TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 7, Number 3 December 29, 1969

OBSERVATIONS ON THE GENUS *MILTHA* (MOLLUSCA: BIVALVIA) WITH NOTES ON THE TYPE AND THE FLORIDA NEOGENE SPECIES

HAROLD E. VOKES
TULANE UNIVERSITY

CONTENTS

ILLUSTRATIONS

I. ABSTRACT

The genus *Miltha* H. & A. Adams, 1857, has been the subject of much misunderstanding and mis-interpretation, largely as a result of the rarity of the type species, "*Lucina*" *childrenae* Gray, in museum collections. Described from "Brazil" by Gray, the species was confused by Carpenter (1864) and following him, Dall (1901, 1903) with the species from Baja California subsequently named *Miltha xantusi* by Dall (1905). At the time of his monograph on "The Tertiary Faunas of Florida" Dall had seen no specimens of the type species and treated *Miltha* as a subgenus of *Phacoides* "Blainville," giving it an unjustifiably broad interpretation that was uncritically accepted by a number of subsequent authors. As a result fourteen species from the Tertiary of eastern North America have been referred to *Miltha*, only two of which, *M. chipolana* (Dall) and *M. caloosaensis* (Dall), are here accepted as correctly referred to that genus, with two others, *M. heracleus* (Dall) and *M. smithwoodwardi* (Maury) being placed in the synonymy of *M. chipolana*. The other ten species are here referred to *Armimiltha, Eomiltha, Plastomiltha* or *Saxolucina*.

Miltha s.s. includes species that, in the adult stages, differ in degree of inflation of the opposite valves; in the species here studied either valve may be inflated with no predominance of one over the other observed in any species. The valves have a fine concentric ornamentation with a weak and obscure radial ribbing. Anterior and posterior dorsal areas are defined by incised grooves; the posterior is well developed, but the anterior may be rather obscure. The lunule is small, confined to the right valve and more or less deeply impressed into the area immediately below the umbos. The adult hinge includes two cardinal teeth in each valve, the posterior right cardinal and the anterior left one are bifid, the others simple, more or less lamellar. There is no trace of lateral teeth in the adult hinge, but both anterior and posterior laterals are present in small, immature forms. These same forms also show a well developed escutcheon, a remnant of which persists in the adult valves as a flat, plate-like protrusion of the right valve that is partly broken away by the action of the enlarging fibrous portion of the ligament.

The interior of the valve bears ridges and grooves that reflect structures in the mantle area including the attachment area of the gill demibranchs, the trend of the large pallial blood vessel and, apparently, the presence of a "non-ridged fold" margining a region of "mantle gills" such as have been described in other lucinid genera by Allen (1958) and others. The anterior and posterior adductor scars show clear evidence that these muscles included both "striated" and "smooth" types of muscle fibers—as do other species of Lucinidae.

The two recent species of *Miltha, M. childrenae* and *M. xantusi* both occur in waters of 28 to 30 fathoms or more in depth, and both appear to prefer fine sandy types of bottom sediment.

The oldest species of *Miltha s.s.* appears to be *M. packi* (Dickerson) from the Domengine Formation, middle Eocene, of California. "*Phacoides*" *montensis* Cossmann is a possible ancestral type. No certain upper Eocene or Oligocene forms have yet been recognized, but the genus is present in the lower Miocene of California, Florida, and New Zealand, persisting to the Recent in tropical waters of the eastern Pacific and the western Atlantic Oceans.

Three species of *Miltha* are present in the Florida Neogene deposits: *M. chipolana* Dall, from the early Miocene Chipola Formation; *M. caloosaensis* Dall, from the upper Miocene Pinecrest beds, and the Pliocene Caloosahatchee Formation; and *M. carmenae*, new species, from the early Pleistocene "Unit A" beds from the region south and south east of Lake Okeechobee, Florida.

II. INTRODUCTION

During a visit to the Pascagoula, Mississippi, station of the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Mrs. Gladys B. Reese, Fisheries Biologist, drew my attention to a collection of specimens of the rare and imperfectly understood *Miltha childrenae* (Gray) that had been dredged by the M/V *Oregon* off the northeastern coast of Brazil. Comparison of these specimens with the original descriptions and specimens in the Tulane University collections of the Florida Neogene species of *Miltha* indicated that there has been much misunderstanding and published misinformation concerning the genus. The following observations are presented in an endeavor to give a more accurate knowledge of the genus and its North American western Atlantic species.

III. ACKNOWLEDGMENTS

The acumen of Mrs. Gladys B. Reese, Fisheries Biologist, who recognized that the Brazilian specimens of *Miltha childrenae* merited study and who called them to my attention is greatly appreciated. I am indebted also to Mr. Harvey R. Bullis, Jr., Base Director of the Pascagoula station, who permitted me to borrow them for comparison with the Florida specimens. Mr. and Mrs. Robert C. Hoerle of West Palm Beach, Florida, gave free access to their extensive collections of fossils from southern Florida and donated a number of specimens to the Tulane University collections; their continuing kindness and cooperation is much appreciated.

The care with which the members of the editorial committee reviewed the manuscript is most sincerely appreciated. Dr. Keen also made available data concerning specimens of *Miltha xantusi* (Dall) in the Stanford University collections, and Dr. Hertlein furnished information on references not available to me.

This study has been part of a program for the investigation of Tertiary and Recent species of Mollusca from the western Atlantic region conducted by my wife and I under the auspices of National Science Foundation Grant GB-6048. Much of the material upon which it is based was collected under the aegis of this grant and the financial assistance of the foundation is gratefully acknowledged.

IV. Genus MILTHA H. and A. Adams, 1857

1857, *Miltha* H. and A. Adams, Genera Rec. Moll., vol. 2, p. 468.
1876, *Milthea* Meek, Rept. U. S. Geol. Surv. Territories (Hayden), vol. 9, p. 130, 131 [as "*Milthea* H. and A. Adams"].
1931, *Milthoidea* Marwick, New Zealand Geol. Surv., Paleont. Bull. 13, p. 70.
1938, *Miltheoidea* Marwick, Chavan, Journ. de Conchyl., vol. 82, p. 64.

Type species, by monotypy, [*Lucina* (*Miltha*)] "*Childreni* Gray" [= *L. childrenae* Gray, 1824]: Recent, Atlantic Ocean off Brazil.

Miltha was proposed as a subgenus of *Lucina* Bruguière with the original diagnosis: "Shell inequivalve, with the surface of the valves nearly smooth. Hinge with the lateral teeth obsolete."

Examination of the original description and illustrations of *Miltha neozelanica* Marshall and Murdock (1921, p. 78, pl. 16, pl. 17, fig. 1) leave no doubt but that this form is a typical *Miltha* and that *Milthoidea* Marwick, 1931, of which this species is type, by original designation, is a synonym of *Miltha* as previously noted by Stewart (1930, p. 191) and by Chavan (1938, p. 64).

A. *History of Previous Interpretation of the Genus*

Distribution of type species.—Although the type species was described as early as 1824 and subsequently well figured (the hinge and interior of the right valve by Sowerby [1826, Genera of Shells, Pt. 27, *Lucina*, fig. 2], and the hinge of the left valve and exterior of the right by Reeve [1850, Conch. Icon., "*Lucina*," sp. 12]), the rarity of the type species has led to much misunderstanding, not only of its provenance and distribution, but also of its essential characters. This misunderstanding apparently was initiated by Carpenter who, in commenting upon a collection of shells made by Mr. J. Xantus at Cape San Lucas, Baja California, lists (1864, p. 620) *Miltha Childreni*, adding: "A few fresh specimens correct the habitat 'Brazil,' previously assigned to this extremely rare and remarkable shell, . . ." Earlier (p. 522), in noting that a price of £10 10s. had been listed for two specimens of this species in the sale of Tankerville collection, he stated: "There is no authority for the statement that it came from Brazil. The Br. Mus. specimens are from the 'Mus. Cracherode,' and are probably West Coast. The only known locality is Cape St. Lucas."

Carpenter's conclusions were accepted by subsequent authors, especially Dall: (1901, p. 812) " . . . the locality, Brazil, given in the Conchologia Iconica, is erroneous."; (1903, p. 1377) " . . . living in the Gulf of California." Later, upon receiving a specimen of the true *childrenae* collected at Pernambuco, Brazil, Dall (1905, p. 110) acknowledged that his above locality citations were in error and (p. 111) named the Gulf of California species *Phacoides* (*Miltha*) *xantusi*. But Dall's 1905 paper seems to have been rather generally overlooked and among others we find Maury stating in the discussion of her "*Phacoides* (*Miltha*)" *smithwoodwardi* (1917, p. 369): "This species is apparently the ancestor of . . . *M. childreni* Gray . . . living in the Gulf of California." As late as 1953, Olsson and Harbison, after correctly citing the species as from Brazil (p. 88), refer to it, on p. 89 as "the Recent *Miltha childreni* from the Gulf of California."

Species previously included in Miltha.—The misunderstanding concerning the essential characters of the species to be referred to *Miltha* appears to stem primarily from the work of Dall, who in 1903 assigned it to a position as a subgenus of *Phacoides* "Blainville" typified by *Lucina jamaicensis* Lamarck, a species with the anterior cardinal obsolete and the posterior reduced, but with strong laterals. He recognized three species groups in his "subgenus" *Miltha* (1903, p. 1374):

"A. Species of which the surface sculpture is characterized by concentric lamellation like *P.* (*M.*) *disciformis* and *hillsboroënsis* of Heilprin.

"B. Species compressed, high, with fine concentric striation, like *P.* (*M.*) *Childreni* Gray and *caloosaënsis* Dall.

"C. Species with sculpture similar to the last but more convex and elongated with a somewhat sinuous basal profile, like *P.* (*M.*) *pandatus* Conrad and *Voorhoevii* [*sic*] Deshayes."

Dall listed or discussed 12 American Tertiary and Recent species that he referred to *Phacoides* (*Miltha*). His arrangement was followed by Maury (1917, pp. 368-9) and by Gardner (1926, pp. 111-2) each of whom added two new species. In terms of present interpretation the following assignments may be made of these species:

1. Forms referred to group "A" of Dall:

Lucina disciformis Heilprin (1886, Trans. Wagner Free Inst. Sci., vol. 1, p. 94, pl. 11, fig. 28) = type of *Armimiltha* Olsson and Harbison (1953, p. 83).

Lucina hillsboroensis Heilprin (1886, *ibid.*, p. 117, pl. 16, fig. 62) = *Armimiltha.*

Cyclas claibornensis Conrad (1865, Amer. Jour. Conch., vol. 6, p. 146) = type of *Plastomiltha* Stewart (1930, p. 191).

Phacoides (*Miltha*) *riocanensis* Maury (1917, Bulls. Amer. Paleontology, vol. 5, p. 369, pl. 61, fig. 7) = *Armimiltha.*

Phacoides (*Miltha*) *heilprini* Gardner (1926, U. S. Geol. Surv., Prof. Paper 142C, p. 112, pl. 19, Figs. 7, 8) = *Armimiltha.*

2. Forms referred to group "B" of Dall:

These are for the most part the species referred to *Miltha s.s.* and discussed in the present paper. It is to be remembered, however, that as noted above, Dall misapplied the name "*Childreni* Gray" to the Gulf of California species now know as *Miltha xantusi Dall.* In addition to *childrenae*, the following named species have been referred to this group: *caloosaensis* (Dall, 1898), *chipolana* (Dall, 1903), *heracleus* (Dall, 1903), and *smithwoodwardi* (Maury, 1917). The latter two are here held to be synonyms of *chipolana.*

In addition to the species listed, Dall added *Lucina claytonia* Harris (1896, Bulls. Amer. Paleontology, vol. 1, p. 183, pl. 16, figs. 10, 10a), stating that it "is also a *Miltha* belonging to group B of the section." This species was tentatively referred by Stewart (1930, p. 184) to *Saxolucina* (*Codalucina*) and by Chavan (1938, p. 70) to *Saxolucina.*

3. Forms referred to group "C" of Dall:

Lucina pandata Conrad (1833, Amer. Jour. Sci., vol. 23, p. 343) = *Eomiltha* Cossmann, 1911.

Phacoides (*Miltha*) *ocalanus* Dall (1903, p. 1375, pl. 50, fig. 14). The position of this species, known only from internal casts, is uncertain. As noted by Dall the cast has the form of *pandata* [= *Eomiltha*], but the elongate structure, interpreted by Dall as the posterior adductor scar, is entirely unlike anything to be observed in *pandata* or other species of *Eomiltha.* The same structure is well shown in Harris' (1951, pl. 39, fig. 7) figure of a specimen from Reddick, Florida, and it cannot, therefore, be interpreted as of pathologic origin. Specimens in the Tulane collection are also similar in this respect, but one seems to show a small, divided posterior adductor scar, similar to those found in *Eomiltha,* occupying the ventral end of the impressed area. This latter shell, however, appears to have had an edentulous hinge and may well represent a species of *Pseudomiltha.*

Phacoides (*Miltha*) *xustris* Gardner (1926, U. S. Geol. Surv. Prof. Pap. 142C, p. 112, pl. 20, figs. 1, 2) = *Eomiltha* Cossmann, 1911.

4. Species tentatively referred to *Miltha* by Dall without assignment to one of his "groups":

"*Dosinia* (later *Lucina*) *gyrata*" Gabb, 1865, (Palaeontology California, vol. 1, p. 168, pl. 23, fig. 148) has been referred to *Eomiltha* by Stewart (1930, p. 192, pl. 12, fig. 11).

Lucina subobliqua Say (1824, Jour. Acad. Nat. Sci. Phila., vol. 4, p. 147). According to Dall (1903, p. 1378) this species "is still unfigured and I have not seen specimens. It would appear to be a *Miltha* from the description, though only four-fifths of an inch in length, and was obtained from the Miocene of Maryland, probably in St. Mary's County." This species appears not to have been reported since its original description, and cannot be given any definite generic assignment at this time.

The Recent species from the Mozambique Channel, *Lucina voorhoevei* Deshayes (1857, Jour. de Conchyl., vol. 6, p. 106, pl. 2, fig. 1), mentioned by Dall as a species of his "group C" has been referred to *Eomiltha* by Stewart (1930, p. 190) and Chavan (1938, p. 93, as "*voorhoovei*").

The general absence in American collections of specimens of the Recent species of *Miltha* and the fact that Dall in his great monograph on the Tertiary Faunas included under that name forms that are today referred to five different lucinid genera rather clearly explains the general lack of appreciation of those characters that serve to delimit the genus.

Furthermore, it is clear from statements made by Dall that he had not seen the original descriptions of Gray. Thus, in 1901 (p. 806), he states: "The type is *Lucina childreni* Gray, 1825, as *Tellina.*", and in 1903 his first entry in the synonymy of his "*Phacoides* (*Miltha*) *Childreni* Gray" is: "*Tellina Childreni* Gray, Ann. Phil., xxv., p. 136, 1824; Zool. Journ., i, p. 221, 1825." In both entries, the dates of which were reversed by Dall following an error first perpetrated by Sowerby, the species was referred to *Lucina*, and in both it was given the feminine termination, "*childrenae.*" It was not until 1828 that it was referred to *Tellina* by Wood in the "Index Testaceologicus."

B. *Characters of Genus* Miltha

Valve inflation.—Perhaps the most striking result of this broad interpretation of the genus has been a failure to realize the significance of the differing degree of inflation of the two valves as a character of generic importance. Yet it was this feature, and especially the fact that of the two specimens available in the Tankerville collection one had an inflated right and the other an inflated left valve, that was the basis upon which Gray first defined the type species (see page 116). An examination (Table 1) of 768 valves of four species from the Western Atlantic region[1] indicates that in *Miltha*, unlike other bivalvian genera with differing inflation of the two valves, either

	LEFT VALVES					RIGHT VALVES					
SPECIES	"flat"		"inflated"			"flat"		"inflated"			TOTAL
childrenae	0	—	1	(= 1)		4	—	4	(= 8)		9
carmenae	47	—	27	(= 74)		46	—	49	(= 95)		169
caloosaensis	89	—	101	(= 190)		118	—	85	(= 203)		393
chipolana	60	—	45	(= 105)		56	—	36	(= 92)		197
	196	—	174	(= 370)		224	—	174	(= 398)		768

Table 1: Tabulation of the distribution of 420 "flat" and 348 "inflated" adult valves of species of *Miltha s.s.* examined during this study. The 9 valves of *M. childrenae* are from the collections of the U. S. Fish and Wildlife Service. Of the others, 166 are in the collections of Mr. and Mrs. R. C. Hoerle, West Palm Beach, Florida, and 593 are in the Tulane University collection.

---

[1] No specimens of *Miltha iheringiana* Doello-Jurado from the Tertiary Entrerrienne Formation of Entre Rios, Argentina, have been available. See: Doello-Jurado, 1919, *Physis*, Rev. Soc. Arg. Sci. Nat., vol. 4, p. 558.

valve may be more inflated than its opposite. The development of differing degree of inflation is a progressive feature in the ontogeny of the individual. Small valves of immature individuals are almost equally inflated and, in general, it is only after they have attained a height of about 25 mm that differentiation can be observed. Of the 768 larger valves available for this study 53% of the left and 56% of the right, or a total of 55% of all specimens, were of the less inflated type, a feature suggesting that the more inflated forms are less resistant to crushing or breakage than are the relatively flatter ones.

In all species the more inflated valve is slightly larger than the less inflated, which fits within it with a slightly beveled edge permitting tighter closure.

