

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC. 17. THE FAMILIES
CUSPIDARIIDAE AND VERTICORDIIDAE (MOLLUSCA: BIVALVIA)

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ABSTRACT

Seven species belonging to two genera of Cuspidariidae and two genera of Verticordiidae are described and figured. Five of them occur in the Neogene sections of the Dominican Republic and their stratigraphic occurrences are given. Two species of the verticordiid genus *Trigonulina* are known from the Recent fauna only: one from the Western Atlantic, the other from the Eastern Pacific. The latter is described as new (*T. pacifica* n. sp.). The two living species are discussed herein for comparative purposes. Out of the five fossil species, only two are well represented (*Cardiomya islahispaniolae* and *Trigonulina bowdenensis*). The remaining three species are known from very few specimens.

RESUMEN

Se describen siete especies pertenecientes a dos géneros de la familia Cuspidariidae y a dos géneros de la familia Verticordiidae. Cinco de ellas se encuentran representadas en las secciones del Neogeno de la República Dominicana; se indican sus ámbitos estratigráficos. Dos especies de verticordidos del género *Trigonulina* solamente se conocen de la fauna actual. *T. pacifica* habita en el Pacífico Oriental y se describe aquí por primera vez; la otra habita en el Atlántico Occidental. Ambas se mencionan con propósitos comparativos. De las cinco especies fósiles, apenas dos están bien representadas (*Cardiomya islahispaniolae* y *Trigonulina bowdenensis*). El material existente de las restantes tres especies es muy escaso.

INTRODUCTION

This paper is a further contribution to the series of taxonomic studies dealing with Neogene fossils from sections situated in the Cibao Valley of the northern Dominican Republic (Text-fig. 1). The project and the framework within which these studies are being carried out have been outlined by Saunders *et al.* (1982) and Saunders *et al.* (1986). Jung (1986, p. 5) listed the most important early collections of molluscs from this area. The material of Cuspidariidae and Verticordiidae available for this paper is not rich. I nevertheless thought it worthwhile studying these two families especially considering the facts that (1) illustrations of these groups in literature are generally rather poor, and (2) the method of scanning electron microscopy allows to produce good illustrations.

As is the case for all the contributions to this series, the material studied has been collected from measured sections. The geographic location of the investigated areas is shown in Text-figure 1. For detailed information as to geographic locations and stratigraphic position of all the collecting stations, as well as to the general biostratigraphic framework and the ages, the reader is referred to the paper by Saunders *et al.* (1986). Formational names have been used with care, because correlations of the sections are not certain.

ACKNOWLEDGMENTS

The material on which this paper is based was collected during field work carried out in the years 1978,

1979, and 1980 as part of the project referred to above. The field work was made possible by a grant from the Swiss National Science Foundation (Grant 2.646-0.76). The financial help and the assistance in the field provided by Institut Français du Pétrole are gratefully acknowledged.

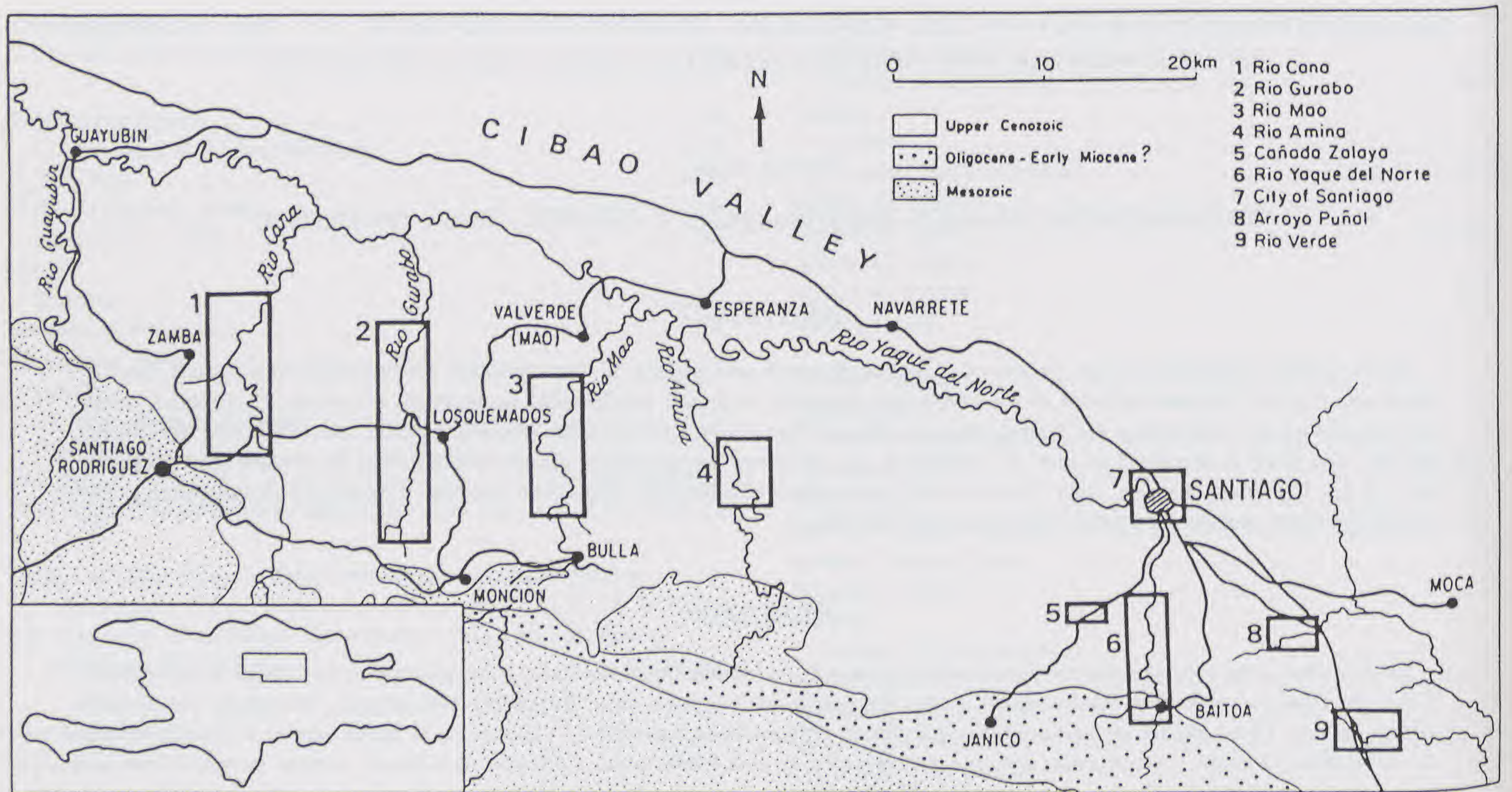
I am indebted to the following persons for the loan of specimens under their care: Gary Rosenberg, Academy of Natural Sciences, Philadelphia, PA, U.S.A.; Alan Kabat, Mark Florence, Jann Thompson, Warren Blow, all of the National Museum of Natural History, Washington, DC, U.S.A.; Kathie Way, The Natural History Museum, London, England; James McLean, Los Angeles County Museum, Los Angeles, CA, U.S.A.

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BIOSTRATIGRAPHY AND
PALEOBIOGEOGRAPHY

A total of seven species belonging to two genera of Cuspidariidae and two genera of Verticordiidae is discussed in this paper. Two species of the verticordiid genus *Trigonulina* are known from the recent fauna



Text-figure 1.—Index map showing location of investigated areas in the Cibao Valley, Dominican Republic (after Jung, 1986, Text-fig. 1).

only, one from the Western Atlantic, the other from the Eastern Pacific. They have been included here for comparative purposes.

The stratigraphic occurrences of the remaining five species are plotted in Text-figures 2–7. The species are not continuously present through a given sequence of sediments, but their occurrences are spotty (Jung and Petit, 1990, p. 88; Jung, 1994, p. 6). The five species occur in the following sections:

Río Gurabo section (Text-figs. 2, 3):

Cardiomya islahispaniolae (Maury, 1917)
Cardiomya distira (Dall, 1903)
Haliris jamaicensis (Dall, 1903)
Trigonulina bowdenensis (Dall, 1903)

Río Cana section (Text-fig. 4):

Cardiomya islahispaniolae (Maury, 1917)
Plectodon granulatus (Dall, 1881)
Trigonulina bowdenensis (Dall, 1903)

Río Mao section (Text-figs. 5–7):

Cardiomya islahispaniolae (Maury, 1917)

Arroyo Zalaya:

Cardiomya distira (Dall, 1903)
Haliris jamaicensis (Dall, 1903)

Arroyo Babosico near La Barranca, Río Yaque del Norte:

Cardiomya distira (Dall, 1903)

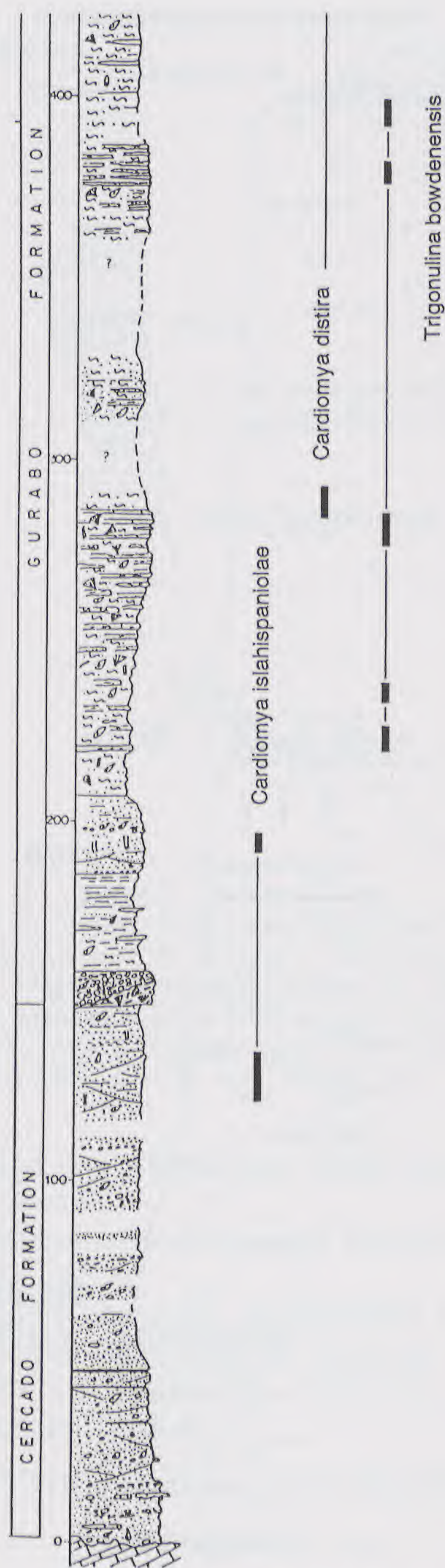
Río Verde:

Trigonulina bowdenensis

As can be seen from the above lists *Cardiomya islahispaniolae* occurs in the sections of Río Gurabo, Río Cana, and Río Mao. *Trigonulina bowdenensis* has been found in the sections of Río Gurabo, Río Cana, and Río Verde. *Cardiomya distira* is recorded from the sections of Río Gurabo, Arroyo Zalaya, and Arroyo Babosico; *Haliris jamaicensis* from the sections of Río Gurabo and Arroyo Zalaya, whereas *Plectodon granulatus* is restricted to the Río Cana section.

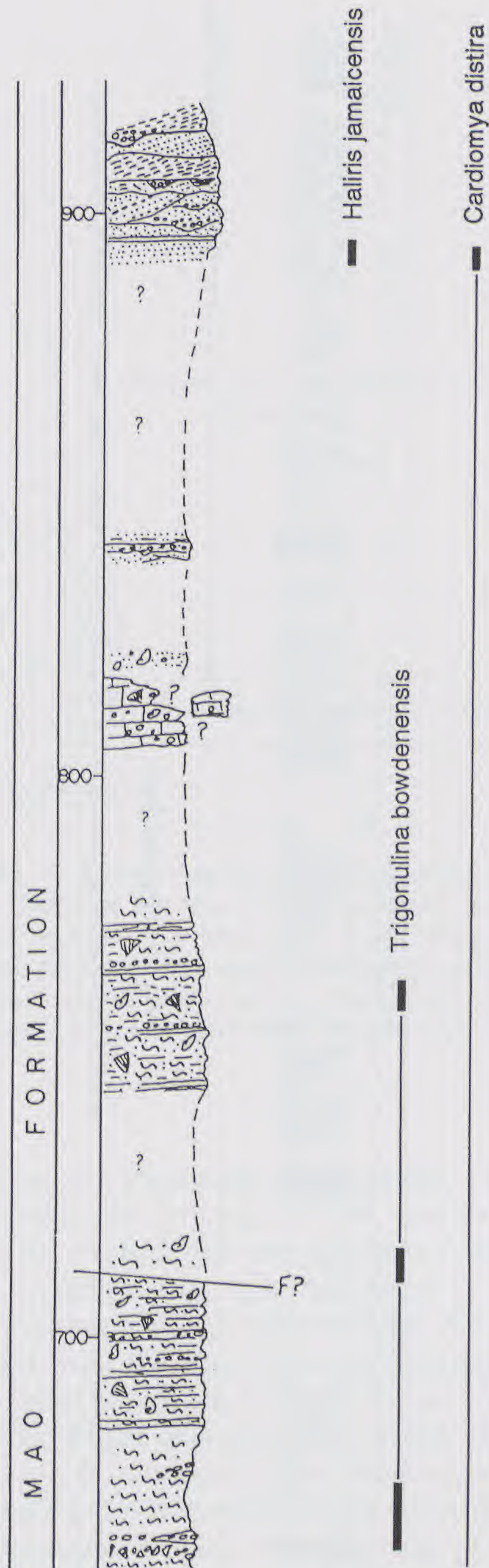
The representation of these five species in the various sections is rather uneven. Four species occur in the Río Gurabo section, three in the Río Cana section, two in Arroyo Zalaya, and a single species in the sections of Río Mao, Arroyo Babosico, and Río Verde.

The numerical representation of the five species in the Dominican deposits is uneven as well. *Trigonulina bowdenensis* is represented by 80, *Cardiomya islahispaniolae* by 52 Dominican specimens. On the other hand *Cardiomya distira* is represented by only eight, *Haliris jamaicensis* by three, and *Plectodon granulatus* by a single specimen. The three latter species therefore are very rare.



Text-figure 2.—Columnar section of Río Gurabo showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 6). Numbers in second column from left refer to thickness in m.

Of the five species mentioned above, only *Cardiomya islahispaniolae* is endemic to the Neogene of the Dominican Republic. Three species, namely *Cardiomya distira*, *Haliris jamaicensis*, and *Trigonulina bowdenensis*, also occur in the early Pliocene Bowden Formation of Jamaica, and *Plectodon granulatus* is known from the middle Miocene Shoal River Forma-

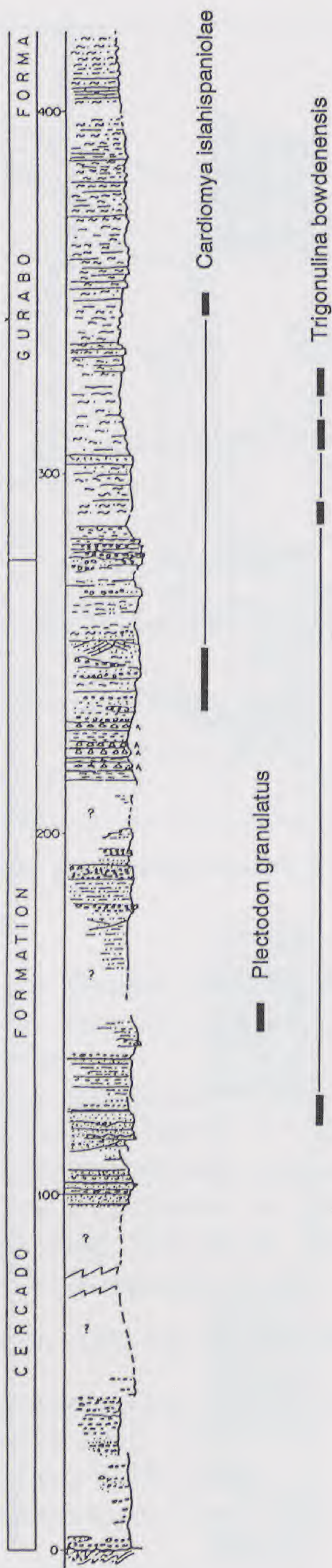


Text-figure 3.—Río Gurabo: upper part of columnar section showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 6). Numbers in second column from left refer to thickness in m.

tion of Florida, the Pliocene of Florida, and from the Recent fauna of the Western Atlantic.

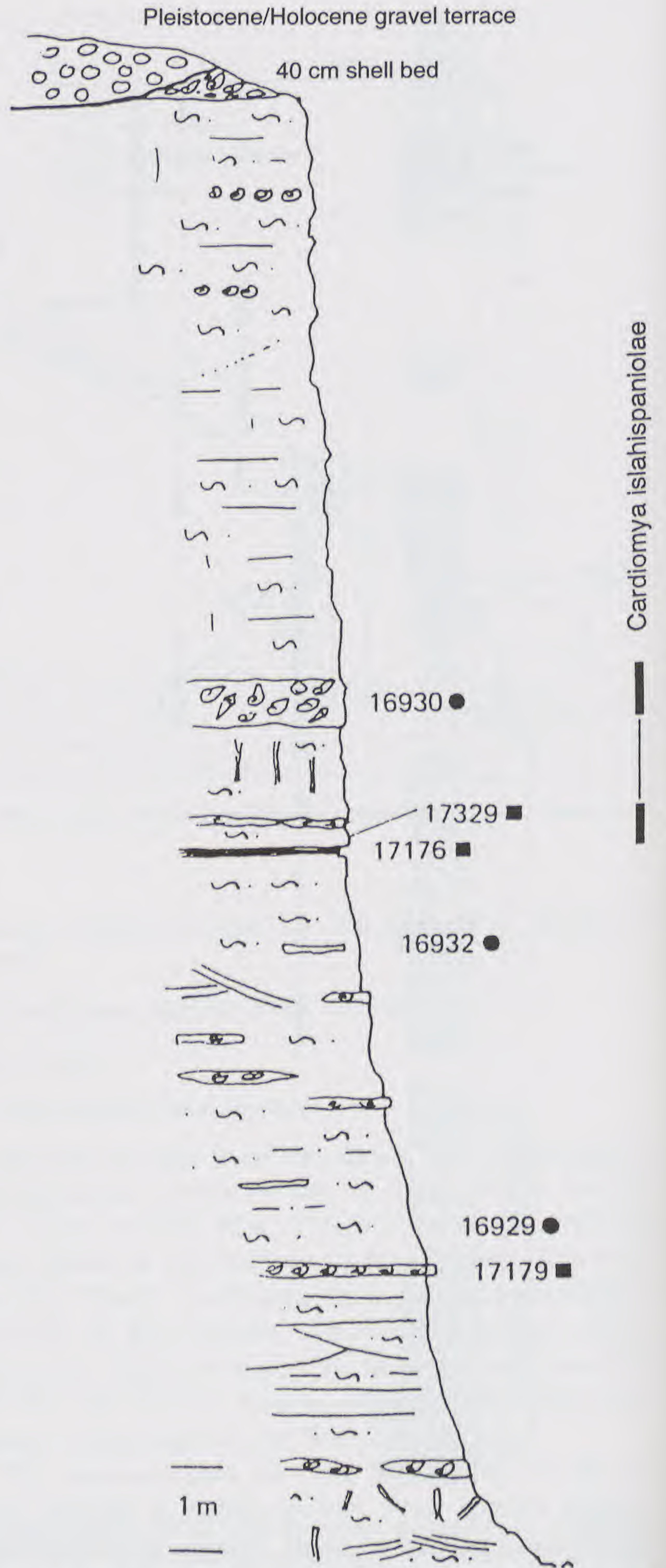
ABBREVIATIONS OF REPOSITORY INSTITUTIONS

ANSP: Academy of Natural Sciences, Philadelphia, PA, U.S.A.

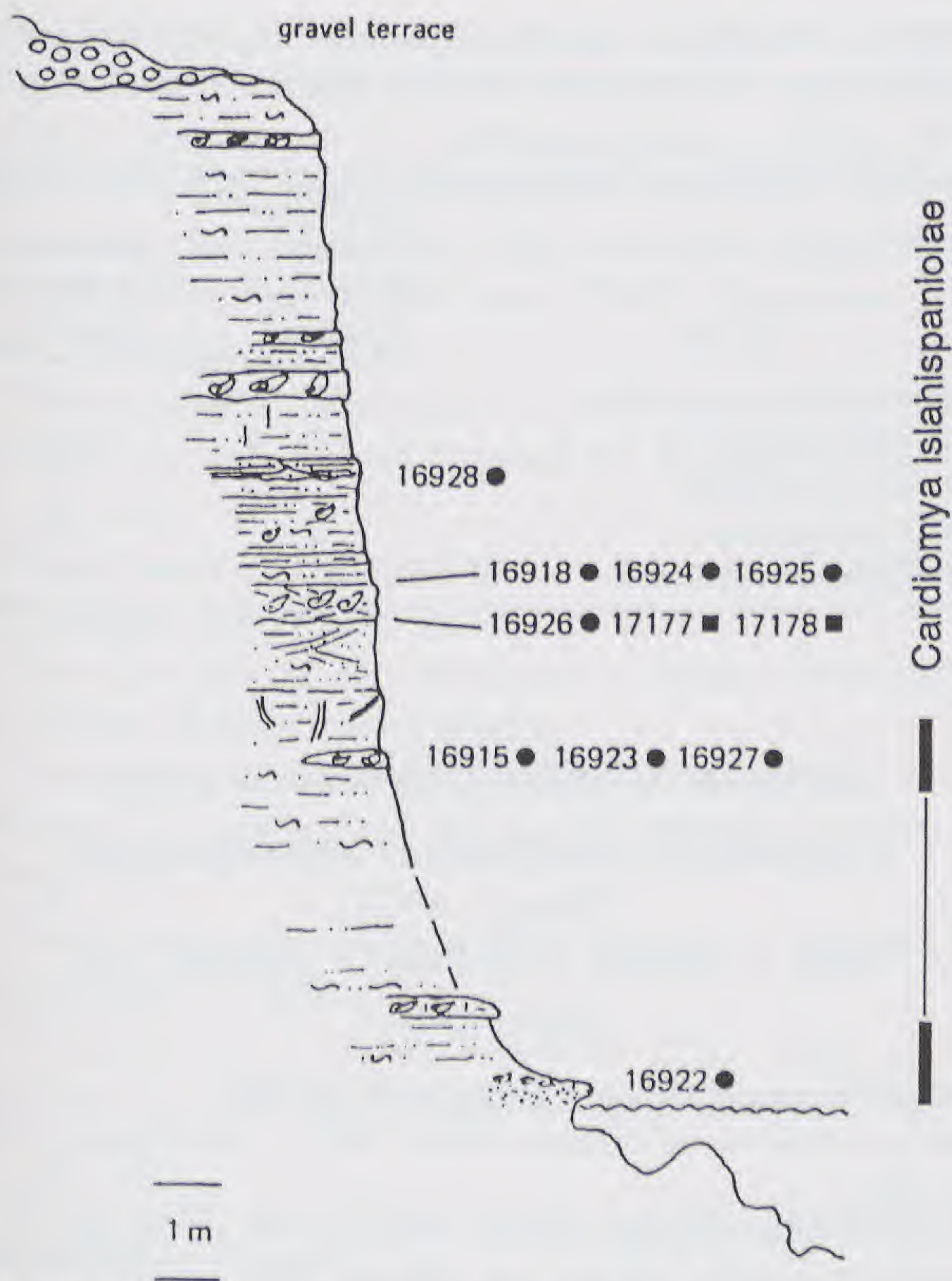


Text-figure 4.—Columnar section of Río Cana showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 16). Numbers in second column from left refer to thickness in m.

