THE UNIVERSITY OF KANSAS
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RECENT MARINE AND LAGOONAL OSTRACODES FROM THE ESTERO DE TASTIOTA REGION, SONORA, MEXICO (NORTHEASTERN GULF OF CALIFORNIA)

By Richard H. Benson and Roger L. Kaesler

University of Kansas Publications

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By RICHARD H. BENSON and ROGER L. KAESLER
Department of Geology, University of Kansas

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ABSTRACT

Recent Ostracoda (16 species, 14 genera) representing four biotopes and two biogeographic realms were collected from two slightly hypersaline lagoons on the west coast of Sonora, Mexico, in the Gulf of California about one-third of its length (440 miles) south of the mouth of the Colorado River. The faunal assemblages represent an open-gulf biotope, a lower-lagoon biotope, an upper-lagoon biotope, and a tidal-flat biotope. They include forms from the Panamanian realm, the Gulf realm (Gulf of Mexico), and the Californian transition zone (ecotone).

The species discussed include seven new species, *Clithrocytheridea sonora, Perissocytheridea swaini, Parakrithella perspicilla, Cushmanidea sagena, Caudites serrata, Basslerites sonorensis,* and *Puriana horrida;* one new subspecies *Aurila conradi* (HOWE & MCGUIRT) *californica;* two species with tentative identifications, *Cythere?* sp. cf. *C.? yorktownensis* (MALKIN), and *Cativella* sp. cf. *C. dispar* HARTMANN; and six previously described species, *Perissocytheridea meyerabichi* HARTMANN, *Cytherura johnsoni* MINCHER, *Loxoconcha lenticulata* LEROY, *Megacythere johnsoni* (MINCHER), *Pellucistoma scrippsi* BENSON, and *Puriana pacifica* BENSON.

Samples were taken from 26 stations in a lagoon about 1.5 miles in width and from 6 stations in a larger lagoon 30 miles to the northwest. Depths sampled range from supratidal to 18 feet in the open gulf and from supratidal to 6 feet in the lagoon; salinity ranges from 36‰ in the open gulf to 48‰ on the tidal flat; and temperature ranges from 18°C in January to 29°C in July and September. The substratum consists of very coarse sand in the open gulf, medium to coarse sand in the lagoon channels, and clay to silt on the tidal flats.

Salinity, tidal currents, and exposure to the atmosphere are the physical factors that seem to have the most effect on the local distribution of the Ostracoda.

Among the ostracodes represented, nine species of eight genera show sufficient ecologic restriction to be used as biotope indicators; but because many of these have so far been found only in Recent sediments, their value as paleoecologic indicators is not yet known.

INTRODUCTION

In recent years taxonomic and ecologic studies involving ostracodes have been carried out by various workers in estuaries, lagoons, and deltaic areas with the purpose of delineating environmental indicator species for near-shore environments. The Gulf of California is a large, elongate *cul-de-sac* opening to the south. Ostracodes and other invertebrates may have been trapped and isolated in the Gulf during the general northern migration of faunas accompanying the warming of the Pacific Ocean during the last glacial retreat, resulting in increased natural selection or formation of relic strandline communities. The purpose of this study is to report on the systematic and biogeographic relationships of the Ostracoda from two small lagoons on the east coast of the Gulf of California (Laguna La Cruz and the Estero de Tastiota), and to describe the new species living in these slightly hypersaline environments (Fig. 1.).

Ecologic data and samples containing ostracodes were provided by MAYNARD M. NICHOLS from collections made during the summer of 1960 while he was working on his doctoral thesis at the University of California at Los Angeles. Because his ecologic study was concerned only with distribution of sediments and Foraminifera in the area and not with the ostracodes, and because the data he could supply at the time of writing of this report was incomplete, the environmental relationships of the fauna described here are fragmentary.

PREVIOUS STUDIES

The first descriptions of Recent marine ostracodes from the Pacific Coast of North America were given by G. W. MÜLLER (1895), who reported two planktonic species from the western coast of Mexico and Central America. Additional planktonic ostracodes were described by JUDAY (1906 and 1907) and by SKOGSBERG (1950), but neither these species nor the ones reported by MÜLLER were found in the Estero de Tastiota.

In 1928 SKOGSBERG described five species of podocopid ostracodes from near Pacific Grove, California. LUCAS (1930) described several more species of ostracodes from Vancouver Island, British Columbia. None of these northern forms were found living in the Gulf of California.

Two abstracts of ecological surveys were published by ROTHWELL (1948a,b) from his study of NATLAND's (1933) collections near Newport Bay, California, and from San Pedro Channel. Although details of ROTHWELL's work are not available, his brief reports encouraged BENSON (1959), who published the first complete study on the ecology of Pacific ostracodes in his

investigation of ostracodes from Todos Santos Bay located on the western coast of Baja California. Although Todos Santos Bay is only about 250 miles north of the Estero de Tastiota, the ostracode fauna there is quite different: only three of the species reported by BENSON are present in the Estero de Tastiota.

Studies of ostracodes from the Pliocene, Pleistocene, and Recent of Southern California were made by LEROY (1943 and 1945), and from the Pliocene of Southern California by CROUCH (1949). One of the species described by LEROY was found in the Estero de Tastiota, but none of those reported by CROUCH were present.

Others have conducted ecologic investigations of the microfauna of the Pacific Coast exclusive of the ostracodes (particularly PHLEGER & EWING, 1962; and WALTON, 1955). F. M. SWAIN is now working on Ostracoda from the deeper parts of the Gulf of California, but thus far neither studies of ostracodes nor general sedimentation studies (by VAN ANDEL & OTHERS) have been published.

ACKNOWLEDGMENTS

Samples and ecologic data for this study were collected by MAYNARD M. NICHOLS during the summer of 1960 while he was working on a sedimentation and foraminiferal study of the Estero de Tastiota region. The authors would especially like to thank Dr. NICHOLS, for without his generosity this study would not have been possible.

Laboratory facilities for washing and picking the samples, illustrating the specimens, and preparing the manuscript have been provided by the micropaleontology section of the Museum of Invertebrate Paleontology and the Department of Geology of the University of Kansas.

Appreciation is expressed to the Phillips Petroleum Company for their sponsorship of a fellowship provided the junior author, making his participation in this investigation possible.

DESCRIPTION OF STUDY AREA

The study area is located on the eastern coast of the Gulf of California about one-third its length (440 miles) south of the Colorado River delta (Fig. 1). It contains two principal divisions, the Estero de Tastiota, lat. 28° 23'N, long. 111° 25'W), and the Laguna La Cruz (lat. 28° 45'N, long. 111° 50'W) at the mouth of the Sonora River. Only four samples obtained from Laguna La Cruz contained ostracodes, and all species represented there were also found in the Estero de Tastiota. Consequently, greater emphasis was placed on the study of the ostracodes found in the Estero de Tastiota.

The Estero de Tastiota is a small, slightly hypersaline lagoon that has been formed in a shallow drainage way at the mouth of the Rio de la Poza on the southern edge of a wide alluvial plain through which protrude isolated remnants of Tertiary volcanics. Along the coast of this alluvial flat, sand dunes rise to a height of about 50 feet. The movement of these sand dunes to the south forms a barrier across the mouth of the estero. Hills of Tertiary rhyolite-andesite and granodiorite (ANDERSON, 1950, p. 5), whose summits reach elevations as high as 1000 feet, lie to the south of the estero and extend southeastward for 50 miles, nearly to Guaymas.

The local physiographic features within the estero show distinct seasonal changes. During the winter months northwesterly winds move sand from the dunes along the shore of the flats north of the estero and build a barrier almost completely across its mouth. During the summer months southerly winds, possibly coupled with thermal expansion of the gulf waters due to increased water temperature, raise the average water-level more than one foot. The 4-foot spring-tide range and the 2.5-foot mean-tide range remain nearly constant throughout this increase. The higher tide and southerly wind combine forces to destroy the barrier opening the mouth of the estero to gulf waters. The barrier is not rebuilt until the winds shift again, because no substantial source of sediment is available from the volcanic rocks along the coast to the south.

The lagoon may be subdivided physiographically into three parts: the **channels,** which contain water at all times; the **tidal flats,** which are submerged at high tide and exposed to the air at low tide; and the mangrove and *Salicornia* **marshes and clay pans,** which are covered only during highest high tides (usually only during the summer). Although sediments are distributed in a complex pattern in the estero, silts and clays generally accumulate on the tidal flats and in the high marshes and clay pans; whereas sand predominates on the channel floors and on the seaward flats outside the narrow inlets. A strong ebb tide has built an extensive tidal delta of medium to coarse sand seaward of the mouth of the lagoon.

The climate of the Estero de Tastiota area is hot and arid. Rainfall averaging 10 inches per year takes place for the most part during the months of August and September, although some precipitation occurs

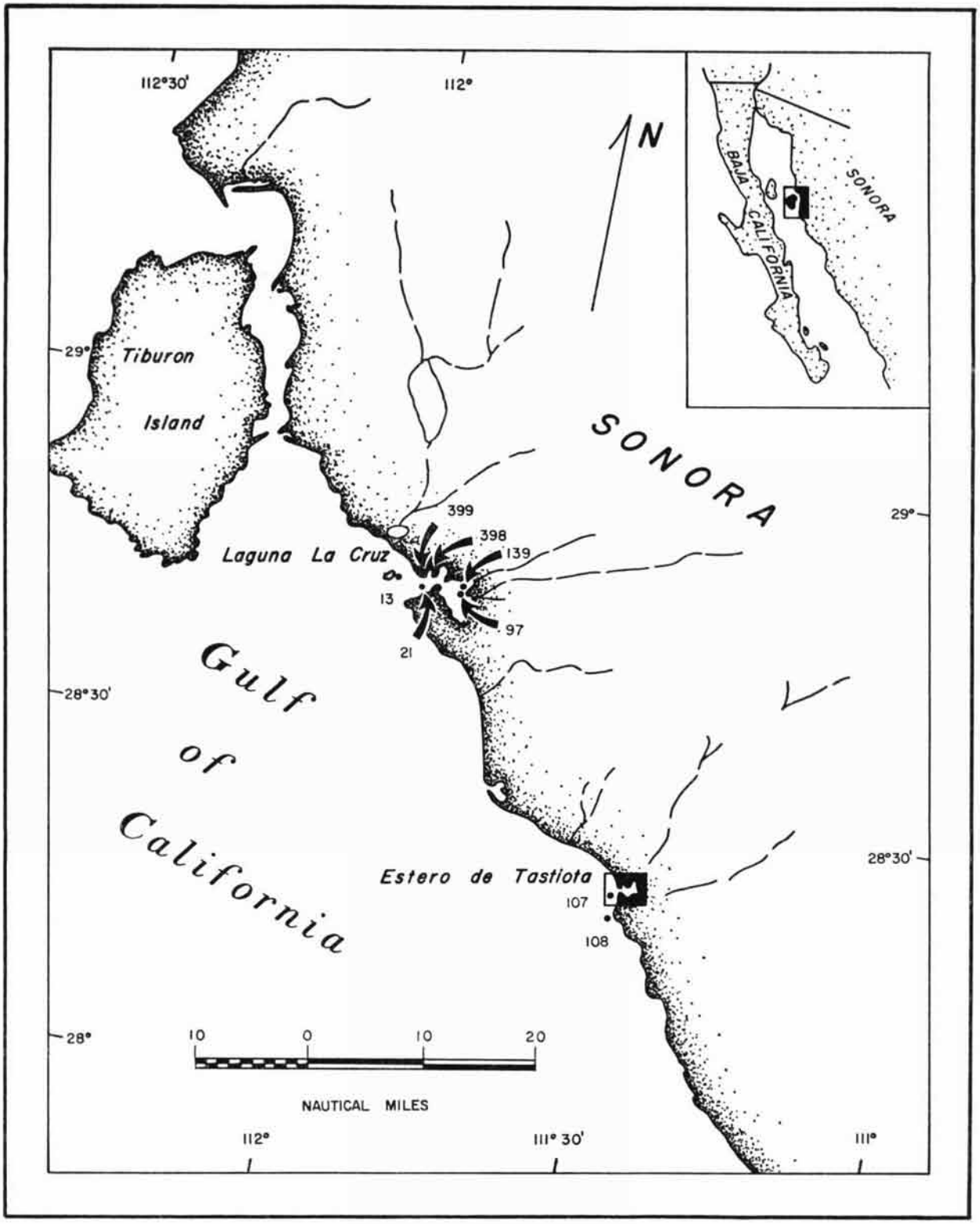

FIG. 1. Location of the study area in Sonora, Mexico, about 440 miles south of the mouth of the Colorado River along the east coast of the Gulf of California. The major study area at the Estero de Tastiota is blocked in; the supplementary stations are indicated separately by original locality numbers (13-399).

during December. The late summer rains are carried in by southerly winds; during the rest of the year northwest winds predominate averaging about 12 miles per hour (4.4 meters per sec). The air temperature at Guaymas reaches a maximum of 32°C (89°F) during July and September and a minimum of 16°C (61°F) during January. The water temperature of the estero shows a similar but slightly less extreme variation. The rate of evaporation is greatest in the summer and least in the winter, but because of dilution by late summer rains, the summer salinity of the estero is highest in early summer and lowest in late summer. The salinity of waters of the open gulf shows seasonal temperature characteristics similar to those in the estero and at Guaymas.

Although the rate of evaporation is greater during the summer than during the winter, destruction of the barrier in the summer permits better circulation and mixing of estero water with gulf water and reduces the salinity during that season. In summer, the salinity is 36.6‰ in the open gulf and 39.8‰ in the upper lagoon; in winter, the salinity of the open gulf drops to 36.1‰ while upper estero salinities rise to 41.5‰. In the high marshes, clay pans, and mangroves the salinity of the water may range from 40‰ to 48‰.

In summary, the Estero de Tastiota is a restricted body of water adjoining another, larger and deeper, restricted body of water. It is very much dependent on the Gulf of California for its initial existence and continuance, and it not only reflects many conditions in the open gulf but in particular magnifies such factors as water temperature and salinity.

OSTRACODE ECOLOGY

GENERAL STATEMENT

In recent years the use of ostracodes in the field of paleoecology as indicator species of marine, brackish-, and fresh-water environments has resulted in increased study of the ecology of Recent Ostracoda. A summary of the more obvious influences of environmental factors on ostracode distribution appears in the *Treatise on Invertebrate Paleontology* (BENSON, 1961, p. Q56-Q63).

The Estero de Tastiota has a salinity consistently higher than normal marine salinity. The faunas of brackish and hypersaline environments often bear strong similarities to each other. The forms that are most tolerant to wide variations in salinity (euryhaline forms) invade both environments and become abundant because of reduced competition. Their presence in normal marine waters is less conspicuous because of dilution by the more numerous forms restricted to that environment, and because of their less successful competition in a generally more highly populated area. PHLEGER & EWING (1962) reported a Foraminifera fauna from a hypersaline environment in coastal lagoons along the west coast of Baja California that is very similar to the one found by PHLEGER & LANKFORD (1957) from brackish water in San Antonio Bay, Texas. Similarly, several species of ostracodes described by SWAIN (1955) from San Antonio Bay also occur in Estero de Tastiota. Furthermore, those species that are confined almost exclusively to the hypersaline environment in the estero are common in brackish-water in San Antonio Bay.

BIOGEOGRAPHY

From their presently known distribution, the ostracode species found in the Estero de Tastiota region are most representative of at least two biogeographic realms: the **Central-American Pacific realm** (sometimes referred to as the Panamanian realm) with described ostracode faunas known only from El Salvador; the **Gulf realm** (including the Gulf of Mexico and probably the southeastern coast of the United States— BENSON & COLEMAN, 1962); and the transition zone (herein called the **California ecotone**) which seems to exist along the Pacific coast of Baja California and southern California separating the Central-American Pacific faunas from the ones along the coast of Oregon, Washington, and British Columbia.

