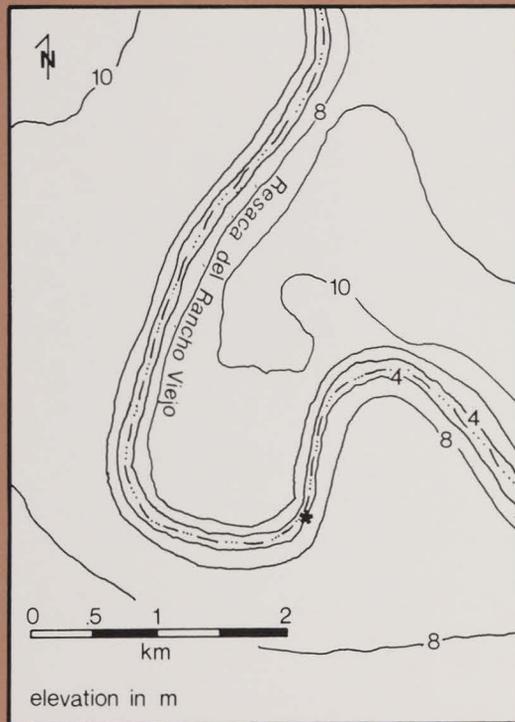


NUMBER 41  
PEARCE-SELLARDS  
SERIES

PALEOECOLOGICAL IMPLICATIONS  
OF A  
HOLOCENE FOSSIL ASSEMBLAGE  
Lower Rio Grande, Cameron County, Texas

Raymond W. Neck



AUGUST, 1985

TEXAS MEMORIAL MUSEUM, THE UNIVERSITY OF TEXAS AT AUSTIN



# Pearce-Sellards Series

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The Pearce-Sellards Series is an occasional, miscellaneous series of brief reports of Museum and Museum-associated field investigations and other research. All manuscripts are subjected to extramural peer review before being accepted. The series title commemorates the first two directors of Texas Memorial Museum, both now deceased: Dr. J. E. Pearce, Professor of Anthropology, and Dr. E. H. Sellards, Professor of Geology, The University of Texas at Austin.

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#### ABSTRACT

A Late Holocene fossil site from extreme southern Texas consists of invertebrate remains dominated by terrestrial, freshwater and brackish water mollusks. Sparse plant remains were recovered. Analysis of the origin of this heterogeneous fossil biota indicates that a brackish marsh was periodically inundated by freshwater runoff. The presence of a marsh clam not known living in the area today is significant; the fossil site is reconstructed to have been a brackish marsh habitat at elevation of 3.6 meters above mean sea level. A brackish marsh at this elevation may indicate high sea levels, although existence of nontidal brackish marshes are known from the lower Texas coast. Changes in river flow and seasonal distribution of local precipitation, and/or regional runoff, are postulated to explain the existence of a saline marsh in an area where this biotype is extremely rare today.

## INTRODUCTION

The purpose of this report is to describe a fossil assemblage discovered in the Holocene alluvial plain of the Lower Rio Grande and to reconstruct paleo-environmental conditions. Additionally, a hypothesis as to the causal factors resulting in the fossil assemblage is postulated. The paleogeological and paleo-climatological implications of the fossil assemblage are also discussed.

Until recent human activities confined the regularly-flooding lower Rio Grande, the Lower Rio Grande "Valley" (actually an alluvial plain) of Texas was very active in hydrogeological terms. The Rio Grande has been an actively meandering stream throughout the Holocene into contemporary time. Several subdeltas were deposited and later partially eroded (LeBlanc 1958). Local course changes left several abandoned channels (Pryor *et al.* 1976), known by the Spanish term *resacas*. Such an active hydrogeological environment undoubtedly was accompanied by dynamic biological systems which responded to changing physical conditions. Few data exist concerning the biological dynamics of the lower Rio Grande. Richards (1939) and Trowbridge (1932:226) reported the existence of Pleistocene fossil molluscan strata, but discussed regional geological phenomena rather than local paleoenvironments.

## FOSSIL SITE

A fossil fauna was located in sediments of the now intermittent Resaca del Rancho Viejo, Cameron County, approximately 9.5 kilometers north of Brownsville (fig. 1 and 2). The fossiliferous layer (6 mm in thickness), consisting of mixed clay and silt, forms the surface deposit of the sloping bank above the lowest portion of the resaca. Below the stratum studied is a 30 mm layer which contains some fossil remains, but which was not intensively sampled because of the lack of the marsh clam. The fossiliferous layer was observed over a distance of 840 meters along the length of Resaca del Rancho Viejo. Width of the sediment has been verified for a width of 33 meters on both sides of the present water channel. The present environment is slightly brackish as expressed by the presence of halophytes, fiddler crabs (*Uca*) and slight salt deposition during drought periods.

