

# ABSTRACT

Thirty-six species of ostracodes have been found in surface and subsurface samples of the Gatún Formation in the Panama Canal Zone. Distribution and stratigraphic ranges of these species are discussed, and correlation of part of the Gatún Formation with the upper part of the Manzanilla Formation in Trinidad is suggested.

## Ostracoda of the Gatún Formation, Panama

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### INTRODUCTION

In 1937, Coryell and Fields described a fauna from a sample near Cativa, Panama Canal Zone. This was the first fossil ostracode fauna to be described in detail from the Caribbean; of 18 species described, 14 and one variety were new, and no less than 9 new genera were established. They concluded that "the definite appearance of modernistic trends and the occurrence of such high degree of ornamentation indicate that in the Caribbean Region rapidly changing environmental conditions accompanied the diastrophic movements which were in progress at that time."

Since then, the present author has found most of these new genera and quite a few of the new species in widely separated localities in the Caribbean, from Trinidad to the Dominican Republic and Guatemala, and stratigraphically from lower Miocene to Recent. It now appears that the Gatún ostracod fauna, instead of being a specialized local fauna, rather is typical for the Neogene of the whole Caribbean region.

The species described by Coryell and Fields were:

- Cytherelloidea leonensis* Howe
- Platella gatunensis* n. sp. (moult)
- Macrocypis dreikanter* n. sp. (not found in the present study)
- Bairdia colonensis* n. sp. (moult)
- Cythere? mylonita* n. sp. = *Pumilocytheridea mylonita* (Coryell and Fields)
- Paracytheridea clara* n. sp. (moult, possibly of *Paracytheridea tschoppi* van den Bold)
- Navecythere delicata* n. sp. (moult of *Cativella navis* Coryell and Fields)
- Favella puella* n. sp. (moult of *Puriana rugipunctata* (Ulrich and Bassler))
- Cativella navis* n. sp.
- Cythereis vughani* (Ulrich and Bassler) = *Orionina serrulata* (Brady)
- Cythereis rugipunctata* var. *gatunensis* n. var. = *Puriana rugipunctata* (Ulrich and Bassler)
- Caudites medialis* n. sp.
- Basslerites miocenicus* (Howe)
- Cytherura bananaformis* n. sp.
- Kangarina quellita* n. sp.
- Luvula palmerae* n. sp.
- Macrocytherina gatunensis* n. sp. (male of *Luvula palmerae* Coryell and Fields)
- Pellucistoma howei* n. sp.

More species than those described by Coryell and Fields have been found, bringing the total up to 37. Where necessary, additional remarks on the species have been made in the part on systematics. Illustrated specimens have been deposited in the H. V. Howe Collections, Louisiana State University (HVH nos. 8221-8240).

### ACKNOWLEDGEMENTS

Through the courtesy of Miss Angelina R. Messina, the writer was able to compare his specimens with the types in the American Museum of Natural History. Moreover, Coryell had donated a slide with topotypes to H. V. Howe's collections in Baton Rouge, which provided continuous checking possibilities as the study progressed.

R. H. Stewart, geologist with the Panama Canal Commission, and Mrs. J. Allen gave guidance in the field and permitted sampling of the cores of old boreholes in the Canal Zone. M. Mumma assisted in the fieldwork which was carried out in June, 1963. L. Nichols, assistant curator of the Geological Museum, Louisiana State University, took the photographs of the specimens.

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### MATERIAL

Six surface and ten subsurface samples yielded the ostracodes on which the present paper is based; all surface samples were collected in calcareous silty clay or silt.

### Localities:

- P. 1: Transisthmus Highway, about 50 meters east of Río Cativa (between Woodring 138 and 140).
- P. 2: On Transisthmus Highway, three miles from Colón, between Woodring 137 and 138.
- P. 3: On side road to refinery at Las Minas Bay, stratigraphically about 100 feet above 1.
- P. 4: Near Las Minas Bay Refinery, stratigraphically highest exposure of the Gatún Formation in this area, about 200 feet above 1.
- P. 11: 0.6 mile on side road to Fort Gulick.
- P. 12: On side road to the south, 2 km. west of Cativa.
- P. 13: Woodring station 136 (at north side of road).
- P. 14: At south side of road, opposite 13. Judging from the fauna, this could be the original Coryell and Fields locality.

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TABLE 1

Distribution of ostracode species in surface and subsurface samples of the Gatún Formation in the Panama Canal Zone, and comparison with their stratigraphic ranges in other parts of the Caribbean (c. *Mutilus confragosus* Range Zone; d, *Procythereis?* *deformis* Range Zone).

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Subsurface samples (from coreholes at the Gatun Locks, Canal Zone):

G-68: N 9° 18' + 1885 feet, W 79° 55' + 971 feet, elevation 3.8 feet.

0-55.5 feet: Recent sand, silt and clay.

55.5–65.5 feet (total depth): Very fine, silty, gray, massively bedded sandstone. Sample at 63 feet (see Table 1).

G-167: N 9° 16' + 3673 feet, W 79° 54' + 5997 feet, elevation 99 feet.

0-12.5 feet: Red, soft, plastic clay.

12.5–19.4 feet: Weathered sandstone.

19.4–40 feet: Gray dense siltstone, locally calcareous.

40-61.5 feet: Gray, massive shale with smaller foraminifera. Samples at 40, 46 and 51 feet yielded no ostracodes, samples at 55, 57 and 58-60 feet did (see Table 1).

61.5–66.5 feet: Gray, massive siltstone. Samples at 64 and 66 feet (see Table 1).

66.5–73.5 feet: Gray, massive shale with smaller foraminifera. Samples at 69 and 73 feet (see Table 1).

73.5–74 feet: Light gray, dense siltstone with pelecypods and gastropods, no ostracodes.

74-82.5 feet: Dark gray massive sandstone (no ostracodes).

82.5–100 feet: Dark gray conglomerate (no ostracodes).  
100–125 feet (total depth): Light to dark gray, coarse-

grained, cross-bedded sandstone with tuffaceous material (no ostracodes).

## BIOSTRATIGRAPHY

The most regularly occurring species of the Gatún ostracode fauna is *Costa walpolei* (van den Bold), which was originally described from the Río Dulce Formation, in Guatemala. It is surprising that this species was not described by Coryell and Fields (1937), as it is well represented in the faunal slide from their locality in the H. V. Howe collections. In the Río Dulce Formation this species occurs only in the upper part, where *Procythereis deformis* (Reuss)? is absent (van den Bold, 1946, Table IIb). The latter species is also absent in the Gatún fauna both in Panama and Costa Rica, but occurs in the underlying Uscari Formation (van den Bold, 1966d, Table 1).

*Procythereis deformis* (Reuss)? has been found in Trinidad from the lower Brasso Formation (*Globigerinatella insueta* Zone) upward to the lower part of the Manzanilla Formation (San Jose Member) (van den Bold, 1966*d*). In Puerto Rico it occurs in the Cibao Formation, and in the Dominican Republic in the Cercado Formation, but in the overlying Gurabo Formation it is replaced by *Mutilus confragosus* (Edwards).