Ornamentation.—The surface in both valves is ornamented primarily by low, round-topped concentric growth lamellae. These are usually stronger near the margins than on the central part of the valve and and often become sufficiently strong on the anterior and posterior dorsal areas to give them a somewhat rugose appearance. In addition to this concentric ornament there is a weak radial ribbing that is usually visible only under strongly oblique lighting (see pl. 1, figs. 1-4). Individual ribs are low and round-topped, variable in width on different parts of the shell, being usually more abundant and narrower toward the umbonal region, becoming wider ventrally, apparently mainly by the dying out of the small groove-like interspaces between them. These ribs are probably most strongly developed —though always very weak—on the valves of *Miltha childrenae* and weakest on those of *M. carmenae.* In both of these species the individual ribs tend to be relatively wider than they are on the valves of *M. chipolana* and *M. caloosaensis.*

A second form of radial ornamentation consists of small, sub-parallel to anastomosing, microscopic grooves (pl. 1, fig. 4, insert). These are best developed in the interspaces between the concentric lamellae and may be an expression of the arrangement of the prisms in the upper shell layer.

Finally, there is also a series of minute raised threads that have a variable but generally tangential trend (pl. 1, figs. 5, 6). These are usually best seen toward the lateral margins of the valves, but occasional remnants may be observed on all parts of the valve surface (see pl. 1, figs. 1 and 2 —to the right of the center of each figure) and presumably would be universally present on completely unworn valves.

The most notable feature of the valve ornamentation is the development of anterior and posterior dorsal areas that are set off from the rest of the surface by grooves radiating from the umbo. The posterior area, always considerably larger and more strongly developed than the anterior, is usually said to bear in its median area a longitudinal sulcus of variable strength that divides it into two more or less equal parts. Examination of well preserved specimens suggests that the surface would better be described as having a rather strong rounded rib on the antero-ventral segment of the area, separated from the main valve surface by the strong sulcus that defines the inner margin of the area. The crest of this rib is equal to the height of the adjacent valve surface, while the portion dorsal to it is depressed below that level. The strength of the so-called "median sulcus" is a factor of the degree of roundness of the rib. If it is well rounded so that the postero-dorsal side is steep, a "sulcus" appears to be present, but if the postero-dorsal slope is broad and gradual no delimiting "sulcus" can be observed (compare figs. 1

→

PLATE 1

Portions of the surfaces of specimens of *Miltha* photographed under strong oblique lighting to emphasize minor features of the valve ornamentation. All magnifications are approximately four diameters except fig. 4 insert, which is fourteen diameters. Figures 1-4 are of median areas of the valve surface to show variations in the radial ribbing; figures 5 and 6 are near the ventral margin to show the obliquely tangential thread-like ridges. Figs. 1 and 6, *Miltha (Miltha) childrenae;* figs. 2 and 5, *M. (M.) carmenae;* fig. 3, *M. (M.) chipolana;* fig. 4, *M. (M.) caloosaensis.*

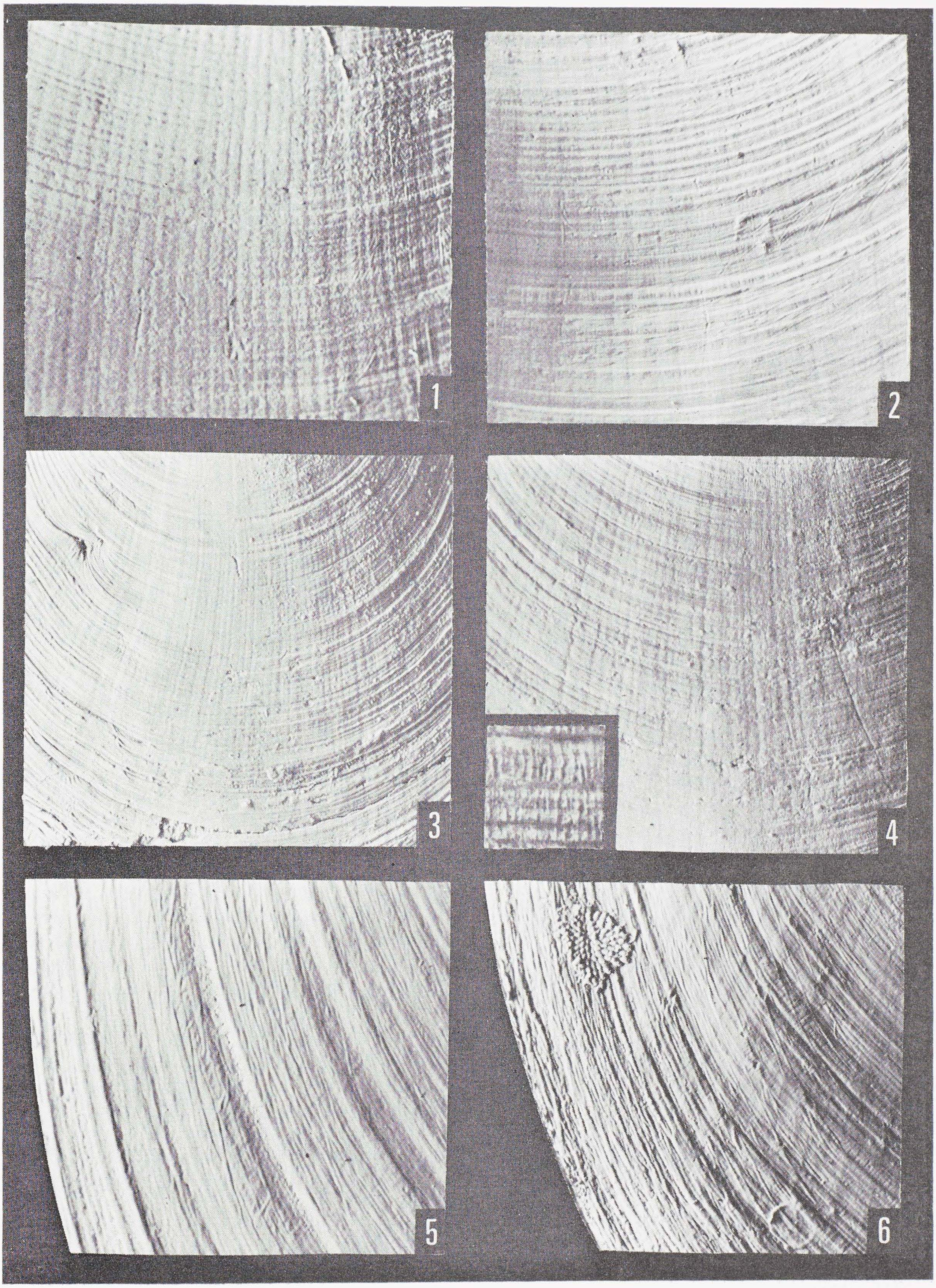


PLATE 1

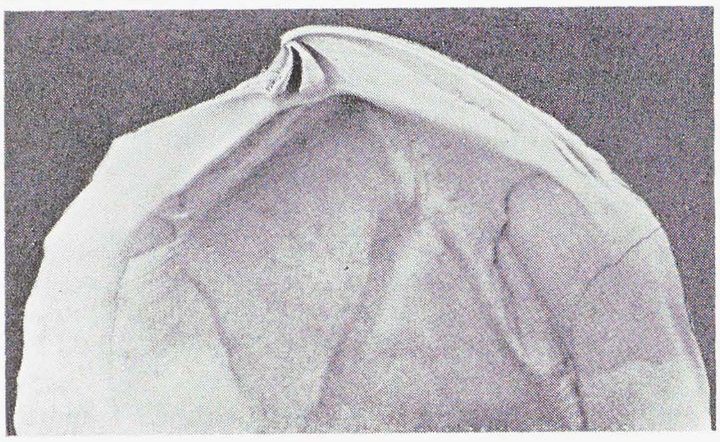
and 4, pl. 4). In none of the specimens studied has it been possible to observe a true median groove on the area.

The strength of this rib is variable and not a character of value for specific discimination within the genus. It is, perhaps, most consistently narrow and steep-sided on *M. caloosaensis*, but even in this species there are numerous specimens with a sloping postero-dorsal side. In contrast, the rib is weak, almost absent, on most specimens of *M. carmenae* but is narrow and high on one individual valve.

The anterior dorsal area is always small and narrowly elongate, usually not strongly delimited from the main surface of the valve. It is best developed on *M. caloosaensis*, with its ventral limits defined, on the more inflated valve, by an irregular, raised rib and, on the flatter valve, by a narrow and shallow rounded groove. Similar though weaker delimiting structures are present in the other species examined. The rib on four of the five available inflated valves of *M. childrenae* is delimited both ventrally and dorsally by a narrow impressed groove, and three of the four less inflated valves have a second shallow groove near the median portion of the area.

The shape and nature of the delimiting structures of the anterior dorsal area is complicated by the manner in which the anterior dorsal margin of the less inflated valve folds over and displaces the adjacent part of the margin of the inflated valve. This tends to accentuate the strength of the rib and the depth of its limiting ventral groove on the inflated valve and usually to broaden and almost erase the groove on the flatter one.

Lunule.—The small lunule has become impressed and limited to the right valve, where it lies closely adjacent to the anterior cardinal tooth and projects to fit into a depressed area on the left valve. In most species the lunular projection on the right valve has impinged upon the anterior cardinal to the extent that the combined projecting margin and the tooth serve almost as a single bifid unit (see pl. 2). In some specimens of *M. chipolana*, however, the lunule has almost completely absorbed the cardinal (text fig. 1).



Text figure 1. Hinge of a right valve of *Miltha chipolana* (Dall) (USNM 646398) in which the impressed lunular margin has almost completely absorbed the anterior cardinal tooth. (× 1½).

The extent to which the lunule has become impressed into the valve varies considerably between species but is relatively constant within them. It is least impressed in *M. childrenae* (pl. 2, fig. 1a), where it lies almost parallel with the anterior dorsal slope of the valve, making an angle of approximately 65° from the vertical of the valve height and is most deeply impressed in *M. caloosaensis*. In this species the lunule is characteristically concave, with its dorsal one-third to one-half vertical to slightly inwardly sloping and its more ventral portion trending anteriorly at an angle of 35° to 40° from the vertical (pl. 2, fig. 3a). The dorsal portion of the lunule in this species tends to overtop and become closely appressed against the dorsal portion of the anterior cardinal tooth, only the ventral segment of the tooth remaining functional. In *M. carmenae* (pl. 2, fig. 2a) the lunule lies at an angle of about 30° to the vertical, but due to the more steeply sloping anterior dorsal margin of the valve is not as deeply impressed as it is in *M. caloosaensis*. There is more variation in the nature of the lunular area in *M. chipolana* than in any of the other species investigated during this study. This is in keeping with the general trend in that in almost all characters noted, the greatest degree of individual variation occurs in this, the oldest of the western Atlantic species. The extremes of this variation in the lunule are represented in the specimens figured (see pl. 2, fig. 4a and text fig. 1). On the average the lunule is very slightly concave inward and the degree of its immersion varies so that its angle with the vertical ranges from 22° to 40°.

The lunular margin of the left valve is excavated for the reception of the projecting lunule of the right. In most specimens the depth of the excavation is approximately equal to the depth of the socket for the reception of the right anterior cardinal tooth. The socket and the excavation are, however, always separated, usually by a slight ridge (see pl. 2, figs. 2b and 4b). In *M. caloosaensis*, where the lunule has impinged most strongly upon the cardinal, and as a result obliterated its dorsal portion, the ridge is more strongly developed and cuts off the dorsal part of the socket becoming fused with the anterior face of the bifid left anterior cardinal tooth.

Ligament.—The ligament is deeply inset between the valves, essentially opisthodetic in position and of the paravincular type. The outer lamellar ligament is relatively thin and elongate, occupying almost the entire posterior dorsal area of the valve. It is inserted in a shallow groove that is deeper and more distinct on the relatively inflated valves than it is on those of lesser inflation. The fibrous resilifer lies well below the lamellar ligament and is considerably shorter. It is received upon a long, more or less lanceolate nymph, whose dorsal margin is slightly raised above the level of the hinge plate but whose ventral side is level with or slightly impressed into the plate except at its posterior extremity where it generally rises to the level of the dorsal side. The anterior end of the nymph parallels the thin posterior cardinal tooth of the right valve, and the socket for its reception in the left and curves dorsal to the tooth to extend all the way to the tip of the umbo. In the left valve the nymphal margin is delimited from the cardinal socket by a thin and low shell lamina.

Two of the right valves of *M. childrenae* show a remnant of the fibrous ligament in the extreme dorsal ends of the cardinal sockets, where it is set on a thin shell lamina, and from which it appears to extend on to the inner edge of the lunule. A number of the fossil specimens also show thin shell laminae bridging the dorsalmost extremities of the sockets slightly below their top, and it may well be that in these as in the Recent specimens, the fibrous ligament while functionally opisthodetic was actually slightly amphidetic in position (pl. 4, fig. 4).

It is interesting to note that the fibrous ligament is preserved in all of our fossil specimens. Fibers from the Recent *M. childrenae* when treated with dilute hydrochloric acid reacted with strong effervescence and were dissolved so completely as to leave no visible organic material even under magnification.

A flange projects at right angles to the right valve slightly below its dorsal edge. In all specimens it is broken away except toward the posterior extremity, where it lies immediately above the groove for the reception of the lamellar ligament (see pl. 2, figs. 1a, 2a, 3a, 4a; pl. 4, fig. 4; pl. 5, fig. 3; pl. 7, figs. 2, 4, 5; pl. 3, fig. 2d). The broken anterior end of the flange is almost always at, or but slightly behind, the posterior end of the nymph and the fibrous ligament, and the breakage would seem to be a function of the "bulging" of this portion of the ligament when compressed by the closing of the valves.

Hinge teeth.—The hinge, in the adult (pl. 2), consists of two cardinal teeth in each valve, of which the posterior cardinal (**3b**) in the right valve and the anterior (**2**) in the left valve are more or less bifid and more strongly developed than the adjacent right anterior (**3a**) and left posterior (**4b**) cardinals. These latter are simple and tend to be rather lamellose. All teeth are somewhat curved, do not completely cross the hinge plate, and all tend to be somewhat undercut along at least one of their sides.

There is a considerable amount of variation within the individual species, but in general it is evident that the bifid cardinals are most deeply divided in *M. caloosaensis*, least so in *M. chipolana* and *M. carmenae*. In the latter species the younger (*i.e.*, smaller) adult specimens have these teeth somewhat more deeply grooved than in the older and larger forms. In view of this fact it may be that since *M. caloosaensis* is the smallest of the species here studied, the greater degree of bifidity is a result of its smaller average size.

The greatest variation occurs in the right anterior cardinal and is a result of the encroachment of the lunular margin. The most striking result of this encroachment is, as noted above, to be found in *M. caloosaensis* where the dorsal segment of the cardinal is obsolete and aborted. In *M. chipolana* and

M. carmenae the anterior end of the cardinal becomes fused against the side of the lunule and the tooth is somewhat shorter than the median cardinal of the same valve. The less deeply impressed lunule in *M. childrenae* overtops the cardinal at its dorsal end and becomes fused against the anterior side of the bifid posterior tooth (pl. 2, fig. 1a) to form a lamellar plate for the reception of the anteriorly projecting ligament. The dorsal end of the anterior cardinal becomes reduced in height but continues under the plate apparently without being otherwise affected by the lunular structure.

C. Development of the hinge and associated shell features

A number of juvenile specimens of *M. chipolana* were secured from matrix washings from Tulane University locality 555 on the banks of the Chipola River, Calhoun County, Florida. Study of these revealed that while the adult specimens of the genus are marked by the absence of anterior and posterior lateral teeth, these are functionally present in the immature stage of development. Furthermore, the lunule, which in the adult is confined to the right valve, is relatively large, lozenge-shaped, and present in both valves. Perhaps most unexpected was the presence of a well-marked, elongate escutcheon in the smaller of the juvenile specimens.

