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# THE MOLLUSCAN FAUNA OF THE ALUM BLUFF GROUP OF FLORIDA

BY

JULIA GARDNER

## PART II. ASTARTACEA, CARDITACEA, CHAMACEA

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5080. First ravine below Shell Bluff, Shoal River, Walton County, Fla.

5184. First ravine below Shell Bluff, Shoal River, Walton County, Fla.

5192. Folk's Creek, 4 miles south of Argyle, Walton County, Fla.

5193. Crowder's Crossing, 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.

5194. 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.

5195. First ravine below Shell Bluff, Shoal River, Walton County, Fla.

5613. Coronet phosphate mine, 5 miles southeast of Plant City, Hillsborough County, Fla.

5618. 3½ miles southwest of De Funiak Springs, Walton County, Fla.

5629. Coronet phosphate mine, 5 miles southwest of Plant City, Hillsborough County, Fla.

5630. 100 yards below Oak Grove Bridge, Yellow River, Okaloosa County, Fla.

5631. Oak Grove Bridge, Yellow River, Okaloosa County, Fla.

5632. Oak Grove, Yellow River, Okaloosa County, Fla.

5633. Oak Grove, Yellow River, Okaloosa County, Fla.

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6196. Rock stratum lying immediately above fuller's earth at Ellenton, Manatee County, Fla.

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6775. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.

6776. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.

6778. Spring on left bank of Suwannee River about 100 yards above Rock Island and about half a mile above White Springs, Columbia County, Fla.

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6801. Lochloosa Creek, near Magnesia Spring, about 3 miles west of Hawthorn, Alachua County, Fla.

7054. 400 feet below bridge, Oak Grove, Okaloosa County, Fla.

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7257. Sexton's marl bed, sec. 11, T. 1 N., R. 10 W., Tenmile Creek, Calhoun County, Fla.

7261. Upper Alaqua Lethu (?) Bluff, near De Funiak Springs, Walton County, Fla.

7264. De Funiak *Cardium* beds, Alaqua Creek, Walton County, Fla.

7468. Sopchoppy, Wakulla County, Fla.

7847. Lake Butler, Bradford County, Fla.

7893. Boynton Landing, Choctawhatchee River, Washington County, Fla.

9957. Gully south of the road and east of the bridge over White's Creek, on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.

9958. Site of Flournoy's old mill, about 1¼ miles northeast of Argyle, Walton County, Fla.

9959. One-fourth mile west by north of Pleasant Ridge Church, 5.2 miles southwest of De Funiak Springs, Walton County, Fla.

9960. Folk's Creek, sec. 21 or 22, T. 3 N., R. 18 W., 6 miles south of Argyle and 1.7 miles from Eucheeanna, Walton County, Fla.

9961. Horse Creek, 1½ miles south of Oak Grove, Okaloosa County, Fla.

9994. John M. P. McClelland's farm, Chipola River, Calhoun County, Fla.

10596. Waldon Bridge over Bruce Creek, 5 miles west of Red Bay, Walton County, Fla.

10603. Gully south of the road and east of the bridge over White's Creek, on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.

10608. White's Creek, half a mile below bridge on Eucheeanna-Knox Hill road, Walton County, Fla.

10609. The Woodyard, three-fourths mile above Shell Landing, Holmes Creek, Washington County, Fla. (lower bed).

10610. The Woodyard, three-fourths mile above Shell Landing, Holmes Creek, Washington County, Fla. (upper limestone.)

10611. White's Creek near water's edge, half a mile below bridge over creek on road from Eucheeanna to Knox Hill, 6.7 miles south of Argyle, 1.7 miles southeast of Eucheeanna, Walton County, Fla.

10612. Chester Spence's farm, 5 miles southwest of De Funiak Springs, at head of Sconter's Mill Creek, Walton County, Fla.

10658. Shell Bluff, Shoal River, 6 miles west-northwest of Mossyhead, Walton County, Fla.

10659. Tanner's mill (Old Senterfeit mill), 4 miles southwest of Laurel Hill, Okaloosa County, Fla.

10660. Lower bed, Alum Bluff, Liberty County, Fla.

10661. Godwin Bridge over Shoal River, 5 to 6 miles northwest of Mossyhead, Walton County, Fla.

10662. Lower bed, Shoal River, between Godwin Bridge and Shell Bluff, 5 to 6 miles west-northwest of Mossyhead, Walton County, Fla.

10663. Crowder's Crossing, 1½ miles below Shell Bluff, Shoal River, Walton County, Fla.

10860. Boynton Landing, 4 miles east of Miller's Ferry, Washington County, Fla.

10869. Folk's Creek, 6 miles south of Argyle, Walton County, Fla.

# THE MOLLUSCAN FAUNA OF THE ALUM BLUFF GROUP OF FLORIDA

By JULIA GARDNER

## PART II. ASTARTACEA, CARDITACEA, CHAMACEA

### INTRODUCTION

The first of the series of papers upon the Mollusca of the Alum Bluff group covered the orders of the Prionodesmacea and the Anomalodesmacea. The Mollusca were by the beginning of Miocene time so far advanced in development that the great majority are included under the highest of the three orders, the Teleodesmacea, characterized in the adult stages by the differentiation of the hinge teeth into distinct cardinals and laterals. This paper, the second of the series, covers the most primitive of the Teleodesmacea in the Alum Bluff group. All three of the superfamilies considered—the Astartacea, the Carditacea, and the Chamacea—are included under Dall's group of the Diogenodonta, which is characterized in the normal forms by one or two laterals and not more than three cardinals. The Carditacea are very closely related to the Astartacea in hinge armature but differ in the development of a pronounced radial sculpture. The Chamacea have until recently been considered an offshooting group from the Carditacea that have been greatly modified by their sessile habit. Some doubt has been thrown upon this relationship by the late morphologic studies of Odhner.

The Alum Bluff group, from which the fauna in question is derived, is divided in descending order into three formations, each of them highly fossiliferous—the Shoal River formation, the Oak Grove sand, and the Chipola formation.

The Chipola carries a subtropical highly diversified fauna conspicuously rich in gastropods. The Oak Grove fauna includes little more than half as many species as that of the Chipola, but some of them, particularly among the bivalves, are exceedingly numerous. The temperature was probably lower than in the Chipola epoch and the water more shallow. In the uppermost formation, the Shoal River, the cool-water element is still strong, and there is evidence of the continued retreat of the sea. The Chipola fauna, as one might expect, is apparently the most widely spread. It has been recognized not only in west and west-central Florida but also on Savannah River and in eastern Texas. The Oak Grove is well developed in western Florida and is probably present across the line in southwestern Georgia and possibly in the Mobile well in southern Alabama at a depth of 1,000 feet. The Shoal River formation is restricted in its known distribution to western Florida. The detailed discussion of the stratigraphy of the Alum Bluff group will follow the systematic treatment of the fauna.

*Local distribution of species of Astartacea, Carditacea, and Chamacea*

pr., Prolific; a, abundant; c, common; p, present; r, rare (not more than half a dozen individuals. The localities within each State and formation are arranged in geographic order from north to south and from west to east. Peninsular localities not listed]

| Species | Georgia—Oak Grove sand | | | Florida—Chipola formation | | | | | | | | | | | | | | | | | Florida—Oak Grove sand | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Near Bainbridge, Ga. | | | 6 miles south of Argyle | 6.7 miles south of Argyle | 5 miles west of Red Bay | Lower bed, The Woodyard | Upper bed, The Woodyard | Boynton Landing | 1 mile west of Baileys Ferry | Sexton's marl bed, Tenmile Creek | 1 mile below Baileys Ferry | | | Tenmile Creek | Lower bed, Alum Bluff | | | Quincy | Near White Springs | Oak Grove, Yellow River | | | | | | 1½ miles south of Oak Grove | 1½ miles south of Oak Grove |
| | 3386 | 3385 | 7148 | 10869 | 10611 | 10596 | 10609 | 10610 | 7893 | 2212 | 7257 | 2213 | 2564 | 3419 | 9994 | 7151 | 2211 | 7183 | 10660 | 3704 | 6776 | 2646 | 5632 | 5631 | 5630 | 5633 | 7054 | 2652 | 9961 |
| Astarte eugonia Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (Ashtarotha) sima Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (Bythiamena) isosceles Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (Bythiamena) wagneri Dall | | | | | | | | | | | | | | | | | | | | | | p | | | | | | | p |
| Crassatellites (Scambula) chipolanus Dall | | | | | | | r | | r | p | | p | p | r | | | | | | | | | | | | | | | |
| densus Dall | | | | | | | | | | | | | | | | | | | | | | a | p | | c | p | c | r | |
| Crassatellites (Crassinella) triangulatus Dall | | | | | | | p | | p | | p | pr | a | c | | p | p | | | | | | | | | | | | |
| tanicus Dall | | | | | | | | | | | | | | | | | | | | | | c | | | | p | p | | a |
| Cardita (Carditamera) apotegea Gardner, n. sp | ?p | ?p | p? | | | | | | r | p | r | c | r | p | r | | c | p | c | | | | | | | | | | |
| defuniak Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Venericardia hadra Dall | | | | | | | r | p | c | p | r | a | c | c | c | r | p | | | ?r | ?r | | | | | | | | |
| himerta Dall | | | | | | | | | | | | | | | | | | | | | | c | p | r | r | r | p | | |
| Venericardia (Pleuromeris) tellia Dall | | | | | | | p | | | | r | c | p | p | | p | c | | r | | | | | | | | | | |
| tellia dasa Gardner, n. sp | | | | | | | r | | | | | c | p | r | | r | | p | | | | | | | | | | | |
| scitula Dall | | | | | | | | | | | | | | | | | | | | | | p | p | r | r | p | r | | a |
| Chama draconis Dall | | | | | | | | | p | r | r | c | p | p | p | p | r | | | | | | | | | | | | |
| Pseudochama chipolana (Dall) | | | | | | | r | | p | p | | c | | p | ?r | | c | p | p | | | a | p | r | p | r | c | | p |
| Pseudochama (Echinochama) arcinella (Linnaeus) Odhner | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Species | Florida—Oak Grove sand | | | Florida—Shoal River formation | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4½ miles southwest of Laurel Hill | 4 miles southwest of Laurel Hill | 3 or 4 miles north of Campton | 6 miles west northwest of Mossyhead | | Dave Adams Mill Creek | Shell Bluff, Shoal River | | 6 miles west-northwest of Mossyhead | First ravine below Shell Bluff | | ½ mile below Shell Bluff | 5 or 6 miles northwest of Mossyhead | | ½ mile below Shell Bluff | ¾ mile west of Shell Bluff | 1¼ miles northeast of Argyle | 1 mile northeast of Argyle station | Upper Alaqua, Lethu(?) Bluff | De Funiak "*Cardium* beds," Alaqua | 4 miles south of Argyle | 6 miles south of Argyle | 6.7 miles south of Argyle | | | 3½ miles southwest of De Funiak Springs | 5 miles southwest of De Funiak Springs | 5.2 miles southwest of De Funiak Springs |
| | 7055 | 10659 | 3749 | 3856 | 2645 | 3732 | 3742 | 3731 | 10658 | 5080 | 5184 | 5195 | 5079 | 10661 | 10662 | 10663 | 3733 | 9958 | 3748 | 7261 | 7264 | 5192 | 9990 | 9967 | 10603 | 10608 | 5618 | 10612 | 9959 |
| Astarte eugonia Gardner, n. sp | | | | | | | | | | | | | r | | | | | | | | | | | | | | | | |
| (Ashtarotha) sima Gardner, n. sp | | | | | | | p | | | | | | p | | | | | | r | | r | | r | c | a | a | p | | |
| (Bythiamena) isosceles, Gardner n. sp | | | | | | | c | | | | r | | | | | | | | | | | | | | | | | | |
| (Bythiamena) wagneri Dall | | | | | | | | | | | | | | | | | | | | | | | r | p | | | | | |
| Crassatellites (Scambula) chipolanus Dall | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| densus Dall | r | r | r | p | p | p | a | p | | c | p | r | r | | | | r | r | r | | | r | r | p | a | p | c | r | p |
| Crassatellites (Crassinella) triangulatus Dall | | | | | | | | | | | | | | | | | | | | | | | | ?r | | | | | |
| tanicus Dall | | a | | r | | | p | | r | | | | a | r | c | | p | | p | r | p | | p | p | ?p | ?p | p | | p |
| Cardita (Carditamera) apotegea Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| defuniak Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | r | | | | | r | p | | ?r |
| Venericardia hadra Dall | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| himerta Dall | r | r | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Venericardia (Pleuromeris) tellia Dall | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| tellia dasa Gardner, n. sp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| scitula Dall | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chama draconis Dall | | | | ?r | | | | | | | | | | | | | | | | | | | | | | ?r | | | |
| Pseudochama chipolana (Dall) | c | p | | | | | | | | | | | | | | | | | | | | | | | r | r | | | ?r |
| Pseudochama (Echinochama) arcinella (Linnaeus) Odhner | | | | | r | r | c | | r | | p | r | | | | | | | | | | | | | r | | | | |

## SYSTEMATIC DESCRIPTIONS

### Phylum MOLLUSCA

### Class PELECYPODA

### Order TELEODESMACEA

### Superfamily ASTARTACEA

### Family ASTARTIDAE

### Genus ASTARTE Sowerby

1818. *Astarte* Sowerby, Mineral conchology of Great Britain, vol. 2, p. 85, pl. 137.