Species from the Recent of the Central-American Pacific realm include *Cativella* sp. cf. *C. dispar* HARTMANN and *Perissocytheridea meyerabichi* (HARTMANN). Those from the Recent of the Gulf realm include *Megacythere johnsoni* (MINCHER), *Perissocytheridea swaini* n. sp., and *Cytherura johnsoni* MINCHER. The first of these latter three species also has been reported from the Miocene of Mississippi and Florida; *C. johnsoni* has also been found in Miocene strata from North and South Carolina. *Cythere?* sp. aff. *C.? yorktownensis* (MALKIN) from the present study area is most closely related to a form described previously only from the Miocene of the Atlantic Coastal Plain. *Aurila conradi* (HOWE & MCGUIRT) *californica,* n. subsp., is one of two apparent descendants of the nominotypical subspecies of Miocene age

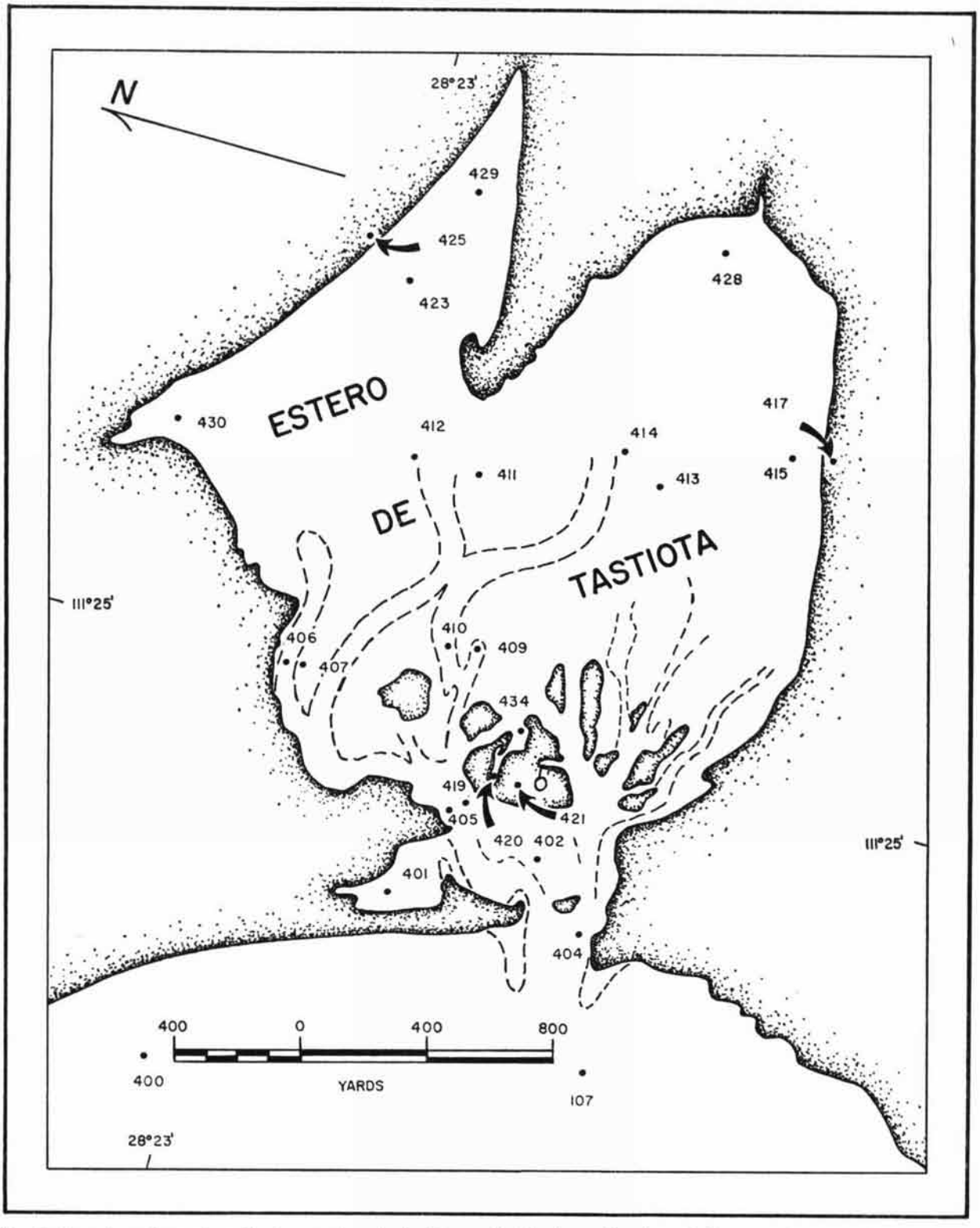

FIG. 2. Location of sample collecting stations in the Estero de Tastiota. Numbers indicate stations at which samples were collected.

from the Atlantic and Gulf coasts. The other Recent subspecies, *Aurila conradi* (HOWE & MCGUIRT) *floridana* BENSON & COLEMAN is common along the northern and eastern shores of the Gulf of Mexico. Those species found in the Estero de Tastiota region that are also represented in the California ecotone include *Puriana pacifica* BENSON, *Pellucistoma scrippsi* BENSON, and *Loxoconcha lenticulata* LEROY. The latter of these species is also found in the Plio-Pleistocene strata of southern California.

The Recent marine and brackish-water ostracode faunas of North America are still poorly known, and the study of their biogeographic distribution and Neogene history is just beginning. The composition of the fauna of the Estero de Tastiota region seems to reflect the presence of the Pliocene seaway through the Central American isthmus as well as the partial isolation of the faunas caused by the interference to migration of the southward-jutting peninsula of Baja California.

The ostracode fauna of the east-central Gulf of California is composed of species arriving from several directions since the Pliocene. Two species have entered from the south along the Pacific coast of Central America and are relatively unmodified as compared to their living southern representatives. The four species also known from the Gulf realm (Gulf of Mexico) are all presently living at approximately the same latitude in both regions indicating the similarity of environmental pressures. The ranges of most of these species extend back into the Miocene and the apparent infraspecific variation between fossil and living forms suggests evolutionary radiation from southeastern North America sometime during middle Neogene with subsequent isolation in the gulfs of Mexico and California during the Pleistocene.

The Recent faunas that have been studied to the northwest of the present study area, on the northern Pacific coast of Baja California and along the shores of southern California, have few if any species in common with those of the Gulf realm, and only three species in common with those of the Estero de Tastiota. The *cul-de-sac* nature of the north-south trending embayment of the Gulf of California and the post glacial general northward migration of warm-water faunas imply the possible formation of relic temperate faunal communities whose predecessors were cut off from following their preferred, northward-migrating, cooler-water habitats along an open coast. The ostracodes of the southwestern coast of North America have not yet been sufficiently studied to demonstrate this relationship adequately, but the possibility of a faunal entrapment similar to that of the brackish-water faunas of the Gulf of Bothnia (SEGERSTRÅLE, 1957) is indicated.

In summary, the reasons for the biogeographic character of a fauna are never readily apparent; however, the relationship of the Estero de Tastiota ostracode fauna to the faunas of the Pacific could be explained in two ways. The first possibility is that northern forms, as represented in Todos Santos Bay in northwestern Baja California, are following the cooler waters of the California Current southward along the coast of California; whereas the species in the eastern Gulf of California are representative of a stable subtropical fauna invading a newly flooded embayment in the Gulf of California without very great selective population pressures. The second possibility is that selective pressures do exist and are caused by the entrapment of relic temperate species, forcing them to adapt to warming and sometimes superhaline waters. Their analogous contemporary species on the open Pacific coast tend to continue their northward migration unimpeded into preferred cooler and sometimes brackish-waters to intermix with lagging northern forms without severe selective pressures to change the character of the fauna. These two possibilities can be better considered after the lagoonal ostracode faunas of the southern Pacific side of Baja California and the eulittoral marine faunas of the northern end of the Gulf of California have been studied.

LOCAL DISTRIBUTION AND ABUNDANCE

The local distribution and abundance of ostracodes in the Estero de Tastiota and those found in Laguna La Cruz are shown in Figure 3. Because of differences in the importance of certain environmental factors, the study area is divided into four recognizable biotopes: open-gulf biotope, lower-lagoon biotope, upper-lagoon biotope, and tidal-flat biotope (Fig. 4).

The **open-gulf biotope** (stations 107 and 108) is characterized by normal marine salinity (36‰) with annual variations of only 0.5‰. Tidal flushing of the estero has built an effluent tidal delta far into the Gulf providing a coarse sand substrate. All species found in the study area are represented in the open gulf, but only two, *Pellucistoma scrippsi* and *Puriana pacifica,* are abundant. *Pellucistoma scrippsi* is rare in other environments and is a good indicator of the open-gulf biotope. *Puriana pacifica* is also abundant in the upper-lagoon biotope. *Aurila conradi californica,* although not abundant in the open gulf, is ab-

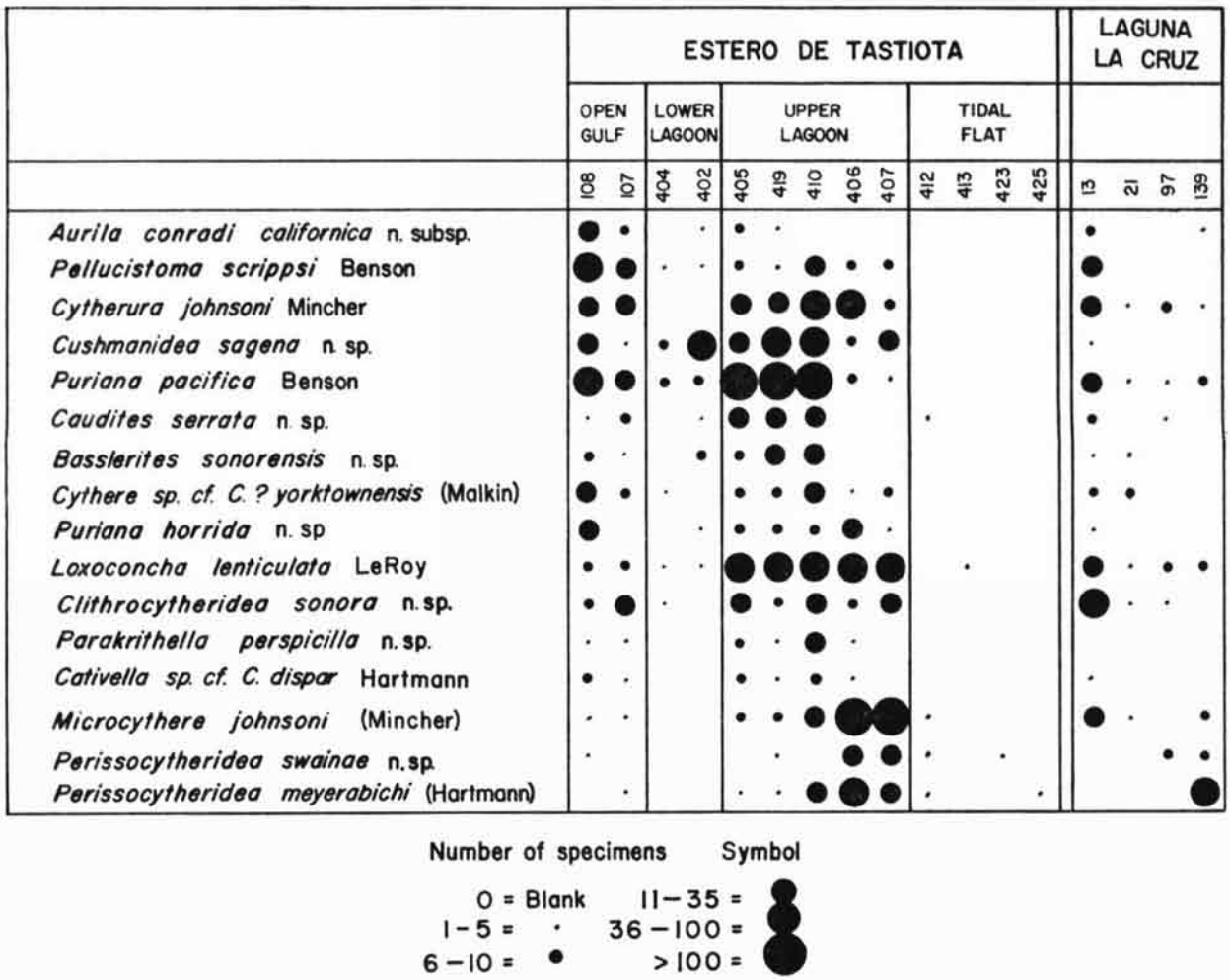

FIG. 3. Faunal distribution chart showing relative number of specimens of each species collected from the various biotopes in the Estero de Tastiota and from Laguna La Cruz. Numbers indicate stations at which samples were collected.

sent or rare in all other environments and is the best indicator of this biotope.

The **lower-lagoon biotope** (stations 402 and 404) includes a 6-foot channel near the mouth of the estero with a coarse sand substrate and an adjoining tidal flat with a coarse, shell-fragment, sand substrate exposed during low tide. A characteristic feature of the lower lagoon is the paucity of its ostracode fauna. Strong currents and wave action in the channel and alternate wetting and drying on the tidal flat are apparently not conducive to the development of a successful population of small, calcareous marine organisms. Twelve species were found in this environment. Two species were represented by sizeable populations: *Cushmanidea sagena*, found most abundantly on the tidal flat, and *Cytherura johnsoni*, restricted to the channel. *Cushmanidea sagena* and possibly *Loxoconcha lenticulata* are indigenous to the lower-lagoon, tidal-flat environment, although only a few specimens of the latter were found.

The **upper-lagoon biotope** is represented at more sampling stations than either the open-gulf or the lower-lagoon biotopes, and it is somewhat more complex. The upper lagoon is characterized by tidal channels. Station 407 lies between two channels and presumably represents a thanatocoenosis containing forms from nearby channels. The predominant sediment type of the substrate is fine to medium sand; the salinity may reach nearly 40‰; and midsummer temperatures range from 29°C to 34°C.

All of the species found in the upper lagoon are also found elsewhere, but most of them were represented in samples from this biotype by only a few specimens. Species characteristic of the upper lagoon

are *Loxoconcha lenticulata, Megacythere johnsoni, Perissocytheridea meyerabichi,* and *P. swaini*. Species found throughout both lagoonal environments are *Cushmanidea sagena* and *Cytherura johnsoni*. *Puriana pacifica* is found abundantly in the open gulf and the upper lagoon but is not present in the lower lagoon. The best indicator species of this biotope is *Loxoconcha lenticulata*. Although *Perissocytheridea meyerabichi* and *P. swaini* are also abundant and found exclusively in this biotype, they are not as widely distributed.

Two subdivisions separated by a distinct faunal break are present within the upper lagoon, but the reason for their separation is not understood. Fewer species are represented in the northern division (stations 406 and 407), which is characterized by the presence of *Megacythere johnsoni, Perissocytheridea swaini,* and *P. meyerabichi*. *Loxoconcha lenticulata* is abundant throughout the upper lagoon. BENSON (1959, p. 33) reported *Loxoconcha lenticulata* associated with spongy plants in the main channel, marsh channels, and salt water lagoon of the Estero de Punta Banda, which is environmentally similar to the Estero de Tastiota. Unfortunately, no floral information is available for the Estero de Tastiota.

The **tidal-flat biotope** has a very small ostracode population. Species from the northern division of the upper lagoon are present on that part of the tidal flat closest to the upper lagoon, but more distant parts of the tidal flat are barren. The environment on the tidal flat is a harsh one. The salinity (40‰ to 48‰) is higher than in the upper lagoon.

Representatives of all species found in Laguna La Cruz were also found in the Estero de Tastiota. Except for the absence of *Parakrithella perspicilla* in Laguna La Cruz, the faunas are identical. The small number of samples and the small ostracode population in Laguna La Cruz make it impractical to delineate any biotopes.

Ostracodes were not found in 15 of the 26 localities sampled in the various parts of the study area. These localities included stations 398-401, 409, 411, 414, 415, 417, 420, 421, 428-430, and 434 shown in Figs. 3 and 4. Most of these sterile localities occurred in areas covered by coarse sand or on the exposed tidal flats.

CONCLUSIONS

The Ostracoda of the Estero de Tastiota, Sonora, Mexico, were studied to determine their usefulness as biotope indicators in an environment ranging from normal marine to slightly hypersaline.

From 31 stations samples were collected containing 2719 ostracode specimens representing 16 species of 14 genera.

Conclusions on the distribution and ecology of the Ostracoda are:

1. Four biotopes determined primarily by differences in salinity, currents, and exposure to the atmosphere were recognized; these differences correlated very closely with the physiography within the estero. The biotopes represented included those of open gulf, lower lagoon, upper lagoon, and tidal flat.

