

MYTILIDAE (MOLLUSCA: BIVALVIA) FROM THE CHIPOLA FORMATION,  
LOWER MIOCENE, FLORIDAHAROLD E. VOKES  
TULANE UNIVERSITY

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## I. ABSTRACT

The bivalve family Mytilidae, previously known from the Chipola Formation by only a few, mostly fragmentary specimens referable to three species, proves to be relatively widely distributed throughout the type area of the formation, being most abundant in localities where coral is also present.

In this paper, ten species in eight genera are reported from the formation. Included are three new species and one new subspecies.

## II. INTRODUCTION

Species of the family Mytilidae exhibit a preference for intertidal and shallow-water environments, including: (a) rocky areas, permitting byssal attachment (Mytilinae); or burrowing into rocks, corals or larger shells (*Gregariella*, *Botula*, most *Lithophaga*); or (b) mud flats for burrowing (Modiolinae). The principal exception to these preferences is afforded by the species of the genus *Crenella*, which are most commonly found on muddy silt or sand bottoms. Living specimens have been taken from depths down to 460 meters in the Pacific Ocean (Bernard, 1983, p. 20) and what obviously were dead valves have been reported from depths as great as 2,290 fathoms [=4,076 meters] (Clarke, 1962, p. 58).

This general preference of most mytiloid forms for shallow-water and intertidal hard-bottom environments where dead shells tend to be destroyed by wave action, has resulted in their being relatively rare elements in the fossil faunas, with *Crenella* being apparently the most widely distributed genus. Thus, it is of considerable interest to find in the Tulane University collections from the type area of the Lower Miocene Chipola formation of northern Florida, ten species referable to eight genera, including each of the four recognized subfamilies (Table 1).

In contrast, prior to this report, Dall (1898b, p. 797) listed only "*Modiolus (Botula) cinnamomeus* Lamarck" [= *Botula fusca* (Gmelin)] and (p. 806) "a single broken valve," identified as "*Modiolaria* sp. indet." [= *Musculus (Ryenella) lateralis praelateralis* n. subsp.]. At the same time, however, he described *Modiolus (Brachydontes) grammatus* var. *curtulus* (p. 794) and *Crenella miniscula* (p. 803) from the lower bed at Alum Bluff on the Apalachicola River, which contains a fauna that appears to be equivalent to that of the uppermost beds of the Chipola Formation on the Chipola River. Gardner (1926, p. 60) reported the occurrence of *Crenella* in the beds at the McClelland Farm on the Chipola River and from Tenmile Creek. Tulane University collections contain more than 700 specimens of *C.*

*miniscula* from 52 of our 57 Chipola localities.

### III. SYSTEMATIC PALEONTOLOGY

Superfamily MYTILACEA Rafinesque, 1815

Family MYTILIDAE Rafinesque, 1815

Subfamily MYTILINAE Rafinesque, 1815

Genus PERNA "Retzius,"

Philipsson, 1788 [ICZN Op. 495]

*Perna* "Retzius" PHILIPSSON 1788, Disert.

Hist. Nat. Nova Testac. Genera, p. 20.

*Chloromya* MÖRCH, 1853, Cat. Conch. Yoldi, pt. 2, p. 52.

?*Mytiloconcha* CONRAD, 1862, Acad. Nat. Sci. Phila., Proc., v. 14, p. 290 [as *Mytiloconcha*, p. 579].

Type species, by subsequent designation, Soot-Ryen, 1955: *Perna magellanica* "Retzius" (= *Mya perna* Linnaeus, 1758). Recent, Straits of Magellan (Type locality, *vide* Soot-Ryen, 1955, p. 30). north to Venezuela (Rios, 1975, p. 197); South Africa from Namibia to Mozambique (Kilburn and Rippey, 1982, p. 159).

*Discussion:* Species referable to the genus *Perna* may be recognized by their dysodont hinge, consisting of one or two small denticles close to the beak, by their pitted resilial ridge below the ligament, and by their margaritaceous shell structure. The latter tends to weaken the rather

thin shells to the point that they are seldom found well-preserved in the fossil record.

The generic name *Perna* usually has been cited as having been proposed by Retzius in 1788, but as was noted by A. E. Ellis in his request to the International Commission on Zoological Nomenclature concerning the genus *Unio* (see Opinion 495, 1957), "This genus was established in a thesis by Philipsson, working under his master Retzius at the University of Lund. By the law or custom then obtaining the professor was treated as the author of all papers which a student under him defended. For this reason the . . . names in this thesis have been attributed . . . to Retzius. It is clear, however, from the title page that Philipsson was the real author of this *Dissertatio* and that the name *Unio* is therefore correctly attributable to him and not to Retzius."

PERNA CRAURA H. E. Vokes, n. sp.

Plate 1, Figures 1-3

*Description:* Shell of medium size, mytiliform, with obliquely elongated, moderately convex valves marked by a rounded umbonal ridge paralleling the anterior margin; umbones relatively small, terminal, pointed; posterior margin slightly convex, almost straight along the length of the ligament, then sharply and subangulately

TABLE 1. DISTRIBUTION OF MYTILOID SPECIES IN THE CHIPOLA FORMATION

	CHIPOLA RIVER	TENMILE CREEK	FARLEY CREEK	Total Number of Localities
Number of localities with mytiloid specimens . . . . .	21	19	15	55
MYTILINAE				
<i>Perna craura</i> n. sp. . . . .	6	0	10	16
<i>Brachidontes curtulus</i> (Dall) . . . . .	5	0	15	20
CRENELLINAE				
<i>Crenella miniscula</i> Dall . . . . .	19	10	15	52
<i>Musculus (Planimodiola) disinflatus</i> n. sp. . . . .	9	0	10	19
<i>M. (Ryenella) lateralis praelateralis</i> n. subsp. . . . .	15	14	14	43
<i>Gregariella arcaforma</i> n. sp. . . . .	2	3	2	7
LITHOPHAGINAE				
<i>Lithophaga antillarum</i> (Orbigny) . . . . .	0	1	3	4
<i>L. (Diberus) bisulcata</i> (Orbigny) . . . . .	2	1	4	7
MODIOLINAE				
<i>Modiolus ducatelii</i> Conrad . . . . .	5	2	6	13
<i>M. sp.</i> (immature <i>ducatelii</i> ?) . . . . .	6	6	10	22
<i>Botula fusca</i> (Gmelin) . . . . .	1	1	1	3

curved into a relatively straight postero-ventral slope that gradually rounds into the ventral end and curves rather sharply around termination of umbonal ridge to pass into the concave anterior slope. Surface smooth, marked only by growth lines that occasionally develop into low lamellae toward outer margins. Hinge below beaks, small, subtriangular, apparently formed by folded edge of obscure lunule, marked by small, elongated ridge-like teeth, usually one, with or without a tiny rounded node across the anterior adjacent groove that receives one of the two teeth of the opposite valve; resilial ridge finely pitted along its entire length; inner margins of valve smooth; muscular pattern not well-preserved, but appears to be similar to that of specimens of *Perna perna* (Linné).