Lunule.—In the smallest of the specimens available the lunule and the escutcheon are both relatively large, elongate, lozenge-shaped, and about equally well developed in both right and left valves. The inner margin of the lunule is raised in both valves with the edge of the right slightly projecting only in its more posterior portion where it is adjacent to the anterior cardinal tooth. In this valve the posterior end of the raised lunular margin is continuous dorsal to the cardinal teeth and unites with the anterior end of the small nymph plate (pl. 3, figs. 2a-2d). In the youngest left valves the posterior end of the lunular margin crosses above the dorsal end of the relatively large and deeply bifid anterior cardinal and passes without evident interruption into the dorsal end of the lamellar posterior cardinal (pl. 3, figs. 1a, b). It thus appears that at this early stage of development the lunular margin of the right valve was dorsal to that of the left. During subsequent growth the lunule does not enlarge as rapidly as does the rest of the valve and thus progressively becomes relatively smaller until in the adult it is only a little longer than the right anterior cardinal. During this development the margin of the right impinges more and more over and against the left, the inner edge of which in turn gradually recedes although retaining the raised margin. This becomes narrow and lamellar and persists as a narrow ridge separating the projecting right lunule from the adjacent anterior cardinal tooth. The connection of the left lunular margin with the left posterior cardinal is broken at an early stage of this development, but the dorsal end of this cardinal is above the

---

→

PLATE 2

Typical hinges of species of *Miltha* (ca. × 1.7). Note in the right valves (figs. 1a, 2a, 3a, 4a) the differing shape and degree of submergence of the impressed lunular margin, and the varied effect of this submergence upon the anterior cardinal teeth; and in the left valves (figs. 1b, 2b, 3b, 4b) the depressed area on the hinge plate for the reception of the right lunular margin and the low ridge that separates this area from the anterior adductor socket. In *M. caloosaensis* (fig. 3b) note that the latter ridge becomes a raised lamella that crosses the socket to fuse with the dorsal portion of the bifid anterior cardinal tooth. Figures 2a and 3a also show well the plate-like remnant of the former escutcheon, the anterior part of which is characteristically broken away, apparently by the action of the enlarged fibrous ligament, portions of which are preserved in all specimens. The corresponding left valves show the very narrow groove, distant from the nymph plate, in which was lodged the thin lamellar ligament. Figs. 1a, 1b: *Miltha (Miltha) childrenae* (fig. 1b being a somewhat immature specimen—the only left valve in the collection); figs. 2a, 2b: *M.* (*M.*) *carmenae* (holotype); figs. 3a, 3b: *M.* (*M.*) *caloosaensis;* figs. 4a, 4b: *M.* (*M.*) *chipolana.*

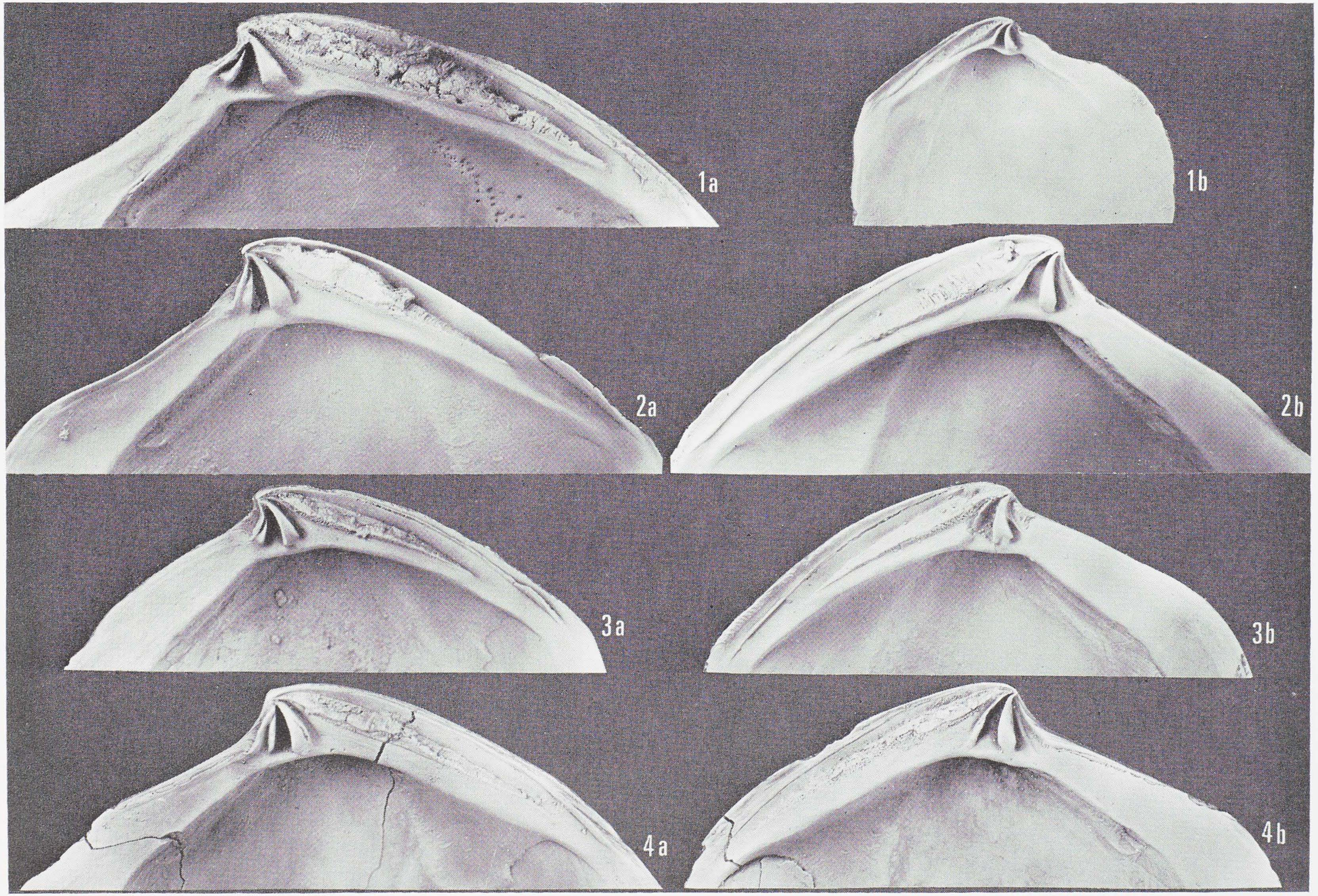


Plate 2

end of the anterior cardinal at all stages of growth.

Escutcheon.—As indicated above, the discovery of a well defined escutcheon present on the more immature valves was quite unexpected, especially since this structure is typically absent in almost all lucinids, except in species of the genus *Myrtea* Turton, 1822. The smallest specimens of *Miltha chipolana* here studied possessed a rather large escutcheon that extended from immediately behind the umbo almost the full length of the posterior dorsal margin. It is almost flat, at right angles to the rest of the valve surface, smooth except for fine lines of growth, and is delimited on its outer side primarily by a series of raised, somewhat thickened ends of the growth lamellae that ornament the main posterior area of the valve, including the dorsal area. In sum total of its features this escutcheon is like that to be seen on *Chione cancellata* (Linnaeus).

As growth proceeds the outer edge of the escutcheonal area appears to rise progressively above the flattened surface. The area of the right valve, as in the development of the lunule, displaces the escutcheonal margin of the left until it is wholly below the projecting valve surface, its former presence marked only by a low ridge dorsal to the groove in which the lamellar ligament is inserted. The "flange" that projects at right angles to the dorsal part of the right valve (see page 101) is the remnant of the escutcheon. It apparently falls victim to the pressures developed by the enlargement of the fibrous ligament, for even in relatively small specimens (pl. 3, fig. 2d; 11.2 mm in length) it has been broken away dorsal to the area occupied by that structure.

Hinge.—The cardinal teeth of the hinge in the immature specimens are similar to those of the adult, the only differences being that the left anterior cardinal is proportionately more trigonal and more deeply bifid, and the left posterior somewhat more robust in the immature form. Initially all cardinal teeth except the right anterior one occupy the full width of the hinge plate.

The striking difference between the juvenile and adult hinges is the presence in the former of anterior and posterior lateral teeth. In these specimens, single small and more or less elongate laterals are present in the left valves that are received in rather prominently developed sub-marginal sockets in the right valves. In the left valve immediately below the anterior end of the well-defined lunule there is an almost nodular anterior lateral tooth (**AII**) the dorsal side of which is continuous with the raised lunular margin, giving the tooth the superficial appearance of being somewhat obliquely transverse to the trend of the hinge plate (pl. 3, figs. 1a, 1b). This tooth is received, in the right valve, in a distinct and prominent socket that occurs between the raised lunular margin and a strong, elongate, anterior lateral (**AI**) that, in the smallest specimen available, appears to arise more from the dorsal side of the valve interior than from the inner edge of the hinge-plate itself (pl. 3, fig. 2b). In all larger specimens (pl. 3, figs. 2a, 2c) it is located upon the inner edge of the plate. This tooth is sub-triangular in profile with its apex situated below the anterior end of the lunular margin. As growth proceeds and the lunular area becomes proportionately smaller, the right lateral tooth becomes relatively more and more elongate and more anterior in position with respect to the portion of the lunular margin that initially formed its opposite element of the lateral socket. As it loses its function as a confining element for the left anterior lateral it becomes reduced in height but persists into the adult hinge, where its presence is marked by a low and inconspicuous raised ridge that

→

PLATE 3

Development of the hinge and associated features in *Miltha* (*Miltha*) *chipolana* (Dall). All figured approximately × 9.6; all specimens from Tulane University locality TU 555, Chipola Formation, Chipola River, Florida. Figures 1a-d, left valves: 1a, USNM 646403; 1b, USNM 646404; 1c, USNM 646405; 1d, USNM 646406. Figures 2a-d, right valves: 2a, USNM 646399; 2b, USNM 646400; 2c, USNM 646401; 2d, USNM 646402.

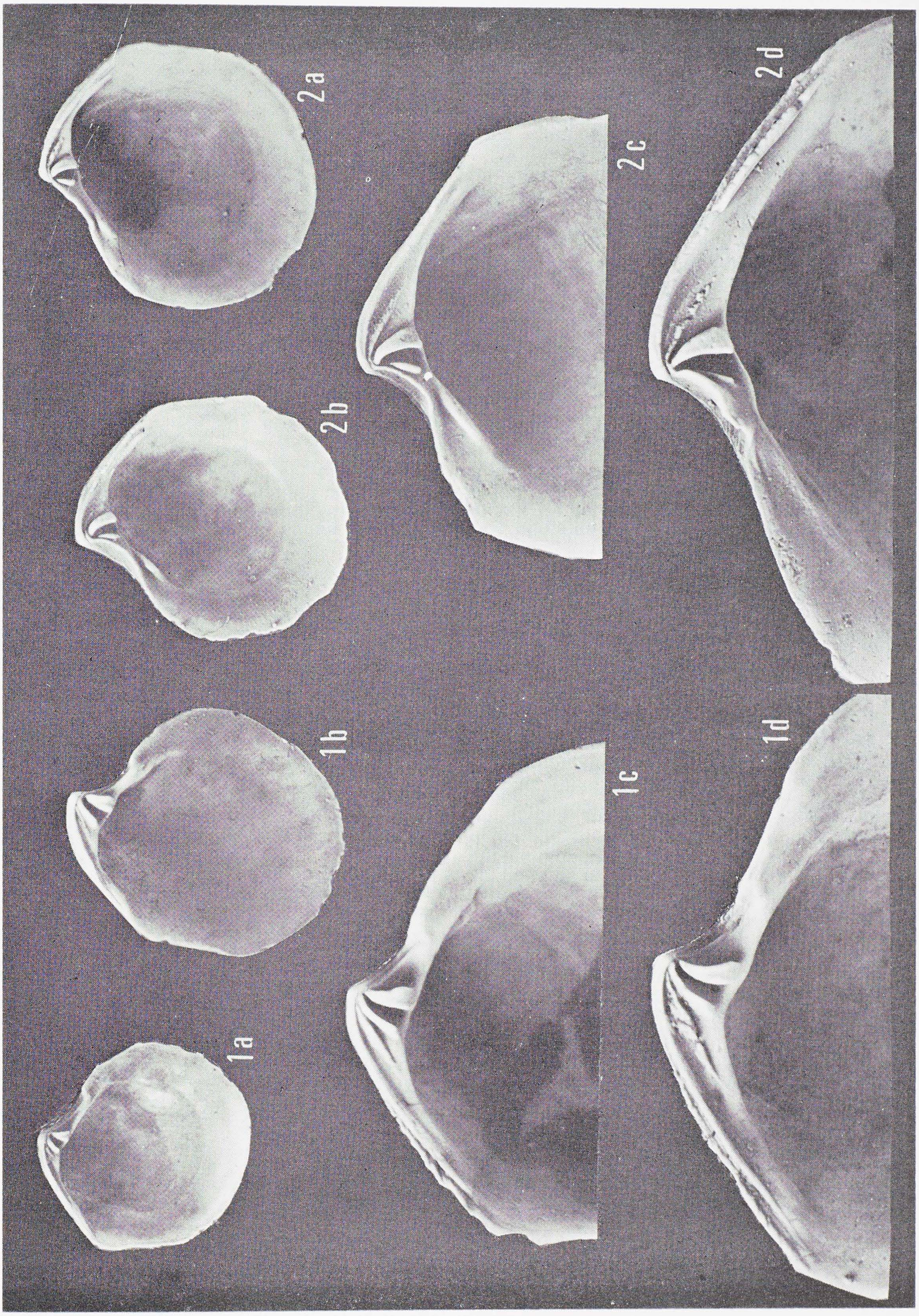
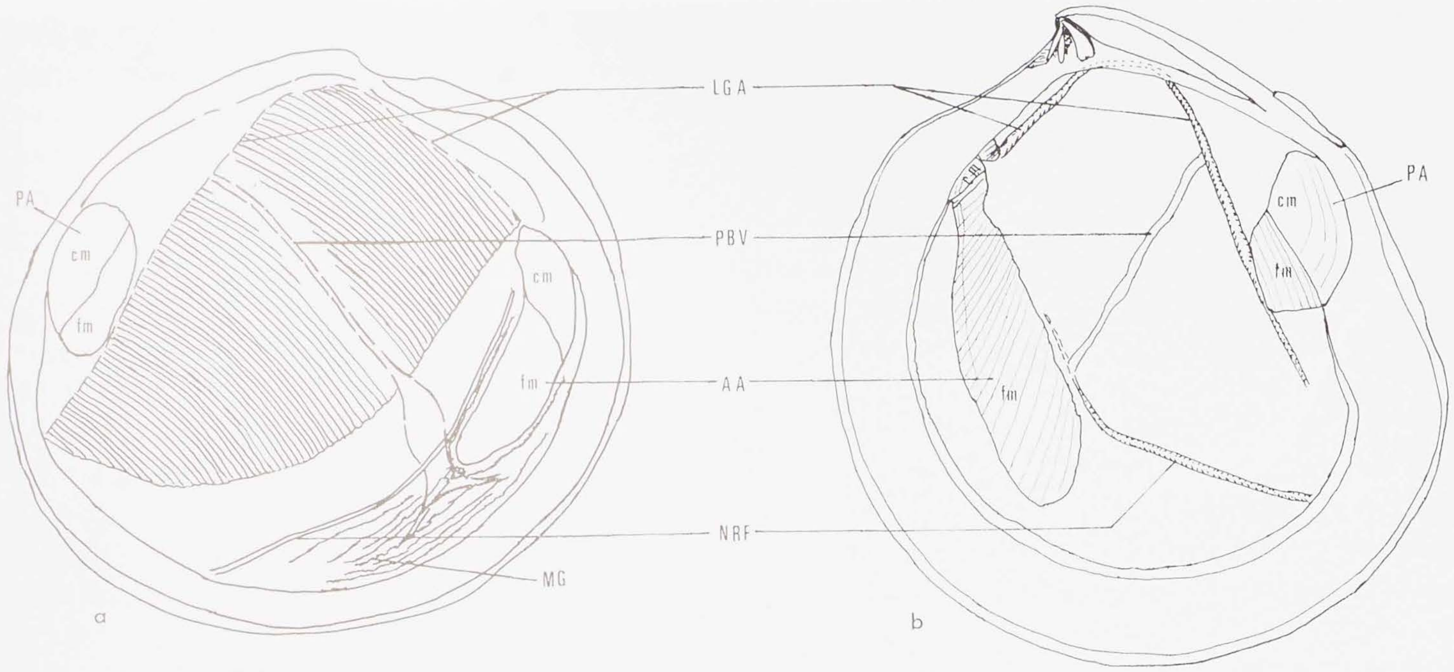


PLATE 3



Text figure 2. Comparison of some features of the anatomy of *Codakia orbicularis* (Linnaeus) —figure a (modified after Allen, 1958, text figures 3 and 29), with markings on the interior of the valves of *Miltha*—figure b. AA—anterior adductor muscle and scar; LGA—line of gill attachment and corresponding ridge in *Miltha*; MG—"mantle gills" of *C. orbicularis*; NRF—"non-ridged fold" of mantle and corresponding ridge on shell of *Miltha;* PA—posterior adductor muscle and corresponding scar; PBV—pallial blood vessel in *Codakia* and corresponding groove in shell of *Miltha*. The letters "cm" and "fm" indicate the areas of "catch" or non-striated muscle fibers and of the "fast" or striated muscle fibers comprising the adductor muscles.

margins the anterior ventral side of the hinge-plate. This marginal ridge is present in all of the species examined.

The left anterior lateral becomes weakened and lost as the adjacent lunular margin is depressed by the enlargement of that of the right. There is some suggestion however (see pl. 3, fig. 1d), that it develops a low anterior ridge-like projection, which forms the low ridge margining the anteroventral side of the hinge-plate in that valve.

The posterior lateral of the left valve (**PII**) is essentially a slender elongate ridge that occupies the full width of the narrowed hinge plate. The top of this ridge is raised slightly above the level of the projecting margin of the escutcheon, which otherwise is higher than the hinge-plate, being separated from that margin by an inconspicuous, shallow groove (pl. 3, fig. 1a, b). This tooth is received in an elongate socket that develops between the raised escutcheonal margin of the right valve and a long, slender, ridge-like posterior lateral tooth (**PI**) developed on the ventral margin of the hinge-plate at its posterior end. Both the left and right laterals die out as the escutcheonal structure is transferred to the right valve and then broken away by the growing fibrous ligament. The posterior portion of the hinge-plates of right and left valves have no areas of contact with each other in any of the adult valves examined and it is evident that no traces of the posterior lateral tooth structures remain at that stage of development.

D. *Structures on interior of the valves and their interpretation*

No study has been made of the anatomy of either of the two Recent species of *Miltha*. Observation of the markings present on the interior of the valves of the species of *Miltha* examined during the present investigation, interpreted in the light of published anatomical studies of species of other genera of Lucinidae (see especially Allen, 1958), serve, however, to permit suggestions as to certain aspects of milthoid anatomy. These internal markings include, in addition to the usual adductor muscle and pallial line scars, two, and occasionally three, linear grooves and ridges[2] that appear to mark the site of important body structures (text fig. 2).

---

[2] It should be noted that the terms "grooves" and "ridges" are here used with respect to the structures visible on the interior of the valve, and that these would be the reverse of the structure present on the mantle area—a "ridge" on the shell reflects a "groove" in the mantle.