Type: *Venus scotica* Maton=*Pectunculus sulcatus* Da Costa. (Recent off the British coast.)

Dall[1] described this genus as follows:

Ligament enfolding the resilium, both external on narrow nymphs. * * * A certain variability in characters usually stable is a marked feature of the genus. After much study of recent species and the diagnoses of groups found in the literature, I am of the opinion that these variations for the most part are such as can not be properly used for the subdivision of the genus. The crenulation of the margin of the valves is not more than of specific value; the obsolescence of the terminal cardinal teeth of the hinge, the greater or less prominence of the lateral laminae are characters which in this genus I have found inconstant even in the species. The flattening of the umbones, which is so conspicuous a character in many of the fossil species when a series of species is studied, is seen to be so gradually modified between one species and another as to admit of no hard and fast line being drawn between those with and those without this character. By taking a single recent species to compare with some fossil form it may chance that marked discrepancies may be noted, but if a series of species be compared, these discrepancies will be found inconstant.

*Astarte* not only originated but culminated as early as the Mesozoic. Though represented in the fossil faunas by approximately 300 species, the recent species number only about 20, most of them boreal. The genus is particularly prolific along the northern New England coast.

The distribution of this characteristically cold-water group is suggestive of the temperature during the deposition of the Alum Bluff. The group is apparently absent during the Chipola, represented in the Oak Grove by a single species, and in the Shoal River by four, one of them anticipating the Chesapeake *undulata*.

Shell rudely quadrate in outline; concentric sculpture rather fine and uniform from the umbones to the basal margin.
*Astarte eugonia* Gardner, n. sp.

Shell rudely trigonal:
- Umbones flattened; lunule not depressed directly in front of the umbones. *Astarte* (*Ashtarotha*) *sima* Gardner, n. sp.
- Umbones not flattened; lunule depressed directly in front of the umbones.
  - Shell normally as high as broad, strongly and evenly sculptured from the umbones to the base.
    *Astarte* (*Bythiamena*) *isosceles* Gardner, n. sp.
  - Shell not so high as broad; sculpture commonly feeble and more or less obsolete toward the base in the adult form. *Astarte* (*Bythiamena*) *wagneri* Dall.

[1] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1486, 1903.

#### Section ASTARTE s. s.

Type: *Venus scotica* Maton=*Pectunculus sulcatus* Da Costa. (Recent off the British coast.)

The restricted section is characterized by the subequilateral valves, the convex umbones, the strong middle cardinal of the right valve and anterior cardinals of the left, and the crenate inner margins.

#### Astarte eugonia Gardner, n. sp.

Plate XVI, Figure 1

Shell small, rather thin, rudely quadrate in outline, moderately inflated from the umbones to the posterior ventral margin; posterior portion of shell compressed. Umbones small, inconspicuous, feebly prosogyrate, flattened at their tips, strongly anterior in position. Posterior dorsal margin rudely parallel to the base; posterior lateral margin squarely truncate; anterior lateral margin bowed slightly in front of the lunule, rounding broadly into the feebly arcuate base. Lunule rather small, narrow, cordate, deeply sunken, sculptured only with incrementals. Escutcheon narrow, lanceolate, defined by the angulation of the shell and the disappearance of the sculpture. External surface sculptured with about 25 concentric ridges, increasing uniformly in size toward the ventral margin, separated by interspaces of approximately the same width. Hinge rather delicate but badly mutilated; middle cardinal of right valve deltoid, not very stout; anterior cardinal of left valve laminar; other teeth not preserved; anterior margin of right valve and posterior margin of left grooved to receive the beveled margins of the opposite valve. Adductor and pallial scars obscure; anterior adductor small, reniform, set close to the lateral margin; posterior adductor scar larger, less ventral in position. Inner margins finely crenate from the extremity of the lunule to the escutcheon.

Dimensions: Altitude, 5 millimeters; latitude, 5.7 millimeters; semidiameter, 2 millimeters.

Type: U. S. Nat. Mus. No. 352471.

Type locality: No. 5079, half a mile below Shell Bluff, Shoal River, Walton County, Fla.

There is no species which closely approaches this small, subquadrate, uniformly sculptured shell. However, there is little doubt of the generic affinities, although the hinge is so imperfectly known.

Occurrence: Shoal River formation, locality 5079[r].

#### Section ASHTAROTHA Dall

Dall[2] characterized this section as follows:

Umbones concentrically sculptured and conspicuously flattened; disk smoother outside of the flattened area; otherwise like *Astarte*.

Type: *Astarte undulata* Say. Miocene.

The type is abundant in the Chesapeake Miocene of the middle Atlantic coast. The section, as a whole,

[2] Dall, W. H., Synopsis of the family Astartidae, with a review of the American species: U. S. Nat. Mus. Proc., vol. 26, No. 1342, p. 936, 1903.

is characteristic of this area, particularly of the Miocene of Maryland.

**Astarte (Ashtarotha) sima Gardner, n. sp.**

Plate XVI, Figures 2–3

Shell of moderate dimensions, compressed, rudely trigonal. Umbones acute, their sides converging at an angle of a little less than 90°. Anterior end feebly excavated at the lunule, bowed out in front of the lunule; posterior margin obliquely truncate, rounding rather abruptly into the base; base line very slightly arched. Tips of umbones abruptly flattened, feebly prosogyrate. Lunule rather narrow, lenticular in outline, slightly wider in the left valve than in the right, defined chiefly by the disappearance of the concentric sculpture. Escutcheon of approximately the same width as the lunule and defined in the same manner but decidedly more produced. Sculpture flattened; tips of umbones closely sculptured, the obtuse ridges becoming gradually coarser and a short distance away from the apices dying out in a few broad waves; ventral portion of shell smooth except for microscopically fine incremental striae. Ligament external, opisthodetic, mounted on a linear nymph bounded dorsally by a deeply incised groove. Right valve armed with an obsolete anterior cardinal, a heavy, elongate, deltoid middle cardinal, and an atrophied posterior cardinal. Left valve with a robust anterior cardinal and, on the other side of the deep subumbonal socket, an almost equally strong and slightly more elongate middle cardinal; left posterior cardinal fused with the ligamentary nymph; all the cardinals transversely sulcate along their inner faces. Right anterior dorsal margin and left posterior dorsal margin sulcated to receive the beveled edges of the corresponding valve. Muscle impressions distinct, of moderate dimensions, the anterior obliquely ovate, the posterior semielliptical, set a little below the median horizontal, the two joined by a distinct pallial line parallel to the base but at some little distance from it. Inner margins very finely dentate.

Dimensions: Altitude 12.5 millimeters; latitude 13.3 millimeters.

Type: U. S. Nat. Mus. No. 352483.

Type locality: No. 3742, Shell Bluff, Shoal River, Walton County, Fla.

This species has an ornamentation similar to that of *A. undulata* Say, its possible descendant, but it is only about half as large as that form, is relatively higher, and has a more restricted sculpture.

Occurrence: Shoal River formation; localities 3742$^{p}$, 5079$^{p}$, 3748$^{r}$, 7264$^{r}$, 9960$^{r}$, 9957$^{c}$, 10603$^{a}$, 10608$^{a}$, 5618$^{p}$.

**BYTHIAMENA, new section**

Shell rather small, heavy, concentrically sculptured, characterized by the abrupt depression of that part of the lunule directly in front of the beaks.

Type: *Astarte isosceles* Gardner, n. sp. (Alum Bluff (Shoal River formation) of Florida.)

**Astarte (Bythiamena) isosceles Gardner, n. sp.**

Plate XVI, Figures 4–8

Shell rather small, heavy, approaching an isosceles triangle in outline, the base straight, the sides nearly equal. Apices narrow, attenuated, arched inward and twisted forward slightly, subcentral in position. Anterior dorsal slope excavated in the lunular region, expanded toward the base; posterior margin oblique or feebly arcuate; base line approximately horizontal, rounding rather abruptly into the lateral margins. Lunule similar in a general way to that of *wagneri* but with its peculiarities much exaggerated; outer limits not very sharply marked, defined by the rather gradual disappearance of the concentric sculpture; area inclosed, wide, cordate, persisting almost to the base; beneath the umbones a smaller area less than half the extent of the larger, profoundly depressed, its outer margin bordered by a sharply defined ridge, the outline in the single valves suggesting a resilifer and striated in a similar manner. Escutcheon normal, not very broad nor very well defined, coexistent with the dorsal margin. External surface concentrically corrugated with rather broad, well-rounded ridges elevated high above the surface, regular in size and spacing from the umbones to the base, separated by slightly narrower, concave interspaces, not far from 25 in number. Inner margins finely dentate. Ligament external, opisthodetic, mounted on a slender nymph outlined dorsally by a deeply incised groove. Hinge area very high and much compressed by the invasion of the lunule. Right anterior and posterior cardinals atrophied; the middle cardinal heavy, cuneiform, very high and much produced; the two cardinals in the left valve stout, laminar, elevated and separated by a profound socket for the reception of the middle cardinal of the right valve; all the cardinals transversely striated on their inner faces. Anterior lateral margin of right valve and posterior lateral margin of left valve sulcated to receive the beveled edges of the corresponding valves. Adductor scars rather large for the group, very distinct, the anterior somewhat reniform in outline, the posterior semielliptical, placed a little below the median horizontal and joined by a simple pallial line rather distant from the basal margin.

Dimensions of right valve: Altitude, 9.0 millimeters; latitude, 9.0 millimeters. Left valve of another specimen: Altitude, 7.5 millimeters; latitude, 7.5 millimeters.

Cotypes: U. S. Nat. Mus. No. 352475.

Type locality: No. 3742, Shell Bluff, Shoal River, Walton County, Fla.

*Astarte wagneri* Dall shares with *A. isosceles* the peculiar character of the lunule, though it is by no

means so conspicuous a character in the Oak Grove species. They differ further in the larger size and broader, less trigonal outline of *A. wagneri* and its less vigorous and less uniform sculpture.

*A. isosceles* is a common species at the type locality, though it is rare elsewhere.

Occurrence: Shoal River formation, localities 3742[c], 5184[r].

**Astarte (Bythiamena) wagneri Dall**

Plate XVI, Figure 9

1903. *Astarte wagneri* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1488, pl. 57, fig. 20.

Dall described this species as follows:

Shell small, subtrigonal, nearly equilateral, with high, pointed, convex, prosogyrate beaks overhanging a very short cordate, deeply excavated lunule; escutcheon narrow, hardly defined; sculpture of about 15 low, rounded, concentric waves with narrower interspaces, and fine, concentric striation more or less obsolete; hinge compressed by the deep lunule, otherwise normal; inner margins smooth; muscular impressions rather small, impressed. Height 10, length 11, diameter 4 millimeters.