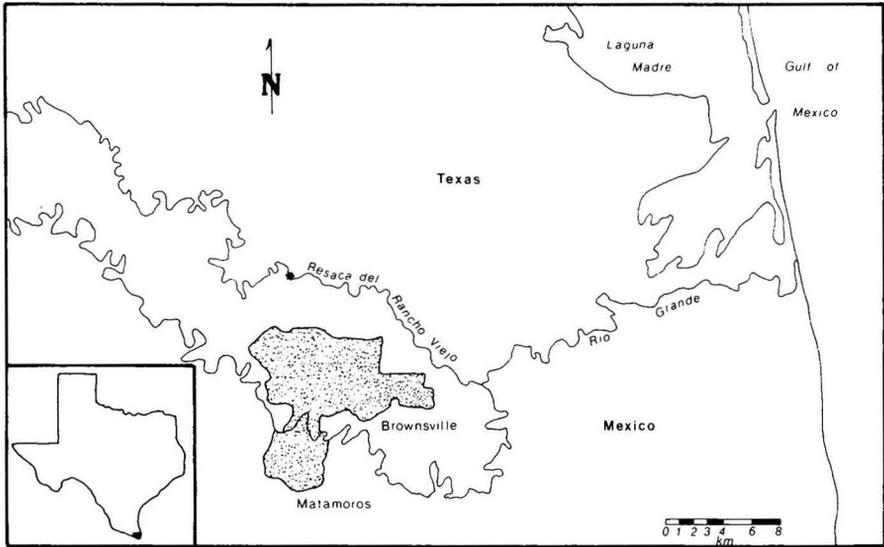


Fig. 1. Map of lower Rio Grande, Cameron County, Texas. Asterisk marks fossil locality.

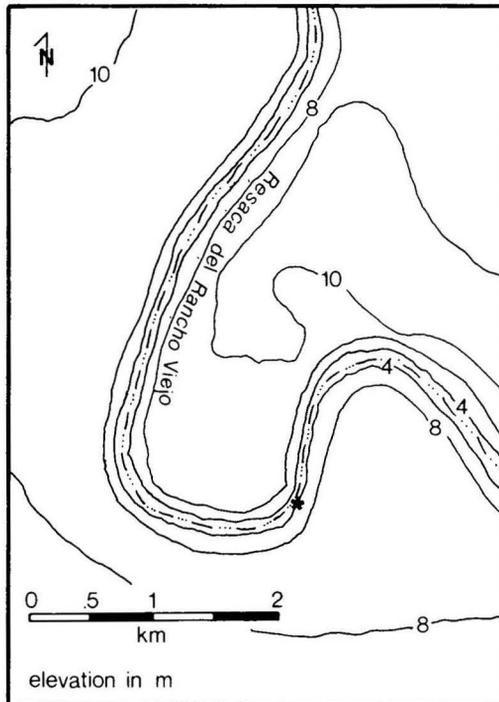


Fig. 2. Localized map of Tejon Biota site.

## FOSSIL ASSEMBLAGE

Following an initial visual survey of the fossiliferous strata, I sampled the biota by two methods. I removed circular portions (10 cm in diameter, located at random) of the layer containing the fossils until approximately 750 cc of material had been gathered. This material yielded the species which are discussed immediately below. Additionally, an *ad libitum* sampling of marsh clam shells was accomplished by recording horizontal and vertical orientation of the valves; the resultant data are discussed below under "Origin of Faunal Assemblage."

Sediment samples were analyzed by soaking the sediments in water followed by screening through soil sieves (No. 8, No. 16 and No. 30—U.S. Standard Sieve Series). Samples were air dried and hand-picked. The most abundantly recovered specimens were shells of two species of freshwater gastropods and one species of marsh clam. Low numbers of arthropods, terrestrial gastropods and plant remains were also recovered. Numbers following scientific names in the following paragraphs are counts from the extracted sample; *ad libitum* sampling of *Cyrenoida* added additional specimens of this species (See Table 1.). The biota discussed below is called the Tejon Biota after the adjacent El Tejon Road. (*Tejón* means "badger" in Spanish; this meaning has no application to the use of the word here.)

Table 1. Number of organisms recorded from Tejon Local Fauna, Resaca del Rancho Viejo, Cameron Co., Texas.

