THE TULANE GEOLOGICAL COLLECTIONS

In 1956 when Harold E. Vokes came to Tulane University to build up the Geology Department and institute a graduate program in Geology and Paleontology, the collections of fossil and Recent material consisted of the remnants of what originally had been exhibited at the Louisiana Cotton Centennial Exposition. This exposition, which marked the 100-year anniversary of the shipment of the first bale of cotton from the port of New Orleans, was held in what is now Audubon Park, across St. Charles Avenue from the present Tulane campus. Like all such expositions at this time, fossils, minerals, zoological specimens, etc., were sent by countries all over the world (there was a beautiful mineral collection from Uruguay, for example). After the exposition ended the material was donated to Tulane University and for the next 70 years comprised a "natural history museum" in the attic of the main administration building, Gibson Hall. However, in 1956, coinciding with Vokes's arrival, the University disbanded the museum and distributed the specimens between the Geology and Biology departments.

In this collection there were beautiful European ammonites and such, but almost no American fossils. Professor Vokes's first order of priority was to establish a collection of stratigraphic guide fossils for the purposes of teaching Stratigraphic Paleontology. To this end, 49 of the first 50 TU fossil localities are Paleozoic.

But soon Professor and Mrs. Vokes turned to the Cenozoic outcrops of the Gulf and Atlantic Coastal Plain, and in 1962 drove from New Orleans to Isla Mujares, Quintana Roo, Mexico, beginning their fascination with the Tertiary formations of the Isthmus of Tehuantepec. In 1968 a longer drive from New Orleans to Panama introduced them to the beautiful outcrops in Panama and Costa Rica, which were subsequently revisited many times. In 1976 political stability finally permitted collecting in the Dominican Republic and for the next eight years this was the scene of greatest interest.

Other trips added localities in France, Australia, New Zealand, South America, and other sites throughout the world. By 1995, when Mr. Vokes's health ended their activites, the Tulane collection numbered 1545 localities, that last number being, of all places, a hitherto undiscovered locality on the Chipola River, in an area where they already had 55 localities.

At the same time the fossils were being collected, Recent mollusks were also being added to the collections, with a total of 666 localities ranging from Iceland to Antarctica, although the vast majority were more tropical in nature -- especially from the Yucatan Peninsula, as a result of the Vokes's publication on the fauna of that area.

But in 1996 Emily Vokes retired from Tulane, Harold having already been required to retire at the then mandatory age of 70 in 1978. With the realization that no one at the Tulane Geology Department any longer had any interest in these collections it was agreed that the material be placed in institutions where it would be conserved (hopefully) in perpetuity. Therefore, the collections have been dispersed to three institutions. All of the Dominican Republic material, as well as the Paleozoic and most of the Mesozoic localities are now at the Paleontological Research Institution, Ithaca, New York. The rest of the non-U.S. Tertiary, as well as a few Mesozoic localities, are now at the U.S. National Museum of Natural History, Washington, D.C. But the bulk of the collection, including almost all of the U.S. Cenozoic localities, as well as all of the Recent mollusks (except for Australia and New Zealand localities, which were given to the USNM) are now in the Florida Museum of Natural History, Gainesville, Florida.

developing elongate shells (figs. 1-3), and adults being proportionally broader (fig. 4). The brachial valve of *G. inexpectans* contains a single internal lamina just below the beak; the pedicle valve has two. Maximum length of *G. inexpectans* is 47 mm in Virginia (Cooper, 1988), and 56 mm in southern Florida (Florida Museum of Natural History collections, University of Florida, subsequently designated UF).

Outcrop occurrence: Olsson (1914) described *G. inexpectans* from fragmented specimens and one lot of over 20 five millimeter shells recovered from a paired specimen of *Chesapecten jeffersonius* found at Kingsmill, Virginia (UF loc. ZVOO6). The senior author discovered a second scallop shell refugium at Carter's Grove (UF loc. ZV008) containing 155 paired specimens averaging 13 mm (Table 1). Contents of the scallop pair were washed through a 0.5 mm screen to remove the fine sand matrix and all shell residue was examined. Brachiopod shells and shell fragments formed greater than 95 percent of the residue. In contrast, screened bulk samples of surrounding outcrop matrix yield mollusc shell residues with less than one percent brachiopod fragments. The *Glottidia* shells from Kingsmill and Carter's Grove were a light tan color, with an internal wash of white under the laminae. These Zone 1, Yorktown Formation (Sunken Meadow

Member of Ward and Blackwelder, 1980) shells lack anoxic indicators such as micro-pyrite crystals, uniform shell blackening, or chemical degradation. Anoxic environments blacken phosphatic shell over a span of days to weeks (Kowalewski, 1996a). Zone 2 *Glottidia* in silt-clay sediment from Rice's Pit (UF loc. ZV004) and Yadkin (UF loc. ZV007) show tan banding alternating with blackened shell. Florida specimens (UF localities listed below) are similarly blackened with tan banding.

Associated Fauna: Campbell (1993) documented 233 species of lower Zone 2 molluscs from Rice's Pit. The senior author (in preparation) has documented some 220 molluscan species from the Zone 1, *Chama*-protected beds at Kingsmill and Carter's Grove.

Fauna contained with the juvenile *Glottidia* population inside the *Chesapecten* pair include a sparse assemblage of heart urchin spines from *Echinocardium orthonotum* (Conrad, 1843 [1844]), and unpaired valves of the bivalves *Cyclocardia granulata* (Say, 1824), *Modiolus pulchellus* Olsson, 1914, and *Astarte vaginulata* Dall, 1903. Olsson (1914) reported urchin spines, *M. pulchellus*, and a valve of *Diplodonta* in association with his encased *Glottidia*.

In Florida, most carbonate shell is leached from the Bone Valley deposits (UF loc. PO002 and UF loc. PO018), leaving

SIZE FREQUENCY OF SCALLOP-ENCASED *Glottidia inexpectans*

length (mm)	number of individuals
9	0
10	1
11	13
12	19
13	37
14	24
15	6
16	0

Brachial valves (one internal lamina) 155 specimens
Pedicle valves (two internal laminae) 156 specimens

Table 1: Frequency Table of maximum length for the population recovered from the scallop shell, and the proportion of brachial and pedicle valves. Length is given for complete valves only.

the phosphatic brachiopods and a considerable vertebrate faunule. Some localities preserve interfingering Bone Valley phosphate sand and Tamiami limestone in outcrop (Morgan, 1994). Because our specimens are from spoil, we can not rule out the possibility of a Tamiami source, but the surrounding matrix has been typical of the Bone Valley member sand, and we believe that all *Glottidia* recovered from these localities are from the Bone Valley. At the Casa de Meadows pit (UF loc. CH026), calcitic shell is preserved. Occurring with *Glottidia* are molluscs including *Dicathais handgenae* Portell and Vokes, 1992, *Ecphora quadricostata* (Say, 1824), *Pterorytis umbrifer* (Conrad, 1832), *Urosalpinx (Vokesinotus) lepidotus* (Dall, 1890), *Euvola raveneli* (Dall, 1898), *Euvola hemicyclicus* (Ravenel, 1834), *Aequipecten muscosus* (Wood, 1828), *Argopecten* sp., *Amusium mortoni* (Ravenel, 1844), *Leptopecten leonensis* (Mansfield, 1932), *Nodipecten collierensis* (Mansfield, 1932), *Limaria caloosana* (Dall, 1898), *Ostrea sculpturata* Conrad, 1840, *Ostrea compressirostra* Say, 1824; the decapods *Calappa* sp. and a majid crab; barnacles including *Arossia glyptopoma* (Pilsbry, 1916), *Chesaconcavus tamiamiensis* (Ross, 1965), and *Tamiosoma advena* Zullo, 1992; and echinoids including *Arbacia improcera* (Conrad, 1843 [1844]) (= *A. crenulata* Kier, 1963), *Eucidaris tribuloides* (Lamarck, 1816), *Encope tamiamiensis* Mansfield, 1932, and *Echinocardium orthonotum* (Conrad, 1843 [1844]) (= *E. gothicum* (Ravenel, 1848)), (fauna from Portell and Vokes, 1992; Portell and Oyen, 1997; UF collections).