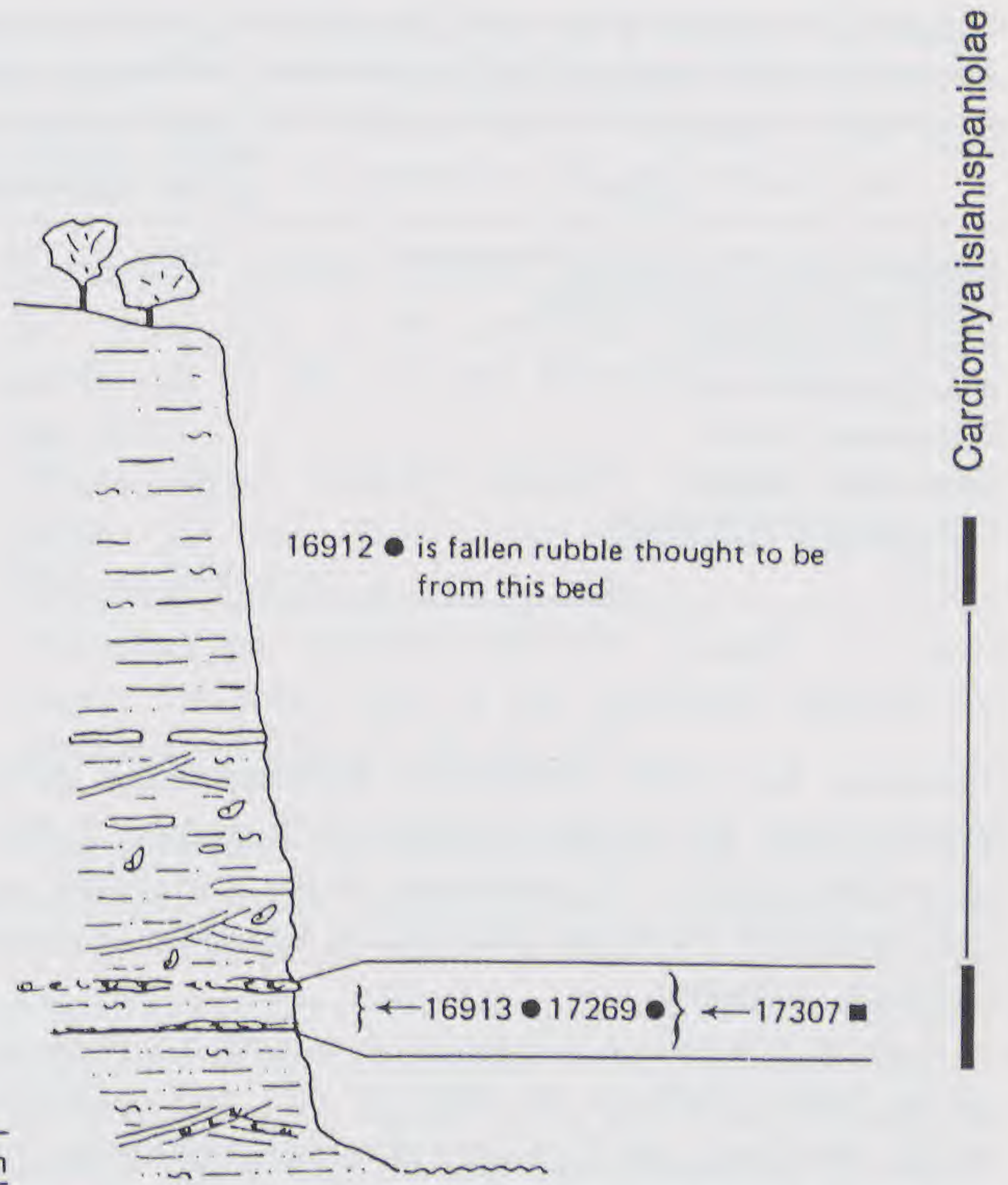
- BMNH: British Museum (Natural History), London, England, now The Natural History Museum, London.
- LACM: Los Angeles County Museum of Natural History, Los Angeles, CA, U.S.A.
- NMB: Naturhistorisches Museum Basel, Switzer-



Text-figure 5.—Section exposed in Maury's Bluff 2 on Río Mao showing occurrence of *Cardiomya (Cardiomya) islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black squares represent localities collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 31).



Text-figure 6.—Section exposed at mouth of Arroyo Bajón on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black squares represent localities collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 32).



Text-figure 7.—Section exposed at the downstream (eastern) end of Maury's Bluff 3 on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black square represents a locality collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 33).

land (the letter G after NMB stands for bivalves).

PRI: Paleontological Research Institution, Ithaca, NY, U.S.A.

TU: Tulane University, New Orleans, LA, U.S.A.

USNM: United States National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

The basis for the preparation of this paper has been the combined collections of the Naturhistorisches Museum Basel and Tulane University. All of the figured specimens of Cuspidariidae and Verticordiidae derived from these collections are deposited in the Naturhistorisches Museum Basel. It was originally planned to examine and refigure the type specimens of all the species of Cuspidariidae and Verticordiidae occurring in the Dominican Republic Neogene as well as the type specimens of species which were most important for comparative purposes.

However, this plan has not been carried out for var-

ious reasons. As mentioned below under *Cardiomya islahispaniolae*, the holotype of that species is badly broken (Fast, 1978, p. 80) and therefore could not be refigured. In addition the type specimens of four species of Cuspidariidae and Verticordiidae described by Dall (1903) from the early Pliocene Bowden Formation of Jamaica have been available to me: *Cardiomya craspedonia*, which does not occur in the Dominican Republic, and *Cardiomya distira*, *Haliris jamaicensis*, and *Trigonulina bowdenensis*, which occur in the Dominican Republic as well. The type lots of all these four species consist of three specimens each. All those specimens are glued to a piece of black paper. I tried to remove the specimens from the black paper using various chemicals in an attempt to dissolve the glue but without success. Lectotypes of all four species have been selected, but they are not refigured herein.

Although the amount of material available for this study is mentioned under each species, a summary of the number of lots and specimens of each species is given in Table 1.

As mentioned above, three of the species discussed herein are also known from the Bowden Formation of

Table 1.—Numbers of lots and specimens of each of the seven species of Cuspidariidae and Verticordiidae dealt with in this paper.

taxon	number of lots	number of specimens
<i>Cardiomya (Cardiomya) islahispaniolae</i>	20	50
<i>Cardiomya (Bowdenia) distira</i>	8	47
<i>Plectodon granulatus</i>	11	22
<i>Haliris jamaicensis</i>	4	10
<i>Trigonulina ornata</i>	6	1049
<i>Trigonulina pacifica</i>	23	1840
<i>Trigonulina bowdenensis</i>	32	112
Total	104	3130

Jamaica, but their numerical representation differs greatly from that in the Dominican Republic. Table 2 gives the number of specimens of the five fossil species available from the Dominican Republic and from Bowden, Jamaica.

A short discussion of species concepts has been given by Jung (1986, p. 9; 1989, p. 37), and definitions of the headings used in the following systematic part may be found in Jung (1989, p. 35) and in Jung and Petit (1990, p. 93). They are not repeated here.

SYSTEMATICS

Family **CUSPIDARIIDAE** Dall, 1886

Genus **CARDIOMYA** A. Adams, 1864

Cardiomya A. Adams, 1864, p. 208

Type species (by monotypy).—*Neaera gouldiana* Hinds, 1843. Recent, seas of Japan.

Diagnosis.—Shell of small to medium size, rostrate. Sculpture consisting of radial ribs. Radial sculpture often restricted to main shell disc or continuing over the rostrum as well. There may be secondary radial ribs. Left hinge with a subumbonal chondrophore but no teeth. Right hinge with a subumbonal chondrophore and one or two lateral teeth. Posterior lateral tooth usually prominent.

Remarks.—*Cardiomya* not only includes Neogene, Pleistocene (Grant and Gale, 1931), and Recent species but also a number of species from deposits of Eocene and Oligocene age (Durham, 1944; Gardner, 1945; Harris, 1919; Meyer and Aldrich, 1886; Turner, 1938; Vokes, 1939). According to the Treatise on Invertebrate Paleontology (p. N854) the oldest record dates back to the late Cretaceous. The stratigraphic range of *Cardiomya* is therefore late Cretaceous to Recent.

Table 2.—Number of specimens available from the Neogene of the Dominican Republic and from the Bowden Formation of Jamaica.

species	specimens from Dominican Republic	specimens from Bowden, Jamaica
<i>Cardiomya islahispaniolae</i>	50	0
<i>Cardiomya distira</i>	8	39
<i>Plectodon granulatus</i>	1	0
<i>Haliris jamaicensis</i>	3	7
<i>Trigonulina bowdenensis</i>	80	32

Subgenus **CARDIOMYA** sensu stricto

Cardiomya (Cardiomya) islahispaniolae
(Maury, 1917)

Plate 1, figures 1–6; Plate 2, figures 1–4;
Text-figure 8

Neaera alternata d'Orbigny. Gabb, 1873, p. 248.

Neaera ornatissima d'Orbigny. Gabb, 1873, p. 248; Guppy, 1876, p. 530.

Cuspidaria islahispaniolae Maury, 1917, p. 196, pl. 26, fig. 20.

Cuspidaria ornatior Pilsbry and Johnson, 1917, p. 195; Pilsbry, 1922, p. 414, pl. 38, figs. 11, 12.

Cuspidaria gabbi Pilsbry and Johnson, 1917, p. 195; Pilsbry, 1922, p. 415, pl. 38, fig. 10.

Description.—Shell of medium size (up to 9 mm in length), delicate, rostrate. Umbos prosogyrate, placed almost centrally. Sculpture consisting of numerous radial ribs. Posteriormost rib more prominent than the others, forming a small carina marking the boundary between main shell disc and rostrum. In addition to this small carina there may be one or more ribs just anterior to it which are more prominent than all the other ribs on the main shell disc and have wider interspaces. There may be a few secondary radial ribs. Except for the more prominent posterior ribs the radial ribs are usually well developed only on the ventral part of the main shell disc. Dorsal part of the main shell disc is smooth or sculptured by concentric growth lines. The rostrum is smooth or sculptured by growth lines. There may be an indication of a radial rib near its postero-dorsal margin, where the growth lines are coarser and more prominent. Left hinge with a subumbonal chondrophore but no teeth; margin bent in a dorsal direction anteriorly and posteriorly. Right hinge with a subumbonal chondrophore and a prominent posterior lateral tooth; antero-dorsal margin bent slightly upwards.

Holotype of C. islahispaniolae.—PRI 28904. This is a right valve which is badly broken according to Fast (1978, p. 80) and Warren Allmon (written communication, September 22, 1993).

Dimensions of holotype of C. islahispaniolae.—Length 9 mm; height 6 mm (Maury, 1917, p. 196).

Type locality of C. islahispaniolae.—Bluff 3 of Maury on Río Mao, Dominican Republic. Cercado Formation (late Miocene). This includes NMB localities 16912, 16913, 17269, and 17307 (Saunders *et al.* 1986, text-figs. 29, 33).

Holotype of C. ornatior.—ANSP 2790. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 12).

Dimensions of holotype of C. ornatior.—Length 5.0 mm; height 2.9 mm.

Type locality of C. ornatior.—"Santo Domingo". No further details are available.

Paratype of C. ornatior.—ANSP 79015. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 11).

Dimensions of paratype of C. ornatior.—Length 4.8 mm; height 2.7 mm.

Holotype of C. gabbi.—ANSP 2791. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 10).

Dimensions of holotype of C. gabbi.—Length 8.0 mm; height 5.3 mm.

Type locality of C. gabbi.—"Santo Domingo". No further details are available.

Paratype of C. gabbi.—ANSP 79016.

Dimensions of paratype of C. gabbi.—Length 7.4 mm; height 5.2 mm.

Remarks.—The 40 available specimens (some of which are incomplete) show variability in rostrum shape and radial sculpture. The rostrum may be relatively long and narrow, or it may be shorter, thus giving the impression of greater width. In some specimens only the posteriormost radial rib is more prominent than the others. In other specimens there may be up to four more prominent radial ribs with wider interspaces. This variability of the radial sculpture obviously has been the reason for the introduction of the names *ornatior* and *gabbi* by Pilsbry and Johnson (1917, p. 195).

As mentioned in the introduction to the systematic paleontology, the type specimens of four species of Cuspidariidae and Verticordiidae described by Dall (1903) from the early Pliocene Bowden Formation of Jamaica are available. Three of them occur in the Dominican Republic as well: *Cardiomya (Bowdenia) distira*, *Haliris jamaicensis*, and *Trigonulina bowdenensis*. For each of these species a lectotype has been selected (see under those species). The same is done for the fourth species, *Cardiomya (Cardiomya) craspedonia*, which does not occur in the Dominican Republic but is compared with *C. islahispaniolae*. As is the case for the other three species the type lot of *C.*

craspedonia consists of three specimens, which had been glued to a piece of black paper and cannot be removed from it without risk of damage. The type specimens of *C. craspedonia* (all left valves) are:

1. Lectotype: USNM 135691. Length 4.5 mm; height 2.7 mm. This is the specimen figured by Dall (1903, pl. 57, fig. 17) and Woodring (1925, pl. 10, fig. 20).
2. Paralectotype: USNM 482409. Length 3.6 mm; height 2.3 mm. This is the specimen figured by Woodring (1925, pl. 10, fig. 22).
3. Paralectotype: USNM 482410. Length 4.3 mm; height 2.8 mm. This is the specimen figured by Woodring (1925, pl. 10, fig. 21).

Comparisons.—*C. islahispaniolae* is similar but nevertheless clearly distinct from *C. craspedonia* Dall (1903, p. 1506, pl. 57, fig. 17) from the early Pliocene Bowden Formation of Bowden, Jamaica. It is not only considerably larger (practically twice as large) than *C. craspedonia*, but *C. craspedonia* has more numerous secondary radial ribs on the main shell disc. In addition the rostrum of *C. craspedonia* is proportionately shorter.

Material.—20 lots with a total of 50 specimens as listed below:

1. 1 spec., ANSP 2790: holotype of *C. ornatior*; "Santo Domingo".
2. 1 spec., ANSP 79015: paratype of *C. ornatior*; "Santo Domingo".
3. 1 spec., ANSP 2791: holotype of *C. gabbi*; "Santo Domingo".
4. 1 spec., ANSP 79016: paratype of *C. gabbi*; "Santo Domingo".
5. 1 spec., NMB locality 16912: Río Mao, Bluff 3 of Maury; Cercado Formation (late Miocene).
6. 4 spec., NMB locality 16913: Río Mao, Bluff 3 of Maury; Cercado Formation (late Miocene).
7. 2 spec., NMB locality 16915: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
8. 1 spec., NMB locality 16917: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
9. 1 spec., NMB locality 16922: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
10. 1 spec., NMB locality 16923: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
11. 2 spec., NMB locality 16929: Río Mao; Cercado Formation (late Miocene).
12. 1 spec., NMB locality 16930: Río Mao, Bluff 2 of Maury; Cercado Formation (late Miocene).
13. 1 spec., NMB locality 15878: Río Gurabo; lower part of Gurabo Formation (late Miocene).

part of the rostrum of the left valve sometimes carrying a few fine radial riblets, but corresponding area of right valve does not. Concave part of rostrum adjoining postero-dorsal margin carrying three or four ribs. Ventral margin of main shell disc evenly rounded. Growth lines usually more clearly developed on right valve. Hinge of left valve consisting of an inconspicuous posterior lateral tooth behind a cavity to receive the posterior cardinal tooth of right valve. This cavity is situated behind the subumbonal chondrophore. Hinge of right valve consisting of a subumbonal chondrophore, a weakly developed anterior cardinal tooth, and a prominent posterior cardinal tooth. Postero-dorsal margin of left valve somewhat thickened to fit groove of postero-dorsal margin of right valve.

Lectotype (selected herein).—USNM 135692. This is the specimen figured by Dall (1903, pl. 57, fig. 16) and Woodring (1925, pl. 11, fig. 1), a left valve.

Dimensions of lectotype.—Length 3.3 mm; height 2.5 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482411. This is the specimen figured by Woodring (1925, pl. 11, figs. 2, 3), a left valve.

Dimensions of paralectotype USNM 482411.—Length 3.1 mm; height 2.3 mm.

Paralectotype.—USNM 482412. This is the specimen figured by Woodring (1925, pl. 11, figs. 4, 5), a right valve.

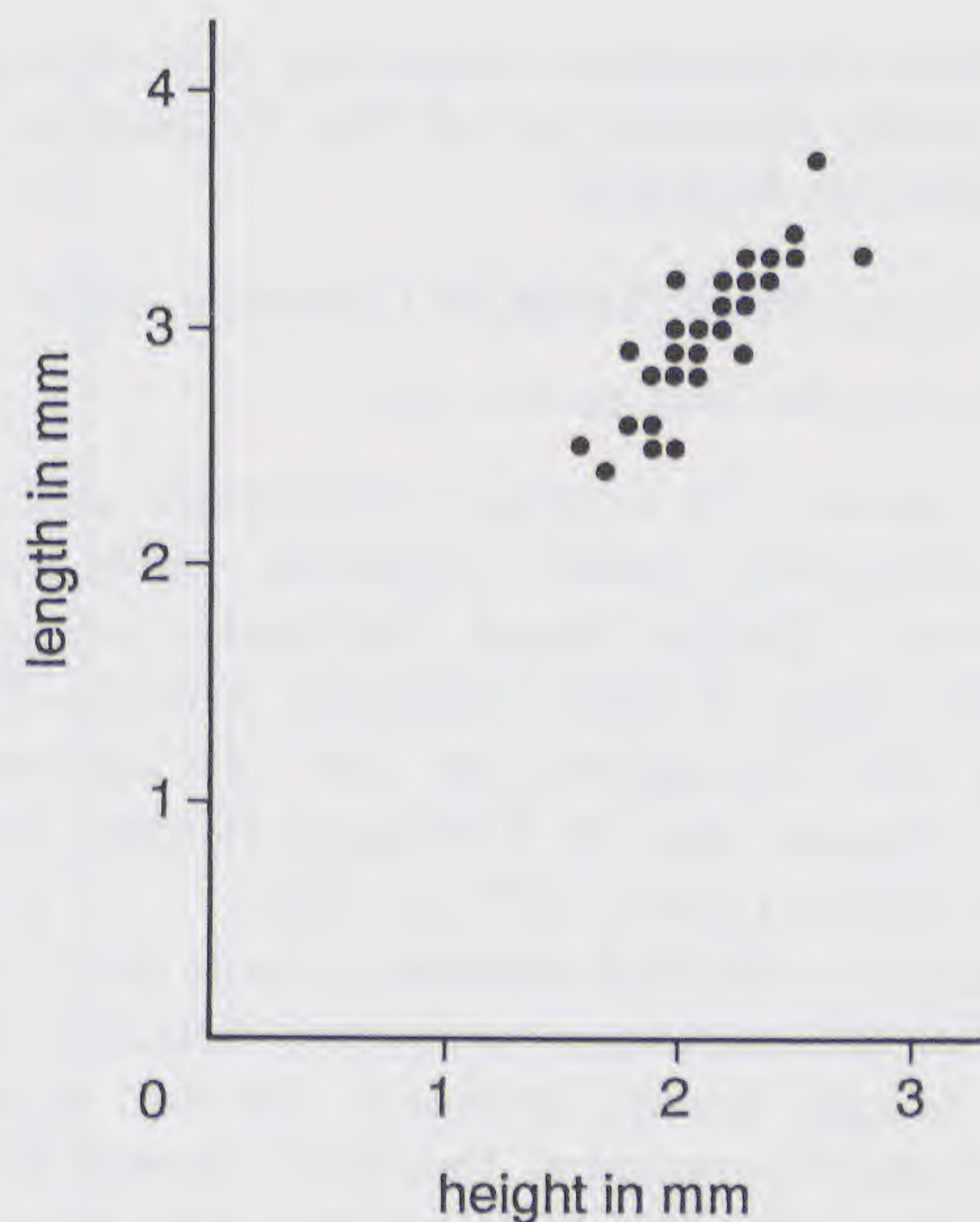
Dimensions of paralectotype USNM 482412.—Length 3.0 mm; height 2.0 mm.

Remarks.—The type lot of this species consists of the lectotype and the two paralectotypes. All three specimens are glued to a piece of black paper. Originally I intended to remove the specimens from the black paper in order to refigure the exterior of the lectotype and to figure its interior. Various chemicals have been used in an attempt to dissolve the glue but without success. The lectotype is therefore not refigured. Instead several topotypes are figured (Pl. 3, fig. 5; Pl. 4, figs. 1–5).

The Dominican Neogene has yielded eight specimens of this species. As hinted at in the above description there is some variability in the development of the radial ribs. They may be stronger or weaker. Sometimes they are evenly developed over the entire main shell disc, sometimes they are restricted to the ventral part of the main shell disc.

Comparisons.—As *Cardiomya (Bowdenia) distira* is the only species of the subgenus known no comparisons can be made.

Material.—Eight lots with a total of 47 specimens as listed below:



Text-figure 9.—Length/height diagram of *Cardiomya (Bowdenia) distira* (Dall, 1903).

- 3 spec., USNM 135692 (lectotype) and two paralectotypes (USNM 482411, 482412). Bowden, Jamaica. Bowden Formation (early Pliocene).
- 1 spec., NMB locality 15846: Río Gurabo, Dominican Republic. Latest Miocene part of Gurabo Formation (Pl. 3, figs. 1–4).
- 5 spec., TU locality 1227A (= NMB locality 18582): Arroyo Zalaya, Dominican Republic; *Globorotalia margaritae* zone (early Pliocene).
- 1 spec., TU locality 1352 (= NMB locality 18584): Río Gurabo, Dominican Republic; middle Pliocene part of Mao Formation.
- 1 spec., TU locality 1403 (= NMB locality 18586): Arroyo Babosico near Río Yaque del Norte at La Barranca; upper part of *Globorotalia margaritae* zone (late early Pliocene).
- 33 spec., NMB locality 10635: Bowden, Jamaica. Bowden Formation (early Pliocene).
- 1 spec., NMB locality 11146: Bowden, Jamaica. Bowden Formation (early Pliocene).
- 2 spec., NMB locality 17617: Bowden, Jamaica. Bowden Formation (early Pliocene).

Measurements.—Plotted in Text-figure 9.

Occurrence.—Río Gurabo section: latest Miocene part of Gurabo Formation: NMB locality 15846 (Saunders *et al.*, 1986, text-figs. 4, 6); middle Pliocene part of Mao Formation: TU locality 1352. *Globorotalia margaritae* zone (early Pliocene) of Arroyo Zalaya (TU locality 1227A) and Arroyo Babosico (TU locality 1403).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Latest Miocene part of Gurabo

Formation; *Globorotalia margaritae* zone (early Pliocene); middle Pliocene part of Mao Formation, northern Dominican Republic.