The latter species appears in Trinidad first in the Springvale Formation, but in the upper part of the Manzanilla Formation (Montserrat and Telemaque Members) both species are absent. In Florida *Procythereis deformis* (Reuss)? occurs in the Alum Bluff Stage; in the Chocataw hatchee Stage it is succeeded by *Mutilus confragosus* (Edwards) in the *Ephora* and *Cancellaria* Zones, but in the *Arca* Zone again both species are absent.

In the higher parts of the Tubará Formation of Colombia and the Cubagua Formation of Venezuela *Mutilus confragosus* occurs, but both species under discussion are absent in the basal parts of these formations. In Panama both species are absent in the Gatún Formation, but *Mutilus confragosus* occurs in the younger parts of the Gatún Formation in Costa Rica.

On this basis, it appears likely that the Gatún Formation (at least the part studied here) is the stratigraphic equivalent of: 1) the higher part of the Manzanilla Formation of Trinidad; 2) the lower part of the Cubagua Formation of Venezuela; 3) the lower part of the Tubará Formation of Colombia; 4) the higher part of the Río Dulce Formation of Guatemala; and 5) the lower part of the Choctawhatchee Formation of Florida. In the Dominican Republic, this particular interval appears to be missing. This correlation is rather similar, but not identical, to the one proposed by Woodring (1959) between Panama, Trinidad and the Dominican Republic.

Of course, it is possible that the absence of one or both species is not due to their restricted and dissimilar stratigraphic ranges, but caused by local ecological conditions. Both species appear to prefer a "near reefal" environment, and to thrive under conditions of calcareous deposition, but both have also been found in non-calcareous deposits. They have been found in overlying or underlying beds, where the accompanying

fauna indicates similarity of environment, which makes it rather unlikely that their absence in the intervening beds is caused by changes in ecological conditions.

It is also necessary to keep the possibility in mind that some species originated in one region and gradually spread out over the Caribbean, as has been demonstrated for some of the faunal elements (van den Bold, 1962, 1965a), so that in one place they occur in immediate succession, whereas in other places they could be separated by a longer or shorter interval of time necessary for their migration. In this case, even this interval of absence would not necessarily be of the same age everywhere. In this respect, compare the development of *Orionina* (van den Bold, 1963a). In order to verify these assumptions the range of a number of Gatún species has been determined in other areas (Table 1; see also remarks in the systematic part). In this respect, the ranges of *Cytherelloidea leonensis*, *Cytherelloidea obliquecostata*, *Orionina serrulata*, *Pterygocythereis miocenica*, *Caudites medialis*, *Semicytherura arayaensis*, *Kangarina quellita*, *Luvula palmerae* and others are of interest. In general, they tend to confirm the stratigraphic position of the Gatún Formation as intermediate between the lower Manzanilla Formation and the Springvale Formation.

The sample (CR 12) from the Río Reventazón area of Costa Rica, which shows the strongest affinity to the fauna of the Gatún Formation in the Panama Canal Zone, appears to be slightly older than the part of the Gatún Formation under discussion here. The presence of *Globigerinoides ruber* and *Globorotalia mayeri* suggests correlation with Bolli's *Globigerinoides ruber* Zone (Bolli, 1966). This sample contains *Cativella navis*, *Basslerites miocenicus*, *Cytheropteron nipeensis*, *Kangarina quellita*, *Eucytherura rohri*, *Luvula palmerae*, *Pellucistoma* sp. and *Pterygocythereis americana* (Ulrich and Bassler) instead of *Pterygocythereis miocenica* n. sp., the species typical of the Gatún Formation. The higher part of the Gatún Formation in the Río Reventazón area bears a striking resemblance to the fauna from borehole G68 (Gatún Locks), which contains *Cytherella polita*, *Cytherella* sp. aff. *pulchra*, *Basslerites miocenicus*, *Costa stokesae*, *Munseyella bermudezi* and *Pterygocythereis miocenica*. The presence of species of *Krithe* and *Bradleya* in the higher part of the Gatún in the Río Reventazón area suggests a deeper-water origin for these sediments. Consequently, the beds penetrated by borehole G68 could have been deposited under slightly deeper-water conditions than the beds of the Gatún Formation outcropping in the Canal Zone and present in borehole G167.

## SYSTEMATIC DESCRIPTIONS

Subclass OSTRACODA Latreille, 1806  
Order PODOCOPIIDA Müller, 1894  
Suborder PLATYCOPIINA Sars, 1866  
Family CYTHERELLIDAE Sars, 1866  
Genus CYTHERELLA Jones, 1849

*Cytherella polita* Brady, var.

*Cytherella polita* Brady var., VAN DEN BOLD, 1966c, pp. 361-362, pl. 1, fig. 5.

**Remarks:** This punctate variety, described from the Tubará Formation of Colombia, occurs in borehole G167 at a depth of 66 feet.

## Genus CYTHERELLOIDEA Alexander, 1929

*Cytherelloidea leonensis* Howe

*Cytherelloidea leonensis* HOWE, 1934, p. 34, pl. 5, fig. 9. - CORYELL and FIELDS, 1937, p. 2, fig. 1a-c. - VAN DEN BOLD, 1946, p. 62, pl. 9, fig. 23. - PURI, 1954, p. 301 (part), pl. 17, fig. 3, text-fig. 14c. - VAN DEN BOLD, 1963c, p. 372.

Not *Cytherelloidea leonensis* HOWE. - VAN DEN BOLD, 1950, p. 80. - VAN DEN BOLD, 1958, p. 396.

**Distribution:** In Florida the range of this species is confined to the *Ecphora* and *Cancellaria* Zones of the Choctawhatchee Formation. In Guatemala it has only been found in the upper part of the Río Dulce Formation, and in Trinidad in the Springvale Formation. The species reported as *C. leonensis* from the La Rosa Formation of Venezuela (van den Bold, 1950) and the upper Brasso Formation of Trinidad (van den Bold, 1958) are slightly different, as was brought out by a recent recheck.

*Cytherelloidea obliquecostata* van den Bold

*Cytherelloidea obliquecostata* VAN DEN BOLD, 1963c, p. 372, pl. 1, fig. 5a-b.

**Distribution:** This species has thus far been found only in the middle part of the Río Dulce Formation (*Cytherelloidea californica* Le Roy? of van den Bold, 1946, p. 62, pl. 9, fig. 24) and in the San Jose Member of the Manzanilla Formation in Trinidad. Its presence in the Gatún Formation may represent its stratigraphically highest occurrence so far.

## Genus PLATELLA Coryell and Fields, 1937

**Remarks:** Genus doubtful. All the specimens examined appear to be young moults; the muscle-scar pattern is identical to that of *Cytherella*.

"Platella" *gatunensis* Coryell and Fields  
Plate 1, figure 8

*Platella gatunensis* CORYELL and FIELDS, 1937, p. 3, fig. 2a-b.

**Remarks:** The dorsal margin forms a flattened slope in the posterior part, as has been illustrated by various authors, who have assigned other species to this genus. This feature occurs in several species of *Cytherella* and *Cytherelloidea* and can hardly be considered of generic significance.

