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

GEOLOGICAL SURVEY PROFESSIONAL PAPER 821

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

*By* FREDERICK M. SWAIN

GEOLOGICAL SURVEY PROFESSIONAL PAPER 821

*Descriptions, illustrations, geographic distribution, stratigraphic ranges, and environmental aspects of microfossils*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 74-600014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 – Price $1.85 (paper cover)
Stock Number 2401-02533

# CONTENTS



# ILLUSTRATIONS

[Plates follow index]

# TABLE

# SOME UPPER MIOCENE AND PLIOCENE(?) OSTRACODA OF ATLANTIC COASTAL REGION FOR USE IN HYDROGEOLOGIC STUDIES

By FREDERICK M. SWAIN


## 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-Thaerocythere 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 *Prodictyocythere*, n. gen., and *Shattuckocythere*, n. gen. The new species are *Murrayina macleani*, n. sp., and *Prodictyocythere 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, coquinoid, 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 Cohansey 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

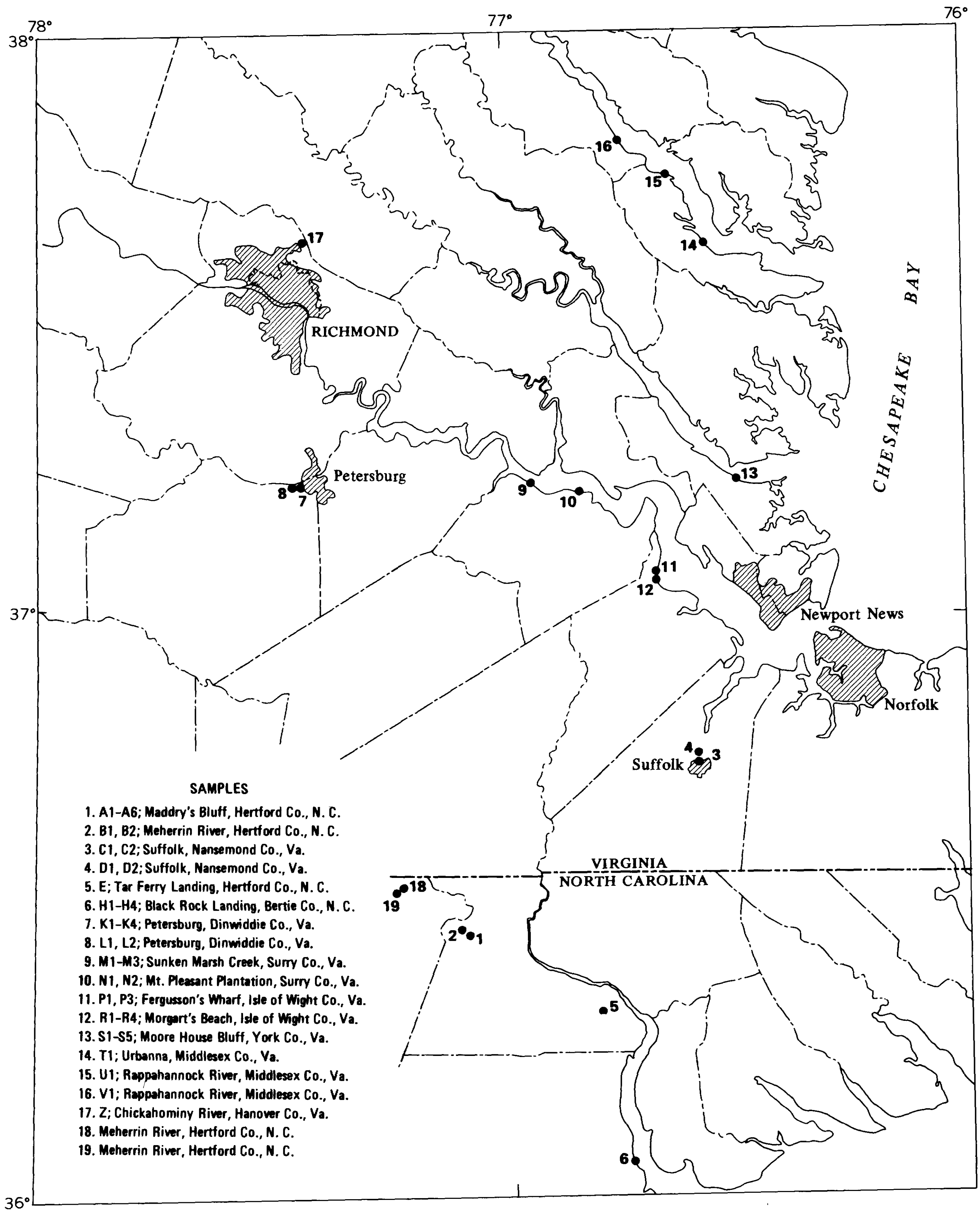



FIGURE 1.—Location of sample sites.

area, Albemarle and Pamlico Sounds, it is underlain chiefly by the Pungo River Formation of middle Miocene age. (See Kimrey, 1965.) In Virginia, the Yorktown Formation is underlain chiefly by beds of Cretaceous, Paleocene, Eocene, and middle Miocene age. In the central and northern coastal areas of Virginia, the Yorktown Formation is underlain primarily by the Calvert Formation and, to a lesser extent, by the St. Marys Formation of middle Miocene age. In Maryland, the Yorktown, or its Cohansey Sand equivalents, rests on the St. Marys Formation and on the Calvert Formation that is transitional to the Kirkwood Formation to the north. In southern North Carolina the Yorktown Formation grades laterally into the Duplin Marl (Stuckey and Conrad, 1958; Stuckey 1958).

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).

## OSTRACODA FROM DEPOSITS OF PLIOCENE(?) AGE

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: *Protocytheretta sahnii* Puri, 1952.

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

TABLE 1.—*Upper Miocene and Pliocene(?) Ostracoda from outcrop samples in North Carolina and Virginia*

| Species | Pre-York-town | Lower York-town | Middle York-town | Upper York-town | Duplin | Plio-cene | Holo-cene |
|---|---|---|---|---|---|---|---|
| *Actinocythereis exanthemata exanthemata* (Ulrich and Bassler) | × | × | × | × | × | × | ? |
| *exanthemata gomillionensis* (Howe and Ellis) | -- | -- | -- | × | × | [1]× | -- |
| *Acuticythereis laevissima punctata* Edwards | -- | -- | × | -- | × | [1]× | -- |
| *laevissima* Edwards | ? | × | × | × | × | × | × |
| *Acuticythereis*? sp. immature | -- | × | × | -- | -- | -- | -- |
| *Aglaiocypris* sp | -- | × | -- | -- | -- | -- | -- |
| *Aurila conradi* (Howe and McGuirt) | -- | × | × | × | × | × | × |
| *Bairdoppilata triangulata* (Edwards) | -- | -- | -- | × | × | × | × |
| *Bensonocythere whitei* (Swain) | × | × | × | × | × | × | × |
| *Campylocythere laeva posteropunctata* Edwards | -- | -- | × | -- | × | × | |
| *laeva* Edwards | -- | × | × | × | × | × | × |
| sp | -- | × | × | -- | -- | -- | -- |
| *Caudites choctawhatcheensis* (Puri) | -- | -- | -- | -- | [2]× | -- | -- |
| *sellardsi* (Howe and Neill) | -- | -- | -- | -- | [2]× | -- | -- |
| *Caudites*? sp | -- | -- | -- | -- | × | × | -- |
| *Cletocythereis mundorffi* Swain (and subsp.) | -- | × | [3]× | -- | × | × | -- |
| *Costa barclayi* (McLean) | -- | -- | × | -- | × | [1]× | -- |
| *Cushmanidea*? *agricola* (Howe and Hough) | -- | -- | -- | -- | [2]× | -- | -- |
| *fabula* (Howe and Dohm) | × | × | -- | -- | -- | -- | -- |
| *ulrichi* (Howe and Johnson) | × | × | × | × | -- | -- | × |
| *Cytherelloidea umbonata* (Edwards) | -- | -- | -- | -- | [2]× | -- | -- |
| *Cytheretta burnsi* (Ulrich and Bassler) | × | -- | × | -- | -- | [1]× | -- |
| *porcella* (Ulrich and Bassler) | × | × | × | × | -- | × | -- |
| *Cytheridea muelleri subsp* | -- | -- | × | -- | -- | -- | -- |
| sp. A | ? | × | -- | -- | -- | -- | -- |
| sp. B | -- | -- | × | -- | -- | -- | -- |
| *Cytheromorpha curta* (Edwards) | -- | -- | -- | -- | [2]× | × | × |
| *warneri* (Howe and Spurgeon) | × | × | × | × | -- | -- | × |
| *Cytheropteron subreticulatum* van den Bold | × | × | × | -- | -- | -- | -- |
| *Cytherura elongata* (Edwards) | -- | × | × | × | × | × | × |
| *forulata* (Edwards) | × | × | × | × | × | × | × |
| cf. *C. gibba* (Müller) | -- | -- | -- | -- | -- | [1]× | × |
| *Echinocythereis clarkana* (Ulrich and Bassler) | × | × | × | -- | -- | -- | -- |
| *Eucythere triangulata* (Puri) | -- | -- | × | -- | -- | -- | × |
| *Haplocytheridea bradyi* (Stephenson) | -- | -- | -- | -- | × | × | × |
| *setipunctata* (Brady) | × | × | × | × | -- | × | × |
| *Hemicytherura howei* (Puri) | × | × | × | × | × | × | -- |
| *Jonesia*? sp | -- | -- | × | -- | -- | -- | -- |
| *Leptocythere paracastanea* Swain | -- | -- | × | -- | -- | -- | -- |
| *Loxoconcha purisubrhomboidea* (Edwards) | ? | × | × | × | × | × | × |
| *reticularis* (Edwards) | × | × | × | × | × | × | × |
| *wilberti* (Puri) | -- | -- | × | × | -- | × | × |
| sp | -- | × | -- | × | -- | [1]× | -- |
| *Muellerina micula* (Ulrich and Bassler) | × | × | × | × | × | × | × |
| *Murrayina macleani*, n. sp | -- | -- | × | -- | -- | -- | -- |
| *Neocaudites triplistriata* (Edwards) | -- | -- | -- | -- | [2]× | -- | -- |
| *Neocytherideis* sp | -- | -- | × | -- | -- | -- | -- |
| *Orionina vaughani* (Ulrich and Bassler) | [4]× | × | × | × | × | × | ? |
| *Paracytheridea altila* (Edwards) | ? | × | × | -- | × | × | × |
| *mucra* (Edwards) | -- | -- | -- | -- | × | [1]× | -- |
| *Paradoxostoma robustum* (Puri) | × | × | × | × | -- | -- | -- |
| *Pontocythere* (*H.*) *agricola duopunctata*, n. subsp | ? | × | × | × | × | [1]× | -- |
| (*H.*) *ashermani* (Ulrich and Bassler) | × | × | × | × | × | × | ? |
| (*H.*) cf. *P.* (*H.*) *rugipustulosa* (Edwards) | -- | -- | -- | -- | [2]× | -- | -- |
| *Prodictyocythere trapezoidalis*. n. gen., n. sp | -- | × | × | -- | -- | -- | -- |
| *Propontocypris howei* (Puri) | -- | × | × | -- | -- | -- | -- |
| *Proteoconcha gigantica* (Edwards) | -- | -- | -- | -- | [2]× | × | -- |
| *multipunctata* (Edwards) | -- | -- | -- | -- | [2]× | × | -- |
| *Protocytheretta sahnii* (Puri) | -- | -- | -- | × | × | -- | × |
| *Pterygocythereis americana* (Ulrich and Bassler) | × | × | × | -- | -- | -- | -- |
| *Puriana rugipunctata* (Ulrich and Bassler) | -- | × | × | × | × | × | × |
| *mesacostalis* (Edwards) | -- | -- | × | -- | × | × | × |
| *Radimella confragosa* (Edwards) | -- | ? | ? | × | × | × | × |
| *Shattuckocythere shattucki* (Ulrich and Bassler) | × | -- | × | -- | -- | -- | ? |
| *similis* (Malkin) | -- | -- | -- | × | -- | [1]× | -- |
| *yorktownensis* (Malkin) | -- | × | × | × | × | × | -- |
| *Thaerocythere schmidtae* (Malkin) | -- | × | × | × | -- | [1]× | -- |
| sp | -- | -- | × | -- | -- | [1]× | -- |
| *Xestoleberis* cf. *X. aurantia* (Baird) | -- | -- | -- | -- | -- | [1]× | × |
| *Xestoleberis*? *ventrostriata* (Swain) | -- | -- | -- | -- | [2]× | -- | -- |

[1] Beds of Pliocene(?) age at Mount Gould Landing and Colerain Landing localities, Bertie County, N.C.
[2] Species obtained from the Duplin Marl in the present collection.
[3] Occurrence of *Cletocythereis mundorffi* subsp.
[4] Previously recorded from pre-upper Miocene of northern South America

### 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 less fossiliferous toward the top; uppermost 3 feet are very 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; 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 Fergusson'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 Morgart'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; *Loxoconcha wilberti* Puri, 1954; *Costa barclayi* (McLean, 1957); *Campylocythere laeva posteropunctata* 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-

pecially 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 megafossils 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: *Aglaiocypris* 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, Va.); *Cythereis alaris* Ulrich and Bassler, 1904 (types from James River); *Cythereis cornuta americana* Ulrich and Bassler, 1904; *Cytherideis ashermani* Ulrich and Bassler, 1904; and *Cytheropteron nodosum* Ulrich and Bassler, 1904; (types from James River, Va.).

Of these species (with modern generic assignments given), *Cytheretta burnsi* (Ulrich and Bassler, 1904), *Echinocythereis? clarkana* (Ulrich and Bassler, 1904), *Actinocythereis exanthemata* (Ulrich and Bassler, 1904), *Muellerina micula* (Ulrich and Bassler, 1904), *Cytheretta porcella* (Ulrich and Bassler, 1904), *Puriana rugipunctata* (Ulrich and Bassler, 1904), *Orionina vaughani* (Ulrich and Bassler, 1904), *Pterygocythereis americana* (Ulrich and Bassler, 1904), *Pontocythere ashermani* (Ulrich and Bassler, 1904), and *Paracytheridea altila* Edwards, 1904 (=*Cytheropteron nodosum*) Ulrich and Bassler, 1904 occur in the Yorktown Formation in the present collections. *Henryhowella evax* (Ulrich and Bassler, 1904), *Echinocythereis? planibasilis* (Ulrich and Bassler, 1904), and *Leguminocytheris? tuomeyi* (Ulrich and Bassler, 1904), however, in the present 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 Yorktown and Grove, Va. Twenty-three of these were found in the present collections from the Yorktown; the other six species are: *Cushmanidea echolsae* (Malkin, 1953); *Pontocythere subaequalis ulrichi* (Howe and Johnson, 1935); *Clithrocytheridea virginiensis* (Malkin, 1953); *Anomocytheridea 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 Ostracoda 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; *Cytheropteron talquinensis* Puri, 1954; *Cytherura lumbertonensis* Edwards, 1944; *Clithrocytheridea virginiensis* Malkin, 1953; *Eucythere* sp.; and *Cushmanidea echolsae* (Malkin, 1953). Among the recorded Yorktown species and subspecies of Ulrich and Bassler (1904), *Cythere clarkana miniscula* 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? clarkana* (Ulrich and Bassler, 1904). "*Cythere 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 Hemicytheridae rather than to the *Trachyleberidae* to which *martini* should be referred. The "*Cythere martini*" of the Yorktown 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 specimens 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 *Pterygocythereis americana* (Ulrich and Bassler, 1904) (Pooser, 1965).

The total number of ostracode species recorded 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 present 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); *Bairdoppilata triangulata* Edwards, 1944; *Proteoconcha gigantica* (Edwards, 1944); *Campylocythere laeva* Edwards, 1944; *Campylocythere laeva posteropunctata* Edwards, 1944; *Acuticythereis laevissima 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* (Münster, 1830) subsp.; *Cytheromorpha curta* Edwards, 1944; *Cytherura elongata* Edwards, 1944; *Eucythere triangulata* Puri, 1954; *Haplocytheridea bradyi* (Stephenson, 1938); *Cletocythereis mundorffi* (Swain, 1952); *Cletocythereis mundorffi* subsp.; *Jonesia*? sp.; *Loxoconcha* sp.; *L. wilberti* Puri, 1954; *Murrayina macleani*, n. sp.; *Radimella confragosa* (Edwards, 1944); *Neocaudites triplistriatus* (Edwards, 1944); *Neocytherideis* sp; *Paracytheridea mucra* Edwards, 1944; *Pontocythere (Hulingsina) agricola* (Howe and Hough, 1935); *Pontocythere (H.) agricola duopunctata*, n. subsp.; *Prodictyocythere trapezoidalis*, n. gen., n. sp.; *Propontocypris howei* (Puri, 1954); *Protocytheretta sahnii* Puri, 1952; *Puriana rugipunctata* (Ulrich and Bassler, 1904); *Puriana mesacostalis* (Edwards, 1944); *Shattuckocythere shattucki* (Ulrich and Bassler); *Shattuckocythere similis* (Malkin, 1953); *Shattuckocythere yorktownensis* (Malkin, 1953); *Thaerocythere schmidtae* (Malkin, 1953); *Thaerocythere* sp.; and *Xestoleberis*? *ventrostriata* Swain, 1956.

## OSTRACODA OF THE DUPLIN MARL

The ostracode species obtained from the Duplin Marl in the collections studied are listed in table 1. The Duplin 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 Duplin Ostracoda are for the most part represented also in the Yorktown Formation, but the following Duplin species were not found in the Yorktown in this collection: *Haplocytheridea bradyi* (Stephenson, 1938), *Proteoconcha gigantica* (Edwards, 1944), *Caudites choctawhatcheensis* (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, *Neocaudites triplistriatus* (Edwards, 1944), *Paracytheridea mucra* Edwards, 1944, and *Xestoleberis*? *ventrostriata* Swain, 1952.

Edwards (1944) described 35 species and four subspecies from the Duplin 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 Duplin 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 Duplin. *Prodictyocythere trapezoidalis* n. gen., n. sp.; *Aglaiocypris* sp.; *Cushmanidea ulrichi* (Howe and Johnson, 1935); *C. fabula* (Howe and Dohm, 1935); *Campylocythere* sp.; *Cytheretta burnsi* (Ulrich and Bassler, 1904); *Cytheretta porcella* (Ulrich and Bassler, 1904); *Cytheridea* sp. B.; *C. muelleri* (Münster, 1830) subsp.; *C.* sp. A; *Leptocythere paracastanea* Swain, 1955;

*Cytheropteron subreticulatum* van den Bold, 1946; *Loxoconcha* sp.; *Shattuckocythere similis* (Malkin, 1953); *Luvula?* sp.; *Murrayina macleani*, n. sp.; *Neocytherideis* sp.; *Paradoxostoma robusta* Puri, 1954; *Pontocythere agricola duopunctata*, 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 OSTRACODA 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 *Basslerites* 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 *Henryhowella evax* (Ulrich and Bassler, 1904) which the present writer considers as being restricted to pre-upper Miocene deposits in 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* subassemblage 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 sublittoral environment. Some of the forms, such as *Cytheromorpha warneri* Howe and Spurgeon, 1935, and *C. curta* Edwards, 1944, and *Leptocythere paracastanea* 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 albomaculata* (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 *Pterygocythereis 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 conradi* (Howe and McGuirt, 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, *Pterygocythereis 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 species of both his *Orionina vaughani* Zone and his overlying *Puriana mesacostalis* Zone.