Genus **PLECTODON** Carpenter, 1864

Plectodon Carpenter, 1864, pp. 611, 638.

Type species (by original designation and monotypy).—*Plectodon scaber* Carpenter, 1864, pp. 611, 638. Recent, Catalina Island, California, to Santa Inez Bay, east coast of Baja California, Mexico (Palmer, 1958, p. 80). Throughout the Gulf of California and south to Panama and the Galápagos Islands, Ecuador, in 20 to 250 m (Keen, 1971, p. 302).

Diagnosis.—Shell of medium to large size (up to 24 mm in length), rostrate, moderately delicate. Antero-ventral margin evenly rounded. Exterior surface of shell covered by pustules. Resilium situated posterior to the umbo. Dorsal margin of left valve twisted just anterior to the umbo forming a small, toothlike projection. No lateral teeth in left valve. Right hinge with an anterior and a posterior lateral tooth.

Remarks.—The holotype of *P. scaber* (USNM 592441) unfortunately is broken into several fragments (see also Palmer, 1958, p. 80). Originally it was mounted on a piece of glass. The fragmentation probably happened when the specimen was removed from the glass. Other material of *P. scaber* is figured here (Pl. 2, figs. 5–8) for comparison with *P. granulatus*.

The stratigraphic range of the genus *Plectodon* is given as Pliocene to Recent (Dall, 1903, p. 1507). The single right valve from the Dominican Republic described below has been collected from sediments of late Miocene age, and the single valve from the middle Miocene Shoal River Formation of Florida reported by Gardner (1926, p. 64) as *Cuspidaria (Plectodon) cf. granulata* Dall extend the range of *Plectodon* from middle Miocene to Recent.

Plectodon granulatus (Dall, 1881)

Plate 2, figures 9, 10; Plate 5, figures 1–4; Plate 6, figures 1–4; Plate 7, figures 1–4; Text-figure 10

Neaera granulata Dall, 1881, p. 111.

Leiomya (Plectodon) granulata Dall. Dall, 1886, p. 300, pl. 3, fig. 8; Dall, 1889, p. 66, pl. 3, fig. 8.

Cuspidaria (Plectodon) granulata Dall. Dall, 1903, p. 1507.

? *Cuspidaria (Plectodon) cf. granulata* Dall. Gardner, 1926, p. 64.

Cuspidaria (Plectodon) scabrata Olsson and Harbison, 1953, p. 67, pl. 1, fig. 2.

Plectodon granulatus (Dall, 1881). Knudsen, 1982, p. 136.

Description.—Shell of medium size (up to 18 mm in length), rostrate, moderately delicate. Antero-ventral margin evenly rounded. Umbos prosogyrate. Exterior surface of shell covered by pustules. In the umbonal area there are fewer or no pustules; instead the growth

lines are more clearly developed. Resilium located behind the umbo and somewhat toward the interior of the shell. Dorsal margin of the left valve twisted just in front of the umbo, forming a small, toothlike projection. No lateral teeth in left valve. Right hinge with an anterior and a posterior lateral tooth.

Lectotype (selected herein).—USNM 63193 (Pl. 2, figs. 9, 10).

Dimensions of lectotype.—Length 11.3 mm; height 6.7 mm.

Type locality.—Off Sombrero Island, Leeward Islands, Lesser Antilles, in 132 m (72 fathoms).

Remarks.—Lot USNM 63193 contains three specimens, the syntypes of *P. granulatus*. The specimen chosen as the lectotype is the left valve figured by Dall (1886, pl. 3, fig. 8). One of the paralectotypes is a right valve, the other paralectotype is also a left valve like the lectotype, but is considerably smaller. The two paralectotypes are USNM 887025 (*ex* USNM 63193).

The Dominican Neogene so far has yielded a single specimen of this species, a right valve. It is not quite complete: its postero-dorsal margin is somewhat damaged (Pl. 5, fig. 1). Unfortunately this unique specimen has been broken during handling for scanning electron microscopy (Pl. 5, fig. 3). Olsson and Harbison (1953, p. 67) state that their *P. scabratus* from the Pliocene of Fort Thompson, Florida, is less "narrow" than Recent specimens of *P. granulatus*. It is not clear, however, what is meant by "narrow". It probably refers to the ratio of height to length. In that respect there is some variability in *P. granulatus*. Two Recent specimens of *P. granulatus* are figured here for comparison (Pl. 6, figs. 1–4; Pl. 7, figs. 1–4).

Comparisons.—The only other species of *Plectodon* is the Recent Eastern Pacific *P. scaber* Carpenter (1864, pp. 611, 638) (for figures see Schenck, 1945, pl. 67, figs. 1–4; Palmer, 1958, pl. 6, figs. 6–8; Keen, 1971, p. 302, fig. 786; and Pl. 2, figs. 5–8). The main differences between the two species is size. *P. scaber* is considerably larger; it actually may be twice as large as *P. granulatus*.

Material.—Twelve lots with a total of 22 specimens as listed below:

1. 1 spec., NMB locality 16857: Río Cana, Dominican Republic; Cercado Formation (late Miocene).
2. 1 spec., USNM 63193: lectotype. Recent; Sombrero Island, Leeward Islands, Lesser Antilles, 72 fms.; Blake Coll.
3. 2 spec., USNM 887025: paralectotypes. Recent; Sombrero Island, Leeward Islands, Lesser Antilles, 72 fms.; Blake Coll.
4. 1 spec., USNM 63194: Recent; Barbados, 100 fms.

5. 6 spec., USNM 94214: Recent; Station 2648: off Cape Florida, 84 fms., sand.
6. 3 spec., USNM 667843: Recent; Station 1306: Campeche Bank off Yucatan, Mexico (22°10'N, 91°40'W), 42 fms., sand.
7. 1 spec., USNM 667668: Recent; Station 470: Campeche Bank off Yucatan, Mexico (22°30'N, 90°15'W), 46 fms., sand.
8. 1 spec., USNM 157815: Recent; Station 2404: between Mississippi Delta and Cedar Keys, Gulf of Mexico; 60 fms., sand.
9. 1 spec., USNM 64003: Recent; Station 2646: off Cape Florida; 85 fms.
10. 3 spec., USNM 97157: Recent; Station 2646: 5 miles off Cape Florida, Gulf of Mexico; 85 fms., sand.
11. 1 spec., USNM 157986: Recent; Station 2646: Recent; off Cape Florida, Gulf of Mexico; 85 fms., sand.
12. 1 spec., USNM 667737: Recent; Station 1241: Campeche Bank off Yucatan, Mexico (20°15'N, 92°10'W), 32 fms., sand.

Measurements.—Plotted in Text-figure 10.

Depth range.—From 37 to 274 m (Knudsen, 1982, p. 137).

Occurrence.—Cercado Formation (late Miocene) of Río Cana section: NMB locality 16857 (Saunders *et al.*, 1986, text-figs. 15, 16).

Distribution.—Shoal River Formation (middle Miocene), Florida? Cercado Formation (late Miocene), northern Dominican Republic. Pliocene, Florida. Recent, southern Florida and Gulf of Mexico throughout the West Indies.

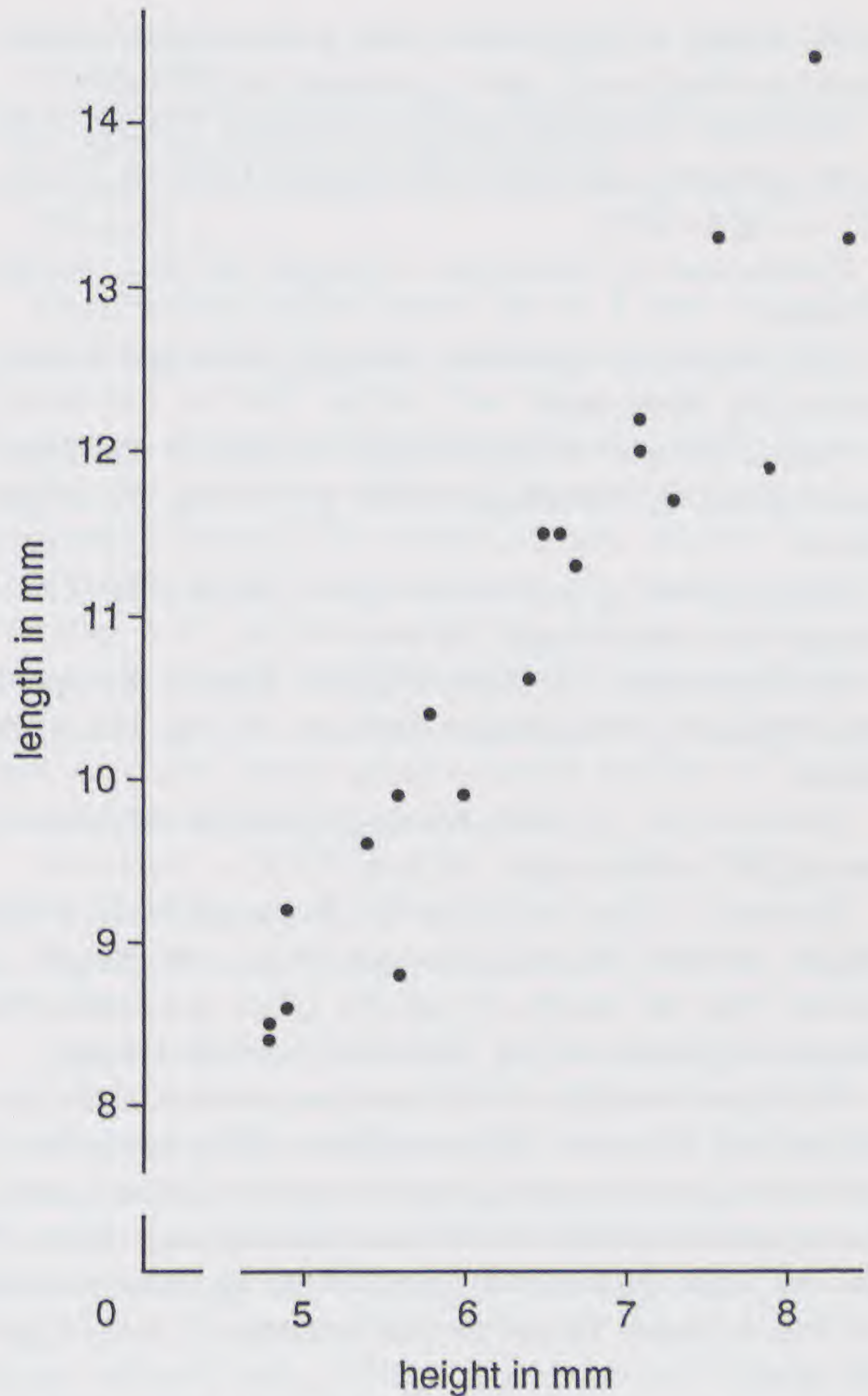
Family **VERTICORDIIDAE** Stoliczka, 1871

Genus **HALIRIS** Dall, 1886

Haliris Dall, 1886, p. 287.

Type species (by original designation).—*Verticordia fischeriana* Dall, 1881. Recent, Gulf of Mexico. North Carolina to Gulf of Mexico to Barbados (Abbott, 1974, p. 563).

Diagnosis.—Shell small (up to 7 mm in length), globose. Umbos strongly prosogyrate. Lunule somewhat depressed. Ventral margin evenly rounded or somewhat angulated near its middle. Entire surface sculptured by numerous radial ribs. No secondary radial ribs. Surface granulated. Interior surface nacreous, its ventral margin fluted. Hinge of left valve consisting of a hardly recognizable, subumbonal cardinal tooth and (only in fully adult shells) an inconspicuous posterior lateral tooth. Hinge of right valve with a prominent, subumbonal cardinal tooth and a posterior lateral tooth.



Text-figure 10.—Length/height diagram of *Plectodon granulatus* (Dall, 1881).

Remarks.—Numerous Recent specimens of the type species, *H. fischeriana*, are available. Some of them are figured (Pl. 8, figs. 1–6) for comparison with *H. jamaicensis*. The stratigraphic range of the genus is Eocene to Recent.

Haliris jamaicensis (Dall, 1903)

Plate 9, figures 1–6; Plate 10, figures 1–4

Verticordia (Haliris) jamaicensis Dall, 1903, p. 1511; Woodring, 1925, p. 93, pl. 11, figs. 9–11.

Description.—Shell small (up to less than 5 mm in length), globose. Umbos strongly prosogyrate. Lunule depressed. Ventral margin slightly angulated near its middle. Surface sculptured by 23 to 26 radial ribs; interspaces narrower on anterior part of shell. Whole surface granulated. Inner surface nacreous, its ventral margin fluted. Hinge of left valve consisting of a hardly recognizable, subumbonal cardinal tooth and (only in fully adult shells) an inconspicuous, posterior lateral

tooth. Hinge of right valve with a prominent, subumbonal cardinal tooth and a posterior lateral tooth.

Lectotype (selected herein).—USNM 135686. This is the specimen figured by Woodring (1925, pl. 11, fig. 10), a right valve.

Dimensions of lectotype.—Length 4.5 mm; height 4.7 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482413. This is the specimen figured by Woodring (1925, pl. 11, fig. 9), a right valve.

Dimensions of paralectotype USNM 482413.—Length 3.8 mm; height 3.8 mm.

Paralectotype.—USNM 482414. This is the specimen figured by Woodring (1925, pl. 11, fig. 11), a left valve.

Dimensions of paralectotype USNM 482414.—Length 3.3 mm; height 3.1 mm.

Remarks.—The lectotype of *H. jamaicensis* is the largest of the 10 available specimens. Its height is greater than its length. In all the other specimens the length is greater (or the same as) than the height.

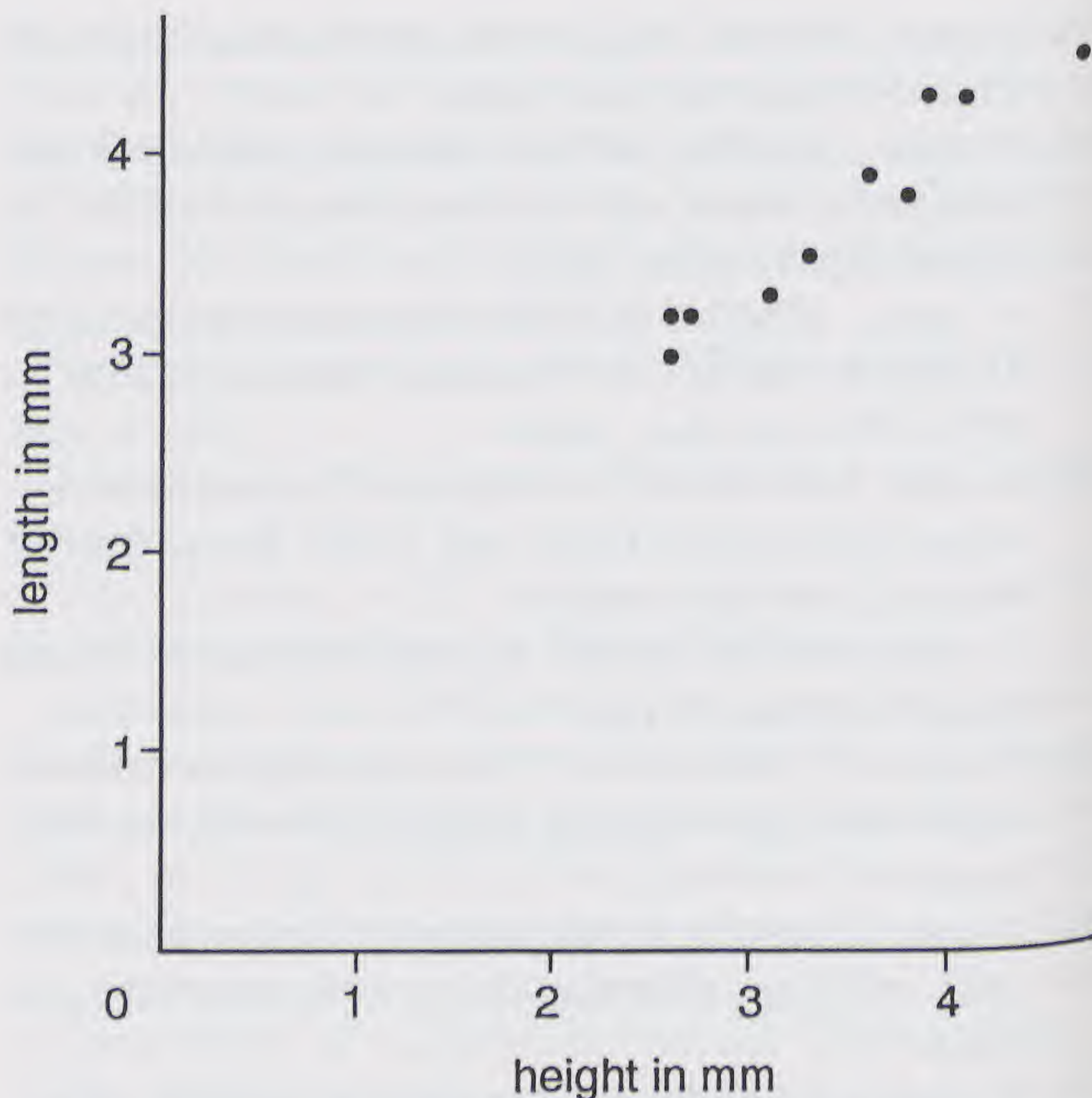
The type material of this species consists of the lectotype and the two paralectotypes mentioned above. All three specimens are glued to a piece of black paper. As explained under *Cardiomya (Bowdenia) distira* it has not been possible to remove the specimens from the black paper. Therefore the lectotype is not refigured here.

Woodring (1925, p. 93) mentioned a fragment from the early Pliocene Bowden Formation of Jamaica that is almost three times as large as the specimens listed below under "Material". More specimens from Bowden would be needed in order to be able to identify the fragment mentioned above.

Comparisons.—*H. jamaicensis* is obviously closely related to the living *H. fischeriana* (Dall) (1881, p. 106), the type species of the genus. *H. fischeriana* is larger than *H. jamaicensis* and has more radial ribs. In addition the ventral margin is evenly rounded in *H. fischeriana* but somewhat angulated in *H. jamaicensis*.

Material.—Four lots with a total of only ten specimens as listed below:

1. 2 spec., NMB locality 15832: Río Gurabo, Dominican Republic; middle Pliocene part of Mao Formation.
2. 1 spec., TU locality 1227A (= NMB locality 18582): Arroyo Zalaya, Dominican Republic; *Globorotalia margaritae* zone (early Pliocene).
3. 4 spec., NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene).
4. 3 spec., USNM 135686 (lectotype) and two para-



Text-figure 11.—Length/height diagram of *Haliris jamaicensis* (Dall, 1903).

lectotypes (USNM 482413, 482414). Bowden, Jamaica; Bowden Formation (early Pliocene).

Measurements.—Plotted in Text-figure 11.

Occurrence.—*Globorotalia margaritae* zone (early Pliocene) of Arroyo Zalaya: TU locality 1227A and middle Pliocene part of Mao Formation of Río Gurabo section: NMB locality 15832 (Saunders *et al.*, 1986, text-figs. 4, 6).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Early Pliocene *Globorotalia margaritae* zone and middle Pliocene part of Mao Formation, Dominican Republic.

Genus TRIGONULINA d'Orbigny, 1842

Trigonulina d'Orbigny, 1842 (see also d'Orbigny, 1845?, p. 327).

Type species (by monotypy).—*Trigonulina ornata* d'Orbigny, 1842 (see also d'Orbigny, 1845?, p. 327). Recent, Massachusetts to Florida and the West Indies, Bermuda, Brasil (Abbott, 1974, p. 563).

Diagnosis.—Shell small (up to almost 6 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply depressed. Sculpture consisting of few, widely spaced, high, and narrow radial ribs projecting beyond ventral margin. On the posterior slope there is a large area without radial ribs. Interior surface nacreous, its ventral margin fluted. Ligament internal. No teeth in left valve. Right valve with a strong, projecting, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.

Remarks.—The Spanish edition of Ramón de la Sagra's *Historia física, política y natural de la Isla de Cuba*, volume 5 (molluscs) of the second part (natural history), is dated 1845. On page 327, where *Trigonulina* and its type species, *T. ornata*, are described, the date is given as 1846. According to Aguayo (1943, p. 38) publication of this edition appears to have started in 1844 already and was probably completed only in 1853. Aguayo is quoting the Spanish edition as of 1845?, to which the present author is adding [1844-1853?] in the "References Cited". Dall (1889, p. 18) did not have access to the Spanish edition.

Both Dall (1889, p. 18) and Aguayo (1943, p. 38) commented on the dates of publication of the French edition. Both authors state that the atlas was published in 1842. The figures of *T. ornata* given in this atlas (pl. 27, figs. 30-33) are an indication as defined in Article 12b(7) of the International Code of Zoological Nomenclature (third edition, 1985).

Trigonulina is here used as a full genus, whereas Abbott (1974, p. 563) and Woodring (1925, p. 92) treated it as a subgenus of *Verticordia* J. Sowerby (1812-1846, p. 68, pl. 639, 1844 [for date of publication of plate 639 see Renevier, 1855, and Sykes, 1906]). On the other hand Keen (1971, p. 302) considered *Trigonulina* as a synonym of the subgenus *Verticordia s.s.* The type species of *Verticordia* is *V. cardiiformis* J. Sowerby (1812-1846, p. 68, pl. 639, 1844) from the Pliocene of England. The original figure shows that the 13 radial ribs are evenly distributed over the entire shell disc. In *Trigonulina*, however, there is a space without radial ribs on the postero-dorsal slope.

T. ornata d'Orbigny, the type species of *Trigonulina*, is not only reported from Western Atlantic waters, but is also said to occur in the Eastern Pacific (Keen, 1971, p. 302). Having looked at a number of lots from both oceans I come to the conclusion that they are distinct and that the species from the Eastern Pacific therefore needs a name. For this reason these two living species are briefly discussed and compared below.

The stratigraphic range of *Trigonulina* is Eocene to Recent.

Trigonulina ornata d'Orbigny, 1842

Plate 11, figures 1-4; Plate 12, figures 1-4; Text-figures 12, 13

Trigonulina ornata d'Orbigny, 1842, pl. 27, figs. 30-33; 1845?, p. 327.

Verticordia caelata Verrill, 1882, p. 566; 1884, p. 278, pl. 30, figs. 9, 9a.

Verticordia (Trigonulina) ornata D'Orbigny. Dall, 1886, p. 290 (part). Dall and Simpson, 1901, p. 498 (part). (For further citations see Dall, 1886.)

Verticordia (Trigonulina) ornata (Orbigny, 1842). Abbott, 1974, p. 563, fig. 6158.

Verticordia ornata (Orbigny, 1846). Knudsen, 1982, p. 128 (part). For additional citations see this publication.

Verticordia ornata (Orbigny, 1842). Rios, 1985, p. 282, pl. 99, fig. 1390 (part).

Description.—Shell small (up to 5 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply impressed in both valves, but more so in left valve. Sculpture consisting of eight to twelve high, narrow, radial ribs anterior to the unsculptured posterior slope projecting beyond the ventral margin. Surface of perfectly preserved valves covered by minute pustules forming rows parallel to the ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.

Holotype.—BMNH Cat. no. 493; Reg. no. 1854.10.4.557, a left valve.

Dimensions of holotype.—Length 2.6 mm; height 2.3 mm.