2. Nine species were sufficiently restricted ecologically to be used as biotope indicators:

Open-gulf: *Aurila conradi californica*
Pellucistoma scrippsi
Open-gulf and upper-lagoon: *Puriana pacifica*
Upper-lagoon: *Loxoconcha lenticulata*
Total lagoon: *Cushmanidea sagena*
Cytherura johnsoni
Upper-lagoon and tidal-flat: *Megacythere johnsoni*
Perissocytheridea meyerabichi
Perissocytheridea swaini

3. Species from two biogeographic realms and a transition zone were recognized in the Estero de Tastiota: the Central-American Pacific realm (Panamanian), the Gulf realm (Gulf of Mexico), and the Californian ecotone.

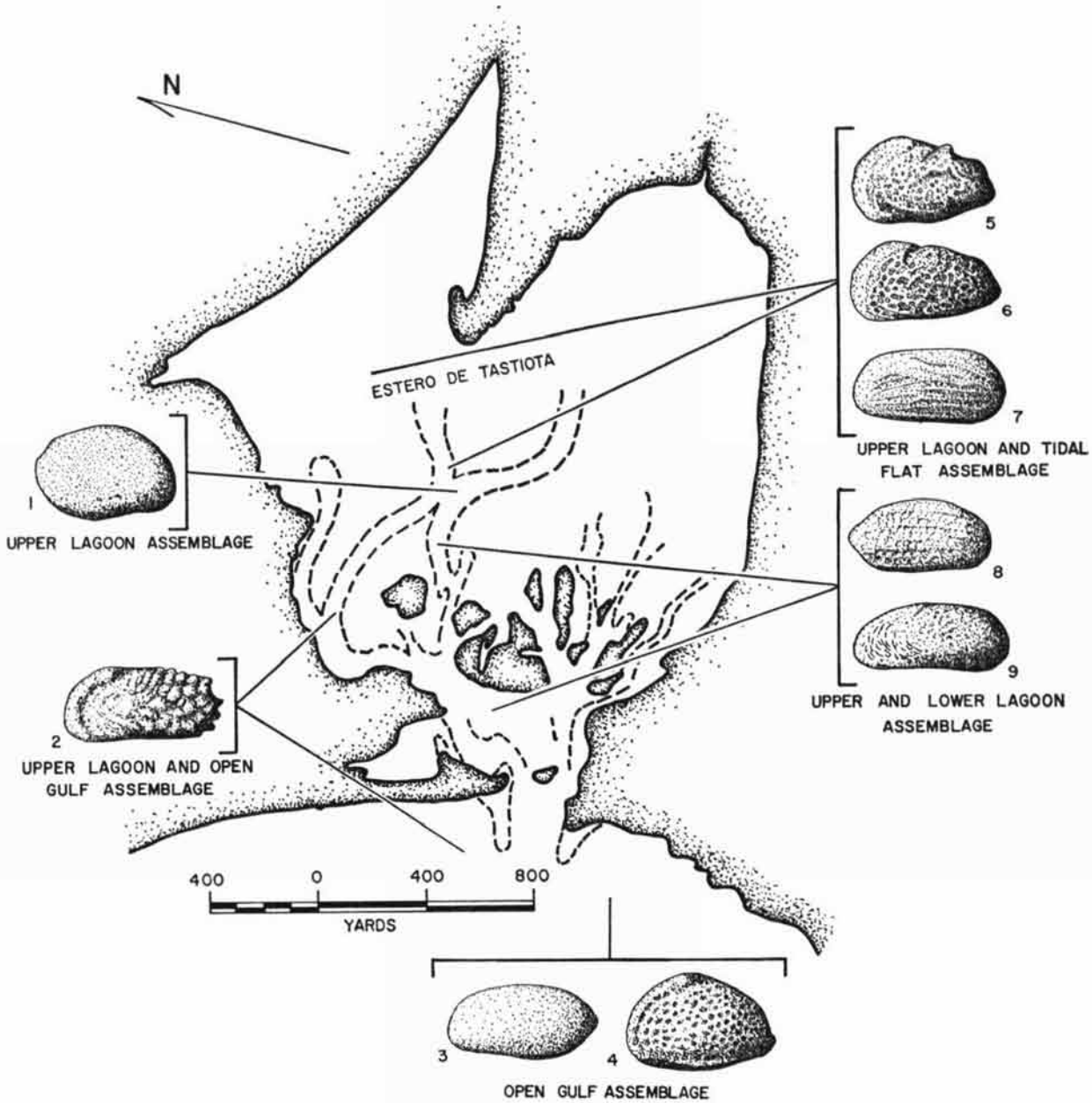

FIG. 4. Diagrammatic illustration of the distribution of characteristic ostracodes in the Estero de Tastiota.

1. *Loxoconcha lenticulata* LEROY.
2. *Puriana pacifica* BENSON.
3. *Pelucistoma scrippsi* BENSON.
4. *Aurila conradi californica* BENSON & KAESLER.
5. *Perissocytheridea swaini* BENSON & KAESLER.
6. *P. meyerabichi* (HARTMANN).
7. *Megacythere johnsoni* (MINCHER).
8. *Cytherura johnsoni* MINCHER.
9. *Cushmanidea sagena* BENSON & KAESLER.

SYSTEMATIC PALEONTOLOGY

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Sars, 1866
Superfamily CYTHERACEA Baird, 1850
Family CYTHERIDAE Baird, 1850
Genus CYTHERE O. F. Müller, 1785

Cythere O. F. MÜLLER, 1785, p. 65; BLAKE, 1931, p. 160; AUCTT.: SYLVESTER-BRADLEY, 1941, p. 1-33; HANAI, 1959b, p. 409-412; HOWE, 1961, p. Q257.

Cytherina LAMARCK, 1818, p. 125.

Cyclas EICHWALD, 1857 (*non* LAMARCK, 1798).

Type-species. Cythere lutea O. F. MÜLLER, 1785, p. 65, pl. 7, figs. 3, 4 [subsequent designation, BRADY & NORMAN, 1889].

Diagnosis. Recognized by its heavy rhomboidal carapace ornamented with punctae and sieve-like normal-pore canals; oval shape in dorsal view; right valve overlapping left valve dorsally and left valve overlapping right valve ventrally. Hinge antimerodont with slight accommodation groove over median bar of left valve; right valve hinge with crenulate median groove extending dorsally past the crenulate terminal teeth. Marginal areas broad with no vestibule or only a trace of one; radial-pore canals few, sometimes slightly bent. *Mio.-Rec.*

Remarks. The genus *Cythere* is comprised of a very few species similar to *C. lutea* plus a number of forms which remain to be classified into a more modern classification than existed when BRADY assigned most of his ornamented marine species to *Cythere.*

Occurrence. Cythere lutea, the type-species (which is the most common species of *Cythere senso stricto*), is a phytal form living primarily in shallow, inner-neritic waters in and among algae (ELOFSON, 1941). Its shape is typical of that of many algae-inhabiting ostracodes, which are generally smooth and disc-shaped. These forms have large antennae with strong dorsal claws.

Species of *Cythere* are generally cold-water forms and have been described from Japan, Alaska, Labrador, Greenland, Iceland, and Northern Europe. *Cythere lutea* is a low arctic-boreal species found only north of Cape Cod on the Atlantic Coast and north of Vancouver, British Columbia, on the Pacific Coast. However, other species of *Cythere* may occur southward; a form described as *?Cythere lutea* lives in the Black Sea-Caspian Sea area.

The only possible warm-water species known is *Cythere? yorktownensis* (MALKIN) which has been reported from the Upper Miocene Yorktown Formation of Virginia from sandy shell-marls containing abundant water-worn shell fragments (MALKIN, 1953, p. 780). In the Estero de Tastiota it is present in similar sediments from the neritic zone.

Cythere is known from Pliocene to Recent in Japan and from Miocene to Recent in North America, but it has been found only in Recent sediments in Europe.

CYTHERE? sp. cf. C.? YORKTOWNENSIS (Malkin), 1953

Pl. 2, Figs. 5, 6; Fig. 5

Eocytheropteron yorktownensis MALKIN, 1953, p. 780, pl. 79, figs. 1-4.

Diagnosis. Distinguished by its small size, very inflated carapace, and smoothly curved marginal outlines. Hinge compound antimerodont with elongate denticulate terminal elements formed by continuation of selvage; median element consisting of three steps

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EXPLANATION OF PLATE 1

PURIANA, CAUDITES, AURILA

(All illustrated forms are from the Estero de Tastiota region)

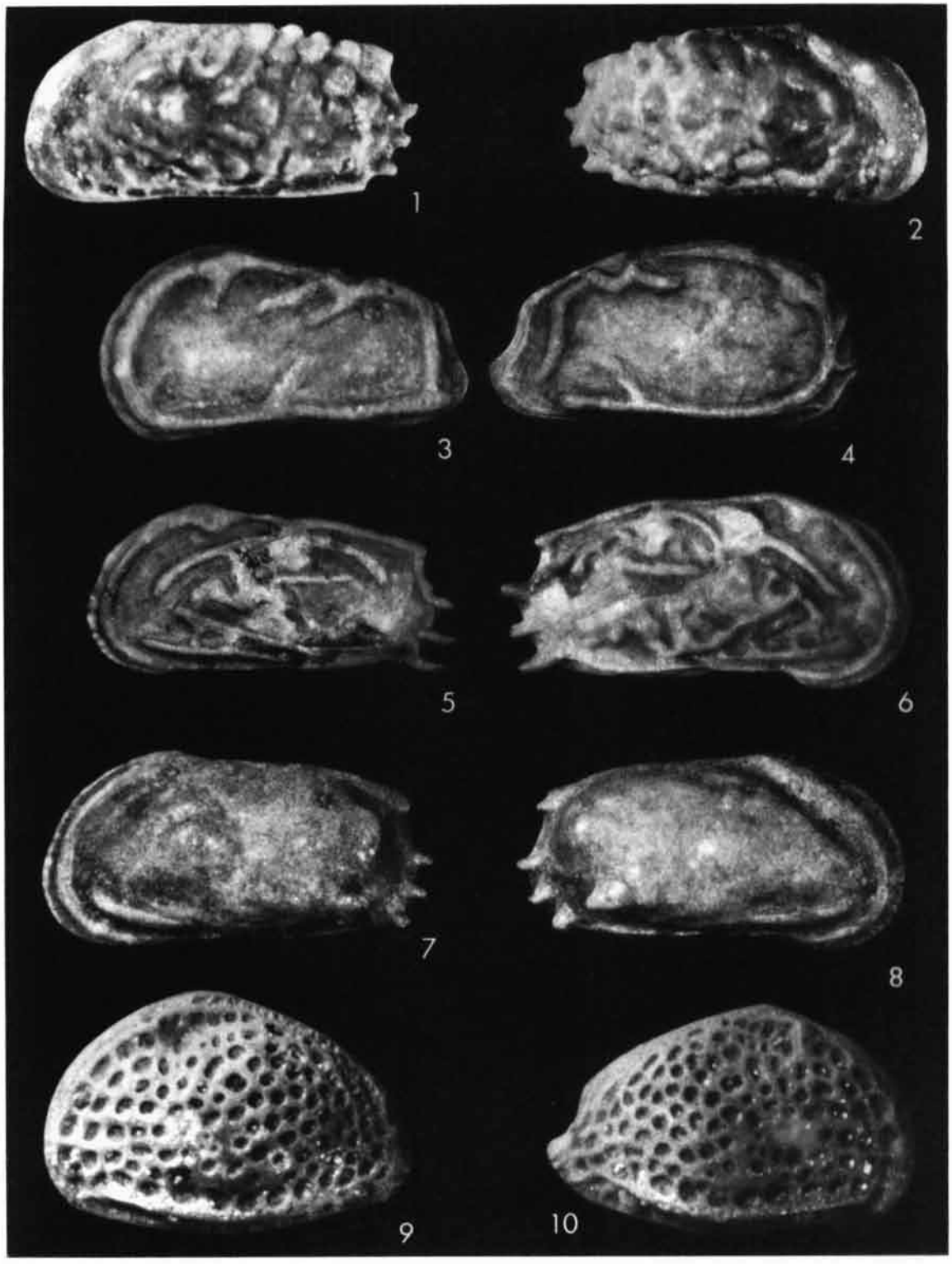
FIGURE — PAGE

1-2.—Puriana pacifica BENSON, 1959; *1,* exterior lateral view of left valve; *2,* exterior lateral view of right valve; ×90 30

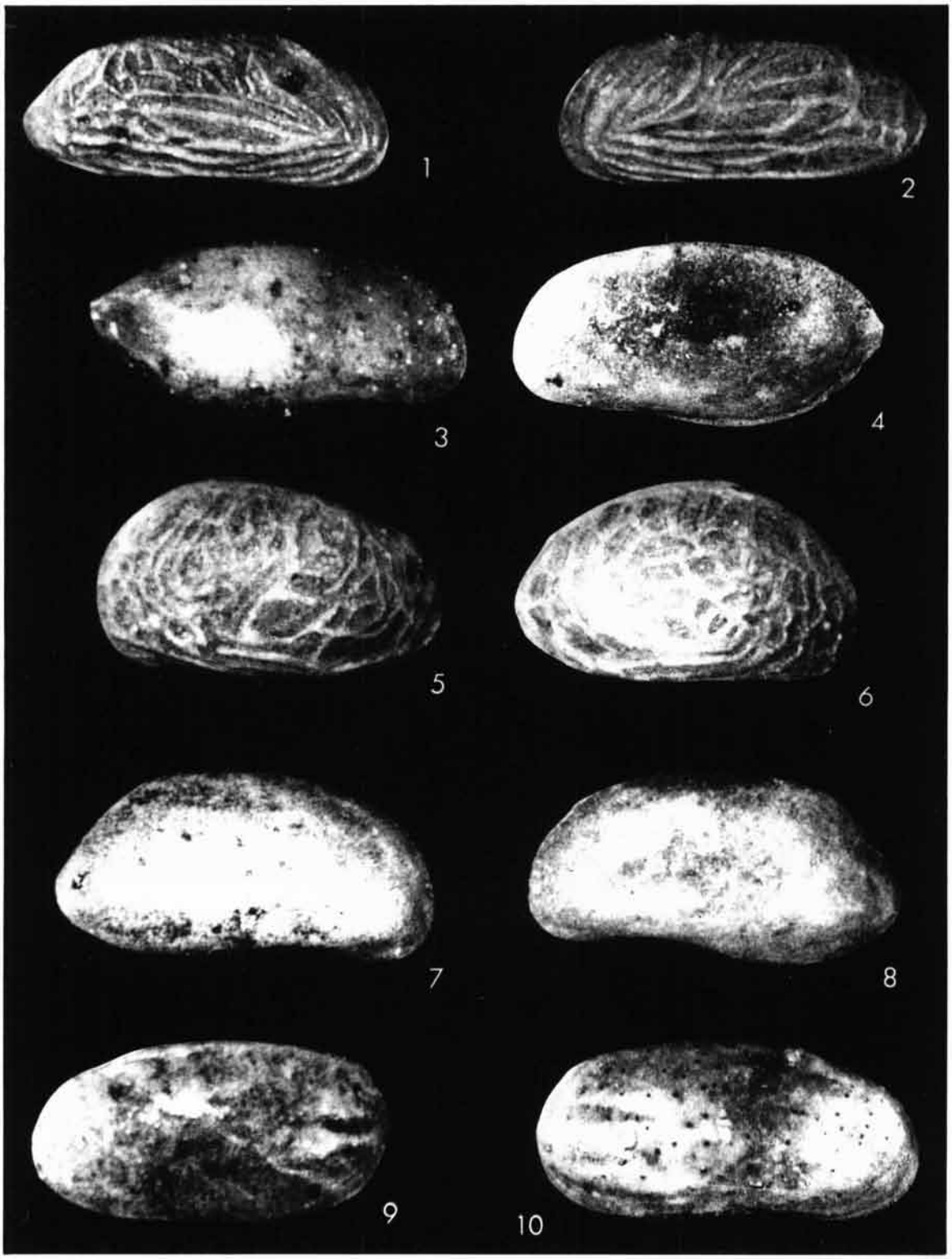
3-4.—Caudites serrata BENSON & KAESLER, n.sp.; *3,* exterior lateral view of left valve, ×120; *4,* exterior lateral view of right valve; ×130 24

5-8.—Puriana horrida BENSON & KAESLER, n.sp.; *5,* exterior lateral view of left valve, ×120; *6,* exterior lateral view of right valve, ×130; *7,* exterior lateral view of left valve of late instar, ×135; *8,* exterior lateral view of right valve of late instar, ×135 30

9-10.—Aurila conradi (HOWE & MCGUIRT) *californica* BENSON & KAESLER, n.subsp.; *9,* exterior lateral view of left valve; *10,* exterior lateral view of right valve; ×95 23



BENSON & KAESLER — Recent Marine Ostracodes, Sonora, Mexico



BENSON & KAESLER — Recent Marine Ostracodes, Sonora, Mexico

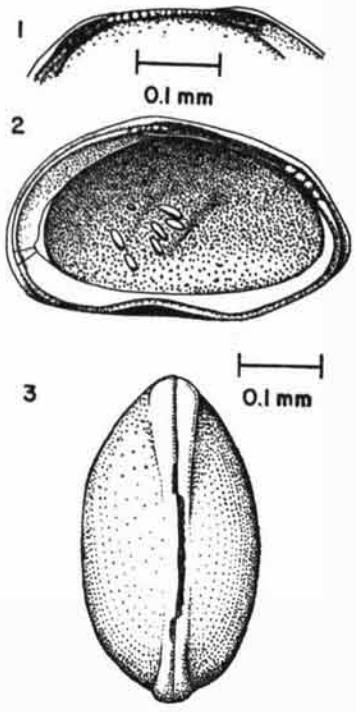


FIG. 5. *Cythere?* sp. cf. *C.? yorktownensis* (MALKIN), 1953.—*1*. Hinge of left valve.—2. Interior of right valve.—*3*. Dorsal view.

including overhanging flange, very thin crenulate connection between terminal teeth, and lower crenulate step joining the proximal ends of the list. Median element of left valve hinge denticulate where it joins the terminal element, smooth or finely crenulate medially. *?Mio.-Rec.*

Dimensions. Length of mature adult 0.33 mm; height 0.20 mm; width 0.19 mm. Length of Miocene species (MALKIN, 1953, p. 778) 0.39-0.46 mm; height 0.20-0.26 mm.