*Puriana mesacostalis* (Edwards, 1944) is cited by Hazel as tentatively indicative of a Pliocene age for the upper part of the Yorktown Formation. Two of the localities he cited as representative of the *Puriana mesacostalis* Zone of the Yorktown Formation are: 0.5 of a mile below Mount Gould Landing, Bertie County, N.C. and 150 yards south of Colerain Landing, Bertie County, N.C. The outcrops at both these localities consist of buff, dark-brown shell hash of different lithologic characteristics than the Yorktown Formation and are post-Yorktown in stratigraphic position as well as in age. Finally, *P. mesacostalis* was described from the upper Miocene Duplin Marl and cannot, by itself, be indicative of Pliocene age of the containing deposits. No definitive evidence has yet been cited for the post-Miocene age of the Duplin, but it does contain many upper Miocene fossils.

## SYSTEMATIC DESCRIPTIONS

### Family PARACYPRIDIDAE Sars, 1923

### Genus AGLAIOCYPRIS Sylvester-Bradley, 1947

*Aglaia* Brady, 1868, Les Fonds de la Mer, v. 1, (1967–71), part I, XVIII, p. 90 [non Renier, 1804; non Swainson, 1927].

*Aglaiocypris* Sylvester-Bradley, 1947, Annals Mag. Nat. History, ser. 11, v. 13, p. 197.

*Aglaja* Schneider, 1949, Microfauna USSR v. 2, All-Union Petrol. Sci-Res. Geol. Expl. Inst., Leningr. (VNIGRI), Trans. v. 30, p. 117. (Misspelling of *Aglaia.*)

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.

#### Aglaiocypris 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

*Propontocypris* Sylvester-Bradley, 1947, Annals Mag. Nat. History ser. 11, v. 13, p. 193.

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 *Arca, Ecphora,* and *Cancellaria* facies of the Choctawhatchee Formation (of former usage) upper Miocene. Hulings recorded the species

[1] Detailed lists of occurrences not presented herein are available in open-file 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

*Bairdoppilata* Coryell, Sample, and Jennings, 1935, Am. Mus. Novitates, no. 777, 5 p., 4 figs.

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 Coast 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 Choctawhatchee Formation (of former usage); middle and upper Miocene, of Florida (Puri, 1954) and is living off the west coast of Florida (Benson and Coleman, 1963).

*Number of specimens.*—100+.

*Ecology.*—The species was found by Benson and Coleman (1963) in water depths ranging from 19 to 239 feet but was most common at depths greater than 60 feet; bottom sediments were sand-sized carbonate shell fragments; salinities ranged from 36.17 to 39.36 parts per mil. The absence of living *B. triangulata* along the present Atlantic coast and shelf and its presence in the Waccamaw, Duplin, and middle Yorktown faunas suggest a similarity of those sedimentary environments with that of the present eastern Gulf of Mexico. *B. triangulata* appears to represent neritic rather than eulittoral or bay environments judging from both its Holocene and fossil distribution.

*Zoogeographic derivation.*—This form seems to have originated in the Miocene 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

*Cytheridea* (*Haplocytheridea*) Stephenson, 1936, Jour. Paleontology, v. 10, p. 696.

*Leptocytheridea* Stephenson, 1937, Jour. Paleontology, v. 11, p. 157.

?*Phractocytheridea* 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 *Phractocytheridea* 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.

*Haplocytheridea ponderosa* (Stephenson). Puri, 1960, Gulf Coast Assoc. Geol. Socs. Trans., v. 10, p. 110; Curtis, 1960, Am. Assoc. Petroleum Geologists Bull., v. 44, pl. 23, fig. 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.

*Haplocytheridea gigantea* Benson and Coleman, 1963, Kansas Univ. Paleont. Contr., Arthropoda, Art. 2, pl. 27, pl. 3, figs. 10–14; text fig. 14.

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

*Haplocytheridea setipunctata* (Brady). Sandberg, 1964, Micropaleontology, v. 10, p. 361; Sandberg, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 508, pl. 3, fig. 12, Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 329, fig. 14; Grossman and Benson, 1967, Kans. Univ. Paleont. Contr., Ecology, Art. 1, p. 64a, pl. 11, figs. 4, 7, pl. 16, figs. 13–18; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 7, pl. 1, figs. 5a–c; pl. 7, figs. 1a, b. Valentine 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 2, figs. 48, 49.

*Occurrence.*—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 bradyi (Stephenson)**

Plate 1, figures 9, 10, 13; plate 8, figures 10a, b

*Cytheridea (Haplocytheridea) bradyi* Stephenson 1938. Jour. Paleontology, v. 12, p. 129, pl. 23, fig. 22, pl. 24, figs. 5, 6, text fig. 10.

*Haplocytheridea bradyi* (Stephenson). Swain, 1955, Jour. Paleontology, v. 29, p. 618, pl. 59, figs. 12a, b; Puri, 1960, Gulf Coast Assoc. Geol. Socs. Trans., v. 10, p. 110, pl. 2, figs. 3, 4, pl. 6, fig. 19, text figs. 4, 5; Sandberg, 1964, Micropaleontology, v. 10, p. 362, pl. 2, figs. 7–16; Hulings and Puri, 1965, Pub. Staz. Zool. Napoli, v. 33, supp., p. 321, fig. 12; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 8, pl. 1, figs. 7a, b, 8a, b; pl. 2, fig. 8; Hall, 1965, Michigan Univ., Natl. Sci. Found. Proj. GB–26, Rept. 4, p. 41, pl. 11, figs. 1–11; Grossman and Benson, 1967, Kans. Univ. Paleont. Contr., Ecology, Art. 1, p. 64a, pl. 11, fig. 2, pl. 17, figs. 15, 16, 18; Valentine, 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 2, figs. 42, 46.

*Haplocytheridea bradyi* Swain, [sic] Byrne, LeRoy, and Riley, 1959, Gulf Coast Assoc. Geol. Socs. Trans., v. 9, p. 240, pl. 4, fig. 10, pl. 5, fig. 11.

*Cytheridea (Haplocytheridea) wadei* Stephenson, 1941, Jour. Paleontology, v. 15, p. 428, text figs. 4, 5, 14–18.

*Haplocytheridea wadei* Stephenson. Puri, 1954, Florida Geol. Survey Bull. 36, p. 231, pl. 3, figs. 5, 6, text fig. 3g.

*Cytheridea (Haplocytheridea) proboscidiala* Edwards, 1944, Jour. Paleontology, v. 18, pl. 508, pl. 85, figs. 8–11; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 58, pl. 5, fig. 14.

*Haplocytheridea proboscidiala* (Edwards) Benson and Coleman, 1963, Kansas Univ. Paleont. Contr., Art. 2, p. 28, pl. 3, figs. 4–9, text fig. 15.

*Occurrence.*—The species is common in the Pliocene(?) at Mount Gould Landing, Bertie County, N.C. It was recorded in the Yorktown Formation of Virginia and North Carolina by Hazel (1971). Also, in the upper Miocene, it is found in the Duplin Marl of North Carolina (Edwards, 1944), and in the Choctawhatchee Formation (of former usage) of Florida (Puri, 1954). It occurs in the Pliocene Waccamaw Formation of North Carolina (Swain, 1968), and the Caloosahatchee Marl of Florida (Stephenson, 1938). It was recorded by Valentine (1971) from the Pleistocene of Virginia. The species occurs living in the Atlantic Ocean off the coast of Virginia (Hulings, 1966), in the Gulf of Mexico (Swain, 1955; Puri, 1960; Benson and Coleman, 1963), and in the Pleistocene of Louisiana (Byrne and others, 1959).

*Number of specimens studied.*—25+.

*Ecology.*—This form, which in some collections is characterized by reversal of valve size and hingement, is at present a neritic, open-shelf species living on sand, silt, or carbonate-ooze bottom.

*Zoogeographic derivation.*—The species apparently originated in the southeastern United States region of the Atlantic Ocean or Gulf of Mexico, in the Caribbean or Carolinian Faunal Provinces.

*Figured specimens.*—USNM 179516–179521.

**Genus CYTHERIDEA Bosquet, 1852**

*Cytheridea* Bosquet, 1852, Acad. Royale Belgique Mém. cour. et Mém. Sav. étrangerès, v. 24, p. 37.

*Cytheridea (Eucytheridea)* Bronstein, 1930, Trav. Comm. étude Lac Bajkal, v. 3, p. 127.

Refer to Moore and others (1961, p. 273) for a diagnosis of shell features of the genus. Type species, *Cythere muellerii* Münster, 1830. Geologic range, Oligocene to Holocene.

**Cytheridea sp. A**

Plate 1, figures 6–8

*Haplocytheridea* sp. aff. *H. israelskyi* Stephenson. Swain, 1952, U.S. Geol. Survey Prof. Paper 234, p. 20, pl. 1, figs. 15–17.

*Cytheridea* characterized by elongate-subovate outline, blunt ends in edge view; surface with large pits and intervening ridges, arranged concentrally 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 schmidtae* (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 ventroposterior 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 well 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 punctation 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 virginiensis* 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

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

*Eucythere* Brady, 1868, Mon. Recent British Ostracoda, Linnean Soc. London Trans. v. 26, p. 429.

A diagnosis of the shell of the genus is given in Moore and others (1961, p. 285). Type species, *Cythere declivis* Norman, 1865. Geologic range, Upper Cretaceous to Holocene.

#### Eucythere triangulata Puri

Plate 1, figure 16

*Eucythere triangulata* Puri, 1954, Florida Geol. Survey Bull. 36, p. 300, pl. 16, figs. 7, 8, text fig. 135; Hall, 1965, Michigan Univ., Natl. Sci. Found. Proj. GB–26, Rept. 4, p. 43, pl. 2, figs. 8–11.

*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

*Cytherideis* 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.

?*Sacculus* Neviani, 1928, Pontif. Acad. Sci., Rome, Mém. Ser. 2, v. 11, p. 72 [not Gosse, 1851 or Hirase, 1927].

*Hemicytherideis* Ruggieri, 1952, Bologna Univ. Ist. Zool., Nota del Lab. Biol. Marina di fano, v. 1, p. 62.

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

*Cytherideis fabula* Howe and Dohm, 1935, Florida Geol. Survey Bull. 13, p. 14, pl. 3, figs. 15, 16, 20, 23, pl. 4, fig. 2; Puri, 1952, Jour. Paleont., v. 26, p. 911, pl. 130, fig. 14, text figs. 3, 4; Puri, 1954, Florida Geol. Survey Bull. 36, p. 287, pl. 9, fig. 14.

*Cushmanidea fabula* (Howe and Dohm). Puri, 1958, Gulf Coast Assoc. Geol. Socs. Trans. v. 8, p. 174, table 1.

*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)**

Plate 1, figure 25

*Cytherideis ulrichi* Howe and Johnson, 1935, Florida Geol. Survey Bull. 13, p. 16, pl. 3, figs. 11–14; Puri, 1952, Jour. Paleontology, v. 26, p. 911, pl. 130, figs. 11–13.

*Cushmanidea ulrichi* (Howe and Johnson). Puri, 1958, Gulf Coast Assoc. Geol. Socs. Trans., v. 8, p. 174, table 1; Grossman and Benson, 1967, Kans. Univ. Paleont. Contr., Ecology, Art. 1, p. 67, pl. 14, fig. 3, pl. 19, fig. 2.

*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.

*Number of specimens studied.*—Seven.

*Ecology.*—The species is living in the Atlantic Ocean on the open shelf off Virginia.

*Zoogeographic derivation.*—As far as can be determined, the species originated in the Western Middle Atlantic Virginian or Carolinian Faunal Provinces.

*Figured specimen.*—USNM 179528.

**Genus PONTOCYTHERE Dubowsky, 1939**

*Pontocythere* Dubowsky, 1939, Trav. Sta. Bol. Karadagh, v. 5, p. 25.

The status of the genus has recently been reviewed by Hulings (1966). Type species, *P. tchernjawksii* Dubowsky, 1939. Geologic range, Miocene to Holocene.

**Subgenus Hulingsina Puri, 1958**

*Hulingsina* Puri, 1958, Gulf Coast Assoc. Geol. Socs. Trans., v. 8, p. 173.

The characteristics of the shell of *Hulingsina* were described by Puri (1958) and by Moore and others (1961). 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.

**Pontocythere (Hulingsina) ashermani (Ulrich and Bassler)**

Plate 1, figures 21, 24; plate 2, figures 1–3; plate 9, figures 12a, b

*Cytherideis ashermani* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 126, pl. 37, figs. 10–16; Howe and others, 1935, Florida Geol. Survey Bull. 13, p. 14, pl. 3, figs. 8–10; Swain, 1948, Maryland Dept. Geology, Mines, and Water Resources Bull. 2, p. 195, pl. 14, fig. 1; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 19; Puri, 1952, Jour. Paleontology, v. 26, p. 910, pl. 13, figs. 4–8, text figs. 1, 2; Puri, 1954, Florida Geol. Survey Bull. 36, p. 286, pl. 9, figs. 4–8; Malkin, 1953, Jour. Paleontology, v. 27, p. 778, pl. 78, figs. 1–3.

*Cytherideis longula* 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.

*Cytherideis semicircularis* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 127, pl. 37, figs. 18–20.

*Cushmanidea ashermani* (Ulrich and Bassler). McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 77, pl. 8, figs. 5a–f; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 67, pl. 8, fig. 9; Hall, 1965, Michigan Univ. Natl. Sci. Found. Proj. GB–26, Rept. 4, p. 39, pl. 12, figs. 14–17.

*Hulingsina ashermani* (Ulrich and Bassler). Puri, 1958, Gulf Coast Assoc. Geol. Socs. Trans., v. 8, p. 173; Benson and Coleman, 1963, Kans. Univ. Paleont. Contr., Arthropoda, Art. 8, p. 45, pl. 6, fig. 5, pl. 8, figs. 1–3; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 323, fig. 12A; van den Bold, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 698; Grossman and Benson, 1967, Kansas Univ. Paleont. Contr., Ecology, Art. 1, p. 68, pl. 14, fig. 2 pl. 20, figs. 13, 14.

*Pontocythere ashermani* (Ulrich and Bassler). Hulings, 1966, Chesapeake Sci., v. 7, p. 51, figs. 2a–g, 6N; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 10, pl. 2, figs. 1a–d, pl. 6, fig. 4, text fig. 8.

*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 Formations 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.

**Pontocythere (Hulingsina) cf. P. (H.) rugipustulosa (Edwards)**

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

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

*Pontocythere rugipustulosa* (Edwards). Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 9, pl. 1, fig. 10, text fig. 7. Valentine, 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 3, figs. 17, 18, 21, 22, 25, 26, 29, 30.

*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 Choctawhatchee 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.

*Figured specimens.*—USNM 179538.

**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**

*Neocytherideis* Puri, 1952, Jour. Paleontology, v. 26, p. 912.

?*Sahnia* Puri, 1952, Jour. Paleontology, v. 26, p. 912.

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 posteromedian. 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 subparallel 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 *Copytus* 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 specimens.*—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, *Cythere gibba* O. F. Müller, 1785. Geologic range, Cretaceous to Holocene.

#### Cytherura cf. C. gibba Muller

Plate 3, figures 4a, b

*Cytherura gibba* (Müller). Sars, 1866, Oversigt af Norges Marine Ostracoder (1865), p. 70.

*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 warneri* Howe and Spurgeon, 1935, another possible brackish-water form. The other associated species, however, do not necessarily imply brackish water conditions, that is, *Actinocythereis exanthemata* (Ulrich and Bassler, 1904); *Costa barclayi* (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

*Cytherura forulata* Edwards, 1944, Jour. Paleontology, v. 18, p. 526, pl. 38, figs. 17–20; Swain 1955, Jour. Paleontology, v. 29, p. 628, pl. 64, figs. 10 a-c, text figs. 35c, 39–2, a, b; Puri, 1960, Gulf Coast Asoc. Geol. Socs. Trans. v. 10, p. 115, pl. 4, figs. 16, 17; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 329, fig. 14; Grossman and Benson, 1967, Kansas Univ. Paleont. Contr., Ecology, Art. 1, p. 69, pl. 13, fig. 5, pl. 19, fig. 8; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 12, pl. 5, fig. 10, text fig. 10; Valentine 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 2, fig. 25, 26.

*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

*Cytherura elongata* Edwards, 1944, Jour. Paleontology, v. 18, p. 526, pl. 88, figs. 21–25; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 50, pl. 7, figs. 23, 25; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 59, pl. 7, fig. 5; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 331, fig. 15; Grossman and Benson, 1967, Kansas Univ. Paleont. Contr., Ecology, Art. 1, p. 69, pl. 13, fig. 6, pl. 19, figs. 9, 10, 14; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 12, pl. 6, figs. 11a–c.

*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 is rare in beds of Pliocene(?) age, locality G–3, Bertie County, N.C.; in the upper Yorktown Formation at locality H–2, Bertie County, N.C.; in the middle Yorktown it is common at locality S–4, James County, Va., rare at localities R–1 and R–2, Isle of Wight County, Va., rare at locality K–3, Dinwiddie County, Va.; and rare at localities C–1, C–2, and D–1, Nansemond County, Va.; rare to frequent in the lower Yorktown at localities A–1, A–3, and A–5 Hertford County, N.C. It was described from the upper Miocene Duplin Marl of North Carolina (Edwards, 1944); also occurs in the Pliocene Waccamaw Formation of North and South Carolina (Swain, 1968) and has been found living off the west coast of Florida (Hulings and Puri, 1965).

*Number of specimens studied.*—25+.

*Ecology.*—The species lives at present in sublittoral euhaline to oligohaline environments and prefers sand-mud bottoms (Hulings and Puri, 1965).

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

*Figured specimens.*—USNM 179548–179550.

### Genus CYTHEROPTERON Sars, 1866

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

*Aversovalva* Hornibrook, 1952, New Zealand Geol. Survey Paleont. Bull. 18, p. 57.

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.

*Cytheropteron* cf. *C. subreticulatum* van den Bold. Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 48, pl. 7, figs. 11, 13. Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 59, pl. 7, fig. 10.

*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

*Cytheropteron* (*Hemicytherura*) Elofson, 1941, Uppsala Univ., Zool. Bidrag fran Uppsala, v. 19, p. 314.

*Hemicytherura* Elofson. Hornibrook, 1952, New Zealand Geol. Survey Paleont. Bull. 18, p. 58.

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.

*Hemicytherura howei* (Puri, 1954). Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda 8, p. 49, pl. 9, figs. 1–4; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 11, pl. 4, figs. 5a, b, text fig. 9.

*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 Choctawhatchee 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* G. W. Müller, 1894, Fauna u. Flora des Golfes von Neapel, 21 Mon., p. 340.

?*Mooreina* Harlton, 1933, Jour. Paleontology, v. 7, p. 21.

The shell features of the genus are diagnosed by Moore and others (1961, p. 299). Type species, *Paracytheridea depressa* Müller, 1894 (= *Cytheropteron bovettensis* Sequenza, 1880). Geologic range, Pennsylvanian (*Mooreina*), Upper Cretaceous to Holocene.

#### Paracytheridea mucra Edwards

Plate 1, figure 23

*Paracytheridea mucra* Edwards, 1944, Jour. Paleontology, v. 18, p. 512, pl. 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 altila 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 nodosa* (Ulrich and Bassler). Howe and others, 1935, Florida Geol. Survey Bull. 13, p. 37, pl. 3, fig. 7; van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 86, pl. 16, fig. 7; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, pl. 51, pl. 3, figs. 19–22.