Gill attachment ridge.—Most prominent of these structures is a ridge that corresponds with the line of attachment of the gill demibranch with the mantle. This extends dorsally from below the most anterior extremity of the posterior adductor scar to a point under the hinge line then bends sharply to trend antero-ventrally subparallel with and just beneath the margin of the hinge plate to a termination at the dorsal side of the small anterior retractor scar. In the less inflated valve the thickening developed along this ridge serves to seal off almost completely the sub-umbonal portion of the valve area. In *M. chipolana*, M. *caloosaensis* and *M. carmenae* the posterior segment of the ridge passes under the hinge plate at a position almost directly under the mid-length of the projecting nymphal plate; in *M. childrenae* the termination is about at the anterior third of the length of the plate. Judging from the illustration given by Keen (1958, p. 99, sp. 198) it is even more anterior in position in the Pacific species *M. xantusi* Dall, lying at a point that would coincide with the prolongation of the posterior cardinal tooth. In *M. carmenae* the ridge is almost straight, while in all of the other species it is slightly arcuate anteriorly towards its dorsal end, being most strongly curved and hence terminating more anteriorly in *M. childrenae.*

Pallial blood vessel groove.—A second, usually well-marked structure occurs in the form of a groove that has a diagonally postero-dorsal trend from a point ventral to the midlength of the anterior adductor scar to an intersection with the posterior segment of the gill attachment ridge. This intersection occurs approximately at a point that would coincide with the crossing of the ridge by a line connecting the dorsal terminations of the two adductor scars (see text fig. 2). This groove marks the position of the large pallial blood vessel that passes from the auricles to the sinuses in the mantle. In most specimens the trend of the groove is almost straight, though minor meandering may occur. There is variation in the angle of trend, the antero-ventral end being somewhat lower with respect to the length of the anterior adductor in *M. chipolana* and *M. carmenae* than it is in *M. caloosaensis* and *M. childrenae.* Keen's figure of *M. xantusi*, mentioned above, suggests that this species has a more ventrally situated anterior termination of this groove than that of any of those here studied.

There is also variation in the trend of the groove on opposite sides of the body of the same individual, apparently a result of the differing convexities of the valves. In the majority of the flatter valves the groove can be observed to pass up onto the crest of the gill attachment ridge, and in a few specimens it crosses that ridge before disappearing, apparently at the point where the pallial vessel passes laterally into the pericardial region. In the more inflated valves the groove does not transgress on the ridge but dies out immediately adjacent to it suggesting that the pericardial area was slightly more remote from the mantle on the more rounded side of the body. In few inflated valves, however, there is what is apparently a shallow prolongation of the groove trending dorsally parallel and immediately adjacent to the inner side of the ridge. The significance of this change of direction is not apparent unless it be that the lateral compression indicated by the lesser inflation of one of the valves results in a slight offset of one auricle with respect to the other.

The interpretation of this groove as marking the position of the pallial blood vessel is borne out by a comparison of the figures showing the position of this structure in the species studied by Allen (1958) with the shells of the same forms in the Tulane University collections. In all of these species the shells show some trace of a groove in the region indicated by Allen as being the site of the pallial vessel. Usually the groove is more pronounced (more deeply impressed) in the relatively compressed, thicker-shelled species—*e.g.*: *Lucina pennsylvanica* (Linnaeus) (Allen, fig. 4, p. 431, and fig. 19, p. 442), *Codakia orbicularis* (Linnaeus) (Allen, fig. 3, p. 430, and fig. 29, p. 452), *Codakia* (*Jagonia*) *orbiculata* (Montagu) (Allen, fig. 30, p. 452); less deeply impressed and accordingly more difficult to detect in the more inflated and usually thinner shelled species—*e.g.*: "*Lucina* (*Loripinus*) *chrysostoma* Meuschen" [= *Anodontia alba* Link] (Allen, fig. 18, p. 441) and *Divaricella* [= *Divalinga*] *quadrisulcata* (d'Orbigny) (Allen, fig. 17, p. 441).

In all of these species the ventral termination of the pallial vessel and of the consequent groove on the interior of the shell occurs at a point behind the postero-ventral end of the elongated anterior adductor muscle. This is in contrast to its position in the species of the genus *Miltha sensu stricto*. In these the ventral termination of the groove occurs closely adjacent to the inner side of the adductor well above its postero-ventral end.

Non-ridged mantle fold.—A third structure and one that is most commonly to be noted on the interior of the valves of the larger specimens in the collections, consists of a rather weak ridge trending antero-dorsally from a point coincident with the inner margin of the pallial line almost to the posterior side of the anterior adductor scar before turning to parallel the adductor to and beyond the pallial blood vessel groove. The ridge, which has been observed in all of the species at present under study, is most strongly developed in the area between the pallial line and the adductor scar but becomes greatly weakened as it parallels the scar and is but seldom visible above the pallial vessel groove.

The ridge appears to mark the position of the "non-ridged fold" of Allen (1958, p. 430, text figs. 3, 29), which he describes and figures as occurring in *Codakia orbicularis* (Linnaeus) and compares with that reported by Pelseneer (1911, p. 39) as occurring in "*Lucina exasperata*" [= *Codakia tigerina* (Linnaeus)]. According to Allen this fold marks the inner margin of the area of "mantle 'gills'" which are wrinkles or "convoluted folds of the inner mantle epithelium." Allen also states (p. 431) that "it seems probable that these 'gills' are respiratory in function . . . Not only are all the pallial blood spaces greatly extended but a large pallial blood vessel is present. This vessel is largest in those species with mantle gills." Allen also notes that the "non-ridge fold" in *Codakia orbicularis* "extends from the palps to the posterior limit of the other folds."

Examination of specimens of *Codakia* in our collections revealed that a faint ridge, similar to, but weaker than that here noted in the species of *Miltha*, may occasionally be seen on the shells of older, more or less gerontic specimens of *Codakia orbicularis*, *Codakia tigerina*, and *Codakia punctata* (Linnaeus). It therefore seems probable that when the anatomy of *Miltha* becomes known "mantle 'gills'" will be found to occur, and judging by the strength of the "non-ridged folds" as compared to those observed in the species of *Codakia*, that these 'gills' will be exceptionally well developed.

Adductor muscle scars.—The posterior adductor scars of the several species of *Miltha* clearly show a differentiation into two elements. The outer portion is smooth or marked by weakly defined "growth lines" that curve parallel with the posterior and ventral edges of the scar. The inner portion, distinctly separated from the outer by an impressed line that appears almost a prolongation of the pallial line, is marked with sub-parallel grooves that trend almost vertically in a dorso-ventral direction. Such differentiation is not well-shown on the anterior adductor scars, which tend also to exhibit sub-parallel grooving that, however, trends sub-diagonally across the muscle attachment area rather than dorso-ventrally. Some specimens possess a slightly more pronounced groove that sets off a small, subtriangular dorsal end of the scar. This

---

→

PLATE 4

Miltha (*Miltha*) *childrenae* (Gray) 116

Figs. 1, 2. USNM 679267-A, right valve of lesser inflation, height 86.2 mm, length 76.6 mm. 1, exterior of valve; 2, interior of valve.

Figs. 3, 4. USNM 679267-B, inflated right valve of smaller individual, height 58.3 mm, length 54.8 mm. 3, exterior of valve; 4, oblique view of hinge and ligamental area (× 3.25). Note remnant of fibrous ligament on inner edge of produced lunular margin, and on small platform at dorsal end of cardinal socket, suggesting a slightly amphidetic ligament.

All specimens from U. S. Fish and Wildlife Service M/V *Oregon* locality 4228, Lat. 20°02′ South, Long. 43°17′ West, 28 fathoms, bottom temperature 84°F. Figs. 1-3 natural size.

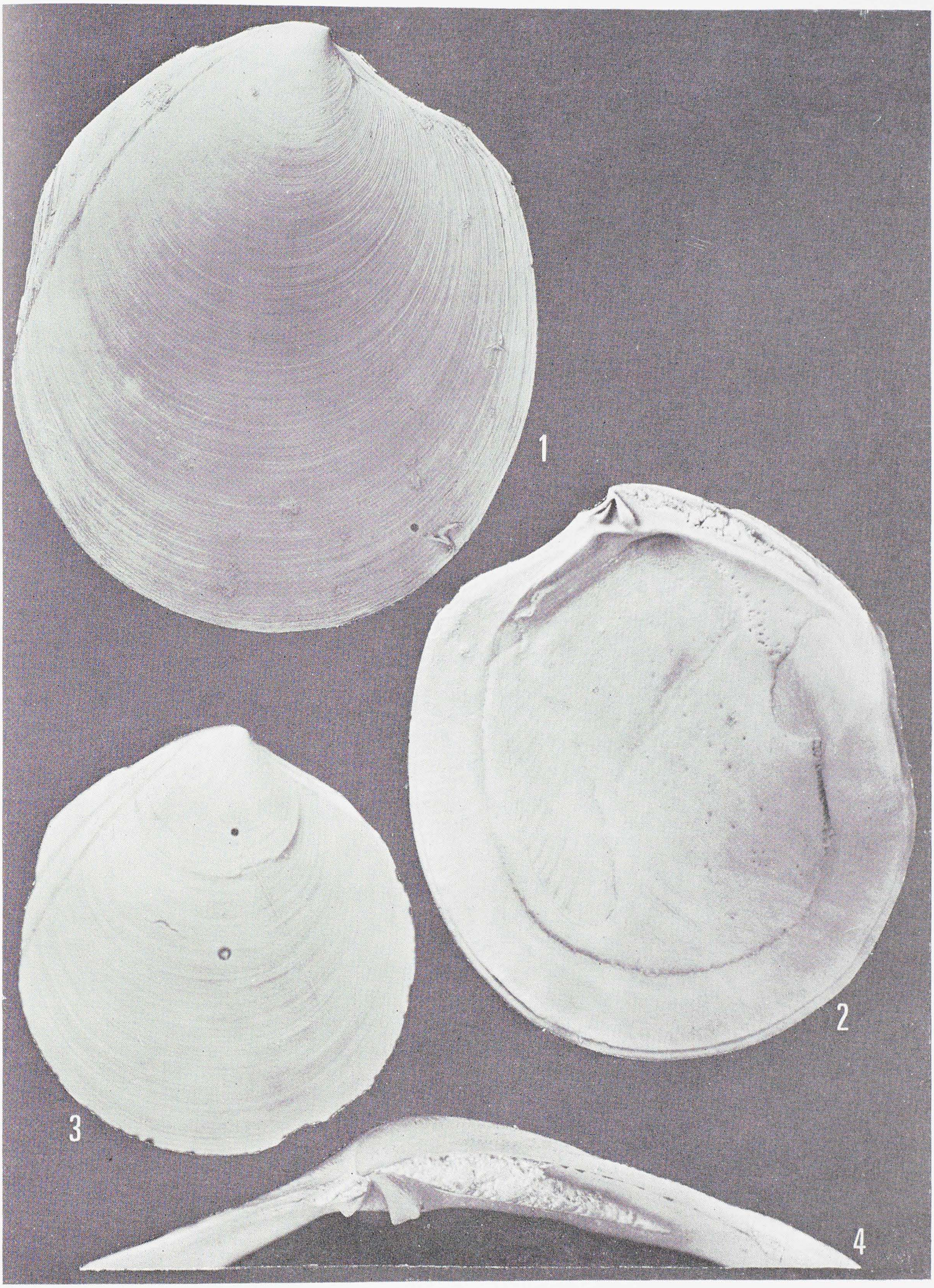


Plate 4

portion usually is also transversely grooved but the grooves are more weakly incised than are those on the ventral segment.

Specimens of *Codakia orbicularis* in our collections exhibit a marking of the posterior adductors that is almost identical to that of the species of *Miltha*. The anterior adductors also have transverse markings on the more ventral parts, but some specimens show a larger dorsal area with only weakly defined "growth lines," as in the posterior scar. These areas of differing "ornamentation" on the muscle scars of *C. orbicularis* agree rather closely with areas of muscle-type differentiation shown in the figures of this species given by Allen (1958, text fig. 28; areas not specifically labelled) and (text fig. 1c) of *Loripes lucinalis* (Turton). In the latter figure the areas are distinguished as being the sites of the "'catch' muscle" and the "'quick' muscle," with the former occupying the dorsal portion of the anterior adductor and the posterior segment of the posterior adductor.

As well summarized by Hoyle (1964, *in* Wilbur and Yonge, vol. 1, p. 315): "The lamellibranch adductors are sometimes divided by a connective tissue sheet into two portions, one of which is composed of smooth muscle fibers (*e.g.*, *Pecten*, *Ostrea*, *Modiolus*). . . . The histological division is correlated with a functional one, the striated portion contracting very quickly and being referred to as the 'fast' portion [= 'quick' muscle of Allen], while the non-striated is much slower and is referred to as the 'slow' portion [= 'catch' muscle of Allen]. It is the slow portion which is principally responsible for the long-maintained, economical contractions which keep the valves closed on exposure, though it is doubtless assisted by periodical contractions of the fast portion in the animal."

I have been unable to locate any specific study of the structure of the muscles of the Lucinidae. An examination of the table given by Bowden (1958, pp. 300-301) would suggest that the so-called "striated portion" probably is of the "doubly obliquely striated type" since true transversely striated muscle is reported only in *Anomia*, *Lima*, *Pecten* (incl. *Chlamys*), *Spondylus*, and *Teredo*. As noted by Hoyle (1961, p. 315) electron microscope studies by Hanson and Lowy have shown that these doubly obliquely striated fibers are "smooth fibers with peripheral, twisted fibrils, rather than fibers with a unique form of cross banding."

Whatever the basic nature of the muscle fiber structure, it appears that the adductor muscles in *Miltha* consist of two differing muscle fiber types. The outer, relatively smooth posterior segment of the posterior adductor and the small, dorsal portion of the anterior adductor would, by analogy with the areas indicated by Allen in his figure of *Loripes lucinalis*, consist of non-striated or "smooth" muscle fibers, while the smaller, vertically grooved, inner area of the posterior adductor scar and the large, transversely grooved area of the anterior adductor scar would be occupied by the so-called "doubly obliquely striated" type of muscle fibers. The impressed line or groove separating the two areas on the adductor scars would thus mark the location of the

---

→

PLATE 5

Miltha (*Miltha*) *chipolana* (Dall) 118

Figs. 1, 4. USNM 646395, height 64.2 mm, length 59 mm. 1, exterior of more inflated left valve; 4, exterior of less inflated right valve. Locality TU 459.

Figs. 2, 3. USNM 646394, height 72.6 mm, length 67.6 mm, diameter (paired valves) 20.7 mm. 2, exterior of more inflated right valve; 3, dorsal view of paired valves. Locality TU 555.

Fig. 5. USNM 646397, height 46.6 mm, length 42.5 mm. Exterior of left valve of lesser inflation, ecotypic variety (?) with unusually straight anterior dorsal margin and subangulate anterior dorsal end; type of *M. smithwoodwardi* (Maury) is a shell of this general outline. Locality TU 549.

Fig. 6. USNM 646396, height 82.9 mm, length 81 mm. Exterior of right valve of lesser inflation illustrating the more elongate variant of this species. Locality TU 820b.

All figures are approximately natural size.

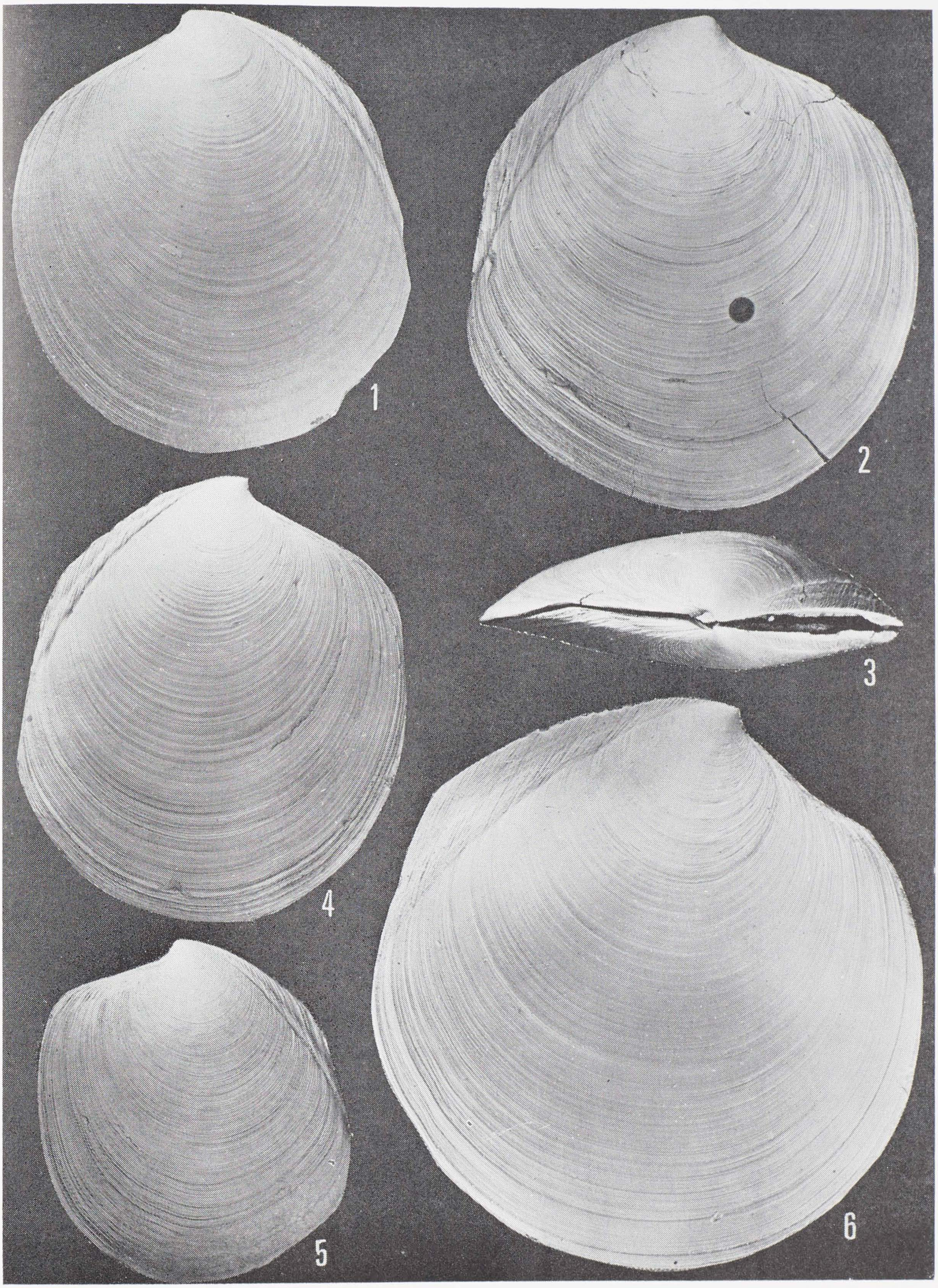


PLATE 5

sheet of connective tissue that separates the two portions of the respective muscles. If this interpretation be correct then the "slow" or "catch" segment of the muscle arrangement is much larger in the posterior adductor with the "fast" or "quick" segment correspondingly enlarged in the anterior adductor. Whether or not this seeming "division of labor" is a result of the development of an anterior inhalant tube in *Miltha,* as in many other Lucinids, can only be determined when specimens of the living animal are available for study.

