p. 23).
Interior of right valve, \(\times 52\), and details of anterior and posterior margins, \(\times 220\), Mount Gould Landing locality, Bertie County, N.C., beds of Pliocene(?) age.
ACUTICYHEREIS, CYTHEROMORPHA, CAMPYLOCYHERE, CUSHMANIDEA, PRODICTYOCYHERE, CYTHERURA, MURRAYINA, SHATTUCKOCYHERE, HAPLOCYETHERIDEA, AND CYTHERETTA
FIGURES 1a–d. *Thaerocythere schmidtae* (Malkin) (p. 40).
   Interior of left valve at two levels of focus, × 77, and details of posterior and anterior margins, × 220, locality E, Hertford County, N.C., Yorktown Formation, upper part.

   Interior of right valve, locality A–1, Hertford County, N.C., × 105, Yorktown Formation, lower part.

3. *Cythereopteron subreticulatum* van den Bold (p. 19).
   Transmitted light view of left valve from outside, locality FP–1, 0.5 of a mile south of Flag Pond, Calvert County, Md., × 105, Choptank Formation.

4a, b. *Hemicytherura howei* (Puri) (p. 20).
   Interior of right valve, × 105, and detail of anterior margin, × 220, locality G–3, Bertie County, N.C., beds of Pliocene (?) age.

5. *Pterygocythereis americana* (Ulrich and Bassler) (p. 23).
   Interior of immature right valve, locality U–1, Essex County, Va., × 105, Yorktown (?) Formation, lower part, or St. Marys (?) Formation.

6a, b. *Leptocythere paracastanea* Swain (p. 26).
   Interior views of left valve at different levels of focus, locality R–3, Isle of Wight County, Va., × 105, Yorktown Formation, middle part.

7. *Loxoconcha* sp. (p. 27).
   Interior of left valve, × 77, locality H–4, Bertie County, N.C., Yorktown Formation, upper part.

   Interior of right valve, locality K–3, Dinwiddie County, Va., × 105, Yorktown Formation, middle part.

9a, b. *Shattuckocythere yorktownensis* (Malkin) (p. 22).
   Interior views of left valve at two levels of focus, locality P–1, Isle of Wight County, Va., × 105, Yorktown Formation, middle part.

10a, b. *Costa barclayi* (McLean) (p. 32).
   Interior of left valve, × 77, and detail of anterior margin, × 220, locality K–4, Dinwiddie County, Va., Yorktown Formation, middle part.

    Interior of left valve, locality O–1, near Cobham Wharf, Surry County, Va., × 77, Yorktown Formation undivided.

12a, b. *Pontocythere* (*Hulingsina*) *ashermani* (Ulrich and Bassler) (p. 16).
   Interior of left valve, × 77, and detail of anterior margin, × 220, locality G–3, Bertie County, N.C., beds of Pliocene (?) age.

    Interior of female paratype right valve, locality C–1, Nansemond County, Va., × 77, Yorktown Formation, middle part.

    Interior of immature left valve, locality at Mount Gould landing, Bertie County, N.C., × 105, beds of Pliocene (?) age.

15. *Loxoconcha wilberti* Puri (p. 28).
    Interior of right valve, locality S–5, James, County, Va., × 105, Yorktown Formation, middle part.

    Interior of right valve, × 52, Seaboard Air Line Railroad Bridge locality, Northampton County, N.C., Yorktown Formation, lower part.
PLATE 10
[Scanning electron microscope photographs]

FIGURES 1a–g. Actinoocythereis exanthemata exanthemata (Ulrich and Bassler) (p. 30).

a, interior of right valve with dorsum tilted toward viewer, × 106; b, c, dorsal views of right valve at slight angle of tilt and greater angle of tilt from vertical, respectively, × 50; d, detail of anterior hinge tooth and socket, × 270; e, detail of posterior hinge tooth, × 270; f, detail of middle part of hinge margin, × 270; g, detail of adductor muscle scar area, dorsal part tilted toward viewer, × 247, Yorktown Formation, middle part, locality C-2, Nansemond County, Va.
ACTINOCYHEREIS
PLATE 11

[Scanning electron microscope photographs]

FIGURES 1a–d. Cletocythereis mundorffii (Swain) (p. 31).
   a, exterior of left valve, × 188; b, dorsal view of left valve, × 93; c, detail of anterodorsal cardinal projection, × 376; d, detail of medial surface ornamentation, × 517, Yorktown Formation, middle part, locality C–1, Nansemond County, Va.

2a–e. Bensonocythere whitei (Swain) (p. 33).
   a, interior of right valve, × 70; b, enlargement of posterior part of right valve, × 178; c, normal canal opening to interior and containing a secondary calcite crystal, × 3000; d, enlargementment of posteroverentral margin of interior of right valve, × 241; e, enlargement of anteroventral margin of interior of right valve, × 241, Yorktown Formation, middle part, locality C–1, Nansemond County, Va.
FIGURES 1a–f. Bensonocythere whitei (Swain) (p. 33).

a, interior of right valve, × 50; b, c, exteriors of two right valves, × 50; d, adductor muscle scar of right valve showing furrow-to-ridge marginal configuration, shell surface tilted away from observer, × 600; e, oblique view of a normal canal opening on interior of valve, × 6,000; f, normal canal with marginally perforated sieve plate opening on valve exterior, × 3,000, Yorktown Formation, middle part, locality C-1, Nansemond County, Va.

2a–h. Orionina vaughani (Ulrich and Bassler) (p. 39).

a, exterior of right valve × 50; b, interior of right valve, × 50; c, enlargement of a normal canal, opening to the interior, × 6,000; d, enlargement of normal canal opening to exterior of valve, sieve plate apparently recrystallized but weakly perforate, × 3,000; e, anteromedian part of valve interior showing adductor and frontal muscle scar spots, note narrow rims on spots, × 400; f, enlargement of adductor muscle scar, × 600; g, enlargement of posteromedian surface ornamentation, × 600; h, enlargement of median surface ornamentation, × 400, Yorktown Formation, middle part, locality C-1, Nansemond County, Va.
PLATE 13
[Scanning electron microscope photographs]

Figures 1a–g. *Aurila conradi* (Howe and McGuirt) (p. 37).

1a, interior of left valve with hinge margin tilted toward observer, × 120; b, enlargement of normal canal, × 6,000; c, ventral view of left valve, × 65; d, dorsal view of left valve, × 65; e, enlargement of muscle scar area, × 600; f, enlargement of hinge margin of left valve, × 450; g, enlargement of anterodorsal part of right valve, × 600, Yorktown Formation, middle part, locality C-1, Nansemond County, Va.

2a–c. *Peterygoxythereis americana* (Ulrich and Bassler) (p. 23).

2a, b, left sides of two shells, × 48; c, enlargement of surface of a, × 190 showing scattered normal pores, lower 1.5 feet of Yorktown Formation, Lees Creek Pit, Texas Gulf Sulphur Co., Beaufort Co., N.C. a and b are slightly tilted to right of observer.