Type locality.—"Jamaica" (from sand). This is the only information given with the original description.

Remarks.—The holotype of *T. ornata* is at hand. Its ventral margin is somewhat damaged. It is a left valve. It is the specimen figured in an idealized way and in mirror-image by d'Orbigny (1842, pl. 27, figs. 30, 31). His Figure 31 shows the interior of the valve with a hinge without teeth, a hinge typical for left valves. The holotype is one of the rare cases of a specimen having only eight radial ribs in front of the posterior slope. Due to its imperfect preservation it is not refigured here.

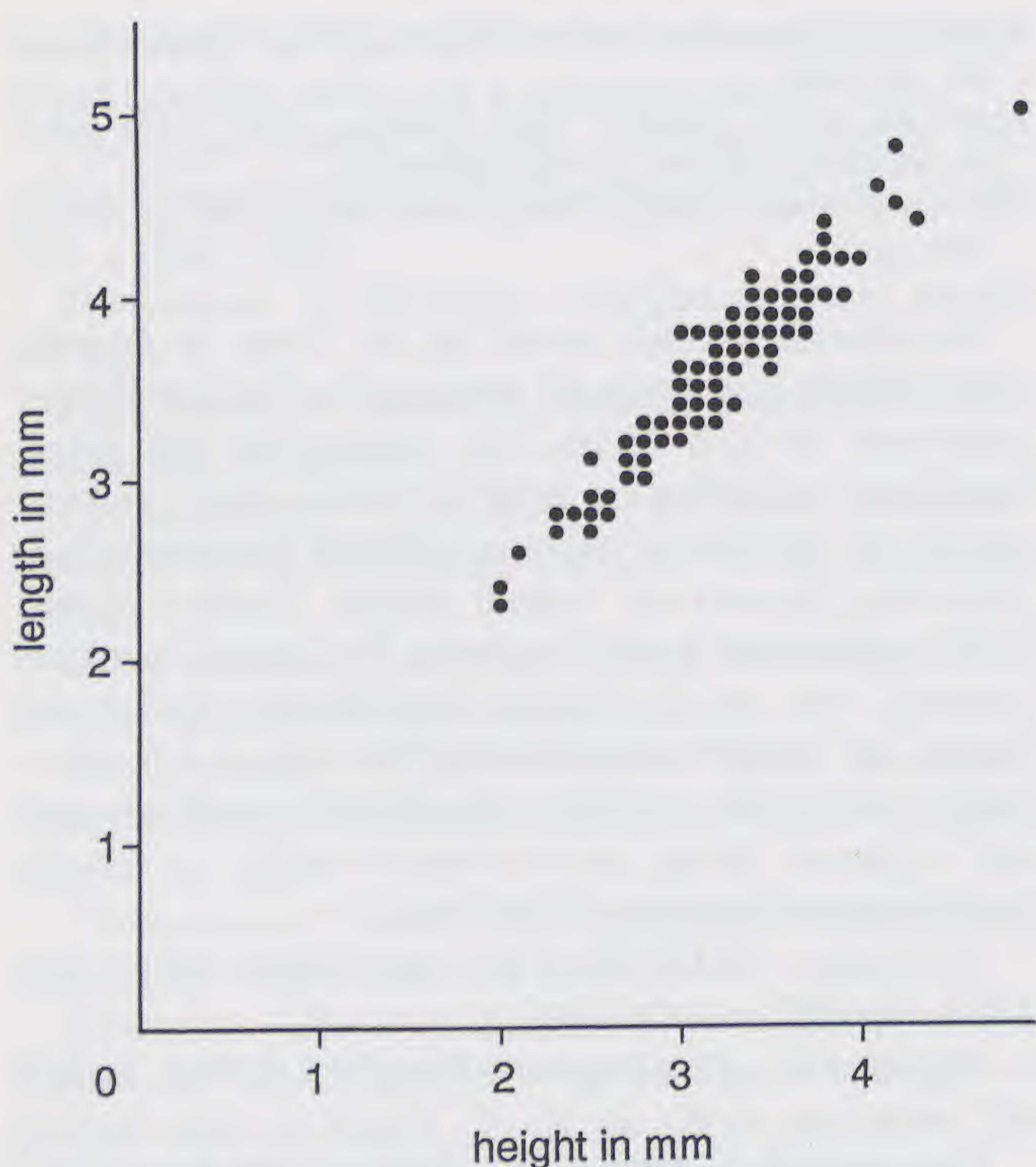
As listed under "Material", six lots with 1049 specimens have been used for the description given above. Out of these 1049 specimens 190 valves have been measured (Text-fig. 12) and their ribs in front of the unsculptured posterior slope counted (Text-fig. 13). As indicated in the description the range of the number of ribs is eight to twelve. However, the extremes are rare (Text-fig. 13); there are only three valves with eight ribs, eight valves with nine ribs, and twelve valves with twelve ribs. In other words one should really describe *T. ornata* as having ten or eleven ribs.

The original description of *Verticordia caelata* Verrill was based on a single right valve with eleven ribs.

Comparisons.—Comparative remarks are given below under *T. pacifica* and *T. bowdenensis*.

Material.—Six lots with a total of 1049 specimens as listed below (quoted from specimen labels):

1. 439 spec., USNM 444664: Eolis Station 368: off Ajax Reef, Florida; 80-100 fms.



Text-figure 12.—Length/height diagram of *Trigonulina ornata* d'Orbigny, 1842.

2. 54 spec., USNM 444479: Eolis Station 178: off Fowey Light, Florida; 68 fms.
3. 3 spec., USNM 63214: off Hatteras; 15–124 fms.
4. 172 spec., USNM 444514: Eolis Station 311: off Govt. cut, Miami, Florida; 75 fms.
5. 337 spec., USNM 444665: Eolis Station 370: off Ajax Reef, Florida; 70–90 fms.
6. 44 spec., USNM 444653: Eolis Station 363: off Fowey Light, Florida; 85 fms.

Measurements.—Plotted in Text-figure 12.

Depth range.—From 5 to 850 m (Knudsen, 1982, p. 128) and 15 to 1256 m (Hertlein and Grant, 1972, p. 344).

Distribution.—Massachusetts to Florida and the West Indies, Bermuda, Brazil (Abbott, 1974, p. 563) or from about 42°N to about 30°42'S (Knudsen, 1982, p. 128). So far *T. ornata* has not been reported as a fossil.

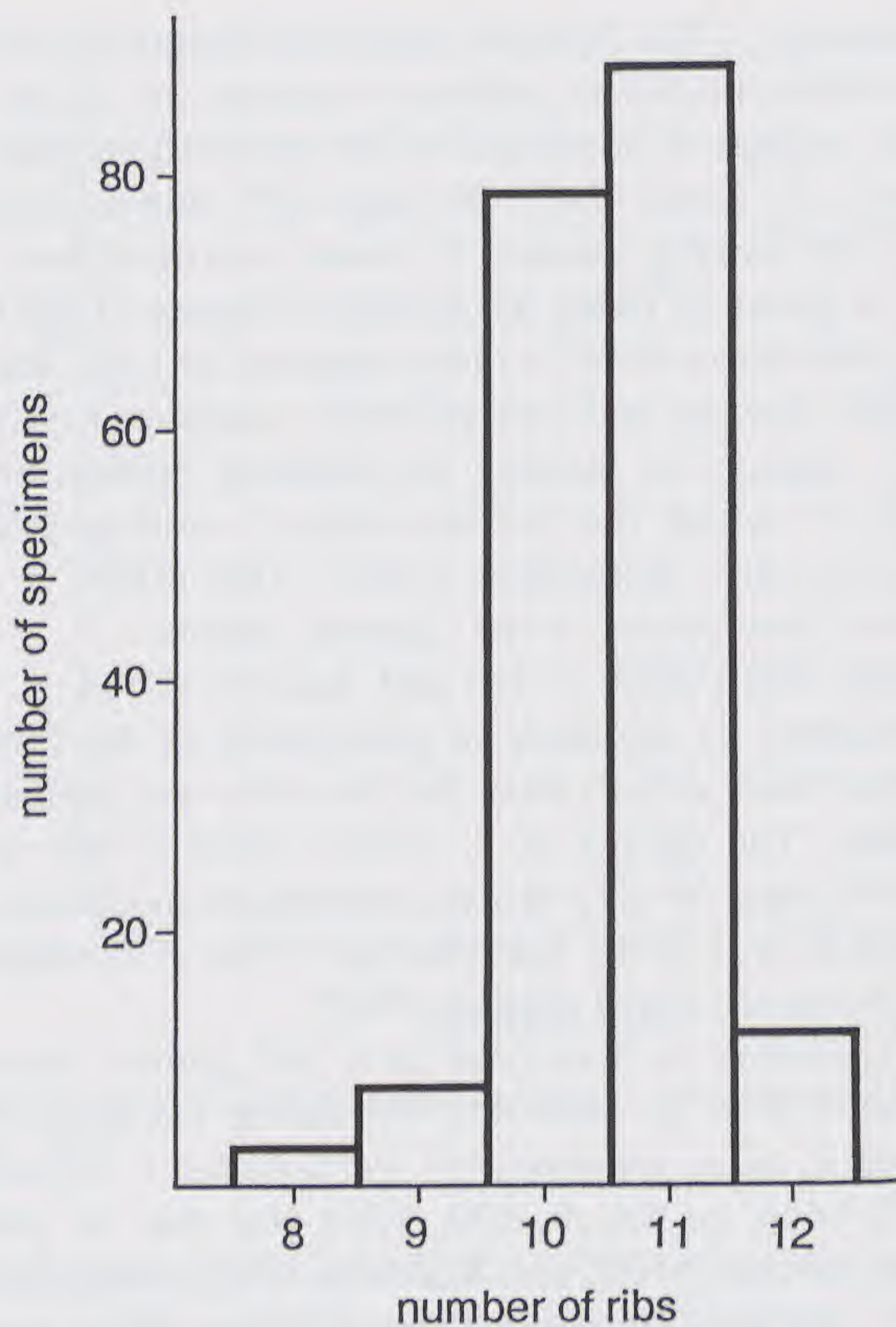
***Trigonulina pacifica*, new species**

Plate 2, figures 11, 12; Plate 13, figures 1–4;
Plate 14, figures 1–4; Text-figures 14, 15

Verticordia ornata (d'Orbigny). Grant and Gale, 1931, p. 266, pl. 13, fig. 4 (part).

Verticordia (Verticordia) ornata (Orbigny, 1846). Keen, 1971, p. 302, fig. 789 (part).

Verticordia (Trigonulina) ornata d'Orbigny. Hertlein and Grant, 1972, p. 344, pl. 43, figs. 23, 26, 27, 31.



Text-figure 13.—Histogram showing rib number distribution of *Trigonulina ornata* d'Orbigny, 1842.

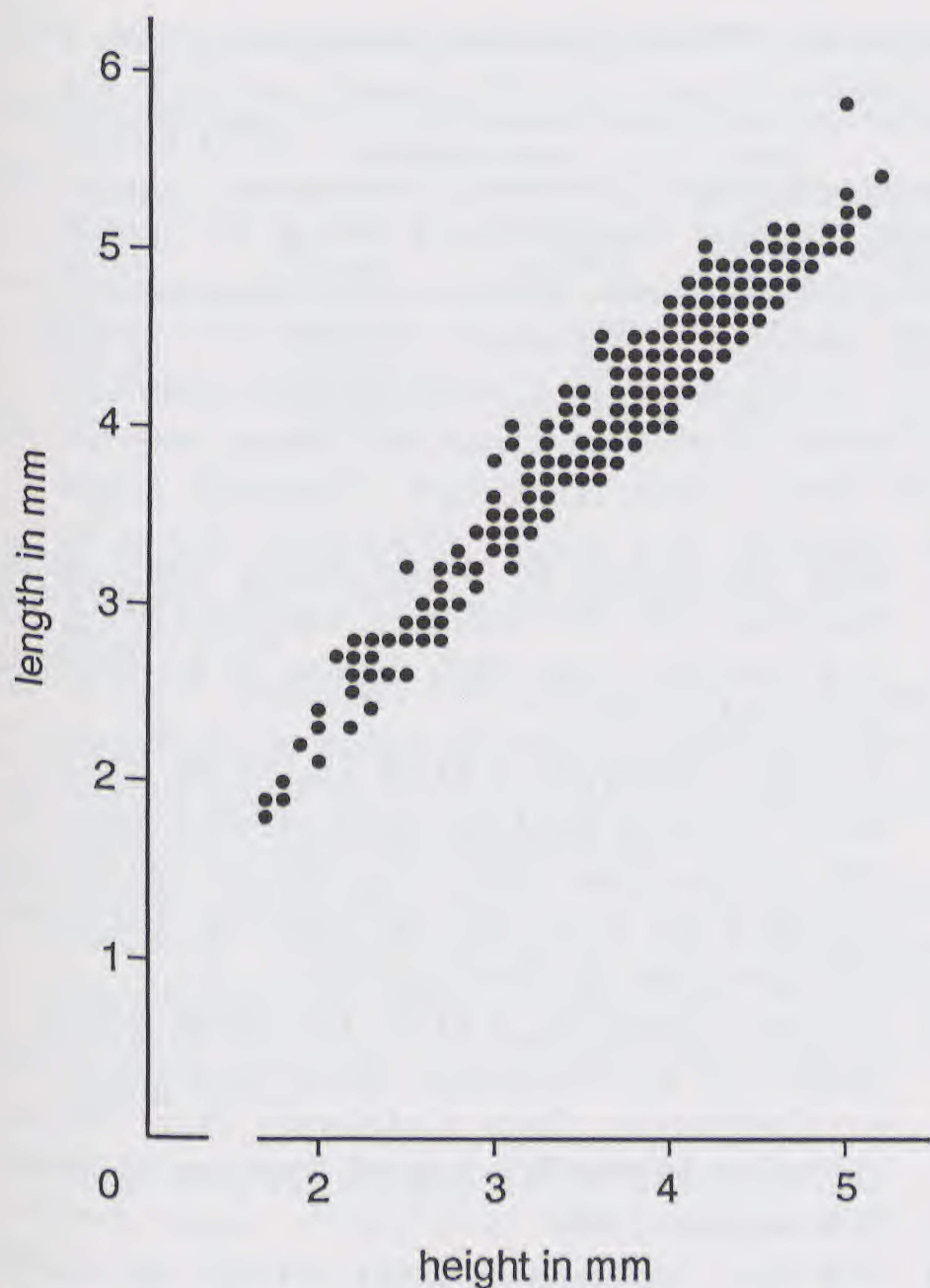
Description.—Shell small (up to almost 6 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply impressed in both valves, but more so in left valve. Sculpture consisting of six to 12 high, narrow radial ribs anterior to the unsculptured posterior slope projecting beyond the ventral margin. Surface of perfectly preserved valves covered by minute, not closely spaced pustules forming rows parallel to the ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive the postero-dorsal margin of left valve.

Holotype.—LACM 2718 (Pl. 2, figs. 11, 12).

Dimensions of holotype.—Length 4.8 mm; height 4.2 mm.

Type locality.—(quoted from specimen label) LACM 65-6.22: 0.4–0.7 miles 110 to 132 degrees T from Ship Rock, Santa Catalina Island, California Channel Islands, California (33°27'N, 118°30'W). Depth: 82 m.

Remarks.—The basis for the above description consists of the 23 lots with 1840 specimens listed under "Material". A total of 320 specimens have been measured (Text-fig. 14) and their ribs in front of the ribless



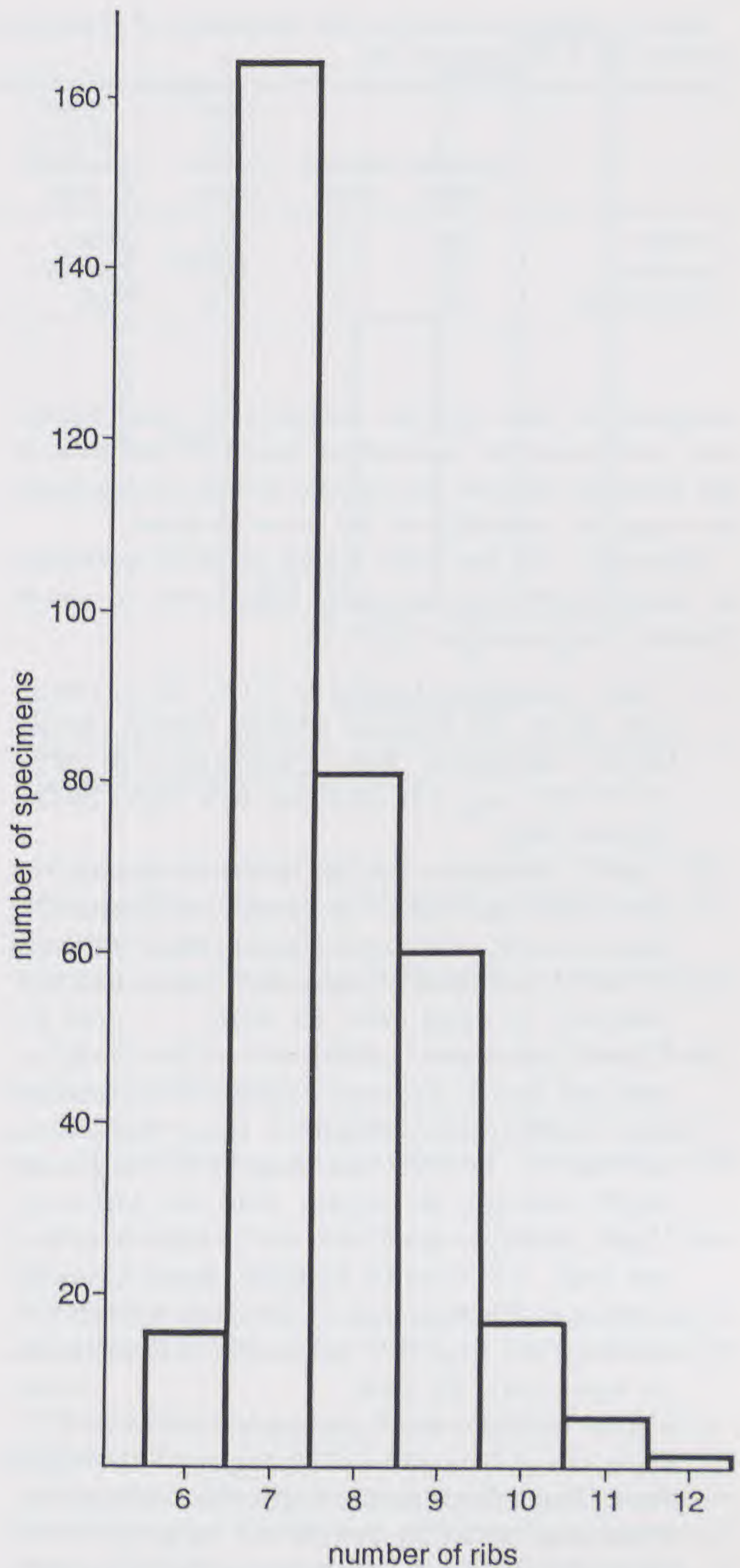
Text-figure 14.—Length/height diagram of *Trigonulina pacifica*, new species.

posterior slope counted (Text-fig. 15). The range of the number of ribs as given in the description is six to 12. But again—as in *T. ornata*—the extremes are rare: there are only 16 valves with six ribs, 17 valves with 10 ribs, six valves with 11 ribs, and a single valve with 12 ribs. It is therefore appropriate to say that the great majority of the valves has seven to nine ribs.

The ribs of *T. pacifica* as a rule are high and narrow. But sometimes there are exceptions with lower and somewhat broader ribs.

Comparisons.—*T. pacifica* reaches larger dimensions than the Recent West Indian *T. ornata* d'Orbigny and has fewer radial ribs. In addition the general outline of the shell is more rounded or oval in *T. ornata*, and the area without ribs on the posterior slope of *T. ornata* is wider than that of *T. pacifica*. *T. pacifica* is considerably larger than *T. bowdenensis* Dall from the early Pliocene Bowden Formation of Jamaica but has about the same number of radial ribs.

The microsculpture of *T. ornata* and *T. pacifica* are clearly different. In both species the microsculpture consists of rounded pustules, which are aligned in rows parallel to the ribs; but in *T. ornata* they are much more closely spaced (Pl. 12, Figs. 2, 4; Pl. 14, Figs. 2, 4). In *T. bowdenensis* on the other hand the



Text-figure 15.—Histogram showing rib number distribution of *Trigonulina pacifica*, new species.

pustules are more closely spaced than in *T. pacifica* but not as closely as in *T. ornata* (Pl. 18, Figs. 2, 4). However, the pustules of *T. bowdenensis* have a different shape; they are not rounded but pointed (Pl. 16, Figs. 3, 5).

The diagnostic features of the three species of *Trigonulina* discussed above are tabulated in Table 3.

Although there are clear differences in the micro-

Table 3.—Diagnostic features of the three species of *Trigonulina* dealt with herein. Numbers of measured specimens: *T. ornata*: 190; *T. pacifica*: 320; *T. bowdenensis*: 79.

	maximum length	maximum height	mean ratio length/height	ribless area on posterior slope	range of number of ribs	most frequent number of ribs	microsculpture		depth range (in m)
							spacing of pustules	form of pustules	
<i>T. ornata</i>	5.0	4.9	1.13	wide	8-12	11	close	rounded	5-1256
<i>T. pacifica</i>	5.8	5.2	1.09	narrower	6-12	7	wide	rounded	18-168
<i>T. bowdenensis</i>	4.0	3.5	1.16	wide	7-10	10	not wide	pointed	—

sculpture of these species, considerably more numerous, well preserved specimens should be looked at in the scanning electron microscope in order to determine the range of variability of the microsculpture.