*Paracytheridea vandenboldi* Puri, 1953, Jour. Paleontology, v. 27, p. 251, (new name); Malkin, 1953, Jour. Paleontology, v. 27, p. 780, pl. 79, fig. 5; Puri, 1954, Florida Geol. Survey Bull. 36, p. 238, pl. 3, fig. 7, text figs. 5a, b; Swain, 1955, Jour. Paleontology, v. 29, p. 625, pl. 62, figs. 6a, b; McLean, 1957, Bulls. Am. Paleontology v. 38, no. 167, p. 75, pl. 8, figs. 4a, b; Brown, 1958, North Carolina Dept. Conserv. Devel: Bull. 72, p. 58, pl. 8, fig. 6; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 49, pl. 18, figs. 22–30; Morales, 1966, México Univ. Nac. Autónoma Inst. Geología Bol. 81, p. 54, pl. 7, fig. 6. Grossman and Benson, 167, Kansas Univ. Paleont Contr., Ecology, Art. 1 p. 70 pl. 12, fig. 5, pl. 17, fig. 2; Swain, 1968, U.S. Geol. Survey Paper 573–D, p. 11, pl. 2, figs. 4a, b.

*Paracytheridea altila* 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 683–D, pl. 3, figs. 31–34.

*Remarks.*—van den Bold (1968) has recently assembled all these forms under the name *P. altila* 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 Choctawhatchee 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 SHATTUCKOCYTHERE 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.

*Paracytheridea*? *wetherellii* (Jones, 1854). Swain, 1952, U.S. Geol. Survey, Prof. Paper 234–A, p. 11, pl. 7, figs. 2–4; Brown, 1928, North Carolina Dept. Conserv. Devel. Bull. 72, p. 49, pl. 8, fig. 8.

*Paracytheridea shattucki* (Ulrich and Bassler, 1904). Malkin, 1953, Jour. Paleontology, v. 27, p. 780, pl. 79, figs. 6–9.

*Paracytheridea*? *shattucki* Malkin, 1953. Hall, 1965, Michigan Univ. Natl. Sci. Found. Proj. GB–26, Rept. 4, p. 49, pl. 18, figs. 12–21.

*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 wetherellii* 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.

*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" wetherellii* 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

*Paracytheridea similis* Malkin, 1953, Jour. Paleontology, v. 27, p. 781, pl. 79, figs. 13, 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

*Eocytheropteron yorktownensis* Malkin, 1953, Jour. Paleontology, v. 27, p. 780, pl. 79, figs. 1–4.

*Cytheropteron yorktownensis* (Malkin). Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 13, pl. 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.

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

A diagnosis of the genus was given by Moore and others. (1961, p. 267). Type species, *Cythereis jonesii* Baird. Geologic range, Cretaceous(?), Eocene(?), Miocene to Holocene.

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).

**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. 29–33.

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

*Cythereis* (*Pterygocythereis*) *cornuta* var. *americana* (Ulrich and Bassler). Howe and others, 1935, Florida Dept. Conserv. Geol. Bull. 2, p. 26, pl. 2, figs. 19, 21–24, pl. 4, fig. 24 (= *P. miocenica* van den Bold, by van den Bold (1968)); Swain, 1948, Maryland Dept. Geology, Mines, and Water Resources Bull. 2, p. 206, pl. 14, fig. 4.

*Pterygocythereis cornuta americana* (Ulrich and Bassler). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 41; Puri, 1954, Florida Geol. Survey Bull. 36, p. 261, pl. 13, fig. 105, text figs. 9d–f.

*Pterygocythereis americana* (Ulrich and Bassler). Malkin, 1953, Jour. Paleontology, v. 27, p. 795, pl. 80, figs. 26–29; Hill, 1954, Jour. Paleontology, v. 28, p. 814; McLean, 1957, Bulls. Am. Paleontology, v. 38, p. 80, pl. 9, figs. 5a–d, 6a–e; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda Art. 8, p. 34, pl. 13, figs. 3, 7, 11–14; pl. 14, fig. 12.

[not] *Pterygocythereis americana* (Ulrich and Bassler). Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 39, pl. 4, figs. 14, 15 (=*Pterygocythereis inexpectata* Blake).

*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 enchelon 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.

*Pseudocytheretta* Cushman, 1906, Boston Soc. Nat. History Proc. v. 32, p. 382.

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

*Prionocytheretta* Mehes, 1941, Geol. Hungarica, Ser. Pal., fasc. 16, p. 60.

The genus was diagnosed in Moore and others (1961, p. 270). Type species, *Cytherina subradiosa* Roemer, 1838. Geologic range, Eocene to Holocene.

**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 nitidula* var. *calvertensis* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene, volume, p. 108, pl. 36, figs. 24, 25 (juv. fide Malkin. 1953).

*Cythere paucipunctata* Ulrich and Bassler, 1904, Maryland Geol. Survey Miocene volume, p. 105, pl. 38, figs. 7–9 (female? 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 Kirkby, 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 Resources 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.

[not] *Cytheretta porcella* (Ulrich and Bassler) Swain, 1952, U.S. Geol. Survey Prof Paper 234–A, p, 45, pl. 4, fig. 7. (=Proteoconcha multipunctata (Edwards), fide Plusquellec and Sandberg, 1969.)

*Cytheretta* cf. *C. plebeia* (Ulrich and Bassler). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 45.

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 *Pterygocythereis 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. tenuistriata* (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.

*Cytheretta*? *sahnii* Puri. Benson and Coleman, 1963, Kansas

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

*Protocytheretta sahnii* (Puri). Puri, 1958, Gulf Coast Assoc. Geol. Socs. 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 Duplin 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 36.28–37.84 parts per mil salinity.

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

*Figured specimen.*—USNM 179585.

### Family BYTHOCYTHERIDAE Sars, 1926

### Genus JONESIA Brady, 1866

*Jonesia* Brady, 1866, Zool. Soc. London Trans., v. 5, p. 362.

*Macrocythere* Sars, 1926, An account of the Crustacea of Norway, v. 9, Crustacea, pts. 13, 14, p. 240.

*Macrocytherina* Coryell and Fields, 1937, Am. Mus. Novitates, no. 959, p. 16.

*Luvula* Coryell and Fields, 1937, Am. Mus. Novitates, no. 959, p. 13.

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, =*Bythocythere acuminata* Sars, 1866]. Geologic range, Miocene to Holocene.

#### Jonesia? sp.

Plate 2, figure 23

Shell elongate sublanceolate to subtrapezoidal in side view, highest posteromedially; 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

*Xestoleberis? ventrostriata* Swain, 1952, U.S. Geol. Survey Prof. Paper 234-A, p. 18, pl. 4, figs. 12, 13.

*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 LEPTOCYTHERE Sars, 1925

*Leptocythere* Sars, 1925, Crustacea of Norway, v. 9, pts. 9, 10, p. 172.

*Leptocythera* Sars, 1925 [error], Crustacea of Norway, v. 9, pts. 9, 10, p. 171.

A recent brief description of the shell of the genus was given by Moore and others (1961, p. 309). Type species, *Cythere pellucida* Baird, 1850. Geologic range, Miocene to Recent.

#### Leptocythere paracastanea Swain

Plate 4, figures 5–8; plate 9, figures 6a, b

*Leptocythere paracastanea* Swain, 1955 Jour. Paleontology, v. 29, p. 640, pl. 62, fig. 7; pl. 63, figs. 1a–c, text figures 39–5a, b. Darby, 1965, Michigan Univ., Natl. Sci. Found. Proj. GB–26, Rept. 2, p. 20, pl. 3, figs. 1–10; pl. 4, figs. 1–9.

*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

*Cytheromorpha* Hirschmann, 1909, Soc. Fauna Flora Fennica, Meddel., v. 35, p. 290.

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). Geologic range, Paleocene to Holocene.

#### Cytheromorpha warneri Howe and Spurgeon

Plate 2, figures 26, 27; plate 3, figure 22; plate 4, figures 1–4; plate 8, figures 2a, b; plate 9, figure 8

*Cytheromorpha warneri* Howe and Spurgeon, 1935, Florida Dept. Conserv. Geol. Bull. 13, p. 11, pl. 2, figs. 5, 8, 9; pl. 4, fig. 4; van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 105; Malkin, 1953, Jour. Paleontology, v. 27, p. 787, pl. 80, figs. 18, 19; Puri, 1954, Florida Geol. Survey Bull. 36, p. 277, pl. 6, figs. 5–7, text figs. 11f, g; Puri and Hulings, 1957, Gulf Coast Assoc. Geol. Socs. Trans., v. 7, p. 187, fig. 11; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 67, pl. 7, fig. 9; Puri, 1960, Gulf Coast Assoc. Geol. Socs. Trans., v. 10, p. 114, pl. 3, figs. 11, 12, text fig. 36; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 51, pl. 11, gs. 3, 5, 8, 10, 11, 13; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 51, pl. 20, figs. 16–25.

*Cytheromorpha* cf. *C. warneri* Howe and Spurgeon. Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 49, pl. 7, figs. 14, 19; McLean, 1957, Bulls. Am. Paleontology, v. 38, p. 70, pl. 7, figs. 3a, b.

*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 (1965), 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. rhomboidea* Fischer, 1855). Geologic range, Cretaceous to Holocene.

#### Loxoconcha sp.

Plate 4, figure 9; plate 9, figure 7

Shell subquadrate in side view, highest posteromedially; dorsal margin nearly straight, anterior 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 Choctawhatchee Formation (of former usage) of Florida, but that form is shorter and higher and has a posteroventral 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.

#### Loxocoucha purisubrhomboidea (Edwards)

Plate 4, figure 10

*Loxoconcha subrhomboidea* Edwards, 1944 [not Brady, 1880], Jour. Paleontology, v. 18, p. 527, pl. 88, figs. 28–32; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 25, pl. 2, figs. 18, 19; Malkin, 1953, Jour. Paleontology, v. 27, p. 787.

*Loxoconcha purisubrhomboidea* Edwards, new name, *in* Puri, 1953, Jour. Paleontology, v. 27, p. 270; Puri, 1954, Florida Geol. Survey Bull. 36, p. 274, pl. 10, fig. 8, text fig. 10h; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 171, pl. 7, figs. 4a–3; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 66, pl. 6, fig. 1, Hall; 1965, Michigan Univ. Nat. Sci. Found. Rept. GB–26, Rept. 41 p. 50, pl. 19, figs. 9, 10, 12, 14; Grossman and Benson, 1967, Kans. Univ. Paleont. Contr., Ecology, Art. 1, p. 74, pl. 15, fig. 1, pl. 18, figs. 10, 12, 14, 15, 17; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 25, pl. 3, figs. 7a–e, pl. 7, fig. 7, text figs. 21c, d.

*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. Socs. Trans., p. 187, fig. 11; Puri, 1960, Gulf Coast Assoc. Geol. Socs. 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

*Loxoconcha reticularis* Edwards, 1944, Jour. Paleontology, v. 18, p. 527, pl. 88, figs. 26, 27; Puri, 1954, Florida Geol. Survey Bull. 36, p. 274, pl. 10, fig. 7, text fig. 10e; Malkin, 1953, Jour. Paleontology, v. 27, p. 786, pl. 80, figs. 13–19; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 72, pl. 7, figs. 5a, b; Brown, 1958, North Carolina Conserv. Devel. Bull. 72, p. 66, pl. 6, fig. 2; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 3, p. 51, pl. 19, figs. 1–5; Grossman and Benson, 1967, Kansas, Univ. Paleont. Contr., Ecology, Art 1, p. 75, pl. 15, fig. 2, pl. 18, figs. 2, 3; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 25. pl. 4, figs. 2a–f, 3, text fig. 22.

*Loxoconcha* cf. *L. reticularis* Edwards. Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 26.

*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

*Paradoxostoma* Fischer, 1855, Akad. Wiss. Munich, Math.-Phys. Kl., v. 7, p. 654.

A diagnosis of the genus was given by Moore and others (1961, p. 315). Type species, *Paradoxostoma dispar* Fischer, 1855. Geologic range Cretaceous(?), Eocene to Holocene.

**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.
*Paradoxostoma robustum* Puri. van den Bold, 1966, Konінkl. Nederlandse Akad. Wetensch. Verh., Afd. Natuurk. v. 23, no. 3, p. 37.

*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**

*Murrayina* Puri, 1954, Florida Geol. Survey Bull. 36, p. 258.

A brief description of the shell features of the genus was given by Moore and others (1961, p. 339). 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 posteroventrally 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 anteromidventrally; 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 ACTINOCYTHEREIS Puri, 1953

*Actinocythereis* Puri, 1953, Am. Midland Naturalist, v. 49, p. 178.

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* (Ulrich and Bassler) 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, Geos., no. 11, p. 8.

*Actinocythereis exanthemata* (Ulrich and Bassler). Puri, 1953, Am. Midland Natuarlist, v. 49, p. 179, pl. 2, figs. 4–8, text figs. e, f; Puri, 1954, Florida Geol. Survey Bull. 36, p. 252, pl. 13, figs. 6–13; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 82, pl. 10, figs. 1a–c; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 64, pl. 3, fig. 4; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, p. 329, fig. 14; Grossman and Benson, 1967, Kansas Univ. Paleont. Contr., Ecology, Art. 1, p. 76, pl. 15, fig. 4, pl. 21, fig. 14; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 14, pl. 2, figs. 5a–f, text fig. 12; Hulings, 1967, Contr. Marine Sci., v. 12, p. 86.

*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–4 (highest of samples in bluff, 1 mile north of Plum Point), Calvert County, Md.; middle part of Calvert Formation, localities PPN–1 (lowest of four samples) PPS–1 (lower of two samples in bluff 1 mile south of Plum Point), and PC–1 (lowest 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' 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 Bossler, 1904); subsurface upper Miocene of North Carolina (Swain, 1952); Chipola Formation, the Oak Grove Member of the Shoal 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 environments 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 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.

*Actinocythereis exanthemata* var. *gomillionensis* (Howe and Ellis). Puri, 1953, Am. Midland Naturalist, v. 49, p. 181, pl. 2, figs. 1, 2; Puri, 1954, Florida Geol. Survey Bull. 36, p. 253, pl. 13, figs. 16, 17.

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

*Actinocythereis exanthemata gomillionensis* (Howe and Ellis). McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 83, pl. 10, figs. 2a–d; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 33, pl. 7, figs. 12–17.

*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) *Arca* 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, *Cythere 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.

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

*Actinocythereis mundorffi* (Swain). Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 64, pl. 2, fig. 16; Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 34.

*Cletocythereis mundorffi* (Swain). Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 15, pl. 2, fig. 6.

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, Hertford 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 subsp.**

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 purisubrhomboidea* 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* Neviani, 1928, Pontif. Acad. Sci., Rome, Mém. Ser. 2, v. 11, p. 72.

*Rectotrachyleberis* Ruggieri, 1952, Gior. Geologia, Bologna, Ser. 2, v. 22, p. 38.

A diagnostic description of the shell of the genus was given by Moore and others. (1961, p. 336). Type species, *Cytherina edwardsi* Roemer, 1838. Geologic range, Paleocene to Holocene.

**Costa barclayi (McLean)**

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

*Murrayina barclayi* McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 87, pl. 11, figs. 4a–f; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 60, pl. 22, figs. 4, 5, 9, 11, 12.

*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.

*Occurrence.*—The species is rare to frequent in the Yorktown Formation undivided, locality O–1[3], 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**

*Echinocythereis* Puri, 1954, Florida Geol. Survey Bull. 36, p. 259.

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 McGuirt, 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.

*Leguminocythereis clarkana* (Ulrich and Bassler). Swain, 1948, Maryland Dept. Geol., Mines, and Water Resources Bull. 2, p. 207, pl. 14, fig. 6; 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 43, pl. 6, fig. 18.

*Trachyleberis clarkana* (Ulrich and Bassler). Malkin, 1953, Jour. Paleontology, v. 27, p. 792, pl. 82, figs. 1–3.

*Echinocythereis clarkana* (Ulrich and Bassler). McLean, 1957, Bulls. Am. Paleontology, v. 38. p. 57–103; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 58, pl. 22, figs. 1, 6–8, 10.

*Remarks.*—*Echinocythereis*? *ligula* (Lienenklaus, 1897) as illustrated by Oertli (1956) from the Ru-

[3] Near Cobban wharf.

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 (Pooser, 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 Pungo 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 unsplit-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.

### Genns BENSONOCYTHERE Hazel, 1967

*Bensonocythere* Hazel, 1967, U.S. Geol. Survey Prof. Paper 573–D, p. 29.

The genus was described fully by Hazel (1967). Type species, *Leguminocythereis whitei* Swain, 1952. Geologic range, Oligocene(?) Miocene to Holocene.

#### Bensonocythere whitei (Swain)

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

*Leguminocythereis whitei* Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 43, pl. 3, figs. 14, 16–18, pl. 4, fig. 1; Malkin, 1953, Jour. Paleontology, v. 27, p. 785–788, pl. 80, figs. 7–12; Brown, 1958, North Carolina Dept. Conserv. Devel. p. 63, pl. 6, fig. 10.

*Leguminocythereis*(?) *whitei* Swain. McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 80, pl. 9, figs. 4a–b.

*Triginglymus whitei* (Swain). Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 36, pl. 15, figs. 2, 5, 6, 8, 9; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 37, pl. 9, figs. 11, 12, 14–19.

*Bensonocythere whitei* (Swain). Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 27, pl. 5, figs. 2, 3, 8–10, pl. 10, figs. 1–8, pl. 11, figs. 1, 2; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 29, pl. 5, figs. 4a, b, text fig. 28. Valentine, 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 1, figs. 14, 19.

*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 doubtfully from the Oligocene, subsurface, of North

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

*Campylocythere* Edwards, 1944, Jour. Paleontology, v. 18, p. 154.

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

#### Campylocythere laeva posteropunctata Edwards

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

*Campylocythere 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, including abundant *Aurila conradi* (Howe and McGuirt, 1935), *Muellerina micula* (Ulrich and Bassler, 1909), and *Loxoconcha purisubrhomboidea* (Edwards, 1952) suggest an open shelf sublittoral habitat.

*Zoogeographic derivation.*—This subspecies, like others of the genus seems to have originated in the waters off southeastern North America and Gulf of Mexico.

*Figured specimens.*—USNM 179663–179666.

#### Campylocythere laeva laeva Edwards

Plate 5, figures 18–20; plate 6, figure 1

*Campylocythere laeva* Edwards, 1944, Jour. Paleontology, v. 18, p. 515, pl. 86, figs. 8–14. (See Plusquellec and Sandberg, 1969, for complete synonymy.)

*Occurrence.*—The species has been found in the following samples of the present collection: beds of Pliocene(?) age, common at locality G–3, Bertie County, N.C.; upper Yorktown Formation, rare at localities H–1, and H–2, Bertie County, N.C.; middle Yorktown Formation, rare at localities S–1, James County, Va., R–1, R–3, and R–4, Isle of Wight County, Va., C–1, C–2, D–1 and D–2, Nansemond County, Va.; lower Yorktown Formation, frequent at locality A–5, Hertford County, N.C. (also see Hazel, 1971).

The species was described from the Duplin Marl, upper Miocene, of North Carolina (Edwards, 1944). It has been found also in the Yorktown Formation of Virginia (Malkin, 1953), in the Pliocene Waccamaw Formation of North and South Carolina (Swain, 1968), in the Pleistocene of Virginia (Valentine, 1971), and is recorded living off the west coast of Florida (Puri and Hulings, 1957; Puri, 1960; and Hulings and Puri, 1965).

*Number of specimens studied.*—26.

*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

*Acuticythereis* Edwards, 1944, Jour. Paleontology, v. 18, p. 519.

Shell shorter and more unequal-ended than *Campylocythere* and right valve tends to be subangulate posteriorly, internally like *Campylocythere*. 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 synomy with *Campylocythere*.