**Dimensions:** Right valve: L: 0.52 mm.; H: 0.32 mm. Left valve: L: 0.48 mm.; H: 0.29 mm. These dimensions are slightly larger than those reported by Coryell and Fields.

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Suborder PODOCOPINA Sars, 1866  
Superfamily BAIRDIACEA Sars, 1888  
Family BAIRDIIDAE Sars, 1888  
Genus BAIRDIA McCoy, 1844

### *Bairdia colonensis* Coryell and Fields?

?*Bairdia colonensis* CORYELL and FIELDS, 1937, pp. 5-6, fig. 3a-b.

**Remarks:** A single right valve of an immature specimen has been found, which possibly belongs to this species. No adult *Bairdia* specimens were encountered in the Gatún Formation. The type of *Bairdia colonensis* is also a moult.

**Dimensions:** L: 0.42 mm.; H: 0.21 mm.

Superfamily CYTHERACEA Baird, 1850  
Family CYTHERIDEIDAE Sars, 1925  
Subfamily KRITHINAE Mandelshtam, 1958  
Genus PARAKRITHELLA Hanai, 1959

### *Parakrithella* sp. Plate 1, figure 1.

**Description:** Carapace elongate ovate, highest at two-thirds of the length from the anterior extremity. Anterior end evenly rounded, dorsal margin gently convex; there is a small indentation at about one-third of the length from the anterior end, where the anterior and dorsal margins meet; ventral margin almost straight, posterior end obliquely rounded, greatest convexity just above the middle. Dorsal view lanceolate, greatest width just behind the middle. Marginal area broad at anterior end, line of concrescence close to outer margin, radial pore canals few, short, straight.

**Dimensions:** L: 0.51 mm.; H: 0.23 mm.

**Remarks:** This species is slightly different from *Parakrithella* sp. of van den Bold, 1963 (p. 378, pl. 4, fig. 4) in having a differently rounded posterior end. It might be closer to *Paracyprideis vicksburgensis* (Howe and Law) of van den Bold, 1946 (p. 78, pl. 7, fig. 4; not *Krithella vicksburgensis* Howe and Law, 1936).

Family CYTHERIDAE Baird, 1850  
Subfamily LEPTOCYTHERINAE Hanai, 1957  
Genus MUNSEYELLA van den Bold, 1957

### *Munseyella bermudezi* van den Bold Plate 1, figure 2

*Munseyella* sp., in MOORE et al., 1961, fig. 246a, la-b.  
*Munseyella* sp. B, VAN DEN BOLD, 1963c, p. 379, pl. 5, fig. la-a;  
VAN DEN BOLD, 1964, p. 9.  
*Munseyella bermudezi* VAN DEN BOLD, 1966b, p. 22, pl. 2, fig. la-b.

**Distribution:** Springvale Formation (Trinidad), Cubagua Formation (Venezuela).

Subfamily PERISSOCYTHERIDEINAE van den Bold, 1963  
Genus PUMILOCYTHERIDEA van den Bold, 1963

### *Pumilocytheridea mylonita* (Coryell and Fields) Plate 1, figure 3a-c; plate 2, figure 2

*Cythere mylonita* CORYELL and FIELDS, 1937, p. 6, fig. 5a-b.

**Description:** Few additional remarks to the original description are necessary, except concerning the marginal area: Broad at the anterior end, line of concrescence and inner margin widely separated, forming a large anterior vestibule; posterior vestibule smaller; radial pore canals about 12 in anterior end, widely spaced. Adductor muscle-scars form a vertical row of 4, in front of which is a vaguely V-shaped antennal scar. If this is true it would throw doubt on the assignment of this genus to the Perissocytherideinae.

Posterior dental area with 5 cusps. The anterior dental area is mostly slightly damaged; up to 6 cusps could be seen. In the median groove, the size of the crenulations increases anteriorly.

**Dimensions:** Female: L: 0.40 mm.; H: 0.17 mm.; W: 0.16 mm. Male: L: 0.45 mm.; H: 0.17 mm.; W: 0.16 mm.

**Remarks:** Differences with *Pumilocytheridea sandbergi* van den Bold lie in the ornamentation, which shows weak wrinkles parallel to the anterior and posterior margins. There is no longitudinal arrangement of ridges. The anterior vestibule is much larger than that in *P. sandbergi*. A similar species was found in Venezuela (*Pumilocytheridea* n. sp. aff. *Cythere mylonita* Coryell and Fields, in van den Bold, 1964, p. 5), but this species is slightly larger and more robust and has a small anterior vestibule.

Subfamily TRACHYLEBERIDINAE Sylvester-Bradley,  
1948  
Genus COSTA Neviani, 1928

### *Costa walpolei* (van den Bold) Plate 1, figure 6a-d; plate 2, figure 1a-b

*Cythereis walpolei* VAN DEN BOLD, 1946, p. 93, pl. 12, fig. 6a-b.

**Holotype:** A complete carapace (S 13020, Pal. Mus. Utrecht) from sample W 2, Río Dulce Formation, Guatemala. Paratypes: D 30737 (Pal. Mus. Utrecht).

**Description:** Carapace short, subrectangular to subtriangular in outline, highest at the pronounced anterior cardinal angle in the left valve, which projects bladelike over the anterodorsal margin of the right valve at two-ninths of the length from the anterior extremity. Anterior end very obliquely rounded, rather coarsely denticulate below; dorsal margin depressed behind the anterior cardinal angle in the left valve, straight, obscured in both valves by an irregular dorsal ridge; ventral outline convex, converging toward the dorsum posteriorly; posterior end angled in the middle, convex and spinose below, slightly concave above. The left valve overlaps the right at both cardinal angles.

Surface covered by rather coarse reticulation. Anterior ridge, starting at the anterior cardinal angle with a small eye-node, parallel to the anterior margin and continuing as a smooth carinate ridge, obscuring the ventral margin and forming the ventral outline of the carapace in side view. Behind the anterior ridge a second, more or less parallel, but more regularly rounded ridge develops and becomes more pronounced ventrally as a ventral ridge, parallel to the ventral outline. Both ridges end at about one-fifth the length from the posterior extremity. Median ridge variably but always weakly developed, slightly convex upward but not forming a continuous line, rather slightly zig-zagging. Just in front of the centre it splits into two ridges giving off a lower anterior branch, just one mesh below the main one. Behind and below this lower ridge a row of meshes is slightly depressed. Dorsal ridge irregularly scalloped, generally convex and ending about one-fourth of the length from the posterior extremity.

Dorsal view plump, short; sides almost parallel in the middle half of the carapace; posterior end compressed.

Marginal area of moderate width, line of concrescence and inner margin coincide, except for a very short distance anteroventrally. Radial pore-canals numerous, slightly sinuous and tending to be in groups of 2, 3 or 4. They are slightly deflected away from the median line of the valve; this deflection increases both upward and downward.

Hinge in the right valve with large, rounded, blunt, terminal teeth, connected by a straight groove which widens anteriorly to a rounded socket.

Muscle-scars a posterior row of 4, somewhat elongate, adductor scars, with a V- or U-shaped frontal scar in front of the second one from above.