E. Ecological Observations

There is little available published information on the ecologic requirements of species of the genus *Miltha.* The specimens of *M. childrenae* taken by the M/V *Oregon* at station 4228 (see page 118) were from 28 fathoms, bottom temperature 84°F [= 30°C]; this is the only record for this species that I have been able to find. Small patches of fine-grained, rather angular, quartz sand were present on some of the specimens. Hertlein and Strong (1946, p. 115) report *M. xantusi* from the Arena Bank, off Baja California, "33 fathoms, sand, weed." Keen (1958, p. 98) reports that most known specimens of *M. xantusi* were taken "off Cape San Lucas, in depths of 30 or more fathoms."[3] Durham (1950, p. 1248) lists *Miltha* among those genera indicative of tropical seas in that they live in water with a minimum temperature of 20°C or warmer, while Hall (1964, map, p. 231) indicates that Cape San Lucas lies at the northern edge of the "Inner Tropical Zone" where (p. 229) "the marine water temperature is 25°C or approximately 75°F for nearly 12 months of the year."

According to Allen (1958, p. 425-427) most species of Lucinidae appear to live in sands or muds where the organic content is low or absent, and many show "a marked tendency . . . to live among the roots of marine grasses . . . "

While studying the collections I was struck by the relative rarity of shells showing evidence of having been bored by molluscan predators. A tabulation revealed that only 33 of the 450 valves checked were so damaged. What was even more striking was that 32 of these 33 valves were of the more inflated type; only one flatter valve had been attacked. This had been attacked twice, although only one hole had been drilled through into the interior of the shell (pl. 6, fig. 5) and this was a small hole suggesting attack by a relatively immature predator.

The low incidence of predation would seem to suggest that *Miltha*, like most other lucinids, is a relatively deeply burrowing form. An explanation for the strong tendency for the predators to attack the inflated valves is not readily apparent. It would seem that if the animal lived with a vertical or sub-vertical orientation of the valves, a predator burrowing through the substrate would have had almost an even chance of coming upon either the flatter or the more inflated valve. But the incidence of boring of the inflated valve is 15.9 percent of the 201 such valves in the present collections while only 0.4 percent of the 249 less inflated valves has been attacked. The only plausible explanation that occurs to me at this time is to suggest that a predator might come upon either the anterior inhalant tube or the posterior siphonal tube and follow these down until they found the shell. This would imply that *Miltha* lives in a more or less horizontal position with the inflated valve uppermost.

F. Notes on Origin and Geologic History of Miltha

Chavan, in his "Essai Critique de Classification des Lucines" (1937-1938), suggested that *Miltha* was derived from a Jurassic form of *Mesomiltha* or *Saxolucina* (1938, table, p. 242). He had previously noted (1938, p. 72) that there was in the "Astartien de Cordebugle (Calvados) une espèce remarquable de *Saxolucina*"[4] and it is probable that this was the species that

---

[3] Dr. A. Myra Keen has informed me (*in litt.*) that the Stanford University collections contain four valves of this species collected by the *Ariel* Expedition, in 1960, from off Cabo Haro, near Guaymas, Mexico, in 15 to 25 fathoms. This represents a considerable extension of the range of this species into the Gulf of California, although still within the "Inner Tropical Zone" of Hall.

[4] *Saxolucina substriata* Chavan, 1937, Jour. de Conchyl., vol. 81, p. 72 (non "*Lucina*" *substriata* Roemer, questionably considered to be a *Saxolucina* by Chavan, 1938, p. 72) = *Discomiltha oehlerti* Chavan, 1952.

he had in mind when he suggested the possibility of a Jurassic saxolucinid ancestral form. However, when he later described the Cordebugle fauna he renamed this species and made it the type of a new genus *Discomiltha* (1952, p. 95) "sans relation directe avec les *Miltha*" (p. 96). It should be noted that although *Discomiltha oehlerti* has a superficially *Miltha*-like external shape, it lacks the distinctive anterior and posterior areas on the valve and appears to have both valves equally inflated. The hinge structure is similar to that of *Saxolucina saxorum* (Lamarck), the Lutetian-Bartonian type species of *Saxolucina* Stewart (1930, p. 184) and so far as can be determined from Chavan's illustration of the right valve (1952, pl. 3, fig. 39), the trend of the pallial blood vessel groove is identical with that to be observed in the figure of the interior of the valve of *S. saxorum* given by Cossmann and Pissarro (1906, pl. 25, sp. 83-23). The derivation of *Saxolucina* from *Discomiltha* seems quite probable, but there is little evidence suggesting any relationship to *Miltha*.

The hinge of "*Lucina*" *pulchra* Zittel and Goubert, the type species of *Mesomiltha* Chavan (1938, p. 231, as subgenus of *Cavilucina* Fischer), as figured by Chavan (1938, p. 233, text fig. 20), differs from that of the immature valves of *Miltha chipolana* (see pl. 3, figs. 1a, b, 2a, b) in having a much narrower hinge plate and more anteriorly situated anterior lateral teeth. More significantly, there is no trace of an escutcheon, which is so prominently developed in the young of *Miltha*.

The earliest species with which I am acquainted that appears probably to be referable to *Miltha s.s.* is the middle Eocene Domengine Formation species "*Lucina*" *packi* Dickerson (1916, p. 484, pl. 36, fig. 12). The type of this species is a very small and immature individual, but larger specimens, which I figured (1939, pl. 10, figs. 8, 12) as *Miltha* (*Eomiltha?*), show a typically miltoid external ornamentation including defined anterior and posterior dorsal areas (fig. 8), and hinge and internal margins (fig. 12). The two separate valves available at that time were collected from different localities and were too closely similar in degree of inflation to permit observation as to whether or not this early form of *Miltha* possessed the characteristic differing inflation of opposite valves that is so marked in the Neogene species.

Chavan (1938, p. 61) interprets the Montian, Paleocene, *Phacoides montensis* Cossmann (1908, p. 15, pl. 2, figs. 1-10) as "une vrai *Miltha*" and apparently as the oldest representative of the genus. But as illustrated by Cossmann this species possesses small anterior and posterior lateral teeth in specimens exceeding 50 mm in height. The anterior laterals are very different in nature and relative position from those to be observed in the young *Miltha chipolana*, and are present in addition to a raised ventral margin of the anterior portion of the hinge plate which, as noted above (p. 106) appears, in the Florida Miocene species at least, to have been derived from the lateral teeth. The Montian species seems not to have had any differing amount of inflation of the two valves. However, the general outline and surface ornamentation, including both anterior and posterior dorsal areas, the nature of the cardinal dentition and of the pallial line, which is distant from the valve margins, as well as the shape and position of the adductor scars are all very similar to features characteristic of *Miltha s.s.*, and the species must be considered as close to, if not directly ancestral to, this group.

Miltha has been reported from the Eocene and Oligocene of Peru by Olsson who (1930, p. 23) clearly was following Dall (1903, p. 1374 *et seq.*) in his broad interpretation of the genus. Of the three species mentioned by Olsson, *Phacoides* (*Miltha*) *woodi* Olsson (1930, p. 23, pl. 2, figs. 9, 12) has the distinctive outline and biconvex shell of *Eomiltha*, "*Lucina*" *paytensis* Woods (1922, p. 70, pl. 4, fig. 5) appears to be a species of the genus *Claibornites*, Stewart, 1930, and *Phacoides* (*Miltha*) *conventus* Olsson (1929, p. 75, pl. 11, fig. 3 [pl. 3, fig. 3 of separate]) is said by Olsson to be "closely related to *P.* (*Miltha*) *claibornensis* Conrad," type species of *Plastomiltha* Stewart, 1930.

So far as I am aware no upper Eocene or Oligocene species that can be certainly referred to *Miltha s.s.* have yet been reported in the paleontologic literature. By the beginning of the Miocene, however, *Miltha* was widely distributed, appearing almost simultaneously in the lower Miocene of California—"*Phacoides* (*Miltha*)" *sanctaecrucis* Arnold (1910, p. 57, pl. 6, fig. 6) of the Vaqueros Formation[5]; of Florida—"*Phacoides* (*Miltha*)" *chipolanus* Dall (1903, p. 1375, pl. 51, fig. 11) of the Chipola Formation; and of New Zealand—*Miltha neozelanica* Marshall and Murdock (1921, p. 78, pl. 16, pl. 17, fig. 1) reported to range from the Waitakian, Lower Miocene, to the Waitotaran, Pliocene, stages. *Miltha* is also known from the Miocene of Argentina—*Miltha iheringiana* Doello-Jurado (1919, p. 558, text fig.) of the Entrerriennne Formation.

Miltha has been reported to have reached South Australia and Tasmania in the upper Miocene. The illustrations of the fragmentary representatives of the South Australian "*Miltha* (*Milthoidea*) *grandis* (Hooper Woods, 1931)"[6] given by Singleton and Woods (1934, p. 208, pl. 8, figs. 1a, b, 2a, b, 3) reveal a hinge of distinctly milthoid aspect. The peculiarly crenulated margin shown in their figure 3 is, however, a feature not represented in any species of *Miltha* (*Miltha*) known to me, and if not a pathologic manifestation would probably suggest that these represent a distinct, undescribed subgenus.

Singleton and Woods also described a *Miltha* (*Milthoidea*) *grandis* subspecies *flindersiana* (1934, p. 210, pl. 8, figs. 4a, b) from the "very late Tertiary or post-Tertiary" of Flinders Island, Tasmania. This form was separated as a distinct species by Wilkins (1962, p. 43, pl. 5, figs. 1, 2) who stated that it is of lower Pliocene age. It does not have a crenulated internal margin but, according to Wilkins, possesses "an obsolete anterior tooth . . . on the right valve." Presumably this must refer to an obsolete anterior lateral tooth since there is a well developed anterior cardinal shown both in the original figure as well as in that given by Wilkins. This feature, as well as the trend of the pallial vessel groove, which is more oblique than that observed in species of *Miltha* (*Miltha*), passing downwards to the posterior end of the anterior adductor scar, suggests that this species is more accurately referred to *Eomiltha* Cossmann, 1911.

Dartevelle and Roger (1954, p. 285 report a "*Miltha*" *harrisi* from beds that they assign to the Burdigalian, Miocene, of Angola. This paper has not been available to me, but I note in the Zoological Record for 1955 that *M. harrisi* is said to be a new name for the *Lucina* cf. *L. landanensis* Newton of Caster (1938, p. 24, pl. 1, figs. 1, 2), described as being from deposits of Eocene age, and said to have an edentulous hinge. This latter feature clearly removes the species from *Miltha s.s.,* and suggests a referral to the genus *Pseudomiltha* Fischer, 1887.

---

[5] Khomenko, 1938 (Trans. Geol. Oil Inst., Ser. a, fasc. 103, p. 43, pl. 8, fig. 2, pl. 9, fig. 5) has reported this species from the early Miocene of northern Sakhalin. The figures given, of two broken specimens, are not adequate to permit evaluation of the record beyond establishing the occurrence of a large lucinid species in the fauna.

[6] This species was described by Hooper Woods (Trans. Roy. Soc. S. Australia, vol. 55, p. 148, pl. 7, figs. 5, 6) as *Dosinia grandis,* a name that is preoccupied by *D. grandis* Nelson, 1870 (Trans. Connecticut Acad. Sci., vol. 2, p. 201). The substitute specific name *hora* has been proposed by Cotton (1947, Rec. S. Australian Mus. vol. 8, no. 4, p. 663).

→

PLATE 6

Miltha (*Miltha*) *caloosaensis* (Dall) 121

Figs. 1, 2, 4. USNM 646407, height 61.9 mm, length 55.5 mm, diameter (paired valves) 15.4 mm. 1, exterior of left valve of lesser inflation; 2, exterior of more inflated right valve; 4, dorsal view of paired valves. Locality TU 796 (upper Miocene).

Figs. 3, 5. USNM 646408, height 55. 2 mm, length 49.8 mm. 3, exterior of more inflated right valve; 5, exterior of left valve of lesser inflation. Locality TU 755 (Pliocene.)

All figures approximately natural size.

Miltha (*Miltha*) *carmenae* H. E. Vokes, new species 122

Fig. 6. Paratype, USNM 646410, height 105.5 mm, length 98.8 mm. Exterior of left valve of lesser inflation (× .9). Locality TU 201.

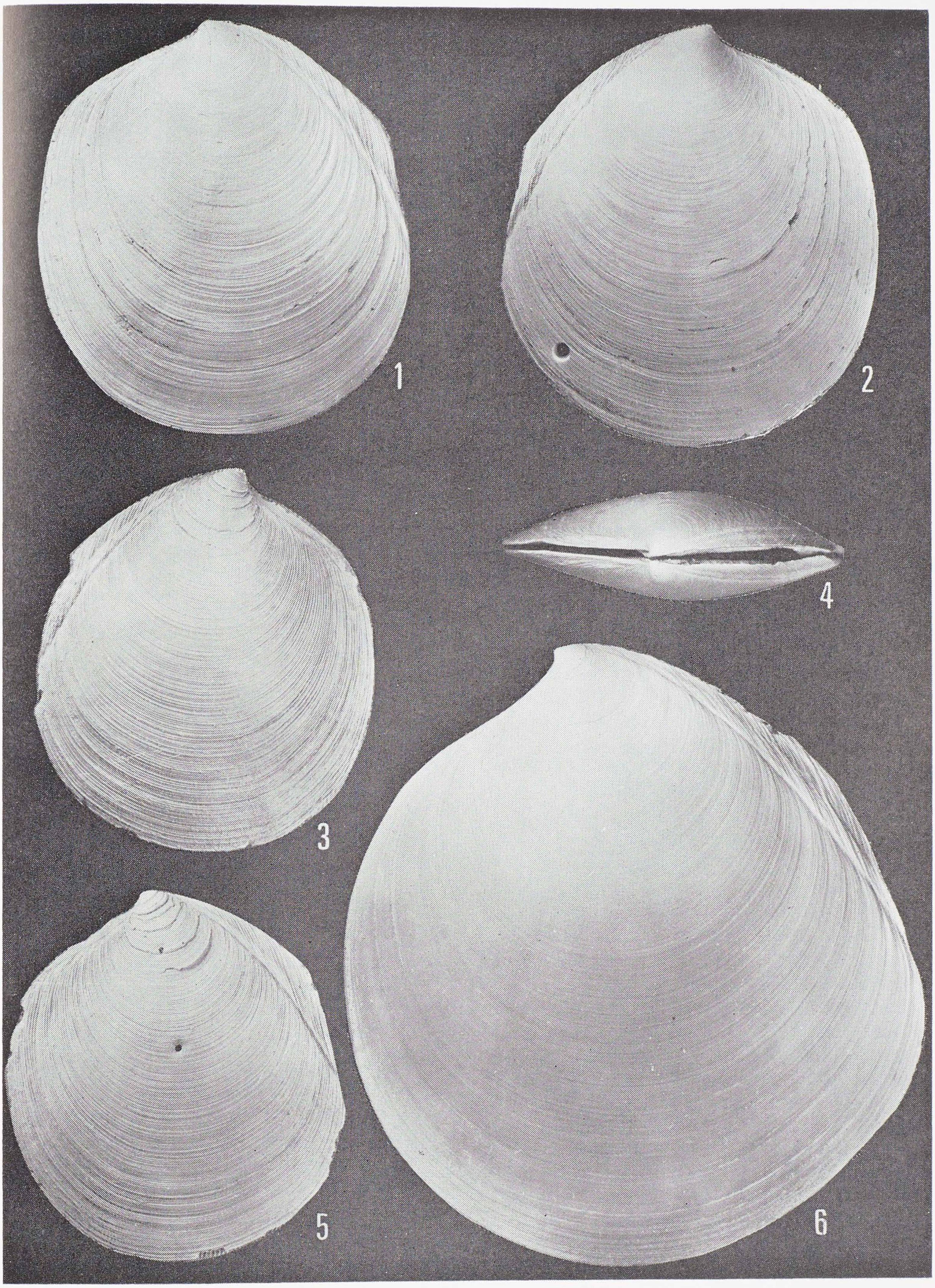


PLATE 6

V. MILTHA (MILTHA) CHILDRENAE (Gray)

Plate 1, Figure 1; Plate 2, Figures 1a, b; Plate 4, Figures 1-4

1824, *Lucina Childrinae* [sic] GRAY, Zoölogical Journal, vol. 1, p. 221.
1825, *Lucina Childrenae* GRAY, Ann. Philos., (n.s.) vol. 9, p. 136.
1825, *Lucina Childreni* Gray, SOWERBY, Cat. Shells Coll. Earl of Tankerville, p. 11.
1826, *Lucina Childreni* Gray, SOWERBY, Gen. Shells, Pt. 27 "*Lucina*," fig. 2.
1828, *Tellina Childreni* [Gray], WOOD, Index Testaceologicus, ed. 2, Supplement, p. 3, pl. 1, *Tellina* fig. 1.
1841, *Lucina Childreni* Gray, REEVE, Conch. Systema, vol. 1, p. 82, pl. 59, fig. 2.
1842, *Lucina Childreni* Gray, HANLEY, Cat. Recent Bivalve Shells, p. 79.
1850, *Lucina Childreni* Gray, REEVE, Conch. Icon., "*Lucina*," pl. 3, sp. 12.
1857, [*Lucina* (*Miltha*)] *Childreni* Gray, H. and A. ADAMS, Genera Recent Moll., vol. 2, p. 468.
1862, *Lucina* (*Miltha*) *Childreni* Gray, CHENU, Man. Conch., vol. 2, p. 120, fig. 579.
Not 1864, *Miltha Childreni* [Gray], CARPENTER, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 620 [= *M. xantusi* Dall, 1905].
Not 1901, *Phacoides* (*Miltha*) *childreni* Gray, DALL, Proc. U. S. Nat. Mus., vol. 23, p. 812 [= *M. xantusi* Dall, 1905].
Not 1903, *Phacoides* (*Miltha*) *childreni* Gray, DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1377 [= *M. xantusi* Dall, 1905].
1905, *Phacoides* (*Miltha*) *childreni* Gray, Dall, Nautilus, vol. 18, no. 10, p. 110-112.
1907, *Phacoides Childreni* Gray, VON IHERING, Anales Mus. Nac. Buenos Aires, vol. 14 (3rd. ser., vol. 7), p. 530.
1921, *Miltha Childreni* Gray, LAMY, Journ. de Conchyl., vol. 65, p. 120, text fig.
1957, *Miltha childrenae* (Gray), WILKINS, Bull. Brit. Mus. (Nat. Hist.), Hist. Ser., vol. 1, no. 4, p. 159, pl. 23, fig. 6.