*Holotype*: USNM 407799; length 36.4 mm, width 22.1 mm, diameter (right valve) 6.2 mm. Type locality: TU 459, Chipola River, Calhoun County, Florida.

*Paratype A*: USNM 407800; length 13.0 mm, width 6.9 mm, diameter (right valve) 1.9 mm; locality TU 459, Chipola River, Calhoun County, Florida.

*Paratype B*: USNM 407801; length (incomplete) 50.4 mm, width ca. 26.5 mm, diameter (left valve) 17.6 mm; locality TU 1048, Farley Creek, Calhoun County, Florida.

*Discussion*: Insofar as the writer is aware this is the first species of true *Perna* to be reported from the fossil faunas of the eastern United States. The name has been used in the past, however, in the sense of *Perna* Bruguière (1789, p. 13; = *Isognomon* Solander in Lightfoot, 1786) or of H. and A. Adams (1857, p. 515, as *Perna* Adanson, a pre-Linnaean name; = *Modiolus* Lamarck).

Woodring (1973, p. 522) noted that casts from the Culebra Formation of Panamá, which he identified as *Mytilus canoasensis* [Olsson] *vidali* Ferreira and Cunha (1959, p. 22, pl. 2, figs. 1a, b; described from the Lower Miocene Pirabas Formation of northern Brazil) show the impression of pits on the resilial ridge. This would appear to be second western Atlantic fossil species of the genus.

*Perna crawa*, n. sp., is represented in the Chipola collections by a large number of specimens, with all except the smaller valves being broken and incomplete. The largest broken valve, from TU 548 on the Chipola River, if complete, would have had a length of about 82 mm, and a width slightly in excess of 45 mm.

The number of "teeth" in the hinge area varies greatly between specimens; a count of some forty apical areas of valves from TU 459 revealed that almost one-half of the right valves had one "tooth," plus a marginal node, with the other half having two "teeth;" there was a similar distribution on the left valve.

The form described and figured by Maury (1910, p. 33, pl. 8, fig. 8) as *Perna solereperta* and based upon an incomplete valve from the Oak Grove Formation, in Santa Rosa County, Florida, is clearly not related to the present species, in which none of the more than 200 mostly incomplete valves show any trace of radiating riblets. The writer actually is not aware of any described species of *Perna* so ornamented. The "two . . . cartilage pits" cited by Maury may possibly represent remnant marginal crenulation resulting from the radial ornament; similar structures are known from *Brachidontes*, *Aulacomya* and other mytiloid genera.

The specific name *crawa* is derived from the Greek term "Krauros," meaning brittle or friable, and is applied in allusion to the fragile nature of the fossil valves.

Genus BRACHIDONTES Swainson, 1840

*Brachidontes* SWAINSON, 1840, Treat. Malac., p. 384.

"*Brachydontes*, Swains., 1840" GRAY, 1847, Zool. Soc. London, Proc., v. 15, p. 199.

*Brachydontes* AGASSIZ, 1846, Nomen. Zool. Index Univ., p. 51 (emend. pro *Brachidontes* Swainson).

Type species, by monotypy, *Modiola sulcata* Lamarck, 1819 [non Lamarck, 1805] = *Area modiolus* Linnaeus, 1767 = *Mytilus citrinus* Röding, 1798. Recent, southern Florida, Yucatan Peninsula and West Indies.

#### BRACHIDONTES CURTULUS (Dall)

##### Plate 1, Figures 4, 5

*Modiolus (Brachydontes) grammatus* var. *curtulus* DALL, 1898, Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. 794.

*Modiolus (Brachydontes) curtulus* Dall. GARDNER, 1926, U. S. Geol. Surv., Prof. Paper 142-A, p. 58, pl. 15, fig. 4.

*Description*: "Shell small but quite solid, cuneate in outline, attenuated toward the umbones; flaring and obtusely angulated along posterior margin, the anterior margin straight or feebly concave, the base line broadly rounded.

Umbones very small, subacute, almost but not quite terminal. Radials along the posterior and ventral margins coarse, heavily corrugated by the incrementals, tending to bifurcate toward the outer margin, not far from 15 in number, those upon the anterior slope almost twice that number and consequently much finer and more crowded and not dichotomous. Ligament groove moderately deep. Hinge edentulous. Adductor scar obscure. Inner margins crenate in harmony with the external sculpture, nearly obsolete toward the umbones." (Gardner, 1926)

*Holotype*: USNM 114578.

*Type locality*: USGS 2211, Alum Bluff (lower bed), Liberty County, Florida.

*Figured specimen*: USNM 407802; maximum length 7.0 mm, height 4.0 mm, right valve; locality TU 548, Chipola River, Calhoun County, Florida.

*Figured specimen*: USNM 407803; maximum length 6.0 mm, height 3.6 mm, left valve; locality TU 548, Chipola River, Calhoun County, Florida.

*Discussion*: Dall (1898b) described *curtulus* as a variety of his new species *Modiolus* (*Brachydontes*) *grammatus*, the type of which came from Ballast Point, Tampa Bay, Florida. He apparently had but one valve, which was subsequently figured by

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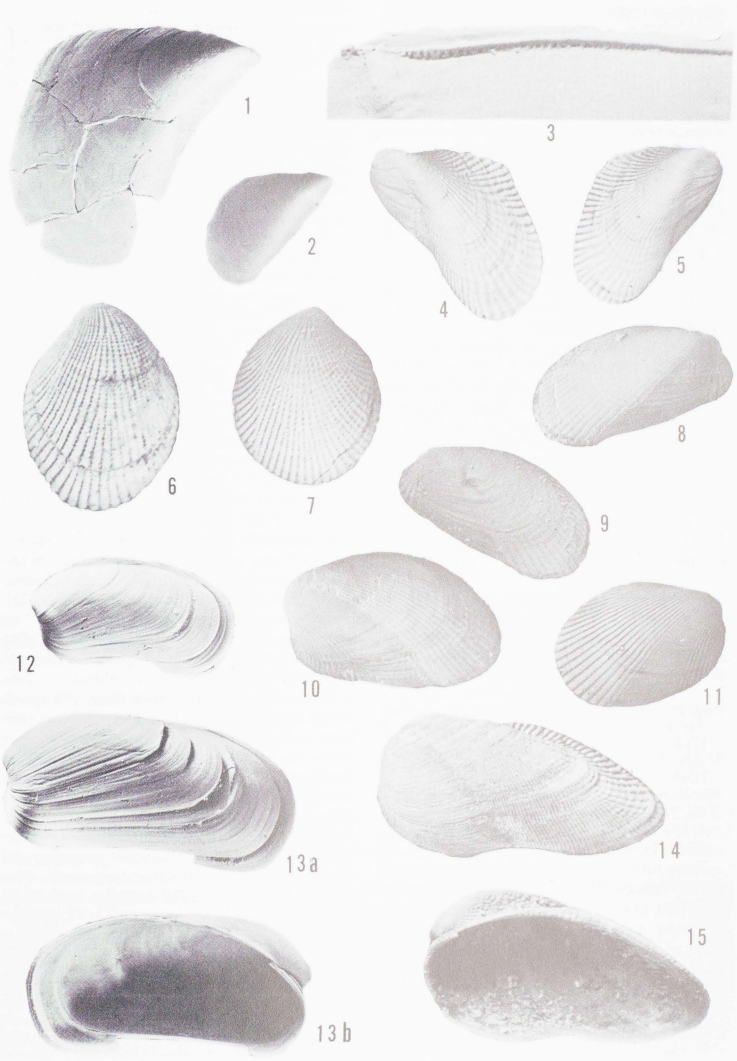


PLATE 1

Gardner (1926, pl. 15, fig. 4). Dall stated: "The variety, which more abundant material might show to be a distinct species, is stouter, more triangular, with coarser and more nodulous ribs and stronger crenulations of the margin. Alt. 12, max. lat. 7, diam. 6 mm" (of paired valves).