<i>Pyrgophorus coronatus</i>	4034
<i>Helicina orbiculate</i>	2
<i>Physa virgata</i>	339
<i>Gastrocopta riograndensis</i>	1
<i>Succinea luteola</i>	2
<i>Glyphyalinia umbilicata</i>	1
<i>Thysanophora horni</i>	1
<i>Cyrenoida floridana</i>	3

## AQUATIC MOLLUSKS

*Pyrgophorus coronatus* (Pfeiffer)—4034. This small hydrobiid snail is found in ponds and slow-moving waters from the West Indies and Mexico northward into Texas as far north as the Guadalupe River (Fullington 1979:46). Carnes (1974) reported deposited specimens in "peaty sediments of the back lagoon marsh" in Quintana Roo, Mexico. Majors (1964) noted numerous empty shells in drift piles but did find living specimens on stalks of "grasslike plants" in a drainage ditch near Harlingen, approximately 32 kilometers northwest of the Tejon Biota site. Living populations appear to be scarce in the area today. Specimens vary in a continuum from very spinose to the smooth form (*texana* phenotype of Pilsbry). Increased spination of gastropod shells has been associated with increased alkalinity/salinity (Goodrich 1934; Real 1973) or "bad" conditions (Boycott 1929). Fullington (1979:47) suggested a tendency for spinose shells of *P. coronatus* to be found in relatively fast water current areas, while smooth shells are generally found in quiet backwaters; however, this relationship has yet to be rigorously examined. Most *P. coronatus* shells from this sample exhibit at least a few spines. Shell height of recovered *P. coronatus* varies from 1.4 to 4.9 mm; shells do not exhibit abrasion marks. This species is by far the most abundant species represented in the recovered sample.

*Physella virgata* Gould—339. The pond snail occurs over much of the southern United States and northern Mexico. Shell morphology is quite variable as an ecogenetic response to variable water conditions, but all Texas populations have been placed in a single taxon (Fullington 1979:164). While *P. virgata* can withstand waters of differing quality, local populations are found in non-moving to slow-current waters; stagnant water is tolerated. Shells recovered tend to be small (height of largest specimen—9.7mm), but modern *P. virgata* shells from Cameron County tend to be equally small. This species was the second most common species recovered in the sample.

*Cyrenoida floridana* Dall—3. The Florida marsh clam is known from salt marshes of the Atlantic and Gulf coasts of the United States. No records of living *C. floridana* are known from Texas (Pulley, pers. comm.). Parker (1960) did not list *C. floridana* from his "low-salinity marsh assemblage." Texas records are restricted to the Holocene of Cameron Co. (Neck & Herber 1981); Herber (1981:596) reported *C. floridana* from Late Holocene deposits dated at  $3160 \pm 50$  B.P. The largest specimen found in the sample of the Tejon Biota measures 18.5 mm in length and 16.7 mm in height, as compared to 13.5 mm and 12.5 mm, respectively, for the largest Florida specimen reported by Dall (1896). Remnants of periostracum have persisted where the valve was in contact with the clay matrix. While most valves were single and parallel to the substrate, several articulated valve pairs in natural position (perpendicular to substrate) were collected. These latter shells have apparently remained *in situ* since time of death.

### MISCELLANEOUS BIOTA

Several other animal species were recovered from the sediment samples. Limited numbers (given in parentheses) of the following terrestrial gastropods were observed: *Helicina orbiculata* (2), *Gastrocopta riograndensis* (1), *Succinea luteota* (2), *Glyphyalinia umbilicata* (1), and *Thysanophora horni* (1). Also recovered were remains of a water scavenger beetle (*Hydrophilus triangularis*), fiddler crab (*Uca* sp.), and non-diagnostic fish scales. All identifiable species represented occur in the close vicinity of the site today.

### PLANT REMAINS

Various plant remains were recovered. Present were halves of the stony exocarp of *Celtis laevigata* Willd., the Texas sugarberry or hackberry, which is common in woodlands flanking the Rio Grande and water-filled resacas. Also present were seeds of smartweed, *Polygonum* sp., a wetland species typical of lentic waters.

### AGE OF FOSSIL SITE

While considerable geological reconnaissance has been reported on the Rio Grande deltaic plain (Trowbridge 1923, 1932; LeBlanc 1958; LeBlanc & Hodgson 1959; Curray 1960; Brown *et al.* 1980), very few absolute dates associated with specific sediments have been published. Following the last glacial maximum (*ca.* 18,000 B.P.), rising sea levels resulted in inundation of the Wisconsinan valley of the Rio Grande, forming a large estuarine area in what is now eastern Cameron County. This Late Wisconsin/Early Holocene bay was much larger than the present-day Laguna Madre, which has been reduced by sedimentation and development of the barrier island system. Sedimentation became more rapid during the period 7000 to 5000 B.P., as sea level began to approach present-day sea level.