The first mention of this species occurs in a footnote appended to a series of "Conchological Observations" published by Gray in the Zoölogical Journal, vol. 1. This has been cited by Dall and others as of 1825, but Wilkins (1957, p. 159) gives the date of publication as June, 1824. It is also of interest to note that Sowerby, in 1825, in his "Catalogue of the Shells contained in the collection of the late Earl of Tankerville" notes (p. 11, sp. 206): "*Lucina Childreni* (a.b.) Gray, in Annals of Philosophy (1824) 2 specimens: one being the reverse of the other." The reference to the Anals of Philosophy was, apparently, a *lapsus*, since the letter of transmittal of Gray's description in that publication is dated "British Museum, Jan. 10, 1825" and the number in which it appeared is dated as "Feb. 1825."[7] As further circumstantial evidence that the Sowerby citation to the Annals of Philosophy was an error for the reference in the Zoological Journal is the fact that the latter was concerned with the "2 specimens: one being the reverse of the other" that were in the Tankerville collection. Concerning these Gray (1824, p. 221) states: "There are two specimens of a new Lucina, in the Tankerville collection, which, as pointed out by my friend Mr. Children, most admirably illustrate this fact [that the valves of certain bivalves may occasionally be reversed]; for the valves, being unequally convex, if the two shells are placed on their most convex valves, their beaks turn toward each other, as the mouths of reversed and regular spiral univalves would do if placed on their backs." A footnote adds: "I call this new shell *Lucina Childrinae* [*sic*, err. pro *L. childrenae*]; it is distinguished from all other Lucinae by being unequivalved, and approaching nearly in form to the Cytherea exuleta; there is also another specimen in the British Museum."

It clearly was this "other specimen" that was the subject of the formal description of the species published in the Annals of Philosophy in 1825, for in his letter of transmittal of his manuscript Gray states: "In the following list I have . . . described some new [species] that are contained in the collection in the British Museum, where most of the species are exhibited with the names, here adopted, attached." This specimen, which was in the collections bequeathed to the British Museum in 1799 by the Rev. C. M. Cracherode, has been selected and figured as the lectotype of the species by Wilkins (1957, p. 159, pl. 23, fig. 6). According to Wilkins it has not proved possible to trace the specimens that were in the Tankerville collection.

Wilkins does not give the dimensions of the lectotype specimen. His illustration (pl. 23, fig. 6), said to be of natural size has

---

[7] It may be noted in passing that Sowerby's erroneous citation apparently was uncritically accepted by Carpenter (1864, p. 522) who states: "*Lucina Childreni* [described by Gray in Ann. Phil. 1824; v. also Zool. Jour. vol. i, 1825, pp. 221-2. . . .]" and perpetuated by Dall (1903, p. 1377).

the left valve in front of, and partially superimposed upon the right, so that the latter cannot be accurately measured. The dimensions of the left, apparently less inflated, valve as measured from the figure are: height 87.8 mm, length 83 mm.

Gray's first notice of the species in the Zoölogical Journal is quoted above. His formal description, in the Annals of Philosophy, was as follows:

"LUCINA *Childrenae*.[8] Testa suborbiculata inequivalvis alba subantiquata; tenuissime radiata substriata: long. 3 unc. Brazil, *Humphreys.* nob. *Zool. Jour.* i. 221."

The first adequate description was given by Reeve in the Conchologia Iconica, "*Lucina*" (1850, pl. 3, sp. 12):

> "Shell rather large, elliptically orbicular, attenuated towards the umboes, inequilateral, flexuously angled posteriorly, one valve flat, the other convex, very thickly striated concentrically, decussated with numerous fine impressed radiating striae, central teeth of the hinge two in number, prominent, divaricate, lateral teeth callus, nearly obsolete; white within and without.
>
> "Hab. Brazil.
>
> "In this fine species sometimes the right valve, sometimes the left is the flat one, the opposite valve in either case being convex."

The statement that the "central teeth of the hinge two in number [are] . . . divaricate" does not accord with the condition of these teeth in the hinges here available for study. As previously noted, the left anterior and the right posterior cardinals are divaricate but the right anterior and left posterior teeth are simple and lamellar. It may be that Reeve interpreted the projecting edge of the small lunule in the right valve as one segment of a bifid tooth, but there is no corresponding structure adjacent to the left posterior cardinal that could be so misconstrued. His excellent figure of the hinge of this valve does show what appears to be an imperfection or shell fragment lodged against the ventral portion of the anterior side of this tooth, but it is difficult to understand how this could be construed as a segment of a bifid tooth.

The general characters of *M. childrenae* have been noted in the general discussion of the genus *Miltha.* The most distinctive feature for the recognition of this species is to be found in the nature of the lunular area and the adjacent right anterior cardinal tooth. As noted above (page 100), the lunule is but little impressed below and is almost parallel with the anterior dorsal margin of the valve, making an angle of approximately 65° with the valve height. In the other species here studied the lunule has a much more vertical trend, usually lying at an angle of less than 40° from the vertical. As a result of this less steeply impressed condition the lunule has had but little dynamic effect upon the right anterior cardinal which, while closely adjacent to it, appears to be distinctly separated throughout its entire length; in the other species the dorsal portion of this tooth either becomes fused on its anterior side with the lunular margin or, as in *M. caloosaensis*, is practically incorporated into the lunule itself.

It may also be noted that the anteroventral margin of the elongate anterior adductor scar is on the whole more nearly parallel with, and relatively somewhat closer to, the adjacent portion of the pallial line

---

[8] It is to be observed that in both of his citations Gray gave his specific name a female termination, apparently naming it in honor of Miss Anna Children, daughter of his "friend Mr. [J. G.] Children," at that time Assistant Keeper of the Natural History Department of the Museum, whom he credited, in the Zoological Journal, as calling it to his attention. Miss Children had been engaged in the British Museum in making drawings of specimens from that collection to illustrate her father's well known "Lamarck's Genera of Shells translated from the French, with plates from original drawings by Miss Anna Children" published in the Quarterly Journal of Science, Literature and Arts, 1822-24.

Dr. Leo G. Hertlein of the California Academy of Sciences has called to my attention a page of "errata" that follows the index to volume one of the Zoological Journal. This contains the statement, "for *childrinae*, read *childreni.*" The index was published in part four of the volume that bears the date of January, 1825 on the table of contents. In view of the fact, noted above, that the paper containing the formal description of the species published in the Annals of Philosophy bears the notation "British Museum, Jan. 10, 1825," it seems almost certain that the errata in the Zoological Journal was prepared by an editor without being approved by the author.

This consistent usage by Gray was overlooked or ignored by contemporary (Sowerby, 1825, 1826; Wood, 1828) and subsequent (Reeve, 1850, H. & A. Adams, 1858, Carpenter, 1864; Dall, 1901, 1903, 1905; etc.) authors, all of whom used the masculine termination, "*Childreni.*"

than it is in the other species here studied. There is, however, a considerable degree of variation in this feature, even between opposite valves of the same specimen, and some specimens of *M. caloosaensis*, especially, are identical in this respect, although on the average they tend to be less strikingly parallel with the pallial margin than is the average of the available specimens of *M. childrenae*.

Early authors have simply cited this species as from "Brazil." The first more specific locality citation of which I am aware is given by Dall (1905, p. 111), who stated that his shell "was recently collected at Pernambuco." The U. S. Fish and Wildlife Service, M/V *Oregon*, collected the specimens here examined at Station 4228, Latitude 20°02′ South, Longitude 43°17′ West, 28 fathoms, bottom temperature 84°F. This locality is off Sao Luís, Est. Maranhão, more than 800 miles northwestward along the coast from Recife, the capital city of Pernambuco. If Dall's more generalized locality was precise, the species is much more widely distributed than its rarity in collections would suggest.[9]

Figured specimen: USNM 679267-A, height 86.2 mm, length 76.6 mm, diameter (right valve, less inflated) 10 mm. *Oregon* stn. 4228.

Figured specimen: USNM 679267-B, height 58.3 mm, length 54.8 mm, diameter (right valve, inflated) 9.8 mm. *Oregon* stn. 4228.

Figured specimen: USNM 679267-C, height 30.5 mm, length 28.8 mm, diameter (left valve, inflated) 5.2 mm. *Oregon* stn. 4228.

VI. SPECIES OF MILTHA S.S. FROM THE NEOGENE DEPOSITS OF SOUTHERN FLORIDA

MILTHA (MILTHA) CHIPOLANA (Dall)

Plate 1, Figure 3; Plate 2, Figures 4a, b; Plate 3, Figures 1a-d, 2a-d; Plate 5, Figures 1-6; Text Figure 1

1903, *Phacoides* (*Miltha*) *chipolanus* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1375, pl. 51, fig. 11.

1903, *Phacoides* (*Miltha*) *heracleus* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1376, pl. 51, fig. 10.

1917, *Phacoides* (*Miltha*) *Smithwoodwardi* MAURY, Bulls. Amer. Paleontology, vol. 5, no. 29, p. 368, pl. 61 (no. 29, pl. 35), fig. 6.

1920, [?] *Phacoides* (*Miltha*) cf. *smithwoodwardi* Maury. MAURY, Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 1, p. 33.

1926, *Phacoides* (*Miltha*) *chipolanus* Dall. GARDNER, U. S. Geol. Surv., Prof. Pap. 142C, p. 110, pl. 19, figs. 3-6 [*heracleus* Dall placed in synonymy].

1930, *Miltha* (*Miltha*) *chipolana* Dall. STEWART, Acad. Nat. Sci. Phila., Spec. Publ. 3, p. 190.

Dall's original description of this species was as follows:

"Shell large, rather thin, compressed, with small, pointed, recurved beaks, over a small, narrow, rather deeply impressed lunule; there is no anterior dorsal area; the posterior area is long, narrow, and divided into two nearly equal parts by an impressed line; sculpture of fine, slightly irregular concentric raised threads, stronger distally, sublamellose on the dorsal area, fainter in the middle of the disk, and rather close-set; radial sculpture of faint, obscure, slightly vermicular markings, hardly visible except in the middle of the disk; anterior adductor scar elongate; posterior short, ovate; cardinal teeth well developed; ligament short, deeply insert. Alt. 75, lon. 71, diam. about 11 mm.

"The figure of this species is restored from a number of fragments which give practically

---

[9] After this manuscript had been submitted for publication, Dr. A. Myra Keen informed me that there were, in the Stanford University collections, four valves collected by Mr. Donald Bryant from beach drift in Todos os Santos Bay, Bahia, Brazil. This locality is more than 400 miles south of Recife, and indicates a distribution along more than 1200 miles of the Brazilian coast.

→

PLATE 7

Miltha (*Miltha*) *carmenae* H. E. Vokes, new species 122

Figs. 1-4. Holotype, USNM 646409, height 82.7 mm, length 76.5 mm, diameter (paired valves) 20.4 mm. 1, exterior of more inflated left valve; 2, dorsal view of paired valves, note manner in which anterior dorsal margin of flatter right valve displaces margin of the left; 3, 4, exterior and interior views of right valve of lesser convexity. Locality TU 201.

Fig. 5. Paratype, USNM 646411, height 62.5 mm, length 58.7 mm. View of hinge (× 1.7) of smaller right valve with lunular margin more deeply impressed than usual in the species, and approaching condition characteristic of *Miltha caloosaensis* (Dall).

Figures 1 to 4 approximately natural size.

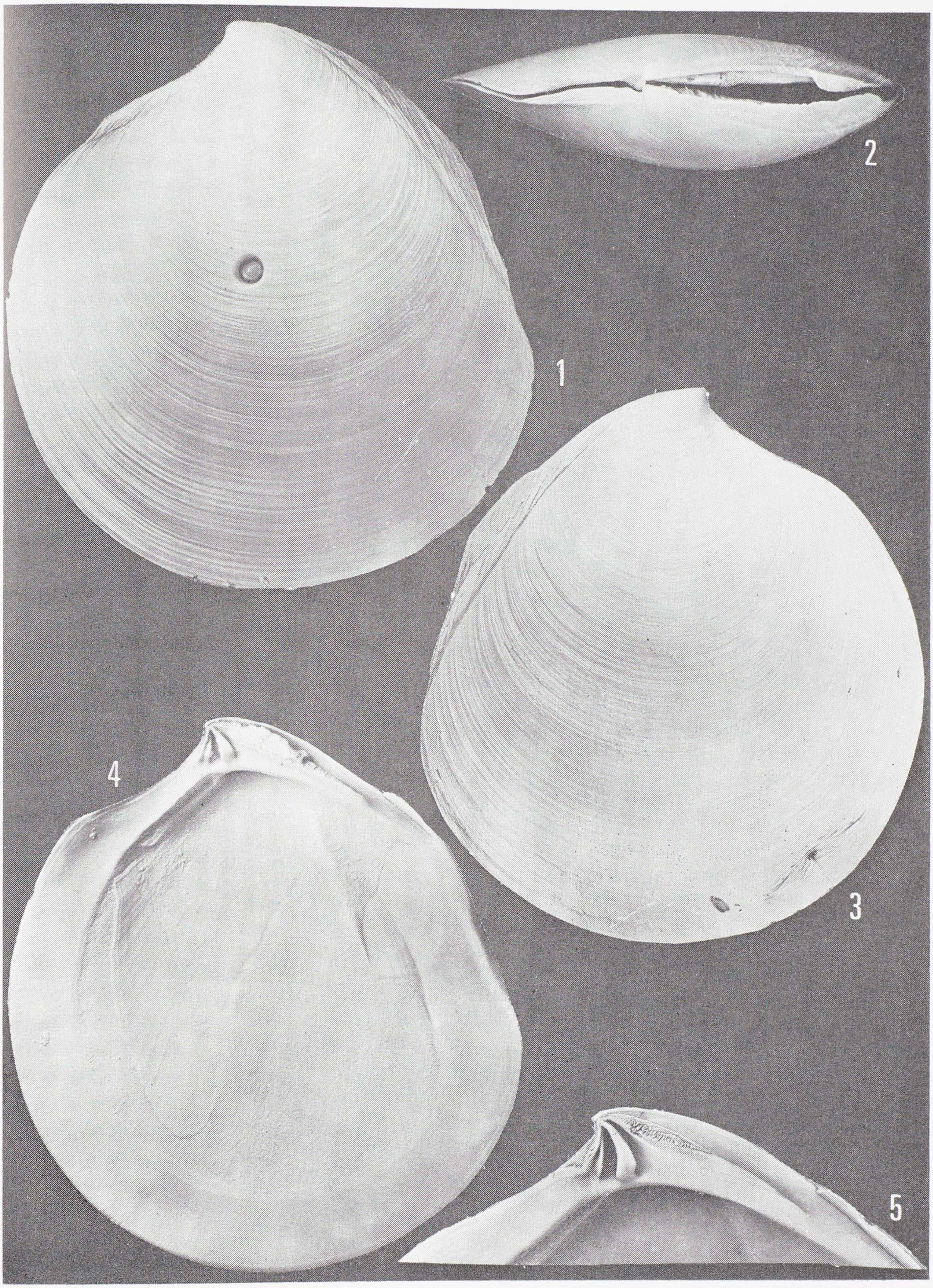


PLATE 7

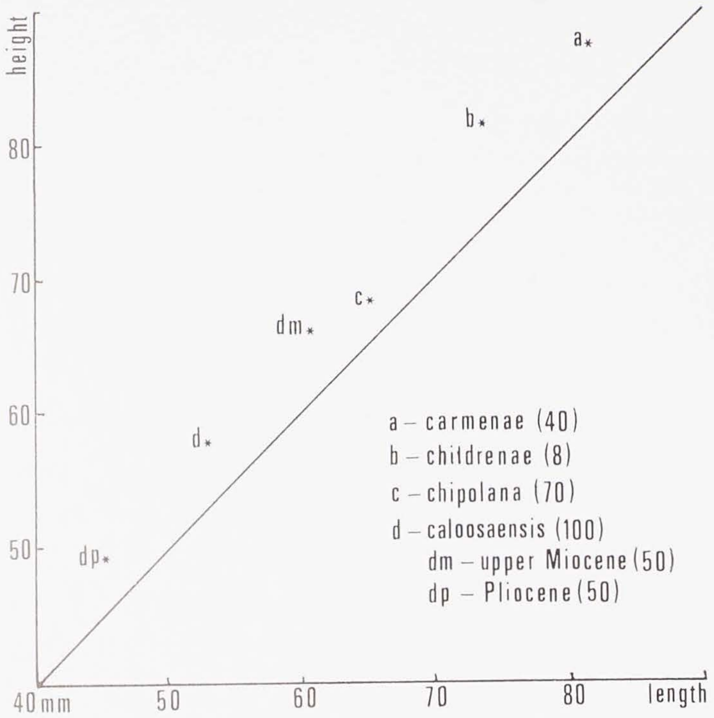
all the characters except the hinge of the left valve. It is a large, very compressed form . . . "

Dall's reference to the species as being "very compressed" and his measurements indicating a diameter of "about 11 mm." in a shell of 75 mm altitude, rather clearly indicate that he had only the flatter, less inflated valves of this species. He did not recognize that the right valve from Alum Bluff, Florida, which he made the type of his new species *heracleus*, actually was the inflated valve of the form that he had just described as *chipolanus*. The Alum Bluff *heracleus* was described as follows:

> "Shell large, convex, subequilateral, rather thick, with small, pointed, prosogyrate beaks over an arcuately impressed, small, sublanceolate lunule; anterior dorsal area narrow and rather short, defined by a shallow sulcus; posterior area narrow elongate, divided by a second longitudinal sulcus into two parts, of which the anterior is wider; sculpture of fine concentric lines, feebler in the middle of the disk, and of faint, nearly obsolete, sparser radial striations; ligament deeply inset, rather long; cardinals normal, rather small and slender. Alt. 80, lat. 77, diam. 30 mm.
>
> " . . . Only one right valve and a fragment have so far been obtained."