Gardner (1926, p. 58) recognized *curtulus* as a separate species, stating: "This form is certainly distinct from the Ballast Point species which is almost sub-cylindrical in outline and ornamented with a fine and delicate radial threading. The lirae in *grammatus* are double the number of those ornamenting *M. curtulus*, and the fluting of the inner edges is consequently much finer and more feeble."

The type specimen, as figured by Gardner, is incomplete with a portion of the postero-ventral margin broken away, and is larger than any of the more 250 specimens from the type area of the Chipola Formation. Our largest specimen, somewhat similarly incomplete, has a maximum length of 10.5 mm. The average number of coarser ribs is nearer 20 than 15. It also should be noted that the hinge area bears a few small and weak teeth, generally two on the right valve and three on the left.

#### Subfamily CRENELLINAE

H. and A. Adams, 1857

Genus CRENELLA Brown, 1827

*Crenella* BROWN, 1827, I11. Conch. Great Britain and Ireland, pl. 31, figs. 12-14.

*Stalagmium* CONRAD, 1833, Foss. Shells Tert. Formations North Amer., v. 1, no. 4, p. 39 [Oct.].

*Myoparo* LEA, 1833, Contrib. to Geol. p. 73 [Dec.].

*Nuculocardia* ORBIGNY, 1842, in DE LA SAGRA, Hist. Fis. Pol. Nat. Isla de Cuba; Pt. 2, Hist. Nat., v. 5, Molluscos; Atlas, pl. 27, figs. 56-59 [Text, p. 338, 1847; Spanish Ed.].

Type species, by monotypy, *Mytilus decussatus* Montagu, 1808. Pliocene - Recent, Circumboreal.

#### CRENELLA MINIScula Dall

Plate 1, Figures 6, 7

*Crenella miniscula* DALL, 1898, Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. 803, pl. 35, fig. 22.

*Crenella miniscula* Dall. GARDNER, 1926, U. S. Geol. Surv., Prof. Paper 142-A, p. 60, pl. 15, fig. 9.

*Description*: "Shell minute, thin, inflated, elongate ovate, feebly radially striated, the striae apparently diverging from a medial line on the disk; not dichotomous; the beaks smooth; inner margins crenulate; valves nearly equilateral. Alt. 1.75, lat. 1.25, diam. 1 mm.

"This little shell is rare in the marl and resembles in a general way *C. divaricata* Orbigny, of which it is the precursor, but has fainter sculpture and smooth beaks, besides being constantly of smaller size, and is more narrow in form than the young of *C. divaricata* of the same length." (Dall, 1898)

"The smooth prodissococonch can be plainly observed in these minute forms. The affinities of the species are obviously with the later Tertiary or Recent members rather than with the Eocene." (Gardner, 1926)

*Holotype*: USNM 114624.

*Type locality*: USGS 2211, Alum Bluff (lower beds), Liberty County, Florida.

*Figured specimen*: USNM 407804; height 2.9 mm, length 2.0 mm, diameter (left valve) 1.2 mm; locality TU 70, Tenmile Creek, Calhoun County, Florida.

*Figured specimen*: USNM 407805; height 2.3 mm, length 2.0 mm, diameter (right valve) 0.85 mm; locality TU 549, Chipola River, Calhoun County, Florida.

*Discussion*: Gardner added the first records of this species from the fauna of the type area of the Chipola Formation, listing it as rare at USGS locality 3419, "McClelland Farm 1 mile below Bailey's Ferry" on the Chipola River and present at locality 7151, Tenmile Creek, Calhoun County, Florida."

Comparison of the more than 700 specimens from 52 Chipola localities in the present collections with numerous specimens from the Recent faunas of the Yucatan Peninsula and the Caribbean Sea area leads the writer to believe that Dall's specimen from the lower bed at Alum Bluff may have been rather worn, for the costae on our specimens are somewhat broader and stronger than on *Crenella divaricata*. The shape is almost equally variable in the two species.

The largest specimen in the collection, a worn valve from TU 655, on Tenmile Creek, has a height of 3.3 mm, and a length of 2.4 mm.

#### Genus MUSCULUS Röding, 1798

*Musculus* RÖDING, 1798, Mus. Bolten., pt. 2, p.

156 [not preoccupied by *Musculus* Martyn, 1787, a non-binomial work].

*Modiolaria* BECK in ROBERT, (?) 1838, Zool. Voy. Recherche en Islande et en Grönlande, pl. 17, figs. 1-4.

"*Lanistes* Humph." SWAINSON, 1840, Treat. Malac., p. 385 [non Montfort, 1810 (Gastr.)].

*Modiolarca* GRAY, 1840, Synop. Cont. Brit. Mus., ed. 42, p. 151 [err. pro *Modiolaria*, fide Sherborn, 1928, Index Anim., p. 4122; however, Gray, 1847, Proc. Zool. Soc. London, v. 15, p. 199, lists type as *Modiola trapezina*].

*Lanistaina* GRAY, 1847, Zool. Soc. London, Proc., v. 15, p. 199 [n. n. pro "*Lanistes* Swainson, 1840; not Montf." + *Modiolaria* 'Beck' Loven, 1846; "*Mytilus discors* cited as type species.]

Type species, by subsequent designation, Iredale, 1915, *Mytilus discors* Linnaeus, 1767. Recent, Circumboreal.

#### Subgenus RYENELLA Fleming, 1959

*Ryenella* FLEMING, 1959, Royal Soc. New Zealand, Trans., v. 87, p. 172.

Type species, by original designation, *Mytilus impactus* Hermann, 1782. Lower Miocene to Recent, New Zealand.

**Discussion:** As pointed out by Fleming in his original description of *Ryenella*, quoting Soot-Ryen, 1955 (p. 73), "*M. impactus* Hermann and similar species . . . 'are more inflated than the typical *Musculus*, and the arrangement of the retractor muscles is quite different . . . the posterior retractors have a strong, elongated branch fastened along the dorsal margin and a single slender branch fastened above the posterior adductor. Whereas in *Musculus* they are continuous and united with the posterior adductor."

#### MUSCULUS (RYENELLA) LATERALIS PRAELATERALIS H. E. Vokes, n. subsp. Plate 1, Figures 10, 11

*Modiolaria* sp. indet., DALL, 1898, Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. 806.