Material.—23 lots with a total of 1840 specimens as listed below (lots arranged from north to south) (quoted from specimen labels):

- 3 spec., paratypes. LACM 63-50.12: 60 m, Humpback Rock, off Hopkins Marine Station, Pacific Grove, Monterey Bay, California (36°38'N, 121°54'W). Leg. J.H. McLean, R/V Tage, 26 November 1963.
- 3 spec., paratypes. LACM 41-80.19: 99-102 m, mud, sand and shell, 1.5 mi NW of Cavern Pt., Santa Cruz Id., California Channel Ids., California (34°04'N, 119°34.4'W). Leg. R/V Velero III (AHF 1300-41), 12 April 1941. Ex AHF.
- 2 spec., paratypes. LACM 40-164.20: 27-91 m, sand and gravel, Anacapa Passage, W of Anacapa Id., California Channel Ids., California (33°59.0'N, 119°32.1'W). Leg. R/V Velero III (AHF 1190-40), 30 October 1940. Ex AHF.
- 1 spec., paratype. LACM 41-74.19: 62-75 m, sand and shell, 0.5 mi S of Gull Id., Santa Cruz Id., California Channel Ids., California (33°56.5'N, 119°49.6'W). Leg. R/V Velero III (AHF 1294-41), 11 April 1941. Ex AHF.
- 8 spec., holotype and 7 paratypes. LACM 65-6.22: 82 m, 0.4-0.7 mi 110 to 132 degrees T from Ship Rock, Santa Catalina Id., California Channel Ids., California (33°27'N, 118°30'W). Leg. R. Reimer et al., R/V Velero IV, 13 February 1965. Ex AHF.
- 4 spec., paratypes. LACM 41-25.17: 75 m, shell, mud and gray sand, 4 mi N of Islas Todos Santos, Pacific Coast, Baja California, Mexico (31°53.3'N, 116°48.3'W). Leg. R/V Velero III (AHF 1245-41), 24 February 1941. Ex AHF.
- 12 spec., paratypes. LACM 75-93.17: 27 m, gravel and shell, W of Isla Smith, Bahía de los Angeles, Gulf of California, Mexico (29°04'N, 113°33'W). Leg. Gale Sphon, D.K. Mulliner, 10 October 1975.
- 21 spec., paratypes. LACM 76-2.21: 18-22 m, sand and gravel, W of Isla Smith, Bahía de los Angeles, Gulf of California, Mexico (29°03.7'N, 113°31.0'W). Leg. Gale Sphon, D.K. Mulliner, 10-16 May 1976.
- 25 spec., paratypes. LACM 71-158.38: 31-37 m, shelly sand, Kellett Channel, S of Isla Cedros, Pacific Coast, Baja California, Mexico (27°57.0'N, 115°08.5'W). Leg. J.H. McLean, P.I. LaFollette, R/V Searcher, 20 October 1971.
- 24 spec., paratypes. LACM 78-120.18: 43-55 m, sandy, off Isla Danzante, Bahía Escondido, Gulf of California, Baja California Sur, Mexico (25°46'N, 111°15'W). Leg. D. Mulliner, G. Sphon, 6 November 1978.
- 384 spec., paratypes. USNM 211469: off La Paz, Baja California, Mexico; 9½-10 fms.
- 623 spec., paratypes. USNM 211458: off La Paz, Baja California, Mexico; 26½ fms.
- 591 spec., paratypes. USNM 151959: near La Paz, off Baja California, Mexico; 9½-10 fms.
- 13 spec., paratypes. LACM 66-23.22: 27-37 m, sand, off Punta Arena de la Ventana, Gulf of California, Baja California Sur, Mexico (24°04'N, 109°49'W). Leg. J.H. McLean, P. M. Oringer, L. Marincovich, 8 April 1966.
- 6 spec., paratypes. LACM 66-22.40: 18-55 m, sand and shell, directly off anchorage at Bahía de los Muertos, Gulf of California, Baja California Sur, Mexico (23°58'N, 109°46'W). Leg. J.H. McLean et al., 8 April 1966.
- 6 spec., paratypes. LACM 66-17.62: 18-37 m, sand, between Rancho El Tule and Rancho Palmilla, Gulf of California, Baja California Sur, Mexico (22°58'N, 109°45'W). Leg. J.H. McLean, P.M. Oringer, 5 April 1966.
- 10 spec., paratypes. LACM 38-5.9: 37-73 m, Bahía Banderas, Jalisco, Mexico (20°40'N, 105°25'W). Leg. G. Willett, 14 February 1938.
- 31 spec., paratypes. LACM 34-2.20: 26-33 m, sand, nullipores, Bahía Braithwaite, Isla Socorro, Islas Revilla Gigedo, Mexico (18°42.5'N, 110°56.22'W). Leg. R/V Velero III (AHF 129-34), 3 January 1934. Ex AHF.

19. 8 spec., paratypes. LACM 38-9.11: 73-128 m, Bahía Guatulco, Oaxaca, Mexico. Leg. G. Willett, 7 March 1938.
20. 11 spec., paratypes. LACM 72-13.26: 37 m, mud, 0.5 to 1.5 mi W Roca Vagares, Bahía Juanillo, Guanacaste Prov., Costa Rica (10°57.47'N, 85°45.3'W). Leg. D. Cadien, P.I. LaFollette, R/V Searcher (Searcher 393), 14 February 1972.
21. 27 spec., paratypes. LACM 72-54.45: 37 m, off Bahía Herradura, Puntarenas Prov., Costa Rica (9°38.8'N, 84°40.8'W). Leg. J.H. McLean, W. Bussing, R/V Searcher (Searcher 451, 457), 10 March 1972.
22. 15 spec., paratypes. LACM 72-53.27: 21 m, sand, anchorage in Bahía Herradura, Puntarenas Prov., Costa Rica (9°37.97'N, 84°40.5'W). Leg. J.H. McLean, R/V Searcher, 9 March 1972.
23. 12 spec., paratypes. LACM 72-57.33: 21 m, sand, anchorage inside small islet 1.5 km S Punta Quepos, Puntarenas Prov., Costa Rica (9°22.72'N, 84°09.68'W). Leg. J.H. McLean, R/V Searcher, 11 March 1972.

Measurements.—Plotted in Text-figure 14.

Depth range.—From 18 to 168 m (Keen, 1971, p. 302).

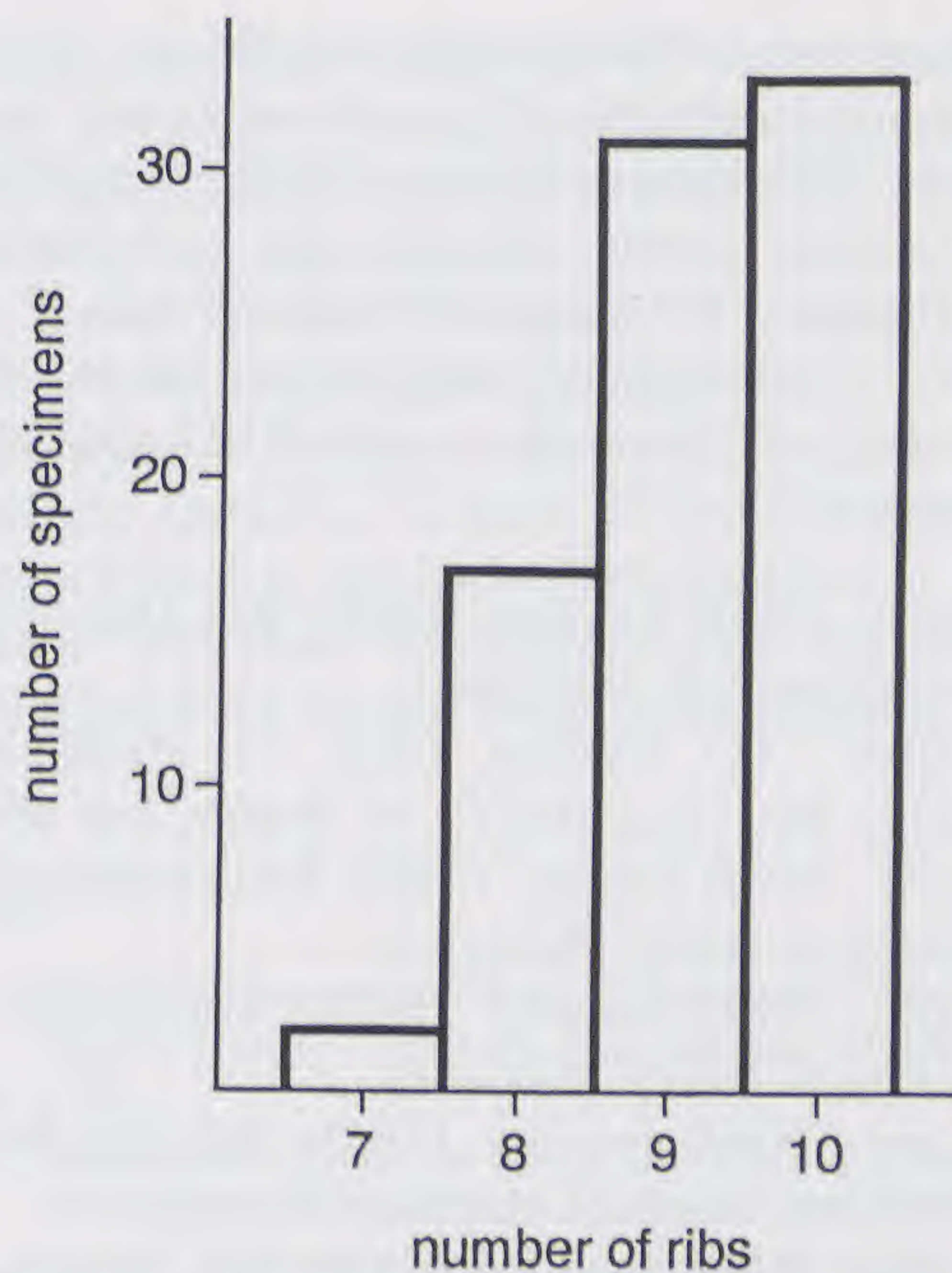
Distribution.—Pliocene of San Diego, California (Hertlein and Grant, 1972, p. 344); Pleistocene of California (Grant and Gale, 1931, p. 266). Recent from Catalina Island, California, through the Gulf of California, south to Peru and the Galápagos Islands (Keen, 1971, p. 302) or from about 34°N to 12°S (Knudsen, 1982, p. 128). The record from Monterey Bay (lot 1) extends the distribution to the north to almost 37°N.

***Trigonulina bowdenensis* (Dall, 1903)**

Plate 15, figures 1-4; Plate 16, figures 1-5; Plate 17, figures 1-4; Plate 18, figures 1-4;
Text-figures 16, 17

Verticordia (Trigonulina) bowdenensis Dall, 1903, p. 1512; Woodring, 1925, p. 92, pl. 11, figs. 6-8.

Description.—Shell small (up to 4 mm in length), oval to rotund. Umbos low, strongly prosogyrate. Lunule more deeply impressed in left valve. Sculpture consisting of seven to 10 high, narrow, radial ribs anterior to unsculptured posterior slope, which project beyond ventral margin. Surface of perfectly preserved valves covered by minute, pointed pustules forming rows parallel to ribs. Along postero-dorsal margin there are two closely spaced, narrow ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.



Text-figure 16.—Histogram showing rib number distribution of *Trigonulina bowdenensis* (Dall, 1903).

Lectotype (selected herein).—USNM 135689. This is the specimen figured by Woodring (1925, pl. 11, fig. 6), a left valve.

Dimensions of lectotype.—Length 3.1 mm; height 2.8 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482415. This is the specimen figured by Woodring (1925, pl. 11, fig. 7), a left valve.

Dimensions of paralectotype USNM 482415.—Length 2.7 mm; height 2.4 mm.

Paralectotype.—USNM 482416. This is the specimen figured by Woodring (1925, pl. 11, fig. 8), a right valve.

Dimensions of paralectotype USNM 482416.—Length 3.0 mm; height 2.5 mm.

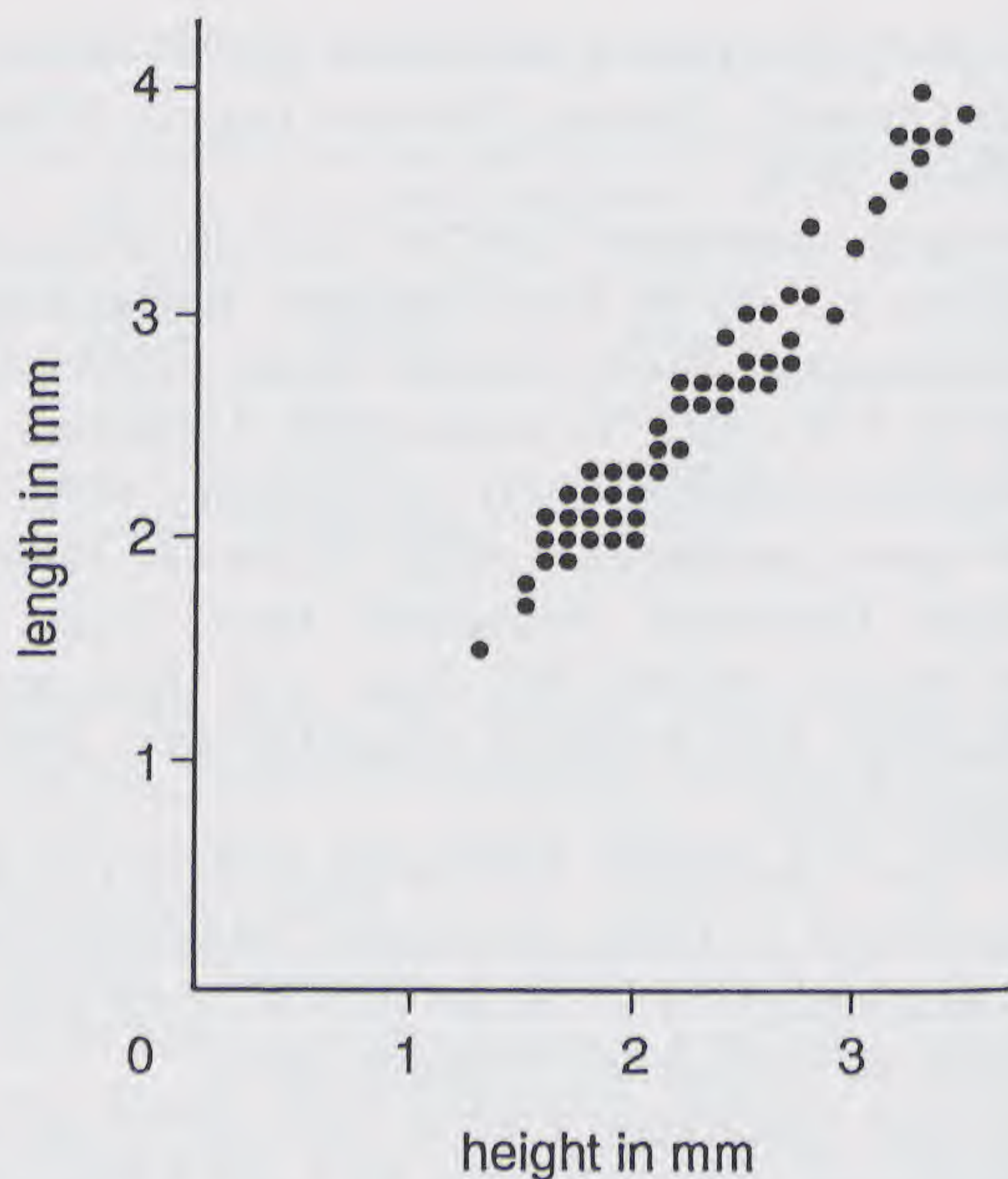
Remarks.—The type material of this species consists of the lectotype and the two paralectotypes mentioned above. All three specimens are glued to a piece of black paper. As explained under *Cardiomya (Bowdenia) distira*, it has not been possible to remove the specimens from the black paper. The lectotype is therefore not refigured here.

As hinted at in the above description, there is some variability as to the number of radial ribs. The large majority of the specimens at hand has eight to 10 radial ribs. Only two valves out of the 90 available specimens have only seven radial ribs (Text-fig. 16). One is from Jamaica, the other from the Dominican Republic.

Comparisons.—The Recent Caribbean *T. ornata* d'Orbigny is larger than *T. bowdenensis* and has more radial ribs. The Recent Eastern Pacific *T. pacifica* has about the same number of radial ribs as *T. bowdenensis* but reaches even larger dimensions than *T. ornata* (see also "Comparisons" under *T. pacifica*).

Material.—32 lots with a total of 112 specimens as listed below:

1. 1 spec., NMB locality 16802: Río Mao; Cercado Formation (late Miocene).
2. 2 spec., TU locality 1293 (= NMB locality 18583): Río Mao, Bluff 1 of Maury; late Miocene.
3. 1 spec., NMB locality 15804: Río Gurabo; Gurabo Formation (early Pliocene).
4. 1 spec., NMB locality 15823: Río Gurabo; Mao Formation (early Pliocene).
5. 2 spec., NMB locality 15828: Río Gurabo; Mao Formation (early to middle Pliocene).
6. 5 spec., NMB locality 15829: Río Gurabo; Mao Formation (middle Pliocene).
7. 12 spec., NMB locality 15846: Río Gurabo; Gurabo Formation (late Miocene).
8. 1 spec., NMB locality 15849: Río Gurabo; Gurabo Formation (late Miocene).
9. 6 spec., NMB locality 15863: Río Gurabo; Gurabo Formation (late Miocene).
10. 1 spec., NMB locality 15864: Río Gurabo; Gurabo Formation (late Miocene).
11. 2 spec., NMB locality 15865: Río Gurabo; Gurabo Formation (late Miocene).
12. 1 spec., NMB locality 15869: Río Gurabo; Gurabo Formation (late Miocene).
13. 1 spec., NMB locality 15937: Río Gurabo; Gurabo Formation (early Pliocene).
14. 1 spec., NMB locality 15945: Río Gurabo; Gurabo Formation (late Miocene).
15. 1 spec., NMB locality 15962: Río Gurabo; Gurabo Formation (early Pliocene).
16. 1 spec., NMB locality 16031: Río Gurabo; Mao Formation (early Pliocene).
17. 2 spec., NMB locality 16034: Río Gurabo; Mao Formation (early Pliocene).
18. 1 spec., TU locality 1210 (= NMB locality 18579): Río Gurabo; Gurabo Formation (early Pliocene).
19. 2 spec., TU locality 1211 (= NMB locality 18580): Río Gurabo; latest Miocene part of Gurabo Formation.
20. 2 spec., TU locality 1215 (= NMB locality 18581): Río Gurabo; Gurabo Formation (late Miocene).
21. 6 spec., NMB locality 16817: Río Cana; Gurabo Formation (early Pliocene).



Text-figure 17.—Length/height diagram of *Trigonulina bowdenensis* (Dall, 1903).

22. 3 spec., NMB locality 16818: Río Cana; Gurabo Formation (early Pliocene).
23. 4 spec., NMB locality 16824: Río Cana; Gurabo Formation (early Pliocene).
24. 1 spec., NMB locality 16828: Río Cana; Gurabo Formation (late Miocene).
25. 1 spec., NMB locality 16832: Río Cana; Gurabo Formation (late Miocene).
26. 2 spec., NMB locality 16833: Río Cana; Gurabo Formation (late Miocene).
27. 1 spec., NMB locality 16961: Río Cana; Gurabo Formation (early Pliocene).
28. 1 spec., NMB locality 17026: Río Cana; Cercado Formation (late Miocene).
29. 10 spec., TU locality 1354 (= NMB locality 18585): Río Cana, Cañada de Zamba; Gurabo Formation (early Pliocene).
30. 5 spec., TU locality 1250 (= NMB locality 18558): Río Verde; Gurabo Formation (late Miocene or early Pliocene).
31. 29 spec., NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene).
32. 3 spec., USNM 135689 (lectotype) and two paralectotypes (USNM 482415, 482416). Bowden, Jamaica; Bowden Formation (early Pliocene).

Measurements.—Plotted in Text-figure 17.

Occurrence.—This species is recorded from the following areas:

Río Mao: Cercado Formation (late Miocene): NMB locality 16802, TU locality 1293 (Saunders *et al.*, 1986, text-fig. 29).

Río Gurabo: late Miocene part of Gurabo Formation: NMB localities 15846, 15849, 15863, 15864, 15865, 15869, 15945 and TU localities 1211, 1215. Early Pliocene part of Gurabo Formation: NMB localities 15804, 15937, 15962, and TU locality 1210. Mao Formation (early Pliocene and early to middle Pliocene): NMB localities 15823, 15828, 15829, 16031, 16034. For location see Saunders *et al.*, 1986, text-figs. 4–6).

Río Cana: Cercado Formation (late Miocene): NMB locality 17026. Late Miocene part of Gurabo Forma-

tion: NMB localities 16828, 16832, 16833. Early Pliocene part of Gurabo Formation: NMB localities 16817, 16818, 16824, 16961, and TU locality 1354 (Saunders *et al.*, 1986, text-figs. 15, 16).

Río Verde: Gurabo Formation: TU locality 1250 (Saunders *et al.*, 1986, text-fig. 38).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Cercado Formation (late Miocene), late Miocene and early Pliocene parts of Gurabo Formation, and Mao Formation (early Pliocene and early to middle Pliocene), Dominican Republic.

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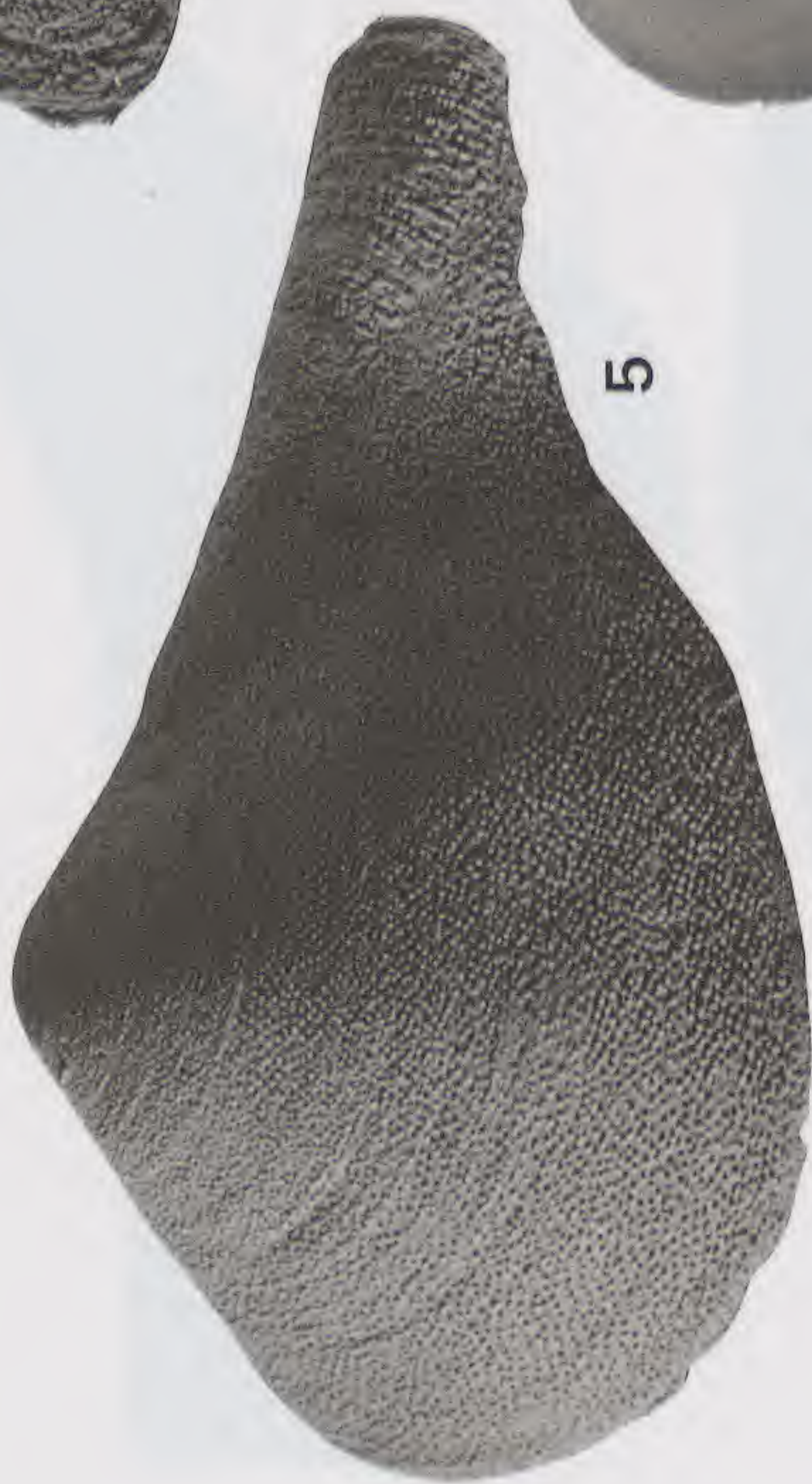
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PLATES

EXPLANATION OF PLATE 1

Figure	Page
1-6. <i>Cardiomya (Cardiomya) islahispaniolae</i> (Maury, 1917).	42
1. NMB G 14145. NMB locality 15907: Río Gurabo, Dominican Republic; uppermost part of Cercado Formation (late Miocene). Exterior of right valve. Length 9.3 mm; height 5.4 mm.	
2, 3. NMB G 14144. NMB locality 16923: Río Mao, Arroyo Bajón, Dominican Republic; Cercado Formation (late Miocene). Right valve. 2. Enlargement of hinge, $\times 30$. 3. Interior. Length 8.4 mm; height 5.2 mm.	
4, 5. NMB G 14146. NMB locality 15903: Río Gurabo, Dominican Republic; upper part of Cercado Formation (late Miocene). Left valve. 4. Interior. 5. Enlargement of hinge, $\times 30$. Length 8.7 mm; height 5.8 mm.	
6. NMB G 14147. NMB locality 16929: Río Mao, Dominican Republic; Cercado Formation (late Miocene). Exterior of left valve. Length 7.6 mm; height 4.8 mm.	