*Dimensions:* L: 0.57 mm.; H: 0.34 mm.

*Remarks:* This species is similar in a general way to *Costa stokesae* van den Bold (1967, pp. 78-79, pl. 1, figs. 1-6; pl. 2, figs. 1-2) from the Gatún Formation of the Río Reventazón area, Costa Rica, and from borehole G68 of the Gatún Locks, but is smaller and has a different and less well defined median ridge. *Costa stokesae* might be a deeper-water equivalent of *Costa walpolei*. Other species belonging to this group are *Acanthocythereis? kugleri* van den Bold, *Costa santacruensis* van den Bold and *Costa barrocoloradensis* van den Bold. This group of species, which appears to be intermediate between *Costa* and *Acanthocythereis*, is well developed in the Miocene of the southeastern Caribbean. These species belong to the "South American" fauna (van den Bold, 1965a) and do not occur very far north of the South American mainland. The presence of *Costa walpolei* in the Río Dulce Formation of Guatemala marks the furthest extension of this group.

# Genus PTERYGOCYTHEREIS Blake, 1933

## *Pterygocythereis miocenica* van den Bold, new species Plate 1, figure 19a-b

- Cythereis* (*Pterygocythereis*) *cornuta* var. *americana* (Ulrich and Bassler). — HOWE et al., 1935 (part), p. 26, pl. 2, figs. 19, 22-24; pl. 4, fig. 24 (not pl. 2, fig. 21 = *P. americana*).  
*Cythereis* (*Pterygocythereis*) *cornuta* var. *americana* (Ulrich and Bassler). — VAN DEN BOLD, 1946, p. 100, pl. 10, fig. 17a-b.  
 Not *Pterygocythereis cornuta* var. *americana* (Ulrich and Bassler). — SWAIN, 1948, p. 206, pl. 13, fig. 4 = *Pt. howei* Hill.  
*Pterygocythereis cornuta americana* (Ulrich and Bassler). — PURI, 1954 (part), p. 261, pl. 13, fig. 2-5; text-fig. 9d-e (not pl. 13, fig. 1; not text-fig. 9f = *Pterygocythereis americana*).  
 Not *Cythereis cornuta* var. *americana* ULRICH and BASSLER, 1904, p. 122, pl. 37, figs. 29-33.  
 Not *Pterygocythereis cornuta americana* (Ulrich and Bassler). — SWAIN, 1951, p. 41.  
 Not *Pterygocythereis americana* (Ulrich and Bassler). — VAN DEN BOLD, 1950, pp. 83-84. — MALKIN, 1953, p. 795, pl. 80, figs. 26-29. — HILL, 1954, p. 814, pl. 99, fig. 7a. — MCLEAN, 1957, p. 80, pl. 9, figs. 5a-f, 6 a-c. — VAN DEN BOLD, 1958, p. 404 (all *Pterygocythereis americana*).  
 Not *Pterygocythereis* cf. *americana* (Ulrich and Bassler). — MALKIN, 1960, pl. 1, fig. 33. — BENSON and COLEMAN, 1963, p. 22, pl. 5, figs. 1-3; text-fig. 10.

*Name:* After its occurrence in the Caribbean Miocene.

*Holotype:* A complete carapace, HVH No. 1039 (Howe et al., 1935, pl. 2, fig. 19).

*Paratypes:* HVH nos. 1040, 1041, 1042 (Howe et al., 1935, pl. 2, figs. 21-24); HVH nos. 2900, 3016, 3017, 3018 (Puri, 1954, pl. 13, figs. 2-5).

*Type locality:* One mile west of Valley Church, Walton County, Florida.

*Stratigraphic horizon:* Shoal River Formation, Miocene.

*Distribution:* Gatún Formation (Panama), Gurabo Formation (Dominican Republic), upper part of Nipe Series (Cuba), Shoal River and Choctawhatchee Formations (Florida).

*Description:* Carapace subrectangular, alate, highest at the anterior cardinal angle at about one-fourth of the length from the anterior extremity. Dorsal margin straight, ventral margin slightly sinuate and converging somewhat posteriorly; posterior end angled below the middle, almost straight above, convex and bearing up to 6 strong, blunt spines below. Anterior margin obliquely rounded, denticulate in the lower half and carrying a strong carina-like rim, which bears 5-6 strong, blunt spines in the lower half. This rim continues backward as the anterior edge of the ala, which ends in a strong spine at three-fifths of the length from the anterior end. This anterior edge is flattened and almost smooth. On the posterior edge of the ala, about at the place of attachment to the carapace proper, are one or two short, flat spines. They were preserved in nearly all left valves, but in only one right valve. The posterior portion of the carapace is strongly compressed. Posterior cardinal angle rounded. In front of it and roughly parallel to the dorsal margin is a faint, convex dorsal

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ridge. Just in front of and below the anterior cardinal angle is a large, rounded eye-node. The interior was adequately described by Howe *et al.* (1935).

**Dimensions:** Holotype, HVH no. 1039: L: 0.95 mm.; H: 0.44 mm.; W: 0.63 mm. Gatún material, left valve: L: 0.80 mm.; H: 0.47 mm.

**Remarks:** This species differs from *Pterygocythereis americana* (Ulrich and Bassler) in a number of respects: It is plumper, the posterior cardinal angle in the left valve is rounded and does not carry a spine, the fluted dorsal crest is replaced by a faint dorsal ridge, and the anterior side of the ala is almost smooth, occasionally showing small depressions, which, however, never show up as strongly as they do in *P. americana*.

The Gatún material differs very slightly from the type, described above: The anterior side of the ala is completely smooth and the carapace is shorter (see dimensions); all other characteristics being identical, I have no choice but to identify these specimens with the Florida species.

*Pterygocythereis howei* Hill (1954, p. 812, pl. 98, fig. 2a-b; pl. 99, fig. 4a-d) is more elongate than the present species, but otherwise very similar. This species appears to be confined to the Upper Oligocene and lowermost Miocene of the Gulf Coast. I have not found it in the Caribbean.

Benson and Coleman (1963, p. 22) in describing *Pterygocythereis* sp. aff. *americana* (Ulrich and Bassler), mentioned the co-occurrence of crested heteromorphs and uncrested tecnomorphs in the eastern Gulf of Mexico. They state that they found no uncrested forms among the fossil representatives of *Pterygocythereis* in the Miocene of Virginia, North Carolina, South Carolina, and Florida. In Florida, however, both forms occur. The crested form or true *Pterygocythereis americana* (see van den Bold, 1950, p. 84) occurs only in the Alum Bluff Stage, whereas the uncrested form, first figured by Howe *et al.* (1935), has been found in the Shoal River Formation (part of the Alum Bluff Stage) and in the Choctawhatchee Stage. In the Caribbean, the crested form appears to be restricted to the *Globorotalia fohsi* s.l. Biozones, whereas the uncrested form appears confined to the *Globorotalia menardii* Zone and stratigraphically higher formations. Therefore, it seems justifiable to separate the crested and uncrested forms in the Miocene, although the Recent ones live together in the eastern Gulf of Mexico. In the Recent of the eastern Caribbean, only the uncrested form has been found.