*Modiolaria* sp., GARDNER, 1926, U. S. Geol. Surv., Prof. Paper 142-A, p. 59.

**Description:** Shell elongately sub-ovate, moderately inflated with broad, rounded posterior-ventral umbonal ridge; prosogyrate somewhat flattened umbones, terminating just posterior to dorsal side of rounded anterior end of valve; ventral margin slightly convex, ventral half of posterior end broadly rounded with dorsal half forming posterior portion of a broadly arched dorsal margin; anterior and posterior thirds of ventral portion of valve surface radially costate

with median area smooth except for growth lamellae, and in most specimens delimited from the costate areas by a rounded sulcus; radial ribs on anterior third and on the ventral half to two-thirds of the posterior area relatively broad and flat-topped with slightly narrower inter-rib areas marked by lamellose crossbars forming a latticed sculpture, the width of the inter-rib area decreasing dorsally on posterior segment until they lose the crossbar sculpture and become linear grooves between the narrowed ribs along the dorsal portion; 15 to 18 ribs present on anterior segment and 40 to 50 on the postero-dorsal one. Inner margin of valves crenate at rib terminations, median area smooth. Hinge area lacking teeth.

**Holotype:** USNM 407806; length 10.0 mm, height 6.0 mm, diameter (left valve) ca. 2.8 mm.

Type locality: TU 825, Farley Creek, Calhoun County, Florida.

**Paratype:** USNM 407807; length 5.8 mm, height 4.1 mm, diameter (right valve) ca. 1.1 mm; locality TU 196, Tenmile Creek, Calhoun County, Florida.

**Discussion:** Dall (1898b, p. 806) reported the presence of a single broken valve representing "a species similar to *Modiolaria lateralis* Say, but marked especially by well-developed latticed sculpture in the interspaces of the radii." Gardner (1926, p. 59) cites the locality as USGS 2564 (= TU 457) and adds that "no further material has been collected which might serve to identify this species."

The present collections contain some 190+ specimens from 43 localities in the Chipola River area, all marked by this characteristic ornamentation. In a few of the small specimens, including the figured paratype, the cross-lamellae extend in some areas over the rib tops as well as in the interspaces. However, the Tulane University collections contain a large specimen of the Recent *M. lateralis* (Say) (1822, p. 264) from off Longboat Key, western Florida, that shows similar cross-lamellae in the intercostal areas near the postero-ventral margin; none of the smaller forms in our Recent collections reveal this feature. The Chipola species also seem to have more numerous radial costae in both the anterior and posterior area than are to be found in the Recent specimens. The similarities in shape and in general features, including the nature of the infra-specific variation present in the two forms, however, strongly suggests that the Chipola species is the early Miocene ances-

tor of the Pliocene (?) to Recent *M. lateralis* (Say).

The species described by Gabb (1881, p. 377, pl. 47, fig. 81) as *Crenella* (*Modiolaria*) *translucida* "from the Pliocene Clay Beds between Limon and Moen, Costa Rica" is, as noted by Dall, (1898b, p. 807) "a very similar species" to *M. lateralis*. As compared with our Chipola form, it is relatively narrower with a straighter ventral margin. The dorsal margin, behind the umbone is broadly arched trending into the more sharply rounded postero-ventral end, and insofar as can be determined from the illustration, the anterior radials are broader and less numerous.

*Musculus praelateralis* is, as mentioned above, represented in the Tulane collections by more than 190 valves. These come from 43 localities extending stratigraphically from the base to the uppermost beds in the exposed sections: 15 of the localities represented are from the banks of the Chipola River, 14 are from along Tenmile Creek, west of the river, and 14 are from Farley Creek, flowing into the river from the east.

Subgenus PLANIMODIOLA Cossmann, 1887

*Planimodiola* COSSMANN, 1887, Cat. Illus.

Coquilles Foss. Eocene Envir. Paris, fasc. 2, p. 159.

Type species, by original designation, *Modiola sulcata* Lamarck, 1805. Middle Eocene, Paris Basin, France.

*Discussion:* Lamarck (1805, p. 123) described *Modiola sulcata*: "Modiola oblongo-spathulata; margine inferiore arcuato, carinato; sulcis transversis diversis." In his discussion he noted that "Cette espèce est remarquable par sa forme . . . oblongue, presque en forme de spatule," with the ornamentation similar to that of "*mytilus discors*, Lin." The species was not illustrated until 1807 (pl. 17, figs. 11a, 11b).

In his description of *Planimodiola* Cossmann noted that the shells are "ovale, aplatie, atténuée en avant, élargie en arrière, caractérisée par deux sinuosités qui limitent, sur le contour antérieur, les extrémités de l'aire dépourvue de côtes rayonnantes; cette aire est largement développée et généralement couverte d'un fin treillis de stries rayonnantes et concentriques; bord antérieur et bord ligamentaire bien crénelés."

Although often considered as being a synonym of *Musculus*, *Planimodiola* is distinguished by its more elongate, less inflated valves with more pronounced and sharply rounded anterior extremities.

## PLATE 2

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3. Figured specimen, USNM 407812 (X 1.5); incomplete valve. View showing complex ornament on posterior area of valve. Locality: TU 1048, Farley Creek.	
4. Figured specimen (X 1.5); view of posterior area of incomplete valve of Recent specimen; compare with fig. 3. Locality: TU R-109, northern Panamá.	
5, 6. <i>Lithophaga (Diberus) bisulcata</i> (Orbigny) . . . . .	170
5. Figured specimen, USNM 407814 (X 1.5); length 28.6 mm, height 11.7 mm. Locality: TU 1196, Farley Creek.	
6. Figured specimen, USNM 407815 (X 1.5); length 24.0 mm, height 9.2 mm. Locality: TU 1196, Farley Creek.	
7. <i>Modiolus ducatelii</i> (Conrad) . . . . .	171
Figured specimen, USNM 407816 (X 1); length 90.0 mm, height 59.8 mm. Locality: TU 1196, Farley Creek.	