EXPLANATION OF PLATE 2

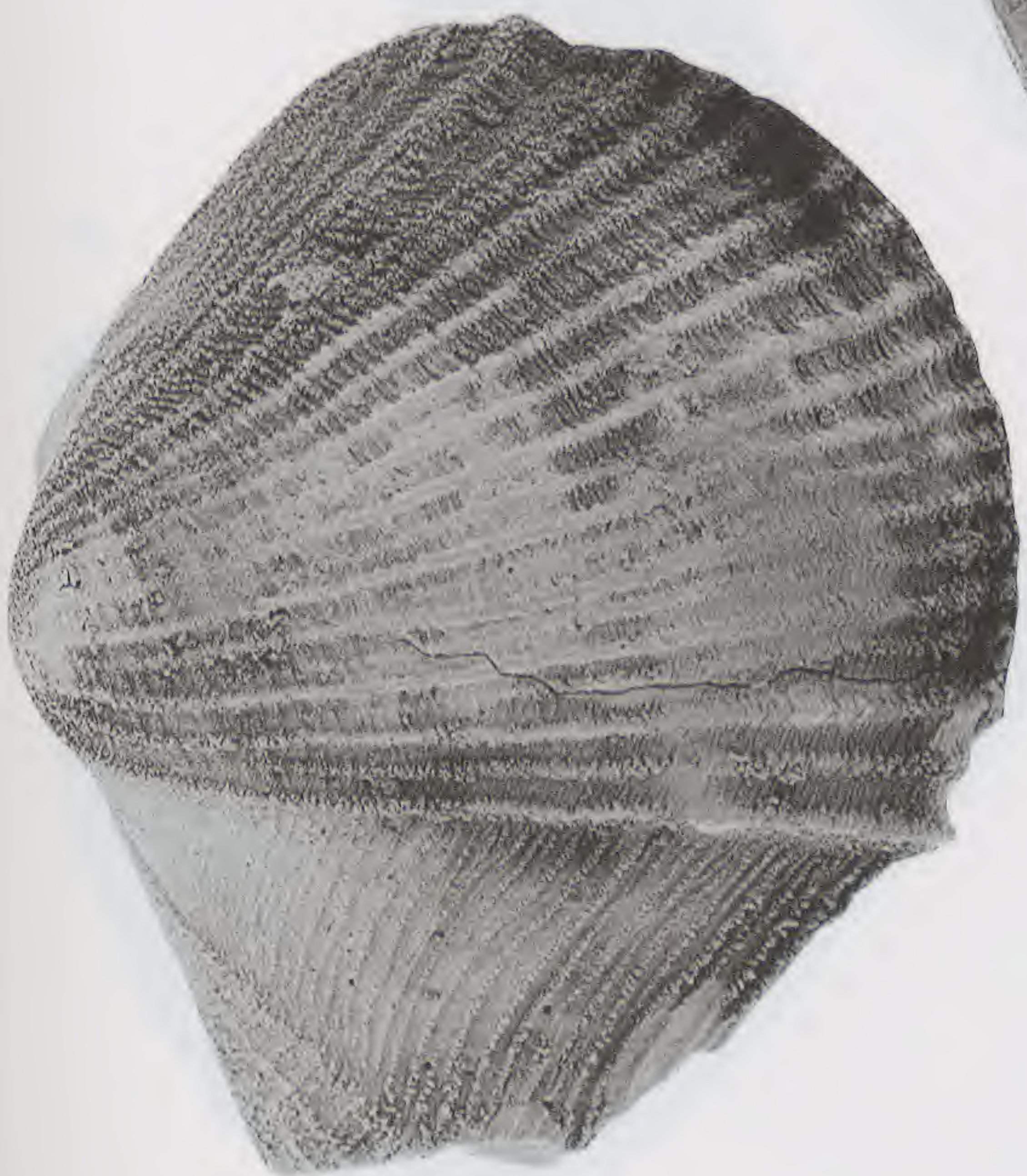
Figure	Page
1-4. <i>Cardiomya (Cardiomya) islahispaniolae</i> (Maury, 1917)	42
1, 2. Holotype of <i>Cuspidaria ornatior</i> Pilsbry and Johnson, 1917. ANSP 2790. "Santo Domingo". Left valve. 1. Exterior; 2. Interior. Length 5.0 mm; height 2.9 mm.	
3, 4. Holotype of <i>Cuspidaria gabbi</i> Pilsbry and Johnson, 1917. ANSP 2791. "Santo Domingo". Left valve. 3. Exterior; 4. Interior. Length 8.0 mm; height 5.3 mm.	
5-8. <i>Plectodon scaber</i> Carpenter, 1864.	45
5, 6. USNM 63943. Catalina Island, California; 16 fms., mud. Left valve. 5. Exterior; 6. Interior. Length 17.6 mm; height 9.9 mm.	
7, 8. USNM 63943. Catalina Island, California; 16 fms., mud. Right valve. 7. Exterior; 8. Interior. Length 17.4 mm; height 9.2 mm.	
9, 10. <i>Plectodon granulatus</i> (Dall, 1881)	45
Lectotype. USNM 63193. Off Sombrero Island, Leeward Islands, Lesser Antilles; 72 fms. Left valve. 9. Exterior; 10. Interior. Length 11.3 mm; height 6.7 mm.	
11, 12. <i>Trigonulina pacifica</i> , new species.	50
Holotype. LACM 2718. Locality LACM 65-6.22: 0.4-0.7 miles 110 to 132 degrees T From Ship Rock, Santa Catalina Island, California Channel Islands, California (33°27'N, 118°30'W). Depth: 82 m. Right valve. 11. Exterior; 12. Interior. Length 4.8 mm; height 4.2 mm.	

EXPLANATION OF PLATE 3

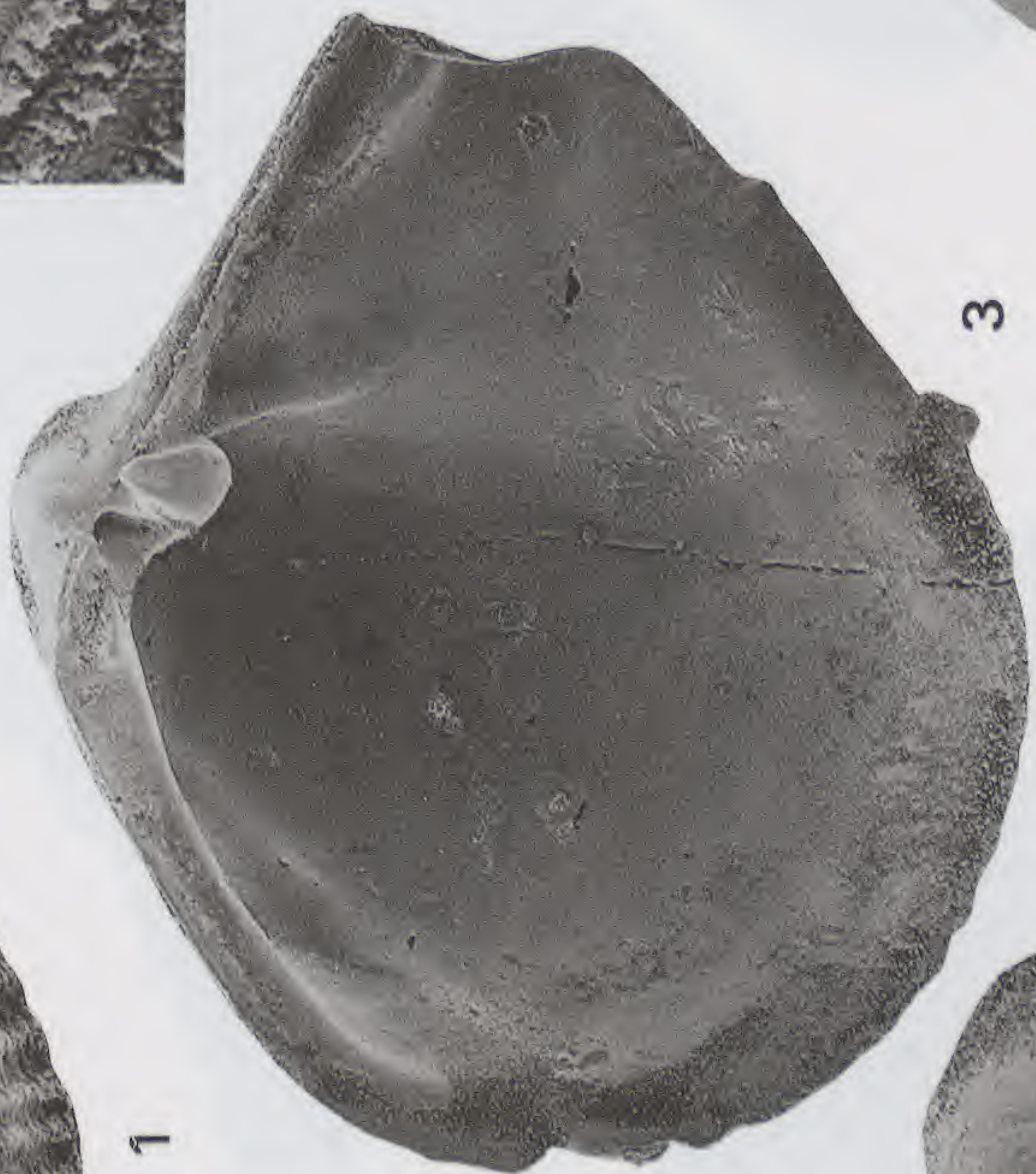
Figure	Page
1-5. <i>Cardiomya (Bowdenia) distira</i> (Dall, 1903)	44
1-4. NMB G 14139. NMB locality 15846 Río Gurabo, Dominican Republic; latest Miocene part of Gurabo Formation. Incomplete right valve. 1. Exterior; 2. Enlargement of sculpture, $\times 120$; 3. Interior; 4. Enlargement of hinge, $\times 60$. Length 2.7 mm; height 2.2 mm.	
5. NMB G 14140. NMB locality 10635: Bowden, Jamaica; type locality of Bowden Formation (early Pliocene). Interior of right valve. Length 3.2 mm; height 2.0 mm.	



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EXPLANATION OF PLATE 4

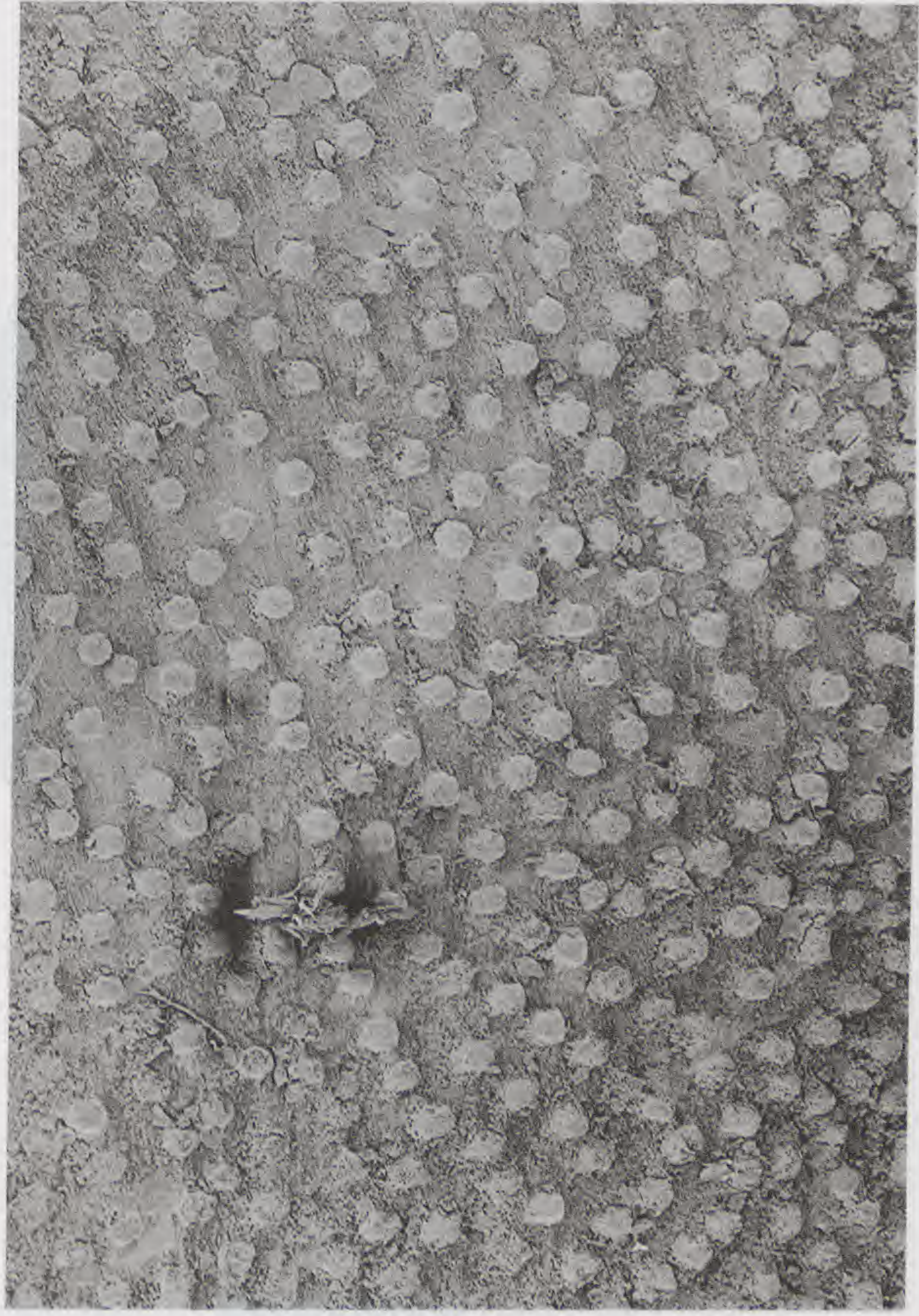
Figure	Page
1-5. <i>Cardiomya (Bowdenia) distira</i> (Dall, 1903)	44
All specimens from NMB locality 10635: Bowden, Jamaica; type locality of Bowden Formation (early Pliocene).	
1, 2. NMB G 14141. Right valve. 1. Exterior; 2. Enlargement of rostrum, $\times 90$. Length 3.0 mm; height 2.0 mm.	
3. NMB G 14142. Interior of left valve. Length 2.9 mm; height 2.3 mm.	
4, 5. NMB G 14143. Left valve. 4. Exterior; 5. Enlargement of rostrum, $\times 65$. Length 3.3 mm; height 2.3 mm.	

EXPLANATION OF PLATE 5

Figure	Page
1-4. <i>Plectodon granulatus</i> (Dall, 1881)	46
NMB G 14138. NMB locality 16857: Río Cana, Dominican Republic; Cercado Formation (late Miocene). Right valve. 1. Interior;	
2. Enlargement of hinge, $\times 20$; 3. Exterior; valve broken during handling for SEM photography; 4. Enlargement of sculpture, $\times 60$.	
Length 10.6 mm; height 6.4 mm.	



3



4



1



2



EXPLANATION OF PLATE 6

Figure	Page
1-4. <i>Plectodon granulatus</i> (Dall, 1881)	46
USNM 94214. Recent. Station 2648: off Cape Florida, 84 fms., sand.	
1, 2. Left valve. 1. Exterior; 2. Interior. Length 8.8 mm; height 5.6 mm.	
3, 4. Right valve. 3. Exterior; 4. Interior. Length 11.5 mm; height 6.5 mm.	

EXPLANATION OF PLATE 7

Figure	Page
1-4. <i>Plectodon granulatus</i> (Dall, 1881)	46
USNM 94214. Recent. Station 2648: off Cape Florida, 84 fms., sand.	
1. Enlargement of left hinge ($\times 30$) of specimen shown on Plate 6, figure 2.	
2. Enlargement of right hinge ($\times 20$) of specimen shown on Plate 6, figure 4.	
3, 4. Enlargement of sculpture of right valve shown on Plate 6, figure 3. 3. Near center of shell disc, $\times 60$; 4. Towards rostrum, $\times 50$.	