In southern Texas, this rapid rise in sea level was accompanied by river valley submergence and filling, in addition to the initial development of an offshore barrier island system by 4500 B.P. (Behrens 1974; Suhm *et al.* 1977; Russell & Suhm 1980). Lohse (1962:55) placed Resaca del Rancho Viejo within the Del Tigre subdelta of the Middle Holocene. The Del Tigre subdelta was a southern extension of the river which followed the more northern Los Cuates subdelta of the Early Holocene. A slight northward shift of the lowermost Rio Grande during the Late Holocene initiated formation of the current Boca Chica subdelta.

Pryor *et al.* (1976) reported carbon-14 dates for two distributary systems of the Holocene Rio Grande: Resaca de la Gringa (5000 B.P.) and a "Southern system" (7000 B.P.). Resaca del Rancho Viejo occurs south of these two systems and is merely labeled (along with Resaca de la Palma) as "youngest" Rio Grande by Pryor *et al.* (1976). The fossil layer from Resaca del Rancho Viejo is likely to be no older than 3000 B.P. (Neck & Herber 1981). This

dating is made relative to known ages of older resaca systems (Pryor, *et al.* 1976; Herber 1981).

#### PALEOENVIRONMENTAL RECONSTRUCTION

The above reported fossil assemblage is basically a freshwater biota with representatives from brackish and terrestrial habitats. The freshwater species are indicative of a freshwater pool, or slow-moving stream, with shallow water and emergent vegetation. The brackish water component, i.e., *Cyrenoida*, indicates brackish marsh. Thorn woodland at the time of deposition would be similar to present-day species composition, although more mesic-adapted species could have been relatively more abundant.

Presence of *C. floridana* indicates a well-developed salt marsh. The Florida marsh clam has long been known from intertidal marshes of Florida and Georgia where it has been found in "brackish, or even tolerably salt water, indifferently" (Dall 1896). Morrison (1954) reported living populations toward the freshwater portion of intertidal marshes in Chesapeake Bay and Delaware. Rehder (1954) reported *C. floridana* as characteristic of "brackish water estuaries" of the Caribbean Province (which includes the southern Texas area), but gave no specific localities. Abbott (1974:466) reports *C. floridana* "in brackish to rather fresh water." More recently, *C. floridana* has been found living in *Spartina/Distichlis* salt marshes associated with Delaware Bay (Leathem, *et al.* 1976) where it is well adapted to live in intertidal marsh areas (Kat 1978). Reports of *C. floridana* from the Gulf of Mexico are sparse; the species has not been reported from Mississippi (Moore 1961), but has been found in Louisiana salt marshes (Harold Harry, pers. comm.). Absence of *C. floridana* from Texas localities with *Spartina/Distichlis* salt marshes is not presently understood, but may be related to periodic droughts which reduce inflow of freshwater.

Delaware salt marsh populations were densest in the *Distichlis spicata* zone (Leathem *et al.* 1976); areas of denser *Cyrenoida* populations were associated with sediments containing increased levels of volatiles (vegetation remains) and water content. This may indicate dependence on sediment-trapped water during low tidal periods and utilization for food of detritus originating from buried organic matter. Increased plant density in areas of *Cyrenoida* occurrence led Leathem *et al.* (1976) to speculate that stem density may ameliorate temperature and light variation as reported by Kraueter and Wolf (1974). In Florida, *C. floridana* is the characteristic bivalve of upper and high marsh zones (Subramanyan *et al.* 1976). Indication that the Tejon Biota site was a high marsh area is given by the absence of typical salt marsh mollusks, e.g. *Truncatella*, *Polymeseda* and *Melampus*.

## ORIGIN OF FOSSIL ASSEMBLAGE

1) This assemblage could represent a freshwater biota which was devastated by an influx of salt water. Salt water could have entered a freshwater system as a hurricane surge tide (Carr 1967; Geiser 1944; Schlesselman 1945) which traveled up Resaca del Rancho Viejo from the Gulf of Mexico. The distance along the course of Resaca del Rancho Viejo to the vicinity of the Laguna Madre of Tejon time would be greater than that of today. The last major transgression of early Holocene delta sediments occurred during the period 3400 to 1900 B.P. (Brown *et al.* 1980:20-22). Biological effects of surge tides associated with hurricanes (Hubbs 1962; Chabreck & Palmisano 1973; Egler 1952; Valentine 1978) includes mortality of freshwater marsh vegetation and transport of marine organisms into freshwater habitats. Sediment transport by modern hurricanes in the Rio Grande area has been discussed by Morton and Pieper (1975).