The most striking characteristic of this species is the deep and very short lunule.

Type: U. S. Nat. Mus. No. 135849.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The species is rare and most of the individuals badly worn. The same peculiar lunule occurs in *A. isosceles* from the Shoal River but in an even more exaggerated form. The Shoal River species is also much higher relatively than *A. wagneri* and strongly ribbed concentrically from the umbones to the base.

Occurrence: Oak Grove sand, localities 2646[p], 9961[p]. Shoal River formation, localities 9960[r], 9957[p].

**Family CRASSATELLITIDAE**

**Genus CRASSATELLITES Krüger**

1823. *Crassatellites* Krüger, Geschichte der Urwelt, vol. 2, p. 466.

Type: *Crassatellites sinuatus* Krüger = *Crassatella gibbosula* Lamarck. (Eocene of the Paris Basin.)

Dall[3] described this genus as follows:

Shell solid, inequilateral, slightly inequivalve, usually subtrigonal, the posterior end longer; valves closed, the ligament and resilium adjacent and internal; hinge of three cardinals in the right valve, of which the posterior is more or less effaced by the resilium, and two in the left valve; the anterior edge of the right and the posterior edge of the left hinge margin grooved to receive the edge of the opposite valve, which is beveled to serve as a lateral lamina; sculpture chiefly concentric and often obsolete except near the umbones.

The genus originated apparently in the Cretaceous, culminated in the Tertiary, and is represented in the Recent faunas by about 40 species, which are confined chiefly to the tropical seas. In the east coast and Gulf Eocene, and in the east coast Miocene, the genus is one of the most prolific and conspicuous of the bivalves.

Only four species have been recognized in the Alum Bluff, two of them large and heavy shells referable to *Scambula*, the other two small, trigonal species referable to *Crassinella*. Curiously enough, one species of *Scambula* and one of *Crassinella* are characteristic of the Chipola, whereas the other species of *Scambula* and the other *Crassinella* are both of them common to the Oak Grove and Shoal River. *C. (Scambula) chipolanus* is not conspicuously common but the other three species are abundant and widely distributed.

Adult shell exceeding 10 millimeters in altitude:
- Nepionic shell free from sculpture during the first 2 millimeters ..... *Crassatellites (Scambula) chipolanus* Dall.
- Nepionic shell concentrically sculptured during the first 2 millimeters ..... *Crassatellites (Scambula) densus* Dall.

Adult shell not exceeding 10 millimeters in altitude:
- Umbonal angle decidedly less than 90° as a rule; concentric sculpture generally sharp. *Crassatellites (Crassinella) triangulatus* Dall.
- Umbonal angle approaching 90°; concentric sculpture generally obtuse ..... *Crassatellites (Crassinella) tanicus* Dall.

**Section SCAMBULA Conrad**

1869. *Scambula* Conrad, Am. Jour. Conchology, vol. 5, p. 48.
1872. *Scambula* Conrad, Acad. Nat. Sci. Philadelphia Proc., p. 51.

Type: *Scambula perplana* Conrad. (Upper Cretaceous (Matawan) of New Jersey.)

Conrad characterized this section in 1869 as follows:

Hinge with two approximate teeth in the right valve, the posterior one direct and ending at the apex; a long anterior double tooth parallel with the straight cardinal line; anterior muscular impression small, rounded.

In 1872 he said:

Shell triangular, compressed; in the right valve one direct tooth under the apex, with a pit on each side of it, and a long lateral tooth anteriorly, posterior dorsal margin carinated, which prominent line fits into a doubled lateral tooth, in the opposite valve, left valve with 2 long approximate direct teeth, and a long anterior marginal lateral tooth, pallial line invisible, inner margin finely crenulated on a raised line.

Dall[4] mentioned the following characters:

Valves with the nepionic shell flattened, the adult usually elongated, the third right cardinal obsolete or absent, the resilium large; the inner margins of the valves rarely crenate but usually smooth.

The type of *Scambula* is commonly given as *subplana*, another species from the Upper Cretaceous of New Jersey, but only the single species *Scambula perplana* is cited by Conrad, both in his original description and in that of 1872.

[3] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1466, 1903.

[4] Idem, p. 1467.

**Crassatellites (Scambula) chipolanus Dall**

Plate XVI, Figure 10

1900. *Crassatellites* (*Scambula*) *chipolanus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 5, pl. 49, fig. 12.
1903. *Crassatellites* (*Scambula*) *chipolanus* Dall, idem, pt. 6, p. 1472.

Dall described this species in 1903 as follows:

Shell subtrigonal, solid, in general form resembling *C. jamaicensis*, but with the nepionic shell small and smooth or concentrically striate, followed by from two to four conspicuous rather distant concentric undulations, after which the whole surface (except the posterior dorsal area) is finely, closely, concentrically ribbed; other characters as in *C. jamaicensis*. Longitude 44, altitude 33, diameter 18 millimeters.

A variety approaches *C. jamaicensis* still more nearly by having the ribs obsolete on the middle of the disk. There is, as far as our material goes, no gradation between the two forms in the matter of the nepionic sculpture, but if further researches should demonstrate that such a gradation exists, this form would stand as a variety, *chipolana*, of the Jamaican shell.

Type: U. S. Nat. Mus. No. 114713.

Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla.

This is a higher shell than *C. densus* Dall, and the posterior extremity is not so produced nor so squarely truncate. Specific differences show up, even in the young, for the umbones of the Chipola species are more acute and the shell is perfectly flat and free from concentric sculpture until it is a couple of millimeters high. Heavy concentric ridges are then abruptly initiated. In the later Alum Bluff form a fine concentric sculpture is developed at the very tips of the umbones, which gradually strengthens until at 2 or 3 millimeters it is very similar to the earliest sculpture of *chipolanus*.

*C. chipolanus* is much less conspicuous in the Chipola fauna than is the analogous *C. densus* in the Oak Grove and Shoal River.

Occurrence: Chipola formation, localities 10609[r], 7893[r], 2212[p], 2213[p], 2564[p], 3419[r].

**Crassatellites (Scambula) densus Dall**

Plate XVI, Figures 11–14

1900. *Crassatellites densus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 5, pl. 39, figs. 9–12.
1903. *Crassatellites* (*Scambula*) *densus* Dall, idem, pt. 6, p. 1472.

Dall described this species in 1903 as follows:

Shell elongate, plump, solid, and thick, the anterior end slightly shorter, the valves subequal; anterior end rounded, posterior end briefly truncate, subrostrate; lunule and escutcheon subequal, lanceolate, deeply impressed; beaks high, full, flattened at the apex; nepionic shell flat, apically smooth, with about five low, sharp, concentric rather distant waves, followed on the anterior slope by fine, close, concentric threading; the remainder of the shell smooth except for incremental lines; posterior dorsal area bounded by a rounded radial ridge, in front of which the shell is slightly constricted; halfway between this ridge and the border of the lunule is a second radial ridge but more faint; hinge normal, laminar grooves and adductor scars deep; internal margins of the valves smooth. Longitude 50, altitude 35, diameter 26 millimeters.

This is well-marked and elegant, recalling on a smaller scale the Miocene *C. turgidulus*.

Cotypes: U. S. Nat. Mus. No. 107382.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

*Crassatellites densus* is almost equally abundant and widely distributed in the Oak Grove and the Shoal River. This distribution, together with its rather large size and thick shell, make it one of the more conspicuous elements in the middle and late Alum Bluff. The Oak Grove individuals have as a rule retained their polish better than those from Shoal River, especially on the dorsal portion of the shell in the depression in front of the posterior keel. The Chipola analogue *C. chipolanus* is decidedly higher and generally heavier. The nepionic sculpture is not initiated at the tips as in *C. densus* but makes its first appearance when the young *chipolanus* is about 2 millimeters tall. *C. jamaicensis* from the Bowden beds resembles *C. chipolanus* in outline, but in the character of the nepionic sculpture it is more closely allied to *C. densus*.

Occurrence: Oak Grove sand, localities 2646[a], 5632[p], 5630[c], 5633[p], 7054[c], 2652[r], 9961[p], 7055[r], 10659[r], 3749[r]. Shoal River formation, localities 3856[p], 2645[p], 3732[p], 3742[a], 3731[p], 5080[c], 5184[p], 5195[r], 5079[r], 3733[r], 9958[r], 3748[r], 5192[r], 9960[r], 9957[p], 10603[a], 10608[p], 5618[c], 10612[r], 9959[p].

**Subgenus CRASSINELLA Guppy**

1874. *Crassinella* Guppy, Geol. Mag., new ser., decade 2, vol. 1, p. 442.
1875. *Crassinella* Guppy, idem, vol. 2, p. 42.

Type: *Thetis parva* C. B. Adams. (Recent in the West Indies.)

Dall [5] described this group in 1903 as follows:

Shell minute, subtriangular, much compressed; the umbones acute, subcentral; hinge with two cardinals in each valve, the lateral laminae developed, the posterior left lateral lamellose behind the ligament; ligament and resilium internal; inner margins of the valves smooth.

**Crassatellites (Crassinella) triangulatus Dall**

Plate XVI, Figure 15

1900. *Crassatellites* (*Crassinella*) *triangulatus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 5, pl. 49, fig. 16.
1903. *Crassatellites* (*Crassinella*) *triangulatus* Dall, idem, pt. 6, p. 1476.

Dall described this species in 1903 as follows:

Shell small, solid, rather compressed, subtriangular, subequilateral; dorsal slopes straight, nearly equal; beaks small, subacute, inclined toward each other; lunule and escutcheon narrow, elongate, emphatically impressed, smooth, subequal; sculpture varying from concentrically striated and nearly smooth to rather distantly feebly lamellose with wider inter-

[5] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1468, 1903.

spaces, the sculpture more distinct, distant, and clean-cut, but less lamellose near the beaks; hinge margin narrow; hinge delicate. Height 3.3, length 3.0, diameter 1.3 millimeters.

Not unlike *C. bowdenensis* but more compressed, higher and shorter, with a different sculpture.

Type: U. S. Nat. Mus. No. 114607.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

*Crassatellites* (*Crassinella*) *triangulatus* suggests *lunulatus*, which is so abundant in the later Tertiary, in its general features and in its range of variation. When the concentric sculpture is laminar, with free sharp edges laid across the shell at regular intervals and an irregular concentric sculpture between, the species is very easily recognized and isolated, but when the lamination becomes obtuse and restricted to the apical region the form approaches very closely to *C. tanicus* of the Oak Grove and Shoal River. It runs smaller than *tanicus*, however, and the average altitude is relatively higher, but it is by the totality of characters that the two species must be separated.

Occurrence: Chipola formation, localities 10609$^{p}$, 7893$^{p}$, 7257$^{p}$, 2213$^{pr}$, 2564$^{a}$, 3419$^{c}$, 7151$^{p}$, 2211$^{p}$. Shoal River formation, locality ?9957$^{r}$.

**Crassatellites (Crassinella) tanicus Dall**

Plate XVI, Figure 16

1900. *Crassatellites* (*Crassinella*) *tanicus* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 5, pl. 49, fig. 11.

1903. *Crassatellites* (*Crassinella*) *tanicus* Dall, idem, pt. 6, p. 1477.

Dall described this species in 1903 as follows:

Shell small, resembling the last species (*C. triangulatus* Dall) in a general way, but with the concentric sculpture in small, smooth, low waves, more numerous and distinct on the beaks and becoming obsolete on the basal half of the shell, which is nearly smooth; there also appears to be rather more tendency to inequilaterality. Height 4.3, length 4.0, diameter 2.2 millimeters.

The sculpture of *C. triangulatus* is in rather sharp, raspy lamellae, but that of *C. tanicus* is in low, rounded, rather flattish waves.