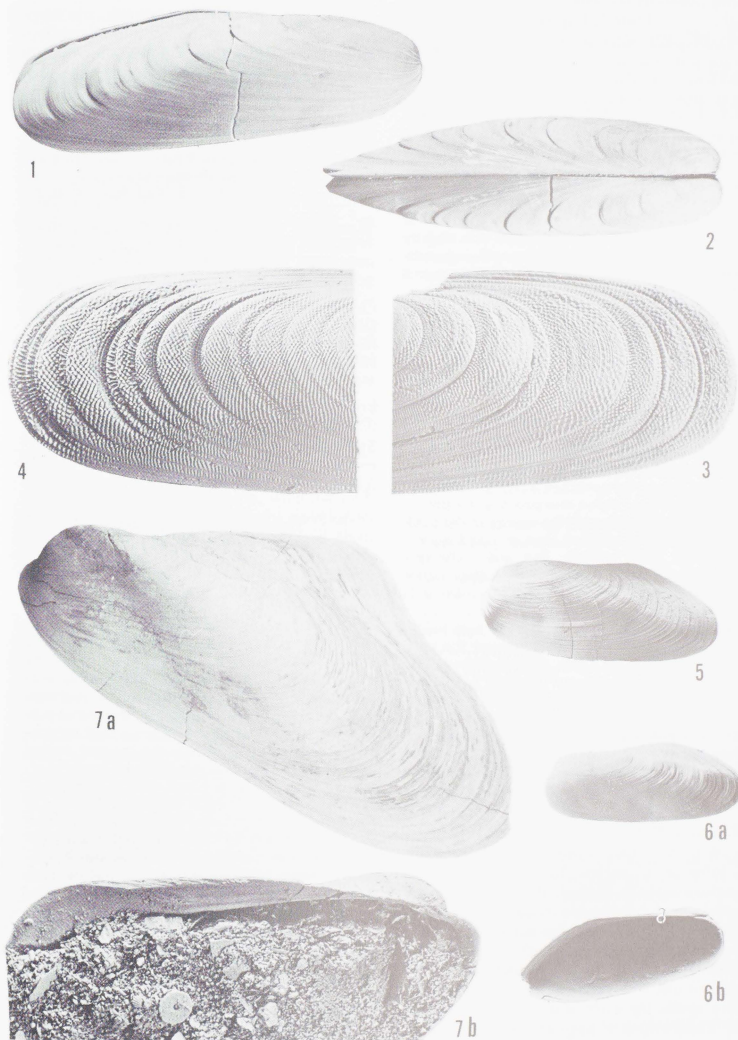


PLATE 2

## MUSCULUS (PLANIMODIOLA) DISINFLATUS

H. E. Vokes, n. sp.

Plate 1, Figures 8, 9

*Description:* Shell relatively small, elongate-ovate with greatest height slightly posterior to mid-length of valves; low, prosogyrate umbones near anterior end, which is slightly produced and broadly rounded; dorsal margin arched, passing into the broadly rounded posterior end; ventral margin almost straight with, however, a weak convexity along the margin of the median, non-ribbed area; anterior and posterior portions of valve surface radially ribbed with eight to ten ribs on the anterior area, the more posterior of these being broad and flat-topped with slightly convexly-bottomed interspaces of approximately equal width, both ribs and interspaces narrowing towards the umbone; the ventral termination of the four or five posteriorly convex interspaces tending to project as rounded areas crenulating the shell margin; posterior area with 26 to 30 wide, flat-topped ribs separated by relatively narrow grooves, the more ventrally situated costae tending to be almost twice the width of those toward the dorsal portion of the valve surface; median, non-ribbed area forming approximately two-thirds of the ventral margin, delimited from the ribbed areas by very shallow grooves, its surface marked only by occasional growth lamellae; valve margins slightly crenulated by terminations of ribs except at the posterior part of the anterior area as noted above; ligamental area smooth, but with relatively strong, tooth-like crenulae immediately below the umbone and on the dorsal slope posterior to the ligament.

*Holotype:* USNM 407813; length 6.6 mm, height 3.4 mm, diameter (paired valves) 2.4 mm. Type locality: TU 458, Chipola River, Calhoun County, Florida.

*Discussion:* The writer is aware of no similar weakly inflated spatulate species of *Musculus* that has been reported from the Western Hemisphere faunas, fossil or Recent. "*Modiolus dalli* Glenn in Clark et al., (1904, p. 367, pl. 97, figs. 9, 10) from the Choptank Formation of Maryland appears to be most closely approximate in degree of inflation of valves, but differs in being proportionately higher relative to valve length, in having a relatively longer, straight dorsal margin with subangulate bend at posterior end, and in apparently lacking the tooth-like crenulations below the umbone and on the dorsal surface posterior to the ligamental area. Judging from the illustrations it appears that the radial costae are narrower and much more

numerous on the posterior area than in the present species.

*Musculus disinflatus*, n. sp., is represented in the Tulane University collections from the Chipola Formation by 79 valves from 19 localities. The largest valve has a length of 8.1 mm.

Genus GREGARIELLA Monterosato, 1884

*Gregariella* MONTEROSATO, 1884, Nomen. Gen. Spec. Conch. Mediterraneae, p. 11.

*Botulina* DALL, 1889, U. S. Natl. Mus., Bull. 37, p. 38.

*Tibialectus* IREDALE, 1939, Gt. Barrier Reef Exped., 1928-9; Moll. I; Sci. Repts., v. 5, no. 6, p. 424.

Type species, by subsequent designation, Crosse, 1855, *Modiolus sulcatus* Risso, 1826 (non Lamarck, 1805, nor 1819) = *Modiolus barbatellus* Cantraine, 1835, = *Modiolus opifex* Say, 1825. Recent, Mediterranean Sea.

*Discussion:* This genus of mytiloids is known to bore into thick-shelled molluscs (Carpenter [1857, p. 124] cites borings in *Spondylus calcifer* and *Murex regius*), rocks (Olsson, 1961, p. 129), and corals (present collections).

## GREGARIELLA ARCAFORMA

H. E. Vokes, n. sp.

Plate 1, Figures 14, 15

*Description:* Shell small, convex, modioliform almost *Arca*-like in general shape with subterminal prosogyrate umbones marked by a broad median sulcus extending to middle of ventral margin; well-rounded anterior margin passing into the ventral one, which is made broadly concave by the umbonal sulcus; posterior end narrowly rounded, almost pointed on ventral portion, then trending anteriorly in a slightly convex, almost straight slope to the broadly angled junction with the relatively straight dorsal margin; surface of anterior end with a few microscopic radial ribs, medial surface smooth up to posterior side of umbonal sulcus, beyond which it is ornamented by fine, rounded radials descending from the crest at posterior side of median inflation and terminating in a descending row at edge of median sulcus; posterior and postero-dorsal surface with stronger divaricating radials often nodose when crossed by rounded concentric growth lamellae; inner margin crenulated by radial ribbing, the crenulae on the anterior end and the posterior portion of ventral margin finer and less conspicuous than those on posterior area and posterior side of dorsal margin beyond the narrow, linear resilifer, but continuing as weak projections dorsal

to that structure; muscle scars not visible.

*Holotype*: USNM 407810; length 9.9 mm, height 4.9 mm, diameter (paired valves) ca. 4.5 mm. Type locality: TU 1196, Farley Creek, Calhoun County, Florida.

*Discussion*: *Gregariella arcaforma* is, in most respects, similar to *G. coarctata* (Carpenter) (1857, p. 123, sp. 172), a Recent Pacific species ranging from Baja California to Ecuador and the Galápagos Islands. The latter species, however, attains a much larger size; Olsson (1961, p. 129) cites a specimen from Manta, Ecuador as "length 28 mm; height 11 mm; diameter 10.8 mm." The largest Chipola specimen has a length of 10.9 mm. In addition, the posterior extremity of *G. coarctata* is rounded rather than almost pointed as in *G. arcaforma*, the radial ribbing toward the anterior end is somewhat stronger, and the ribs more numerous than in our species.