3



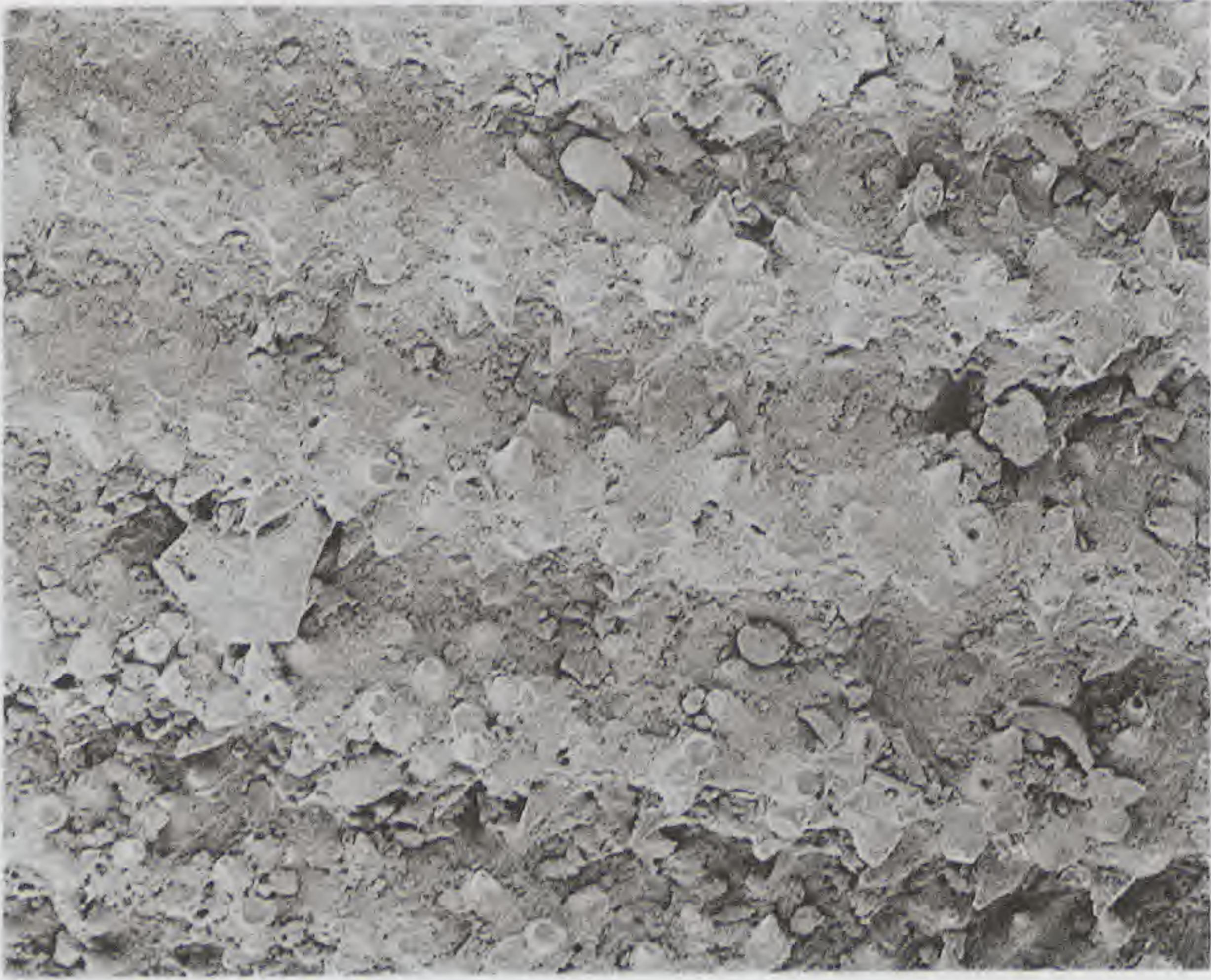
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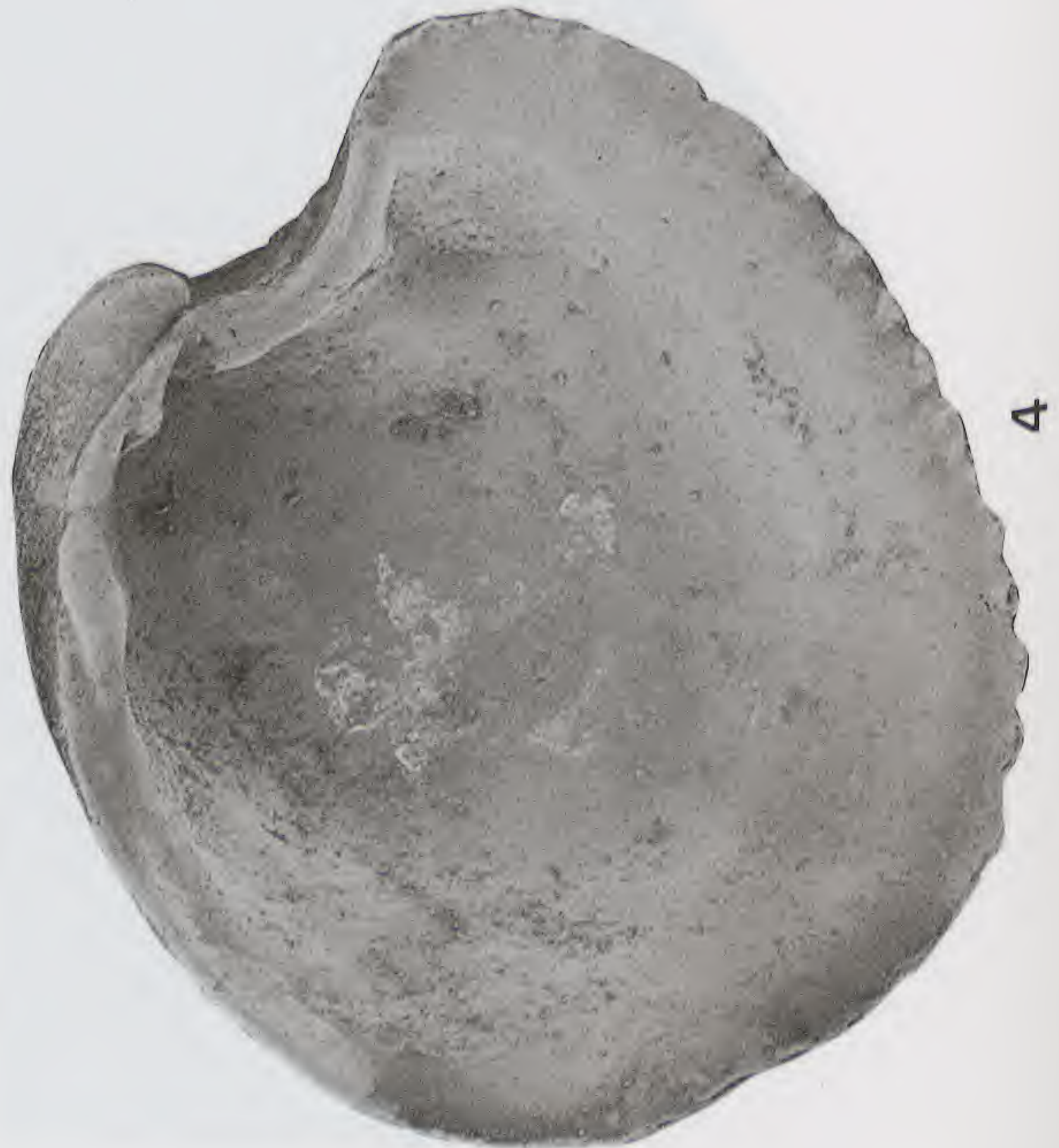
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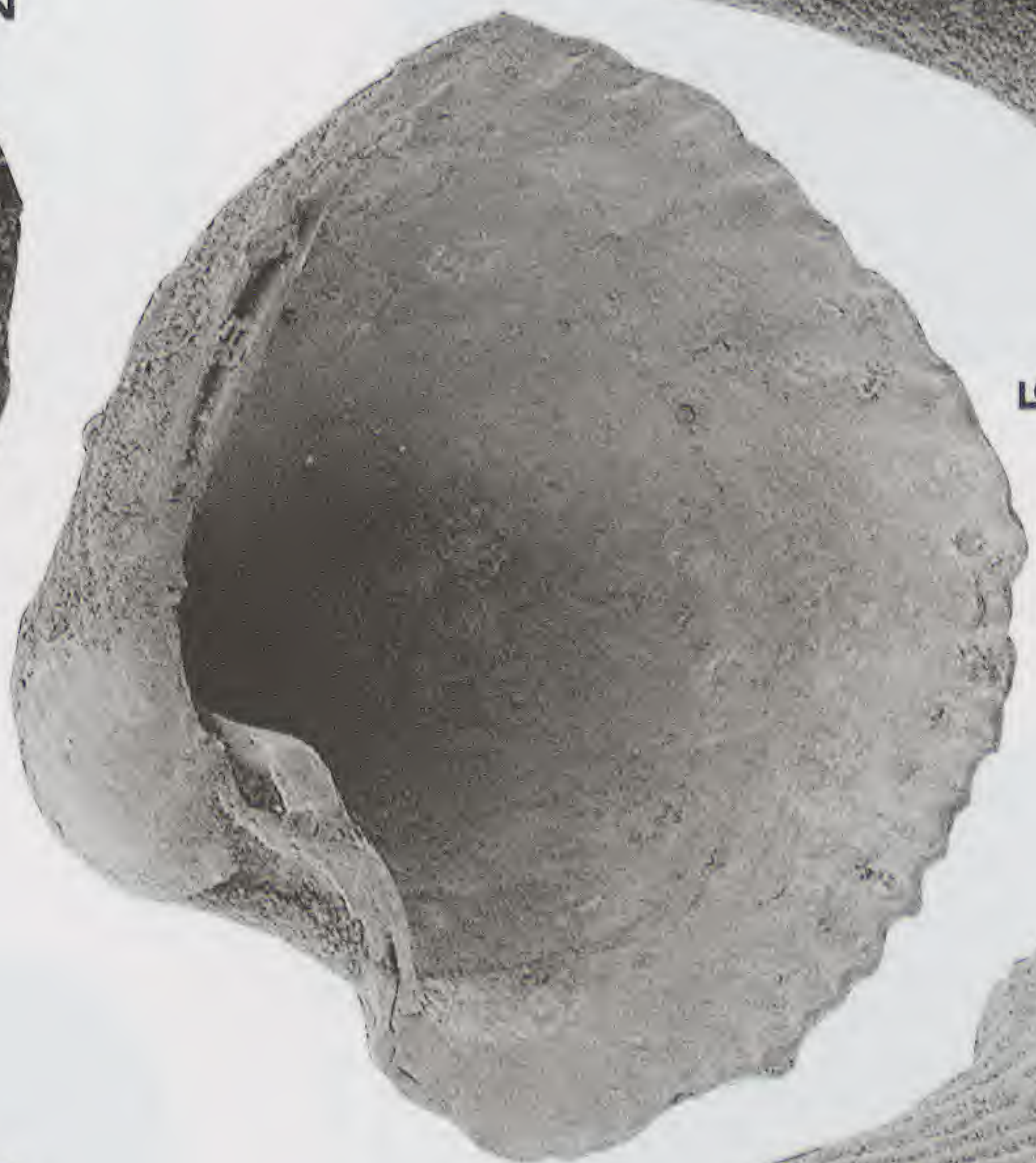
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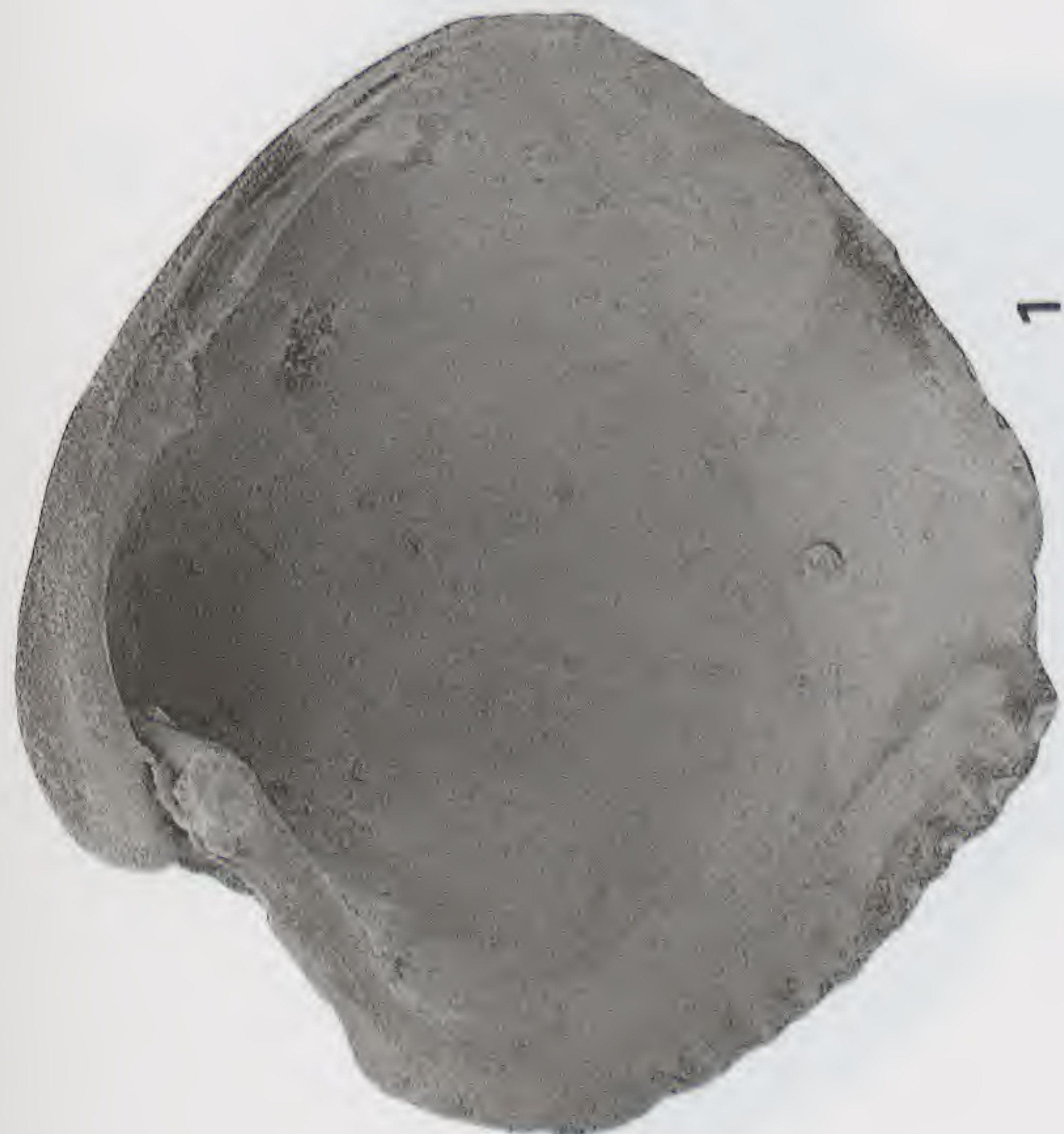
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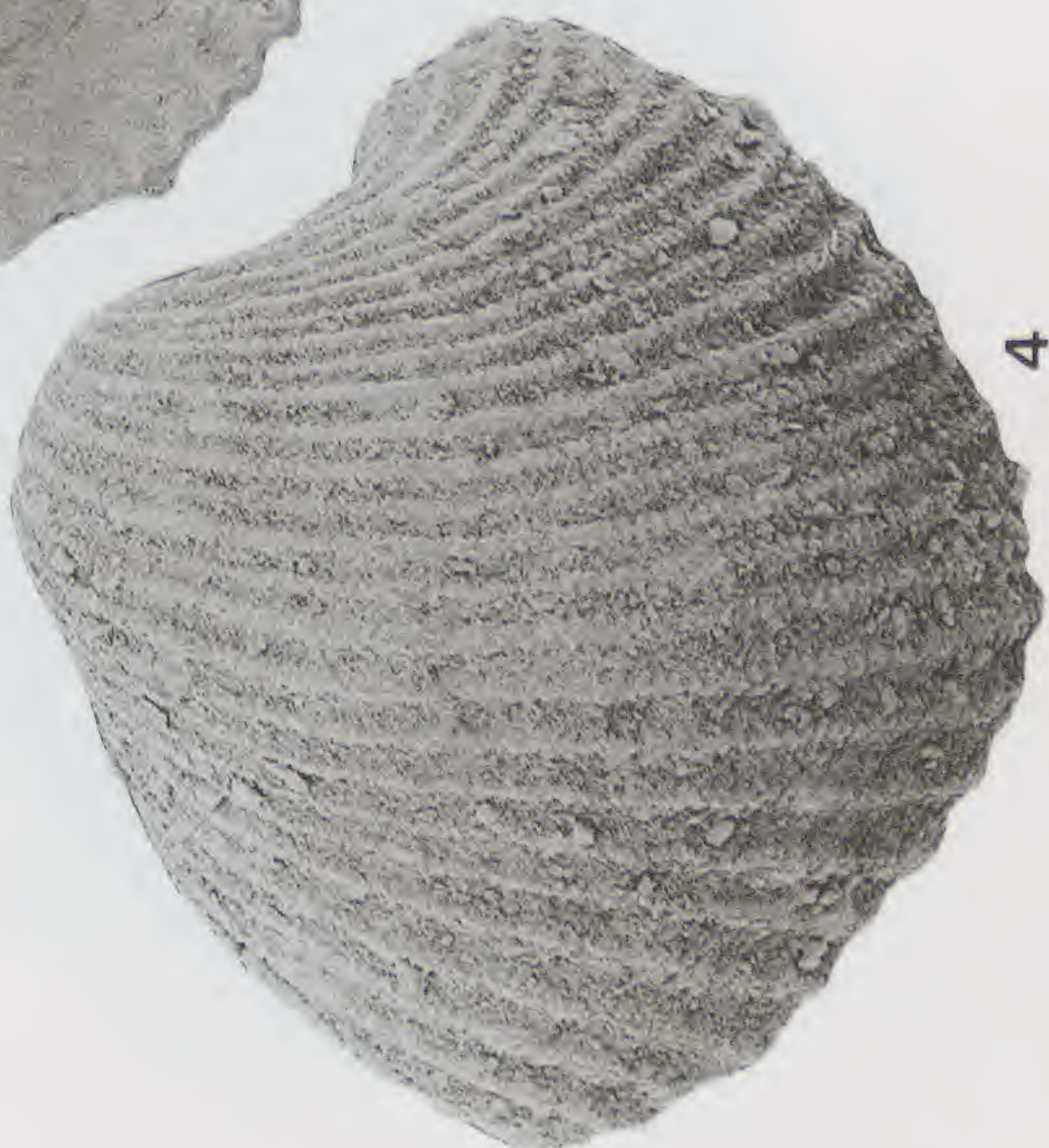
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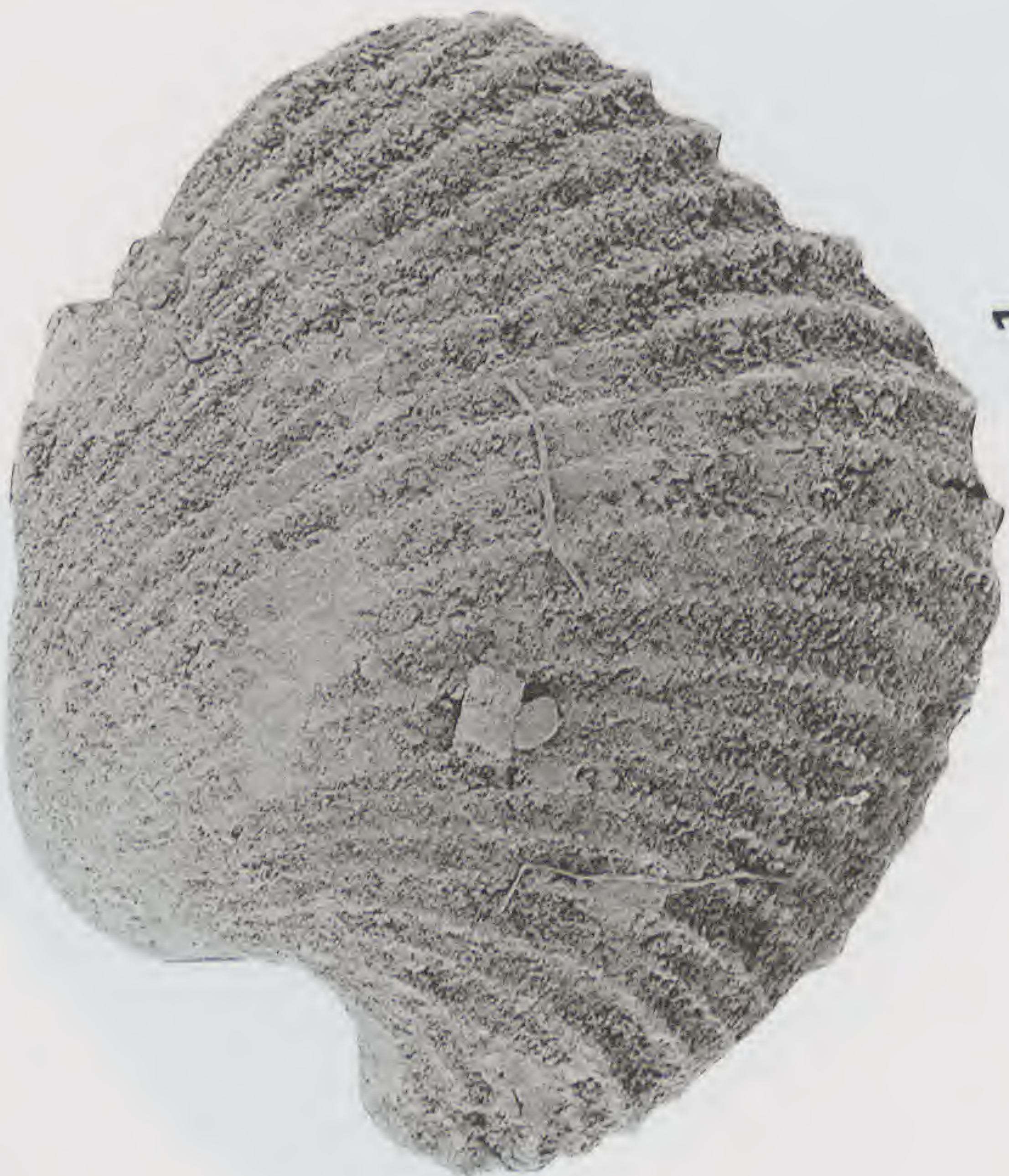
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NMB G 14158. NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene). Left valve. 1. Exterior; 2. Enlargement of sculpture, $\times 100$; 3. Interior; 4. Enlargement of hinge, $\times 50$. Length 3.2 mm; height 2.6 mm.	

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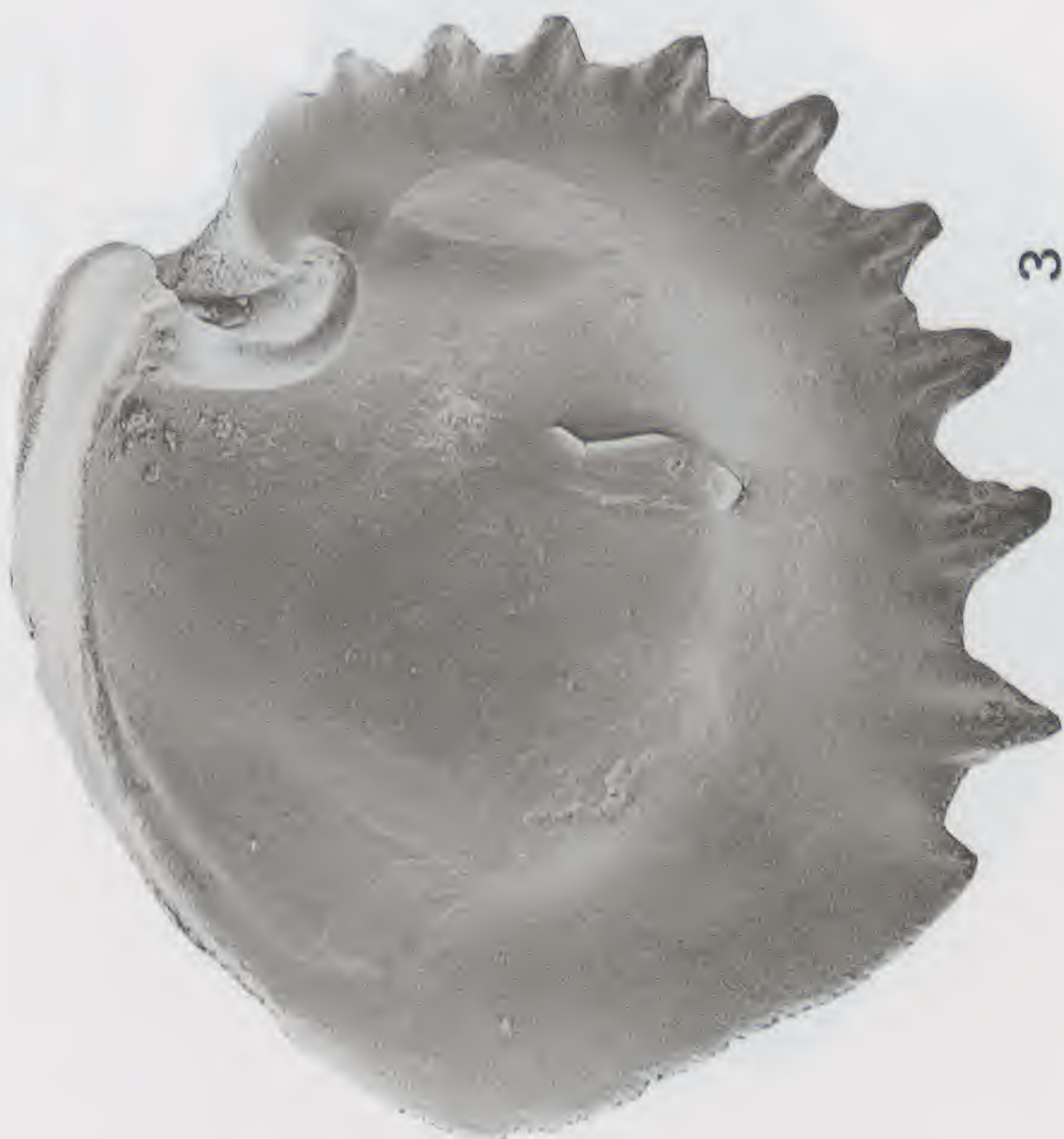
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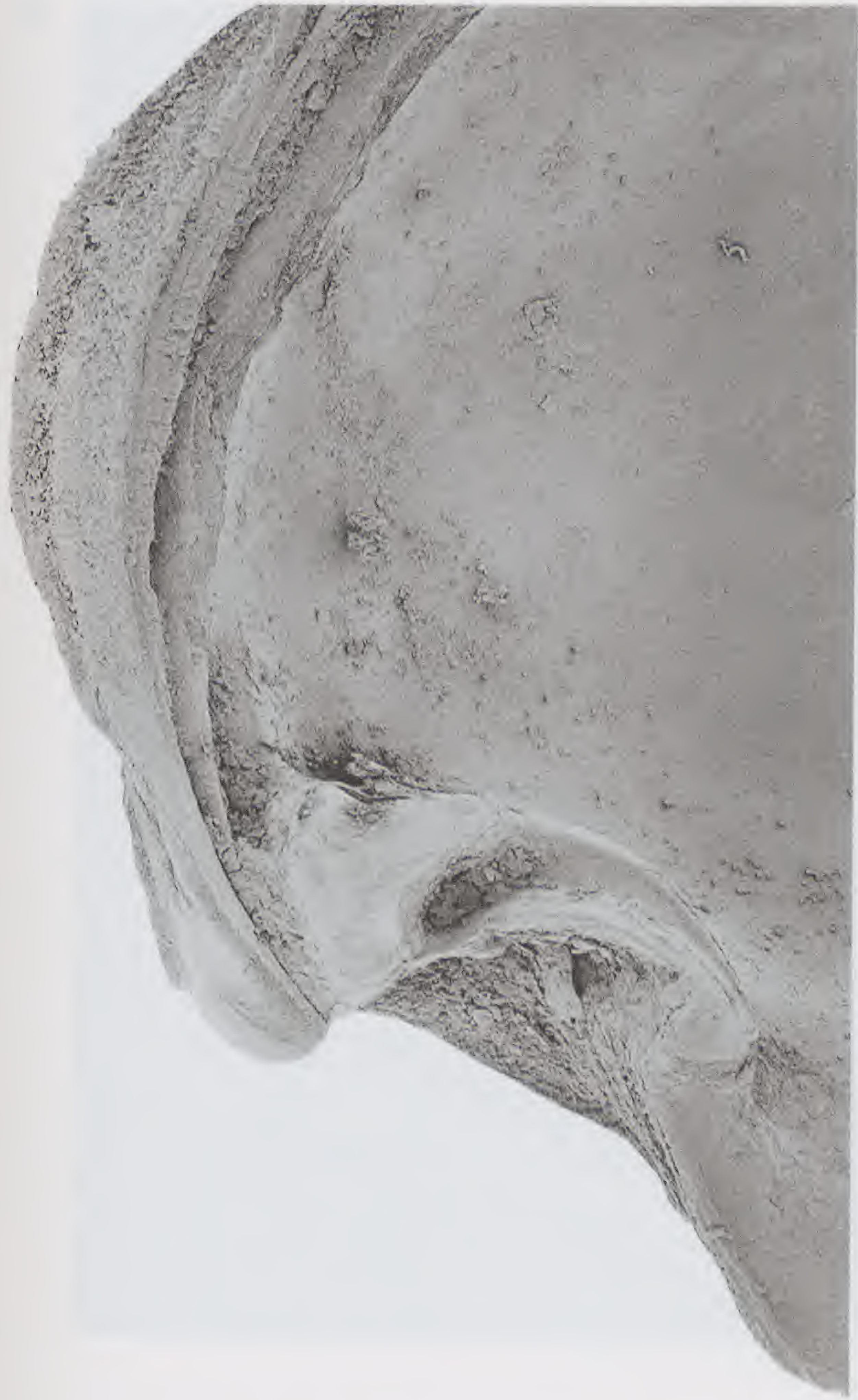
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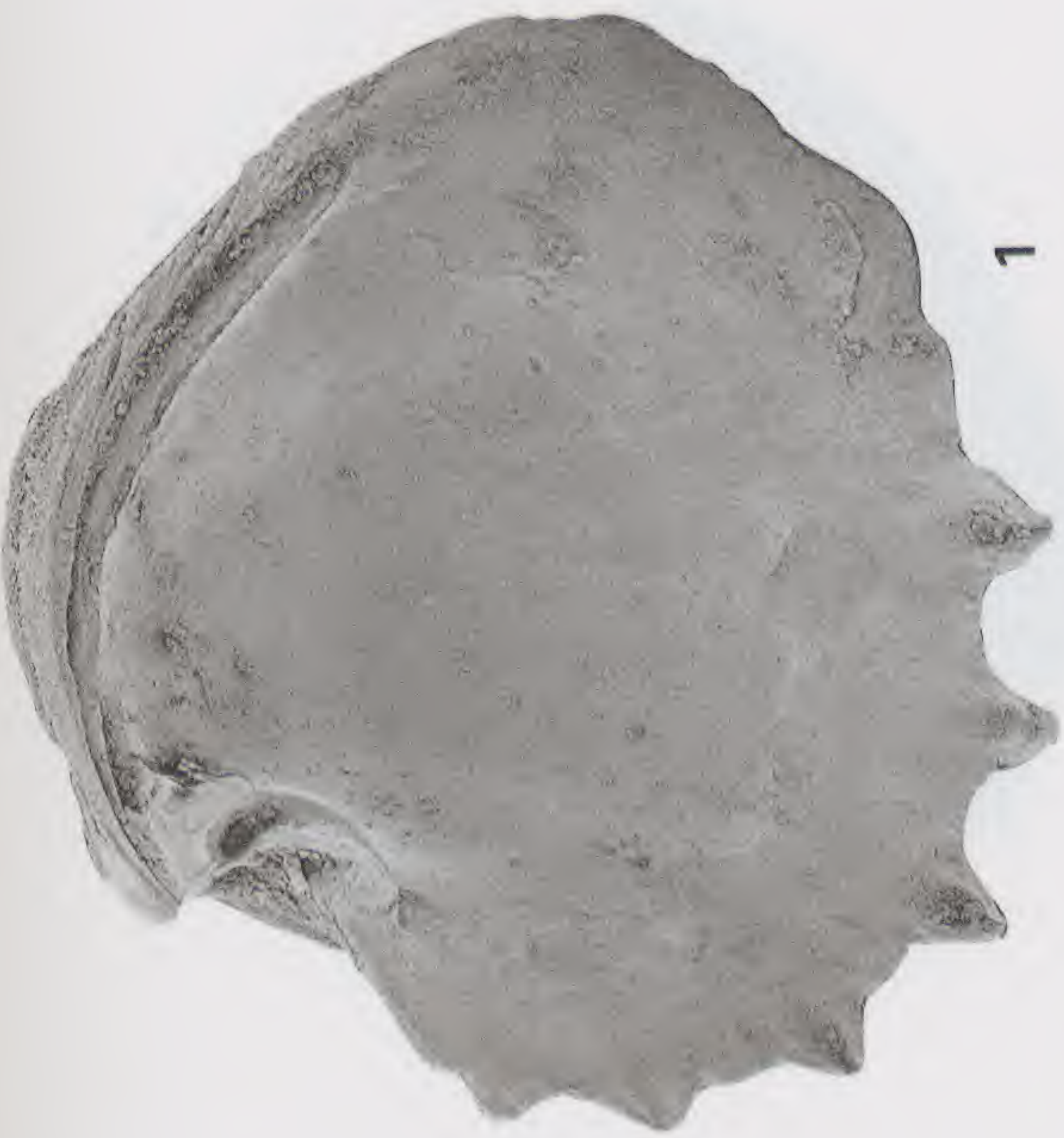
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| 1, 2. Interior of right valve. Length 4.8 mm; height 4.7 mm. 2. Enlargement of hinge, ×35. | |
| 3, 4. Interior of left valve. Length 4.7 mm; height 4.3 mm. 4. Enlargement of hinge, ×40. | |