Cotypes: U. S. Nat. Mus. No. 135852.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The shell is not quite so small as that of *C. triangulatus* and is usually a little more compressed and relatively broader. The dorsal slopes are nearly straight and approximately equal, and the base strongly arcuate, the resulting outline approaching closely in typical forms to a sector of 90°. The lunule and escutcheon are coextensive with the dorsal margins, are decidedly impressed, and are defined both by the angulation of the valve and the abrupt disappearance of the concentric sculpture. The sculpture dies away from the umbones more rapidly as a rule than it does in *triangulatus* and is usually absent altogether upon the ventral portion of the shell. In a number of individuals there is a very pronounced resting stage about halfway between the umbones and the base, and below this the shell increases less rapidly in latitude and is perfectly smooth. The shell is consequently decidedly higher relatively than the normal *tanicus* and is less ornamented. The fact that this peculiar outline and conspicuous lack of sculpture almost invariably accompanies a pronounced resting stage suggests some local environmental condition but nothing which might induce permanent characters.

The species is more abundant and more widely distributed in the Shoal River than in the type formation.

Occurrence: Oak Grove sand, localities 2646$^{c}$, 5633$^{p}$, 7054$^{p}$, 9961$^{a}$, 10659$^{a}$. Shoal River formation, localities, 3856$^{r}$, 3742$^{p}$, 10658$^{r}$, 5079$^{a}$, 10661$^{r}$, 10662$^{c}$, 3733$^{p}$, 3748$^{p}$, 7261$^{r}$, 7264$^{p}$, 9960$^{p}$, 9957$^{p}$, ?10603$^{p}$, ?10608$^{p}$, 5618$^{p}$, 9959$^{p}$.

**Superfamily CARDITACEA**

Dall [6] said:

This group seems to have branched off from the astartoid radical in the early Mesozoic, forming in one sense a sort of parallel series with the Astartidae, with which it is contrasted most obviously by its prevailingly radial sculpture and prolonged posterior cardinal tooth."

**Family CARDITIDAE**

Dall [7] gives the following description:

This family is of ancient origin and is represented in the Mesozoic by several groups. * * *

The hinge has been compared to that of the Veneridae, but in my opinion the resemblance is slight and superficial. The venerid hinge has never less than three left cardinals, which show no traces of torsion, while the Carditidae have never more than two, and the posterior one invariably long drawn out, a feature characteristic of the family. The most fully developed hinge is met with in such forms as *Carditamera*, which exhibits a hinge with the formula $\frac{\text{L. oi.oioio.oi}}{\text{R. io.ioioi.io}}$, though the anterior and posterior right cardinals are in the adult shell almost obscured by the stem of the anterior right lateral and the nymph respectively, though quite recognizable in the young shells. The cardinals are almost invariably finely, transversely striated. In such forms as *Venericardia antiquata* Linné the formula is reduced to $\frac{\text{L. o.oioi.o}}{\text{R. o.ioio.o}}$ by degeneration. It is evident when such changes take place in the growth of the individual, and when certain of the teeth are or may be obsolete in the developed shell, that too much stress in classification should not be placed on these mutable features. In fact, the subdivisions of the principal genera must be based chiefly on form, the types of which, it must be acknowledged, are rather unexpectedly constant in the faunas following that of the early Eocene.

[6] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 3, p. 540, 1895.

[7] Idem, pt. 6, p. 1406, 1903.

### Genus CARDITA (Bruguière) Lamarck

1798. *Cardita* Bruguière, Tableau encyclopédique et méthodique, vol. 1, pls. 233, 234.
1801. *Cardita* Lamarck, Systême des animaux sans vertèbres, p. 118.

Type: *Cardita variegata* Lamarck = *Cardita calyculata* (Bruguière) Linnaeus. (Recent in the Mediterranean.)

Shell slightly gaping ventrally, elongate, subquadrate, very inequilateral. Umbones usually low, notably anterior. Lunule small but well differentiated. Escutcheon ill-defined. Sculpture strong, radial, the ribs commonly imbricated or squamose. Ligament external, opisthodetic, parivincular. Hinge armature of right valve consisting of two or three divergent cardinals, the posterior much elongated, with the addition, in the subgenus *Carditamera*, of well-defined laterals; hinge of left valve furnished with two cardinals, the posterior obliquely elongated, and with an anterior and a posterior lateral; muscle impressions strongly defined. Pallial line simple. Inner margins crenate.

The genus has been recognized in strata as early as the Triassic. During the Tertiary it constituted one of the more notable elements in the pelecypod faunas, and, though it is never a dominant factor in the recent seas, its distribution in the shallow waters is almost universal.

### Section CARDITAMERA Conrad

1838. *Carditamera* Conrad, Fossils of the Tertiary formations of the United States, p. 11.

Type: *Cypricardia arata* Conrad. (Miocene and Pliocene of the middle and southern Atlantic slope.)

Conrad described this section, which he termed a genus, as follows:

> Shell equivalve, oblong; cardinal tooth in the right valve single, much elongated, compressed and nearly parallel with the basal margin; in the left valve two, profoundly diverging, the posterior one corresponding with that in the opposite valve; lateral teeth two, distant, short, pyramidal; muscular impressions large; pallial impression entire.
>
> The genus is nearly allied to *Cypricardia*, but wants the three cardinal teeth and the long lateral tooth of that genus; from *Cardita* it is distinguished by the lateral teeth. The projection of the lunule in the right valve gives it the appearance of having two cardinal teeth. I know of this fossil species only, and a recent one nearly allied to it on the coast of Florida.
>
> Shell less than twice as broad as it is high; radials not conspicuously flattened upon their summits.
>
> *Cardita (Carditamera) apotegea* Gardner, n. sp.
>
> Shell approximately twice as broad as it is high; radials conspicuously flattened upon their summits.
>
> *Cardita (Carditamera) defuniak* Gardner, n. sp.

### Cardita (Carditamera) apotegea Gardner, n. sp.

Plate XVII, Figures 1–2

1903. *Cardita (Carditamera) tegea* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1412 (part).

Dall described *C. tegea* as follows:

> Shell elongate inequilateral, with low, rather anterior beaks and about 16 strong radial more or less carinated and imbricated ribs, the anterior ribs more distinctly and regularly crenulate, the posterior more irregular; the interspaces about as wide as the ribs, and on the anterior half of the shell squarely channeled; posterior end of the shell produced and pointed, anterior end rounded, base mesially slightly concave; lunule small, deeply impressed, the anterior lateral tooth very prominent; hinge teeth normal, rather slender; inner margins of the valves deeply fluted. Length 43, height 24, diameter 22 millimeters. The beaks are situated at about the anterior sixth of the shell.
>
> The original figure of this species in Part I was taken from a silicious pseudomorph, which perhaps had been derived from a specimen which had been somewhat worn before being fossilized. Though certainly identical with the Chipola specimens from which the description is written, the sculpture is less well preserved and smoother.

Dall's description was made for the most part from the specimens from Chipola River, though his type locality is Ballast Point. The earlier species is much more elongated transversely than *C. apotegea* and probably never attains so great a size. The radials are more commonly 17 or 18 in number than 16. From the anterior margin to the posterior keel they gradually increase in prominence and become less and less closely spaced. There is a gradual transition, too, from the nodose incremental sculpture of the anterior area to the posterior sculpture, characterized by exceedingly fine incremental striae and, especially in the young forms, by here and there a spinose process. There are generally two or three subequal costals which radiate from the umbones to the posterior basal angle and which are coarser and more distantly spaced than any others upon the shell. Behind them, in most individuals, are two relatively fine lirae and behind these a costal almost as coarse and as spiny as those outlining the posterior angle. The marginal rib is also spinose but not so coarse as that next to it. The costals are all of them abruptly arched and form sharp angles with the flattened interspaces. The muscle impressions are large and very distinct, though united by an obscure pallial line. The figured specimen from Ballast Point, which serves as the type of *C. tegea* Dall, measures 33.0 millimeters in latitude and 16 millimeters in altitude with a semidiameter of 5.5 millimeters.

Dimensions of right valve: Altitude, 23.5 millimeters; latitude, 41.0 millimeters; semidiameter, 11.3 millimeters. Dimensions of left valve of another specimen: Altitude, 22.5 millimeters; latitude, 40.0 millimeters; semidiameter, 11.3 millimeters.

Cotypes: U. S. Nat. Mus. No. 352476.

Type locality: No. 2211, Alum Bluff (lower bed), Liberty County, Fla.

The young forms are higher relatively than the adults and much more inclined to expand posteriorly.

*C. apotegea* is closely allied to the type of the section. The umbones are slightly more prominent in *arata*, though otherwise the outlines of the two forms are very similar. The number of ribs is also the same in both and they are similarly arranged. The sculpture upon the anterior portion of the shell is, however, less laminar and more nodose on the Chipola species and the sculpture upon the posterior portion more spiny. The group is by no means so commonly represented in the Alum Bluff as in the later formations. No trace of it has been found in the Oak Grove of Florida, and in the Shoal River it is represented by a single rare and restricted species readily separable from *C. apotegea* by the smaller size, more elongated outline, lower umbones, and more compressed anterior portion and the rather more numerous, more flattened, and more closely spaced radials. The forms from Decatur County, Ga., are probably identical with this species, though too poorly preserved for positive identification.

Occurrence: Chipola formation, localities 7893$^{r}$, 2212$^{p}$, 7257$^{r}$, 2213$^{c}$, 2564$^{r}$, 3419$^{p}$, 9994$^{r}$, 2211$^{c}$, 7183$^{p}$, 10660$^{c}$, ?5613$^{c}$. ?Oak Grove sand, localities ?3386$^{p}$, ?3385$^{p}$, ?7148$^{p}$.

**Cardita (Carditamera) defuniak Gardner, n. sp.**

Plate XVII, Figure 3

Shell rather small, much elongated transversely, approximately twice as broad as it is high, compressed anteriorly, noticeably expanded along the posterior keel. Umbones low, broadly rounded, acute and prosogyrate at their incurved tips, placed within the anterior fourth in the adult but relatively farther back in the young. Anterior margin steeply sloping at the lunule, bowed out in front of the lunule; posterior dorsal margin parallel to the base except for the broad mesial constriction of the basal margin; posterior lateral margin obliquely truncate, rounding rather abruptly into the base. Lunule small, depressed, bounded by an incised linear groove. Sculpture similar in general character to that of the type of the section; radials 18 (rarely 19), flattened upon their summits, the seven or eight upon the anterior portion of the shell separated by little more than linear interspaces, those upon the medial depression wider and less closely spaced, the two or three upon the posterior keel much more prominent than the others and separated by interspaces of approximately their own width; behind them, as in *C. apotegea*, two rather fine lirations followed by two moderately prominent marginal ribs, that next the dorsal margin finer than the one in front of it; nodes or spines altogether absent, the incremental lamellae commonly distinct anteriorly though obsolete, as a rule, upon the posterior half of the shell. Inner margins fluted in harmony with the external sculpture. Ligament external, opisthodetic, mounted on a slender and much elongated nymph. Hinges of the only right valves available too badly worn to preserve any but generic characters; left anterior cardinal short, trigonal, separated from the elongated laminar posterior cardinal by an asymmetrically cuneate pit; anterior lateral in left valve merely a small, rather compressed tubercle, the left posterior margin grooved beyond the ligament nymph to receive the posterior lateral of the right valve. Anterior adductor scar large, elliptical in outline, impressed, set far forward just within the expanded anterior margin, the marginal flutings reaching almost to the edge of the scar; posterior adductor rudely quadrate, set high up under the posterior extremity of the dorsal margin so that the ventral limit of the posterior adductor is nearly in line with the dorsal limit of the anterior. Pallial line obscure.

Dimensions: Altitude, 16.0 millimeters; latitude, 32.0 millimeters; semidiameter, 6.5 millimeters.

Type: U. S. Nat. Mus. No. 352477.

Type locality: No. 7264, De Funiak "*Cardium* beds," Alaqua Creek, Walton County, Fla.

*C. defuniak* suggests the Miocene *C. protracta* in its elongated outline but differs from it and from all the other described species of the group in the simplicity of the costals and their close spacing, especially upon the anterior portion.