Genus CATIVELLA Coryell and Fields, 1937

*Cativella navis* Coryell and Fields  
Plate 1, figure 5

*Cativella navis* CORYELL and FIELDS, 1937, p. 9, fig. 9. – VAN DEN BOLD, 1946, p. 104, pl. 12, fig. 11. – VAN DEN BOLD, 1950, p. 85. – PURI, 1954, p. 262, pl. 11, figs. 3–7, text-fig. 9i–k. – VAN DEN BOLD, 1958, p. 404, pl. 3, fig. 4.  
*Navecythere delicatula* CORYELL and FIELDS, 1937, p. 7, fig. 7.

**Distribution:** In the eastern Caribbean, this species first appears in the upper part of the Lower Miocene. In Florida, however, it has not been found until the upper Middle Miocene. All evidence indicates a northward and westward migration of this species during the Miocene.

Genus PURIANA Coryell and Fields, 1954

*Puriana rugipunctata* (Ulrich and Bassler)  
Plate 1, figure 7

*Cythere rugipunctata* ULRICH and BASSLER, 1904, p. 118, pl. 38, figs. 16–17.  
*Favella puella* CORYELL and FIELDS, 1937, p. 8, fig. 8a–c.  
*Cythereis rugipunctata* var. *gatunensis* CORYELL and FIELDS, 1937, p. 10, fig. 11.  
*Favella rugipunctata* (Ulrich and Bassler). – EDWARDS, 1944, p. 524, pl. 88, figs. 5–6.  
*Puriana rugipunctata* (Ulrich and Bassler). – PURI, 1954, p. 257, pl. 12, figs. 18–19, text-fig. 8k.  
*Puriana puella* (Coryell and Fields). – PURI, 1954, p. 257, pl. 12, fig. 17.

Subfamily HEMICYTHERINAE Puri, 1953  
Genus CAUDITES Coryell and Fields, 1937

*Caudites medialis* Coryell and Fields  
Plate 1, figure 4

*Caudites medialis* CORYELL and FIELDS, 1937, p. 11, fig. 12a–d. – VAN DEN BOLD, 1966c, pl. 1, fig. 7.

**Distribution:** This species has been found in the Gatún Formation of Panama and Costa Rica, in the Tubará Formation of Colombia, in the Gurabo Formation of the Dominican Republic, and in the Telemaque Member of the Manzanilla Formation in Trinidad. In Colombia and the Dominican Republic it occurs together with *Mutilus confragosus* (Edwards); in Panama, Costa Rica and Trinidad it has been found below the first occurrence of this species.

Genus ORIONINA Puri, 1954

*Orionina serrulata* (Brady)

*Cythereis vauhani* (Ulrich and Bassler). – CORYELL and FIELDS, 1937, p. 9 fig. 10 (not *Cythere vauhani* Ulrich and Bassler, 1904).  
*Orionina serrulata* (Brady). – VAN DEN BOLD, 1963a, pp. 44–45, pl. 4, figs. 1–6, text-fig. 5, figs. 6–7, 8a–d).

**Distribution:** In Trinidad, the lower boundary of the range of this species lies at the base of the Manzanilla Formation; other formations in which this species has been recognized, e.g. Gurabo (Dominican Republic), Tubará (Colombia), are always stratigraphically above this horizon, so that it has been impossible to check if its base forms a true stratigraphic level. In view of the persistence of *Orionina vauhani* (Ulrich and Bassler) up to the Pliocene in Florida, it seems likely that the influx of *Orionina serrulata* could occur at progressively higher stratigraphic levels from southeast to northwest.

Subfamily CYTHERURINAE Müller, 1894  
Genus CYTHERURA Sars, 1866

*Cytherura bananaformis* Coryell and Fields  
Plate 1, figure 18

*Cytherura bananaformis* CORYELL and FIELDS, 1937, p. 12, fig. 14a-d.

*Distribution*: So far the species has not been found outside the Gatún Formation of Panama.

*Cytherura swaini* van den Bold

*Cythere swaini* VAN DEN BOLD, 1963c, p. 395, pl. 9, fig. 4a-b.

The one specimen from the Gatún Formation is somewhat shorter and thicker than the type specimens, but exhibits the same ornamentation.

Genus SEMICYTHERURA Wagner, 1957

*Semicytherura arayaensis* van den Bold

*Semicytherura arayaensis* VAN DEN BOLD, 1966b, p. 31, pl. 4, fig. 3a-b.

*Distribution*: Both in Trinidad and in northeastern Venezuela, this species occurs only below beds with Springvale fauna (*Mutilus confragosus*). This is in agreement with its occurrence in the Gatún Formation.

Genus KANGARINA Coryell and Fields, 1937

*Kangarina quellita* Coryell and Fields  
Plate 1, figure 14

*Kangarina quellita* CORYELL and FIELDS, 1937, p. 13, fig. 15a-c.—VAN DEN BOLD, 1958, p. 416, pl. 5, fig. 8.—VAN DEN BOLD, 1963c, p. 396, pl. 10, fig. 3.

*Kangarina chipolensis* PURI, 1954, p. 246, pl. 8, fig. 10; text-fig. 6g.

Not *Kangarina quellita* Coryell and Fields.—PURI, 1954, p. 248, pl. 4, fig. 9.—KEIJ, 1954, p. 226, pl. 5, fig. 8.—MALKIN, 1960, pl. 1, fig. 24.

*Distribution*: Florida: Alum Bluff Stage; Trinidad: Navarro River Member of Brasso Formation (upper part of *Globorotalia fohsi* Zone), Tamana Formation, Manzanilla Formation; Colombia: lower part of Tubará Formation; Panama: Gatún Formation; Costa Rica: Gatún Formation (CR 12, *Globigerinoides ruber* Zone); Dominican Republic: Gurabo Formation. In Trinidad, *K. quellita* occurs together with *Mutilus confragosus* in Biche Calyx hole 44; the same combination is found in the Gurabo Formation.

Genus CYTHEROPTERON Sars, 1866

*Cytheropteron nipeensis* van den Bold  
Plate 1, figure 11

*Cytheropteron nipeensis* VAN DEN BOLD, 1946, p. 113, pl. 16, fig. 1a-b.

*Holotype*: A complete carapace (S 13062, Pal. Mus., Utrecht).

*Paratypes*: D 27202 (Pal. Mus., Utrecht).

*Remarks*: This species was originally described from the upper part of the Nipe Series of Cuba. It differs from *Cytheropteron palton* van den Bold, from the Cubagua Formation of northeastern Venezuela, by the presence of a circular pit in the anterior side of the ala.

*Dimensions*: L: 0.52 mm.; H: 0.23 mm.; W: 0.24 mm. (left valve).