Price and Kornicker (1961) discussed hurricane flotsam found buried in mainland clay dunes and barrier island sand dunes of Cameron County. No shell was discovered, however; the majority of flotsam consisted of asphalt lumps, coral fragments, tropical seeds, pumice and other similar materials more bouyant than shell fragments. However, Kat (1978:103) reported that individuals of *C. floridana* exhibit two techniques by which flotation occurs. Closed valve surfaces which dry during low tidal periods permit individuals to float at the surface until capillary flow of water over the shell breaks the surface tension. *C. floridana* may also take air into the mantle cavity during shell gaping. Feeding may occur during surface floating periods. Some control may be exerted over float period length as air bubbles may be expelled at will.

Death of over 4,000 *P. coronatus* is indicative of an alteration of water condition. Desiccation/heating of a pool due to extreme drought (Lowry 1959) is possible, but would not explain the existence of *C. floridana* in a freshwater habitat. Cold shock deaths due to unusually severe periodically-occurring (Haddock 1963; Orton *et al.* 1967) freezes have been reported for Laguna Madre and similar bay areas along the south Texas coast (Gunter & Hildebrand 1951; Moore 1976). However, all of the aquatic mollusks occur farther north than the study locality. While one would expect individuals of such species to withstand even record extreme cold events of the Lower Rio Grande, existence of locally adapted cold-intolerant populations cannot be ruled out. The most likely cause of death of the freshwater snails will be discussed after consideration of the second alternative.

2) Alternatively, a brackish biota could have been devastated by a freshwater/sediment influx following torrential rains (Hubbs 1962; Zimmerman & Chaney 1969; Russell & Wood 1976). Flood debris found along high water levels in creeks and rivers often contains much shell materials as well as living individuals. Hurricane Beulah in 1967 brought torrential rains which caused

extensive flooding and ponding (Grozier *et al.* 1968; Baker 1971).

Orientation of *in situ* fossil shells can provide clues as to the method of deposition and transport of the shells to their fossilized resting spot. Water is less likely to move a shell from a convex-up position than from a concave-up position (Johnson 1957), because the current can reach under and lift the periphery of a concave-up shell. Orientation of *C. floridana* shells was measured at the sediment surface by recording shell position as convex side "up" or "down," in addition to noting the compass direction of the umbo. Of 19 single valves over 12 mm length, 18 were convex-up. Such a preponderance of convex-up over concave-up indicates underwater movement as the former position is the more stable position.

Shells in a current will tend to rotate to expose a symmetrical cross-section to the current (Johnson 1957). Depending upon left-right valve asymmetry and swash zone dynamics, some species exhibit a surplus of either left or right valves (Martin-Kay 1951; Lever 1958). However, no significant inequality (11 left; 8 right valves) was detected for *C. floridana*. A significant hydrological asymmetry apparently exists between right and left valves of *C. floridana*, since umbo orientation of left valves ( $\bar{X} = 201.0^\circ$ ,  $n = 10$ ) differs significantly ( $t < .05$ ) from umbo orientation of right valves ( $\bar{X} = 266.9^\circ$ ,  $n = 8$ ) (see fig. 3). Upstream direction is  $220^\circ$  at sampling plot (downstream current direction is  $40^\circ$  azimuth).

Studies by Nagle (1967) with the fossil brachiopod *Rhipidomella* (which has a shell shape similar to *C. floridana*) revealed non-diagnostic orientation in response to wave action, but a distinct tendency (37 of 41 readings) for the umbo to be directed toward the current (within  $90^\circ$  either direction). *C. floridana* shells tended to orient upstream with 12 of 18 valves positioned with umbo within  $90$  degrees of upstream direction. Kornicker and Armstrong (1959) found that the thicker, i.e., heavier, part of a shell (dorsal margin with umbo for *C. floridana*) tended to drag in the upstream direction as an anchor. In a study of *Dinocardium robustum* (a shell similar in general shape, although much larger, than *C. floridana*), Kornicker and Armstrong (1959) found that left valves rotated counterclockwise while right valves rotated clockwise. Assuming a tendency for the dorsal margin to orient upstream, identical rotational tendencies are exhibited by *C. floridana*. Average rotation of left valves is  $19^\circ$  counterclockwise, while right valves rotated an average of  $46.9^\circ$  clockwise (fig. 3). The inequality in apparent rotation may indicate that a downstream current from a direction of approximately  $235^\circ$  deposited these shells. Bank overtopping with associated loop bypassing could have resulted in such a current direction. Utilization of  $235^\circ$  (rather than  $220^\circ$ ) as the upstream direction from which the water flowed does not result in an increase of shells with umbo oriented upstream (still 12 of a total of 18).