#### 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–3 and K–4, Dinwiddie County, Va., C–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 leguminocythereidid 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 *Dictyocythere* 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.

### Prodictyocythere trapezoidalis, n. gen., n. sp.

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

*Diagnosis.* — *Prodictyocythere* 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 HEMICYTHERIDAE Puri, 1953
### Subfamily HEMICYTHERINAE Puri, 1953

#### Genus RADIMELLA Pokorny, 1968

*Radimella* Pokorny, 1968, Acta Universitatus Carolinae—Geologica, No. 4, p. 360.

*Diagnosis.*—"Carapace rather varying in shape, hemicytheroid, elongate-oval or subquadrate, 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. Dorsomedian 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.

#### Radimella confragosa (Edwards)

Plate 6, figures 11–13

*Hemicythere confragosa* Edwards, 1944, Jour. Palentology, v. 18, p. 518, p. 86, figs. 23–26; Swain, 1952, U.S. Geol. Survey Prof. Paper, 234–A, p. 43, pl. 6, figs. 13, 14; Puri, 1953, Washington Acad. Sci. Jour., v. 43, p. 176, pl. 1, figs. 4–6; Puri, 1954, Florida Geol. Survey Bull. 36, pl. 266, pl. 11, figs. 10a–12; van den Bold, 1958, Micropaleontology, v. 4, p. 71; Brown, 1958, North Carolina Dept. Conserv. and Devel. Bull 72, p. 66, pl. 7, fig. 1.

*Mutilus confragosa* (Edwards). Puri, 1960, Gulf Coast Assoc. Geol. Socs. 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.

*Radimella confragosa* (Edwards). Pokorny, 1968, Acta Universitatus Carolinae Geologica, no. 4, p. 364; Hazel, 1971, U.S. Geol. Survey Prof. Paper 704, p. 6.

*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 *Radimella* 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

*Auris* Neviani, 1928, Pontif. Acad. Sci., Rome, Mém. Ser. 2, v. 11, p. 72 (not Spix, 1827).

*Aurila* Pokorny, 1955, Acta Universitatus, Carolinae-Geologica 3, p. 17.

The shell characteristics of *Aurila* were summarized by Howe in Moore and others (1961, p. 302). Type species, *Cythere convexa* 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

*Hemicythere conradi* (Howe and McGuirt), 1935, Florida Geol. Survey Bull. 13, p. 27, pl. 3, figs. 31–34, pl. 4, fig. 17; Edwards 1944, Jour. Paleontology, v. 18, p. 518, pl. 86, figs. 17, 18; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 42, pl. 6, figs. 9–12; Puri, 1953, Washington Acad. Sci. Jour., v. 43, p. 176, pl. 2, figs. 1, 2; Malkin, 1953, Jour. Paleontology, v. 27, p. 796, pl. 82, figs. 16–18; Puri, 1954, Florida Geol. Survey Bull. 36, p. 306; Swain, 1955, Jour. Paleontology, v. 29, p. 635, pl. 62, figs. 3a–c; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 65, pl. 6, fig. 17.

*Aurila conradi* (Howe and McGuirt). McLean, 1957, Bulls, Am. Paleontology, v. 38, no. 167, p. 84, pl. 11, figs. 7a, b; Puri, 1960, Gulf Coast Asoc. Geol. Socs. Trans., v. 10, p. 129, pl. 3, figs. 9, 10; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, supp., p. 323, fig. 12A.

*Aurila conradi conradi* (Howe and McGuirt). Pooser, 1965, Kansas Univ. Paleont. Contr. Arthropoda, Art. 8, p. 48, pl. 17, figs. 1, 2, 12, 13; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 32, pl. 6, figs. 10–19, 23; Swain 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 23, pl. 5, figs. 7a–i, text fig. 20.

*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

*Caudites* Coryell and Fields, 1937, Am. Mus. Novitates 959, p. 10.

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.

### Genns MUELLERINA Bassiouni, 1965

*Muellerina* Bassiouni, 1965, Dansk Geol. Fören. Medd. v. 15, pt. 4, p. 508.

The characteristics of the genus were diagnosed by Bassiouni (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). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 29, pl. 3, figs. 8, 15.

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

*Murrayina martini* (Ulrich and Bassler). Puri, 1954, Florida Geol. Survey Bull. 36, p. 256, pl. 12, figs. 11–13, text figs. 8e, f; McLean, Bulls. Am. Paleontology, v. 38, p. 11, figs. 1a–c, 2a, b, 3a–d; Brown, 1958, North Carolina Dept. Conserv. Devel. Bull. 72, p. 65, pl. 3, fig. 3; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropda, Art. 8, p. 60, pl. 21, figs. 3, 5, 8; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 34, pl. 9, figs. 1–10, 13.

*Murrayina micula* (Ulrich and Bassler), Williams, 1966, Kansas Univ. Paleont. Inst., Paper 11, p. 31, text figs. 18–7, 25.

*Muellerina 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, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 16, pl. 3, figs. 2a–h, 3a, b, 4a, b, 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 Miocene Calvert Formation and occurs in the upper Miocene Duplin Marl and the Pliocene Waccamaw Formation in the present collection.

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 lienenklausi* 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

*Orionina* Puri, 1954, Florida Geol. Survey Bull. 36, p. 253.

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.

*Cythereis vaughani* (Ulrich and Bassler). Howe and others, 1935, Florida Geol. Survey Bull. 13, p. 25, pl. 3, figs. 24, 25; pl. 4, fig. 13; [not Coryell and Fields, 1937, Am. Mus. Novitates, no. 956, p. 9, fig. 10a. = *O. serrulata* Brady; Edwards, 1944, Jour. Paleontology, v. 18, p. 522, pl. 87, figs. 27, 28; van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 88, pl. 10, fig. 1; 1950, Jour. Paleontology, v. 20, p. 83.

*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.

*Orionina bermudae* (Brady). van den Bold, 1957, Micropaleontology, v. 3, p. 242, table 1 [not pl. 1, figs. 12a, b,=*Orionina similis* van den Bold]; 1958, Micropaleontology, v. 4, p. 403 [part] [not pl. 5, fig. 9,=*Orionina serrulata* (Brady)]; Puri and Vernon, 1959, Florida Geol. Survey Spec. Pub. 5, p. 151, 154, 156, 182, 197, 406 [not p. 243,=*Orionina bradyi*, van den Bold. fide van den Bold, 1963]; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 61, pl. 17, figs. 3, 8, 10, 11.

*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 Meherrin 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

*Thaerocythere* Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 25.

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 schmidtae (Malkin)

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

*Trachyleberis* cf. *T.? reesidei* (Swain). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 30, pl. 3, fig. 13 [not Cythereis reesidei Swain, 1948.]

*Hemicythere schmidtae* Malkin, 1953, Jour. Paleontology, v. 27, p. 796, pl. 82, figs. 19–23; Brown, 1953, North Carolina Dept. Conserv. Devel. Bull. 72, p. 66, pl. 3, fig. 1.

*Thaerocythere schmidtae* (Malkin). Hazel, 1967, U.S. Geol. Survey Prof. Paper 564, p. 26.

*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 sublittoral to open-shelf environment judging from associated abundant *Cytherura, Aurila,* and *Cytheromorpha.*

*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

*Trachyleberis*? cf. *T. angulata* (Sars), Swain, 1952, U.S. Geol. Survey, Prof. Paper 234–A, p. 29, pl. 3, figs. 9–12 [placed in *Thaerocythere* by Hazel (1967)].

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. schmidtae* (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

*Favella* Coryell and Fields, 1937, Am. Mus. Novitates 959, p. 8, [not Jorgensen, 1925].

*Puriana* Coryell and Fields, by Coryell in Puri, 1953, Jour. Paleontology, v. 27, p. 750.

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 Hemicytheridae-Thaerocytherinae.

#### Puriana rugipunctata (Ulrich and Bassler)

Plate 7, figures 19, 20

*Cythere rugipunctata* Ulrich and Bassler, 1904, Maryland Geol. Survey, Miocene volume, p. 118, pl. 30, figs. 16, 17.

*Cythereis rugipunctata* (Ulrich and Bassler). Howe and others, 1935, Florida Dept. Conserv. Geol. Bull. 13, p. 23, pl. 1, figs. 18, 20–22, pl. 4, figs. 22, 23.

*Favella rugipunctata* (Ulrich and Bassler). Edwards, 1944, Jour. Paleontology, v. 18, p. 524, pl. 88, figs. 5, 6; van den Bold, 1946, Contr. study Ostracoda, Amsterdam, de Bussy, p. 100, pl. 10, fig. 3; 1950, Jour. Paleontology, v. 24, p. 86; Malkin, 1953, Jour. Paleontology, v. 27, p. 797, pl. 83, fig. 24.

*Trachyleberis? rugipunctata* (Ulrich and Bassler). Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 38, pl. 6, fig. 8.

*Puriana rugipunctata* (Ulrich and Bassler). Puri, 1953, Jour. Paleontology, v. 27, p. 751, 1954, Florida Geol. Survey Bull. 36, p. 257, pl. 12, figs. 16, 19, text fig. 8h; McLean, 1957, Bulls. Am. Paleontology, v. 38, no. 167, p. 89, pl. 11, figs. 4a–d; Puri, H. S. and Hulings, N. C., 1957, Gulf Coast Assoc. Geol Socs. Trans, v. 7, p. 174, 176, 183; Brown, 1958, North Carolina Dept. Conserv. and Devel. Bull. 72, p. 63, pl. 4, fig. 10; Puri, 1960, Gulf Coast Asoc. Geol. Socs. Trans., v. 10, p. 126, pl. 6, fig. 18; Benson and Coleman, 1963 Kansas Univ. Paleont. Contr. Arthropoda, Art. 2, p. 43, pl. 8, figs. 1, 2, text fig. 27. (not pl. 8, fig. 5=*mesacostalis*); van den Bold, 1963, Micropaleontology, v. 9, p. 368, 370, 371; Pooser, 1965, Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, p. 61, pl. 17, figs. 4–7, 9; Hulings and Puri, 1965, Pub. Staz. Zool., Napoli, v. 33, Supp., p. 321, fig. 12; Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 36, pl. 8, figs. 1–5, 7; Grossman and Benson, 1967 Kansas Univ. Paleont. Contr., Ecology, Art. 1, p. 72, pl. 14, fig. 8, pl. 21, figs. 11–13; Swain, 1968, U.S. Geol. Survey Prof. Paper 573–D, p. 18, pl. 5, figs. 8a–c, pl. 7, fig. 4, text figs. 16, 17. Valentine, 1971, U.S. Geol. Survey Prof. Paper 683–D, pl. 2, figs. 31, 36.

*Carinocythereis rugipunctata* (Ulrich and Bassler). Sylvester-Bradley, in Moore and others 1961, Treatise on Invertebrate Paleontology, v. Q, p. 336.

*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, subsurface 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, 1960; Hulings and Puri, 1965; Benson and Coleman, 1963), Georgia (Hall, 1965), and North Carolina (Grossman, 1967).

*Number of specimens studied.*—25+.

*Ecology.*—The species is living at present in Pamlico 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

*Favella mesacostalis* Edwards, 1944, Jour. Paleontology, v. 18, p. 524, pl. 88, figs. 1–4; Swain, 1952, U.S. Geol. Survey Prof. Paper 234–A, p. 41.

*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*, fide Hall, 1965].

*Puriana mesacostalis* (Edwards). Hall, 1965, Michigan Univ. Nat. Sci. Found. Proj. GB–26, Rept. 4, p. 37, pl. 8, figs. 6, 8–14, 17.

*Puriana mesicostalis* (Edwards). Swain, 1968 (error in spelling), U.S. Geol. Survey Prof. Paper 573–D, p. 19, pl. 4, fig. 13, pl. 5, fig. 13.

*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.

## REFERENCES


Alexander, C. I., 1936, Ostracoda of the genera *Eucythere, Cytherura, Eucytherura,* and *Loxoconcha* from the Cretaceous of Texas: Jour. Paleontology, v. 10, p. 639–694, pl. 93.

Baird, William, 1850, The natural history of the British Entomostraca: Royal Soc. [London] Proc. p. i–viii, 1–364, pls. 1–36.

Bassiouni, M. A. A., 1965, Über einige Ostracoden aus dem Interglazial von Esbjerg: Dansk Geol. Foren. Medd., v. 15, p. 507–518.

——— 1969, Ostracoden aus dem Eozän von Ägypten: I. Trachyleberidinae Geol. Jahrb. v. 87, p. 383–426, pls. 24–28.

Benda, W. K., and Puri, H. S., 1962, The distribution of Foraminifera and Ostracoda off the Gulf Coast of the Cape Romano area, Florida: Gulf Coast Assoc. Geol. Socs., Trans., v. 12, p. 303–341.

Benson, R. H., 1959, Ecology of Recent ostracodes of the Todos Santos Bay region, Baja California, Mexico. Kansas Univ. Paleont. Contr., Arthropoda, Art. 1, p. 1–80, 11 pls., 20 text figs.

Benson, R. H., and Coleman, G. L., 1963, Recent marine ostracodes from the eastern Gulf of Mexico: Kansas Univ. Paleont. Contr., Arthropoda, Art. 2, p. 1–52, pls. 1–8, figs. 1–33.

Blake, C. H., 1933, New Crustacea from the Mount Desert region, Ostracoda *in* Biological Survey of the Mount Desert region: Proctor, 1933, pt. 5, p. 229–241.

Bold, W. A., van den, 1946, Contribution to the study of Ostracoda with special reference to the Tertiary and Cretaceous microfauna of the Caribbean region: Dissertation, Utrecht Univ., J. H. de Bussy, Amsterdam, 167 p., 8 pls.

——— 1950, Miocene Ostracoda from Venezuela: Jour. Paleontology, v. 24, p. 76–88, pls. 18, 19, 4 text figs.

——— 1963, Upper Miocene and Pliocene Ostracoda of Trinidad: Micropaleontology, v. 9, p. 361–424, pls. 1–12.

——— 1964, Nota preliminar sobre los ostrácodo del Mioceno-Reciente de Venezuela: Univ. Cent. Venezuela, Geos., no. 11, p. 9–14.

——— 1968, Ostracoda of the Yague Group (Neogene) of the northern Dominican Republic, Bulls. Am. Paleontology, v. 54, no. 239, p. 1–106, 10 pls., 8 text figs.

Bosquet, J., 1852, Description des Entomostracés fossiles des terrains Tertiaires de la France et de la Belgique: Acad. Royale Belgique, Mém. cour. et Mém. Sav. étrangerès, Sci., Lettres, Beaux-Arts de v. 24, 142 p., 6 pls.

Brady, G. S., 1866, On new or imperfectly known species of marine Ostracoda, Zool. Soc. London Trans., v. 5, p. 359–393, pls. 57–62.

——— 1867–1886, Descriptions of Ostracoda *in* de Folin and Perier Les Fonds de la Mer: Paris, v. 1, pt. 1, p. 1–48, 1867, 1868; p. 49–112, 1868, p. 113–176, 1869; pt. 2 p. 177–256, 1870, p. 257–272, 1871, p. 273–316, 1872, pls. 1–32 (date unknown); v. 2, pt. 1, p. 9–13, 19–28, 166, 194–200, pls. 12, 14, 15, 1886?.

——— 1868, A monograph of the Recent British Ostracoda, Linnean Soc. London Trans., v. 26, p. 353–495, pls. 23–41.

——— 1870, Notes on Entomostraca taken chiefly in the Northumberland and Durham district, 1869, Nat. History Soc. Northumberland and Durham Trans., v. 3, p. 361–373. pls. 12–14.

Brady, G. S., and Norman, A. M., 1889, A monograph of the marine and fresh water Ostracoda of the North Atlantic and of northwestern Europe, Section 1, Podocopa: Royal Dublin Soc., Sci. Trans., ser. 2, v. 4, p. 63–270, pls. 8–23.

Brady, G. S., and Robertson, D., 1872, Contributions to the study of the Entomostraca, no. VI, On the distribution of the British Ostracoda, Annals Mag. Nat. History, ser. 4, v. 9, p. 48–70, pls. 1, 2.

Bronstein, Z. S. 1930, Beiträge zur Kenntnis der Ostracodenfauna des Baikalsees, Trav. étude Lac Bajkal: Leningrad, v. 3, p. 117–157.

Brown, P. M., 1958, Well logs from the coastal plain of North Carolina, North Carolina Dept. Conserv. and Devel. Bull. 72, 99 p., 8 pls. 9 text figs.

Byrne, J. V., LeRoy, D. O., and Riley, C. M., 1959, The chenier plain and its stratigraphy, southwestern Louisiana, Gulf Coast Assoc. Geol. Socs. Trans., v. 9, p. 237–259, pls. 3–9.

Clark, W. B., and Miller, B. L., 1906, A brief summary of the geology of the Virginia Coastal Plain: Virginia Geol. Survey Bull. 2, p. 11–24.

Cooke, C. W., 1945, Geology of Florida: Florida Geol. Survey Bull. 29, p. 180–195.

Coryell, H. N., and Fields, S., 1937, A Gatun ostracode fauna from Cativa, Panama, Am. Mus. Novitates, no. 959, 19 p., 2 pls.

Coryell, H. N., Sample, C. H., and Jennings, P. H., 1935, *Bairdoppilata*, a new genus of Ostracoda with two new species, Am. Mus. Novitates, no. 777, 5 p., 4 figs.

Cushman, J. A., 1906, Marine Ostracoda of Vineyard Sound and adjacent waters, Boston Soc. Nat. History Proc., v. 32, p. 359–385, pls. 27–38.

Dall, W. H., 1898, A table of North American Tertiary horizons, correlated with one another and with those of western Europe, with annotations: U.S. Geol. Survey 18th Ann. Rept., pt. 2, (papers chiefly of a theoretic nature)3, p. 338; also published in 1897 as 55th Cong. 2d sess., H. Doc.

Darby, D. G., 1965, Ecology and taxonomy of Ostracoda in the vicinity of Sapelo Island, Georgia: Michigan, Univ. Natl. Sci. Found. Proj. GB–26, Rept. 2, 76 p., 33 pls.

Dubowsky, N. W., 1939, Zur Kenntnis der Ostracoden-Fauna des Schwarzen Meeres: Trav. Sta. Biol., Karadagh, v. 5, p. 3–68, text figs 1–68.

Edwards, R. A., 1944, Ostracoda from the Duplin Marl (upper Miocene) of North Carolina: Jour. Paleontology, v. 18, p. 505–528, pls. 85–88.

Egger, J. G., 1901, Ostrakoden aus Meeresgrundproben, gelothet von 1874–1876 von S. M. S. Gazelle: Akad. Wiss. Munich Abb., Math.-Phys. Kl. Königlich Bayerischne, v. 12 (1900–1901), p. 413–477.

Elofson, Olof, 1941, Zur Kenntniss der marinen Ostracoden Schwedens, mit besonderer Berücksichtigung des Skageraks: Uppsala Univ., Zool. Bidrag from Uppsala, v. 19, p. 215–234, 52 text figs.

Fischer, S., 1855, Beitrag zur Kenntnis der Ostracoden. Akad. Wiss. Munich, Math.-Phys. Kl. 7, v. 3, p. 635–666, pls. 1, 2.

Grossman, Stuart, and Benson, R. H., 1967, Ecology of Rhizopodea and Ostracoda of southern Pamlico Sound Region, North Carolina: Kansas Univ. Paleont. Contr., Ecology, Art, 1, p. 1–90, pls. 1–21, text figs. 1–17.