A second species of inarticulate brachiopod, *Discradisca lugubris* (Conrad, 1834) commonly occurs with *G. inexpectans* at Casa de Meadows, and at all Virginia localities. *Discradisca lugubris* is referred to *Discinisca* in most literature, but Cooper (1988) assigns it to *Discradisca*. *Discradisca lugubris* arose in the late Miocene in Virginia and survived into the Plio-Pleistocene Caloosahatchee Formation (UF collections).

Zoogeographic and Stratigraphic Distribution of Glottidia inexpectans: The Yorktown Formation (Pliocene) of the Virginia and northern North Carolina Coastal Plain was divided into a lower Zone 1 and an upper Zone 2 by Mansfield (1944). Ward and Blackwelder (1980) have further divided the Yorktown into four members. A general review of the stratigraphy and its complexities can be found in Campbell (1993). Scott (1988), Morgan (1994) and Allmon *et al.* (1996) provide detail for the Florida formations from which we here report *Glottidia*.

Hertlein and Grant (1944), Chuang (1964a), Cooper (1988), and Portell and Oyen (1997) are the only published records of this species subsequent to Olsson's original 1914 report. The type lot (Paleontological Research Institution 3518, 3519, 3520, and 3521) was collected from Zone 1 beds of the Yorktown Formation (Lower Pliocene), at Kingsmill, north bank of the James River near Williamsburg, Virginia. Subsequent collecting at the type locality confirmed an abundance of fragmented *Glottidia*. This exceptional outcrop has been destroyed by development in 1996. Previously unreported Zone 1 *Glottidia* localities include the spillway of Tutter's Neck Pond just east of Williamsburg, Virginia, and the bluffs at Carter's Grove approximately 1.5 km east of Kingsmill. The scallop-encased *Glottidia* population here reported (Plate 1, UF 81774) is from Zone 1 sands at Carter's Grove.

Chuang (1964a) redescribed the species based on an adult specimen from the lower Zone 2 beds of the Yorktown Formation at the Hampton Heights Dairy Pit. Subsequently, *Glottidia* have been recovered from laterally equivalent beds at Rice's Pit, Hampton, Virginia (Cooper, 1988, USNM 551520a-i; Virginia Museum of Natural History, and USC-Spartanburg collections) and at the Chesapeake Development Co. Pit (Yadkin, City of Chesapeake: USC-Spartanburg collections).

Portell and Oyen (1997) provided the first documentation of *G. inexpectans* outside Virginia. It is also present in the Raysor Marl near Cross, South Carolina (USC-Spartanburg collections; see LOCALITY DATA below).

IV. INTERPRETATION

Ecology of Recent Glottidia: Five species of Recent *Glottidia* have been documented (Dall, 1920; Emig, 1983). *Glottidia albida* (Hinds, 1844) was originally described from Magdalena Bay, Baja California, in 14 meters of water. This species may have a commensal slipper snail (*Crepidula nivea glottidiarom* Dall, 1905) on one or both valves (Dall, 1905; 1920). Keen (1971) synonymized *Crepidula nivea* C. B. Adams, 1852, with *Crepidula striolata* Menke, 1851, but made no mention of Dall's variety or of commensalism. The presence of commensal taxa suggests that *G. albida* is a shallow burrowing species. *Glottidia albida* has been recorded as far north as Monterey Bay, California. Recorded bathymetry ranges from intertidal to 477 meters (Jones and Barnard, 1963; Plaziat *et al.*, 1978).

Glottidia palmeri Dall, 1871, was described from the head of the Gulf of California, with additional records from southern California (Dall, 1920). It is common in lower intertidal mud flats in northeastern Baja California (Kowalewski, 1996a; Kowalewski and Flessa, 1994). Plaziat *et al.* (1978) record a bathymetry of intertidal to one meter. Dead shells of *in situ G. palmeri* are found at a depth of 10 to 20 cm below the sediment surface (Kowalewski (1996a:253).

Glottidia semen (Broderip, 1835) is a little-known Ecuadorian species based on an unique record dredged in 31 meters (Emig, 1983; Plaziat *et al.*, 1978). It may prove synonymous with one of the better-known species.

Glottidia audebarti (Broderip, 1835) was collected in hard, compacted, intertidal sand at a depth of 18 cm. Its type locality is Bay of Guayaquil, western Ecuador. Davidson (1888, posthumous) united *G. audebarti* with the western Atlantic *G. pyramidata* (Stimpson, 1860), a usage continued by Olsson (1914) and Crowder (1931). Dall (1920) showed the two taxa to be distinct. He speculated that after Davidson's death, an incorrect synonomy may have been rendered by the editors. Chuang (1964a) noted that Olsson compared his new fossil species with *G. audebarti* and *G. pyramidata*. Olsson (1914) compared his species with *G. audebarti* only in the sense that the western

Atlantic *G. pyramidata* was considered a synonym. Plaziat *et al.* (1978) record a bathymetry for *G. audebarti* of intertidal to 13 meters.

Glottidia pyramidata (Stimpson, 1860) was described from muddy sand at low tide, Beaufort, North Carolina. Stimpson (1860) reported that Agassiz had a brachiopod specimen from the South Carolina coast. As *G. pyramidata* is the only coastal brachiopod in the area, we may assume that the Agassiz specimen is the first record from that state. Crowder (1931) gave a typical length of 27 mm and width of 10 mm, and reports specimens as "tidal, in vertical burrows, Cape Hatteras to Florida." Fox and Ruppert (1985: 44, 243, 270) reported *G. pyramidata* in mud burrows from protected beach at Debidue Island, South Carolina. They systematically sampled a set of habitats along the northern, central, and southern beaches of South Carolina, so the absence of *G. pyramidata* in two of the three areas sampled indicates patchy, disjunct distribution. Dall (1920) stated that Henderson found the species among the roots of sea grasses 2 feet below the water-sediment interface which would place them well below normal sampling efforts. However, Thayer and Steele-Petrovic (1974) used detailed observation and X-radiography to determine that the normal burrow is "U" shaped and no more than 5 cm deep. Paine (1963) suggests that the Henderson record may represent specimens buried by storm deposition. Alternatively, the Henderson report might be a lapse for "two feet of water." Recorded range is from Hampton and Fort Wool, Virginia, to southern and western Florida, Puerto Rico, and Louisiana (Cooper, 1973; Emig, 1983; Paine, 1970). Life span is about 20 months (Rudwick, 1970). In Florida, colonies of *G. pyramidata* are subject to predation by Tonguefish (*Symphurus plagiusa*) (Cooper, 1973), by Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) (Mason and Clugston, 1993; UF collections), and by larger shorebirds such as Willets (*Catoptrophorus semipalmatus*) (Paine, 1962, 1963). Although sturgeon feed indiscriminately on shallow infaunal organisms (Gilbert, 1989), one sturgeon contained over 500 *G. pyramidata* (UF collections).

Paine (1962) reported up to 90 per cent infection of *G. pyramidata* by a gymnophalline metacercaria trematode larvae, but dismissed the Willet as host of the adult trematode due to a lack of infesting organisms. The records here cited suggest that fish may possibly be host to the adult parasite. Plaziat *et al.* (1978) recorded a bathymetry for *G. pyramidata* of intertidal to 73 meters.