In many ways *Miltha chipolana* is the most variable of the species here studied. In general the valves are slightly higher than long; the length in 50 specimens measured, averaging 95% of the height but varying from slightly less than 84% in the relatively highest form to 109% in the relatively longest. Figures 1 and 4 on plate 5, represents a specimen of average height —length proportions (text fig. 3), while figure 6 on the same plate is one of the more elongate forms. This variation is not a function of differing proportions during growth; the relatively highest specimen measured has a height of 49.3 mm and a length of 41.3 mm, while the longest has a height of 45.5 mm and a length of 49.6 mm.

Concentric surface ornamentation is similar to that found on all of the species studied, and the same weak tangential lineation of minute raised threads is present. The radial ribbing is, on the whole, more variable than in the other species, perhaps a little more strongly developed than that on *M. carmenae*, but with the majority of the ribs being much narrower. However, there is an apparent tendency toward variation in this feature and occasional ribs will be two to three times the width of those adjacent.



Text figure 3. Average height-length proportions of adult specimens of the species of *Miltha* examined during this study. The number in parenthesis represents the number of measurements averaged for each species.

The shape and trend of the anterior dorsal margin is, perhaps, the most variable feature of the species. In almost all specimens this margin has an almost straight outline, sloping away from the usually low and inconspicuous umbones. The slope of this margin relative to the vertical of the height of the shell varied, among the 25 specimens measured, from 67° to 80°. The majority of the specimens from the stratigraphically lower localities tend to have a somewhat steeper slope, averaging around 62° to 65°, while an ecotype or variety that occurs with forms of typical slope angle, mainly in the stratigraphically higher beds, has a margin that trends almost horizontally and is sharply subangulate at its anterior end (pl. 5, fig. 5). The figure given by Maury (1917, pl. 61, fig. 6) of her *Phacoides* (*Miltha*) *smithwoodwardi* from the Cercado Formation of the Dominican Republic, suggests a specimen that approaches this latter form. Miss Maury compared her specimen with *M. caloosaensis*, but not with *M. chipolana*, of which it is here held to be a synonym.

Figured specimen: USNM 646394, height 72.6 mm, length 67.6 mm, diameter (paired valves) 20.7 mm (right valve 14.2 mm, left valve, 7.5 mm). Locality TU 555.

Figured specimen: USNM 646395, height 64.2 mm, length 59 mm, diameter (paired valves) 15.8 mm (right valve 9.1 mm, left valve 6.8 mm.). Locality TU 459.

Figured specimen: USNM 646396, height 82.9 mm, length 81 mm, diameter (right valve of lesser convexity) 9.1 mm. Locality TU 820b.
Figured specimen: USNM 646397, height 46.6 mm, length 42.5 mm, diameter (left valve of lesser convexity) 5.5 mm. Locality TU 549.
Figured specimen: USNM 646398, height 44.4 mm, length 42.2 mm, diameter (convex right valve) 7 mm. Locality TU 549.
Figured specimen: USNM 646399, height 4.2 mm, length 3.6 mm, right valve. Locality TU 555.
Figured specimen: USNM 646400, height 4.3 mm, length 4.1 mm, right valve. Locality TU 555.
Figured specimen: USNM 646401, height 7.8 mm, length 6.8 mm, right valve. Locality TU 555.
Figured specimen: USNM 646402, height 11.5 mm, length 11.2 mm, right valve. Locality TU 555.
Figured specimen: USNM 646403, height 3.2 mm, length 3.1 mm, left valve. Locality TU 555.
Figured specimen: USNM 646404, height 4.4 mm, length 3.8 mm, left valve. Locality TU 555.
Figured specimen: USNM 646405, height 8.1 mm, length 7.5 mm, left valve. Locality TU 555.
Figured specimen: USNM 646406, height 10.5 mm, length 9.9 mm, left valve. Locality TU 555.

Distribution:
Tulane University localities 70, 196, 453, 458, 459, 546, 547, 548, 549, 555, 655, 820b, 821, 824, 825, 826, 827, 950, 998, 999.

MILTHA (MILTHA) CALOOSAENSIS (Dall)

Plate 1, Figure 4; Plate 2, Figures 3a, b; Plate 6, figs. 1-5

1898, *Lucina* (*Miltha*) *caloosaënsis* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 923, pl. 28, fig. 1.
1903, *Phacoides* (*Miltha*) *caloosaënsis* Dall. DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1376.
1905, *P.* [*Phacoides*] *caloosana* [*sic*] Dall. DALL, Nautilus, vol. 18, no. 10, p. 112.
1953, *Miltha* (*Miltha*) *caloosaënsis* (Dall). OLSSON and HARBISON, Acad. Nat. Sci. Phila., Mon. 8, p. 89 [part].
1958, *Miltha* (*Miltha*) *caloosaensis* (Dall). DUBAR, Florida Geol. Surv., Geol. Bull. 40, p. 169.

This species was originally named, with an illustration only, by Dall in 1898, but the description did not appear until 1903:

> "Shell elevated, rather compressed, short, finely concentrically striated; beaks small, pointed, slightly curved forward over an exceedingly minute and almost obsolete lunule; anterior dorsal area short, narrow, feebly defined; posterior area long, wider, defined by a narrow sulcus, with a less pronounced sulcation dividing the area lengthwise into nearly equal parts; there are traces of very minute radial striation on some specimens; resilium shorter than the ligament, both deeply insert and partly covered by the dorsal margin, which is usually broken away; teeth and scars normal, well developed; disk internally with a well-marked oblique sulcus. Alt. 53.0 (to 63.0), lon. 47.0, diam. 13.5 mm.
>
> "The lunule is better developed in the older specimens and more in the right than in the left valve. Some specimens have the right valve less convex than the left. The species is very like *P.* (*Miltha*) *Childreni* Gray [*xantusi* Dall], but is proportionately more elevated, with a more delicate hinge and smaller muscular impressions. . . . "

The original figure gave no locality information beyond the geologic age, "Pliocene;" the 1903 description added: "Pliocene of the Caloosahatchee and Shell Creek, Florida." While this species has in the past been thought to be restricted to the Caloosahatchee Formation (DuBar, 1958, p. 169, Olsson and Petit, 1964, p. 520), Tulane University collections reveal that it is rather widely distributed in the upper Miocene Pinecrest beds of southern Florida. The Caloosahatchee specimens are in general smaller than those from the Miocene. The average dimensions of 50 of the larger Caloosahatchee specimens in the Tulane collections are: height 49.4 mm, length 45.4 mm; the largest is 65.2 mm high and 61 mm long. The average dimensions of 50 upper Miocene specimens are: height 65.8 mm, length 60.8 mm; the largest being 92.1 mm high and 81.4 mm long.

Miltha caloosaensis is the smallest of the species of *Miltha* here being considered (text fig. 3). Although the upper Miocene specimens average almost as large as *M. chipolana*, the Pliocene specimens average approximately 20 mm shorter and narrower than that species. Compared with other Florida Tertiary species *M. caloosaensis* is more regularly elongate-ovate in form with lower, less prominent umbones and shorter and, usually, more rounded anterior dorsal margin. In these features it is similar to the Recent *M. childrenae*, from which it may be distinguished, as from the other Florida Tertiary species, by the deeply impressed, concave lunule in the right valve, the anterior portion of which trends almost vertically and is closely appressed against the dorsal part of the anterior cardinal tooth, which becomes so reduced, especially in its height, as to be almost obliterated. The corresponding area of the left valve is particularly marked by the fact that the low lamellar ridge separating the incised area for the reception of the lunular margin from the anterior cardinal socket trends across the socket towards its dorsal end and becomes appressed against the side of the bifid left anterior cardinal tooth. A somewhat similar situation is occasionally present in the variable *M. chipolana*, but these specimens may be distinguished by the fact that the ridge separating the lunular area from the anterior cardinal socket in the left valve is never as high and lamellar in shape, and the depressed area for the reception of the lunular margin is narrower, usually only about one-half as wide as it is in specimens of *caloosaensis* of the same relative size.

Figured specimen: USNM 646407, height 61.9 mm, length 55.5 mm, diameter (paired valves) 15.4 mm—(right valve, 9.3 mm, left valve 6.8 mm; the left fitting slightly inside the right). Locality TU 796 (upper Miocene).

Figured specimen: USNM 646408, height 55.2 mm, length 49.8 mm, diameter (paired valves) 14.2 mm (right valve 7.8 mm, left valve, 6.5 mm). Locality TU 755 (Pliocene).

Distribution:

Caloosahatchee Formation, Pliocene: Tulane University localities 79, 519, 536, 539b, 579, 583, 755, 768, 974, 975, 980.

Pinecrest beds, upper Miocene: Tulane University localities 520, 540, 728, 729, 730, 736, 740, 741, 742, 756, 769, 796, 797, 933, 979, 981, 982, 985, 1000.

MILTHA (MILTHA) CARMENAE

H. E. Vokes, new species

Plate 1, Figure 2; Plate 2, Figures 2a, b; Plate 6, Figure 4; Plate 7, Figures 1-5

1953, *Miltha* (*Miltha*) *caloosaënsis* (Dall). Olsson and Harbison, Acad. Nat. Sci. Phila., Mon. 8, p. 89 (in part—"large specimens . . . from Clewiston and Belle Glade").

1964, "*Miltha* sp. (large)," Olsson and Petit, Bulls. Amer. Paleontology, vol. 47, no. 217, p. 521.

Description: Shell large for the genus, subcircular in outline with moderately prominent concentric and exceedingly weak radial ornamentation, the latter visible only under strongly oblique lighting. Valves unequally inflated. Umbones high, prominent; posterior dorsal slope broadly convex, descending at an angle of approximately 55° from the vertical; posterior margin almost straight, sloping posteroventrally; postero-ventral margin relatively sharply rounded into the broadly and equally convex ventral and anterior margins; anterior dorsal margin concave immediately below and in front of the umbones, becoming straight for a short distance before rounding into the anterior margin, the angle from the umbo to the anterior end of the margin being approximately 65° from the vertical of the valve height. Anterior dorsal area almost not delimited in the flatter valves, with only a very obscure margining groove, but with a strong tendency in the larger specimens to curve laterally against, and somewhat to displace the anterior end of the dorsal area of the more inflated valve; anterior dorsal area of inflated valves with a broad marginal rib that becomes enlarged and prominent in the area of displacement by the less inflated valve. Posterior dorsal areas well-marked, long, with a deep marginal groove but with the dorsally adjacent rib always low, broad and inconspicuous, so there is no suggestion of a second "medial" groove on the area.

Hinge plate broad, usually with a narrow, raised rib on its anterior ventral edge. Cardinal teeth two in each valve, the left anterior and the right posterior relatively broad and obscurely bifid, the right anterior and left posterior simple; all teeth arcuate with their anterior faces broadly concave. Lunule small, deeply impressed and confined to the right valve, marked more or less like the posterodorsal area with a strong groove separating the lunular surface from the rather corrugated edge of the impressed area of the valve, and with an adjacent ill-defined ridge that passes rather gradually into a more depressed flattened area near the inner margin of the lunule. The posterior (inner) face of the lunule is closely appressed against the right anterior cardinal but separated from it by a shallow groove, such that the projecting edge of the lunule and the top of the cardinal have the appearance of a single rather deeply bifid tooth. Ligament and nymph plate typical of the genus.

Pallial line distant from the valve margin, entire, relatively wide and impressed, its surface marked by irregularly spaced low ridges that appear almost as if radiating from a point a short distance below the umbones (see text fig. 2b). Anterior adductor scar long, relatively broad, its ventral face with less curvature than the pallial line so that its ventral end is more approximate to the pallial line than is its median area; posterior ventral end broadly rounded, posterior dorsal side almost straight; the surface marked by oblique, subparallel low ridges similar to those of the pallial area. Posterior adductor scar, reniform, broadly rounded ventrally, the dorsal side straight to slightly concave, the low point of the concavity situated at a groove that divides the scar into two unequal areas, the outer of which is relatively smooth, marked only by concentric lines of muscle increase, the inner with fine sub-parallel ridges similar to those on the anterior adductor and pallial line. Other internal markings as in the genus (see pp. 106-110).

Holotype: USNM 646409, height 82.7 mm, length 76.5 mm, diameter (impaired valves) 20.4 mm (right valve, 12.3 mm, left valve, 8.2 mm). Locality TU 201.

Paratype: USNM 646410, height 105.5 mm, length 98.8 mm, diameter (left valve of lesser convexity) 9 mm. Locality TU 201.

Paratype: USNM 646411, height 62.5 mm, length 58.7 mm, diameter (right valve of lesser convexity) 6.4 mm. Locality TU 978.

Distribution:

Tulane University localities 201, 727, 731, 978, 987, 988.

This appears to be the largest of the known species of the genus *Miltha*, one specimen in the Hoerle collection is 127.6 mm high and 122.5 mm long; the average dimensions of the 40 adult specimens sufficiently perfect to permit accurate measurement are: height 87.0 mm, length 81.7 mm. It is probable that adequate collections of *M. childrenae* will show that species approaches *M. carmenae* in overall dimensions (text fig. 3); the average dimensions of the adult specimens in the present collection, plus those of the lectotype (see page 116) and of the specimen mentioned by Dall (1905, p. 112) are: height 81 mm, length 73.8 mm. *M. carmenae* easily may be distinguished from *M. childrenae* as well as from the other species in the Florida Neogene deposits by the relatively high umbones and the more steeply sloping dorsal margins, especially the anterior one where the rather large concavity immediately in front of the umbones accentuates their apparent elevation.

Miltha carmenae is moderately common in the deposits of the unnamed post-Caloosahatchee formation, "Unit A" of Olsson and Petit (1964, p. 521), in the region about Lake Okeechobee, especially to the east and southeast of the lake. The sediments and faunas from these deposits appear to suggest deposition in somewhat more off-shore waters than were the deposits from the more western outcrops of the formation.

This species is named for Carmen, the daughter of the late Mr. Thomas S. Hughes, of Fort Pierce, Florida, who appears to have been the first to recognize that it represented an undescribed species and who used this name in his manuscript field notes.

VII. LOCALITY DATA

The following are Tulane University fossil localities:

70. Chipola Fm., Ten Mile Creek, at bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida.

79. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks north and south side of Caloosahatchee River, at Ortona Lock (Sec. 27, T42S, R30E), Glades Co., Florida.

196. Chipola Fm., Ten Mile Creek, about ¼ mile upstream from bridge of Florida Highway 73 (NE ¼ Sec. 11, T1N, R10W), Calhoun Co., Florida.

201. Unnamed post-Caloosahatchee formation, spoil banks at pit just south of Belle Glade (at Belle Glade Camp), Palm Beach Co., Florida.

453. Chipola Fm., lower beds at Alum Bluff, Appalachicola River (NE ¼ Sec. 24, T1N, R8W), Liberty Co., Florida.

458. Chipola Fm., east bank of Chipola River, above Farley Creek (SW ¼ Sec. 20, T1N, R9W), Calhoun Co., Florida.

459. Chipola Fm., east bank Chipola River, steep bank about 1500 ft. above mouth of Taylor Lake Branch (NW ¼ Sec. 29, T1N, R9W), Calhoun Co., Florida.

519. Caloosahatchee Fm., Harney Pond Canal spoil banks, at Florida Highway 78, northwest side of Lake Okeechobee (NW ¼ Sec. 18, T40S, R33E), Glades Co., Florida.

520. Pinecrest beds, spoil banks, canal 0.9 mile east of Brighton on Florida Highway 70 (Sec. 25, T37S, R32E), Highlands Co., Florida.