Occurrence: Shoal River formation, localities, 7264$^{r}$, 10608$^{r}$, 5618$^{p}$, ?9959$^{r}$.

**Genus VENERICARDIA Lamarck**

1801. *Venericardia* Lamarck, Système des animaux sans vertèbres, p. 123.

Type: *Venericardia planicosta* Lamarck. (Eocene of the Paris Basin.)

Shell nonbyssiferous, closed, rounded, trigonal or cordate. Umbones anterior, prosogyrate. Lunule small but deep. Escutcheon narrow and elongate. Sculpture dominantly radial. Ligament external, opisthodetic, parivincular. Hinge dentition in the right valve consisting of three oblique cardinals; in the left valve of two; laterals of both valves absent or very feeble. Muscle impressions strongly defined. Pallial line entire. Inner margins crenate.

The group is largely restricted in the Alum Bluff to the Chipola and Oak Grove formations. Each of these two formations has a characteristic *Venericardia* s. s., which forms a conspicuous element in the fauna. Each has also a representative of *Pleuromeris*, the Chipola form, however, being much more common than the Oak Grove and so variable that one race of

variants has been given subspecific rank. An indeterminate species closely allied to the Oak Grove *Pleuromeris scitula* occurs in the Shoal River formation.

Adult shell exceeding 10 millimeters in altitude:
- Outline of interior somewhat obliquely elliptical; umbones very strongly anterior ..... *Venericardia hadra* Dall.
- Outline of interior subcircular to elliptical; umbones within the anterior fourth ... *Venericardia himerta* Dall.

Adult shell not exceeding 10 millimeters in altitude ... *Pleuromeris*.
- Outline normally ovate; costals rarely exceeding 13 in number ..... *Venericardia* (*Pleuromeris*) *tellia* s. l.
  - Costals very narrow, finely beaded upon their summits ..... *Venericardia* (*Pleuromeris*) *tellia* Dall.
  - Costals relatively wide, corrugated upon their summits ..... *Venericardia* (*Pleuromeris*) *tellia dasa* Gardner, n. subsp.
- Outline rounded, trigonal; costals commonly exceeding 13 in number ..... *Venericardia* (*Pleuromeris*) *scitula* Dall.

### Venericardia hadra Dall

Plate XVII, Figures 11–12

1903. *Venericardia hadra* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1429, pl. 53, figs. 11, 13.
1910. *Venericardia chipolana* Maury, Bull. Am. Paleontology, vol. 4, No. 21, p. 34, pl. 8, fig. 9.

Dall described this species as follows:

Shell solid, robust, obliquely oblong, the beaks full, prominent, prosogyrate, and nearly anterior; anterior side short, bluntly rounded, posterior side longer, compressed, roundly subtruncate behind; sculpture of about 19 radial ribs, of which the posterior five or six are smaller and less elevated than the others; anterior ribs stout, sometimes with a thread or terrace laterally, the summit articulated rather sparsely with small, squarish, transverse nodules, which have a tendency to become obsolete behind and below; interspaces narrower than or subequal to the ribs, partially channeled; lunule extremely small and deeply incised; hinge normal; the anterior cardinal pustular, the interior margins with shallow flutings. Length 47, height 38, diameter 36 millimeters.

A remarkably fine species, abundant in the Chipola beds, and not likely to be confounded with any but the following species [*V. himerta* Dall].

The length of the type is 41.5 millimeters; the altitude, 38.0 millimeters; the diameter, 31.0 millimeters.

Type: U. S. Nat. Mus. No. 114730.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

The Chipola species is certainly very close to its Oak Grove analogue, and the young *hadra*, which are relatively higher and more rounded than the adults, are very difficult to separate from the young *himerta*. Even at this stage, however, the Oak Grove forms show a constantly higher relative altitude. The sculpture characters of the two forms are inseparable, even the microscopically fine honeycomb texture of the intercostals being exhibited by both species. Young *hadra* are rather easily confused, too, with *Pleuromeris tellia* Dall, though the greater number of costals and their finer sculpture will serve to isolate the *hadra*.

*Venericardia chipolana* Maury is nothing more than a half-grown *hadra*. The costals widen very decidedly toward the base, so that the adults appear much more closely and heavily sculptured than the adolescents.

Occurrence: Chipola formation, localities 10609[r], 10610[p], 7893[c], 2212[p], 7257[r], 2213[a], 2564[c], 3419[c], 9994[c], 7151[r], 2211[p], ?3704[r], ?6776[r], ?6800[r], ?5629[r], ?4986[r].

### Venericardia himerta Dall

Plate XVII, Figure 13

1900. *Cardita* sp. Dall, Wagner Free Inst. Sci. Trans., vol. 5, pl. 40, fig. 16.
1903. *Venericardia himerta* Dall, idem, vol. 3, pt. 6, p. 1430, pl. 53, fig. 12.
1915. *Venericardia himerta* Dall, U. S. Nat. Mus. Bull. 90, p. 132 (part).

Dall described this species in 1903 as follows:

Shell robust, large, convex, with full, prosogyrate beaks which completely conceal the lunule and are situated at the anterior fourth of the valve; hinge line horizontal, the dorsal margin slightly arched over it, the anterior end produced near the hinge line, rounded, and then curved obliquely toward the lower posterior end of the valve; posterior end very bluntly rounded, almost at right angles to the hinge line; sculpture of about 20 strong, broad, slightly rounded, flattish ribs, crossed by narrow, sharp, low imbrications with their short slopes on the dorsal side, separated by somewhat narrower channeled interspaces, the whole crossed by rather irregular, coarse, concentric striations. In the young the ribs are relatively narrower, higher, and more regularly and distantly imbricate; hinge normal, the hinge plate narrower than in *V. hadra*, the inner margins heavily and deeply fluted. Length 53, height 46, diameter 37 millimeters.

This fine species externally has a good deal the look of *V. hadra*, but on looking at the inner face of an adult valve we see that the beaks in the latter are more anterior, the hinge line broader and more arched, the lunule exposed, and the outline of the disk, omitting the beaks, is nearly a regular oval, while in *V. himerta* the form is more nearly rounded trigonal, more abrupt behind, and more produced just in front of the beaks. The latter species also attains a larger size.

The length of the type is 54.0 millimeters; the height, 52.0 millimeters; the diameter of the single valve, 24.5 millimeters.

Type: U. S. Nat. Mus. No. 164555.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The species listed as *V. himerta* Dall from the "silex beds" of the Tampa formation is apparently an ill-preserved *V. serricosta* Heilprin. It is certainly not the Oak Grove species.

*V.* (*Pleuromeris*) *scitula* Dall is much more easily separated from young *himerta* than is *Pleuromeris tellia* from young *hadra*. *Pleuromeris scitula* is a more trigonal, less inequilateral form than the juveniles of *himerta*, the radials are less numerous, less sharply sculptured upon their summits, increase more rapidly in width, and are less arcuate.

Occurrence: Oak Grove sand, localities 2646[c], 5632[p], 5631[r], 5630[r], 5633[r], 7054[p], 9961[p], 10659[r], 7055[r].

### Subgenus PLEUROMERIS Conrad

1867. *Pleuromeris* Conrad, Am. Jour. Conchology, vol. 3, p. 12.

Type: *Pleuromeris decemcostata* Conrad = *Venericardia tridentata* Say var. *decemcostata* Conrad. (Recent off the Florida coast; fossil in the Pliocene and Pleistocene of the southern Atlantic coast.)

Conrad described this group as follows:

Equivalve, triangular, radiately ribbed; hinge in the right valve with one broad, nearly direct concave or broadly furrowed recurved tooth, the upper extremity acute and opposite or above the apex of the shell; hinge in the left valve with three teeth, the anterior one small and fitting into a cavity in the opposite valve.

### Venericardia (Pleuromeris) tellia Dall

Plate XVII, Figure 5

1903. *Venericardia* (*Pleuromeris*) *tellia* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1432, pl. 56, fig. 2.

Dall described this species as follows:

Shell small, solid, rounded or ovate, slightly inequilateral, with a lanceolate escutcheon and a subcordate, smooth, impressed lunule; sculpture of 12 or 13 narrow, squarish, closely nodulous radial ribs separated by wider interspaces, faintly concentrically striated; beaks rather low, slightly prosogyrate, situated at the anterior third; hinge heavy, the laterals distinct; internal margins strongly fluted. Length 4.0, height 3.5, diameter 2.75 millimeters.

Exceptional specimens may reach a length of 5 millimeters, and some specimens are shorter and higher than others.

Type: U. S. Nat. Mus. No. 114611.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

The shell is thinner than in the subspecies *dasa*, and the costals are more narrow and more finely beaded upon their summits. The sculpture in *tellia* is more regular than that exhibited by the young of *V. hadra*, and furthermore the costals are less numerous and less arcuate.

Occurrence: Chipola formation, localities 10609[p], 7257[r], 2213[c], 2564[p], 3419[p], 7151[p], 2211[c], 10660[r].

### Venericardia (Pleuromeris) tellia dasa Gardner, n. subsp.

Plate XVII, Figure 6

Shell very small, heavy, inflated, subtrigonal in outline. Umbones only slightly anterior. Anterior dorsal slope a little less gentle than the posterior, the base line strongly arcuate, merging with no perceptible break into the rounded lateral margins. Lunule very small, quite deeply impressed. Escutcheon exceedingly narrow, lanceolate. Radials rather wide, elevated lirae corrugated upon their summits, arcuate upon the anterior part of the shell but more oblique posteriorly; intercostals deeply channeled, not so wide as the costals except toward the lateral extremities. Inner margins fluted in harmony with the external ribbing. Ligament external, opisthodetic, mounted on a slender laminar nymph. Hinge normal for the species but not heavier than in *tellia* s. s. Muscle scars similar in size and position to those of *tellia* s. s. but more distinct because of the heavier shell. Pallial line obscure.

Dimensions: Altitude, 3.3 millimeters; latitude, 3.5 millimeters.

Type: U. S. Nat. Mus. No. 352478.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

*Venericardia tellia dasa* differs from *tellia* s. s. in the heavier shell and less delicate sculpture. The costals are quite wide in the subspecies and corrugated by the incremental sculpture, but they do not appear to be finely beaded upon their summits as in *tellia* s. s. In the extreme end members of this subspecies, the costals are reduced to 10 or 11 in number, with a corresponding increase in width. The resulting sculpture is very far removed from that of the type of *tellia* s. s.

Occurrence: Chipola formation, localities 10609[r], 2213[c], 2564[p], 3419[r], 7151[r], 7183[p].

### Venericardia (Pleuromeris) scitula Dall

Plate XVII, Figure 4

1903. *Venericardia* (*Pleuromeris*) *scitula* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1433, pl. 56, fig. 15.

Dall described this species as follows:

Shell small, much resembling the last species (*Venericardia* (*Pleuromeris*) *tellia* Dall) but larger, more elevated, and triangular, with 12 to 16 low, broad ribs with narrower interspaces, the ribs crossed by small, elevated, concentric threads or ridges, more prominent distally than in the middle of the disk, and nowhere very conspicuous; lunule and escutcheon smooth, large for the size of the shell, the ribs on the dorsal slopes smaller and feebler than those on the disk; beaks small, high, erect, nearly central. Length 5, height 5, diameter 4 millimeters.

While in many respects similar to the last species, the differences seem to authorize its separation specifically.

Type: U. S. Nat. Mus. No. 135853.

Type locality: No. 2646, Oak Grove, Yellow River, Okaloosa County, Fla.

The Oak Grove species runs a little larger than its Chipola analogue and is decidedly higher relatively. The radials are lower and broader as a rule and less arcuate distally. The nearly central umbones, rudely trigonal outline, and broad, straight ribs will also serve to separate this small species from the juvenile *V. himerta*. Closely allied forms are imperfectly represented in the Shoal River formation.

Occurrence: Oak Grove sand, localities 2646[p], 5632[p], 5631[r], 5630[r], 5633[p], 7054[r], 9961[r].

## Superfamily CHAMACEA

### Family CHAMIDAE

One of the most comprehensive and satisfactory of the group studies has been made upon this family by Odhner, and I offer no apology for incorporating his results into this paper in considerable detail.