Paine (1963) provided a thorough analysis of the ecology of *G. pyramidata*. Spawning is coincident with spring tides which maximizes offshore transport of larvae. *Glottidia* larvae were a common component of the plankton, and after three weeks of development were swept by the tides and currents into the shallow sublittoral and littoral areas where they settled in optimal habitats, most frequently in sand stabilized by sea grass. Paine (1963) also records planktic "drift larvae" well removed from "optimal habitat" and presumably lost. More recent works document offshore populations in 40 m (Paine, 1970) and 73 m (Cooper, 1973), suggesting that *G. pyramidata* is sparingly distributed across the shelf, but as an infaunal species is rarely collected in deeper waters.

Based on these records, *Glottidia* appears to be most common in intertidal to shallow subtidal tropical and subtropical protected muddy sands where it creates straight (Kowalewski, 1996a) or "U"-shaped burrows. When feeding, the animal creates a diagnostic pattern of one large oval hole flanked by two smaller holes (Rudwick, 1970):

Paleontology and Paleoecology of Glottidia inexpectans: We report a range for *G. inexpectans* essentially congruent with that of the Recent *G. pyramidata*. In both species, southern Florida specimens are larger than more northern populations. *Glottidia pyramidata* grows continuously until death at about 20 months (Paine, 1963). Growth and spawning are interrupted by winter temperatures in the Carolinas and northern Florida populations, but are continuous throughout the year in the southern Florida populations (Paine, 1963). Consequently, southern populations produce larger animals (Dall,

1920). Allmon *et al.* (1996) document upwelling as a nutrient source for the rich Lower and Middle Pliocene faunas of southern Florida. This increase in nutrients should improve diet for the filter-feeding *Glottidia*, further promoting maximum growth. Consequently, size differences between the Virginia and Florida populations are ecologic rather than taxonomic, and all Pliocene lingulid populations from Virginia to Florida are interpreted as representing *G. inexpectans*.

Although the Eocene to Recent distribution of *Glottidia* in the eastern Pacific is semicontinuous (Hertlein and Grant, 1944; Paine, 1963), the distribution of fossil *Glottidia* in the Atlantic and Gulf Coastal plains is disjunct, consisting of *G. glauca* Chuang, 1964c, rare in the lower Claibornian Eocene of Texas (Chuang, 1964c); *G. inexpectans* in the Lower Pliocene, Virginia to Florida; and *G. pyramidata* in the Recent. The lack of continuum may be real, or may be an artifact of selective taphonomic destruction (Kowalewski, 1996b). Lingulids are not likely to be preserved unless catastrophically buried (Kowalewski, 1996a, 1996b). The distribution of Recent *Glottidia* (Plaziat *et al.*, 1978), and their reproductive biology (Paine, 1963) argue for shallow water, coastal habitat, an environment rarely preserved in the Oligocene, and only occasionally in the Miocene of the Atlantic Coastal Plain. However, much of the Pleistocene deposition preserved in the Carolinas and Florida is beach and intertidal to shallow subtidal habitat seemingly well suited for *Glottidia*. Alternatively, during the Pleistocene, numerous tropical and subtropical invertebrate genera retreated to Caribbean refugia. *Glottidia* are conspicuously missing in the Caribbean Cenozoic (Cooper, 1955; Harper *et al.*, 1995, 1997; Emily Vokes, 1996, pers. comm.). This lack of evidence for Caribbean refugia and lack of intervening populations, even when prime lingulid habitat and exceptional preservation occur, suggest that the species of Western Atlantic *Glottidia* may represent independant colonizing events. However, the extinction of *G. inexpectans* approximately coincides with the closing of the Isthmus of Panama, and a western Atlantic refugium

seems more parsimonious than Holocene recruiting of eastern Pacific stock across the land-bridge.

Mortality: The scallop-enclosed population recovered in this study averaged 13 mm (Table 1). The assemblage forms a tight cluster with normal distribution around the mean. Olsson (1914) reported a similar scallop-enclosed population averaging about 5 mm. The uniform size in the two juvenile populations strongly suggest mass mortality. In our specimens, the brachiopods were recovered from within closed valves of *Chesapecten jeffersonius*, which were partially filled with fine sand. The plane of commissure was parallel to bedding, and the scallop appeared to be in life position. This suggests that the scallop shell was slightly gaping in quiet water and partially filled with sediment. The *Glottidia* larvae settled in a single spat-fall, colónized the shell, and then died of starvation or oxygen deprivation after the scallop valves closed, either by relaxation of the ligament, or by burial of the shell. Starvation seems more likely because the shells lack anoxic indicators such as micro-pyrite crystals, shell blackening, or chemical degradation. Alternatively, artic-

ulated pairs may have washed into the shell. However, juvenile *Glottidia* shells are selectively destroyed upon reworking, and brachial valves are more subject to fragmentation than pedicle valves during transport (Kowalewski, 1996a). Also the sediment surrounding the scallop shell yielded a different faunule with abundant small disarticulated clam shells, but few brachiopods.

Paine (1963) determined that the vast majority of *Glottidia* die as larvae. Survivors preferentially populate sea grass beds, achieving a maximum density of greater than 1300 per square meter (Kowalewski, 1996a). The scallop-enclosed population of *G. inexpectans* here reported contained 156 individuals in a 15 cm diameter, circular shell. The area of containment is therefore 0.057 square meters which projects an equivalent population density of 2737 animals per square meter. This density is too great to be explainable by random drift of passive larvae. Settling *Glottidia* larvae are photonegative (Charles Thayer, 1996, pers. comm.), and those settling near a large, gaping bivalve with horizontal commissure would find the shadow attractive. Lingulids attach their pedicles to the base or wall of their