536. Caloosahatchee Fm., south bank of Caloosahatchee River about one mile east of La Belle (Sec. 3 & 4, T43S, R29E), Hendry Co., Florida. (Designated as type locality of the Caloosahatchee Formation by Olsson *in* Olsson and Petit, 1964, p. 519.)

539b. Caloosahatchee Fm., Shell Creek (lower beds), about eight miles east of Cleveland (Sec. 30, T40S, R25E), Charlotte Co., Florida.

540. Pinecrest beds, Miami Canal spoil banks, one to three miles south of pumping station at Palm Beach county line, Broward Co., Florida.

546. Chipola Fm., Ten Mile Creek, about 1½ miles west of Chipola River (NE ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida.

547. Chipola Fm., west bank of Chipola River, about 2000 ft. above the mouth of Four Mile Creek (SW ¼ Sec. 29, T1N, R9W), Calhoun Co., Florida.

548. Chipola Fm., west bank of Chipola River (NW ¼ Sec. 29, T1N, R9W), Calhoun Co., Florida.

549. Chipola Fm., east bank of Chipola River, about ¼ mile below Four Mile Creek (NE ¼ Sec. 32, T1N, R9W), Calhoun Co., Florida.

555. Chipola Fm., east bank of Chipola River, about 1000 ft. above the mouth of Four Mile Creek (SW ¼ Sec. 29, T1N, R9W), Calhoun Co., Florida.

579. Caloosahatchee Fm., Miami Canal spoil banks, four miles north of pumping station

at Broward county line, Palm Beach Co., Florida.

583. Caloosahatchee Fm., Miami Canal spoil banks, seven miles north of pumping station at Broward county line, Palm Beach Co., Florida.

655. Chipola Fm., Ten Mile Creek, about 0.1 mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida.

727. Unnamed post-Caloosahatchee formation, borrow pits 2.2 miles east of U. S. Highway 27, 15 miles south of South Bay, Palm Beach Co., Florida.

728. Pinecrest beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, just across from U. S. Corps of Engineers Structure 65-D (Sec. 33, T36S, R33E), Okeechobee Co., Florida.

729. Pinecrest beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, approximately ½ mile south of U. S. Corps of Engineers Structure 65-D (S ½ Sec. 33, T36S, R33E), Okeechobee Co., Florida.

730. Pinecrest beds, embankment of Seaboard Airline Railroad, just west of Kissimmee River (NW ¼ Sec. 20, T36S, R33E), Highlands Co., Florida.

731. Unnamed post-Caloosahatchee formation, West Palm Beach Canal spoil banks, at junction of U. S. Highways 441 and 98, seven miles west of Loxahatchee, Palm Beach Co., Florida.

736. Pinecrest beds, spoil banks on south side of Florida Highway 70 and east side of Kissimmee River, Okeechobee Co., Florida.

740. Pinecrest beds, levee fill, L-28, 3.6 miles west and 2.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.

741. Pinecrest beds, levee fill, L-28, 3.6 miles west and 3.6 miles south of pumping station on Miami Canal at Palm Beach county line, Broward Co., Florida.

742. Pinecrest beds, levee fill, L-28, 3.6 miles west and 5.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.

755. Caloosahatchee Fm., Miami Canal spoil banks, 17.4 miles north of pumping station at Broward county line, Palm Beach Co., Florida.

756. Pinecrest beds, spoil banks west side of Elkcan Waterway, Port Charlotte Development, 2.3 miles southeast of Port Charlotte Railroad Station (formerly Murdock) and 1.7 miles east of U. S. Highway 41 (Sec. 10, T40S, R22E), Charlotte Co., Florida.

768. Caloosahatchee Fm. and unnamed post-Caloosahatchee formation mixed, spoil banks north side of Caloosahatchee River, 5½ miles west of Ortona Lock (NW ¼ Sec. 35, T42S, R29E), Glades Co., Florida.

769. Pinecrest beds, spoil banks east side of Kissimmee River, 1½ to two miles south of U. S. Corps of Engineers Structure 65-D (NE ¼ Sec. 35, T36S, R33E), Okeechobee Co., Florida.

796. Pinecrest beds, material exposed during construction of "Alligator Alley," 12.8 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

797. Pinecrest beds, material exposed during construction of "Alligator Alley," 13.3 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

820B. Chipola Fm., Farley Creek (lower beds), at bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

821. Chipola Fm., Farley Creek, 0.1 mile east of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

824. Chipola Fm., Farley Creek, about ½ mile upstream from bridge of Florida Highway 275 (SE ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

825. Chipola Fm., Farley Creek, at abandoned mill about ¼ mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

826. Chipola Fm., Farley Creek, about 0.1 mile west of abandoned mill which is ¼ mile west of bridge of Florida Highway 275 (on section line between Sec. 20 & 21, T1N, R9W), Calhoun Co., Florida.

827. Chipola Fm., Farley Creek, about ½ mile west of bridge of Florida Highway 275 (SE ¼ Sec. 20, T1N, R9W), Calhoun Co., Florida.

933. Pinecrest beds, material exposed during construction of "Alligator Alley," 21.5 miles east of Florida Highway 29, Collier Co., Florida.

950. Chipola Fm., Chipola River, west bank about 2000 ft. above the mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W), Calhoun Co., Florida.

974. Pinecrest beds, north side Caloosahatchee Canal, 2½ to 3½ miles west of center of former Lake Hicpochee (now drained) (unmapped area, T42S, R32E), Glades Co., Florida.

975. Caloosahatchee Fm., spoil banks, north side Caloosahatchee Canal, 0-½ mile west of center of former Lake Hicpochee (now drained) (unmapped area, T42S, R32E), Glades Co., Florida.

978. Unnamed post-Caloosahatchee formation, spoil banks at pit on south side of waterworks, about 1½ miles northeast of South Bay, Palm Beach Co., Florida.

979. Pinecrest beds, Port Charlotte Development, spoil banks just north of Seaboard Railroad, two miles north of U. S. Highway 41, on canal 1½ miles southwest of junction with Florida Highway 771 (Sec. 4, T40S, R22E), Charlotte Co., Florida.

980. Caloosahatchee Fm., Port Charlotte Development, spoil banks on north side U. S. Highway 41, on canal 3.3 miles northwest of Florida Highway 771 (Sec. 3, T40S, R21E), Charlotte Co., Florida.

981. Pinecrest beds, Port Charlotte Development, spoil banks on south side of U. S. Highway 41, on canal 3.3 miles northwest

of Florida Highway 771 (Sec. 3, T40S, R21E), Charlotte Co., Florida.

982. Pinecrest beds, Port Charlotte Development, spoil banks on northwest side of Florida Highway 771, on canal 3½ miles southwest of junction with U. S. Highway 41 (Sec. 15, T40S, R21E), Charlotte Co., Florida.

984. Pinecrest beds, Port Charlotte Development, spoil banks 0.8 mile south of Florida Highway 771, on canal 1.9 miles southwest of junction with U. S. Highway 41 (Sec. 14, T40S, R21E), Charlotte Co., Florida.

985. Pinecrest beds, Port Charlotte Development, spoil banks about ½ mile northeast of Florida Highway 771, on U-shaped canal 3.3 miles southwest of junction of U. S. Highway 41 (Sec. 10, T40S, R21E), Charlotte Co., Florida.

987. Unnamed post-Caloosahatchee formation, spoil banks south side West Palm Beach Canal, at Loxahatchee, on U. S. Highway 98, Palm Beach Co., Florida.

988. Unnamed post-Caloosahatchee formation, spoil banks, West Palm Beach Canal at Twenty Mile Bend Recreation Area, about one mile east of junction of U. S. Highways 98 and 441, Palm Beach Co., Florida.

998. Chipola Fm., bank of Ten Mile Creek about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida.

999. Chipola Fm., Farley Creek, about 900 feet downstream from bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

1000. Pinecrest beds, borrow pit at east end of 17th Street, 3.2 miles east of Tuttle Road, about 8 miles east of U. S. Highway 301 in Sarasota (T36S, R19E), Sarasota Co., Florida.

VIII. Literature Cited

Allen, J. A., 1958, On the basic form and adaptations to habitat in the Lucinacea (Eulamellibranchia): Philos. Trans., Roy. Roy. Soc. London, (B), no. 684, v. 241, p. 421-484, 1 pl., 53 text figs.

Arnold, Ralph, 1909 [1910], Paleontology of the Coalinga District, Fresno and Kings Counties, California: U. S. Geol. Surv., Bull. 396, 173 p., 30 pls.

Bowden, J., 1958, The structure and innervation of lamellibranch muscle: Internat. Rev. Cytol., v. 7, p. 295-335.

Caster, K. E., 1938, Macroscopic fauna of the Quimbriz (Eocene) Formation on the Luculo River, Angola: Comun. Serv. Geol. de Portugal, v. 20, p. 1-48, pls. 1-10.

Carpenter, P. P., 1864, A supplementary report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America: Rept. Brit. Assoc. Adv. Sci. (1863), p. 517-686 (August, 1864).

Chavan, Andre, 1937-1938, Essai critique de classification des Lucines: Jour. de Conchyl., v. 81, p. 133-153, 198-216, 237-282; v. 82, p. 59-97, 105-130, 215-243; 1 table, 20 text figs.

Chavan, Andre, 1952, Les Pélécypodes des sables astartiens de Cordebugle (Calvados): Mém. Suisses de Paléont., v. 69, 132 p., 4 pls., 82 text figs.

Cossmann, Maurice, 1908, Pélécypodes du Montien de Belgique: Mém. Mus. roy. Hist. nat. Belg., v. 5, 76 p., 8 pls.

Cossmann, Maurice, and A. Peyrot, 1909-1912, Conchologie Néogénique de l'Aquitaine; Tome 1. Pélécypodes (Clavagellidae à Lucinidae): (Extract from Actes Soc. Linn. Bordeaux, vols. 63 to 65), p. 1-220, pls. 1-7, text figs. 1-28, 3 maps (18 Dec., 1909); p. 221-428, pls. 8-18, text figs. 29-80 (4 Mar., 1911); p. 429-718, pls. 19-28, text figs. 81-135 (15 May, 1912).

Cossmann, Maurice, and Georges Pissarro, 1904-1906, Iconographie complète des coquilles fossiles de l'Éocène des environs de Paris: v. 1, pls. 1-16 (31 Dec., 1904), pls. 17-45, title page and Table alphabetique (1906).

Dall, W. H., 1901, Synopsis of the Lucinacea and of the American species: Proc. U. S. Nat. Mus., v. 23, p. 779-833, pls. 39-42.

Dall, W. H., 1903, Contributions to the Tertiary fauna of Florida: Trans. Wagner Free Inst. Sci., v. 3, pt. 6, p. i-xiv, 1219-1654, pls. 48-60, 2 tables.

Dall, W. H., 1905, Note on *Lucina* (*Miltha*) *childreni* Gray and on a new species from the Gulf of California: Nautilus, v. 18, no. 10, p. 110-112.

Dartevelle, E., and J. Roger, 1954, Contribution de la connaissance de la faune du Miocène de l'Angola: Comun. Serv. Geol. de Portugal, v. 35, p. 227-312, pls. 1-5.

Dickerson, R. E., 1916, Stratigraphy and fauna of the Tejon Eocene of California: Univ. Calif. Pubs., Bull. Dept. Geol., v. 9, no. 17, p. 363-524, pls. 36-46, 14 text figs., map.

Doello-Jurado, M., 1919, Une nouvelle espece de "*Miltha*" du tertiare de l'Argentine: Physis, v. 4, p. 558-562, 1 text fig.

DuBar, J. R., 1958, Stratigraphy and Paleontology of the late Neogene strata of the Caloosahatchee River of southern Florida: Florida Geol. Surv., Bull. 40, 267 p., 12 pls., 48 text figs., 10 tables, 4 correlation charts.

Durham, J. W., 1950, Cenozoic marine climates of the Pacific Coast: Geol. Soc. Amer., Bull., v. 61, p. 1243-1264, 3 text figs.

Gardner, Julia, 1926, The molluscan fauna of the Alum Bluff Group of Florida. Part III. Lucinacea, Leptonacea, Cardiacea: U. S. Geol. Surv., Prof. Pap. 142-C, p. i-iv, 101-149, pls. 18-23.

Hall, C. A., Jr., 1964, Shallow-water marine climates and molluscan provinces: Ecology, v. 45, no. 2, p. 226-234, 6 text figs., 2 tables.

Harris, G. D., 1951, Preliminary notes on Ocala bivalves: Bulls. Amer. Paleontology, v. 33, no. 138, p. 219-272, pls. 30-42.

Hertlein, L. G., and A. M. Strong, 1946, Eastern Pacific Expeditions of the New York Zoological Society. XXXV. Mollusks from the

West Coast of Mexico and Central America. Part IV: Zoologica, v. 31, pt. 8, p. 93-120, pl. 1.

HOYLE, G., 1964, Muscle and Neuromuscular Physiology: Chap. 10, p. 313-351, 7 text figs., *in* WILBUR, K. M., and C. M. YONGE, Physiology of Mollusca, v. 1, xii + 473 p. Academic Press, New York & London.

KEEN, A. M., 1958, Sea shells of tropical west America. xi + 624 p., 10 color plates, 1709 figs., 6 text figs. Stanford, California.

MARSHALL, P., and R. MURDOCK, 1921, Some Tertiary Mollusca, with descriptions of new species: Trans. New Zealand Inst., v. 53, p. 77-84, pls. 14-19.

MAURY, C. J., 1917, Santo Domingo type sections and fossils, pt. 1; Mollusca: Bulls. Amer. Paleontology, v. 5, no. 29, p. 165-415, pls. 27-65, map; pt. 2; Stratigraphy: *ibid.*, v. 5, no. 30, p. 416-460, pls. 66-68, correlation chart.

OLSSON, A. A., 1929, Contributions to the Tertiary Paleontology of Northern Peru; Part 2, Upper Eocene Mollusca and Brachiopoda: Bulls. Amer. Paleontology, v. 15, no. 57, p. 67-116, pls. 9-15.

OLSSON, A. A., 1930, Contributions to the Tertiary Paleontology of Northern Peru; Part 3, Eocene Mollusca: Bulls. Amer. Paleontology, v. 17, no. 62, p. 1-96, pls. 1-12.

OLSSON, A. A., and ANNE HARBISON, 1953, Pliocene Mollusca of southern Florida, with special reference to those from North Saint Petersburg: Acad. Nat. Sci. Phila., Monograph 8, 457 p., 65 pls.

OLSSON, A. A., and R. E. PETIT, 1964, Some Neogene Mollusca from Florida and the Carolinas: Bulls. Amer. Paleontology, v. 47, no. 217, p. 509-574, pls. 77-83.

PELSENEER, PAUL, 1911, Les Lamellibranches de l'Expédition du Siboga. Partie Anatomique: Siboga-Exped., Monograph 53a, 126 p., 26 pls. Leiden, E. J. Brill, Ltd.

REEVE, L. A., 1850, Monograph of genus *Lucina*: 11 pls., *in* Conchologia Iconica, or illustrations of the shells of molluscous animals. London.

SINGLETON, F. A., and N. H. WOODS, 1934, On the occurrence of the Pelecypod genus *Miltha* in the Australian Tertiary: Proc. Roy. Soc. Victoria (N.S.), v. 46, pt. 2, p. 207-213, pl. 8.

STEWART, R. B., 1930, Gabb's California Cretaceous and Tertiary type Lamellibranchs: Acad. Nat. Sci. Phila., Spec. Publ. 3, 314 p., 17 pls.

VOKES, H. E., 1939, Molluscan faunas of the Domengine and Arroyo Hondo formations of the California Eocene: Ann. New York Acad. Sci., v. 38, p. 1-246, pls. 1-22, 1 text fig., 4 tables.

WILKINS:, G. L., 1957, The Cracherode shell collection: Bull. Brit. Mus. (Nat. Hist.), Hist. Ser., v. 1, no. 4, p. 121-184, pls. 20-25.

WILKINS, R. W. T., 1962, *Miltha* in the Southeastern Australian Tertiary: Jour. Malacol. Soc. Australia, no. 6, p. 43-49, pl. 5, 1 text fig.

WOODS, HENRY, 1922, Palaeontology of the Tertiary Deposits; Section A: p. 51-113, pls. 1-20, *in* T. O. BOSWORTH, Geology of the Tertiary and Quaternary periods in the Northwest part of Peru. London, Macmillan & Co.

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION—I

A NEW SPECIES OF *EOMILTHA* (MOLLUSCA: BIVALVIA)

HAROLD E. VOKES
TULANE UNIVERSITY

While engaged in the study of the species of *Miltha s.s.* from the Neogene deposits of Florida I noted the presence in collections from the Chipola Formation of an undescribed species of the genus *Eomiltha.* This form, which is rather rare, represents the first record of the genus in the faunas from the type area of the formation, although Gardner described (1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 112, pl. 20, figs. 1, 2), as "*Phacoides* (*Miltha*)" *xustris*, a form that is to be referred to *Eomiltha* from the lower beds exposed at Alum Bluff, Liberty County, Florida. At that locality (= TU 453) about ten feet of the uppermost beds of the Chipola Formation are exposed during low water stages of the Apalachicola River. The present species is found at localities that occur approximately at the top of the basal third of the section in the type area; it thus is believed to be stratigraphically lower and hence somewhat older than *E. xustris.*

Genus EOMILTHA Cossmann, 1912

Eomiltha COSSMANN, 1912, Act. Soc. linn. Bordeaux, vol. 65, p. 269 [issued separately as: Cossmann and Peyrot, Conch. Néog. de l'Aquitaine, v. 1, livr. 3, p. 650, 1912].

Type species, by original designation, *Lucina contorta* Defrance, Thanetian Stage, Paleo-