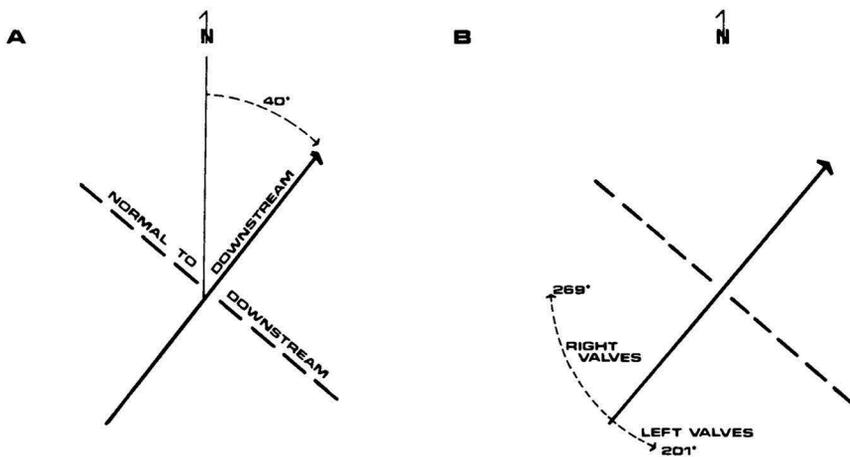


Fig. 3. Orientation of valves of *Cyrenoida* relative to water movement. See text for details.

The above analysis indicates that *C. floridana* shells were deposited under water by a downstream current. Shells of *P. coronatus* were lying in various directions with no predominant orientation (fig. 4). Such a non-diagnostic orientation could have resulted from the lack of a significant long axis upon which the current could act; alternatively, shells of this species may have been deposited in quiet water. Shells of *P. virgata* also showed random orientation (fig. 4).

The preferred hypothesis involves devastation of a brackish fauna by influx of freshwater and associated suspended sediment as the likely origin of this fossil assemblage. While the brackish water fauna is represented by only a single species, paired articulated *Cyrenoida* shells were found *in situ* vertically oriented in the sediment. Death of large numbers of *P. coronatus* and *P. virgata* probably followed death of *C. floridana* as the freshwater body dried out. Several (unindurated) internal molds of the marsh clam (found between

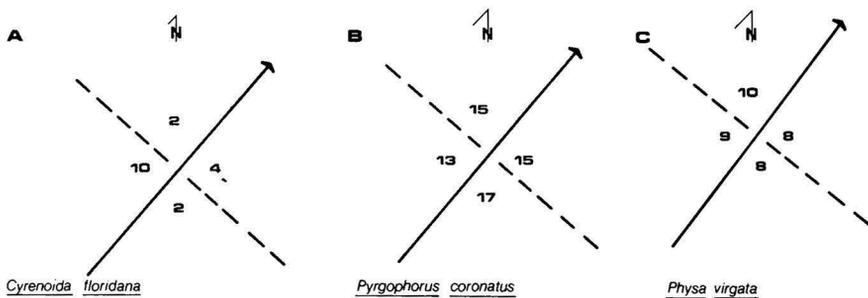


Fig. 4. Orientation of shells of *Cyrenoida*, *Pyrgophorus* and *Physa* relative to water movement. See text for details.

paired articulated *in situ* valves) contain several *P. coronatus*. Another possibility involves the transport of already "dead" shells into the fossil layer area via the original freshwater impulse.

The probable origin of this fossiliferous layer involved runoff freshwater which inundated a brackish marsh. The water probably originated from a heavy thunderstorm rather than river floodwater distribution. Hubbs (1962) reported on the effects of heavy rains due to Hurricane Carla in 1961 within one kilometer of the Resaca del Rancho Viejo locality.

#### PALEOGEOLOGICAL AND PALEOCLIMATOLOGICAL IMPLICATIONS

With the exception of the Florida marsh clam, *C. floridana*, all species found in the assemblage are present in the general area of the site today. Presence of *C. floridana* indicates the presence of a *Spartina/Distichlis* salt marsh, a biotope which is rare in the southern Laguna Madre today except near the Rio Grande (Hoese 1967; Chapman 1974: fig. 1; Brown *et al.* 1980:72; pers. obs.). Examination of small stands of *S. alterniflora* by the author revealed no *C. floridana*. Existence of widespread salt marsh (as demonstrated by the presence of *C. floridana* in a geographical area where it does not exist today) would indicate an alteration of the dominant geo-climatic regime since the time of deposition. Presently, salinities in the Lower Laguna Madre are generally too high to allow extensive salt marsh development (Hoese 1967). The semi-arid lower Texas coast is dominated by wind-tidal flats which replace the coastal marshes of the upper and middle Texas coast. Wind tidal flats generally occur below 0.9 meter above msl although some areas extend up to about 1.5 meters above msl (Brown *et al.* 1980:23, 75).