Hall, D. D., 1965, Paleoecology and taxonomy of fossil Ostracoda in the vicinity of Sapelo Island, Georgia: Michigan Univ. Natl. Sci. Found. Proj. GB–26, Rept. 4, 79 p., 20 pls.

Harlton, B. H., 1933, Micropaleontology of the Pennsylvanian Johns Valley shale of the Ouachita Mountains, Oklahoma, and its relationship to the Mississippian Caney shale: Jour. Paleontology, v. 7, p. 3–29, pls. 1–7.

Hazel, J. E., 1967, Classification and distribution of the Recent Hemicytheridae and Trachyleberididae (Ostracoda) off northeastern North America; U.S. Geol. Survey Prof. Paper 564, 49 p., 11 pls., 2 text figs.

——— 1968, Ostracodes from the Brightseat Formation (Danian) of Maryland; Jour. Paleontology, v. 42, p. 100–142, pls. 21–26, 17 text figs.

——— 1970, Ostracode zoogeography in the southern Nova Scotian and northern Virginian faunal provinces; U.S. Geol. Survey Prof. Paper 529–E, 21 p., 69 pls., 11 text figs.

——— 1971, Ostracode biostratigraphy of the Yorktown Formation (upper Miocene and lower Pliocene) of Virginia and North Carolina, U.S. Geol. Survey Prof. Paper 704, 13 p., 6 text figs.

Hill, B. L., 1954, Reclassification of winged *Cythereis* and winged *Brachycythere,* Jour. Paleontology, v. 28, p. 804–826, pls. 97–100.

Hirschmann, Nikolaj, 1909, Beitrag zur Kenntnis der Ostracoden-fauna des finnischen Meerbusens, Soc. Fauna Fennica, Meddel., v. 35, p. 282–297, pl. 1, text figs. 1–12.

Hornibrook, N. de B, 1952, Tertiary and Recent marine Ostracoda of New Zealand: New Zealand Geol. Survey, Paleont. Bull. 18, 82 p., 18 pls.

Howe, H. V., and others, 1935, Ostracoda of the *Arca* zone of the Choctawhatchee Miocene of Florida: Florida Dept. Conserv. Geol. Bull. 13, 47 p., 4 pls.

Howe, R. C., 1963, Type Saline Bayou Ostracoda: Louisiana Dept. Conserv. Geol. Bull. 40, 62 p., 4 pls. 4 figs.

Hulings, N. C., 1966, Marine Ostracoda from western North Atlantic off the Virginia coast: Chesapeake Sci., v. 7, p. 40–56.

——— 1967, A review of the Recent marine podocopid and platycopid ostracods of the Gulf of Mexico: Contr. Marine Sci., v. 12, p. 80–100, 1 text fig.

Hulings, N. C. and Puri, H. S., 1965, The ecology of shallow water Ostracoda of the west coast of Florida: Pub. Staz. Zool., Napoli, v. 33, supp., p. 308–344, text figs. 1–17.

Ishizaki, Kunihiro, 1971, Ostracodes from Aomori Bay, Aomori Prefecture, northeast Honshu, Japan: Tohoku Univ. Sci. Rept., 2d ser. (Geol.), v. 43, p. 59–97, pls. 1–7.

Jones, T. R., 1856, Notes on the Entomostraca (Entomostraca of the Osborne and Hempstead Series) *in* Edwards Forbes' on the Tertiary Fluvio-Marine Formation on the Isle of Wight: Great Britain Geol. Survey Mem., p. 157–158, pl. 7.

Juday, Chauncey, 1907, Ostracoda of the San Diego region: II. Littoral Forms: California Univ. Pubs. Zoology, v. 3, no. 9, p. 135–150, pls. 18–20.

Keroher, G. C., and others, 1966, Lexicon of geologic names of the United States for 1936–1960; U.S. Geol. Survey Bull. 1200, 3 parts.

Kimrey, J. O., 1965, Description of the Pungo River Formation in Beaufort County, North Carolina: North Carolina Dept. Conserv. and Devel. Bull. no. 79, 131 p.

Kirkby, J. W., 1860, On Permian Entomostraca from the shell limestone of Durham, with notes on the species by T. Rupert Jones: Tyneside Natl. Field Club, Tr. v. 4, p. 122, 4 pls.

LeGrand, H. E., and Brown, P. M., 1955, Guidebook of excursion in Coastal Plain of North Carolina: North Carolina Div. Mineral Resources Spec. Pub., 43 p.

Lienenklaus, E., 1897, Die Ostrakoden des mittleren Norddeutschlands: Deutsch. Geol. Gesell. Zeitschr. p. 3–73, 4 pls.

Lucus, V. Z., 1930, Some Ostracoda of the Vancouver

Island region: Contr. Canadian Biol. Fisheries, v. 6, no. 5, p. 397–416 [1931].

Maddocks, R. F., 1969, Revision of Recent Bairdiidae (Ostracoda): U.S. Natl. Mus. Bull. 295, 126 p., 63 figs.

Malde, H. E., 1959, Geology of the Charleston phosphate area, South Carolina: U.S. Geol. Survey Bull. 1079, p. 28–34.

Malkin, D. S., 1953, Biostratigraphic study of Miocene Ostracoda of New Jersey, Maryland and Virginia: Jour. Paleontology, v. 7,. p. 761–799, pls. 78–82, 14 text figs.

McKenzie, K. G., and Swain, F. M., 1967, Recent Ostracoda from Scammon Lagoon, Baja California: Jour. Paleontology, v. 41, p. 281–305, pls. 29, 30; 36 text figs.

McLean, J. D., Jr., 1957, The Ostracoda of the Yorktown Formation in the York-James Peninsula of Virginia: Bulls. Am. Paleontology, v. 38, no. 167, p. 57–103, pls. 7–12.

Mehes, Gyula, 1941, Budapest kornyékének felsooligocén ostracodai: Geol. Hungarica, Ser. Pal., pt. 16, 95 p., 7 pls. 143 text figs.

Mincher, A. R., 1941, The fauna of the Pascagoula Formation: Jour. Paleontology, v. 15, p. 337–348.

Moore, R. C., and others, 1961, Treatise on invertebrate paleontology Part Q, Arthropoda 3, Crustacea, Ostracoda: 442 p., 334 figs.

Morales, G. A., 1966, Ecology, distribution, and taxonomy of Recent Ostracoda of the Laguna de Terminos, Campeche, Mexico: México Univ. Nac. Autónoma Inst. Geologiá Bol. 81, 103 p., 8 pls., 46 figs.

Müller, G. W., 1894, Die Ostracoden des Golfes von Neapel und der angrenzenden Meeres-Abschnitte, Naples Sta. Zool: Fauna u. Flora des Golfes von Neapel, Mon. 21, p. i–viii, 1–404, pls. 1–40.

——— 1912, Das Tierreich, no. 31, Ostracoda Königl: Berlin, Preuss. Akad. Wissenschaften, 434 p.

Neale, J. W., 1964, Some factors influencing the distribution of Recent British Ostracoda: Pub. Staz. Zool., Napoli, v. 33, supp., p. 247–307, 1 pl., 11 text figs.

Neviani, A., 1928, Ostracodi fossili d'Italia I. Vallebiaja (Calabriano): Pontif. Acad. Sci., Rome, Mém., Ser. 2, v. 11, p. 1–120, 2 pls.

Oaks, R. Q., and Coch, N. K., 1963, Pleistocene sea levels, southeastern Virginia: Science, v. 140, no. 3570, p. 979–983.

Oertli, H. J., 1956, Ostracoden aus der Oligozänen and Miozänen Molasse der Schweiz, Schweiz. Naturf. Gesell: Schweizer Paläont. Abh., v. 74, 119 p., 16 pls.

Owens, J. P., and Minard, J. P., 1960, The Geology of the north-central part of the New Jersey coastal plain: Johns Hopkins Univ. Studies Geology, no. 18, Guidebook 1, p. 27.

Plusquellec, P. L., and Sandberg, P. A., 1969, Some genera of the ostracode subfamily Campylocythereinae: Micropaleontology, v. 15, p. 427–480, pls. 1–10.

Pokorný, Vladimir, 1955, Contribution to the morphology and taxonomy of the subfamily Hemicytherinae Puri, Acta Universitatus Carolinae-Geologica 3, 35 p.

——— 1969a, *Radimella*, gen. n. A new genus of the Hemicytherinae (Ostracoda, Crust.) Acta Universitatus Carolinae-Geologica 1968–4, p. 369–373, text figs. 1–12.

——— 1969b, The genus *Radimella* Pokorny, 1969 (Ostracoda, Crustacea) in the Galapagos Islands, Acta Universitatus Carolinae-Geologica no. 4, p. 293–334, pls. 1–8, text figs. 1–39.

Pooser, W. K., 1965, Biostratigraphy of Cenozoic Ostracoda from South Carolina: Kansas Univ. Paleont. Contr., Arthropoda, Art. 8, 80 p., 22 pls., 7 text figs.

Puri, H. S., 1952, Ostracode genus *Cytherideis* and its allies: Jour. Paleontology, v. 26, p. 902–914, pls. 130, 131, text figs. 1–14.

——— 1953a, The ostracode genus *Trachyleberis* and its ally *Actinocythereis*, Am. Midland Naturalist, v. 49, p. 171–181, pl. 1, 2.

——— 1953b, Taxonomic comments on "Ostracoda from wells in North Carolina, Part 1: Cenozoic Ostracoda" by F. M. Swain: Jour. Paleontology, v. 27, p. 750–752.

——— 1954, Contributions to the study of the Miocene of the Florida Panhandle: Florida Dept. Conserv. Geol. Bull. 36, 345 p., pls. 1–17, 14 text figs.

——— 1958, Ostracode genus *Cushmanidea*, Gulf Coast Assoc. Geol. Socs. Trans., v. 8, p. 171–181, 2 pls.

——— 1960, Recent Ostracoda from the west coast of Florida: Gulf Coast Asoc. Geol. Socs. Trans., v. 10, p. 107–149, pls. 1–6.

Puri, H. S., and Hulings, N. C., 1957, Recent ostracod facies from Panama City to Florida Bay area: Gulf Coast Assoc. Geol. Socs. Trans., v. 7, p. 167–190.

Remane, A., 1940, Einführung in die zoologische Ökologie der Nord-und Ostsee: Tierwelt der Nord-und Ostsee, v. 1, p. 1–238.

Ruggieri, G., 1952, Nota preliminare sugli Ostracodi di alcune spiaggie Adriatiche: Bologna Univ. Inst. Zool., Nota del Lab. Biol. Marina di Fano, v. 1, no. 8, p. 57–64.

Sandberg, Philip, 1964, Larva-adult relationships in some species of the ostracode genus *Haplocytheridea*: Micropaleontology, v. 10, p. 357–368, pls. 1, 2.

Sars, G. O., 1866, Oversigt af Norges marine Ostracoder: Norske Vidensk.-Akad. Forh. (1865), p. 1–130.

——— 1928 An account of the Crustacea of Norway, v. 9: Ostracoda, Bergen Museum, 277 p., 119 pls. [1922–1928].

Schmidt, R. A. M., 1967, New generic assignments for some Pleistocene Ostracoda from Alaska: Jour. Paleontology, v. 41, p. 487, 488, pl. 62.

Schneider, G. F., 1949, Ostracod fauna from the Miocene of the Caucasus and Crimea: Microfauna USSR, v. 2, All-Union Petrol. Sci.-Res. Geol. Expl. Inst., Leningrad (VNIGRI), Trans., n.s., v. 30, p. 89–182, pls. 1–10.

Smith, R. H., 1941, Micropaleontology and stratigraphy of a deep well at Niceville, Okaloosa County, Florida, Am. Assoc. Petroleum Geologists Bull., v. 25, p. 263–286.

Spangler, W. B., and Peterson, J. J., 1950, Geology of Atlantic coastal plain: Am. Assoc. Petroleum Geologists Bull., v. 34, p. 1–99.

Stephenson, M. B.. 1936, Shell structure of the ostracode genus *Cytheridea*: Jour. Paleontology, v. 10, p. 695–705, pl. 94.

——— 1937, Middle Tertiary Ostracoda of the genus *Cytheridea*: Jour. Paleontology, v. 11, p. 145–159, pls. 26, 27.

——— 1938, Miocene and Pliocene Ostracoda of the genus *Cytheridea* from Florida: Jour. Paleontology, v. 12, no. 2, p. 127–148, pls. 23, 24, 20 text figs.

——— 1941, Notes on the subgenera of the ostracode genus *Cytheridea*: Jour. Paleontology, v. 15, p. 424–429, text figs. 1–20.

Stuckey, J. L., 1958, Geologic map of North Carolina (1:500,000): North Carolina Div. Mineral Resources.

Stuckey, J. L., and Conrad, S. G., 1958, Explanatory text for geologic map of North Carolina, North Carolina Div. Mineral Resources Bull. 71, p. 45.

Sutton, A. H., and Williams, J. R., 1939, Ostracoda from the Weches Formation at Smithville, Texas: Jour. Paleontology, v. 13, p. 561–574, pls. 63, 64.

Swain, F. M., 1948, Ostracoda from the Hammond well *in* Anderson, J. L., and others, Cretaceous and Tertiary subsurface geology: Maryland Dept. Geology, Mines, and Water Resources Bull. 2, p. 187–212, pls. 12–14.

——— 1952, Ostracoda from wells in North Carolina, Part 1, Cenozoic Ostracoda: U.S. Geol. Survey Prof. Paper 234–A, 58 p., 7 pls.

——— 1955, Ostracoda of San Antonio Bay, Texas: Jour. Paleontology, v. 29, no. 4, p. 561–646, pls. 59–64.

——— 1963, Pleistocene Ostracoda from the Gubik Formation, Arctic Coastal Plain, Alaska: Jour. Paleontology, v. 37, p. 798–834, pls. 95–99, 13 text figs.

——— 1967, Ostracoda from the Gulf of California: Geol. Soc. America Mem. 101, 130 p., 9 pls., 58 text figs.

——— 1968, Ostracoda from the upper Tertiary Waccamaw Formation of North Carolina and South Carolina: U.S. Geol. Survey Prof. Paper 573–D, 37 p., 7 pls.

Swain, F. M., and Brown, P. M., 1964, Cretaceous Ostracoda from wells in the southeastern United States: North Carolina Dept. Conserv. and Devel. Bull. 78, 55 p., 5 pls.

——— 1972, Lower Cretaceous Jurassic(?), and Triassic Ostracoda from the Atlantic coastal region: U.S. Geol. Survey Prof. Paper 795, 55 p., 10 pls.

Sylvester-Bradley, P. C., 1947, Some ostracod genotypes: Annals Mag. Nat. History, ser. 11, v. 13, p. 192–199.

Tressler, W. L., and Smith, E. M., 1948, An ecological study of seasonal distribution of Ostracoda, Solomons Island, Maryland region, Chesapeake Biol. Lab. Pub. 71, p. 3–57, pls. 1–4.

Ulrich, E. O., and Bassler, R. S., 1904, Systematic paleontology of the Miocene deposits of Maryland: Ostracoda, Maryland Geol. Survey, Miocene volume, p. 98–130, pls. 35–38.

Valentine, P. C., 1971, Climatic implication of a late Pleistocene ostracode assemblage from southeastern Virginia: U.S. Geol. Survey Prof. Paper 683–D, 28 p., 4 pls.

Wagner, C. W., 1957, Sur les Ostracodes du Quaternaire récent des Pays-Bas et leur utilisation dans l'étude géologique des dépôts holocènes: Mounton & Co., The Hague, p. 1–259, 50 pls. 21 figs.

——— 1964, Ostracods as environmental indicators in Recent and Holocene estuarine deposits of the Netherlands: Pub. Staz. Zool., Napoli, v. 33, supp., p. 480–495, 6 text figs.

Williams, R. B., 1966, Recent marine podocopid Ostracoda of Narragansett Bay, Rhode Island: Kansas Univ. Paleont. Contr. Inst., Paper 11. 36 p., 27 figs.

# INDEX

[Italic page numbers indicate both major references and descriptions]

# 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.

# PLATE 1

[Scanning electron microscope and optical microscope photographs]

FIGURE 1. *Bairdoppilata triangulata* Edwards (p. 12).
Right side of shell; locality S–5, James County, Va., × 32, Yorktown Formation, middle part.

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

3, 15. *Propontocypris howei* (Puri) (p. 11).
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, 11, 12. *Cytheridea* sp. B (p. 14).
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.

5. *Cytheridea muelleri* subsp. (p. 14).
Right side of shell; locality C–1, Nansemond County, Va., × 69, Yorktown Formation, Middle part.

6–8. *Cytheridea* sp. A (p. 13).
6. Exterior of left valve; locality C–1, Nansemond County, Va., × 69, Yorktown Formation, Middle part.
7. Exterior of left valve; locality A–1, Hertford County, N.C., × 69, Yorktown Formation, lower part.
8. Exterior of right valve; Mount Gould Landing locality, Bertie County, N.C., × 69, Beds of Pliocene(?) age.

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

14. *Shattuckocythere shattucki* (Ulrich and Bassler) (p. 21).
Left side of shell; locality P–1, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

16. *Eucythere triangulata* Puri (p. 15).
Right side of shell; locality D–1, Nansemond County, Va., × 69, Yorktown Formation, middle part.

17. *Paracytheridea altila* Edwards (p. 20).
Exterior of right valve; locality P–3, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

18. *Pontocythere* (*Hulingsina*) cf. *P.* (*H.*) *rugipustulosa* (Edwards) (p. 17).
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.

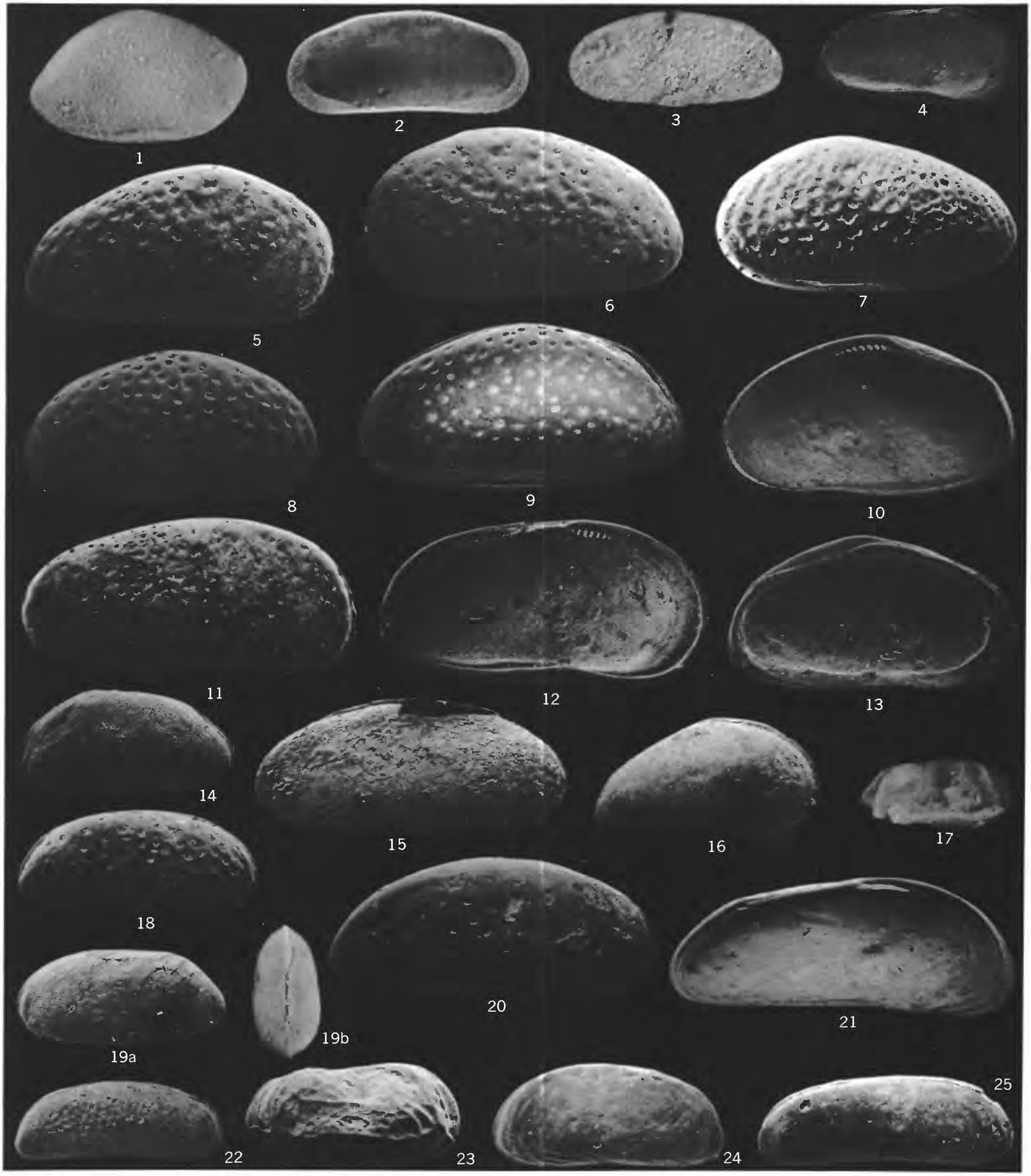
20. *Cushmanidea fabula* (Howe and Dohm) (p. 15).
Right side of shell; locality N–1, Surry County, Va., × 69, Yorktown Formation, lower part.