*Cytheropteron* sp.  
Plate 1, figure 10

*Description*: Carapace ovate, alate, highest in the middle. Anterior end obliquely rounded, dorsal margin sinuate, convex in the middle, posterior end a subdorsal caudal process, ventral margin sinuate, swinging upward into the posterior margin. Dorsal view sagittate, widest at the posterior end of the ala, at about three-fifths of the length from the anterior extremity. The anterior and posterior sides of the ala are each formed by two ridges. The lower anterior one connects the tip of the ala with the anterior margin; the upper anterior one diverges from it forwardly and ends behind the middle of the anterior margin. The lower posterior one connects the tip of the ala with the posterior end; the upper one first strikes upward in the direction of the middle of the posterior half of the dorsal margin and then, at one-fourth of the distance between the tip of the ala and the dorsal margin, it bends backward and again forward, forming a circle which passes just below the central convexity of the dorsal margin.

*Dimensions*: L: 0.47 mm.; H: 0.25 mm.

*Cytheropteron* sp. aff. *C. leonensis* Puri

*Cytheropteron* sp. aff. *C. leonensis* PURI.—VAN DEN BOLD, 1966b, p. 34, pl. 3, fig. 1a-c.

*Remarks*: This species, which may be identical to the Choctawhatchee species from Florida (Puri, 1954, p. 242, pl. 4, figs. 11-12; text-fig. 6c-d), differs from *Cytheropteron subreticulatum* van den Bold (1946, p. 113, pl. 14, fig. 6a-c) by the absence of the thickened rim along the ventral side of the carapace, which splits posteriorly into two diverging ridges.

Genus EUCYTHERURA Müller, 1894

*Eucytherura rohri* (van den Bold)

Plate 1, figure 13a-b; text-figure 3a-b

*Loxoconcha?* *rohri* VAN DEN BOLD, 1958, p. 408, pl. 4, fig. 5a-b. *Eucytherura ruggierii* van den Bold.—VAN DEN BOLD, 1963 (part), table 7.

*Eucytherura* aff. *ruggierii* van den Bold.—VAN DEN BOLD, 1964, p. 9.

*Loxoconcha?* *rohri* van den Bold.—VAN DEN BOLD, 1966a, table 1. *Eucytherura rohri* (van den Bold).—VAN DEN BOLD, 1966b, p. 32, pl. 4, fig. 6a-b.

**Remarks:** In addition to the description of the exterior (van den Bold, 1958,) a few remarks should be made about the interior as displayed by specimens in the Gatún Formation: Hinge in the right valve consists of a blunt anterior tooth, followed by a narrow socket, which corresponds to a small anterior tooth in the left valve; this socket continues into a finely crenulate, narrow groove; posterior tooth blunt, square. The median bar in the left valve lies a good distance below the dorsal outline, which in side view projects over the dorsal outline of the right valve. Marginal area fairly broad, line of concrescence and inner margin coincide, radial pore canals small in number (about 7 at the anterior end), straight, simple and widely spaced.

**Dimensions:** L: 0.34 mm.; H: 0.20 mm.; W: 0.18 mm.

Genus *PARACYTHERIDEA* Müller, 1894

*Paracytheridea tschoppi* van den Bold

*Paracytheridea tschoppi* VAN DEN BOLD, 1946, p. 85, pl. 16, figs. 6a-c, 7.

?*Paracytheridea tschoppi* van den Bold. — KEIJ, 1954, p. 220, pl. 4, fig. 4. — VAN DEN BOLD, 1957, p. 245, pl. 4, fig. 7. — BENSON and COLEMAN, 1963, pp. 33-34, pl. 6, figs. 7, 9-10; text-fig. 20a-b.

?*Paracytheridea* sp. 1, DROOGER and KAASSCHIETER, 1958, p. 91. Not *Paracytheridea tschoppi* van den Bold. — KINGMA, 1948, p. 74, pl. 7, fig. 12a-b.

**Holotype:** A left valve (S 13004, Pal. Mus. Utrecht) from sample T 1451, upper part of Nipe Series, Cuba.

**Paratypes:** D 27225 (Pal. Mus. Utrecht).

**Remarks:** All subsequently described specimens have a less blunt and less oblique anterior end than the original specimens; also, the posterodorsal boss is much less developed than in the specimens from the Nipe Middle Miocene and from the Gatún Formation (the last two series of specimens appear to be identical). However, Benson and Coleman commented on the great variation in this development even at one locality, in their study of Recent fauna. Therefore, I hesitate to restrict this species to those specimens with a blunt anterior end and a high and spinose posterodorsal boss.

*Paracytheridea clara* Coryell and Fields

*Paracytheridea clara* CORYELL and FIELDS, 1937, p. 6, fig. 6a-c.

**Remarks:** A few specimens have been found that correspond closely to the given description and figures. All are young moults, presumably of *Paracytheridea tschoppi* van den Bold. As no positive identification could be made, and as I am at the moment not absolutely certain about the amount of variability that should be recognized in the latter species, and as, moreover, this would cause the suppression of the name *P. tschoppi*, which has been used by other workers in the Caribbean, I have kept the two species separate for the time being.

Subfamily BYTHOCYTHERINAE Sars, 1926  
Genus PSEUDOCERATINA van den Bold, 1965

*Pseudoceratina droogeri* van den Bold

*Pseudoceratina droogeri* VAN DEN BOLD, 1965b, pp. 161-164, pl. 1, figs. 1-4; text-figs. 1-2.

**Remarks:** A single valve of this species was found in sample P 11. As this species occurs very commonly in Las Minas Bay, Panama, a sample from which was being washed at the time of handling of this sample, it is not completely excluded that this represents contamination. However, in that case, I would have expected other, more abundant species from the Recent material to show up as well.

Family PARADOXOSTOMIDAE Brady and Norman, 1889

Genus LUVULA Coryell and Fields, 1937

*Luvula palmerae* Coryell and Fields  
Plate 1, figure 16; plate 2, figure 4

*Luvula palmerae* CORYELL and FIELDS, 1937, p. 16, fig. 16a-b. — VAN DEN BOLD, 1958, p. 416, pl. 4, fig. 3a-c.

*Macroclytherina gatunensis* CORYELL and FIELDS, 1937, pp. 16-17, fig. 17a-d.

Not *Luvula palmerae* Coryell and Fields. — PURI, 1954, pp. 294-295, pl. 15, fig. 12; text-fig. 13a = *Pellucistoma* sp.

**Distribution:** Outside the Canal Zone this species has only been found in the Río Reventazón area of Costa Rica (*Globigerinoides ruber* Zone), and at about the same stratigraphic level in the upper Navarro Member of the Brasso Formation in Trinidad.

**Description:** The exterior was adequately described by Coryell and Fields. Interior: Hinge in the right valve consists of a peculiar curved anterior tooth, which extends below the slightly widened anterior end of the hinge-groove, which is also slightly widened posteriorly. The groove is not bordered ventrally by a distinct ridge. The posterior tooth is similar to the anterior one, but much more weakly developed. Hinge in the left valve consists of a median bar, thickened on both ends in front of and behind which there are terminal, but rather indistinct sockets.

Marginal area very broad at the anterior end; line of concrescence and inner margin widely separated there, forming a large anterior vestibule. Posteroventral vestibule less developed, and the marginal area is less broad here. The anterior vestibule is somewhat irregularly shaped, extended where the radial pore-canals begin with a widened base. Radial pore-canals fairly numerous (15-20) at the anterior end, two sometimes rising from the same indentation of the line of concrescence. Muscle-scars a posterior row of 4, with an irregularly rounded scar in front.