The Recent western Atlantic species *Gregariella coralliophaga* (Gmelin) (1791, p. 3359) is also a larger form, attaining lengths in excess of 25 mm. It also has a more gently sloping dorsal margin, with the radials on that area less strongly developed and proportionately more abundant than in the present Chipola forms. It seems quite probable, however that the latter is ancestral to the Recent species.

The form from the Tampa Limestone at Ballast Point, Florida, described by Dall as *Modiolus (Gregariella) minimus* (1898b, p. 797, pl. 35, fig. 26), was based upon "a siliceous pseudomorph, retaining but little of the external surface." Mansfield (1937, p. 220) states that "only a silicified fragment of the original shell is preserved on one beak of the holotype." This fragment is not visible on Dall's inadequate illustration of the dorsal surface of the pseudomorph. Although Dall's measurements of the type - "Alt. 8, lat. 3.5, diam. 4 mm" - are comparable with those of most specimens of the present species, it is not possible to make any comparison of the two forms.

Present Tulane University collections contain valves of *Gregariella arcaforma* from seven localities.

Subfamily LITHOPHAGINAE  
H. and A. Adams, 1857

#### Genus LITHOPHAGA Röding, 1798

- Lithophaga* RÖDING, 1798, Mus. Bolten., pt. 2, p. 156.  
*Lithophagus* MEGERLE, 1811, Ges. Nat. Fr. Berlin, Mag., v. 5, p. 69.  
*Lithodomus* CUVIER, 1817, Le Regne Animal, v. 2, p. 471.  
*Lithodoma* BLAINVILLE, 1823, Dict. Sci. Nat., v. 27, p. 66.  
 Type species, by monotypy, *Lithophaga mytiloides* Röding = *Mytilus lithophagus* Linnaeus. Recent, Mediterranean Sea.

#### LITHOPHAGA ANTILLARUM (Orbigny)

##### Plate 2, Figures 1-4

- Lithodomus antillarum* ORBIGNY, 1842, in DE LA SAGRA, Hist. Fis. Pol. Nat. Isla de Cuba; Pt. 2, Hist. Nat., v. 5, Moluscos; Atlas, pl. 28, figs. 12, 13 [Text, p. 351, 1847; Spanish Ed.].  
*Modiola corrugata* PHILLIPI, 1846, Abbild. und Beschreib. Conchyl., v. 2, p. 147, pl. 1, fig. 1.  
*Lithodomus stramineus* DUNKER in REEVE, 1858, Conch. Icon, v. 10, *Lithodomus*, pl. 2, fig. 11.  
*Lithophaga dactylus* Sowerby. MÖRCH, 1853, Cat. Conch. Yoldi, pt. 2, p. 55 [not of Sowerby, 1824].  
*Lithophagus caribaeus* Philippi. DALL, 1889, U. S. Natl. Mus., Bull. 37, p. 38 [not of Philippi, 1847].  
*Lithophaga straminea* (Reeve). DUNKER, 1882, Conchylien-Cabinet, ser. 2, v. 8, pl. 2, figs. 1, 2.  
*Lithophaga antillarum* (Orbigny). DALL, 1898, Wagner Free Inst. Sci., Trans., v. 23, pt. 4, p. 799.  
*Lithophaga (Lithophaga) antillarum* (Orbigny). VOKES and VOKES, 1983, Mesoamer. Ecol. Inst., Mon. 1 (Mid. Amer. Res. Inst., Publ. 54), p. 36, pl. 34, fig. 7.  
*Description*: "*Lithodomus* testa elongata, recta, epidermide fusciscente; latere buccali angustato, obtuso; latere anali dilatato; subacuminato; regione palleali ligamentique transversim striata; latere anali (adulto) striis divaricatis ornato, intus iridescente; latere anali tenue.  
 "Dimension. Longitud . . . 70 millim . . . 3 polgadas."  
 "Esta especie es mayor que la anterior y mas prolongada; tambien se distingue por su color bermejo y por las estrias trasversales que cubren en la juventud los dos lados de la concha, dejando en medio una parte lisa, las cuales se vuelven divergentes en la edad adulta. Es propia de Cuba, la Martinica y la Guadalupe." (Orbigny, 1847)

*Figured specimen*: USNM 407811; length 74.0 mm, height 23.7 mm, diameter (paired valves)

21.5 mm; locality TU 1048, Farley Creek, Calhoun County, Florida.

*Figured specimen:* USNM 407812; length (incomplete) 50.7 mm, height (of fragment) 24.4 mm; locality TU 1048, Farley Creek, Calhoun County, Florida.

*Discussion:* *Lithophaga antillarum* may be distinguished from *L. nigra* (Orbigny) (1842, pl. 28, figs. 10, 11), the only other Recent species of *Lithophaga* s.s. in the warmer waters of the western Atlantic Ocean, by its lighter color and by the fact that the posterior area of the valves is marked by a pattern of irregularly radiating or chevron-shaped lirations or rows of low nodes, formed by the lateral extension of the transverse lirae that are present on the more anterior part of the valves. The Chipola specimen here figured (pl. 2, fig. 3) is the most complexly patterned valve that the present writer has observed, although it is closely approximated by one from the sub-Recent of the northern coast of Panamá (pl. 2, fig. 4).

The form described by Gardner (1926, p. 60, pl. 15, fig. 10) as *Lithophaga oryzoides*, with the type from the Alum Bluff Group at Oak Grove on the Yellow River in Okaloosa County, Florida, and said to be present also in beds of Chipola age at Boynton Landing on the Choctawhatchee River, Washington County, although compared to "*L. niger* D'Orbigny," clearly is not to be referred to *Lithophaga* s.s. The essentially modioliform shape with narrowed posterior end suggests that, if it is indeed a *Lithophaga*, it might represent a form similar to *L. (Myoforceps) aristata* Dillwyn, in which the secondary posterior shelly prolongations have been lost during fossilization.

*Lithophaga antillarum* is not common in the Chipola collections, the specimen here figured being the only relatively complete one with paired valves. A second rather fragmented pair, plus one almost complete valve and numerous fragments, representing four localities, are present in the Tulane University collection.

#### Subgenus DIBERUS Dall, 1898

*Diberus* DALL, 1898, Wagner Free Inst. Sci., Trans., v. 3, p. 4, p. 799.

Type species, by original designation, *Lithophaga plumula* (Hanley, 1843) (as *Modiola*). Recent, Gulf of California to Peru.

#### LITHOPHAGA (DIBERUS) BISULCATA (Orbigny) Plate 2, Figures 5, 6

*Lithodomus bisulcatus* ORBIGNY, 1842, in DE LA SAGRA, Hist. Fis. Pol. Nat. Isla de Cuba; Pt. 2, Hist. Nat., v. 5, Moluscos; Atlas, pl. 28, figs. 14-16 [Text, p. 352, 1847; Spanish Ed.]

*Modiola appendiculata* PHILIPPI, 1846, Abbild. und Beschreib. Conchyl., v. 2, p. 150, pl. 1, fig. 4.

*Lithophaga appendiculata* Philippi. MÖRCH, 1853, Cat. Conch. Yoldi, pt. 2, p. 56.