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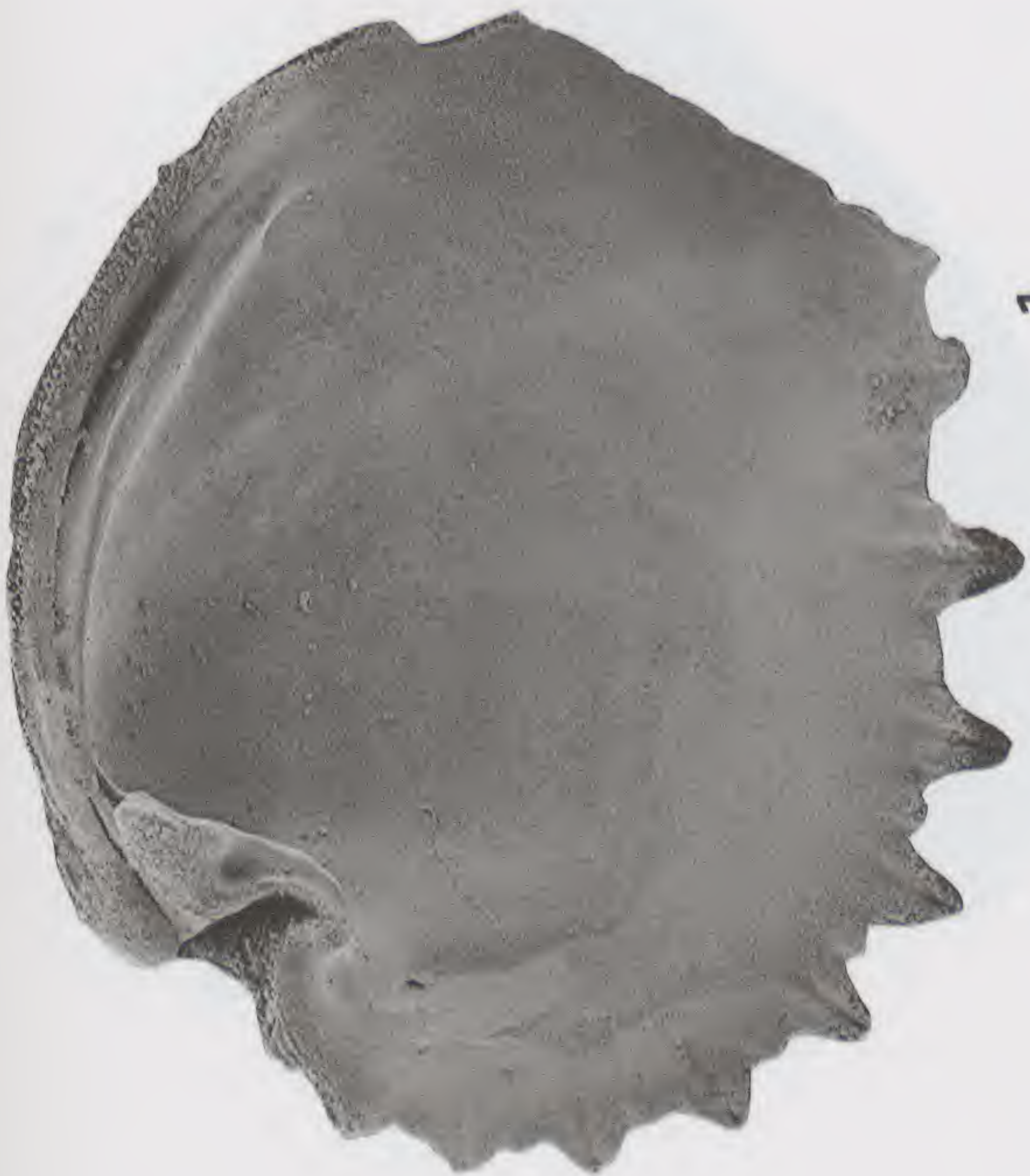
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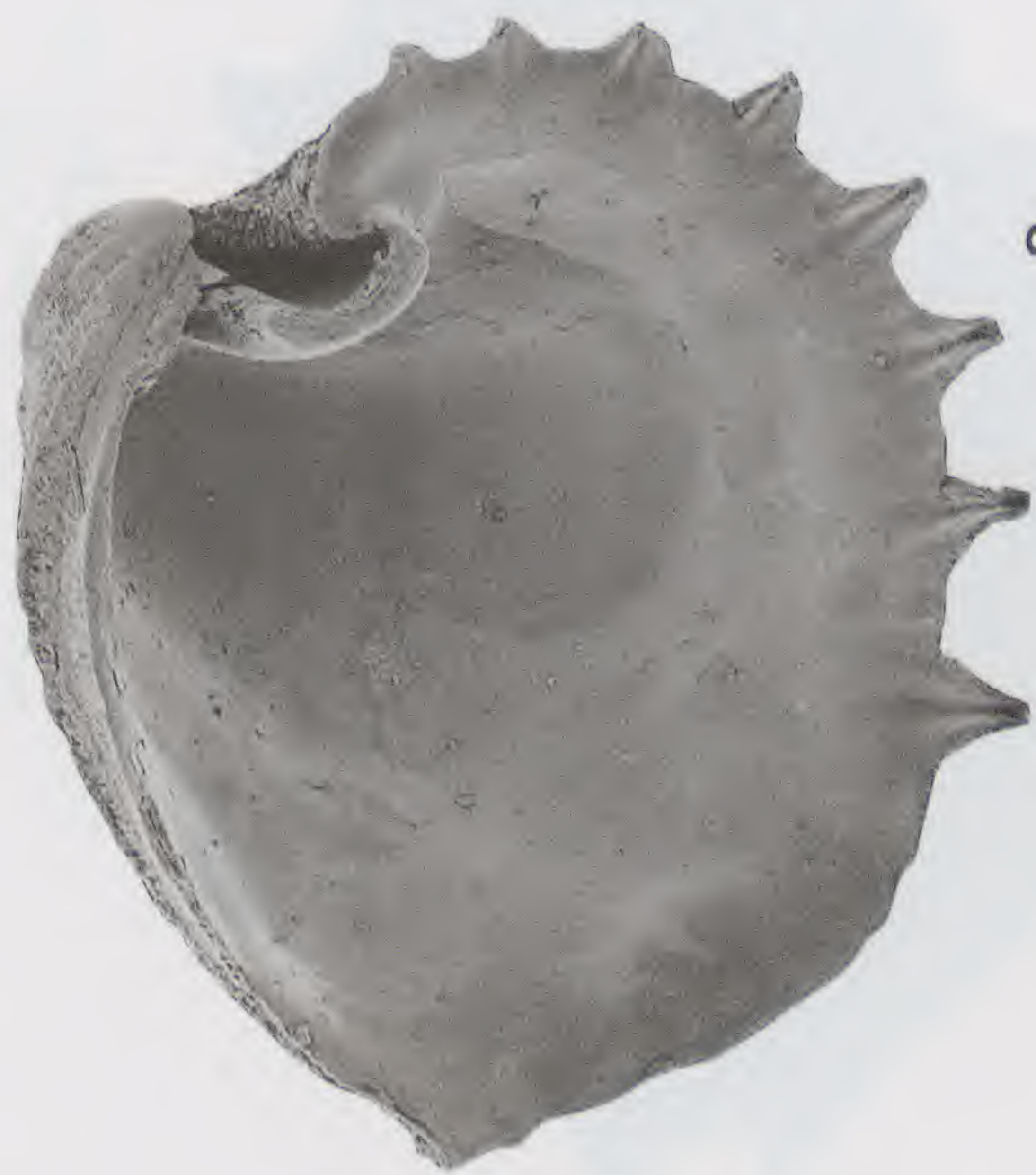
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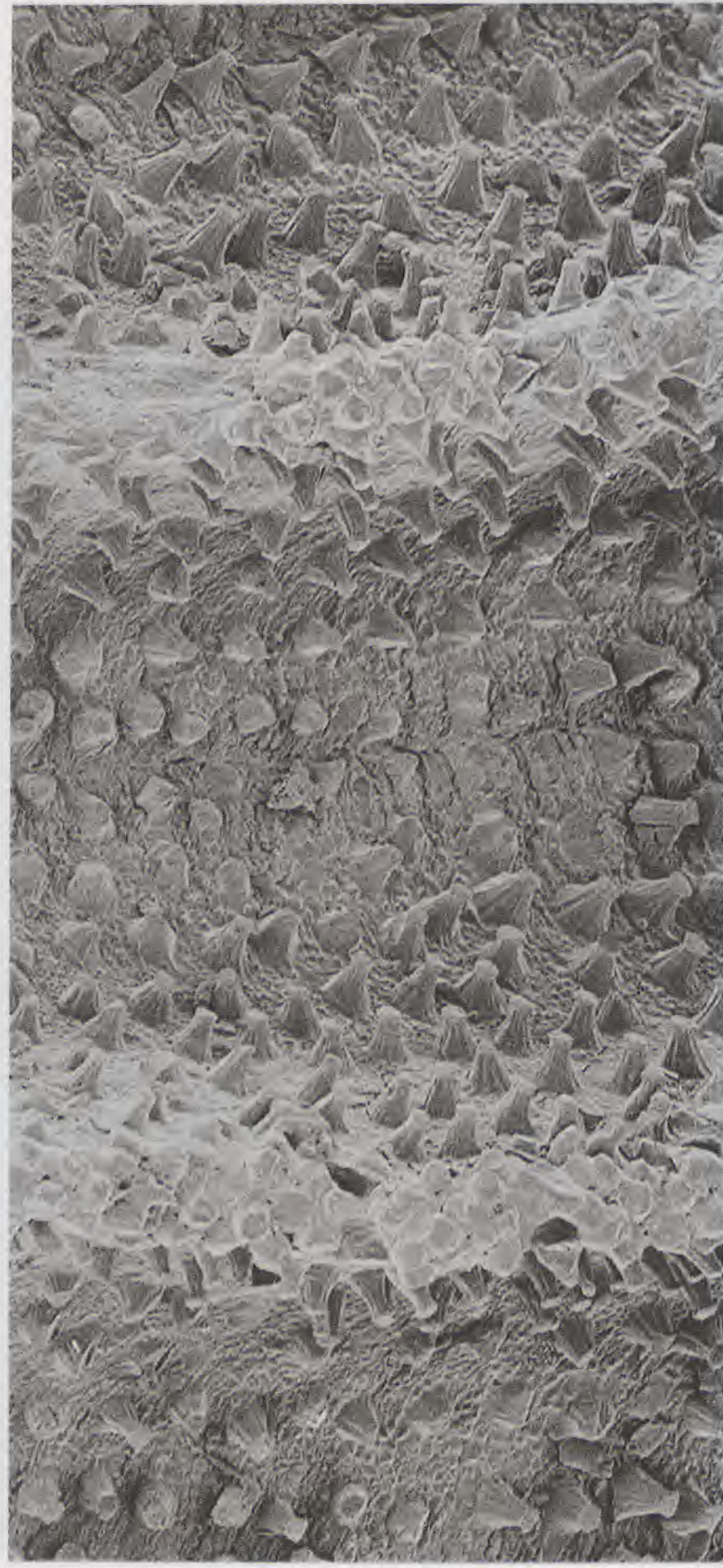
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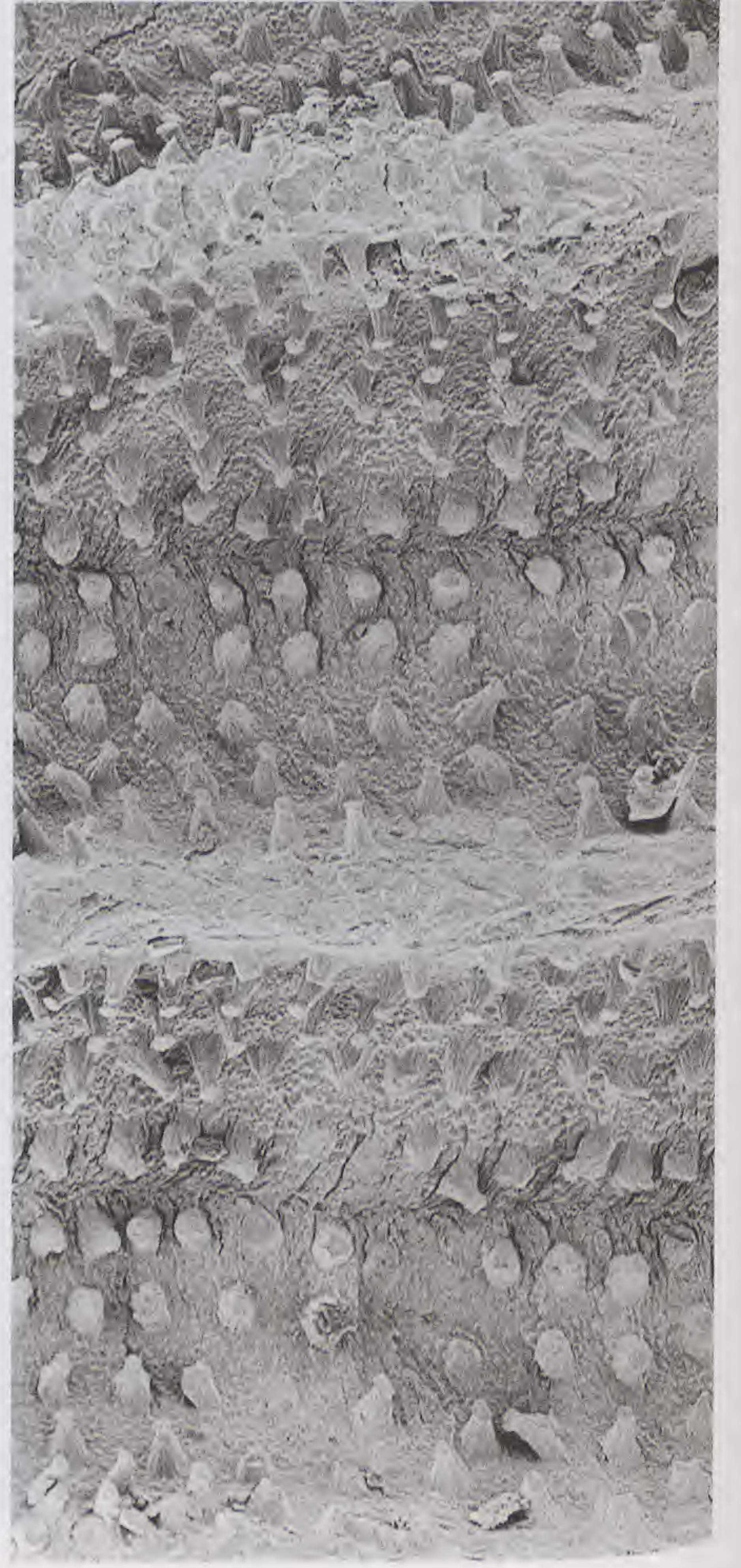
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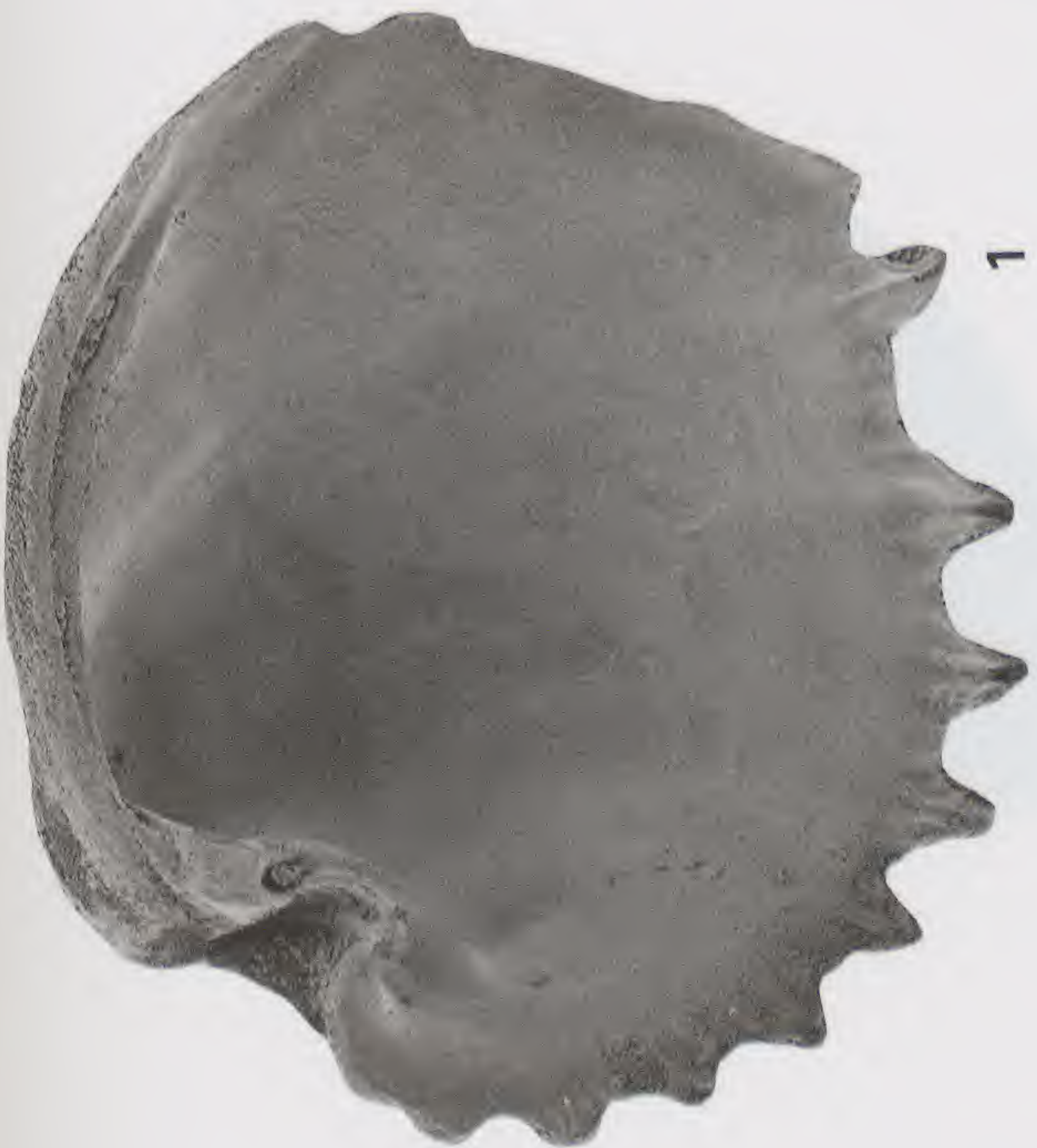
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