21, 24. *Pontocythere* (*Hulingsina*) *ashermani* (Ulrich and Bassler) (p. 16).
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.

23. *Paracytheridea mucra* Edwards (p. 20).
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.




*BAIRDOPPILATA, AGLAIOCYPRIS, PROPONTOCYPRIS, CYTHERIDEA, HAPLOCYTHERIDEA, SHATTUCKOCYTHERE, EUCYTHERE, PARACYTHERIDEA, PONTOCYTHERE,* AND *CUSHMANIDEA*

## PLATE 2

[Scanning electron microscope and optical microscope photographs]

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.

4–7. *Pontocythere* (*Hulingsina*) cf. *P.* (*H.*) *rugipustulosa* (Edwards) (p. 17).

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. subsp. (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 G–3, Bertie County, N.C., × 72, beds of Pliocene(?) age.

11. *Pterygocythereis americana* (Ulrich and Bassler) (p. 23).

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

12–15. *Cytheretta burnsi* (Ulrich and Bassler) (p. 23).

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.
14. Interior of left 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.

16–18. *Cytheretta* cf. *C. burnsi* (Ulrich and Bassler) (p. 23).

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, 20. *Cytheretta porcella* (Ulrich and Bassler) (p. 24).

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.

21. *Protocytheretta sahnii* (Puri) (p. 24).

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

22. *Cytherura forulata* (Edwards) (p. 18).

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

23. *Jonesia*? sp. (p. 25).

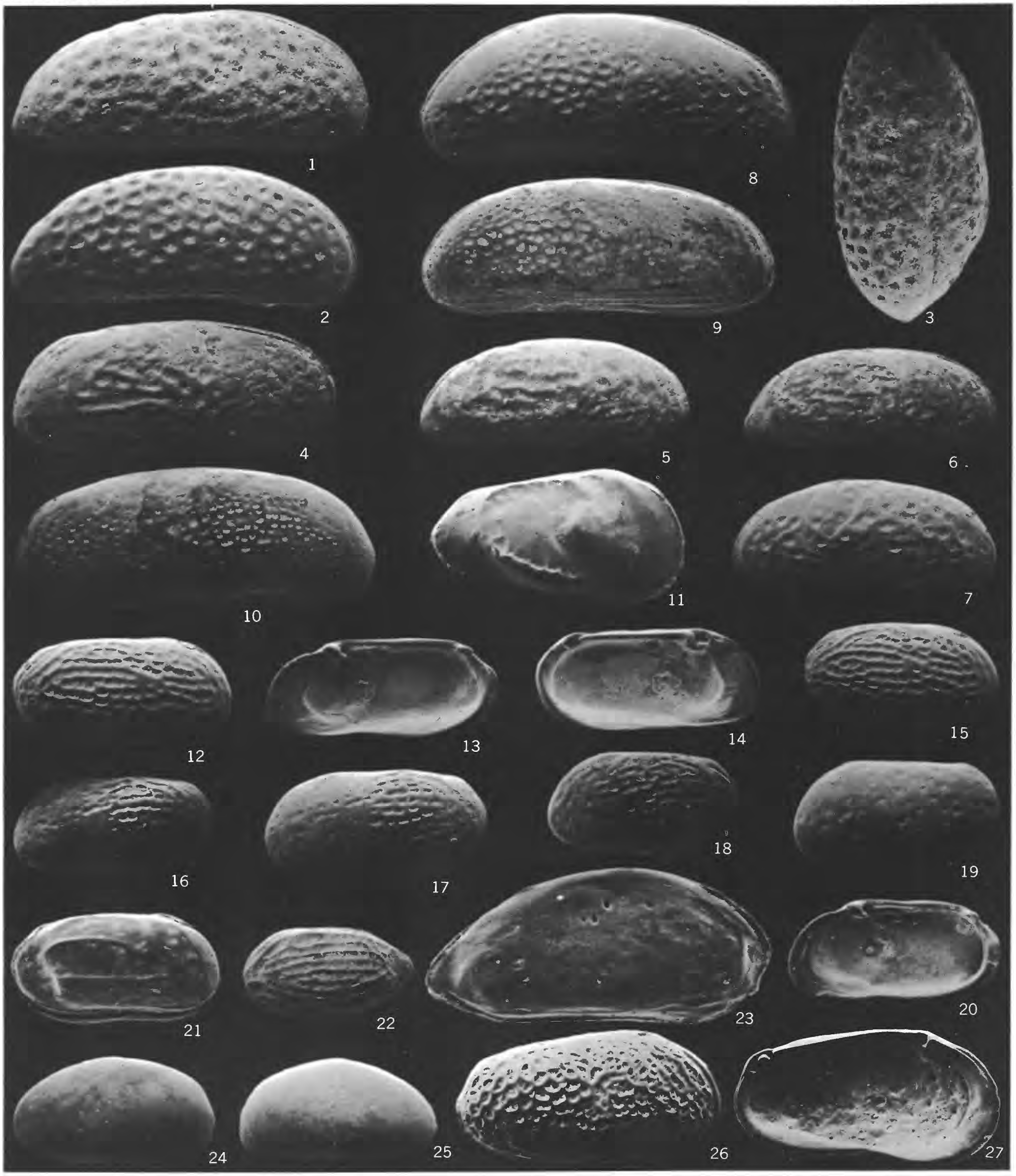
Right side of shell, locality C–1, Nansemond County, Va., × 150, Yorktown Formation, middle part.

24, 25. *Xestoleberis* cf. *X. aurantia* (Baird) (p. 25).

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]

FIGURES 1–3. *Cytherura elongata* (Edwards) (p. 19).

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.
6. Left side of shell; Mount Gould Landing locality, Bertie County, N.C., × 143, 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.

9–15. *Shattuckocythere yorktownensis* (Malkin) (p. 22).

9. Exterior of male left valve; Mount Gould Landing locality, Bertie County, N.C., × 150, beds of Pliocene(?) age.
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.

16–21. *Hemicytherura howei* (Puri) (p. 20).

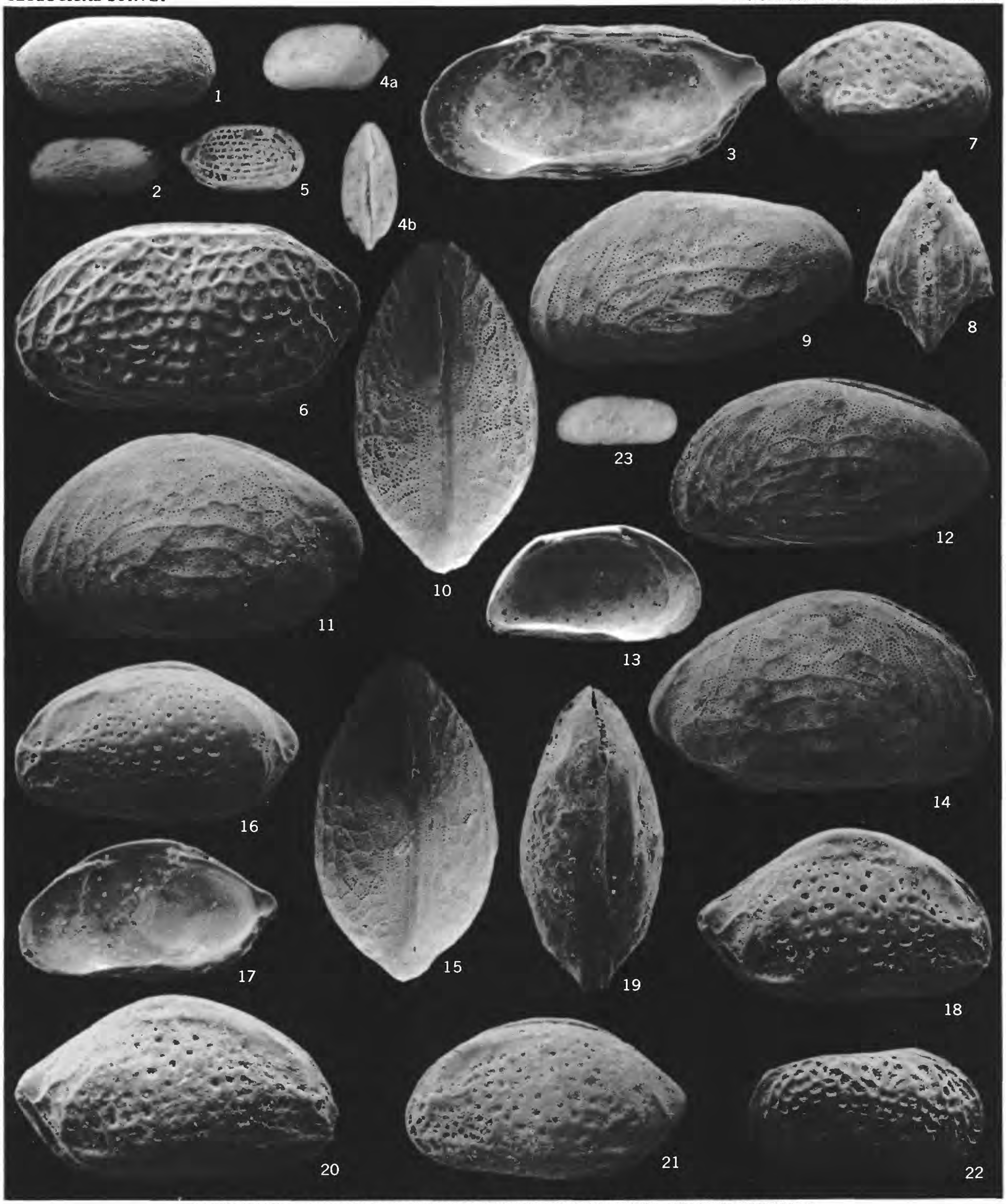
16. Left side of male shell; locality G–3, Bertie County, N.C., × 75, beds of Pliocene(?) age.
17. Interior of right valve; locality G–3, Bertie County, N.C., × 75, beds of Pliocene(?) age.
18. Right side of female shell; locality S–1, James County, Va., × 75, middle part of Yorktown Formation.
19. Dorsal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

FIGURES 1–4. *Cytheromorpha warneri* (Howe and Spurgeon) (p. 26).

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.

5–8. *Leptocythere paracastanea* Swain (p. 26).

5. Interior of female right valve; questionably representing this species, locality G–3, Bertie County, N.C., × 75, beds of Pliocene(?) age.
6. Right side of a female? shell compressed and distorted by compaction; 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).

Left side of shell; locality H–4. Bertie County, N.C., × 75, Yorktown Formation, upper part.

10. *Loxoconcha purisubrhomboidea* (Edwards) (p. 27).

Right side of shell; locality D–2, Nansemond County Va., × 75, Yorktown Formation, middle part.

11, 12. *Loxoconcha reticularis* (Edwards) (p. 28).

Left side and ventral views (the latter slightly oblique) of two shells; locality R–1, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

13. *Loxoconcha wilberti* (Puri) (p. 28).

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

14, 15. *Paradoxostoma robustum* (Puri) (p. 28).

14. Right side of small immature? shell; locality A–5, Hertford County, N.C., × 75, Yorktown Formation, lower part.
15. Left side of shell; locality S–4, James County, Va., × 75, Yorktown Formation, middle part.

16–21. *Murrayina macleani* n. sp. (p. 29).

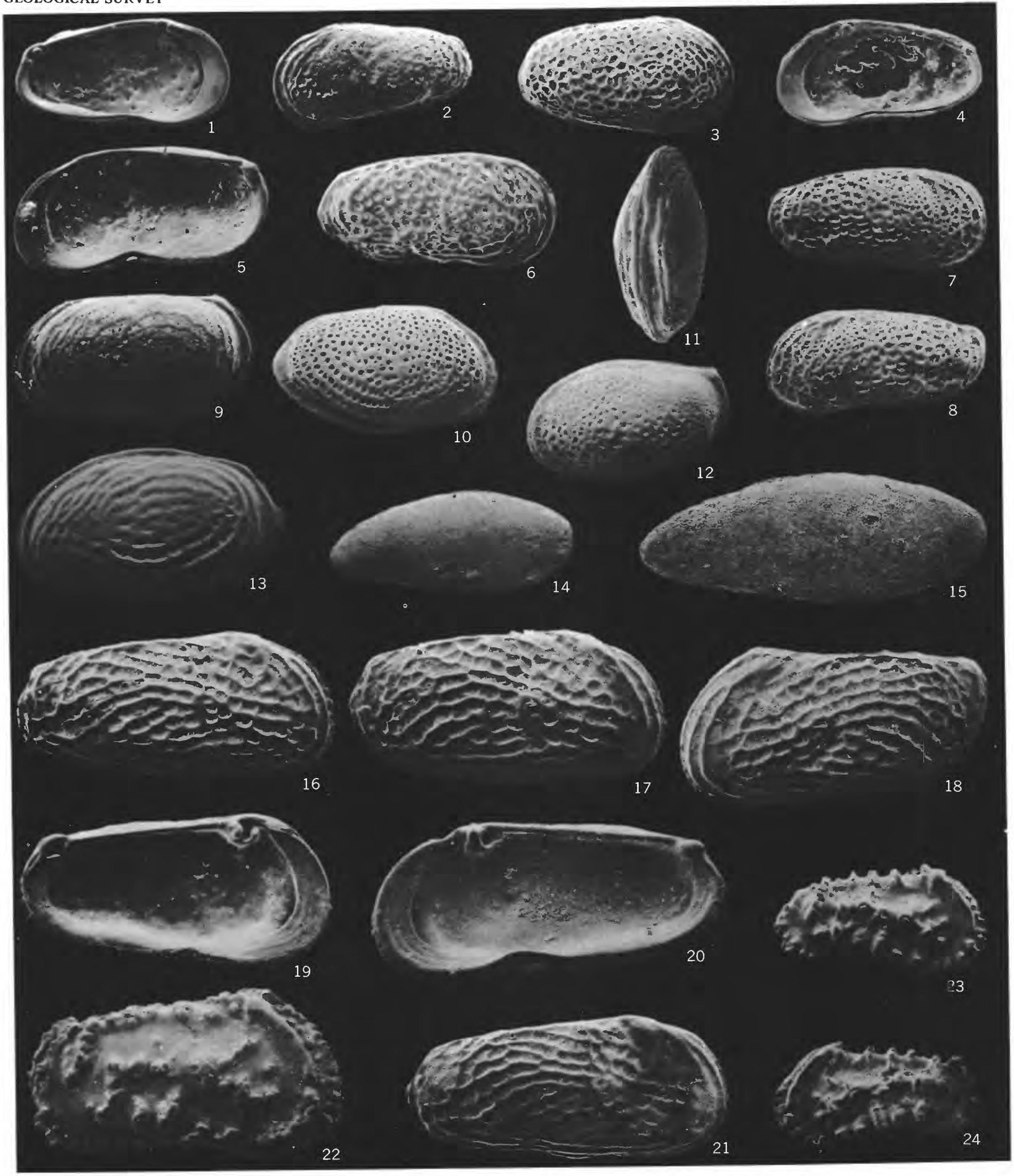
16. Exterior of holotype male right valve; locality P–2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
17. Exterior of paratype female right valve; locality P–2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.
18. Exterior of paratype female left valve; locality 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).

Exterior of right valve; locality R–2, Isle of Wight County, Va., × 75, Yorktown Formation, middle part.

23, 24. *Actinocythereis exanthemata exanthemata* (Ulrich and Bassler) (p. 30).

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, LEPTOCYTHERE, LOXOCONCHA, PARADOXOSTOMA, MURRAYINA,* AND *ACTINOCYTHEREIS*

# 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.

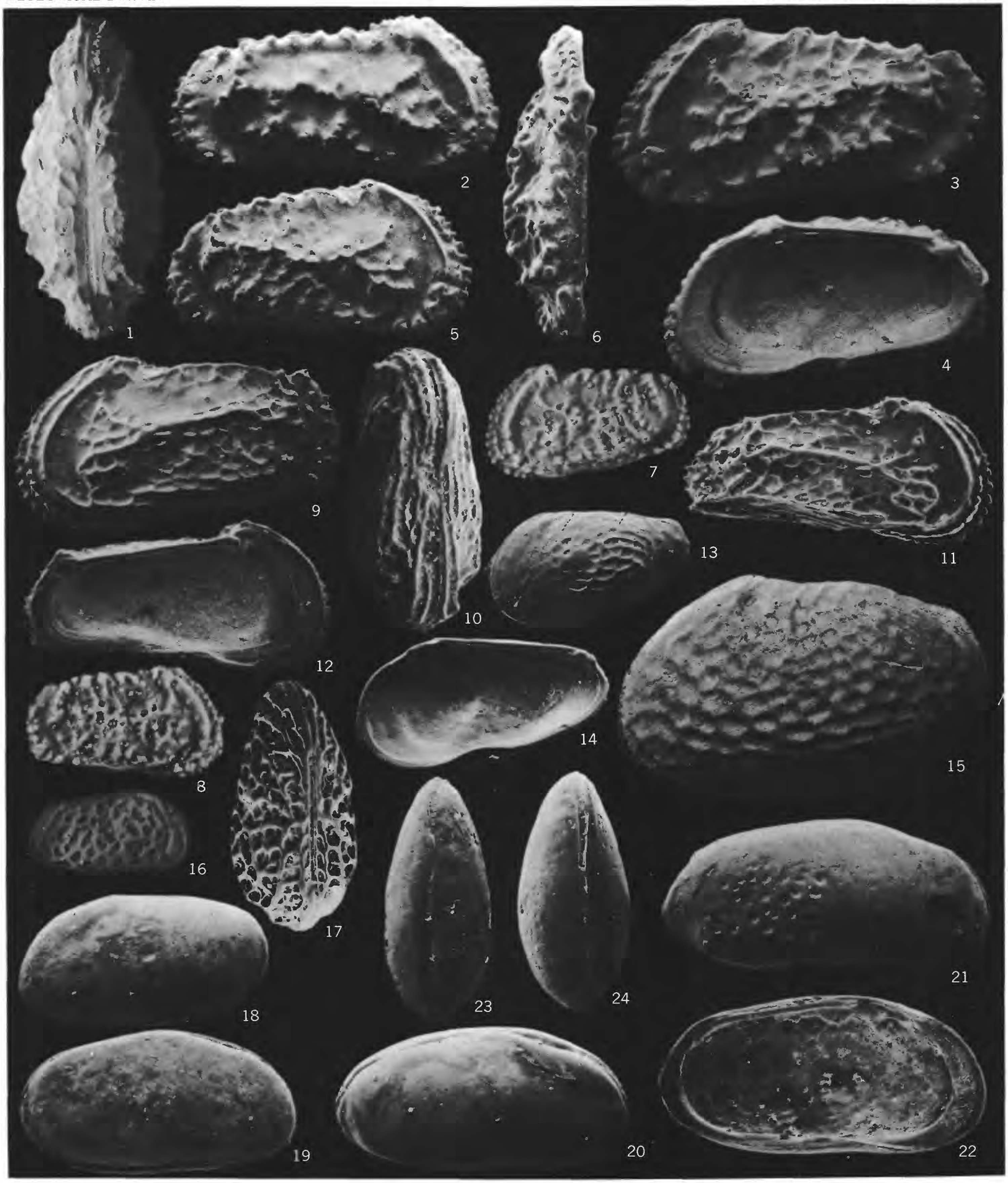
9–12. *Costa barclayi* (McLean) (p. 32).
- 9. Exterior of female left valve; locality C–1, Nansemond County, Va., × 75, Yorktown Formation, middle part.
- 10. Ventral slightly oblique view of shell; locality K–3, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.
- 11. Exterior of male right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

13–15. *Echinocythereis? clarkana* (Ulrich and Bassler) (p. 32).
- 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).
- 16. Exterior of right valve; Mount Gould Landing locality, Bertie County, N.C., × 45, beds of Pliocene(?) age.
- 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.