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PLATE 1

Figures

1-5. *Glottidia inexpectans* Olsson, 1914.
  1. UF 81774, length 13.9 mm, pedicle valve from *Chesapecten*-enclosed population. UF loc. ZV008.
  1a. External surface (note more pointed apex).
  1b. Internal view showing double laminae.
  2. UF 81774, length 14.4 mm, another pedicle valve from enclosed population. UF loc. ZV008.
  2a. External surface.
  2b. Internal detail.
  3. UF 81774, length 13.7 mm, brachial valve from enclosed population. UF loc. ZV008.
  3a. External surface (note rounder apex of valve).
  3b. Internal view showing single lamina.
  4. UF 11840, fragment length > 35 mm. Note predatory gastropod bore hole. UF loc. PO002.
  5. UF 11840, nearly complete pedicle valve. Length 56 mm. UF loc. PO002.
  6. *Chesapecten jeffersonius* (Say, 1824). Pair containing the *Glottidia* population. Maximum width 156 mm, maximum height 142 mm, average diameter 149 mm. UF loc. ZV008.
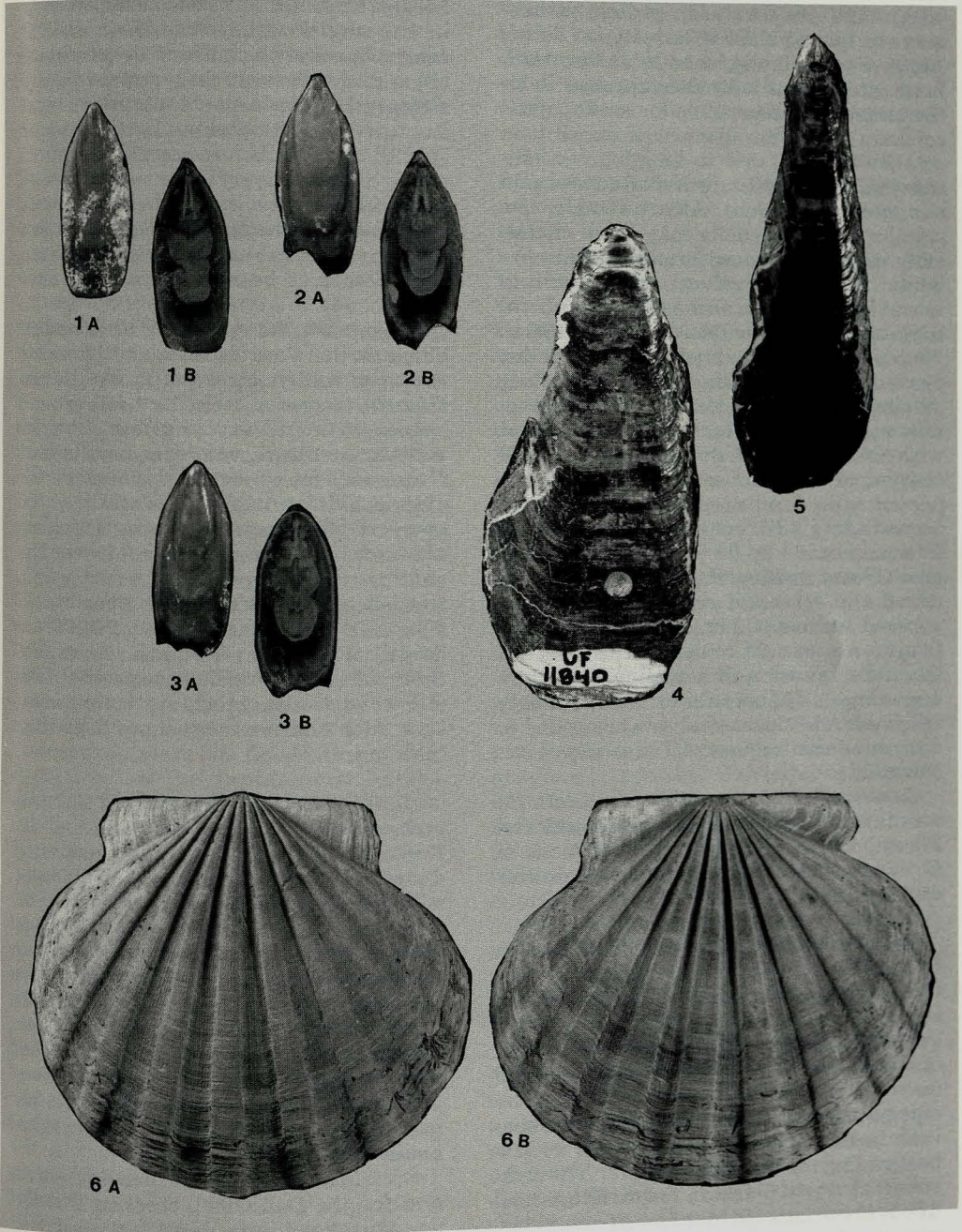 6a. Right valve UF 81775.
  6b. Left valve UF 81775.

PLATE 1

numbers must combine structural integrity with protection from chemical deterioration. The 155 pairs of juvenile *G. inexpectans* here reported and the smaller population reported by Olsson (1914) were preserved within paired valves of *Chesapecten jeffersonius,* a large species of scallop with thick, well-inflated valves. The added protection afforded by this microhabitat appears essential for preservation of unbroken, subadult shells in sand. Stiff silt-clay beds of lower Zone 2 Yorktown and leached silty sand deposits of southern Florida occasionally preserve broken adult *Glottidia* imbedded in matrix.

Glottidia inexpectans has been recovered from mid-shelf assemblages in Virginia indicative of a paleobathymetry of 40 to 60 meters. The Florida assemblage seems indicative of shallower waters, perhaps subtidal to 20 meters.

Glottidia species have been documented from the Atlantic Coastal Plain and Gulf Coast Eocene, Pliocene, and Recent. The stratigraphic gap between the Eocene and Pliocene *Glottidia* may be real, rather than an artifact of taphonomic megabias (Kowalewski, 1996b). However, the western Atlantic and eastern Pacific populations have been physically separated since the Middle Pliocene, necessitating an Atlantic origin for the Recent species.

The exceptional occurrence of abundant paired juvenile *Glottidia* indicates an unusual taphonomic event. *Glottidia* larvae settled in a single spat-fall, colonized a gaping scallop shell, and then died of starvation after the valves closed. Reworking is unlikely because juvenile shells are fragile, pedicle valves are more subject to breakage, and the fauna of the contained sediment differs substantially from that surrounding the scallop shell.

V. ACKNOWLEDGMENTS

VI. LOCALITY DATA

The following are collecting localities of the Invertebrate Paleontology Division, Florida Museum of Natural History, University of Florida (UF).

VIRGINIA
ZV004 Rice's Pit. Shell pit off Fox Hill Road, Hampton, Virginia. (Hampton Quadrangle, USGS 7.5 minute series, 37 degrees, 03 minutes, 37 seconds north, 76 degrees, 14 minutes, 33 seconds west). Lower Zone 2, Yorktown Fm.

ZV006 Kingsmill 01. North bank of James River, 100 meters east of the Marina at Kingsmill Estates, just southeast of Williamsburg, Virginia. (Hog Island Quadrangle, USGS 7.5 minute series, 37 degrees, 13 minutes, 05 seconds north, 76 degrees, 38 minutes, 45 seconds west). Zone 1, Yorktown Fm.

ZV007 Chesapeake Development pit. End of Cooke's Mill Road, between the communities of Yadkin and Deep Creek, Chesapeake, Virginia. (Norfolk South Quadrangle, USGS 7.5 minute series, 36 degrees, 45 minutes, 13 seconds north, 76 degrees, 22 minutes, 05 seconds west). Lower Zone 2, Yorktown Fm.

ZV008 Carters Grove 01. North bank of James River, Carter's Grove Plantation, 4 km southeast of Williamsburg, Virginia. (Hog Island Quadrangle, USGS 7.5 minute series, 37 degrees, 12 minutes, 35 seconds north, 76 degrees, 38 minutes, 02 seconds west). Zone 1, Yorktown Fm.

ZV009 Tutters Neck Dam 01. Spillway of Tutter's Neck Dam, Williamsburg, Virginia. (Williamsburg Quadrangle, USGS 7.5 minute series, 37 degrees, 15 minutes, 05 seconds north, 76 degrees, 41 minutes, 10 seconds west). Zone 1, Yorktown Formation.

SOUTH CAROLINA
ZS013 Lockheed Martin Berkeley County Quarry. Six km south of Rt. 6, on Rt. 59 between Eutaw Springs and Cross, South Carolina. (Cross Quadrangle, USGS 7.5 minute series, 35 degrees, 21 minutes, 08 seconds north, 80 degrees, 14 minutes, 04 seconds west). Raysor Marl.

FLORIDA

CH026 Casa de Meadows 02. Shell pit approximately 1.2 km east of Grove City, Charlotte County, Florida (NE 1/4, NE 1/4, Sec. 16, T41S, R20E; Englewood Quadrangle, USGS 7.5 minute series). Lower Tamiami Fm.

PO002 Ft. Green #13 Dragline. Sand and phosphate pit approximately 6 km south of Bradley Junction, Polk County, Florida (NE1/4, Sec. 2, T32S, R23E; Baird Quadrangle, USGS 7.5 minute series). Bone Valley Member, Peace River Fm.

PO018 Palmetto Mine. Sand and phosphate pit approximately 5 km northeast of Baird, Polk County, Florida (E 1/2, Sec. 9, T32S, R24E; Baird Quadrangle, USGS 7.5 minute series). Bone Valley Member, Peace River Fm.