Material. Nearly all of the 61 specimens examined had both valves intact.

Remarks. Although this species was originally described by MALKIN as *Eocytheropteron yorktownensis,* it seems to be more closely related to *Cythere.* As originally described by ALEXANDER (1933, p. 195, 196), *Eocytheropteron* has an arched dorsal margin, a sharply upturned caudal process, and a modified antimerodont hinge in which the median element consists of a series of teeth rather than a crenulate bar. This species has a compound antimerodont hinge, but its left valve median element is a distinctly crenulate bar.

In his discussion of *Cythere* and related genera, HANAI (1959b, p. 409) lists three familial characteristics that further support the designation of this species as the genus *Cythere:*

(1) merodont hinge with crenulate anterior and posterior teeth;

(2) overlap of the right valve dorsal margin over the left valve with a furrow between the flange and the terminal teeth;

(3) lack of strong alae.

The inflated venter of this species is strongly suggestive of *Eocytheropteron,* however; and it is possible that this form is transitional between *Eocytheropteron* and *Cythere.*

Occurrence. Cythere? sp. cf. *C.? yorktownensis* (MALKIN) was found in the open-gulf and the upper-lagoon environments; in the former, in very coarse-grained sand with much fragmental shell material. No specimens were found on the tidal flats, and few were found in the lower lagoon. This species is apparently adapted to normal marine and slightly hypersaline environments, and its small, sturdy carapace enables it to withstand the impact of shifting sand.

EXPLANATION OF PLATE 2

CLITHROCYTHERIDEA, PELLUCISTOMA, CYTHERE?, PARAKRITHELLA, BASSLERITES

(All illustrated forms are from the Estero de Tastiota region)

FIGURE PAGE

1-2.—Clithrocytheridea sonora BENSON & KAESLER, n. sp.; *1,* exterior lateral view of right valve; *2,* exterior lateral view of left valve; ×120 16

3-4.—Pellucistoma scrippsi BENSON, 1959; *3,* exterior lateral view of right valve; *4,* exterior lateral view of left valve; ×120 28

5-6.—Cythere? sp. cf. *C.? yorktownensis* (MALKIN), 1953; *5,* exterior lateral view of left valve; *6,* exterior lateral view of right valve; ×170 14

7-8.—Parakrithella perspicilla BENSON & KAESLER, n. sp.; *7,* exterior lateral view of right valve; *8,* exterior lateral view of left valve; ×110 20

9-10.—Basslerites sonorensis BENSON & KAESLER, n.sp.; *9,* exterior lateral view of left valve; *10,* exterior lateral view of right valve; ×100 25

Family CYTHERIDEIDAE Sars, 1925

Subfamily CLITHROCYTHERIDEINAE Kollmann, 1958

Genus CLITHROCYTHERIDEA Stephenson, 1936

Cytheridea Bosquet *(partim)*, 1852, p. 37.

Cytheridea (Clithrocytheridea) Stephenson, 1936, p. 702; van den Bold, 1946, p. 24; Swain, 1951, p. 23.

Clithrocytheridea Stephenson, 1944, p. 449, 450; Malkin, 1953, p. 782; Keij, 1957, p. 57; Howe, 1961, p. Q275, Q276.

Type-species. Cytheridea? garretti Howe & Chambers, 1935, p. 14, pl. 1, figs. 4, 5; pl. 2, figs. 11, 12; pl. 6, figs. 10, 11.

Diagnosis. Distinguished by its elongate, sometimes subrectangular carapace with posterior obliquely rounded or downturned and obliquely truncate. Surface commonly with numerous ridges and reticulations. Hinge antimerodont with right valve having distinctly denticulate terminal elements and crenulate median groove; left valve with undulatory terminal sockets separated by finely crenulate median bar. Marginal area broad with numerous radial-pore canals. *L.Cret.-Rec.*

Remarks. Species included in the genus *Clithrocytheridea* exhibit a wide variety of forms with few features in common except an antimerodont hinge and a tendency toward subrectangular shape. Its relationship to other antimerodont hinge-bearing groups, such as *Perissocytheridea,* is not readily apparent. Furthermore, its relation to common antimerodont genera of the Jurassic seems remote. It has often been classified with holomerodont forms, although it is not yet known how the change from positive to a negative median element takes place. A complete understanding of the phylogeny and classification of *Clithrocytheridea* awaits study of morphologic features in addition to the hinge.

Occurrence. The genus *Clithrocytheridea* is very poorly understood ecologically. Neither Swain (1955) nor Benson (1959) reports having found living species belonging to it. Pooser (1962, personal communication) found species of *Clithrocytheridea* in inner-neritic sediment from the Miocene of South Carolina. Species of this genus seem to favor normal marine to slightly hypersaline waters.

CLITHROCYTHERIDEA SONORA Benson & Kaesler, n.sp.

Pl. 2, Figs. 1, 2; Fig. 6

Diagnosis. Distinguished by its elongate shape, subparallel, longitudinal, rib-like ornamentation, and sulcus extending from the dorsal margin to the median line. *Rec.*

Description. Carapace elongate, slender, moderate in size, strongly constructed; elongate with parallel sides in dorsal view; elongate, slightly reniform in lateral view; greatest height at anterior cardinal angle. Dorsal margin long, straight, sloping toward posterior; ventral margin sinuate. Anterior end drawn out, obliquely rounded; posterior end caudate. Valves equal in size. Surface with granulose texture, few normal-pore canals; ornamented with subparallel, longitudinal, bifurcating ribs, and with faint, smooth sulcus extending from dorsal margin to medial line.

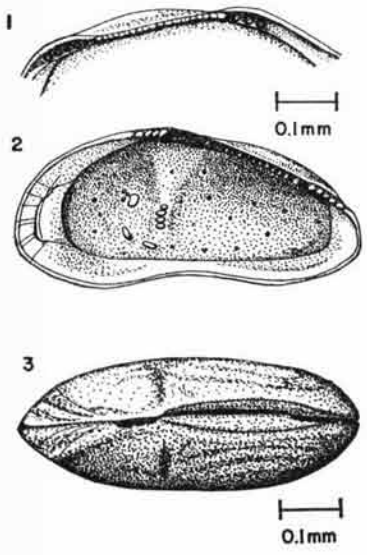


Fig. 6. *Clithrocytheridea sonora* Benson & Kaesler, n. sp. —*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Hinge antimerodont with right valve bearing coarsely crenulate terminal teeth separated by crenulate median groove; left valve with coarsely crenulate terminal grooves separated by finely crenulate median bar. Marginal area broad; radial-pore canals straight, few in number, found only in anterior portion of carapace; line of concrescence coincides with inner margin except at deep and abrupt anterior vestibule. Selvage of left valve overlaps that of right valve. Muscle-scar pattern consists of vertical row of four adductor scars situated in shallow pit that does not show on external surface, two oblique mandibular scars, and antennal muscle scar that may be subdivided.

Dimensions. Length of holotype 0.50 mm; height 0.22 mm; width 0.20 mm.

Material. Specimens examined 107; about half had both valves intact. Types reposited in the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology: holotype number RLK 414621; paratypes RLK 414628.

Occurrence. *Clithrocytheridea sonora* is found in the marine environment of the open gulf (station 107), but it is more common in the slightly hypersaline environment of the upper lagoon (stations 407 and 410). No specimens were observed from the tidal flat and very few have been fund in the lower lagoon. This species seems to be limited to marine and slightly hypersaline conditions, apparently where the current is minimal; but it is not able to survive under the conditions that prevail on the tidal flat—more extreme hypersalinity, high temperature, and alternate submersion and exposure to the atmosphere.

Genus PERISSOCYTHERIDEA Stephenson, 1938

Perissocytheridea STEPHENSON, 1938, p. 144; EDWARDS, 1944, p. 511; SWAIN, 1955, p. 618; HOWE, 1961, p. Q280, Q281.

Iliocythere HARTMANN, 1953, p. 310; ———, 1957, p. 141, 142.

Ilyocythere Klie, HARTMANN, 1953, p. 310-316.

Type-species. Cytheridea? matsoni STEPHENSON, 1935, p. 192, 193, pl. 5, figs. 1, 2, 7, 8.

Diagnosis. Recognized by its smooth to reticulate, tumid, subpyriform carapace. Hinge antimerodont, similar to that of *Clithrocytheridea.* Marginal area fairly narrow, with anterior vestibules. Strong sexual dimorphism. *Mio.-Rec.*

Remarks. Perissocytheridea is considered by HOWE (1961, p. Q280) to have a pitted or reticulate surface, but he suggests that the group of smooth *Perissocytheridea. Ilyocythere* cannot be diagnosed from KLIE's be considered as a synonymous variant of *Perissocytheridea. lyocythere* cannot be diagnosed from KLIE's (1939) description of the carapace. HARTMANN (1933, 1957a,b) has described four species which he assigned to *Ilyocythere* (misspelled *Iliocythere*), of which at least two, possibly three, forms have pitted or reticulate surfaces. After examination of the type-specimens, he considers the characteristics of the appendages, the shape of the carapace, and the hinge of these forms to be congeneric with the type-species of *Ilyocythere.* No mention is made by HARTMANN of the relationship of *Ilyocythere* to *Perissocytheridea;* KLIE (1939, p. 365) compared *Ilyocythere* with *Leptocythere,* but this latter genus is now thought to be rather far removed from *Ilyocythere.* Without having studied the types of *Ilyocythere,* and from the evidence presented thus fai, we judge that the ornamented species of HARTMANN belong to *Perissocytheridea,* and that the smooth forms originally assigned to *Ilyocythere* by KLIE be retained in that genus until they have been redescribed and compared with the type-species of *Perissocytheridea.* Future workers may wish to combine these forms or to maintain them separately in the same subfamily.

Occurrence. Brackish-water (euryhaline) species now assigned to *Perissocytheridea* have been reported from Curaçao by KLIE (1939) and from mangrove swamps in Brazil and El Salvador by HARTMANN (1953). SWAIN (1955) reported several species from San Antonio Bay, Texas, in brackish-water lagoonal sediments and a few specimens from normal marine waters. BENSON & COLEMAN (1963) described a new species from the eulittoral shelf of the eastern Gulf of Mexico. Species of this genus generally seem to have a wide salinity tolerance and may be found in brackish, normal marine, and hypersaline environments.

PERISSOCYTHERIDEA MEYERABICHI (Hartmann, 1953) Benson & Kaesler, 1962, (n. comb., nom. correct.)

Pl. 4, figs. 1-5, Fig. 7

Ilyocythere meyer-abichi HARTMANN, 1953, p. 310-314, figs. 1-10 (n. imperf.); ———, 1957, p. 141.

Diagnosis. Distinguished by its reticulate surface with an arched row of reticulations extending from middle of each valve toward caudal process; smooth areas next to the anterior and posterior margins. *Rec.*

Description. Carapace subrectangular, large strong; outline oval in dorsal view, subrectangular in lateral view, males with inflated posterodorsum. Greatest

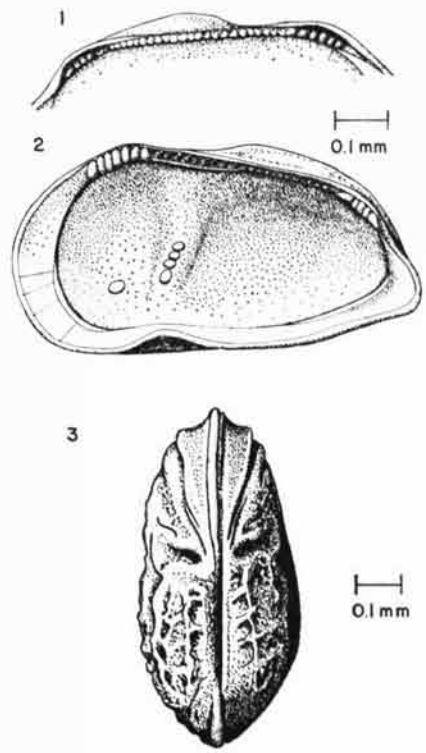


FIG. 7. *Perissocytheridea meyerabichi* (HARTMANN), 1953. —*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

height at anterior cardinal angle, greatest width medial. In lateral view dorsal margin long, straight; ventral margin convex in overall aspect but slightly sinuate in anterior half. Anterior end obliquely drawn out in males. Left valve overlaps right valve. Surface reticulate except on smooth anterior and posterior ends; reticulations aligned roughly parallel to medial line, dorsally arched in posterior half; eye tubercle indistinct or absent.

Hinge elongate, typical antimerodont; marginal area of moderate width; radial-pore canals few, obscured; vestibule very narrow, absent ventrally; selvage coincides with flange on most of margin. Adductor muscle-scar pattern vertical row of four, mandibular scars obscured.

Material. Ninety-one specimens were examined, of which very few were intact.

Dimensions. Length of adult male 0.66 mm; height 0.34 mm; width 0.28 mm.

Remarks. Perissocytheridea meyerabichi differs from the type-species *(P. matsoni)* by having larger, more regularly arranged reticulations. The pits of the reticulate surface of *P. brachyforma* SWAIN (1955, p. 622) are arranged in longitudinal rows and are not arched or emphasized as they are in *P. meyerabichi.* The males of *P. meyerabichi* have a sulcus just anterior to the swollen posterior region that is emphasized in the reticulate surface. *P. rugata* SWAIN (1955, p. 622) is more strongly reticulate than *P. meyerabichi,* which is more reticulate than *P. bicelliforma* SWAIN (*partim,* 1955, p. 621).

Perissocytheridea meyerabichi is herein transferred from *Ilyocythere* KLIE to *Perissocytheridea* because of its reticulate surface which is characteristic of the latter genus. *Ilyocythere (senso stricto)* has many traits in common with *Perissocytheridea* (such as hinge and general shape) and may be synonymous with it, as suggested by HOWE (1961, p. Q280) and BENSON & COLEMAN (1963, p. 29). The carapace of the types of both forms should be compared before they are considered one genus.

Occurrence. Perissocytheridea meyerabichi is abundant only in the upper-lagoon biotype (stations 406, 407, 410). It is present on the tidal flat but is poorly represented in the open gulf. It was originally described by HARTMANN (1953) from the mangrove and eulittoral areas of the Pacific coast of El Salvador. It flourishes best in polyhaline waters.

PERISSOCYTHERIDEA SWAINI Benson & Kaesler, n.sp.