**Dimensions:** L: 0.49 mm.; H: 0.25 mm.

*Remarks:* The measurements given by Coryell and Fields indicate a magnification  $70\times$  instead of  $100\times$ , and the greatest height (0.16 mm.) was apparently calculated from the dimensions of the figure and divided by the wrong magnification. If divided by 70 the greatest height becomes 0.24 mm. *Luvula palmerae* is accompanied by a few specimens that have all the characteristics of *Macrocytherina gatunensis* Coryell and Fields. The only difference between the two species is the different shape of the posterodorsal margin in side view. This difference is interpreted here as sexual dimorphism. The shape of the marginal area is reminiscent of genera of the Paradoxostomidae (e.g., *Pellucistoma* and *Paracytherois*), and the proper place for *Luvula* is more likely to be in this family than in the Bythocytherinae where it was placed by the original authors. In the Treatise (Moore et al., 1961, p. 268) it was placed in synonymy with *Jonesia* (Bythocytheridae).

Genus PELLUCISTOMA Coryell and Fields, 1937

*Pellucistoma howei* Coryell and Fields  
Plate 1, figure 17; plate 2, figure 5

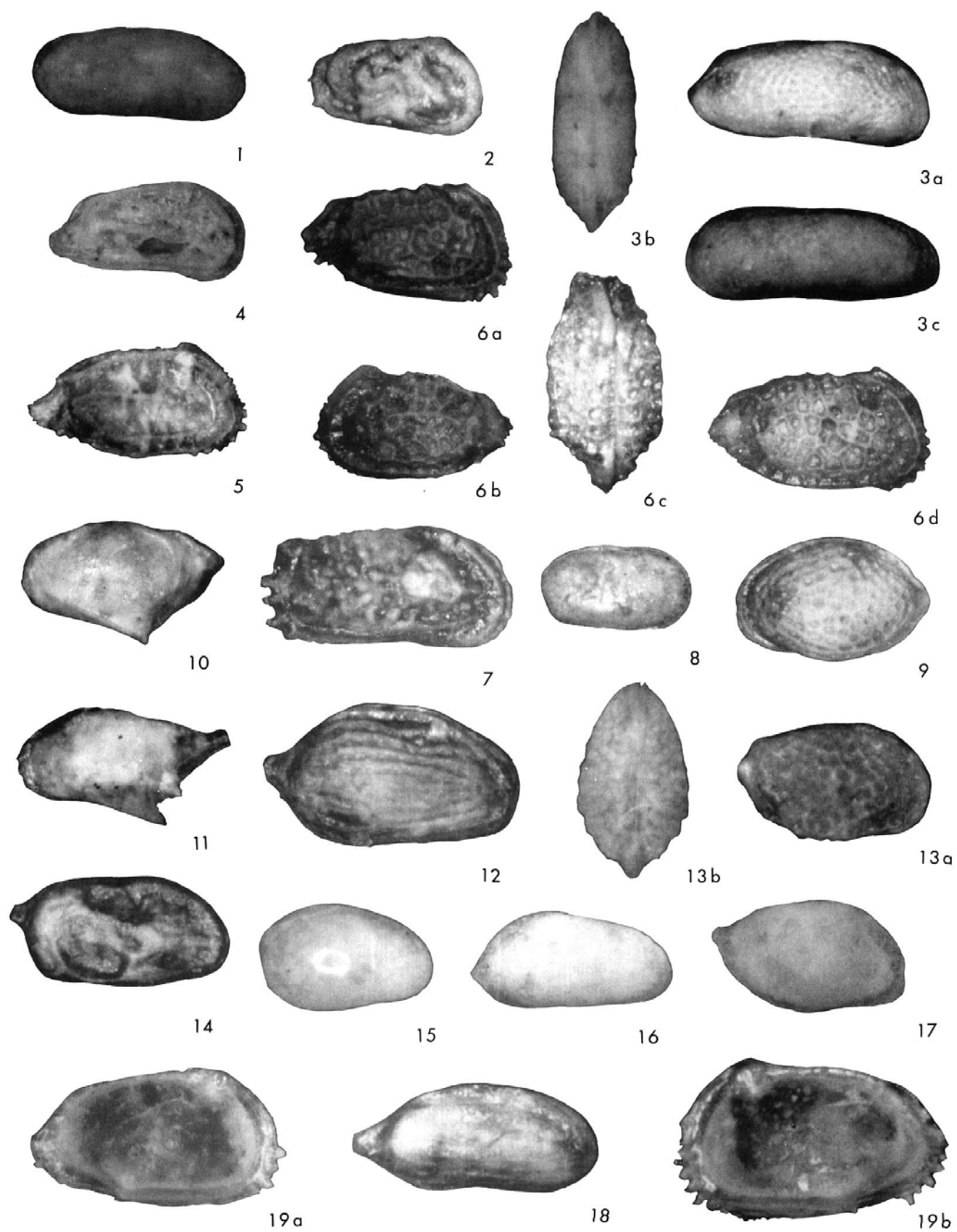
*Pellucistoma howei* CORYELL and FIELDS, 1937, p. 17, fig. 18a-c. Not *Pellucistoma* aff. *howei* Coryell and Fields. — MALKIN, 1960, pp. 481, 483, figs. 5, 10; pl. 2 (top), fig. 3; pl. 2 (bottom), fig. 19.

*Remarks:* The original description is quite adequate. The hinge, however, in the right valve shows a more elaborate structure than Coryell and Fields indicated and is very much similar to what Edwards (1944, p. 528) described for *Pellucistoma magniventra*.