21–24. *Campylocythere laeva posteropunctata* (Edwards) (p. 34).
- 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.




*ACTINOCYTHEREIS, CLETOCYTHEREIS, COSTA, ECHINOCYTHEREIS?,*
*BENSONOCYTHERE,* AND *CAMPYLOCYTHERE*

# PLATE 6

[Scanning electron microscope and optical microscope photographs]

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. *Acuticythereis 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.

4–6. *Acuticythereis laevissima laevissima* (Edwards) (p. 35).
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. *Acuticythereis*? sp. (p. 35).
Exterior of a right valve; locality A–5, Hertford County, N.C., × 75, Yorktown Formation, lower part.

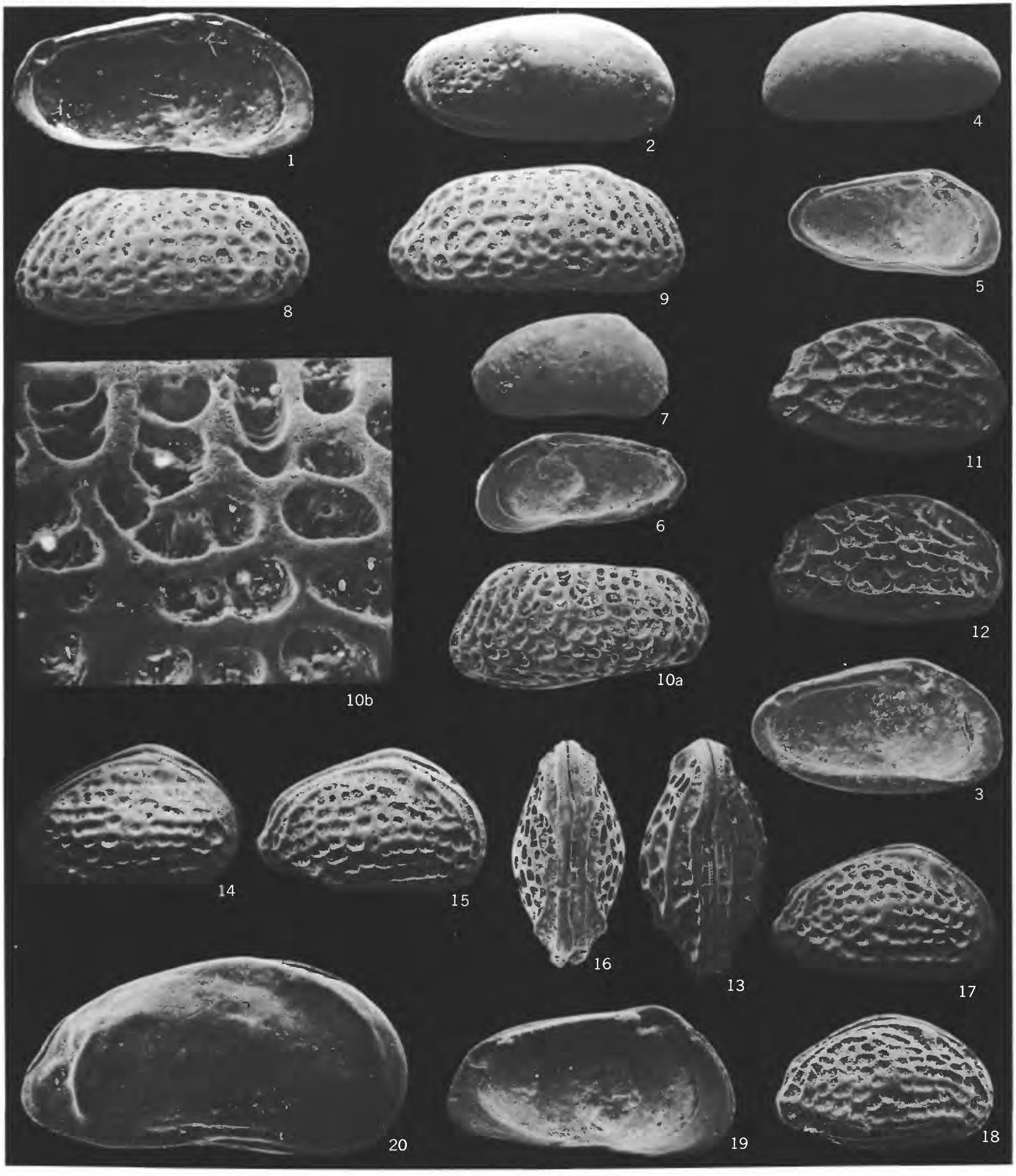
8–10. *Prodictyocythere trapezoidalis*, n. gen. n. sp. (p. 35).
8. Exterior of holotype left valve; locality C–1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
9. Exterior of paratype right valve; locality C–1, Nansemond County, Va., × 76.5, Yorktown Formation, middle part.
10a, b. 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.

11–13. *Radimella confragosa* (Edwards) (p. 36).
Right sides and ventral view of three shells; Mount Gould Landing locality, Bertie County, N.C., × 75, beds of Pliocene(?) age.

14–18. *Aurila conradi* (Howe and McGuirt) (p. 37).
All are from locality K–4, Dinwiddie County, Va., Yorktown Formation, middle part.
14, 15, 17. Right sides of three shells in which greatest height is well anterior to midlength, × 75.
16. Dorsal view of shell, × 75.
18. Right side of shell in which greatest height is near midlength, × 75.

19. *Thaerocythere schmidtae* (Malkin) (p. 40).
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.




*CAMPYLOCYTHERE, ACUTICYTHEREIS, PRODICTYOCYTHERE, RADIMELLA, AURILA, THAEROCYTHERE,* AND *CAUDITES*

# PLATE 7

[Scanning electron microscope and optical microscope photographs]

FIGURES 1–8. *Muellerina micula* (Ulrich and Bassler) (p. 38).

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.

9–15. *Thaerocythere schmidtae* (Malkin) (p. 40).

Positions of normal pores are shown on most of the specimens; sieve plates were not observed.

9. Left side of female shell; locality S–5, James County, Va., × 75, Yorktown Formation, middle part.
10. Dorsal view of female shell; locality A–1, Hertford County, N.C., × 75, beds of Pliocene(?) age.
11. Right side of male shell; locality G–3, Bertie County, N.C., × 75, beds of Pliocene(?) age.
12. Exterior of female right valve; locality A–1, Hertford County, N.C., × 75, Yorktown Formation, lower part.
13. Left side of female shell; locality A–1, Hertford County, N.C., × 76.5, Yorktown Formation, lower part.
14. Left side of female shell; locality A–1, Hertford County, N.C., × 75, Yorktown Formation, lower part.
15. Interior of female left valve; locality A–1, Hertford County, N.C., × 76.5, Yorktown Formation, lower part.

16. *Thaerocythere* sp. (p. 40).

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

17. *Orionina vaughani* (Ulrich and Bassler) (p. 39).

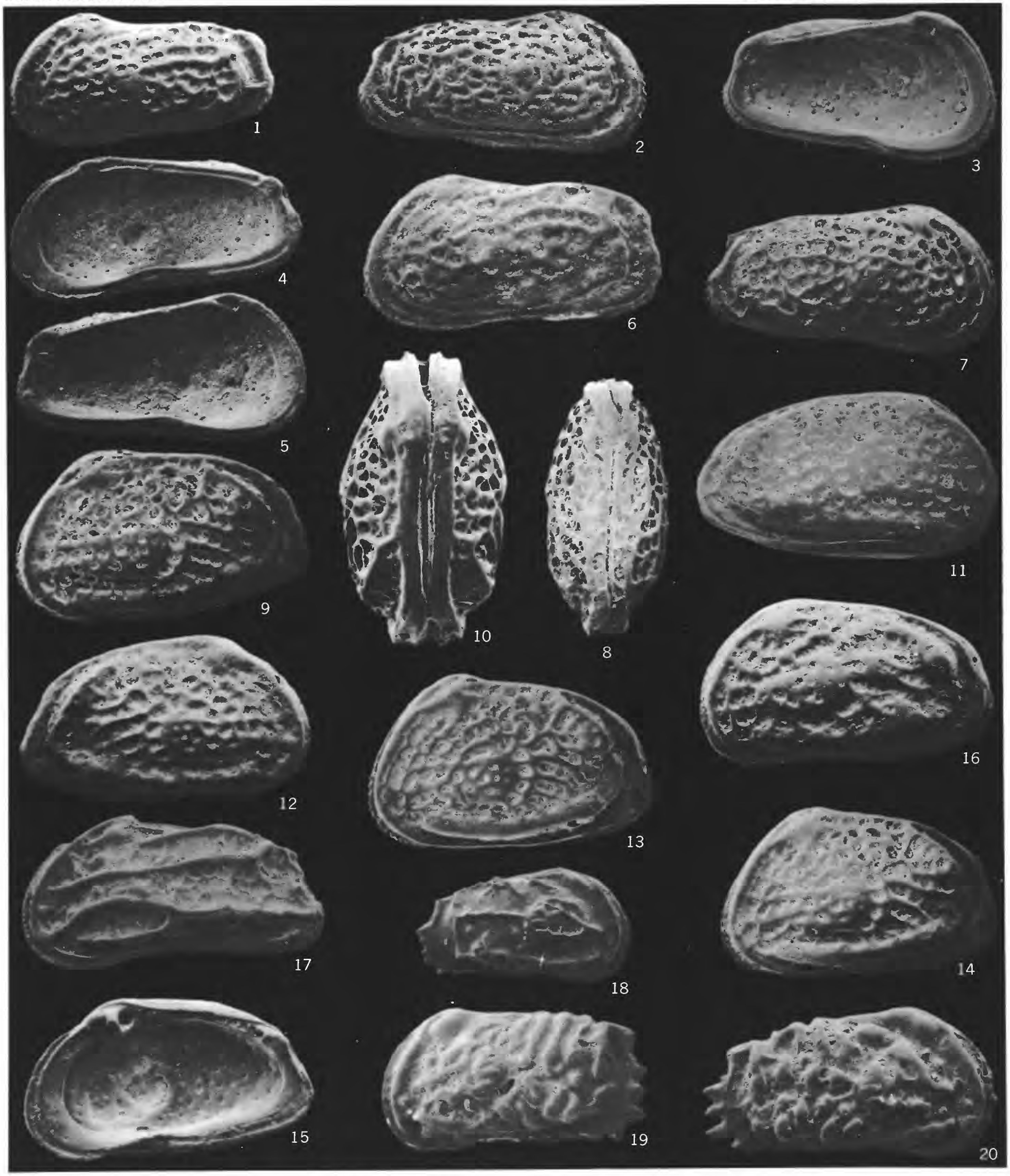
Exterior of left valve; K–4, Dinwiddie County, Va., × 76.5, Yorktown Formation, middle part.

18. *Puriana mesacostalis* (Edwards) (p. 42).

Exterior of immature right valve; locality K–4, Dinwiddie County, Va., × 75, Yorktown Formation, middle part.

19–20. *Puriana rugipunctata* (Ulrich and Bassler) (p. 41).

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, × 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., × 77, Yorktown Formation, upper part.

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

4a, b. *Cushmanidea fabula* (Howe and Dohm) (p. 15).
Interior of left valve, × 77, and muscle scar, × 220, locality N–1, Surry County, Va., Yorktown Formation, lower part.

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

6. *Prodictyocythere trapezoidalis*, n. gen., n. sp. (p. 35).
Interior of paratype right valve, locality C–1, Nansemond County, Va., × 150, Yorktown Formation, middle part.

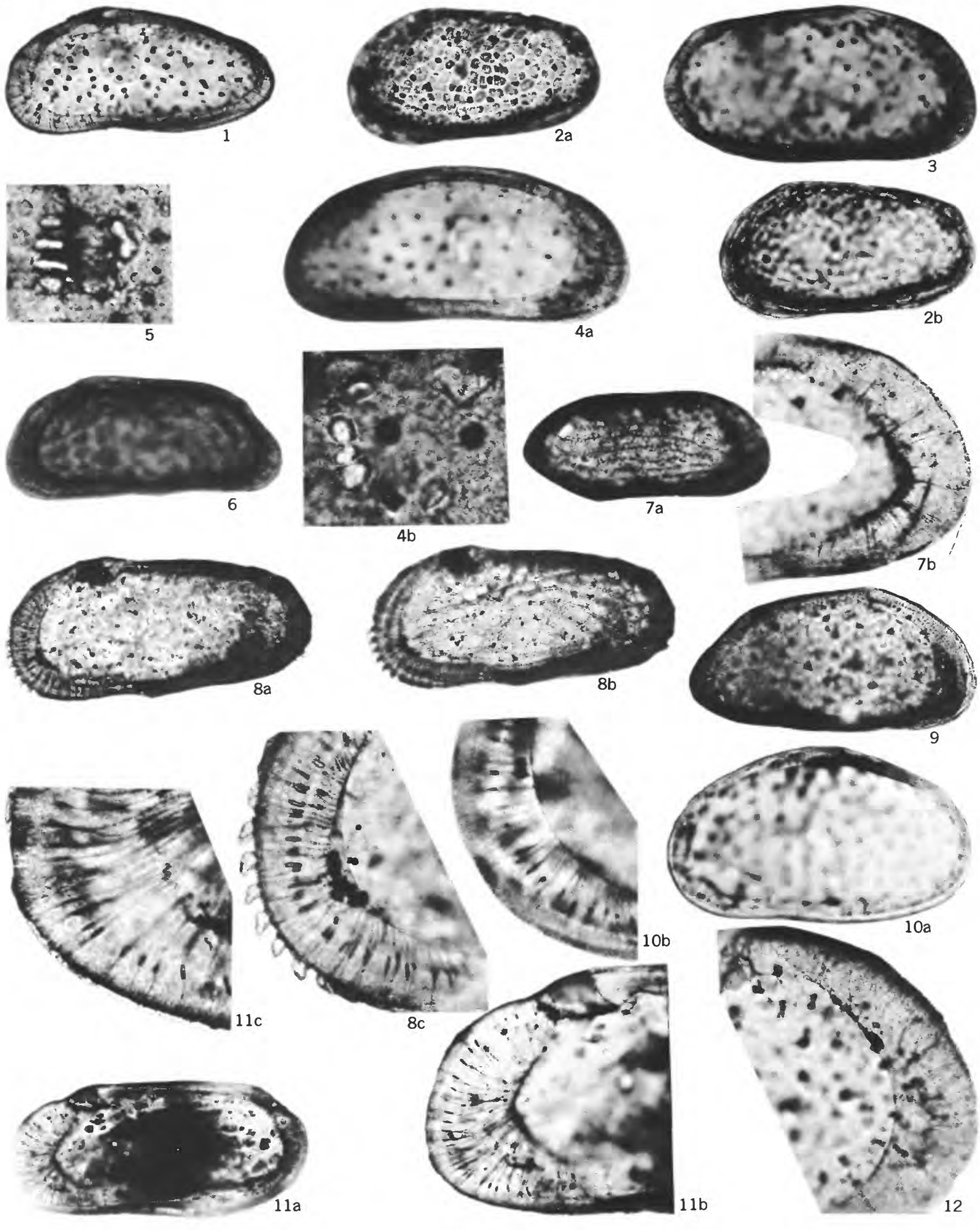
7a, b. *Cytherura elongata* Edwards (p. 19).
Interior of left valve, × 77, and detail of anterior margin × 220, locality K–3, Dinwiddie County, Va., Yorktown Formation, middle part.

8a–c. *Murrayina macleani*, n. sp. (p. 29).
Interior views of right valve at different levels of focus, × 75, and detail of anterior margin × 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., × 105, Yorktown Formation, middle part.

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

11a–c. *Cytheretta burnsi* (Ulrich and Bassler) (p. 23).
Interior of right valve, × 52, and details of anterior and posterior margins, × 220, Mount Gould Landing locality, Bertie County, N.C., beds of Pliocene(?) age.




*ACUTICYTHEREIS, CYTHEROMORPHA, CAMPYLOCYTHERE, CUSHMANIDEA, PRODICTYOCYTHERE, CYTHERURA, MURRAYINA, SHATTUCKOCYTHERE, HAPLOCYTHERIDEA*, AND *CYTHERETTA*

# PLATE 9

[Transmitted light photographs]

FIGURES 1a–d. *Thaerocythere schmidtae* (Malkin) (p. 40).
Inerior 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.

2. *Cytherura elongata* Edwards (p. 19).
Interior of right valve, locality A–1, Hertford County, N.C., × 105, Yorktown Formation, lower part.

3. *Cytheropteron 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.

8. *Cytheromorpha warneri* Howe and Spurgeon (p. 26).
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.

11. *Costa barclayi* (McLean) (p. 32).
Interior of left valve, locality O–1, near Cobham Wharf, Surry County, Va., × 77, Yorktown Formation undivided.