Pl. 3, Figs. 9, 10; Fig. 8

Perissocytheridea bicelliforma SWAIN *(partim),* 1955, p. 621, pl. 3, figs. 3a,b; pl. 64, fig. 4.

Diagnosis. Distinguished by its triangular shape and lack of pronounced dimorphism; surface finely reticulate in random pattern accentuated with two large, pointed nodes on the posterior. *Rec.*

Description. Carapace subtriangular, inflated, of moderate size and strength. Ovate and inflated in dorsal view; subtriangular in lateral view without marginal spines, with distinct posterior cardinal angle. Greatest height at anterior cardinal angle; greatest width at posteroventral nodes. Dorsal margin straight, long, with well-defined cardinal angles; ventral margin convex with slight sinuation as seen from interior. Anterior end broadly rounded; posterior end obliquely truncate, sloping, with short, blunt posteroventral point. Left valve slightly overlaps right valve. Surface of carapace finely reticulate to punctate in random pattern except in smooth anterodorsal portion; two nodes located on the posterior half of carapace, one just posterior to central dorsal region and one pos-

EXPLANATION OF PLATE 3

CUSHMANIDEA, MEGACYTHERE, CATIVELLA, CYTHERURA, PERISSOCYTHERIDEA

(All illustrated forms are from the Estero de Tastiota region)

FIGURE — PAGE

1-2.—Cushmanidea sagena BENSON & KAESLER, n.sp.; *1,* exterior lateral view of right valve; *2,* exterior lateral view of left valve; ×105 21

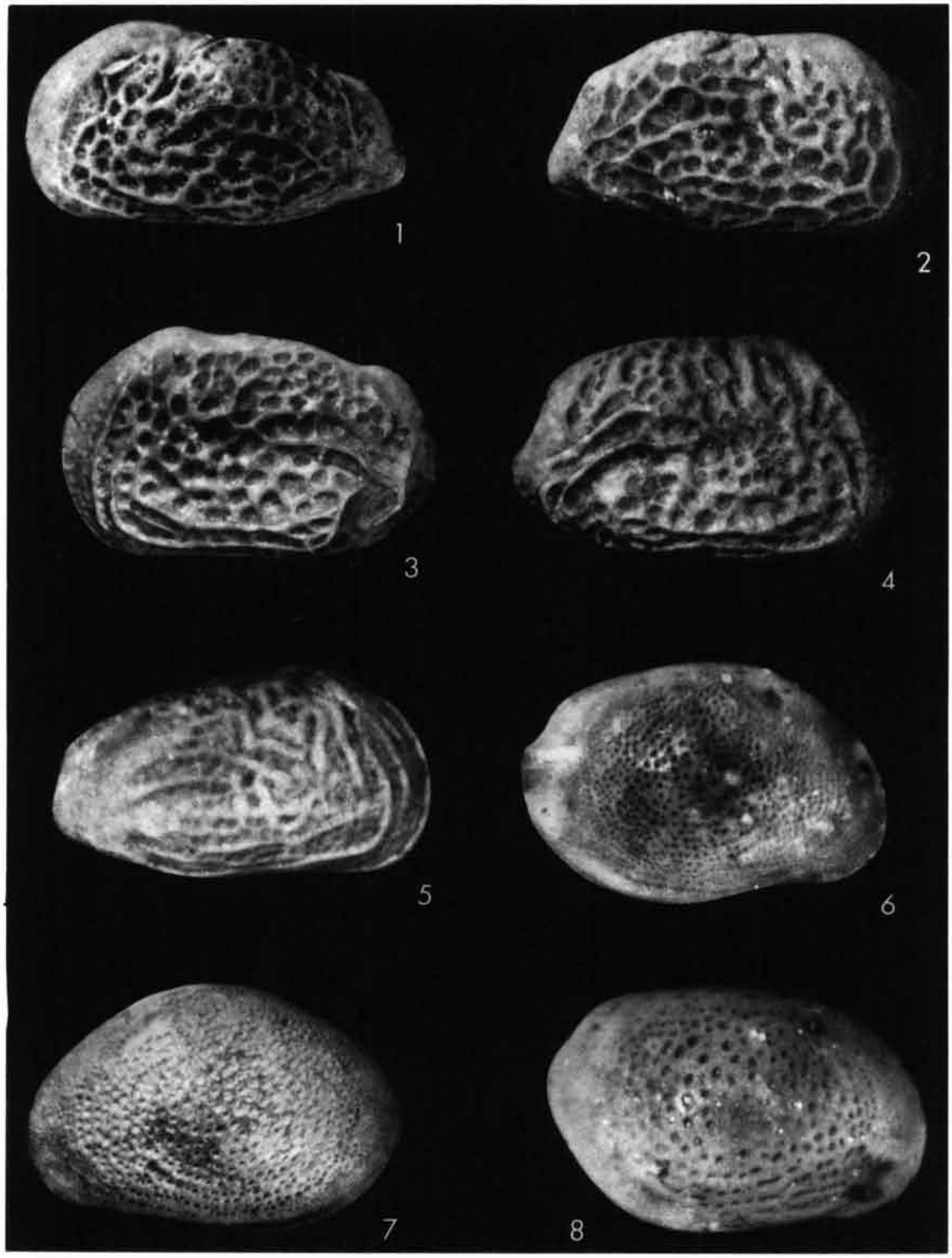
3-4.—Megacythere johnsoni (MINCHER), 1941; *3,* exterior lateral view of right valve; *4,* exterior lateral view of left valve; ×120 28

5-6.—Cativella sp. cf. *C. dispar* HARTMANN, 1959; *5,* exterior lateral view of left valve; *6,* exterior lateral view of right valve; ×120 29

7-8.—Cytherura johnsoni MINCHER, 1941; *7,* exterior lateral view of left valve; *8,* exterior lateral view of right valve; ×130 22

9-10.—Perissocytheridea swaini BENSON & KAESLER, n. sp.; *9,* exterior lateral view of left valve; *10,* exterior lateral view of right valve; ×120 18

BENSON & KAESLER — Recent Marine Ostracodes, Sonora, Mexico



BENSON & KAESLER — Recent Marine Ostracodes, Sonora, Mexico

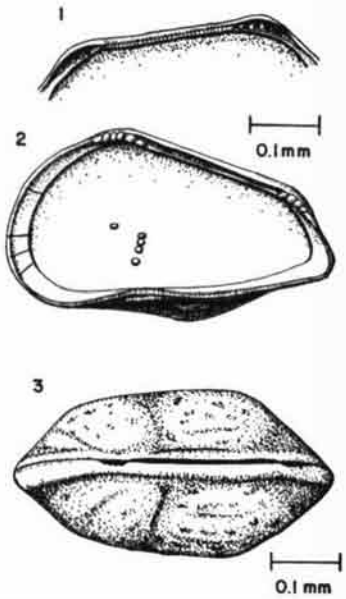


FIG. 8. *Perissocytheridea swaini* BENSON & KAESLER, n. sp. —*1*. Hinge of left valve.—*2*. Interior of right valve.—*3*. Dorsal view.

terior to central lateral region; eye tubercle subdued and merging with reticulate surface.

Hinge delicate, antimerodont; right valve with denticulate terminal teeth separated by finely crenulate median groove; left valve with coarsely crenulate terminal sockets separated by finely crenulate terminal bar. Duplicature narrow, without vestibules; radial-pore canals few and straight in anterior end and absent in posterior end; line of concrescence coincides with inner margin; selvage coincides with flange. Muscle-scar pattern consists of 4 adductor scars in a vertical row with one subcircular antennal scar above and anterior to these; mandibular scars obscured by surface ornamentation.

Dimensions. Length of holotype 0.51 mm; height 0.30 mm; width 0.30 mm.

Material. Fifty-three specimens were examined, most of which were not intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology; holotype RLK 414622; paratypes RLK 414629.

Remarks. SWAIN (1955, pl. 64) included some specimens that are conspecific with the presently described species in *Perissocytheridea bicelliforma,* suggesting that they were immature instars. However, *P. swaini* is ornamented with distinct nodes and is much more triangular than adults of *P. bicelliforma;* also *P. swaini* appears to have a mature antimerodont hinge. Because no specimens of *P. bicelliforma* were found in Estero de Tastiota, and because of the mature characteristics expressed in this form, which seem to establish its existence as a separate species, it is here named *P. swaini.*

Occurrence. Perissocytheridea swaini is abundant in the upper lagoon and is present on the tidal flats. It is associated most abundantly with *Megacythere johnsoni, Perissocytheridea meyerabichi,* and *Loxoconcha lenticulata.* The presence of *P. swaini* on the tidal flats in Estero de Tastiota and in brackish- to normal-marine water on the Gulf Coast (SWAIN, 1955) indicates that it is euryhaline and may be able to withstand exposure to high temperature and occasionally to the atmosphere.

Subfamily KRITHINAE Mandelstam, in Bubikan, 1958

Genus PARAKRITHELLA Hanai, 1959

Neocyprideis HANAI, 1959a, p. 299, 300 (*non* APOSTOLESCU, 1956).
Parakrithella Hanai, (*nom. subst.*) HOWE, 1961, p. Q289.
Type-species. Neocyprideis pseudadonta HANAI, 1959a, p. 300, pl. 17, figs. 5-9, text-figs. 2a,b.

Diagnosis. Recognized by its carapace similar to *Krithe* in lateral view, but with more obliquely rounded anterior; lenticular in dorsal view, but with more obliquely rounded anterior; lenticular in dorsal

EXPLANATION OF PLATE 4

PERISSOCYTHERIDEA, LOXOCONCHA

(All illustrated forms are from the Estero de Tastiota region)

FIGURE PAGE

1-5.—Perissocytheridea meyerabichi HARTMANN, 1953; *1,* exterior lateral view of left valve of male, ×95; *2,* exterior lateral view of right valve of male, ×95; *3,* exterior lateral view of left valve of female, ×125; *4,* exterior lateral view of right valve of female, ×125; *5,* exterior lateral view of right valve of late instar of male, ×124 17

6-8.—Loxoconcha lenticulata LEROY, 1943; *6,* exterior lateral view of right valve; *7,* exterior lateral view of left valve; *8,* exterior lateral view of right valve; ×100 26

view without incised posterior. Anterior vestibule irregular, abrupt, and deep with clustered radial-pore canals; posterior vestibule irregular and shallow. Muscle-scar pattern consists of a subvertical row of 4 adductor scars with one or two antennal scars in front these and two closely spaced mandibular scars obliquely below them. Hinge pseudadont, sometimes with crenulations in the posterior one-third. In the type-species the left valve has a groove, but in *Parakrithella perspicilla* the hinge is reversed and the right valve has the groove. *?Plio.-Pleist.-Rec.*

Occurrence. Reported by HANAI (1959a, p. 300) from Recent beach sands of Japan and from Plio-Pleistocene (?) marls of Okinawa. In the Estero de Tastiota, one species of this genus is found in normal marine and slightly supersaline waters. Only two species have been assigned to this genus, and they are too poorly known ecologically to permit any conclusions to be drawn about the environmental preference of the genus as a whole.

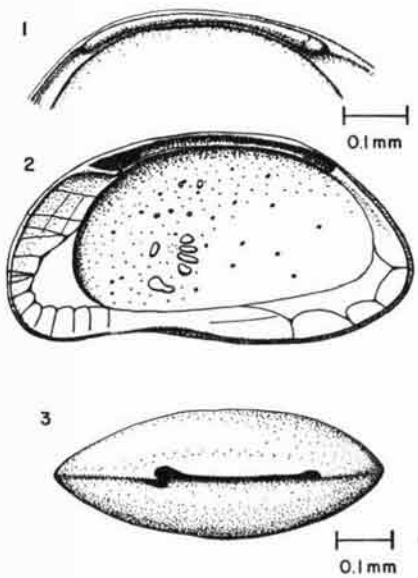


FIG. 9. *Parakrithella perspicilla* BENSON & KAESLER, n. sp. —*1*. Hinge of left valve.—*2*. Interior of right valve. —*3*. Dorsal view.

PARAKRITHELLA PERSPICILLA Benson & Kaesler, n.sp.
Pl. 2, Figs. 7, 8; Fig. 9

Diagnosis. Distinguished by its obliquely rounded anterior, less complex anterior vestibule, and less coarsely crenulate hinge that shows hinge reversal. *Rec.*

Description. Carapace delicate, elongate, and lenticular, medium in size; lenticular in dorsal view and slightly reniform in lateral view with downward posterior swing; greatest height and greatest width medial. In lateral view, dorsal margin gently, evenly arcuate, nearly parallel to venter, without distinct cardinal angles; ventral margin convex except for slight sinuation in anterior portion; anterior end smooth and obliquely rounded; posterior end smooth with downward swing. Left valve slightly overlaps right valve. Surface smooth with numerous normal-pore canals, particularly near central region of carapace.

Hinge pseudadont or reinforced adont with groove on right valve terminating posteriorly with slightly deeper socket and anteriorly with socket bordered ventrally by short socket-lock. Hinge of left valve consisting of very faintly crenulate to smooth bar, terminated posteriorly by a slightly raised, elongate tooth, and anteriorly by a very distinct, minute, rounded tooth. Marginal area broad except at ventral sinuation; about fifteen radial-pore canals located in the anterior, some of which group or tend to bifurcate; only about four to seven canals found in the posterior. Line of concrescence coincides with inner margin along the venter; scalloped in deep, abrupt anterior vestibule and in shallower, less abrupt posterior vestibule; selvage weakly formed. Muscle-scar pattern consisting of four adductor scars in one slightly curved vertical row, two fused mandibular scars, and one rounded antennal scar possibly accompanied by faint posterior one.

Remarks. This species differs from *Parakrithella pseudadonta* HANAI by its more downturned anterior end and reversed pseudadont hinge which is without the coarse crenulations on the posterior one-third, although it may have very fine crenulations.

Dimensions. Length of holotype 0.55 mm; height 0.29 mm; width 0.20 mm.

Material. A total of 27 specimens were examined; very few had both valves intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology. Holotype RLK 414626; paratype RLK 4146210.

Occurrence. Parakrithella perspicilla is limited in the Estero de Tastiota to open-gulf and upper-lagoon environments. It is apparently a normal marine species that is adapted for life in somewhat more hypersaline environments, although it is not suited to the adverse conditions that prevail on the tidal flat. Its presence in the channel (stations 419 and 405) suggests that it may thrive in strong tidal currents as well as in quiet water.

Subfamily NEOCYTHERIDEIDINAE Puri, 1957

Genus CUSHMANIDEA Blake, 1933

Cytherideis AUCTT. (*non* JONES, 1856, p. 157).

?Sacculus NEVIANI, 1928, p. 72.

Pontocythere DUBOWSKY, 1939, p. 29; OERTLI, 1956, p. 56; PURI & HULINGS, 1957, p. 174.

Hemicytherideis RUGGIERI, 1952, p. 60; KEIJ, 1957, p. 80.

Cushmanidea BLAKE, 1933, p. 233; PURI, 1958, p. 171, 181; HANAI, 1959, p. 292-297; HOWE, 1961, p. Q290.

Type-species. Cytheridea seminuda CUSHMAN, 1906, p. 374, pl. 33, figs. 62-64; pl. 34, figs. 76, 77.

Diagnosis. Recognized by carapace with very elongate anterior end; surface smooth or with reticulations tending to parallel margin. Hinge lophodont; right valve with elongate anterior tooth formed by enlargement of selvage, elongate median groove formed between selvage and overhanging flange, and short posterior tooth extending posteriorly into selvage. Distinguished from *Hulingsina* PURI by presence of elongate anterior end and by less pronounced downcurving and attenuation of posterior end. Differs from *Neocytherideis* by usually being larger, having stronger lophodont hinge and wider anterior. *Eoc.-Rec.*

Occurrence. KRUIT (1955, p. 484, 485) described two species of this genus (*C. turbida* and *C. retroflexa*) from marine sands of the Rhône delta. ELOFSON (1941) found *Cushmanidea elongata* (BRADY) in the littoral zone, in lagoons, and in the mouths of streams. It is a eurythermal and euryhaline species (WAGNER, 1957, p. 45) and is usually found on a sand substrate. Species of *Cushmanidea* have been found in polyhaline parts of Pamlico Sound, North Carolina. In general, species of *Cushmanidea* are euryhaline and may be found in sediment ranging from mud to coarse sand.

CUSHMANIDEA SAGENA Benson & Kaesler, n sp.