### Genus CHAMA (Linnaeus) Bruguière

1758. *Chama* ?Linnaeus, Systema naturae, 10th ed., p. 691 (part).
1792. *Chama* Bruguière, Histoire naturelle des vers, p. xiii, pl. 385.
1798. *Chama* Bruguière, Tableau encyclopédique et méthodique, vol. 1, pls. 196–197.
1919. *Chama* Odhner, K. svenska Vet.-Akad. Handl., Band 59, No. 3, p. 75.

Type: *Chama lazarus* Linnaeus. (Recent in the Indian Ocean.)

Dall [8] described this genus as follows:

In the typical *Chama* the shell is sessile, very inequivalve, with the free valve (as in all sessile mollusks) flatter, with more or less lamellose or spiny irregular sculpture; there is no defined lunule; the ligament is narrow, set in a deep, narrow groove, revolving with the rotation of the valves, the resilium sometimes partly separated and deeply submerged; the pallial sinus simple, the adductor scars large, subequal, usually rough, the mantle adhering by minute processes which penetrate the tubules of the inner shell layer in some species. * * *

The name *Chama* is derived from a Greek word meaning a hiatus or a gaper, and hence Da Costa and some of the other early writers objected to the Linnean use of it for a genus which closes very tightly, but the objection has not been sustained.

As is natural, owing to their variability and the fact that the spines or lamellae may in individuals become obsolete, the number of species of *Chama* seems to have been exaggerated by authors. On the other hand, these very factors render it more difficult to discriminate between nearly allied species which may really deserve separation.

Odhner, in his paper listed in the synonomy above, restricts the genus *Chama* to forms characterized by "shell with the apices twisted to the right and the left valve attached to the substratum; nepionic shell very small (about 0.5 millimeter), with concentric and radial sculpture; lateral teeth persistent; no marginal teeth of the adult shell; dentition $\frac{2(a+b)\ 4b\ 6b}{3a\quad 1\ 3b\ 5b}\ \frac{II}{I}$. Animal with a finger-shaped coecal appendage projecting forward from the left side of the stomach; nephridia with the pericardial tubes entirely embedded in the distal sacs."

Only a single species of the true *Chama* has been recognized in the Alum Bluff—*C. draconis* Dall—apparently absent in the Oak Grove but present in the Chipola and the Shoal River.

Shell attached in adult stage; the two valves differing widely in convexity:
  Shell attached by right valve_____*Chama draconis* Dall.
  Shell attached by left valve__*Pseudochama chipolana* (Dall).
Shell not attached in adult stage; the two valves not differing widely in convexity_____*Echinochama arcinella* Linnaeus.

#### Chama draconis Dall

Plate XVII, Figures 7–8

1903. *Chama draconis* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1399, pl. 56, figs. 17, 18.

Dall describes this species as follows:

Shell irregular, attached by the anterior end of the right valve, which usually acquires a trigonal or semicircular outline; sculptured on the right valve with a curious, blistered verruculation not unlike convex scales of a saurian or Gila monster, and also at the margin of the attachment with broad, irregular, concentrically striated foliations; on the posterior slope there is a tendency to form two or three radial series of small, rather distant foliations, which, or part of them, are often obsolete; near the posterior dorsal margin is a well-marked radial sulcus and often another parallel to it but much more feeble; left valve much flatter, irregularly concentrically lamellose, the lamellae rising into foliations in two or three radial series behind, the foliations and most of the surface with fine vermicular or partly divaricate radial fluting or threading; adductor scars small; internal margins finely crenulate. Average diameter about 25 millimeters.

This is a rather common species with a surface recalling that of *Echinochama.*

Cotypes: U. S. Nat. Mus. No. 114724.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

The sculpture is more simple and more laminar in character than in *Pseudochama chipolana,* and the twist of the beaks of the attached valve is normally in the opposite direction. Differences between the two species show up even in the prodissoconch, for that of *C. draconis* is perceptibly more elongated transversely than that of *P. chipolana.* A couple of large right valves in the collections of the National Museum from Shoal River have many characters in common with *draconis,* but they are double the size of the Chipola species and seem to be more finely sculptured radially. The normal form is present, however, in the Shoal River material collected by Mr. Aldrich.

Occurrence: Chipola formation, localities 7893[p], 2212[r], 7257[r], 2213[c], 2564[p], 3419[p], 9994[p], 7151[p], 2211[r]. Shoal River formation, localities ?3856[r], ?5618[r]. Aldrich collection from Shell Bluff, Shoal River (rare).

### Genus PSEUDOCHAMA Odhner

1917. *Pseudochama* Odhner, K. svenska Vet.-Akad. Handl., Band 52, No. 16, p. 30.

Type: *Pseudochama cristella* (Lamarck). (Recent from the Gulf of Siam to Java, the Molluccas, and Australia.)

Odhner says:

I have referred this species to a new genus, *Pseudochama,* which comprises the so-called "inverse" Chamas, opposite to the normal or dextrally twisted ones, to which the old name is to be restricted. A complete discussion of this opinion and the reasons for establishing the new genus will be published in a special paper; here I only give a summary of the distinguishing points and the characteristics of the new genus. The dentition of these "inverse" or "sinistral" Chamas is developed in a quite different manner from that of *Chama* s. s.; the final result becomes a feature that is somewhat like the mirror image of the dentition of a *Chama,* so that the attached valves, in the former case the right, in the latter the left one, grow symmetric to each other, which has given rise to a misinterpretation of the conditions prevailing, known as the theory of the symmetric valves, and to a new denomination (by Munier-Chalmas) in opposition to the rule of homology. * * * *

After a close investigation of many forms of Chamas, considering their ontogeny as well as the conchological and the anatomical conditions, I was convinced that a division into the

[8] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1396, 1903.

two genera *Chama* and *Pseudochama* (comprising also *Echinochama*) is necessary. The distinguishing characteristics are the following:

The dentition in *Chama* may be expressed (in accordance with Bernard, 1895) thus: $\frac{\text{Left valve: } 2a+b\ 4b\ II}{\text{Right valve: } 3a\ i\ 3b\ I}$. That of *Pseudochama* has the formula $\frac{\text{Left valve: } 2a\ 2b\ 4b\ II}{\text{Right valve: } i\ 3b\ I}$. The difference is more obvious in young than in older shells. The nepionic shell in *Chama* is very small (about 0.5 millimeter) and has a minute sculpture of close radiating and somewhat more distant concentric riblets (cf. Anthony, 1905). In *Pseudochama* the nepionic shell is sculptured just as in *Echinochama* with rather remote concentric lamellae, and no or only traces of radiating riblets; further its size is more considerable (1.4 to 2.5 millimeters). There are also some points of difference in the anatomical characteristics, inasmuch as *Chama* has a stomachal coecum directed forward, which is wanting in *Pseudochama*, and the nephridia of the former genus have the pericardial tubes wholly embedded in the external sacs, while in *Pseudochama* they are left uncovered on their median side.

In 1919 Odhner [9] brought out a much more extended and elaborate discussion entitled "Studies on the morphology, the taxonomy and the relations of recent Chamidae." In this paper he characterized his genus as follows:

Shell with the apices twisted to the left and the right valve attached; nepionic shell distinct; adult shell with a left marginal tooth. Animal without lateral coecal appendage of the stomach; nephridia with the pericardial tubes not covered on their median side by the distal sacs.

A detailed study of the conchologic and morphologic characters of the group led him to the following conclusions in regard to its genesis [10]:

Our investigation has led to the result that the recent *Chamidae* must be divided into two well-defined genera *Chama* and *Pseudochama*, of which the former is to be derived from sinistral, the latter from dextral forms of *Diceras*. On the other hand, both genera exhibit a striking similarity to different genera of Megalodontidae. In consideration of their great agreement with each other in their anatomy it is more probable that both genera have originated from a single and common source, which we have assumed to be *Diceras*, than that they represent earlier offshoots from different points of the *Megalodus* tribe. The agreement with Megalodontidae, however, undoubtedly speaks in favor of a genetic continuity between Chamidae and Megalodontidae in the way that is maintained by the paleontologists. Anatomical facts indicate that Chamidae occupy a separate position among the Lamellibranchia, and this might be in accordance with the view presented here, while, on the contrary, both anatomical and paleontological facts decidedly speak against a close relation between Chamidae and Astartidae or Carditidae.

There is, however, a circumstance that might be interpreted as a support against the opinion deduced here as to the relation of Chamidae, namely the sculpture of the shell. The forms of *Diceras*, like those of Megalodontidae, are smooth or furnished with a feeble concentric sculpture, while the Chamidae show the greatest variation in their sculpture. Even if the comparison is extended to the nepionic stage of the recent Chamidae, it results only in a statement of contrasts both in form and ornamentation. The sharp lamellae of a *Pseudochama* as well as the weak ones and the radiating striation of a *Chama* have no parallels in the adult shell either of *Diceras* nor of *Megalodus*. Boehm [11] tells us what difficulty these contrasts offer for the understanding of the problems concerning the origin of Chamidae. He remarks "dass die Embryonalschale von *Echinochama arcinella* nicht die mindeste äussere Ähnlichkeit weder mit *Megalodon*, noch mit *Protodiceras*, noch mit *Diceras* besitzt. * * * Die äusseren Formen hier und dort sind vollkommen voneinander verschieden."

As an explanation of this peculiar state of affairs two alternatives are conceivable. 1. Both *Diceras* and (perhaps also) *Megalodus* have nepionic stages similar to those of Chamidae and differing from the full-grown shells; in this case they should be traceable on the umbones when these are still in a good state of preservation. The differences between the young *Diceras arietina* and the full-grown one are, however, not great enough to support such a supposition, but a still younger stage would perhaps enable us to find out whether a mode of development similar to that of Chamidae is also characteristic for *Diceras* or not.

If this is not the case there still remains the second alternative for explaining this state of affairs. 2. From the shape and sculpture of the umbonal nucleus in *Chama* and *Pseudochama*, which differs from those of the extra-umbonal shell and is sharply defined from it, we conclude that the postlarval development is not a direct one, as in Cardiidae and Veneridae for example, but proceeds indirectly and is complicated by a metamorphosis, something like that of *Unio* with its glochidium larva. This nepionic stage interjacent between the prodissoconch and the permament stage, is to be considered as a juvenile specialization or a coenogenetical larval stage, which has arisen through a development produced somewhat beyond the direct line of evolution. The umbonal shell, consequently, may be regarded as a character proper to Chamidae without any correspondence in their earlier ancestors.

That such a view is supported is proved by the following circumstances. The nepionic shell varies considerably in size in *Pseudochama*. It seems to be larger in *Echinochama* (where it attains 2.4 millimeters in length and has six lamellae) than in other forms of *Pseudochama* (at least *P. ferruginea*, where it seems to vary from 1.2 millimeters with four lamellae to a somewhat larger size with five, and in *P. gryphina*, where it attains 1.4 millimeters with about four lamellae). In *Pseudochama* (*Eopseuma*) *pusilla* it is about 2 millimeters; the upper and smoother portion measures 0.8 to 0.9 millimeter and has about four rather prominent lamellae and traces of about four radial rows of squamulae; the peripheral part has many radiating squamuliferous ridges. Further, in *Chama* the nepionic shell is very small (0.5 millimeter) and its smoother upper portion is only about one-fourth of the entire umbonal shell. In the *spinosa* group of *Chama*, however, the nepionic shell is comparatively large. Hence we find that the more the characteristics of the hinge or the sculpture of the shell differ from a more primitive stage (most in *Echinochama* and the *Chama spinosa* section, less in *Eopseuma* and the remaining Chamas), or the more specialized these characters become when full grown, the larger is the smooth or only concentrically sculptured portion of its nepionic shell. It seems as if smoothness or a radial sculpture were primitive in the earliest stages of development; during the course of specialization a concentric ornamentation appears, which ultimately occupies the whole of the nepionic shell as this becomes larger. Or, to put it briefly, the nepionic shell is subject to a caenogenetic specialization, relative to the advanced development of the adult shell. In *Eopseuma*, we may repeat, teeth 1 and 3b are separated and of uniform size during life, while in the Pseudochamas mentioned 3b is still traceable as a distinct tooth separated from 1, but the latter has greatly exceeded 3b in size; in *Echino-*

[9] K. svenska Vet.-Akad. Handl., Band 59, No. 3, p. 75, 1919.
[10] Idem, pp. 91–94.
[11] Boehm, G., *Megalodon, Pachyerisma* und *Diceras:* Naturf. Gesellsch. Freiburg Ber., Band 6, pt. 2, p. 21, 1891.