Family XESTOLEBERIDIDAE Sars, 1928  
Genus XESTOLEBERIS Sars, 1866

# PLATE 1

- 1 *Parakrithella* sp.  
Left valve, exterior view,  $\times 75$ ; sample P. 14; HVH no. 8221.
- 2 *Munseyella bermudezi* van den Bold  
Right valve view,  $\times 100$ ; sample P. 14; HVH no. 8222.
- 3 *Pumilocytheridea mylonita* (Coryell and Fields)  
a, female, right valve view; b, female, dorsal view; c, male, exterior of left valve; all  $\times 100$ ; sample P. 14; HVH no. 8223.
- 4 *Caudites medialis* Coryell and Fields  
Right valve view,  $\times 80$ ; sample P. 12; HVH no. 8226.
- 5 *Cativella navis* Coryell and Fields  
Right valve, exterior view,  $\times 80$ ; sample P. 14; HVH no. 8238.
- 6 *Costa walpolei* (van den Bold)  
a, female, right valve view; b, female left valve, exterior view; c, female, dorsal view; d, male, right valve view; all  $\times 65$ ; sample P. 11; HVH no. 8225.
- 7 *Puriana rugipunctata* (Ulrich and Bassler)  
Right valve view,  $\times 75$ ; sample P. 14; HVH no. 8227.
- 8 *Platella gatunensis* Coryell and Fields  
Right valve, exterior view,  $\times 50$ ; sample P. 14; HVH no. 8239.
- 9 *Loxoconcha banesensis* van den Bold  
Left valve, exterior view,  $\times 100$ ; sample P. 14; HVH no. 8228.
- 10 *Cytheropteron* sp.  
Left valve, exterior view,  $\times 80$ ; sample P. 12; HVH no. 8229.
- 11 *Cytheropteron nipeensis* van den Bold  
Left valve, exterior view,  $\times 75$ ; sample P. 12; HVH no. 8240.
- 12 *Cytherura* ex gr. *johnsoni* Mincher  
Right valve, exterior view,  $\times 100$ ; sample P. 14; HVH no. 8236.
- 13 *Eucytherura rohri* (van den Bold)  
a, right valve view; b, dorsal view; both  $\times 100$ ; sample P. 11; HVH no. 8235.
- 14 *Kangarina quellita* Coryell and Fields  
Male right valve, exterior view,  $\times 100$ ; sample P. 14; HVH no. 8234.
- 15 *Xestoleberis* sp.  
Right valve view,  $\times 75$ ; sample P. 11; HVH no. 8232.
- 16 *Luvula palmerae* Coryell and Fields  
Right valve view,  $\times 75$ ; sample P. 12; HVH no. 8230.
- 17 *Pellucistoma howei* Coryell and Fields  
Right valve, exterior view,  $\times 75$ ; sample P. 14; HVH no. 8233.
- 18 *Cytherura bananaformis* Coryell and Fields  
Right valve view,  $\times 125$ ; sample P. 12; HVH no. 8237.
- 19 *Pterygocythereis miocenica* van den Bold, n. sp.  
a, right valve, exterior view; b, left valve, exterior view; both  $\times 60$ ; sample P. 11; HVH no. 8224.



*Xestoleberis* sp.  
Plate 1, figure 15

**Description:** Carapace in side view pyriform, highest at about five-eighths of the length from the anterior extremity. Anterior end low, obliquely rounded; anterior margin continuous with the arched dorsal margin; ventral margin sinuate, concave in anterior third, swinging upward into the posterior end, which is slightly angled above the middle. Left valve conspicuously overlapping the right dorsally and posteriorly. Dorsal view pyriform, widest just behind the middle; anterior end blunt, posterior end broadly rounded.

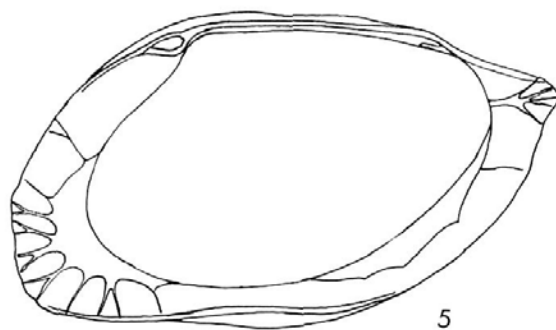
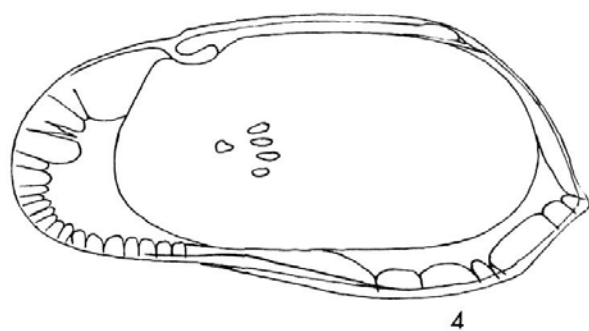
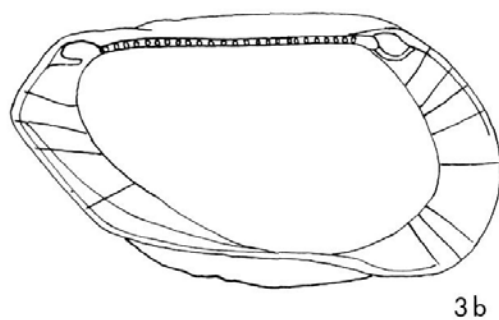
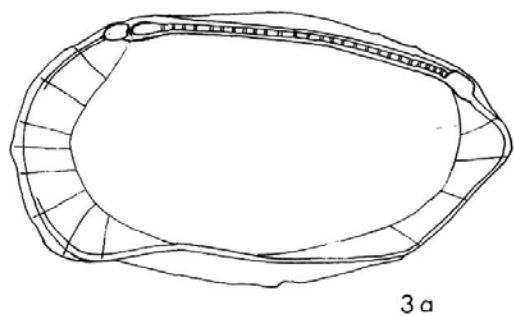
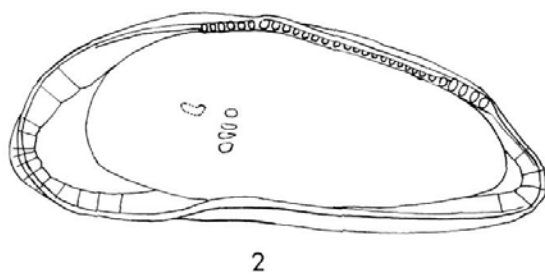
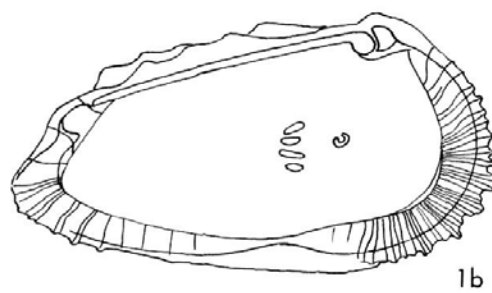
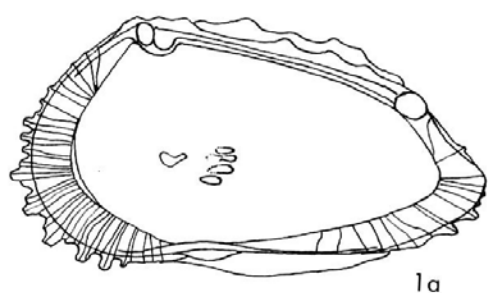
**Dimensions:** L: 0.42 mm.; H: 0.26 mm.; W: 0.25 mm.

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## PLATE 2

- 1 *Costa walpolei* (van den Bold)  
a, left valve, interior view; b, right valve, interior view; both  $\times 100$ ; sample P. 11; HVH no. 8225.
- 2 *Pumilocytheridea mylonita* (Coryell and Fields)  
Right valve, interior view,  $\times 175$ ; sample P. 14; HVH no. 8223.
- 3 *Eucytherura rohri* (van den Bold)  
a, left valve, interior view; b, right valve, interior view; both  $\times 175$ ; sample P. 11; HVH no. 8235.
- 4 *Luvula palmerae* Coryell and Fields  
Right valve, interior view,  $\times 160$ ; sample P. 14; HVH no. 8231.
- 5 *Pellucistoma howei* Coryell and Fields  
Right valve, interior view,  $\times 160$ ; sample P. 14; HVH no. 8233.



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