Such hypersaline conditions have recently been aggravated by anthropogenic factors (i.e., management of Rio Grande flooding, although they have been developing naturally for several thousand years (see Morton & Pieper 1975). Development of a single, relatively cohesive island off the south Texas coast into present-day Padre Island began approximately 5000 years ago as sea level approached present-day condition (Fisk 1959).

Under natural conditions, present-day Resaca del Rancho Viejo was a long lake of varying depth; drainage was blocked by the northward shift of the Rio Grande as it abandoned the Del Tigre subdelta to form the modern Boca Chica subdelta. Prior to this course change by the lowermost Rio Grande, Resaca del Rancho Viejo may have had a discharge route to the Gulf of Mexico (Lohse 1958). However, occurrence of brackish marshes at present elevations of approximately 3.6 meters above msl would require one or more environmental conditions: 1) relative Holocene sea level at elevations higher than previously suggested, 2) much greater tidal amplitudes than occurring at present, 3) occurrence of non-tidal brackish marsh with perched water table.

(1) Elevated Relative Sea Level. Most studies of Holocene sea levels have indicated a general trend of increasing elevation with periodic reversals (Cur-

ray 1960; Shepard 1960; Frazier 1974); however, many difficulties are inherent to sea level studies (Guilcher 1969; Morner 1971; Clark *et al.* 1978). Little indication of sea levels higher than present-day levels has been reported (but see Fairbridge 1958, 1961, 1974; Nelson and Bray 1970; Sneh and Klein 1984). Numerous glacial termini fluctuations have been reported for the Holocene into historical time (Denton and Karlen 1973). However, such fluctuation in glacial ice budgets would have only minor effects on sea level; reduction of Greenland and Antarctic icecaps is required for major rises in sea level. Sneh and Klein (1984) report sea levels in the Mediterranean Sea at one meter above present level at 1500 B.P. and imply a general worldwide condition. Morner (1969) suggested a variable sea level between 3100 and 2400 B.P. involving two transgressions and two regressions; one of these transgressions included a rise above present sea level. Some marsh and estuarine studies along the U. S. Atlantic coast indicate possible variable sea levels (Weiss 1974; Carmichael 1980), but the regional geology is quite different from the western Gulf of Mexico. Sea level at Harbor Island on the south central Texas coast was 6 and 2 meters below present levels in 4900 B.P. and 3400 B.P., respectively (Amdurer *et al.* 1979). Current sea level rise at Port Isabel (near Resaca del Rancho Viejo) has been estimated to be 0.5 cm/yr, mainly due to land subsidence (Swanson & Thurlou 1973). Rise in global mean sea level has been estimated to be 12 cm in the past 100 years (Gornitz *et al.* 1982).

A previous indication of possible higher-than-present sea level in South Texas during the Holocene was discussed by Fulton (1975:181) who reported occurrence of marine foraminifera in core drillings at levels above present sea level. Higher sea level would explain such an occurrence (although hurricane surge tide transport is also possible), in addition to explaining the somewhat anomalous (according to Fulton) height of natural levees of the deltaic plain. The apparent anomaly is the result of erosion of the delta front during the Late Holocene. Although tectonic uplift would result in lowering relative sea levels, such an occurrence is unexpected in an actively depositing deltaic system which is normally characterized by compaction and subsidence. The Mississippi Delta is currently subsiding at a rate of 30 centimeters per century (Akers and Holck 1957; Shepard and Lankford 1959). Note should be made of the discussion of the absence of evidence for Holocene sea level higher than present by Shepard (1960:340). Presence of a brackish marsh at the Tejon Biota site could have resulted from higher sea level but cannot be used as unarguable evidence for such a higher sea level.

(2) Greater Tidal Amplitudes. Tides within the Gulf of Mexico have long been enigmatic (Marmer 1954; Zetler & Hansen 1970). Coastal areas of the Gulf of Mexico experience one of two tidal regimes: 1) diurnal, with one low tide and one high tide in a lunar day; or 2) mixed, with great inequalities between the two low tides and/or two high tides of the lunar day. Gulf tides are classically of very low amplitude, generally less than two meters. The tidal

regimes of the Gulf of Mexico appear to be related to the intermediate size of the body of water, external influences from the Atlantic Ocean and the Caribbean Sea, and harmonic dynamics of the nearly enclosed water body. No major changes in the tidal regimes of the Gulf of Mexico would be expected, given present geographical and sea level conditions (Mid-Holocene to present).