*chama* a separation of these teeth is scarcely visible, and besides that the shell has become almost equivalve, which seems to be a secondarily acquired property. In *Eopseuma* the nepionic shell strikingly recalls that of *Chama*, and this genus shows a closer resemblance to its presumed ancestors (the sinistral *Diceras*) than does *Pseudochama* to the dextral *Diceras*. In *Chama* the caenogenetic metamorphosis and the subsequent progressive development has made the type less distanced from its ancestors than has been the case in *Pseudochama*.

It is evident that the genus *Pseudochama* has consequently been subject to a progressive development both as regards its full-grown and its nepionic stages, while *Chama* has remained more constant and conservative. It is perhaps even possible that the concentric sculpture of the nepionic *Pseudochama* is an atavism, being a reappearance of that of the earliest known Cretaceous species, such as *Chama haueri* Zittel. If a true member of Chamidae at all, this form appears most likely to belong to *Pseudochama*. * * *

Finally we may admit the possibility that both Veneridae and Cardiidae, which, from an anatomical point of view, seem to have a common origin with Chamidae, might have originated from forms closely related to the nepionic stages prevailing in Chamidae, as the nepionic shell of a *Pseudochama* reminds one of a *Venerupis* and that of a *Chama* is like a *Cardium*. Both families appear at a relatively late period, and their origin from Chamidae is admitted by paleontologists. No facts on which an exact opinion on these questions can be based have hitherto been presented, and both anatomical and ontogenetical investigations must be carried out before we are able to judge with certainty about the mutual relations of Chamidae, Cardiidae and Veneridae.

The general distribution of the Recent species of *Pseudochama* is similar to that of *Chama*, and like it there is a single Alum Bluff species referable to it. The subgenus *Echinochama* is excluded.

**Pseudochama chipolana (Dall)**

Plate XVII, Figures 9–10

1903. *Chama cnipolana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1398, pl. 56, figs. 19, 20.

Dall described this species as follows:

Shell irregular in shape, but usually rounded, with the lower valve deep and the upper one nearly flat, with a rotation of nearly two whorls in old specimens; sculpture of the attached valve (usually the left but sometimes the right) low, irregular, concentric lamellae and rounded radial ridges, which become on the lamellae short channeled spines; the radials vary in size but are usually close set; the free valve has the concentric sculpture more or less suppressed, the radials finer and more regular, hardly spinose; there are frequently radials on which the spines are better developed set at regular intervals, the intervening radials without spines; the adductor scars are rather short and rounded; there is a polished, smooth border between the pallial line and the margin, the latter being finely radially grooved or striate. The shell is commonly an inch in diameter but reaches twice or thrice that size in senile individuals, judging from fragments obtained.

Two small valves are figured, since the older valves are invariably worn and do not show the sculpture well.

Cotypes: U. S. Nat. Mus. No. 114725.

Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla.

This species might more properly have been christened *dodona*, as it is a much more conspicuous element in the Oak Grove fauna than in the Chipola. The sculpture is much finer and more detailed than that of the coexistent *C. draconis*, and the clockwise twist of the beaks when the attached valve is viewed with the inner surface uppermost will normally serve as an excellent diagnostic for separation.

Occurrence: Chipola formation, localities 10609[r], 7893[p], 2212[p], 2213[c], 3419[p], ?9994[r], 2211[c], 7183[p], 10660[p]. Oak Grove sand, localities 2646[a], 5632[p], 5631[r], 5630[p], 5633[r], 7054[c], 9961[p], 7055[c], 10659[p]. Shoal River formation, localities 10603[r], 10608[r], ?9959[r], Aldrich collection from the Shoal River (rare).

**Subgenus ECHINOCHAMA Fischer**

1887. *Echinochama* Fischer, Manuel de Conchyliologie, p. 1049.

Type: *Echinochama arcinella* Linnaeus. (Recent along the east coast of the Americas from Hatteras to Brazil.)

Dall [12] says:

In the genus *Echinochama* the shell is nearly equivalve, and sessile in most cases only while young; the sculpture is radial, spinose, and regular; a large impressed and conspicuous lunule exists, and also an obscure escutcheon.

The geologic and geographic range of the group are not extensive, for it has been in existence only since the early Miocene, and the Recent species are confined, apparently, to the waters bordering the shores of tropical America.

Odhner [13] characterized this group as follows:

Shell with distinct lunula, nearly regular and equivalve, attached when young, usually free when adult, ribbed and spiny. Nepionic shell large, elongated (about 2.4 millimeters).

Only the single species is known in the Alum Bluff and that the type of the genus first described from the Antilles.

The hinge construction of the group is similar to that of the normal *Pseudochama*, but as the characters of the genus as proposed by Fischer are based largely upon the character of the type species *Echinochama* has been retained as a subgeneric name.

**Pseudochama (Echinochama) arcinella (Linnaeus) Odhner**

Plate XVII, Figures 14–16

1767. *Chama arcinella* Linnaeus, Systema naturae, 12th ed., vol. 1, pt. 2, p. 1139.
1789. *Cochlea histrix* Martyn, Universal conchology, pl. 132, fig. 2.
1789. *Cochlea crista galli* Martyn, idem, pl. 132, fig. 1.
1817. *Arcinella spinosa* Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 142, pl. 13, fig. 1.
1846. *Chama arcinella* Linnaeus. Reeve, Conchologica Iconica, vol. 4, *Chama*, pl. 5, figs. 26, 26a.

[12] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1396, 1903.

[13] Odhner, N. H., Results of Dr. E. Mjöberg's Swedish Scientific Expeditions to Australia, 1910–1913, pt. 17, Mollusca: K. svenska Vet.-Akad. Handl., Band 59, No. 3, p. 75, 1919.

1846. *Chama arcinella* Lamarck. Conrad, Am. Jour. Sci., 2d ser., col. 1, p. 404.
1853. *Chama arcinella* Linnaeus. D'Orbigny, in Ramón de la Sagra, Histoire de l'île de Cuba, Mollusques, vol. 2, p. 362, pl. 28, figs. 28–29.
1853. *Arcinella arcinella* Linnaeus. Mörch, Catalogue Conchyliorum, Comes de Yoldi, p. 37.
1855. *Chama arcinella* Linnaeus. Tuomey and Holmes, Pleiocene fossils of South Carolina, p. 22, pl. 7, figs. 4–6.
1857. *Chama (Arcinella) spinosa* Schumacher. H. and A. Adams, Genera of Recent Mollusca, vol. 2, p. 464.
1858. *Chama arcinella* Emmons, North Carolina Geol. Survey Rept. p. 287, fig. 209.
1858. *Chama arcinella* Linnaeus. Holmes, Post-Pleiocene fossils of South Carolina, p. 23 (pl. 5, fig. 1, excluded).
1863. *Arcinella arcinella* Linnaeus. Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 576.
1864. *Chama (Arcinella) arcinella* Linnaeus. Meek, Check list of the invertebrate fossils of North America, Miocene: Smithsonian Misc. Coll., No. 183, p. 8 (name only).
1866. *Arcinella cornuta* Conrad, Am. Jour. Conchology, vol. 2, p. 105.
1873. *Chama arcinella* Linnaeus. Gabb, Geology of Santo Domingo, Am. Philos. Soc. Trans., vol. 15, p. 251.
1887. *Chama arcinella* Linnaeus. Heilprin, Wagner Free Inst. Sci. Trans., vol. 1, p. 103 (name only).
1887. *Chama (Echinochama) arcinella* Linnaeus. Fischer, Manuel de conchyliologie, p. 1049.
1903. *Echinochama arcinella* Linnaeus. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1405.
1908. *Chama arcinella* Linnaeus. Rogers, Shell Book, p. 361, pl. 81, facing p. 357, fig. 3.

Linnaeus described this species in 1767 as follows:

C. testa sulcata muricata excavato punctata cardinis callo sessili. Habitat in O. Americano Spengler.

Testa magnitudine pruni, longitudinaliter sulcata sulcis excavato, punctatis, poris imbricato, muricatis; margo crenulatus. Natis subaequales. Ani regio cordata, intrusa, papillosa rugosa. Cardinis callus prominens, valde singularis sulcis 4-angustis quas lamellae totidem, in opposita cavitate, intrant.

Shell equivalve, inequilateral, attached only in the young, moderately inflated. Umbones broad, tumid, involute, prosogyrate. Lunule broadly cordate, conspicuous, clearly defined. Escutcheon suggested but not defined. Outline of inner margins rudely subcircular, excepting for a pronounced lobate projection in front of the lunule. External surface bristling with 5 or 6 radial series of spines, which are strongest on the medial and anterior portions of the valves, where, in the recent shells, they not uncommonly exceed half an inch in length; interradial spaces and lunule roughly tuberculated. Ligament groove moderately deep. Right valve furnished with a single prominent, subumbonal dental projection, corrugated on both its dorsal and ventral surfaces; socket in left valve correspondingly deep and correspondingly rugose. Muscle impressions irregularly oblong, the anterior a little more elongated and a little higher; pallial line simple, not very distant from the ventral margin. Inner margins crenate.

The Shoal River species does not attain the dimensions reached by some of the Recent individuals and the spines seem a little heavier, but there is no constant difference by which the mid-Tertiary form can be separated from the Recent. In fact, there is more variation shown among the Recent forms than between the fossil and the Recent. The characters of the Shoal River individuals are remarkably constant.

The species was apparently first initiated at this horizon, for certainly temperature conditions must have been equally favorable during Chipola time. The absence of the group during the Chesapeake, however, is probably due to the cooling of the waters.

The Bowden species, *E. antiquata*, is less inflated and much more closely sculptured than *E. arcinella*.

Occurrence: Shoal River formation, localities 2645[r], 3732[r], 3742[c], 10658[r], 5184[p], 5195[r], 10603[r].

Outside occurrence: Miocene: Duplin formation, North Carolina, Georgia. Pliocene: Waccamaw formation, South Carolina; Nashua marl, Florida. Pleistocene: South Carolina to Florida. Recent: Hatteras to São Paulo, Brazil, in 0 to 26 fathoms.

# PLATES XVI–XVII

# PLATE XVI

[The figured specimen is the type unless otherwise stated]

FIGURE 1. *Astarte eugonia* Gardner, n. sp. (p. 83). Exterior of left valve; altitude, 5.0 millimeters; latitude, 5.7 millimeters.

FIGURES 2–3. *Astarte* (*Ashtarotha*) *sima* Gardner, n. sp. (p. 84).

2. Interior of right valve; altitude, 12.5 millimeters; latitude, 13.3 millimeters.
3. Exterior of right valve; altitude, 12.5 millimeters; latitude, 13.3 millimeters.

FIGURES 4–8. *Astarte* (*Bythiamena*) *isosocles* Gardner, n. sp. (pp. 84–85).

4. Exterior of left valve (cotype); altitude, 7.5 millimeters; latitude, 7.5 millimeters.
5. Interior of left valve (cotype); altitude, 7.5 millimeters; latitude, 7.5 millimeters.
6. Interior of right valve (cotype); altitude, 9.0 millimeters; latitude, 9.0 millimeters.
7. Exterior of right valve (cotype); altitude, 9.0 millimeters; latitude, 9.0 millimeters.
8. Profile of right valve (cotype), showing lunule.

FIGURE 9. *Astarte wagneri* Dall (p. 85). Exterior of left valve; altitude, 10.0 millimeters; latitude, 11.0 millimeters. (After Dall.)