Pl. 3, Figs. 1,2; Fig. 10

Diagnosis. Distinguished by its very coarse reticulate pattern on the posterior half of the carapace becoming concentric with anterior margin. *Rec.*

Description. Carapace elongate, large, of moderate strength; wedge-shaped in dorsal view with inflated posterior; in lateral view elongate and slightly tapered toward anterior end, without marginal spines; nearly circular in end view; greatest height and width just anterior to middle; anterior end drawn out, tapered, and obliquely rounded; posterior end rounded, slightly turned down. Valves nearly equal in size, but left valve overlaps right valve. Carapace with moderate number of normal-pore canals not visible from exterior; ornamented with anterior and ventral ridges

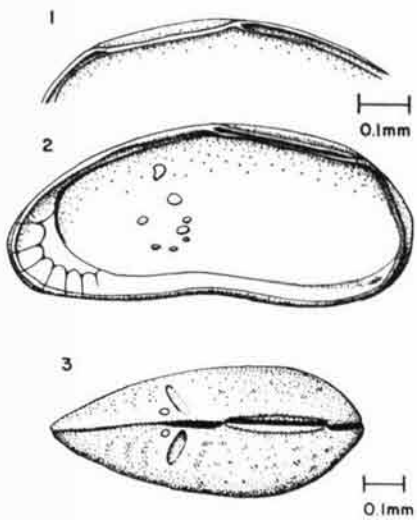


FIG. 10. *Cushmanidea sagena* BENSON & KAESLER, n. sp. —*1.* Hinge of left valve.—*2.* Interior of right valve. —*3.* Dorsal view.

paralleling margin and with coarse reticulate pattern posteriorly; moderate sulcus extending from dorsal margin to median line.

Hinge lophodont; right valve with smooth median groove separating two, elongate, terminal teeth which merge with selvage anteriorly and posteriorly; left valve with smooth median bar separating terminal grooves formed between flange and selvage. Marginal area broad anteriorly, narrow elsewhere; anterior radial-pore canals few in number and straight; very few in posterior; line of concrescence coincides with inner margin except in anterior vestibule where it becomes scalloped; selvage low anteriorly, merging with flange ventrally becoming very pronounced. Muscle-scar pattern consists of three adductor scars located in pit and arranged in vertically trending arc with a larger, more obscure scar dorsally, two elongate ventral mandibular scars, and one circular antennal scar.

Dimensions. Length of holotype 0.59 mm; height 0.24 mm; width 0.24 mm.

Material. A total of 333 specimens was examined, of which about half had both valves intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology ;holotype RLK 414627, paratypes RLK 4146214.

Remarks. Cushmanidea sagena is very similar to *C. kashiwarensis* HANAI (1959a, p. 297), but *C. kashiwarensis* has no parallel ridges along the anterior, is less ornamented on the posterior half, and has a less drawn out anterior. It also bears a strong similarity

to *C. eclosa* MALKIN (1953, p. 778), but has a much more reticulate posterior and is without the large pits characteristic of that species. *C. sagena* differs from *C. elongata* (BRADY) by having fewer normal-pore canals, a more highly ornamented exterior, and a less downturned posterior.

Occurrence. *Cushmanidea sagena* has been found in abundance in both the lower- and upper-lagoon environments. It is also present in the open gulf. The fact that no specimens were found on the tidal flats indicates that this species is not adapted for survival under environmental extremes. Found abundantly with *Cushmanidea sagena* are *Basslerites sonorensis, Puriana pacifica, Caudites serrata,* and *Loxoconcha lenticulata.*

Family CYTHERURIDAE G. W. Müller, 1894

Genus CYTHERURA Sars, 1866

Cytherura SARS, 1866, p. 60; MÜLLER, 1894, p. 286; SARS, 1925, p. 199; ALEXANDER, 1933, p. 690; STEPHENSON, 1946, p. 316; HORNIBROOK, 1952, p. 50; SWAIN, 1955, p. 626; HANAI, 1957, p. 16; WAGNER, 1957, p. 74; HOWE & LAURENCICH, 1958, p. 308; POKORNÝ, 1958, p. 285; BENSON, 1959, p. 51; REYMENT, 1961, p. Q291; BENSON & COLEMAN, 1963, p. 31.

Type-species. *Cythere gibba* O. F. MÜLLER, 1785, p. 66, pl. 7, figs. 7-9 [subsequent designation BRADY & NORMAN, 1889].

Diagnosis. Distinguished by having subquadrate, often delicate carapace with distinct median or dorsal caudal process. Surface usually irregularly ribbed or reticulate, with small eye tubercles. Marginal area narrow as compared to *Semicytherura,* few radial-pore canals. Hinge in right valve consists of single or rarely double terminal teeth separated by groove with no lower confining ridge and an accommodation groove passing dorsally over all three elements. Strong sexual dimorphism. *Cret.-Rec.*

Occurrence. The genus *Cytherura* has been widely studied ecologically. It is most frequently represented in mesohaline brackish water at depths usually less than 20 meters and is a very eurythermal form (ELOFSON, 1941). However, it has been reported from both marine and brackish water (SWAIN, 1955; BENSON, 1959); it occurs in slightly hypersaline and normal marine waters of the Estero de Tastiota and is apparently euryhaline.

CYTHERURA JOHNSONI Mincher, 1941

Pl. 3, Figs. 7, 9; Fig. 11

Cytherura johnsoni MINCHER, 1941, p. 343, pl. 47, figs. 1a-d; SWAIN, 1955, p. 627, pl. 64, figs. 8a-c, text-figs. 35b and 38, 8a,b, and 89, 1a-c; PURI & HULINGS, 1957, p. 174, 176, 183, 188; PURI, 1960, p. 114, pl. 4, figs. 14, 15; BENSON & COLEMAN, 1963, p. 00, fig., pl. 00, figs.

Cytherura forulata EDWARDS, 1944, p. 526, pl. 88, figs. 17-20; MALKIN, 1953, p. 789; SWAIN, 1955, p. 628, pl. 64, figs. 10a-c, text-figs. 35c and 39, 2a,b; PURI & HULINGS, 1957, p. 176, 183; PURI, 1960, p. 115, pl. 4, figs. 16, 17.

Cytherura elongata EDWARDS, 1944, p. 526, pl. 88, figs. 21-25; SWAIN, 1955, p. 628, pl. 64, figs. 12a,b.

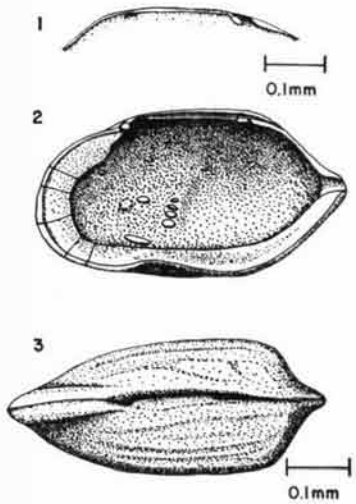


FIG. 11. *Cytherura johnsoni* MINCHER, 1941.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Diagnosis. Distinguished by its straight to slightly curved dorsal margin and small medial to slightly corsal caudal process. Ornamentation consisting of approximately 10 longitudinal ribs converging anteroventrally, with smaller reticulating cross-ribs between. *Mio.-Rec.*

Dimensions. Length of mature adult 0.45 mm; height 0.21 mm; width 0.20 mm. Dimensions of holotype (EDWARDS, 1944, p. 526): length 0.41 mm; height 0.27 mm.

Material. Very few of the 346 specimens examined had both valves intact.

Occurrence. *Cytherura johnsoni* occurs most abundantly in the upper-lagoon environment (stations 406, 407, 410) but also has been found in the open gulf and lower lagoon. No specimens were found on the tidal flat. *C. johnsoni* has a fairly wide salinity tolerance and is particularly well-adapted to slightly hypersaline environment in the Estero de Tastiota.

Family HEMICYTHERIDAE Puri, 1953

Genus AURILA Pokorný, 1955

Cythereis JONES *(partim)*, 1849, p. 14, 15; AUCTT.

Hemicythere SARS *(partim)*, 1925, p. 182; AUCTT.

Cythereis gruppo Auris NEVIANI *(partim)*, 1928, p. 72.

Cythereis (Eucythereis) ELOFSON *(partim)*, 1941, p. 283.

Aurila POKORNÝ, 1955, p. 17; WAGNER, 1957, p. 59; HOWE, 1961, p. Q302 (*non* POKORNÝ, 1958, p. 268).

Type-species. *Cythere convexa* BAIRD, 1850, p. 174, pl. 21, fig. 3.

Diagnosis. Distinguished from other almond-shaped hemicytherids by its very massive carapace, and shortened holamphidont hinge with high, narrowly stepped anterior tooth and incised reniform posterior tooth on the right valve. *Mio.-Rec.*

Occurrence. Species of *Aurila* are found in normal marine and slightly brackish water, but rarely in the hypersaline environment, although the senior author has found two species from Recent sediments of the west coast of Florida in water with salinity as high as 40‰. Species of this genus are found in substrata ranging from fine to coarse sand.

Aurila convexa (BAIRD), the type-species, is a littoral marine form living in depths less than 50 meters on sandy bottoms and substrates of shell debris. It is a very eurythermal species (2-3 to 26°C) but is limited to waters with salinities below 26‰.

AURILA CONRADI (Howe & McGuirt, 1935) CALIFORNICA Benson & Kaesler, n. subsp.

Pl. 1, Figs. 9, 10; Fig. 12

Diagnosis. Distinguished from *Aurila conradi conradi* by its more vaulted dorsum; smaller, circular, more pitlike reticulations; and the lack of a clearly defined ventral and anterior rim. *Rec.*

Description. Carapace almond-shaped, moderately robust. Inflated in dorsal view with flattened anterior rim and posterior extremity; greatest height at anterior cardinal angle, greatest width medial. In lateral view dorsal margin boldly arched, tapered toward posterior; ventral margin slightly convex with an obscured ventral sinuation just anterior to the middle. Anterior end obliquely rounded; posterior end pointed posteroventrally, sloping, slightly caudate. Valves of equal size. Surface reticulate anteriorly, coarsely punctate posteriorly with nearly smooth subcentral area; weak anterior rim paralleling anterior margin and extending along venter to posteroventer; distinct eye tubercle, distinct ventrolateral ridge.

Hinge holamphidont; right valve with stepped anterior tooth and extension of selvage, postjacent socket, weak median groove, elongate, weakly incised posterior tooth; left valve with complementary hinge elements, including faintly crenulate median bar and posterior socket reinforced with small tooth to fit into incision in right valve posterior tooth; elongate depression (accommodation groove) on left valve without vertical bars. Marginal area broad anteriorly, of moderate width posteriorly; vestibule very narrow, with very many radial-pore canals; prominent selvage along entire margin. Muscle-scar pattern obscured.

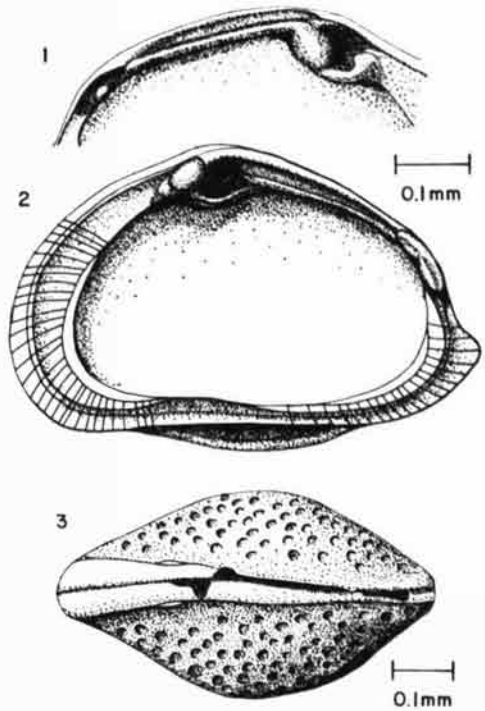


FIG. 12. *Aurila conradi* (HOWE & MCGUIRT) *californica* BENSON & KAESLER, n. subsp.—*1.* Hinge of left valve. —*2.* Interior of right valve.—*3.* Dorsal view.

Dimensions. Length of mature adult 0.61 mm; height 0.37 mm; width 0.30 mm. This size corresponds very closely with the size of the "cotypes" of *Aurila conradi conradi* described by HOWE & MCGUIRT (1935, p. 27).

Material. Thirty-one specimens were examined of which nearly all had their carapaces intact.

Remarks. Including the form described above, three subspecies of *Aurila conradi* now are recognized: *A. conradi conradi, A. conradi floridana,* and *A. conradi californica.* The development of *A. conradi californica* appears to be in the direction of a heavier, more robust, reticulate carapace, an opposite trend to that of the more honeycomblike, fragile, reticulate carapace of *A. conradi floridana* BENSON & COLEMAN (1963). The ribbing above the hinge needed in *A. conradi floridana* to reinforce the arched dorsum is not present in the massive *A. conradi californica,* even though the latter form is more highly arched. The caudal extension of both subspecies is sharper and more pronounced than that of the nominotypical form. The well-formed ventral marginal rim of *A. conradi conradi* is subdued in the other two subspecies. The Miocene nominotypical subspecies appears to be ancestral to the Recent Gulf and Atlantic subspecies

A. conradi floridana and the Recent Pacific subspecies *A. conradi californica.*

Occurrence. In the Estero de Tastiota region *Aurila conradi californica* is found principally in the open gulf, but it is also found in the hypersaline environment of the tidal flat. *A. conradi californica* has the most restricted ecologic range of any ostracode species found in the estero. It is most commonly associated with *Pellucistoma scrippsi* and *Puriana pacifica.*

Recent subspecies of *A. conradi* are usually found only in nearshore sediments. *A. conradi floridana* has been reported by SWAIN (1955, p. 635) from San Antonio Bay and by PURI (1960, p. 130) from the west coast of Florida. It is present in the eastern Gulf of Mexico in salinities from 36‰ to 40‰. (BENSON & COLEMAN, 1963).

Genus CAUDITES Coryell & Fields, 1937

Caudites CORYELL & FIELDS, 1937, p. 10; LEROY, 1943, p. 273; VAN DEN BOLD, 1946, p. 31; PURI, 1953a, p. 176; PURI, 1953c, p. 265; BENSON, 1959, p. 66; PURI, 1960, p. 130; HOWE, 1961, p. Q302.

Type-species. Caudites medialis CORYELL & FIELDS, 1937, p. 11, figs. 12a-d.

Diagnosis. Recognized by its thick-shelled, subtriangular, compressed, elongate carapace usually with coarse peripheral ribs; caudal process below medial line; hemiamphidont hinge with high, spirelike anterior tooth and crenulate posterior tooth. *Eoc.-Rec.*

Occurrence. Caudites has been reported by BENSON (1959, p. 66) from tide pools in Todos Santos Bay. Species of this genus are found only in North America; they have never been found in abundance and are probably restricted to tropical or semitropical marine environments.

CAUDITES SERRATA Benson & Kaesler, n.sp.

Pl. 1, Figs. 3, 4; Fig. 13

Diagnosis. Distinguished by having short caudal process; left valve dorsal ridge extending farther to posterior than does dorsal ridge of right valve (best observed in dorsal view); dorsal ridge of both valves serrate in lateral view, having two peaks and one trough. *Rec.*

Description. Carapace subquadrate, of moderate size, strongly constructed; outline in dorsal view elongate, compressed, wedge-shaped; with jagged posterior, and with dorsal ridge of left valve extending farther to posterior than on right valve; subrectangular, caudate in lateral view with distinct posterior cardinal angle; greatest height at anterior cardinal angle; greatest width at posterodorsum. Dorsal margin straight, long, sloping toward posterior end with distinct posterior cardinal angle; ventral margin long and concave; anterior end non-spinose, obliquely rounded with slight marginal flange; posterior end truncate dorsally with caudal extension ventrally; above caudal extension concave portion of margin meets the dorsal margin at nearly right angles. Valves subequal. Smooth surface texture in central region; ornamented with coarse anterior rim, fading at anteroventer. Pronounced ventrolateral ridge extending from marginal rim at anteroventer toward posteroventer, turning abruptly toward dorsum, bending posterior cardinal angle toward the anterior and extending about two-thirds of distance to eye tubercle. Across dorsal margin this ridge develops an M-shaped pattern with anteriorly slanted bars of M continuing faintly across carapace toward location of subcentral tubercle. Coarse anterior ridge extends weakly toward posterior end from eye tubercle and passes M-shaped ridge dorsally along margin.