*Lithodomus biexcavatus* REEVE, 1857, Conch. Icon., v. 10, *Lithodomus*, pl. 4, figs. 22a, b.

*Lithophaga (Diberus) bisulcata* (Orbigny). DALL, 1898, Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. 801.

*Lithophaga (Diberus) bisulcata* (Orbigny). VOKES and VOKES, 1983, Mesoamer. Ecol. Inst., Mon. 1 (Mid. Amer. Res. Inst., Publ. 54), p. 36, pl. 34, fig. 9.

*Description:* "*Lithodomus* testa elongata, sub-lanceolata, laevigata, epidermide fusca; latere buccali brevi; latere anali elongato, producto, oblique truncato, externe calcareo induto, radiatum bisulcato; apice bilamellato.

"Dimension. Longitud . . . 20 millim . . . 11 lineas.

"Esta concha es vecina del *L. caudigerus* de la costa africana, y se distingue por el encostamiento exterior formado dos surcos profundos que parten del vértice y van á la region anal, donde dejan en medio una lámina prolongada mucho mas allá de la concha. Se halla en Cuba, la Jamaica, la Martinica, la Guadalupe y Santo Domingo." (Orbigny, 1847)

*Figured specimen:* USNM 407814; length 28.6 mm, height 11.7 mm, diameter (left valve) 5.9 mm; locality TU 1196, Farley Creek, Calhoun County, Florida.

*Figured specimen:* USNM 407815; length 24.0 mm, height 9.2 mm, diameter (left valve) 4.1 mm; locality TU 1196, Farley Creek, Calhoun County, Florida.

*Discussion:* As noted by Orbigny, it is the external incrustation that forms the two deep sulcations, which extend from the umbone to the posterior margin. Examination of Recent specimens show that the incrustation is exceptionally thick in the area between the two sulci and that its almost vertical lateral sides serve to emphasize the bisulcate appearance. When the incrustation is removed, as in the fossil specimens where it is not preserved, the sulci on the valve surface are broad and shallow and not very obvious.

*Lithophaga (Diberus) bisulcata* is not rare in the collections from the Chipola Formation, being represented by 106

specimens, of which 14 are paired valves. These come from seven localities, at all of which corals are present.

The form from Preston Sink, Alachua County, Florida, described by Gardner (1936, p. 14, pl. 8, figs. 5-7) as *Lithophaga cookei* from the "Hawthorn formation? of the Alum Bluff group," differs from the present species in that the outline of the holotype mold has the greatest height toward the anterior end rather than at a point transverse to the postero-dorsal angulation.

#### Subfamily MODIOLINAE Keen, 1958

Genus MODIOLUS Lamarck, 1799 [ICZN Op. 325]

*Volsella* SCOPOLI, 1777, *Introd. Hist. Nat.*, p. 397 [suppressed, ICZN Op. 325].

*Modiolus* LAMARCK 1799, *Mém. Soc. Hist. Nat. Paris*, v. 1, p. 87.

*Modiola* LAMARCK, 1801, *Syst. Anim. sans Vertèbr.*, p. 113.

*Perna* "Adanson" H. and A. ADAMS, 1858, *Gen. Recent Moll.*, v. 2, p. 515.

*Eumodiolus* IHERING, 1900, *Malac. Soc. London, Proc.*, v. 4, p. 87.

Type species, by tautonymy, *Mytilus modiolus* Linnaeus, 1758. Recent, Circumboreal, southward to Bay of Biscay and Cape Hatteras in Atlantic Ocean and ? to Baja California and Japan in the Pacific Ocean.

#### MODIOLUS DUCATELII (Conrad, 1840)

##### Plate 2, Figure 7

*Modiola Ducatellii* CONRAD, 1840, *Foss. Medial Tertiary United States*, no. 2, p. 53, pl. 28, fig. 2.

*Description*: "Shell profoundly elongated, ventricose, valves contracted obliquely from the apex to the middle of the basal margin; lines of growth coarse and prominent; extremity of hinge line salient and rounded; posterior extremity regularly rounded; anterior extremity rather prominent and pointed.

"*Locality*. Cliffs of Calvert, Md. Professor Ducatel." (Conrad, 1840)

*Figure specimen*: USNM 407816; length 90.0 mm, height 59.8 mm, diameter (left valve) 15.6 mm; locality TU 1196, Farley Creek, Calhoun County, Florida.

*Discussion*: According to Glenn (*in Clark et al.*, 1904, p. 366), this species is known from the Calvert, Choptank and St. Mary's formations. Although Conrad cited the specific name as for "Professor Ducatel," at that time State Geologist of Maryland, his original spelling included

two "l's in the name of the species, and also earlier for his *Venus Ducatelli*" (1838, [1840] pt. 1, p. 8, pl. 4, fig. 2). As far as the writer is aware, the earliest emendation to a single "l" was that of Dall, 1893, in his Republication of the Conrad work where, in the "Explanation of the Plates" (p. 118-129), he added to the explanation of plate 4, figure 2 (p. 118) and plate 28, figure 2 (p. 123), respectively, that the name "should be *Ducateli*" and "should be written *Ducatellii*."

In 1898b (p. 793) Dall listed four species of *Modiolus* from the Tertiary of the eastern United States, as the only "valid species belonging to the section *Modiolus* as restricted . . . except *M. tulipus* Lam., which occurs in the later rocks of the West Indies." The four species were, in addition to *M. ducatelii*: *M. silicatus* Dall, 1898b (p. 793, pl. 27, fig. 28, where it is identified as *M. tampaensis* Dall), from the "Upper Oligocene silex beds at Ballast Point, Tampa Bay, Florida" (now considered to be of Early Miocene age); *Modiolus inflatus* (Tuomey and Holmes) (1857, p. 33, pl. 14, fig. 3), from the Miocene of New Jersey and Pliocene of South Carolina; and *Modiola gigas* Wagner in Dall (1898a, p. 10, pl. 2, fig. 3A, B), ?Pliocene, Yorktown, Virginia (see Olsson, 1914, p. 13).

*Modiolus ducatelii* is represented in the Tulane University Chipola collections by many valves, mostly incomplete. The one figured here is the most perfect in the collection but fragments, especially from TU 555 on the Chipola River, indicate that the species attains dimensions at least one-third larger in overall size, and reveal a tendency for a progressively greater prolongation of the posterior extremity relative to the increase in size of other parts of the valve. Younger specimens with a shorter posterior agree so very closely with the figure of a specimen from the Lower Miocene of New Jersey, identified by Whitfield (1984, p. 39, pl. 6, fig. 3) as "*Modiola inflata*" [= *Mytilus inflatus* Tuomey and Holmes, (1857, p. 33, pl. 14, fig. 3: "Pliocene," South Carolina)] that the writer is inclined to believe these Early Miocene forms represent the present Conrad species.

In addition to the specimens here definitely identified as *M. ducatelii*, the Tulane collections contain many small

modiolid-like forms that are essentially subtriangular in outline but lack all trace of any posterior prolongation. The largest complete specimen has a length of 6.1 mm and a height of approximately 3.9 mm. These are considered as representing young, possibly newly hatched specimens of *M. ducatellii*, especially since valves up to 30 mm in length that are associated with typical adult forms of that species similarly show no trace of the posterior prolongation. The smallest specimen upon which such a trend can be observed has a length of approximately 33 mm, unfortunately the anterior end of this valve has been broken so that no precise measurement can be made.