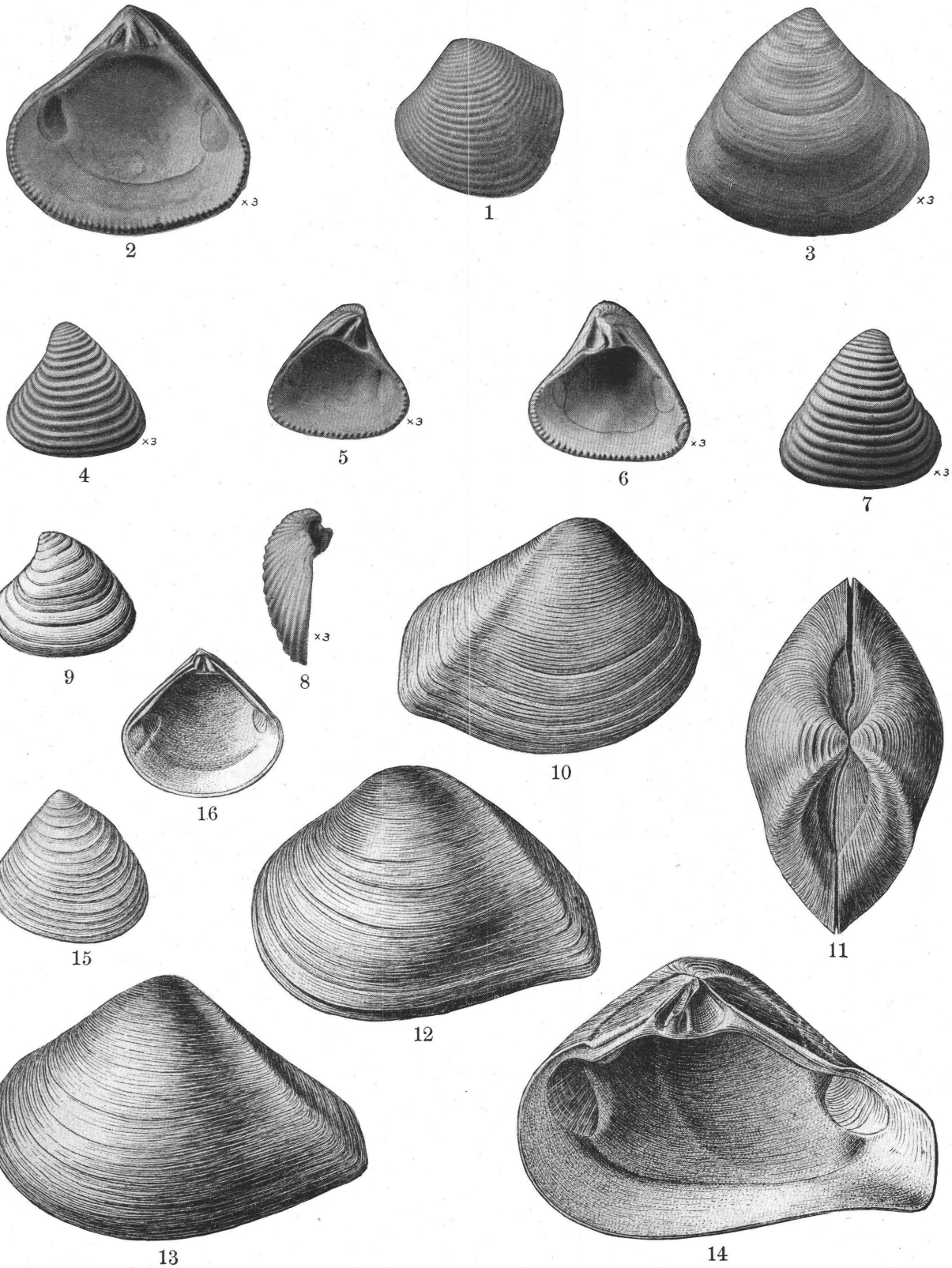
FIGURE 10. *Crassatellites* (*Scambula*) *chipolanus* Dall (p. 86). Exterior of right valve; altitude, 33.0 millimeters; latitude, 44.0 millimeters. (After Dall.)

FIGURES 11–14. *Crassatellites* (*Scambula*) *densus* Dall (p. 86).

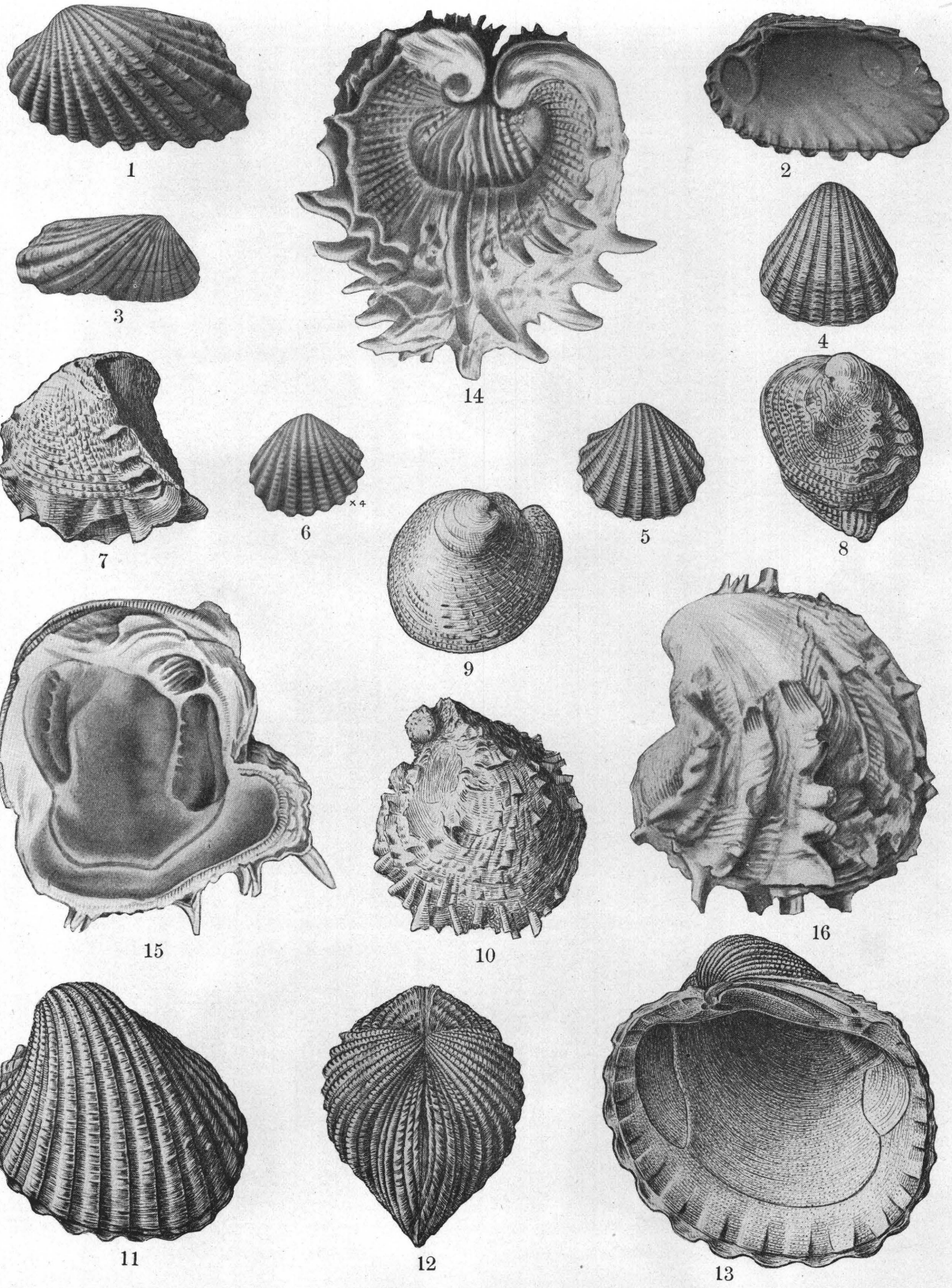
11. Apical view of double valves (cotype). (After Dall.)
12. Exterior of left valve (cotype); altitude, 34.5 millimeters; latitude, 48.0 millimeters. (After Dall.)
13. Exterior of left valve (cotype); altitude, 35.0 millimeters; latitude, 50.0 millimeters. (After Dall.)
14. Interior of right valve (cotype); altitude, 39.0 millimeters; latitude, 58.0 millimeters. (After Dall.)

FIGURE 15. *Crassatellites* (*Crassinella*) *triangulatus* Dall (pp. 86–87). Exterior of left valve; altitude, 3.3 millimeters; latitude, 3.0 millimeters. (After Dall.)

FIGURE 16. *Crassatellites* (*Crassinella*) *tanicus* Dall (p. 87). Interior of left valve (cotype); altitude, 3.5 millimeters; latitude, 3.7 millimeters. (After Dall.)




TELEODESMACEA OF THE ALUM BLUFF GROUP




TELEODESMACEA OF THE ALUM BLUFF GROUP

## PLATE XVII

FIGURES 1–2. *Cardita* (*Carditamera*) *apotegea* Gardner, n. sp. (pp. 88–89).

1. Exterior of left valve (cotype); altitude, 22.5 millimeters; latitude, 40.0 millimeters.
2. Interior of right valve of another individual (cotype); altitude, 23.5 millimeters; latitude, 41.0 millimeters.

FIGURE 3. *Cardita* (*Carditamera*) *defuniak* Gardner, n. sp. (p. 89). Exterior of right valve; altitude, 16.0 millimeters; latitude, 32.0 millimeters.

FIGURE 4. *Venericardia* (*Pleuromeris*) *scitula* Dall (p. 91). Exterior of left valve; altitude, 5.0 millimeters; latitude, 5.0 millimeters. (After Dall.)

FIGURE 5. *Venericardia* (*Pleuromeris*) *tellia* Dall (p. 91). Exterior of left valve; altitude, 3.3 millimeters; latitude, 3.8 millimeters. (After Dall.)

FIGURE 6. *Venericardia* (*Pleuromeris*) *tellia* subsp. *dasa* Gardner, n. subsp. (p. 91). Exterior of right valve; altitude, 3.3 millimeters; latitude, 3.5 millimeters.

FIGURES 7–8. *Chama draconis* Dall (p. 92).

7. Exterior of attached right valve (cotype); altitude, 27.0 millimeters; latitude, 26.0 millimeters (exclusive of projecting lamellae). (After Dall.)
8. Exterior of free left valve of another individual (cotype); altitude, 20.0 millimeters; latitude, 19.0 millimeters. (After Dall.)

FIGURES 9–10. *Pseudochama chipolana* (Dall) (p. 94).

9. Exterior of free right valve (cotype); altitude, 20.0 millimeters; latitude, 21.0 millimeters. (After Dall.)
10. Exterior of attached left valve (cotype); altitude, 30.0 millimeters; latitude, 25.0 millimeters. (After Dall.)

FIGURES 11–12. *Venericardia hadra* Dall (p. 90).

11. Exterior of left valve; altitude, 38.0 millimeters; latitude, 41.5 millimeters. (After Dall.)
12. Apical view of double valves of same individual; altitude, 38.0 millimeters; latitude, 41.5 millimeters; diameter, 31.0 millimeters. (After Dall.)

FIGURE 13. *Venericardia himerta* Dall (pp. 90–91). Interior of right valve; altitude, 52.0 millimeters; latitude, 54.0 millimeters. (After Dall.)

FIGURES 14–16. *Pseudochama* (*Echinochama*) *arcinella* (Linnaeus) Odhner (pp. 94–95).

14. View of double valves showing lunule (not the type); natural size. (After Tuomey and Holmes.)
15. Interior of left valve (not the type); natural size. (After Tuomey and Holmes.)
16. Exterior of left valve (not the type); natural size. (After Tuomey and Holmes.)

NOTE.—The types of formerly described species have been remeasured, and some of the dimensions stated differ from those given in the original descriptions.

# INDEX



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