Hinge hemiamphidont with high, spirelike anterior tooth on right valve, a postjacent socket, a smooth median groove, and loculate posterior tooth; left valve with deep anterior socket, postjacent tooth, smooth median bar, and subdivided posterior socket. The marginal area is narrow with numerous, straight radial-pore canals; line of concrescence coincides with inner margin except for a shallow anterior vestibule;

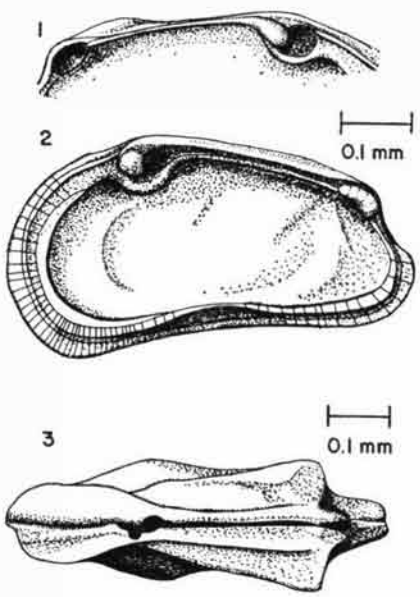


FIG. 13. *Caudites serrata* BENSON & KAESLER, n.sp.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

selvage well-developed, removed from outer margin. Muscle-scar pattern obscured, located in small pit.

Dimensions. Length of holotype 0.46 mm; height 0.24 mm; width 0.17 mm.

Material. A total of 68 specimens were examined, all of which had both valves intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology; holotype RLK 414623; paratypes RLK 4146213.

Occurrence. Caudites serrata occurs principally in the upper lagoon (stations 405, 419, 410) in association with *Puriana pacifica, Basslerites sonorensis,* and *Cushmanidea sagena.* It is found to a very limited extent in the open gulf and at only one station (412) on the tidal flat. It is probably tolerant to variations in salinity, but is particularly well adapted to the slightly hypersaline conditions that are present in the upper lagoon.

Remarks. This species bears a strong resemblance to *Caudites fragilis* LEROY (1943, p. 372), but *C. fragilis* has a smaller tooth on the left valve, a ridge extending diagonally across the carapace from the posterodorsum to the anteroventer, bifurcating at the anterior, is more caudate, and lacks the serrate dorsal ridge. *C. sellardsi* (HOWE & NEILL) (HOWE AND OTHERS, 1935, p. 29), another similar form, is more caudate and is without a serrate dorsal ridge. The type-species *C. medialis* has a horizontal, bifurcating median ridge and is also more caudate than *C. serrata.*

Family CAMPYLOCYTHERIDAE Puri, 1960
Genus BASSLERITES Howe, in Coryell & Fields, 1937

Basslerella HOWE, in HOWE AND OTHERS, 1935, p. 30 (*non* KELLETT, 1935; *nec* BOUČEK, 1936); PURI, 1960, p. 127.

Basslerites HOWE, *in* CORYELL & FIELDS, 1937, p. 11; LEROY, 1943, p. 368; EDWARDS, 1944, p. 520; PURI, 1953c, p. 280; VAN DEN BOLD, 1958, p. 405; BENSON, 1959, p. 68; HOWE, 1961, p. Q307.

Type-species. Basslerella miocenica HOWE, 1935, p. 31, pl. 1, figs. 19, 24-26.

Diagnosis. Recognized by an ovate carapace with elongate anterior and generally featureless, smooth outer surface; hinge modified holamphidont with an elevated posterior tooth on right valve and sharp posterior cardinal angle that gives the posterior an upturned or truncate appearance. *Mio.-Rec.*

Occurrence. BENSON (1959, p. 69, 71) has reported *Basslerites delreyensis* from sublittoral environment in Todos Santos Bay in water slightly less saline than normal marine and with a substrate consisting of very fine sand. *Basslerites miocenica* and *B. tenmilecreekensis* have been found in Pamlico Sound, North Carolina, in nearly normal marine water on a sand substrate in depths from 10 to 30 feet. Species of *Basslerites* are usually restricted to salinities close to normal marine and are most frequently found in the eulittoral zone on sand or silty-sand substrate.

BASSLERITES SONORENSIS Benson & Kaesler, n. sp.

Pl. 2, Figs. 9, 10; Fig. 14

Diagnosis. Distinguished by longitudinal grooves on either side of and parallel to median line at the posterior end. *Rec.*

Description. Carapace ovate, elongate, thick-walled; ovate in dorsal outline, but flattened toward anterior end; subovate in lateral outline with dorsum and venter nearly parallel; greatest height at middle. Dorsal margin arcuate with hinge less than two-thirds as long as carapace; ventral margin almost straight, but slightly sinuate anterior to middle; anterior end drawn out, obliquely rounded; posterior end foreshortened past hinge, broadly, evenly rounded with very gently concave depression near the dorsal margin of right valve where left valve overlaps. Left valve overlaps right everywhere except dorsally where right valve overreaches left valve. Surface smooth, carapace translucent to transparent with numerous oblique normal-pore canals; without ornament except for two

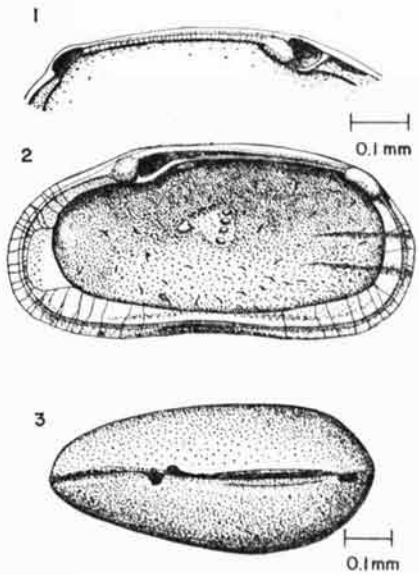


FIG. 14. *Basslerites sonorensis* BENSON & KAESLER, n. sp.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

grooves on posterior end parallel to and on either side of median line.

Hinge modified holamphidont; right valve with spirelike anterior tooth, postjacent socket, median groove overlapped by dorsal flange, and oval posterior tooth; flat, toothlike projection, ventral to postjacent socket; left valve with anterior socket, oblique postjacent tooth, crenulate median bar, and posterior socket. Marginal area broad anteriorly, narrow ventrally; radial-pore canals moderate in number, curved, and branched; very few found posteriorly. Line of concrescence coincides with inner margin except at abrupt, deep anterior vestibule. Selvage prominent on right valve, grading into anterior and posterior teeth, coinciding with flange and forming median bar on the left valve. Muscle-scar pattern consists of vertical row of four adductor scars located very high in carapace, almost entirely above median line; one irregular, heart-shaped antennal scar anterior to adductor scars; and one mandibular scar was observed very near ventral margin.

Dimensions. Length of holotype 0.59 mm; height 0.26 mm; width 0.25 mm.

Material. Sixty-five specimens were examined of which about half had both valves intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology; holotype RLK 414625; paratype RLK 4146212.

Remarks. This species is very similar to *Basslerites miocenica* (HOWE, 1935, p. 30, 31), and *B. delreyensis* LEROY (1943, p. 368), but neither of these species is ornamented with the parallel posterior grooves.

Occurrence. Basslerites sonorensis is present in abundance in upper-lagoon channels; it is also found less abundantly in the open gulf and in the lower lagoon. No specimens were found on the tidal flat. This species is adapted to life in normal marine and slightly hypersaline environment and is probably euryhaline.

Family LOXOCONCHIDAE Sars, 1925

Genus LOXOCONCHA Sars, 1866

Loxoconcha SARS, 1866, p. 61; ———, 1926, p. 217-222; ALEXANDER, 1936, p. 693; MURRAY, 1938, p. 586; ELOFSON, 1941, p. 322-326; EDWARDS, 1944, p. 526; KEIJ, 1957, p. 139; BENSON, 1959, p. 51; HOWE, 1961, p. Q313; AUCTT.

Type-species. Cythere impressa BAIRD, 1850, p. 173, pl. 21, fig. 9; (*non* M'COY, 1844) (=*C. rhomboidea* FISCHER, 1855).

Diagnosis. Recognized by its rhomboidal to ovoid carapace, venter commonly sinuate and broadly rounded in posteroventer, dorsum straight to slightly arched. Surface pitted, reticulate, or smooth. Hinge gongylodont with crenulate or median element. Marginal area moderately broad, narrow anterior and posterior vestibules. Radial-pore canals moderately numerous. Muscle-scar pattern consisting of vertical row of four scars with a single reniform antennal scar. Sexual dimorphism strong. *Cret.-Rec.*

Occurrence. Species of *Loxoconcha* have been found under a wide variety of ecological conditions in brackish (SWAIN, 1955, p. 629; KRUIT, in KRUIT & VAN ANDEL, 1955, p. 487) and hypersaline water (BENSON, 1959, p. 51). They have a depth range from intertidal to 30 fathoms (BENSON, 1959) and are found on substrates that may range from organic mud to coarse sand. ELOFSON (1941, p. 426) has reported several burrowers.

The type-species, strongly eurythermic and euryhaline, was reported by ELOFSON (1941) as living in marine habitats rich in plants in depths from 5 to 10 meters. *Loxoconcha elliptica* was found (ELOFSON, 1941) living among plants in brackish, usually mesohaline water of only a few meters depth.

LOXOCONCHA LENTICULATA LeRoy, 1943

Pl. 4, Figs. 6, 7, 8; Fig. 15

Loxoconcha lenticulata LEROY, 1943, p. 360, pl. 60, figs. 19-23; pl. 61, figs. 34-36; pl. 62, figs. 13, 14; figs. 2f,g; BENSON, 1959, p. 51, pl. 4, figs. 3a-d, pl. 8, fig. 9, 10.

Diagnosis. Distinguished by having its entire surface covered with minute punctae, many normal-pore canals; well-defined, typically gongylodont hinge; faint eye tubercle; dorsal margin usually broadly arched. *Pleist.-Rec.*

Dimensions. Length of mature adult 0.61 mm; height 0.38 mm; width 0.30 mm. Length of holotype 0.74 mm; height 0.47 mm; width 0.38 mm (LEROY, 1943, p. 361).

Material. Two hundred twenty-four specimens were examined, about half of which had both valves intact.

Remarks. This species resembles *Loxoconcha matagordensis* in external ornamentation, but it has a much more robust hinge; the anterior teeth of the right valve are much larger, and the posterior terminal element is more typically gongylodont.

Occurrence. Loxoconcha lenticulata has been reported by LEROY (1943) from the Timms Point Formation (Pleistocene) and widely distributed but not abundant from Recent sediments of Avalon Bay, Santa Catalina Island, and Monterey Bay off Southern California.

BENSON (1959, p. 34) reported this species from the Estero de Punta Banda in slightly hypersaline en-

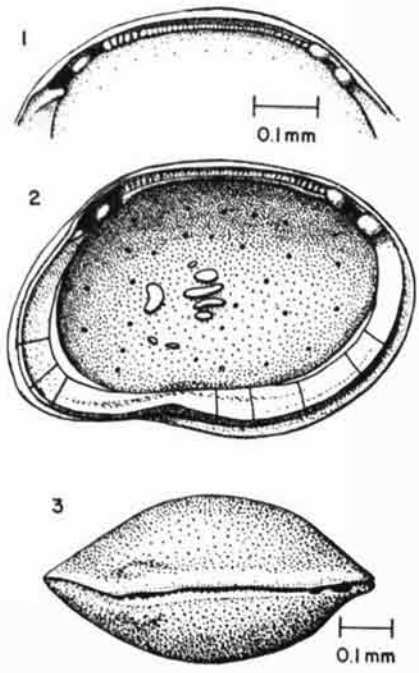


FIG. 15. *Loxoconcha leticulata* LEROY, 1943.—*1*. Hinge of left valve.—*2*. Interior of right valve.—*3*. Dorsal view.

vironment associated with filigreed algae. In the Estero de Tastiota it is found almost exclusively in the upper-lagoon biotope with very few representatives from the lower lagoon, a few from the open gulf, and only one specimen from the tidal flat. It is found abundantly with *Caudites serrata, Cushmanidea sagena, Cytherura johnsoni,* and *Megacythere johnsoni.*

Family PARADOXOSTOMATIDAE Brady & Norman, 1889

Subfamily CYTHEROMATINAE Elofson, 1938

Genus MEGACYTHERE Puri, 1960

Microcythere MINCHER, 1941 (*non* MÜLLER, 1894), p. 344; PURI, 1954, p. 290; SWAIN, 1955, p. 641; VAN DEN BOLD, 1957, p. 237.

Megacythere PURI, 1960, p. 119.

Type-species. Megacythere robusta PURI, 1960, p. 122, pl. 2, figs. 14, 15; text-figs. 10, 11.

Diagnosis. Carapace elongate, highest near posterior, with slightly sinuate venter nearly parallel to straight dorsum; surface ornamentation varied, commonly consisting of numerous horizontal bifurcating ribs. Hinge of right valve with strong anterior socket bordered ventrally by raised, almost toothlike ridge; anterior socket connected to posterior socket by narrow, possibly crenulate groove; posterior socket less pronounced than anterior one and not bordered ventrally by ridge, the ventral bar of median groove having faded out about midway along median element; bar dorsally bounding median element, clearly extension of very weak selvage. Hinge of left valve essentially complementary to right valve, consisting of very thin median ridge with slightly enlarged terminal teeth; lap-joint, elongate depression analogous to the accommodation groove of more robust carapaces, above median ridge. Muscle-scar pattern consisting of four adductor scars in oblique row; two nearly circular mandibular scars; one oval antennal scar. *Mio.-Rec.*

Remarks. Species of this genus were formerly included in *Microcythere* MÜLLER, but they do not conform at all well to the type, *Microcythere inflexa* MÜLLER.

A species apparently very similar to *Megacythere johnsoni* (MINCHER) has been described by HARTMANN (1957, p. 158) as *Paracytheroma costata* HARTMANN. Although details of the hinge are not described, the outline and ornamentation of the carapace are nearly identical to *M. johnsoni.* The outline of the type-species of the genus *Paracytheroma* [*P. pedrensis* JUDAY (1957, p. 137)] is also very similar to that of *Megacythere* PURI, although it is without ornamentation.

Unfortunately, *Paracytheroma* JUDAY has been defined only on the basis of soft parts without discussion of the carapace morphology. If *P. costata* HARTMANN is identical with *Megacythere johnsoni* (MINCHER), the possibility would be strongly suggested that other species of *Megacythere* PURI, including the type-species *M. robusta* PURI, might also belong to *Paracytheroma* JUDAY. In this case *Megacythere* PURI would become a junior synonym of *Paracytheroma* JUDAY.

The classification of species into the genus *Paracytheroma* JUDAY is paleontologically impractical, because it was conceived on soft parts without consideration of the carapace. The genus *Megacythere* is paleontologically tangible, because it was conceived from examination of the carapace and has been discussed (as *Microcythere*) in a number of reports. A study comparing the soft parts and carapaces of these two genera is essential to:

(1) test the separateness of each genus, and to eliminate *Megacythere* PURI, if it is a junior synonym;

(2) add paleontological significance to *Paracytheroma* JUDAY;

(3) increase the understanding of *Megacythere* PURI, if it is a valid generic name.

MEGACYTHERE JOHNSONI (Mincher), 1941

Pl. 3, Figs. 3, 4; Fig. 16

Microcythere johnsoni MINCHER, 1941, p. 344; pl. 47, figs. 4a-d; PURI, 1954, p. 290; SWAIN, 1955, pl. 641, pl. 63, figs. 2a-c; pl. 64, fig. 7; text-fig. 39, 3; VAN DEN BOLD, 1957, p. 237, pl. 4, fig. 1.