Genus BOTULA Mörch, 1853

*Botula* MÖRCH, 1853, Cat. Conch. Yoldi, pt. 2, p. 55.

Type species, by subsequent designation, Dall, Bartsch and Rehder, 1938, *Mytilus fuscus* Gmelin. Recent, North Carolina and Bermuda, southward to north of Rio de Janeiro, Brazil.

*Discussion:* *Modiolus cinnamomeus* Lamarck, designated as type species by Dall, 1898b (p. 792) was cited by Mörch as "*Modiola cinnamomea* var. Lam." in the synonymy of *Botula fusca*; hence *M. cinnamomea* s.s. is not an available species.

BOTULA FUSCA (Gmelin)

Plate 1, Figures 12, 13

*Mytilus fuscus* GMELIN, 1791, Systema Naturae, ed. 13, v. 1, pt. 6, p. 3359.

*Modiolus (Botula) cinnamomeus* Lamarck, DALL, 1889, U. S. Natl. Mus., Bull. 37, p. 38 [*B. cinnamomea* is now known to be an Indo-Pacific species].

*Botula fusca* (Gmelin). VOKES and VOKES, 1983, Mesoamer. Ecol. Inst., Mon. 1 (Mid. Amer. Res. Inst., Publ. 54), p. 36, pl. 34, fig. 11.

*Description:* Shell moderately small, inflated, oblong, arcuate, with arched dorsal margin and concave ventral one; enrolled umbones at upper anterior extremity of valve in front of rounded anterior margin; posterior margin relatively wide and rounded; shell surface usually marked by prominent concentric ridges formed during growth rest periods, otherwise smooth; hinge edentulous, ligament long, narrow.

*Figured specimen:* USNM 407808; length 10.1 mm, height 8.2 mm, diameter (left valve) 4.4 mm; locality TU 547, Chipola River, Calhoun County, Florida.

*Figured specimen:* USNM 407809; length 26.0 mm, height 12.8 mm, diameter (left valve) 7.4 mm; locality TU 1048, Farley Creek, Calhoun County, Florida.

*Discussion:* This species is rare in the Chipola fauna, being represented in the Tulane collections by five incomplete paired valve specimens and one single valve from TU 547, a coral reef locality on the Chipola River, one paired valve form from the Chattahoochee/Chipola contact on Tenmile Creek at TU 830, and one valve from TU 1048 on Farley Creek, a locality marked by numerous heads of *Porites* and *Stylopora*, together with numerous *Antillophyllia chipolana* Weisbord.

Gardner (1926, p. 59) cited "a single battered valve" that she identified as "? *Modiolus (Botula) cinnamomeus* Lamarck" from locality 2213, one mile [= ca. one-half mile] below Baileys Ferry, on the Chipola River. This specimen is presumed to be the basis of Dall's (1898b, p. 797) record of the occurrence of "*Modiolus cinnamomeus*" in the "Chipola marl Chipola River."

IV. LOCALITY DATA

The following Tulane University locality numbers are all in the Chipola Formation, Calhoun County, Florida.

70. Tenmile Creek, at bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W).
196. Tenmile Creek, about 1/4 mile upstream from bridge of Florida Highway 73 (NE 1/4 Sec. 11, T1N, R10W).
457. West bank of Chipola River, about 1/2 mile below Tenmile Creek (SW 1/4 Sec. 17, T1N, R9W) (same as USGS 2213, 2564, and 3419, "One mile below Bailey's ferry").
458. East bank of Chipola River, above Farley Creek (SW 1/4 Sec. 20, T1N, R9W).
459. East bank of Chipola River, steep bank about 1,500 feet above the mouth of Taylor Lake Branch (NW 1/4 Sec. 29, T1N, R9W).
547. West bank of Chipola River, about 2,000 feet above Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W).
548. West bank of Chipola River, at bend about 1,800 feet south of mouth of Farley Creek (NW 1/4 Sec. 29, T1N, R9W).
549. East bank of Chipola River, about 1/4 mile below Fourmile Creek (NE 1/4 Sec. 32, T1N, R9W).

555. East bank of Chipola River, about 1,000 feet above Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W).
655. Tenmile Creek, about 0.1 mile downstream from bridge on Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W).
825. Farley Creek at abandoned mill about 1/4 mile west of bridge on Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W).
830. Tenmile Creek, at powerline crossing about one mile west of Chipola River (SE 1/4 Sec. 12, T1N, R10W).
1048. Farley Creek, south bank, about 0.8 miles east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W).
1196. Farley Creek, north bank about 0.8 mile east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W).

The following is a Recent Tulane locality number.

- R-109. Fill for refinery at Bahia las Minas, Isla Payardi, Prov. of Colon, Panamá (radiocarbon dated at 7,000 y.b.p.).

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AN UNUSUAL DISTORTED SPONDYLUS FROM THE MOÍN  
FORMATION (PLEISTOCENE), COSTA RICA

HAROLD E. VOKES  
TULANE UNIVERSITY

A single left valve of a much distorted specimen of *Spondylus bostrychites* Guppy (1867, p. 176) was collected from Tulane locality 953 at Moin Hill, the type locality of the Moín Formation (Gabb, 1895, p. 80) considered to be of early Pleistocene age (Akers, 1972, pp. 42-44, fig. 3).

The valve under consideration appears to have attained essentially a normal adult size and ornamentation, with a height of 115 mm, a width of 107.3 mm, and a diameter of 36.5 mm. Then the anterior margin began to trend inwards with coarsely rugose, non-ornamented growth increments accumulating diagonally to margin an increasingly smaller valve opening. Prior to the onset of distortion the inner margin had a width of about 100 mm; this was reduced to 66 mm. The marginal dis-

tortion appears essentially to have been confined to the anterior side and to have tended to tilt the left valve relative to its original normal position. This is evidenced by the fact that the rugose increments progressively overlap posteriorly around the valve margin such that the area of distorted growth gradually passes from a width of about 32 mm on the anterior side to being essentially absent just below the posterior end of the hinge area.

That this same distortion affected the hinge area is evidenced by the greater width of its anterior portion and by the fact that the resilial pit tends to develop a slight posteriorly trending curve in its later stages.

The right valve was not found and its condition is unknown. It seems probable,



however, that it must have developed a similar distortion as the inter-valve marginal area became progressively narrower. The reason for this distorted growth is not evident; the outer surface of the valve shows no evidence of any damage. It may be that the right valve was the one damaged; the fact that the anterior margin of the distorted segment is relatively straight, rather than rounded, and that the entire margin is irregularly undulating, not smooth, is indicative of extreme distortion in that valve also.

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Text figure 1, *Spondylus bostrychites* Guppy; height 115.0 mm, width 107.3 mm, diameter 48.0 mm; locality TU 953, Moín, Costa Rica ( $X \frac{1}{2}$ ).