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The genus *Sarahcarcinus* Blow and Manning, 1996, is transferred from the family Cancridae to the family Portunidae. This reassignment is based on a single specimen also provided by Mr. Palmer, which exhibits a portunid-like front and orbits, characters unavailable for study in formulating our original description.

Repositories: Holotypes and some paratypes are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., and The Charleston Museum, Charleston, South Carolina. Some paratypes, where indicated, are deposited in the Virginia Museum of Natural History, Martinsville, Virginia.

Abbreviations:
ChM No. PI, The Charleston Museum, Invertebrate Paleontology Catalogue Number.

M.M., quarries owned and operated by Martin Marietta Aggregates.

NMNH, National Museum of Natural History, Smithsonian Institution.

USGS, the U.S. Geological Survey (when used with a number indicates a locality).

USNM, abbreviation for catalogue numbers of the former U.S. National Museum, now the National Museum of Natural History.

VMNH, Virginia Museum of Natural History.

Measurements: Expressed in millimeters as follows: cl, carapace length, maximum longitudinal measurement; cw, carapace width, maximum transverse measurement; prl, propodus length, length of palm or combined length of palm and fixed finger; prh, propodus height; prt, propodus thickness; l, length, overall; w, width, overall.

III. ACKNOWLEDGMENTS

IV. SYSTEMATIC PALEONTOLOGY

Family MENIPPIDAE Ortmann, 1893
MARTINETTA, new genus

Diagnosis: Carapace large (cw exceeding 130 mm), transversely oval, strongly convex longitudinally, moderately convex transversely; length about 3/4 carapace width, broadest at anterolateral angle, regions weakly defined.

Fronto-orbital margin slightly less than 1/3 carapace width.

Front quadrilobate, width less than 1/4 carapace width, deflexed at about 45° along midline.

Orbit relatively small, marginal, V-shaped in dorsal view, composed of 4 lobes separated by three closed fissures; inner lobe eavelike, raised well above median and outer orbital lobes.

Basal antennal article relatively narrow, length slightly less than twice width, terminating well below inner angle of suborbital lobe.

Anterolateral margins without lobes or fissures, usually armed with 14 to 16 distinct denticles.

Protogastric and mesogastric regions distinctly elevated, forming broad platform.

Chelipeds unequal in males, right chela larger, massive, height of propodus about four-fifths length, distinctly highest distally.

Type Species: Martinetta palmeri, new species, by present designation and monotypy.

Etymology: This genus is named for Martin Marietta Aggregates in recognition of their considerable contribution to paleontology through their generosity in granting access to their commercial excavations which have provided so

many professional, student and amateur pale-
ontologists with a much needed and enjoyed
window to the past. Gender feminine.

Remarks: In dorsal outline and antero-
lateral denticulation, *Martinetta* very
closely resembles the genus *Harpacto-
carcinus* A. Milne-Edwards, 1862, type
species by orginal designation (p. 46), *H.
punctulatus* (Desmarest, 1822). It can,
however, be separated immediately from
Harpactocarcinus on the basis of its pro-
portionally small, V-shaped (in dorsal out-
line) orbits alone. In contrast, the orbits of
Harpactocarcinus are proportionally much
larger and semi-circular in shape.
Martinetta also has a narrower front, and
broader, more elliptical carapace outline
than *Harpactocarcinus*. *Martinetta* can
further be distinguished from *Harpacto-
carcinus* by its: 1) more transversely flat-
tened carapace; 2) relatively longer
anterolateral margin; 3) low, thin orbital
margins, unlike the raised, thickened
orbital margins of *Harpactocarcinus*; 4)
distinctly elevated protogastric and meso-
gastric regions; and 5) much shorter and
much higher distally, more quadrate, mas-
sive right chela.
Martinetta also appears to be consider-
ably larger than the average specimen of
Harpactocarcinus. Both of our specimens
are about 20% to 25% larger than the
largest of more than 300 specimens of *H.
punctulatus* (including the type of Des-
marest) and *H. jacquoti* A. Milne-
Edwards, 1865, measured by Via (1969, p.
241-256).
The small V-shaped orbits and lack of
deep branchial grooves, characteristic of
Martinetta, easily distinguish it from the
genus *Harpactoxanthopsis* Via, 1959,
which is represented in the South
Carolina middle Eocene by *H. carolinensis*
(Rathbun, 1935).
In outline and general form, the right or
major chela of *Martinetta* is similar to that
found in the genus *Eocarpilius* Blow and
Manning, 1996. However, the right chela
of *Martinetta* can be easily distinguished
from *Eocarpilius* as follows: 1) *Martinetta*
has a strong spine on the superior distal
margin of the carpus, which is lacking on
the carpus of *Eocarpilius*; 2) the superior
margin of the propodus of *Martinetta* is
much straighter than that of *Eocarpilius*;

and 3) the proximal tooth of the right
propodus of *Martinetta* is much lower and
shorter than the same tooth of
Eocarpilius. In *Martinetta* the proximal
tooth of the propodus is about one-third its
length in contrast to one-half the length of
the propodus in *Eocarpilius*.
To a lesser extent *Martinetta* is also
somewhat similar to the extant genus
Menippe, which is represented in the
Middle Eocene Castle Hayne Limestone of
North Carolina by *M. burnsi* Rathbun,
1935. This fossil species is based on an
incomplete, large, left propodus (holotype
USNM 371580) and a series of other par-
tial chelae which do not appear to have
been associated. In outline, the left propo-
dus of the holotype of *M. palmeri* is very
similar to that of the holotype or left
propodus of *M. burnsi,* but unlike the lat-
ter where the left propodus is thickest
proximally, in *M. palmeri* the propodus is
thickest medially. In addition, the superior
margin of the left propodus of *M. palmeri*
is relatively smooth with a few very weak
ridges along its inner surface. By contrast,
the ridges found on both the inner and
outer surfaces of the left propodus of *M.
burnsi* are reticulated, more prominent,
and much more extensive. No carapace or
fragment thereof of the distinctive cara-
pace of *Menippe* has thus far been report-
ed from the carolinian Eocene. Members of
both genera have proportionally small
orbits and raised protogastric and meso-
gastric regions which form a platform.
However, the continuous unbroken, den-
ticulated margin of *Martinetta* easily dis-
tinguishes it from the deeply cut, lobate
margin distinctive of *Menippe.*

MARTINETTA PALMERI, new species
(Plate 1, figure 1; text-figure 1)

Description: Carapace large (cw exceeding
130 mm), transversely oval, strongly convex
longitudinally, moderately convex transversely;
length about 3/4 carapace width, broadest just
posterior to midline at anterolateral angle,
regions very weakly defined.
Fronto-orbital margin slightly less than 1/3
carapace width.
Front quadrilobate, relatively narrow, width
less than 1/4 carapace width, deflexed at about
45° along midline.
Frontal lobes subcarinate along lateral mar-

gins, submedian pair distinctly larger than lateral lobes; submedian lobes subparallel to midline, rounded in dorsal outline, close set, flattened, produced well beyond lateral lobes but not below dorsoventral plane; lateral lobes obliquely set to midline, laterally directed, subacute in dorsal outline, widely separated from submedian lobes, much thicker anteriorly than submedian lobes, each set clearly below inner orbital eave-like lobe and separated from the latter by a distinct lateral indentation.

Orbit relatively small, marginal, V-shaped in dorsal view, composed of 4 lobes separated by 3 closed fissures; inner lobe largest, eavelike, raised well above median and outer orbital lobes; outer orbital lobe about twice width of small median lobe and slightly greater than 1/2 width suborbital lobe; outer orbital angle defined by strong denticle, latter set just above anterolateral margin. Suborbital margin strongly concave, finely granulated below, inner angle subacute, strongly produced, visible in dorsal view.