Diagnosis. Distinguished by its very numerous bifurcated, curved, subparallel, longitudinal ribs that extend nearly to the anterior and posterior extremities of carapace, and by its parallel dorsum and venter. *Mio.-Rec.*

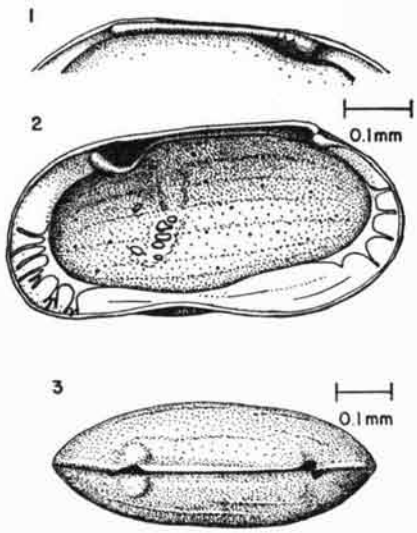


FIG. 16. *Megacythere johnsoni* (MINCHER), 1941.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Dimensions. Length of mature adult 0.52 mm; height 0.26 mm; width 0.19 mm. Length of holotype 0.53 mm; height 0.27 mm (MINCHER, 1941, p. 344).

Material. Of the 271 specimens examined, nearly all were single valves.

Occurrence. This species has been reported by SWAIN (1955, p. 584, 641) from San Antonio Bay in slightly brackish water. In the Estero de Tastiota it occurs almost exclusively in the northern division of the upper lagoon. None were found in the lower lagoon, and very few in the open gulf. A few specimens were found on the tidal flat. *Megacythere johnsoni* seems to be particularly tolerant of hypersaline conditions.

Megacythere johnsoni was found with *Cytherura johnsoni, Loxoconcha lenticulata, Perissocytheridea swairi,* and *Perissocytheridea meyerabichi.*

Genus PELLUCISTOMA Coryell & Fields, 1937

Pellucistoma CORYELL & FIELDS, 1937, p. 17; EDWARDS, 1944, p. 528; VAN DEN BOLD, 1946, p. 35; PURI, 1954, p. 289; BENSON, 1959, p. 58; SYLVESTER-BRADLEY, 1961, p. Q317, Q318; BENSON & COLEMAN, 1963, p. 40.

Javanella KINGMA, 1948, p. 89.

Type-species. Pellucistoma howei CORYELL & FIELDS, 1937, p. 17, 18, figs. 18a-c.

Diagnosis. Recognized by its small, smooth, lenticular to spatulate, delicate, transparent carapace with caudal process above midline; marginal areas broad with wide, irregular anterior vestibule and a narrow, intermittent posterior vestibule. Radial-pore canals few in number, sometimes branching. Hinge modified merodont, sometimes with median bar on left valve. *Mio.-Rec.*

Occurrence. In general, species of *Pellucistoma* are found in salinities greater than 30°/oo.

PELLUCISTOMA SCRIPPSI Benson, 1959

Pl. 2, Figs. 3, 4; Fig. 17

Pellucistoma scrippsi BENSON, 1959, p. 58, pl. 5, figs. 4a,b; pl. 9, figs. 5, 6.

Diagnosis. Distinguished by its gently arched dorsum, medial caudal process, and smoothly curved outer margin. *Rec.*

Dimensions. Length of mature adult 0.52 mm; height 0.26 mm; width 0.15 mm. Length of holotype 0.69 mm; height 0.53 mm; width 0.27 mm.

Material. Of 141 specimens examined, nearly all were disarticulated.

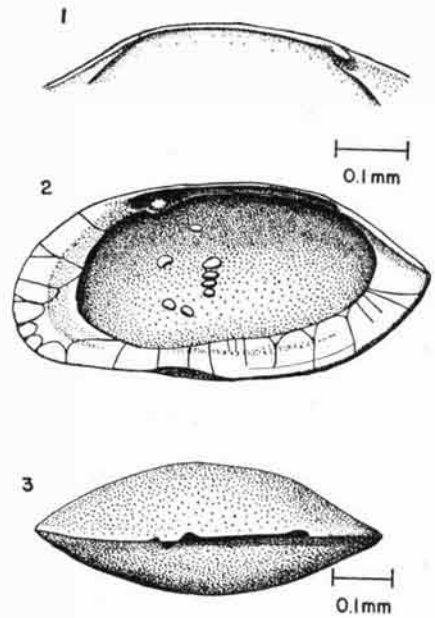


FIG. 17. *Pellucistoma scrippsi* BENSON, 1959.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Remarks. *Pellucistoma scrippsi* BENSON bears a strong resemblance to *P. magniventra* but can be distinguished from it by the latter's exaggerated posterior height and reduced anterior. It differs from *P. howei* by having a much less caudate posterior.

Occurrence. BENSON (1959, p. 58) has reported a few specimens of *P. scrippsi* from shallow water in normal marine salinities. In the Estero de Tastiota *P. scrippsi* is very common in the open-gulf biotope, but it occurs in small numbers in all biotopes except the tidal flat. It is found associated with *Aurila conradi* and *Puriana horrida*.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

Genus CATIVELLA Coryell & Fields, 1937

Navecythere CORYELL & FIELDS, 1937, p. 7.

Cativella CORYELL & FIELDS, 1937, p. 9; TRIEBEL, 1941, p. 346; VAN DEN BOLD, 1946, p. 104; ———, 1950, p. 85; PURI, 1954, p. 261, 262; VAN DEN BOLD, 1957a, p. 243; ———, 1958, p. 404; HARTMANN, 1959, p. 234; VAN DEN BOLD, 1960, p. 167; SYLVESTER-BRADLEY, 1961, p. Q336.

Type-species. *Cativella navis* CORYELL & FIELDS, 1937, p. 9, fig. 9a.

Diagnosis. Recognized by its carapace tapering sharply toward posterior end with three, raised, subparallel ribs—one dorsal, one ventral and one medial; accuminate posterior end; eye-tubercle distinct; hinge holamphidont. *Olig.-Rec.*

Occurrence. BENSON (1959, p. 58) has reported *Cativella semitranslucens* (CROUCH, 1949), misclassified as *Pterygocythereis,* from a marine environment in Todos Santos Bay, Baja California, living on a very fine substrate. In the Estero de Tastiota *Cativella* sp. cf. *C. dispar* HARTMANN is found in fine to coarse sand in normal marine and slightly hypersaline environment.

CATIVELLA sp. cf. C. DISPAR Hartmann, 1959

Pl. 3, Figs. 5, 6; Fig. 18

Cativella dispar HARTMANN, 1959, p. 234, 235; fig. 168-172.

Diagnosis. Distinguished by its straight dorsal margin, smooth surface between the ridges, distinct posterior cardinal angle, and perforated rim extending continuously from posteroventer around anterior margin and along dorsum to posterodorsum. *Rec.*

Description. Carapace of moderate size, strongly constructed; subtriangular in lateral outline, tapered toward posterior end. Greatest height at anterior cardinal angle; greatest width in middle. Dorsal margin straight in lateral view, sloping toward the posterior; ventral margin slightly convex, sinuate when viewed from interior. Anterior end broadly rounded; posterior end with prominent caudal process. Left valve overreaches right valve. Surface with smooth texture; ornamented dorsally, anteriorly, and ventrally with continuous, perforated marginal rim; anterior margin with three to five short, blunt spines; posterior end ornamented with about six spines; perforated ventrolateral ridge about two-thirds length of carapace with posteriorly pointing spines extending across ventral half of carapace; perforated lateral ridge three-fourths length of carapace crossing carapace medially but closer to dorsum in posterior half than in anterior.

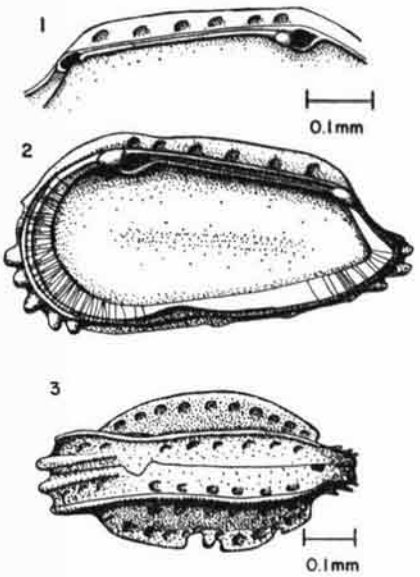


FIG. 18. *Cativella* sp. cf. *C. dispar* HARTMANN, 1959.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Hinge holamphidont with slightly crenulate median element; radial-pore canals straight, numerous in anterior and few in posterior. Line of concrescence coincides with inner margin; duplicature narrow; vestibule absent. Selvage very close to flange anteriorly and coincides with flange posteriorly. Muscle-scar pattern obscured.

Dimensions. Length of mature adult 0.55 mm; height 0.28 mm; width 0.23 mm.

Material. Twenty-six specimens were examined, nearly all of which had both valves intact.

Remarks. Several Tertiary species of *Cativella* have been described by VAN DEN BOLD (1957a, 1958, 1960) from the Early Oligocene to Miocene, by CORYELL & FIELDS (1937), and by CROUCH (1949, p. 597), classified as *Trachyleberis,* from the Pliocene. *Cativella moriahensis* (VAN DEN BOLD, 1960, p. 167; Early Oligocene) shows much the same carapace outline as *C.*

navis (CORYELL & FIELDS, 1937, p. 9) but has coarse reticulations on the surface between the punctate ribs. VAN DEN BOLD (1957a, p. 243) has described *Cativella* sp. cf. *C. semitranslucens* (CROUCH) from the Miocene. This form is similar to *C. moriahensis* but has coarse ridges normal to the perforated ribs rather than coarse reticulations. Other Miocene forms such as *C. navis* and the Pliocene species *C. semitranslucens* (CROUCH) are ornamented with nodes instead of ridges on the surface between the longitudinal ribs. Recent species of *Cativella* are usually even less ornamented than the Miocene specimens. However, the trend toward less ornamentation does not hold true in all cases: *Cativella* sp. (TRIEBEL, 1941, p. 346) from the Recent of Mexico has coarse ridges normal to the longitudinal ribs.

Genus PURIANA Coryell, 1953

Favella CORYELL & FIELDS, 1937, p. 8; EDWARDS, 1944, p. 523, 524 (*non* JORGENSEN, 1925).

Puriana CORYELL, *in* PURI, 1953b, p. 751; SWAIN, 1955, p. 634; VAN DEN BOLD, 1957a, p. 9; ———, 1957b, p. 244; BENSON, 1959, p. 60; SYLVESTER-BRADLEY, 1961, p. Q341; BENSON & COLEMAN, 1963, p. 46.

Type-species. Favella puella CORYELL & FIELDS, 1937, p. 8, fig. 8a-c, juvenile; [=*Cythereis rugipunctata gatunensis* CORYELL & FIELDS, 1937].

Diagnosis. Characterized by a small subquadrate carapace, ornamented by posterodorsal, subvertical, and lateral ridges, spines, and knobs, anterior marginal rim, subcentral tubercle, and three to five heavy spines on posteroventral margin. Marginal area moderately broad, sometimes with narrow vestibule. Hinge holamphidont with all elements distinct. *Mio.-Rec.*

Occurrence. Species of Puriana are usually restricted to normal marine water. PURI & HULINGS (1957) report *Puriana* from the inner neritic zone from Florida; BENSON & COLEMAN (1963) have found this genus represented in the eastern part of the Gulf of Mexico in normal marine conditions in depths from 19 to 239 feet. In the Estero de Tastiota two species have been found, both in a normal marine and in slightly hypersaline environments.

PURIANA PACIFICA Benson, 1959

Pl. 1, Figs. 1, 2; Fig. 19

Puriana pacifica BENSON, 1959, p. 60, 62; pl. 5, figs. 5a,b; pl. 10, fig. 1.

Diagnosis. Distinguished by its isolated nodes arranged in subvertical rows, particularly on posterior half of carapace. *Rec.*

Dimensions. Length of mature adult 0.67 mm; height 0.33 mm; width 0.33 mm. Length of holotype 0.60 mm; height 0.33 mm; width 0.30 mm.

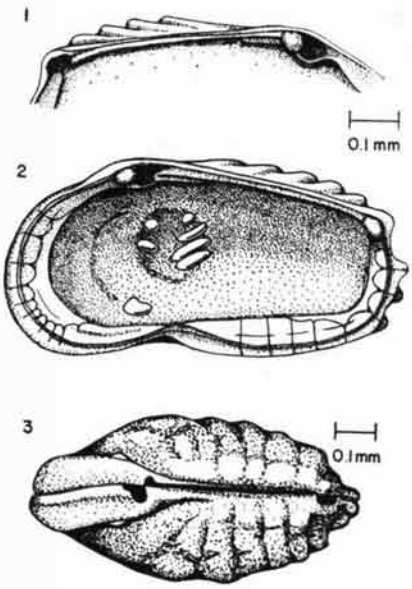


FIG. 19. *Puriana pacifica* BENSON, 1959.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

Material. Of 542 specimens examined, about half were intact.

Occurrence. From Todos Santos Bay, BENSON (1959, p. 61, 62) reported *Puriana pacifica* as a good indicator of a salt-water lagoon environment. The same conclusion is applicable in the Estero de Tastiota, where *P. pacifica* is found most abundantly in the upper-lagoon biotope. It is also fairly common in the open gulf. It occurs abundantly with *Caudites serrata, Basslerites sonorensis,* and *Cushmanidea sagena.*

PURIANA HORRIDA Benson & Kaesler, n.sp.

Pl. 1, Figs. 3, 4; Fig. 20

Diagnosis. Distinguished by its carapace ornamentation with numerous short, emphasized, branching ridges running nearly parallel to the dorsal and ventral margins but curving around the subcentral tubercle. *Rec.*

Description. Carapace large, elongate, inflated, robust; outline ovate, jagged in dorsal view; in lateral view dorsum and venter parallel with distinct posterior cardinal angle. Greatest height and greatest width in middle. Dorsal margin forms long, gentle arc; ventral margin long, slightly sinuate, paralleling dorsum; anterior end obliquely rounded, faintly denticulate, with produced lip; posterior end compressed with short caudal process in ventral half of carapace and three long spines below median line extending

outward from margin. Valves equal; surface ornamented with anterior marginal rim, subcentral tubercle, faint eye tubercle, and numerous, short, emphasized, branching ribs tending to parallel margins but bending around subcentral tubercle; ridge almost half as long as carapace extending along anteroventer.

Hinge holamphidont with all elements distinct; marginal area broad anteriorly with few, straight radial-pore canals; line of concrescence coincides with inner margin except at shallow anterior vestibule. Selvage very pronounced on right valve and located well away from flange, coinciding on the left valve with the flange on posterodorsal portion of carapace. The muscle-scar pattern located in pit; not observed.

Dimensions. Length of holotype 0.51 mm; height 0.23 mm; width 0.23 mm.

Material. Of 43 specimens examined, almost half had both valves intact. Types reposited with the micropaleontology section of the University of Kansas Museum of Invertebrate Paleontology; holotype RLK 414624; paratypes RLK 4146211.

Remarks. This species is clearly very closely related to *Puriana puella;* however it lacks the transverse ridge pattern in the posterior half of the carapace and does not have a trifurcating ridge over the subcentral node; it is marked, instead, by longitudinally oriented ribs.

Occurrence. Puriana horrida occurs abundantly in the open-gulf and less abundantly in the upper-lagoon biotope. No specimens were found on the tidal flat, and very few in the lower lagoon. Species found most abundantly with *P. horrida* are *Aurila conradi, Pellucistoma scrippsi,* and *Cativella* sp. cf. *C. dispar.* No information is available on its adaptation to the brackish-water environment.

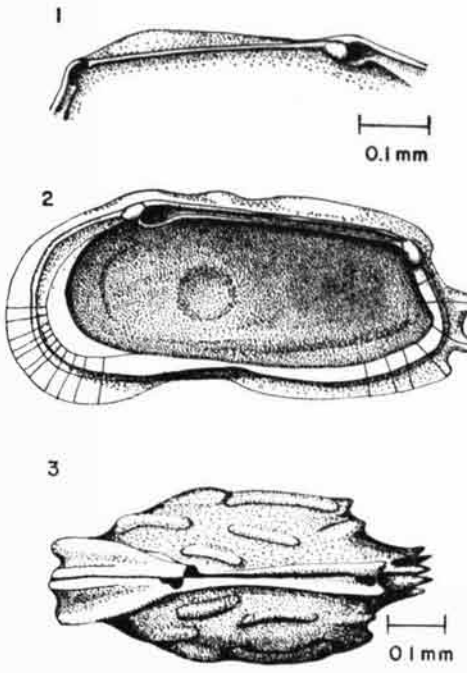


FIG. 20. *Puriana horrida* BENSON & KAESLER, n. sp.—*1.* Hinge of left valve.—*2.* Interior of right valve.—*3.* Dorsal view.

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