(3) Non-Tidal Brackish Marsh. Water tables in deltaic sediments are characteristically close to the soil surface due to proximity to sea level and substantial water inflow. Natural water tables of the lower Rio Grande have been reduced by anthropogenic engineering activities, i.e., drainage ditches and construction of the upstream Falcon Reservoir. One method of artificially lowering the water table of marshes is ditching, which also affects the natural plant communities (Bourn & Cottam 1950; Chapman 1960). The only significant headward-eroding stream in the lower Rio Grande area is the Arroyo Colorado (Brown *et al.* 1980). While development of this stream began during glacial periods of the Wisconsin, pirating of Rio Grande water flow became significant only during the latter part of the Holocene (since 4500 B.P.). Such pirating would not have affected direction of surface drainage of Resaca del Rancho Viejo, but it may have reduced the amount of water discharged, or lowered the water table.

Of possible significance to the occurrence of salt marsh habitat in the lower Rio Grande during the Holocene is the report of Brown *et al.* (1977:52) of brackish marsh deposits near Laguna Larga, Kleberg County, Texas, at elevation of 10 to 15 ft above msl. They postulated regional uplift, or higher than present sea level, while considering the possibility of the sediment originating in "modern lakes and lagoons which formed several thousand years ago when sea level reached its approximate present level." Such lakes would require an impervious bottom with a perched water table. These lakes may result from local evaporation which draws subsurface salinity to the surface. Aerial input of salt spray could also be involved. The nearest equivalent present-day areas are associated with Port Bay, a tertiary bay feeding Copano Bay (Brown *et al.* 1977:52). This area is less than one meter above msl and supports extensive fresh and brackish water marshes with modern tidal creeks (Brown *et al.* 1976:53).

If one were to assume that at least a portion of Resaca del Rancho Viejo was once a non-tidal brackish lake of the Rio Grande delta, presence of *Cyrenoida* would add a hitherto unreported, although not unlikely, environment for this species. Maintenance of salinity levels could have involved evaporation of periodic floodwaters, drainage from upstream saline areas, evaporative surfacing of subterranean salt, and inland transport of salt spray. Either subaerial transport (via dispersal agents, such as the muddy feet of water fowl) or high-water subaqueous transport would be required to explain the origin of the *Cyrenoida* population in Resaca del Rancho Viejo.

The requirement of one of the above alternatives would be negated by

assumption of temporary dispersal to a marginal habitat, such as *Cyrenoida* floating up the resaca from suitable habitat in the Laguna Madre on a storm surge. Such movement is possible, but the large size of the specimens and existence of young individuals indicates favorable habitat at the site. If such flotation had occurred, *C. floridana* shells would not be restricted to the small area studied, but would occur in downstream sediments also.

Occurrence of *C. floridana* in relatively boreal areas such as Chesapeake Bay and Delaware Bay indicates warm winter water is not a physical factor controlling distribution. Ironically, higher temperatures associated with the decreasing rainfall during the Holocene may have caused the local extinction of *C. floridana*. Seasonality of rainfall may have changed. Presently, the seasonality index of rainfall in South Texas is quite strong with peak precipitation in May/June and September. More equable rainfall, i.e., precipitation more evenly distributed throughout the year, would also foster growth of salt marshes because of the moderated salinity levels.

Alteration of the point of debouchment of the Rio Grande would also have had a moderating effect on the salinity variation of the Lower Laguna Madre. During historical times, a channel of the Rio Grande (Corvinas mouth) with its own distributaries shunted freshwater directly into South Bay, the southernmost part of the Laguna Madre in Texas. At that time *Spartina* marshes were probably somewhat more abundant than today. While I know of no data on such putative decline of salt marshes of the lower Rio Grande during the historical period, Webster (1850) maps fairly extensive salt marshes associated with Boca Chica and Brazos Santiago passes. Loss of freshwater inflow into this area of the Lower Laguna Madre apparently caused decline of oyster production of this area since 1900 (Hedgpeth 1953:139). Price and Gunter (1942) discuss geological and biological changes in South Texas during the historical period. Much of the Texas coast has experienced historical loss of salt marsh habitat (McGowen and Brewton 1975). Diversion of additional freshwater inflow into the Laguna Madre would have eliminated periods of hypersalinity which are inimicable to *Spartina* and probably *C. floridana*.

#### CONCLUDING REMARK

Loss of *Cyrenoida* micro-habitat in southern Texas involved diminution of suitable habitat of salt marshes dominated by *Spartina alterniflora* and *Distichlis spicata*. Habitat loss was triggered by either less effective precipitation, or increases in seasonality of rainfall. Salt marsh habitat was gradually occupied by vegetation-free wind tidal flats. The loss of an emergent plant layer caused greater fluctuations of temperature and substrate water. Subsequent greater generation of hydrogen sulfide in upper substrate layers would also be inimicable to the survival of *Cyrenoida* individuals.

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