Antennae incomplete; basal antennal article relatively narrow, lateral margins straight, subparallel, length slightly less than twice width, terminating well below inner angle of suborbital lobe. Basal article not reaching or in contact with lateral frontal lobe.

Antennule incomplete; basal article subtriangular in outline, outer lateral margin with weak carinae anteriorly, inner lateral margin with strong carinae. Article in contact with lateral margin of basal article of antenna along its entire length.

Anterolateral margins without lobes or fissures, strongly arched, converging anteriorly, slightly upturned at anterolateral angle; margins rounded, moderately thick, armed with 14 to 16 distinct, subconical, upturned denticles of subequal size; denticles usually equidistant, sometimes paired; posteriormost pair widely separated from denticle at anterolateral angle; latter strongest of all marginal denticles, distinctly upturned. Dorsal and ventral margins, where unweathered, smooth with scattered

punctae; denticles and surfaces near anterolateral angle finely granulate; ventral surfaces just below denticles finely granulate.

Posterolateral margins weakly sinuous in dorsal outline, strongly convergent posteriorly, length about 4/5 length of anterolateral margins. Margins sightly concave anteriorly where steep; slightly convex, inflated posteriorly.

Posterior margin very weakly convex in dorsal outline, width (estimated) less than 2/3 width of front; margin defined by very low, smooth, flattened, narrow, rim.

Dorsal surface without distinct grooves, regions ill defined, surfaces where unweathered, punctate; surfaces of front, orbits and anterolateral margin appear finely granulate.

Protogastric and mesogastric regions distinctly elevated forming broad platform, margins convergent posteriorly; platform weakly sulcate anteriorly along midline, bordered posterolaterally by shallow depressions.

Urogastric and cardiac regions weakly defined by shallow depression formed by epimeral muscle scars. Urogastric region weakly elevated, badly weathered; cardiac region with two widely spaced, laterally placed, small circular pits, surface otherwise smooth, flattened transversely, very weakly sulcate along midline.

Posterior gastric pits distinct, though small, circular, closely spaced, visible just anterior to epimeral muscle scars.

Intestinal region broader than long, moderately elevated, weakly separated from cardiac region, distinctly separated from branchial regions by broad, shallow grooves.

Pterygostomian region, where adjacent to buccal cavity, broader than subhepatic margin, surface smooth.

Buccal cavity subquadrate, width slightly less than 1/4 carapace width.

Third maxilliped broken, incomplete. Merus about 2/5 length of ischium, concave laterally, raised medially, with shallow, narrow depression along inner margin. Ischium ill-defined, fragmentary.
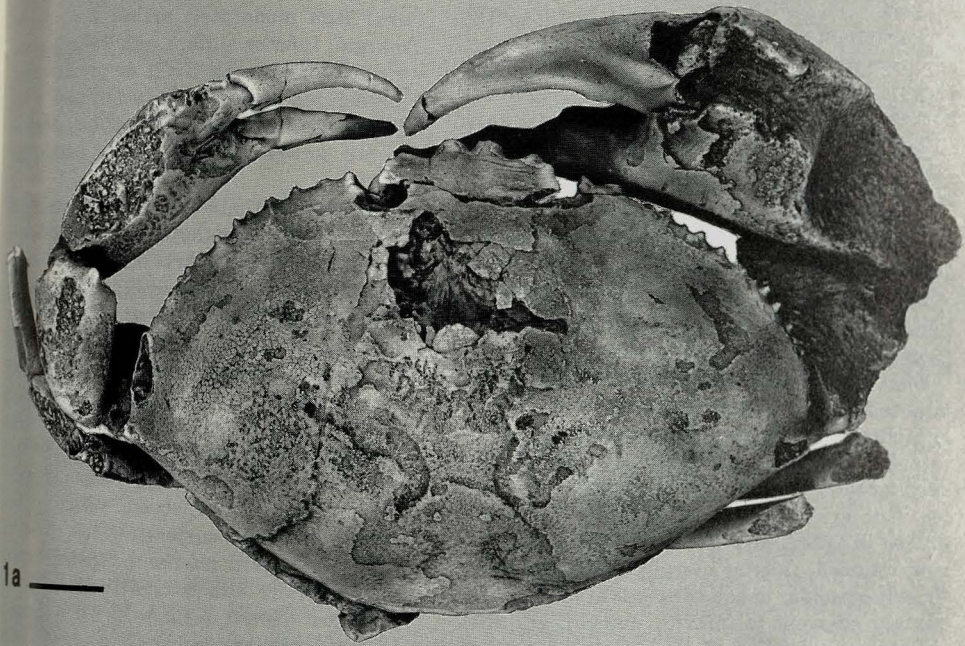

PLATE 1

1. *Martinetta palmeri* Blow and Manning, n. gen. and sp.
    1a. Male holotype, articulated specimen in dorsal view, (USNM 496363), cl 91.9 mm, cw 126.7 mm; right propodus prl 106.4 mm, prh 56.1 mm, prt 31.5 mm; left propodus prl 78.1 mm, prh 30.7 mm, prt 19.9 mm. Scale = 20 mm.
    1b. Male holotype above in ventral view. Scale = 20 mm.

Locality: M.M. Orangeburg Quarry, Orangeburg Co., South Carolina. Santee Limestone.

1a ____
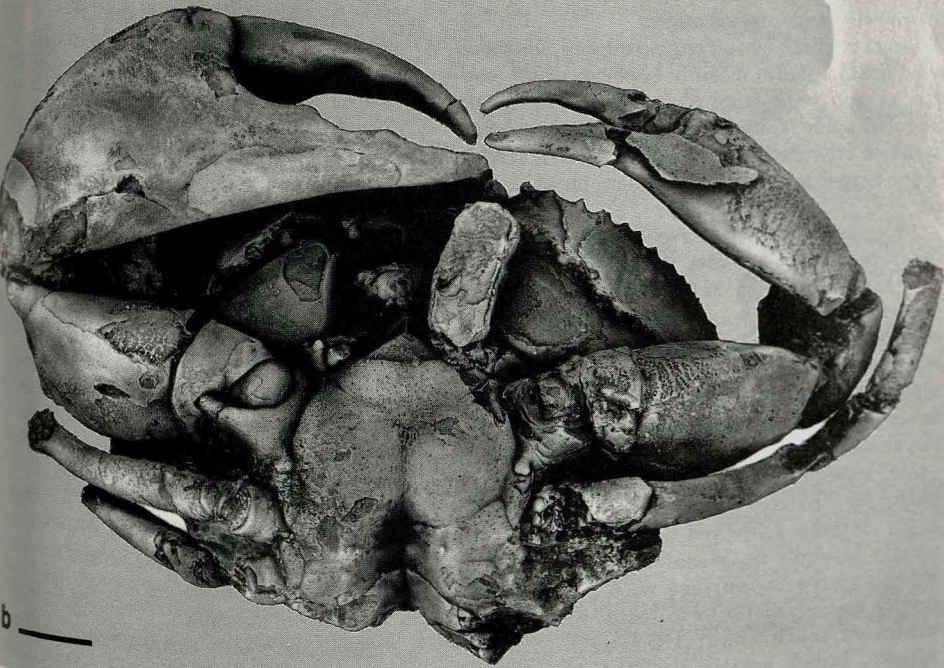
1b ____

PLATE 1

Mandibles visible, broken distally, otherwise covered.

Sternum of male relatively narrow, about 1/3 carapace width, lateral margins convergent posteriorly, sternites 7, and particularly 8, very narrow.

Abdomen lacking, width (estimated) about 1/2 width of sternum, with somites broadening gradually posteriorly as inferred from outline of narrow, deep, abdominal depression.

Chelipeds unequal in males, right or major chela about twice the size of the left or minor chela. Surfaces of both right and left chelipeds punctate and very finely granulate. Most surfaces appear smooth to the unaided eye.