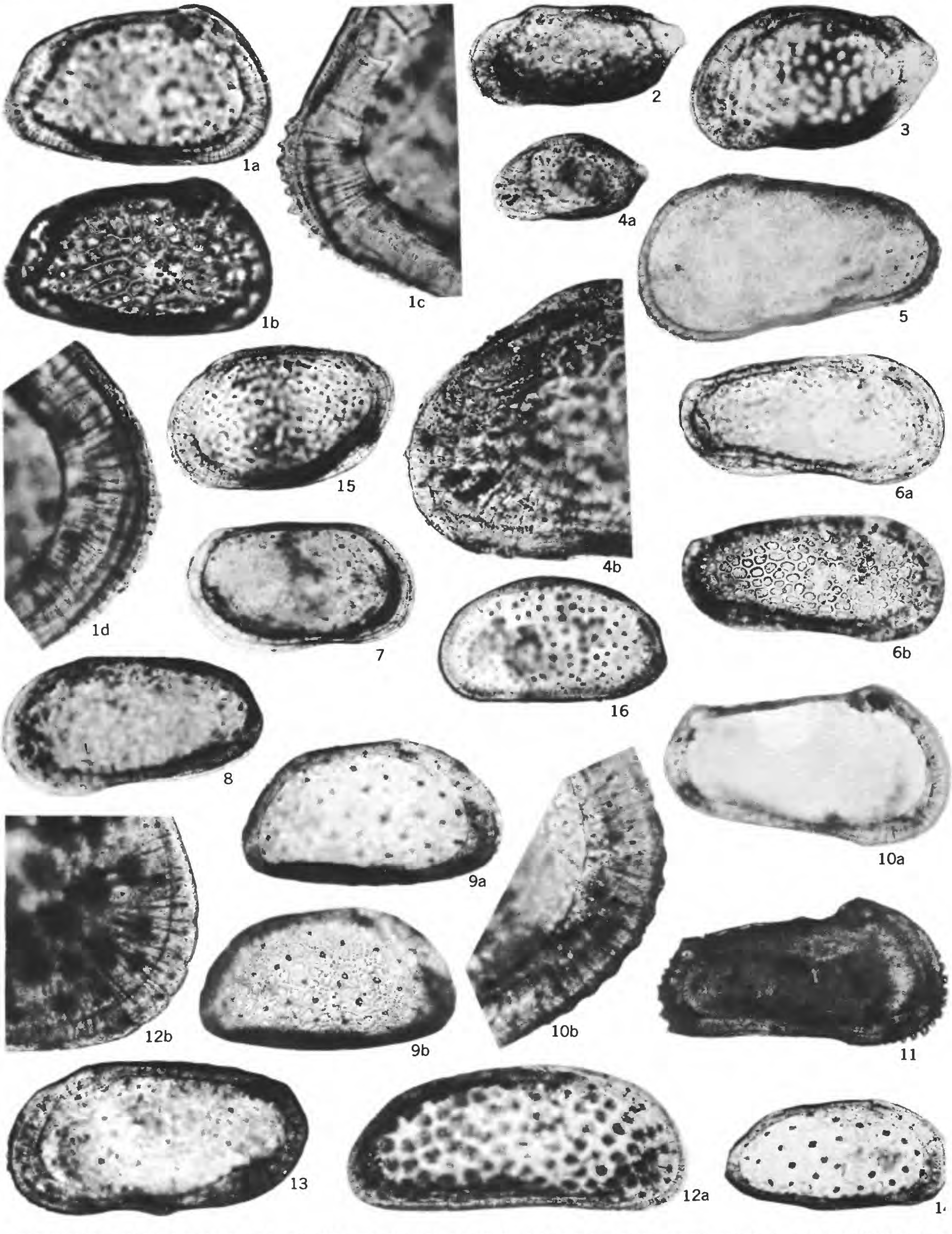
12a, b. *Pontocythere* (*Hulingsina*) *ashermani* (Ulrich and Bassler) (p. 16).
Interior of left valve, × 77, and detail of anterior margin, × 220, locality G–3, Bertie County, N.C., beds of Pliocene(?) age.

13. *Murrayina macleani*, n. sp. (p. 29).
Interior of female paratype right valve, locality C–1, Nansemond County, Va., × 77, Yorktown Formation, middle part.

14. *Shattuckocythere similis* (Malkin) (p. 22).
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.

16. *Haplocytheridea setipunctata* (Brady) (p. 12).
Interior of right valve, × 52, Seaboard Air Line Railroad Bridge locality, Northampton County, N.C., Yorktown Formation, lower part.

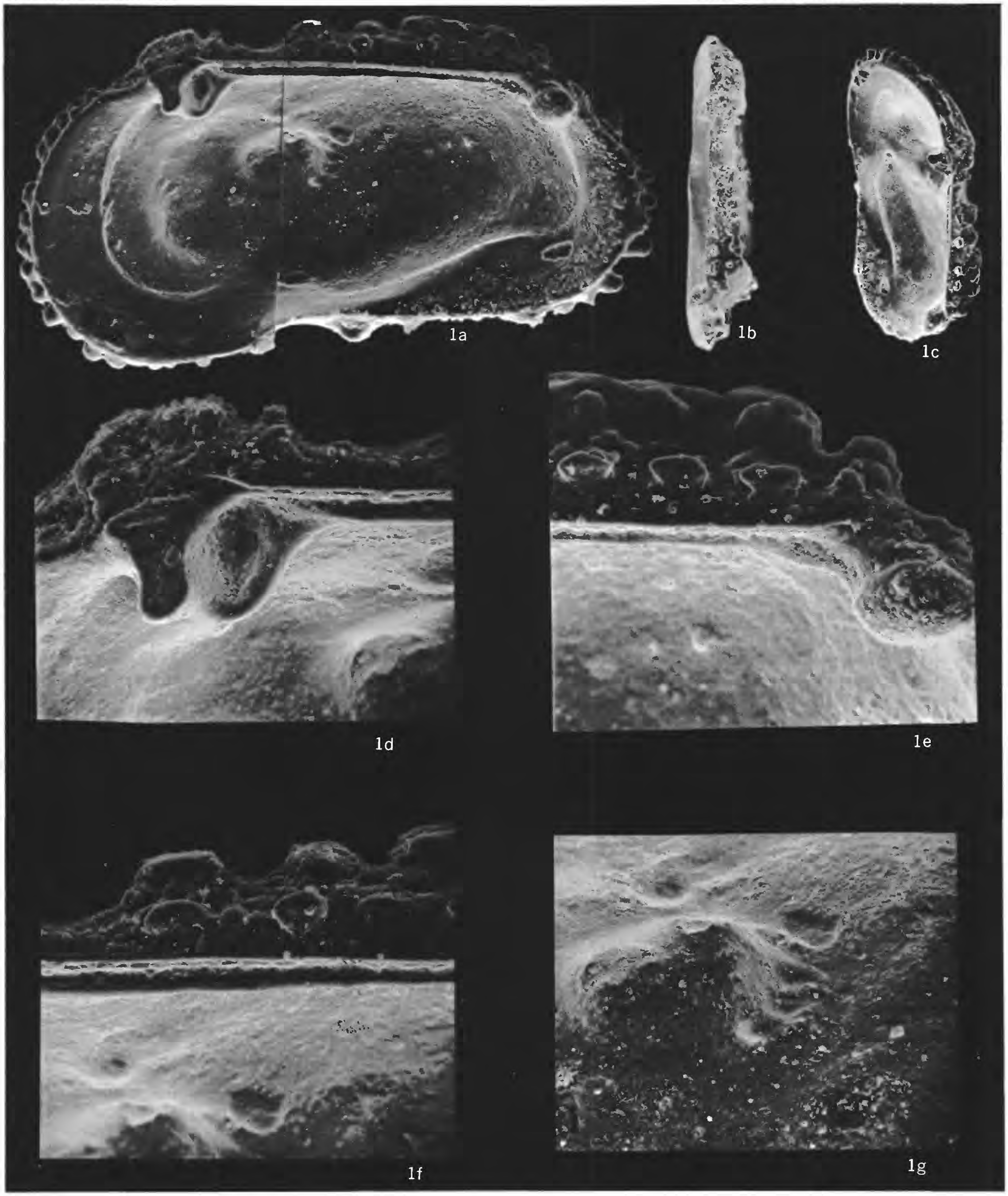



*THAEROCYTHERE, CYTHERURA, CYTHEROPTERON, HEMICYTHERURA, PTERYGOCYTHEREIS, CYTHEROMORPHA*
*... PONTOCYTHERE, MURRAYINA, SHATTUCKOCYTHERE,* AND *HAPLOCYTHERIDEA*

## PLATE 10

[Scanning electron microscope photographs]

FIGURES 1a–g. *Actinocythereis 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.




*ACTINOCYTHEREIS*

## PLATE 11

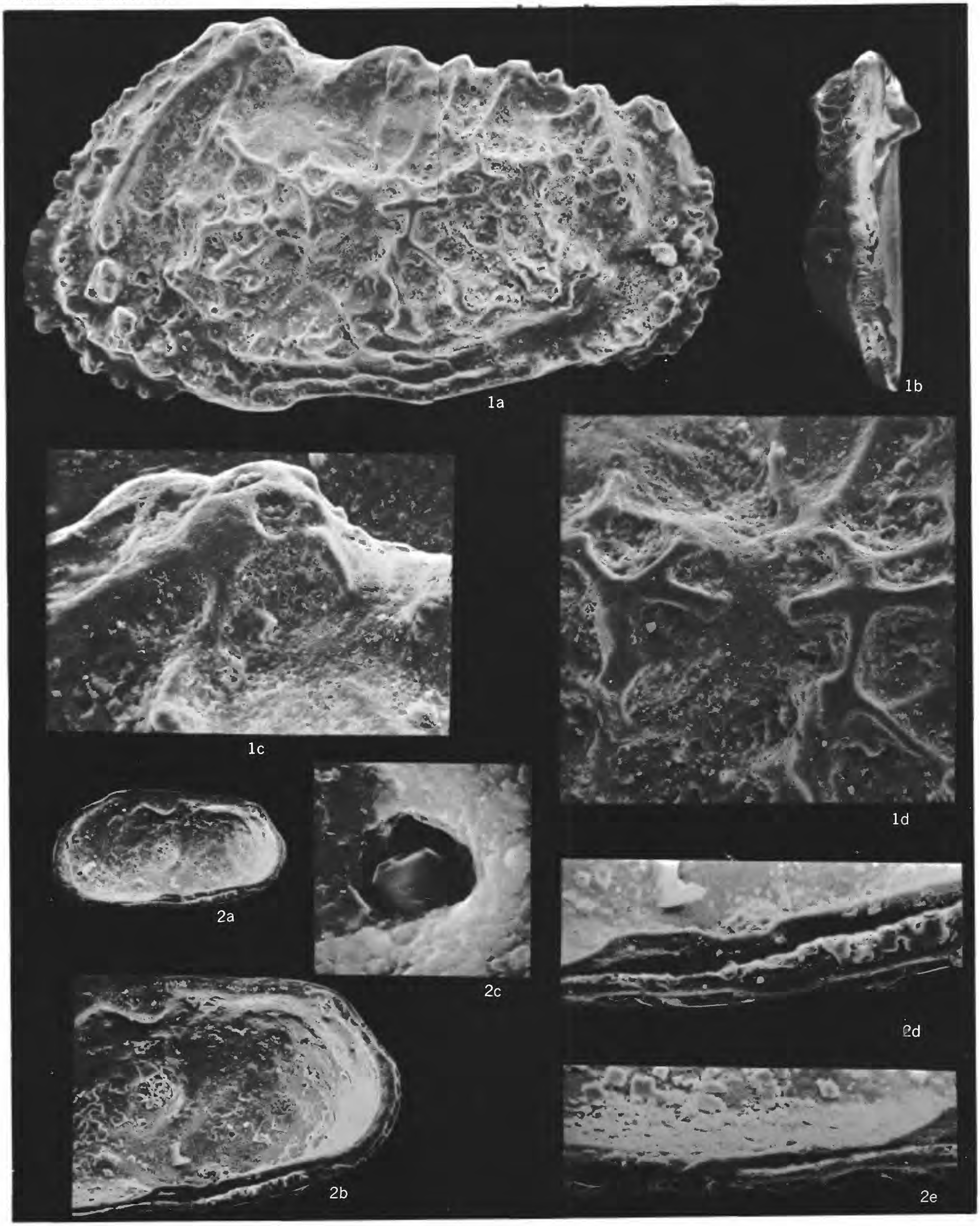
[Scanning electron microscope photographs]

FIGURES 1a–d. *Cletocythereis mundorffi* (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 posteroventral 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.




*CLETOCYTHEREIS* AND *BENSONOCYTHERE*

# PLATE 12

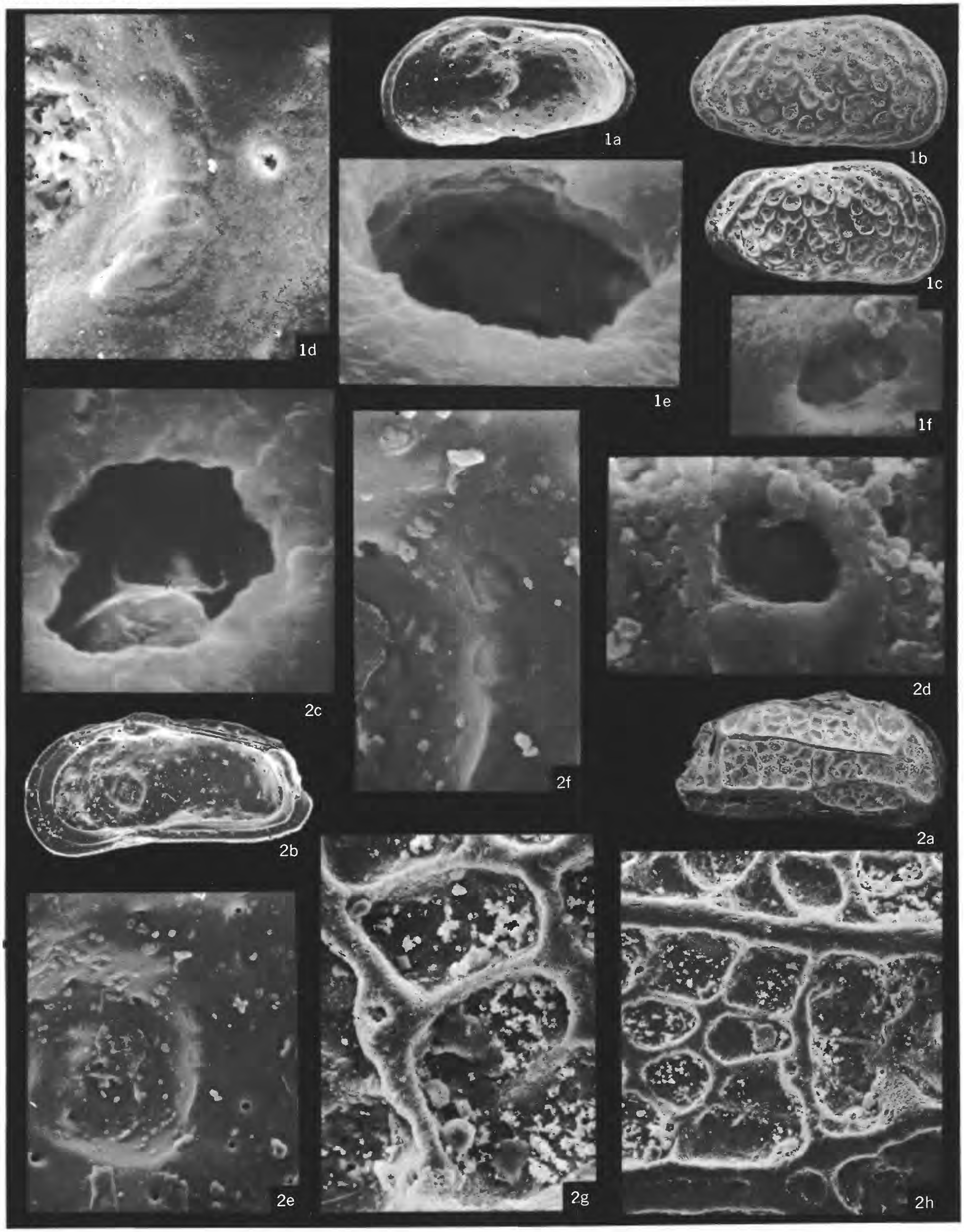
[Scanning electron microscope photographs]

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.




*BENSONOCYTHERE* AND *ORIONINA*

# PLATE 13

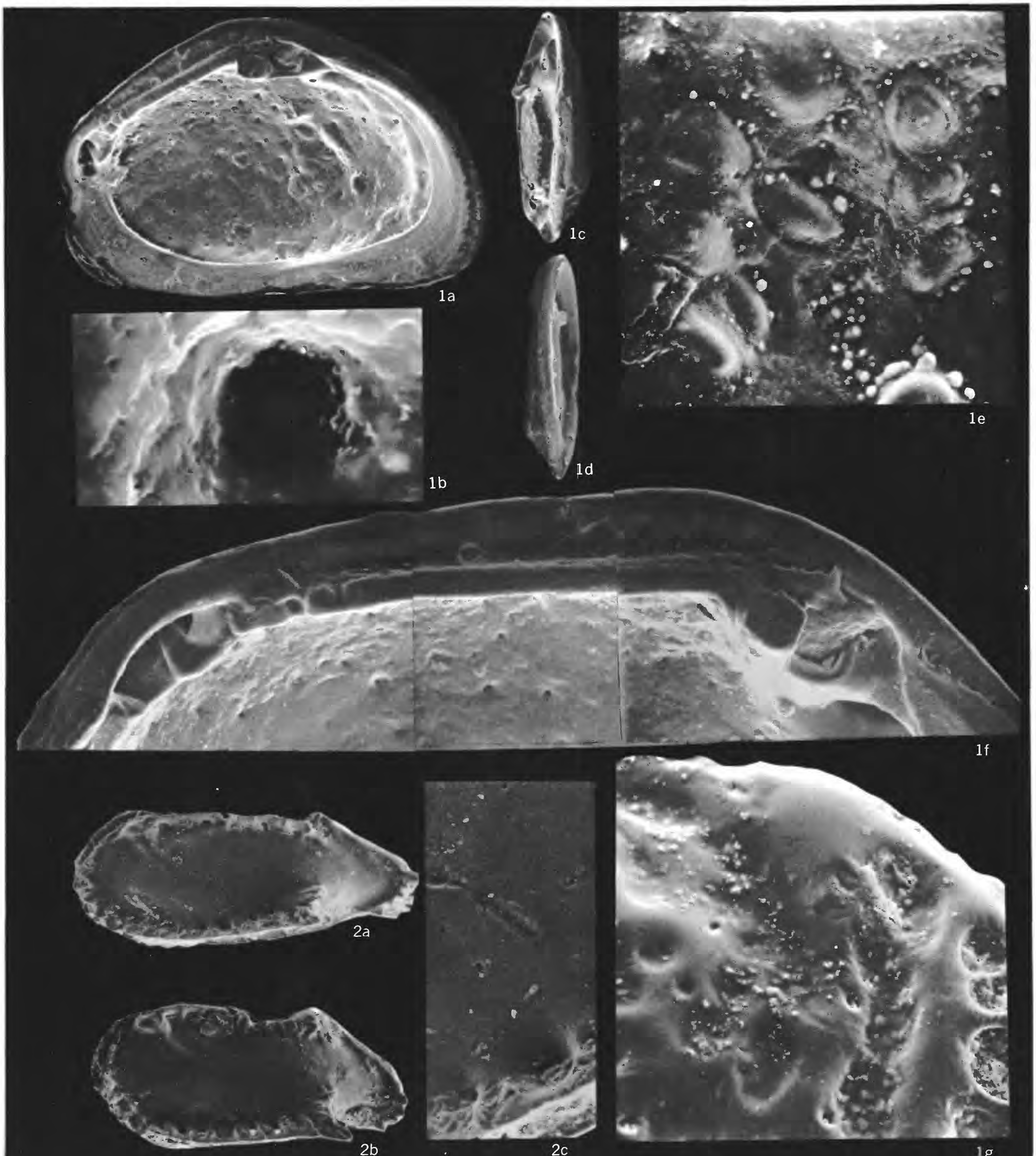
[Scanning electron microscope photographs]

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

*a*, 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. *Peterygocythereis americana* (Ulrich and Bassler) (p. 23).

*a*, *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.




*AURILA* AND *PTERYGOCYTHEREIS*