Meri of chelipeds short, length of each subequal to length of associated carpi, each distinctly highest distally; outer surface inflated, punctate with fine granules; inner surface concave, very smooth with few small punctae and very few fine granules. Superior margin strongly arched in lateral and dorsal views; margin narrow, rounded. Inferior margin broad, flattened. Punctae appear most concentrated on outer surface adjacent to inferior margin; granules appear most concentrated along superior margin and distally adjacent to insertion of carpus at superior and inferior angles.

Carpi of chelipeds strongly inflated, flattened near inferior distal margin; superior distal margin armed with a single, strong, obliquely directed spine; spine situated between superior point of articulation with propodus and strong, inner carpal angle; latter swollen, blunt, rounded.

Propodus of major or right cheliped of male massive, height of palm about 4/5 its length, highest distally, steeply sloping proximally; superior margin weakly arched; surface of entire palm densely granulate; outer surface with scattered punctae, most concentrated along or near superior and inferior surfaces; inner surface with weak reticulated ridges near superior margin. Fingers about 4/5 length of palm, subequal in length, widely gaping along entire length; fixed finger in dorsal view moderately deflected inward along entire length, nearly straight in lateral view along inferior margin; superior surface with 2 large, subequally spaced, molariform teeth; first or proximalmost tooth about 1/3 length of finger, largest, broad, greatly elevated distally, stepping down vertically to second, smaller tooth; second tooth about 3/4 width of first, blunt, very rounded marginally, steeply elevated above distal third of finger; tip of finger moderately

upturned, obtuse; moveable finger in dorsal view deflected inward along distal third, in lateral view moderately arched along superior margin; inferior surface with 2 closely spaced, molariform teeth; first or proximalmost, largest, set in opposition to first tooth of fixed finger; second about 1/2 size of first, obtuse, set to fall between first and second teeth of fixed finger.

Propodus of minor or left cheliped of male much smaller than that of major, height of palm about 3/5 length, highest distally, superior surface gently sloping proximally; surfaces of palm badly eroded, fragment of original surface punctate and densely granulate. Fingers of subequal length, 3/5 length of palm; fixed finger deflected downward and inward; superior surface with at least three badly abraded teeth; first or proximalmost obtuse, second highest and like third, subcarinate; distal third of superior surface lacking; tip of finger, obtuse, weakly upturned; moveable finger moderately deflected downward and inward; inferior surface lacking proximally; surface with two subcarinate teeth, proximalmost highest; teeth set to fall in opposition on either side of second or largest tooth of fixed finger; tip of finger obtuse.

Ambulatory legs 1, 2 and 3? present, incomplete; length of 1st excluding dactylus slightly more than 2/3 width of carapace; length of merus of 1st leg about twice length of carpus and 1 1/2 times length of propodus; length of meri of each leg gradually decreasing posteriorly; meri compressed laterally, inner surfaces curved gently forward [anteriorly]; superior surface of legs finely granulate, other surfaces smooth with scattered punctae.

Description of the dorsal aspect of the carapace based principally on paratype ChM No. PI 15214. Description of the ventral aspect of the carapace and the chelipeds based principally on the male holotype. Both specimens are partially articulated with most of their respective cuticles intact.

Etymology: This species is named for the collector of the holotype Mr. Billy T. Palmer, Sr., United States Navy, Retired, who brought it to our attention and in recognition of his volunteer work and extensive collecting efforts for The Charleston Museum.

Holotype: Nearly complete male carapace with articulated chelipeds and ambulatory legs (USNM 496363) cl 91.9 mm, cw 126.7 mm (spines at anterolateral angle missing); estimate of cw complete, 131.0 mm; incomplete right propodus (superior margin missing along
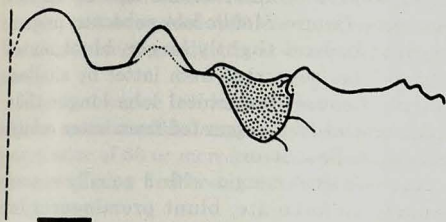
Text-figure 1. *Martinetta palmeri* Blow and Manning n. gen. and sp. Paratype, right frontal lobes and orbit in dorsal view, (ChM No. PI 15355), estimated cw 140.0 mm. Scale = 4 mm.

Locality: M.M. quarry SE of Jamestown, Berkeley Co., South Carolina. Santee Limestone.

distal half) prl 106.4 mm, prh 56.1 mm, prt 31.5; incomplete left propodus (superior margin broken, nearly complete) prl 78.1 mm, prh 30.7 mm, prt 19.9 mm.

Type Locality: M.M. Orangeburg Quarry, Orangeburg County, South Carolina. Santee Limestone.

Paratypes: Incomplete carapace with fragments of sternum and articulated right merus and incomplete left cheliped (ChM No. PI 15214) cl 95.2 mm, cw 130.3 mm (left margin eroded, nearly complete) estimate of cw complete to tips of denticles 140.0 mm; right merus (nearly complete) l 45.6 mm; left propodus prl 34.3 mm, prh 14.5 mm, prt (covered). M.M. Berkeley Quarry, Berkeley County, South Carolina. Santee Limestone.

Associated weathered right and left halves of incomplete carapace (VMNH 904). Fragmentary right half of carapace including partial orbit, anterolateral margin with adjacent ventral surface and pterygostomian region intact, and articulated merus with fragments of carpus and propodus present, cw 86.7 mm, estimated cw of entire carapace, if complete, 165.0 mm; right merus l 38.8 mm; fragment of left half of carapace including partial anterolateral margin with adjacent ventral and pterygostomian region surfaces, overall length of fragment 48.2 mm; M.M. Georgetown Quarry, Georgetown Co., South Carolina. Santee Limestone.

Carpus and propodus of right or minor cheliped (ChM No. PI 15295) combined length of both [carpus and propodus] 108.3 mm, prh 38.7 mm, prt 24.9 mm. Incomplete carpus and propodus of right cheliped, fingers lacking (ChM No. PI 15296) prl (to base of fixed finger) 61.0 mm, prh 53.2 mm, prt 29.9 mm. Incomplete right or major propodus with associated incomplete front, right orbit, and about half? of the right anterolateral margin of carapace (ChM No. PI 15355) prl (incomplete, proximal end missing) 105.3 mm, prh (incomplete, superior margin missing) 56.5 mm, prt (incomplete, cuticle of inner surface missing) 35.1 mm. (ChM Nos. PI 15295, PI 15296 and PI 15355) M.M. Quarry SE of Jamestown, Berkeley Co., South Carolina. Santee Limestone.

Occurrence: Santee Limestone, South Carolina.

Remarks: Of the two large crabs known to co-occur in the Santee Limestone, *Martinetta palmeri* and *Eocarpilius carolinensis,* carapaces of the latter are by far the more common. The three articulated specimens of *M. palmeri* on which our description is based and two or three others collected or seen by Mr. Palmer are the only specimens of this large crab known to the authors.

Family XANTHIDAE MacLeay, 1838

XANTHIDAE MacLeay, 1838, p. 59 [name on *Official List*].

EOHALIMEDE Blow and Manning, 1996

Type species: Eohalimede walleri Blow and Manning, 1996, p. 22, by original designation.

EOHALIMEDE SAUNDERSI, new species
Text-figure 2

Eohalimede walleri Blow and Manning, 1996, p. 22, paratype only (USNM 484581).

Diagnosis: Very similar to *Eohalimede walleri* in carapace outline, placement of prominences, and general character, but without mushroom-shaped prominences. In contrast to the mushroom-shaped prominences of *E. walleri,* the elevated surfaces of this new species are covered with clusters of tubercles.

Description: Carapace suboctagonal, width greater than length, broadest at second lateral tooth; regions well defined, distinctly elevated, apex of most with distinctive clusters of small
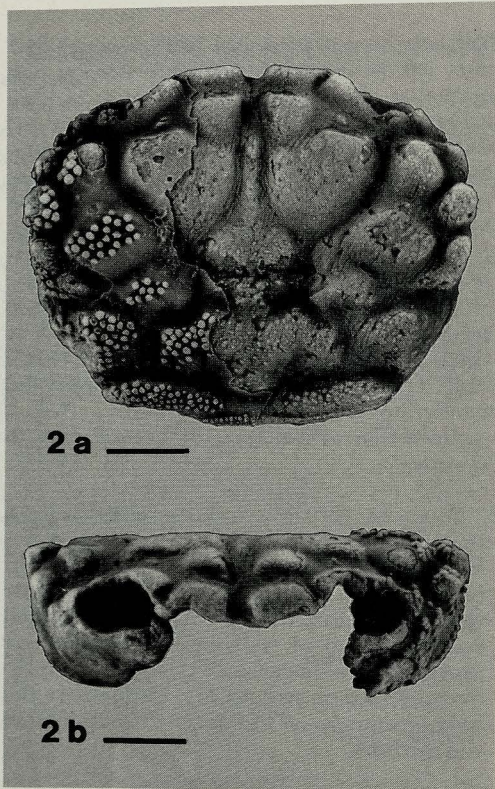
Text-figure 2. *Eohalimede saundersi* Blow and Manning n. sp. (2a.) Holotype, carapace in dorsal view, (ChM No. PI 15210), cl 9.5 mm, cw 11.0 mm. Scale = 2 mm. (2b.) Holotype above, carapace in anterior view. Scale = 2 mm.

Locality: M.M. Orangeburg Quarry, Orangeburg Co., South Carolina. Santee Limestone.

tubercles, surfaces of carapace though very finely punctate, appearing smooth to unaided eye.

Fronto-orbital width about 3/4 carapace width.

Front weakly projecting, bilobed, with deep, wide, median incision, width about 1/3 carapace width; lobes weakly divergent, truncate, thickened anteriorly, lower margins beaded.

Orbit oval (length 1 1/3 height), about half width of front, not produced beyond margin of carapace, composed of four unequal lobes, each decorated marginally with small, low, tubercles. Inner orbital lobe swollen, length slightly

longer than middle and outer orbital lobes combined, separated from middle lobe by distinctive, deep fissure. Middle lobe subacute, projecting just beyond slightly larger, blunt, outer orbital lobe, separated from latter by shallow, narrow fissure. Suborbital lobe longer than inner orbital lobe, separated from outer orbital lobe by shallow fissure.

Anterolateral margin with 3 equally spaced, densely tuberculate, blunt prominences (or rounded teeth); first and second round, third elongate; first distinctly smaller than second and slightly smaller than third, set well behind orbit, flanked mesially by broader, elongate, hepatic cluster of tubercles; second and particularly third flanked mesially by large subrectangular epibranchial cluster of tubercles.

Posterolateral margin with a large, broadly triangular, raised prominence of clustered tubercles boarded laterally by deep grooves; outer or lower flank of prominence broadest, flattened; inner or upper surface of prominence narrowing while extending onto mesobranchial region, where highest.

Posterior border slightly concave at midline, width about one-third carapace width, margin defined by finely beaded rim.

Dorsal surface, exclusive of postfrontal and epigastric regions, regularly ornamented with about 17 clusters of low, peg-like tubercles; superior surfaces of tubercles round, smooth; surfaces between tubercle clusters, broad, smooth.

Postfrontal region narrow, deep, outermost surface lacking, without tubercles, apparently smooth.

Epigastric region very inflated anteriorly where truncated and highest, surfaces without tubercles, smooth.

Protogastric region broadly subcircular, not subdivided into lobes, surface with about 15 scattered tubercles; tubercles appear largest and most concentrated along anterolateral margin.

Mesogastric region broad basally, low, covered with tubercles; anterior extension slender, low, with three tubercles, one posterior and two near anterior end where extension separates epigastric lobes basally.

Urogastric region low, very narrow, ridgelike; surface defined by transverse row of 7 to 8 small tubercles; row separated from base of mesogastric region by narrow shallow groove marked by distinct, close set, slit-like, posterior gastric pits.

Cardiac region T-shaped; cross of T with 2

relatively small, submedian, elongate, tubercle clusters, each paired with slightly smaller, sub-circular, metabranchial tubercle cluster; base of T a single, much smaller, oval cluster of tubercles.

Intestinal region low, smooth, bordered laterally on metabranchial region by narrow, elongate cluster of 50 or more low tubercles; cluster rising, widening and becoming more dense laterally.

Branchial region uneven, subregions distinct, elevated and separated by shallow, smooth, grooves.

Epibranchial region with largest tubercle cluster, subrectangular in shape, obliquely directed inward, anteriorly converging; cluster set near outer angle of protogastric lobe and separated from same by cervical groove.

Mesobranchial region with two tubercle clusters, the first, a central, single small cluster set near the submesial angle with the urogastric lobe and the second, a much larger cluster extending from the posterolateral margin.

Metabranchial region defined by prominent, elongate, transversely placed tubercle cluster near the posterolateral angle and a single much smaller subcircular cluster adjacent to the cardiac lobe.

Description based on complete dorsal aspect of carapace with much of the cuticle intact.

Etymology: This species is named for Albert E. Saunders of The Charleston Museum, in recognition of his contribution to South Carolina paleontology and in grateful appreciation for his years of support for the first author's research.

Holotype: Carapace (ChM No. PI 15210) cl 9.5 mm, cw 11.0 mm.

Type Locality: M.M. Orangeburg Quarry, Orangeburg Co., South Carolina. Santee Limestone.

Paratypes: Incomplete internal mold, without surface detail, of carapace with remnant of base of front present and the left lateral margin lacking (USNM 484581) cl (incomplete) 12.1 mm, cw (incomplete) 11.9 mm; locality USGS 26882 M.M. Berkeley Quarry, Berkeley County, South Carolina. Santee Limestone.

Incomplete carapace, remnant of left orbit present, right orbit and right anterolateral margin lacking (ChM No. PI 15200) cl 12.3 mm, cw 13.7 mm (incomplete), estimated cw 14.4 mm; M.M. quarry SE of Jamestown, Berkeley Co., South Carolina. Santee Limestone.

Occurrence: Santee Limestone, South Carolina.

Remarks: Those regions with elevated tubercle clusters appear highest and more coarsely tuberculate anteriorly with each sloping posteriorly, suggesting that these short ridges, like the much longer ridges found in *Lophoranina* (see Savazzi, 1981), might have aided this species in back burrowing.

Only three specimens of this species are thus far known to us.

V. LOCALITY DATA

M.M. Georgetown (= Jamestown) quarry, approx. 2.8 miles (4.5 km) N 33°E of Jamestown, on W side U.S. 17A, Georgetown Co., South Carolina.

M.M. Berkeley (= Cross) quarry, approx. 5.3 miles (8.5 km) SE of Eutawville, and about 2.2 miles (3.5 km) S 20°E of South Carolina Rtes. 6 and 45 intersection with secondary hwy 59 (Berkeley-Orangeburg Co. line road) on E side of secondary hwy 59, Berkeley Co., South Carolina.

M.M. quarry, S side South Carolina Rte. 45, 4.2 miles SE of South Carolina Rtes. 45 and 41 intersection in Jamestown, Berkeley Co., South Carolina .

M.M. Orangeburg quarry, W side South Carolina Rte. 59, 5.7 miles N of South Carolina Rte. 311, Orangeburg Co., South Carolina.

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December 30, 1997